DELHI METRO RAIL CORPORATION LIMITED

TECHNICAL SPECIFICATION OF 25KV AC TRACTION (RIGID OHE), 33KV AUXILIARY SUB STATIONS (ASS), ASSOCIATED CABLING FOR UNDERGROUND STATION

(Revision: 0)

(December 2023)

DELHI METRO RAIL CORPORATION LTD.

Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi - 110001

DELHI METRO RAIL CORPORATION LIMITED

(A Joint Venture of Govt. of India & Govt. of NCT of Delhi)

CONTRACT PACKAGE:

Design, Detail Engineering, Manufacture, Supply, Installation, Testing and Commissioning of 25KV AC Traction (RIGID OHE), 33KV Auxiliary Sub Stations (ASS), Associated Cabling and SCADA Systems for Underground Station of …. and ….. of Phase-….. Delhi MRTS Project.

PART 2: EMPLOYERS REQUIREMENTS
SECTION VI : EMPLOYERS REQUIREMENTS
SUB SECTION B: PARTICULAR SPECIFICATIONS (PS)

PART – 1: RIGID OHE

DELHI METRO RAIL CORPORATION LTD.

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CHAPTER – 1

INTRODUCTION

1. INTRODUCTION

1.1 Scope and Purpose

1.1.1 This specification defines the objectives, guidelines and requirements for the contractor's Design, Supply, Installation, Testing and Commissioning of 25kV Rigid Overhead Contact System (ROCS), associated switching station (FP, SS, SSP and SP) with 25 kV associated cabling and SCADA System in the following corridors:

a.) Underground Section Details

1.1.2 The works to be executed under the Contract include the design, supply, installation, validation / verification, testing, including integrated testing and commissioning, technical support and documentation for a complete System necessary to deliver the requirements of these Specifications.

~~1.1.3 Since the system of traction on Phase-I, II & III of Delhi Metro consisting of elevated corridors and underground corridors have been commissioned at 25 kV AC, it shall be the endeavour that the new system shall meet the quality standards and equipment rating of existing installations at underground & elevated locations.~~

~~1.1.4 The Delhi Metro Rail Corporation (DMRC) has successfully completed Phase-I, II & III of MRTS project comprising of following lines:-~~

~~S. No~~	~~Line No~~	~~Details~~
~~1.~~	~~Line-1~~	~~Rithal to New Bus Adda (Gaziabad)~~
~~2.~~	~~Line-2~~	~~Samaypur Badli to Hudda City Centre.~~
~~3.~~	~~Line-3~~	~~Dwarka Sec-21 to Noida Electronic City~~
~~4.~~	~~Line-4~~	~~Yamuna Bank to Vaishali~~
~~5.~~	~~Line-5~~	~~Kirti Nagar/Inderlok to Brig. Hoshiar Singh (Bahadurgarh)~~
~~6.~~	~~Line-6~~	~~Kashmere Gate to Raja Nahar Singh (Balabgrah)~~
~~7.~~	~~Line-7~~	~~Majlis Park to Shiv Vihar~~
~~8.~~	~~Line-8~~	~~Jankpuri Wet to Botanical Garden.~~
~~9.~~	~~Line-9~~	~~Dwarka to Dhansa Bus stand.~~
~~10.~~	~~AEL~~	~~Airport Express Line- New Delhi to Dwarka Sector-21~~

1.2 Relevant Documents

1.2.1 This Specification should be read in conjunction with the General Conditions (GC), the Particular Conditions (PC), the General Specification (GS), the Employer's Drawings and any other document forming part of the Contract.

1.2.2 In the event of a conflict between the general specifications (GS) and this Specification, this Specification shall prevail.

1.2.3 In the event of a conflict between this Specification and any other standards or specification quoted herein, the requirements of this Specification shall prevail.

1.2.4 The order of precedence, with item a) having the highest priority, is:

a) Particular Specification

b) International Standards referenced herein.

c) Other International Standards

d) General Specification

e) Indian Railway Standards

f) Indian Standards

g) Other National Standards

1.2.5 Notwithstanding the precedence specified in clauses 1.2.1, 1.2.3 and 1.2.4 the Contractor shall always immediately seek advice from the Employer in the event of conflicts between Specifications.

1.3 Design Service of the Works

1.3.1 The Contractor shall be responsible for the design service of the Works and shall satisfy himself that the tentative capacities, ratings and quantities of equipment as specified herein meet the operational requirements for the underground portion of contract of DE-08.

1.3.2 The contract price shall deem to include any necessary additional equipment, equipment of higher capacities and higher ratings for the systems and sub-systems necessary for the complete, safe, reliable and operable power supply system for the underground portion of the works.

1.3.3 The proposed capacities, ratings and number of equipment as a result of the design development shall be demonstrated by a proper design and Traction Power simulation study and subject to review by the Employer.

END OF CHAPTER

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CHAPTER – 2

OVERVIEW OF THE PROJECT

2. OVERVIEW OF THE PROJECT

2.1 General

This Chapter gives an overview of the Project and the information provided in this Chapter is for reference only.

2.2 Contract Name

2.2.1 The contract……. consist of the works of Design, Supply, Installation, Testing and Commissioning of 25kV Rigid Overhead Contact System(ROCS), associated switching station (FP,SS,SSP and SP) with 25kV associated cabling and SCADA system for

- U/G corridors of the ……….. (Corridors to be mentioned)

2.2.2 Trains are electric multiple unit (EMU). Modern rolling stock with stainless steel body and VVVF 3-phase drive with regenerative braking has been utilised. The cars are air-conditioned.

2.2.3 ~~DMRC~~ has planned to adopt Communication Based Train Control (CBTC) System i.e., driverless train. Contractor shall adopt best international procedures & practices during designing of ROCS. Signalling system as adopted for existing section (if there are extension of existing sections, please mention the signalling system integration requirements) may also be implemented. The contractor has to consider the CBTC system requirements while designing the ROCS. The necessary interface required shall have to be done by the contractor. For each corridor signalling system features, the common interface between signalling, telecom and traction contractor has to be adopted, interface issues are mentioned in the interface document.

2.2.4 The rolling stock maintenance depot details and locations.

2.2.5 25kV single phase AC traction has been utilised with flexible Overhead Equipment (OHE) on elevated section and Rigid Overhead Contact System (ROCS) on underground sections.

2.2.6 Section in the contract have been provided with Un-Attended Train Operation (UTO)..

2.2.7 Platform Screen Doors Gates (PSG)/Platform Screen Doors (PSD) may be installed in the underground as well as elevated stations. Contractor has to interface with PSD/PSG contractor for design and other requirements of the ROCS.

2.2.8 (Tunnel Details to be mentioned) Closed type Tunnel Ventilation System has been used in U/G stations. The station public areas are air-conditioned while the plant rooms are provided with supply/exhaust system. Tunnel ventilation is primarily achieved by the movement of vehicles inside the tunnel under normal working conditions. Tunnel Ventilation Fans installed at each end of the stations are used to provide supplementary ventilation at times of high temperatures, and under congested traffic or emergency conditions. Booster fans have also been used at appropriate locations for use under emergency conditions or in case of a tunnel fire, the tunnel ventilation system is used for smoke extraction by operating tunnel ventilation fans in push pull mode. During emergency fire condition within a station, the station air handling system is operated for smoke removal.

2.3 Corridors/Sections Under Contract…….

2.3.1 The Phase-IV project comprises following Corridors:

Sl. No.	Corridor	Expected Date of Commissioning

However, the alignment of above corridors, number of stations and revenue opening date may change during design and construction stage.

2.3.2 Details of switching station of.

S.No.	Sectioning Name	Type of Switchgear used	Remark

Following are the sectioning posts planned for different sections/corridors under the contract:-

S. No.	Sectioning Name	Type of Switchgear used	Remark

*Location of feeding post shall depend upon the RSS land location, feeding post may be subject to change as per the location of RSS.

2.4 **Operation Control Center**

(Details of OCC of corridors/sections under the contract)

2.5 **Power supply (Details of interlinking power supply and RSS feeding the sections/corridors under the contract)**

Sr. No.	RSS	Supplies Power to Corridor
1		
2		
3		
4.		

Sr. No.	RSS	Supplies Power to Corridor
5.		

The present details of the corridor (which may go under change) are as follows:-

S. no.	Name of Station	Type of Corridor	Chainage (Meter)	Distance from previous station(Meter)	Platform Type

2.6. **Key Challenges**

The traction systems for the underground portion shall be adequate, safe and reliable. The following are the Key challenges presented to the contractor.

a) The specified level of reliability, availability, and maintainability and safety requirements of the System shall be achieved and verified by the Contractor by analysis, simulation, testing and commissioning, and system demonstrations as required in this Specification.

b) The space requirement given in the tentative layouts of Sectioning Rooms, etc. shall be critically reviewed by the Contractor to economise on space and also to provide a layout amenable to good maintenance and operation practices, to achieve an overall economic design.

c) Various interfacing issues with other Contractors are required to be resolved to ensure timely completion of the Works. Whilst most of the interface issues have already been addressed, some of them are yet to be identified or finalised during the progress of the work. It is the Contractors' responsibility to ensure that all interfacing issues are clearly defined and agreements sought from all concerned Contractors in accordance with the GS and the interface requirements.

d) The System Design shall meet the specified performance and operational requirements stipulated in this Particular Specification. The Contractor shall carry out a study to assess the work to be done to suppress the effect due to 25kV ac traction (EMI/EMC) on Civil Engineering RCC construction, power, telecom, control, ETS and signalling circuits etc. for safety of public, personnel and equipment. These studies shall form part of detailed system design.

Since passenger and personnel safety is involved in humid RCC tunnel environment for a high-capacity metro system, the long-time& short time induced voltage rise above earth potential shall be carefully computed based on reliable field data.

e) 25kV AC & 415 V AC and control cables will require laying at different levels within Auxiliary Substations, Cable Galleries, Stations, Train Tunnels and under croft. Liaison with the Civil Contractor & other Electrical System Contractors shall be undertaken to ensure that workable solutions for cable installation are established in advance keeping in view the maintenance requirements.

f) The cable feeders, overhead current collection system, other system components shall be designed to withstand the atmospheric pollution and ambient conditions furnished in GS (clause 1.12) relevant to the location where installed. However, the equipment installed in open at the ground level or inside buildings at ground level shall be designed for working in the tropical conditions existing in the area and under the maximum ambient temperature and relative humidity levels prevalent in the area.

g) The entire Scope of Works shall generally meet design requirements of fire safety in accordance with NFPA-130 Standard for Fixed Guide-Way Transit System, 2020edition, except where amended by this PS.

h) The entire installation shall meet the protective provisions relating to electrical safety and immunity, including those required against induced Emf caused by 25 kV AC traction.

END OF CHAPTER

CONTRACT PACKAGE – …..

CHAPTER – 3

SCOPE OF WORKS

3. SCOPE OF WORKS

3.1 General

3.1.1 This Specification establishes requirements for the Design, Supply, Installation, Testing and Commissioning of 25kV Rigid Overhead Contact System (ROCS), associated switching station (FP,SS, SSP and SP) with 25kV associated cabling and SCADA system for the U/G corridors under the contract to be mentioned.

3.2 Scope

The Contractor shall supply all equipment and materials necessary to meet the requirements of ROCS works, include but not be limited to the following: -

a) Design, Supply, Installation, Testing & Commissioning of 25 kV Rigid Overhead Contact System (ROCS) for the Underground Portion of…………

b) Design, Supply, Installation, Testing & Commissioning 25 kV Switching posts (SS, SP, SSP and FP) using Gas Insulated Switchgears (GIS type) interrupters/ CBs and/or AIS Circuit Breakers/Interrupters/isolators, Load break switches as applicable and their associated 25kV cabling/copper jumpers. (No 25kV cable shall be directly terminated at ROCS without the use of Load break switch-LBS).

c) Load Break Switches shall be installed at 25kV in-feed and sectioning post, wherever applicable as per SLD.

d) Design, Supply, Installation, Testing & Commissioning of Underground neutral section for traction supply. 25 kV Neutral Section in the underground portion. Neutral Section is planned to be installed in Round tunnel (TBM) as specified in Chapter-4.

e) 25 kV & 3.3 kV AC cable from RSS/TSS to the feeding post at respective location as defined in the contract.

f) Interlinking of 25kV power supply for Bi-directional Power transfer between Existing lines or new lines or between new and existing lines, as applicable may be executed by the contractor with necessary protection and interlocks. (Only if there is interlinking)

g) Design, Supply, Installation, Testing & Commissioning of protection scheme and relays for 25kV Traction system at interlinking works etc. Distance, Over-current & Earth fault relay for the protection of 25kV system for interlinking works (as per protection scheme approved by Engineer).

h) Interrupters/ Circuit Breakers for stabling sidings, Y-siding, link line etc as per SLD.

i) Design, Supply, Installation, Testing & Commissioning 25 kV Surge arrestors/LA's AIS or GIS type for each elementary section of the corridor.

j) 25 kV AC Cable works and cable support system including return current cabling in tunnel. In tunnels and station box structures, Contractor will provide & install the supports for cable hangers as per requirement. Design, Supply, Installation, Testing

& Commissioning of Retractable Catenary (MOCS) for any Depot at DMRC network.

k) Transition arrangement of 25 kV Rigid OCS to 25 kV flexible OHE in different ramp portions (as applicable).

l) Transition arrangement of 25 kV FOCS to Retractable Catenary (MOCS) in depots (as applicable)

m) Supply of contact wire for complete tension length from Transition arrangement of 25 kV Rigid OCS at …………

n) Earthing system (based upon traction power simulation study & EMI / EMC simulation study) including providing of METs, Copper cable (as applicable), relevant connections to OCS & all other services (hydrant pipe, track, walkway, tunnel reinforcement etc).

o) Centre Line marking, supports location marking, drilling, Supply and fixing of anchor fasteners for OCS supports.

p) Supplying and Fixing of Tunnel earth wire (Size of TEW will be based upon simulation study).

q) Provision of Thermite /Exothermic welds in track for connection of cables for return current continuity and for earthling of equipment.

r) Traction Power Simulation Study & simulation study for EMI / EMC and calculation of voltage induced in different services e.g. Rail, 33 kV cable, 25 kV cables, Earth wire, S&T cables, Tunnel Earth wire, LCX, Coaxial cables, etc. Also, magnetic field produced in a Transverse Plan of the Track.

s) All minor civil works or modifications required for installation of the equipment and restoring to final finishes.

t) Transfer of Technology.

u) Coordination with Contractors responsible for 25kV flexible OHE & other Systems.

v) Integrated Testing during train trials.

w) Validation (Auditing) of design & installation of ROCS through Independent Agency as per IEC and other relevant Standards. The tenderer/consortium partner/designer shall not be the part of Validation (Auditing) Agency.

x) Facilitate Power block during trials up to ROD (Manpower for the same should be deployed by the contractor).

y) Protective provisions relating to electrical safety and earthing which include earthing of equipment, cables and non-current carrying metallic components of this Contract, etc.

z) All protective measures to suppress EMI/EMC effects due to 25 kV AC traction

aa) Works Train for transportation of materials & equipment and for construction purposes.

bb) Supply of spares.

cc) Supply of Consumables during DLP

dd) Special tools, testing and diagnostic equipment and measuring instruments.

ee) Training

ff) Documentation. Supervision of Maintenance during DLP

gg) Services

hh) Shock treatment charts, first aid boxes, respiratory equipment and danger notice plates etc as per relevant safety standards and CEA regulations etc.

ii) Contractor's Design team shall supervise the installation of 25kV Rigid Overhead Contact System (ROCS), for the Underground and elevated section, switching station (FP, SS, SSP, SP) with 25KV associated cabling for the Underground and elevated Portion of……….

jj) Contractor will be required to interface with SCADA Contractor to enable them for implementation of SCADA system for the Rigid OCS and switching posts. Suitable OFC communication cables/link between all Rigid OCS and TSS equipment, from trackside sectioning posts to nearest station etc. shall be provided by contractor.

kk) In a general manner, all works, facilities and services and other components as required whether or not specified necessary to deliver the requirements of ROCS works to ensure a perfect and complete execution under this scope and relevant code and standards and to this specification.

ll) Any other item of work as may be required to be carried out for completing the work under this Contract in all respects in accordance with the provisions of the Contract and/or to ensure the safety of installation during and after execution.

mm) Contractor shall provide Rail cum road vehicle-RRV during the complete execution of ROCS works. The quantity of RRV's required is mentioned in part-I of the tender documents. The vehicle shall be capable of running before/after laying of track in tunnel, during pre/post installation, checks of ROCS (Static & Dynamic clearances etc). The vehicle shall have the provision of pantograph having same design & dimension used in the rolling stock of the section has to interface with rolling stock contractor for the details of pantograph.

nn) The work of extension of 25kV ROCS/Interlinking between existing section and new sections shall be done under power block in non-revenue hours as per laid down O&M procedures. After the successful energization of ROCS and during the later stage, work will be done under power block during day or night as required due to operational requirement or train trials or as per the circumstances.

oo) During installations all the activities will be executed at site as per the joint interface and sequence of access agreed between the contractors. The execution work may be conducted round the clock in shifts as per the joint interface agreed between the contractors after shared access agreed by them, the Contractor shall depute his staff, manpower, labour etc.

pp) Payments of wages to be paid to labour & staff according to statutory requirements of working hours.

All the provisions for the above shall be included in the pricing of the tender.

3.3 Services

The Services to be performed by the Contractor shall include, but not be limited to, the following:

a) Design, supply, system quality management, installation, testing including integrated testing and commissioning of the complete system as brought out above.

b) Presentations, reviews and audit support as specified in this Specification.

c) Contractor shall install ROCS, even without laying of track with use of rail cum road vehicle having all statutory requirement fulfilled e.g. emission norms, fitness, permit etc. as applicable during execution of work. However, centre line of track shall be made available to ROCS Contractor by other designated Contractor (Civil/Track)

d) Interface management as specified in this Specification.

e) Design, identification of locations and installation for concrete foundations for trackside equipment's.

f) System operations and maintenance support services.

g) Training for Employer's training instructors, operations staff, maintenance staff and engineering staff.

h) Decommissioning, removal and/or disposal of temporary works.

i) Prototyping as applicable as per the design submissions

j) Defects liability of Permanent Works after commissioning as stipulated in the General Conditions (GC) and Particular Conditions (PC).

k) Contractor shall be responsible for providing all assistance, manpower for giving 'Power Block', earthing of ROCS, during Power Block by providing & fixing discharge rod for facilitating train trails upto revenue operation.

l) Assisting in obtaining statutory clearances (e.g. design clearance from Ministry of Railways and Sanction of Commissioner of Railway Safety) and submittal of information asked for by statutory bodies (e.g., Government of India, Ministry of Railways, Commissioner of Railway Safety, Ministry of Power, BSES, MTNL/BSNL, PTCC, etc.) in particular format as directed by Employer.

m) Assisting in obtaining Right of way for cable path permission from civic agencies as directed by Employer.

3.4 Documentation

The documentation to be delivered by the Contractor shall include, but not be limited to, the following items: -

3.4.1 Design Stage

a) Description of general design philosophy.

b) System simulation reports based on Traction Power simulation study and EMI/EMC effects.

c) System reliability, availability, maintainability and safety evaluation reports.

d) Fault level calculations and short-circuit current curves.

e) Automatic fault identification and isolation arrangement.

f) Feeding arrangements under various supply failure scenarios.

g) Restrictions, if any, under receiving supply failures.

h) Determination of equipment ratings.

i) Determination of space requirement.

j) Design and proving protection system and its calculations.

k) Lightning protection measures.

l) Latest type test reports for equipment selected.

m) Detailed design drawings and reports.

n) Detailed interface reports and interfacing design drawings.

3.4.2 Construction Stage

a) Construction and Installation Plan.

b) Factory Acceptance Test Plan for equipment, components and its integration.

c) Quality Plans.

d) Installation, operation and maintenance instruction of all equipment.

e) Operation and Maintenance Manuals.

f) Records and drawings of equipment installed.

g) All other records of construction, including hidden parts.

h) Site test report of equipment.

i) As built drawings including interface drawings. and

j) Other documentation as required, by the Employer.

3.5 **Furniture and other statutory requirements**

3.5.1 The Contractor shall provide requisite furniture duly approved at the FP, SSP, SP & SS Rooms & interlinking feeding posts etc.

3.5.2 The Contractor shall provide Single Line diagram, Earthing & Bonding Diagram, Fire Extinguishers, shock treatment charts, insulating mats as per IS 15652: 2006, fully equipped first-aid boxes, danger boards, warning boards, restricted clearance board, Protective Covers, etc. being statutory requirements in adequate number and shall be exhibited at required locations.

3.6 **Key Dates and Access Dates**

The Key Dates and Access Dates applicable to this Particular Specification are given under Bidding Forms.

3.7 **Items of Work Excluded from Contract**

The following items of work associated with the System will be provided by other Contractors and are excluded from the Contract. However, the Contractor shall provide timely inputs such as necessary drawings, instructions, hardware and materials to the relevant other contractors as required. These items are detailed in Chapter 13 of this Specification.

3.7.1 In tunnel and station box structures, E&M Contractor to provide and install the supports for cable hangers as per design requirements of ROCS contractor. ROCS Contractors shall interface suitably with E&M contractor. Vertical risers/support structures for installation of cables to ROCS/BM/CB/LBS etc. May be required to be provided by ROCS contractor according to site requirements

3.7.2 Other civil engineering works viz. building, access roads, surrounding walls, shutter doors (if required by ROCS contractor) will be provided by Civil Contractors for FPs, SSPs, SPs and SSs. ROCS and Civil Contractors shall interface suitably.

3.7.3 Earth mats and earthing electrodes in ASS and for ROCS will be supplied and installed by other Contractors. However, earthing connection to all ROCS equipment from earth MET to be done by ROCS contractor.

3.7.4 The Receiving Sub Stations, Flexible OHE and SCADA related to Flexible OHE and SCADA at OCC will be provided by other contractor.

3.8 **Provision of Work Sites**

The Contractor will be provided Work Site at suitable locations along the corridor for storage, setting up workshop, stabling of vehicles and setting up of offices during construction period. The plan for office building will be duly approved by the employer. The contractor will be required to provide at least one air-conditioned room in each of his site office for the employer's representative with necessary communication facility. The work site may be provided within 6 months of the issue of LOA.

For Sections/corridors :

Land Details of the sections/corridors to be mentioned.

Contractor may please note the following regarding the allotted temporary land for :-

I. The land is having undulations. The development works within the area allocated to any Contractor shall be within the scope of the Contractor and nothing extra shall be payable on that account. The bidders must visit the site before quoting to get acquainted with the extent of development work required in the allocated area. Nothing extra will be paid for development of the land.

II. A common approach road is to be constructed for approaching the land pockets allocated to various contractors. The construction of this road along with drain and its maintenance shall be done by Civil Contractor and the cost of construction of this road, drainage work along with maintenance of road / drain shall be shared amongst all the contractors in proportion to the land area allocated to them.

III. Land shall be handed over to the contractor free of any rent upto the period of actual commissioning of the corridor plus 90 days more for demobilizing and clearing of the site. Any stay beyond this period shall not be allowed and in case of delay in vacating the land beyond this period, rent shall be charged from the Contractor for the full land at the rate at which DDA will charge the rent from DMRC.

IV. All the site structures, offices, stores, fencing, boundary or any other structure constructed by the contractor during his use has to be dismantled and land is cleared for handing over to DDA or any other external agency. Area shall be clear from all the waste material etc.

V. The connections like, telephone, electricity etc which contractor may have taken during his use on the land allocated may have to be closed by the contractor. Any dues arising out of the allotted space shall have settled by contractor during his use.

3.9 Optional Items

For interlinking and other works DMRC may provide the GIS panels dismantled from other installations of DMRC network. These items have to be collected by the contractor from DMRC premises and shall have to install tested and commissioned by the contractor. The original equipment manufacturer of the equipment has to be roped in for the re-installation and commissioning. For this item shall be created as per GC/PC and shall be treated as additional item.

3.9.1 Not used

END OF CHAPTER

CONTRACT PACKAGE – ….

CHAPTER – 4

DESIGN AND PERFORMANCE REQUIREMENTS

4. DESIGN AND PERFORMANCE REQUIREMENTS

4.1 General

4.1.1 The design, supply, installation, testing and commissioning of the Rigid OCS system shall meet the design and performance requirements within the design environments specified in this PS.

4.1.2 The Design & Drawings for the Civil, Architectural works shall be done in the BIM 3D modelling. The designs and drawings shall be prepared & integrated with the civil/architectural BIM models by the contractor. The latest software's of the Revit, Navisworks of the BIM shall be utilized at the time of designing and clash detection etc.

4.1.3 The contractor shall have to create all the facilities related to the design and modelling related to GAD and other drawings with BIM. It shall be responsibility of the ROCS contractor that the design, drawings prepared by him are collaborating with the civil/ architectural or other agencies as deputed by SWC (System wide contractors) for creating the 3D models of their system/works.

4.1.4 Necessary manpower, staff having with requisite skills of BIM and other software's as per requirements shall have to be deployed by the contractor during the designing stage. All necessary Interface's for the preparation of the 3D model with incorporation of the ROCS/ASS requirements to be done by the contractor. All the correspondence related to the BIM modelling shall be done by the ROCS contractor.

4.1.5 Drawings and layouts etc as required shall be extracted from the finalized BIM 3D model shall be submitted to the Engineer in charge for its review and approval.

4.1.6 Further for Project management and updation of site progress Employer may hire Project Management agencies/software (VPP & STAMP etc.) .The contractor has to update all the progress daily progress, daily events, daily schedule and work programme, on site photographs, on site videos etc on the software/website as directed by the Engineer in charge.

4.1.7 DMRC intent to make payments and Vendor approvals through online portals, the contractor has to depute competent team for online submission and other works related activities. Necessary training for his staff shall have to be arranged by the contractor as per DMRC software's/websites/portals. Competent persons having experience of online submissions and project monitoring through online portal has to be hired for this work .Approval of Engineer in charge have to be taken for the person being hired with details of work experience.

4.1.8 The ROCS contractor shall have Licensed BIM Software.

4.2 Design Environment

4.2.1 Climate Conditions/Operating Environment stipulated in clause 1.12 of General Specification shall apply. Wherever the equipment is installed in open at the surface level or inside buildings at surface level, the same shall be designed for working in the tropical conditions existing here and the ambient temperature and humidity levels pertaining to Delhi area.

4.2.2 Isoceraunic level: Average 30 thunderstorm days per year as per IS 2309:1989

4.2.3 Tunnel walls may be wet and seepage water will normally be present in the invert. The system design shall, therefore, take into consideration the effect of seepage and continue to operate in such wet and humid conditions.

4.3 Salient features of the Metro System

4.3.1 The salient features of the underground Corridor are as follows (Subject to change as per the design requirement of the corridors/sections):

4.3.1.1 General

S. No.	Description	Unit	Standard Gauge
(i)	Gauge	mm	1435
(ii)	No. of tracks	Nos.	2
(iii)	Shortest radius of curve		
	on main lines	m	200
	on Depot lines	m	150
(iv)	Maximum gradient	%	4%
(v)	System of current collection tunnel		25 kV AC Rigid Overhead Contact system
(vi)	Type of platforms		Island/Side
(vii)	Length of platforms	m	140 (approx)
(viii)	Design Speeds		
	Main Line	km/h	95

S. No.	Description	Unit	Standard Gauge
	Depot Access Line	km/h	95
	Depot Test Track	km/h	95
	Crossovers	km/h	40

4.3.2 **Underground Section** (Subject to change as per the design requirement of the corridors/sections):

4.3.2.1

Cross Section

(i) Box tunnel - 4700 x 5200mm

(ii) Diameter of bore tunnel - 5600mm (5700 ± 100mm)

(Construction tolerance ± 100mm**)**

Finished tunnel for single track after as-built tolerances shall be of minimum 5600 mm internal dia with the design axis of the tunnel. This means that at no point of circumference of as built tunnel, distance between designed axis of the tunnel and internal surface of tunnel shall be less than 2800 mm

For some sections tunnels may be constructed with NATM technology, the contractor has to interface with tunnel constructing contractor for details of the construction. ROCS designs suitable for the NATM construction adopted by the civil contractor has to be developed by contractor.

The tolerances for the design internal dia of minimum 5700 mm for single track tunnel shall be as under:

a) The internal profile of lining shall not depart from its design position by more than 30mm. This means that the centre of the tunnel at any cross section may deviate from the designed centre upto 50 mm, provided the internal dia at that cross section is equal to 5700 mm.

b) The internal profile of any ring of shield-driven tunnels shall not deviate from a true circle by more than 25 mm. That is, any diameter of the as-built ring shall not differ from the design internal diameter by more than 50mm. However, this tolerance shall not be permitted where tolerance at 4.3.1.2 (a) has been utilized.

c) The plane of the leading face of each ring, including a taper ring, shall not depart at any point from the plane surface by more than 6 mm.

d) Steps between abutting segments shall not be greater than 5mm.

e) The roll of adjacent circle joint bolt holes shall not be greater than 5 mm; the maximum total bolt hole roll of any ring is 40 mm from the design position.

i)	Depth of rail below ground level	-	10 to 20 m approx.
ii)	Overall length of station box	-	Approx. 280-290m
iii)	Width of station box	-	Approx. 25-30m
iv)	Width side platform	-	Approx. 5m
v)	Width of island platform	-	Approx. 10 -15m

Note: The above parameters are to be ascertained and to be confirmed from civil contractors.

4.3.2.2 **Provision of Neutral section in Round Tunnel**

As above, finished round tunnels shall be available to the contractor for providing the neutral section in ROCS wherever required. The interface for the same has to be done by the contractor at the time of finalization of track alignment, tunnel construction with the designated Civil contractor, overlap type neutral section as provided in earlier build section of previous phases of MRTS has to be accommodated in the Round tunnel construction.

The neutral section shall have clearance as per IEC 60913 and any arrangement for the provision of withstand of lightning in phase etc. or earthing has to be accommodated in the above round tunnel section. Details of the civil construction of Neutral section are provided in the Appendix-C along with Interface details.

The Neutral section design shall be similar to existing neutral sections of DMRC underground network. In case a new design is proposed by the contractor, the contractor shall conduct simulation study to prove the suitability of the neutral section, considering the dynamics of ROCS design & pantograph interaction at the design speed of the main line. Necessary supports, earthing, cabling/Jumper terminations etc. has to be accommodated in the round tunnel construction.

The neutral section shall be provided anywhere in the MRTS network as per alignment. Contractor shall submit the details of the design and other details of the neutral section within two months after the award of contract. Construction of the neutral section in round tunnel shall be part of the milestone of the corridor.

All arrangement required for the reliable operation of the neutral sections shall be done by the contractor.

Note: Above parameters are to be ascertained and to be confirmed from Civil Contractors.

4.4 Basic Design Philosophy and Requirements

4.4.1 Proven Design

The Contractor shall develop the design based on this specification and on proven and reliable Engineering Practices. The design details shall be submitted with technical data and calculations to the Engineer for review.

The System, including all Sub-systems and Equipment shall be of proven design.

Sub-systems and Equipment proposed by the Contractor shall have been in use and have established their performance reliability on at least one Mass Rapid Transit System or Suburban Railway System in Revenue Service over a period of at least two years.

Where similar equipment or Sub-systems of a different rating are already proven in service, then the design shall be based on such equipment. In case these stipulations are not fulfilled, the Contractor shall furnish sufficient information to prove the basic soundness and reliability of the offered Sub-system and can be adopted only after the approval of the employer. The system will be permitted to be energized only after the technical audit by an independent renowned agency.

4.4.2 The design philosophy should meet the following criteria:

a) Application of state-of-the-art Technology

b) Service proven design

c) Design life 30 years

d) Minimum life cycle cost

e) Low maintenance cost

f) Use of interchangeable, modular components

g) Extensive and prominent labelling of parts, cables and wires

h) Use of unique serial numbers for traceability of components

i) High reliability

j) Low energy loss

k) System safety

l) Adequate redundancy in system

m) Fire and smoke protection

n) Use of fire retardant materials

o) Environment friendly

p) Adherence to operational performance requirements

q) Maximum utilisation of indigenous materials and skills, subject to quality conformity

4.4.3 Adequate margin shall be built into the design particularly to take care of the higher ambient temperatures, dusty conditions, and high seasonal humidity, etc. prevailing in Delhi.

4.5 Design Management and Control

4.5.1 In order to ensure that the requirements of this Particular Specification are met, the Contractor shall establish and maintain documented procedures using, ISO 9001 to control and verify the design of the System and all its equipment. These procedures shall be subject to review by the Engineer.

4.5.2 The Contractor shall establish and maintain a systematic, documented, comprehensive, and verifiable system integration process throughout the execution of the Contract.

4.5.3 This process shall ensure that interfaces and interaction between System, infrastructure, sub-systems, software, and operating and maintenance requirements have been identified and engineered to function together as a system.

4.6 System Integration Process

4.6.1 The Contractor shall systematically identify and formally document all design, manufacturing and operational interfaces between equipment within the System, and between the System and external systems, facilities, operations and the environment likely to affect or be affected by the System.

4.6.2 A mechanism and assigned project responsibility for interface management and control shall be provided, such that every identified interface has a defined resolution process that can be monitored.

4.6.3 The Contractor shall define methods to confirm compatibility between System equipment and carrying out integration tests at different stages of the design and interface management process to demonstrate that all equipment functions perform properly, both individually and as part of the complete System.

4.6.4 The Contractor shall ensure that performance, availability, and safety requirements are addressed in the design process and that the reliability and maintainability of all equipment will enable the service performance to be met.

4.6.5 The system integration process shall be capable of audit by the Engineer

4.7 Interface Management Plan

4.7.1 The Contractor shall submit to the Engineer for review an Interface Management Plan (IMP) and Detail Interface Documents, in accordance with the General Specification, which defines how the Contractor will systematically identify and document technical interfaces.

4.8 Design Submission Requirements

4.8.1 The Contractor shall perform his designs for the Contract in accordance with the requirements of this PS and the GS. The Contractor shall submit to the Engineer for his review, relevant design information as identified under each stage. Such submissions shall incorporate the relevant Standards applicable.

4.8.2 The design submission requirements are detailed in the General Specification.

4.9 Traction Power Supply Performance Requirements

The following data shall be used for all normal and emergency performance requirements of traction power supply system.

4.9.1 Rolling stock characteristics and train operation data (Details to be changed as per the RS contractor or type of Rolling Stocks)

Traction power supply of shall be designed taking into consideration the rolling stock characteristics and train operation data given below Table 4.9-1 and Table 4.9-2

Table 4.9-1Typical Rolling stock characteristics and train operation data

Item	Metro Corridor
Maximum design speed	95 km/h
Maximum service speed	85 km/h
Schedule speed with 30 seconds station stop and 8% coasting excluding terminal station turn-round time	32 km/h
Acceleration 0-30 km/h for fully loaded train on tangent track	1 m/s^2
Service braking rate from 85 Km/h to standstill (fully loaded train on tangent track)	1.0 m/s/s
Emergency braking rate from 85-0 km/h	1.3 m/s/s
Expected adhesion but not limited to	18%
Train configuration	4MC+2TC(2DMC+2TC+2MC)
Type of rolling stock	Modern stainless-steel cars with VVVF 3 phase drive

Item	Metro Corridor
Type of Braking	Electro-pneumatic service friction brake, Electric regenerative brake, emergency pneumatic brakes
Design headway between trains	90 Seconds
Maximum gradient	4%
Maximum current drawn by 6-car fully loaded train	To be ascertained from Rolling Stock Contractor

Table 4.9-2 Car weights and passenger capacities (Details to be changed as per the RS contractor or type of Rolling Stocks)

Type of car	Tare weight	Total passenger carrying capacity @ 8 passengers per square metre	Total passenger weight @ 65 kg per passenger
Motor car	42.10 Tonnes	380	24.7 Tonnes
Trailer car	40.85 Tonnes	380	24.7 Tonnes

The tentative rolling stock characteristics are subject to confirmation from Rolling Stock Contractor.

Further details such as power drawn versus time and distance characteristics for level of services at design headway may be ascertained from the Rolling Stock Contractor.

4.9.2 Performance Requirements of Traction Power Supply System

Traction power supply system shall meet the requirements given below in Table 4.9-3 in respect of maximum and minimum voltages at any overhead current collection point.

Table 4.9-3 Voltage Requirements

Voltage	Metro Corridor
Nominal voltage	25 kV ac
Minimum Voltage	19 kV ac

Maximum voltage	27.5 kV ac

4.10 Performance Features Required

4.10.1. Contractor shall provide built-in diagnostics and remote monitoring functions for each microprocessor-based equipment and module of the systems such that the performance requirements can be demonstrated.

4.10.2 The reliability and maintainability processes and procedures shall be planned, integrated and developed in conjunction with the operating environment, and the design, development and production functions to permit the most effective and economical achievements of the systems and equipment design objective.

4.10.3 The systems shall meet or exceed the requirements for safety and reliability as specified in national or International Standards for such mass rapid transit system. The reliability of the systems designed, supplied and installed is the principal element for availability. It is essential that the System reliability is as high as reasonably practicable.

4.10.4 A high design standard incorporating redundancy if practicable, flexible system arrangement, together with good quality products, and adherence to strict construction standards, are required to ensure high reliability of systems installed for smooth operation of train services.

4.11 Not used

4.12 Availability

4.12.1 Service Availability Targets

Please Refer Appendix-H for detailed Reliability, Availability, and Maintainability plan

4.12.1.1 System availability to ensure that the reliability of the Systems does not jeopardize the reliability of services of the MRTS.

4.12.1.2 The Systems shall be designed to ensure that failure of any major equipment, caused by an external accident or negligence of internal staff, will not lead to unavailability of the whole System, other than temporary outage of the failed equipment. Four classes of severity of failure are as under:

i. Failure affecting revenue services
ii. Failure affecting reduced frequency of revenue (train) services
iii. Failure not affecting revenue services at all.
iv. Failure due to external reasons i.e. flooding, rain water falling, grid power failure, negligence of internal staff etc.

4.12.1.3 All elements of the systems shall be able to be maintained during out-of-traffic hours to avoid interrupting passenger train services.

4.12.1.4 Figure for service availability are hereby specified in 'failures per annum' in each of the above four classes of severity of failure referred above under clause 4.12.1.2. The failure per annum in each of the four classes of severity of failures shall not be more than as specified here as under:

(i) Near zero (ii) Near Zero (iii) Two per year (iv) No target

In case of ROCS remains unavailable during revenue service hours due to failure attributable to the contractor, Engineer with approval of employer may at his sole discretion impose a penalty on the contractor, commensurate with the revenue and opportunity loss to the Employer. Minimum penalty shall be Rs.10,000/- per hour or part thereof and maximum penalty shall be Rs.5,00,00/- per hour or part thereof. The decision of Employer shall be final and binding.

Both reliability and maintainability in terms of time to restore service or implement mitigation measures to work around the occurrence of a fault are to be considered. The service availability targets include failure of the System power supplies, but exclude grid supply failures affecting multiple primary substations.

4.13 Detailed Availability Requirements

4.13.1 As far as is reasonably practicable, failures of the overhead line, or support equipment shall not cause loss of traction supply to more than one line, nor to sections of route that do not pass over the section of line where the fault occurred. Provision shall be made, through section isolators and other means, to allow reconfiguration of the traction power supply to feed the overhead line in areas not directly affected by the fault.

4.13.2 The Contractor shall define maintenance and test procedures of various equipment to ensure adequate availability of the traction power supply.

4.13.3 Indoor components and cabling shall be so located as to prevent exposure to water and moisture. Adequate care shall be taken to ensure that derating of indoor equipment does not take place.

4.13.4 Means shall be adopted, in the design and installation of the System, to prevent equipment and component failures or overhead line structural collapse, as far as reasonably practicable. Mechanical joints of conductors, which may be susceptible to failure, shall, where practicable, not be located in close proximity to passenger platforms.

4.13.5 Not Used

4.14 Maintainability

4.14.1 The Contractor shall undertake maintainability analysis to assess the preliminary maintainability targets of the systems.

4.14.2 The Contractor shall state the maintainability requirements, and demonstrate that System maintainability is sufficient to support the claimed System reliability and availability performance. The Contractor shall demonstrate that maintenance errors have been considered, and, as far as is practicable, the risk of maintenance-induced faults has been mitigated by the appropriate design.

4.14.3 The equipment to be supplied by the Contractor must be designed for minimum or no maintenance. Maintenance activity required must be capable of being performed with minimum or no impact on the train service.

4.14.4 Maintenance equipment and materials should not be stored at the trackside unless essential for efficient and safe operation. This is particularly important in restricted access areas such as tunnels.

4.14.5 Maintenance activities may be classified into two areas, routine preventative and corrective, both of which affect service availability. Other maintenance strategies such as condition monitoring may be incorporated.

4.14.6 Routine/preventive maintenance periods shall be limited to non-operational maintenance hours during the night or if essential during off peak periods.

4.14.7 To optimise speedy corrective maintenance, techniques employing automatic diagnostics test points, and rapid repair facilities shall be provided. In addition, especially the OCS System and the associated traction power cable network shall be so arranged that the corrective maintenance work can be easily carried out under accidental crippled operation.

Please Refer Appendix-H for detailed Reliability, Availability, Maintainability plan.

4.15 Safety

4.15.1 Safety Requirements

- The installation design shall incorporate measures to avoid presenting safety hazards to people.
- The Systems design shall incorporate measures to provide for its safe management and operation.
- The Systems shall not give rise, or be subject to, dangerous interactions within the railway or with other systems. The design of the systems shall consider the safety and reliability of interface to the adjoining transit system such as surface corridor or Northern Railway. The design shall also consider potential interfaces with Road System.
- The installation shall meet the fire safety requirements generally as per NFPA130.
- The design of the earthing system shall conform to IEEE-80/2000, IS 3043: 1987 and EN 50122-1 with latest amendments, as applicable.

4.15.2 Safety Targets

- The Contractor shall show that the Systems can be maintained safely. The Contractor shall prepare a Quantified Risk Assessment (QRA) to model the risk to (a) travelling public and (b) maintenance and operations staff. The QRA may be based on a comparison of System features and operating practices with other underground metro systems for which risk levels are known. The QRA shall address the risk of electrocution from the OHE/ OCS and other equipment as well as EMI effects of 25kV traction. For maintenance personnel key elements of the QRA shall include as a minimum an assessment of the risk of being struck by a train while working line-side, of falls during maintenance, of electrocution. Accidental charging of dead section due to problem with SCADA posing safety hazard shall also be addressed.

- The Contractor shall demonstrate that the Systems have been designed to minimize the risk due to operator and maintainer error, considering both the ergonomic aspects of the system design to reduce the likelihood of error, and protective measures adopted to mitigate the consequence of such error.
- The Contractor shall demonstrate that risk to passengers, members of public, including trespassers is low as reasonably practicable.

4.16 System Requirements.

4.16.1 Design for horizon year 2051 (Subject to change as per the requirement of the corridor as year of the contract).

The system shall be designed by Contractor to support the movement of ultimate maximum capacity transportation in the horizon year 2051. In the horizon year it is planned to run 6 Car (2DMC+2TC+2MC). Headway details of the line shall be provided to successful contractor after award of the works. System shall be designed considering IEC 50119, IEC 60913 and other railway standards. Calculations/studies are to be carried out in respect of designing the traction system considering the horizon year loading or max. feeding possible in any system whichever is higher.

4.17 **Conformity with Governing Specifications and other Statutory Requirements**

4.17.1 The work shall be carried out in accordance with the following governing specifications and other statutory rules:

- CEA Safety regulations, 2010
- CEA Construction regulations 2010
- Central Safety regulations, 2010
- Regulations laid down by Chief Electrical Inspector to the government.
- Rules and Regulations prescribed by local authorities as applicable.
- Relevant, Indian Standards, IEC Standards, CENELEC, British Standards, 25kV AC traction Manual of Indian Railways & DMRC, DMRC ACTM, DMRC standard design specifications of traction items, technical instructions issued by DMRC and other National/ International standards as applicable. Appendix-B of this Specification gives a list of relevant standards, which may be referred to. However, the list is not exhaustive.

4.17.2 The Contractor shall furnish information asked by a statutory body (e.g., Government of India Ministry of Railways, Ministry of Power, BSNL/MTNL, TRANSCOM/ DISCOM, Commissioner of Railway Safety, BSNL/ MTNL etc.) in particular format as directed by Engineer. Any documents, studies, test reports, compliances required for getting safety clearances from any authority shall be submitted by the contractor.

4.18 Electrical Sectioning of 25 kV OCS

4.18.1 OCS shall be divided into electrically isolated sections at selected locations by provision of interrupters at insulated overlaps at the turnouts or air-gap overlaps. Sectioning shall be provided to permit isolation of OCS in small sections for maintenance, to isolate faulty OCS in case of fault/accident, and to permit evacuation of passengers from stations by bringing the train up to station. The sectioning shall be such that in case of fault, the faulty section can be isolated quickly and the trains in the healthy section on the same track can either be brought to a station or can be taken on the other track through emergency cross-over depending upon the operational requirement. Basic sectioning arrangement has been depicted in the tender drawings. If required, sectioning arrangement may be modified by contractor to provide better sectioning scheme with the consent of Employer. However, Contractor shall take approval from Employer for the final sectioning arrangement.

4.18.2 The Contractor shall interface with respective DDCs, Civil Design Build and Construction Contractors for accommodating 25 kV switchgear in the stations/niche/viaduct as well as for routing of cables and their connections at switchgear and at OCS.

4.19 EMI Study, Interface with other Contractors, Earthing and Bonding and Return Current Circuits

4.19.1 EMI Study

As a result of EMI and Traction Power simulation Study the number and disposition of return current conductors, TEW & Earth wires, their sizes and interval between rail connections shall be established.

The EMI/EMC study & Traction Power simulation shall be carried out for complete line considering already operational sections, depots & RSS's. The Traction Power simulation shall be carried out as per clause 10.1.1 of chapter 10. The limiting values concluded from study should be clearly brought out and stated in tabular form.
The number of locations of impedance bond, S-bond,α-bond shall be jointly finalised with S&T contractor to ensure adherence to IEC safety standards of step and touch potentials and CCITT regulations in regard to S&T circuits.

The minimum sizes of Aluminium TEW and Return Conductors are as follows:

TEW-240 sqmm AAC

RC - 240 sq.mm AAC

These are the minimum sizes which are to be provided by the contractor. If as per simulation study the higher sizes are required, then the same shall be accounted in the quoted price. There shall be no variation on account of **higher sizes.**

Earthing and bonding scheme shall be similar to followed in Phase-III of DMRC (subject to change as per the simulation studies)i.e. bonding of continuous metallic service (Raw water pipe, Fire hydrant pipe, walkway etc.) shall be bonded at an interval of 250 m approximately. Track rails shall be bonded at 500m interval.

4.19.2 **Overhead Line Equipment Earthing System**

The Contractor shall design a suitable and effective earthing system for the entire ROCS installation so that the Touch and step potentials are within safe limits.

4.19.3 **Traction Bonding**

The Contractor shall design bonding system in Metro Corridor. The bonding shall ensure safety of passenger, personnel, equipment, adjacent buildings, structures and reliable and safe performance of LT and HT power, control system, signal and telecom circuits and smooth passage of return current back to substation.

4.19.4 **Traction Return**

On the main line, both rails/one rail of the tracks shall be utilized as the traction return rails. Continuity & impedance bonds, S-Bond and α-Bond shall be provided wherever required. Necessary interface with S&T Contractor shall be detailed out.

For bonding, Thermite/Exothermic Welding to be provided with suitable size cable.

4.19.5 Based on the results of EMI study, a detailed interface plan for Civil, Electrical, Signal and Telecom works shall be prepared to ensure adequate safety of works.

<u>END OF CHAPTER</u>

CONTRACT PACKAGE – …..

CHAPTER – 5

FUNCTIONAL REQUIREMENTS

5. FUNCTIONAL REQUIREMENTS

5.1 Functional Role

5.1.1 The installation shall deliver safe, adequate and reliable 25 kV AC traction power supply to the electric trains via overhead current collection system.

5.1.2 The Contractor shall prepare and submit specifications, which provide a clear description of the functional requirements of each of the system, sub-system and equipment proposed. This description shall indicate acceptable levels of performance, for system/ subsystem equipment within the stipulated environment. The Contractor shall identify by manufacturer model and parts number each system equipment, which plans to install.

5.1.3 The Contractor shall work out a detailed interlocking and protection scheme to prevent inadvertent operation of circuit breakers resulting in electrical accident by short circuiting of two sources of supply. The operating arrangement incorporating the system interlocking requirements shall be proposed by the Contractor for review by Engineer.

5.1.4 Unless specific authorization to the contrary is given in writing by the Employer, all design shall conform to the latest applicable standards.

5.2 Functional Interface with others

5.2.1 Functional Interface with other Contractors and Authorities has been attached in Part-2 of this specifications.

5.3 Functional Performance of the System

This is addressed in Chapter 4 of this Specification.

5.4 Functional Safety

5.4.1 General

5.4.1.1 In accordance with clause 4.15 (clause may change as per the changes in chapter 4) of this Specification, the overhead current collection system shall be designed and constructed to ensure safety to passengers, the Employer's staff and the general public.

5.4.2 Specific safety requirements

5.4.2.1 Safety Legislation and Regulations are included in clause 4.19 (clause may change as per the changes in chapter 4) of this Specification. The System shall comply with all Enactments and Rules framed there under.

5.4.2.2 The System shall comply with all the relevant safety documentation of the Employer, including, but not limited to 'Project Safety Manual' and any update thereof provided by the Engineer.

5.4.3 Risks on Functional Safety

5.4.3.1 The risks on functional safety System will include, but not be limited to, the following items:-

a) Malfunctioning of equipment due to EMI, such as picking up parasitic induced voltage.

b) Explosion or Fire at SP/SS and other sectioning rooms, trackside sectioning posts..

c) Equipment safety;

d) Damage to overhead conductors;

e) Damage to overhead current collection system equipment;

f) Damage to 25 kV traction feeder cables;

g) Damage to return conductors or earth conductors;

h) Electrical safety including safety clearance from exposed live conductors;

i) Safety for passengers, the Employer's staff and public, including trespassers as far as is reasonably practicable; and

The Contractor shall minimise the above-mentioned risks to a level as low as reasonably practicable in the design and construction of System.

END OF CHAPTER

CONTRACT PACKAGE – ------

CHAPTER –

DESIGN CRITERIA AND

PERFORMANCE SPECIFICATION

GENERAL

6. DESIGN CRITERIA AND PERFORMANCE SPECIFICATION - GENERAL

6.1 Brief Description of the System

6.1.1 25 kV AC Traction Overhead Current Collection System

6.1.1.1 The Contractor shall provide 25 kV AC rigid overhead conductor rails on main lines of underground including stabling lines at terminal stations as outlined in Chapter-10. Overhead conductor rail shall be of aluminium with easily insertable copper contact wire.

6.1.1.2 Control Panels

All the remote-controlled switchgear of the entire power supply system shall be equipped with local/remote switch to enable local operation with indication to OCC.

6.1.2 Protective Relaying and Metering Scheme

The Protective Relaying Scheme shall be such as to ensure maximum discrimination resulting in highest reliability and stability of power supply as well as safety of equipment and personnel. Paralleling of 25 kV supply from adjacent Receiving Substation shall be prevented.

6.1.3 Earthing and Earth Conductors

Suitable design of earth system shall be developed for the SP, SS, SSP and FP, wherever applicable, as per the stipulations of this Specification. The entire work of system earthing shall be the responsibility of the ROCS Contractor. The Contractor will also take up extension of these earths to cable galleries and train tunnels & Colour Code for equipment and cables.

The Contractor for review by Engineer shall propose an appropriate colour code scheme for equipment and cables of different voltage.

6.1.4 Drawings

The schematic and general concept drawings related to power supply and civil requirements are given in Employer's Drawings*.*

6.1.5 Foundation/Civil works related Tracks side switching posts at underground section.

The ROCS contractor shall carry out necessary interface with civil contractor for foundation works for erecting structure to be used for various switching equipment. The details (Loading, schematic, conceptual drawings etc.) for the foundations shall be provided by ROCS Contractor. However, minor civil works required for making track side switching post operational in all respect shall be under the scope of the contractor. Fencing for the protection of the equipment shall have to be provided by the contractor.

6.2 **Not used**

6.3 **Not Used**

6.4 **Design of Earth System**

6.4.1 System protective earthing for providing electrical safety on entire system including earthing of noncurrent carrying metallic components, cable supports, etc shall be designed by respective elevated and underground traction contractor. The earthing system shall conform to IS 3043:1987, EN 50122-1 and IEEE 80 with latest version/amendments.

The earth system shall in scope of this contract consist of: -

a) Earthing Systems in Switching Posts. Apart from the conventional underground GIS type switching stations, AIS type switching posts will also be installed alongside the track or the crossover or the station niche area in underground sections. The earthing system for the same shall also be done by the ROCS contractor as per the requirements mentioned under relevant clauses.

b) Earth Conductors to earth non-live metallic parts of overhead current collection system.

c) The system of earth and return current conductors shall ensure a safe earthing system and return current conduction.

   In view of the caution required for passenger and personnel safety in an underground metro system operated on 25kV AC traction using rails for return current, the design for step & touch potentials will need abundant care. This is further aggravated by damp tunnel environment. Accordingly, the touch and step potential shall be designed based on allowable continuous touch and step potential below the values defined in EN 50122-1 and CCITT directives.

d) Earthing and, if required, isolation of long railings, metallic parts at stations and concrete reinforcements.

   In underground sectioning room MET shall be provided by E&M contractor, DE-08 contractor shall have to make necessary arrangements for earthing of all relevant items of switching post with MET.

   DE-08 contractor shall have to make necessary arrangements for earthing of all relevant items of switching post, alongside track or crossover as per Earthing & bonding scheme.

   The Contractor shall carry out entire design study of the earthing system on the basis of safety to public and maintenance personnel against touch and step potential and fire hazards and finalise the design, sizes and layout of main earth conductors in the tunnels, cable galleries etc.

Based on EMI study, suitable return conductor and TEW of requisite size shall run in the tunnel. Minimum size of conductors has already been specified in clause 4.19.1 of PS.

6.4.2 The maximum earth resistance of entire System shall meet the following requirements:

Table 6.4-1 Maximum Earth Resistance

Location	Each Electrode	Max. Earth resistance (ohms)
SP/SS/FP/SSP	5	1.0
Other locations	10	To meet the requirements of IS 3043:1987, IEEE 80, EN50122-1

6.5 Not used

6.6 Short Circuit Capacity

The Contractor shall ensure that power supply system including cables installed shall be capable of withstanding the TRANSCOM/GENCO fault levels at the points of common coupling and down. The fault levels to be catered for generally are given in Table 6.6-1 below. Specific requirements (if they are different) are furnished in the equipment/sub-system specifications.

Table 6.6-1 Design Short Circuit Levels

S.N	System Voltage(kV)	Breaking Capacity in MVA	Fault Current in kA	Fault Duration in Seconds
1.	25 AC	-	14	3
2.	0.415 AC	-	50 minimum	1

6.7 Insulation Coordination

6.7.1 The nominal voltages and corresponding maximum voltages shall be as follows

Nominal Voltage	Maximum Voltage
25kV	27.5kV

25 kV AC equipment shall have insulation levels according to DMRC AC Traction Manual and the European Standards EN 50124, Railway Applications – Insulation co-ordination.

6.8 **Switchgear and panels**

6.8.1 All indoor switchgear and panels shall be vermin proof, constructed from mild steel finished with anti-corrosion paint. The proposed colours shall be submitted for review by Engineer. Anti-condensation heaters shall be supplied wherever necessary. Specific requirements are furnished in the equipment/sub-system specifications.

6.9 **Galvanisation of All Indoor/Outdoor Steel Works:**

6.9.1 Steel structures and all Small Part Steel works (SPS) shall be hot dip galvanised.

6.9.2 The galvanisation shall be done only after cutting and drilling work is over. Galvanised bolts, nuts and spring washers shall be used for assembly work.

6.9.3 The coating of zinc for Steel structures and all Small Part Steel works (SPS) shall be in accordance to Technical Instruction no. 24 of DMRC attached with the PS. Contractor is also advised to consider the local, environmental & Corrosion effects in design. Zinc Coating shall be according to the latest RDSO specification for heavy polluted/marine and chemically polluted areas.

6.9.4 Galvanisation shall comply with the standards mentioned below:

i. Galvanization of all steel structures and all SPS works in DMRC phase-IV shall be as per Technical Instruction no. 24 of DMRC.
ii. IS:4759-1979: Specification for Hot Dip Zinc Coatings on Structural Steel and other allied Products.
iii. IS:209-1979: Specification for zinc.
iv. IS:2629-1966: Recommended Practice for Hot Dip Galvanizing of Iron and Steel.
v. IS:6158-1971: Recommended Practice for Safe-guarding against Embrittlement of Hot Dip Galvanized Iron & Steel Product.
vi. IS:2633-1972: Method of Testing Uniformity of Coating on Zinc Coated Articles.
vii. IS:6745-1972: Method for Determination of weight of Zinc Coating on Zinc coated iron and steel articles(with amendment No. 1).
viii. ASTM A-123 (1978): Spec. for Zinc (Hot Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strips.

6.9.5 Wherever galvanising on ferrous components has been damaged in handling, the same shall be given two coats of zinc chromate primer and two coats of aluminium paints conforming to IS 2339.

6.10 Protection Scheme for Power Supply Equipment:

6.10.1 The Contractor shall define the philosophy and furnish a scheme of protection with fast discrimination and reliable operation based on latest state-of-the-art computerised logic protection scheme. The zones of protection shall overlap providing second and third tier back-up protections. The scheme of protection shall be fully co-ordinated with RSS Contractor and existing sub-stations, whichever the case may be.

6.10.2 Contractor shall submit detailed fault calculations, relay settings and fault co-ordinated curves showing proper protection, discrimination between all upstream and downstream equipment.

6.11 Modular Equipment and Components

6.11.1 To the extent possible all components shall be modular in construction to facilitate easy troubleshooting and replacement of components to minimize down time of the system.

6.12 Control and Power Cables

6.12.1 Detailed specifications of power and control cables are given in Anneure attached with tender documents. The run of various cables shall be designed so as to ensure minimum de-rating.

6.12.2 Equipment Earthing Terminals

6.12.3 All equipment shall have at least two readily accessible separate earth terminals, which shall be identified by symbol of earth mark adjacent to the terminals.

6.13 Not Used.

6.14 Electrical Safety and Earthing

6.14.1 General

The scope of work includes Design, Supply, Installation, Testing and Commissioning of protective measures/equipment relating to electrical safety and earthing based on protective measures against electromagnetic induction due to 25kV AC traction.

Following Specifications shall be followed in addition to the National Codes of practices on earthing, and the Employer's safety documentation. The track bonding shall also conform to these specifications:

EN 50122-1. Railway applications: Fixed Installation

Part 1: Protective provision relating to electrical safety and earthing.

IEEE 80 and IS 3043.

In all cases of safety and protective measures those against electric shock shall have highest priority.

6.14.1.1 Design criteria and performance specification

6.14.1.2 General Requirements

6.14.1.3 The Contractor shall design the entire system of earthing, bonding, and connections of return current circuit, means of measuring of track voltages, determination and calculation of safe touch and step potentials. The design shall also include the construction details and methods to be followed by other underground Contractors, so that their entire work is rendered safe for both the protection aspects of electrical safety. The Contractor shall interface with other Contractors in this regard.

6.14.1.4 Laying of tracks

6.14.1.5 The Contractor shall inter-face with track laying Contractor, Civil contractors, for track laying work and with S&T Contractor for provision of Impedance Bonds, S Bond, α Bond and E&M Contractors (as applicable).

6.15 Electromagnetic Compatibility (EMC) Requirements

6.15.1 General

EMC study shall be conducted for complete Line-8 (from Botanical Garden to R K Ashram and complete section of Line-10 underground as well as elevated section. In addition to this the study shall include the all 25kV & 3.3 kV Cabling laid in tunnels or viaduct sections. Failure cases of the main source shall be taken into account considering the feed from its standby source RSS. The section other details are provided in clause 10.1.1 of chapter 10 of PS Rigid OHE. The details of agency to be hired for conducting the study has to be submitted for approval from engineer. Independent agency (which shall be not part of contractor) has to be hired for this study.

6.15.2 The requirements stated below shall be read in conjunction with the EMC Requirements in the General Specification. The limits should be as per the latest applicable ICNIRP standard. The EMC report should clearly indicate the values of exposure of magnetic fields near to the general passenger and workers at stations platforms and working areas. Magnetic shielding plan along with the modifications in design and equipment if any required to limit the exposure of magnetic fields within the safe limits has to be provided by the contractor.

6.15.3 An EMC Control Plan shall be submitted for review by Engineer

6.15.4 The EMC Control Plan shall include measures to reduce conducted, induced, and radiated emissions, especially the levels of harmonic, to acceptable values as specified by the relevant international standards.

6.15.4 The plan shall analyse EMI/EMC impacts on the trackside equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding, bonding, shielding, filtering, and cabling arrangements.

6.15.5 The Contractor is required to conduct type tests as well as full EMC tests. Tests to be conducted shall include but not limited to the following standards:

a) Overall compliance:

EN50121-1, EN50121-2, EN50121-5 and EN50123

b) Specific standards:

i. Immunity

Electrostatic discharge	IEC 61000-4-2
Radio frequency fields	IEC 61000-4-3
Power frequency magnetic field	IEC 61000-4-8
Pulse magnetic field	IEC 61000-4-9
Damped oscillatory magnetic field	IEC 61000-4-10

ii. Emission:

Radiated emission	EN50121-5
Conducted emission	EN50121-4
	IEC61000-2-6/
	IEC61000-3-2/
	IEC61000-3-3/
	IEC61000-3-4

Examples of EMC tests and their respective test levels extracted from selected international standards are given in Table 6.15-1 of this Specification. However, this table is by no means exhaustive and the Contractor shall refer to the respective standards for further information.

All tests shall be conducted at severity levels specified by EN50121 and/or the Engineer, whichever are more stringent.

6.15.1 Intra-System EMC

The Contractor shall ensure that all intra-system EMI/EMC are taken care of through proper design and other special measures. All major sub-systems shall be tested for emissions and immunities in accordance with the appropriate international standards for equipment operating in railway or similar industrial environment. Examples of these international standards are given in, but not limited to Table 6.15-2 of this Specification. Where testing is not applicable due to factors such as size of sub-system or availability of test facilities, letter of no objection shall first be obtained from the Engineer for waiver of such tests.

6.15.2 Inter-System EMC

The Contractor shall ensure that all OCS equipment is designed and constructed in accordance with the latest issues or versions of internationally recognized EMC standards, including but not limited to EN50082, EN50121, EN50123, EN50155, IEC60571 and IEC61000 or equivalents, to ensure proper functioning. Consideration shall be given to the EMC of the complete Delhi MRTS.

6.15.3 Safety-Related System Interference

Special attention shall be given to the interference with safety-related operations. Special tests shall be designed to ensure that the emissions whether conducted, induced, or radiated conform to the specific requirements of the safety-related systems. Adequate safety margins between the immunity levels of these safety-related systems and the emission levels of other electrical and electronic equipment shall be adopted. Measures shall be taken to reduce the levels of the unwanted emissions. These measures shall include but not limited to the following actions:

a) Proper use of filters to minimise harmonic generation.

b) Proper use of power line filters to reduce conducted emissions.

c) Proper use of shielded cables to reduce radiated emission.

d) Proper use of magnetic shielding to minimise magnetic coupling from transformers.

e) Proper use of surge arrester (see EN50123-5).

f) Proper use of 25kV return conductors to maximize protection.

The Contractor shall also provide computations on the expected conducted and radiated emissions from the power supply system due to electrical fault, load fluctuations, and/or system imbalance. Their effects on the safety-related equipment, especially the probabilities of leading to an unsafe operation shall be determined. An appropriate technical construction file suitable for safety audit shall be developed to demonstrate EMC compliance.

6.15.4 Non-Safety-Related Systems Interference

6.15.5.1 Contractor shall take measures to ensure that EMC is achieved between power supply system and all other equipment as specified by the latest version of the relevant International Standards or by the Engineer.

6.15.5.2 All radiated emissions, either via the power cables, rectifiers, transformers or any other system components, shall be minimised such that they conform to the appropriate international standards. Special reference shall be made to the compliance of EN50121-5, EN50123, and IEC61000-2.

6.15.5.3 All power cables shall be properly shielded where applicable, not only to reduce radiated emissions from the cables, but also to reduce the possibility of the cable picking up unwanted RF noise. Reference shall be made to IEC61000-4-6 and IEC61000-4-16.

6.15.5.4 The Contractor shall ensure that all conducted emissions, including but not limited to harmonics, shall not interfere with telephone, communications, supervisory and control, automatic fare collection, train protection and control, and other MRTS equipment either via the rectifier transformer to the primary 33kV system or via the rectifier to the DC traction power system. Reference shall be made to EN50121-5, EN50123, IEC 61000-2.

6.15.5.5 The Contractor shall also co-ordinate with other contractors whose equipment are connected to the power supply system and are likely to inject unwanted emissions into the power supply system to reduce such emissions. Reference shall be made to EN50121-2, EN50121-4, EN50121-5, IEC61000-3 and IEC 61000-4-7.

6.15.5 Environment EMC

The Contractor shall ensure that radiated emissions from the power supply cable are maintained at an internationally acceptable level. The Contractor shall also ensure that the power cables are protected from RF radiations from All India Radio (AIR), Doordarshan, Mahanagar Telephone Nigam Limited (MTNL), Videsh Sanchar Nigam Limited (VSNL) and others.

6.15.6 Installation and Mitigation Guidelines

IEC61000-5 series of guidelines shall be observed wherever applicable.

6.15.7 Earthing

6.15.8.1 An earthing system shall be designed to ensure personnel safety and protection of installations against damage. It shall also serve as a common voltage reference and to contribute to the mitigation of disturbances.

6.15.8.2 To achieve the primary goal of assuring personnel safety and damage control, a low impedance path shall be made available to the large current generated due to lightning or power system fault. The potential differences (touch and step voltages) between any two points shall be as low as possible. Safety considerations also require the chassis or enclosure to be earthed to minimise shock hazards to passengers and Employer's staff.

6.15.8.3 To achieve the secondary goal of providing protection for sensitive and interconnected electronic and electrical systems, earthing shall be designed to minimise the noise voltage generated by currents from two or more circuits flowing through a common earth impedance and to avoid creating earth loops susceptible to magnetic fields and differences in earth potential.

6.15.8.4 Earthing shall also be designed to accomplish the following minimum requirements:

a) Protect personnel and equipment from electrical hazards, including lighting, where practical.

b) Reduce potential to system neutrals.

c) Reduce or eliminate the effects of electrostatic interference and electromagnetic interference arising from within the MRTS.

d) Provide a single-point earthing method for all equipment enclosures, cabinets, drawers, assemblies and sub-assemblies.

6.15.8 Bonding

6.15.9.1 Bonding all exposed metallic parts of all equipment, Civil structures and connecting them to the earthing network is a way for meeting safety requirements and to minimise noise voltages due to potential differences.

6.15.9.2 Direct bonding shall be used wherever practical. Where indirect bonding via bonding strap is used to connect two isolated items, the bond shall satisfy the following minimum requirements and prevailing international standards, for example, IEC61000-5-2.

a) Proper bonding procedure, including appropriate surface treatment before and after the bonding process, is adopted.

b) Proper use of bond material to minimise electrolytic corrosion.

6.15.10 Cabling

6.15.10.1 The cables used shall be adequately protected against external interference. Additional protective measures, including but not limited to the use of metallic conduit, armour, ferrite choke, EMI filters shall be used to reduce such external interference wherever required. Covered conduit is preferred.

6.15.10.2 A cable routing plan shall be designed to minimise likelihood of coupling between parallel cables. The Contractor shall refer to guidelines recommended by IEC61000-5-2 wherever possible.

Table 6.15-1 Immunity levels at various power ports

Enclosure port

Test	Severity level
RF field	800-1000 MHz, 20 V/m, 80%AM 1kHz
RF field - pulse modulated	900 MHz, 20 V/m, 50% duty cycle, PRF 200 Hz
Power frequency magnetic field	50 Hz, 100 A/m

Electrostatic discharge	6 kV contact, 8 kV air
RF common mode	0.15-80 MHz, 20 V, 80%AM at 1kHzsource impedance 150 ohms
Fast transients	2 kV, 5/50 Tr/Th nanoseconds, PRF 5 kHz

Port for process, measurement and control lines, and long bus and control lines

Test	Severity level
RF common mode	0.15-80 MHz, 20 V, 80%AM at 1kHz source impedance 150 ohms
Fast transients	4 kV, 5/50 Tr/Th nanoseconds, PRF 5 kHz
Transients common/diff modes	1.2/50 Tr/Th μsec, 2 KV (c), 1 kV (d)
Power frequency	150 V rms
Power frequency common mode	650 V rms

DC input and DC output power ports

Test	Severity level
RF common mode	0.15-80 MHz, 20 V, 80%AM at 1KHz source impedance 150 ohms
Fast transients	4 kV, 5/50 Tr/Th nanoseconds, PRF 5 kHz
Transients common/diff modes	1.2/50 Tr/Th μsec, 2 kV (c), 1 kV (d)

AC input and AC output ports

Test	Severity level
RF common mode	0.15-80 MHz, 20 V, 80%AM at 1kHz source impedance 150 ohms
Fast transients	4 kV, 5/50 Tr/Th nanoseconds, PRF 5 kHz
Transients common/diff modes	1.2/50 Tr/Th μsec, 2 kV (c), 1 kV (d)

Earth port

Test	Severity level
RF common mode	0.15-80 MHz, 20 V, 80%AM at 1kHz source impedance 150 ohms

Table 6.15-2 Typical International Standards on EMC

BS EN 50082-1	Electromagnetic compatibility _ Generic immunity standard Part 1: Residential, commercial and light industry.
Pr EN 50082-2	Electromagnetic compatibility _ Generic immunity standard Part 2: Industrial environment.
DD ENV 50121-1	Railway applications _ Electromagnetic compatibility Part 1: General
DD ENV 50121-2	Railway applications _ Electromagnetic compatibility Part 2: Emission of the whole railway system to the outside world.
DD ENV 50121-3-1	Railway applications _ Electromagnetic compatibility Part 3-1: Rolling Stock _ Train and complete vehicle _ limits for emission and immunity.
DD ENV 50121-3-2	Railway applications _ Electromagnetic compatibility Part 3-2: Rolling stock _ Emission and immunity of apparatus.
DD ENV 50121-4	Railway applications _ Electromagnetic compatibility Part 4: Emission and immunity of the signalling and telecommunications apparatus.
DD ENV 50121-5	Railway applications _ Electromagnetic compatibility Part 5: Emission and immunity of railway fixed power supply installations.
EN 50155	Railway applications - Electronic equipment used on rolling stock
IEC 571-1	Electronic equipment used on rail vehicles Part 1: General requirements and tests for electronic equipment
IEC 571-2	Electronic equipment used on rail vehicles Part 2 : Standardisation of certain mechanical and electrical quantities - Principles of test devices
IEC 571-3	Electronic equipment used on rail vehicles Part 3 : components, programmable electronic equipment and electronic reliability
IEC 61000-1-1	Electromagnetic compatibility Part 1: General Section 1: Application and interpretation of fundamental definitions and terms
IEC 61000-2-1	Electromagnetic compatibility Part 2: Environment Section 1: Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems
IEC 61000-2-2	Electromagnetic compatibility Part 2 : Environment Section 2 : Compatibility levels for low-frequency conducted

	disturbances and signalling in public low-voltage power supply systems
IEC 61000-2-3	Electromagnetic compatibility Part 1 : Environment Section 3 : Description of the environment - radiated and non-work-frequency-related conducted phenomena
IEC 61000-2-4	Electromagnetic compatibility Part 2: Environment Section 4 : Compatibility levels industrial plants for low frequency conducted disturbance
IEC 61000-2-5	Electromagnetic compatibility Part 2 : Environment Section 5 : Classification of electromagnetic environments
IEC 61000-2-6	Electromagnetic compatibility Part 2 : Environment Section 6 : Assessment of the emission levels in the power supply of industrial plants as regards low-frequency conducted disturbances
IEC 61000-2-7	Electromagnetic compatibility Part 2: environment Section 7 : Low frequency magnetic fields in various environment
IEC 61000-2-9	Electromagnetic Compatibility Part 2: environment Section 9 Description of HEMP environment – radiated disturbance
IEC 61000-2-10	Electromagnetic Compatibility Part 2 –10 environment – description of HEMP environment – conducted disturbance
IEC 61000-3-2	Electromagnetic compatibility Part 3 : Limits Section 2 : Limits for harmonic current emissions
IEC 61000-3-3	Electromagnetic compatibility Part 3: Limits Section 2 : Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current - 16A
IEC 61000-3-5	Electromagnetic compatibility Part 3: Limits Section 5 : Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16A
IEC 61000-3-6	Electromagnetic compatibility Part 3: Limits Section 6 : Limitation of emission of harmonic currents for equipment connected to medium and high voltage power supply systems
IEC 61000-3-7	Electromagnetic compatibility Part 3: Limits Section 7 : assessment of emission limits for fluctuating loads in MV and HV power systems
IEC 61000-3-8	Electromagnetic compatibility Part 3: Limits Section 8 signalling on low voltage installations – emission levels, frequency bands and electromagnetic disturbance levels

IEC 61000-4-1	Electromagnetic Compatibility Part 4: Testing and measuring techniques Section 1 : Overview of immunity tests
IEC 61000-4-2	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 2 : Electrostatic discharge immunity test
IEC 61000-4-3	Electromagnetic compatibility Part 4:- Testing and measuring techniques Section 3 : Radiated radio frequency electromagnetic field - immunity test
IEC 61000-4-4	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 4 : Electrical fast transient/burst immunity test
IEC 61000-4-5	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 5 : Surge immunity test
IEC 61000-4-6	Electromagnetic compatibility Part 4 : Testing and measuring techniques Section 6 : I*mmunity to c*onducted disturbances, induced by radio frequency fields
IEC 61000-4-7	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 7 : General guide on harmonics and inter harmonics measurements and instrumentation, for power supply systems and equipment connected thereto
IEC 61000-4-8	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 8 : Power frequency magnetic fields immunity test
IEC 61000-4-9	Electromagnetic compatibility Part 4 : Testing and measuring techniques Section 9 : Pulse magnetic field immunity test
IEC 61000-4-10	Electromagnetic compatibility Part 4 : Testing and measuring techniques Section 10 : Damped oscillatory magnetic field immunity test
IEC 61000-4-11	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 11 : Voltage dips, short interruptions and voltage variations immunity test
IEC 61000-4-12	Electromagnetic compatibility Part 4 : Testing and measuring techniques Section 12 : Oscillatory waves immunity test
IEC 61000-4-15	Electromagnetic compatibility Part 4: Testing and measuring techniques Section 15 flicker meter – functional and design specification
IEC 61000-4-16	Electromagnetic compatibility Part 4-16: Testing and measuring techniques – test for immunity to conducted, common mode disturbances in the frequency range 0Hz to 150kHz

IEC 61000-4-24	Electromagnetic compatibility Part 4 : Testing and measuring techniques Section 24 Test methods for protective devices for HEMP conducted disturbance
IEC 61000-5-1	Electromagnetic compatibility Part 5: Installation and mitigation guidelines Section 1 : General considerations
IEC 61000-5-2	Electromagnetic compatibility Part 5 : Installation and mitigation guidelines Section 2 : Earth and cabling
IEC 61000-5-5	Electromagnetic compatibility Part 5 : Installation and mitigation guidelines Section 5 Specification of protective devices for HEMP conducted disturbance

6.16 **Contractor responsibilities:**

Contractor's responsibilities shall include but not be limited to:

a) Provision and maintenance in good condition sufficient tools, mechanical equipment and apparatus necessary to complete the work within the agreed schedule.

b) Transporting and storage in safe and satisfactory condition all materials brought to their depot.

c) Provision of temporary 415 V, 3-phase AC power for construction and testing

d) Provision of temporary water supply

6.17 **Works excluded from the scope of the Contract:**

6.17.1 Civil Engineering Works pertaining to cable galleries, underground switching/sectioning posts are excluded from this Contract as the same form a part of the Civil Engineering Contracts. The optimum space requirements shall be furnished to the designated Civil Contractors, however, in order to have minimum impact on the existing Civil Engineering design, efforts shall be made to accommodate the above installations in the room sizes already firmed up switching rooms. Access for replacement of equipment and for personnel shall be ensured through interfacing with the designated Civil Contractors.

6.17.2 All Civil Engineering construction works including building E&M services at underground switching/sectioning posts rooms, and cable galleries connecting SP and SS to train tunnel are excluded. These shall form part of Civil & E&M Contract. Earth mat at underground traction switching posts shall also be done by designated Civil Contractors to the design requirement of the Contractor.

6.18 **Compliance with Directives:**

All works shall comply with directives and requirements mentioned below:

6.18.1 Compliance with electromagnetic compatibility as per requirements of this Specification.

6.18.2 Development and implementation of a Quality Management Plan. This is detailed out in Chapter 14 of this Specification

6.18.3 Preparation and finalization of schematic general arrangement, detailed construction drawings through to "As-Built drawings". This is detailed out in chapter 20 of this Specification.

6.18.4 Training and transfer of technology needs shall be complied with as indicated in Chapter -19 of this Specification

6.18.5 Interface co-ordination shall be maintained with other Contractors and agencies as detailed out in Chapter 13 of this Specification.

6.18.6 Spare parts, special tools and test equipment shall comply as indicated in chapter 18 of this Specification.

6.18.7 Packing, shipping and delivery shall comply with stipulations of Chapter 15 of this Specification.

6.18.8 The scope of work shall cover all optional items as stipulated in this Contract.

END OF CHAPTER

CONTRACT PACKAGE – DE-08

CHAPTER – 7

DESIGN CRITERIA AND PERFORMANCE SPECIFICATION FOR SWITCHING STATIONS

7 DESIGN CRITERIA AND PERFORMANCE SPECIFICATION – SWITCHING STATIONS

7.1 Design Criteria and Performance Specification: Traction Supply Equipment.

The scope of the contract include but not limited to complete Design, supply, installation, testing and commissioning of 25kV switching stations (SSP, SP, SS, FP, interlinking etc.) with associated cabling, earthing, SCADA system, protection (wherever required) to make sectioning complete in all respect. The sectioning posts may be at station area, trackside or crossover as per the sectioning diagram. The details are provided in the sectioning scheme attached with tender documents.

7.1.1 The Traction Supply Equipment includes:

- Circuit Breakers
- Interrupters/BMs
- Motorised Isolators
- Load Break Switches and its accessories.
- Instrument transformers.
- Marshalling Box/ACDB/DCDB.
- Mast and its accessories.
- Other items such as connectors, Jumpers, 25kV cables, Control cables etc.

The following table indicates the stations having 25kV Switching stations in network and the method of achieving sectioning - 25KV GIS/ 25KV AIS in NICHE.

S. No	Section/ Line	Station where Switching room located	25kV Switching post	25kv sectioning to be designed with following
1				
2				
3				
4				
5				

6				
7				
8				
9				

Further, following table indicates the 25kV interlinking works in proposed and existing network.

25kV Interlinking works .:

S. No	Name of Station	From	To	Remarks

7.1.2 **Governing specification of 25 kV AC traction equipment are summarised as under.**

Table – Governing Specifications.

Sr. No.	Equipment	Governing Specifications
1	25 kV Circuit Breaker	EN 50152, EN 50124-1,2 , IEC 62271
2	25 kV Interrupters/BM	IEC 62271-1, EN 50152, EN 50124-1,2
3	25 kV Gas Insulated Switchgear (GIS)	IEC 60298, IEC 62271-200, IEC 62271-1 & IEC 62271-102, EN-50124 (1,2)
4	25kV Load Break Switch	IEC 62271-200, IEC 62271-1 & IEC 62271-103
5	Earthing of Substation	As per IEEE 80 with latest amendments.
6	110V control supply should be taken from nearest ASS.	
7	Cable specifications	Please see chapter 8

8	Environment Condition	Class B environment as per Clause 1.12 of GS.
9	Instruments Transformers	IEC 61869

7.1.3 25 kV GIS type Switchgear (Circuit Breakers, Interrupters)

The incoming 25 kV switchgear shall be GIS Type with 25kV Potential Transformer (PT) and Surge Arrestors.

The switchgear shall be designed to work under Class B environment as specified in Clause 1.12 of GS. Broad parameters are furnished in Annexure A of chapter-7A of PS.

The metal-enclosed switchgear shall be SF_6 gas insulated and the circuit interrupting device shall be of vacuum type.

GIS as offered should be fully type tested as per latest IEC standards. Type test report shall have to be submitted with vendor approval proposal.

GIS should be modular design, and it should be possible to add feeders panels if required.

Suitable means of expansions should be provided in the metal enclosure and pipelines to absorb the actual thermal expansion and contraction of the SF6 equipment and to facilitate the alignment of the switchgear assembly.

The metal enclosure for the SF6 gas insulated equipment modules shall be made from aluminium alloy/ stainless steel.

7.1.3.1 Earthing

All non-live metal parts shall be connected to the earth be corrosion protected and labelled in conformity with the IEC 60617-2.

7.1.3.2 Paint Work

Painting should be suitable for corrosive atmosphere, and to comply with IEC 60721-2 & 5

7.1.3.3 Interrupters& Motorised Isolator shall be GIS Type (as per sectioning diagram attached with these specifications)

Interrupters & Motorised Isolator shall be GIS Type. All Interrupters & Motorised Isolator shall follow the same electrical and mechanical characteristics and must be in accordance with governing specifications (including latest modifications) as mentioned in the table provided under clause 7.1.2 above.

7.1.3.4 Overvoltage protection:

Surge arresters of suitable ratings are to be provided in 25KV GIS switchgears for protection against over-voltages. Leakage current monitor and Surge counters are also to be provided with all surge arrester. The details are as per chapter 7 A & 7 B shall have to be submitted for approval of Engineer.

7.1.4 **25 kV Isolators**

Each Isolator shall be GIS type and shall be of proven design & shall be on busbar side for integral isolation facilities i.e., a 3-position isolator with On-Off-Earth positions.

- Electric operation where required and manual operating capability
- Locking and interlocking devices
- Open / Closed auxiliary contacts

All isolators shall follow the same electrical and mechanical characteristics and must be in accordance with IEC standards.

25kV GIS shall be suitable to accommodate 2X400mm^2 cable as per sectioning and other requirement.

7.1.4.1 Not Used

7.1.4.2 Operating Mechanism

The operating mechanism for CB shall be motor operated spring type and shall be able to withstand 10,000 operations.

Electrical tripping and closing devices shall be suitable for operation from 110V DC batteries.

All auxiliary and control cables and wirings shall have suitable marking, such as ferrule markers, which shall clearly identify their function and shall match the control schematic drawings and wiring diagrams. The markers shall fit firmly over the outer diameter of individual cable and each wire core. Marks shall be printed and legible. For easy identification, colour coding shall be used to differentiate various functions of the cable and wires. All auxiliary and control wirings shall also be complete with cable lugs for termination.

A relay and instrument compartment shall be located at the front of each switchgear unit and shall be provided with a hinged door for access to the internal wiring and terminals. Gaskets shall be used to provide close sealing. The height of the instrument panel above floor level should be at suitable Height from the floor for easy access to the instrument panel.

Anti-condensation heaters with humidity control function shall be installed for each switchgear panel.

Relay and instrument panel shall have minimum IP protection rating of IP-4X.

7.1.5 The broad parameters of these equipment have been indicated in chapter-7A.

Notes for 25kV System:-

- One set of SF6 Gas Evacuation, Refilling kit as per latest specification should be provided. Number of cylinders depending upon the quantity of complete evacuation of SF6 gas from GIS should also be provided in spares as per clause 18.2 provided in chapter-18 of these specifications. Specification and other details of the SF6 gas charging-discharging kit should be selected in confirmation to the GIS equipment manufacturer. Approval from the engineer should be taken before procurement of the same.
- Clear visual indications of isolator and earthing switch.
- In order to eliminate the possibilities of failures due to over voltages switching surges etc. the contractor shall submit the calculations, study report based on the switchgear selected for the 25kV sectioning. Surge arrestors along with counter are to be provided in the sectioning post to protect each & every elementary section and component. Contractor shall submit calculations for the selection ratings of Surge arrester for review of engineer.
- In order to have uniformity in panels, switchgears and other equipment's opening /closing cabinet, single key for door operation (square type) shall be provided.
- U/G Traction Contractor will provide control cables from HT Panels to inside the RTU with glands, lugs and ferruling and carry out terminations at HT panel end. While the dressing and termination in TBs inside the RTU shall be carried out by SCADA Contractor. The signal wise cable termination details shall be shared with SCADA contractor for termination at RTU end.
- Each Switching station post shall have Marshalling box, which shall be provided by the U/G contractor as according to interface requirements of SCADA system. The Marshalling box shall provide all the necessary input signal connections including those from analog meters, from field equipment and the output signal connections to the field equipment for SCADA. In addition, the Marshalling box shall provide facilities for interconnection between the signals to/from RTU and signal from/to the field units.
- AC / DC cables from the ACDB / DCDB to the RTU will be provided by U/G Traction Contractor.

7.2 Voltage transformers for GIS panels

Voltage transformers of the metal-enclosed encapsulated type are preferred. Other types may be submitted to the Employer's Representative for review and approval. VTs should be provided with Isolation mechanism.

Voltage ratio for VT shall be 27500V/110V.

The secondary windings shall be connected to the secondary circuit through a LV fuse or a miniature circuit breaker (MCB).

For protection and measurement applications, the VTs shall be of dual Class 3P/0.5. The burden of VTs shall be suitably designed with a margin of 40% for future additions of instrumentations, and submitted to the Employer's Representative for review and approval. VT shall comply to IEC 61869-1 & 61869-3.

VT shall be provided at all elementary section in 25kV switching station of underground section. All VTs should be protected by Surge arresters against over-voltages. As per EN 50152 the inductive PT should have certain characteristics to avoid generation of ferro-resonance and to withstand over-voltages caused by it. High primary resistance, not less than 50,000 ohms is considered to be one of essential requirements for avoiding ferro-resonance.

7.3 Current transformers for GIS panels

When CTs are used for protection and measurement purposes, they shall have the appropriate ratio, class and burden in line with the functions they are used for.

All current transformers shall have a 3-second short-time current rating of not less than the maximum System fault level.

Current transformers shall have an output rating adequate to cater for the burden connected to them and shall function satisfactorily under the maximum system fault condition.

All current transformers shall be installed with the P1 terminals adjacent to the busbars.

All connections from secondary windings shall be brought out and taken by means of separate insulated leads to a terminal board mounted in an accessible position. Where multi-ratio secondary windings are required, a label shall be provided at the secondary terminal board clearly indicating the connections required for each ratio. The connections and ratios in use shall be shown on all diagrams of connections.

Current transformers shall have the appropriate ratio depending upon their application.

The Contractor shall prepare a schedule of CTs to be installed, and submit the same for the Engineer's review.

The secondary windings of current transformers shall adopt single point earthing. The earth connection shall be made at a terminal block via a removable link.

7.4 25kV AIS Switchgear

7.4.1 General Specifications of 25 kV Switchgears in Underground section with AIS switchgear (Circuit Breakers, Interrupters, Load Break Switch and Isolators)

7.4.1.1 Operating Conditions

Equipment has to be designed to operate under:

- Outdoors tropical conditions and underground environment conditions shall be as per General Specification Clause no. 1.12 or otherwise specified in Equipment Specifications.

- Electromagnetic specific environment (complying with EN 50121-5)
- Plus 10%, minus 15% supply voltage variations.

7.4.1.2 These apparatuses shall be pole mounted with the switching part at pole top level, separated from the control equipment located at parapet level and base pole mounted, both connected together with suitable control cables through a single multipin connector.

They shall consist of:

- A switching apparatus, along with all its mechanism box (actuator assembly, spring/magnet unit assembly, auxiliary switch assembly, sensors, Illumination lamp, thermostat, counter etc.) at top pole mounted.
- A control box assembly (auxiliary switch assembly, illumination lamp, L&R switch, control cards, MCBs, Push buttons, toggle switch etc.) located at parapet level, at base pole mounted.

7.4.1.3 All apparatus shall follow the same electrical and mechanical characteristics and must be in accordance with IEC 62271-1, IEC 62271-100, IEC 62271-102, IEC 62271-103, IEC 62505-2, RDSO specifications ETI/OHE/16(1/94) as per to latest version.

7.4.1.4 Protections against corrosion

All metal pieces (including Fasteners, bolts, screws etc.) shall be realised with stainless materials.

Stainless could be obtained either:

- By using stainless material
- Or by hot dip galvanizing (in accordance with TI-24 of DMRC and as per clause 6.9.3.

7.4.1.5 Earthing

All non-live metal pieces including support shall be connected to the earthing collector, which shall have sufficient section to withstand short circuit currents, and shall be corrosion protected and labelled in conformity with the IEC standard 60617-2.

7.4.1.6 Powder coated Paint Work (if required)

The paint work if required to be done on any part of the equipment shall only be done with Power coated paint. The painting work shall be suitable for dusty, sandy, highly polluted etc. atmosphere, and has to comply with IEC 60721-2-5.

After baring, all metal surfaces shall receive anti-corrosion process:

- Natural stainless for bolts & screws and support
- Rust-proofing and anti-corrosive-paint for other metal surfaces

- Then all metal surfaces other than stainless steel shall be painted in accordance with the rules of art with three coats of non-metallic paint of the same quality as that used for outdoor transformers.
- The total thickness shall not be less than 120 µm.
- This protection shall be fully guaranteed for five years starting from provisional taking over.
- If any noticeable deterioration by rust or corrosion appears before this time elapses, the U/G contractor shall be responsible for repainting at his own expense and for renewing his guarantee for the work performed.

7.4.1.7 The Contractor shall submit an undertaking to make arrangement, for the availability of adequate supply of spares of the equipment/materials during its operational period.

7.4.1.8 If, there is any modification/up-gradation/obsolescence of any of the supplied & installed equipment, OEMs shall inform DMRC in advance, so that sufficient spares can be purchased/ stocked or other appropriate actions shall be taken by DMRC to ensure smooth operation in future.

7.4.1.9 All Electronic components/sub-parts of equipment shall only be of Industrial grade.

- It may also be noted that temperature inside the metal enclosed equipment placed in open sun may go up to 70^{o}C inside enclosure. This aspect shall be taken care while designing the equipment and its electronics
- The Terminal Board for the output (control supply) of any panel (CB, LBS, Isolator, etc.) shall only be factory fitted.
- All the electronic cards supplied shall have following minimum requirements-

  a. As per IEC 61086, all printed board assemblies shall be protected on both sides with a protective transparent coating, in order to prevent deterioration or damage due to such causes as moisture and atmospheric contaminants. The coating shall not have any adverse reaction with any other materials or components used on Delhi/NCR environmental condition

  b. Damp heat run test as per IEC 60068-2-78 standards.

  c. Dry heat run test as per IEC 60068-2-2 standards

  d. In addition, the details of configuration in the card, block diagram of the card and waveform signature of each test points for each card shall be submitted by DE-08 contractor.

  e. All auxiliary relays/contactors, electronic components shall be of heavy duty/Industrial grade and PCB should have conformal coating suitable for pollution level "Very heavy" for Delhi as per IEC 815-1986 & IS 13134-1992. <u>**IEC 61086** : for conformal coating.</u>

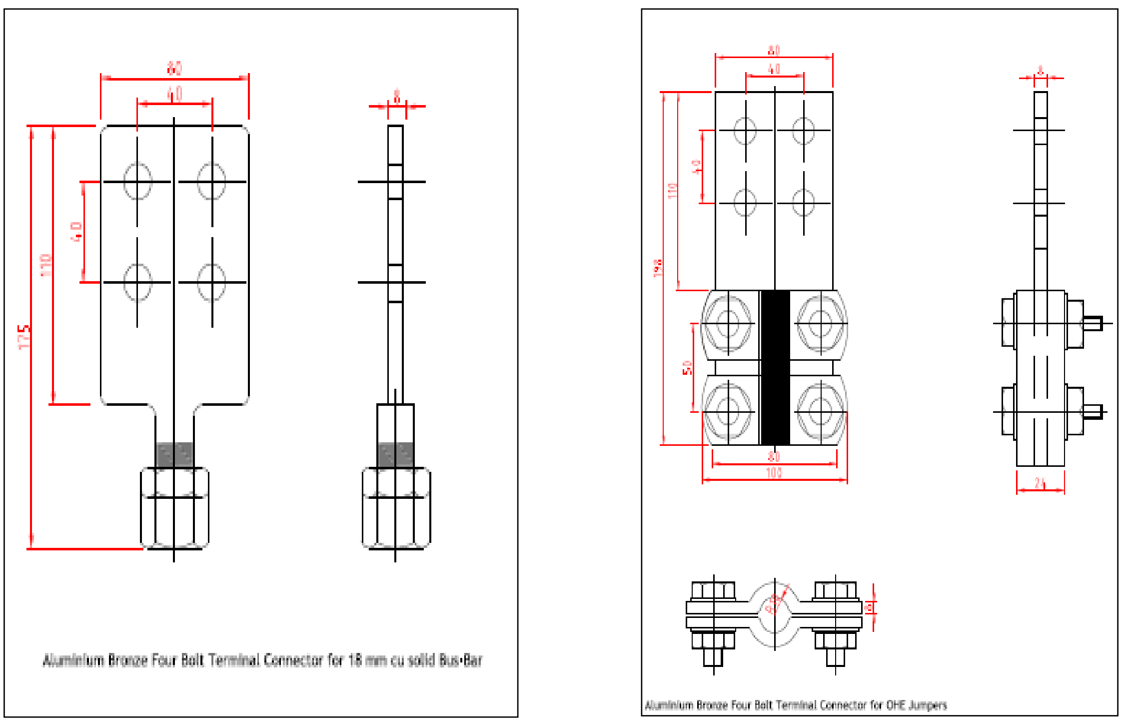
  f. All the cards of the relay should have conformal coating to avoid the environmental impact to the functioning of the relay.

All electronic equipment shall withstand surges, electrostatic discharge and transient burst as per IEC 62236-3-2. The suitable surge protection device conforming to relevant standard shall be provided as per the requirement and approval of Engineer In-charge.

7.4.1.10 All the measuring instruments, in the panels shall be of digital type only.

7.4.1.11 The equipment shall withstand at least minimum 10,000 operations without any signs of deterioration. The necessary documentation to support the minimum operation shall be submitted.

7.4.1.12 The jumpers shall not be connected directly to flange of Interrupter/Circuit Breaker ***(BM/CB***). The four holes type of connector used in Indian Railway (RI-1009) shall be used for connection of jumper with Interrupter/Circuit Breaker ***(BM/CB***) flange. Spacing of holes of the Interrupter/Circuit Breaker (BM/CB's) flange must be matching with jumper connector ***(RI-1009) used in Indian Railway design***.



Indicative drawing of jumper connector (RI-1009)

7.4.1.13 The 25 kV Switchgears shall be subjected to vibrations on account of running trains on the near-by Railway tracks as well as due to its own operation.

The amplitude of these vibrations lies in the range of 30 to 150 microns, with instantaneous peaks going up to 350 microns. These vibrations occur with rapidly varying time periods in the range of 15 to 70ms.

The 25 kV switchgears shall be tested to cater the impact of these vibration level.

7.4.1.14 The bimetallic strips *as* per the requirement shall be provided by the Contractor.

7.4.1.15 The control and Monitoring box of equipment shall be mounted at convenient height for the ease of maintenance.

7.4.1.16 The Door opening of any equipment shall not hinder the maintenance of the equipment. The door of equipment shall be opened away from the mast on which the equipment is mounted. The special hydraulic type doors having vertical movement for closing and opening shall be preferred.

7.4.1.17 The Mounting arrangement of equipment shall be provide/vetted by Original Equipment manufacturer (OEM) of equipment.

7.4.1.18 The silicone rubber gaskets shall only be used in switchgears and other equipment to ensure full tightness and be protected so as to withstand the effects of the various corrosive agents present in the atmosphere (pollution, temperature, humidity, etc.).

The gasket shall only be procured from sources approved by Engineer in Charge.

7.4.1.19 It shall be ensured by the contractor that only single type of lock & key (square key) of reputed make with minimum of SS 304 grade shall be used for different type of doors of all equipment of 25 kV, 33 kV panels, Marshalling Kiosk (MK)

/CB/Isolators/LBS/RTU (Remote Terminal Unit) /Other panels etc.) of sources approved by Engineer In charge.

7.4.1.20 Name Plates of approved design shall be furnished at front and back of each cubicle.

Rating Name Plate be provided with a rating plate marked with the following:

- Name of the Manufacturer and Year of Manufacture
- Purchase Order Number and Date
- Type, Designation & Serial Number
- Rated Voltage
- Current Rated
- Frequency
- Number of Poles
- Rated Short Circuit Breaking Current
- Rated Short Circuit
- Making Current Short Time Current
- Rated Insulation Level
- Rated Operating sequence
- Aux. Voltage (DC/AC)
- Property Label- "Property of DMRC."

7.4.1.21 Adequate number of Danger and caution notice shall also be provided as per the statuary guidelines as approved by Employer.

7.4.1.22 Mock-up of each installation/equipment shall be done by OEM for the training of DMRC staff and correct installation procedure. The scheme of installation shall be approved by Engineer in-charge.

7.4.1.23 The Bill of Material of each equipment shall be approved by Engineer-In- Charge

7.4.2 **Circuit Breakers / Interrupters**

In addition to clause 7.4.1, the Circuit Breaker/ Interrupters shall be supplied as per the IEC 62271-1 & 62271-100. The operating mechanism of Circuit Breaker/ Interrupters shall be Magnetic Actuator/Spring Charge type.

Each Circuit Breaker / interrupter shall be Vacuum type, with a proven technology and shall include:

- Up & down stream connectors

- Life sealed unit pole.
- Energy accumulation type actuation system (electromechanical springs or magnetic actuated mechanism)
- Electric and manual arming capability (Tripping and closing coils motor)
- Under-voltage tripping coil (Auxiliary voltage off)
- Locking and interlocking devices for multiple interlocking
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable.
- SCADA integration compatibility.
- Vibration Pad.

All Circuit Breaker/ Interrupters shall have provision for pre-drilled copper plates in order to receive 2x400 Sq. mm Aluminium cables. The bimetallic strips required for connection in any case shall be provided by the Contractor.

The approved vendors of 25kV circuit breakers/Interrupters are to be adopted and encourage to modify the design for the specific requirement on the installation of these breakers on the viaduct and in the tunnel area.

7.4.3 Isolators (Motorized)

In addition to above clauses , all motorized Isolators shall follow the same electrical and mechanical characteristics and must be in accordance with RDSO specification no TI/SPC/PSI/ISOLTR/0210 (07/2021) or latest including rated voltage level of 27.5 kV, 1600mm creepage distance for all insulators(pedestal & Tie Rod) and 250 kV (peak) Basic Insulation Level (BIL) which are to be followed.

The double pole motorized isolators, wherever used, shall be used to isolate both i.e., 25 kV as well as 3.3 kV Return Cable simultaneously.

The Isolator shall be air insulated type and shall include:

- Up & down Stream connectors
- Vertical break
- Motor operated where required and manually operated capability
- Composite type Support Insulators (pedestal and operating rod).
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable

- All isolators to be procured from RDSO approved source only.
- SCADA integration compatibility.

The Installation of isolators shall be carried out in the supervision of supplier or alternatively post inspection shall be carried out by OEM after installation. Any deficiency observed during inspection shall be rectified.

Following points shall be ensured at the time of installation.

- Surface contact resistance of every isolator shall be recorded in closed condition, before commissioning which has to been ensured within limits after improving alignment and surface contact area.
- All nut bolts of isolator shall be tightened with torque wrench only.
- There shall be a gap of minimum 500 mm between male & female contact of the isolator when in open condition.
- Provision of arcing horns must be ensured at the time of installation by the contractor.

The isolator operation must be toggle spring assisted in such a way that it does not get stuck in mid-position. It must either be completely open or completely closed. In case of failure to provide adequate power during opening or closing - the switch must go back to its original position with the help of the toggle spring mechanism. The spring must be compressed and released with the help of the provided operating mechanism (motor or manual) and should work without the help of any external secondary source.

The spring shall be made up of the following material and contractor shall submit the required test reports of spring to employer for approval.

- Steel grade – X5CrNiMo17-12-2 or equivalent
- Steel grade no. 1.4401c or equivalent
- Tensile strength – 1150 MPa (min) - 1330 MPa (max)

The double isolators shall be supplied with provision of earthing heel.

The isolators shall be mounted on OHE Mast at maintainable height. The scheme of isolator installation shall be approved by Engineer in-charge.

All isolators shall have provision for pre-drilled copper plates in order to receive 2 x 400 sq. mm Aluminium cable. The bimetallic strips required for connection in any case shall be provided by the Contractor.

7.4.4 Load Break Switch (LBS) in Underground & Elevated section:

In addition to above clause, the load break switch shall include

- The LBS of air insulated type.
- For underground section "On Load" Load Break Switch is to be provided.
- The LBS is designed to be operated by rod with linear movement (motorized and/or manual).
- Composite insulator with creepage distance of 1600 mm.
- Practically maintenance-free.
- Locking and interlocking devices.
- Open / Closed auxiliary contacts.
- All load break switch shall be in accordance with IEC 62271-1, IEC-62271-103, IEC62505-2.
- SCADA integration compatibility.
- LBS shall be used on all the mainline Feeding Posts and at ROCS end, wherever specified in the sectioning drawing. The scheme of LBS installation shall be approved by Engineer in-charge.
- The Load Break Switch shall be mounted on OHE mast (in elevated section) and wall/ceiling or as per requirement (in the underground section) at maintainable height. The scheme of Load Break Switch installation shall be approved by Engineer in-charge.

Double Pole LBS

This shall be used to isolate both i.e., 25 kV as well as 3.3 kV Return Cable simultaneously at 25kV interlinking locations. The arc quenching mechanism for on load isolation of 25 kV shall only be required for 25kV cables. For the 3.3 kV return isolation shall be done without any arc quenching mechanism. All other specifications shall remain same.

7.4.5 Monitoring Box of 25 kV Switchgears

In addition to above clause , the monitoring box shall be made of Stainless steel (Grade SS 316, minimum 1.25 mm thick sheet) with mirror finish compact enclosure.

The monitoring box shall be of category IP-55 as per IEC 60529. The monitoring box shall be made by Folded and welded from a single piece with protection channel around the door opening.

The Doors of monitoring box shall be easily openable and maintainable, flush-mounted, with foamed-in seal, concealed hinges, 130 degree opening angle as per VDI, cam lock with double-bit insert as per DIN 43668.

Mounting plate of monitoring box shall be of 3 mm thickness sheet steel with system punching, depth adjustable stud mountings, zinc-plated. Surface finish shall not be less than 240 Grain size brushed, totally enclosed, dust-proof and water tight type, equipped with:

- Access doors with padlocks.
- 415/230 V heating device.
- 110 V DC control and monitoring relays and motors
- Remote control and monitoring multi-pin connector.
- Internal lighting controlled by door position
- 230 V AC plug
- 3 positions switch (Remote / local / manual)
- Single Handle door operation (Facade or beside)
- apparatus position indicator (Facade)
- Label (Facade)
- Ease of maintenance.

The Control card shall be compatible to work on both AC and DC power supply. The scheme of power supply to card in such a way that in the event of failure of DC supply, automatic switchover on AC supply shall be done.

Castle key arrangement, for mechanical interlocking, to be provided in Mechanism Box as applicable.

Door design shall be such that it should not infringe with SOD in any condition.

Note :

- Any handle operation shall disable motor supply.
- All equipment shall withstand 2 kV, 50Hz for 1 minute.
- Box should be delivered with 8 pre-drilled cable holes of 30 mm diameter and a free space for releasing coil.
- The redundant earthing connectors shall be located externally.

7.4.6 Transmitting Mechanism

The transmitting mechanism components (operation rods, articulations, etc.) shall be able to withstand 10,000 operations without any maintenance (except greasing).

7.5 Voltage Transformers (VT)

The Voltage transformer shall be manufactured in accordance with IEC 61869-3. The Voltage transformer shall be pole mounted, dry cast resin type, suitable for outdoor/underground operation as per requirement.

7.5.1 The voltage transformer shall comply to EN 50152-3-3 for use of Single-Phase AC Traction System.

7.5.2 The core shall be build-up of high-grade cold rolled grain oriented non-ageing steel laminations. It shall be ensured that self-heating has to comply with the climatic conditions defined, and is less than 1^0C per hour.

7.5.3 The voltage transformer shall be suitable for secondary load of 30 VA.

7.5.4 The structure of 25 kV, 50 Hz railway electrification network may easily generate Ferro – resonance phenomenon. The inductive Voltage Transformer shall have the necessary characteristics in order to avoid generation of Ferro resonance phenomenon & the over voltages caused by the same.

To prevent generation of Ferro – resonance, following features shall be adopted: -

a) Minimum resistance of primary winding at 100^oC shall be >50 k Ohm.

b) Flux density shall be such that at Umax2, the saturation point is not reached(refer EN 50163).

c) Suitable Air gap in the core of the VT to be provided to avoid saturation and Ferro resonance.

7.5.5 Features to be adopted for prevention of damages in Voltage Transformer

a) Ability to withstand without damage on primary side a voltage wave obtained by summing a sinusoidal wave at rated frequency with a square wave at 1/3 of rated frequency, with a total peak value of approx. 1.6 Un.

b) Suitability to operate continuously at 1/3 rated frequency & rated voltage.

7.5.6 Voltage factor of 1.9 (1.9 Un for 8 hours at rated frequency).

7.5.7 Ferro - resonance withstand test: Voltage transformer will be considered suitable to withstand ferro – resonance if these characteristics are checked & tested. This consists of a temperature – rise test at rated voltage, rated burden and 1/3 rated frequency. The standard temperature rise over ambient shall not be exceeded.

7.5.8 External flashover Test: The outdoor unit shall be able to withstand an external flashover of the primary bushing and be capable of continued service. This is done by repeating dielectric, partial discharge & accuracy tests after a flashover. The flashover is made by creating a permanent conduction on creepage distance of insulator. The voltage applied shall be U max1, resulting fault current being maintained for 100 ms up to the values of 16 kA R.M.S.

7.5.9 These tests are special type test to be conducted through independent lab & approval on this regard to be taken from DMRC.

7.5.10 All voltage transformers shall follow the same electrical and mechanical characteristics and must be in accordance with IEC standard 61869-3.

7.5.11 As the primary is connected directly to the catenary/ROCS, which is designed for 14 kA short-circuit current, voltage transformers shall be able to withstand electrodynamics and thermal stresses resulting from this level of short circuit current.

7.5.12 All Electronic components/sub-parts shall be of Industrial grade only.

7.5.13 The Bill of Material shall be approved by Engineer-In- Charge

7.5.14 Accessories

Each voltage transformer shall consist of primary connectors, live-insulated transformer, and a connecting box.

Any metal part, which is not live, shall be connected to the two distinguished earth separately.

7.5.14.1 Primary Connectors:

25kV connectors shall be made of bronze pipe or copper jumper (as per requirements in elevated and underground section) of suitable size and shall be approved by Engineer In charge.

7.5.14.2 Secondary Connecting Box

Secondary winding connection shall be realised through a dust-proof and water tight type (IP55) connecting box fitted with a 4.0 A fuse and able to receive 2x10mm² screened-cable.

This cable shall enter the connecting box through a cable seal.

7.5.14.3 Transformer

Voltage transformer shall have a ratio of 27500/110 V and shall be dry resin type. It shall be ensured that self-heating is less than 1°C per hour The self-heating has to comply with the climatic conditions defined in General specifications.

The maximum temperature rises over ambient shall be in accordance with the insulation class, as defined in the IEC standard 61869-3 latest version. The core shall be built up of high-grade cold rolled grain oriented non-ageing steel laminations.

7.5.14.4 Voltage transformer connections

One end of primary windings shall be connected to the catenary and the other end to the earth collector (BEC/TEW/similar earth conductor). As the primary is connected directly to the catenary, which is designed for 14 kA short-circuit current, voltage transformers shall be able to guarantee electrodynamics and thermal stresses resulting from this level of short circuit current.

Secondary windings shall be connected to the auxiliary networks via the connecting box.

Support shall be pre-drilled for pole fixation and fitted with carrying devices (hook or ring).

VT mounting & jumper connection arrangement: A mock up arrangement for VT mounting & jumper connection arrangement shall be provided by DE-08 for approval of Employer's Engineer for further installation.

The Post Insulator for the support of jumper wire and Safety Screen to safeguard against the shattered pieces shall be provided at each Voltage Transformer and Capacitive Sensor as per technical instruction-17 (which shall be applicable for VTs and CS installed at elevated section).

7.6 Voltage Capacitive Sensors (CS)

The construction features are:

- External silicon coating that provides low weight and better resistance to shocks, and ensures a longer life.
- A central cylinder made of fibre glass, which provides adequate levels of electrical insulation, mechanical strength, humidity absorption, etc.
- Aluminium caps features located at the top, two located at the bottom, and a central stud, on the bottom from where the secondary signal is obtained.

It will be equipped with current loop converter equipment which will adapt voltage levels from any unit of measurement and converts to a proportional value of current loop (4-20 mA). It will enable control centres to receive line voltages measurements in real-time.

Current loop converter will be located in a sealed box adapted to the sensor support. The converter will transform the voltage from the sensor to the corresponding current of current loop converter 4-20 mA.

It will connect to the sensor to sample the voltage reading and it will have a power strip with four terminals (two inputs of auxiliary voltage and two that send level output 4-20 mA). All the printed circuit board will be coated with silicone which makes it completely waterproof.

The Post Insulator for the support of jumper wire and Safety Screen to safeguard against the shattered pieces shall be provided at each Voltage Transformer and Capacitive Sensor as per technical instruction-17 (which shall be applicable for VTs and CS)

The Bill of Material of Equipment shall be approved by Engineer-In- Charge

7.7 Current transformers

Primary connectors

Consist of up & down stream connectors, made of pre-drilled copper plates in order to receive connector fittings rated at 1250 Amps for 2x400 mm^2 cable or bus bar connection. The connectors shall be able to handle at least 2500A for 5 min without overheating.

Secondary connecting box

Secondary winding connection will be realised through a dust-proof and water tight type (IP55) connecting box and able to receive 2x10mm^2 copper screen-cable.

This cable will enter the connecting box through a cable seal.

Transformer

Current transformers shall be dry resin, and shall ensure that self-heating shall be less than 1°C per hour.

The self-heating has to comply with the climatic conditions defined in General Conditions. The maximum temperature rises over ambient should be in accordance with the insulation medium, as defined in the IEC standard 61869-2.

All Electronic components/sub-parts shall be of Industrial grade.

The Bill of Material of Equipment shall be approved by Engineer-In- Charge

7.8 25 kV Lightning Arrester

The metal-oxide types Lighting Arrester of composite housing type for outdoor application as per TI-32 of DMRC and IEC 60099-4 shall be provided at each elevated and underground switching post (alongside track) and Tunnel face. The Lighting Arrester shall be installed with every Voltage Transformer along with safety screen panels, pedestal insulators, necessary fittings and accessories. The indicative arrangement is shown in Technical Instruction-20 which shall also be applicable for underground switching station alongside the track. The arrangement shall be approved by Engineer In charge.

They Lightning arrester shall correspond to the class discharge-3 of the IEC 60099-4 and contain a string of resistor, whose active part shall be composed of perfectly homogeneous resistors.

The bill of material shall be approved by Engineer-In- Charge

7.9 Marshalling box/Kiosk (MK) with AC-DC Box

7.9.1 General Description

At every Switching Station, Marshalling Box shall be provided. The Marshalling Box for Switching Stations in Elevated lines and underground switching station (alongside the track) shall be provided on the parapet of the viaduct and the available space in the underground switching post. Suitable holding down bolts are provided on the parapet by the Viaduct Contractor. Suitable arrangement for installing Marshalling box at underground switching post shall be made by the DE-08 contractor.

The Marshalling box shall be made of Stainless steel (Grade SS 316, minimum 1.25mm thick sheet) with mirror finish enclosure (compact enclosure). The Marshalling box shall be of category IP55. The Marshalling box shall be made by Folded and welded from a single piece with protection channel around the door opening.

The Marshalling Box shall be provided with suitable base arrangement, so that the box can be properly placed on the parapet and bolted with the help of nuts, washers and lock-nuts as necessary.

The Door shall be easily openable and maintainable with flush-mounted, with foamed-in seal, concealed hinges, 130 degree opening angle as per VDI, cam lock with double-bit insert as per DIN43668.

Normally one marshalling box shall be installed for one switching station. Where number of equipment are comparatively higher, more than one marshalling box may be required. Suitable arrangement for track crossing of C&M cables shall be done by DE-08 contractor.

The cable dressing at marshalling box shall be proper and tied. Cables shall be tied on each bracket with heavy duty nylon cable tie (UL listed Nylon 6.6 material) for elevated section. The cable tie shall be UV resistant and Flammability shall be of UL94 V2 rating. LSZH cable tie shall be used for underground section. The GTP of cable Ties shall be approved by the Engineer In-charge.

The spare holes of marshalling box shall properly be sealed with sealant.

The bill of material shall be approved by Engineer-In-Charge.

7.9.2 Size of Box

The width across track of the Box shall not exceed 0.60 m and the max height shall not be more than 1.0 m. The size of Marshalling box with doors (in open condition) shall be decided based on the schedule of dimensions of DMRC.

7.9.3 Connections

All Control & Monitoring (C&M) cables from the pole mounted switchgear and pole/wall mounted LBS including potential transformer and Low Voltage (LT) and DC Wiring between the apparatus and Marshalling Box shall be suitably terminated in the Terminals inside the Box. From the Marshalling Box, connections shall be taken to the relevant equipment installed in the ASS, including but not limited to the following:

- LT Wiring from the ACDB/DCDB (inside ASS) to the Marshalling Box. The low voltage cables as per the size approved by Engineer in charge. The DC cables with copper conductors of not less than 10 sq. mm cross section shall only be used.
- C&M cables from Equipment to Marshalling Box and then Marshalling Box to RTU (inside ASS). The cabling schedule along with type and size of the cable shall be approved by Engineer in-charge.

The control cables and low voltage cables shall be supplied as per Chapter 8 of particular specification.

END OF CHAPTER

CONTRACT – …….

EMPLOYER'S REQUIREMENT

PARTICULAR SPECIFICATIONS

CHAPTER – 7A

TRACTION NETWORK TECHNICAL SHEET

7.10 **Traction Network Technical Sheet**

Note:-These specifications are the bare minimum requirement, the Contractor has to fulfil and submit the details during technical submissions of the equipment design & executions proposals. The final requirements of the specifications will depend upon the Traction power simulation studies and based upon that the contractor has to provide the material over and above to these specifications which shall be finally approved by Engineer In-charge.

Annexure 'A'

7.11 **25 kV Gas Insulated Switchgear (GIS)**

Standards	**Unit**	**IEC 62271-200, IEC 62271-1 & IEC 62271-102, EN 50124-1,2**
Bus bar		Copper
Nominal Voltage	V	25kV
Rated Voltage	V	27.5kV
Frequency	Hz	50 Hz ± 5 %
Power frequency withstand voltage for one minute	V	95 kV
Lightning Impulse withstand voltage	V	200kVp
Continuous rated current		2000A
For line CBs and OHE feeder CBs as per scheme provided	**A**	**2000A**
Short Circuit making current	A	40 kA
Short Circuit breaking current	A	16 kA for 3 sec
Overload current rating	A	3200A for 5 minutes 2400A for 10 minutes
Degree of protection of Gas Compartment		IP 64

Standards	**Unit**	**IEC 62271-200, IEC 62271-1 & IEC 62271-102, EN 50124-1,2**
Degree of protection for drive cabinet		IP 3X
Degree of protection for low voltage cabinet		IP 3X
No. of switching cycles at rated current.		10000 Cycles
Type of Circuit Breaker		Vacuum
Auxiliary voltage for closing coil, tripping coil, spring charge motor		110 V DC (Tolerances as per IEC standards)
Internal arc classification		FLR
Loss of Gas		< 1% per annum.
Sequence on short circuit		O-0.3sec-CO-3min-CO
Maximum closing time	ms	100
Maximum opening time	ms	70
No of Pole		1

7.12 **Detailed specifications of 25 kV Circuit Breaker/Interrupter/BM (AIS), Refer TI-35 of DMRC** attached in tender documents Appendix-D**.**

7.13 **Detailed specifications 25 kV Current Transformer, Voltage Transformer & Lightning Arresters (outdoor type), Refer TI-32 of DMRC Appendix-D**

7.14 25 kV ISOLATORS

Descriptions	Unit	Values Required
Manufacturer		
Place of manufacture		
Standards		RDSO specification no TI/SPC/PSI/ISOLTR/0210 (07/2021) or latest, IS 2071-1, IEC 60060-1, IEC 62271-200, EN 50163 & IEC 60850
Poles		1 or 2, as required
Operating voltage / earth	kV	27.5
Frequency	Hz	50
Rated Lightning Impulse withstand (1.2/50 micro second)	kV peak	250
Rated Power frequency withstand voltage-one minute	kV r.m.s.	95
Insulation withstand voltage (permanent)	kV	52
Operating current	A	1250
Withstand Over-current (3s /peaks)	kA	20 / 50

Opening / closing mode		Motorized/Manual
Operating time		8.5 s
Auxiliary supply voltage (control)	Vcc	110
Auxiliary contacts open/closed position		8
Operating cycles		10000
Degree of protection for auxiliary cubicle		IP55
Minimum Creepage Distance of Insulator	mm	1600

7.15 **25 kV** LOAD BREAK SWITCH

Descriptions	**Unit**	**Values Required**
Manufacturer		
Place of manufacture		
Standards		IEC 62271-1, 62271-103, IEC 62505-2
Poles		1
Indoor or outdoor installation		
Mechanical Endurance Class		3
Electrical class		E1
Rated cable charging breaking current	A	32
Operating voltage / earth	kV	27.5
Frequency	Hz	50

Rated Impulse withstand (1.2/50 micro second)	kV peak	250
Rated Power frequency withstand voltage-one minute	kV r.m.s.	95
Rated normal current	A	2000
Withstand Over-current (3 s /peaks)	kA	20 / 50
Opening / closing mode		Motorized & Manual
Operating time		
Auxiliary supply voltage (control)	Vdc	110
Auxiliary contacts open/closed position		
Operating cycles (mechanical)	cycles	10 000
Degree of protection for auxiliary cubicle		IP55
Minimum Creepage Distance of Insulator	Mm	1600
Rated breaking current	A	2000
Electrical life time of the vacuum bottle (on load)		2000 switching cycles at rated current
Rated making short circuit current	kA	16

7.16 **Voltage Capacitive sensor**

Descriptions	Unit	Values Required
1 Sensor data		
Manufacturer		
Place of manufacture		
Standards		IEC 61869-5
Type		Cast resin

Erection		Outdoor
Service frequency	Hz	50
Rated Impulse withstand (1.2/50 micro second)	KV peak	250
Rated Power frequency withstand voltage-one minute	kV r.m.s.	95
Nominal Voltage, U_n	kV	27.5
Insulation withstand voltage (permanent)	kV	52
Sensor capacity	pF	40
Operation		Continuous operation
Response time	s	< 0.2
Type of measurement		RMS precision of 3%
2 Current loop converter data		
Supply voltage:	Vac	230 ± 20%, 85-265 VAC, 86-370 VDC
Output:	mA	4-20
Consumption:	W	2
Input/ Output:	VDC / mA	0 - 100 /4 - 20
Linear:	%	1
Precision:	%	2
Response time:	s	0.2
Output limit:	mA	24

7.17 25 kV CURRENT TRANSFORMERS for GIS

Descriptions	Unit	Values Required
Manufacturer		
Place of manufacture		
Standards		IEC 61869-1,2
Nominal Voltage, U_n	kV	25
Rated Frequency	Hz	50
Type		Cast resin
Erection		Indoor
Rated Lightning Impulse withstand (1.2/50 micro second)	kV peak	~~250~~ **200**
Rated Power frequency withstand voltage-one minute	kV r.m.s.	95
Transformation ratio/Accuracy class/ rated output	Core 1	1600-800/1, 5P10, 20VA Protection class
	Core 2	800-400/1, 5P10,10VA Protection class
Rated secondary current	A	1
Rated short-time thermal current for 1 sec	kA	25
Rated dynamic current	kAp	62.5
Degree of protection		IP55
Highest voltage of the equipment, (Um), (Phase to Neutral)	kVrms	30

Highest voltage of the equipment, (Usys), (Phase to Neutral)	kVrms	30
Rated primary (Phase to Neutral) voltage of 25kV CT	kVrms	30
Rated continuous thermal current	A	120% of rated primary current

7.18 25 kV VOLTAGE TRANSFORMER FOR GIS

Descriptions	Unit	Values Required
Manufacturer		
Place of manufacture		
Standards		IEC 61869-1,3
Type		Cast resin
Erection		Indoor
Rated frequency	Hz	50
Rated Lightning Impulse withstand (1.2/50 micro second)	KV peak	~~250~~ **200**
Rated Power frequency withstand voltage-one minute	kV r.m.s.	95
Nominal Voltage	kV	27.5
Resistance of Primary winding		Not less than 50000 ohms at 10°C*
Actual transformation ratio		27500 / 110
Rated Output	VA	Rated output=30VA at PF=0.8 lagging

Accuracy Class for Measurement	Cl	1 for indication purpose 0.5 for meeting purpose.
Accuracy Class for protection	Cl	3P
Degree of protection		IP55
MTBF	Million Hours	2.5
Overvoltage Withstand (Phase to neutral)	kVrms	45 (150% of rated voltage) for 30 sec
Rated thermal limiting output (Thermal burden)	VA	275 (max. load without overheating)

7.19 Surge Arresters for 25kV GIS

Descriptions	Unit	Values Required
Manufacturer		
Place of Manufacture		
Manufacturer Drawing reference		
Standard		IEC 60099-4 and RDSO Specification No. ETI/PSI/71 (1/87) with A&C slip no. 1 to 7 or Latest Version
Lightning Arrester type		Non-linear Metal Oxide Resistor type, gapless
Nominal System Voltage	Phase-to-Earth	25.5 kV
Temporary overvoltage TOV (Umax3)	kVrms	38.75

Rated Voltage for lightning Arrester	kV	42
Rated Frequency	Hz	50
MCOV (Maximum Continous operating voltage of the lightening Arrester)	kV	35
Nominal discharge current (8/20 micro sec wave)	kAp	10
Peak value of switching impulse current (30/60 micro sec wave))	kAp	1
Max.residual voltage at nominal discharge current (at 10 kAp, 8/20 micrso sec wave)	kVp	125
Max.residual voltage at switching impulse current (current at 1000Ap,30/60 micro sec wave)	kVp	75 to 95
Pressure Relief Class		A
Lightning Impulse withstand of arrester insulation	KV peak	170
Power frequency voltage withstand for arrester insulation	kV rms	105
Peak value of High current impulse (4/10 micro sec wave)	kA	100 kA
Line discharge class	Cl	3
Rated Short Circuit current of arrester	kA	16
Thermal Energy rating (min), Withstand		
Repetitive charge transfer rating (min), Qrs		
Enclosure		

Length		

END OF CHAPTER

CONTRACT –

EMPLOYER'S REQUIREMENT
PARTICULAR SPECIFICATIONS
CHAPTER-7B
TEST SHEETS

7.20 TEST SHEETS

7.21 **Detailed specifications of 25 kV Circuit Breaker/Interrupter/BM (AIS), Refer TI-35 of DMRC Appendix-D.**

7.22 **Detailed specifications 25 kV Current Transformer, Voltage Transformer & Lightning Arresters (outdoor type), Refer TI-32 of DMRC Appendix-D**

7.23 **25 kV GIS (IEC 62271-100)**

INDICATIONS	**TYPE OF TEST**			
	Type	**Routine**	**FAT**	**On site**
Dielectric Test	✓	✓	✓	
Radio interference voltage test	✓			
Measurement of resistance of the main circuit	✓	✓	✓	✓
Temperature rise Tests	✓			
Short time with stand current and peak with stand current	✓	✓		
Tightness tests	✓	✓	✓	✓
EMC test	✓			
Mechanical operation test at ambient Temperature	✓	✓@	✓	✓
Short circuit current making breaking tests	✓			

Capacitive current switching test- Line charging current	✓			
Capacitive current switching test- Cable charging current	✓			
Verification of the degree protection	✓			
Low & high temperature test	✓			
Static terminal Load test	✓			
Pressure tests of gas filled compartment	✓			
Interlocking			✓	✓
Visual inspection/physical dimension			✓	✓
Measurement of operation time			✓	✓
Insulation resistance test			✓	✓
Contract Resistance test			✓	✓

@ The Mechanical operation test shall be done as a Routine test and comprise of five opening and five closing operations at each of the rated, maximum and minimum control voltages. The contact travel characteristics shall be recorded for each closing and tripping operation and operation test (110%,100%,85% &70% of control supply).

NOTE: These tests are indicative subject to be change as required by Engineer- in-charge.

7.24 25 kV ISOLATORS

INDICATIONS	**TYPE OF TEST**			
	Type	**Routine**	**FAT**	**On site**

Visual Examination of Isolator and its parts	✓	✓	✓	✓
Dimensional verification of parts	✓	✓	✓	✓
Assembly an interchange ability	✓	✓	✓	
Measurement of resistance of main circuit and earth circuit (before and after mechanical endurance test	✓	✓		
Temperature rise test (before and after mechanical endurance test)	✓	✓		
Mechanical endurance test	✓	✓		
Short time rated current test	✓			
One-minute wet power frequency test across the isolating distance and to earth	✓	✓	✓	
Impulse voltage with stand test across isolating distance and to earth	✓			
Galvanisation test	✓	✓	✓	
Chemical analysis of materials- Copper contract, spring, fasteners and Bus bar	✓			
Physical test on springs and fastener and copper strips	✓			

Aux. Circuit insulation			✓	✓
Insulation Resistance Test (open & close condition)			✓	✓
Contract Resistance close condition			✓	✓
Operational check & record the motor current			✓	✓

NOTE: These tests are indicative subject to be change as required by Engineer- incharge.

7.25 **25 kV LOAD BREAK SWITCH (IEC 62271-1, 62271-103, IEC 62505-2)**

INDICATIONS	TYPE of TEST			
	Type	Routine	FAT	On site
Dielectric Tests	✓			
Temperature rise	✓			
Mechanical operation	✓	✓@		✓
Lightning impulse withstand voltage	✓			
Measurement of the resistance of the main circuit	✓	✓	✓	✓
Short time withstand current and peak withstand current tests	✓			
Test to prove the ability of the switch to make and break the specified currents	✓			
Test of prove satisfactory mechanical operation and endurence	✓			
Verification of the protection	✓			
Tightness tests	✓			
Electromagnetic compatibility (EMC) tests	✓			
Additional tests on auxiliary and control circuits	✓		✓	✓
X- radiation test procedure for vacuum interrupters	✓			
Lightning withstand voltage	✓			
All devices operation checking	✓	✓	✓	✓

Functioning times	✓	✓	✓	✓
Saline fog	✓			
Wiring		✓	✓	✓
Interlocking		✓	✓	✓
Painting & external visual inspection		✓	✓	✓
Exchangeability of similar devices		✓	✓	
Aux. Circuits insulation			✓	✓
Insulation Resistance Test (open & close condition)			✓	✓
Contract Resistance close condition			✓	✓
Operational check & record the motor current			✓	✓

NOTE: These tests are indicative subject to be change as required by Engineer- incharge.

7.26 25 kV CURRENT TRANSFORMERS (IEC 61869-2)

INDICATIONS	**TYPE of TEST**			
	Type	**Routine**	**FAT**	**On site**
Temperature rise	✓			
Lightning impulse withstand voltage	✓			
Short circuit withstand	✓			
Test of accuracy	✓			
EMC	✓			

Primary windings Voltage withstand at 50 Hz		✓	✓	
Secondary windings Voltage withstand at 50 Hz		✓	✓	
Between section Voltage withstand at 50 Hz		✓	✓	
Transformer ratio		✓	✓	✓
Terminal marking		✓	✓	✓
Visual inspection		✓	✓	✓
Polarity test				✓
Continuity Test				✓
Insulation resistance test			✓	✓

NOTE: These tests are indicative subject to be change as required by Engineer- in-charge.

7.27 25 kV VOLTAGE TRANSFORMER (IEC 61869-3)

INDICATIONS	TYPE of TEST			
	Type	**Routine**	**FAT**	**On site**
Temperature rise	✓			
Impulse voltage withstand test on primary terminals	✓			
Short circuit withstand	✓			
Test of accuracy	✓			
Electromagnetic Compatibility (EMC) tests	✓			

Short circuit withstand capability test	✓			
Primary windings Voltage withstand at 50 Hz		✓	✓	
Partial discharge measurement		✓		
Secondary windings Voltage withstand at 50 Hz		✓	✓	
Between section Voltage withstand at 50 Hz		✓	✓	
Transformer ratio		✓	✓	
Terminal marking		✓	✓	✓
Visual inspection		✓	✓	✓
Measurement of capacitance and dielectric dissipation factor		✓	✓	
Internal arc fault test		✓		
Insulation resistance Test			✓	✓

NOTE: These tests are indicative subject to be change as required by Engineer- in-charge.

7.28 25 kV VOLTAGE CAPACITIVE SENSOR (IEC 61869-5)

INDICATIONS	**TYPE of TEST**			
	Type	**Routine**	**FAT**	**On site**
Null responders DC	✓			
Operating time tests	✓			

Dielectric tests with industrial frequency for1 min	✓			
Dielectric tests: lightning impulse withstand voltage	✓			
Climatic tests	✓			
Short circuit withstand	✓			
Corrosion Test	✓			
Response values at different voltages		✓	✓	
Try auxiliary voltage		✓	✓	
Limit Value converter output (mA)		✓	✓	
Output voltage converter in open circuit		✓	✓	
Capacitive sensor test		✓	✓	
Terminal marking		✓	✓	✓
Visual inspection		✓	✓	✓
Exchangeability of similar devices		✓	✓	

NOTE: These tests are indicative subject to be change as required by Engineer- incharge.

7.29 **25 kV Lightning Arrester (IEC 60099-4 and RDSO Specification No. ETI/PSI/71 (1/87) with A&C slip no. 1 to 7 or Latest Version)**

INDICATIONS	**TYPE OF TEST**			
	Type	**Routine**	**FAT**	**On site**
Insulation With stand tests on the arrester housing	✓	✓		

Residual Voltage test	✓	✓	✓	
Test to verify long term stability under continuous operating voltage	✓	✓	✓	
Repetitive charge transfer with stand	✓	✓		
Heat dissipation behaviour verification	✓	✓		
Operation duty test	✓	✓		
Power frequency voltage versus time	✓			
Short- circuit tests	✓	✓	✓	
Environmental tests	✓			
Test to verify the dielectrical withstand of the internal components of an arrestor	✓	✓	✓	
Test of internal grading components	✓			
Polluted housing test	✓			
Partial Discharge test	✓		✓	
Insulation Resistance measurement			✓	✓
Measurement of reference voltage		✓	✓	
Visual inspection		✓	✓	✓
Leakage current test		✓	✓	

Surge counter reading			✓	✓
Checking of healthiness			✓	✓

NOTE: These tests are indicative subject to be change as required by Engineer- in-charge.

END OF CHAPTER

CONTRACT PACKAGE –-----

CHAPTER – 7C

CIVIL WORKS

7.30 CIVIL WORKS

7.30.1 INTRODUCTION

7.30.2 GENERAL

The ROCS Contractor will be required to execute certain civil work along the line and at various Power Supply installations, for erection and commissioning of the various electrical equipment and systems. While executing such civil works, the ROCS Contractor will have to maintain close interface with the various other contractors responsible for execution of civil works at Viaducts, Metro Stations, Underground section, Car Depot etc., wherever and whenever required.

7.30.3 LOCATIONS

Broadly, the Contractor will be required to execute civil works at the following locations:

- Installation of OHE Masts / Portals etc.
- Traction Switching Stations on the Viaduct/Depot
- Along Viaduct.
- Traction Switching Stations in the underground section.
- Along the track in the underground section (Including crossover area and niche).

The above list is indicative only and the Contractor will be required to execute all necessary civil works to enable the Power Supply equipment's/systems to be installed and commissioned.

7.30.4 NATURE OF WORKS

The specific nature of civil works, required to be done at different locations, will be different and will depend upon the locations. Broadly, the services to be provided at Metro Stations, underground section etc. may be limited to those services which are required for supplementing the designs etc., already provided by the Detailed Design Consultant/Contractor, responsible for Design/Construction of such installations (Metro Stations, underground section etc.). The services to be provided by the Contractor are broadly described in the subsequent paragraphs.

7.30.5 INSTALLATION OF OHE MASTS for trackside switching posts.

In the underground section, the locations where switching stations are to be installed at crossover areas, niche at Lowering/Retrival shafts, station end etc. wherever required, the contractor shall have to carry out necessary civil works for the installation of all items related to switching station. However, the contractor shall interface with designated civil contractor for the foundation work in the underground section.

Notwithstanding the above, the contractor shall make all the arrangements to make the switching station operational (as per the approved design) in all respects.

7.30.6 TRACTION SWITCHING STATIONS

7.30.6.1 GENERAL

The design of Traction Overhead Equipment provides for Switching Stations along the Line, by means of pole-mounted switchgear, wherever applicable. The Civil Works required to be done along the Line, at switching station locations are described below.

7.30.6.2 C&M PANELS

At every Switching Station a Control & Monitoring Panel, approximately 3.0m x 0.6m may have to be installed in the underground switching stations. In case of underground switching stations, necessary interface has to be done by the DE-08 contractor for the foundation works. However, the minor civil work to complete the erection of items shall be the responsibility of contractor.

The Contractor will be required to install the C&M panel in underground switching stations and secure it properly with suitable nuts, locknuts and washers. The Contractor shall also be required to provide Grouting Mix (GP-2) for ensuring that there are no gaps between the bottom of panel/mast and ground.

In addition, suitable pipe shave to be provided to link the C&M panel outlet to the cable trough running along the track or in the vicinity of the switching station. Similarly, a link, by means of pipes will have to be provided between the cable trough and the Control Mechanism box of the pole-mounted switchgear, like interrupters, isolators circuit breakers, Load Break Switch etc.

7.30.7 PIPE CONDUITS BETWEEN UP AND DN TRACKS THE SWITCHING STATION

At Switching Station along trackside, it may be necessary to run the cables (power and/or control) from UP track to DN track and vice versa. The Contractor will have to provide the necessary pipe conduits to carry such cables. The number, size and arrangement of such pipe conduits will be decided depending upon the actual site conditions obtaining.

7.30.8 VIADUCT LIGHTING (Only if it is in the scope of the contract)

Viaduct Lights shall be installed all along the viaduct.

From each station, 2 cables have to be laid, one on each direction.

Viaduct Lights shall be placed at every14 meters approx. They shall ensure a protection of IP 65. The cable along the viaduct should be of the same cross section throughout.

The cables shall be laid on cable brackets along the line on the parapet. To connect the viaduct lights, cable connection boxes shall be installed on the parapet.

The cable from connecting box to viaduct light shall be laid in conduits. The conduit shall enter into the connecting box to ensure proper sealing of the system.

The connecting box shall ensure the connection of the Light by means of cable. Due to the difference in size between the main cables and the light cable, connecting plates will ensure this reduction.

The cable termination shall not be open but shall only permit the screwing in order the cable do not fall and touch any other parts in case of bad tightening of the bolt.

The connecting box shall be fixed on the parapet, under the viaduct light.

The connecting box shall be waterproof and dust-proof, with tubes placed in position with a protection level of IP-65.

All cables should meet the design criteria specified for 415 V cables.

7.30.9 **IN THE UNDERGROUND SECTION**

SWITCHING STATIONS

The contractor may have to undertake all works regarding the installation of brackets (or any other arrangement) for cable laying in the switching station to make the switching station complete in all respects.

7.30.10 **EARTHING OF SWITCHING STATION**

The contractor shall make all the necessary arrangements for earthing of all the equipment of switching stations as per the approved design.

7.30.11 **FENCING AND ACCESS GATE FOR UNDERGROUND SWITCHING STATION**

The contractor shall carry out necessary civil work for installation of fencing at switching station as per the approved design. This shall also include access door, locking assembly, caution and danger notices, indication board or any other requirements as per approved drawing.

The design of the fencing shall be approved by the engineer-in-charge.

END OF CHAPTER

CHAPTER – 8

DESIGN CRITERIA AND PERFORMANCE SPECIFICATION CABLING AND CONTROL SYSTEM

8. DESIGN CRITERIA AND PERFORMANCE SPECIFICATION –SWITCHGEAR, CABLING, PROTECTION & CONTROL SYSTEM.

8.1 Scope of Works

The scope of work under this chapter includes, complete design, supply, delivery at site, installation, testing and commissioning of, but not limited to, following:

Specifications for following equipment are covered in this Chapter

i) 25 kV ac traction switchgears

ii) Complete ac and dc Control source and systems.

iii) Single core 25 kV cable, return current cable to feed the traction power to OCS as per design requirements.

8.2 Cabling System

8.2.1 General

8.2.1.1 The cabling system includes supply, laying, jointing and terminations of 25 kV ac traction and return current and 415 V auxiliary supply cables, Control cables, earth bus return current conductors etc. Types and sizes of cables are given below in Table 8.2-1

Voltage		Duty	Core material and size (sq mm)	Number of cores	Brief description	Remarks
Nominal (kV)	Max.(kV)					
25 AC for laying underground tunnel and elevated section	52 AC	Traction power	Aluminium 400 mm^2	Single core	Halogen free FRLS for underground and FRLS for elevated, outer sheath flexible XLPE insulated	For extending power from TSS to Feeding Post and for jumpering and other uses inside the tunnel, viaduct and cable galleries.
25 AC return current	3.3 AC	Traction power	Aluminium 400 mm^2	Single core	Halogen free FRLS for underground and FRLS for elevated, outer sheath flexible XLPE insulated	For bonding in tunnels, viaducts and other uses inside the tunnel and viaduct and cable galleries.
0.415/0.240 AC	1.1 AC	Power	Copper, sizes as required	4	Halogen free FRLS for underground and FRLS for elevated, outer sheath flexible XLPE insulated	Auxiliary supply from ASS to Underground/elevated Switching station & within switching stations

Voltage		Duty	Core material and size (sq mm)	Number of cores	Brief description	Remarks
Nominal (kV)	Max.(kV)					
0.240 AC	0.65AC	Control	Copper, sizes as required	As per the requirement	Halogen free FRLS for underground and FRLS for elevated, outer sheath flexible XLPE insulated	For Control and monitoring use

8.2.1.2 Not used

8.2.1.3 The contractor shall use a colour code scheme for different voltage grade cables after the receipt of letter of no objection from Engineer.

8.2.1.4 The Contractor shall submit a certified test report for low-smoke halogen-free and anti-termite materials to be used in the manufacture of cables. These tests shall be in accordance with international standards / specifications.

The Contractor shall submit a certified test report each for flame-retardant tests on cables and for physical properties of materials to be used.

Test to prove the Power Cable and Metallic Screen Short Circuit Withstand Capacity to be conducted as per the relevant Standard Recommendations. If no guidelines are available, as a general practice routine test such as High Voltage, Partial Discharge, Electrical Parameters etc., to be conducted prior and after performing short test on the cables, to prove the integrity of cables under short circuit test.

The entire work of cable laying for power, traction, control, etc. shall ensure that EMI as a result of 25 kV ac single phase traction does not deteriorate the performance of installation nor cause danger to equipment and personnel. Details have been given in Chapter 6 (Subject to change as per the changes in the chapter-6).

8.2.1.4.3 **25 kV Traction Cables**

For Detailed technical specifications of 25kV cables including joints and terminations Refer Appendix-….. (Refer appropriate appendix), DMRC specification DMES- T/0019/ DMRC-E-TR- CABLE-3

Also, Sheath Voltage limiters to be installed in 25kV Cable feeders wherever required, calculations for the same to be submitted for the approval of engineer. Generally, SVL to be installed in all cable feeders having length more than 1kM.

8.2.1.4.3.1 **Connecting Junctions**

Connecting junctions shall reconstitute perfectly all elements of the 25kV cables, so as to obtain electrical and mechanical characteristics at least equal to those of the cable.

The Contractor will submit to the Engineer, for approval, a detailed description of the technique foreseen for execution of connections in MV lines.

However, maintenance and repair being able to be carried out only during a short period of time, at night, due consideration shall be given to connection processes having the following characteristics, quality being otherwise equal:

- Quickness of execution,
- Possibility of replacement without having to disturb the cable,
- Small bulk

8.2.1.5 RETURN CURRENT CABLES

Each feeder from RSS/TSS or any other feeding arrangement shall consist of two nos. phase cable (25 kV) and two nos. Return Cable (3.3kV).

For Detailed technical specifications of 3.3 kV cables including joints and terminations, Refer Appendix-E, DMRC SPECIFICATION NO. DMES- T/0020/ DMRC-E-TR- CABLE-3

8.2.1.6 415V AC Power Cable

8.2.1.6.1 General

The Contractor shall design, manufacture, supply, install, test and commission 415V, single core, circular, compacted stranded copper conductor, cross-linked polyethylene insulated thermosetting compound over sheath power cable and accessories. All cables shall be armoured and screened.

The power cables shall be designed and constructed in accordance with the most up-to-date experience for a system of this voltage level and shall incorporate the latest improvements of design and manufacture for the type of cable required was currently employed in the industry.

8.2.1.6.2 System Earthing

The low voltage system on which the cables are used shall have its neutral earthed at the main LV switchboard.

8.2.1.6.3 Rating

The cable shall be rated in accordance with the following ratings:

a) Rated voltage : 1.1kV

b) Rated frequency : 50Hz

c) The numbers of cables installed for each circuit shall be based on the rating of equipment and taking into consideration of the following:

Installation method

(i) Horizontally touching one another.

(ii) In cast-in pipes

8.2.1.6.4 Cable Construction

The conductor shall be of Class 2 annealed circular, sector compacted, stranded, plain copper type and complying with Clause 4.2 of IEC 60228.

8.2.1.6.5 Insulation

The insulation shall be of cross-linked polyethylene (XLPE) type and complying with the relevant test requirements specified in IEC60502 / IS7098. The insulation shall have a high degree of cross-linking, free from contaminants and voids, good heat resistant and shall be treated by the extrusion process.

The XLPE insulation shall be suitable for use on power cables in wet and dry conditions at temperatures not exceeding 90^0C for normal operation and 130^0C for emergency overload condition.

The nominal thickness of the XLPE insulation shall be determined by the test method specified in IEC 60811. The average thickness of insulation shall not be less than the nominal thickness.

8.2.1.6.6 Over sheath and screen

The over sheath shall be of a layer of extruded thermosetting compound that meets the requirement stipulated in Clause 8.1.2.4 c). It shall be extruded over the insulated core. The sheath shall also be compatible with the operating temperature of the cable. The over sheath shall incorporate and approved anti-termite mixture. The anti-termite mixture shall not be soluble in water. Screen shall be provided for negating the effects of single phase traction system

8.2.1.7 CONTROL CABLE

8.2.1.8 The Contractor shall design, manufacture, supply, install, test and commission all control cables as specified. All cables shall be armoured and screened.

8.2.1.8.1 All cables shall be provided with identification labels at both ends. The Contractor shall install the cables in accordance with relevant Indian/International Standards. The cables shall be installed on cable trays, in ducts or clipped to ceiling and wall. All spare control cables inclusive of pilot cables shall be properly labelled and terminated onto terminal blocks of the equipment.

8.2.1.9 Conductor

The conductor shall be circular stranded or compact stranded conductor composed of annealed copper wires complying with IEC 228.

8.2.1.10 Insulation

The conductor shall be insulated with extruded XLPE complying with IEC 60502. Suitable separator tape or tapes may be applied over the conductor.

8.2.1.11 Core Identification

The cores shall be identified by various coloring/numbering systems with the acceptance of the Engineer.

8.2.1.11.1 Stranding of Multi-Core Cables

The required number of cores shall be stranded with jute or other suitable materials fillers in round shape. A low smoke and halogen free tape shall be applied.

8.2.1.12 Shielding

An annealed copper tape shall be applied over the binding tape. The binder tape of low-smoke and halogen-free materials may be applied on it.

8.2.1.13 Inner Sheath

Extruded black low-smoke, halogen-free and anti-termite compound sheathing complying with Clause 8.2.1.4 c) shall be provided.

8.2.1.14 Bedding

The bedding shall be wrapped with low smoke, halogen free tape material.

8.2.1.15 Armouring

Armouring shall comply to IS 7098-1

8.2.1.16 Outer Sheath

Extruded black low-smoke, halogen-free and anti-termite compound sheath complying with Clause 8.2.1.4 c) shall be provide. The anti –termite mixture shall be of an approved make and shall not be soluble in water.

8.2.1.17 Cables Routes and Installations

The route plan, spacing of cables and method of laying shall ensure their safety, ease of inspection and renewal and minimum de-rating of power cables. The cables from RSS (TSS) to Feeding post shall be laid in the underground cable trench and sufficient space shall be provided in the trench to accommodate the cable for the ASS, pilot wire and for Signalling etc. The contractor needs to interface will all the concerned system wide contractor for the same. Permanent route and straight through joint markers shall be provided on the route. Details to be submitted for review and approval by the Engineer.

8.2.1.18 General

All cable ends shall be provided with high strength, silicone rubber type identification labels and all control cable terminals shall be provided with non-metallic, non-flammable and durable sleeve type identification ferrules.

The identification labels shall be provided at eye level from the substation floor and shaft base and at each position where cables change direction. For cases where groups of cables are routed, cable identification labels shall be provided at not exceeding 10m interval.

The cable identification labels shall remain legible and not suffer degradation from weathering throughout the specified life of the equipment. All cable identification labels shall be subject to review by the Engineer.

All cables in the tunnels shall be tightened with halogen free cable ties over an equal distance. The material and the dimensions (i.e. width, length and thickness) of cable clamps and cable ties shall be subject to the review by the Engineer.

8.2.1.19 The underground cable gallery will be separated from other rooms by 3 hours fire-rated walls. All penetrations through these walls shall be sealed with fire-rated materials with waterproof properties. Details of proposed type of material to be submitted for review by Engineer. The entire design jointly prepared with Civil Contractor shall be subjected to the review by the Engineer.

8.2.1.20 The Contractor shall be fully responsible for all civil works (such as drilling on cable basement walls, floor openings or wall openings) deemed necessary for the installation of the complete cabling works in the substations. The Contractor shall ensure that the floor openings, wall openings, cable openings, trunking and conduits used for his cabling works shall be sealed with water proof fire retardant material of the same rating as the fire compartment wall or floor. The ceiling compound shall be non-toxic (not harmful) and the chemical be chemically inert when in contact with cables and the associated equipment's.

8.2.1.21 The cable hangers in sub-stations shall be supplied and installed by the Contractor. This will require close interface with the Civil Contractors. For tunnels, cable galleries and stations, all hangers, inserts, nuts and bolts and accessories will be supplied by the Contractor in accordance with interface specifications with Contractors.

8.2.1.22 Cable terminations

The cable lugs shall be compression type. Cable connector shall be of silver plated or tinned plated copper. The bolts and nuts shall be of stainless steel. Heat shrinkable sleeve shall be provided over the exposed conductor below the cable lug. Lock washers shall be installed under each bolt head and under each nut. The cable lug or cable connector shall have two 360° indentations. Cable lugs, thimbles, terminations, termination blocks, DIN rail etc. shall be of reputed make and approval shall be taken from the engineer in-charge. The cable terminations used in underground section (AIS type) shall have specifications equivalent to outdoor type terminations.

<u>JOINTS AND TERMINATIONS OF 25kV/ 3.3KV CABLES</u>

Joints and termination for cables (FRLS / FRLSOH) work shall be carried out as per best engineering practices by qualified (OEM certified) persons only. The location of joints should be marked with details of location in the as built drawings.

Cable joint shall reconstitute perfectly all elements of the 25kV cables, so as to obtain electrical and mechanical characteristics at least equal to those of the cable.

The terminations for 25 KV cables (AIS/GIS type) should be provided with adequate safety and clearance in tunnel and equipment's. All supporting structures shall be provided with proper safety margin in design. For 25kV terminations in tunnels the terminations, cables and its accessories should be adequately supported considering the safe clearances under static and dynamic conditions.

Contractor shall submit the detailed technical document for all types of Cable joints, terminations i.e. GIS/ AIS, Indoor/outdoor etc. for review & approval of engineer.

8.2.2 LT Cables

8.2.2.1 LT cables include 415 V, 3 phase ac, 240V ac and 110V dc auxiliary supply cables, control cables. All cables shall be armoured and screened.

8.2.2.2 Auxiliary supply from the panel to various equipment shall be through copper cable of required size.

8.2.3 Control Cables

8.2.3.1 Multicore control cables used in substations shall be armoured. Those laid in cable gallery, cable ducts, cable trenches or in train tunnel shall also be armoured unless they are provided with protective conduit for mechanical and fire safety requirements. The conductor shall be minimum 2.5 sq.mm whereas cables used for CT circuits shall be minimum 4 sq.mm. The contractor shall prepare layouts and drawings based on the civil, CSD, WOD, SEM drawings for all the services of ROCS system.

8.2.3.2 The above drawings have been included in Civil contract packages for reference of Civil Engineering contractors who will provide adequate space for run of various cables in stations, tunnels and where applicable as per the requirement given by the Contractor.

8.2.3.3 Other drawings forming part of Civil contracts, vis. Tunnel plan drawings, tunnel cross section drawings, alignment plan drawings, BCC / Administration building drawings, station plan and cross section drawings are given in the Employer's Drawings.

8.3 Switchgear, Remote Control and Protection

8.3.1 25 kV Switchgear

8.3.1.1 General

These specifications are applicable for the 25 kV interlinking works where bi-directional metering and protection has to be provided. The metering specifications have been provided in Appendix-D of these tender documents. The protection specifications are detailed below.

No protection shall be provided at SS, SP, SSP and underground FP. DE-08 contractor has liaison with RSS contractor for protection of the OCS system. Detailed parameters of ROCS, along with route length has to be provided to RSS contractor for detailed calculations & setting of protection. ROCS contractor wherever required has to prepare and submit the protection settings as per network. The protection scheme as per Appendix-D of PS has to be followed.

8.3.1.2 The characteristics and specification of 25 kV Switchgears have been furnished in Chapter 7.

8.4 Control Module

In general, control module shall include but not limited to the following:

8.4.1 The interlocking of power supply system shall not be limited to the requirement specified herein. The Contractor shall also comply with the interlocking requirements elsewhere in this specification. The Contractor shall ensure that inadvertent operation which will result in human injury or equipment damage is prohibited by the interlocking scheme. In general, the interlocking shall be achieved through redundant means such as:

a) Programme logic

b) Electrical circuits

c) Mechanical key/ Pad lock etc.

8.4.2 The Contractor shall submit detailed proposal for the interlocking facilities for the review by the Engineer.

8.5 Not Used

8.6 Protection Relay Module

8.6.1 General requirement of protection relay module at Feeding post

Each PCU shall be integrated with a protection relay module within which standard protective relay features are incorporated. The protection system to be designed for bus-bars, feeders and other equipment shall comply with IEC 60255 or BS 142. The application, performance and testing of protection relay modules shall be in accordance with the appropriate IEC standards.

All protection relay modules shall comply in accordance with the following IEC test requirements:

a) Dielectric test voltage (IEC 60255-5) 2.0kV, 50Hz, 1min

b) Impulse test voltage (IEC 60255-5) 5kV, 1.2/50ms, 0.5J

c) High frequency disturbance test (IEC 60255-22-1 Class III)

i) Common mode 2.5kV, 1MHz, 2s

ii) Differential mode 1.0kV, 1MHz, 2s

d) Electrostatic discharge test (IEC 60255-22-2 and IEC 61000-2 Class IV)

i) Air discharge 15kV

ii) Contact discharge 8kV

e) Fast transient (IEC 255-22-4 Class IV)

i) Power supply inputs 4kV

ii) other inputs 2kV

f) Magnetic field (IEC 61000-4-8) 400A/m

g) Electromagnetic field test (IEC 61000-3 Class III) 10V/m 150khz to1000MHz

The protective relay modules shall be microprocessor based numerical type with continuous monitoring and self-diagnostic features to identify faulty modules or components. The protective scheme shall be so designed that the system remains stable during switching operation and other disturbances.

In the event of a system fault, the protection module shall be able to record values of a minimum latest five cycles with time stamping such as phase currents and earth fault current. The fault data shall be captured and displayed at the PCU's digital display and at the remote OCC. The system should remain disabled until manual reset/ acknowledgement is done at the local or at the remote OCC. The local manual reset shall be capable of being reset without the necessity of opening the front cover. Minimum 5 oscillography disturbance records should be provided.

The DC trip supply for the circuit breaker shall continuously be monitored by the individual protection relay module within the PCU.

In cases where two or more phase elements are included in one protection module, identification of each element shall be provided.

8.6.2 Types of Protection Relay Modules

The protection relay modules shall include all the protection requirements. The protection requirements shall comply with the latest IEC standards. The protection scheme shall include as required for Traction power supply circuits, relaying out of following types:

Separate test blocks shall be provided in the panels for testing of relays/ meters. Minimum 10% BO/BI contact are to be provided. Relay settings should be readable from HMI and the model selected should have feature of interlocking by-pass for local operation during testing.

All the electronic cards supplied shall have following minimum requirements-

a) As per IEC 61086 & 60815, all printed board assemblies shall be protected on both sides with a protective transparent coating, in order to prevent deterioration or damage due to such causes as moisture and atmospheric contaminants. The coating shall not have any adverse reaction with any other materials or components used on Delhi/NCR environmental condition.

b) All electronic cards used in IEDs, Relays, Breakers, Invertors, Battery Chargers/DCDB, PLC, AVRs and all other electronic cards should confirm to environment factor class minimum 3C2 as per IEC 60721-3-3 for highly Polluted area. All applicable Cards must have conformal coating and must be tested for H2S, So2 and mixed gas tests as per IEC 60068-1 & 2, 60068-2-60 for a minimum duration of 10 days for confirming to the environment class 3C3 as per IEC 60721-3-3. A certificate to this effect shall be submitted before delivery of material. Relays, cards and all equipment must be capable for Very heave pollution level in Delhi NCR as per IEC.

c) All electronic cards, assemblies, sub-assemblies and components thereof used in equipment, relays, IED, PLC etc. Supplied this contract shall be of Industrial grade only as per relevant standards and shall be suitable for the ambient temperature range between -0.6°C to 50°C. All applicable cards must have also tested for Environmental test as per IEC 60571 / EN 50155 and shall be done in accordance to IEC 60068. Details of test are mentioned below:

i. Damp heat run test as per IEC 60068-2-78 standards for class T3.
ii. Low Temperature Test
iii. Change of Temperature Test
iv. Cyclic Humidity Test
v. Driving Rain test
vi. Dust & Sand Test & Mould Growth test
vii. Dry heat run test as per IEC 60068-2-2 standards

d) In addition, the details of configuration in the card, block diagram of the card and waveform signature at the beginning & end of each such block for each electronic card used in the equipment along with documentation each test points for each card shall be submitted by DE-08 contractor.

e) All auxiliary relays/contactors, electronic components shall be of heavy duty/Industrial grade and PCB should have conformal coating suitable for pollution level "Very heavy" for Delhi as per IEC 815-1986 & IS 13134-1992. IEC 61086 : for conformal coating.

f) All the cards of the relay should have conformal coating to avoid the environmental impact to the functioning of the relay.

g) All Electrical Panels shall be completely metal enclosed, suitably IP rated as per relevant application and shall be dust, moisture and vermin proof.

8.6.2.1 Protections - common type for all circuits:

a) Over current Protection

Over current with high set instantaneous tripping module shall operate with selectable characteristic such as definite time or normal inverse, very inverse, extremely inverse and long-time of the four inverse time (IDMT) type characteristics as specified in IEC 255 and BS 142. The current and time setting shall be variable continuously over the range.

b) Busbar Protection

If the detailed system analysis requires provision of busbar differential protection at a substation, the same shall be provided having one zone per busbar section with overlapped protective zones. The details of this protection scheme, wherever applicable, shall be subject to review by the Employer's Representative.

The protection shall include a bus supervisory scheme for alarm monitoring at the OCC. In the event of an operation of the busbar protection, the pertinent fault data shall be displayed at the PCU and at OCC.

The busbar protection scheme shall be such that any secondary component failure shall not cause the operation of the busbar protection.

c) Trip Circuit Supervision (TCS)

Trip circuit supervision protection shall be provided to continuously supervise the integrity of each circuit breaker tripping circuit with the circuit breaker in the open or close position, and shall initiate an alarm in the event of the following fault conditions:

i) Loss of control supply.

ii) An open circuit in trip circuit

iii) A fail-to-trip condition after closing of a trip contact

Such trip circuit supervisory protection signals shall be interfaced with the respective PCUs for the supervisory operations. The alarm shall be time-delayed to prevent it operating during momentary dips in the DC supply voltage, or when the circuit breaker is opening.

d) Hand Reset Lockout Protection

Hand reset lockout protection in each switchgear bay shall be provided to prevent re-closing of breaker following operation of certain protection relay circuits, e.g. differential or pilot wire, earth (ground) fault and line test lock out of CB. Such hand reset lockout protection shall also be interfaced with the PCUs for the necessary functions.

8.6.2.2 Protection:

8.6.2.2.1 To be provided only at the Interlinking feeding posts

No protection shall be provided at the sectioning posts (SP, SSP, SS etc.)

8.6.2.2.2To be provided at interlinking between existing line and new lines wherever 25kV circuit breakers are provided. Salient features are as follows:

25 kV OCS protection the principal and feature of the protection shall be as described below:

a) <u>Minimum impedance protection</u>

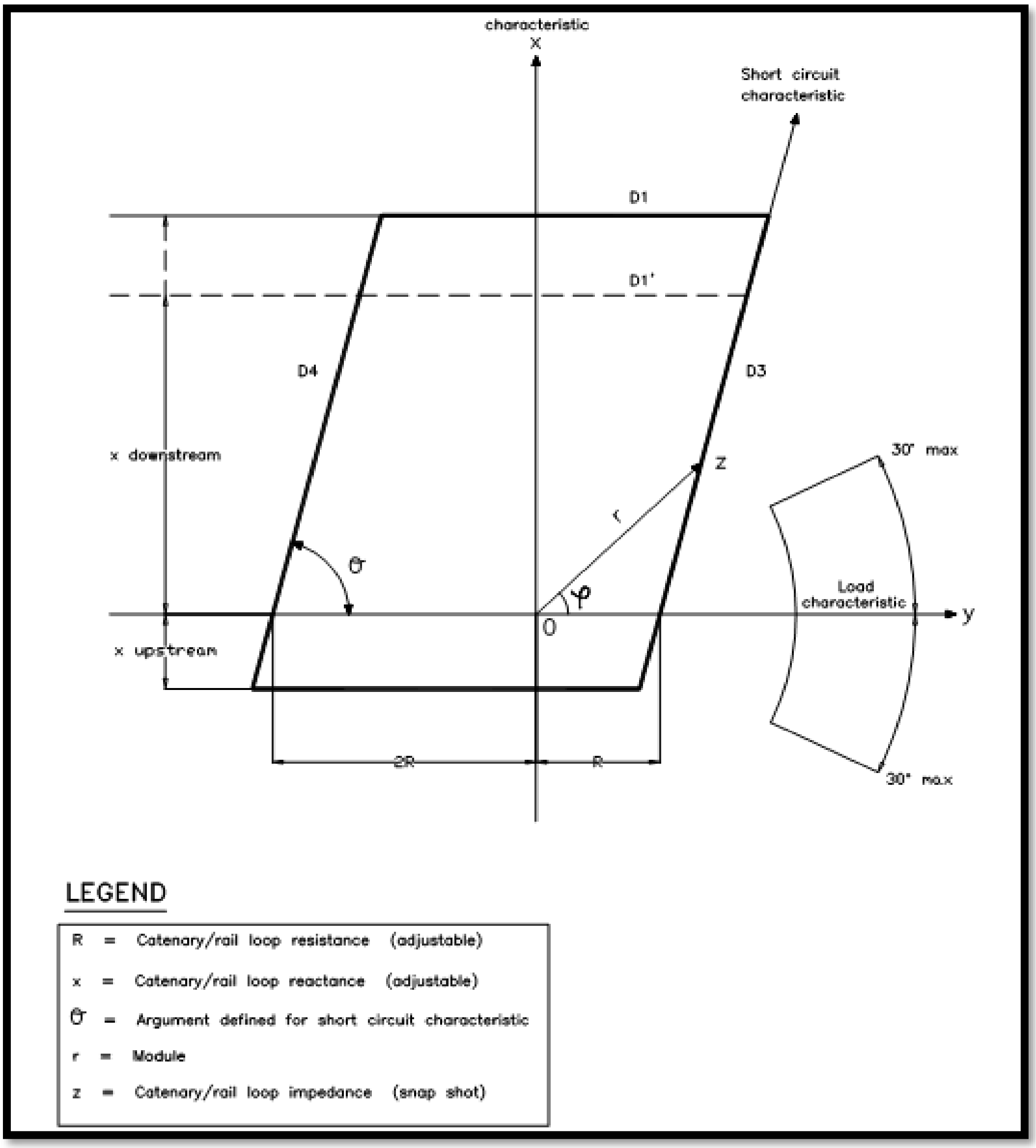
This module is a single-phase impedance measuring (in R-X co-ordinates) relay, which operates when the impedance value falls below a selected adjustment threshold.

The minimum impedance module defines the quadrilateral characteristic by fixing the straight lines D1, D2, D3 and D4.

The possibilities of adjusting the various elements of the parallelogram enable it to be adapted to various network conditions.

This protection is directional and selective; it makes a distinction between a high load and a distant fault of small intensity.

The minimum impedance protection is self-supervised and an internal fault in the protection entails the tripping of the associated circuit-breaker.



b)

Over current protection

An over-current protection is designed to detect faults occurring very close to the feeder station.

This protection causes the tripping of the circuit breaker when the current reaches a value exceeding the highest load on the network.

Two stages of operation are foreseen:

an instant one,

a time-delayed one.

The tripping curves shall be of two types:

constant over time,

if necessary, dependent over time, following an inverse, highly inverse or extremely inverse characteristic.

Selectivity of protections

Selectivity calculation shall be based on the second-stage time-outs of over-current protections.

As a rule, for a 25 kV fault, it shall be admitted that the time-out must be minimum but not nil to avoid tripping on a transient current or a load transfer.

Therefore, HV protections shall be calculated with a longer timing, which remains below the power supplier line protection set values.

c) **Other protections**

These protections shall mainly concerned with the monitoring of the state and operation of:

- SF6 gas pressures of HV and 25 kV circuit breakers if any,
- non availability of auxiliary supply (d.c.).

Two stages are involved:

- the first one is an alarm,
- the second one causes tripping (except for the SF6 gas pressure which entails blocking) of the equipment concerned.

d) **Protection back up**

Protections have a direct action on the tripping gear of circuit breakers for which information must flow to OCC.

In case a protection is inoperative, a tripping order shall be sent to the higher-level circuit breaker via the local supervision after time delay (except for the power supplier HV circuit breakers).

e) **Protection scheme for emergency traction feed from other line – at the interchange stations or at other location as specified shall be possible. The protection scheme shall cover such emergency feed arrangement satisfactorily.**

8.7 **Not Used**

8.8 **Fault-Diagnostic Facilities**

8.8.1 Full built-in tests (BIT) shall be incorporated in PCU system. The BIT shall test all hardware, software and interfaces of the systems. The BIT shall enable the operator/maintenance personnel to carry out trouble-shooting and maintenance of the system effectively.

8.8.2 Critical faults are defined as faults that will cause stoppage or major degradation of system performance. The protection and control system shall be designed to achieve a minimum of 99.99% fault detection capability of all critical faults using BIT. For critical faults not covered by BIT, the Contractor shall provide a list of these faults and explain how they can be readily detected by other means.

8.8.3 The scope of the BIT diagnostics shall include but not limited to the following:

a) Power-up test

This test shall be executed during system start-up. Every part of the system shall be tested to indicate the readiness of the system as a whole. It shall be activated at system cold start or upon operator request.

b) Background test

This BIT shall run continuously with background test during system operation. The purpose of this procedure is to alert the operator if a fault is found. In the running, the BIT shall update the status on the BIT-Page on the display, and it shall be intelligent enough to help the operator to perform off-line BIT effectively. This test shall at least cover line replaceable unit.

c) Off-line test

This BIT shall be activated when in-depth troubleshooting is required to diagnose the failure. This BIT shall be able to locate a faulty shop replaceable unit (SRU) card and allow the maintenance and troubleshooting to be carried out.

8.9 **Testing Facility**

Two notebook computers based on the latest generation hardware using high-speed processor with sufficient memory (SSD type), colour display and licensed software shall be provided with all programme utilities and necessary interconnected cables required for testing, commissioning, simulating, programming and parameterisation of protection control system. The model and make of the computer (i.e. hardware and software) shall be subject to review by the Employer’s Representative. These two notebook computers shall be connected to the PCU interface port to perform the following functions as a minimum:

a) Configuration and parameterisation protection control system

b) Load, read out of configuration data

c) Control, interlocking, inter-tripping logic re-programming

d) Relay simulation test

e) Simulation of the control system

f) Read out and display of protection control system diagnostic messages.

8.10 **Not Used.**

8.11 **Not Used.**

8.12 **AC/DC Control source system.**

8.12.1 **General**

8.12.1.1 110V DC control supply should be taken from the nearest ASS and the loading requirement should be considered in battery and battery charger sizing of corresponding ASS AC/DC distribution boards and all other accessories.

The power supply requirements of complete ASS equipment and sectioning equipment have to be taken while calculating the capacity of common battery bank (for both sectioning post & ASS). If required higher size battery bank may be provided on the basis of additional load of 25 kV sectioning equipment. Additional spare capacity of 10% may be take for all loading while calculating the 110 V power supply requirements.

Cost of additional DC supply requirements for sectioning post equipment is in-built in the tender price no additional shall be paid on the price mentioned in specific item of ASS BOQ.

8.12.1.2 **AC and DC distribution boards**

AC and DC distribution boards and its accessories shall be provided with sufficient spare circuits. The equipment offered shall be in conformity with the relevant Indian Standards. DC supply network shall have DC series MCB.

8.12.2 **Miscellaneous works to be done by Contractor.**

8.12.2.1 Contractor shall be responsible for minor civil engineering works incidental upon breaking and making good on account of installations to be provided.

8.12.2.2 Design and installation of rigid and strong cable trays, cable brackets, hangers, clamps and all fixing in TSS to ensure easy installation, proper laying, each of inspection and replacement of cables.

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 9

Not Used

CONTRACT PACKAGE –

CHAPTER – 10

DESIGN CRITERIA AND
PERFORMANCE SPECIFICATION
RIGID OVERHEAD CONTACT SYSTEM

10. DESIGN CRITERIA AND PERFORMANCE SPECIFICATION-RIGID OVERHEAD CONTACT SYSTEM (ROCS)

10.1 General Requirements

10.1.1 Scope of Work

10.1.1.1 This specification covers complete design, supply, installation, testing and commissioning of 25 kV AC rigid overhead contact system (OCS) including switching stations (SSP, SPS, SS,FP and Interlinking) with associated cabling, earth conductor, return conductors, drilling and fixing of anchor fasteners for OCS supports, earthing and bonding as per EMI/EMC Study in the tunnels and stations on underground section. The transition from rigid overhead conductor system to the flexible overhead catenary system in the ramp portion of the elevated section of main line shall be designed for smooth current collection and to ensure that there is no traction jerk or sparking and undue wear of contact surfaces.

The Traction Power simulation study shall be carried out by the U/G Contractor for complete line, considering already operational sections, depots & RSS's. Main & standby feeding arrangements considering outage scenarios of RSS, case of extended feed, suitability of the feed extension etc are to be covered in the power simulation study. The minimum & maximum power requirements of each RSS during normal loading, extended feed, outage scenario, worst case's etc has to be simulated considering the horizon year as per clause no. 4.16.1 of chapter 4. The minimum & maximum voltages in OCS during normal loading, extended feed, outage scenario, worst case's has to simulated & tested after execution. The maximum fault current in the system shall also be calculated considering all scenarios. Independent agency (shall not per part of contractor in any way) shall be hired for the traction power simulation study. Approval of method statements, software and other requirements has to be taken from Engineer before hiring any agency. The hired shall have experience of conducting these kind of studies for at least 5 years. Details of credentials of agency shall have to be submitted for approval from Engineer.

The necessary interface for carrying out the simulation study shall be in the scope of the contractor.

The study shall be submitted for approval of employer.

10.1.2 **Route Particulars**

The alignment follows cut and cover & Bore tunnel sections. The two tracks are in separate tunnels except at stations.

10.1.3 **Sectioning**

The conceptual schematic electrical sectioning diagram is depicted in schematic power supply diagram given in the volume-5, Tender Drawings. The provision of Neutral Section, Sub Sectioning and Paralleling Posts (SSP), Sectioning and

Paralleling Posts (SP), Sub-Sectioning (SS), isolating arrangement, 25 kV cable connections, and jumpers shall be provided in accordance with the sectioning arrangement.

10.1.3.1 **OCS Sub-Sectioning Arrangement inside the Tunnel**

Inside the tunnel at departure ends of Metro stations, OCS Sub-Sectioning (SS) shall be provided. The OCS Sub-Sectioning arrangement shall be with an insulated Air gap across which a Jumper shall be provided.

At SSP, SP, FP, interlinking and SS circuit breakers/ interrupters (GIS or pole mounted BMs (AIS type), as per specifications) shall be used for sectioning.

10.1.3.2 **Sectioning and Paralleling Posts (SPs).**

The Contractor shall design the Neutral Section of ROCS type. The Contractor shall Interface and Co-ordinate with RS contractor to finalise the location of STOP/START Board at Neutral Section. The Design & layout and feeding arrangement shall be furnished by Contractor for Engineer's approval.

10.1.3.3 Earth mats Design and calculation should be submitted to Employer and Contractor shall interface with E&M, DDC and Civil Contractor.

10.1.3.4 The performance specifications of traction switching equipment 25 kV, viz. load break switches/interrupters and motorised isolators; are given in Chapter 7 of this specification.

10.1.3.5 For locating the sectioning devices, viz. interrupters and isolators in the underground stations, the Contractor shall interface with designated Civil Contractors for necessary room space complete with access for personnel and provision for replacement of equipment.

10.1.3.6 To enable train to stop ahead of the insulated overlaps when power block is taken behind the section, necessary interface shall be ensured with Signalling Contractor.

10.1.3.7 **For safety & protection of structure & equipments, suitable arc catchers shall be provided in the neutral section area. The integration of this system should be done with the earthing & bonding of ROCS**

10.1.4 **Traction Power supply**

10.1.4.1 **Traction Power supply for (Section to be mentioned with details of RSS /ASS /Traction etc. for entire corridors/sections)**

~~The power supply to this corridor will be fed through R K Ashram Marg Feeding Post from R K Ashram Marg Receiving Sub Station (RSS), Madhuban Chowk Feeding Post from Madhuban Chowk RSS and the sector under each sub-station will depend upon the location of the Neutral Section. The power supply available from power utilities at these places will be converted to 33kV for station Auxiliary supply and 25 kV Single Phase for traction supply.~~

~~Also this is an extension of present Line-8 Botanical Garden to Janakpuri West of Phase–III of Delhi MRTS Project, the power supply to this corridor will be fed by extension of power supply through existing section of Phase-III at Janakpuri West from Palam RSS or any other RSS of the line.~~

~~Intake power for this section is also likely to be received at 66kV from Transco grid sub-station at Madhuban Chowk RSS and at 66kV from Transco grid sub-station at R. K. Ashram . The power at 66kV at both the places will be converted to 33kV for station Auxiliary supply and 25 kV single phase for traction supply. These two RSS shall act as standby to each other. The second standby power for Traction and auxiliary supply will be arranged from Palam RSS of existing Line-8 corridor. Also power supply from the existing RSS's of the operating line-8 may be extended to the new sections.~~

~~For emergency extension of power supply between line-1 and line-8 ext. interlinikng of 25 kV is planned in this work, this feed shall be bi-directional and shall be utilised in lines in case of emergency.~~

10.1.4.2 **~~Traction Power supply for Aerocity–Tughlakabad U/G & Elevated section (Standard Gauge – Line-10)~~**

~~The power supply to this corridor will be fed through Vasant Kunj Feeding Post from Vasant Kunj Receiving Sub Station (RSS), Sangam Vihar or Khanpur Feeding Post from Sangam Vihar or Khanpur RSS and The sector under each sub-station will depend upon the location of the Neutral Section. The power supply available from power utilities at these places will be converted to 33kV for station Auxiliary supply and 25 kV Single Phase for traction supply.~~

~~Intake power for this section is also likely to be received at 66kV from Transco grid sub-station at Vasant Kunj RSS and at 66kV from Transco grid sub-station at Sangam Vihar or Khanpur. The power at 66kV at both the places will be converted to 33kV for station Auxiliary supply and 25 kV single phase for traction supply. These two RSS shall act as standby to each other.~~

~~The OCS and the connected feeders & Jumpers shall be designed to carry the full current of peak time traffic of horizon year under normal feed conditions as well as with one OCS sub- sector being out of commission. The current carrying capacity of OCS shall exceed 800 Amps with worn out contact wire.~~

~~In addition to the above-mentioned sources of power, interlinking works have been proposed in various sectors of Line-10 and Line-08 ext. for maintaining the standby supply to one another. The same has been indicated in the sectioning scheme and SLDs attached under tender drawings.~~

10.1.5 Earthing and Bonding

Suitable earthing and bonding arrangement in accordance to EN 50122-1 and CENELEC Standard shall be provided in the underground sections and tunnels for conduction of return current and safety against hazardous touch and step potentials under normal and the fault conditions. For reference, the Indian Railway & DMRC AC Traction Manual may be referred to in addition to the practice of bonding and earthing adopted in Phase III or latest phases of DMRC.

The sizes of Aluminium TEW and Return Conductors are as follows:

TEW-240 sq.mm AAC

RC - 240 sq.mm AAC

These are the minimum sizes which are to be provided by the contractor. If as per simulation study the higher sizes are required then the same shall be accounted in the quoted price. There shall be no variation on account of **higher sizes.** Also as per DMRC Phase-III practice following scheme is adopted:

a) all continuous metallic services (trackside) are bonded with earthing conductors at MET provided at every 250 mtrs approximately and at tunnel cross passages. Earthing & bonding scheme may be developed considering the same.

b) For return current track rails are bonded at with earthing conductors at MET provided at every 500 mtrs approximately through exothermic welding. Interface is to be done with track contractor for the selection of type of exothermic weld. All the details related to the welding system adopted shall be submitted to Engineer In-charge for approval.

c) Earthing & bonding network of both lines are also connected to Earth mats of station at both ends of platform.

d) Earthing conductors of Up & Down line are interconnected at cross passages through a transverse link.

In addition to the above, the earthing scheme shall also include the arrangement taking into account earthing of switching stations alongside the tracks, associated cabling and SVLs.

10.1.6 Interface with other Contractors

For providing rigid OCS, the Contractor shall interface with other Contractors. Any problems for the installation of rigid OCS due to lack of co-ordination with related other Contractor shall be corrected at the Contractor's expenses.

10.2 Definitions

Composite aluminium Rigid Overhead Contact system

The overhead conducting composite aluminium rail with copper contact wire including Earthing conductors, support fittings and insulators for distribution of electric power to the train.

Expansion joint/Overlaps	Mechanical joint for absorbing expansion of rigid contact wire due to temperature changes
Air section/Insulated Overlaps	Electrical sectioning of OCS for separating feeding network.
Anti-Creep Anchor	Anti-creep equipment in the middle of a contact wire length so as to prevent the rigid contact wire from unidirectional creeping.

End approach	The Sloping end portion of Rigid Conductor rail so as to maintain smooth pantograph passage
Jumper wire for rigid conductor system	Jumper conducting annealed copper wire for electrical continuity at expansion joints and crossovers. It also includes flexible insulated conductor from cable termination to rigid rail.
Feeder cables	25 kV Feeding cables from 25 kV switchgear to rigid conductor rail for supplying traction power.
Feeder cables system	Feeder cables, their supports, associated terminals and connectors
Return current circuit	Running track rails and conductors forming part of traction return current circuit.
Supporting fixture	Adjustable supporting fitting for conductor rail so as to maintain the geometry of height and stagger of contact wire with respect to the track.
Support Insulator	Insulator for supporting rigid conductor rail.
Water Proofing Cover	Non-metallic cover for conductor rail to prevent corrosion from leakage water in tunnel.

10.3 Rigid Overhead Contact System

10.3.1 Design Parameters

10.3.1.1 Type of overhead contact system

The Rigid Overhead Contact system shall include 25kV ac overhead rigid conductor rail with contact wire, associated jumpers, support structures and ancillary equipment.

10.3.1.2 Clearances - Minimum Electrical and Mechanical Clearance

The minimum electrical and mechanical clearances shown in Table 10.3.1.2 shall not be infringed under the worst operating conditions of the overhead line equipment, the rolling stock and pantograph.

Table 10.3.1.2 - Minimum Electrical and Mechanical Clearance(mm)

Item	Normal inside Tunnel
25kV Live metal to earth Static Dynamic (passing)	 270 170

25kV Live Metal to Vehicles -Static - Dynamic (passing)	 290 190
Gap at Insulated Overlap or air- gap on rigid OCS between conductors of different electrical sections	400
Gap at Uninsulated Overlap or expansion joint on rigid OCS	200

The minimum clearances inside the tunnel for 25 kV traction are those specified in IEC 60913 with latest amendments.

The values shown in the Table above shall be used as a minimum. In the event of additional space being available, the space shall be used to enhance the electrical clearances above the stated values, before consideration is given to increase the system height.

In case of any deviation due to site condition clearances must comply to latest edition of IEC 60913. Approval of engineer is to be taken in such cases.

The Contractor shall interface with designated civil Contractors to verify bored tunnel, box tunnel and station box cross-sections and also in respect of moving dimensions.

10.3.1.3 Mechanical Clearance

Mechanical clearance to any point from the OCS with power off shall be adequate to provide for manoeuvring of working tools while carrying out maintenance work on the OCS. During detailed designing, the contractor shall ensure that the minimum clearance between pantograph and insulator is ≈100mm.

10.3.1.4 Rolling stock Height

The locked down height of the pantograph is 4048 mm, the minimum OCS height is 4318 mm.

10.3.1.5 Supporting structure

10.3.1.5.1 Safety of supporting structure

Supporting steel structure for overhead contact system shall have a safety factor not less than 3 times yield point strength of steel against dynamic operational loads. Grouting shall be designed with a factor of safety as 4 and shall be load tested individually for all the locations by the contractor.

Detailed static and dynamic load calculation, anchor pull out load etc are to be submitted for approval of employer. Reports of the Pull out tests in the approved format shall be submitted by the contractor after completion of each section/corridor.

10.3.1.5.2 Anchor plug and anchor bolt of supporting fixture.

Anchor bolt shall be installed for the supporting fixtures of rigid conductor rail at intervals finalised on basis of detailed design. The type of bolts shall be mechanical anchor fastener of stainless steel (Grade A4) of adequate design. Nuts & washers shall also be of stainless steel (Grade A4).The supporting fixtures shall have facility of adjustment so as to install the rigid OCS at the designed height with the requisite stagger of the conductor rail. Yielding point strength of the fixtures and fitments shall have adequate factor of safety, considering worst loading/torsion conditions and dynamic loading on account of pantograph thrust and movement. The Contractor shall furnish the supporting design details.

10.3.1.5.3 Supporting steel fixture

The supporting steel fixtures shall be provided at suitable intervals based on design consideration. The interval between successive fixtures shall not permit undue sag and vibrations. The contractor shall furnish the supporting data of similar systems, which may have been provided by him on other metro systems with 25kV ac rigid conductor OCS. The steel work shall be hot dip galvanized in accordance to para 6.9 of chapter 6 and the nuts, bolts and washers shall be stainless steel of Grade A4 for moist and polluted tunnel atmosphere. Only stainless steel split pins of suitable sizes shall be used wherever required. Beta pins not to be used.

10.3.1.5.4 Support Insulator

Type of OCS support insulator to be provided shall be a proven one.

The electrical and mechanical properties of support insulator for the 25 kV ac rigid conductors shall be in accordance with the recommendations of IEC 60383 / 61109. The minimum creepage distance of the insulator shall be 1100 mm, wet power frequency withstand voltage shall be 110 kV and dry lightning impulse withstand voltage shall be 250 kV in accordance with the recommendations of IEC 60913.

The mechanical design should be proven to take the Flexural stress to support the design train headway of 90 seconds.

Supporting insulator fixture shall permit free sliding of Rigid conductor to allow for expansion on account of temperature changes.

10.3.1.5.5 Preventing loosening of nuts and bolts

Adequate measures shall be taken for preventing all bolts and nuts from becoming loose, through use of lock nuts/ spring washers. Only stainless steel split pins of suitable sizes shall be used wherever required.

10.3.1.6 Expansion Joint/ Overlaps

10.3.1.6.1 Typical arrangement and Interval between expansion joints.

Expansion joints shall be provided at suitable intervals but the maximum interval may be allowed up to 500m depending upon the site condition.

Convertible overlaps (i.e. UIOL to IOL or vice versa) are to be implemented on both sides of platform (station box) for flexibility in opening of section for revenue services /Power Block flexibility.

10.3.1.6.2 Parallel contact wires at expansion joint / Overlaps

Parallel contact wires shall be of adequate length to provide for suitable expansion joint/ overlap assembly with provision for adequate number of flexible continuity jumpers.

Separation distance between two OCS sections at expansion joint / overlap shall not be less than 200mm to ensure smooth passage of pantograph. No expansion joint / overlap shall be provided in the station platform area. Suitable gradient will be provided to ensure smooth change over. The expansion joint/ overlap may be erected at site or prefabricated from the manufacturing works.

10.3.1.7 Sectioning equipment

10.3.1.7.1 Air-gap section (Insulated overlap)

The structure of air-gap section shall be same as that of an expansion joint/overlap. At insulated air-gaps, separation distance between two OCS sections at the overlap shall not be less than 400 mm, with two OCS sections aligned such that pantograph passes satisfactorily. No air-gap section shall be provided in the station platform area. Air-gap sections shall be provided at the crossovers to segregate two sections. In case air-gaps are not found practicable, only in exceptional circumstances the section insulators may be permitted.

10.3.1.8 Jumper wire for rigid conductor

Jumper wires for rigid conductor shall be of stranded annealed copper with adequate current carrying capacity. Connection of jumper wire to rigid conductor rail shall be through suitable bimetallic terminals each having at least two fixing bolts. Bolts shall not conduct any current. Jumper wire shall be flexible to allow creeping of rigid conductor. The design shall ensure that the jumper loops remain at least 75 mm above the contact plane.

10.3.1.9 Midpoint Anchors

Anchors shall be provided for prevention of unidirectional creeping of rigid conductor rail.

10.3.1.9.1 Location of anchoring

Anchoring shall be provided in the middle of one conductor run length between two expansion joints.

10.3.1.9.2 Anchoring Insulators and Hardware

The design shall be such that the Insulator and hardware used at anchoring location shall be least affected by passing pantographs. Materials for anchors shall be corrosion resistant such as hot dip galvanized or of stainless steel. Suitable bimetallic fitment shall be integral with the hardware to prevent electrolytic corrosion to aluminium.

10.3.1.10 Rigid conductor rail and contact wire

Conductor rail shall be of Aluminium alloy section with wearing copper contact wire. Chemical composition of the conductor rail may be provided by the contractor at the time of detailed design submission. Sections of transportable lengths will be joined together to form lengths up to 500m between expansion joints. The contractor shall furnish the merits of the conductor rail system offered indicating the life, speed potential of installation, strength and conductivity of joints, maintainability and the supporting details including performance of similar rigid conductor systems if provided by him on any other metros system.

In regard of the wearing copper contact wire size, RDSO specification no. ETI/OHE/76 (6/97) or EN 50149 should be followed (as per approval). Contact Wire shall be Hard Drawn Grooved Round Bottom Copper(Cu-ETP) of 150 sqmm area. Contact wire shall be made from continuous cast copper (CCC) rod. The contact wire should be without any joint.

Since Aluminium Alloy conductor will come directly in contact with the Copper contact wire, contractor will provide the mitigation measures to eliminate bimetallic/galvanic corrosion of conductor rail. In the event of usage of conducting grease to mitigate the galvanic/bimetallic corrosion, following should be minimum requirements of such conductive grease;

a. Minimum life: The minimum life of conducting grease should commensurate with the service life of contact wire and not greasing will be required after installation of contact wire.
b. Electrically conductive: Electrical Conductivity of the joint should be good after application of the grease.
c. High weather resistance: Requisite layer of the conductive layer should be long lasting and withstand minimum temperature of 0 deg C and max temperature of 65 deg C
d. High water resistance: It should retain its layer of requisite thickness for its service life.
e. Environment Friendly: It should be environment friendly.
f. Method statement for application of grease along with quantity required shall have to be prepared and submitted for approval of engineer.
g. During installation greasing work if required shall have to be conducted by the greasing pump. Mechanism required for installation of grease pump along with contact wire insertion tool has to be developed on the rail cum road vehicle for smooth installation of ROCS.

Contractor to note that the conductor rails will be installed in tunnel environment, where humidity may be as high as 100% and water seeping from tunnel may fall directly on the installed conductor rails. It may be considered that water dripping in the tunnels may be acidic or basic in nature. Spare Conductor Rails should have the surface treatment such that the high humidity and/or dripping water do not corrode the conductor rails.

Contractor shall conduct joint survey of the constructed tunnels for locations of the possible seepage/water dripping ~~,~~ and surface treated conductor rails supplied as spare shall be installed at such locations and equal number of conductor rails will be handed over to DMRC as spares.

One month before completion of DLP, a joint survey shall be done by the contractor with DMRC O&M to identify the locations of water seepage/dripping and ~~,~~ Protection covers shall be provided at all such locations. At locations where continuous dripping is noted on the ROCS, suitable measures to divert seepage/dripping water may be provided by the contractor after interface with the civil contractor.

Due to weather conditions of underground tunnels, the Aluminium Conductor rail may face aggravated aging due to moist and damp conditions, there might be water leakage on the Aluminium Conductor rails. As an intrinsic property the Aluminium Conductor rail shall have good clamping force on the contact wire in all weather conditions. The clamping force shall not deteriorate due to environmental condition in the underground tunnels. The clamping force exerted on the contact wire shall be calculated and submitted for review of Engineer as per design of ROCS system.

The Clamping force test shall be included in the acceptance tests. The clamping force of Aluminium Conductor rail shall be checked during installation. Requisite measures to increase the clamping force at water dripping locations shall be taken by the Contractor.

Protection cover: Locations of water dripping may also be identified by the contractor at the time of installation and commissioning of ROCS. Protection covers on the conductor rail at all such locations are to be provided, so that the dripping water does not come in direct contact with the conductor rails. Protective covers should be capable of preventing conductor rail from continuous dripping of water from the soffit of the tunnel. Also, shroud should be provided at the support location (Cantilever) duly protecting ROCS from dripping water. These shrouds should be so designed that they should be able to integrate with protection cover provided at the conductor rail nearby so that there is no chance of water ingress to the rail. Shrouds provided should be rigidly installed so that during train operation these should not disengage due to piston effect of the air in tunnels. The material of protective covers should be Fire Retardant Low Smoke, Zero-Halogen (FRLSOH). The details of the composition of the materials and its properties may be submitted during detailed design stage.

Water tight rail joints: During installation, at the locations identified as prone to water seepage, Sealant or suitable means should be used at the CR joints to avoid any water ingress inside the conductor rail.

Provision of drainage of water: Holes of sufficient sizes at suitable intervals shall be provided at an interval of not more than 5 mtr. Minimum dia. of the drainage hole should not be less than 8 mm.

10.3.1.11 Standard length of conductor rail system

Standard length of conductor rail offered shall not be generally less than 10 metres. However, the length offered shall be supported by the data of various metro systems using similar/same size rigid conductor OCS and the site condition.

10.3.1.12 Protection cover for rigid conductor rail

Protection cover with Warning Boards of material and design to be approved by the Employer for rigid conductor rail shall be provided at station area, below the ventilation ducts and where there is a possibility of maintenance personnel inadvertently coming close to the rail. In case of continuous provision of protection covers, Warning Boards shall be provided/ printed on the protection cover at 5m intervals. The waterproof cover shall be provided on the conductor rail where water leakage will occur in the tunnel. The material should be Fire Retardant Low Smoke, Zero-Halogen (FRLSOH). The details of the composition of the materials and its properties may be submitted in the design.

Contractor may be instructed to provide protection cover at leakage prone areas as per site conditions. However, before handing over the system to DMRC, Identification of leakage area and provision of CR cover shall be done by Contractor through continuous monitoring. Any damage to ROCS shall be repaired at the cost of contractor.

10.3.1.13 Height of rigid conductor rail and contact wire

Minimum Height of the contact wire plane shall not be less than 4318 mm from the safety distance criterion as per EN-50122-1 and keeping safety clearance and electrical clearance as per IEC 60913.

10.3.1.14 Stagger of rigid conductor and contact wire

Stagger of rigid conductor contact wire shall be limited to ± 200 mm, nominal, from rail centre on tangent track and on the curves, however, the value of stagger shall be finalised based on pantograph profile obtained from the rolling stock Contractor. Stagger of rigid conductor and contact wire (200mm) shall be achieved over a suitable length to avoid grooving on the pantograph current collection strips.

10.3.1.15 The design of OCS shall permit a displacement of track by ± 50 mm horizontally without need for changing any component.

10.3.1.16 Permissible gradient of contact wire

Gradient of contact wire shall be not more than 1/1000 on main tracks and not more than 2/1000 on stabling line tracks at terminal stations. Deviation from these limiting values shall only be with specific permission of the Engineer. The junction with level contact surface shall be joined by a transition gradient half that adopted for the main gradient.

10.3.1.17 Cross Over

The separation of contact wire at centre of the turn out shall be not less than 250 mm and not more than 300mm from the track, which it serves at any point after the take off.

10.3.1.18 Transition from Rigid to Flexible Catenary System

The transition from Rigid overhead conductor system in the tunnels to flexible overhead catenary system in the ramp portion shall be so designed that passage of the trains (electrical multiple units) is as smooth as possible without resulting in any pantograph jerk, sparking and wear of components. The X-sectional area of copper (current carrying capacity) to remain the same throughout the installation. The design should be a proven one.

10.3.1.19 Indicators Boards

a) OCS section indicator Boards shall be provided at approach to each electrical section of OCS, which shall be visible to Train Operators (Drivers) from an adequate distance.

b) Number plates shall be provided at support locations, the numbering scheme to be adopted shall be submitted for review of Engineer.

c) Warning indicator Board shall be provided at approach to termination of contact wire.

d) "Warning: 25kV ac" Boards shall be provided at locations and intervals as per rule of opening metro railways and as decided upon by the Employer. These boards shall be prominently displayed at the platform at frequent intervals.

e) Caution boards shall be provided at each Rigid OHE location along with number plate in 25kV Rigid OCS. The caution board should not infringe the electrical clearances of the 25kV traction requirements as per standards. The fixing of caution board on the Rigid OHE location should be marked in detail design & submitted for the review of engineer.

10.3.1.20 Joints, connectors and clamp fittings

Joints, connector and clamp fittings used in ROCS and its earthing system shall be designed to withstand 1.5 times of rated current carrying capacity (nominal & short circuit) of the conductor it is joining. Testing of these fittings should comply IEC 61284:1997. Wedge type PG clamps to be used for earthing& bonding connections.

Contactor may be requested to demonstrate the clamping force of the conductor rail during installation

10.4 Contractor's Design Responsibility

10.4.1 Design Environment

This is furnished in clause 1.12 of GS and clause 4.2 of this Specification.

10.4.2 Traction Power Supply Performance Requirement

These are addressed in clause 4.9 of this Specification.

10.4.3 Detailed Design of the OCS

10.4.3.1 Based on the survey of entire route, the Contractor shall offer the most suitable OCS profile including OCS sectioning and work out in detail the OCS construction plan including return current longitudinal (continuity) and transverse (equalizer) bonding plan.

10.4.3.2 The above application designs shall be based on standard arrangement Design principles and specially for:

a) OCS supports and spans, adequate common parallel run at expansion joint.

b) Arrangement of jumper connections at expansion joints and at feeder connections.

c) As far as possible section insulators shall not be used on the main line. The X-overs, turnout etc shall be designed through over laps. In case if it is inevitable to use section insulator in any section, the approval for the same shall have to be obtained from DMRC.

d) Transition arrangement with flexible OHE to be such that area of X-section remains the same throughout this section.

e) The insulator and OCS fittings must be able to take the fluxul stresses to accommodate train headway of 90 seconds.

10.4.3.3 The components and fittings shall be of type and metallurgy, which are rust and corrosion proof. Steel components shall be hot dip galvanised. Nuts, bolts, spring washers and split pins shall be suitable grade stainless steel preferably A4.

The fittings, jumpers etc shall need minimum maintenance and to the extent possible shall be of 'fit and forget' type.

Insulators suitable for humid and urban polluted atmosphere of Delhi shall be used. The insulator shall be oil resistant and the surface finish should be such that least amount of dust is able to accumulate on the insulator surface.

The design shall be coordinated fully with the requirements of the signalling and train control system, final track work, tunnel work and any specified design requirements that those systems or facilities may dictate for the operation and management of the services.

10.4.4 Submittals

10.4.4.1 Basic Design

Based on the basic designs worked out and route survey, the Contractor shall prepare and submit a detailed OCS final design, together with hardware applications design appropriate for the whole Project. The design of the support and anchor assemblies shall ensure adequate clearance from the pantographs under dynamic conditions.

The submittal shall include a tabulated allocation of all parts for the OCS.

The Contractor shall select a full range of proven OCS components, and shall demonstrate by means of engineering calculations that all elements of the selected system are capable of meeting the Design Criteria, Safety, and Operational requirements as stated in these Specifications. When computer programs are proposed for use, the Contractor shall submit typical hand calculations, together with comparable computer data input and output, for verification of the program, together with a description of the software.

10.4.4.2 Drawings for review

Construction drawings shall be prepared and verified at site. The site verified plans shall be submitted to the Employer for review. These shall include but not be limited to:

a) General Traction Power supply diagram.

b) Schematic sectioning Diagrams.

c) OCS construction Plans.

These shall include chainage of all support anchors and air gaps, height over rail level and other general particulars. On-site verification of the plans shall be carried out and based on final construction plan. OCS layout shall be finalized for construction.

d) OCS layout plan:

Based on the finalised construction plan, OCS layout plan shall be developed and submitted for review by Engineer.

The OCS layout plan incorporating following information shall be submitted:

- The alignment of the conductor.
- Chainage of each support structure location.
- Exact chainage of all expansion joints, anchors and air gaps.
- Direction and value of stagger at each location.
- Clearance of live conductors to fixed structures with respect to reference chainage.
- Alignment and layout of feeders.
- Jumper connections to switches and feeder tails.
- List of infringements, if any.
- Numbering of each support structure with respect to reference chainage
- Location and serial number of isolator switches.
- Final Sectioning diagram drawn to a convenient scale showing identification number of section insulators and elementary sections.
- Transition Element drawing (from Rigid OCS to Flexible OHE).
- General arrangement of OCS at SSP, SP and SS.
- FP/IOLs shall be designed in a location preferably 250m before any signalling post. No curve location in the track alignment should be used for installing IOLs. Layout plan should be prepared as per the track alignment drawings of the line indicating all the chainages, curve, cant etc. All the plans should be submitted to engineer in-charge for approval.

e) OCS profile drawings

In case the height of contact wire is changed, an OCS profile drawing showing the actual height of the contact wire at each location and the gradient adopted until normal height of contact wire is achieved.

f) Return current and Earthing and Bonding plan

Return current circuit Earthing and bonding plan in interface with Track construction Contractor, Signalling and Train Control Contractor.

10.4.4.2.1 **Proceed to construction**

Based on finalized plans field construction work may proceed.

10.5 Construction Requirement

10.5.1 Track route and layout inspection and preparation of installation work

As preparatory work prior to installation, the location and position of supporting fittings, rigid conductor rail and anchoring shall be verified and marked at site. Height of the tunnel from top of rail at various locations shall be confirmed.

10.5.2 Installation of supporting structure

10.5.2.1 Supporting structure

Supporting anchor bolts shall be supplied and installed by the Contractor. The marking of the template shall be done by the contractor as per correct track centre line and tunnel/ rolling stock alignment. The location of the anchor bolt shall be away from the tunnel segment edge minimum (200 mm away from the tunnel segment edge). Mapping of the tunnel segments may be done in order to refrain from damaging the segment bars.

10.5.2.2 Supporting Insulator and accessories

Supporting insulator and accessories for rigid conductor rail shall be mounted on supporting structure to enable adjustment of the conductor to required stagger as per the final design drawings.

10.5.3 Installation of rigid conductor and contact wire.

10.5.3.1 Transporting material

Care shall be taken that no breakage, dent, crack or bending of any component takes place during transportation. Adequate care shall be taken to prevent any damage due to rust by applying rust prevention paint. Painting schedule to be submitted for review by Engineer.

Materials delivered at work site shall be laid up neatly at nominated locations so that interference does not occur from other works going on nearby.

10.5.3.2 Installation of rigid conductor rail and contact wire

During installation of the rigid conductor rails track centre line to be jointly checked with engineers representative's. The correct track centre line making shall be responsibility of the contractor, any deviation noted shall have to be corrected by the contractor. Due to any reason after installation it is noted that the ROCS installation is not as per SOD requirements and the current collection zone of pantograph is deviating from ROCS, all rework/reinstallation of ROCS has to be done by the contractor, no extra payments shall be made on account of rework due to deviation in tract centre line.

Due care shall be taken while handling the rigid conductor rail that no twisting or bending or development of any crack takes place. Temporarily supporting the rail with one end cantilevering should be prohibited.

While installing the rigid conductor rail, safe practices shall be adopted.

The erection of conductor rail shall be commenced from the anchor structure and continued on to the expansion joint.

Before installation of the end approach of expansion joint, adjustment of final length shall be in accordance with the measured temperature in the tunnel.

On curved track, the conductor rail lengths appropriately bent to requisite curvature taking into account track conditions and deviations of contact wire shall be provided.

On turnouts the level of the crossover contact wire shall be raised so that it does not come in contact with train pantographs running on the main track, and for the trains negotiating the turnout, the passage and current collection by pantograph is smooth.

Adequate tensile force shall be maintained in the contact wire.

The contractor shall interface with Tunnel and Station Civil Contractor and shall be responsible for Centre line Marking of Track (even without its laying) on the roof of the tunnel.

The Contractor shall submit the OCS installation plan to Employer for approval.

10.5.3.3 Jointing the rail

If the rail lengths are bolted together, the bolting process shall be of proven design with use of proven components.

10.5.3.4 Earthing Clamps

Earthing clamps for fixing earthing rods shall be provided at sufficient locations e.g. at both ends of platforms in station area, at overlaps in both rail sections, at anti creep anchor.

10.6 **Installation of Feeding System**

10.6.1 Not Used

10.6.2 Return conductor and earth conductors

10.6.2.1 Return Conductor.

Return conductor shall be aluminium conductor conforming to Bureau of Indian Standards, specification IS: 398 (Part I)-Latest Revision.

Conductor of adequate size to be finalized by EMC simulation study.

10.6.2.2 Earth Conductor

Earth conductor (TEW) shall be aluminium conductor conforming to Bureau of Indian Standards, specification IS: 398 (Part I)-Latest Revision. Conductor of adequate size to be finalized by EMC simulation study.

Suitable bimetallic connectors to be provided between any copper and aluminium connection in earthing system

10.6.2.3 Main Earth Terminals (MET) shall be of Aluminium of suitable size (i.e. it should withstand minimum 1.5 times of rated or short circuit current of 25kV system) with minimum 2 spare holes.

10.7 Submittals of Designs and drawings for review

The designs and drawings for the cable runs, connection and jumpering arrangement of the 25 kV feeder cables to the OCS and Earthing and return current conductors shall be submitted to Engineer for review. The drawings shall include but not be limited to the following:

a) General arrangement drawings for each type of joint and connection

b) Individual Site location drawings over the entire route.

c) Bonding and Earthing plans over the entire route.

10.8 Cable Installation Requirements

10.8.1 General

As preparation work prior to cable installation, the location and position of cable supporting fittings shall be ascertained and actually at site in coordination with other civil works so as to avoid any error in installation.

Provision of adequate clearance for running cables across tracks and at location of jumpers to OCS should be ensured through interface with Civil Contractors who may have to provide niches to obtain such extra clearance.

10.8.2 Cable laying

10.8.2.1 Cable protection

At any location where any damage or rubbing to cables or touching with walls is expected, fibre glass or equivalent cable protection cover shall be provided.

10.8.2.2 Bending of cables

Bending of cable shall be executed gradually and bending radius of the cable shall be not less than allowable bending radius of cable. Bending of cables shall not be executed repeatedly. Special precaution shall be taken for bending at cable ends where shrinkable sleeves and petticoats are fitted.

10.9 Final Adjustment and Measurement of OCS

After the equipment has been finally adjusted, the equipment shall be subject to final measurements jointly with the Employer. The checks shall include but not be limited to:

a) Support location member, its height above rails level and stagger, gradients in OCS.

b) Contact wire height at mid span between successive support members.

c) Anchors, expansion joints and air gap separations.

d) Clearance checks to ensure pantograph passing clearances, both electrical and mechanical clearance Pantograph test to ensure smooth shock free passage especially at section insulators at air gaps, at turnouts, crossovers and change of height of the contact system.

e) Fittings or jumpers and cable connection to

- Overhead conductor rail
- Return current circuit connected to running rails

10.10 Site Testing and Inspection

In accordance with Chapter 14 of this Specification and the GS a detailed protocol for inspection and testing of complete OCS shall be prepared and the tests and complete methodology for testing shall be submitted for review by the Engineer.

10.10.1 Installation checks and tests

a) Visual inspection of overhead contact system installation, check of components; electrical and mechanical clearances, air gaps and general alignment.

b) Anchor Pullout test

c) Checking of the electrical clearances (SED) of the erected OCS

d) Continuity test of each joint in traction and return current circuit.

e) Insulation resistance of 25 kV ac overhead contact system shall be as per international standards.

f) Physical examination of rail bonds.

g) Checking of construction gauge

h) Return current continuity test, testing of joints.

i) Earth resistance test.

10.10.2 Partial Acceptance Tests

10.10.2.1 Tests

After physical verification and measurements, tests as indicated below but not limited to these, shall be carried out.

10.10.2.1.1 Anchor Pullout test

Anchor pullout test to be conducted by the contractor on the grouted anchor bolts and foundation bolts (if done by grouting metho). Anchor pullout test reports have to be submitted to Engineer after completion of the tunnel section grouting.

10.10.2.1.2 Checking of the Electrical clearances of erected OCS

All the OCS locations shall be checked as per DMRC ACTM and *Table 10.3.1.2.* The format of the schedule of electrical dimensions (SED) and Schedule of Dimensions (SOD) has to be prepared by the contractor. Approved format shall be used for joint checking of the clearances with O&M. All arrangements required for the measurement have to be done by the contractor.

Any locations noted with below minimum value of clearances shall have to be attended by the contractor.

The infringements if noted shall have to be rectified by the contractor. All clearances have to be maintained as per IEC-60913, SOD and DMRC ACTM (latest amendments)

10.10.2.1.3 Circuit continuity, loop resistance test

The purpose of this test is to obtain the OCS section. These test checks both the OCS and the rail return system for electrical continuity. The test entails short-circuiting a discrete section of the OCS by connecting the OCS to the rails at one end and applying a variable ac voltage at the other end. The length of section under test should be approximately 1.0 - 2.0 km (i.e. in the station to station zones). An ac source with variac to provide requisite testing current.

10.10.2.1.4 Measurement of Insulation resistance.

Meggering of OCS sections at 5 kV and record results in accordance to DMRC ACTM

10.10.2.1.5 The Contractor shall be responsible for all adjustments required as a result of these tests.

10.10.3 System Acceptance Tests

Energisation, short circuit test, local testing of sectioning post equipment (SCADA) shall be part of system acceptance test.

10.10.3.1 Energisation:

For energisation procedure DMRC ACTM shall be followed. Energisation shall be done with meggering and continuity test conducted on the OCS.

Successive Energisation

Each electrical section shall be energised successively at 25kV AC from for one minute with adjacent sections isolated and connected to traction earth. Finally, entire section shall be energized for at least 24 hrs.

10.10.3.1.1 Short circuit tests shall be carried out as per a detailed test protocol, which shall be submitted for review by Engineer.

10.10.3.1.1 Pantograph tests (current collection test) will be performed using a self-powered transit vehicle in order to identify any locations where arcing may occur. Arcing locations identified during test must be attended.

10.10.4 Integrated Testing and Commissioning

10.10.4.1 All the items of supply and required for completion of the work in all respects, testing and commissioning of the overhead equipment system as well as associated work for facilitating trial run of the rolling stock and Integrated Testing and Commissioning shall form part of the work covered by the contract whether specifically stated or not.

During train trial contractor shall be responsible for providing and fixing discharge rods during power block permission/Cancellation before ROD.

10.10.4.2 High speed tests shall be carried out by means of running the trains initially at slow speed, then increasing the speed in stages up to full speed permitted for the section. On successful completion of the high speed tests, the OCS shall be declared fit for pre-revenue system tests. Arcing locations identified during test must be attended and test has to be repeated.

10.10.4.3 The Contractor shall be required to operate and maintain the OCS until Taking Over by the Employer.

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 11

SCADA (The Detailed Specifications along with terms and conditions of SCADA are mentioned in the chapter-12 of FOCS. The same can be made a part of the contract if SCADA is in the scope of this contract.). The signal lists may be modified as per requirements.

11. SCADA Signal List:

SCADA testing has to be done by the contractor as per the plan approved. Manpower for local, remote testing has to be approved by the contractor. Joint testing schedule with SCADA contractor, DMRC O&M and other members have to be prepared and submitted for approval. The interface requirements are given in the Appendix-C attached with the tender documents. The list of input/output signals is provided in Appendix-K of this tender documents. The list is minimum value of signals to be jointly checked, detailed signal list as per OEM and equipment specifications have to be prepared during execution of the work. The contract shall be considered not closed until the SCADA signals are jointly checked as requirements of DMRC operation and maintenance teams.

Please refer Appendix-K for Input/ Output signal of equipment.

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 12

RETRACTABLE CATENARY(MOCS) (Only if MOCS is the part of the contract, otherwise the chapter may be deleted)

12 RETRACTABLE CATENARY- (MOVEABLE OVERHEAD CONDUCTOR SYSTEM-MOCS)

12.1 Description

12.1.1 The retractable catenary system will be used in the inspection Bay Track of depots included in this project.

12.1.2 Rigid Catenary will be hung to several swivelling jib arms, motorized or not. The union of rigid catenary and jib arms is named "retractable rigid catenary" or movable overhead conductor system (MOCS)

12.1.3 To ease the rolling stock roofing maintenance operation. The retractable rigid catenary will enable:

- In normal position: The arrival and departure of trains by electrical traction inside the building. The train electric motors testing, pantograph testing and other operation requiring overhead contact line.
- In "Retracted" position: The possibility of intervention over the trains at all points, by means of roof working platforms, lifting platforms or baskets, or gantry crane on the total length of the workshops.

12.1.4 The folding of the rigid catenary is achieved with the simultaneous motorization according to the horizontal plan of all jib arms. The swivelling action to retract the catenary is only possible when all safety conditions are made:

- Power supply of the catenary
- Footbridges accesses
- Gantry crane position
- Lifting jacks

12.1.5 It is required than these elements be interlocked in order to avoid accidents.

12.1.6 In the swivelling movement, the rigid catenary will be always parallel to the track axis, and it will move transversally from the track centre to the retracted position.

12.1.7 Assembly

12.1.8 Before and after of the retractable catenary section, will be installed a section of fixed rigid catenary in order to ensure a perfect transition between conventional catenary, with mechanical stress and retractable catenary, without it.

12.1.9 To do this transition it is needed to use at least:

One transition element which allows the smooth adaptation between conventional and rigid catenary.

One ramp of rigid catenary to make the transition between fixed and retractable rigid catenary.

One anchor for the set, in order to maintain mechanical tension of the conventional contact wire.

12.1.10 The transition element must be covered with a PVC cover to avoid the entrance of water inside of aluminium profile.

12.1.11 The transition between fixed rigid catenary and retractable catenary is made by means two ramps. The overlap between two sections of rigid catenaries will have at least 1.2 m of length. The maximum length of the inclined section of the ramps must be of 400mm. the length of retractable catenary from the last swivelling support must be lower than 2.5m.

12.1.12 Distance between supports will vary from 8 to 12 m according to maintenance workshops architecture. Supports must allow the double turn with respect to their axis in order to avoid that they bear the minimum stress caused by the length of the rigid catenary profiles. The fixation of the suspension bridles must allow the adjustment of the transition ramps between fixed and retractable catenary.

12.1.13 The installed structure shall be as per the approved drawings and the contact wire height is maintained at 5200mm based on the DMRC SOD for depots.

Since the flexible OHE is installed outside the Inspection Bays, for maintaining smooth pantograph movement from Transition from Flexible-OHE to MOCS or as required to be provided.

12.1.14 Interlocking

The contractor shall propose and submit the interlocking philosophy of MOCS for review by Engineer. The castle key based interlocking shall be provided in Interlocking System

In order to ensure the safety of the system and working personal in the Inspection Bay, following interlocking arrangement shall be provided –

- Interlock between OHE and MOCS Operation
- Interlock between MOCS Operation and Platform Access
- Interlock between MOCS Operation and Crane Movement

The contractor has to state each IBL line at every type for providing the Interlocking scheme as below:-

i. Interlock between OHE and MOCS Operation
ii. MOCS Operation for taking access to maintenance platform and Crane**.**
    (a) Access to only maintenance platform without retracting MOCS
    (b) Access to maintenance platform and Crane after retracting of MOCS
iii. Interlock between MOCS Operation and Platform Access
iv. Interlock between MOCS Operation and Crane Movement
v. MOCS Operation for returning access to maintenance platform and Crane**.**
    (a) Access has been taken for only maintenance platform without retracting MOCS
    (b) Access to maintenance platform and Crane after retracting of MOCS.

Any other interlocking required as per requirement during execution

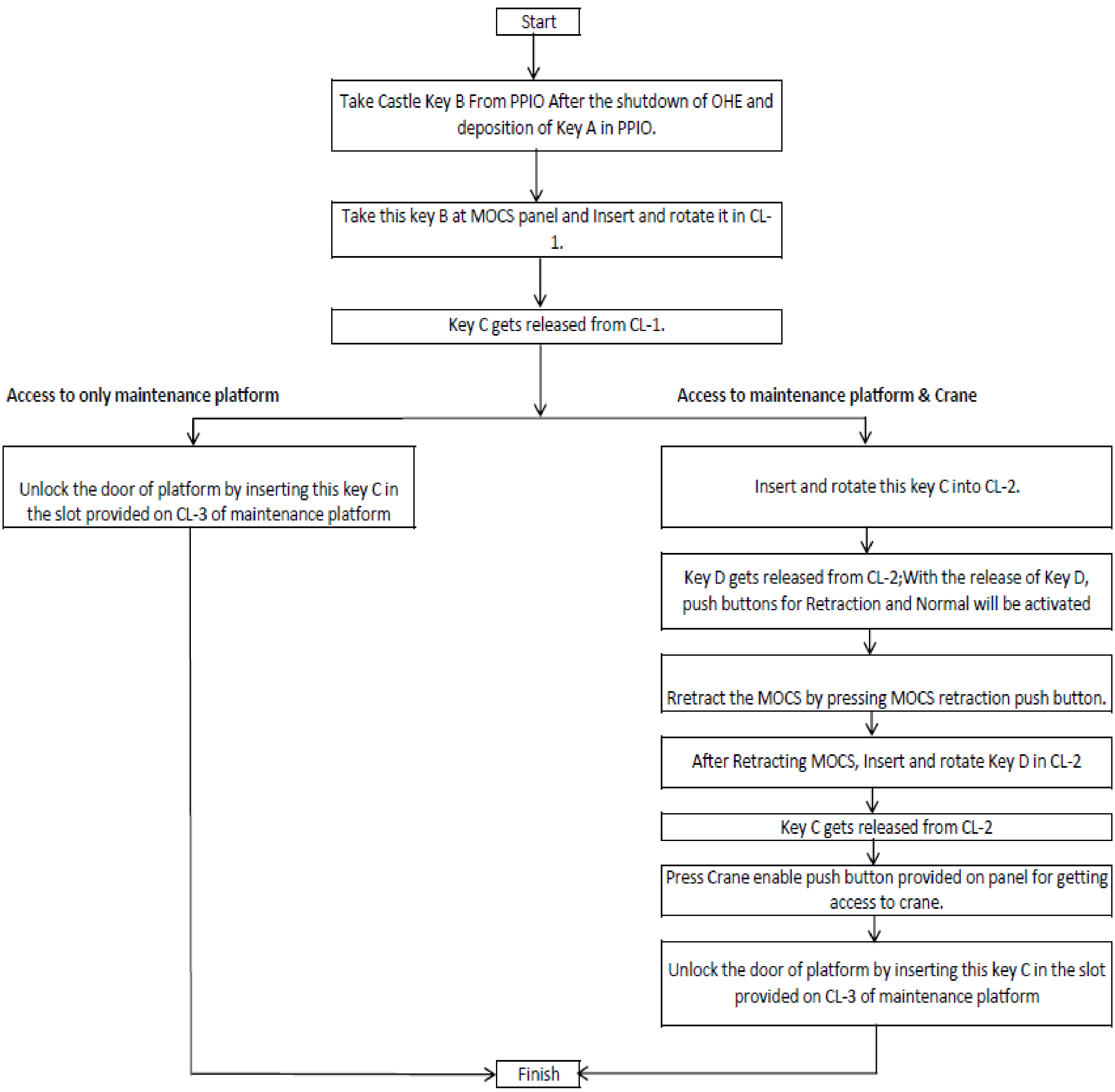
Annexure-A

Flow chart for interlocking as mentioned below

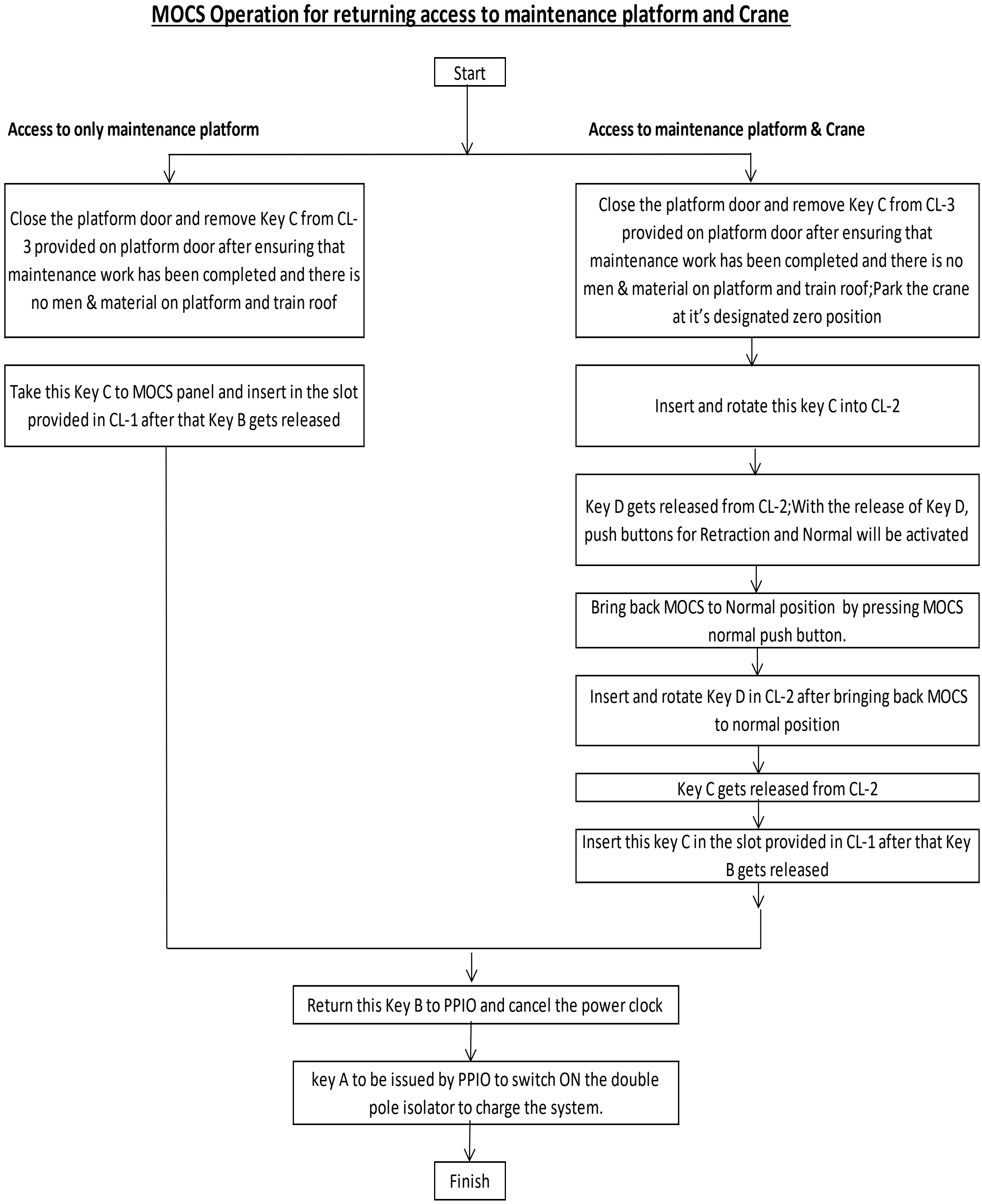
Operation Sequence

Retraction

MOCS Operation for taking access to maintenance platform and Crane



Back to Normal Position



1) Details of Castle Lock to be provided on Platform Access Door-

-As shown in the below drawings of castle lock, it has the arrangement of primary lock and secondary lock.

-Single key has been provided in primary lock and four nos. keys have been provided in secondary lock.

- Keys provided in the primary lock are taken out only when all the keys of secondary lock are inserted in secondary lock.

-For example, if any of the S1 key of secondary lock is not inserted in the castle lock, removal of key B1 of primary lock is not possible.

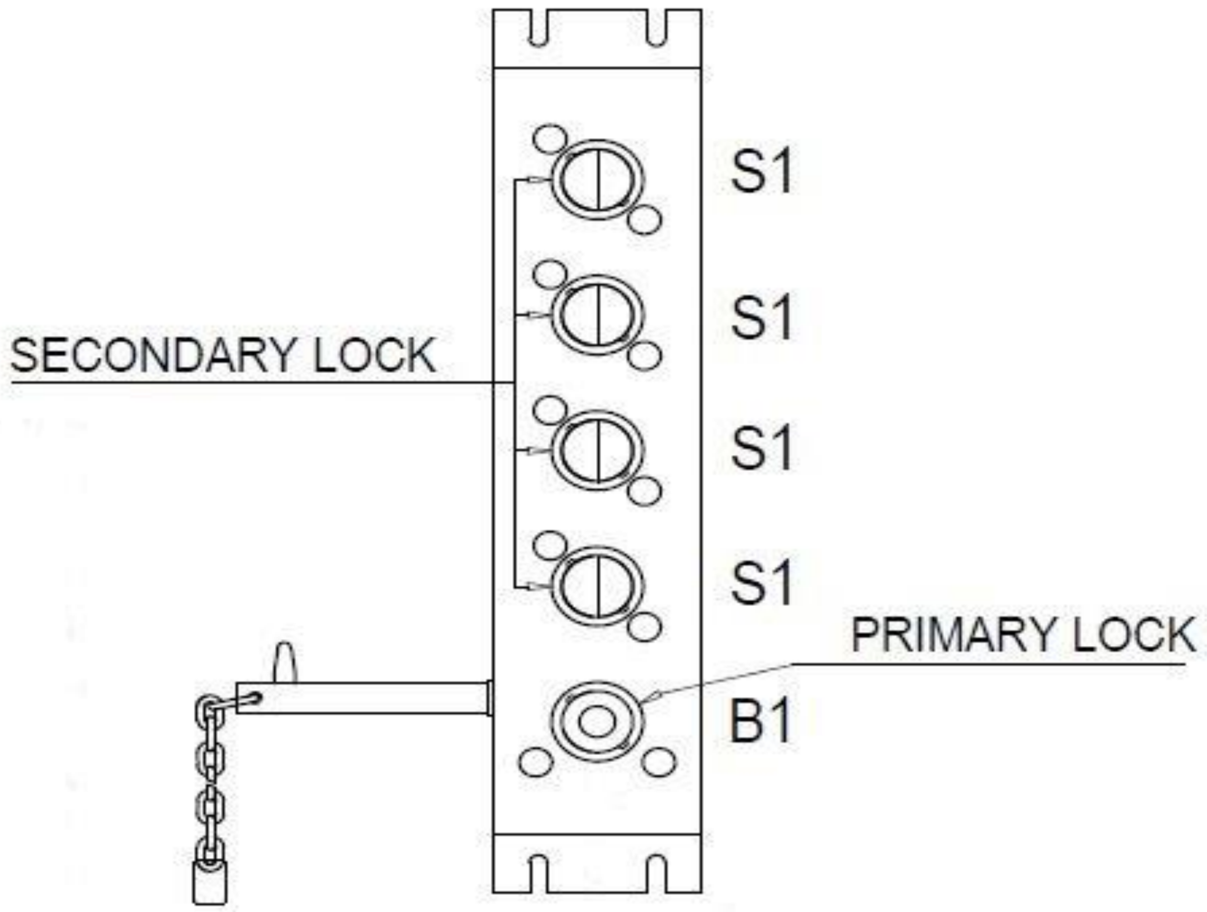


Image: Platform access door castle lock

(Image shown above is only representational purpose only; Key numbering may change as per site suitability.)

vi. Salient Features

Salient feature as described above shall be similar to all the depots. The schemes to be provided for each depot after setting the locking of the OHE, PPIO, Isolator crane Panel Platform door access and other safety features. ~~Petlon make or any other equivalent~~ castle keys are required to be provided for the OHE interlocking with MOCS. Multiple slot castle keys shall be provided at different location for installation, method and safe operation of retractable OHE during charging and discharging of MOCS castle keys of Mechanical/Electrical type with electrical tripping in the power supply and control panel needs to be provided.

Indication lights of the states of retractable catenary charge /discharge has to be provided at each and every IBL. The indication lights shall be weather proof outdoor type LED which shall give the indication as per operation of MOCS. Scheme for the same has to be provided by the contractor for approval of Engineer in-charge.

12.1.15 Salient Features

- Every step shall be double interlocked to ensure safety.
- At a time, only one castle key will be available with the person taking power block to avoid any problem.
- All operations clearly indicated on panel by glow lights.
- Complete sequence can also be seen on HMI provided.
- Separate interlock Operating Sets for each IBL to avoid any confusion.
- Special earthing arrangement is to be provided so that the MOCS is earthed as soon as it is retracted.
- Contractor will submit mechanical interlocking scheme for approval of Engineer.

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 13

PHYSICAL INTERFACE

13 PHYSICAL INTERFACE

13.1 GENERAL

13.1.1 The Contractor shall interface with relevant authorities and other contractors to ensure the effective and compatible coordination of all aspects of design, installation, testing and commissioning of Works.

13.2 CONTRACTOR'S RESPONSIBILITY

13.2.1 The Contractor shall ensure that all the interface items as listed in, but not limited to, clause 13.3 of this Specification shall be included in the Interface Management Plan.

13.2.2 Other items not mentioned in the interface items but are relevant to the design, installation, testing and commissioning of the Permanent Works, shall also be included in the Interface Management Plan.

13.3 PHYSICAL INTERFACE DETAILS

Contractor has to deploy experienced manpower for interface with the stakeholders. For reviewing the project progress, regular interface meetings shall be done by the co-ordinating department, contractor representative have to attend all such meetings and submit the weekly report to Engineer for his review.

Common interface programme shall be developed by the civil/SBC contractor regarding access and shared working. Details of working schedule/work programme along with the mobilisation schedule have to be shared by the contractor to civil/SBC for preparation of common interface programme.

The list of relevant contractors/ DDC's is as under:

1) Civil Contractor
2) S&T Contractor
3) SCADA & Elevated line Traction Contractor
4) Track Contractor
5) Rolling Stock Contractor
6) E&M
7) VAC
8) RSS contractor
9) PSD Contractor
10) O&M
11) DDCs
12) Any other contractor for associated work.

For detailed interface requirements with above contractors, please refer Appendix-C.

13.4 INTERFACE DETAILS FOR REPORTING

The Contractor shall have to report the interface with relevant contractors/ DDC's and other agencies all aspects of design, installation, testing and commissioning of Works on online portal designated for the same by Employer. Project monitoring is planned via web based system on which day to day reporting related to site progress, difficulties in access, issues related to safety, work programme and other activities are required has to reported, updated by the contractor authorized personals.

DMRC is utilizing STAMP for project monitoring contractor has to report all the updates on same and interface and follow up on online portal.

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 14

TESTING, COMMISSIONING AND VERIFICATION

14. TESTING, COMMISSIONING AND VERIFICATION

14.1 General

14.1.1 Tests shall be performed in accordance with Chapter 9 of GS. The list of checks for various equipment is given under chapter-7B of PS in addition to the forthcoming clauses.

14.1.2 For Validation of design of 25KV Rigid OCS, Contractor shall arrange auditing of design of 25kV ROCS, as per IEC and other relevant Standards from reputed Independent Agency (Auditor), who have already undertaken the similar job in past for other Metro system. The auditor shall submit separate reports for validation of design, drawings and installation of ROCS.

Two stage reports should be submitted, one for design validation & auditing, other for installation validation, auditing after installation of ROCS. Final validation report should cover installation & design of 25kV ROCS, the reports should clearly certify that design/installation has been done according to applicable standards and international safe practices.

The contractor/consortium partner or his designer shall not be the part of Validation (Auditing) Agency.

14.1.3 The Contractor shall develop a full test plan and submit for review by Engineer. The tests mentioned herein are indicative and minimum requirement.

14.1.4 Test Certificates

Three sets of all principal test records and test certificates duly endorsed by the Contractor's Professional Engineer are to be submitted for the review by the Engineer in accordance with the specifications of this contract. These test records and certificates shall be supplied for all tests, whether or not the Engineer has witnessed them. The information given on such test certificates shall be sufficient to identify the materials or equipment to which the certificate refers.

Test reports of ROCS material & Accessories shall be provided by the contractor at the time of Design approval stage as per Annexure-1.

14.1.5 Factory Acceptance Tests

14.1.5.1 FAT shall comprise Type Tests, Sample Tests, Routine Tests, Life, Endurance and Destruction Tests and any additional tests required by the Engineer. FAT plan as per GS should be submitted for approval for engineer.

14.1.5.2 The testing shall be conducted such as to simulate the working conditions as closely as possible.

14.1.5.3 Upon the request of the Engineer, type tests, life, Endurance and destruction tests shall be carried on components and assemblies to verify the design loading.

14.1.5.4 All the tests shall be conducted both on the assembly and on the members/ components of each product in accordance with design specifications and applicable Standards.

14.1.5.5 Contractor shall certify the matching of all components of ROCS.

14.1.6 Type test

The contractor shall submit the type test certificates of the material, equipment's, Items, sub- items and all assemblies as proposed for the works as per the vendor approval policy and GS.

For items that are similar to items mentioned in Guidelines for the validity period of type test(s) conducted on major electrical equipment in power transmission issued by Central Electricity Authority-CEA. Type test validity shall be as per clause 2.0 of Guidelines issued by Central Electricity Authority-CEA. For other items validity of type test shall be as GS clause 3.5.1.8

14.1.7 Third Party Testing

Third Party type testing of the materials and components including all type of cables may be conducted under the contract. Random samples of the material shall be taken in the instructions of Engineer in charge. Their samples shall be tested as per the relevant applicable standards mentioned in the contract. Contractor shall facilitate in the collection of the samples and transportation to & from the testing laboratory identified by the engineer in charge. All the costs related to this shall be borne by the contractor. For Third party testing during the course of the contract as applicable for the testing of material at the laboratory anywhere in India shall be paid by the employer. Contractor has to ensure according to the contract specifications. Type, Routine, Sample testing shall be performed as per the contract specification and mentioned standard.

During Third party testing, if a sample fails then the samples shall be collected from the same lot / material and shall be tested for the complete tests (as per the earlier failed sample) Second sample shall be tested in the laboratory other than the laboratory tested for the first sample.

Second sample if passed the complete testing material shall be put in services at the project. If 2nd sample fails again all the material shall be replaced by the contractor and the delay if any for procurement of the material due to fail shall be considered as non-conformance and applicable penalty may be imposed on the contractor cost of testing the 2nd samples shall be borne by the contractor.

Please refer 3rd Party Testing Policy no DMRC/DE/Instruction/87

14.2 Contractors Responsibilities for On-site Testing

14.2.1 The Contractor shall be responsible to carry out all tests as required by the Engineer. During the course of erection, the Engineer shall have full access for inspecting the progress of work and checking the accuracy as may be required. On completion of erection and prior to commissioning, all equipment shall be tested to the acceptance by the Engineer in accordance with an agreed Inspection and test plan to demonstrate that it is entirely suitable for commercial operation. Any special/additional tests as directed by engineer shall be done by the contractor.

14.2.2 Contractor shall arrange temporary power supply (DG set) in addition to general lighting during drilling, anchoring, fixing of Brackets). Permanent lighting in the tunnel & station will be provided by E&M contractor or other.

The Contractor shall be responsible for providing temporary electricity supply, all instruments, gauges, test equipment, tools, accessories, personnel, services and any other facilities required for the execution of all tests and inspection. Wherever necessary, the Contractor shall provide two or more sets of testing equipment, tools, etc. to expedite testing. All test equipment shall be accompanied with the appropriate calibration certificate from an approved testing authority before submission to the Engineer. Tests shall not proceed until no objection is received from Engineer.

14.2.3 Test equipment, tools, etc. necessary for subsequent preventive and corrective maintenance are to be provided to the Engineer as specified herein and shall be available to assist the tests. The use of these test equipment, tools etc shall be subject to review by the Engineer.

14.2.4 The Contractor shall also employ a qualified and competent Professional Engineer (P.E) for the supervision of the entire work covered by this contract and the appointed professional engineer shall be fully responsible for the proper installation, testing and commissioning of all the equipment. The appointed P.E. shall produce all certificates of supervision of work for all works covered under this contract. Contractor's Design team shall supervise the installation of ROCS and certify that installation is as per approved design.

14.2.5 Energisation shall be carried out in stages, and shall include, traction sectioning and paralleling posts, and OCS on the mainline. Energisation of the OCS shall be carried out progressively in stages. For the energisation of certain OCS sections, turn-on of power may require putting up of temporary works e.g. cable diversion, additional earthing provision, etc. to ensure the safety of workers working in the adjacent non-energised area. Such work inclusive of sectional testing of traction power shall be deemed to be included in the contract.

14.2.6 The Contractor shall be responsible for surveillance and security of the power supply systems including padlocking or otherwise maintaining control of the substation, padlocking of Switchgear and circuit breaker units, distribution switchboards, power panels, etc. throughout all energisation stages of the installation. The Contractor shall interface with the other Contractors to assure no downstream cables or other electrical equipment is energised before it has been tested and before other involved Contractors facilities are ready and secured. The Contractor's responsibility for surveillance and security of the system shall remain in force for each part of the system until such a time that the Employer takes over the System.

14.3 **Re-Testing**

14.3.1 When defects are detected in the equipment accessories, etc during the commissioning tests, the Contractor shall ensure that adequate spares are kept on site. The Contractor shall, on receipt of no objection from the Engineer make use of spares intended for preventive and corrective maintenance to rectify defects detected during the tests. No objection will generally be given to make use of the spares provided the Contractor undertakes to replenish the spares at the earliest possible date. The Contractor shall submit details of all tests prior to testing and all tests shall be carried out in the presence of the Engineer and to his complete satisfaction.

14.3.2 Should the plant or any portion thereof fail to give the performance required, then any further tests that may be considered necessary by the Engineer shall be carried out in a similar manner by the Contractor.

14.3.3 If any item fails to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site, the Engineer may reject the item or defective component thereof, whichever is considered necessary and after adjustment or modification as directed by the Engineer, the Contractor is to submit the item for further inspection and/or test. In the event of the defect on any item being of such a nature that the requirements of this Specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Contractor at his own expense, for the acceptance by the Engineer.

14.4 **Installation Tests**

14.4.1 Installation Tests

14.4.1.1 An inspection and visual verification of ratings and connections of equipment, instrument transformers and auxiliary circuits, installation tests shall be carried out.

14.4.1.2 After installation of equipment, visual inspection and operational tests on un-energized equipment shall be carried out to check the following:

a) Cleanliness;

b) Workmanship;

c) Confirmation of items conforming to ratings specified;

d) Water and dust proofing;

e) Levelling, mounting and positioning;

f) Joints and connections tightness;

g) Cables – dressing, bending radii, jointing and finish at terminals;

h) Clearances and dimensions in conformity with drawings;

i) Earthing, bonding, and continuous earth conductors

j) Functioning of, interrupters, isolating and earthing switches and their interlocks;

14.4.1.3 Earth resistance measurements – individually and of the subsystem and system as required.

14.4.1.4 Measurement of Insulation Resistance

The insulation resistance of 25 kV cables shall be tested in accordance with manufacturer's instructions. All LV circuits and traction return cables shall be tested with a 500 V insulation tester. All sections of OCS shall be tested using a 5 kV insulation tester and record results in accordance to DMRC ACTM.

Testing may done multiple times in different section before or after energisation of the ROCS. The contractor has to arrange the equipment manpower for testing as per requirements

14.4.1.5 Continuity Test and Contact Resistance: - Continuity of all circuits shall be verified. Contact resistance of all high current joints and bolted contacts, shall be measured with a Ductor set. Earth system joints shall also be measured.

14.4.1.6 Testing of GIS equipment as per relevant IEC:

- Gas Leakage Test
- Contact resistance Test
- Mechanical & Electrical Operational Test
- High Pot Test of Bus Bar Chamber
- A vertical & horizontal alignment

14.4.1.6.1 Secondary and primary injection tests

Tests shall be carried out at a minimum of three settings if multiple settings are available. Test results of operation boundaries and operating times shall be recorded.

14.4.1.7 Not Used

14.4.1.8 Control, Indication and Alarm Functions

Insulation resistance and continuity of all cores of cables shall be identified and tested.

The correct functioning of all control, indication and alarm devices shall be verified.

14.4.1.9 Switchgear

14.4.1.9.1 All switchgear, including circuit breakers, interrupters isolating and earthing switches, shall be operated to prove that the operating gear, tripping devices, protective gear and mechanical interlocking are satisfactory.

14.4.1.9.2 SF6 gas leakage test shall be performed where applicable.

14.5 Partial Acceptance Tests

14.5.1 These tests form part of on-site and System Acceptance Tests as part testing of the equipment and system. The partial acceptance tests for ROCS shall be carried out as per clause 10.10.2 of this specifications which includes but limited to following tests:

- Circuit continuity, loop resistance test
- Measurement of Insulation resistance.
- Pantograph tests

14.5.1.1 Functional Tests and Interlock Tests

All control and protection functions and electrical/mechanical interlocks shall be tested.

14.5.1.2 Primary Injection Tests

The Contractor shall carry out primary injection tests on each protective system, to prove the auxiliary circuit connections, the relay fault setting values, the correct metering indications and the stability limits.

14.5.1.3 AC/DC Pressure Tests

14.5.1.3.1 The insulation resistance of all circuits shall be measured before and after the dc pressure test using a 5kV insulation tester. The minimum phase-to-phase and phase-to-earth insulation resistance shall be 100 mega ohms.

Pressure tests shall be carried out on completed cable lengths of high voltage cables in accordance with IEC 60502.

14.6 System Acceptance Tests

14.6.1 Energisation

14.6.1.1 For energisation procedure DMRC ACTM shall be followed.

14.6.1.2 The Contractor shall prepare operation safety rules and procedures for the review of the Engineer before Energisation. Energisation procedures shall be in accordance to DMRC ACTM.

14.6.1.3 The Contractor shall carry out all necessary checks to ensure safe Energisation.

14.6.1.4 All power equipment shall be subject to inspection by inspectors from the Electrical Inspectorate of Employer before Energisation. The Contractor shall ensure all Employer's requirements are met.

14.6.1.5 Contractor shall be responsible for reliable operation of Traction Power equipment. As per requirement of Employer Contractor shall disconnect and subsequent reconnect the jumper of OCS or operate Circuit Breaker/Interrupter.

14.6.2 **Tests**

SAT shall include but not be limited to: -

14.6.2.1 Short Circuit Tests on OCS

14.6.2.2 Short Circuit Tests on the 25 kV OCS shall be carried out to prove correct operation of protection equipment and to ensure that the dynamic strength requirements of overhead equipment are met.

14.6.2.3 Short circuit tests may be conducted multiple times in same or different sections to check the correctness of the installation and as per operational requirements. Contractor has to depute the required manpower during the short circuit test and comply applicable safety procedures. Engineer can instruct to carry out short circuit test in already charged installations and new installations simultaneously. The contractor shall be require to provide the manpower for the same and conduct short circuit test as per instructions.

14.6.2.4 Short Circuit Tests shall be carried out on every overhead equipment line feeder.

14.7 **Integrated Testing and Commissioning**

14.7.1 Integrated Testing and Commissioning refers to those tests undertaken in order to demonstrate that the various components of the MRTS operate satisfactorily between one another and meet all specified requirements for design, operability, safety, and integration with other works and systems. These tests shall be entirely within the requirements of one or more of the project contracts or they shall involve a multiplicity of contract procedure.

14.7.2 Those systems that can be tested without depending on the running of trains, will have their integration tests scheduled to commence as early as possible. It is preferable that any interface problems associated with these "trainless" system tests be identified and resolved prior to the commencement of test running.

14.7.3 The following is an indicative listing of those Integrated Testing and Commissioning functions that necessarily be integrated with others to demonstrate that the equipment and controls installed therein meet the Contract Specifications and demonstrate a safe-to-operate condition. This listing is not exhaustive and shall be updated by the appropriate contractor, or by the Engineer, to demonstrate functionality, completeness and safety of the installed works.

a) Power system functional tests.

b) EMI/EMC tests.

c) Short circuit tests on OCS.

d) Not Used.

e) Measurement of step & touch potential to validate the result obtained by Simulator study.

f) Current Collection Test- Arcing locations identified during test must be attended and test has to be repeated.

14.7.3.1 On-load Tests and Directional Tests

14.7.3.2 Once sufficient load current is established, voltages and currents into protection and metering equipment shall be verified to ensure correct operation of protection relays and accuracy of meter readings at local and remote locations.

14.8 Service Trials

14.8.1 The Contractor shall provide special and general attendance during the Service Trials period such that the persons who carried out the On-Site Testing and Commissioning are available on Site to solve any problem arising from the Service Trials.

14.9 Performance Verification

14.9.1 The Contractor shall carry out all Performance Tests to verify that the performance of the System meets the Employer's Requirements after the substantial completion of the Works.

14.9.2 One of the Performance Tests which shall be carried out by the Contractor in conjunction with Other Contractors or relevant parties (e.g.DOT) is the measurement of EMI levels at locations to be specified by the Engineer. Such measurements shall be carried out prior to energisation of the Traction Power System, and then during Service Trials and commercial operation of the train services to ensure that the EMI levels comply with the requirements of this Specification.

14.9.3 Should the performance of the System deviate from the Particular Specification, the Contractor shall make every effort to rectify the deviation in the shortest possible time, and to the satisfaction of the Engineer.

14.10 **Minimum Safety equipment to be provided in 25 kV switching posts.**

- Fire protection equipment, such as fire buckets, sand buckets, portable fire extinguishers, wall-mounted or wheel-type fire extinguishers etc.
- Caution and warning notices
- First Aid charts and First Aid boxes
- Tool Board
- Safety tools: first-aid kit, first-aid and electric dangers drawings, Shock treatment Chart, insulated gloves, stool and, stretcher, Caution & warning notices.
- Key box
- Insulated mat as per latest IS / IEC
- Gas Resuscitation Kit
- Any other requirement for safety as per statutory regulation such as CEA Regulation, 2010.
- A-Type ladder, Bamboo Stick

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 15

PACKAGING, SHIPPING AND DELIVERY

15. PACKAGING, SHIPPING AND DELIVERY

15.1 General

15.1.1 All the stipulations laid down in the GS shall apply.

15.2 Packaging and Shipping

15.2.1 All equipment Goods and materials shall be properly inspected to ensure that there are no defects before shipment. An inspection tag bearing the words “INSPECTION PASSED” giving reference number to the inspection date and details to permit verification of inspection details shall be attached to those items inspected satisfactorily.

15.2.2 The four adjacent sides of each package shall be marked with permanent paint with the following information:

a) CONSIGNEE

b) COMMODITY

c) CONTRACT No

d) SHIPPING MARK

15.2.3 Appropriate caution notices such as “FRAGILE”, “HANDLE WITH CARE”, “KEEP DRY”, KEEP UPRIGHT” along with visual display symbols internationally accepted shall be conspicuously displayed on the outside surfaces of boxes, crates and packages.

15.3 Delivery

15.3.1 The Contractor shall be responsible for transportation and delivery of materials to site or to the storage space and shall continue to be responsible for its safe storage, handling, erection and commissioning.

15.4 Specific Requirements

15.4.1 Power and Control cables

a) Cables shall be supplied on drums of adequate strength in the longest possible lengths consistent with the requirement.

b) Each cable drum shall have a distinct identification number displayed on the outside flange. It shall also display following additional particulars

i) Voltage designation

ii) Length

iii) Conductor Size

iv) No. of cores

v) Drum No.

vi) Gross and net weights

c) The cable shall be inscribed with Delhi Metro Rail Corporation.

d) An arrow showing direction of rolling shall be shown. Both ends of the cables shall have heat shrinkable caps. The caps shall incorporate a sealant which melt on heating at temperatures well above outdoor ambient expected in Delhi area.

15.4.2 Sub assemblies

15.4.2.1 All the products shall be completely assembled before packing and shipping. If impracticable, the products shall be delivered in sub-assemblies clearly marking on each such assembly the identity of the particular assembly to which it belongs so that lots of different sub assemblies can be collected and stored together to form full assemblies at site.

15.4.3 Gas Insulated Switchgear and other switching equipment

15.4.3.1 All enclosures of GIS shall be filled with inert gas before packing.

15.4.3.2 Necessary precautions shall be taken during shipping, handling and storage as per manufacturer's recommendations.

15.4.4 Rigid OCS and Retractable catenary

15.4.4.1 Necessary precautions shall be taken during shipping, handling and storage as per manufacturer's recommendations

END OF CHAPTER

CONTRACT PACKAGE – DE-08

CHAPTER – 16

INSTALLATION

16. INSTALLATION

16.1 General Requirements

16.1.1 The Contractor shall comply with all Enactments in executing the Works, including but not limited to all statutory provisions on occupational health and safety.

16.1.2 The Contractor shall co-ordinate with Other Contractors in the execution of the Works.

16.1.3 The Contractor shall also co-operate with all Relevant Authorities in the execution of the Works.

16.1.4 The installation of all equipment shall be undertaken at all times by suitably trained and competent employees of the Contractor, to the satisfaction of the Employer's Representative.

16.1.5 Only appropriate tools, plant, equipment and vehicles shall be used.

16.1.6 Installation of all equipment shall be in accordance with the Construction and Installation Plan described in the GS.

16.1.7 Installation of all equipment shall conform to the best industry practices.

16.1.8 Precautions shall be undertaken to ensure the safety of personnel and equipment for all installation works.

16.1.9 The Contractor shall, prior to starting any installation work, identify any possible hazards, and implement measures of eliminating and/or controlling such potential hazards, in line with safe working practices.

16.1.10 Further details on Site safety management are described in Chapter 17 and Appendix 2 of the GS.

16.1.11 The Contractor shall ensure that all areas of work are sufficiently illuminated for the works to be undertaken and that a safe system of work is employed for all activities.

16.1.12 The Contractor shall operate a robust system for the control of persons entering or working upon the site. The system shall include as a minimum:

a) register of all employees;

b) personal identification, with photograph;

c) levels of competency;

d) date of expiry;

e) date of issue;

f) signature; and

g) register of all visitors.

16.1.13 The Contractor shall co-operate, at all times, with the Engineer and Other Contractors to ensure that the Site is protected from unauthorised admission, either wilfully or otherwise.

16.1.14 The Contractor shall make due provision for the safe access and egress to the Site of Works for its staff and subcontractors. This access shall be maintained such that it is free of all hazards and is in a safe condition throughout the duration of the Works.

16.2 Specific Requirements

16.2.1 The installation work pertaining to this Contract shall include, but not be limited to the following: -

a) Finalisation of the Construction and Installation Programme;

b) Survey on Site and review the technical requirements shown in this Specification and the Employer's Drawings;

c) Production of the calculation sheets and installation drawings for Site installation;

d) Installation in accordance with the finalized installation drawings;

e) Co-ordination with Other Contractors;

f) Submission of the installation reports and records;

g) Testing and commissioning, as per finalized protocol and programme.

h) Production of as built drawings, documents, calculation sheets, and records.

16.3 Construction and Installation Plan

16.3.1 The Contractor shall undertake installation work in stages as shown in the detailed installation programme. Installation, testing and commissioning of later stages shall not impact revenue operation of earlier stages.

16.3.2 As a minimum, the detailed Construction and Installation Plan shall include but not be limited to all the activities described in clause 16.2 of this PS and clause 3.6.1 of the GS, installation details and methods of all activities equipment and tools to be used for installation, safety issues, supervision, temporary land occupation needed and the vehicles to be used for installation.

16.3.3 Manual Handling

To facilitate handling of traction and auxiliary power equipment in underground stations during installation and maintenance thereafter, the Contractor shall closely co-ordinate and interface with Civil Contractors for installation of the material handling equipment necessary for loading/ unloading of electrical equipment from flat rail cars on tracks, including any travelling hoist arrangements required as well as for provision of hatches wherever required.

The work of installation of the hoists, if needed, shall be closely coordinated with Civil Contractors who will have to design the structures, install the beams at appropriate locations and provide the hoists.

The entire material handling plan for the movement of bulky equipment, such as 25 kV interrupters etc. shall be carefully planned.

16.4 **Works Area**

16.4.1 The Contractor will be given temporary work sites as stipulated in clause 3.8 of this Specification.

16.4.2 The Contractor shall comply with the requirements specified in Chapter 17 of the GS in relation to the use of works sites allocated to the Contractor.

16.5 **Temporary Works**

16.5.1 The design of the Temporary Works shall be submitted to the Engineer for review.

16.5.2 All Temporary Works shall be removed on completion of the Section, or as directed by the Employer's Representative.

16.5.3 All Temporary Works shall be clearly distinguishable from the Permanent Works.

16.6 **Works Train**

16.6.1 The Contractor shall provide a minimum of one set of rail cum road vehicle for construction with statutory exhaust pollution norms as applicable.

16.6.2 For the use of any Works Train, the Contractor shall ensure its safe loading, restraint against shifting while in motion and that the dimensions of materials and/or equipment carried shall not exceed the space constraints (Schedule of moving dimensions) of tunnels and that no other track and tunnel related installation will be damaged during its use.

16.6.3 The Contractor is advised to carefully consider the Works Train design so that the working platforms have the flexibility to enable the train to pass the height restriction and yet be of sufficient height for safe and efficient installation of the OCS, when on Site.

16.7 **Site Supervision and Safety Issues**

16.7.1 The Contractor shall set up a Site supervision system, which shall be part of the overall safety, system assurance and quality management system.

16.7.2 Details of Health and Safety requirements at Site are described in Chapter 18 of the GS and Safety & Health Manual.

16.8 **Quality Management**

16.8.1 The Contractor shall adopt an appropriate quality management system throughout the entire Site installation period to ensure that the System performance requirements as specified in Chapter 4 of this PS are achieved.

16.8.2 The Contractor shall provide sufficient number of suitably experienced supervisors and skilled workers to ensure that the progress and quality of the work, both on Site and in the Contractor's workshops, are maintained to the satisfaction of the Employer's Representative.

16.8.3 Supervisors shall have a minimum of five years' previous experience in a supervisory capacity on similar projects and all the skilled workers including linesmen electricians fitters and craftsmen, shall have a minimum of two years' previous experience in installation of similar systems.

16.8.4 The Contractor's supervision system shall be responsible not only for the supervision of the Concerned system installation but also for the supervision of the installation of the primary fixing system (civil inserts), the earth mats systems, etc. that are to be installed by the Civil Contractors. The supervisors shall work on a full-time basis during the entire installation process.

16.8.5 The Contractor shall maintain a set of drawings at each project site which accurately reflect the current status of field changes. The Contractor shall obtain letter of no objection from the Engineer for any such changes. The Contractor shall prepare final drawings showing the as built configuration. These drawings shall be developed in a logical format to facilitate routine system maintenance and troubleshooting. All drawings and details shall be endorsed by the Contractor.

16.8.6 The Engineer reserves the right to undertake, at any time, checks on the proficiency of the Contractors staff, licensing and all associated documentation. Should any of the Contractors staff be found incompetent or unlicensed he shall be removed from the site until their Competency has been established.

16.9 Installation of Cables

16.9.1 Laying of Cables

16.9.1.1 The Contractor shall co-ordinate with the Civil Contractors for the installation of cables in cable galleries, trenches, ducts, troughs, risers and shafts.

16.9.1.2 The cable system shall, during installation, be fully protected from mechanical damage and be generally accessible at all points for inspection along its entire route. Suitable cable markers shall be provided for covered cables upon completion of installation.

16.9.1.3 Should it prove necessary to cut any cable during installation, all cut ends shall be properly sealed.

16.9.1.4 The maximum pulling force of any cable during installation shall not exceed the design force of cables.

16.9.1.5 All cables shall be installed in the formed cable trenches, shafts, tunnels, hangers, trays and brackets. The minimum recommended bending radius of the cables shall not be exceeded during installation. Cable shall be laid as per relevant IS & IEC Standards.

16.9.1.6 All materials used for termination, jointing and installation of cables in tunnel and confined spaces shall have flame retardant, low smoke, halogen free characteristics.

16.9.1.7 The detailed instructions for cable laying has been attached under Appendix-D

16.10 Workmanship

16.10.1 General

16.10.1.1 All the installation shall be carried out according to the instructions shown in this Specification and Employer’s Drawings.

16.10.1.2 All assemblies of equipment and their components and parts shall be completely interchangeable if they are of similar type

16.10.1.3 The style and procedure of the workmanship shall be consistent throughout the Works. Unless otherwise specified, the Engineer shall decide the final colours for all paint work and other finishes to be applied to any part of the Works.

16.10.1.4 All parts, which are subject to, wear or damage by dust shall be completely enclosed in dust proof housings.

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 17

SUPERVISION AND PLANNING OF MAINTENANCE

17. SUPERVISION AND PLANNING OF MAINTENANCE

17.1 General

17.1.1 The scope and requirements of supervision and planning of maintenance are stipulated in Chapter 12 of GS

17.1.2 The following outlines the Employer's maintenance strategy, different levels of maintenance, the Maintenance Management System and the arrangement for maintenance.

17.1.3 The Contractor shall make use of all relevant information to provide supervision of maintenance.

17.2 Employer's Maintenance Strategy

17.2.1 Maintenance Strategy

17.2.1.1 The Contractor shall ensure that the design of the software and hardware of the system designed, installed and commissioned is supportable throughout the service life of the System to address, as a minimum, the following:

a) design errors in the System;

b) operational changes;

c) environment changes; and

d) changes in infrastructure.

17.2.1.2 According to the maintenance strategy, all equipment and infrastructure supplied for the 'Project' must be designed for minimum or no maintenance. Maintenance activities required must be capable of being performed with little or no impact on the train service. In addition, the maintenance work systems shall ensure safety of personnel and equipment.

17.2.1.3 During the Defects Liability Period (DLP) maintenance of all Works will be conducted by the Employer under the supervision of the Contractor.

17.2.1.4 The Contractor shall ensure that in order to supervise maintenance during the DLP, personnel are always available with the relevant skills and level of competence.

17.2.1.5 The Contractor, upon noticing any defects, deficiency in quality and quantity of spares and materials shall without delay arrange for alternative source of supply and submit his proposal to the Engineer for review.

17.2.1.6 The consumable (if any) during DLP will be supplied by Contractor.

17.3 Different Levels of Planned Maintenance

17.3.1 Routine preventative maintenance will be carried out at regular intervals based on condition, reliability, usage, and service history and equipment manufacturers' recommendations. The Operating and Maintenance Manual shall describe the different levels of planned maintenance.

17.4 **Supervisory Staff**

17.4.1 For this Contract, clause 17.4.2 of this Specification supersedes clause 12.3.1 of GS.

17.4.2 The Contractor shall provide supervisory maintenance staff who are expert in all the different levels of fault finding, maintenance and repair of the various systems supplied under the Contract covering at least the following: -

a) Cabling system 25 kV ac traction and return, and 415V ac

b) 25 kV SS/SP, isolating and earthing switches

c) 25 kV rigid OCS and return circuits

d) EMI protective provisions, earthing and bonding.

17.4.3 Stipulations of clauses 12.3.2, 12.3.3 and 12.3.4 of the GS shall apply here.

17.5 **Maintenance during DLP**

17.5.1 Maintenance Management System (MMS) and Maintenance Arrangement

17.5.1.1 During non-operation time, sections of line will be closed for maintenance work. The minimum time for possession periods is 3 hours. Ideally, this time shall be the free time available for work. It excludes time required for trains to return to their stabling point and time required to take and give up possession. This time is, however, not available for maintenance in depot.

17.5.2 Competency of Personnel

17.5.2.1 During the DLP the Contractor shall support the Employer with sufficient trained and competent personnel.

17.5.2.2 Such persons shall have their generic competence established and must demonstrate their specific competence and knowledge in the particular systems, environment and procedures.

17.5.2.3 The Contractor shall provide evidence of specific competence and knowledge, which shall include:

a) assessment and certified training in particular software applications and operations;

b) recording of competence and work in the license holders logbook; and

c) receiving or in receipt of sufficient and current exposure to the area of work that the holder is licensed for.

17.5.2.4 Routine spot checks on licensing may be carried out from time to time by the Engineer qualified personnel on the proficiency of the Contractor staff.

17.5.2.5 In the event of a failure, the Contractor shall undertake the management and investigation necessary to identify and rectify the cause.

17.5.2.6 Should the Employer, during the DLP require further investigations at other Sites throughout the system, the Employer will formally request the Contractor to Undertake such investigations.

17.5.3 Testing and Re-commissioning of System and Equipment

17.5.3.1 In the event of a failure requiring modifications to the System, the Contractor shall undertake any testing and re-commissioning required.

17.5.3.2 Any such modification shall be submitted for review by the Engineer.

17.5.4 Temporary Alterations to Restore Service

17.5.4.1 The Contractor shall undertake any temporary modifications necessary to maintain service.

17.5.4.2 Any such modification shall be submitted for review by the Engineer.

17.5.5 Discrepancies between Installation and Design Records

17.5.5.1 Should the Contractor discover inconsistencies between the maintenance drawings and documentation and the installed equipment, the Contractor shall correct all such errors within two weeks.

17.5.6 Communications

17.5.6.1 The Contractor shall ensure that adequate communication facilities are provided to its staff during the DLP.

17.5.7 Location of Staff

17.5.7.1 The Contractor shall be responsible for locating staff such that the Contractor meets its obligations.

17.5.8 Storage of Equipment and Materials During the Maintenance Period

17.5.8.1 The Contractor shall ensure that no equipment is to be stored along the trackside.

17.5.8.2 The Employer will provide defined storage locations for the support of the different levels of Maintenance.

17.5.8.3 The Contractor shall satisfy itself and the Engineer that the storage locations for equipment and materials will meet the performance requirements of this PS.

17.5.9 Maintenance Regimes

17.5.9.1 The Contractor shall provide documented maintenance regimes to be followed by the Employer upon substantial completion of various components of the work until the end of the DLP.

17.5.9.2 The Contractor shall produce a maintenance regime for the equipment that shall comprise two constituent parts, corrective and routine/preventative maintenance.

17.5.9.3 Routine/preventative maintenance shall be non-intrusive to the day-to-day operation of the train service and be capable of being pre-planned in advance of the work.

17.5.9.4 Corrective maintenance shall be available 24 hours per day, able to respond to all foreseeable circumstances.

17.5.9.5 The maintenance regime shall cover all parts and equipment of the system designed, installed and commissioned by the Contractor.

17.5.9.6 The Contractor shall take into account the requirements of the operations and maintenance when determining and proposing its maintenance regime.

17.5.10 Scope and Hours of Coverage

17.5.10.1 The regime and structure of corrective maintenance shall be robust in design.

The Contractor shall provide a full 24 hour On-Call coverage and shall be such that initial response and rectification of failure are in accordance with the following:

a) assistance to first line and corrective maintainer within 30 minutes, upon request of first line maintainer;

b) 24 hour from notification to collection for third line maintenance; and

c) replacement or repair of component from factory within 2 weeks including transportation time. Any extension to this time shall be agreed with the Employers and a replacement provided.

17.5.10.2 All elements of First Line preventative maintenance shall be carried out and completed during non-traffic hours without interrupting train services.

17.5.11 Failure Investigations

17.5.11.1 The Contractor shall conduct failure investigations.

17.5.11.2 The OCC Controller will determine priorities in the event of a conflict between the Contractor and other contractors during failure investigation.

17.5.11.3 Disputes between the Contractor and other Contractors will be resolved by the Engineer.

17.5.11.4 The Contractor shall make available to the Employer all test and failure data as required.

17.6 **Not used**

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 18

SPARES, SPECIAL TOOLS, TESTING AND DIAGNOSTIC EQUIPMENT AND MEASURING INSTRUMENTS

18. SPARES, SPECIAL TOOLS, TESTING AND DIAGNOSTIC EQUIPMENT AND MEASURING INSTRUMENTS

18.1 General

18.1.1 The Contractor shall supply spare parts, special tools and test equipment in accordance with the requirements of Chapter 13 of GS and this Specification.

18.2 Contract Spares

Spares shall be supplied & maintained as per the spare policy attached as Appendix-J**. <u>The spares shall be provided as per the spare list attached in the Spare Policy with this tender document.</u>**

18.3 Second Sourcing

18.3.1 The Contractor shall identify principal and second-source suppliers that can supply the Contract Spares

18.3.2 The Contractor shall ensure that second-source supplier information is maintained up to date upto a period of 10 years after taking over of whole works. The Contractor will provide support to the Employer to a reasonable extent regarding the second-source supplier information throughout the service life of the system.

18.3.3 The Contractor shall make the second-source supplier information available to the Engineer at the time of submission of the final design and taking over of the works.

18.4 Long Lead Times

18.4.1 The Contractor shall identify the lead times for all spare parts. Parts with long lead times shall be identified in the spares list.

18.5 Routine Change

18.5.1 In the event that any item of the supply requires to be routinely changed or calibrated regardless of whether it appears in the spares list or not, it shall be identified to the Engineer together with the routine change interval.

18.6 Shelf Life

18.6.1 In the event that any of the spares identified have a particular life or storage requirement, this shall be made known to the Engineer with the submission of the spares list, including the necessary action for disposal or storage.

18.7 Special Tools, Testing and Diagnostic Equipment and Measuring Instruments

The Contractor shall supply adequate quantity of special tools, testing and diagnostic equipment and measuring instruments in accordance with clause 13.6 of GS in order to carry out all the functions necessary for operation and maintenance of the entire system and also considering the requirements as described in the Operation and Maintenance Manuals.

CONTRACT PACKAGE –

CHAPTER – 19

TRAINING AND

TRANSFER OF TECHNOLOGY

19. TRAINING AND TRASFER OF TECHNOLOGY

19.1 General Requirements

19.1.1 The Contractor shall provide comprehensive training to the Employer's staff in accordance with the requirements contained in this PS and in the GS (Chapter 10). A central training school has been planned in the Depot area for this purpose.

19.1.2 The training shall be carried out at such locations where the greatest benefit for trainees may be gained. This may be in India, at place of manufacture, assembly or testing, or at such other locations as may be necessary. All places of training shall be subject to review by Employer's Representative.

19.1.3 The training courses and/or sessions shall include system performance requirements and all major equipment and works designed, by the Contractor.

19.1.4 The specific objectives of each course, training facilities to be used, the qualification and experience of the training instructors and the assessment criteria shall be developed by the Contractor and submitted to the Engineer for review at least three months before any course is conducted.

19.1.5 Manuals to be used for training, including the manuals to the instructors and trainees, shall be delivered to the Engineer at least six months before the issue of the Substantial Completion Certificate for the Works, as required under Chapter 10 of the GS. The training manuals shall be submitted in original plus five hard copies and in electronic format.

19.1.6 The Contractor shall provide full-time on-Site management and co-ordination of the entire training programme to ensure the continuity of classes, and proper distribution of training materials, and be responsible for interfacing with the instructors.

19.1.7 The training courses shall be delivered to all relevant Employer's staff, including instructors, operation and maintenance engineering staff.

19.1.8 The proposed training requirements are given at the end of this Specification

19.2 Mock Up for Training

19.2.1 The Contractor shall install mock up equipment for system and any such facility(s) as considered necessary for the training of Employer's staff in the training school.

19.2.2 The training mock up shall include but not limited to the following: -

a) OCS system components

b) Contact, messenger and aerial earth wires;

c) Section insulator;

d) Jumper and cable connections to OHE;

e) Rail bonds and cable rail connections of return circuits;

f) Circuit breakers, Interrupters and their component assemblies;

g) Isolators;

h) Pantograph of rolling Stock, Circuit Breaker, GIS, etc.

i) Clear photographs of various equipment such as transformers, their windings, rectifier and inverter sets;

j) Samples of various clamps and fitting used;

k) Control panel, protection schemes, earthing and bonding arrangement;

19.2.3 The Contractor shall submit full details of the training span and other mock up equipment, photographs etc. including proposed training activities and objectives, for the Engineer review.

19.2.4 The Contractor for training purposes shall also supply any special tools and equipment required to be used.

19.3 TRAINING PLAN

19.3.1 The Contractor shall submit a Training Plan in accordance with the requirements of the General Specification. In addition, the Training Plan shall include the following:

19.3.1.1 Details of the Contractor's ability to carry out the necessary training.

19.3.1.2 Details of the proposed approach to structuring and providing the courses required.

19.3.1.3 Course details including duration, maximum number of trainees, ratio of trainees to trainers, facilities required or available and prerequisites for attending the course.

19.3.1.4 Recommendations for additional training or alternative means by which the Employer's training objectives may be met.

19.3.2 The Training Plan shall be submitted for review by the Engineer and will be Implemented in a timeframe such that complete and comprehensive training has been received by the designated Employer's staff prior to the System Acceptance test.

19.4 Training of Employer's Training Instructors (ETI)

19.4.1 The objective of the training is to enable the Employer's Training Instructors to be competent to deliver future courses for other employees of the Employer.

19.4.2 The Contractor shall provide training to the Employer's Training Instructors on the various Systems. Aspects covered shall include, but not be limited to, the following:

a) Configuration of the entire System, including interface with the DMRC Traction Sub Stations supply system at the in feed points;

b) Feature and functional principles of the entire System;

c) System design aspects including but not limited to design standards, design criteria and parameters, short-circuit and other calculations, insulation and protection co-ordination;

d) Details of major equipment and material including but not limited to 25 kV circuit breakers, isolators, voltage and current transformers, OCS conductors, fittings, assemblies and protection relays, batteries and chargers, and cables of different types and their joints used in the System;

e) System operation and maintenance management and procedures;

f) Earthing and bonding arrangement, covering safety aspects of touch and step potential safety to personnel, passengers and outsiders.

19.5 **Operations Staff Training**

19.5.1 The objective of the training is to enable the Employer's operations staff to be familiar with the Systems, with focus on the operational aspects under normal and emergency conditions.

19.5.2 The training shall also enable the trainee to acquire full capability for identification, trouble shooting and rectification of faults in the specified duration. After classroom training which includes mock ups of equipment, the staff shall be trained in actual operation.

19.6 **Maintenance Staff Training**

19.6.1 The objective of the training is to enable the Employer's maintenance staff and Engineering staff to be familiar with the Systems focus on the maintenance aspects of the System including but not limited to the following:-

a) Full understanding of all the equipment, sub-systems and system, their function, maintenance and overhaul requirements.

b) Procedures to be followed for unscheduled maintenance and repair.

c) Identification of failed components and sub-systems in electronic equipment by use of special test kit as necessary.

d) Modification in the software to extend or modify the control, monitoring and protection functions.

19.7 **Not used**

19.8 **Transfer of Technology**

19.8.1 Tenderer shall submit the detailed plan of transfer of technology along with MOU with suitable Indian companies or company having proven track record and working in related areas for major systems / subsystems in accordance with clause 10.7 of GS.

19.8.2 TOT shall be essential and shall include system assembly, installation, maintenance and software modification / customisation and training of Employer's personnel to cover the systems/ subsystems:

- Rigid OCS
- GIS and other equipment at switching station in underground and elevated section.
- Traction Power Supply equipment
- Retractable catenary/MOCS

19.8.3 TOT shall essentially include the following aspects as a minimum:

- Engineering or extensions and up gradations of the System
- Re-engineering to suit changed traffic conditions
- Incorporation of optional facilities
- Change in parameters of Rolling Stock
- Any other configuration / programmes required for maintenance / up gradation of hardware software.

19.8.4 The Transfer of Technology shall require involvement of Employer's personnel in each of Sub-systems during the Contract period. The sponsored engineers shall be under the technical administrative control of the Contractor. It is tentatively proposed to deploy 2 No. Employer's personnel for this purpose.

19.8.5 The Contractor shall undertake to supply or make arrangement with the original manufacture supply additional equipment required for replacement or expansion of the network in future.

19.8.6 The contractor shall undertake to provide, if required during the life of the equipment ordered, technical assistance in the form of additional drawings, maintenance practices and technical advice.

19.9 Training requirements

Table 2 - Man-Weeks of Contractor's Training Instructors for training Employer's operating personnel in India

	Man-weeks
OHE/OCS/MOCS	4
25kV Traction Equipments (including SS, SSP, SP, FP and interlinking) and all type of cables	4

Table 3 - Man-Weeks of Contractor's Training Instructors for training Employer's maintenance personnel in India

	Man-weeks
OHE/OCS/MOCS	8
EMI/EMC, bonding and earthing system requirements, Electrical Safety & earthing	4
25kV Traction Equipments (including SS, SSP, SP, FP and interlinking) and all type of cables	4

Cost of above training may be included in the works

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 20

OPERATION AND MAINTENANCE DOCUMENTATION

20. OPERATION AND MAINTENANCE DOCUMENTATION

20.1 General

20.1.1 The Contractor shall provide Operation and Maintenance manuals, for use by supervisory, operating and technical staff of Employer. All Operation & Maintenance manuals shall be provided in English. The Contractor shall provide the Operation and Maintenance manuals in soft copy also.

20.1.2 Requirements of submission have been furnished in Chapter 11 of GS.

20.1.3 Each and every manual shall be divided into indexed sections explaining the subject matter in logical steps. Most manuals shall consist of A4-size printed sheets bound in stiff-cover wear-resistant binders clearly and uniformly marked with the subject matter and reference number. Where alternative sizes are proposed, (e.g.A5/A6 pocket books of schematic wiring diagrams) these shall be submitted for review of Employer. The binding shall allow for all subsequent changes and additions to be readily effected.

20.1.4 Information shall be provided in pictorial form wherever possible and shall include step-by-step instructions and views of the particular equipment including exploded views. Programmable equipment shall be supplied with sufficient flow charts and fully documented programmes to enable faults to be quickly identified and system modification to be undertaken at any time.

20.1.5 The Contractor shall provide clarifications and amendments to the Operation and Maintenance manuals as necessary during the Defects Liability Period. Updates shall be provided for the originals and all copies.

20.2 Operation Manuals

20.2.1 The Contractor shall provide operation manuals explaining the purpose and operation of the complete system together with its component subsidiary systems and individual item of equipment. The characteristics, ratings and any necessary operating limits of the Equipment and Sub-systems shall be provided. The Operation Manuals shall focus on operation aspects under normal and emergency conditions.

20.3 Maintenance Manuals

20.3.1 The Contractor particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing programme.

20.3.2 The Contractor shall provide documentation for all hardware and software for computer systems and other associated electronic equipment to meet the following requirements. Such documents shall include but not be limited to:

i) manufacturers' documentation supplied as standard with the equipment;

ii) hardware configuration with details of expansion capabilities and options;

iii) programme loading instructions, including runtime environment configuration;

iv) programme listing including comprehensive 'comment statements' in hard copy and soft format for source code, compilers and development tools necessary to modify and recompile software;

v) Flow charts, data flow diagrams and state diagrams as appropriate;

vi) description of software modules including purpose, linkage with other modules, error routines and any special considerations;

vii) memory maps for both internal and peripheral memory showing description of all programmes, data files, overlay areas, memory available for expansion and the like;

viii) loading and operating instructions for diagnostic programmes and specifically developed debugging tools; and

ix) programming manuals relevant to operating systems, languages, development tools, etc.

20.3.3 The manual shall also include inspection/overhaul procedure and periodicity of various inspection/overhaul schedules in detail including the tools, special tools/plants, and facilities required. The manual shall be subject to review by the Engineer.

20.3.4 The maintenance manual shall also include an illustrated parts catalogue of all plant supplied and shall contain sufficient information to identify and requisition the appropriate part by maintenance staff. The catalogue shall comprise 3 sub-sections.

20.3.5 The first shall be an alphanumeric parts list, which shall include the following information:

i) Part number

ii) Description

iii) Name of manufacturer

iv) Quantity and Unit

v) Part number of next higher assembly (usually a line replaceable unit).

vi) Cross-reference to figure number.

vii) Category: e.g. consumable, line replaceable unit, repairable.

viii) Life-expected life, Mean time between failure or mean distance between failure where available.

ix) General or specific purpose

20.3.6 The second is a series of illustrations to indicate the location of each replaceable item which shall be clear and progressive with exploded views to enable parts to be identified easily by cross-reference with the alpha-numeric list.

20.3.7 And the third an indicative price list which shall list in alpha-numeric sequence the part number with the price, lead time and vendor.

20.4 Interactive Manual

20.4.1 The contractor shall submit in English language Interactive Electronic Technical Manuals (IETMs) to manage technical documentation. IETMs shall compress volumes of text into CD-ROMs which may include sound and video, and shall allow readers to locate needed information rapidly than in paper manuals.

20.4.2 This IETM shall follow the structure and format of a printed book, with indexes and table of contents that are hyperlinked into the content of the document. All figures, tables and section references shall be linked.

20.4.3 The data to be stored in a relational database, obtaining benefits of data integrity and removal of data redundancy. Relationships in the content that are presented as hyperlinks are mapped directly to relations in the database scheme. The IETM shall be able to change the content dynamically based on user's navigation and input through the content; the content may now be user specific.

20.5 Quantity of Manuals

20.5.1 The Contractor shall supply Original plus two hard copies of Operating Manuals; Maintenance Manuals and Subsystems / Systems spare parts catalogue. These Manuals and Catalogue shall also be submitted in electronic interactive format.

20.5.2 The format of the electronic copies shall be proven in at least two other applications and shall allow for links between parts catalogue and maintenance instructions.

20.5.3 The Documents Management System and Language used shall be subject to Engineer's review.

20.6 Not Used

END OF CHAPTER

CONTRACT PACKAGE –

CHAPTER – 21

PROGRAMME REQUIREMENTS

The programme requirements (Key Dates) for the contract

have been defined in the Bidding Forms

CONTRACT PACKAGE –

CHAPTER – 22

SITE FACILITIES (MAY BE CHANGED AS PER REQUIREMENT)

22 SITE OFFICE

22.1 General

The Contractor shall have their site office accommodation, equipment, communication and drawing facilities and transport throughout the course of the works and for so long a period of time during the defects liability period as the Engineer may require. The details of the accommodation and other facilities are as under.

22.2 Site Offices

Site office of the contractor should be fully equipped with the following basic adequate facilities:

- High speed Internet and Wi-Fi
- Computers, printers, plotters and other devices for designing of the BIM model.
- Phones (Landline Telephone& Mobile connectivity to essential staff)
- Video conferencing
- Photocopier
- Computer with coloured A4& A3 size printer & other as required
- Flashdrive, Hard disk memory device of suitable memory
- Plotter
- Digital Camera

END OF CHAPTER

Annexure-1 As per Chapter 14 Clause no 14.1.4 (PS Rigid OHE)

Test Reports to be submitted during Design Submission of ROCS

S. No.	Item	Type test	Requirements.
1	25 kV Insulators for ROCS	Specified Cantilever load test	Should withstand at least 3 times the calculated design load
		Lightning impulse withstand voltage test	As per IEC 61109
		Power Frequency Withstand test	As per IEC 61109
2	25 kV Insulators for ROCS (Anchor)	Dry Lightning impulse withstand voltage test	As per IEC 61109
		Wet Power frequency test	As per IEC 61109
		Mechanical Load-time test	Should withstand at least 3 times the calculated design load
3	All type of Clamps Used in ROCS.	Tensile load test	Should withstand at least 3 times of the calculated design load
		Temperature Rise test	Permanent Temperature rise shall not be more than 35 deg C above ambient temp of 45 deg C at maximum current carrying capacity of the Clamp.
		Short circuit test	It should withstand minimum 14kA for 3 sec
		Short circuit test	It should withstand minimum 14kA for 3 sec
4	Aluminium Conductor Rail including transition elements, Rail Ramps.	Temperature-rise test	Permanent Temperature rise shall not be more than 35 deg C above ambient temp of 45 deg C at maximum current carrying capacity of the Aluminium Conductor Rail.
		Test of clamping force on Contact wire after application of conducting grease.	At least three times the calculated designed value.
		3-point bending test on CR	As per OEM design.

DELHI METRO RAIL CORPORATION LIMITED

(A Joint Venture of Govt. of India & Govt. of NCT of Delhi)

CONTRACT PACKAGE:

Design, Detail Engineering, Manufacture, Supply, Installation, Testing and Commissioning of 25KV AC Traction (RIGID OHE), 33KV Auxiliary Sub Stations (ASS), Associated Cabling and SCADA Systems for Underground Station of Line-………. and Elevated station of Line-……... of Phase-……………. Delhi MRTS Project.

PART 2: EMPLOYERS REQUIREMENTS

SECTION VI : EMPLOYERS REQUIREMENTS

SUB SECTION B: PARTICULAR SPECIFICATIONS (PS)

PART – 2: ASS

Note: These specifications are the bare minimum requirement, The Contractor has to fulfill while designing & executions. The final requirements of the specifications will depend upon the simulation studies and based upon that the contractor has to provide the material over and above to these specifications which shall be finally approved by DMRC.

DELHI METRO RAIL CORPORATION LTD.

Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi –110 001

CHAPTER 1

Introduction & Project Overview

Contents

1. INTRODUCTION

GNCTD/other statutory body vide their letter no. ………………… dated……….. has conveyed the approval of ….. nos…corridors….. with following details: Corridors…… length……elevated …. UG etc. to be mentioned.

Accordingly for the Elevated portion of the corridors mentioned above, the 25kV OHE along with all the required power supply arrangement along the elevated corridor(s) shall be executed under the contract…………….

2. CONTRACT OVERVIEW

The project comprises of (Design, Detail Engineering, Manufacture, Supply, Installation, Testing and Commissioning of 25KV AC Traction (RIGID OHE), 33KV Auxiliary Sub Stations (ASS), Associated Cabling and SCADA Systems for Underground Station of Line-8 Ext. and Underground Station & Elevated station the following corridors:

a.) Corridor's details to be given

2.1 Commissioning Dates

The expected date's of commissioning for the contract are as follow:-

Sl. No.	Corridor	Expected Date of Commissioning
1.		
2.		

However, the alignment of above Corridors and commissioning dates may change during design and construction stage. The contractor has to interface with the civil, track and other system wide contractors for latest access dates and prepare their work programme accordingly.

The project shall be monitored under the System for Tracking And Monitoring of Projects (STAMP) with Building Information Modelling (BIM)., access to the same shall be provided by DMRC. Contractor has to update the status of work progress on the STAMP as per requirements with necessary media interface's and update the daily work progress with necessary media interfaces and update the daily work progress.

Also vendor payments have to process payments and technical approvals on vendor payment portal-VPP. The contractor has to depute staff for thesame.

3. SCOPE AND PURPOSE

3.1 Purpose of this Document

This Specification defines the objectives, guidelines and requirements for

a.) Design and design verification of the items, equipments and power supply system of the 33 kV auxiliary network & SWR's as per particular specifications. The Responsibility for the complete designing of the Works lies with the Contractor. Design of SWR, Auxiliary system and SCADA as detailed in chapter-8 "DESIGN & VERIFICATION" shall be in the scope of the contractor. The details of the design related activities is defined in chapter 8E of PS.

b.) Supply, Installation, Testing and Commissioning of Auxiliary Substations and SCADA interface for underground section of ………..

c.) Supply, Installation, Testing and Commissioning of Auxiliary Substations and SCADA interface for underground & Elevated section of………………..

d.) Interlinking/modification works at various locations as detailed under chapter 8D of PS are included in this project.

There will be no DDC for these works. The works to be executed under the Contract include Design, Detail Engineering, Manufacture, Transfer of Technology, Delivery, Installation, Testing, including Integrated Testing and Commissioning, technical support, supervision of maintenance, training of Employer's staff and documentation for a complete System necessary to deliver the requirements of this Specification.

3.2 Relevant Documents

This Specification should be read in conjunction with the General Conditions (GC), Particular Conditions (PC), Employer's Requirements (General specifications and Particular specifications) and Tender Drawings the General Specification (GS), the Employer's Drawings and any other document forming part of the Contract.

In the event of a conflict between the GS and this Specification, this Specification's shall prevail.

In the event of a conflict between this Specification and any other standards or specification quoted herein, the requirements of this Specification shall prevail.

The order of precedence, with item a) having the highest priority, is:

a) Particular Specification

b) General Specification

c) Indian Railway Standards

d) Indian Standards

e) International Standards referenced herein.

f) Other International Standards

g) Other National Standards.

Notwithstanding the precedence specified, the Contractor shall always immediately seek advice from the Employer in the event of conflicts between Specifications.

3.3 Design and Verification of Deisgn

The ratings and sizes of various equipments are mentioned in the contract. The contractor has to review all the ratings and sizes with respect to the requirements that may come out after finalizing the interface and site requirements. All the designs of the items, equipements and power supply arrangement has to be carried out by the contractor according to this particular specifications. The designs shall be based on the latest national as well as international standards and shall comply with the CEA regulations and other saturatory requirements. For designing the equipments, items, systems and power supply arrangement necessary manpower may be required to be deputed during execution of the project. The details of experience and qualification of the design staff has to be submitted to engineer for review. The reposibility of durabily of designs of the 33 kV system shall lie with the contractor. Minimum service life of the major equipments shall be 30 years.

There will be no DDC for these works, the Contractor shall thoroughly satisfy himself that the tentative capacities, ratings and quantities of equipment as specified herein meet the operational requirements.

Taking into account the technical and other data contained in the Bid document, the Bidder shall verify the ratings, quantities of equipment etc as specified herein and if the Bidder considers any additional equipment, equipment of higher capacities and higher ratings for the systems and sub-systems or any other additions necessary for the complete, safe and reliable operable power supply system, he shall include such items in his bid, as additional items, providing all clarifications and justifications for the same.

The design requirements have been defined on chapter 8E of PS.

4. OVERVIEW OF PROJECT

4.1 Corridors

S.No	Corridor	Line	Remarks

4.2 Power Supply for the corridors

4.2.1 Receiving Substations

Under Normal conditions, electric power to the (section to be mentioned) is supplied by the following Receiving Substations, hereinafter referred to as RSS.

Sr. No.	RSS	Supplies Power to Corridor

Under Normal conditions, electric power to the Aerocity to Tughlakabad (U/G) section (Standard Gauge - Corridor is supplied by the following Receiving Substations, herein after referred to as RSS.

S. No.	RSS	Supplies Power to Corridor

In addition to the above, power supply interlinking has been planned at various locations in both lines to maintain standby supply as per SLD as provided in tender drawings.

4.2.2 Traction & Auxiliary Supplies

At the DMRC Receiving Substations, the Incoming High Voltage Supply will be stepped down

- to 27.5 kV, single phase and will be fed to the traction overhead equipment, through a Traction Substation (TSS), located in the same premises as the RSS.
- to 33kV, three phase and will be fed to the 33 kV Auxiliary Network and the Auxiliary Substations, to meet the Auxiliary power demand at stations and en-route, through an Auxiliary Main Substation (AMS), located in the same premises as the RSS.

CHAPTER 2

Scope of Work

Table of Contents

1. GENERAL

A general description of the broad scope of work, relating to works covered in this Tender, is given below. It shall, however, be clearly understood that the description is for the purpose of general guidance only and is not exclusive. For complete appreciation of the Scope, the Specifications, Bills of Quantities along with their Explanatory notes, Drawings and other relevant paragraphs of the Tender documents shall be referred to.

DMRC has issued different technical instructions regarding the equiment specifications, methods of installation, general technical data of instruments, protection philosophy, interlocking etc. The contractor has to comply with the requirements mentioned in the technical instructions issued by DMRC. During course of contract DMRC may issue new technical instructions or modify the old technical instructions in order to improve the performance and reliabilty of the systems. The contractor has to follow all the technical instruction issued pre or post tendering process.

1.1 Items of work

The following items of work are within the Scope of this Tender:

a) Design and design verification of the items, equipments and power supply system of the 33 kV auxiliary network & SWR's as per particular specifications. The Responsibility for the complete designing of the Works lies with the Contractor. Responsibility for the complete designing of the Works lies with the Contractor. Design of SWR, Auxiliary system and SCADA as detailed in chapter-8 "DESIGN & VERIFICATION" shall be in the scope of the contractor. The details of the design related activities is defined in chapter 8E of PS.

b) The works to be executed under this Contract includes design, validation of design, transfer of technology, delivery, installation, testing, including integrated testing and commissioning, technical support, DLP, maintenance, training of Employer's staff and documentation for a complete System necessary to deliver the requirements of this Specification.

c) Supply and Erection of 33 kV Insulated cables in Underground & adjoining stations of elevated, in tunnel/viaduct/ground and at other places as detailed in subsequent paragraphs.

d) Supply and Erection of 33 kV / 415 V Auxiliary Transformers and associated Switchgear and Equipment in all ASS's, in Underground Stations

e) Modification/Interlinking works, as required, at already erected installations, as defined under chapter 8D.

f) Design, Supply, Installation, Testing and Commissioning of all interlinking (details are as per Chapter 8 of the PS) of 25kV and 33kV kV switching systems of the 'elevated' and at Grade corridors shall be part of this contract.

g) All Testing, integrated testing, and Commissioning of all erected equipment.

1.2 Corridors Covered by this Tender

This Tender covers the relevant works in the underground sections from Scope (Details of the corroidors to be given).

1.3 GENERAL

In general, Contractor is responsible for all works relating to 33 kV Power Distribution Network and Auxiliary Substations in the various Corridors, except for certain items of work which are specifically excluded from the Contractor's Scope and which would be carried out by other Contractors/Agencies.

1.4 DE-08 CONTRACTOR'S SCOPE

S. No	Name of Corridor	Section	Scope

1.4.1 Auxiliary Main Substations (AMS)

1.4.1.1 The Auxiliary Main Substations (AMS) are located in the premises of Receiving Substations (RSS). A different Agency is entrusted with the work of supply and installation of these RSS's. RSS Contractor will provide the necessary HV System including HV Switchgear, Bus bar etc. and also the 66 kV (or 132 kV or 220 kV) / 33 kV, 3 phase transformers. RSS Contractor will also construct the AMS room and supply and install the 33 kV Switchgear and other equipments in the AMS. ROCS Contractor will required to supply and install the 33 kV cables from the outgoing 33 kV Switchgear at the AMS, up to the designated ASS.

Inside the AMS room and in the RSS premises, cable paths for installation of 33 kV cables and Control & monitoring cables and SCADA communication for RSS to designated TER room will be provided by the RSS Contractor. However, cable paths beyond the boundary walls of the RSS upto the entry point into the tunnels/underground stations/Elevated station/Viaduct, will be required to be provided by the Contractor.

For underground section: - Cable path, including Cable entry shafts, suitable cable trays, cable ladders, cut-outs etc for travel of 33 kV and control cables from the entry point into the tunnels upto the entry point into the ASS will be provided by the Station Building Contractor/Station E&M Contractor. Cable paths for cables inside the ASS Room shall be provided by the Contractor.

For elevated section: - Cable path, including Cable entry shafts, suitable cable trays, cable ladders, cut-outs etc for travel of 33 kV and control cables from the entry point of elevated station/viaduct upto the entry point into the ASS of elevated station will be provided by the Contractor. Cable paths for cables inside the ASS Room shall be provided by the Contractor.

<u>For details, please refer to Chapter 8 – Auxiliary Network and Interface matrix attached to these tender documents.</u>

1.4.2 Auxiliary Substations (ASS)

1.4.2.1 The following works shall form part of this Tender:

Supply, erection, testing and commissioning of all equipments at all Underground ASS's, including, but not limited to,

- 33 kV / 415 V transformers
- 33 kV Switchgear
- 33 kV cables and Control Cables
- 33 kV Cables inside the ASS
- All control cables required for ASS
- All LT cables required for interconnection of equipments etc in the ASS (excluding those required for connection from 415V side of Auxiliary Transformer)
- All measuring and protective devices
- Batteries and battery chargers
- Cable paths and earthing
- Safety equipment and

all other items required for successful and satisfactory working of the ASS, at all ASS's.

1.4.2.2 Location *of ASS vis-à-vis Electrical Switch Room*

For underground section: -

The ASS equipment in those ASS's which are located in the underground sections will be installed in a suitable room located normally at platform level. In some cases, ASS may be either at the concourse or ground level, in the passenger stations or in Ancillary building.

For elevated section: -

The ASS equipment in those ASSs which are located in the elevated sections will be installed in a suitable room, either at the concourse level, platform level or ground or FOB level in the passenger stations.

The ASS is combined with the LT Panels, which will be provided by E&M contractor.,:

- E&M Contractor will provide LT Bus duct (Sandwiched Type) with Adopter Box and Flexible links or LT cable connections including all nut and bolts (required for connection) between the Auxiliary Transformer at the ASS, and the Main Incoming LT Panel. DE-08 Contractor will have to maintain necessary interface with the E&M Contractor to ensure Proper installation of LT Bus Duct or cable connections.

- In case of 415V cable connection on secondary side, multiple (4 runs) 3.5 Core, 415V armored cables shall be provided by E&M contractor. The contractor shall provide suitable termination arrangement with required no. of terminals for each cable, so that E&M contractor can directly terminate 415V cables without any modification work on transformer. The connecting links shall be provided by The contractor.

- Contractor is to providing 33 kV cables, equipment etc. on the 33 kV side. Contractor will provide and ensure suitable interlocking arrangements approved by Engineer in-charge between the above 415 V Incoming and HT transformer Panel and the Auxiliary Transformer enclosure door.

- Contractor will provide the necessary protection relays for Transformer Protection as per the latest protection philosophy of DMRC (Technical Instrcution-10) attached as Appendix-D. Auxiliary Transformers shall be fully protected against any downstream electrical faults on the 415 V Distribution system in the station premises.

1.4.2.3 Room size

The Room for accommodating the ASS (and ESR) equipment's will be built by other Agencies. Room sizes and shapes may be different in different ASS. Nevertheless, an approximate area of 180-230 sq.mtr, with a minimum height of 4.0 m (in the Transformer and Panel area) will be provided for accommodating ASS Transformers, panels and equipment along with 415V panels. Typical Equipment Layout Plans for ASS are indicated in specified ASS drawings. Contractor will, however, be required to submit Equipment Layout Plans for every ASS in Coordination with Civil & E & M Contractor, depending upon the types, sizes etc. of the ASS equipment proposed to be used by him.

The ASS located in the station may have bottom or Top entry of cables depending upon availability of space. Contractor should interface with civil contractor and Architect in this regard.

1.4.2.4 Cable cut-outs and Sealant System

For Underground section: -

Cable cut-outs for entry/exit of HT, LT and C&M cables will be provided by the Station Building Contractor (SBC). For this purpose, Contractor shall interface with civil contractor and furnish detail of Cut out required in ASS Slab for bottom Entry or Top entry of Power and Control cables. Necessary sealants and gaskets, wherever required shall be provided by the contractor.

For Elevated section: -

All the cables entry in to Viaduct, Station building, ASS, Control Buildings & Panel / equipment, switching posts equipment, SCADA equipment etc. shall be sealed with EPDM based modular cable sealing system. The Cable Sealing System shall provide foolproof protection against "Fire, Water, Dust, Dirt, Humidity, Vibrations, Temperature Variations, Pull Tension, Noise as well as Rodents. The system must meet the following requirement: -

- The system shall be based on Multidiametertechnology and shall made up of halogen free EPDM (Ethylene Propylene Diene Terpolymer) cross-linkable rubber compound with Low Smoke Index.
- The system must be type tested for the Water/Fire/gas tightness.
- The system shall conforming to IP 66/67 for Buildings & IP 55 for Cabinets/Panels as per IEC: 60529.
- The System shall be Fire Resistance for 3 Hrs with Single side installation only as per UL-1479 along with UL Certificates No back-to-back installation is allowed.

- Fire Flammability resistance shall be of UL (V-0) as per UL94 ans Insulation&Integrity EI 120 as per BS476.
- Fire hazard levels HL3 according to EN 45545.
- Total Halogen Content shall not > 1500 ppm in totality as per EN/IEC 61249-2-21 and Toxic Index shall not > 15 ppm as per NF X70-100:2006.
- The System should be CE Certified & Complied to ETAG 026 Part 1 and 2 for fire resistant walls and floors in buildings
- The System shall be Vibration proof and conform to Category-A, Class 1 as per IEC 61373.
- Heat radiation classification - M2 class as per NF-P 92-512.
- The system shall be UV protected and shall meet the requirement of 1000 hrs as per ISO 815-1 and ISO 4892-2.
- The system sh all be anti rodent and certificareputes NABL accridiated lab / institution.
- The sealing system must have built –in spare capacity i.e. option for adding more cables in to the same system.
- Lubricants / Assembly gel should not have the property of adhesiveness
- One single module can seal a cable of several different diameters simply by peeling away layers.
- All the relevant Test Certificates shall be issued from NABL accredited LAB with scope of testing facility or issued from International reputed agency like UL, SP, LNE and RST.

1.4.2.5 Cable paths

For Underground section:

Cable paths required for management of LV and C&M cables, inside the ASS Rooms, shall be provided by E&M Contractor.

For Elevated section:

The cable path for HT equipment in station areas including ASS shall be provided by the contractor. The path shall be comprised of cable support, cable hangers, cable trays, cable dropping etc. The steel to be used for cable path shall be hot dip galvanised as per IS-4759 (latest revision) with minimum Zinc coating of 610 gm/m2. Since pre cast structures shall be used in station building, proper interface with Station building contractor shall be done for cable paths.

The cable path from RTU to Telecom Equipment Room, wind speed sensor and earthquake sensors shall be provided by the E&M contractor. contractor shall do necessary interface with E&M contractor.

1.4.2.6 Equipment handling

Heavy equipment, such as transformers and 33 kV panels shall be brought by road by DE-08 Contractor. Wherever required, they shall be lifted to the loading/unloading platforms with the help of crane etc, by Contractor. The equipment shall be moved to their respective position/foundations, with the help of Trolley/ rollers. Lifting Hooks, if required by Contractor for shifting / installing the equipment shall be provided by Station Building contractor (SBC), for which contractor will interface with SBC. All equipment shall have provision of lifting eyebolts for lifting of equipment.

The lifting of equipment shall only be done as per the approved method statements duly vetted by manufacturer and approved by DMRC.

Due to construction work near ASS, the surrounding shall be dust prone. All equipment in ASS shall be covered from removable dust proof cover till the charging to avoid dust accumulation in equipment. The covers shall only be removed only when to work on equipment and before energisation of equipment.

1.4.2.7 Equipment mounting

The SBC will provide a finished floor. Contractor may, if required, fix equipments on the floor with the help of anchor fasteners. For ASS at elevated stations, contractor shall fix equipments on the floor with the help of anchor fastner on mounting channels/pedestal having clearances from floor of at least 30 mm. In general, no additional concreting is considered necessary to be provided in the ASS Rooms. The ASS shall be painted with epoxy paint by station building contractor therefore, If any concrete pedestals/foundations are required to be provided to mount transformers/equipment, the same shall be provided before epoxy paint by Contractor, after obtaining approval from Employer. If any damage to the epoxy paint shall be done contractor, penalty shall be imposed and restoration of epoxy paint shall be done by the contractor up to satisfaction of employer.

1.5 Tentatively, the following list shows the number of ass's in the various corridor:-

<table>
<tr><th rowspan="2">S. no.</th><th rowspan="2">Name of ASS connected to the Loop</th><th colspan="2">Tentative no. of Transformer</th><th rowspan="2">Total ASS</th></tr>
<tr><th>ASS-1</th><th>ASS-2</th></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td rowspan="6"></td></tr>
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</table>

(At Underground stations, there are 2 ASS's at each station, except at Interchange station)

(At all elevated stations, there is one ASS at every station which has two loops)

2. TENTATIVE LIST OF STATIONS

2.1 CORRIDORS (STANDARD GAUGE)

S. no.	Name of Station	Type of Corridor	Chainage (Meter)	Distance from previous station(Meter)	Platform Type

3. DOCUMENTS AND MANUALS

The contractor shall have to supply, in English language, all the following drawings and documents according to the time table defined below which may be modified according to the contractual planning of the equipment supply.

3.1 Two months after the order

- Preliminary Design Document based on the design details available with the tender documents. The design document shall cover the design varifcation part of the work as per clause 3.3 of of chapter 1 PS ASS.
- One short bill of quantities for the supplies, with the precise limits of each interface.
- one overall planning of the stations execution
- for all high, medium and low voltage equipment:
  - final overall dimensions drawings
  - handling drawings
  - detailed installation drawings
- civil engineering and outfitting guide drawings
- detailed construction timetable, precisely defining the various equipment construction stages
- a list of general purpose apparatuses so as to reduce as much as possible, the different types required.
- Any other drawings, documents required by the Engineer In-charge

Under no circumstance may the various detail modifications required for perfecting of the installations and requested within 1 month after supply of the drawings entitle the manufacturer to delay the delivery or to ask for a price increase of his supply.

3.2 Four months after the order

For all high, medium and low voltage equipment

- final schematic diagram, Single line diagrams, and layouts.

3.3 Six months after the order

- the wiring diagrams for the whole installations, including the schematic diagrams and the execution diagrams of the grounding circuits and of the interlocking
- the general assembly and operating manuals for the whole equipment
- a general guide for preventive maintenance of the various pieces of equipment
- a complete list of sub-contractors

The selection of these suppliers is at the manufacturer discretion and entirely under his responsibility. No approval that may have been given to him, in this respect, might release him from any of his responsibilities.

3.4 Nine months after the order

For the ASS in its final form

- the complete list of the auxiliary apparatuses
- the general maintenance guide
- the station descriptive manual
- the station manoeuvring manual

3.5 Three months before in-plant acceptance of the first equipment

- detailed set of the high, medium and low voltage equipment and of the power transformer drawings, in their final form:
- overall dimensions
- handling
- schematic and wiring diagrams
- detailed drawings of each auxiliary
- electrical and mechanical interlocking diagrams
- detailed part list

The manufacturer shall have to supply an absolutely complete list of the apparatus component parts with their referencing and their drawing number so as to enable setting-up the supplies and spare store general listing (in form of computerised list). The manufacturer shall supply the relevant catalogues and subscription to the updating for each part of these catalogues.

- detailed operating manuals of all accessories, auxiliaries and special tooling
- detailed manuals of preventive maintenance specific to each apparatus

- a recapitulative note specifying the transportation modes, the various handling methods and the storage precautions

If the manufacturer deems it necessary to carry out additional modifications after supply of the documents and data required above, he shall notify this as soon as possible and request approval.

This shall in no event be a justification for extension of the construction time he must comply with in all cases.

3.6 One month after in-plant acceptance tests of each piece of equipment

The manufacturer shall deliver the related detailed certificate and the detailed test report.

3.7 One month after putting into service

All documents whose updating will have been required so as to bring them in accordance with the actual works executed on the site and during testing and commissioning of the stations shall have to be supplied to the Employer for updating their documentary files.

The manufacturer shall be responsible for the production of the documentary files. The structure of these files shall be defined at the beginning of the study; a systematically updated and re-issued table of contents shall be produced and included with each supply or additional documents.

The manufacturer shall have to supply entirely all the various files including folders, insets filing boxes, etc.

The manufacturer shall have to define, for each apparatus, the required maintenance operations: lubrications, checking or replacement of wear parts, etc. and shall indicate the following for each of these apparatus:

- the frequency
- the process: locking, drainage, pre-disassembly, etc.
- the special tooling required
- the personnel qualification and quantity requirements
- the approximate duration

3.8 As Built Drawings

The contractor shall prepare the as built and other drawings defined as:

- As built drawing depicting the completed works that have been certified as complete.
- Shop drawings containing information related to the permanent works.

- Working drawings containing information related to the temporary works depicting the construction of permanent works.

3.9 Electronic Drawing Format

All the drawings shall be prepared in AUTOCAD 2020 or latest version which shall be compatible with Windows latest version.

3.10 MODELLING

3.10.1 The Design & Drawings for the Civil, Architectural works shall be done in the BIM 3D or above modeling. The designs and drawings shall be prepared & integrated with the civil/architectural BIM models by the contractor. The latest software's of the Revit, Navisworks of the BIM shall be utilized at the time of designing and clash detection etc.

3.10.2 The contractor shall have to create all the facilities related to the design and modeling related to GAD and other drawings with BIM. It shall be responsibility of the contractor that the design, drawings prepared by him are collaborating with the civil/ architectural or other agencies as deputed by SWC (System wide contractors) for creating the 3D models of their system/works.

3.10.3 Necessary manpower, staff having with requisite skills of BIM and other software's as per requirements shall have to be deployed by the contractor during the designing stage. All the necessary Interface's for the preparation of the 3D model with incorporation of the ROCS/ASS requirements to be done by the contractor. All the correspondence related to the BIM modeling shall be done by the contractor.

3.10.4 Drawings and layouts etc as required shall be extracted from the finalized BIM 3D model shall be submitted to the Engineer in charge for its review and approval.

3.10.5 Further for Project management and updation of site progress Employer may hire Project Management agencies/software (VPP & STAMP etc.). The contractor has to update all the progress daily progress, daily events, daily schedule and work programme on the software/website as directed by the Engineer in charge.

DMRC intent to make payments and Vendor approvals through online portals, the contractor has to depute competent team for online submission and other works related activities. Necessary training for his staff shall have to be arranged by the contractor as per DMRC softwares/websites/portals. Competent persons having experience of online submissions and project monitoring through online portal has to be hired for this work. Approval of Engineer in charge have to be taken for the person being hired with details of work experience.

4. SUMMARY

The work to be performed shall include but not be limited to:

- Providing the required 25 kV/ 33KV cable path from TSS to Feed FP's / AMS to ASS in Underground & Elevated Sections,
- Supply and installation of a duplicate 33 kV Auxiliary Power Network and associated protection, in Underground & specified Elevated portions and in specified elevated/ramp sections, continuous to Underground Sections,
- Supply, installation, testing and commissioning of 33kV/415-Volt Auxiliary Substations, in Underground & Elevated Stations,
- Modification work at desiginated places.
- Provision of all the construction drawings, documents, and as-built drawings required to supply, install, test and commission the above installations.
- Supply of spare parts, tools and equipment for Power Supply
- Deal and resolve in co-ordination with the employer/Employer's Engineer the Interface with other Contractors to ensure timely completion of the Works
- Ensure Technology Transfer and Training to Employer's staff.

Note the entire installations shall :

- be realised to withstand the atmospheric pollution and ambient conditions furnished in General specifications relevant to the location where installed;
- meet the protective provisions relating to electrical safety;
- meet design requirements of fire safety in accordance with NFPA-130 Standard for Fixed Guide-Way Transit System, latest edition, except where amended by this PS.
- Meet the design requirements of Electromagnetic Compatibility in accordance the EN standard 50121-1 to 5 and EN 61000 series.
- Meet the Project Safety and Environment requirements as per “Conditions of contract on Safety & Health and Environment (SHE) ”.

CHAPTER 3

Interfaces

INRODUCTION

1.1 OBJECTIVE

The design and construction of the Delhi Metro Railway, is a complex multidisciplinary project, requiring close interaction and co-ordination between the various designers and builders. The objective of the "Interfacing document" is to define as clearly as possible the Scope of Work of different Agencies, so that the problems which could arise during the Execution Stage are greatly minimized, if not eliminated. Notwithstanding the above, it is imperative that the contractor shall maintain a close Interface with the other concerned Contractors and Design Consultants, so that the problems faced at site, if any, are communicated through 'Interface requests' and discussed in periodical 'Interface meetings', to arrive at logical and expeditious solutions, to ensure smooth progress of physical works and realization of the scheduled dates of completion of works.

1.2 INTERFACING REQUIREMENTS

The following is an indicative list of the Contractors/Consultants/Agencies with whom the concern Contractor shall essentially interface. The List is not, however, exclusive and the Contractor shall ensure that any site problem, as and when it arises, is clearly and conclusively discussed with the appropriate Agency and solutions arrived at.

1) Civil Contractor
2) S&T Contractor
3) SCADA & Elevated line Traction Contractor
4) Track Contractor
5) Rolling Stock Contractor
6) E&M
7) VAC
8) RSS contractor
9) O&M
10) DDCs
11) Any other contractor for associated work.

For detailed interface requirements with above contractors, please refer Appendix-C.

In addition to this, the contractor is also required to interface with some external agencies during execution of the work.

a. Power supply and other agencies
b. Statutory bodies and government/private agencies for the execution of the work. For cabling and other works regular interface may be required with DDA, PWD, IGL, NDMC, MCD, Fire department, DJB, CPWD or any other civic agency under whose jurisdiction the work may be executed etc.

13.1 INTERFACE DETAILS FOR REPORTING

The Contractor shall have to report the interface with relevant contractors/ DDC's and other agencies all aspects of design, installation, testing and commissioning of Works on online portal designated for the same by Employer. Project monitoring is planned via web based system on which day to day reporting related to site progress, difficulties in access, issues related to safety, work programme and other activities are required has to reported, updated by the contractor authorized personals.

DMRC is utilizing STAMP for project monitoring contractor has to report all the updates on same and interface and follow up on online portal.

CHAPTER 4

Testing and Commissioning

Table of Contents

1. TESTING

This Chapter describes the testing & commissioning relating to the Auxiliary Substations and 33 kV Auxiliary Network, in conformity with the requirements of international standards and Railway practices. Testing constitutes an essential obligation to satisfy the Railway System.

1.1 TESTING CONDITIONS AND EQUIPMENT ACCEPTANCE

The contractor will have to carry out all the tests and checks required guaranteeing the Employer of the good construction and the satisfactory operation of all power supply installation.

Also the contractor shall co-ordinate & arranges testing equipment etc. required for testing facilities.

The various high, medium and low voltage equipment will be subjected to all the tests required under equipment test sheets, (lists are not exhaustive) as per the relevant IEC or other standards mentioned in the technical & performance specification of each equipment or otherwise.

It is reminded that the contractor is totally entrusted with full responsibility of assembly and installation of all pieces of equipment mentioned in this specification, with supplying the maintenance equipment and the special tooling which shall be delivered as soon as equipment installation will be completed and with the various duties he is bound to regarding witnessing of tests at commissioning and supervision after energising.

1.1.1 Documents related to the tests

The contractor shall draft and submit to the Employer approval of "the testing lists", which he will have to supply in their final form one month before in-plant acceptance of the equipment.

These lists shall be extremely detailed and include for each piece of equipment:

- The list of the in-plant tests,
- The operating mode (testing procedure) describing how to proceed to perform properly the test,
- The testing book indicating the expected result of the various tests and provision to indicate the obtained result during the test and to record all observations.

For the on-site tests, the contractor will have to draft a testing lists which will include, for each testing stage and for each piece of equipment the list of all the operations to be carried out and the precise mentions, for each of these, of the interventions to be executed, of the references required for proper identification of the equipment (testing procedure) and of the results which can be expected from these tests with provision to indicate the obtained result during the test and to record all observations (testing book).

The contractor will have to supply the various certificates and the relevant computation sheets, at the latest one month after the tests.

1.2 TESTING CONDITIONS

The Employer will appoint representative who will be in charge of supervising the design, the manufacturing and the assembling of the equipment in the contractor's workshops.

They will be empowered to halt the proceeding of any assembly work, which would not be in accordance with the stipulations, and to have replaced every part damaged during assembly or transportation.

They will witness the in-plant tests.

All delays which could arise from additional tests from modifications required due to defects will not be used by the contractor to justify price increase or time extensions.

Each piece of equipment will be subjected to two successive tests: in the plant and on the site after assembly.

These tests will be carried out by the contractor, under his responsibility and in the presence of the Employer and consulting engineer.

Each of these tests will be subjected to a certificate. Provisional acceptance will be granted only after execution of the both sets of tests.

1.2.1 Type test

The contractor shall submit the type test certificates of the material, equipment's, Items, sub-items and all assemblies as proposed for the works as per the vendor approval policy and GS.

For items that are similar to items mentioned in Guidelines for the validity period of type test(s) conducted on major electrical equipment in power transmission issued by Central Electricity Authority-CEA. Type test validity shall be as per clause 2.0 of Guidelines issued by Central Electricity Authority-CEA. For other items validity of type test shall be as GS clause 3.5.1.8

1.2.2 In-plant testing

In plant testing concern type and routine tests

- Type tests are tests performed on one or two of a equipment series
- Routine test are tests performed on each equipment

These tests will enable checking the quality of the equipment and its compliance with the specifications.

Once the Equipment have passed the in-plant acceptance tests, it shall be delivered and installed under the contractor responsibility.

Concerning some type tests, test certificates issued by recognized agencies will be able to be supplied if the contractor cannot carry out these tests himself and if the test certificates are related to a similar equipment of same capacity and design.

However, the tests of checking the operation of isolators and earth isolators will have to be performed as routine test.

The final factory tests will be carried out on the fully assembled equipment as specified. Thereafter, if required and permitted by the technical features of the equipment, the equipment may be dis-assembled for transportation purposes. The dis-assembly should not, however, cause any deterioration of the technical performance of the equipment. In respect of certain routine tests, it may be necessary to repeat the tests at more than one stage, and the Contractor should ensure that this is done, as required by the Employer's representative. The fact that certain tests had to be carried out on the equipment and/or any part, at more than one stage, cannot be claimed by the Contractor, as reason for any failure/sub-standard technical performances of the equipment.

1.2.3 After shipment and Preliminary tests

1.2.3.1 After shipment

It should be performed at this stage the tests verifying that any damage have taken place during transportation.

They should include, at least, the tests listed in the column "after shipment "of each concerned equipment test sheet

1.2.3.2 Preliminary tests

It should be performed at this stage the tests verifying that equipment have been installed and assembled correctly.

They should include, at least, the following:

- All test listed in the column "on site "of each equipment test sheet
- Conformity of the assembly and wiring with the contractor's drawings and instructions
- Sealing of all pipe junctions, and the tightness of bolts and connections;
- Proper function of each part of equipment, of each equipment and of sections
- Cleanliness of installations

1.3 Third Party Testing

Third Party type testing of the materials and components including all type of cables may be conducted under the contract. Random samples of the material shall be taken in the instructions of Engineer in charge. Their samples shall be tested as per the relevant applicable standards mentioned in the contract. Contractor shall facilitate in the collection of the samples and transportation to & from the testing laboratory identified by the engineer in charge. All the costs related to this shall be borne by the contractor. For Third party testing during the course of the contract as applicable for the testing of material at the laboratory anywhere in India shall be paid by the employer. Contractor has to ensure according to the contract specifications. Type, Routine, Sample testing shall be performed as per the contract specification and mentioned standard.

During Third party testing, if a sample fails then the samples shall be collected from the same lot / material and shall be tested for the complete tests (as per the earlier failed sample)

Second sample shall be tested in the laboratory other than the laboratory tested for the first sample.

Second sample if passed the complete testing material shall be put in services at the project. If 2nd sample fails again all the material shall be replaced by the contractor and the delay if any for procurement of the material due to fail shall be considered as non-conformance and applicable penalty may be imposed on the contractor cost of testing the 2nd samples shall be borne by the contractor.

Please refer 3rd Party Testing Policy no DMRC/DE/Instruction/87

1.4 SHORT CIRCUIT TEST OF HV CABLES

In addition to all other required testing, the HV cables shall be tested to verify the short circuit rating of conductor and metallic sheath. Short circuit Test shall be conducted as per the relevant Standard.

If no guidelines are available, all routine tests such as high voltage, partial discharge, electrical parameters etc., to be conducted prior and after performing short circuit test on cables, to prove the integrity of cables under short circuit test.

Contractor shall submit Short-Circuit test Plan for the approval of Engineer.

2. COMMISSIONING

2.1 GENERAL

The Commissioning description, based on the following frame, will have to be defined by the contractor and submitted to the Employer.

Once the contractor will have completed the after-shipment tests, and the various pieces of equipment installation, the assignment should include:

Station/site tests

Putting into service tests

After energising

The Employer and the consulting engineer will be empowered to ask for any additional testing they may deem necessary.

The contractor will have to supply the testing installations and measuring apparatuses required to this effect.

In accordance with the stipulations, provisional acceptance will then take place, followed by final acceptance at the end of the guarantee time.

2.2 STATION TESTS

The testing period shall mandatorily be included in the period of the works stated in the contract project

All putting into tests will be carried out in co-operation with the Employer or its representative.

It should be performed at this stage the tests verifying that the different sections are electrically and mechanically compatible.

They should include, at least, the following:

- Tests requiring several sections to operate at once,
- Internal and between sections operational and safety Interlocking tests,

2.3 PUTTING INTO SERVICE TESTS

It should be performed at this stage the tests verifying that the different equipment are acting correctly when energised.

2.4 INTEGRATED TESTING AND COMMISSIONING

The general testing having shown proper operation, an overall integrated test of the installations, should be performed, after the first 15 days of operation, during which the various actuation and operation situation (putting into service, normal actuation, failure tripping, including SCADA) will be simulated.

2.5 SPECIFIC TESTS

Once the installation of the various pieces of equipment will have been completed, and the common test performed, some equipment will require specific tests.

The list of this tests shall be included in the "On site testing" document, which the contractor will have to supply.

CHAPTER 5

Installation and Construction

1. REQUIREMENTS

1.1 General Requirements

The Contractor shall comply with all Enactments in executing the Works, including but not limited to all statutory provisions on occupational health and safety.

The Contractor shall co-ordinate with Other Contractors in the execution of the Works.

The Contractor shall also co-operate with all Relevant Authorities in the execution of the Works.

The installation of all equipment shall be undertaken at all times by suitably trained and competent employees of the Contractor, to the satisfaction of the Employer's Representative.

Only appropriate tools, plant, equipment and vehicles shall be used.

Installation of all equipment shall be in accordance with the Construction and Installation Plan described in the GS.

Installation of all equipment shall conform to the best industry practices.

Precautions shall be undertaken to ensure the safety of personnel and equipment for all installation works.

The Contractor shall, prior to starting any installation and construction work, identify any possible hazards, and implement measures of eliminating and/or controlling such potential hazards, in line with safe working practices.

Further details on Site safety management are described in Conditions of Contract on Safety & Health and Environment.

The Contractor shall ensure that all areas of work are sufficiently illuminated for the works to be undertaken and that a safe system of work is employed for all activities.

The Contractor shall operate a robust system for the control of persons entering or working upon the site.

The system shall include as a minimum:

- register of all employees;
- personal identification, with photograph;
- levels of competency;
- date of expiry;
- date of issue;
- signature; and
- register of all visitors.

The Contractor shall co-operate, at all times, with the Employer's Representative and Other Contractors to ensure that the Site is protected from unauthorised admission, either wilfully or otherwise.

The Contractor shall make due provision for the safe access and egress to the Site of Works for its staff and subcontractors.

This access shall be maintained such that it is free of all hazards and is in a safe condition throughout the duration of the Works.

1.2 Specific Requirements

The installation and construction work pertaining to this Contract shall include, but not be limited to the following: -

- Finalisation of the Construction and Installation Programme;
- Survey on Site and review the technical requirements shown in this Specification and the Employer's Drawings;
- Production of the calculation sheets and installation drawings for Site installation;
- Production of specific site designs and drawings based on typical designs and drawings supplied;
- Installation in accordance with the finalised installation drawings;
- Co-ordination with Other Contractors;
- Submission of the installation reports and records;
- Testing and commissioning, as per finalised protocol and programme.
- Production of as built drawings, documents, calculation sheets, and records.

1.3 Construction and Installation Plan

The Contractor shall undertake installation work in stages as shown in the detailed installation programme. Installation, testing and commissioning of later stages shall not impact revenue operation of earlier stages.

As a minimum, the detailed Construction and Installation Plan shall include but not be limited to all the activities described in clause 1.1 of this PS and the relevant clause of the GS, installation details and methods of all activities, equipment and tools to be used for installation, safety issues, supervision, temporary land occupation needed and the vehicles to be used for installation.

1.3.1 Manual Handling

To facilitate handling of equipment during installation and maintenance thereafter, the Contractor shall closely co-ordinate and interface with station contractor, Via-ducts contractor, track contractor, depot Contract and Signalling & Telecommunications Contractor for installation of the material handling equipment as below:

- Travelling hoists and unloading jib cranes for traction substations.
- Any other handling arrangement in order to ensure smooth handling of ASS equipment, from point of receipt at site to the final point of installation

The work of installation of the hoists and jib cranes shall be closely co-ordinated with Viaduct and Station Building and track contractors who will have to design the structures, install the beams at appropriate locations and provide the hoists and jib cranes.

The entire material handling plan for movement of bulky item such as OHE Conductors, Steel and Concrete masts, 33 kV cables, 33 kV & 25 kV Switchgear and Transformer at Auxiliary Substations etc, shall be carefully planned.

1.4 Works Area

The Contractor will be given temporary work sites as stipulated in this Specification.

The Contractor shall comply with the requirements specified in the relevant Chapter of the GS in relation to the use of works sites allocated to the Contractor.

1.5 Temporary Works

The design of the Temporary Works shall be submitted to the Employer's Representative for review.

All Temporary Works shall be removed on completion of the Section, or as directed by the Employer's Representative.

All Temporary Works shall be clearly distinguishable from the Permanent Works.

1.6 Works Train

The Contractor shall provide for himself the required number of Work Trains for Construction, considering the necessity to work on multiple Corridors simultaneously. A minimum of 3 work trains is considered necessary.

For the use of any Works Train, the Contractor shall ensure its safe loading, restraint against shifting while in motion and that the dimensions of materials and/or equipment carried shall not exceed the space constraints (Schedule of moving dimensions) and that no other track related installation will be damaged during its use.

The Contractor is advised to carefully consider the works train design so that the working platform have the flexibility to enable this train to pass the height restriction and yet be of sufficient height for safe and efficient installation of OHE when on site.

1.7 Site Supervision and Safety Issues

The Contractor shall set up a Site supervision system, which shall be part of the overall safety, system assurance and quality management system.

Details of Health and Safety requirements at Site are described in the relevant Chapter of the GS.

The Contractor shall adopt an appropriate quality management system throughout the entire Site installation period to ensure that the System performance requirements as specified in this PS are achieved.

The Contractor shall provide sufficient number of suitably experienced supervisors and skilled workers to ensure that the progress and quality of the work, both on Site and in the Contractor's workshops, are maintained to the satisfaction of the Employer's Representative.

Supervisors shall have a minimum of five years' previous experience in a supervisory capacity on similar projects and all the skilled workers including linesmen electricians fitters and craftsmen, shall have a minimum of two years' previous experience in installation of similar systems.

The Contractor's supervision system shall be responsible not only for the supervision of the concerned system installation but also for the supervision of the installation of the primary fixing system (mast foundation), the earth mats and systems, etc. The supervisors shall work on a full-time basis during the entire installation process.

The Contractor shall maintain a set of drawings at each project site which accurately reflect the current status of field changes. The Contractor shall obtain letter of no objection from the Employer's Representative for any such changes. The Contractor shall prepare final drawings showing the as built configuration. These drawings shall be developed in a logical format to facilitate routine system maintenance and troubleshooting. All drawings and details shall be endorsed by the Contractor.

The Employer's Representative reserves the right to undertake, at any time, checks on the proficiency of the Contractors staff, licensing and all associated documentation. Should any of the Contractor's staff be found incompetent or unlicensed he shall be removed from the site until their Competency has been established.

1.8 Installation of Cables

The Contractor shall co-ordinate with the Civil Contractors wherever necessary, for the installation of cables in cable galleries, trenches, ducts, troughs, risers and other locations.

The cable system shall, during installation, be fully protected from mechanical damage and be generally accessible at all points for inspection along its entire route. Suitable cable markers shall be provided for covered cables upon completion of installation.

Should it prove necessary to cut any cable during installation, all cut ends shall be properly sealed.

The maximum pulling force of any cable during installation shall not exceed the design force of cables.

All cables shall be installed in the formed cable trenches, shafts, hangers, trays and brackets. The minimum recommended bending radius of the cables shall be adhered to during installation.

All materials used for termination, jointing and installation of cables in confined spaces shall have flame retardant, low smoke, halogen free characteristics.

1.9 Workmanship

All the installation shall be carried out according to the instructions shown in this Specification and Employer's Drawings.

All assemblies of equipment and their components and parts shall be completely interchangeable if they are of similar type

The style and procedure of the workmanship shall be consistent throughout the Works.

Unless otherwise specified, the Employer's Representative shall decide the final colours for all paint work and other finishes to be applied to any part of the Works.

All parts, which are subject to, wear or damage by dust shall be completely enclosed in dust proof housings.

2. PROGRAMME REQUIREMENT

2.1 GENERAL

The Contractor shall prepare a detailed plan of all activities and submit to the Employer for approval. The plan shall be prepared in such a manner that all activities are properly correlated and all activities are completed within the scheduled time to ensure target dates for commercial operations.

This Specification specifies Revenue Operation Dates, Key Dates and Access Dates specific to this contract.

The date of commencement of commercial operations shall be referred to as Revenue Operation Date (ROD).

The expected date of Revenue Operation Date (ROD), for the various Sections/Corridors have been given in Bidding Forms.

Accordingly, the Power Supply works in the Section, shall be ready for commissioning at least 6 months before the specified ROD.

In addition to the requirements specified in the General Specification, the Contractor shall programme the Works in accordance with a pre-determined sequence to meet various Key Dates and Access Dates so as to meet the Target Dates of commercial opening.

2.2 CHANGE IN KEY DATES (KD) AND ACCCESS DATES (AD)

The bidder's attention is invited to the various Key Dates and Access Dates, described in the subsequent paragraphs. It is essential that the Contractor shall achieve the identified work by the specified Key Date mentioned against it, failing which Liquidated Damages shall become leviable as set out in the Contract.

The access dates are dependent on other agencies/system contractor e.g. station building contractor, viaduct contractor, track work contractor etc. involved in the project. The contractor shall interface and maintain close liason with other agencies for timely availability of the access. In case the contractor finds that there is slippage and the likely access may not be adhered to, the contractor shall inform the employer well in advance for the likely delays in access to site.

The Employer will, on his part, make all efforts to provide to the Contractor access to information as well as to various locations at stations/track/viaduct, in stages, in order to plan/execute his activities for time-bound completion of his obligations under the Contract, as per the Access Dates mentioned in the subsequent paragraphs. If, however, due to any reasons, the Employer is not in a position to provide access or shared access, as per the stated Access Dates, the Employer, in these circumstances, will inform the Contractor, in writing, about the proposed revised Access Date, at least 8 weeks before the scheduled Access Date. The Contractor shall suitably make necessary changes in his Work Program and shall ensure that, irrespective of the revised Access Dates, the concerned Key Dates are adhered to.

Wherever the access dates overlap, the contractor shall ensure that there is sufficient resources to meet the key dates. Multiple work front availability should not hamper the execution schedule, necessary agumentation of manpower, machinery, equipment, personals may be done by the contractor to meet the targets as per the available access.

2.2.1

a. Work may be done under power block during day or night as required due to operational requirement or train trials or as per circumstances. The contractor has to depute sufficient staff/manpower for work in shifts and execute the work according the acess available. For the works which are in existing operating network, the power block schedule will be prepared by DMRC O&M, the contractor has to submit the weekly work planning schedule in advance for incorporation in the O&M power block schedule. A personal shall be deputed by the contractor for interface and co-ordination with the DMRC O&M and other agencies.

b. Various sections of main line are generally planned to be commissioned in different stages as defined under respective key dates. These sections on main lines / depots may further be split up into additional stages. Contractor shall take into account such situations & schedule his work activities accordingly Contractor shall not have any extra claim on such accounts.

2.3 KEY DATES

Key dates are dates which are to be achieved by the Contractor and which are considered to be essential for the successful completion of the Project to the original planned schedule.

Each Key Date includes a number of stages. These stages are inter-related with a flow of activities for the purpose of effective monitoring and implementation; certain intermediate stages have been identified for each Key Date, These are essential to the completion of the Site Development, Construction, supply, Installation testing and commissioning of power supply, power distribution and Auxiliary Substations in the Section/Corridor. The time schedule for these stages has been defined in the Key Dates.

The Key Dates indicated in the Schedule of Key Dates are mentioned in terms of the time period reckoned from the commencement of the works, and the deliverables for each Key Date shall be achieved by the midnight of the last day of the week mentioned.

If the identified work is not achieved by the stated Key Dates, liquidated damages may become applicable as set out in the Contract.

Interfacing with relevant Designated Contractors and other agencies for achievement of Key Dates shall be the responsibility of Contractor.

As per the requirements of Chapter-3 of the General Specification, the Contractor shall submit the Work Program and other sub programs such as Procurement & Manufacturing Program, Installation Program etc. duly complying with the below Key Dates, to the Engineer for approval. Optimum scheduling of the material procurement shall be ensured in tandem with the commissioning and ROD requirements. The Contractor shall go ahead with procurement only after the Procurement Program along with procurement specification of the equipment / material has been approved by the Engineer. "No-Objection" in respect of manufacturer / vendor / subcontractor for material / equipment shall be obtained from Engineer before placement of orders.

The work program prepared may have to be updated on STAMP, the contractor has to prepare the work program in format/software compatible to the STAMP. Any manpower required for this work has to be deployed by the contractor.

The monthly progress reports and site progress status, daily progress, safety reports etc with site pictures have to be updated on a common portal used for phase-IV. All contractor site supervisors may be informed to download the portal access programs and login ID and other details shall be provided by the Employer. All staff deployed by the contractor should be conversent the requirement of STAMP and other portals, necessary training if required shall have to be arranged by the contractor at his own cost.

Description of each Key Date is as detailed below:

2.3.1 STAGE 1 – Key Date 1 to Key Date 5 (KD-1 to KD-5) : Commissioning of ASS’s

Achievement : Commissioning of Auxiliary Sub stations, after completing erection of all equipments at various ASSs, as per specifications in the GS and PS of this Tender, for achieving these Key Dates.

2.3.2 STAGE 2– Key Date 6 (KD 6): Completion of the acceptance test after integerating testing of SCADA.

Achievement : Completion of Integrated Testing, completion of all finishing works and carrying out service trials for satisfactory operation of the System.

2.3.3 STAGE 3– Key Date 7 (KD 7): Taking over of the system

Achievement : After completion of all works and satisfactory trial running of system. Supply of “As built” drawings and training and supply of manuals / documents as laid down in the Specifications, will also required to be completed in time including approval of the Commissioner of Metro Railway Safety.

2.4 ACCESS DATES

The Contractor will require access to information as well as to various locations at station/track/viaduct, etc., in stages, in order to plan his activities for time-bound completion of his obligations under the Contract.

The dates on which such access becomes available will be provided after award of the work and contractor shall update the work program to achieve the key dates.

Please refer Bidding Forms for details of key dates.

CHAPTER 6

Maintenance & Training

CONTENTS

1. INTRODUCTION

This Chapter describes the maintenance philosophy and training of maintenance staff for power supply, control & monitoring installations taking into account international standards and Railway practices.

The Contractor shall provide comprehensive training and documentation to the employer’s staff in accordance with the requirement of this chapter and the chapter of General Specifications.

This training shall enable all the installations, to be operated and maintained in the most efficient and safe manner, so as to achieve the maximum reliability and economy required by such Mass Rapid Transit System.

2. GENERAL PRINCIPLES OF AN EFFICIENT MAINTENANCE SYSTEM

The maintenance philosophy and management described below should be seen within the framework of the state of the art and the general prevailing reference standards with regard to the maintenance of durable goods (in particular, standards X60-000, X60-010 and X 60-020 AFNOR) ISO 55000 standards and other Industrial maintenance standards .

As regards the implementation of these philosophy and practices, they are based to a large extent on those which have been in service on the French Railways (SNCF) for very many years (and particularly within the field of high-speed railway transportation).

They therefore benefit from the results of long practical experiences, along with numerous observations, reflections and experiments which have provided a means of optimising both the quality of the service offered (safety, regularity) and the cost of obtaining this level of quality.

This experience has demonstrated that, within the field of maintenance, sources of considerable progress can be derived from the interactive upgrading of the three essential components, namely man, the equipment and the procedures.

2.1 Maintenance Management

The management of the maintenance process entails defining various levels of responsibility and enabling them to implement the strategic orientations defined by the directing authority:

by defining their respective missions,

by setting objectives for each person,

by translating these objectives into action plans,

by implementing the means required to carry out action plans,

by diagnosing the causes of any deviation from the set objectives,

- by taking corrective measures concerning the action plans or the objectives

This management process requires a global approach and helps to improve the performance of the maintenance work of different components with quality, on time and at low cost.

It must be implemented at three levels:

at the level of human resources and management in the context of the scheduling of work, the allocation of human resources and the training of personnel,

at the skills level to ensure quality, safety and suitable working conditions,

at an economic and financial level to ensure responsible management of production, spare parts, purchasing and miscellaneous costs.

The quality of this management depends on the capability of those entrusted with operation and maintenance responsibilities:

to exploit the results of management within their field of responsibility,

to react in the event of any deviation from the action plans defined with a view to achieving the set objectives.

Within the context of this approach, the management control function ensures timely advice to be given to those with operational and maintenance responsibility:

by placing at their disposal the tools and information required for piloting and diagnosis,

by participating in carrying out this diagnosis,

by participating in the task of defining the objectives to be achieved.

In conclusion, the process of maintenance management must incorporate two major components: the management of human resources and the study of the most suitable means of achieving the set objectives.

This is one of the first guidelines of maintenance organization in the various relevant centres

3. IMPLEMENTATION OF MAINTENANCE

3.1 The Levels of Preventive Maintenance

The maintenance plan is based on four levels of preventive maintenance which differ according to the nature and scope of the interventions carried out there:

level 1: systematic in-service examinations, which provide a means of detecting (without any specific tools and by personnel who are not necessarily skilled) any anomalies which may have occurred in service according to a random or fortuitous process, and which may affect traffic and safety,

level 2: systematic periodic inspections, which allow skilled personnel to ensure that, taking account of the service to be provided until the next scheduled intervention of similar importance, the equipment or the element inspected offers predetermined guarantees of reliability.

level 3: the replacement of elements which are triggered within the framework of systematic preventive maintenance (when the element reaches the end of the programmed potential) or conditional maintenance (when it is noted in the course of an inspection that the normal operation threshold criteria have been reached), but also within the framework of corrective maintenance,

level 4: interventions on dismantled elements and structural equipment (such as body) carried out to restore the elements concerned to the same level of operation as an identical new one. These interventions (or overhaul operations) usually involve resources related to a reconstruction of the element in question.

The frequency of the maintenance operations defined in the cycle can be expressed either in time (e.g.: every 6 months) or in units of actual utilization (e.g., months of operation, electrical power or current flowing through an equipment, mechanical wearing). The choice depends essentially on the foreseeable or observed disparity in service of elements belonging to the same family within the relevant cycle.

3.2 Determining Requirements in Terms of Facilities and Tools

The achievement of the objectives assigned to the maintenance division with regard to quality, safety and regularity for the lowest possible overall cost requires the implementation of a number of resources which must be perfectly tailored to the requirements.

The facilities and tools are part and parcel of the resources placed at the disposal of the maintenance division to achieve the set objectives.

Owing to the cost of these facilities, the number of maintenance center to be equipped and the necessity of keeping the maintenance actions consistent and uniform, the main choices of facilities and tools are integral part of the System maintenance policy and program.

When determining these requirements, in-depth knowledge in the dedicated maintenance plan is needed while taking due account of the experience acquired in similar fixed installation which has been in service for several years.

4. SUPERVISION AND PLANNING OF MAINTENANCE

4.1 General

The scope and requirements of supervision and planning of maintenance are stipulated in the GS.

The following outlines the Employer's maintenance strategy, different levels of maintenance, the Maintenance Management System and the arrangement for maintenance.

The Contractor shall make use of all relevant information to provide supervision of maintenance.

4.2 Employer's Maintenance Strategy

4.2.1 Maintenance Strategy

The Contractor shall ensure that the design of the software and hardware of the system designed, installed and commissioned is supportable throughout the service life of the System to address, as a minimum, the following:

Design errors in the System;

operational changes;

environment changes; and

Changes in infrastructure.

According to the maintenance strategy, all equipment and infrastructure supplied for the 'Project' must be such as to ensure for minimum or no maintenance. Maintenance activities required must be capable of being performed with little or no impact on the train service. In addition, the maintenance work systems shall ensure safety of personnel and equipment.

During the Defects Liability Period (DLP) maintenance of all Works will be conducted by the Employer under the supervision of the Contractor initially for 02 months from start of DLP. Further extensions if required shall be communicated by the Engineer after start of DLP.

The Contractor shall ensure that in order to supervise maintenance during the DLP, personnel are always available with the relevant skills and level of competence.

The Contractor, upon noticing any defects, deficiency in quality and quantity of spares and materials shall without delay, arrange for alternative source of supply and submit his proposal to the Employer's Representative for review.

4.3 Different Levels of Planned Maintenance

Routine preventative maintenance will be carried out at regular intervals based on condition, reliability, usage, and service history and equipment manufacturers' recommendations. The Operating and Maintenance Manual shall describe the different levels of planned maintenance.

4.4 Supervisory Staff

The Contractor shall provide supervisory maintenance staff who are expert in all the different levels of fault finding, maintenance and repair of the various relevant systems supplied under the Contract:

25 kV ROCS

Switching Stations, including associated switchgear.

Cabling system

Auxiliary Substations

SCADA Integration

Stipulations of the relevant clauses of the GS shall apply here.

4.5 Maintenance During DLP

4.5.1 Maintenance Management System (MMS) and Maintenance Arrangement

During non-operation time, sections of line will be closed for maintenance work. The minimum time for possession periods is 3 hours. Ideally, this time shall be the free time available for work. It excludes time required for trains to return to their stabling point and time required to take and give up possession. This time is, however, not available for maintenance in depot.

4.5.2 Competency of Personnel

During the DLP the Contractor shall support the Employer with sufficient trained and competent personnel.

Such persons shall have their generic competence established and must demonstrate their specific competence and knowledge in the particular systems, environment and procedures.

The Contractor shall provide evidence of specific competence and knowledge, which shall include:

assessment and certified training in particular software applications and operations;

recording of competence and work in the license holders logbook; and

receiving or in receipt of sufficient and current exposure to the area of work that the holder is licensed for.

Routine spot checks on licensing may be carried out from time to time by the Employer's Representative qualified personnel on the proficiency of the Contractor staff.

In the event of a failure, the Contractor shall undertake the management and investigation necessary to identify and rectify the cause.

Should the Employer, during the DLP require further investigations at other Sites throughout the system, the Employer will formally request the Contractor to undertake such investigations.

4.5.3 Maintenance requirements

Testing and Re-commissioning of System and Equipment

In the event of a failure requiring modifications to the System, the Contractor shall undertake any testing and re-commissioning required.

Any such modification shall be submitted for Employer's Representative review.

Temporary Alterations to Restore Service

The Contractor shall undertake any temporary modifications necessary to maintain service.

Any such modification shall be submitted for Employer's Representative review.

Discrepancies between Installation and Design Records

Should the Contractor discover inconsistencies between the maintenance drawings and documentation and the installed equipment, the Contractor shall correct all such errors within two weeks.

Communications

The Contractor shall ensure that adequate communication facilities are provided to its staff during the DLP.

Location of Staff

The Contractor shall be responsible for locating staff such that the Contractor meets its obligations.

Storage of Equipment and Materials During the Maintenance Period

The Contractor shall ensure that no equipment is to be stored along the trackside.

The Employer will provide defined storage locations for the support all the different levels of Maintenance.

The Contractor shall satisfy itself and the Employer's Representative that the storage locations for equipment and materials will meet the performance requirements of this PS.

Maintenance Regimes

The Contractor shall provide documented maintenance regimes to be followed by the Employer upon substantial completion of various components of the work until the end of the DLP.

The Contractor shall produce a maintenance regime for the equipment that shall comprise two constituent parts, corrective and routine/preventative maintenance.

Routine/preventative maintenance shall be non-intrusive to the day-to-day operation of the train service and be capable of being pre-planned in advance of the work.

Corrective maintenance shall be available 24 hours per day, able to respond to all foreseeable circumstances.

The maintenance regime shall cover all parts and equipment of the system designed, installed and commissioned by the Contractor.

The Contractor shall take into account the requirements of the operations and maintenance when determining and proposing its maintenance regime.

Scope and Hours of Coverage

The regime and structure of corrective maintenance shall be robust in design.

The Contractor shall provide a full 24 hour On-Call coverage and shall be such that initial response and rectification of failure are in accordance with the following:

assistance to first level and corrective maintenance within 30 minutes, upon request of first line maintainer;

24 hour from notification to collection for third level maintenance; and

Replacement or repair of component from factory within 2 weeks including transportation time. Any extension to this time shall be agreed with the Employers and a replacement provided.

All elements of First Line preventative maintenance shall be carried out and completed during non-traffic hours without interrupting train services.

Failure Investigations

The Contractor shall conduct failure investigations.

The OCC Controller will determine priorities in the event of a conflict between the Contractor and other Contractors during failure investigation.

Disputes between the Contractor and other Contractors will be resolved by the Employer's Representative.

The Contractor shall make available to the Employer all test and failure data as required.

4.6 Software Support

4.6.1 General

The Contractor shall submit to the Employer's Representative for review, the software support plan at least 90 days before commencement of software installation.

All changes, bug fixes, updates, modifications, amendments, new versions shall not result in any non-conformance with this Specification.

The Contractor shall submit all new versions to the Employer's Representative for review at least 2 weeks prior to their installation.

The new versions of software shall not degrade the operation of the System.

4.6.2 Security Obligations

Within 14 days of the installation of any software into the Permanent Works by the Contractor, the Contractor shall submit to the Employer's Representative for retention by the Employer two back up copies of the software, which shall include, without limitation :

a) all source and executable code;

b) all design documentation relating to the software; and

c) any specified development tools required for maintenance of the software, including, but not limited to, editors, compilers and linkers.

Any software item delivered by the Contractor to the Employer's Representative pursuant to the above Paragraph shall not be translated or modified by the Employer without the prior consent of the Contractor unless:

a) the owner of the software becomes insolvent or has a receiving order made against it or makes an arrangement or assignment or composition with or in favour of its creditors (including the appointment of a committee of inspection) or goes into liquidation or commences to be wound up or has a receiver, liquidator, trustee or similar officer appointed over all or any part of its undertaking or assets or if distress, execution or attachment is levied on, or if an encumbrance takes possession of, any of its assets or any proceeding or step is taken which has an effect comparable to the foregoing in any relevant jurisdiction; or

b) the owner of the software ceases to trade; or

c) the owner of the software assigns copyright in the software and the Contractor fails within 60 days of such assignment to procure in favour of the Employer, a licence from the new owner in the same terms as that required by the Contract; or

d) the Contractor is in breach of any of his obligations under the Contract.

4.6.3 **Other obligations**

Error Correction

The Contractor shall inform the Employer’s Representative immediately when a fault is discovered within delivered software or documentation.

On receipt of a request from the Employer’s Representative for identification or further diagnosis of a failure or fault, the Contractor shall provide appropriate resources.

The Contractor shall provide written details as to the nature of the proposed correction to the Employer’s Representative.

Training

The Contractor shall provide training for Employer's staff to enable the Employer to make proper use of any new versions.

Fixes or Patches

The Contractor shall notify the Employer promptly of any fixes or patches that are available to correct or patch faults.

The Contractor shall detail any effect such fixes or patches are expected to have, upon the System.

New Versions

The Contractor shall ensure that all new versions are fully tested and validated on the simulation and development system prior to installation.

The Contractor shall ensure that all new versions are fully tested and commissioned once installed on the Site.

The Contractor shall deliver to the Employer any new version, together with the updated Operation and Maintenance Manuals. The Employer shall not be obliged to use any new version and that shall not relieve the Contractor of any of its obligations.

Any effect upon the performance or operation of System that may be caused by a new version shall be brought to the Employer's attention.

Debugging and Trace Software

The Contractor shall provide debugging or trace logging software.

The Contractor shall not install debugging or trace logging software that affects the performance or functionality of the System.

Routine and Corrective Maintenance Procedures

Routine and corrective maintenance procedures shall be supplied for all equipment. The format shall be as follows:

a) Uniform format and layout irrespective of equipment supplier;

b) Colour coding for each activity;

c) Cross referenced to the Operation and Maintenance Manuals; and

d) Document control information.

Operation Activities

All operational activities shall comply with the Employer's safety rules, and requirements of the Operation and Maintenance Manuals.

The Contractor shall recommend in detail the frequencies for preventive and corrective maintenance, and what items of work are to be carried, including but not limited to the following:

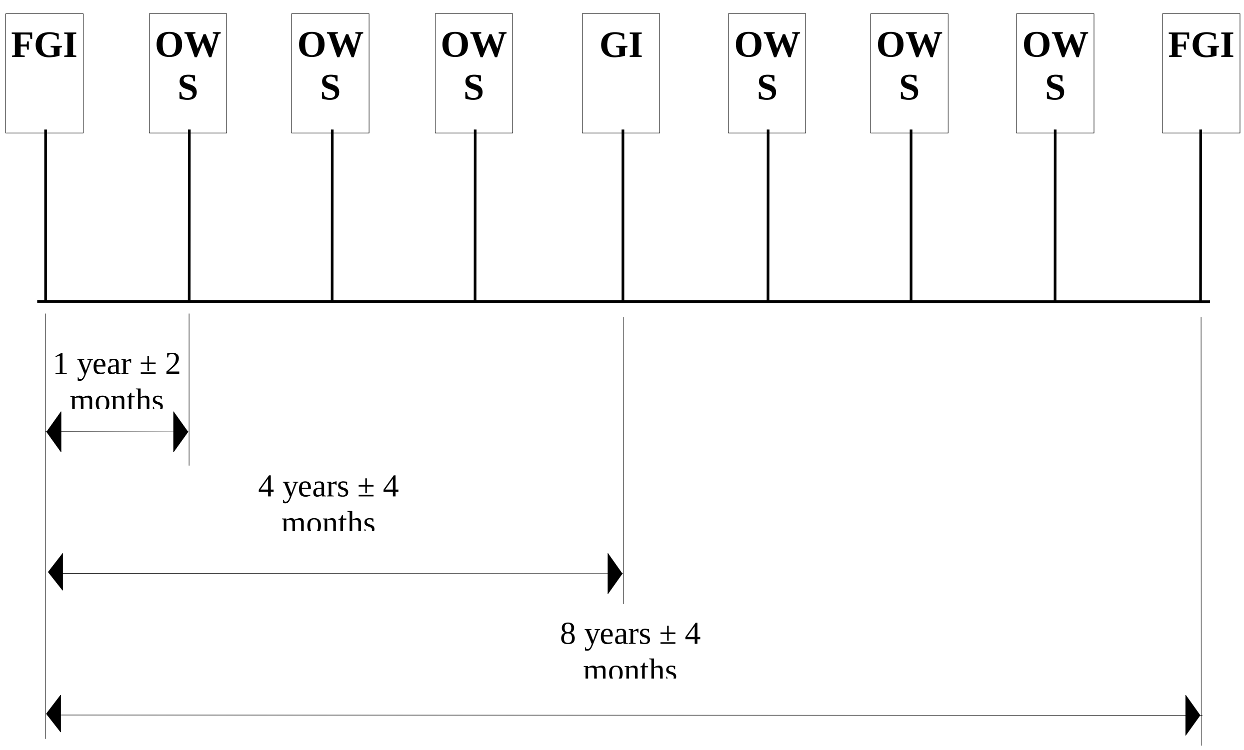
a) Step-by-Step procedure to carry out the task;

b) Diagrams and flow charts for illustration, if applicable;

c) Precautions for the maintenance personnel to follow; and

d) Estimated duration and manpower required.

4.7 Preventive maintenance periodic inspections cycle



FGI : Full General Inspection

OWS : Other Works Systematic

GI : General Inspection

5. OPERATION AND MAINTENANCE DOCUMENTATION

5.1 General

The Contractor shall provide Operation and Maintenance manuals, for use by supervisory, operating and technical staff of Employer.

Requirements of submission have been furnished in the relevant Chapter of GS.

Each and every manual shall be divided into indexed sections explaining the subject matter in logical steps.

Most manuals shall consist of A4-size printed sheets bound in stiff-cover wear-resistant binders clearly and uniformly marked with the subject matter and reference number.

Where alternative sizes are proposed, (e.g. A5/A6 pocket books of schematic wiring diagrams) these shall be submitted for review of Employer' Representative.

The binding shall allow for all subsequent changes and additions to be readily effected.

Information shall be provided in pictorial form wherever possible and shall include step-by-step instructions and views of the particular equipment including exploded views.

Programmable equipment shall be supplied with sufficient flow charts and fully documented programs to enable faults to be quickly identified and system modification to be undertaken at any time.

The Contractor shall provide clarifications and amendments to the Operation and Maintenance manuals as necessary during the Defects Liability Period. Updates shall be provided for the originals and all copies.

5.2 Operation Manuals

The Contractor shall provide operation manuals explaining the purpose and operation of the complete system together with its component subsidiary systems and individual item of equipment. The characteristics, ratings and any necessary operating limits of the Equipment and Sub-systems shall be provided. The Operation Manuals shall focus on operation aspects under normal and emergency conditions.

5.3 Maintenance Manuals

The Contractor particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing programme.

The Contractor shall provide documentation for all hardware and software for computer systems and other associated electronic equipment to meet the following requirements.

Such documents shall include but not be limited to:

manufacturers' documentation supplied as standard with the equipment;

hardware configuration with details of expansion capabilities and options;

programme loading instructions, including runtime environment configuration;

programme listing including comprehensive 'comment statements' in hard copy and soft format for source code, compilers and development tools necessary to modify and recompile software;

flow charts, data flow diagrams and state diagrams as appropriate;

description of software modules including purpose, linkage with other modules, error routines and any special considerations;

memory maps for both internal and peripheral memory showing description of all programmes, data files, overlay areas, memory available for expansion and the like;

loading and operating instructions for diagnostic programmes and specifically developed debugging tools; and

programming manuals relevant to operating systems, languages, development tools, etc.

The manual shall also include inspection/overhaul procedure and periodicity of various inspection/overhaul schedules in detail including the tools, special tools/plants, and facilities required.

The manual shall be subject to review by the Employer's Representative.

The maintenance manual shall also include an illustrated parts catalogue of all plant supplied and shall contain sufficient information to identify and requisition the appropriate part by maintenance staff.

The catalogue shall comprise 3 sub-sections.

The first shall be an alphanumeric parts list, which shall include the following information:

Part number

Description

Name of manufacturer

Quantity and Unit

Part number of next higher assembly (usually a line replaceable unit).

Cross-reference to figure number.

Category: e.g. consumable, line replaceable unit, repairable.

Life-expected life, Mean time between failure or mean distance between failure where available.

General or specific purpose

The second is a series of illustrations to indicate the location of each replaceable item which shall be clear and progressive with exploded views to enable parts to be identified easily by cross-reference with the alpha-numeric list.

And the third an indicative price list which shall list in alpha-numeric sequence the part number with the price, lead time and vendor.

5.4 Quantity of Manuals

The Contractor shall supply Original plus two hard copies of Operating Manuals; Maintenance Manuals and Subsystems / Systems spare parts catalogue.

These Manuals and Catalogue shall also be submitted in electronic format in portable hard disks.

The format of the electronic copies shall be proven in at least two other applications and shall allow for links between parts catalogue and maintenance instructions.

The Documents Management System and Language used shall be subject to Employer's Representative's review.

6. TRAINING

6.1 General Requirements

The Contractor keeping the above aspect in view shall provide comprehensive training to the Employer's staff in accordance with the requirements contained in this PS and in the GS. A central training school has to be been planned for this purpose.

The training shall be carried out at such locations where the greatest benefit for trainees may be gained. All places of training shall be subject to review by Employer's Representative.

The training courses and/or sessions shall include system performance requirements and all major equipment and works designed, by the Contractor.

The specific objectives of each course, training facilities to be used, the qualification and experience of the training instructors and the assessment criteria shall be developed by the Contractor and submitted to the Employer's Representative for review at least three months before any course is conducted.

Manuals to be used for training, including the manuals to the instructors and trainees, shall be delivered to the Employer's Representative **at least six months before the issue of the Substantial Completion Certificate for the Works**, as required under the relevant Chapter of the GS. The training manuals shall be submitted in original plus **Two** hard copies and in electronic format in portable hard disks.

The Contractor shall provide full-time on-Site management and co-ordination of the entire training programme to ensure the continuity of classes, and proper distribution of training materials, and be responsible for interfacing with the instructors.

The training courses shall be delivered to all relevant Employer's staff, including instructors, operation and maintenance engineering staff.

The proposed training requirements are given at the end of this Chapter.

There shall be no separate cost for training and other related requirements. Cost has been included in overall cost of contract.

6.2 Mock-Up for Training

The Contractor shall install mock-up equipment for system and any such facility(s) considered necessary for the training of Employer’s staff in the training school.

The training mock-up shall include but not limited to the following: -

Clear Cut Section drawings / photographs of various power supply equipments such as Circuit Breakers, Interrupters, Current Transformers, Potential Transformers, Lightning Arresters and Isolators.

Cut Section drawings / photographs of HV & MV cables

Cut Section drawings / photographs of Gas Insulated Switchgear

Clear photographs of transformers, their windings,bushings etc.

Samples of various clamps and fittings used

Samples of various conductors used

Clear drawings and photographs of Control panel, protection schemes, earthing and bonding arrangement;

The Contractor shall submit full details of the training span and other mock up equipment, photographs etc. including proposed training activities and objectives, for the Employer’s review in accordance with clause 6.1 of this Specification.

6.3 Training Plan

The Contractor shall submit a Training Plan in accordance with the requirements of the General Specification. In addition, the Training Plan shall include the following:

Details of the Contractor’s ability to carry out the necessary training.

Details of the proposed approach to structuring and providing the courses required.

Course details including duration, maximum number of trainees, ratio of trainees to trainers, facilities required or available and prerequisites for attending the course.

Recommendations for additional training or alternative means by which the Employer’s training objectives may be met.

The Training Plan shall be submitted for review by the Employer’s Representative and will be implemented in a timeframe such that complete and comprehensive training has been received by the designated Employer’s staff prior to the System Acceptance test.

6.3.1 Training of Employer's Training Instructors (ETI)

The objective of the training is to enable the Employer's Training Instructors to be competent to deliver future training courses for other employees of the Employer.

The Contractor shall provide training to the Employer's Training Instructors on the various Systems. Aspects covered shall include, but not be limited to, the following:

Configuration of the entire System, including interface with the supply system at the feeding points;

Feature and functional principles of the entire System;

System design aspects including but not limited to design standards, design criteria and parameters, short-circuit and other calculations, insulation and protection co-ordination;

Details of major equipment and material including but not limited to 25kV circuit breakers, interrupters, isolators, voltage and current transformers, Conductors, fittings, assemblies and protection relays, and cables of different types and their joints used in the System;

Details of 33 kV Switchgear and protection;

System operation and maintenance management and procedures;

Earthing and bonding arrangement, covering safety aspects of touch and step potential, safety to personnel, passengers and outsiders.

SCADA Integration.

6.3.2 Operations Staff Training

The objective of the training is to enable the Employer's operations staff to be familiar with the Systems, with focus on the operational aspects under normal and emergency conditions.

The training shall also enable the trainee to acquire full capability for identification, trouble shooting and rectification of faults in the specified duration. After classroom training which includes mock ups of equipment, the staff shall be trained in actual operation.

6.3.3 Maintenance Staff Training

The objective of the training is to enable the Employer's maintenance staff and Engineering staff to be familiar with the Systems focus on the maintenance aspects of the System including but not limited to the following:-

Full understanding of all the equipment, sub-systems and system, their function, maintenance and overall requirements.

Procedures to be followed for unscheduled maintenance and repair.

Identification of failed components and sub-systems in electronic equipment by use of special test kit as necessary.

Modification in the software to extend or modify the control, monitoring and protection functions.

6.4 Computer Based Training (CBT)

The Contractor shall submit, for the Employer's Representative's review, the following CBT information documents:

Operation of the Auxiliary Power Systems;

Maintenance of Auxiliary Power Systems;

Operation Bay Controllers;

Operation of Substation Automation System;

The CBT Information Document on Operation of individual System shall contain, but not be limited to, the following:

General introduction of the System, its functionality and objectives (including the RAMS requirement);

Single line diagrams;

Description of the System operation principles, for both normal and emergency operation conditions;

An overview on the System configuration, including interface with other agencies;

General description of the functions of each key equipment and components of the System with photographs showing the appearance of each of them;

Where they are located throughout the System;

List of potential hazards that may arise in operating the System; and

Any specific points to note in operating the System to ensure safety to personnel (the Employer's staff and members of the public) and equipment.

Electric shock treatment.

The CBT Information Document on Maintenance of individual System shall contain, but not be limited to, the following:

General description of the functions of key components of the System, with photographs showing the appearance of each of them;

A general description of the proposed maintenance strategy of the System and major components;

The maintenance plan and procedures proposed for the System and major components in accordance with the MMS;

A general description of the 1st, 2nd 3rd and 4th maintenance activities (as described above) required for the System and major components;

An introduction to the special tools and equipment required for maintaining the System and major components;

A description of the symptoms of the common faults found on the System;

Simulation of faults on the entire System, and how to promptly restore the system; and

Other points to be noted in effectively maintaining the System.

6.5 TRAINING REQUIREMENTS

Table 2 - Man-Weeks of Contractor's Training Instructors for training Employer's operating personnel in India.

Description	Man-weeks
GIS,AIS and other switchgear	4
Cables & Transformers	
Electrical safety & Earthing	
SCADA Integration	

Table 3 - Man-Weeks of Contractor's Training Instructors for training Employer's maintenance personnel in India.

Description	Man-weeks
GIS,AIS and other switchgear	4
Cables & Transformers	
Electrical safety & Earthing	
SCADA Integration	

CHAPTER 7

Definition and Lists

Table of Contents

1. DRAWINGS LIST

1.1 SECTION DETAILS

Sr. No.	DRAWING DESCRIPTION
	AUXILIARY NETWORK DRAWINGS
1	
2	

2. MAIN APPLICABLE INTERNATIONAL STANDARDS

All equipment of the Contract shall comply with the EMC standards EN 50-121-1 to 5. Concerning the tests, when not defined into the EN 50121, the equipment shall comply with the relevant EMC standard of the series IEC 61000.

Standard Number	Title
IEC 38	IEC standard voltage
IEC 44-6	Instructions related to protection current transformer for transient state response
IEC 62271-100	High voltage circuit breaker for alternating current
IEC 59	IEC standard current
IEC 99-4	Metal oxide surge arrester without gaps for A.C. systems
IEC 62271-102	Alternating current disconnectors and earthing switches
IEC 60383-1 & 2	Insulators and fittings for overhead lines. Insulators of ceramic material or glass for overhead line with nominal voltage higher than 1000 V. Requirements
IEC 60502	Power cables with extruded insulation and their accessories for rated voltage from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV).

Standard Number	Title
	Part 2: rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
IEC 60529	Degrees of protection provided by enclosures (IP code)
IEC 617-2	Graphical symbols for diagrams. Part 2: symbol elements, qualifying symbols and other symbols having general application.
IEC 694	Common specifications for high-voltage switchgear and control gear standards
IEC 721-3-4	Classification of environmental conditions- Classification of groups of environmental parameters and their severities- Stationary use at non weather protected locations.
IEC 840	Power cables with extruded insulation and their accessories for rated voltage above 30kV (Um = 36 kV) up to 100 kV. Test methods and requirements.
IEC 865	Earth mesh and earth procedure code
IEC 889	Hard-drawn aluminium wire for overhead line conductor
IEC 60071	Insulation co-ordination
IEC 60076	Power transformer
IEC 61000	Electromagnetic compatibility
IEC 61508-3	Functional safety of electrical/electronic/programmable safety-related systems. Part 3: software requirements

Standard Number	Title
EN 10025	Hot Rolled Products of Non-Alloy Structural Steels: Delivery Conditions
EN 10034	Structural Steel I and H Sections – Tolerances on Shape and Dimensions
EN 10055	Hot Rolled Steel Equal Flange Tees with Raduised Root and Toes – Dimensions and Tolerances on Shape and Dimensions
EN 10056	Structural Steel Equal and Unequal Leg Angles
EN 10083	Quenched and Tempered Steels
EN 10088	Stainless Steels
EN 1301	Aluminium and Aluminium Alloys
EN 50163	Supply Voltage of Traction System
EN 60811	Insulating and Sheathing Materials of Electric Cables
ENV 50121-5	Railway Application Electromagnetic Compatibility Part 5: Fixed Power Supply Installations
EURONORM 19	IPE Beams; I-Beams with Parallel Flange Facings and Steel Products – IPN Beams – Dimensions
IEC 60398	General Test for Electro-heating Equipment
IEC 1131	Programmable controllers
IEC 265.1	High Voltage Switch
IEC 502	Insulated and protected cables for power supply network
IEC 61869	**Current Transformers**
IEC 61869	**Voltage Transformer**
IEC 60137	Insulated Bushing for rated Voltage above 1 kV
IEC 60157	Low Voltage Switchgear Circuit Breakers

Standard Number	Title
IEC 60168	Tests on Indoor and Outdoor Post Insulators of Ceramic Material or Glass for Systems with Nominal Voltages greater than 1000 V
IEC 60228	Conductor of Insulated Cables
IEC 60273	Dimensions of Indoor and Outdoor Post Insulators and Post Insulator Units for Systems with Nominal Voltages greater than 1000 V
IEC 60296	Insulating oils for transformers
IEC 60297	Dimensions of mechanical structures of the 482.6 mm (19 in)
IEC 60372	Locking Devices for Ball and Socket Couplings of String Insulator Units – Dimensions and Tests
IEC 60376	Sulphur Hexafluoride
IEC 60383	Insulators for Overhead Lines with a nominal Voltage above 1000 V
IEC 60502	Power Cables from 1 kV to 30 kV
IEC 60591	Test for OHCS Ceramic or Glass Insulators above 1 kV
IEC 60591	Sampling Rules and Acceptance Criteria when applying Statistical Control Methods for Mechanical and Electromechanical Tests on Insulators of Ceramic Material or Glass for Overhead Lines with a Nominal Voltage greater than 1000 V
IEC 60721	Environmental conditions :Specifications for painting
IEC 622	Sealed Nickel-Cadmium prismatic rechargeable single cell.
IEC 801	Electromagnetic Compatibility for Industrial-process Measurement and Control IEC 870
ISO 1035	Hot Rolled Steel Bars
ISO 1190	Copper and Copper Alloys
ISO 1234	Split Pins

Standard Number	Title
ISO 1337	Wrought Coppers (having Minimum Copper Contents of 99,85%) – Chemical Composition and Forms of Wrought Products
ISO 1460	Metallic Coatings – Hot Dip Galvanised Coatings on Ferrous Materials – Gravimetric Determination of the Mass per Unit Area
ISO 1461	Metallic Coatings – Hot Dip Galvanised Coatings on Fabricated Ferrous Products – Requirements
ISO 2092	Light Metals and their Alloys – Code of Designation based on Chemical Symbols
ISO 2340	Clevis Pins without Head
ISO 2341	Clevis Pins with Head
ISO 261	ISO General Purpose Metric Screw Threads – General Plan
ISO 262	ISO General Purpose Metric Screw Threads – Selected Sizes for Screws, Bolts and Nuts
ISO 2859/1	Sampling Procedures for Inspection by Attributes – Sampling Plans Indexed by Acceptable Quality Level (AQL) for Lot-by-lot Inspection
ISO 3768	Metallic Coatings – Neutral Salt Spray Test (NSS Test)
ISO 4014	Hexagon Head Bolts – Product Grades A and B
ISO 4017	Hexagon Head Screw Bolts – Product Grades A and B
ISO 4032	Hexagon Nuts, Style 1 – Product Grades A and B
ISO 404	Steel and Steel Products – General Technical Delivery Requirements
ISO 657	Hot Rolled Steel Sections
ISO 68	ISO General Purpose Screw Threads – Basic Profile
ISO 8402	Quality Management and Quality Assurance – Vocabulary

Standard Number	Title
ISO 898	Mechanical Properties of Fasteners
ISO 9000	Quality Management and Quality Assurance Standards
ISO 9001	Quality Systems – Model for Quality Assurance in Design / Development, Production, Installation and Servicing
ISO 9002	Quality Systems – Model for Quality Assurance in Production and Installation
ISO 9003	Quality Systems – Model for Quality Assurance in Final Inspection and Test
ISO 9004	Quality Management and Quality System Elements
ISO 965	ISO General Purpose Metric Screw Threads
UIC 505-1	Railway Transport Stock – Rolling Stock Construction Gauge
UIC 505-4	Effects on the Application of the Kinematic Gauges defined in the 505 Series of Leaflets on the Positioning of Structures in relation to the Tracks and of the Tracks in relation to each other
UIC 606-1 OR	Consequences of the Application of the Kinematic Gauges defined by UIC Leaflets in the 505 Series on the Design of the Contact Lines
UIC 606-2 OR	Installation of 25 kV and 50 or 60 Hz Overhead Contact Lines
UIC 608 OR	Conditions to be complied with for the Pantographs of Tractive Units used on International Services
UIC 791 R	Quality Assurance of Overhead Line Equipment
UIC 811-1	Technical Specifications for the Supply of Axles and Trailing Stock
UIC 812-2	Solid Wheels for Tractive and Trailing Stock – Tolerances
UIC 870 O	Technical Specification for Grooved Contact Wires

Standard Number	Title
IEC 28	International specification of soft annealing type copper
IEC 99-2	Expulsion type lighting arresters
IEC 99-1	Non-linear resistor type gapped surge arresters for A.C. system
IEC 62271-200	Alternating current disconnectors and earthing switches
IEC 62271-100,102	GIS Switchgears
IEC 146-1-3	Semiconductor converters, general requirements and line commutated converters. Transformers and reactors
IEC 146-1-2	Semiconductor converters, general requirements and line commutated converters. Application guide
IEC 146-1-1	Semiconductor converters, general requirements and line commutated converters. Specifications of basic requirements.
IEC 196	IEC standard frequencies
IEC 228	Conductors of insulated cable
IEC 265-1	High voltage switches for rated voltage above 1 kV and less than 52 kV
IEC 296	New insulating mineral oil specification for transformers
IEC 298	A.C. metal enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 72,5 kV
IEC 502-2	Extruded solid dielectric insulated power cables and their accessories for rated voltage from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
~~**IEC 551**~~	~~**Determination of transformer and reactor sound level**~~
IEC 622	Alkaline secondary cells and batteries- Sealed nickel-cadmium parallelepiped rechargeable single cells

Standard Number	Title
IEC 721-3-3	Classification of environmental conditions- Classification of groups of environmental parameters and their severity- Stationary use at weather protected locations.

Standard Number	Title
IEC 1131	Programming languages – Programmable controllers– Part 3
IEC 1131	Programmable Logic Controllers
IEC 297-3	Dimensions of mechanical structures of the 482.6 mm (19 in) series
IEC 571	Electronic equipment specification
IEC 60870	Transmission Protocol
IEC 801-1	Electromagnetic compatibility for industrial-process measurement and control equipment – General introduction
IEC 801-2	Electromagnetic compatibility for industrial-process measurement and control equipment – Electrostatic discharge requirements
IEC 801-3	Electromagnetic compatibility for industrial-process measurement and control equipment – Radiated electromagnetic field requirements
IEC 801-4	Electromagnetic compatibility for industrial-process measurement and control equipment - Electrical for transient/burst requirements
IEC 801-5	Electromagnetic compatibility for industrial-process measurement and control equipment – Shock wave requirements
IEC 801-6	Electromagnetic compatibility for industrial-process measurement and control equipment – Immunities to disturbances conducted and induced by radio fields
IEC 848	Preparation of block diagrams for control systems
IEC 870-1-1	Control equipment and systems – General principles

Standard Number	Title
IEC 870-2-1	Control equipment and systems – Power supply and environment conditions
IEC 870-3	Control equipment and systems – Interfaces (electrical characteristics)
IEC 870-4	Control equipment and systems – Performance requirements
IEC 870-5	Control equipment and systems – Transmission protocol

3. DEFINITION OF ABBREVIATIONS

Abbreviations	Meaning
AC	Alternating Current
ACOCB	Alternating current outgoing circuit breaker
ACRC	Alternating current rectifier contactor
ACRCB	Alternating current rectifier circuit breaker
AMS	Auxiliary main sub Station
ASS	Auxiliary Sub Station
AT	Auxiliary transformer
ATCB	Auxiliary Transformer Circuit Breaker
ATIS	Auxiliary Transformer Isolator
B	Traction bus bar
BA	Batteries
BAIT	Batteries interrupter
C&C	Control & Communication

Abbreviations	Meaning
CAMS	Computer Aided Maintenance System
CB	Circuit Breaker
CCB	Coupling circuit breaker
CIS	Coupling Isolator
CTATP	Current Transformer for protection of Auxiliary Transformer
CTC	Current transformer for coupling
CTIM	Incoming Current Transformer for Measures
CTT	Current transformer for traction transformer
CTTTP	Current Transformer for Protection of Traction Transformer
DC	Direct Current
DCAC	Direct current auxiliary contactor
DCACC	Direct current auxiliary coupling contactor
DCOCB	Direct current outgoing circuit breaker
DCRC	Direct current rectifier contactor
DTN	Data Transmission Network
TRANSCO	Transmission Company (erstwhile DVB)
ECC	Energy Control Centre
EIS	Earthing Isolator
EMIS	Energy Management and Information System
GRC	General Remote Control
IED	Intelligent Electronic Device
IS	Isolator

Abbreviations	Meaning
IR	Indian Railways
IT	Interrupter
OCC	Operations Control Centre
ITC	Coupling interrupter
L	Hand operated traction isolator
LAAT	Surge arrester for Auxiliary Transformer
LAN	Local Area Network
LATT	Surge arrester for Traction Transformer
LBCB	Lighting bridge circuit breaker
LBCCB	Lighting bridge coupling circuit breaker
LBCCT	Lighting bridge coupling current transformer
LBCT	Lighting bridge current transformer
LBCVT	Lighting bridge coupling voltage transformer
LBEIS	Lighting bridge earthing isolator
LBVT	Lighting bridge voltage transformer
LEIS	Line Earthing Isolator
LFCB	Lighting feeder circuit breaker (spare)
LFEIS	Lighting feeder earthing isolator
LIS	Line Isolator
LV	Low Voltage
LVACB	Low voltage auxiliary circuit breaker
LVACCB	Low voltage auxiliary coupling circuit breaker

Abbreviations	Meaning
LVAT	Low voltage auxiliary transformer
LVATCB	Low voltage auxiliary transformer circuit breaker
LVATEIS	Low voltage auxiliary transformer earthing isolator
LVCB	Low voltage circuit breaker
LVCCB	Low voltage coupling circuit breaker
MC	Metro Corridor (Underground Alignment Line 2)
MCCB	Metro corridor circuit breaker
MCEIS	Metro corridor earthing isolator
MCIS	Main coupling isolator
MMI	Man Machine Interface
HMI	Human Machine Interface
MVCB	Medium Voltage Circuit Breaker
NMS	Network Management System
NGR	Neutral Ground Resistor
OCC	Operation Control Centre
OHE	Over-Head Equipment
PCW	Power Control Workstation
PICOP	Person In Charge Of Protection
PLC	Programmable Logic Controller
PNCT	Primary neutral current transformer
PNEIS	Primary neutral earthing isolator
PNLA	Primary neutral surge arrester

Abbreviations	Meaning
RC	Rail Corridor
RCCB	Rail corridor circuit breaker
RCEIS	Rail corridor earthing isolator
RSS	Receiving Sub Station
SCADA	Supervisory Control And Data Acquisition System
SNCT	Secondary neutral current transformer
SNEIS	Secondary neutral earthing isolator
SNLA	Secondary neutral surge arrester
SP	Sectioning and Paralleling Post
SSP	Sub-Sectioning and paralleling Post
T	Transformer
TCB	Traction Circuit breaker
TEIS	Transformer Earthing Isolator
TSS	Traction Sub Station
TT	Traction transformer
TTCB	Traction Transformer Circuit Breaker
TTIS	Traction Transformer Isolator
UPS	Uninterruptible Power supply
VDU	Video Display Unit
VT	Voltage Transformer
VTB	Voltage Transformer for traction bus bar
VTBB	Bus Bar Voltage Transformer

Abbreviations	Meaning
VTC	Voltage transformer for coupling

4. SPARE PART LIST

4.1 GENERAL

Spares shall be supplied & maintained as per the spare policy attached as Appendix-J.

The spares shall be provided as per the spare list attached in the Spare policy with this tender document.

CHAPTER 7

Definition and Lists

Table of Contents

1. DRAWINGS LIST

1.1 SECTION DETAILS

Sr. No.	DRAWING DESCRIPTION
	AUXILIARY NETWORK DRAWINGS
1	
2	

2. MAIN APPLICABLE INTERNATIONAL STANDARDS

All equipment of the Contract shall comply with the EMC standards EN 50-121-1 to 5. Concerning the tests, when not defined into the EN 50121, the equipment shall comply with the relevant EMC standard of the series IEC 61000.

Standard Number	Title
IEC 38	IEC standard voltage
IEC 44-6	Instructions related to protection current transformer for transient state response
IEC 62271-100	High voltage circuit breaker for alternating current
IEC 59	IEC standard current
IEC 99-4	Metal oxide surge arrester without gaps for A.C. systems
IEC 62271-102	Alternating current disconnectors and earthing switches
IEC 60383-1 & 2	Insulators and fittings for overhead lines. Insulators of ceramic material or glass for overhead line with nominal voltage higher than 1000 V. Requirements
IEC 60502	Power cables with extruded insulation and their accessories for rated voltage from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV).

Standard Number	Title
	Part 2: rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
IEC 60529	Degrees of protection provided by enclosures (IP code)
IEC 617-2	Graphical symbols for diagrams. Part 2: symbol elements, qualifying symbols and other symbols having general application.
IEC 694	Common specifications for high-voltage switchgear and control gear standards
IEC 721-3-4	Classification of environmental conditions- Classification of groups of environmental parameters and their severities- Stationary use at non weather protected locations.
IEC 840	Power cables with extruded insulation and their accessories for rated voltage above 30kV (Um = 36 kV) up to 100 kV. Test methods and requirements.
IEC 865	Earth mesh and earth procedure code
IEC 889	Hard-drawn aluminium wire for overhead line conductor
IEC 60071	Insulation co-ordination
IEC 60076	Power transformer
IEC 61000	Electromagnetic compatibility
IEC 61508-3	Functional safety of electrical/electronic/programmable safety-related systems. Part 3: software requirements

Standard Number	Title
EN 10025	Hot Rolled Products of Non-Alloy Structural Steels: Delivery Conditions
EN 10034	Structural Steel I and H Sections – Tolerances on Shape and Dimensions
EN 10055	Hot Rolled Steel Equal Flange Tees with Raduised Root and Toes – Dimensions and Tolerances on Shape and Dimensions
EN 10056	Structural Steel Equal and Unequal Leg Angles
EN 10083	Quenched and Tempered Steels
EN 10088	Stainless Steels
EN 1301	Aluminium and Aluminium Alloys
EN 50163	Supply Voltage of Traction System
EN 60811	Insulating and Sheathing Materials of Electric Cables
ENV 50121-5	Railway Application Electromagnetic Compatibility Part 5: Fixed Power Supply Installations
EURONORM 19	IPE Beams; I-Beams with Parallel Flange Facings and Steel Products – IPN Beams – Dimensions
IEC 60398	General Test for Electro-heating Equipment
IEC 1131	Programmable controllers
IEC 265.1	High Voltage Switch
IEC 502	Insulated and protected cables for power supply network
IEC 61869	**Current Transformers**
IEC 61869	**Voltage Transformer**
IEC 60137	Insulated Bushing for rated Voltage above 1 kV
IEC 60157	Low Voltage Switchgear Circuit Breakers

Standard Number	Title
IEC 60168	Tests on Indoor and Outdoor Post Insulators of Ceramic Material or Glass for Systems with Nominal Voltages greater than 1000 V
IEC 60228	Conductor of Insulated Cables
IEC 60273	Dimensions of Indoor and Outdoor Post Insulators and Post Insulator Units for Systems with Nominal Voltages greater than 1000 V
IEC 60296	Insulating oils for transformers
IEC 60297	Dimensions of mechanical structures of the 482.6 mm (19 in)
IEC 60372	Locking Devices for Ball and Socket Couplings of String Insulator Units – Dimensions and Tests
IEC 60376	Sulphur Hexafluoride
IEC 60383	Insulators for Overhead Lines with a nominal Voltage above 1000 V
IEC 60502	Power Cables from 1 kV to 30 kV
IEC 60591	Test for OHCS Ceramic or Glass Insulators above 1 kV
IEC 60591	Sampling Rules and Acceptance Criteria when applying Statistical Control Methods for Mechanical and Electromechanical Tests on Insulators of Ceramic Material or Glass for Overhead Lines with a Nominal Voltage greater than 1000 V
IEC 60721	Environmental conditions :Specifications for painting
IEC 622	Sealed Nickel-Cadmium prismatic rechargeable single cell.
IEC 801	Electromagnetic Compatibility for Industrial-process Measurement and Control IEC 870
ISO 1035	Hot Rolled Steel Bars
ISO 1190	Copper and Copper Alloys
ISO 1234	Split Pins

Standard Number	Title
ISO 1337	Wrought Coppers (having Minimum Copper Contents of 99,85%) – Chemical Composition and Forms of Wrought Products
ISO 1460	Metallic Coatings – Hot Dip Galvanised Coatings on Ferrous Materials – Gravimetric Determination of the Mass per Unit Area
ISO 1461	Metallic Coatings – Hot Dip Galvanised Coatings on Fabricated Ferrous Products – Requirements
ISO 2092	Light Metals and their Alloys – Code of Designation based on Chemical Symbols
ISO 2340	Clevis Pins without Head
ISO 2341	Clevis Pins with Head
ISO 261	ISO General Purpose Metric Screw Threads – General Plan
ISO 262	ISO General Purpose Metric Screw Threads – Selected Sizes for Screws, Bolts and Nuts
ISO 2859/1	Sampling Procedures for Inspection by Attributes – Sampling Plans Indexed by Acceptable Quality Level (AQL) for Lot-by-lot Inspection
ISO 3768	Metallic Coatings – Neutral Salt Spray Test (NSS Test)
ISO 4014	Hexagon Head Bolts – Product Grades A and B
ISO 4017	Hexagon Head Screw Bolts – Product Grades A and B
ISO 4032	Hexagon Nuts, Style 1 – Product Grades A and B
ISO 404	Steel and Steel Products – General Technical Delivery Requirements
ISO 657	Hot Rolled Steel Sections
ISO 68	ISO General Purpose Screw Threads – Basic Profile
ISO 8402	Quality Management and Quality Assurance – Vocabulary

Standard Number	Title
ISO 898	Mechanical Properties of Fasteners
ISO 9000	Quality Management and Quality Assurance Standards
ISO 9001	Quality Systems – Model for Quality Assurance in Design / Development, Production, Installation and Servicing
ISO 9002	Quality Systems – Model for Quality Assurance in Production and Installation
ISO 9003	Quality Systems – Model for Quality Assurance in Final Inspection and Test
ISO 9004	Quality Management and Quality System Elements
ISO 965	ISO General Purpose Metric Screw Threads
UIC 505-1	Railway Transport Stock – Rolling Stock Construction Gauge
UIC 505-4	Effects on the Application of the Kinematic Gauges defined in the 505 Series of Leaflets on the Positioning of Structures in relation to the Tracks and of the Tracks in relation to each other
UIC 606-1 OR	Consequences of the Application of the Kinematic Gauges defined by UIC Leaflets in the 505 Series on the Design of the Contact Lines
UIC 606-2 OR	Installation of 25 kV and 50 or 60 Hz Overhead Contact Lines
UIC 608 OR	Conditions to be complied with for the Pantographs of Tractive Units used on International Services
UIC 791 R	Quality Assurance of Overhead Line Equipment
UIC 811-1	Technical Specifications for the Supply of Axles and Trailing Stock
UIC 812-2	Solid Wheels for Tractive and Trailing Stock – Tolerances
UIC 870 O	Technical Specification for Grooved Contact Wires

Standard Number	Title
IEC 28	International specification of soft annealing type copper
IEC 99-2	Expulsion type lighting arresters
IEC 99-1	Non-linear resistor type gapped surge arresters for A.C. system
IEC 62271-200	Alternating current disconnectors and earthing switches
IEC 62271-100,102	GIS Switchgears
IEC 146-1-3	Semiconductor converters, general requirements and line commutated converters. Transformers and reactors
IEC 146-1-2	Semiconductor converters, general requirements and line commutated converters. Application guide
IEC 146-1-1	Semiconductor converters, general requirements and line commutated converters. Specifications of basic requirements.
IEC 196	IEC standard frequencies
IEC 228	Conductors of insulated cable
IEC 265-1	High voltage switches for rated voltage above 1 kV and less than 52 kV
IEC 296	New insulating mineral oil specification for transformers
IEC 298	A.C. metal enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 72,5 kV
IEC 502-2	Extruded solid dielectric insulated power cables and their accessories for rated voltage from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
~~**IEC 551**~~	~~**Determination of transformer and reactor sound level**~~
IEC 622	Alkaline secondary cells and batteries- Sealed nickel-cadmium parallelepiped rechargeable single cells

Standard Number	Title
IEC 721-3-3	Classification of environmental conditions- Classification of groups of environmental parameters and their severity- Stationary use at weather protected locations.

Standard Number	Title
IEC 1131	Programming languages – Programmable controllers– Part 3
IEC 1131	Programmable Logic Controllers
IEC 297-3	Dimensions of mechanical structures of the 482.6 mm (19 in) series
IEC 571	Electronic equipment specification
IEC 60870	Transmission Protocol
IEC 801-1	Electromagnetic compatibility for industrial-process measurement and control equipment – General introduction
IEC 801-2	Electromagnetic compatibility for industrial-process measurement and control equipment – Electrostatic discharge requirements
IEC 801-3	Electromagnetic compatibility for industrial-process measurement and control equipment – Radiated electromagnetic field requirements
IEC 801-4	Electromagnetic compatibility for industrial-process measurement and control equipment - Electrical for transient/burst requirements
IEC 801-5	Electromagnetic compatibility for industrial-process measurement and control equipment – Shock wave requirements
IEC 801-6	Electromagnetic compatibility for industrial-process measurement and control equipment – Immunities to disturbances conducted and induced by radio fields
IEC 848	Preparation of block diagrams for control systems
IEC 870-1-1	Control equipment and systems – General principles

Standard Number	Title
IEC 870-2-1	Control equipment and systems – Power supply and environment conditions
IEC 870-3	Control equipment and systems – Interfaces (electrical characteristics)
IEC 870-4	Control equipment and systems – Performance requirements
IEC 870-5	Control equipment and systems – Transmission protocol

3. DEFINITION OF ABBREVIATIONS

Abbreviations	Meaning
AC	Alternating Current
ACOCB	Alternating current outgoing circuit breaker
ACRC	Alternating current rectifier contactor
ACRCB	Alternating current rectifier circuit breaker
AMS	Auxiliary main sub Station
ASS	Auxiliary Sub Station
AT	Auxiliary transformer
ATCB	Auxiliary Transformer Circuit Breaker
ATIS	Auxiliary Transformer Isolator
B	Traction bus bar
BA	Batteries
BAIT	Batteries interrupter
C&C	Control & Communication

Abbreviations	Meaning
CAMS	Computer Aided Maintenance System
CB	Circuit Breaker
CCB	Coupling circuit breaker
CIS	Coupling Isolator
CTATP	Current Transformer for protection of Auxiliary Transformer
CTC	Current transformer for coupling
CTIM	Incoming Current Transformer for Measures
CTT	Current transformer for traction transformer
CTTTP	Current Transformer for Protection of Traction Transformer
DC	Direct Current
DCAC	Direct current auxiliary contactor
DCACC	Direct current auxiliary coupling contactor
DCOCB	Direct current outgoing circuit breaker
DCRC	Direct current rectifier contactor
DTN	Data Transmission Network
TRANSCO	Transmission Company (erstwhile DVB)
ECC	Energy Control Centre
EIS	Earthing Isolator
EMIS	Energy Management and Information System
GRC	General Remote Control
IED	Intelligent Electronic Device
IS	Isolator

Abbreviations	Meaning
IR	Indian Railways
IT	Interrupter
OCC	Operations Control Centre
ITC	Coupling interrupter
L	Hand operated traction isolator
LAAT	Surge arrester for Auxiliary Transformer
LAN	Local Area Network
LATT	Surge arrester for Traction Transformer
LBCB	Lighting bridge circuit breaker
LBCCB	Lighting bridge coupling circuit breaker
LBCCT	Lighting bridge coupling current transformer
LBCT	Lighting bridge current transformer
LBCVT	Lighting bridge coupling voltage transformer
LBEIS	Lighting bridge earthing isolator
LBVT	Lighting bridge voltage transformer
LEIS	Line Earthing Isolator
LFCB	Lighting feeder circuit breaker (spare)
LFEIS	Lighting feeder earthing isolator
LIS	Line Isolator
LV	Low Voltage
LVACB	Low voltage auxiliary circuit breaker
LVACCB	Low voltage auxiliary coupling circuit breaker

Abbreviations	Meaning
LVAT	Low voltage auxiliary transformer
LVATCB	Low voltage auxiliary transformer circuit breaker
LVATEIS	Low voltage auxiliary transformer earthing isolator
LVCB	Low voltage circuit breaker
LVCCB	Low voltage coupling circuit breaker
MC	Metro Corridor (Underground Alignment Line 2)
MCCB	Metro corridor circuit breaker
MCEIS	Metro corridor earthing isolator
MCIS	Main coupling isolator
MMI	Man Machine Interface
HMI	Human Machine Interface
MVCB	Medium Voltage Circuit Breaker
NMS	Network Management System
NGR	Neutral Ground Resistor
OCC	Operation Control Centre
OHE	Over-Head Equipment
PCW	Power Control Workstation
PICOP	Person In Charge Of Protection
PLC	Programmable Logic Controller
PNCT	Primary neutral current transformer
PNEIS	Primary neutral earthing isolator
PNLA	Primary neutral surge arrester

Abbreviations	Meaning
RC	Rail Corridor
RCCB	Rail corridor circuit breaker
RCEIS	Rail corridor earthing isolator
RSS	Receiving Sub Station
SCADA	Supervisory Control And Data Acquisition System
SNCT	Secondary neutral current transformer
SNEIS	Secondary neutral earthing isolator
SNLA	Secondary neutral surge arrester
SP	Sectioning and Paralleling Post
SSP	Sub-Sectioning and paralleling Post
T	Transformer
TCB	Traction Circuit breaker
TEIS	Transformer Earthing Isolator
TSS	Traction Sub Station
TT	Traction transformer
TTCB	Traction Transformer Circuit Breaker
TTIS	Traction Transformer Isolator
UPS	Uninterruptible Power supply
VDU	Video Display Unit
VT	Voltage Transformer
VTB	Voltage Transformer for traction bus bar
VTBB	Bus Bar Voltage Transformer

Abbreviations	Meaning
VTC	Voltage transformer for coupling

4. SPARE PART LIST

4.1 GENERAL

Spares shall be supplied & maintained as per the spare policy attached as Appendix-J.

The spares shall be provided as per the spare list attached in the Spare policy with this tender document.

CHAPTER 8 A

Auxiliary Network (Underground & Elevated)

Contents

1. AUXILIARY NETWORK

1.1 General

The various electrical and electro-mechanical installations in passenger stations are required to be provided with electrical power at 415 V 3 phase. For this purpose, power at 33 kV from the Auxiliary Main Substations (AMS) located in the premises of the High Voltage Receiving Substations (RSS), is transported to the Auxiliary Substations (ASS) located in the premises of passenger stations, through duplicate feeders made up of 33 kV insulated cables. The 33 kV power is transformed to 415 V power by means of 33 kV/ 415 Volt cast resin dry type transformers of suitable capacity installed in the ASS's. The Auxiliary Power Network essentially consists of the following:

- 33 kV duplicate feeder from the AMS to a designated ASS in the Corridor, in appropriate cable path, wherever applicable.

- A 33 kV cable Network, comprising of duplicate 33 kV insulated cables of suitable capacity, laid in cable trenches, on brackets, in pipes ,etc. inthe Viaduct, tunnel or at-gradeor inside station premises as applicable.
- Connection of the 33 kV cables to the 33 kV panels/transformers located in the ASS
- 33 kV /415 V Auxiliary Transformers of suitable capacity and associated 33 kV and 415V Switchgear and other Auxiliary Equipment, installed in the ASSs at various passenger stations.

In this document Medium Voltage is referred to 33 kV, High Voltage to the incoming Voltage at the RSS (66 kV, 132 kV or 220 kV) and Low Voltage are under 1100 V.

The design requirements of the works have been defined in chapter 8E of these specification.

1.2 Broad Network Details for different Corridors

The tender document covers the following corridor:

a) Underground Section (details of the section to be mentioned)

(**The Supply and Installation of Auxiliary Main Substations located in the premises of High Voltage Receiving Substations (RSS), is not within the scope of this Tender**).

Each AMS, under normal conditions, feeds 33 kV power to a specified number of ASS's located on either side of the AMS. The following "**Loop definition Table**" shows the details of ASS's fed from each AMS, via the particular Loop.

Loop Definition Table

Section Name

AMS	LOOP NO.	NAME OF ASS FED BY THE LOOP		REMARKS
		UNDERGROUND	ELEVATED	

1.3 General Description of Scope of Work

A general description of the broad Scope of Work, relating to 33 kV Auxiliary Network, covered in this Tender, is given below. **It shall, however, be clearly understood that the description is for the purpose of general guidance only and is not exclusive**. For complete appreciation of the Scope, the Specifications, Bills of Quantities along with their Explanatory Notes, Drawings and other relevant paragraphs of the Tender Documents shall be referred to.

1.3.1 Auxiliary Main Substations (AMS)

1.3.1.1 Broad scope of work in the AMS

The Auxiliary Main Substations (AMS) are located in the premises of Receiving Substations (RSS). A different Agency is entrusted with the work of supply and installation of these RSS's. The above Agency hereinafter referred to as RSS Contractor, will provide the necessary HV System including HV Switchgear, Busbars etc and also the 400kV/220kV/132kV/66 kV/ 33 kV, 3 phase transformers. The RSS Contractor will also construct the AMS room and supply and install the 33 kV Switchgear and other equipments in the AMS. The Contractor will be required to supply and install the 33 kV cables from the outgoing 33 kV Switchgear at the AMS, upto the designated ASS entry-point in the ASS's in Underground Stations & Elevated station (as applicable) for charging of the ASS.

Inside the AMS room and in the RSS premises, cable paths for installation of 33 kV cables and Control & monitoring cables and SCADA communication for RSS to designated TER room will be provided by the RSS Contractor. However, cable paths beyond the boundary walls of the RSS upto the entry point into the tunnels/underground stations/Elevated station/viaduct, will be required to be provided by the Contractor.

Cable path, including Cable entry shafts, suitable cable trays, cable ladders, cut-outs etc for travel of 33 kV and control cables from the entry point into the tunnels upto the entry point into the ASS in undergeround corridor will be provided by the Station Building Contractor/Station E&M Contractor.

Cable path, including Cable entry shafts, suitable cable trays, cable ladders, cut-outs etc for travel of 33 kV and control cables from the entry point of elevated station/viaduct upto the entry point into the ASS of elevated station will be provided by the Contractor.

Cable paths for cables inside the ASS Room in underground & elevated corridor shall be provided by the Contractor. The sealing of the cable cut-outs will be done by RSS Contractor in the RSS premises. The contractor shall do necessary interface with RSS contractor, elsewhere, it will be the responsibility of the contractor.

1.3.1.2 **25kV cables from RSS/TSS to the Traction Feeding Post**

In addition, the Contractor will be required to supply and install 25kV Traction cables from the outgoing 25kV Switchgear at the TSS, up to the 25kV Feeding station located in the Underground station/Elevated station/viaduct.

Cable paths for installation of 25 kV Traction cables & 3.3kV Return cables (for Main Line and Depot) and Control cables and SCADA communication from RSS to designated TER room, which include also supply and laying of required HDPE pipes for SCADA cables, and 2 Nos 100mm dia HDPE pipe for telecom cable of telecom contractor, shall be provided by the contractor. However, inside the TSS and in the RSS premises will be provided by the RSS Contractor.

The contractor shall interface with RSS contractor for suitable cable paths comprise of GI cable supports with polyamide strips, HDPE pipes, cable trough etc. wherever required.

However, cable paths beyond the boundary walls of RSS up to the entry points into the tunnels/ underground station /Elevated station/viaduct, will be required to be provided by the Contractor.

While providing cable route from RSS to Feeding Post, Two Nos 100 mm diameter HDPE Pipe for Telecommunication cable of telecom contractor shall be provided by OHE contractor. The contractor shall do necessary interface with Telecom contractor for meeting the timeline of cable laying.

Cable path, including cable entry shafts, suitable cable trays, cable ladders, cut-outs etc for travel of 25kV cables and control cables from the entry point into the Underground stations/tunnels, upto entry point into the Feeding Station room will be provided by the Station Building Contractor/Station E&M Contractor.

On viaduct, Cable path (Cable Brackets) shall be provided by viaduct contractor. The contractor shall interface with viaduct contractor for suitable GI cable brackets with polyamide strips cable trough etc. wherever required.

Cable path, including cable entry shafts, suitable cable trays, cable ladders, cut-outs etc for travel of 25kV cables and control cables from the entry point of elevated station/viaduct, upto entry point into the Feeding Post will be provided by the Contractor.

Cable paths for cables inside the Feeding Station Room shall be provided by the Contractor.

1.3.1.3 **Laying Alternatives,**

From 1.3.1.1 and 1.3.1.2 above, it could be seen that the Contractor is required to provide cable paths for both 33kV and 25kV cables, between the RSS boundary and entry points into the tunnels/underground stations/elevated station/viaduct. Depending upon the route finally selected for laying both 33kV & 25kV cables along with 3.3kV Return cables (For Main Line and Depot) and Control cables and SCADA communication for RSS to designated TER room which shall include spare pipes as stated in the pricing document, which include also supply and laying of required HDPE pipes for SCADA cables, and 2 Nos 100mm dia HDPE pipe for telecom cable of telecom contractor, if it is approved by the Employer, both the types of cables may be laid in the same cable path or alternatively, in different cable paths.

The prices for cable paths for different alternatives shall be included in the relevant sub-items of the BOQ.

1.3.2 **In the Viaduct, in Tunnel and at Grade**

The following works shall form part of this Tender:

- Supply, laying, jointing, termination, protection, testing and commissioning of all 33kV cables and line differential protection in Tunnels, viaduct & elevated section, between ASS's, between ASS & AMS and links to other Corridors, if any.
- The supply, laying, jointing and termination at either end, protection, testing and commissioning of 33kV Cables (FRLSOH in underground portion & FRLS in elevated portion) between,
- Name of sections to be mentioned
- Between designated AMS to designated ASS at Underground & Elevated Section as per SLD.
- Interlinking between existing lines & new lines as per chapter 8D.

Shall form part of this Tender. The ASS Equipments including supply and erection of 33kV switchgear panels at ASS of all stations of Line-…. and Underground stations of Line-….. ext. will be with in the Scope of the Contractor.

1.3.3 In the Auxiliary Substations (ASS)

The following works shall form part of this Tender:

Supply, erection, testing and commissioning of all equipments at all ASS's, including, but not limited to,

- 33 kV /415 V Cast Resin Dry Type transformers
- 33 kV panels and switchgears (GIS and AIS as applicable)
- 33 kV Cables, 415 V/LV cables and DC cables for control supply of ASS equipment and RTU.

- C&M cables from ASS equipment to designated terminal board/strip in the RTU.
- All control and monitoring cables required for ASS. AC and DC supply from ACDB and DCDB shall also be extended up to RTU by contractor.
- All measuring and protective devices including Pilot wire relay protection.
- SCADA communication cable from RSS gateway to nearby station shall be supplied by SCADA contractor but it will be laid by the contractor in HDPE pipes under supervision of SCADA contractor. HDPE pipes shall also be supplied and laid by contractor. The necessary interface shall be done by contractor.
- Batteries and battery chargers
- Cable paths and earthing from MET to ASS equipment. Earth mat risers will be provided by SBC (in underground section) & by E&M (in Elevated section) and earthing from earth risers up to and including MET will be provided by E&M contractor. The earth strips from equipment to MET shall be laid under floor concrete therefore proper permanent identification on each strip to which it belongs shall properly be marked.
- Safety equipment as per CEA Regulation 2010 and
- ACDB's & DCDB's
- Cable trays/brackets in underground sections for laying all C&M, AC/DC cables etc. shall be provided by E&M Contractor.
- The Cable path (cable brackets) on viaduct shall be provided by viaduct contractor. The contractor shall interface with viaduct contractor for suitable GI cable brackets with polyamide strips cable trough etc. wherever required.
- For Line- : In adjoining elevated station ASS cable, brackets from platform to ASS (inside shaft etc.) and inside ASS shall be provided by the contractor.

  For Line-8 Ext. : In adjoining elevated station, all arrangements from tunnel mouth upto the point of termination such as cable brackets, supports, cable trays etc. as required, in the area beyong underground section, shall be arranged by Elevated Traction contractor, however the cables shall be provided and laid by contractor.
- The cable path for laying of Telecom cables from RSS to nearest elevated station shall be provided by the contractor.

Supply and erection of any other items required for successful and satisfactory working of the ASS, at all ASS's shall be within the scope of this Tender.

1.4 NOT USED

1.5 MANNING OF COMMISSIONED ASS'S

The Employer may call upon the Contractor to provide skilled supervisors / skilled workers / unskilled workers in the ASS's already commissioned and handed over to the Employer, for manning the installations, before commencement of the Revenue operation of the line.

The Contractor shall provide the necessary staff team for the purpose. The staff team deployed at the ASS'sshall be thoroughly conversant and competent to operate the various switchgear and systems and shall be able to provide auxiliary power, if so desired by the Employer, to other Agencies working in the Station area or elsewhere and also to provide power shut-downs of the commissioned systems, if so directed by the Employer. The Contractor shall be paid under the relevant BOQ item, for the services. It shall also be ensured by the Contractor that deployment of such staff team will not, in any way, affect the completion of other works within the specified Key Dates.

For measurement purposes a period of 8 hours of deployment of one skilled staff shall be considered as one man days. Three shifts per day shall be provided. The roaster of manning staff shall be approved by Engineer in-charge.

The Contractor shall be responsible for ensuring minimum wages and all labour laws compliances, insurances and medical benifits, as prescribed by the Ministry of Labour, State Government and/or Central Government, provisions of Minimum Wages Acts and other statutory provisions (revised time to time) irrespective of rates quoted. **No extra payment shall be made on account of any change in minimum wages. Necessary communication facilities required to be provided to manning staff for reporting incidence by the manning staff shall have to be provided by the contractor.**

The staff deputed shall have competency training and know-how of the ASS installation and other electrical equipments. Necessary training as per the CEA requlations for the staff has to be provided by the contractor. The competency certificate of each manning staff shall be approved by Engineer In-Charge.

2. Power Supply Interlinkings Works

The contractor has to provide the 25 kV and 33 kV power supply interlinkings as per the items provided in the BOQ schedule. All works related to proper safe operation of the interlinking supply shall be done by the contractor. The details of the interlinkings are referred in Chapter 8D of PS.

3. AUXILIARY SUBSTATIONS IN UNDERGROUND SECTIONS

3.1 General

Auxiliary Substations (ASS), located in passenger stations and Mid Shaft are meant for transformation of power from 33 kV to 415 V through the 33 kV / 415 V Dry type distribution transformers and the 415 V protections.

The contractor shall be required to install equipment of underground and elevated corridor as per BOQ and specifications in all these ASSs.

3.2 Locations of ASS

The following are the locations of ASS’s in the Underground Stations, of the corridor.

Corridor Name…

<table>
<tr><th>Sr. No.</th><th>Name of Station</th><th>ASS Ref.</th><th>Tentative No. of transformer to be catered for at each ASS*</th><th>Location Level</th><th>Remarks</th></tr>
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		ASS-2	1 X 2500 KVA		

***** The number and capacity of the transformers are tentative and is subject to confirmation.

3.3 General Technical Requirements

3.3.1 Location of ASS's

In every Underground station, there are generally 02 Auxiliary Substations (ASS-1 and ASS-2) located near the ends of platform, however the location of the ASS may vary according to station architecture. In certain cases, they may be located on the concourse or ground level. For details of locations of ASS, refer para 3.2 above. Tender drawings may be referred for further details.

At all elevated stations, there is one ASS at every station which has two circuit loops. The ASS equipment in those ASS's which are located in the elevated sections will be installed in a suitable room, either at the concourse level, platform level or ground level in the passenger stations.

3.3.2 Electrical Switch Room (ESR)

Generally, the ASS Room is combined with the Electrical Switch Room (ESR), which accommodates the LT equipments and panels. All equipments on the LT Panels, including 415 V Circuit Breakers (Incoming and Coupler) will be supplied and installed by the Station E&M Contractor. Connection between the 33 kV/415V Transformer Secondary and the LT Board, by means of cables or bus duct (sandwiched type) will also be done by the E&M Contractor. The DE-08 Contractor shall maintain necessary interface with the E&M Contractor to ensure proper installation of LT Bus duct/cable. The Contractor shall provide and ensure suitable interlocking arrangements between the above 415 V LT Incoming Breaker and the HT breaker and also the Auxiliary Transformer enclosure door. For extension of power supply from transformer LT side necessary extension links have to be provided by the cotractor. Flexible links shall be provided by the E&M contractor.

The Contractor will provide the necessary protection relays for Transformer Protection eg. Differential relay (only UG station), Standby Earthfault relay, Breaker failure relay and Restricted Earth fault relay. The Contractor shall also interface with E&M Contractor for matching the CT characteristics to ensure tripping of HT and LT breakers in case of Transformer fault within the zone of protection. In addition, Instantaneous and IDMT Overcurrent and Earthfault protection (50, 50N, 51, 51N) and Temperature protection shall be provided, to ensure that the Auxiliary Transformers are fully protected against any downstream electrical faults on the 415 V Distribution systems in the station premises.

Pilot wire relay protection with necessary CT´s will be provided for all 33 kV cable links between ASS within a station or between two ASS of adjacent stations for cables laid in underground/elevated sections.

For protection scheme of DMRC, contractor shall refer Technical Instruction-10 attached in Appendix-D.

3.3.3 Room size

The Room for accommodating the ASS (and ESR) equipments will be built by other Agencies. Room sizes and shapes may be different in different stations. Nevertheless, an approximate area of generally 180 - 230 sq.m., with a minimum height of 4.0 m (in the Transformer and Panel area) will be provided for accommodating ASS Transformers, panels and equipment. Layout of ASS is enclosed in the tender drawing. However, contractor shall review and examine the ASS equipment layout of each ASS and based upon the dimension of equipment selected, develop the working drawing of each ASS in coordination with Civil and E&M Contractor.

The ASS located in the station may have bottom or Top entry of cables depending upon availability of space.The Contractor should interface with civil contractor and Architect in this regard.

3.3.4 Cable cutout

Cable cut-outs for entry/exit of HT, LT and C&M cables will be provided by the Station Building Contractor (SBC). For this purpose, the Contractor will have to maintain an interface with the SBC.

If due to the Contractor changing the Equipment layout or for any other reason, the location of cut-outs are required to be changed, Contractor, interfacing with the Station building Contractor shall ensure necessary changes to be made or if the cut-outs are already provided at site, shall make his own arrangements for providing new cut-outs and closing the cut-outs already made at site.

The cut-outs need to be sealed by a fire sealant; the specifications for the same shall be approved by the engineer in-charge.

3.3.5 **Equipment handling**

The equipment, such as transformer and 33 kV panels shall be brought by road, as per requirements. The equipment shall be moved to their respective position/foundations, with the help of trolley, roller, crane etc as per requirement.

In the case of Underground ASS's located at Platform level, the movement of heavy equipments, like Transformers and HT Panels will be via the track and knock-down walls will be provided in the ASS Room for entry of heavy equipments. In the case of those ASS's located in the Concourse level, a suitable Cut-out (Hatch) of approximately 3.5mx3.5m will be provided to facilitate the heavy equipments being taken to the Concourse level. The Contractor will interface with Station building Contrator for proper size and position of cutout along with hooks for lifiting the equipments.

In case of elevated section, the heavy equipment such as transformer, HT panel etc shall be lifted to loading/unloading platform with the help of crane etc. and then moved to their designated location with the help of trolley roller etc. by the contractor. In station not having loading/unloading deck, cut outs will be provided for moving heavy equipment. The contractor shall interface with station building contractor for proper size and position of cut-out along with hooks for lifting the equipment.

3.3.6 **Cable paths**

In case of underground section, Cable paths required for management of HT, LT and C&M cables, inside the ASS Rooms, shall be provided by the E&M Contractor. Cable path inside trench/utility gallery/undercroftshall be provided by the E&M contractor.

In case of elevated stations, the cable path for HT equipment in station areas including ASS shall be provided by the contractor. The path shall be comprised of cable support, cable hangers, cable trays, cable dropping etc. The steel to be used for cable path shall be hot dip galvanised as per IS-4759 (latest revision) with minimum Zinc coating of 610 gm/m2. Since pre cast structures shall be used in station building, proper interface with Station building contractor shall be done for cable paths. The cable path from RTU to Telecom Equipment Room (TER) and wind speed sensor shall be provided by the E&M contractor. contractor shall do necessary interface with the E&M contractor.

3.3.7 **Equipment mounting**

The Station Building Contractor will provide a finished floor. The Contractor may, if required, fix equipments on the floor with the help of anchor fasteners. In general, no additional concreting is considered necessary to be provided in the ASS Rooms. If any concrete pedestals/foundations are required to be provided to mount transformers/equipment, the same shall be provided by the Contractor, after obtaining approval from Employer.

3.3.8 Earthing in the Underground & Elevated ASS

The Contractor shall provide an earth bus inside the ASS, using 50X6mm G.I. flats. The design and layout of the earth bus shall be submitted by the Contractor for Employer's approval. The Main Earth Terminals (MET) will be provided by the System Vide Contractor (E&M), generally 4 to 6. The Contractor shall make connections of the Transformer Neutral, Metallic bodies of equipments etc to the earth bus/MET, as per approved drawing. The Contractor shall comply the standards and rules and regulations as applicable: -

a) IEEE -80 'IEEE Guide for Safety in AC Substation Grounding'

b) IS 3043 'Indian Standard Code of Practice of Earthing'

c) BS 7430 'Code of Parctice of Earthing'

3.3.9 **Panel Keys & Locks**

Square Keys & Locks of reputed make shall be used for all panels/equipments/enclosures in the ASS room for operational convenience. Similar type Padlocks, keys etc shall be used for all equipements, so that interchangeability is maintanined in all the equipements.

4. 33 KV / 415 V AUXILIARY TRANSFORMERS

4.1 GENERAL

This specification defines the main technical characteristics required for the 33000/415-240V dry type transformers to be used in Auxiliary Substations (ASS).

The transformer offered shall be complete in all respects with all parts and accessories necessary for their efficient operation in sub-stations. All such parts & accessories shall be deemed to be within the Scope of this Specification whether specifically mentioned or not.

Transformer shall satisfy the following requirements and shall also comply with standards in force when the transformers are manufactured, particularly IEC60076, IEC 726, BS 171, IEC publication no.1963, IS 2026 and IS 11171, latest IE Rules and BEE Guidelines, applied in the manner altered, amended or supplemented by this specification, wherever applicable. In all cases, latest revision to these specifications referred to above shall apply.

For Complete technical spectifications of transformer, **Refer Appendix-E, DMRC specifications - DMES-T0005/DMRC-E-TR-TRANSF-05** shall be followed. Surge Arresters also to be provided in Ph-Ph as per DMES/T0005/DMRC-E-TR-TRANSF-05 shall be single or multiple

The transformer shall be Cast resin type.

Design considered for the transformer being supplied under this contract shall include the requirement of frequency of energization of transformer beyond 24 times a year as per clause 4.2 point (i) of IEC 60076-11 (2018).

The transformers shall be commissioned under the supervision of the OEM representative as per the Installation, testing and commissioning plan vetted by OEM and approved by the Engineer.

For elevated section, the transformer shall be provided with Automatic Fire Protection System (indirect Low-Pressure Type). Depending upon the rating and size of transformer in the ASS and the total volume content, the quantity requirement of Fire Protection element shall be calculated by the Contractor and submitted to the Employer's representative, for approval.

The GTP of transformer, surge arrester and fire suppression system shall be approved by Engineer in-charge.

5. 33KV SWITCHGEAR

5.1 GENERAL

The Switchgear in ASS shall be 36 KV, 3 phase, 50 Hz, which when erected shall form a complete switchboard having SCADA/SAS compatibility.

The Switchgear will comprise of:

- 33 kV Cut-off Circuit Breaker Cubicles for Ring Main Network.
- 33 kV Circuit Breaker Cubicles for feeding transformers
- 33 kV Coupling Breaker Cubicles, for looping circuit 1 and 2.

along with Bus riser wherever required.

The switchgear offered shall have a basic insulation level (BIL) of not less than 170kV peak.

For ASS in the under-ground section: -

The switchgear shall be of the single busbar with 3-phase enclosure indoor metal-enclosed extendable type, which, when erected, shall form a complete switchboard.

The metal-enclosed switchgear shall be gas insulated and the circuit interrupting device shall be of vacuum type.

The switchgear shall be capable of operating in class B environment stipulated in clause 1.12 of General Specification.

For ASS in the elevated section: -

The switchgear shall be air insulated Metal clad indoor VCB type switchgear unit having SCADA/SAS Compatible facilities. All the equipment shall be suitable for satisfactory operation in tropical climate and dry dust laden atmosphere. The equipment shall be able to withstand wide range of temperature variation (-5º to 50ºC). Temperature rise shall be guided by as per IEC: 62271. The plant/apparatus/equipment supplied shall comply in all respect with the requirement of CEA regulations / ISS / IEC with latest amendment. The 33kV switchgear (for both UG and elevated ASS) shall comply with the following IEC standards (latest):

62271, 62271-100, 62271-102, 62271-103, 62271-200, 60376, 61869, 61869-3, 61869-2, 60028, and 60721-2-5,, 60529, 60051-2,

5.2 33KV GAS INSULATED SWITCHGEAR

5.2.1 General Description

All non-welded assemblies shall be assembled by means of bolts and nuts with mandatory use of lock-washers. All panels, separating partitions and accessories shall be mounted similarly, in such a way so as to withstand indefinitely the vibrations transmitted, in particular by the resetting mechanism of the circuit-breakers and their actuation.

5.2.2 Electrical characteristics

Rated voltage:	36 kV
Operation voltage:	33 kV
Frequency	50 Hz
Rated busbar current	1250A
Rated current of feeders:	630/1250 A
Rated current of transformer feeders:	630 A
Rated short time withstand current	25kA – 1 sec
Rated short circuit breaking current	25kA
Rated short circuit making current	62.5kA
Lightning impulse test (BIL) voltage:	170 kVp
Power frequency test voltage:	70 kVrms
Auxiliary supply voltage:	110V DC
Degree of protection (hv compartment):	IP65
Degree of protection (lv compartment):	IP3X

5.3 GENERAL REQUIREMENT

(i) GIS supplier should have minimum experience of 05 years for manufacturing of similar GIS substations. The type of GIS offered should have been in satisfactory operation for atleast three years. Contractor should submit performance certificate from the employer.

(ii) The 33kV equipment shall be built according to the SF_6 gas insulation technology.

(iii) 33kV GIS as offered should be fully type tested as per latest IEC standards at the time of submitting the bid.

(iv) The equipment installed shall offer all necessary facilities for equipping and connecting the equipments sections to follow, without entailing any shut down of equipment already in service.

(v) In the event of arching in a compartment, the arches should not extend to the neighbouring compartment/Panel. Any failure to the enclosure of the compartment shall not lead to damages in the neighbouring compartments.

(vi) Suitable means of expansions should be provided in the metal enclosure and pipelines to absorb the actual thermal expansion and contraction of the SF6 equipment and to facilitate the alignment of the switchgear assembly.

(vii) The metal enclosure for the SF_6 gas insulated equipment modules shall be made from aluminium alloy/ stainless steel.

(viii) GIS should be of modular design, and it should be possible to add feeder panels if required. Any addition of panels at a later date or exchange of panels, irrespective of it's location in the switchboard.

(ix) Inter-panel auxiliary and control wiring shall have terminals in each relevant cubicle so placed for the bus wiring to be readily run from unit to unit. Auxiliary and control wiring to be connected to other equipment shall be wired to terminals at the rear of individual cubicles, suitably located for the wiring to be extended via multi-core cabling run in floor ducts. All auxiliary and control wiring shall be separated from high-voltage conductors, even though the latter are insulated by earthed metal enclosures.

(x) All auxiliary and control cables and wirings shall have suitable marking, such as ferrule markers, which shall clearly identify their function and shall match the control schematic drawings and wiring diagrams. The markers shall fit firmly over the outer diameter of individual cable and each wire core. Marks shall be printed and legible. For easy identification, colour coding shall be used to differentiate various functions of the cable and wires. All auxiliary and control wirings shall also be complete with cable lugs for termination.

(xi) A relay and instrument compartment shall be located at the front of each switchgear unit and shall be provided with a hinged door for access to the internal wiring and terminals. Gaskets shall be used to provide close sealing. The height of the instrument panel above floor level shall not exceed 2,000mm unless otherwise reviewed without objection by the Engineer who may require the Contractor to provide, at its own cost, suitable means for easy access to the instrument panel.

(xii) Each panel shall have individual voltage sensing device which can provide the condition of status of power cables. **This individual voltage sensing device shall be compatible with**

the interlocking devices & relays of the panels. Voltage based interlocking of earthswitch/Circuit breaker/Isolator etc. can be developed through output contacts of this voltage sensing device.

(xiii) Gas sensing device shall have provision of two stage setting, low and very low, alarm and tripping command can be generated in case of change in gas pressure in each chamber.

(xiv) Anti-condensation heaters with humidity control function shall be installed for each switchgear panel.

(xv) The switchboard shall be designed to cater for future extension.

5.3.1 **Detail Description –Equipment & Accessaries**

5.3.1.1 **Circuit Breakers**

5.3.1.1.1 Circuit breakers shall employ vacuum interrupters and shall have busbar side integral isolation facilities, i.e. a 3-position isolator with On-Off-Earth positions.

The circuit breakers shall have rated operating sequence (duty cycle) of: O–0.3s–CO–3min–CO as per IEC 62271.

The endurance class of Electrical, Mechanical & restrike performance operations of all breakers, earth Switch, isolator etc needs to mentioned in the GIS equipment proposal.

5.3.1.2 **Operating Mechanisms**

5.3.1.2.1 The circuit-breaker switch mechanisms shall be of spring-powered stored energy operation by means of a motor charged spring with manual and electrical released, or solenoid operated.

5.3.1.2.2 The mechanism shall be of the trip free type so that the circuit-breaker shall be free to open during the closing operation immediately after the operation of its tripping device. The circuit-breaker shall be capable of closing fully and latching, against its rated making current. The various parts shall be of substantial construction, carefully fitted to ensure free action, and designed to reduce mechanical shock during operation to a minimum.

5.3.1.2.3 In the event of a spring breaking, it shall still be possible to open the circuit-breaker safely.

5.3.1.2.4 Circuit-breaker spring operated mechanisms shall have the following additional features:

- If the circuit-breaker is opened and the springs charged, it shall be possible to close, and then trip the circuit-breaker;
- If the circuit-breaker is closed and the springs charged, there shall be sufficient energy to trip, close, and then trip the circuit-breaker;
- Mechanical indication shall be provided to indicate the state of the spring; and
- Motor charged mechanisms shall be provided with means for charging the springs by hand. A shrouded push button for releasing the springs and an electrical release coil shall also be provided.

5.3.1.2.5 All circuit-breaker operating mechanisms shall be fitted with an electrical shunt trip release coil and a mechanical hand tripping device.

5.3.1.2.6 Tripping and closing circuits shall be provided with a fuse or miniature circuit breaker on each unit and shall be independent of each other and all other circuits. A trip circuit supervision scheme shall be incorporated for every circuit.

5.3.1.2.7 The electrical tripping and closing devices shall be operated satisfactorily, with a maximum temperature of 55°C inside the 33kV switchgear enclosure, over a DC voltage range as follows:

- Closing solenoids 85 to 110% of rated voltage
- Spring charging motor 85 to 110% of rated voltage
- Closing release coil 85 to 110% of rated voltage
- Shunt trip release coil 70 to 110% of rated voltage

5.3.1.2.8 All operating coils for use on the DC supply shall be connected in such a way that failure of insulation to earth does not cause the coil to become energised.

5.3.1.2.9 Auxiliary switches shall be provided in circuit breaker tripping circuits to interrupt the tripping supply as soon as the circuit breaker has completed the tripping operation. An auxiliary switch shall be provided in closing circuits to ensure that the closing circuit is open after a close has been made.

5.3.1.2.10 A proven positively-driven mechanically-operated indicating device shall be provided to show whether a circuit breaker is in the open or closed position.

5.3.1.2.11 Locking facilities shall be provided so that the circuit breaker, if required, can be prevented from being closed when it is open, and from being manually tripped when it is closed. It shall not be possible to gain access to the tripping toggle or any part of the mechanism which would defeat the locking of the manual trip.

5.3.1.3 **BUSBARS AND CONNECTIONS**

5.3.1.3.1 Busbars and connections between the pieces of apparatus forming the equipment of a cubicle shall be of high-conductivity copper. The conductivity shall not be less than 99.9% of that of a "Standard Annealed Copper", as per IEC 60028.

5.3.1.3.2 Busbar connections and their supports shall be of an approved type, designed to withstand all normal and abnormal conditions arising in the System. They shall be capable of carrying the current equivalent to the breaking capacity of the switchgear for 3 seconds.

5.3.1.4 **INSULATION GAS**

5.3.1.4.1 The Contractor shall submit details on quantity, quality and density of SF6 gas to be used in the switchgear in accordance with IEC 60376.

5.3.1.4.2 The GIS shall be grouped into suitable gas compartments with each compartment fitted with a monitoring pressure gauge/sensor and a pressure relief device.

5.3.1.4.3 The gas shall still insulate the 33kV power frequency voltage when the SF_6 gas pressure drops to 1 bar and the gas leakage rate shall be guaranteed to be less than 0.1% by mass per year.

5.3.1.4.4 The GIS shall be so designed that an internal arc fault in a compartment will not affect other gas compartments, and compartments for operating mechanism and protection relays. The high-pressure gas or air from the GIS during an internal arc fault shall be directed or vented to a direction away from the operator. The Contractor shall provide type test reports for the internal arc test. Rating of internal arc classification shall be FLR as per IEC 62271-200.

5.3.1.4.5 Internal insulation level between live parts and earth when the pressure of the gas goes to the atmospheric pressure should not be less than 1.2*33/1.732 kV.

5.3.1.4.6 SF_6 Gas apparatus warning sign shall be provided on the GIS.

5.3.1.4.7 All special tools and equipment for installation, testing, commissioning, operation and maintenance of the GIS shall also be supplied by the Contractor. These include a suitable sized gas handling unit mounted on a trolley for purging, refilling and other gas works. The trolley shall be able to retain the SF_6 gas purged from any gas zones of the GIS.

5.3.1.5 **Switchgear Interlocking**

5.3.1.5.1 Where a circuit breaker or other switchgear is fitted with means for mechanical or electrical operation, interlocks shall be provided so that it is impossible for the electrical and mechanical devices to operate simultaneously.

5.3.1.5.2 An electrical or a mechanical key interlocking system shall be provided whereby it is not possible to apply an earth to a section of the busbar until all circuit breakers which can feed that section are locked open.

5.3.1.5.3 The earthing devices shall be provided with interlocks to ensure correct operation in conjunction with the associated circuit breaker. The earthing devices shall be provided with both electrical and mechanical interlocks to ensure correct operation in conjunction with the associated circuit breaker. Operation of the earthing device should not necessiate an additional step of closing the circuit breaker separately.

5.3.1.5.4 The isolators and the associated circuit breaker which are integral parts of the switchboard shall be equipped with mechanical interlocking to ensure that the isolators cannot be operated unless the associated CB is opened. For the same reason, motorised isolator shall be installed with electrical interlock to provide the same interlocking logic.

5.3.1.5.5 Means shall be provided whereby the electrical tripping of the circuit breaker is rendered inoperative during earthing operations both when closing and when closed in the earthed position.

5.3.1.5.6 Where interlocking over a distance is required, two independent criteria shall be used, e.g. absence of a voltage and remote feeding circuit breaker open. Indication of the remote condition shall be by single purpose circuit, care being taken that the conductors used are adequately screened and shielded to minimise both transverse and longitudinal voltages resulting e.g. from electromagnetic induction, differences in earth potential or other causes. The Contractor shall ensure that voltages dangerous to personnel or deleterious to correct operation shall not arise.

5.3.1.5.7 Not Used

5.3.1.5.8 The mechanical closing button of circuit breaker shall be interlocked with the selective closing conditions of the circuit breakerthat are imperative such that operation of the mechanical closing button shall be prohibited if the closing conditions of the circuit breaker are not fulfilled.

5.3.1.6 **Locking Facilities**

5.3.1.6.1 Padlocking facilities shall be provided for mechanical trip on circuit breakers to prevent manual tripping.

5.3.1.6.2 All cubicle access doors, other than those which are interlocked with a switching device, shall be provided with pad-lock type locking facility.

5.3.1.7 **Earthing and Earthing Devices**

5.3.1.7.1 All earth bars and terminals including those in the switchboard and inside the ASS shall be tinned copper.

5.3.1.7.2 All metal parts other than those forming part of an electrical circuit shall be directly connected to a high conductivity copper earth busbar which shall run the full length of and be bolted to the main frame of the switchboard.

5.3.1.7.3 At the position where joints or terminations occur, the earth busbar shall also be tinned. The earth busbar shall be rated to carry currents equal in magnitude and duration to that associated with the short circuit rating of the equipment.

5.3.1.7.4 The metallic cases of all instruments, relays or other associated components mounted on the switchgear shall be connected to the earth busbar by copper conductors of not less than 2.5mm^2 cross-sectional area.

5.3.1.7.5 When components are provided for mounting separately, each shall be provided with an earthing terminal of not less than 30mm^2 cross-sectional area.

The Individual GIS panel should be with PT isolation arrangement to conduct all the after-installation tests on HT cabling system as per requirement of Standards. A manual disconnector/**isolating mechanism** must be provided to isolate the Line & Bus VTs. Cable connected VTs are not acceptable.

5.3.1.8 **Control Facilities**

5.3.1.8.1 All circuit-breakers shall be capable of being operated electrically from the OCC via the SCADA system.

5.3.1.8.2 Proven, positively driven mechanical indicating devices shall be provided on all equipment to indicate whether the primary equipment is in the OPEN or CLOSED position. Care shall be exercised in the design and fitting of these indicators to ensure that the indicating device and associated apparatus does not interfere with the correct operation of the circuit-breaker or isolator.

5.3.1.8.3 Each circuit breaker shall be provided with the necessary auxiliary contacts and internal wiring to permit remote control and indication.

5.3.1.8.4 Separate switches for local electrical operation shall be installed for each circuit breaker and they shall be of a proven pistol-grip type or any other as approved by engineer. They shall have CLOSE and TRIP positions, with a spring return to a NEUTRAL position. The switches shall be lockable in the NEUTRAL position by means of a padlock

5.3.1.8.5 A separate LOCAL / REMOTE CONTROL selector switch shall be provided for each circuit-breaker. In addition to the contacts in the control circuits, the switch shall have contacts closed in the LOCAL position for remote indication of switch positions. The switch shall have two positions, and shall be lockable at both positions by means of a padlock.

5.3.1.8.6 Electrical tripping and closing devices shall be suitable for operation from 110V DC batteries.

5.3.1.8.7 Exposed LV 220V AC terminals inside each Control cubicle shall be adequately shrouded to avoid accidental human contact.

5.3.1.9 **Auxiliary Switches**

5.3.1.9.1 Proven, positively direct-driven auxiliary switches shall be provided on all primary switching devices as required for indication, control and interlocking. Auxiliary switches shall be robust, shall have a positive wiping action when closing and shall be mounted in an accessible position clear of operating mechanisms. Three sets of spare switches comprising of normally-open and normally-closed contacts shall be provided on each unit.

5.3.1.9.2 Auxiliary switches shall be of the changeover type to be either normally-open or normally-closed, and shall be positively lockable in the desired position.

5.3.1.9.3 Auxiliary switches shall be designed to make, break and carry, without undue heating, the current of their associated circuit or a current of three amperes DC, whichever is the higher.

5.3.1.10 **Cable Entry**

Cable connection shall be bottom/top entry as per the requirment. Cable termination shall be inner/outer cone plug in type. Suitable cover should be provided at all the cable entry locations of the GIS panel to avoid unitentional contact of the live parts by rodents etc. Contractor shall obtain approval from employer for the above scheme.

Back side cover shall be required to be provided if no maintenance is recommended frorn the rear portion of GIS.

5.3.1.11 **Testing Facilities**

5.3.1.11.1 All fixed and moving portions of the switchgear shall be provided with facilities to enable high voltage tests to be carried out.

5.3.1.11.2 When Energymeters, current transformers and protective relays are fitted, facilities including but not limited to isolation links, test blocks and test plugs shall be provided for primary and secondary injection tests to be performed. These facilities shall be such that wires and connections need not be disconnected for the tests to be made.

5.3.1.12 **Current Transformers**

5.3.1.12.1 When CTs are used for protection and measurement purposes, they shall have the appropriate ratio, class and burden in line with the functions they are used for.

5.3.1.12.2 All current transformers shall have a 3-second short-time current rating of not less than the maximum System fault level.

5.3.1.12.3 Current transformers shall have an output rating adequate to cater for the burden connected to them and shall function satisfactorily under the maximum system fault condition.

5.3.1.12.4 All current transformers shall be installed with the P1 terminals adjacent to the busbars.

5.3.1.12.5 All connections from secondary windings shall be brought out and taken by means of separate insulated leads to a terminal board mounted in an accessible position. Where multi-ratio secondary windings are required, a label shall be provided at the secondary terminal board clearly indicating the connections required for each ratio. The connections and ratios in use shall be shown on all diagrams of connections.

5.3.1.12.6 Current transformers shall have the appropriate ratio depending upon their application.

5.3.1.12.7 Secondary connection wirings shall have adequate rating to cater current requirement as approved by engineer and should not be less than 1.5mm^2 copper conductorsFRLSOH cables.

5.3.1.12.8 The class of all protection CTs shall be as per GTP.

5.3.1.12.9 The Contractor shall prepare a schedule of CTs to be installed, and submit the same for the Engineer's review.

5.3.1.12.10 The secondary windings of current transformers shall adopt single point earthing. The earth connection shall be made at a terminal block via a removable link.

5.3.1.13 Voltage Transformers

5.3.1.13.1 Voltage transformers of the metal-enclosed encapsulated type are preferred. Other types may be submitted to the Employer's Representative for review and approval.

5.3.1.13.2 The secondary windings shall be connected to the secondary circuit through a LV fuse or a miniature circuit breaker (MCB).

5.3.1.13.3 The nominal VT ratio shall be 33kV/110V.

5.3.1.13.4 For protection and measurement applications, the VTs shall be of dual Class 3P/0.5. The burden of VTs shall be decided by the Contractor with a margin of 40% for future additions of instrumentations, and submitted to the Employer's Representative for review and approval.

5.3.1.13.5 The PT shall be provided with manual disconnector switch/**isolating mechanism** to isolate the Line & Bus VTs. Cable connected VTs are not acceptable.

5.3.1.14 Paint-Work

5.3.1.14.1 Painting should be suitable for polluted atmosphere and has to comply with IEC 60721-2-5 standard

5.3.1.14.2 As a minimum, an initial coat of rust-proofing and anti-corrosion paint will be applied after baring of all metal surfaces; then they will be covered with two coats of paint and one finishing coat, colour to be defined. The Contractor shall submit to the Employer, the complete details of the Switchgear Cubicles Metal work and Paintwork details, including details of the structure, process of finish and painting etc, for Employer's approval.

5.3.1.15 Identification

The front of each cubicle shall carry a nameplate indicating its identification number and function. The text and type of nameplate shall be defined.

5.3.1.16 **Fitting & Accessories**

As a minimum following fittings and accessories shall be provided

a) Mechanically operated tripping and closing device

b) Local / Remote /off control switch and indication lamps

c) Operation counter

d) Supporting frame if needed

e) Name plate

f) Foundation bolts

g) Semaphore indicators

h) Meters

i) CTs & PTs as required

j) Protection as required

6. 33 KV AIR INSULATED SWITCHGEAR (AIS)

6.1 GENERAL

The Switchgear in ASS shall be 36 KV, 3 phase, 50 Hz air insulated Metal clad indoor VCB type switchgear unit having SCADA/SAS Compatible facilities. All the equipment shall be suitable for satisfactory operation in tropical climate and dry dust laden atmosphere.

The equipment shall be able to withstand wide range of temperature variation (-5º to 50ºC). Temperature rise shall be guided by as per IEC: 600694.

The plant/apparatus/equipment supplied shall comply in all respect with the requirement of CEA Regulation / ISS / IEC with latest amendment.

Basically, the Switchgear will comprise of:

- 33 kV Cut-off Circuit Breaker Cubicles for Ring Main Network.
- 33 kV Circuit Breaker Cubicles for feeding transformers
- 33 kV Coupling Breaker Cubicles, for looping circuit 1 and 2.

along with Bus riser wherever required.

The switchgears shall conform to latest revision with amendment available of relevant standards, rules and codes some of which are listed herein for ready reference.

S. No.	Standard	Item
1	IEC-62271-100	Circuit Breaker
2	IEC-62271-1,100,200;	Indoors switchgear and control gear
3	IEC 61869-1,2	Current Transformers
4	IEC 61869-1,3	Voltage Transformer
5	IEC 60255	Protective Relays
6	IEC 60051-2	Digital Ammeter & Voltmeter

7	IEC 62271-102	Alternating current disconnector (isolators)
8	IEC 60529	Classification of degrees of protection
9	IEC-62052-11, 62053-22 /CBIP Report	Tri Vector Meter

6.1.1 **Switchgear Cubical**

- **General Data**

The Switchgear shall be factory assembled, totally enclosed, metal clad, dead front cubicle. All Switchgears cubicles shall be of the same type. All non-welded assemblies shall be assembled by means of bolts and nuts with mandatory use of lock-washers.

The Switchgear shall be dust, moisture and vermin proof complying with degree of protection of not less than **IP-4X.** The panels shall be of Metal Clad compartmentalized design with all the compartments viz. Circuit Breaker, Bus Bar etc. separated by metallic partitions. The switchgear panels shall be rigid without using any external bracing.

The switchgear shall be complete with all necessary wiring fuses, auxiliary contacts, terminal boards etc.

The observation window on the CB compartment door shall be provided. Observation window shall be of same material and construction as the type tested design/construction.

The design of the panels shall be such that no permanent or harmful distortion occurs either when being lifted by eye bolts or when moved into position by rollers or trans pallets.

All panels, separating partitions and accessories shall be mounted similarly, in such a way so as to withstand indefinitely the vibrations transmitted, in particular by the resetting mechanism of the circuit-breakers and their actuation.

Each cubicle shall be equipped with anti-condensation heater controlled by thermostat.

Only one type of lock & key (square key) except (castle locks and keys) of minimum SS-304 grade for different type of doors of all equipment of 25 kV and 33 kV (MK/CB/Isolators/LBS/RTU/Battery Charger/ACDB/DCDB/Other panels etc.) of reputed make as approved by Engineer In-charge shall only be used.

The measuring meters in 33 kV panels shall be of digital type only.

The rack in/rack out handles, earth switch handle, CB mechanical handle and spring charge handle shall be supplied individually for each 33 kV Circuit Breaker. Two set of PT rack in/rack out ramp, CB rack in/rack out ramps and Busbar earthing trolley (withdraw able type) shall be supplied with each ASS. 10% of spare nuts and bolts per distribution board of panels shall also be supplied. ***One set of spare of each type castle lock arrangement per ASS shall supplied.***

The price of spare items has been included in BOQ of 33 kV panels. The DE-08 contractor shall advise to quote the prices accordingly.

6.1.2 **Electrical Characteristics**

The service voltage is 33 kV.

The insulation level is 36 kV minimum

All parts of the cubicle (bus-bars, sliding connector, partition passages) shall be capable of permanently withstanding the temperature rise over ambient caused by the currents and shall match the nominal rating of the circuit-breaker provided.

The cubicles shall be capable of withstanding without any damage, the loads generated by 1500 MVA peak short-circuits. The number and frequency of those are not limited in time.

6.2 Cubicles Common Part

6.2.1 **Make-Up/ Construction feature**

- Each cubicle will be metal clad type, air insulated, made of:
- Busbar set compartment
- Cable end compartment
- Low voltage (measure, protection & monitoring) compartment
- Apparatus connector compartment with shutter

- Withdrawal trolleys
- Metal clad envelope with appropriate hanging devices.

Compartments will be physically separated from each other by metal partitions, which shall not heat up due to induced magnetic fields action.

All panels, separating partitions and accessories shall be mounted similarly, in such a way so as to withstand indefinitely the vibrations transmitted, in particular by the resetting mechanism of the circuit breakers and their actuation.

All non-welded assemblies shall be assembled by means of bolts and nuts with mandatory use of lock-washers.

All nuts & bolts used for sealing of compartments/chambers shall be minimum as far as possible without affecting the maximum vibration level of the panels.

Internal and external metal partitions are connected to the earth, high voltage electrical links are realized with bushing.

Auxiliary voltage shall be 110 V dc (+10%, -20 %) for motors, monitoring and control circuits.

Note that all parts of the cubicle (bus-bars, sliding connector, partition passages) shall be capable of permanently withstanding the temperature rise over ambient caused by the currents and shall match the nominal rating of the apparatus.

All MV Panels shall be placed in ASS with the direction of station from where 33 kV incoming supply is coming and also 33 kV Outgoing supply is going.

The gap between different distribution boards in ASS shall properly be sealed with robust arrangement as approved by Engineer in-charge.

6.2.2 **Equipment**

Cubicles will mainly be equipped with:

- **Trolley Compartment:**

➢ Fixed earthing plug-in contact

➢ A shutter automatically protecting live pieces when the apparatus is plugged-out.The arrangement for locking of shutter to avoid its opening during maintenance shall also be provided. The shutter shall also be provided with suitable reflective danger signage.

- Grounding of the frame of the trolley
- A safety interlocking access to the fixed insertion connectors if the circuit-breaker is not in the cubicle or if it is in the withdraw position.
- A precise device for displaying the end of insertion travel with limit switch.
- A fixed plug-in socket enabling the flexible connection to be made for control and monitoring of the circuit-breaker.
- The interlocking corresponding to the function of the cubicle
- A general connecting terminal for low voltage circuits of the cubicle. The terminals shall be tightened by screws; no other connecting device shall be used. An annunciation device for 33 kV voltage on, by mean of a capacitive divider with LED lamps (one per phase), glowing permanently in live conditions. LED lamps shall indicate the presence of 33 kV voltage on incoming & outgoing side. In case of common bus voltage, indication for presence of 33 kV Supply shall be provided in cut – off Circuit Breaker only.
- Safety caution board shall be provided.

- **Bar Set Compartment:**

- 33 kV, 1250 A bar set, mounted on insulators, suited to withstand 1500 MVA peaks short-circuit.
- Inter-cubicles high-voltage connectors.
- **The bus bar shall be made of Copper material**

In principle, the bus bar shall be of rectangular cross-section. Alternatively, hollow tubular Busbar are acceptable, provided they meet the current requirement of 1250 A.

To earth the Busbar during maintenance, a bus bar earthing trolley (withdrawable type) shall also be provided**.**

An annunciation device for 33 kV voltage on, by mean of a capacitive divider with LED lamps (one per phase), glowing permanently in live conditions.

The clearance from Busbar to any earthed part shall strictly be conforming to latest IEC standard.

- **Cable end Compartment:**

- One or two sets of three current transformers for protection and measurement.

- Three display lamps for voltage on fed by capacitive dividers, annunciation lamps being installed on the front face of the cubicle (LED lamps included). LED lamps shall indicate the presence of 33 kV voltage on incoming & outgoing side. In case of common bus voltage, indication for presence of 33 kV Supply shall be provided in cut – off Circuit Breaker only.

- End-boxes for 33kV three-phase cables of dry type Aluminium or copper with appropriate cross-section, this box shall be supplied complete with all the necessary materials for installing the cable and completely making the end connection.

- The connection braids between the two sets of bus bar, the current transformers and the cable end-box, with sufficient gap so that when the braids are removed, the output terminals from the cable box be sufficiently distant from any earth, thus enabling the high voltage cable to undergo dielectric tests or any fault finding to be carried out by applying high voltage.

- A cable head earthing isolator, actuated manually, complete with the necessary interlock. Positions of the earthing isolator shall be visible through a glazed port.

This compartment height shall be at least 800 mm to ease cable connection and be equipped with an external cable support device. All CB panels shall have integral earth switch for cable side earthing.

- **Low voltage Compartment:**

- Voltage presence capacitor dividers, relay and facade LED indicator light. LED lamps shall indicate the presence of 33 kV voltage on incoming & outgoing side. In case of common bus voltage, indication for presence of 33 kV Supply shall be provided in cut – off Circuit Breaker only.

- Open/closed and connect/disconnect position indicator LED lights and contacts.

- Facade measurement indicators (counter, Ammeter & Voltmeter when required)

- Facade mimic visual diagram.

- Control and monitoring devices for the CB (programmable logic control)

- Control and monitoring, multi pin connector.

- Lockable access door.

- LED lamp for illumination, heater controlled with thermostat, AC socket etc.

- **Withdrawal Trolley:**

➢ Self-contained trolley fitted with rollers allowing 3 positions:

➢ Plugged-in

➢ Plugged-out (test position)

➢ out of the cubicle

➢ The Apparatus (see Circuit breaker here after chapter)

➢ an apron panel of sheeting, on the front face, carrying the control button and the open and closed position annunciation via mechanical display,

➢ a low voltage connector for all the control and annunciation (flexible multiple in connectors to the corresponding receptacle on the cubicle) with a device for securing the plug when handling the circuit-breaker,

➢ a grounding contact connecting the frame circuit of the circuit-breaker to the cubicle grounding bus-bar,

➢ all the interlocking mechanisms,

➢ a plugging actuator if necessary,

➢ a manual actuating auxiliary system, provided with an interlocking device to avoid electrical control in this case,

➢ Auxiliary annunciation contacts displaying whether the circuit-breaker is in open or closed position, connected to the terminal board of the low voltage circuits. Spare open and closed contacts shall be available in addition to those used for low voltage control and monitoring circuits.

➢ An operating counter.

The actuating system shall be of energy accumulation type, with low transient current consumption when arming the circuit breaker. It shall be equipped with an anti-hunting device.

- **Cubicles arrangement**

➢ All cubicles, boxes or sheaths must be rigidly fastened to the floor.

- Cubicle level adjustment can be realized with special steel sections initially anchored in position.

- The assembly level thus executed will enable smooth pulling of the trolleys in the cubicles.

- **Cubicles Grounding**

- Each cubicle shall comprise a Copper grounding bus-bar of suitable cross-section to which each of the metal masses of the component parts of the cubicle shall be connected, together with those of the instrument transformers.

- The grounding bus-bars of the various cubicles shall form a linkage interconnected together and a common single collector line shall be provided for connecting it to the earthing circuit of the station.

- The withdrawal trolley will be connected to this grounding bus-bar via a plug-in/out contact.

- The cable end manual earthing isolator position shall be visible, through a glazed port.

- The bimetallic strips shall be provided by DE-08 contractor, wherever required

- **Paint Work**

- Painting should be suitable for polluted atmosphere and has to comply with IEC 60721-2-5 standard

- As a minimum, an initial coat of rust-proofing and anti-corrosion paint will be applied after baring of all metal surfaces; then they will be covered with two coats of paint and one finishing coat, colour to be defined. The contractor shall submit to the Employer, the complete details of the Switchgear Cubicles Metal work and Paintwork details, including details of the structure, process of finish and painting etc. for Employer's approval.

- **Protection level**

The switchgear and control gear should have the minimum degree of protection (in accordance with IEC 60529)

- **IP 4X** for the enclosure for rated current up to 1250A
- **IP 3X** for the partition between compartments

Identification

The front of each cubicle shall carry a nameplate indicating its identification number and function. The text and type of nameplate shall be defined later.

Response to a fault

The response to various type of faults in system shall be as per the Technical instruction -26 of DMRC attached in Appendix-D.

6.2.3 Apparatus

- **Make-up & Equipment**

Each apparatus shall be tri-phases and Vacuum type (however in case of interlinking the type of apparatus shall be similar to existing).

Each apparatus shall include: -

- Up & down stream plug-in connectors
- Life insulated poles
- Energy accumulation type actuation system (electromechanical springs)
- Electric and manual arming capability (Tripping and closing coils motor)
- Under-voltage tripping coil (Auxiliary voltage off)
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable.

- **Current transformers**

Each Current transformer will be installed in the cable end compartment between the downstream pole and the cable connector and at least one in current Transformer in busbar compartment.

Cable end compartment volume will allow current transformer easy access and removal.

Current transformers shall be cast resin type.

Current transformer performances shall be as per technical sheets included into the relevant Chapter.

- **Voltage transformers**

Each Voltage transformer shall be installed in the cable end compartment, connected between the downstream pole and the cable connector through HBC fuses

Cable end compartment volume will allow voltage transformer easy access and removal.

Voltage transformers shall be cast resin type.

The Voltage transformer shall be provided with Surge arrester.

Voltage transformer performances shall be as per technical sheets included in the relevant Chapter.

- **Self-interlock requirements**

Apparatuses can be plugged-in or out, only if opened.

All access to the fixed plug-in parts is prevented when the apparatus is withdrawn.

The interlock shall fulfill the following conditions:

- When unplugged and withdrawn from the cubicle, the apparatus shall inhibit opening of the flaps covering the receptacles and shall enable the key to be turned.
- By turning the lock and withdrawing the key, it shall not be possible to plug-in the circuit breaker.
- In addition, for the circuit breaker cubicles, it shall be possible to actuate the earth isolator only after first unplugging the circuit breaker and withdrawing the first key.
- Conversely, the earth isolator being closed, it shall not be possible to unlock the cubicle in order to plug incircuit breaker.
- The type of lock shall be selected among equipment considered as being safety equipment.
- A general diagram of the key interlocks for the station, indicating all the locks provided for the present equipment shall be prepared.

NOTE: It shall invariably be possible to padlock the interlocks.

There will be two kinds of apparatus:

A) Cut – off / Ring Main/Interlinking/incomer Circuit Breaker

The function of the Cut – off / Ring Main Circuit Breaker is to isolate a 33 kV cable, on load or fault.

Coupling circuit breaker will ensure the continuity of supply by creating a loop on the 33 kV cables.

They shall have the following characteristics

Voltage rating: 36 kV, 50 Hz

Current rating: 1250 A

Operating voltage: 33 kV

Breaking capacity: 12.5 kA

Closing capacity: 31.25 kA peak

Acceptable short duration current: 12.5 kA RMS for 3 seconds

B) Transformer Circuit breakers

This cubicle is made to supply, protect and earth the ASS power transformer or any specified outgoing 33 kV feeder.

They shall have essentially the following characteristics

Voltage rating: 36 kV, 50 Hz

Current rating: 400 A

Operating voltage: 33 kV

Breaking capacity: 12.5 kA

Closing capacity: 31.25 kA peak

Acceptable short duration current: 12.5 kA RMS for 3 seconds

The characteristics shall be adequate to cater to the transformer size they protect.

6.2.4 Bar-Raising

- **Function**

This cell shall enable linking between two cells when the parts to be connected are one at the bottom of the cell and the other at the top of the cell.

- **Description**

This cell shall comprise a compartment, closed by bolted-on panel, access to which shall be prohibited in normal operation. Internal equipment shall mainly comprise one set of vertical bars of a rated current, mounted on insulator.

DMRC shall inspect the prototype of each type of 33 kV panel of approved vendors before commencement of bulk manufacturing by vendors. If any modification in prototype will required by DMRC, it shall be the responsibility of contractor/vendor to modify the product accordingly. After the successful inspection of prototype, formal approval shall be given by Engineer in-charge for bulk manufacturing of equipment.

The bill of material of equipment shall be approved by Engineer in-charge.

7. Medium Voltage Switchgear Interlocking

It is to be taken care that communication of all signals related to CB, Isolator and EarthSwitch should be hard wired to RTU and not through protection relays.

The medium voltage switchgear interlocking has several purposes:

- To avoid any paralleling between two transformers of the AMS in remote control mode
- To avoid any paralleling between two transformers of the AMS in local control mode
- To avoid the earthing of a cable under voltage presence

For this purpose, the 33 kV network is divided into suitable loops.

Normally, the ASS's connected to the various loops will derive power supply from the respective loop only. However, in an emergency situation, when one of the AMS's is totally out-of-service and consequently the loop connected to this AMS is in itself not able to derive power from the AMS, it would be necessary to resort to linking of the loops. When this is required to be done, the linking circuit breakers which are provided for this purpose are closed in a sequence so as to ensure that the two loops are not linked when both loops are live. Suitable interlocking shall be provided for this purpose.

<u>The various type of interlocking shall be provided in 33 kV system as per DMRC interlocking scheme (Technical Instruction-12) of DMRC attached in Appendix-D.</u>

7.1.1 Interlocking in remote control mode

In remote control mode it shall be possible to operate any <u>Ring Main</u> CB and <u>coupling CB</u> without any mechanical interlocking. That could be possible through the medium of the remote/local knob when in remote position.

7.1.1.1 1st Case, Both RCCB/<u>MCCB</u> Closed

To avoid any paralleling between the both transformers of the AMS, the software shall authorise the closing of all <u>Ring Main</u> CB and <u>coupling CB</u> of one loop except one (that is to say it shall be possible to close N-1 apparatuses on each loop)

7.1.1.2 2nd Case, Only One RCCB/<u>MCCB</u> Is Closed

In this case, there is no risk of paralleling between the both transformers. Consequently, it shall be possible to close all <u>Ring Main</u> CB and <u>coupling CB</u>. But it shall be impossible to close back the second RCCB/<u>MCCB</u> until the correct configuration of the both loop, that is to say the opening of one <u>Ring Main</u> CB or one <u>coupling CB</u> on each loop, to reach to previous condition when the both RCCB are closed.

7.1.2 **Interlocking In Local Control Mode**

In local control mode it shall be possible to operate any Ring Main CB and coupling CB with a mechanical interlocking. That could be possible through the medium of the remote/local knob when in local position.

To avoid any paralleling between both the transformers of the AMS, the mechanical interlocking shall authorise the closing of all Ring Main CB and coupling CB except one on each loop, including the relevant RCCB/MCCB (that is to say it shall be possible to close N-1 apparatuses, including the RCCB, on each loop).

7.1.3 **Loops Coupling Interlocking**

Loops can be, if required, interconnected with the help of appropriate, apparatuses, with suitable interlocking to avoid any paralleling between transformers. The Loops are provided with an interconnection arrangement between their respective feeders (ie Feeder cable 1 and cable 2). The loop coupling interrupters shall be provided with interlocking so as to ensure that it is not possible to couple two loops when both loops are live.

7.1.4 **Earthing interlocking**

A mechanical interlocking linkage shall be built in to prevent the grounding switch being closed if the main circuit breaker is closed.

On the other hand, a lock interlocking shall forbid the earthing isolator closing until the circuit breaker at the other extremity of the same cable of the nearest ASS is locked in open position.

7.1.5 **Local Interlocking**

a) Each MV board shall include a non-return interlocking system, formed by security locks, to allow safe inspection of the transformer.

   This interlocking system shall make it necessary to open a main LV circuit breaker (LVCB) and lock it open and unplugged before closing the protection bay ground isolating switch. Once this switch has closed, it shall be possible to open the door of the transformer bay.

b) All 33 kV cable coupling bays shall include systems to interlock interrupters and grounding isolators to make it possible to work on a bay without cutting the main 33 kV cable.

c) High-security locks shall form these interlocks.

d) Ring of 33 kV system shall be (N-1) type.

For Air Insulated Switchgear: -

The CB rack in/rack out Interlocking are tabulated below: -

Interlock	Function of interlock	Method of operation of interlock
Between the racking-in of the moving part and the installation of the low voltage plug.	The racking-in of the moving part is impossible if the low voltage is not connected.	The racking handle cannot be inserted to desired position.
Between the racking-in of the moving part and the earthing switch "closed".	Racking-in of the moving part is impossible if the earthing switch is closed.	Earthing interlock lever prohibits VCB movement.
Between the closure of the earthing switch and the position of the moving part.	Closure of the earthing switch is impossible as soon as the moving part is in the course of being racked in or is "racked-in".	Earthing interlock lever prohibits "ON" movement.
Between the racking-in and the closed state of the moving part.	Racking-in of the moving part is impossible if the latter is closed.	Interlock lever prohibits insertion of the crack handle.
Between the closing of the moving part and racking-in	Closing of the moving part is impossible outside of the "Racked-n" or "Test" positions.	Electrical and manual command controls of the moving part are impossible.
The rear cover opening & earthing switch closure.	Opening of rear cover is impossible if the earthing switch is in "OFF" condition.	The interlock lever prohibits of rear cover movement.

Cubicle front door opening & moving part in racked-in condition.	Opening of the front door is impossible if the moving part is racked-in.	The interlock lever prohibits the front cover movement.
Between Low voltage plug & position of moving part in racked-in condition.	Opening of the LV plug is impossible if the moving part is racked-in.	The interlock lever prohibits the LV plug opening.

7.1.6 **Response to a Fault**

The response to various type of faults in system shall be as per the Technical instruction -26 of DMRC attached in Appendix-D.

8. 33 KV (MEDIUM VOLTAGE) CABLES

8.1 General

33 kV Cables are required to be used in the Auxiliary Network, for supply of power at 33 kV to various ASSs located at Stations and in the Depot. The Auxiliary Network consists of double 33 kV feeder circuits, each feeder consisting of 3 Single core cables, run in trefoil arrangement.

The 33 kV Cables shall conform to IEC 60502 and shall be of 18/30 kV (36 kV) grade.

Cable Details	**Conducting Core**
From AMS/RSS to ASS	400sqmm Copper
33 kV Ring Main (Underground/Elevated & Underground section)	400sqmm Aluminium
33 kV CB to Transformer (33 kV/415 V) (Underground/Elevated & Underground section)	400sqmm Aluminium

For Detailed specification of cables, **Refer DMRC SPECIFICATION NO. DMES-T/0018/ DMRC-E-TR-CABLE-2** attached in Appendix-E.

8.2 Governing Specifications

Refer DMRC SPECIFICATION NO. DMES-T/0018/DMRC-E-TR-CABLE-2 attached in Appendix-E.

8.3 Connecting Junctions - MV Ends

Refer DMRC SPECIFICATION NO. DMES-T/0018/ DMRC-E-TR-CABLE-2 attached in Appendix-E.

8.4 Execution Rules

The entire supply shall be executed according to all Rules of the Art pertaining to professional-grade equipment, and in compliance with the technical specifications and specifications of the International Electrotechnical Commission relative to power supply cables (IEC 60055-1, 60055-2 and 60502-1). The supply shall be delivered, upon request by the client, only after execution of in-plant inspection operations and satisfactory testing according to the technical requirements imposed.

The cables shall pass all the tests stipulated in the IEC 60502 rules in force on the date of the order.

The sleeves and the insulating materials used shall meet the guarantee requirements imposed.

The equipment shall be capable of withstanding intensive use without alteration, and of performing its duty even after extended idle period.

8.5 Atmospheric and Climatic Conditions

The entire equipment shall be designed for operation in hot weather, according to the climatic conditions.

The equipment shall be sturdy and properly treated against corrosion. This protection shall be suited to the various environmental conditions encountered in the various parts of the network.

It must be noted that environmental conditions shall be very severe during construction; these conditions shall not be the cause of any alteration of equipment or material whether already installed or simply stored.

8.6 Cable Technical and Test Sheet

The tests shall be performed according to the corresponding IEC standard.

8.7 Cable Laying Specification

8.7.1 General

MV cables shall be laid all along the line in tunnel, viaduct/elevated section and in ground wherever required.The cables shall be laid as per the technical instruction-25 attached in Appendix-D. Cabling of 25 kV, 33 kV, 3.3 kV and control cables may be laid individually or together depending upon the location of RSS, Station or viaduct. The contractor has to conduct site surveys of the individual sites for preparing the cable laying layout drawings. The method selected for cabling shall ensure full safety and operational access of the cables laid. The liasoning required for acquiring the cable laying permissions from different Govt./private agencies has to be done by the contractor.

The cable laying shall be generally in accordance with IS 1255-1983 and manufacturer's recommendations. After installation of the cables validation/certification from the cable manufacturer has to be submitted by the contractor, that the cables have been laid as per cable manufacturer recommendations.

The contractor shall also supply the two HDPE pipe/Trench for telecom cables from RSS boundary to Viaduct/stations.

The heat elongation/contraction of the cables has to be taken into consideration for cable laying. Cable shall be laid in a slightly waved line, similarly to sine curve in order to allow controlled movement.

They shall be supplied on reels, the standard of which shall be determined according to the laying conditions.

This specification defines all types of work related to installation of cable routings, laying out and laying of the cables, at grade, on viaduct.

The Contractor shall produce a stake-out plan at 1:500 scale, which shall indicate the precise laying position and the type of routing (in channel or inside duct), accounting for all specific location of the line (Track crossings and entry into electrical stations).

8.7.2 **Cable Routing**

8.7.2.1 Laying between the AMS and the designated ASS.

The scope of cabling from AMS to ASS is in scope of the contractor. The details of cabling are provided in the technical instruction-25 attached in Appendix-E.

8.7.2.2 LAYING IN TUNNELS

Cables shall be laid in the cable supports on the tunnel wall.

Supports/Brackets will be provided by E&M Contractor. The Contractor is to interface with E&M Contractor for route and location. The supply and installation of trefoil clamps is under the scope of this contract. 33kV danger boards will be provided at every 100 mtr and also at locations wherever cables have to cross under tracks.

Inside UG-station, cables shall be laid inside ASS room in under croft /cellar, in HDPE pipes, along/across track, in cable galleries, shaft etc.

8.7.2.3 LAYING IN BETWEEN TUNNELS AND VIADUCT

The Contractor shall lay the cable in between UG and adjoining Elevated station & Existing Elevated/UG station in case of Interlinking works

The Contractor shall interface with Station building contractor for cable cut-out for entry of 33kV cable to the Auxiliary substation and shall also interface with Elevated Traction Contractor for cable path and termination of 33kV cable. The cable path inside the Elevated station building will be provided by the Elevated traction contractor.

8.7.2.4 CABLES INSTALLATION

8.7.2.4.1 Laying out

The cables shall be supplied to the laying work site in suitable unit lengths, coiled on reels whose average weight shall not exceed about 8000 kg for Al/copper-cored cables, as well as for aluminum-cored cable.

If cables are laid after the track is in position, then these reels shall be delivered by train as close as possible to the point of utilization, accounting for the constraints generated by the actual traffic on the existing line.

Laying out of the cables can be made manually or mechanically. The mechanical devices (electric or pneumatic) used for laying out the cables shall be so constructed that they would prevent damaging the cables. These devices shall be submitted to the client's representative for approval.Provision of pulling eye in cable to be ensured during manufacturing, to keep the possibility of mechanical laying out of cable at site.

Should mechanical laying out not accepted, for whatever reason, the contractor shall execute laying out of the cables with the number of personnel deemed necessary by the client's representative.

The laying team shall be under the authority of a supervisor qualified for this type of work.

To execute laying out, this supervisor shall comply with the instructions given by the client's representative in charge of technical supervision of cable laying.

All necessary precautions shall be implemented during operation to prevent any deterioration of the cable; the cable shall not be subjected to any twisting around its axis, and not be bent to a radius smaller than the minimum bending radius specified by the cable manufacturer. It shall be subjected only to the traction efforts strictly required to lay it out. In no event may the cable bear against the ground or against fixed stops; it shall rest onto rollers, situated sufficiently close to one another.

The ends of two successive reel lengths shall overlap by about two meters to enable cropping the cable ends before execution of the connection sleeves.

When the client's representative estimates that laying out of cables in a single length 200 to 500 m risks generating abnormal strains in the cable, one or several looping may have to be made. A cable looping is defined as being any operation that requires previous laying out of the cable outside the channel or cableways.

When two cable courses are superimposed inside channels, each course shall be separated by means of isolating plates every 3 m.

8.7.2.4.2 **Tagging**

All cables laid inside channels, or on cable-tray shall carry an 8 x 5 cm Aluminium tag placed every 10mtr and in specific locations such as connection sleeves, entry into and exit from ducts, possible pulling chambers.

These tags, fastened via two clamps, shall bear the labels approved by the Employer.

Tagging of cables plays a part in safety as regard identification of the cables in case of incident, and shall be made very carefully and the Contractor shall be responsible for any error or for any incident subsequent to such an error.

The tags shall be fastened right after the laying out of each reel.

RFID tags shall have to be provided in the underground cablinf from RSS and interlinking cabling. The RFID tag shall have to be approved by Engineer and shall have service life of more than 20 years. Details are further provided in clause 8.7.5 of this PS.

8.7.3 **Sealing of cut-outs**

<u>For underground section:</u>

Sealing of 33 kV cable and control cable cutouts in the ASS for the equipments installed by the contractor are in the scope of work of the Contractor. Sealing material for underground section shall be as per details mentioned below in Elevated section.

The Contractor shall interface with SBC contrators for cable cutouts. The Contractor shall be responsible for sealing of unused cutout, if any.

<u>For Elevated section:</u>

All the cables entry in to Viaduct, Station building, ASS, Control Buildings & Panel / equipment, switching posts equipment, SCADA equipment etc. shall be sealed with EPDM based modular cable sealing system. The Cable Sealing System shall provide foolproof protection against "Fire, Water, Dust, Dirt, Humidity, Vibrations, Temperature Variations, Pull Tension, Noise as well as Rodents. The system must meet the following requirement.

- The system shall be based on Multidiameter technology and shall made up of roxylon halogen free EPDM (Ethylene Propylene Diene Terpolymer) cross-linkable rubber compound with Low Smoke Index.
- The system must be type tested for the Water/Fire/gas tightness.
- The system shall conforming to IP 66/67 for Buildings & IP 55 for Cabinets/Panels as per IEC: 60529.
- The System shall be Fire resistance for 3 Hrs with Single side installation only as per UL-1479 along with UL Certificates No back-to-back installation is allowed.
- Fire Flammability resistance shall be of UL (V-0) as per UL94 ans Insolation& Integrity EI 120 as per BS 476.
- Fire hazard levels HL3 according to EN 45545.
- Total Halogen Content shall not > 1500 ppm in totality as per EN/IEC 61249-2-21 and Toxic Index, Shall not > 15 ppm as per NF X70-100:2006.
- The System should be CE Certified & Complied to ETAG 026 Part 1and 2 for fire resistant walls and floors in buildings
- The System shall be Vibration proof and conform to Category A, Class 1 as per IEC 61373.
- Heat radiation classification - M2 class as per NF-P 92-512.
- The system shall be UV protected and shall meet the requirement of 1000 hrs as per ISO 815-1 and ISO 4892-2.
- The System shall be anti-rodent and certificate shall be from reputed NABL accredited lab / institution.
- The sealing system must have built –in spare capacity i.e. option for adding more cables in to the same system.
- Lubricants / Assembly gel should not have the property of adhesiveness
- One single module can seal a cable of several different diameters simply by peeling away layers.

- All the relevant Test Certificates shall be issued from NABL accredited LAB with scope of testing facility or issued from International reputed agency like UL, SP, LNE and RST.

8.7.4 **Cable Cleats:**

Suitable Cable Cleats (material : SS-316) and intermediate restraint (metallic/non-metallic/composite) according to the size and short circuit current carrying capability of the cable shall be used for securing cable in electrical installation relying on the mounting surfaces as per latest edition of IEC 61914.

The GTP and make of cable cleat shall be approved by Engineer in-charge.

Apart from the cable cleats, the cable dressing shall be proper and tied cables shall be tied on each bracket with heavy duty nylon cable tie (UL listed Nylon 6.6 material). The cable tie shall be UV resistant and Flammability shall be of UL94 V2 rating. The GTP and arrangement of cable Ties shall be approved by the Engineer In-charge.

8.7.5 **Mapping of utilities of cabling and other services executed by the contractor**

The contractor has to survey all the utilities with GIS/GPS mapping techniques. The mapping may be done with latest survey devices and shall have to be correct as per positioning co-ordinates which may be used by other agencies to indentify cables etc embedded by DMRC.

RFID route markers are required to be provided with positioning co-ordinates to identify the cables after laying. The RFID tag shall be approved by engineer. The device selected shall have to be compatible with the DMRC RFID tag locator. The details of RFID tags shall be plotted and submitted in the as built drawings.

As per requirements of the agencies the GIS data of underground utilities has to be mapped on the Delhi Geo Spatial Data Infrastructure (DGSDI). The as built data submitted by the contractor shall have to be as per requirements of DGSDI. The utilities mapping of all the RSS cabling/interlinking cables etc of the contract shall be on part of the contractor for cabling works.

8.7.6 **Sheath Voltage Limiter**

The Contractor shall provide sheath voltage limiter. The Contractor shall submit the calculations for induced sheath voltage for each circuit and if the induced sheath voltage crosses the limiting values, suitable cable bonding shall be provided. The calculation shall be supported with IEEE-575 and other relevant standards.

8.7.6.1 General

In Medium Voltage power lines, three single core cables are used in place of three core cables. In the single core power transmission, the cables are usually covered with a metallic sheath to prevent ingress of moisture, protect the core from possible mechanical damage and create an earthed shield.

Unlike the three core cables, the Single core cable behaves like a transformer. The current carrying conductor of the cable acts as the primary winding and the metallic sheath as the secondary. The field of the current carrying conductor induces a voltage in the metallic sheath of the cable.

8.7.6.2 Sheath Induced Voltage:

The magnitude of the EMF induced in the cable sheath is directly proportional to the magnitude of the load current carried by the conductor, the mutual inductance between sheaths of the cables, the spacing between the cables and the cable length.

Es = 314. I. L volts/m

Es = Sheath Voltage.

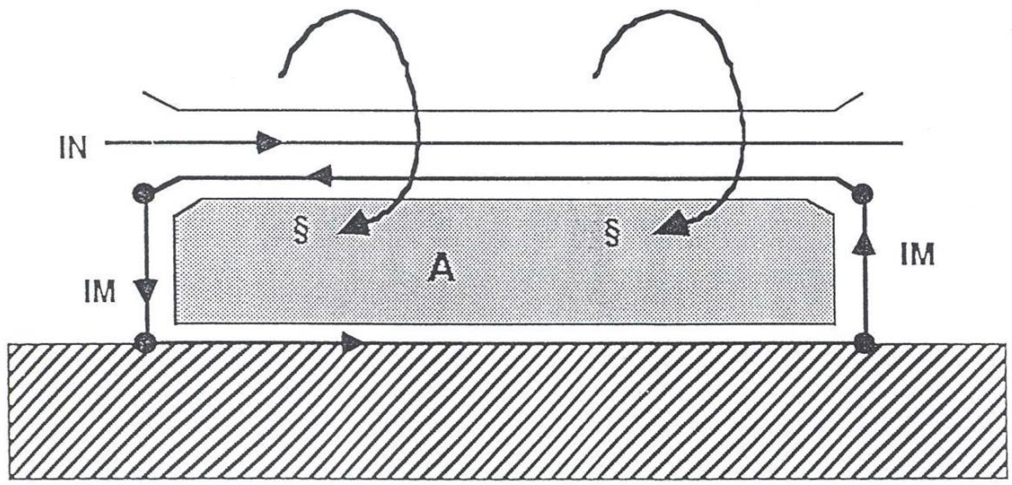
I = Current in the conductor

L = Mutual inductance between the sheaths of cables

This induced EMF causes a circulating current to flow in the sheath when both ends of the metallic sheath are bonded to the ground.

8.7.6.3 Circulating Currents:

Circulating currents are generated in the metallic sheaths of the cables when the cable's insulated conductor is carrying alternating current and its metallic sheath is bonded to ground at both ends. It doesn't matter what metal the layer is. If it's metal and grounded at both ends there will be a current induced into it. The magnitude of this circulating current depends on the current in the conductor and the impedance of the loop formed by this layer and the ground path.



This sheath circulating current causes sheath-circulating losses and causes heating. In such cases, the cables must be de-rated to 70% of their normal conductor current.

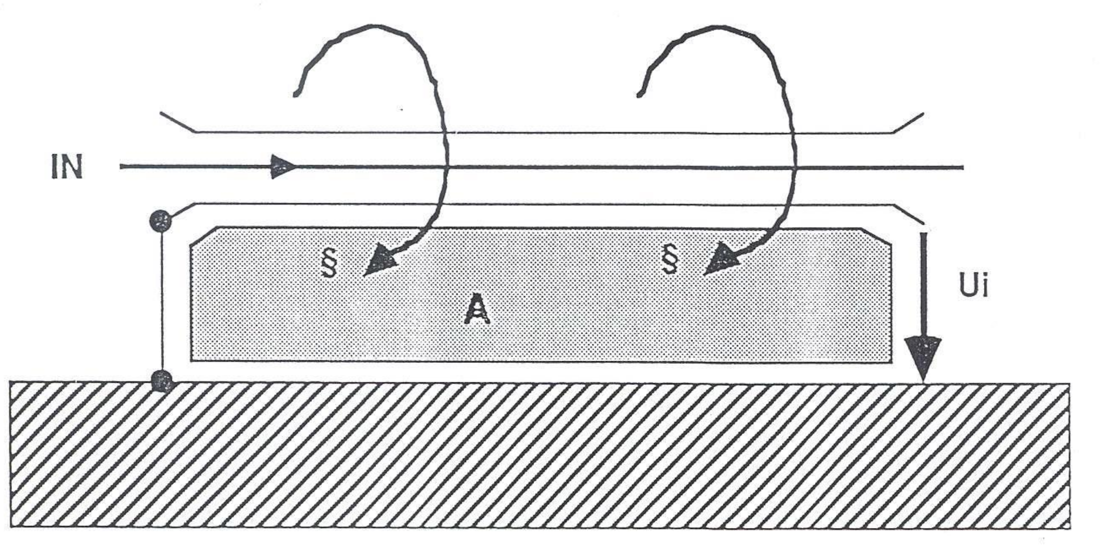
To utilize the full capacity of the cable, special bonding methods are employed.

Sheath Bonding methods:

- Single Point Bonding
- Mid Point Bonding
- Cross Bonding

8.7.6.3.1 Single Point Bonding

In single point bonding, one end of the sheath is grounded and the other end is kept floating. Usually the supply end is grounded.

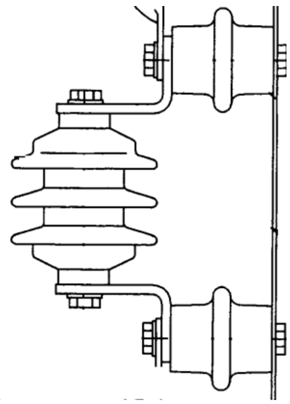


When the cable's Armour / sheath / concentric ground is floating at one end, a standing voltage will be generated on this metallic layer. The magnitude of this standing voltage is directly proportional to conductor current and to cable length. It's also proportional to the spacing between cables and how they're laid out (i.e. flat or trefoil), but current and length are the big factors. Generally standing voltage is not of concern except if the runs are long and / or conductor current is high.

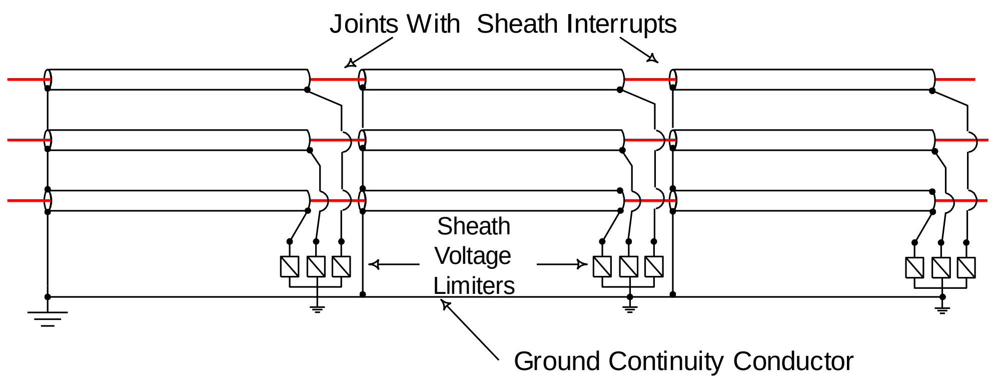
As per the earthing practices as laid down in IS 3043; Latest Version, this standing voltage should not exceed 65 Volts. Typically, Single point bonding is adopted for feeder lengths not exceeding 1km.

During installation care must be taken to ensure that cable jackets are not damaged. If they are damaged the Armour or sheath could make contact with ground along the run. This forms ground loops, which would, allow circulating currents to flow and this causes cables to overheat. Sparking and cable failures have also been observed at points where cable jackets have been damaged and these circulating currents are allowed to flow to ground.

The floating end should be insulated from the ground. A Sheath Voltage Limiter is installed at the floating end so as to ensure that sheath does not see very high voltages at the time of fault. If the sheath is damaged, moisture ingress & flow of circulating current shall happen.



For longer feeder lengths, multiple single point bonding can be carried out with a ground



continuity conductor.

8.7.6.3.2 Mid point Bonding:

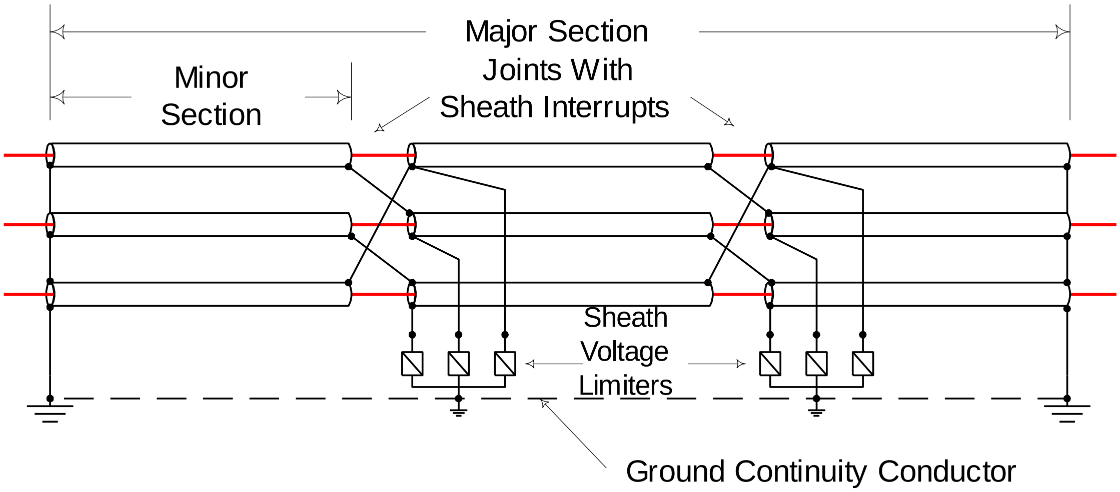
In this method, the bonding is carried out at the center of the cable feeder and the other two ends are grounded through SVL. This ensures that the sheath standing voltage is halved.

8.7.6.3.3 Cross-bonding:

For longer feeder lengths wherein the Sheath induced voltages are high, cross bonding of sheaths is to be carried out.

The sheaths are electrically transposed at every splice, reducing both currents and voltages. SVL's are needed at 2 out of 3 joint locations, and a ground continuity conductor is often installed (but not mandatory).

The sheath bonding Copper cables (3.3 kV) of appropriate size, link boxes, sheath voltage



limiters and other accessories are to be provided. The link boxes should be suitable for underground burial and shall be housed in a common bay near the jointing bay. The length of sheath bonding cables should not exceed 10 m.

Depending upon the route finally chosen, the Contractor shall prepare a design for Bonding, and shall establish that with the Bonding method adopted, the sheath voltages do not exceed the max permissible limit.

In case Cross Bonding becomes necessary, the sheaths have to be electrically transposed at every 'straight though joint' location and Sheath Voltage Limiters (SVL) may require to be provided at 2 out of 3 Joint locations. This shall be decided during the design of the Bonding method.

The contractor will be required to submit and obtain approval from DMRC for the calculation that bonding method selected by him, single point bonding/ mid point bonding/ cross bonding, ensures that the sheath voltage is limited to less than 65 V in case of ultimate full loading of cable i.e. considering short time overloading also. Generally, cross bonding is to be used if feeder length is more than 3 km.

9. LOW VOLTAGE SWITCH BOARD (LVSB)

The Low Voltage Switch Board (LVSB) is meant to provide and protect the 415 V / 240 AC Supply of the Station Building. **The LVSB will be supplied and erected by the E&M Contractor for the Stations**. The connection between the Secondary of the Auxiliary Transformers and the LVSB, in the underground stations (by means of cables or Bus duct) **will also be done by the station E&M Contractor**. The Contractor shall interface with the respective E & M Contractor to ensure that

- Adequate facilities are available at the Auxiliary Transformer Secondary side to receive cable / Bus-duct connection
- The Transformer Cubicle doors are provided with the necessary mechanical system interlock between the door, the LV Breakers and HV Breakers.
- LT CTs for diffential protection, REF protection and stand-by earth fault protection.

10. 110V DC POWER SUPPLY SYSTEM

10.1 General

The 110V DC Power requried for the equipments at the ASS as well as for those for the equipment for the Traction Switching Station located in station or on trackiside, shall be met from the 110V DC Power Supply System provided at the ASS.

This DC system provided at the ASS is to be designed to cater to the DC power requirement of equipments at ASS and adjoining 25kV Switching Station whereever applicable.

10.2 System Description

10.2.1 110V DC supply for 33kV ASS & 25kV Switching room

The 110V DC Power Supply System shall consist of 1 Battery set and 2 battery chargers. The Battery set shall be designed to cater to the full requirement of 110 V DC power of all equipments in the ASS and switching station, with an 8-hours backup. The capacity of the battery shall be designed by the Contractor taking into account the permitted voltage tolerance of the individual loads, the power consumption of various loads, the length of time they are in operation and the manner in which they draw power. The precise capacity of battery shall be determined to ensure total autonomy of the station and switching station (wherever available) for 8 hours as required to retain the power supply of the control/monitoring auxiliaries and protection relays in case of total failure of the AC sources. The battery capacity selected shall not be less than 180 AH, in any case. Out of the 2 Battery chargers, one shall be in service normally and the other as Standby. In the case of failure of the 'In Service' battery charger, the 'Standby' battery charger shall come into service through an 'Automatic Changeover' system.

10.2.2 Not used

10.2.3 **The batteries shall be of insulated pole type and wired in floating voltage mode.**

In normal situation and for each normal battery-charger set, the charger shall supply the control and monitoring circuits and shalldeliver the battery trickle charge. In the case of failure of the 'In Service' battery charger, the 'Standby' battery charger shall come into service through an 'AutomaticChangeover' system.

In case of fade-out of the AC voltage, the battery shall immediately and without break replace the charger to ensure permanent power supply of the circuits and controls.

The entire 110V DC distribution and the batteries shall be isolated from the earth satisfactorily. The overall condition of this isolation shall be monitored permanently by a specific and highly reliable device.

10.3 Other Technical Requirements

The fundamental demand on a DC system is that it must be robust, simple and clearly arranged.

The DC system shall be based on the following principles:

- High selectivity
- Main distribution board located adjacent to the battery room
- No common main fuse for battery
- An installation, which is free from the risk of, short-circuits between the battery and the main distribution board.

The DC system shall be earthed across a high resistance resistor, so that simple earth fault shall not cause tripping of the system.

The DC system shall be designed to allow unloading tests, boost charging and maintenance of each to be carried out during normal operation; this implies that provision shall be made for isolating the battery and the associated rectifier from the load.

Since the entire system cannot be designed so that short-circuit shall never occur, it must be provided with circuit protection, these shall provide absolute and safe selectivity, so that tripping is confined to the minimum. Only rapid protection characteristic may be used.

10.4 Equipment Specification

The following 110V DC Source equipmentshallbeprovided in the ASS Room.

10.4.1 **Battery**

- Batteries shall be of stationary compact, nickel-cadmium type consisting of 85 cells. They shall be maintenance free and if connection between batteries through the cables, cable shall be Fire Retardent Low Smoke Type Zero Halogen (FRLS OH) for Underground Section & fire-retardant low smoke type (FRLS) for elevated section. The battery shall comply with IEC 62259/ IEC 60623/60622. The minimum capacity of the Batteryshall not belessthan 180AH. The batteries shall be design for ambient temperature of 50-degree C.
- The cells shall be housed in high-strength impact resistant & alkali-resistant containers and should be transparent/ translucent to facilitate checking of electrolyte level.
- Vent plugs with seal shall be provided. Construction of cells shall be to ensure proper air circulation between the cells for heat dissipation/ ventilation. The vent plug shall be of robust design.
- Battery shall have provision for electrolyte top up to ensure electrolyte level does not fall below recommended level.
- The containers shall be strong enough, so that excessive bulging of container does not occur during service. Cells shall be supplied in filled & charged state or otherwise electrolyte dry form & battery water separately or in liquid form shall be shipped as desired by the owner.
- Nickel plated copper inter-cell connectors shall be only be used for connecting up adjacent cells. Inter-row connectors shall be of flexible PVC insulated copper cable. Bolts, nuts and washers shall be of stainless steel. All fastners shall be tightened with torque wrench with secific torque.
- All terminals and cell inter-connectors shall be fully insulated or have insulation shrouds.
- Separate terminals shall be provided on the end cell for connecting load through DCDB and for connecting charger leads. All terminals shall be of suitably sized nickel-plated steel.
- Suitable corrosion resistant steel battery racks and cable supports shall be provided. Metallic racks shall be properly earthed. The bottom tier of stand shall have a ground clearance of 150 mm minimum above the floor. Racks shall be made of alkali resistant powder coated mild steel to ensure corrosion resistance.
- The polarity and battery cell number marking of the terminals shall be marked for identification and marking shall be permanent and non-deteriorating.
- Battery shall be connected through its own battery distribution board to the main board, and shall have its own supervisory equipment to indicate and alarm for the maximum and minimum voltage levels on float-charge and earth fault.

The Contractor shall submit the battery sizing calculations as per IEEE-1115 to DMRC engineer in-charge for approval. The batteries shall be designed taking into the loading requirements as per clause 8.12.1.4 of Rigid OHE PS.

- The battery protection shall be as close as possible to the battery and shall be contained in separate enclosure for negative and positive pole respectively. The enclosure shall be made of insulating material. The connection between the battery and its protection shall consist of single conductor and shall be run in such a manner so that they are protected from physical damage.

10.4.2 **Battery Charger**

The Battery Charger shall be Float cum Boost type suitable for charging Ni-Cd cells, fully compartmentalized with metal sheet and duly certified, accepted by the battery manufacturer. <u>The contractor shall ensure compatibility of battery charger with batteries. The contractor shall submit the undertaking for compatibility from both vendors i.e. battery and battery charger.</u>

AC PowerSupply :

- Voltage : ~~230V~~/415V, +10%, -15%
- Frequency : 50 Hz ± 3%
- Maximum short-circuit current : 4000 A rms.
- Recharge to 80% of the battery capacity : 8 hours

DC Output :

- Power supply voltage : 110 V +0%, -15%
- Operating period after AC supply failure : 8 hours
- Constant power drain : shall be decided by the Contractor, to deliver the full duty. The minimum capacity of the Battery shall not be less than 180Ah.

Battery charger shall have the provision of Alarm in case of low battery and also have the feature of battery reverse polarity Protection. All control and monitoring signals of battery charger to be communicated to OCC through SCADA. Battery charger shall have potential free contacts to indicate the status of battery charger at ASS as well as OCC through SCADA. Also, potential free contacts shall be provided for giving Alarm signal to SCADA system for failure of Main battery charger and Switching of the Load on the other Hot standby battery charger.

Also, the signals of battery charger to be communicated to OCC with soft signals on SCADA IEC 61850 protocol.

Ripple content in the output voltage in any case shall not be more than 3%.

External/Internal cabling of the battery charger shall be Fire Retardant Low Smoke Zero Halogen type (FRLS-OH), for Underground Section & fire-retardant low smoke type (FRLS) for elevated section.

MCB of type D to be provided for battery charger.

Charger:

The charger shall comprise of an inlet transformer and silicon diode/thyristor or thyristor bridge for converting 3 phase AC supply to DC voltage. All auxiliary relays/contactors, electronic components shall be of heavy duty/Industrial grade and PCB should have conformal coating suitable for pollution level "Very heavy" for Delhi as per relevant IEC & IS 13134-1992.

The regulation system shall consist of plug-in modules fitted with polarization devices.

The charger shall include the following monitoring and measuring devices:

- Maximum and minimum DC voltages (threshold values to be defined)
- Charger shut-down due to an internal fault.
- General alarm for remote monitoring

The charger shall include the following control devices:

- a main On/Off switch,
- a normal/boost selector switch,
- a control deliberated discharge.

The AC and DC terminal strips shall be separated from each other.

Each battery charger shall be:

- designed to ensure operation according to the battery ratings as described below,
- installed in a sheet cabinet with feet, closed by panels.
- Ventilation shall be natural.

All Main and Control Cards should be tested for Environmental Tests as per IEC 60571 and shall be done in accordance to IEC 60068 from independent accredited laboratory on one sample battery charger selected randomly from entire supply of chargers under the contract. Details of test mentioned below:

- Dry Heat Test
- Low Temperature Test (in case applicable for Delhi ambient temperature range)

- Change of Temperature Test
- Damp Heat Test
- Driving Rain Test
- Surge test
- Electro Static Discharge Test
- Electric Fast transient test

Type Test certificate of Battery Charger to be provided.

10.4.2.1 CHARACTERISTICS

Major characteristics are described in the annexed technical sheet. The chargers shall be diode and thyristors regulated type, wired as Graetz bridge.

10.4.2.2 OPERATING AND FLOATING RATES

The voltage at the charger current output terminals shall be automatically kept within ±1% for variations of +10% / -15% of the AC voltage and of +3% of the frequency, whatever may be the output required.

The residual ripple ratio shall be as low as possible (less than 3%) so as not to disturb the various operating circuits.

Equalization charge operation

This charge shall be able to take place up to the floating voltage within +1% under the same conditions as above.

Automatic change-over from floating to equalization charge and conversely

Following any failure of more than five minutes of the AC supply network, the charger shall automatically revert to the charge position right upon return of the voltage and shall remain on this position throughout the time set by an adjustable timer (from 1 hour to 20 hours). After this time, the charger shall return to floating operation. The charger shall remain in floating operation if the network failure is shorter than five minutes.

Direct operation

The charger shall be capable of operating directly, without the battery, under the same conditions of accuracy as for the floating and charge modes.

Manually controlled operation

Operation in manual control shall be possible, i.e. it shall be possible to execute manual adjustment of the voltage in case of malfunction of the regulator.

Alarms

The status of all battery chargers shall be indicated at the OCC (through SCADA), as per the following convention:

Green – Healthy and in-service, Yellow – Healthy and standby, Red – Defective.

The change of status from "Healthy" to "Defective" shall be accompanied by an audible alarm/hooter, both at the ASS and in the OCC. However, if the ASS is unmanned, it shall be possible to nullify the audible alarm function at the unmanned ASS.

10.4.2.3 **PROTECTIONS AND MONITORING**

The charger shall be fitted with the following protections installed at it's rear:

- The battery chargers shall be provided with surge protection devices of suitbale type and ratings.
- A device limiting the current output by the rectifier to its rated current value with sufficient capabilities of adjustment and possible pick-up of the set point value
- Switching diodes,
- breakers with fuse elements for overall protection on the transformer primary,
- breakers with fuse elements in series with each rectifier component (diodes and thyristors).
- breakers for the various auxiliary circuits,
- an on/off switch controlling a three pole make-break switch (MCB) with magneto-thermal protection on the AC circuit and a two pole make-break switch with magneto-thermal protection on the DC circuit.Tripping curve characteristics of MCB of battery charger shall be graded/selected with proper current settings. Fuses if required shall also be selected with proper current ratings.
- the specific protection to ensure satisfactory operation and protection of the set.
- The control card circuit and capacitor shall be placed away from transformer to protect them from heat produced by transformer/heater.
- The capacitor used in battery charger shall only be of industrial grade only and of aluminium can with stud construction type which is having the minimum allowable temperature range of 85°C or higher with better cooling feature.

- All Electronic components/sub-parts of equipment shall only be of Industrial grade.

- It may also be noted that temperature inside the metal enclosed equipment go up to 70ºC inside enclosure. This aspect shall be taken care while designing the equipment and its electronics
- The Terminal Board shall only be factory fitted.
- All the electronic cards supplied shall have following minimum requirements-
- As per IEC 61086, all printed board assemblies shall be protected on both sides with a protective transparent coating, in order to prevent deterioration or damage due to such causes as moisture and atmospheric contaminants. The coating shall not have any adverse reaction with any other materials or components used on Delhi/NCR environmental condition
- Damp heat run test as per IEC 60068-2-78 standards.
- Dry heat run test as per IEC 60068-2-2 standards
- In addition, the details of configuration in the card, block diagram of the card and waveform signature of each test points for each card shall be submitted by DE-08 contractor.

All electronic equipment shall withstand surges, electrostatic discharge and transient burst as per IEC 62236-3-2. The suitable surge protection device conforming to relevant standard shall be provided as per the requirement and approval of Engineer In-charge.

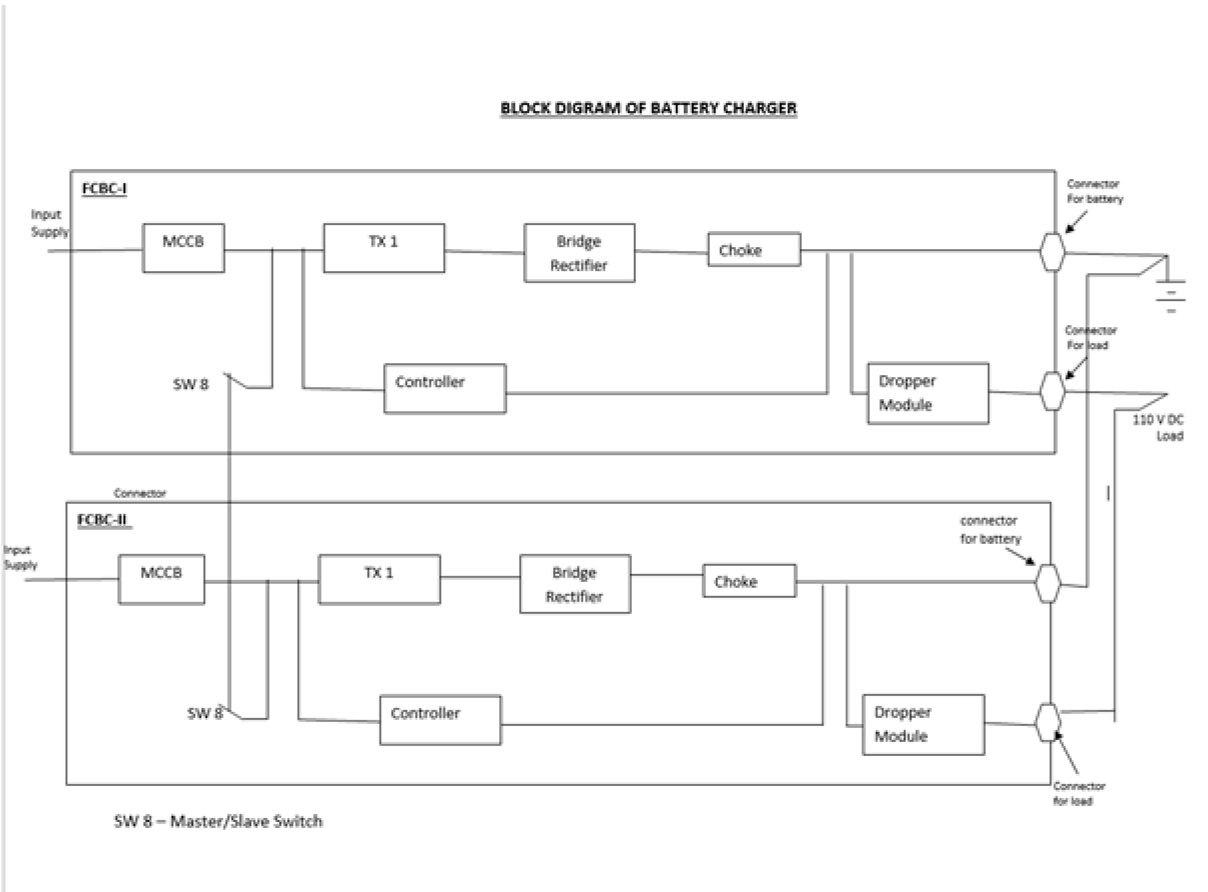
10.4.2.4 **Miscellaneous**

The battery charger equipment shall also include:

- a signalling light denoting the opening of the make-break switch on the AC side, controlled by the tripping of one of the Miniature Circuit Breaker protecting the various circuits of the apparatuses,
- a signalling light denoting the opening of the make-break switch on the DC side through actuation of the magneto-thermal relay,
- a digital voltmeter indicating the voltage on the AC side
- a digital voltmeter indicating the voltage on the DC side
- A centre-zero ammeter or digital ammeter which shall indicate whether the battery is under charge or the battery is only delivering the load.
- the position of the various circuit-breakers and of the protection and fault relays shall be monitored through two flip-flop stages.
- An inspection light shall be fixed inside the charger compartment, which will automatically come "on" when the charger compartment is opened for inspection. This

shall be independent of the "on/off" position of battery changer and shall be operative when the 415 V supply is available to the charger.

- DMRC may inspect the prototype of battery charger of approved vendors before commencement of bulk manufacturing by vendors. If any modification in prototype will be required by DMRC, it shall be the responsibility of the contractor/vendor to modify the product accordingly. After the successful inspection of prototype, formal approval shall be given by engineer in-charge for bulk manufacturing of equipment.
- Illustrative Block Diagram of Battery Charger



11. 110 V DC DISTRIBUTION BOARD

11.1 Description

Distribution of the 110 V DC sources shall be gathered inside single cabinet called DC auxiliary.

These cabinets shall be equipped with doors, fitted with flexible seals, close via lock-bars and on which shall be installed a mimic diagram with signalling lights denoting the position of the main apparatuses.

All indication lamps shall be LED type. DC system shall be provided with the DC compatible MCBs/circuit breakers.

11.2 Equipments

Each cabinet shall include the following (list not restrictive):

- Isolating switch
- Master power supply circuit breakers
- Non return diodes and Set of normal/stand by supply bars
- The current and voltage protection relays
- The isolation monitoring
- The suitable surge protection device conforming to relevant standard shall be provided as per the requirement and approval of Engineer In-charge.
- Automatic and manual device for change over from one source to another, with selector switches for automatic and manual, with or without break.

11.3 Outgoing Feeders

The outputs, protected by circuit-breaker, whose rating shall be selected according to the power of the installation services, corresponding to the distribution circuits intended to be supplied. Also, output feeders to the 25kV Switching station to be provided wherever available.

Bus bar of DCDB shall be Electrolytic copper with heat shrinking sleeves. Internal cabling/wiring of DCDB shall be Fire retardant low smoke Zero halogen type (FRLSOH) for underground section and fire-retardant low smoke type (FRLS) for elevated section. Wiring of suitable sizing shall be selected to carry the full load current. MCB shall be selected for providing discrimination between incoming and outgoing feeders. 20% spare MCB's to be kept as spare in DCDB.

11.3.1 AC Distribution Board

For providing AC 415 V supply, AC Distribution Board shall be provided in the ASS. Incoming feeders of ACDB shall be provided with earth leakage circuit Breakers along with MCCB/MCB. Bus Bar and MCB for all the feeders shall be sufficiently rated to provide the overloading and short circuit protection. Bus Bar of ACDB shall be electrolytic copper with heat shrinking sleeves. Internal cabling/wiring of ACDB shall be Fire retardant low smoke Zero halogen type (FRLSOH) for underground section and Fire retardant low smoke type (FRLS) for elevated section. Minimum Clearance between Phases and Earth/Neutral shall be 20 mm.

All indication lamps shall be LED type.

MCB of type D to be provided for battery charger. 20% spare MCB's to be kept as spare in ACDB

Minimum IP rating of ACDB and DCDB shall be IP-43.

ACDB supply shall be taken from the essential power panel of E&M. The ASS contractor will interface with the E&M contractor in this regard.

The type-2 surge protection device conforming to relevant standard shall be provided as per the requirement and approval of Engineer In-charge.

12. LT BUS DUCT (SANDWICHED TYPE)/415 CABLES

LT Bus Duct (sandwiched type)/415V Cables shall be provided between LV terminals of Transformer and LT Main Incomer panel by E&M contractor.

13. NOT USED

14. PROTECTIONS

14.1 General Definition

The purpose of the protection equipment is to ensure insulation or de-energising of equipment whose operating conditions have become abnormal to avoid:

- Any major repercussions on the traffic
- Any damages or dangerous effects on person and equipment.

The Contractor shall supply and install the protection system as stipulated in this TS. The protection system based on modular sets must comply with a high performance standard.

- Safety of operation
- Safety is ensured by the means of:
- Cyclic self test ensuring general supervision on software of equipment.
- In case of fault, a watchdog is activated.
- All of inputs are insulated in galvanic and capacitive view and complemented.

Please refer Appendix-D for detailed protection philosophy of Phase-IV network.

14.2 Performances requirements for the protection system including relays.

. Please refer Appendix-H for RAMS policy of DMRC. The relays supplied shall be of the latest version and shall have the highest performance characteristics as per the current practices.

The components and sub parts of the relays shall be designed considering their installation in the closed environment with dust during the installation stages. The environmental protection aspects of the relays have to be considered. Details of the mitigation measures for the environment to be submitted by the relay manufacturers. The relays may be installed in the elevated/underground metro stations having very heavy pollution zones near the metro stations. The ingress of the dust and other chemical pollutants such as Sulphur and other corrosive gases may be considered while selecting the relay models and components.

In protection system heavy duty industrial grade components and sub-components, contractors, auxiliary relays, timers, or any other devices as may be required shall be used. The bill of material of each component/sub-component shall be mentioned by the contractor in technical proposal.

Any special mitigation measures for the reliability of the protection system has to be taken by the contractor for safe operation. The environmental factors of the stations may be studied by the contractor before selection of the relays and protection components.

Performance parameters as provided in the annexure shall be monitored after installation of the protection system. If any performance failure of the complete system or component of the protection system, relays the contractorshall arrange the replacement the complete system or components of the protection system, relaysafter notice form the Engineer.

The protection system shall deploy numerical relays and shall comply with a high performance standard regarding :

14.2.1 **Reliability**

This criterion defines the mean time between failures (MTBF) which has to be calculated for about 10 years.

14.2.2 **Maintainability**

This criterion represents the mean time for repairing (MTTR) and has to be considered only by replacement of faulty function or sub assembly.

The MTTR does not exceed 2 hours not including the dead time to reach the site.

14.2.3 **Availability**

This is expressed in terms of ratio using the formula:

Percentage Availability= $\left\{1 - \frac{\text{Downtime}}{\text{Total time}}\right\} \times 100$

And has to represent a level of 99.95 %.

Please refer Appendix-H for RAMS policy of DMRC.

14.2.4 **Safety of operation**

Safety is ensured by the means of:

- Cyclic self test ensuring general supervision on software of equipment.

In case of fault, a watchdog is activated.

- All of inputs are insulated in galvanic and capacitive view and complemented.

14.2.5 **Electro magnetic compatibility**

Due to the consequent interference levels in the premises, protection equipment has to present sufficient level of immunity defined by the following standards:

- IEC 61000.4-2 Class 3,
- IEC 61000.4-4 Class 4,
- IEC 61000.4-5 Class 3.

Such criteria shall be obtained by using either digital type relays or specific PLC cards.

14.3 Description of Protection

14.3.1 Relays

14.3.1.1 General Description

All relays shall conform to the requirements of IS:3231/IEC-60255/IEC61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear. The relay shall have a front panel back lit LCD display to display the parameters. Protection facilities with fast discrimination and reliable operation, base on micro-processor technology, shallprovide the protection scheme logic. All the relays must be type tested in accordance to relevant standards as per the vendor policy including the environmental tests as per IEC 60571.

The supply of relays should be inclusive of necessary software and hardware for interfacing with a PC, to be supplied by the DE-08 contractor.

All the instantaneous relays should be capable of operating the circuit breaker within a maximum duration of 120 ms from the occurrence of the fault. This time duration should include the dead time of the relays and this feature should be demonstrated during testing of the relays.

All main protective relays shall be of fully numerical type and shall comply as per IEC 61850 standard. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these. All the relays shall be directly connected to the inter bay bus using Electrical/fiber optic cables and shall support peer to peer communication. The relays shall generate GOOSE messages as per IEC 61850 standards for interlocking and also to ensure interoperability with third party relays. Each relay should also generate an ICD file in XML format for engineering/ integration to an independent SCADA system. All the relays shall have suitable rear and front ports for connectivity to SCADA and PC/LAPTOP.

The relay shall have inbuilt auto reclosure, disturbance recorder, fault locator, event logger facility and additional features shall also be indicated over and above the features already specified.

The certificate for IEC 61850 Compliance from KEMA/CPRI, type test certificate from any Govt. recognized Test House and performance certificate shall require to be submitted.

14.3.1.2 DRAW-OUT / PLUG-IN TYPE

All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

14.3.1.3 OPERATION VOLTAGE / CURRENT

All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and times shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

14.3.1.4 AUXILIARY RELAYS / CONTACTS

The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme: contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts. **An MTR to be used to extend the tripping command from the various protection relays to the respective circuit breaker**

14.3.1.5 RESET

All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-reset type contacts. All protective relays and timers shall be providing with externally hand reset positive action operation indicators with inscription. All protective relays which do not have built-in hand-reset operation indicators shall have additional auxiliary relays with operation indicators (Flag relays) for this purpose. Similarly, separate operating indicator (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as winding temperature protection, sudden pressure devices, fire protection etc

14.3.1.6 TIMERS

Timers shall be of solid-state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided

14.3.1.7 DENERGISATION OF CONTROL RELAYS

No control relay which shall trip the power circuit breaker when the relay isde-energised shall be employed in the circuits.

14.3.1.8 ISOLATION OF TRIP CIRCUIT FOR TESTING

Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

Also, itshould be possible to by-pass interlocking if any acheieved through protection relays, in the case of local operationduringtesting.

14.3.1.9 SHUNT / SERIES RELAYS

Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.

b) Seal-in-unit obtain adequate current for operation when one or two relays operate simultaneously.

c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

d) Trip-circuit seal-in required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall be only seal-in the trip output(s), but also the relevant initiation signals to other scheme function, (e.g. initiate signals to the circuit-breaker failure function, etc.) and the alarm output signals.

e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

f) For the current seal-in method, the seal-in shall be maintained until the circuit breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the sealing shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single and three-pole tripping.

g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping.

Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

14.3.1.10 SPARE PAIR OF CONTACTS

All protective relays and alarm relays shall be provided withminimum 10% spare BI and BO contacts not less than two numbers of each type wired to terminals exclusively for future use.

14.3.1.11 SETTING RANGES

The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

14.3.1.12 LIST OF INSTALLATIONS USING THE TYPES OF RELAYS

The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

14.3.1.13 PHASE INDICATIONS

All relays and their drawings shall have phase indications as R-Red, Y-Yellow and B-Blue

14.3.1.14 SCOPE OF NUMERICAL RELAYS

For numerical relays, the scope shall include the following:

a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.

b) The relay shall have suitable for communication protocol as per IEC 61850/60870-5-103 for connectivity to SCADA.

c) Protection Settings configured in the respective relays should be readable from HMI.

d) All the cards of the relay should have conformal coating to avoid the environmental impact to the functioning of the relay.

e) While selecting relays, the local environment and pollution norms to be considered. Accordingly suitable IP rating to be selected for relays.

<u>The Relay shall also have following facilities:</u>

- The Relay shall have adjustable type of settings (instantaneous type, Delayed type, protection zones, stage settings etc.) as per the requirement of DMRC.
- The same relay shall be provided with both 1A and 5A CT inputs and shall be selectable at site.
- The relay shall have facility to store and display all the parameters necessary for post fault analysis (Pre and Post fault recording minimum 500ms).
- Relay shall have facility to display all the operational and faults parameters and events including status of DI/DO signal on HMI.
- The relay shall be capable of measuring and storing values of a wide range of events, faults and disturbances. The relay shall have facility to record at least 200 Events (including DI status) and 05 Fault records with time stamping (oscillography record).
- The CT terminals on the relay shall be suitable for ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit.
- The relay shall be suitable to accept both AC and DC supplies. The rated DC voltage shall be 110V.
- The numerical relay shall provide with supervisory functions such as trip circuit supervision, CB monitoring, CT supervision, DC supervision etc.
- The front panel of Relay shall have ingress protection rating of IP-52.
- The details of configuration in the card, block diagram of the card and waveform signature of each test point for each card shall be submitted by DE 08 contractor.
- The Relay shall also be used to authorize the operation of the incoming isolators and earthing isolators on no load

14.3.1.15 COMMUNICATION PORTS OF RELAY

The relays should have communication ports for local communication for relay settings, modifications, extraction and analysis of fault/event/ disturbance records from a laptop and for communication.

The Relay shall have IEC 60870-5- 103, IEC 61850, Modbus, DNP3 communication protocol for system communication and USB / RS232/RS485 / RJ45 (Ethernet) port for uploading/downloading settings and records locally through PC or laptop.

Relay shall have dual ports for RSTP and PRP redundancy for SCADA connectivity IEC 61850, IEC-60870-103, DNP3, Modbus protocols.

The relay shall have time synchronization functionality on SNTP/NTP ± 1.0 ms typically.

14.3.1.16 FACILITIES FOR FAULT ANALYSIS

The relays shall have the following tools for fault diagnostics

a) Fault record

The relay shall have the facility to store fault records with information on cause of trip, date, time, trip values of electrical parameters.

b) Event record

The relay shall have the facility to store time stamped event records with1ms resolution.

c) Disturbance records

At least 5 secs of disturbance records shall be provided in the offered Numerical relays. Each record shall store data from at least 5 analogue channels and 16 digital channels. The data from DR function shall be available in IEEE/COMTRADE format and shall be compatible with the relay test kit being supplied under this contract.

14.3.1.17 **APPLICABLE STANDARD**

All numerical relays must comply relevant IEC standards as follows: -

S. No.	**Tests**	**Standards**
	Emission tests	

1	Radiated emission	IEC 60255-26
2	Conducted emission	IEC 60255-26
	Immunity tests - Radiated disturbances	
3	Immunity to radiated fields	IEC 61000-4-3
4	Electrostatic discharge	IEC 61000-4-2
5	Immunity to magnetic fields at network frequency	IEC 61000-4-8
6	Pulse Magnetic field immunity	IEC 61000-4-9
	Immunity tests – Conducted disturbances	
7	Immunity to conducted RF disturbances	IEC 61000-4-6
8	Electrical fast transients (EFT)	IEC 61000-4-4
9	Surges	IEC 61000-4-5
10	Damped oscillatory wave (1 MHz)	IEC 61000-4-18
11	Voltage alternating component (ripple)	IEC 61000-4-17
12	AC voltage dips and interruptions	IEC 61000-4-11
13	DC voltage dips and interruptions	IEC 61000-4-29
	Mechanical robustness	
14	Vibrations	IEC 60255-21-1
15	Shocks	IEC 60255-21-2
16	Seismic	IEC 60255-21-3
	Climatic withstand	
17	Cold	IEC 60068-2-1
18	Dry Heat	IEC 60068-2-2
19	Change of temperature	IEC 60068-2-14
20	Damp heat cyclic	IEC 60068-2-30
21	Damp heat steady state	IEC 60068-2-78
22	Flowing mixed gas corrosion test	IEC 60068-2-60
	Safety	
23	Enclosure safety test	IEC 60529
24	1.2/50 μs impulse voltage withstand	IEC 60255-27
25	Dielectric voltage withstand	IEC 60255-27
26	Insulation resistance	IEC 60255-27
	Communication	
27	Communication	IEC 61850, IEC-60870-103, Modbus, DNP3

14.3.1.18 ENVIRONMENTAL PERFORMANCE OF RELAYS

The Auxiliary sub-stations shall not have provision of air-conditioning plant. Therefore, the relays shall be designed for operating satisfactorily under the climatic conditions of ambient temperature and relative humidity variation from 0ºC to 55ºC and 50% to 95% respectively. The temperature during storage and transit may reach up to 70 ºC.

The Relay shall be installed in severe polluted zone; therefore, relay shall be designed for safe working in immediate neighborhood of industrial sources with chemical emissions. The chemical active substance in surrounding shall be taken as of level 3C3 of IEC-60721-3 for design PCBs of relay. All printed board assemblies shall be protected on both sides with a protective transparent coating, in order to prevent deterioration or damage due to such causes as moisture and atmospheric contaminants. The coating shall not have any adverse reaction with any other materials or components used on Delhi/NCR environmental condition. All relay shall be type tested as per IEC-60068-2-60 for Acidic and heavy pollution environment, H_2S, SO_2, mixed gas tests

All the electronic cards supplied shall have following minimum requirements-

a) As per IEC 61086 & 60815, all printed board assemblies shall be protected on both sides with a protective transparent coating, in order to prevent deterioration or damage due to such causes as moisture and atmospheric contaminants. The coating shall not have any adverse reaction with any other materials or components used on Delhi/NCR environmental condition.

b) All electronic cards used in IEDs, Relays, Breakers, Invertors, Battery Chargers/DCDB, PLC, AVRs and all other electronic cards should confirm to environment factor class minimum 3C2 as per IEC 60721-3-3 for highly Polluted area. All applicable Cards must have conformal coating and must be tested for H_2S, So2 and mixed gas tests as per IEC 60068 -1 & 2,60068-2-60 for a minimum duration of 10 days for confirming to the environment class 3C3 as per IEC 60721-3-3. A certificate to this effect shall be submitted before delivery of material. Relays, cards and all equipments must be capable for Very heave pollution level in Delhi NCR as per IEC.

c) All electronic cards, assemblies, sub-assemblies and components thereof used in equipment, relays, IED, PLC etc. Supplied this contract shall be of Industrial grade only as per relevant standards and shall be suitable for the ambient temperature range between -0.6°C to 50°C. All applicable cards must have also tested for Environmental test as per IEC 60571 / EN 50155 and shall be done in accordance to IEC 60068. Details of test are mentioned below:

i. Damp heat run test as per IEC 60068-2-78 standards for class T3.

ii. Low Temperature Test

iii. Change of Temperature Test

iv. Cyclic Humidity Test

v. Driving Rain test

vi. Dust & Sand Test & Mould Growth test

vii. Dry heat run test as per IEC 60068-2-2 standards

d) In addition, the details of configuration in the card, block diagram of the card and waveform signature at the beginning & end of each such block for each electronic card used in the equipment along with documentation each test points for each card shall be submitted by the contractor.

e) All auxiliary relays/contactors, electronic components shall be of heavy duty/Industrial grade and PCB should have conformal coating suitable for pollution level "Very heavy" for Delhi as per IEC 815-1986 & IS 13134-1992. IEC 61086 : for conformal coating.

f) All the cards of the relay should have conformal coating to avoid the environmental impact to the functioning of the relay.

g) All Electrical Panels shall be completely metal enclosed, suitably IP rated as per relevant application and shall be dust, moisture and vermin proof.

14.3.2 **Zones of Protection**

14.3.2.1 The zones of protection shall overlap providing back-up protections the scheme of protection shall be fully coordinated with the infeed network from dmrc.

14.3.2.2 The contractor shall ensure proper coordination among different level of protection being applied in the design such that equipment failures will cause minimum disruption to the railway system operation. Contractor shall submit detailed fault calculations, relay settings and fault co-ordinated curves showing proper protection, discrimination between all upstream and down stream equipment.

14.3.2.3 An interlocking and protection scheme that prevents inadvertent operation of switchgear resulting in electrical accident by inadvertent or spurious re-energisation of the supply shall be submitted to the engineer's representative for review and approval.

14.3.2.4 Any 33kv cable or switchgear faults in the 33kv ring-main system will be cleared first by incoming feeder panel circuit breaker and backup by the outgoing 33kv feeder circuit breaker at rss side.

14.3.2.5 To detect the location of the fault in the 33kv ring-main system, a detection relay shall be installed for all 33kv feeder panels at each ASS which will send to the OCC an indication that it detects a fault. This will be seen on the screen of the OCC equipment and the fault could be located between the last relay detecting the fault and the first relay not detecting the fault. With these indications, the operator will be able to take the necessary measure to isolate the faulty section and to reenergize the healthy part of the network.

14.3.3 Hydraulic or thermal protections

These protections, such as lack of pressure or abnormal temperature, shall include measuring elements situated on the protected apparatus, actuating a contact (mandatory of flip-flop type) which represents the start of the protection line.

14.3.4 Electrical protections

14.3.4.1 PROTECTION DESCRIPTIONS

The various type of protection shall be provided in ASS as per the DMRC protection Philosophy (Technical Instruction-10). The contractor shall submit the detail protection scheme in line with Technical Instruction-10 of DMRC for approval of Engineer In-charge. Technical instruction-16 shall be referred for the relay setting and configuration – Password protection

The Response protection relay on various type of faults shall be as per Technical Instruction-26 of DMRC.

All these Technical Instructions are attached in Appendix-D of the PS

14.3.4.2 PROTECTIONS THROUGH LACK OF MONITORING VOLTAGE

Each cut-out apparatus shall include a device controlling its opening and preventing it from any re-closing in case of lack of monitoring voltage.

14.3.4.3 PROTECTIONS THROUGH LACK OF AC VOLTAGE

Ensured by means of phase - phase voltage measurements with adjustable threshold, possibly associated to time delay, adjustable as well. The measurement shall be supplied from the secondary of the voltage transformers.

14.3.4.4 PROTECTION AGAINST PHASE-PHASE SHORT-CIRCUITS

Ensured by means of current relays (primary current measurement relays with adjustable threshold, associated to time delay also with adjustable threshold). The current relay shall be supplied from the secondary of the current transformers.

14.3.4.5 OVER CURRENT PROTECTIONS

This function ensures the tripping of concerned circuit breaker when the current values reach the highest allowable load on the network in instantaneous or delayed time conditions.

Harmonic Blocking/Restraint feature should be available for the respective Over Current/Earth Fault Protections.

Following the network configuration, pre-set tripping thresholds could be commuted via automatic interlocking or voluntary action.

Tripping curves characteristics could be:

- At constant time (DMT) with the feature of configuring at least 2 Stage DMT protections to be available for all Over current and Earth Fault Relays.
- At dependant time following a characteristic:
- Inverse,
- Very inverse,
- Extremely inverse.

14.3.4.6 PROTECTION AGAINST ZERO SEQUENCE FAULTS

At the output level, these shall be ensured by means of zero sequence current measuring relays (obtained through associating of the currents from the current transformers). These relays shall not be affected by the capacitive currents in the cables during unbalanced operating times which occur on the power supply (such as earthing fault of the other cables, etc.).

14.3.4.7 DIFFERENTIAL PROTECTIONS

Based on the instantaneous comparison, for each phase between the bar set or transformer incoming current and outgoing current, through current transformers.

14.3.4.8 SYNCHRO-COUPLER RELAY

Not Used.

14.3.5 Staging of the protections

Selectivity of the protection arrangements shall be provided so as to avoid all unwanted tripping.

The time delay of the various circuit breakers shall be set so as to ensure chronological selectivity of the tripping.

The supplier shall define precisely the minimum intervals between the various protection stages, accounting for the timings and for the actuation times of each one of the apparatuses involved.

To avoid unwanted tripping, it shall be necessary, in particular, to account for transient phenomenon such as energising of transformers and engagement of cables.

Following details of the relays needs to be submitted by the contractor for the each model of the relay selected in their technical proposal: -

S. No	**GTP of relay (to be filled by Manufacturer)**	
1	Make	
2	Model	
3	Variant selected	
4	Standard IEC	
5	Series of the relay	
6	Firmware series &updation requirements to be mentioned.	
7	Communication Interface	
8	Type of FO communication	
9	Type of Protection Application	
10	No of Disturbance records	
11	Display type	
12	Memory	
13	No. of Phases	
14	No. of Current Input	
15	Secondary protection current rating 1A / 5A	
16	No. of Voltage Input	
17	Secondary protection Voltage rating	
18	No. of BI/BO contacts	
19	No. of Spare contacts Min. 4	
20	No of Output LED	
21	Current Rating of Contact	
22	Aux. power supply Rating	
23	Type of Conformal Coating	
24	Type of Module Plug-in or draw out type	
25	IP protection	

26	Operating Time	
	Min	
	Max.	
27	Relay Size	
28	Power Supply type (AC/DC) & requirements of supply source	

14.3.6 **Installations**

The Relay used must provide full reliability and operating safety and not represent a weak spot for the tightness of equipment. The Relays shall never indicate any wrong data, not lose their accuracy regardless of ambient temperature or of the operating incident concerned.

14.3.7 **Testing and Commissioning**

The contractor shall submit the detailed testing and commissioning scheme in consultation with OEM for all type of protection relay for the approval of Engineer In-charge.

All protection schemes/logics etc. shall be tested from primary side using primary injection kit. Also, all configurations, LED indication, tripping time, relay times shall be tested at site as per approved scheme.

14.4 33 kV Cable Protection

The entire 33 kV Cables Network shall be protected by means of Line Differential protection with Pilot wires, which will automatically trip the 33 kV Circuit Breakers on either end of the faulty Section of the Cable. Line Differntial protection with Pilot wires shall also be provided for the Section of 33 kV cables between ASS1/ASS2 and ASS3 at the Underground Station & Elevated station. In addition not limited to, Instantaneous and IDMT Overcurrent and Earthfault protection (50, 50N, 51, 51N) shall be provided, Over Current relay with Directional/Non Direction as required, to ensure that the network is fully protected against any faults on the 33kV Ring Main Network. Therefore, the functioning of these protections shall trip the either end of circuit breaker of 33kV power supply network.

Please refer Technical Instruction-26 for detailed protection philosophy of Phase-IV network attached in Appendix-D of the PS

14.5 ASS Equipment Protection

14.5.1 Transformer protection

The transformer is protected against fault by the followings

- F 50: Instantaneous over current protection
- F 51: Time delayed over current protection
- F50 N: Instantaneous earth fault protection (zero sequence)
- F51 N: Time delayed earth fault protection (zero sequence)
- 87T TransfomerDifferential protection
- 51G Standby earthfault protection
- 64: REF Protection (For UG and Depot ASS)
- 50BF breaker failure protection

For Transformer differential protection, the Contractor shall provide the required Current Transformers in MV panels. In addition, the control cables between the MV breakers and LV Breakers shall also be provided by the Contractor.The necessary C&M cables for Transformer shall be supplied and installed by the contractor. The E&M Contractor will provide the LT side CT. The E&M Contractor shall also interface with ROCS Contractor for matching Accuracy Class and CT characteristics to ensure tripping of HT and LT breakers in case of Transformer fault within the zone of protection.

The functioning of these protections shall trip the MVCB & corresponding LVCB.

Moreover, it shall be protected against heating by a two-threshold temperature protection.

The first threshold shall transmit an alarm to the ECC as well as in the ASS.

The second threshold shall trip the respective MVCB and corresponding downstream LVCB and transmit an alarm to the ECC.

The details of the protection have been explained in the **Technical Instruction-26 for detailed protection philosophy of Phase-IV network attached in Appendix-D of the PS**

14.5.2 Low voltage protection

The low voltage circuit breaker supply and installation by the E&M Contractor shall be equipped with magneto-thermal protection to protect the main circuit against short-circuit, over-current and earth fault. This protection shall be thermal compensated to take into account the ambient temperature. This protection shall be equipped on the LVCB1 and LVCB2. The tripping of LVCB1 or LVCB2 shall also ensure tripping of the corresponding HV side breaker of the transformer (MVCB1 or MVCB2), by inter-tripping.

The selectivity shall take into account the time delay and the current level of the downstream protections.

15. LOW VOLTAGE CABLES AND WIRING

This specification is made to define the characteristics of low voltage cables used for distribution, control and monitoring. They shall be supplied either in A.C. or in D.C. They shall be used for electrical connection between apparatuses of RSS, TSS, 25 kV switching stations, AMS and ASS.

All LV cables, Control and Monitoring cables shall be armoured Fire Retardant Low Smoke Zero Halogen Type (FRLSOH) for Underground section and Fire Retardant Low Smoke Type (FRLS) for Elevated section complying with BS 6724 for cables, BS 7211 for Wires and BS 7846 for Cables used for Emergency services and for safety system…

15.1 General

Conductors supplied for low voltage or remote-control lines shall have a bare copper core.

Semi flexible conductors shall be used; rigid conductors shall be prohibited.

The conductors' cross-section shall be a standard value, and shall never exceed 240mm^2; above this value, the appropriate number of conductors shall be connected in parallel.

The minimum cross-section of conductors shall not be less than 1.5 mm^2.

The voltage rating of distribution cables shall be 1100 Volts.

Grounding conductors shall have green/yellow-stripped insulation.

Neutral conductors are to be deemed as being active conductors.

Cables and wires shall be treated to withstand flames propagation.

All Low Voltage (LV)/C&M cables shall be of armoured and screened.

15.2 Cable Cross Section Determination

Determining the technical core section of a cable implies determining the smallest standard cross-section in the type of cable selected which, under the applicable environmental conditions, could satisfy the following criteria:

(i) Normal temperature rise

(ii) Maximum voltage drop

- 3% for main distribution lines (between primary and secondary cabinets)
- 3% for lighting circuits

- 5% for power circuits
- 12% for motor circuits during start-up

(iii) Overload and short-circuit

(iv) Protection against indirect contact

(v) If heavy currents are to be carried, the economic section must also be taken into account.

The DE-08 contractor shall submit the cable sizing calculation considering the above said aspects and relevant standards for the approval of Engineer in-charge.

15.3 Standards

All cables shall comply with the IEC standards (IEC 60228 and IEC 227) in force and shall, at least, have satisfied the following tests:

- Dielectric strength,
- Insulation resistance,
- Core resistance,
- Flash-over voltage,
- Insulation stability in a conductive environment,
- Capacitance and differential capacitance,
- Smoke opacity: NBS chamber test,
- Combustion gas analysis,
- Calculation of conventional pollution index,
- Calculation of the conventional toxicity index,
- Measurement of insulation and cladding thickness
- Measurement of diameters,
- Composition and dimensions of the conductive cores,
- Cable construction and identification of cores,
- Tensile properties of insulating and protective cladding mixtures,
- Thermal aging of insulation and protective cladding mixtures,
- Resistance of insulation and cladding materials to pressure at high temperature,
- Resistance of cladding to mineral oils,

- Resistance of cladding to acids and alkalis,
- Resistance of protective cladding to tearing,
- Core bending,
- Coiling at low temperature.

And for the corresponding cables:

- Category C 2 cables (non-flame propagating),
- Category C 1 cables (non-fire propagating),
- Category CR1 cables (Fire-resistant cables).

15.4 Identification

All conductors, cables, wiring, terminals and apparatuses shall be identified according to the indications of the diagrams.

This identification shall be placed so as to be easily read from the accessible face of the cable or wiring

In all structures, cables shall be marked both at their ends and approximately every 20 meters over their full length, particularly when they change of direction, enter conduits, etc.

Along the track, cables shall be identified in the pulling chambers and at their ends.

The identification shall be realized with Tag-Holder providing the following guarantees:

- Easy fastening,
- Non flammable,
- Permanence of the marking
- Easy reading.

The tag-holder and its bi-directional marking type shall be submitted to the employers approval.

15.5 Connections

All connections, whether made by end-fittings, sleeves or terminals, shall comply with good trade practice.

The connection terminal blocks supplied by the contractor shall be identified and includes space enabling precise referencing of all terminals, also possessing all guarantees of permanence and fastening.

The crimped section of cables shall be insulated by heat-retractable sleeve.

The screen of screened cables shall be connected to ground and continuity shall be ensured.

Cable jointing and termination to be carried by OEM approved jointers. Cable jointing method statement should be vetted by cable manufacturers.

15.6 Cable laying

In general, the cable laying shall comply with the principle of separation between the control and monitoring circuits and the auxiliary circuits of the building (lighting, power, and miscellaneous auxiliaries).

The routings and supports of the two circuit networks shall be wholly separated.

Depending on the room gone through and the runs used by the equipment wiring and links, their purpose (supply or distribution of the auxiliary circuit cabinets) or the nature of the specific element concerned (wiring, frame), several different arrangements may be selected to carry the cables and wires, however, in all cases, good care has to be taken to avoid contact between conductors and sharp edges of sheets, iron, … etc.

Systematically, for control and monitoring cables, all the links of a section shall include 15% spare conductors with at least one spare conductor per cable.

The Cable shall be laid as per the Technical Instrcition-25 of DMRC.Please refer Appendix-D.

For Elevated section: The cable dressing shall be proper and tied cables shall be tied with heavy duty nylon cable (UL listed Nylon 6.6 material) tie at the interval of 500 mm. The cable tie shall be UV resistant and Flammability shall be of UL94 V2 rating.

For Underground section: The cable dressing shall be proper and tied cables shall be tied with LSZH tie at the interval of 500 mm.

The GTP of cable Ties shall be approved by the Engineer In-charge.

15.6.1 Supports

15.6.1.1 Cable-Ways of Perforated Sheet

This shall be the normal laying mode of the link conductors.

It shall be used systematically along wiring runs necessitating special mechanical protection, precaution or when it is necessary to carry several cable-way levels inside limited space.

Their width shall be defined to enable addition of at least 15% of the number of the cables initially foreseen.

In general, when sheets shall be superimposed, the clear heights between one another shall be defined so as to provide perfect accessibility to the cable layers they carry.

All necessary arrangements shall be taken to enable addition or possible replacement of a conductor in a layer and, consequently, to enable its pulling. Several superimposed layers of cables may use the same support sheet but superimposition shall be limited to cables of the same section. If crossings are required between cables or layers coming from different sections, a metal element shall be placed between the layers in way of the crossing. The extent and number of the fastening fittings shall be determined so as to avoid all distortions between rests. The anchoring process of the fittings shall be suited to the supporting element concerned.

15.6.1.2 Cable-Way On Fittings Or Bridges

This arrangement shall be used only for small layers, not justifying the use of slabs.

The fittings or bridges shall be sized accounting for possible addition of 15% additional cables.

One independent fitting shall be provided per set of conductors coming from a same section; in no event may conductors coming from different sections be fastened to a common fitting or bridge.

The number of fittings or bridges shall be determined so as to avoid all cable scalloping between fastenings.

15.6.1.3 Insulating Tubes

When conductors are gathered in strands, they may be laid inside an insulating tube. This solution may be used only for short runs.

15.6.1.4 Metal Tube

Certain circuits may have to be protected by means of rigid steel tubes or flexible metal tube; all the necessary precautions shall be taken to insulate the fastening so as not to cause contacts between masses of different categories. These metallic tubes shall be properly earthed.

15.6.2 Fastening of Cables and Conductors to their Supports

Fastening of the cables to their supports, whether perforated steel, fittings or bridges, shall be made by means of loosening-proof clamps made of flexible insulating material and by mean of mechanical tightening.

If several cables of the same section use a common horizontal run, they shall be able to be gathered and clamped by the same fastening clamp.

Fastening of conductors shall always be provided immediately next to their connection ends. In no event may connection to a terminal block be deemed as being fastening and permanent strain may be exerted on the terminals.

15.6.3 Mechanical Protection of Cables and Conductors

In all cases when the layout of the conductors of bar set of the earthing circuits could render them vulnerable (floor crossings, vertical layers or horizontal crossings through service passages), the necessary mechanical protection for the cables and conductors shall be ensured.

These protections shall show sufficient strength to prevent any damage to the cables and conductors following impacts, which may occur during equipment handling operations; they shall also possess good resistance against corrosion.

For vertical layers, the contractor shall ensure supply and installation of sheet casing ensuring efficient protection up to a height of 2 meters above ground. In case of single or limited number of conductors a spare tube shall always be laid.

Whenever LV cables or conductors are placed along a run adjacent to or crossing MV cables, full steel protection on the LV cables shall be provided.

It shall enable possible pulling of the MV cables without risking to damage the insulating material of MV cable.

This metal protection shall be connected to the nearest LV earthing collector and shall ensure electrical protection in the event.

All cable trays and supports shall be suitably connected to Earthing system at two distinct and separate points. Wherever cutting / welding process required at site, Contractor shall ensure that cold galvanizing zinc paint should be applied after doing the process.

15.6.4 Sealing of cut-outs

Cut-outs of the Low Voltage cables will be sealed by contractor. The Contractor shall interface for the cable cutouts with SBC. **For complete details Refer clause 8.7.3 above.**

16. EARTHING

E&M Contractor will provide an Earth bus (MET) inside the ASS. Various metallic objects in ASS will be connected through suitable G.I. flats to the Earth bus (MET – Main Earth Terminal) by the Contractor. The bimetallic strips required for connection in any case shall be provided by the Contractor.

Connection from a main earth terminal (MET) for transformer neutrals to the earthing stations in the ground will be provided by E&M Contractor. Connection from the transformer neutral to this Earth bus (MET) for transformer neutrals will be provided by the Contractor. Interconnection between the ASS Main Earth Terminal and Station earth mat will be provided by E&M Contractor.

The Auxiliary transformer neutral is required to be connected to the ASS earth by means of 2 independent connections. In addition, in underground & Elevated stations, the Contractor will have to run an earth bus inside the ASS room, and all non-current-carrying metallic parts of the various equipments will require to be connected to this earth bus. The earth bus will ultimately have to be connected to the ASS earth, which may be an earth-mesh or a series of interconnected earth electrodes.

Earthing and bonding of metal sheath, metal screen (if any), armour of cable if any and all metal pipes or conduits in which cables to be laid should be according to IS: 3043 latest edition, IEEE 80 and approved by Engineer In-charge during detailed design stage. Tagging of all individual connection to MET has to be done.

The ASS floors and walls shall be provided with epoxy paints. The contractor shall interface with station building contractor for providing of earthing strips embedded in concrete. No Earthing strips shall be allowed on top of the floor of the ASS. Any damage to epoxy paints during execution of ASS work shall be rectified by the contractor and shall also attract penalty.

17. SAFETY REQUIREMENTS

Safety of equipments in the ASS shall be provided as per statutory regulations. The indicative list of safety equipments shall be not limited to the following:

a) Clean agent (NOVEC 1230) based flooding system for electrical panel protection in Elevated station

b) Tool Board.

c) Safety tools: first-aid kit, first-aid and electric dangers drawings, insulated gloves, stool and, stretcher, Caution & warning notices.

d) Each Electrical Panels/transformer/battery/battery charger/ACDB/DCDB shall be provided with insulating mats of ribbed surface, complying to IS 15652, laid in front of and at the rear of the switch board. The insulation mats shall be continuous sheets of minimum thickness as per IS, 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.

   1000 mm wide of required length as required for applicable voltage or as per approval of Engineer-Incharge.

e) Fire protection equipment, such as fire buckets, sand buckets, portable fire extinguishers, wall-mounted or wheel-type fire extinguishers etc.

f) Key BOX

g) Gas Resuscitation Kit.

Any other requirement for safety as per statutory regulation such as CEA Regulation, 2010 with latest updates & version.

Type testing and random tests of safety items like rubber mat, fire suppression, fire detection system etc. shall be done to ensure safety of all concerned.

17.1 CLEAN AGENT (NOVEC 1230) BASED FLOODING SYSTEM FOR ELECTRICAL PANEL PROTECTION IN ELEVATED STATION

17.1.1 General

- The scope covers supply, installation, testing, and commissioning of automatic clean agent-based flooding system complete for electrical panels (33kV switchgear panels ACDB & DCDB, battery charger etc. in the ASS shall be protected against fire by means of an automatic fire **detection** ~~detector~~ and **suppresion** ~~extinguisher~~ system) 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 low-pressure 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.
- The Cylinder must be filled in a UL / FM / PESO approved plant.

- The electrical panel fire suppression system shall be complete with clean agent 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 control panel in case of fire in the concerned panel, indication of fire / discharge status should come in main fire alarm control panel. System provider / vendor has to submit authorization for use of clean agent / gas from the manufacturer.

17.1.2 **Design Requirements**

- All the detecting devices, alarm, indicating devices, containers and other related equipment shall have required approvals & Authorization.
- All installations shall conform to NFPA / LPCB requirements.
- 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.

17.1.3 **System Equipment**

17.1.3.1 Tubing shall be UL listed.

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 minimum 195 psig and maintains the system in the "OFF" position. The tube shall burst at temp. 100^0C-120^0C. Tube should be marked with OEM name. The tubing shall perform three functions:

- Heat Detection,

- System Activation and
- Clean Agent discharge.

17.1.3.2 Clean Agent Container

- Design, fabricate, certify, and stamp containers in accordance with the requirements of NFPA (DOT / TPED). Containers shall be standard model and size for 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 an isolation valve that interfaces with the detection tubing. The Isolation 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 / TPED requirements.

17.1.4 **Technical and Installation Requirements**

- Provide sufficient amount of extinguishing agent, inert to 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.
- Interface system with main fire alarm control panel and BMS.
- All doors and holes in the enclosed / equipment should be closed or sealed to maintain the tightness of enclosure.
- The clean agent based Pre-Engineered automatic direct fire suppression system / each component shall be UL / FM / LBCP / VDS approved.
- Each clean agent pre-engineered automatic system is equipped with its own detection / discharge tubing. Vendor to submit detailed drawings & calculations based on NFPA & specifications for approval.

- 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.
- The Clean Agent is to be stored in DOT / TPED steel cylinders as a liquefied compressed gas, super- pressurized with Dry Nitrogen to min. 195 psig at 70°F. The ambient operating temperature range for all system components should be 0-degree C to 54-degree C.
- 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 / TPED requirements.
- Provide wall-mounted painted steel bracket to mount the container / valve assembly in a vertical (upright) position. Each bracket should be equipped with at least two integral quick-clamp straps as per manufacturer standard practice.
- Install equipment as indicated on the approved shop drawings, and in accordance with requirements of NFPA-70 and NFPA-2001.
- All the necessary accessories required for operation of system shall be part of supply from single manufacturer and the complete system shall have proven record of accomplishment and international third-party approvals like UL, FM, LPCB, VDS or any other reputed certification as applicable. The system shall be designed and endorsed by OEM.
- The installation and commissioning of the system should be by manufacturer or their authorised channel partner. The final connections between equipment and system detection tubing should be under direct supervision of factory trained and certified representative of manufacturer.
- It shall be so designed that it does not affect the IP ratings of electrical panels. The sub-contractor has to coordinate with manufacturer 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 through suitable size of connector.
- The tubing shall be manufactured from specially processed polymer material to achieve the desired heat detection and delivery characteristics.
- 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.
- Distribution of detection tubing shall be ensured in each compartment of the panel viz. Busbar section, switchgear section and cable alleys etc. with routing on any two sides. mounting / installation of the detection tube to be as per manufacturer's design.

- The authorised vendor / OEM shall be submitting all the relevant import documents for components (if imported) of the system to ensure authenticity and traceability.

17.1.5 **Control Box**

- Each unit / cylinder of the gas flooding system shall be provided with separate control box.
- The control box shall be capable of giving audio and visual alarm in the event of gas release and shall also be compatible for interfacing with existing station fire alarm system. It shall relay the signal to the FACP in case of release of clean agent.

  The ROCS contractor shall do necessary interface with E&M contractor.
- The control box enclosure shall be at least IP 54 rated.
- Wiring of the Control Box shall be FRLSH as per IS 694 and shall be minimum 2.5 sqmm.
- The control box shall be fire red in colour having 2 mm thick CRCA sheet with powder coated finish. The unit shall contain indication for System Healthy, Mains Healthy and Gas Release.
- The unit shall also have signal silence button. All components such as hooter, strobe, indication lamps, chip shall be of superior make subject to approval by Engineer-in-charge.
- Third party test reports for IP and Functionality of the system to be submitted before approval. The system shall be supplied and certified by OEM of the flooding system or their authorized vendor.

The control box shall be provided with 240 V single phase UPS Power supply arrangement which is to be provided by E&M contractor. The contractor shall do necessary interface with E&M contractor.

18. ELECTRO-MAGNETIC COMPATIBILITY: GENERAL

An EMC Control Plan shall be submitted by the contractor as specified in the Employer's Requirements: General Specification for review by the Employer.

The EMC control plan shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified by EN50121. The plan shall specify measures to increase immunity of the system and all its subsystems.

<u>All Electronics equipment/sub-parts shall be of Industrial grade.</u>

The Plan shall specify basic' protective measures proposed for all electrical and electronic subsystem and components and specify measures to be adopted for selected subsystems and components.

The Plan shall analyze EMI and EMC impacts on the design of the system, all other train-borne equipment and track- side equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding, bonding, and shielding, filtering and cabling arrangements.

Contractor is required to conducted full EMI tests at locations adjacent to television and radio transmission stations airport, and other transmitting commercial stations to be agreed with the Employer. These tests shall include simulated fault conditions.

The radiated emissions shall not exceed the levels permitted by the relevant standards.

Conductive emissions shall be below the levels deemed by the signaling equipment to the satisfaction of the Employer. This condition shall be met by each individual piece of equipment.

Power cables and data cables shall be physically separated from each other. A power cable shall be located and arranged such as to minimize electrical induction or interference to train control and communication circuits as a result of traction, auxiliary or other currents, both static' transient or flowing.

19. INTER-SYSTEM EMI

The Contractor shall ensure that all equipments are designed and constructed in accordance with the latest issues or version of internationally recognized EMC standards, including but not limited to CISPER, EN50082, EN50121(1-5), EN 50123, EN 50155, IEC 60571-1, IEC61000, or equivalents, to ensure proper functioning.

20. SAFETY-RELATED SYSTEM INTERFERENCE

Special attention must be given to the interface with safety-related operations and equipment such as the signaling and telecommunication systems. special tests must be designed to ensure that the full range of emissions, whether conducted, induced, or radiated, individually or in combination with one another conform to the specific requirements of these safety related systems. Adequate safety margin must be ensured between the immunity levels of these safety-relate systems and the emission levels of the system specified by prevailing international standards.

The subsystems and components which could possibly give rise to the level of emissions under both normal and fault conditions (conducted, induced or radiated) that may, affect the safety –related systems must be identified. the quantified risk assessment must be carried out as part of hazard analysis to determine the probabilities and effects of such interference. measures must be taken to reduce emissions. the reliability of subsystems as well as the additional measures, e.g. filter, must be investigated.

The probabilities of various conditions which could lead to an unsafe operation must be determined. an appropriate technical construction file suitable for safety audit must be developed to demonstrate. emc compliance will be sent to the employer. The contractor shall note that the signaling contractor shall be responsible for determining the limits of interference for both the trackside and train-borne signaling equipment, to ensure safe operation of the trains, high frequency radiated coupling through common mode, differential-mode, or ground loop mechanisms.

21. ENVIRONMENTAL EMC

The equipment shall not produce significant interference with aeronautic equipment, radars, global positioning system, tracking systems, radio, television, tape recorders or players, heart pace makers, radar, computer systems, magnetic media, portable and cellular telephones pagers, etc.; in the train or external audible systems as per international standard EN 50121(1-5). this includes action by static electricity, magnetic fields and electric fields.

Effect of emission on explosive or volatile/flammable material must be considered. Bs6656:2002 (assessment of inadvertent ignition of flammable atmospheres by radio-frequency radiation-guide) and other related standards shall be adhered to.

Effect of low frequency magnetic field produced by traction currents on Delhi metro MRTS grounding system as well as electrolytic weakening of structures shall be taken care of.

22. GUIDELINES

IEC61000-5 installation and Mitigation Guidelines must be observed wherever applicable.

22.1 THIRD PARTY TESTS

- During the execution stage, DMRC may conduct the test on any type of fixture from third party independent lab at its own cost,to ensure the quality of material supplies. If any of the samples fail in the test, the cost of the test along with the complete replacement of whole lot shall be borne by the Contractor.
- If contractor represents, two random samples from the failed lot shall be collected by the contractor in the presence of DMRC representative and after duly sealing the samples will be sent to two different NABL accredited labs (as approved by Engineer Incharge) for conducting all those re-tests, which were conducted earlier on the failed sample. Cost of the testing including the collection of sample and to and fro transportation of samplesshall be borne by the contractor.
- If both the samples pass all the tests, supplied lot will be deemed as accepted by DMRC, but in case of failure of any of the samples collected by the contractor, complete lot shall be deemed as rejected and contractor shall have to replace the whole lot.
- The delay, if any for the procurement of the replacement material due to failure, shall be considered as non-compliance and applicable penalty shall be imposed on the contractor.

23. VIADUCT LIGHTNING

23.1 GENERAL

The scope of work shall cover the supply, installation, testing and commissioning of the lighting system.This specification covers the LED lighting that shall be used for general lighting in DMRC.

23.2 ABBREVIATION

FRLSH	Fire Retardant Low Smoke and low halogen
FRLSZH	Flame Retardant Low Smoke Zero Halogen
LED	Light Emitting Diode.
EPC	Engineering, Procurement and Construction
OEM	Original Equipment Manufacturer
NABL	National Accreditation Board for Testing and Calibration Laboratories
LPD	Lighting Power Density
NBC	National Building Code
ECBC	Energy Conservation Building Code
CCT	Correlated color temperature
CRI	Color Rendering Index
R Number	Registration Number
SMD	Surface Mounted Device
COB	Chip On Board
RoHS	Restriction of Hazardous Substances
CISPER	International Special Committee on Radio Interference

AC, DC	Alternating Current , Direct Current
EMC/EFT /ESD	Electromagnetic compatibility/ Electrical Fast Transient /Electrostatic Discharge
IEC/BIS	International Electrotechnical Commission / Bureau of Indian standards
IP	Ingress Protection
SDCM	standard deviation in colour maintenance
THD	Total Harmonic Distortion
PMMA	*Poly Methyl Methacrylate*
CRCA	Cold Rolled Close Anneal
UGR	Unified Glare Rating
PCB	Printed Circuit Board

23.3 APPLICABLE STANDARDS

Latest revision of all codes and standardsare to be followedwherever specified otherwise for installation and requirements, Indian standards codes of practice or the relevant British Standard codes of practice is to be followed, in absence of any standards.

The luminaries shall conformation to standards as per IEC 60598/IS 10322 and shall have electrical safety as per IEC 61000, 61547, 61347, 62471, 60958, 62560, 60838-2-2, IEC 62262.

IEC 62471 or IS 16108-Standard for Photobiological Safety of lamps and lamp systems.

IEC 62031- Standard for LED Modules for general lighting- safety specifications.

IEC 61347-2-13- or **IS 15885 (Part 2 /Sec 13)**Standard for particular requirements for DC or AC supplied electronic controlgear for LED modules.

IEC 60838-**2-2**-Standard for particular requirements/ connectors for LED modules.

IEC 62384 or**IS 16104** - DC or AC supplied electronic control gear for LED modules - Performance requirements.

EC DIRECTIVE 2002 / 95 / ECand Related Commission-Restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment including lighting.

IEC 61000-3-2 or**IS 14700-3-2** "Electromagnetic compatibility (EMC) - part 3-2: limits - limits for harmonic current emissions (equipment input current ≤ 16 A per phase)

IEC 61000-3-3-(EMC) for limits on voltage changes, voltage fluctuations and flicker.

IEC 61547 Standard for Equipment for general lighting purposes- immunity requirements.

CISPR 15 - Limits and Methods Of Measurement of Radio Disturbance Characteristics Of Electrical Lighting And Similar Equipment.(applicable on type A luminare specified in Table A below andall fixtures having wattage greater than 50 watts).

IEC 61000-4-11 Electromagnetic compaitability, Testing and measurement techniques- voltage dips, short interruptions and voltage variation immunity tests.

LED Characteristics standards- **LM-80, TM-21.**

Luminaire standard **-LM79,L70 and B50.**

IEC 60068/2/78 or IS 9000 / Part IV : for damp heat test.

IEC 61086 : for conformal coating.

IS 1239: Part 1: 2004 Steel Tubes, Tubulars and Other Wrought Steel Fittings - Specification - Part 1: Steel Tubes.

IS 1239: Part 2: 1992 Mild steel tubes, tubulars and other wrought steel fittings, Part 2 Mild steel tubulars and other wrought steel pipe fittings.

23.4 ENVIRONMENTAL CONDITIONS

S.No	Description	Value
a	Ambient temperature	0.60 to 47.2^{0}C
b	Maximum relative humidity	100%
c	All equipment must be designed for Vibration Level of 3g in X,Y and Z directions.	

A. Viaduct Lighting Specifications

Lighting layout along with details of selection of approved light fittings,is to be submitted by the contractor for review and approval ofEngineer-Incharge. The final submitted layout dialux reports (with IES file of all luminare and other parameters) shouldduly comply the lux level design criteriagiven in the lux chart. The lighting design shall also meet the best level of uniformity ratio.

The kW loading and LPD (Light Power Density) in W/m^2 shall comply with the latest NBC/ECBC requirements.

The tolerances in the wattage/efficacy/harmonics and other parameters shall be as per the latest IEC/IS.

The light fittings or its paint shall not emit toxic/corrosive gases in case of fire and shall be non-combustible and fire-resistant type.

The emergency lighting installation shall fully comply with NBC or other relevant safety standards.

Each luminaire and its driver should be **BIS certified and related "R" Number** of BIS should be printed on the luminaire and driver.

The lighting fixtures and accessories shall give continuous trouble free operation during the defined life and their performance,shallnot deteriorate with time.

DMRC reserves the right of testing of products for its conformity in accordance with mentioned specifications.

Driver of luminaire shall preferably be in separate compartment, other than LED compartment. Mock-up of fixture and driver installation maintenance shall be given by OEM.

B. LED Make And Specifications

- The LED Chip manufacturers should have registered office In India.The OEM should provide letter of undertaking from LED supplier indicating the LED make , type and quantity supplied for the lot to be delivered.
- LED shall have an SDCM (standard deviation in colour maintenance) of less than or equal to 5.
- The LED efficacy shall be more than 85% at a junction temperature of 85^0C.
- Manufacturer has to submit the TM-21 ,LM-80 reports along with relevant documents.

C. LED Driver And Control Circuit Specifications

- LED driver shall be marked as per latest Standards.
- The LED driver shall be constant current type.
- Potted driver with silicon based compound shall be provided for outdoor luminaries. The potting material should have atleast thermal conductivity of 0.8 W/mK. It should be moisture resistance and should be fire retardant. An unpotted sample of the driver also needs to be submitted at time of inspection. MSDS of potting material to be submitted.

- Over temperature protection / Thermal fold back should be provided in all luminaries drivers.
- Industrial grade or higher grade components should be used for manufacturing of driver.
- The driver shall be able to withstand surge (EFT+ESD interference) of minimum 4kV of 1.2 / 50 microseconds voltage waveform (IEC 61000-4-5). Outdoor Luminaires shall have surge protection of minimum 10 KV in common as well as differential mode.
- The driver shall have under voltage, over voltage and short circuit protection and auto recovery mode.
- Output current ripple content shall be less than or equal to10% on load.
- Output current regulation shall be +/- 5% of the rated current.
- Output voltage ripple shall be within 3%.
- Total harmonic distortion shall be less than or equal to 10%.
- The LED driver of all outdoor fittings should comply to CISPR 15 for limits and method of measurement of Radio Interference Characteristics.
- The control gear shall becompliant to IEC 61347-2-13 or IS 15885-Part 2/Sec 13.
- The driver shall have an efficiency >85% at rated nominal voltage and at full Load.
- It shall have a power factor > 0.95. at rated nominal voltage and full load
- It should give consistent performance in the input voltage range of 165V-270V at 50 Hz . The driver should have nominal voltage of 240 V.The output voltage of the driver shall be designed to meet the power requirement for the system.
- The driver shall be able to withstand 440 V for 8 hrs for all luminaries. After the application of high voltage, the performance parameters namely THD, PF, regulation and efficiency should not deteoriate.
- The OEM shall submit damp heat test report confirming to IEC 60068/2/78 or IS 9000 / Part (IV).
- The driver should have facility for cut off at over voltage.
- The driver shall have inbuilt inverse polarity protection.
- The Current Waveform Shall beCompliant to EN 61000-3-2.
- The equipments shall comply with IEC 61547 for EMC immunity requirements.
- The driver should be designed for ambient temperature , Ta = 40 degree celcius and the life of the driver shall be 50000 hrs (at full load and failure rate of less than 10%). Accordingly Tc (case temperature) is to be decided by OEM.

- Measurement of Tc to be recorded during inspection after placing luminare in ON condition in thermal chamber at Ta=40 ^{0}C, after temperature has stabilization . Tc should not be more than specified value.
- Driver should be paired with luminarie that uses 20% less wattage than the maximum rated wattage of the driver.

D. LED Luminaire Specifications

- The system luminous efficacy (actual lumen coming out of LED Luminaries) of the LED luminaries (of the system):
- The product shall be available in the colour temperature range of 4000K - 5700 K.
- Manufacturer has to submit the LM-79 ,L70 and B50 test report along with relevant documents and IES file of all luminairies.
- It shall have CRI> 70 for outdoor applications.
- The fixture shall be surface suspended or recessed type depending on the application area.
- The housing & diffuser shall be robust and conforming to relevant standards and shall have UV and corrosion resistance protection.
- The luminaries shall have a high quality clear toughened glass or non-yellowish polycarbonate or PMMAdiffuser with diffused reflection having a maximum transmissivity of 85% with fire retardant feature.
- For the outdoor applications it shall have a clear toughened glass.
- It shall have a proper thermal management to dissipated heat. The heat sink should be made of extruded aluminium/die cast aluminium having high conductivity.
- The fixture shall be suitable to work in diverse atmospheric condition like humidity, dust, corrosive etc.
- The fixture shall have a minimum ingress (IP) and impact protection (IK) rating depending upon the area of application as per Table-A.
- The power factor of the overall system shall be >0.95 at full load
- Manufacturer shall have in-house laboratories for carrying out acceptance tests and shall have **NABL accreditionfor in-house laboratories** to perform ~~out~~ all applicable photometric tests.
- Provision shall be made in the fixture for incoming power supply termination, preferably directly at the back of housing.
- All the internal wiring of the fixture shall be of FRLSZH type, copper conductor.

- All screws should be SS 304 or higher grade.
- Connectors used for input AC and output DC connections must be screw type connector. Makes of connectors to be used : Phoenix, WAGO and Harting.
- Extruded/die cast aluminium housing shall be robust, heavy duty & anodized.
- Luminaire shall be embossed or screen printed with manufacturer Name and logo. Also the following information shall be marked on durable adhesive sticker as per IS code:
  - Type of fitting/Manufacturer name/ Manufacturing year and month /wattage /Lumen/ Efficacy/ R number/IP/IK/ambient temp/CCT/CRI.
  - The lumen maintenance of the LED fittings (of the system not chip) shall not be less than 70% after 50000hrs.
  - Additional following reports are to be submitted by the manufacturer, from NABL accredited third party or UL/ILAC listed lab :

  a) The luminaire should be tested as per IS 10322/IEC 60598 standards and following test reports should be submitted: Heat Resistance Test, Thermal Test, Ingress Protection Test, Electrical / Insulation Resistance Test, Endurance Test, Humidity Test.

  b) Should be compliant to LM-79-8/IS 16106: approved method for the Electrical and Photometric Measurements of Solid-State Lighting Products LM-79 testing of the complete luminaire.

  c) Should be compliant to LM-80 IESNA: Approved Method for Measuring Lumen Maintenance of LED Light sources and LED lumen depreciation time to L70 based on LM-80 data to estimate lifetime based on performance data collected from IESNA LM-80.

Table-A -Minimum Parameters of LED luminaire

Type of Fitting	Fixture Description	Lumen Out put	Efficacy Lm/W	CCT	CRI	Type of Body	IP Rating	IK Rating	Outdoor /Indoor
Type-M	Viaduct light	>2400	120	4000 - 5700 K	70	Pressure Die-Cast/ Extruded Aluminium	66	7	Outdoor

E. Failure Rate

The period of first six months from the date of energisation of light fixtures or from revenue operation, whichever is earlier, will be considered as stabilization period. The failure of the luminaire during this period will not be counted. Thereafter, failure rate of luminaire should not exceed 5 % of the total luminaire installed, till the end of warranty period.

24. Interface with SCADA Equipments

- The various equipments provided in the ASS shall be controlled and monitored by a centralized control centre (OCC) installed at desiginated place. The necessary Supervisory Operation Control and Data AcquisitionSystem (SCADA) including the Remote Terminal Units (RTU) at the ASS will be provided by the SCADA contractor. However, the following works shall be in the scope of the contractor
- Supply and installation of interface Marshalling box, if required, in the Underground/Elevated ASS's. The Marshaling Box shall provide for the input signal connections, including those from analog meters, from field equipments and the output signal connections to the field equipments. In addition, the Marshalling Box shall provide for the necessary connection from/to the RTU's. The Marshalling box shall provide facilities for interconnection between the signals to/from RTU and signals from/to the field units.
- The contractor will provide control cable inside the RTU with glands while the dressing and termination in TBs inside the RTU shall be carried out by Traction Contractor. The contractor shall interface with SCADA contractor for signal wise cable termination details. The connection between the RTU terminals and the field equipment terminals, via copper cables, shall be made by the contractor. The Contractor shall tag the either end/ of the cable with proper notificationand the signal wise cable termination details shall be shared with SCADA contractor for termination at RTU end.
- The Contractor shall interface with SCADA Contractor, for proper connection and functioning for the conveyance of signals from/to field equipments to/from RTU.
- The tentative I/O list for ASS (Underground & Elevated) is shown in **Appendix-K for I/O signal of equipments.**

25. MULTIFUNCTION METER/ENERGY METER

The contractor shall refer the technical instruction-28 for detailed specifications of Multi-function meter/energy meter attached in Appendix-D.

26. Firestop/Fire Sealing Material for Underground Section

26.1 General

This Section specifies the scope of work for supply and installation of the tested and listed Firestopping system, combination of materials or devices to form an effective barrier against the spread of flame, smoke and gases, and maintain the integrity of fire resistance rated walls, floors and ceiling-floor assemblies, including through- penetration. Through penetration include annular space around pipes, tubes, conduits, wires, cables, vents etc. Relevant codes and standards up to latest revision shall be applicable.

26.2 Standards

Relevant Codes and Standards

ASTM E 814: Standard test method for fire test of Through Penetration fire stops.

ASTM E 84: Standard test method for Surface burning characteristics of building materials.

UL 1479: Fire Test of Through Penetration firestops

UL 723: Test for Surface burning Characteristics of building materials

UL 2079: Standard for tests for fire resistance of building joint systems.

UL Fire Resistance- Fire Resistance Directory

26.3 System Description

26.3.1 **Firestopping Materials**

Provide firestopping materials from manufacturer consisting of commercially manufactured, asbestos free, non-toxic, UL Listed, for use with applicable construction and penetrating items, complying with following minimum requirements:

26.3.2 **Fire Hazard Classification**

Material shall have a flame spread tested in accordance with ASTM E84 or UL 723.

26.3.3 **Toxicity**

Material shall be non-toxic, should not contain hazardous chemicals and not harmful to humans at all stages of application and during fire conditions.

26.3.4 **Fire Resistance Rating**

Firestop Systems shall be UL Fire Resistance listed approved with "F" rating at least equal to Fire rating of wall or Floor in which penetrated openings are to be protected. Fire rating of 2 hours or more shall be used in underground stations as per the applications. It should also pass hose stream test.

- Through Penetrations

Firestopping materials for through -penetrations, as described in General section, shall provide F, fire resistance ratings in accordance with ASTM E814 or UL 1479.

26.3.5 **Material Performance**

All firestop materials shall comply the following minimum requirements –

(i) Firestop materials shall be capable of installation at temperatures of 5 to 50 degrees Celsius.

(ii) Firestopping material must convey a manufacturer's written document guaranteeing the performance of material for the sustainable lifetime of structure.

26.3.6 **Submittal Requirements**

i. Submit detail drawings including manufactures descriptive data, typical details conforming to UL Fire Resistance testing laboratory, installation instructions & UL listing details for a firestopping assembly in lieu of fire test data or report. For those applications for which no UL tested system is available through a manufacturer, a manufacturer's engineering judgement, derived from similar UL system designs and based on IFC (International Fire council) guidelines shall be submitted for review and approval before installation of firestop. Submittal shall indicate the firestopping material to be provided for each type of application.

ii. Submit certificates attesting that firestopping intumescent material complies with the specified requirements- For all firestop material used in through penetration systems, manufacturer shall provide certification from UL of passing the "Ageing and Environmental Exposure Testing" as per clause 9 of UL 1479. All the 3rd party type test certificate should be submitted which should be tested at reputed Lab.

iii. Submit documentation of training and experience of installer.

26.4 QUALITY INSURANCE

26.4.1 **INSTALLER**

Engage an experienced installer who is: -

i. FM research approved in accordance with FM AS 4991, or operating as a UL Certified Firestop contractor, or

ii. Certified or otherwise qualified by the firestopping manufacturer as having the necessary staff, training, and a minimum of 2 years' experience in the installation of manufacturer's products in accordance with specified requirements. The installer shall have been trained by a direct representative of the manufacturer (not distributor or agent) in the proper selection and installation procedures. The installer shall obtain the manufacturer written valid certification of training and retain proof of certification for the duration of installation.

iii. Installer should be also be approved at the time of Vendor and Technical approval.

26.5 DELIVERY, STORAGE AND HANDLING

Deliver materials in the original unopened packages or containers showing name of manufacturer and the brand name. Store materials off the ground, protected from damage. Materials should be stored at required temperature as mentioned by manufacturer on product labels.

26.6 INSPECTION

i. Before installation of firestop material, installer should submit detail site survey report along with relevant UL tested system drawings or Engineering Judgements as mentioned in Para E19..3.2 (i) for review through contractor to the client. This is to ensure that UL Tested system / Engineering Judgment's should comply with site conditions.

ii. Manufacturer should make minimum two visits at each site, first at the start of the work to ensure that the work is going on as per authorized method and second at the time of completion of the work to ensure that things are as per recommendations and submit report to Employer, for quality of work at the completion of the work.

iii. Submit written reports indicating the locations of and type of penetrations and type of firestopping material used at each location. Each location to be marked with Printed Stickers mentioning the firestop material and UL Listed or Engineering judgements drawing no. along with name of Installer firm and person and fire rating provided.

27. SPECIAL EQUIPMENTS

27.1 WIND SPEED SENSOR

The objective of the wind speed sensor (ultrasonic type) is to generate ultrasonic waves by means of two pair of transducers to measure the wind speed so that audio visual alert can be generated when the wind speed goes above the set speed. The system should meet the application in metro train operation requirement.

The Ultrasonic wind sensor should be robust and light weight with corrosion free housing and with no moving parts. These sensors should be entirely electric and should have high reliability.

It should be a 2-axis ultrasonic wind sensor, providing wind speed data in Digital ASCII or MODBUS RTU.

A. Wind speed sensor specifications:

Output	:	DIGITAL ASCII / RS485 MODBUS RTU (0 to 60 m/s) with Option for 4-20 mA Output.
Ultrasonic Output Rate	:	0.25, 0.5, 1, 2 or 4 Hz
Accuracy	:	± 2%
Resolution:	:	0.01 m/s
Operating voltage	:	12-30 VDC
Current Draw	:	Same as sensor output
Response Time	:	< 0.25 sec
Operating Temperature	:	-35ºC to 70ºC
Operating Humidity	:	<5% to 100% RH
Precipitation:	:	Up to 300mm/hr
Output port	:	Compatible with SCADA system with simultaneous recording & display in the Display Unit & also output to SCADA System
Start-up time		<5 sec

MTBF	:	> 10 years
Protection Class	:	IP 66
EMC:	:	EN 61326
Weight	:	approximately 0.5 Kg

B. Ultrasonic Anemometer:

Structure of Anemometer should be compact, lightweight, corrosion free & stable. Wind Speed Sensor output should be suitably modified to be displayed in SCR and at the same time should be fed to respective RTU at station for further display at OCC & BCC by SCADA contractor. Calibration certificate from relevant independent laboratory/agency should be submitted at the time of supply.

C. Display Unit–

- 7-inch LED based screen graphical display unit should be used for displaying real time data. The display should show wind speed in kmph in whole number up to one decimal place.
- Wind speed threshold should be configured for visual alerts & alarms and should be customizable. Visual alert & alarm should be configurable for multiple wind speeds as stated in Para 1.7 below.
- Speed of Wind (Km/h), output current (in mA) & different range of wind speed with different colour coding (graphical format) should be displayed on the screen of wind sensor.
- It should be able to sense/measure rapid changes of wind speed from received inputs immediately & shall be configurable for two stage alarm with hooter, locally and remotely through SCADA**.**

D. Audio Alarm/Hooter –

- Audible Hooter/Speaker must be installed to play audible alert tones automatically when wind speed goes over specified threshold limit.
- Operator must be able to acknowledge & stop audio visual alerts.
- Time of Alert & Acknowledge must be recorded in log files.
- Provision of simulation of High Wind conditions, must be there for local testing of system/hooter.

E. Accessories –

- Multicore shielded FRLS data cables, of copper conductor (8 Core, 0.5 square mm) to be used on work. The cable used should be of approved brand only.
- All Mounting brackets for wind sensor should be manufactured from high-grade galvanized iron/stainless steel and should be wall or pole mounted as per site requirement. They shall be designed to withstand the required wind pressure.
- DMRC will provide only 230V AC outlet & Earth Ground Connection, necessary power supply arrangement for the equipment, is in the scope of contractor.
- Suitable protection/isolation/amplification etc. required to meet the functional requirement of the system, should be provided by the contractor
- High quality Analog to Digital Converter of reputed make to be provided.
- Signal Isolator/Surge Arrestor from reputed approved brand to be used for data & power lines.

F. Integration:

The wind speed sensors will be installed on top of the metro stations/building as per the instructions of Engineer-in-charge. The wind speed sensors should give wind speed indication and A/V alarm at SCR and it shall be further taken upto respective RTU of Station/building .The SCADA Contractor shall furthur transmit the data from RTU to OCC/BCC through respective RTU of the station/building, for giving alarm of the wind speed at OCC/BCC, so that train operation can be regulated as per designated speed and if wind speed exceeds next set higher limit, train operation can be stopped.

G. On Reporting/ Detection of high speed wind, an audio visual indication should come at SCR & OCC. When wind speed increases beyond 70 Kmph an audio visual indication should set in which can be reset manually, & if the wind speed increases further to 90 Kmph, one more audio visual indication should be generated in SCR as well as respective OCC even if the earlier alarm was manually reset. This second alarm shall also be possible to reset manually.

27.2 EARTHQUAKE SENSOR

The requirement of Earthquake sensor is to detect even feeble earthquake and generate an alarm on the OCC. The objective is that the earthquake can be detected and alarm to be generated in the OCC to take a decision to stop the train operation.

A. Earthquake Warning System Specification:

No of proposed nodes	:	Minimum 3 (1 no in OCC & 1no each in 2 Nos. RSS) or as approved
Connectivity	:	LAN
Individual Nodes	:	Seismic warning System (SWS) (Accelerometer + Seismic Data Acquisition System) with LAN Connectivity
Alarm Generation	:	On thresholding (Programmed PGA Value, resolution, 0.05g
Data packet	:	Containing timing and data values
Central Recording System	:	Recording and alert packet generation at Central Control Room (OCC)

B. Specifications of Seismic Warning System (SWS)

I. Sensor:

Type	:	Force Balance Accelerometer
Component	:	Three (Tri-Axial)
Full Scale Range	:	± 1g (Capability to adjust ± 2g also)
Frequency Response	:	DC to 100 Hz
Operating temperature	:	-10^{0}C to 50 ^{o} C
Cross-Axis sensitivity	:	<1%
Dynamic Range	:	> 130 dB
Connection	:	Military style metal connector

II. Seismic Data Processing Unit

No. of Channel	:	Three (Programmable)
Recording Mode	:	User Selectable Continuous and Triggering mode
Sampling Mode	:	Programmable
Timing	:	GPS timing unit
System Triggering	:	amplitude Triggering, STA/LTA Triggering
Alarm Logic	:	Programmable up to 3 (One for each channel)
Alert signal	:	On exceeding Peak Ground Acceleration (PGA) (Minor and Major alarm as per PGA)
Connectivity	:	Ethernet
Data Storage	:	Internal in GB
Software	:	Data viewing software
Date Downloading	:	Using IP address (to be provided by Client)
Pre-event memory	:	Over Ethernet connectivity Programmable up to 100 sec
Post-event memory	:	Programmable up to filling of internal memory

The signals of Earthquake sensor should be integrated in OCC through RTU via the SCADA System. Each Earthquake sensor shall be provided with the necessary auxiliary contacts and internal wiring to permit remote control and indication. In case of any event, a report should be generated automatically. Also alarm should generate along with change in screen display.

C. Earthquake Warning System requirements: -

The following shall be considered for Reporting/Detection of Occurrence of Earthquake: -

Si. No.	PGA Value	Earthquake Severity	Alarms
1	0.0-0.039 g	Low	Only Visual
2	0.039-0.18 g	Moderate	Both Visual & Audio
3	Above 0.18 g	Strong	Both Visual & Audio

I. **Design of Earthquake Warning System: -**

The contractor shall design and propose the locations of installing the system for proper monitoring of condition of Earth quake for the entire line and Depot. The rating and selection of equipment and their interface shall be developed according to the requirements and subject to Employer's review and consent. The requirements given in specifications for Earthquake Sensors are generic in nature. The basic requirement is to detect even feeble Earthquake and generate an alarm in OCC, with one seismic sensing node shall be provided at OCC & with minimum 2 nos seismic sensing nodes in the field, all duly integrated in one network, & all strategically located.

II. **Earthquake – Zone ……**

III. **Seismic Survey –** The contractor shall be responsible for carrying out seismic survey from some authorized agency to capture real time data of seismic noise required for parameterization of Earthquake sensors for selection of proposed locations of required Earthquake sensors with details of foundation and room requirements housing the Earthquake sensor at respective locations. The civil activities for this work is of specialized nature, hence all civil works to be in the scope of the contract. The seismic survey report with recommendations on basis of land feasibility and arresting a complete route network of proposed complete corridors and selection of locations for deployment of Earthquake sensor system, shall also be got reviewed from Government Seismology Department.

IV. **Healthy status of Each Node –** Whenever any node becomes faulty, or breaks communication, then change of colour of that node and visual indication/ display should appear on screen in OCC. Also, screen colour should change as per PGA value of event. Whenever any event occurs then its PGA value, time & date should appear on the screen.

V. **Remote access of Earthquake Warning system –** The contractor should make arrangement in the system to facilitate OEM for remote access for carrying out any modification/ rectification work remotely for the system functional requirements, without access to the metro SCADA System.

VI. **Future addition of Nodes –** The contractor should ensure that the system to be developed should be able to cater future addition of minimum 2 nodes of other connecting future corridors to be operational from the same central control system at OCC.

The above specification are minimum. The system should be designed to meet functional requirements and operation should be user friendly.

27.3 THERMAL IMAGING SYSTEM

27.3.1 General

The Thermal Imaging System shall be portable equipment, which is handy and simple to use with interactive menu.

27.3.2 Specifications

The system shall have following specifications:-

- The Thermal Imaging System shall have an infrared image resolution of 240x180 (43200) pixels.
- The Thermal sensitivity of the system shall be 0.05°C.
- The camera should be capable to measure temperature in two range: -20°C to 120°C and 0°C to +65°C.
- The image frequency 9thermal) shall be 60Hz.
- The Thermal imaging System shall have Touch screen LCD display for user interface and displaying thermal/visual/PIP and fused images.
- The camera must have video recording and video output facility with following functions:
- Non-Radiometric R Video Recording.
- Non-Radiometric R Video Recording.
- The camera must have Bluetooth and Wi-Fi facility.
- The camera should have facility to connect through Wi-Fi with I-Phone, I-Pad or any android based phone for remote control of the camera/streaming of images.
- The camera should have MSX facility for crisp and clear thermal images.
- Three thermal imaging system shall also have an inbuilt digital camera for capturing visual images with built in LED light.
- There shall be provision for overlaying infrared picture on the normal picture (PIP) and shall have facility to blend the thermal and digital images.
- The system shall have a laser locator for association of the hot or cold spot in the infrared image with the physical target. The laser shall be activated with a control button for the same.

  The infrared camera shall have 3 spot meters and 3 boxes with max, min and average and auto hot and cold spot markers.

The storage temperature range of the Thermal imaging System shall be up to 70°C and the Operating temperature range shall be up to 50°C.

CHAPTER 8 – PART B

Auxiliary Network (Underground & Elevated)

Contents

1. 33KV GIS CIRCUIT BREAKER

Data sheets are required to be filled and submitted with the Vendor/technical particulars approval. All details and documents have to be jointly signed and stamped by the manufacturer/vendor/OEM and contractors representative.

1.1 MVCB (FOR TRANSFORMER PROTECTION)

Sr. No.	INDICATIONS	U	Values Required
1	Manufacturer		
2	Place of manufacture		
3	Standards		IEC 62271-1, 62271-100, 62271-102, 62271-200
A	**CUBICLE**		
1	- Class		Indoor
2	- Rated insulation voltage	kV	36
3	- Rated operating voltage	kV	33
4	- Rated frequency	Hz	50
5	- Rated short time duration power frequency withstand voltage	kV r.m.s.	70
6	- Rated lightning impulse withstand voltage	kV peak	170
7	- Cubicle rated current	A	1250
8	- Bar set rated current	A	1250
9	- Allowable overcurrent for 1 second	kA r.m.s.	25
10	- Instantaneous overcurrent	kA peak	62.5
11	- Number of flip-flop contacts for circuit-breaker plugging-in and plugging-out monitoring	minimum	
12	- Number of flip-flop contact for earthing isolator	minimum	

Sr. No.	INDICATIONS	U	Values Required
	open/closed position monitoring		
13	- Number of flip-flop contacts for isolator open/closed position monitoring	minimum	
14	- Approximate dimensions of the cubicle - Width - Depth - Height - Depth with circuit-breaker plugged-out	 mm mm mm mm	 600 1330 2400
15	- Protection degree		IP65 for HV, IP 3X for LV
16	- Earthing isolator making capacity	kA	
17	- Overall dimension drawing number		

	INDICATIONS	U	Values Required
	2) CIRCUIT-BREAKER/ INTERRUPTER (Vacuum Type)		
	Three pole type		
1	- Rated insulation voltage	kV	36
2	- Rated operating voltage	kV	33
3	- Rated frequency	Hz	50
4	- Rated short time duration power frequency withstand voltage	kV r.m.s.	70
5	- Rated lightning impulse withstand voltage	kV peak	170
6	- Rated short time duration power frequency withstand	kV r.m.s.	

	voltage across isolating distance @		
7	- Rated lightning impulse withstand voltage across isolating distance @	kV peak	
8	- Rated current	A	630
9	- Allowable overcurrent for 1 second	kA r.m.s.	25
10	- Instantaneous overcurrent	kA peak	62.5
11	- Breaking capacity	kA r.m.s	25
12	- Making capacity	kA peak	62.5
13	- Breaking mode:		
14	- Opening time	ms	≤70
15	- Breaking time	ms	≤80
16	- Closing time	ms	≤100
17	- Rated operating cycle		O-0.3s-CO-3 min-CO
18	- Breaking capacity of cable at no load	A	
19	- Number of auxiliary contact for open/closed position of the circuit-breaker	O/O O/C	
20	- Auxiliary supply voltage	V dc	110
21	Supply voltage for motor drive circuits	V dc	110
22	- Allowable variation range of supply voltage		+10%, -15%
23	- Power consumption of auxiliary	VA	
24	- Coils consumption: - engagement coil - release coil	 A A	
25	- Consumption of arming motor	A	

26	- Maximum noise level during opening and closing actuation	dB	
27	Degree of protection for auxiliary circuit		IP3X

1.2 33kV GIS CIRCUIT BREAKER (for Ring Main Feeder)

Sr. No.	Particulars	Unit	Technical Particulars
A	**Switchgear Panel**		
1.	Standard		IEC 62271-1, 62271-100, 62271-102, 62271-200
2.	Class		Indoor
3.	Type		GIS
4.	Nominal system Voltage	KV	33
5.	Highest System Voltage	KV	36
6.	Frequency	Hz	50
7.	Nominal Current Rating	A	1250
8.	One Minute Power frequency withstand Voltage	kV (rms)	70
9.	1.2/50 microsecond Impulse withstand Voltage	kV (peak)	170
10.	Rated short time duration power frequency withstand voltage across isolating distance @	kV r.m.s.	
11.	Rated lighting impulse withstand voltage across isolating distance @	kV Peak	
12.	Symmetrical breaking capacity	kA	25

13.	Making Capacity	kA	62.5
14.	Short time current for 1 sec	kA	25
15.	Degree of Protection		IP-65 for HV, IP-3X for LV
16.	- Approximate dimensions of the cubicle - Width - Depth - Height - Depth with circuit-breaker plugged-out	 Mm Mm mm	 600 1330 2400
B	**CIRCUIT BREAKERS**		
	Type		Vacuum
1.	Reference Standard		IEC 62271-1, IEC 62271-100, 62271-102, 62271-200
2.	Rated Voltage	KV	33
3.	Rated Frequency	Hz	50
4.	Rated Insulation Voltage	KV	36
5.	No of Poles		3
6.	Nominal current rating	A	1250 A
7.	One Minutes Power frequency withstand Voltage	KV (rms)	70
8.	1.2/50 microsecond Impulse withstand Voltage	KV (peak)	170
9.	Allowable Overcurrent for 1 sec	KA	25
10.	Opening time	ms	<=70
11.	Breaking time	ms	<=80

12.	Closing time	ms	<=100
13.	Arcing time (max)	ms	
14.	Rated operating cycle		O-0.3s-CO-3min-CO
15.	Breaking capacity of cable at no load	A	
16.	Number of auxiliary contact for open/closed position of the circuit-breaker	O/O O/C	
17.	Auxiliary Supply voltage	V dc	110
18.	Supply voltage for motor drive circuits	V dc	110
19.	Allowable variation range of supply voltage		+10%, - 15%
20.	Coils Consumption: - engagement coil - release coil	A	
21.	Consumption of arming motor	A	
22.	Maximum noise level during opening and closing actuation	dB	
23.	Degree of protection for auxiliary circuit		IP 3X

2. 33KV AIS SWITCHGEAR

2.1 SWITCH GEAR CUBICLES LINE, TRANSFORMER (MVCB)

DESCRIPTION	U	VALUES
		Required
Manufacturer		
Place of manufacture		
Standards		IEC 62271-1, IEC 62271-200
1) CUBICLE (FIXED PART)		
- Class		Indoor
- Rated insulation voltage	kV	36
- Rated operating voltage	kV	33
- Rated frequency	Hz	50
- Rated short time duration power frequency withstand voltage	kV r.m.s.	70
- Rated lightning impulse withstand voltage	kV peak	170
- Bar set rated current	A	1250
- Allowable overcurrent for 3 second	kA r.m.s.	12.5
- Instantaneous overcurrent	kA peak	31.25
- Number of flip-flop contacts for circuit-breaker plugging-in and plugging-out	minimum	
- Number of flip-flop contact for earthing isolator open/closed position monitoring	minimum	

- Number of flip-flop contacts for isolator open/closed position monitoring	minimum	
- Maximum dimensions of the cubicle* - Width - Depth - Height - Depth with circuit-breaker plugged-out	 mm mm mm mm	 1225 2700 2600
-Protection degree		IP 3X
- Earthing isolator making capacity	kA	5
-Overall dimension drawing number		
Internal Arc Test Duration	s	1

* Dimensions shown are indicative only

DESCRIPTION	U	VALUES
		Required
2) CIRCUIT-BREAKER (MOVABLE PART)		
Three pole type		
- Rated insulation voltage	kV	36
- Rated operating voltage	kV	33
- Rated frequency	Hz	50
- Rated short time duration power frequency withstand voltage	kV r.m.s.	70
- Rated lightning impulse withstand voltage	kV peak	170
- Rated short time duration power frequency withstand voltage across isolating distance	kV r.m.s.	80
- Rated lightning impulse withstand voltage across isolating distance	kV peak	195
- Rated current	A	400
- Allowable overcurrent for 3 second	kA r.m.s.	12.5
- Instantaneous overcurrent	kA peak	31.25
- Breaking capacity	kA r.m.s	12.5
- Making capacity	kA peak	31.25
- Breaking mode:		
- Opening time	ms	≤65
- Breaking time	ms	≤80
- Closing time	ms	≤100
- Rated operating cycle		O-0.3s-CO-3min-CO

- Breaking capacity of cable at no load	A	
- Number of auxiliary contact for open/closed position of the circuit-breaker	O/O O/C	
- Auxiliary supply voltage	V dc	110
Supply voltage for motor drive circuits	V dc	110
- Allowable variation range of supply voltage		+10%, -15%
- Power consumption of auxiliary	VA	
- Coils consumption: - engagement coil - release coil	 A A	
- Consumption of arming motor	A	
- Maximum noise level during opening and closing actuation	dB	
Degree of protection for auxiliary circuit		IP3X
Internal Arc Test Duration	s	1

2.2 SWITCH GEAR CUBICLES (RING MAIN CIRCUIT BREAKER)

DESCRIPTION	**U**	**VALUES**
		Required
Manufacturer		
Place of manufacture		

Standards		EC 62271-1, 62271-200.
1) CUBICLE		
- Class		Indoor
- Rated insulation voltage	kV	36
- Rated operating voltage	kV	33
- Rated frequency	Hz	50
- Rated short time duration power frequency withstand voltage	kV r.m.s.	70
- Rated lightning impulse withstand voltage	kV peak	170
- Bar set rated current	A	1250
- Allowable overcurrent for 3 second	kA r.m.s.	12.5
- Instantaneous overcurrent	kA peak	31.25
- Number of flip-flop contacts for circuit-breaker plugging-in and plugging-out monitoring	minimum	
- Number of flip-flop contact for earthing isolator open/closed position monitoring	minimum	
- Number of flip-flop contacts for isolator open/closed position monitoring	minimum	
- Maximum dimensions of the cubicle * - Width - Depth - Height - Depth with circuit-breaker plugged-out	 mm mm mm mm	 1225 2700 2600
-Protection degree		IP 3X
- Earthing isolator making capacity	kA	5

-Overall dimension drawing number		
Internal Arc Test Duration	s	1

* Dimensions shown are indicative only

DESCRIPTION		U	VALUES
			Required
2) CIRCUIT BREAKER(MOVABLE PART)			
Three pole type			
- Rated insulation voltage		kV	36
- Rated operating voltage		kV	33
- Rated frequency		Hz	50
- Rated short time duration power frequency withstand voltage		kV r.m.s.	70
- Rated lightning impulse withstand voltage		kV peak	170
- Rated short time duration power frequency withstand voltage across isolating distance		kV r.m.s.	80
- Rated lightning impulse withstand voltage across isolating distance		kV peak	195
- Rated current	For Line	A	1250
	For PD	A	1250
- Allowable overcurrent for 3 second		kA r.m.s.	12.5
- Instantaneous overcurrent		kA peak	31.25
- Breaking capacity		A r.m.s	12.5

- Making capacity	kA peak	31.25
- Breaking mode:		
- Opening time	ms	≤70
- Breaking time	ms	≤80
- Closing time	ms	≤100
- Rated operating cycle		O-0.3s-CO-3min-CO
- Number of auxiliary contact for open/closed position of the circuit-breaker	O/O O/C	
- Auxiliary supply voltage	V dc	110
Supply voltage for motor drive circuits	V dc	110
- Allowable variation range of supply voltage		+10%, -15%
- Power consumption of auxiliary	VA	
- Consumption of arming motor	A	
- Maximum noise level during opening and closing actuation	dB	
Degree of protection for auxiliary circuit		IP3X
Internal Arc Test Duration	s	1

2.3 33KV BUS RISER AND METERING CUBICLES

DESCRIPTION	**U**	**VALUES**
		Required
Manufacturer		

Place of manufacture		
Standards		IEC 62271-200
CUBICLE		
- Class		Indoor
- Rated insulation voltage	kV	36
- Rated operating voltage	kV	33
- Rated frequency	Hz	50
- Rated short time duration power frequency withstand voltage	kV r.m.s.	70
- Rated lightning impulse withstand voltage	kV peak	170
- Bar set rated current	A	1250
- Allowable overcurrent for 3 second	kA r.m.s.	12.5
- Instantaneous overcurrent	kA peak	31.25
- Maximum dimensions of the cubicle * - Width - Depth - Height	 mm mm mm	 750 1400 2600
-Protection degree		IP 3X
- Earthing isolator making capacity	kA	5
-Overall dimension drawing number		
Internal Arc Test Duration	s	1

* Dimensions shown are indicative only

3. CURRENT TRANSFORMER

3.1 33KV CURRENT TRANSFORMER (TCT) FOR MVCB CELL

INDICATIONS	U	Values Required
Manufacturer		
Place of manufacture		
Port of embarkation		
Standards		IEC 61869-1 IEC 61869-2
Rated insulation voltage	kV	36
Operating voltage	kV	33
Rated frequency	Hz	50
Rated power frequency short duration withstand voltage	kV	70
Rated lightning impulse withstand voltage	kV	170
Actual transformation ratio	A	200-100-50/ 1-1-1
Secondary Core 1 - Protection - Accuracy class - Rated output	VA	5P20 or 10P20 (for lower tapping) 10 or 5
Secondary Core 2 - Measurement - Accuracy class - Rated output	VA	0.5, M5 10
Secondary Core 3 - Protection - Accuracy class - Rated output	VA	PS 10
Short-circuit current allowable for 3 seconds	kA	12.5
Permanent operation without danger	In	
Overheating	In	
Overcurrent class		

3.2 PROTECTION CT (PCT) FOR CUT-OFF MOTORIZED CIRCUIT BREAKERS

INDICATIONS	U	Values Required
Manufacturer		
Place of manufacture		
Port of embarkation		
Standards		IEC 61869-1 IEC 61869-2
- Rated insulation voltage	kV	36
- Operating voltage	kV	33
- Rated frequency	Hz	50
- Rated power frequency short duration withstand voltage	kV	70
- Rated lightning impulse withstand voltage	kV	170
Actual transformation ratio	A	800-400 / 1/1/1
Secondary Core 1 - Protection - Accuracy class - Rated output	VA	5P15 or 10P20 (for lower tapping) 10 or 5
Secondary Core 2 - Measurement - Accuracy class - Rated output	VA	0.5, M5 10
Secondary Core 3 - Protection - Accuracy class - Rated output	VA	PS 10

Permanent operation without danger	In	1.2
Overheating	In	>1.2
Overcurrent class		

4. 33 KV VOLTAGE TRANSFORMERS

INDICATIONS	U	Values Required
Manufacturer		
Place of manufacture		
Port of embarkation		
Standards		IEC 61869-1 IEC 61869-3
- Rated Primary Ph-Ph voltage 33 kV PT	kV	36
- Highest voltage for equipment, Um	kV	36
- Highest voltage for equipment, Usys	kV	36
- Rated frequency	Hz	50
- Rated power frequency withstand voltage (1min)	kVrms	70
- Rated lightning impulse withstand voltage(1.2/50 μs)	kVp	170
Actual transformation ratio - Primary winding - secondary winding	 kV V	 $33/\sqrt{3}$ $110/\sqrt{3}$
Accuracy class for Protection	Cl	3P
Accuracy class for Measurement*	Cl	0.5
Rated output	VA	30

INDICATIONS	U	Values Required
MTBF	Million Hours	2.5

*Wherever measurement is applicable.

5. AUXILIARY TRANSFORMERS

5.1 AUXILIARY TRANSFORMER 500KVA, 1000 KVA, 2000 KVA & 2500 KVA (FOR METRO STATION / DEPOT POWER SUPPLY)

(**Refer Appendix-E of PS, DMRC specifications - DMES-T0005/DMRC-E-TR-TRANSF-05)**

6. 110 V DC BATTERY CHARGER

INDICATIONS	U	Values Required
Manufacturer		
Type of battery charger		Float Cum Boost Charger
Standards		IEC 60146
3 Phases power supply	V AC	415
Frequency	Hz	50

INDICATIONS	U	Values Required
Rated DC voltage	V DC	110
Power conversion		Silicon diode/thyristor or thyristor bridge (Full Wave) for converting 3-phase supply to DC voltage.
Cooling		Natural cooling
Allowable output voltage variation - for +10% variation of supply voltage - for +5% variation of frequency		 +1% +1%
Average winding Temperature rise over Ambient	Degree	90
Internal Cabling /Wiring		FRLSOH (For Underground) and FRLS for elevated section
Residual ripple ratio		Less than 3 %
Recharge to 80% of the battery capacity		8 hours
Meters		
Voltmeter on AC side		To be provided
Voltmeter on DC side		To be provided
Ammeter on DC side		To be provided
Alarms		To be provided
AC Main Fail		To be provided
DC Overvoltage		To be provided

INDICATIONS	U	Values Required
DC Under Voltage		To be provided
Charging fail		To be provided
Battery low		To be provided
Battery Output Voltage		To be Provided
One pair of Potential Free Contact grouping all fault to be provided for remote Annunciation at OCC		To be provided
Protections		
Current Limit Protection		To be provided
Soft start feature		To be provided
Surge suppressor		To be provided
HRC Fuse at rectifier Output		To be provided
Battery Reverse Polarity protection		To be provided
Automatic Changeover feature To be provided		To be provided
Switchgear		
Input Side		MCCB/MCB
Output side		MCB

7. 110 V BATTERIES

INDICATIONS	U	Values Required

INDICATIONS	U	Values Required
Manufacturer		
Place of manufacture		
Port of embarkation		
Standards		IEC 60622,IEC 60623, IEC 62259
Type		Ni-Cd in Polypropylene Container
Stationary compact		
Maintenance free		
Capacity offered for 10 hours discharge duration	Ah	*
Voltage per cell	V	
Number of cells		
Rated operating voltage	V DC	110
Maximum output current	A	
Documentation to be supplied		
Dimensions - Length - Width	 mm mm	
Total weight	kgf	

* The capacity of the battery shall be designed by the Contractor taking into account the permitted voltage tolerance of the individual loads, the power consumption of various loads, the length of time they are in operation and the manner in which they draw power. The precise capacity of battery shall be determined to ensure total autonomy of the station for 8 hours. Battery capacity shall not be less than 180 AH, in any case.

8. SURGE ARRESTER

S. No.	Particulars	Values Required (Phase to Phase/Phase to Earth)
1	Model Type	Gapless metal oxide
	Nominal Voltage Frequency	33 kv 50 Hz
2	MCOV (Maximum Continous operating voltage of the lightening Arrester)	39kV/29kV
3	Classification	10KA (Nominal discharge current)
4	High Current Operation Duty	100kA
5	Line Discharge Class	3
6	Rated Voltage	48kV/36kV
7	Temporary Over voltage (L-G)	35 kV RMS
8	Energy withstand	7.8kJ/kV at Ur
9	Residual Discharge @current discharge with	
9a	Switching Surge-	
	-250A	101kVp/80.3 KVp
	-500A	As per IEC 60099-4, class 3 surge arrester to be tested at 250A and 1000A.
	-1000A	106.8 KVp/84.9 KVp
	Wave 8/20 Micro sec	
	-5 KA	120 KVp/95.2 KVp
	-10 KA	127.4 KVp/101.2 KVp
	-20KA	137 KVp/109.1 KVp

9. 33 KV LIGHTNING ARRESTER

INDICATIONS	U	VALUES REQUIRED
Manufacturer		
Place of Manufacture		
Manufacturer Drawing reference		
Standard		IEC 60099-4
Type of Substation		Indoor
Lightning Arrester type		Non-linear Metal Oxide Resistor type, gapless
Nominal System Voltage	Phase-to-Earth	19 kV
Possible variation in the Auxiliary Supply Voltage	kV	30 kV to 36 kV
Maximum continuous operating voltage	kV rms	29 kV
Rated frequency	Hz	50
Rated Voltage for lightning Arrester	kV rms	36
Nominal discharge current(8/20 micro sec wave)	kAp	10
Peak value of switching impulse current(30/60 micro sec wave)	Ap	500
Max. discharge Voltage at nominal discharge current	kVp	91
Max. residual voltage at switching impulse current	kVp	62

Rated Impulse withstand of arrester insulation	KV peak	170
Power frequency withstand voltage for arrester insulation	kV	70
Pressure Relief Class		A
Line discharge class		3
Creepage distance	mm	Silicone rubber with 1300 mm

CHAPTER 8 – PART-C

Auxiliary Network (Underground & Elevated)

Table of Contents

1. **33KV SWITCHGEAR AIS**

1.1 33 KV CIRCUIT BREAKER (IEC 62271-1, IEC 62271-200)

1.1.1 Part Fixed & Moving

INDICATIONS	TYPE OF TEST			
	Type	Routine	FAT	On site
Dielectric Test	✓	✓	✓	
Radio interference voltage test	✓	✓	✓	
Measurement of resistance of the main circuit	✓	✓	✓	✓
Temperature rise Tests	✓	✓		
Short time with stand current and peak with stand current	✓	✓		
Tightness tests	✓	✓	√	√
EMC test	√			
Mechanical operation test at ambient Temperature	√	√@	√	√
Short circuit current making breaking tests	√			
Capacitive current switching test- Line charging current	√			
Capacitive current switching test- Cable charging current	√			
Verification of the degree protection	√			
Low & high temperature test	√			

Static terminal Load test	✓			
Pressure tests of gas filled compartment	✓			
Internal Arc Test	✓			
Interlocking			✓	✓
Visual inspection/physical dimension			✓	✓
Measurement of operation time			✓	✓
Insulation resistance Test			✓	✓
Contract Resistance test			✓	✓

@ The mechanical operation test to be done as a Routine test shall comprise of five opening and five closing operations at each of the rated, maximum and minimum control voltages. The contact travel characteristics shall be recorded for each closing and tripping operation and operation test (110%, 100%, 85% & 70% of control supply).

These FAT & On Site tests are indicative and subject to change as required by Engineer In-charge.

1.2 33 KV INTERRUPTER (IEC 62271-1, IEC 62271-200)

1.2.1 Fixed & Moving Part

INDICATIONS	TYPE OF TEST			
	Type	Routine	FAT	On site
Dielectric Test	√	√	√	
Radio interference voltage test	√			
Measurement of resistance of the main circuit	√	√	√	√
Temperature rise Tests	√	√		
Short time with stand current and peak with stand current	√	√		
Tightness tests	√	√	√	√
EMC test	√			
Mechanical operation test at ambient Temperature	√	√@	√	√
Short circuit current making breaking tests	√			
Capacitive current switching test- Line charging current	√			
Capacitive current switching test- Cable charging current	√			
Verification of the degree protection	√			

Low & high temperature test	✓			
Static terminal Load test	✓			
Pressure tests of gas filled compartment	✓			
Internal Arc Test	✓			
Interlocking			✓	✓
Visual inspection/physical dimension			✓	✓
Measurement of operation time			✓	✓
Insulation resistance test			✓	✓
Contract Resistance test			✓	✓

@The mechanical operation test to be done as a Routine test shall comprise of five opening and five closing operations at each of the rated, maximum and minimum control voltages. The contact travel characteristics shall be recorded for each closing and tripping operation and operation test (110%, 100%, 85% & 70% of control supply).

These FAT & On Site tests are indicative and subject to change as required by Engineer In-charge.

2. **AUXILIARY TRANSFORMER**

INDICATIONS	TYPE of TEST			
	Type	**Routine /FAT**	**On site**	**Specials**
Temperature rise*	X			
Lightning impulse withstand voltage test*	X			
Short circuit test*				X
Partial Discharge	X	X		
Sound Test		X		X
Separate-source voltage withstand test		X		
Measurement of winding resistance		X	X	
Measurement of voltage ratio		X	X	
Measurement of no load loss and current		X		
Visual inspection		X	X	
Sound test		X		
Vector Group		X	X	
IR test		X	X	
Magnetizing Current test		X	X	
Magnetic Balance Test			X	
Functional Test			X	

* For these tests, the Contractor could provide a report on similar equipment

3. **BATTERY CHARGERS**

INDICATIONS	TYPE of TEST			
	Type	**Routine/ FAT**	**On site**	**Specials**
Temperature rise*	X			
Surge test	X			
Electrical Static Discharge Test	X			
Electrical Fast Transient test	X			
Damp Heat and Dry Heat Test	X			
IR test		X	X	
HV test		X		
Rated short duration power frequency withstand voltage		X		
Floating& boost operation mode test		X		
Equalization operation mode test		X		
Direct operation mode test		X		
Functional & operational test		X	X	
Annunciation & protection test		X	X	
Output voltage stability, ripple & efficiency test		X		
Verification of Boost and Float voltage settings limit as per recommendations of Battery Vendor.			X	
Visual inspection		X	X	

* For this test, the Contractor could provide a report on a similar equipment

4. **110 V DC BATTERY**

INDICATIONS	TYPE of TEST			
	Type	Routine/ FAT	On site	Specials
Electrical specifications checking (on one cell)	X			
Visual inspection		X	X	
Capacity measurement	X	X	X	
Open circuit voltage test		X	X	
DC leakage test			X	
Endurance test	X			

5. **AC AND DC AUXILIARY CABINETS**

INDICATIONS	TYPE of TEST			
	Type	**Routine/ FAT**	**On site**	**Specials**
Rated short duration power frequency withstand voltage test		X		
Operation checking		X	X	
IR test		X	X	
Visual inspection		X	X	

6. **33KV GIS**

INDICATIONS	TYPE of TEST			
	Type	**Routine/ FAT**	**On site**	**Specials**
	As per IEC 62271			
Rated short duration power frequency withstand voltage test		X	X	
Temperature rise test				
Measuring of the resistance of circuits/ CRM		X	X	
Partial discharge test		X		
Short –time withstand current and peak withstand current test on Main circuit &Earthing circuit				
Verification of Making and breaking capacity of Circuit breaker				
Rated operating sequence				
Insulation resistance			X	
CB Opening & Closing Timing		X	X	
IP rating				
Functional & Operational Checks		X	X	
LV cabinet control cable FRLSOH tests*		X		
Tightness Test		X	X	
Gas Quality Test		X	X	
Visual inspection		X	X	

* For this test, the Contractor could provide vendor test reports.

7. CURRENT TRANSFORMER

INDICATIONS	TYPE of TEST			
	Type	Routine/ FAT	On site	Specials
IR Test	As per IEC 61869		X	
Temperature Rise Test				
Power Frequency Withstand Voltage Test		X		
Inter Turn Over Voltage Test				
Polarity Test		X	X	
Ratio Test		X	X	
Knee point characteristics		X	X	
winding resistance Test		X	X	
Visual inspection		X	X	

8. POTENTIAL TRANSFORMER

INDICATIONS	TYPE of TEST			
	Type	**Routine**	**On site**	**Specials**
Lightening Impulse Test	As per IEC 61869			
Short circuit Withstand capability				
Temperature Rise test				
IR Test			X	
Ratio Test		X	X	
winding resistance Test		X	X	
Visual inspection		X	X	

9. **33 KV LIGHTNING ARRESTOR (IEC 60099-4 AND RDSO SPECIFICATION NO. ETI/PSI/71 (1/87) WITH A&C SLIP NO. 1 TO 7 OR LATEST VERSION)**

INDICATIONS	TYPE OF TEST			
	Type	Routine	FAT	On site
Insulation with stand tests on the arrester housing	✓	✓		
Residual Voltage test	✓	✓	✓	
Test to verify long term stability under continuous operating voltage	✓	✓	✓	
Repetitive charge transfer with stand	✓	✓		
Heat dissipation behaviour verification	✓	✓		
Operation duty test	✓	✓		
Power frequency voltage versus time	✓	✓		
Short- circuit tests	✓	✓	✓	
Environmental tests	✓			
Test to verify the dielectric withstand of the internal components of an arrestor	✓	✓	✓	
Test of internal grading components	✓	✓		
Polluted housing test	✓			
Partial Discharge test	✓		✓	
Insulation Resistance measurement			✓	✓

Measurement of reference voltage		✓	✓	
Visual inspection		✓	✓	✓
Leakage current test		✓	✓	
Surge Counter reading			✓	✓
Checking of healthiness			✓	✓

These FAT & On Site tests are indicative and subject to change as required by Engineer In-charge.

10. **33KV CABLE**

INDICATIONS	TYPE of TEST			
	Type	Routine	On site	Specials
IR Test	As per IEC 60502	X	X	
Hot set		X		
Short Circuit test*				X
High Voltage Test		X	X	
Measurement of Resistance		X		
Partial discharge test		X	X	
Capacitance Test		X		
Flame Spread Test		X		
Acid Gas Generation		X		
Smoke density test		X		
Oxygen index test on outer sheath		X		
Temperature index test on outer sheath		X		
Outer sheath test		X	X	
Visual check		X	X	

*Test to prove the Power Cable and Metallic Screen Short Circuit Withstand Capacity to be conducted as per the relevant Standard Recommendations. If no guidelines are available, as a general practice routine test such as High Voltage, Partial Discharge, Check of Electrical Parameters etc., to be conducted prior and after performing short circuit test on the cables, to prove the integrity of cables under short circuit test.

CHAPTER 8 D
Design Services of Auxiliary Network (Underground and Underground Switching stations SWR’s

TABLE OF CONTENTS

1.1 BASIC DESIGN REQUIREMENTS

The works to be executed under the Contract include the design, supply, installation, verification, testing, including integrated testing and commissioning, technical support and documentation for a complete System necessary to deliver the requirements of these Specifications of following corridors:-
(Details of the corridors to be given)

The Design/Design Verification of the works shall be undertaken by a Contractor who has experience in the design of similar works as in the scope of tender. Approval of the proposed Contractor(s) intended to be engaged shall be obtained from DMRC before engaging by the Contractor.

The Contractor shall be responsible for the design service of the works and shall satisfy himself that the tentative capacities, ratings and quantities of equipment as specified herein meet the operational requirements for MRTS Project.

The proposed capacities, ratings and number of equipment as a result of the design development shall be demonstrated by a proper design and simulation study and subject to review by the Employer.

The Contractor shall be responsible for assisting in obtaining statutory clearances (e.g. design clearance from Ministry of Railways and Sanction of Commissioner of Railway Safety) and submittal of information asked for by statutory bodies (e.g., Government of India, Ministry of Railways, Commissioner of Railway Safety, Ministry

Tenderer should note the requirements of warranties and obligations contained in Clause F guarantees and liabilities of GC.

The Design Philosophy should meet the following criteria:

- Application of state-of-the-art Technology
- Service proven design
- Low maintenance cost
- Use of interchangeable, modular components
- Use of unique serial numbers for traceability of components
- High reliability
- Low energy loss
- System safety

- Adequate redundancy in system
- Use of fire retardant materials
- Environment friendly
- Adherence to operational performance requirements
- Optimum utilization of indigenous materials and skills, subject to quality conformity.
- Adequate margin shall be built into the design particularly to take care of the higher ambient temperatures, dusty conditions, and high seasonal humidity, highly polluted zone etc. prevailing in Delhi NCR.

1.2 AUXILIARY POWER SUPPLY VOLTAGE

The design of power requirement of auxiliary system of DMRC including the interlinking of various lines at different voltage levels. The contractor shall do integrated system study, including the power supply arrangement required, taking into account the power supply arrangements already approved by the Employer

Optimization study, which will include prescribing of the power supply arrangements for all Corridors under **normal, emergency** conditions and voltage drop at farthest end in each case. This study will take into account emergency conditions arising due to failure of one or more power sources, transmission network and/or power supply equipment.

The detailed report for overall reliability of the power supply system, under various conditions shall be submitted.

Power for auxiliaries at stations, depots and along the line, this will be worked out by the Contractor based on station E&M design and inputs from Employer based on experience.

The 33 kV auxiliary power supply system shall operate in such a way to ensure that system voltage shall comply with the following requirements:

- Normal system voltage - 33 kV
- Maximum system voltage - 36 kV
- Minimum voltage under normal - 33kV-5% feeding
- Minimum voltage under loss of - 33 kV-10% any one supply

1.2.1. Safety

All equipment shall be adequately earthed, insulated, screened or enclosed as may be appropriate to ensure the protection of the equipment and safety of those concerned in its operation and maintenance and also to other DMRC staff or members of the public.

The equipment shall comply with the requirements of all relevant statutory acts, rules, regulations and orders. The earthing design shall be as per IEEE 80, IS 3043 and ACTM requirements.

1.2.2. Design Parameters of Sub-stations (SWR's & ASS's)

The layout of substation shall be Aesthetic, economical and easy for access and maintenance as far as possible.
The design of auxiliary power supply & SWR's system shall have following features:

- Design of AC supplies (single & three phase) for internal use in the substation for several function such as illumination, battery charging, fire protection system, space heaters in cubicles & Marshalling kiosks. Reliability of AC supply should be the prime criteria while designing the system standby arrangement.
- Design of D.C. auxiliary power supply system shall consider the requirement for closing and tripping of circuit breakers, emergency lighting, control board indications etc.
- The battery arrangement with double set of battery charging rectifier shall be considered with voltage as 110 volts. The battery shall be capable of supplying – momentary current required for operation of switch gear, continuous load of indicating lamps, holding coils for relays, contractors etc. and emergency lighting load.

1.2.3. Interlocks

- To ensure the safety of equipment & operating personnel & to prevent unauthorized and inadvertent operation of equipment, interlocks of mechanical type/castle key type/electrical type shall be designed.
- Normally, the interlock between isolators to isolators, isolator to circuit breaker & circuit breaker to circuit breaker shall be designed depending upon the safety and operational requirements.

The interlocking scheme shall be submitted by contractor to employer for approval.

1.2.4. The contractor shall prepare and submit the following **ASS & SWR's drawings**

- Location plan and schematic diagram
- Layout drawings
- Power and control cable run layout diagram
- Structural assemble and structures drawings
- Foundation of Equipment (if Required) layout drawings

- Control, protection scheme and metering arrangement drawing
- Relay Settings
- Any other drawing required for execution of work

1.3 CONTRACT DRAWINGS

Additional contract drawings or revisions to the contract drawings previously issued for construction shall be prepared by the contractor and submitted to the Employer’s Representative. Where changes to the contract drawings are required, the contractor shall be responsible for preparing detailed design onto drawings to be issued to the Contractor after approval of Engineer in-charge.

1.4 SYSTEM WIDE INFORMATION

The contractor shall incorporate information relating to system wide equipment and services into suitable drawings. The timing for issue of these drawings will be determined by the Employer’s Representative dependent upon the award of the system wide Contracts. Final system wide requirements defined by system wide contractors shall be incorporated into the drawings for construction. The contractor shall prepare and issue intermediate submissions of the drawings as necessary to meet the constructions schedule.

1.5 SITE MEETINGS

The contractor shall attend all site meetings concerning the work under the scope of his tender. The interface manager shall be appointed by contractor for attending the site office. The CV of interface Engineer shall be approved by Engineer in-charge.

1.6 AS-BUILT-DRAWINGS OF THE WORKS

The contractor shall review the contract record drawings and as-built drawings information submitted by the contractors to the Employer Representative on a continuous basis prior to the issuance of the Certificate of Completion for the construction contract. The contractor shall prepare relevant calculations reconciled with as-built conditions, and information necessary for the maintenance of the works.

1.7 CO-ORDINATION WITH CONSTRUCTION CONTRACTOR & CONTRACTOR

During the construction phase, the contractor shall be responsible for expeditious implementation of the evolved designs and sorting out any design interface problems with the construction contractors and other contractors working on the section including the depot. Special care shall have to be exercised for timely implementation and necessary interfaces for commissioning receiving cum traction substation to enable availability of traction power supply for rolling stock commissioning trials and trial runs on the section prior to commercial opening of the section.

1.8 COMPUTER PROGRAMS

The contractor shall submit details and verification of all computer programs it intends for use to the Employer's Representative for acceptance prior to use in making calculations. These shall include the computer program manuals, input and output printout of a typical example and previous records of its use by the contractor.

The contractor may also be required to perform test calculations using the program so that the results may be compared with those obtained by other means.

The Software should have been used for designing similar type of installations (traction and auxiliary systems) for MRTS systems. The Contractor shall submit the credentials for the software for approval to the Employer.

2. CHECKING PROCEDURES

2.1 GENERAL

The contractor shall appoint a design team for design submitted by them and Design verifications. The designs shall be prepared on best engineering practices as per IEC and other relevant standards.

2.2 DESIGN CALCULATIONS

Each page of design calculations, including any amendments thereto, shall be endorsed as checked and approved prior to issuing to the Employer's Representative by being initialed and dated by both the originator and the checker.

2.3 DRAWINGS AND DOCUMENTS

Each document and drawing, including any revisions thereto, shall be endorsed as checked and approved prior to issue to the Employer's Representative by being initialed and dated by both originator and checker. In addition to compliance with the requirements of the documentation each drawing, where appropriate, shall be checked to ensure compliance with the contractor's certified design calculations.

2.4 CERTIFICATION

The Certificate signed by the minimum Project Manager level of the contractor stating that all drawings and documents have been checked and approved in accordance with the agreement, shall accompany all documents and drawings issued by the contractor to the Employer's Representative for acceptance.

3. QUALITY ASSURANCE PLAN

The Quality Assurance Plan (QAP) shall be submitted by the contractor to the Employer's Representative for approval before commencement of any work. The QAP must include

- Organizational structure.
- Design control-including study and design input/analysis;
- Checking of documents
- Documents control;
- Subcontractor control;
- Internal quality audit; and
- Corrective action;

The contractor shall also identify the requirements of Quality Level List in the QAP for the contract.

Notwithstanding acceptance by the Employer's Representative, the contractor shall remain responsible for the quality of works and design.

4. DOCUMENT

- Inception report

  The contractor on mobilization would submit an inception report indicating the details of manpower deployment and strategy for delivering the work as per required time frame. A detailed methodology and action plan will also be submitted. "Schedule of Payment" may be referred in this regard.
- Design Submission
- Intermediate submission
- Submission of Documents for ministry of Railways Review (As applicable)

  The contractor shall submit all the technical documents necessary for DMRC to request approval from the Ministry of Railways for use of the Delhi MRTS. Documents shall include:

  - Appropriate design reports
  - Design assumptions
  - Calculations
  - Drawings
  - Test Procedures
  - Required test results
- Final Review Submission
- Final Review Procedure
- Submission of Final Design

5. DELIVERY OF DOCUMENTS

After the Employer's Representative has accepted the submission of the final designs, the contractor shall deliver the drawings in hardcopy and electronic format on CD/DVD to the Employer's Representative.

The contractor shall furnish a complete set of CAD drawings in CD/DVD to the Employer Representative, prepared in accordance with requirements.

5.1 DELIVERY OF DOCUMENTS TO CONSTRUCTION CONTRACTOR

The CONTRACTOR shall issue the documents to the Contractor "For construction". This shall also include all "Good for construction" drawing containing all details required by the construction contractor for execution of the work.

6. SCHEDULE OF MATERIALS

The contractor shall prepare the Schedule of Material/Bill of Materials for the associated elevated/at grade/underground construction contract for all corridors for ASS and SWR's including all spares including maintenance vehicles & construction vehicles.