**DESIGN, DETAIL ENGINEERING, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF 25 KV AC TRACTION (RIGID OHE), 33 KV AUXILIARY SUB STATIONS (ASS), ASSOCIATED CABLING AND SCADA SYSTEMS FOR UNDERGROUND CORRIDORS OF JAIPUR MASS RAPID TRANSPORT SYSTEM PROJECT PHASE-1B**

# CONTRACT PACKAGE – JP/EW/1B/E2

# EMPLOYER'S REQUIREMENTS

# TECHNICAL SPECIFICATION

# PART – 1: RIGID OHE

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# CHAPTER – 1

# INTRODUCTION

# 1 INTRODUCTION

## 1.1 Scope and Purpose

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 U/G corridors of the Chand Pole to Badi Chaupar

1.1.1 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.

1.1.2 Since the system of traction on Phase-I of Jaipur Metro consisting of elevated corridors and the 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 locations.

## 1.2 Relevant Documents

1.2.1 This Specification should be read in conjunction with the General Conditions of Contract (GCC), the Special Conditions of Contract (SCC), 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 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) Technical 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 Engineering 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 contracts of Phase-1B of Jaipur metro project.

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 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 Jaipur Metro Phase IB Project

2.2.1 The Jaipur Metro Phase-IB project network consists02 station.

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 Signalling System as adopted for the existing JMRC Lines shall be implemented. The phase-1A project has been provided with Automatic Train Operation system (ATO).

2.2.4 Rolling stock maintenance Depot for Manasarovar

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 NOT USED

2.2.7 '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.

### 2.2.8 Jaipur Metro Phase-IA Project

Details of the existing Switching Stations :-
Traction power at 25 kV is fed to the operational Corridor from Traction Substations located in the premises of Receiving Substations (RSS) at Mansarovar and Sindhi Camp. The traction feed is further divided into several Substations, with the help of Switching Stations, whose locations are shown below:-

| Sr. No. | Name of Switching Stations | Type of Switching Stations | Approx. Chainage |
|---|---|---|---|
| 1 | Mansarovar | FP | -00.778 |
| 2 | Mansarovar | SS | -00.549 |

| | | | |
|---|---|---|---|
| 3 | Shyam Nagar | SSP | 02.037 |
| 4 | Civil Lines | SP | 05.235 |
| 5 | Sindhi Camp | FP | 07.720 |

### 2.2.9 **Details of Phase-1B**

The power supply to the proposed corridor will be extended from the Chandpole underground station. The 25 KV supply is feed at 2 locations in the present operational line, Mansarovar park & Sindhi camp.

### 2.2.10 **Power Supply**

2.2.10.1 The power supply for Existing Phase-I line is from

| Receiving Sub station | Location | Incoming Voltage | Power Source |
|---|---|---|---|
| RSS-1 | Mansarovar | 132 kV | Mansarovar GSS (220 / 132 kV) |
| RSS-2 | Sindhi Camp | 132 kV | GIS Substation, PWD Bungalow at Station Road (near RSRTC Bus Stand) |

## 2.3 **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, 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 Technical 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, 2010 edition, except where amended by this TS.

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 – JP/EW/1B/E2

# 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)& SCADA, associated switching station (FP, SS, SSP and SP) with 25 kV associated cabling for **Section Chand Pole to Badi Chaupar**

## 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) 25 kV Rigid Overhead Contact System (ROCS) for the Underground Portion of under any of the lot as described above.

b) 25 kV Switching posts (SS, SP, SSP and FP) using Gas Insulated Switchgears (GIS) type interrupters/ CBs as applicable.

c) 25 kV AC cable from RSS/TSS to the feeding post at respective location as defined in the pricing document.

d) Differential relay for the protection of 25kV cable between TSS/RSS and FP.

e) Interrupters/ Circuit Breakers for stabling sidings, Y-siding, link line etc.

f) 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.

g) 25 kV Neutral Section in the underground portion.

h) Design, Supply, Installation, Testing & Commissioning of protection scheme and relays for 25kV Traction system at SP, SSP etc.

i) Transition arrangement of 25 kV Rigid OCS to 25 kV flexible OHE in different ramp portions.

j) Earthing system (based upon simulation study) including providing of METs, Copper cable, relevant connections to OCS & all other services (hydrant pipe, track, walkway, tunnel reinforcement etc).

k) Centre Line marking (on co-ordinates provided by Civil/track contractor), supports location marking, drilling, Supply and fixing of anchor fasteners for OCS supports.

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

m) Provision of thermosetting welds in track for connection of cables for return current continuity and for earthing of equipments.

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

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

p) Transfer of Technology.

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

r) Integrated Testing during train trials.

s) Validation (Auditing) of design & installation of ROCS through Independent Agency as per IEC and other relevant Standards as per clause 14.1.2 of TS.

t) Facilitate Power block during trials upto ROD (manpower for the same should be deployed by the contractor).

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

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

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

x) Supply of Spares

y) Supply of Consumables during DLP

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

aa) Training

bb) Documentation. Supervision of Maintenance during DLP

cc) Services

dd) Furniture, shock treatment charts, first aid boxes and danger notice plates

ee) Contractor's Design team shall supervise the installation 25kV Rigid Overhead Contact System (ROCS), switching station (FP, SS, SSP and SP) with 25kV associated cabling for the Underground Portion of Jaipur MRTS Phase-III Project.

ff) Contractor will be required to provide SCADA system according to latest standards and specifications. The design of the SCADA should be prepared and submitted to Engineer in charge for approval. All the equipments, cables, connectors, links, connections, interface devices etc required for the successful operation of the underground SCADA system has to be provided by the ROCS contractor. The price of the SCADA system is included in the ASS works BOQ of this document.

gg) To enable implementation of SCADA system for the Rigid OCS and Switching Posts ROCS contractor has make all necessary interface.. The SCADA system proposed may be compatible/integrated with the existing SCADA system of Jaipur 1A, all the details of existing system has to be arranged by the contractor (ROCS contractor to note that at present operating section of Jaipur phase-1A ABB SCADA system is provided). The entire local works and connectivity upto Operational control centre has to be maintained by ROCS contractor. Suitable OFC Communication cable/ link between all Rigid OCS, and TSS equipments shall be provided by JP/EW/1B/E2contractor.

hh) 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 specifications.

ii) 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.

## 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 pollution norms minimum EURO-II. 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 equipments, Neutral Section, SSP, SP and SS.

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.

j) Defects liability of Permanent Works after commissioning as stipulated in the General Conditions of Contract (GCC) and Special Conditions of Contract (SCC).

k) Contractor shall be responsible for providing all assistance, manpower for giving 'Power Block', earthing 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, BSNL, PTCC, etc.) in particular format 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 simulation study and EMI/EMC effects.

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

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

g) Automatic fault identification and isolation arrangement.

h) Feeding arrangements under various supply failure scenarios.

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

j) Determination of equipment ratings.

k) Determination of space requirement.

l) Design and proving protection system and its calculations.

m) Lightning protection measures.

n) Latest type test reports for equipment selected.

o) Detailed design drawings and reports.

e) 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 by Engineer at the SSP, SP & SS Rooms etc.

3.5.2 The Contractor shall provide Single Line diagram, Earthing & Bonding Diagram, Fire Extinguishers, shock treatment charts, insulating mats as per IS15652: 2006 (superseding IS5424: 1969), 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 Technical Specification are given in Chapter 21 of this Specification.

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 tunnels and station box structures, Contractor will provide & install the supports for cable hangers.

3.7.2 Other civil engineering works viz. building, access roads, surrounding walls, shutter doors will be provided by Civil Contractors for SSPs, SPs and SSs. JP/EW/1B/E2 and Civil Contractors shall interface suitably.

3.7.3 Earth mats and earthing electrodes in ASS and in tunnels will be supplied and installed by other Contractors. However, earthing connection to all ROCS equipment from earth met to be done by JP/EW/1B/E2contractor.

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.

3.9 **Optional Items**

3.9.1 Not used

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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 TS.

## 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 Jaipur 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:

### 4.3.1.1 General

| S.no. | Description | Unit | Standard Gauge (Line-1) |
|---|---|---|---|
| (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 In tunnel | | 25 kV AC Rigid Overhead Contact system |
| (vi) | Type of platforms | | Island/Side |
| (vii) | Length of platforms | m | 140 (approx) |
| (viii) | Design Speeds | | |

| S.no. | Description | Unit | Standard Gauge (Line-1) |
|---|---|---|---|
| | Main Line | km/h | 95 |
| | Depot Access Line | km/h | 95 |
| | Depot Test Track | km/h | 95 |
| | Crossovers | km/h | 40 |

#### 4.3.1.2 Underground Section

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.

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: 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 Equipments 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 equipments or Sub-systems of a different rating are already proven in service, then the design shall be based on such equipments. 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 Jaipur.

## 4.5 Design Management and Control

4.5.1 In order to ensure that the requirements of this Technical 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 TS 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

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 4.9-1Rolling 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 | 3MC+2DTC+1TC |
| Type of rolling stock | Modern stainless steel cars with VVVF 3 phase drive |
| Type of Braking | Electro-pneumatic service friction brake, Electric regenerative brake |
| 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**

| **Type of car** | **Tare weight** | **Total passenger carrying capacity @ 10 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**

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.

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 specified in 'failures per annum' in each of the four classes of severity of failure. 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 Proven Section insulators shall be designed so that their frequent adjustments are not required.

## 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.

## 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 50122-1with latest amendments.

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 2031.**

The system shall be designed by Contractor to support the movement of ultimate maximum capacity transportation in the horizon year 2031. In the horizon year it is planned to run 6 Car (3MC+2DTC+1TC) EMU trains at 2.25 minute headway during peak periods in each direction and, therefore, System shall be designed for 2.5 headway.

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 Regulations 2010
- Indian Electricity Act 2003 with latest amendments.
- 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 (as applicable) 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 for by a statutory body (e.g., Government of India Ministry of Railways, Ministry of Power, BSNL, TRANSCOM/ DISCOM, Commissioner of Railway Safety, State Electrical AuthoritiesBSNL 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 and with section-insulators at the turnouts or air-gap overlaps. Sectioning shall be provided to permit isolation of OCS in sm**all sections **for maintenance, to isolate faulty OCS in case of fault/accident, and to permit evacuation of passengers from stations by bringing the train upto 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 need 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, Design Build and Construct Contractors for accommodating 25 kV switchgear in the stations 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 simulation Study the number and disposition of return current conductors, OPC, TEW & Earth wires, their sizes and interval between rail connections shall be established. The number and location of impedance bonds, S-Bond, α-Bond shall be jointly finalized 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 EMI/EMC study shall be carried out for the complete sections of phase-1A & 1B sections of the line .The already operational sections, depots & RSS's should also be considered for conducting the study. The limiting values concluded from study should be clearly brought out and stated in tubular form

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, ETS, 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 Thermosetting 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.

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# CHAPTER – 5

# FUNCTIONALREQUIREMENTS

# 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.

This is addressed in Chapter 13 of this Specification.

## 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 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 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 Room.

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 – JP/EW/1B/E2

# CHAPTER – 6

# 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 Corridor including stabling lines at terminal stations as outlined in Chapter-10. Overhead conductor rail shall be of composite 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 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**.**

6.2 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 non current carrying metallic components, cable supports, etc shall be designed by respective contractor JP/EW/1B/E2. The earthing system shall conform to IS 3043:1987, EN 50122-1 and IEEE 80 with latest amendments.

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

a) Earthing Systems in Switching Posts.

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 optional being below as per EN 50122-1 and CCITT Directives.

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

In underground Switching Posts, earth mat / earth electrodes shall be provided by Civil Contractors to the requirements of the JP/EW/1B/E2 Contractor.

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, OPC of requisite size shall run in the tunnel.

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

Table 6.4-1 Maximum Earth Resistance

| **Location** | **Earth resistance (ohms)** | |
|---|---|---|
| | **Each electrode** | **Total earth system** |
| **SP/SS** | 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.No. | 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 Indian Railway 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.

## 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 shall be not less than 1000 gm/$m^2$ in accordance to ETI/OHE/13(4/84).

### 6.9.4 Galvanisation shall comply with the standards mentioned below:

| | |
|---|---|
| IS-209/1992 | Zinc Ingot-Specification |
| IS-800/1984 | Code of practice for General Construction in steel. |
| IS-802 (PT-II),1978 | Code of practice for use of Structural Steel in Overhead Transmission Line Towers-part II Fabrication , Galvanizing, Inspection and Packing. |
| IS-802 (Part-III),1978 | Code of practice for use of Structural Steel in Overhead Transmission Line Towers-part 3 Testing. |
| IS-808/1989 | Hot Rolled steel Beam, Column, Channel & Angle Section. |
| IS-813/1986 | Scheme of Symbol for Welding. |

| | |
|---|---|
| IS-814/1991 | Covered Electrodes For Manual Metal Arc Welding of Carbon & Carbon Manganeses steel-Specification. |
| IS-816/1969 | Code of practice for use of Metal Arc Welding for General Constructions in Mild steel. |
| IS-1730/1989 | Steel plates , sheets, Strips & Flats for Structural & General Engineering purposes- Dimensions. |
| IS-1732/1989 | Steel Bars, Round &Square for Structural & General Engineering purposes- Dimensions. |
| IS-1852/1985 | Specifications For Rolling and Cutting Tolerances For hot Rolled steel products. |
| IS-2062/1999 | Steel For General Structural purpose- Specification. |
| IS-2629/1985 | Recommended practice for hot dip Galvanizing of Iron and Steel. |
| IS-2633/1986 | Method for Testing Uniformity of Coating on Zinc Coated articles. |
| IS-4759/1996 | Hot dip Zinc Coatings on Structural Steel and Other Allied products- Specification. |
| IS-6745/1972 | Determination of Mass of Zinc Coat-Ing on Zinc Coated Iron And Steel Articles. |
| IS-7215/1974 | Tolerances For Fabrication of Steel Structures. |
| IS-13229/1991 | Zinc For Galvanizing-Specification. |
| RDSO SPECIFICATIONS ETI/OHE/13(4/84) | RDSO Specification For Galvanization of steel Structures. |

All latest standards and specifications with amendments are to be followed for galvanisation work

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.

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 section 8.2. The run of various cables shall be designed so as to ensure minimum de-rating.

6.12.2 Equipment Earthing Terminals

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

6.14.1.1 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.

6.14.1.2 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 with latest amendment.

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

6.14.1.3 Design criteria and performance specification

6.14.1.4 General Requirements

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.

6.14.1.5 Laying of tracks

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.

## 6.15 Electromagnetic Compatibility (EMC) Requirements

### 6.15.1 General

6.15.1.1 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 top the general passenger and workers at stations platforms and working areas. Magnetic shielding plan along with the modifications in design and equipments if any required to limit the exposure of magnetic fields within the safe limits has to be provided by ROCS contractor.

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

6.15.1.3 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.

6.15.1.4 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.

6.15.1.5 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.

### 6.15.2 Intra-System EMC

The Contractor shall ensure that all intra-system EMI 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.

### 6.15.3 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 Jaipur MRTS.

### 6.15.4 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 systems 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.

### 6.15.5 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, IEC61000-2.

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.

### 6.15.6 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.

### 6.15.7 Installation and Mitigation Guidelines

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

### 6.15.8 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.

### 6.15.9 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/Thμsec, 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/Thμsec, 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/Thμsec, 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 – JP/EW/1B/E2

# 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.

7.1.1 The Traction Supply Equipment includes:

- Circuit Breakers.
- Interrupters
- Motorised Isolators
- Instrument transformers.
- Other items such as connectors, cables, etc.

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

**Table – Governing Specifications.**

| Sl. No. | Equipment | Governing Specifications |
|---|---|---|
| 1 | 25 kV Circuit Breaker | EN 50152, EN 50124-1, IEC-62771 |
| 2 | 25 kV Interrupters | IEC 60694, EN 50152, EN 50124-1, IEC-62271 |
| 3 | 25 kV Gas Insulated Switchgear (GIS) | IEC 60298, IEC 60694& IEC 60129, IEC-62271 |
| 4 | Earthing of Substation | As per IEEE 80 with latest amendments. |
| 5 | 110 Volt tubular lead-acid, stationary compact, maintenance free batteries of adequate capacity for 10 hours discharged duration | IEC 622 |
| 6 | 110 Volt dc Battery Charger for the above batteries. | IEC 146 |
| 7 | Cable specifications | Please see chapter 8 |

7.1.3 **27.5 kV Switchgear (Circuit Breakers, Interrupters).**

The incoming 27.5 kV switchgear shall be GIS Type (Indoor).

The switchgear shall be designed to work under indoor conditions as specified. Broad parameters are furnished in Annexure A.

Small part steel work shall be either of stainless steel or hot dip galvanized.

7.1.3.1 Earthing

All non live metal parts shall be connected to the earth be corrosion protected and labeled in conformity with the IEC standard 617-2.

7.1.3.2 Paint Work

Painting should be suitable for corrosive atmosphere, and to comply with IEC 60 721-2 & 5

7.1.3.3 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 EN 50152, EN 50124-1, and IEC 56 with latest modifications.

7.1.4 **25 kV Isolators**

Each Isolator shall be GIS type and shall be proven design.

- 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 number of Copper 240 Sq mm cables (as per approved design)in each panel.

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 without any maintenance except periodic grease applications.

7.1.5 **The broad parameters of these equipment have been indicated at Annexure 'A'.**

**Annexure 'A'**

**25 KV GAS INSULATED SWITCHGEAR (GIS)**

| **Standards** | **Unit** | **IEC 60298, IEC 60694& IEC 60129,IEC 62271** |
|---|---|---|
| Bus bar | | Copper |
| Service Voltage | | 25kV |
| Maximum Service Voltage | | 27.5kV |
| Rated Voltage | | 52kV |
| Frequency | | 50 Hz $\pm$ 5 % |
| Rated AC Withstand Voltage | | 95 kV |

| **Standards** | **Unit** | **IEC 60298, IEC 60694& IEC 60129,IEC 62271** |
|---|---|---|
| Rated lightning-peak withstand voltage | | 200 kV |
| Continuous current rating | | |
| **For line CBs and OHE feeder CBs as per scheme provided** | | **2000 A** |
| **For other CBs (link CBs, CBs of SPs) as per scheme provided** | | **1200 A at 45î C 1250 A at 40î C** |
| Rated peak current | | 40 kA |
| Short time current rating | | 16 kA for 3 sec |
| Overload current rating | | 3200A for 5 minutes<br>2400A for 10 minutes |
| Degree of protection of Gas Compartment | | IP 64 |
| Degree of protection for drive cabinet | | IP 3X |
| Degree of protection for low voltage cabinet | | IP 3X |
| No. of switching cycles at rated service current | | 10000 Cycles |
| Type of Circuit Breaker | | Vacuum |
| Auxiliary voltage for closing coil, tripping coil, spring charge motor | | 110 V DC |
| Metal enclosure Bus bar Chamber Cubicle | | Stainless Steel<br>Sheet metal/Powder coated |
| Loss of Gas | | < 1% per annum. Gas Charging equipment to be supplied |
| Rated short circuit current switching cycles | | 100 cycles at 16 kA |
| Sequence on short circuit | | CO-15 sec-CO |
| Maximum closing time | ms | 100 |
| Maximum opening time | ms | 70 |

| **Standards** | **Unit** | **IEC 60298, IEC 60694& IEC 60129,IEC 62271** |
|---|---|---|
| No of Pole | | 1 |

Note:-

- **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. 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.**
- **Each Switching Station Post shall have Marshalling box which shall be provided by the JP/EW/1B/E2 contractor to act as interface for 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 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 connection between the Marshalling box terminals and the field equipment terminals, Marshalling box terminals and the RTU and interconnection between the terminal blocks of the Marshalling Box via copper cables, shall be made by the JP/EW/1B/E2 Contractor. The JP/EW/1B/E2 Contractor shall tag the either end/ of the cable with proper notification.**

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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

8.1.1 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 switchgear

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 inside the tunnel 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 | 52.5 ac | Traction power | Copper 240 | Single core | Halogen free FRLS outer sheath XLPE insulated | For extending power from TSS to Feeding Post and for jumpering and other uses inside the tunnel and cable galleries. |
| 25 ac return current | 1.1 / 3.3 as required | Traction power | Copper 240 | Single core | Halogen free FRLS outer sheath XLPE insulated | For bonding in tunnels and other uses inside the tunnel and cable galleries. |
| 0.415 ac | 1.1 ac | Power | Copper, sizes as required | 4 | Halogen free FRLS outer and inner sheath, Armoured, XLPE insulated | Auxiliary supply from U/G SP and SS |

| Voltage | | Duty | Core material and size (sq mm) | Number of cores | Brief description | Remarks |
|---|---|---|---|---|---|---|
| Nominal (kV) | Max.(kV) | | | | | |
| 0.240 ac | 1.1 ac | Power | Copper, sizes as required | 2 | Halogen free FRLS outer and inner sheath,<br>Armoured,<br>XLPE insulated | Auxiliary supply to equipment in U/G sections |
| 0.240ac | 0.65 ac | Control | Copper, sizes as required | As per the requirement | Halogen free FRLS outer and inner sheath,<br>Armoured Screened<br>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 a) The cabling system shall meet the requirements of

Standards / specification given below and other relevant specifications:

IS- 7098 part- I, II, III, 8130, 5831, 3975, 1255, 1554, 5216, 10810(Pt-41), 10810(Pt-58), 209, 10418, 10462(Pt I), 10810(Pt-61), 10810(Pt-62)

BS 6121, 5468

IEC 38, 228, 540, 287, 332, 60502, 548, 811, 821, 60840

b) The cable design and installation shall also generally comply with local codes, regulations and standards viz.,

Central Electricity Authority Regulations (CEA)2010 as amended from time to time.

Regulations laid down by the electrical Inspector.

Regulations of the Electricity supply Authority, i.e. DISCOM/ TRANSCO etc.

Fire safety Regulations of the National Building code.

NFPA 130 2010 on Fixed Guide way Transit Systems.

NFPA 70E on Recommended Practice for Electrical Equipment Maintenance.

c) XLPE insulation, flame retardant, low-smoke, halogen-free (LSOH) shall meet the following requirements:

The flame propagating criteria of IEEE Standard 383 with a minimum test short circuit time of five (5) minutes.

IEC 332 Part 1 and IEC 332 Part 3 tests on single and bounced cables under fire conditions (category C).

Limiting Oxygen Index of at least 30 to ASTM D 2863.

A temperature index (TI) of 260$^{o}$C to ASTM D 2863.

All insulation shall be moisture and heat resistant, with temperature ratings appropriate to the application conditions and in no case lower than 90ºC

Compounds of additives to the cable over sheath for anti-termite resistance shall comply with Internationally acceptable Regulations.

Environmental designed life span of cables shall not be less than 30 years.

Test of gases evolved during combustion of electric cables by measuring the pH and conductivity in accordance with IEC 754 part 2.

Measurement of smoke density of electric cables in accordance with IEC 61034.Smoke Density maximum 30 % as per ASTM D 2843.

Cables constructed with FRLS properties should have Smoke Density maximum 50 % as per ASTM D 2843.

d) The above requirements shall be met without compromising mechanical and electrical properties of the cables both during and after installation and other requirements of the specification.

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.

e) The entire work of cable laying of 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.

8.2.1.4.3 **25 KV TRACTION CABLES**

- 25kV cable connections at all locations of FP, SSP, SP & SS Interrupters and Isolating Switches.

8.2.1.4.3.1 Cable Characteristics

25 kV cable shall be dry-insulated, radial-field, based on proven technology.

8.2.1.4.3.1.1 25 kV cables construction

The cable shall be insulated with chemically cross-linked polyethylene, with semi-conducting screen over a copper conducting core, and insulating envelope and (a) polyvinyl chloride protective sheath-for the cables to be laid outside the tunnel (b) low smoke zero halogen fire retarding protective sheath-for the cables to be used inside the tunnel.

- Operating voltage: 27.5 kV,
- Specified voltage: 52 kV (according to IEC 840),

- Conductors: copper with 240 mm² for all applications. No. of cables in parallel shall be proposed during detail design stage for approval of Engineer.
- The short circuit rating of conductor and screen should be 14 KA for 3 seconds

8.2.1.4.3.1.2 Characteristics

- Conducting Core

  The conducting core shall be made of bare annealed copper, according to class 2 per publication IEC 60228.

- Core Screen

  The screen placed over the core shall consist of extruded covering of semi-conducting material.

- Insulating Envelope
  The insulating envelope shall consist of extruded solid dielectric, made of chemically cross-linked polyethylene (Triple extrusion process). Its nominal thickness and tolerances shall comply with the requirements set forth in standard IEC 60502-2.

- Insulating Envelope Screen

  The screen placed over the insulating envelope shall consist of a non-metallic semi-conducting part, associated to a metallic part.

  The non-metallic part, consisting of a semi-conducting material, will be easily separable from the insulant in order to facilitate cleaning of the latter.

  This semi-conducting material will constitute a mat to protect the insulant from expansion strains.

  The metallic part applied over the semi-conducting part will consist of stranded wire with copper tape.

  Suitable Armouring should be provided for mechanical protection.

- Outer Protective Sheath

  Anti-corrosion outer protective sheath shall be provided. The nominal thickness of this sheath shall be determined according to the requirements set forth in standard IEC 60502-1

  The protective sheath will carry the indications listed below, in letters and digits:-

- designation of ownership,
- nature and cross-sectional area of conductors,
- specified cable voltage,
- phase numbering,
- manufacturer's name.

8.2.1.4.3.1.3 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.

RETURN CURRENT CABLES

- Each feeder will consist of two nos. phase cable (25 kV) and two nos. Return Cable (3.3kV).

- The 3.3kV cable shall be 1.9/3.3 kV grade, single core, 240 sq. mm stranded copper conductor XLPE insulated copper wired screen, tape armouring, FRLS/ FRLSOH sheathed cables. It shall confirm to IEC 60502-1 latest for construction and for testing. The nominal thickness of insulation for 3.3kV cables shall not be less than 2.0 mm. As per IEC 60502-1. Construction details as per 25kV cables should be followed as per specification. Fault level for copper wire screen should be considered minimum 1 KA for 3 Seconds based on their detailed design.

8.2.1.4.4 **415V ACPower Cable**

8.2.1.4.4.1 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.

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.

8.2.1.4.4.2 System Earthing

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

8.2.1.4.4.3 Rating

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

a) Rated voltage : 1.1kV (as per IS 7098 part-1)

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

8.2.1.4.4.4 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 228.

8.2.1.4.4.5 Insulation

The insulation shall be of cross-linked polyethylene (XLPE) type and complying with the relevant test requirements specified in 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 $90^0$C for normal operation and $130^0$C for emergency overload condition.

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

8.2.1.4.4.6 Over sheath

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.

8.2.1.4.5 **CONTROL CABLE**

8.2.1.4.5.1 The Contractor shall design, manufacture, supply, install, test and commission all control cables as specified.

8.2.1.4.5.2 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.

8.2.1.4.5.3 Conductor

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

8.2.1.4.5.4 Insulation

The conductor shall be insulated with extruded XLPE complying with IS 7098 part-1. Suitable separator tape or tapes may be applied over the conductor.

8.2.1.4.5.5 Core Identification

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

8.2.1.4.5.6 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.

8.2.1.4.5.7 Inner Sheath

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

8.2.1.4.5.8 Bedding

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

8.2.1.4.5.9 Armouring

Two steel tapes shall be applied helical in the same direction over the tape bedding. The outer tape shall be approximately centered over the spaces between the convolutions of the inner stall tape.

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.

8.2.1.5 **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 need 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.

8.2.1.6 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 tie clamps spread over an equal distance.The material of cable clamps and cable ties shall be subject to the review by the Engineer.

8.2.1.7 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.

8.2.1.8 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 equipments.

8.2.1.9 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.

8.2.1.10 **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 zinc plated or 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 and connectors shall have 2-hole or 4-hole tongues.

JOINTS AND TERMINATIONS OF 25kV/ 3.3KV CABLES

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

The terminations for 25 KV cables (AIS/GIS) should be provided with adequate safety and clearance in tunnel and equipments. 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 from Rolling Stock.

### 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.

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 un-armoured. Those laid in cable gallery, cable ducts, cable trenches or in train tunnel shall be armoured unless they are provided with protective conduit for mechanical and fire safety requirements.

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

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

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 busbars, feeders and other equipment shall comply with IEC 255 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 255-5) 2.0kV, 50Hz, 1min

b) Impulse test voltage (IEC 255-5) 5kV, 1.2/50ms, 0.5J

c) High frequency disturbance test (IEC 255-22-1 Class III)

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

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

d) Electrostatic discharge test (IEC 255-22-2 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.

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 schema shall include as required for Traction power supply circuits, relaying out of following types:

#### 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 second level over temperature of transformer or 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 – for OCS and traction power circuit, and CBs at TSS:

- 25 kV feeder protection including OHE protection
- Line pilot wire Differential protection for 25KV feeders

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

**a) <u>Bus bar</u>**

The protection shall consist of :

F 50: Instantaneous over current protection

F 51: Time delayed over current protection

F50 N: Instantaneous earth fault protection (homopolar)

F51 N: Time delayed earth fault protection (homopolar)

Each portion of OCS fed by a circuit breaker is called "sector".

Each sector is sub-sectioned into elementary sections (catenary section between two breaking apparatus).

The sectors of same direction are put in parallel at the level of the paralleling station through interrupters.

The entire fault on:

the catenary network, together with the switchgear directly connected thereto,

the rolling stock (upstream the circuit breakers),

the paralleling stations (bus-bars, switchgear,),

are detected and protected by the circuit breakers of the feeder station according to the following sequence:

a fault is detected by the two protection devices (minimum Z and Over current) of the same direction through the paralleling,

the related two circuit breakers are switched off,

the fault localisation system is put into service (operation is described later),

the paralleling interrupters open due to the lack of power on the two tracks after a temporisation of about 500 ms,

The re-closing order is given to circuit breaker within about 7 seconds,

If the fault remains (10% of the cases):

- the circuit breaker of the faulty sector trips and this is blocked open for 12 mn,
- the fault locator determines the faulty elementary section
- the circuit breaker for the healthy sector switches on.

If the fault is transient (90% of the cases):

the 2 circuits breakers re-close, the paralleling interrupters close following the energising of the two sectors, after a temporisation of approximately 1 mn.

**b) <u>Minimum impedance protection</u>**

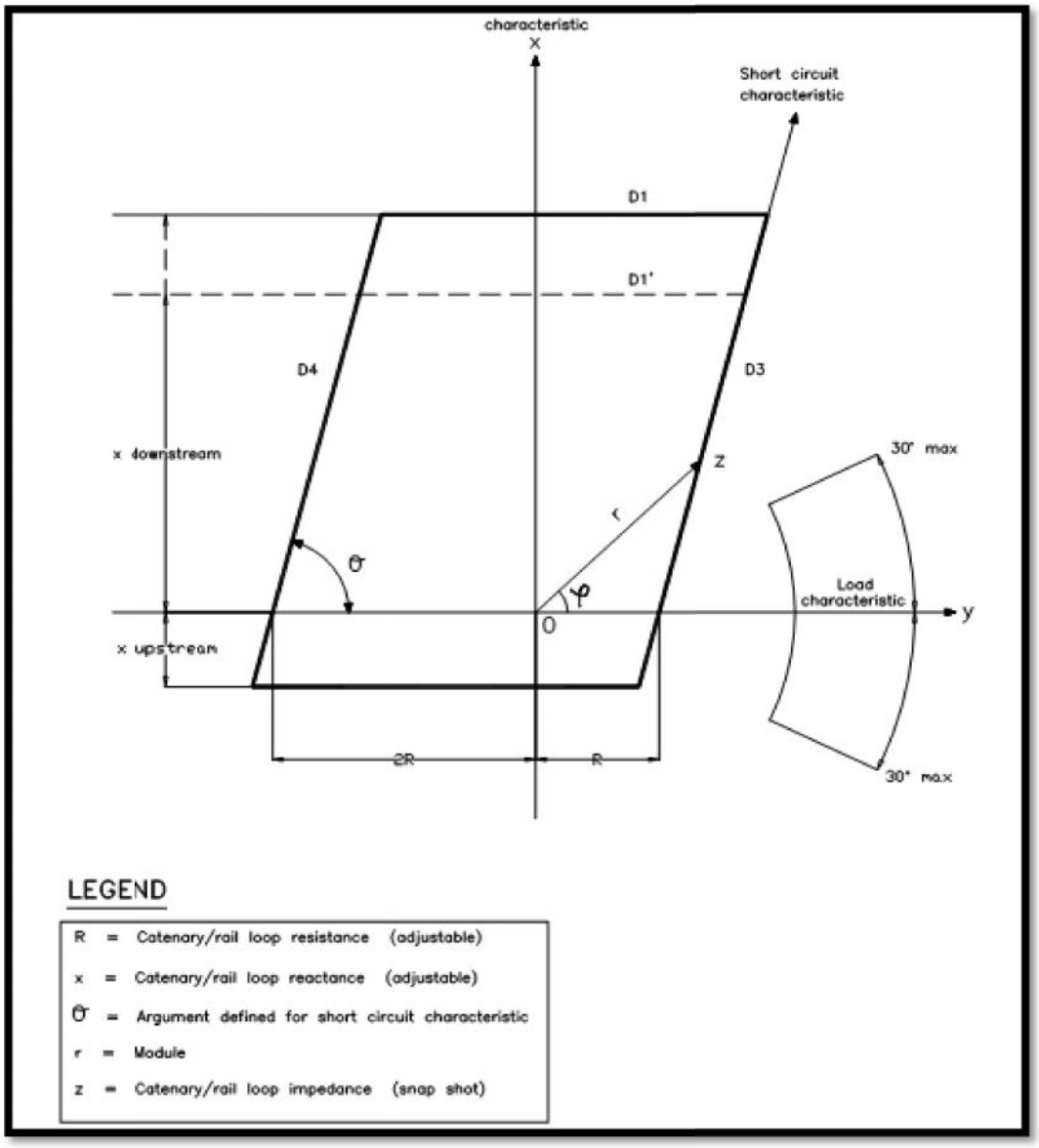
This module is a single-phase impedance measuring (in R-X co-ordinates) relay, which operates when the impedance value falls below a selected adjustment threshold.

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.




**c) <u>Over current protection</u>**

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.

**d) 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.

**e) 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).

**f) 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, 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 AC/DC Control source system shall include maintenance free Tubular type Lead-Acid battery banks, battery chargers, AC/DC distribution boards and all other accessories.

8.12.1.2 Not Used

8.12.1.3 Stationary type battery shall be provided. The batteries shall be automatically float charged to maintain the optimum charge during normal operation while feeding the switchgear steady state control current requirements.

The control voltage range for all equipment shall be 70-140 V DC except for DC motors where the operating voltage range shall be 100-140 V DC

8.12.1.4 The total ampere-hour capacity of the battery bank shall be designed to provide, in the event of AC power or charger failure.

a) Entire load requirement for the protection, indication control and monitoring of the entire equipment for a continuous duration of 4 hours for traction switching posts:

b) Within the above-mentioned four hour period it shall be possible to perform the following operations successfully:

i) Each 25kV Circuit Breaker at least five tripping and five closings operations

ii) Each 25 kV interrupters.

iii) The batteries terminal voltage shall not be less than 90 V DC after the tripping for each of the 66 kV/33kV/25kV AC switchgear in the switch room at the end of the four hours period.

c) The batteries shall be design to have the capacity to close 2 ac circuit breakers simultaneously. The basis of the ampere-hour capacity of the battery bank and other design calculations shall be submitted for review by the Engineer for each location. The Contractor shall be required to verify the performance by actual site tests.

8.12.2 **Battery specification**

This specification covers the methods of Design, Manufacture, assembly of components, testing at manufacturer's works, packing, supply and delivery to site, Tubular type lead-acid stationary batteries in Mono-block Poly Propylene container and associated accessories.

8.12.2.1 Applicable Standards (Latest revision)

BIS - 13369-1992

IS-1885: Electrical vocabulary, secondary cells and batteries

IS-1069: Water for storage batteries

IS-266: Sulphuric acid for storage batteries

IS-8320: General requirements for methods of tests for lead-acidStorage batteries.

IS-1146: Specification for rubber and plastics container for leadAcid storage batteries

IS-6071: Synthetic separator for lead acid batteries

8.12.2.2 **Terminology**

TYPE

The battery shall be Lead Acid Tubular type in Monoblock Poly Propylene container. The cells of the batteries shall be similar in type and shape. It requires regular topping and maintenance during life time of the battery. The batteries should preferably be of 12 volts.

ACCEPTANCE TEST

Tests carried out on samples selected from a lot for the purpose of verifying the acceptability of the lot

LOT

All batteries of the same type, design and rating manufactured by the same factory during the same period using same process and materials offered for inspection at a time shall constitute a lot.

ELECTROLYTE

Aqueous solution of Sulphuric acid for ionic conduction and electrochemical reaction during passage of current through a cell.

TERMINAL AND POSTS

A post of a cell or battery to which an internal electrical circuit is connected.

8.12.2.3 **Design and Constructional features of Battery (**Materials & Construction)

The cells of the batteries shall be similar in type and shape. The nomenclature shall be 12T100P, 12T130P etc.

Overall dimensions masses and capacity of 12V units.

| Voltage | Capacity @ | Maximum Overall Dimension | | | Weight (Kg.) approx | |
|---|---|---|---|---|---|---|
| V. | C10 rate Ah | Length | Width | Height | With Acid | Without Acid |
| 12 | 100Ah | 500mm | 187mm | 421mm | 56.90 kg/ | 29.80 kg |
| 12 | 130Ah | 500mm | 187mm | 421mm | 66.90 kg/ | 40.60 kg |

These dimensions are subject to revision after receiving details from manufacturers. Dimension may be interchange.

**Terminal Post and Connectors:**

Positive and negative posts shall be clearly and unambiguously identifiable.

**Positive Plates:**

The plates shall be of first class material and workmanship and shall be free from blow-holes, cracks and other imperfections. The tubular positive plates shall consist of a suitable bar with spines cast of suitably alloyed lead to give adequate mechanical strength and minimum electrical resistance.

The tubular spines shall be cast of an alloy of Pb and Antimony with Antimony content not greater than 3% by weight. The casting shall be done using proper controlled procedure preferably using high pressure casting machine with an operating pressure not less than 90-100 Bars. Low antimony alloy (not greater than 3%) will ensure low water loss and a guaranteed topping up frequency of not more than once in 12-18 months. High pressure cast spines will ensure a long life and trouble-free operation. Porous, acid resistant and oxidation resistant tubes shall be inserted one overeach spine. After insertion, the tube shall be adequately filled and packed with active material (preferable through a rotary shaking machine) before their lower ends are closed by common plastic bar. The construction and material of tube shall be such as to reduce the loss of active material and shall be ableto withstand normal internal stresses developed during service.

Dimension of positive plates

| | | 130 Ah | 100 Ah |
|---|---|---|---|
| Height of positive plates | - | 244 mm | 262 mm |
| Thickness of positive plates | - | 8.25 mm | 8.25 mm |
| Area of positive plates | - | 336 sqcm | 361 sqcm |
| No. of positive plates | - | 03 | 02 |

These dimensions are subject to revision after receiving details from manufacturers.

**Negative Plates:**

The negative plates shall be of flat pasted type and should be made of lead-calcium alloy. The pasting shall be done on an automated machine for better control of process parameters. It should have adequate mechanical strength and would be so designed that active material is maintained in intimate contact with the grid under normal working conditions throughout the life of the battery.

Dimension of negative plates

| | | 130 Ah | 100 Ah |
|---|---|---|---|
| Height of negative plates | - | 232 mm | 259 mm |
| Thickness of negative plates | - | 4.57mm + 3.2 mm | 3.2 mm |
| No. of negative plates | - | 02 Inter + 2 End | 03 |
| Area of negative plates | - | 329 sqcm | 360 sqcm |

These dimensions are subject to revision after receiving details from manufacturers.

**Separators**:

The separators shall be micro-porous polyethylene (PE) type to avoid direct as well as side shorts. Providing explosion vents and type of vent and filling plugs are explosion proof

Microporous ceramic made. It should be acid resistant, chemically inert and should have excellent oxidation resistance and high degree of porosity to ensure minimum internal resistance. Average volume porosity should be more than 45%. It should not exhibit any tendency to swell or shrink at temperature encountered during operation. Micro-porous separators shall conform to latest IS: 6071.

**Containers**:

Containers shall preferably be made of Poly Propylene giving outstanding chemical resistance, rigidity and toughness with very high insulating qualities which eliminate the need for separate cell insulators. Thickness of container is03 mm. and material of container is PPCP. It shall have adequate mechanical strength, cracking etc. during the life span of battery when operating under expected temperature range and due to action of static and dynamic loads and the action of electrolyte. The containers shall conform to latest edition of IS-1146.

**Cell Lids**

It should be moulded from opaque Mono block Poly Propylene and sealed to the container. The cell lids shall be made of suitable polypropylene material for heat sealing. The material shall confirm to IS-1146

**Micro-porous Ceramic Vent Plugs**

The vent plugs should be specially designed incorporating a micro-porous ceramic filter which effectively returns all acid spray to the cell, but allow free exit of oxygen and hydrogen which is generated at the end of boost charging. On removal, the plugs shall permit drawing of the electrolyte sample for servicing and of checking of the electrolyte level. The vent plug should preferably is flame retardant type to prevent any fire hazard in the battery room.

**Connectors and fasteners: (Flexible)**

Connectors shall be made of copper and completely insulated with rubber/plastics. Connectors should be adequately designed to carry maximum duty cycle as specified and shall offer minimum resistance. Connectors shall be adequately designed to withstand various stresses due to temperature changes, attack of acid and dynamic forces that could occur during the operation of the battery .Fasteners should be made of copper, brass, stainless steel or any to prevent corrosion.

**Electrolyte**:

The electrolyte shall be battery grade sulphuric acid conforming to latest edition of relevant IS 266. The strength of the electrolyte in the cell during operation shall conform to the governing IS specification for the cell. Required quantity of electrolyte for the initial filling with 10% extra quantity shall be supplied in no-returnable non-degradable acid resistant strong plasticcontainers.IS-1069-1964.

**Water**:

Water used in preparation of electrolyte and also to bring the level of electrolyte to the correct position during the course of operation or testing shall conform to the latest edition of IS-1069.

**Terminal Post:**

Positive and negative terminal posts of the cells shall be clearly and unmistakably identifiable. Terminal posts shall be designed to accommodate external bolted connections conveniently and positively. All metal parts of the terminals shall be of lead coated type. Bolts, heads and nuts, except seal nuts, shall be hexagonal and shall be lead coated. Terminal posts shall be adequately fixed to prevent its turning or twisting when the connectors are being fixed or removed. The junction between terminal posts and cover and between the cover and container shall be adequately sealed to prevent any seepage of the electrolyte. All terminals shall be provided with insulated covers.

**Ampere –Hour Rating:**

The rating assigned to; the cell or battery shall be the capacity expressed in ampere hours (after correction to 27 degree C) stated by the manufacturer to be obtainable when the cell or battery is discharge at the 10 hr. rate to the end voltage of 1.80 volts per cell.

**Capacity in AH at various duration of discharge and corresponding ECV**

| | (Ah output) 130 Ah | (Ah out put) 100 Ah |
|---|---|---|
| 1 hour ECV. 1.75 | 61.5 | 47.5 |
| 3 hour ECV. 1.80 | 88 | 68 |
| 5 hour ECV. 1.80 | 102.5 | 79 |
| 10 hour ECV. 1.80 | 123 | 95 |
| Maximum momentary current | 240 Amp | 185 Amp |
| For 1 min till 1.60 ECV | | |
| Number of charging discharging | 1200 cycles | 1200cycles |
| Cycle at 80% Depth of discharge | | |
| Expected life of battery under | 8-10 years | 8-10 years |
| Normal operation & maintenance Condition | | |

8.12.2.4 **Service Condition**

The battery is required to work at ambient temperatures up to 45 degree C.

8.12.2.5 **General Requirements for Tests**

Specific Gravity of Electrolyte:

The specific gravity of fully charged cells shall be adjusted to 1.240 +/- 0.005at 27˚C.and at full charge 1.245+/- 0.005

**Temperature Correction:**

The capacity of the cell shall be corrected to 27˚C using the proper temperature correction factor pertaining to the type of the cell and the rate of discharge. The temperature correction should be made using factors supplied by the manufacturer but shall generally conform to some national or international standard for the similar type of cell.

**Variation of capacity with temperature**

| Discharge Rate | Factor for variation in capacity Per $^{o}$C R |
|---|---|
| C10 | 0.43 |
| C9 | 0.45 |
| C8 | 0.47 |
| C7 | 0.50 |
| C6 | 0.54 |
| C5 | 0.58 |
| C4 | 0.62 |
| C3 | 0.68 |
| C2 | 0.76 |
| C1 | 0.90 |

Note:- Capacity temperature correction is not a true linear relationship.

8.12.2.6 **Tests**:

**Test for Capacity:**

The cell shall be tested for its rated capacity output. The fundamental requirement shall be a discharge for 10 hours whilst discharge at other rates ,as decided mutually between the manufacturer and purchaser, May also be performed.

A fully charged cell shall be allowed to stand idle for a period of 12- 24 hours before performing this test. The cell shall be discharged at a constant current of I10 = C/10 where C is the rated 10 hour discharge capacity of the subject t cell till the voltage of the cell reaches 1.80 volts per cell. In case of more than one cell being tested at a time (in most of the cases), the discharge to be discontinued at a time when the voltage of the group has reached 1.80 x nvolts where n is the number of cells in the group.

The capacity of the cell thus established shall have to be corrected for temperature variation during the test if the temperature is different from 27deg. C. The temperature correction shall be as per the relevant IS for the type of the cell in question.

The battery should be very robust construction and provide 1200 – 1500cycles of charge and discharge at 10 hour rate of discharge to 1.75 vpc with a service life of 8-10 years. Battery should also be quickly recharged at higher at higher current (within 06 hours) up to 2.75 VPC without affecting the performance. The ampere hour and watt hour efficiency should be more then80%.

It should withstand high ambient temperatures up to 35$^{o}$C constantly and 40$^{o}$C intermittently without losing much of its service life.

The capacity output, at the first discharge, corrected to 27˚C shall not be less than 85% of the rated capacity of the cell. The cell shall reach 100% of its rated capacity within 5 charge-discharge cycles.

**Test for Charging Efficiency:**

Since the cells are expected to operate at various state of charge (SOC), the charging efficiencies at various depth of discharge needs to be measured and standardized for this application. Typically, charge efficiencies at 80%, and10% SOCs are to be notified.

**Charge Efficiency at 80% SOC:**

A fully charged cell shall be discharged at a constant current of I10 for 2 hours.

The voltage at the end of 2 hours (V1) to be very meticulously noted. The cell, then, shall be charged at a constant current of I10 for 2 hours and after a rest period of 2-4 hours shall again be discharged at a constant current of I10. The time taken to reach the voltage V1 is to be noted during this discharge.

The ratio of these two times would be designated as the charge efficiency of the cell. The time of discharge shall change to 9 hours for 90% SOC. The rest procedure being similar to the one explained.

The cell appropriate for this application should have the following charging efficiencies:

80% SOC 80%

10% SOC 90%

**Retention of Charge**

The charge retention of a cell is the capability of the cell to retain its capacity during the period of no charge, i.e. when not connected to the system, during transportation or storage. A fully charged cell shall be discharged for capacity appreciation. The capacity output shall be noted as C1. After recharge the cell shall lie in open circuit condition for a period of 28 days. During this period ,the temperature of the cell shall be kept close to $27^{o}$ C as much as practically possible. After completion of 28 days of idle standing, a second capacity discharge is to be performed. The capacity, corrected to $27^{o}$ C thus obtained, shall not be lower than 95% of the earlier actual capacity C1.

**Water loss**:

The cell/ battery after being fully charged shall be kept on a float charge of 2.4volts per cell at a temperature of 40 deg. C for 21 days at a stretch. The loss of water due to evaporation and self discharge shall not be more than 0.65 grams per Ah.

The battery shall reach an equilibrium state of charge within 72 hours of such charging. This shall be indicated by the float current after 72 hours of constant float. The float current shall not be more than 3 mA per Ah.

**Battery Racks:**

The battery racks shall be constructed from good quality of high strength good quality mild steel sections. These battery racks shall be painted by the bidder with two coats of acid/ alkali resistant paint of approved make. When steel stands are used, they should be painted with acid resistant grade .The racks shall be of Single tier/ two tier construction depending on the final layout based on space availability.

**Marking**:

Each cell shall be marked to meet the requirements of relevant Indian standards. In addition, each cell shall be legibly numbered serially to identify the cell during manufacture,

testing, installation and operation of battery to identify after having assembled into battery bank in battery racks. Following marking however, shall be provided

a) Manufacturer's type and trade name

b) Electrolyte level (min & max)

c) Type of container and standard AH capacity as per IS

d) Polarity marking as per relevant IS

A set of loose stickers shall be provided to mark the cells position in the assembled battery bank at site so that a cell removed for maintenance can be put back in original position.

8.12.2.7 **Other information**

a) Battery system shall not be earthed. Battery connections shall be as short as possible using flat bus bolted to the terminals and shall be coated with clean electrolyte resistance Vaseline grease. All necessary inter-cell/unit connectors including insulted inter-row and inter-tier connectors provided shall be electrolyte resistant.

b) A minimum 600mm space around the batteries shall be provided for ease of access and maintenance. The batteries shall be provided with a continuous voltage monitoring signal to be displayed at the local battery charger panel and at remote OCC. In addition an alarm 'battery voltage level low' shall be activated at the battery channel charger panel and at OCC if battery voltage falls below the pre-set level.

c) Contractor may offer, for review by Employer's Representative, other types of batteries based on technical merit and whole life cycle cost.

### 8.12.3 Battery Charger

8.12.3.1 The Contractor shall provide automatic constant voltage and current limiting type of chargers for each 110V DC battery system suitable for float, rapid and boost charging of batteries and simultaneously supply continuous DC loads. The charger shall be compatible with the equipment requirement and shall perform according to specified requirements.

8.12.3.2 Two battery chargers shall be provided for each battery set, one being standby.

8.12.3.3 The charger shall operate from 3 phase 415V, 50 Hz. Supply

8.12.3.4 The charger shall be protected against low battery voltage, short circuit at the output by employing current limiting feature and reverse battery voltage.

8.12.3.5 The battery charger and its main components shall comply with relevant Indian standards.

### 8.12.4. Battery Discharging Kit

Automatic Battery Discharge kit
Discharge capacities :

| Battery Voltage | Max. current |
|---|---|
| 12V | 50A |
| 24V | 110A |
| 48V | 110A |
| 110V | 110A |
| 220V | 55A |
| 480V | 55A |

With Cable Set GA-00550
Transport Case GD-00054
With Standard accessories

### 8.12.5. CB Timing Kit

Electronic Time Interval Meter,
Channel : Maximum Eight in PIR mode.
Control of Breaker : Through 300V / 30 A SSRs Trip and close the connected CB
Output : 4 line 20 character backlit LCD, RS 232 C port for downloading data to PC
Printer : Inbuilt, thermal printer
Paper : Thermal, 55 mm wide roll
Test Lead : Set of 15m, wear resistant Test Cables
Range : 999 milliseconds maximum
Resolution : 1 millisecond
Measuring Accuracy : Value +/- 0.05% +/- 1digit
Power : 230V AC +/- 15%, 50 Hz +/- 10%, 25 VA
with 15 meter test leads and downloading and analysis software

### 8.12.6. Power Analyser

General information :
The power analyser should provide complete solution, which includes the following components:

a. Power quality analyzer and recorder.
b. Device shall be suited for portable application.
c. On-board recording of all channels waveforms continuously for at least 7 Days at fix sampling rate of [512] per cycle for voltage and [512] current
d. Power Quality analysis software

Measurements : The device shall measure and report at least the following parameters:

A. Voltage:

Phase to neutral and phase to phase, for all three phases and neutral to ground.• Phase angles for each voltage relative to each other.• Cycle by cycle values• Average for 200 milliseconds as per IEC 61000-4-30• Aggregation as per IEC 61000-4-30• Flickers shall be measured and displayed in accordance to IEC 61000-4-15 (PLT, PST).• Fast flickering shall be measured and displayed for shorter periods. The minimum is• displaying short voltage flicker of 2 second and 1 minute.

B. Current:

Phase to neutral and phase to phase, for all three phases and neutral to ground• Phase angles for each current relative to voltages.• Cycle by cycle values• Average for 200 milliseconds as per IEC 61000-4-30• Aggregation as per IEC 61000-4-30•

C. Power

Watts – total and per phase• VARs – total and per phase• VA – total and per phase• True Power Factor – total and per phase• Displacement Power Factor – total and per phase• Cycle by cycle values•Average for 200 milliseconds as per IEC 61000-4-30• Aggregation as per IEC 61000-4-30•

D. Frequency as per IEC 61000-4-30

E. Energy Watt-hr received and delivered• VA-hr received and delivered• VAR-hr received and delivered• Power demand shall be calculated using a sliding window comprised of a configurable• amount of 1 second sub-intervals. The meters shall be supplied with preset to 15 minute intervals.

Recording

I. Parameters and Duration

a. The device shall be capable of record all raw data (e.g. waveform) of its input channels continuously, using its native sampling rate (current: [512], Voltage: [512] samples per cycle) and accuracy, for a period of minimum 7 Days. The raw data (waveforms) shall be recorded.
b. The recording shall be done automatically without the need to set triggers and/or thresholds

II. Storage

a. The recorded data shall be kept on board on flash memory of 256 MB.
b. The records in the device shall not be lost even if all voltage sources disappear for 7 Days.

III. Display

a. The supplied software shall be able to retrieve every cycle of the network, according to user request, in any resolution and time period.
b. The resolution shall be from 7 Days to one sample (i.e., 16 microseconds for 512 samples per cycle at 50 Hz network). The time period can be from 1 millisecond to few Days.
c. There shall be no limit between the time period and resolution (e.g., it shall be possible to display data from 7 Days with 1 millisecond resolution). If the display doesn't have sufficient resolution, the software shall display the minimum, maximum and average for each displayable pixel.
d. The supplied software shall be able to display all the electrical parameters that the device can measure, to any period and resolution from 1 cycle to few years.

Communication

a. The device shall have the following ports: [01] Integral fast Ethernet ports with bui•lt-in router. One (1) integral PoE in (power Over Ethernet) port• RS-422/485, both 2- and 4-wire (optional)• RS-232•
b. The device shall have integral web server, which allows monitoring all real-time information using standard Internet Explorer 7 or higher. The web server shall provide access to all device features, such as real-time monitoring, power quality status, remote control and full device configuration. The device will communicate to the designated tablet PC
c. Communication protocols: OPC• DNP3• Modbus – RTU• Modbus – TCP•
d. The device shall have integral OPC, Modbus RTU, Modbus-TCP and DNP 3. Server for seamless integration with SCADA systems. The OPC server shall not require any additional hardware of software.

Display and reports

a. The software shall be able to display all parameters in tabular view and graphical trends.
b. It shall be possible to display trend graph of all RMS parameters.

c. It shall be possible to display trend graph of all harmonics (THD and individual).
d. It shall be possible to display trend graph of all waveforms.
e. It shall be possible to display trend graph of frequency.
f. It shall be possible to display power quality events on timeline graph.
g. Items B to F shall be able to be displayed on the same graph with same Y axis and multiple Y-axis.
h. Items B to F shall be able to be displayed as cycle by cycle or per IEC 6100-4-30 Class A calculation method.
i. It shall be possible to display Items B to F aggregations according to IEC 6100-4-30 Class A
j. It shall be possible to display all information from all devices on the same graph.
k. The trends shall be for any period from 1/10th of a cycle to few years.
l. The maximum time to display one graph, or to perform zoom in or out operations, shall not be more than 30 seconds on an average computer.
m. It shall be possible to change line colours and as well as line types for any trend.
n. All graphs shall allow exporting the data in CSV format and the graphs themselves in Windows compatible graphic format.
o. The software shall be able to generate periodic and on-demand reports, both pre-defined and customized. Separate report for Transient and Event should be generated.
p. The reports shall include as a minimum summary report of all RMS values and Harmonics (Min / Max / Avg), energy consumption report and EN50160 report.
q. The software shall be able to display events and alarms information from the device, including list of all active alarms and indication when an alarm is activated.
r. The software shall be able to display all power quality events, as per EN 50160 and/or user defined events (both level and parameter), in a tabular view. It shall be possible to filter and sort the data based on at list the following: time, event's type, event's duration, event's depth and event's severity (a calculated value for every event based on its type, duration and depth).

8.12.3 **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.

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

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

8.12.5.2 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 – JP/EW/1B/E2

# CHAPTER – 9

# NOT USED

# CONTRACT PACKAGE – JP/EW/1B/E2

# CHAPTER – 10

# DESIGN CRITERIA AND PERFORMANCE SPECIFICATION RIGID OVERHEAD CONTACT SYSTEM

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

## 10.1 General Requirements

### 10.1.1 Scope of Work

This specification covers complete design, supply, installation, testing and commissioning of 25 kV ac rigid overhead contact system (OCS) including switching Stations (SSP, SP, SS and FP) with 25kV 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.

### 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 and SS circuit breakers/ interrupters (GIS) 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 Not used

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

10.1.3.5 Not used.

10.1.3.6 Not used.

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

10.1.3.8 Not used

10.1.3.9 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.

10.1.3.10 Not used.

10.1.3.11 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.

### 10.1.4 Traction Power Supply for (Line-Standard Gauge)

At the 25kV rigid OCS will be directly connected to the existing 25kV rigid OCS 25 kV through Jumpers or Cables. 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.

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.

25kV feed from RSS through suitable arrangement of Circuit breakers (GIS type with minimum rating of 2000 A) with all necessary OCS protections and interlocks shall be provided.

### 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 ac Traction Manual may be referred to in addition to the practice of bonding and earthing adopted on Line No. 2.

### 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 support fittings and insulators for distribution of electric power to the train.

Expansion joint: Mechanical joint for absorbing expansion of rigid contact wire due to temperature changes.

Air section: Electrical sectioning of OCS for separating feeding network.

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: Insulated 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 | 270 |
| Dynamic (passing) | 170 |
| 25kV Live Metal to Vehicles | |
| -Static | 290 |
| - Dynamic (passing) | 190 |
| Phase Difference (47.6kV) | |
| Static | 530 |
| Dynamic (passing) | 350 |
| 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.

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

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.

10.3.1.5.2 Anchor plug and anchor bolt/ Chemical fasteners 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 similar to existing Line No. 2 or chemical fasteners of adequate design. 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 and the nuts, bolts and washers shall be G.I/stainless steel of suitable grade for moist and polluted tunnel atmosphere.

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 conductor shall be in accordance with the recommendations of IEC 383 / 1109. 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 fluxul 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.

10.3.1.6 Expansion Joint

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.

10.3.1.6.2 Parallel contact wires at expansion joint

Parallel contact wires shall be of adequate length to provide for suitable expansion joint assembly with provision for adequate number of flexible continuity jumpers. Separation distance between two OCS sections at expansion joint shall not be less than 200mm to ensure smooth passage of pantograph. No expansion joint shall be provided in the station area. Suitable gradient will be provided to ensure smooth change over. The expansion joint 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

The structure of air-gap section shall be same as that of an expansion joint. 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 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. 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 requirements or EN should be followed (as per approval). *Contact Wire shall be Round Bottom, 150 sq mm area and shall comply with latest RDSO standard ETI/OHE/76 (6/97) or EN 50149 specifications. Contact wire shall be made from Continuous Cast Copper (CCC) rod of minimum 23 mm diameter as per RDSO Specification. Also, Contact wire shall be hard Drawn Grooved Copper contact Wire complying to RDSO standard ETI/OHE/76 (6/97).*

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 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).

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 $\pm$ 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 $\pm$ 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.

## 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 JMRC.

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 and spring washers shall be suitable grade stainless steel.

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 Jaipur 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.

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.

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

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.

## 10.6 Installation of Feeding System

### 10.6.1 Design requirement of traction power cables

25 kV feeder cables shall conform to the specifications of these cables given in clause 8.2. The number of cables constituting a feeder shall take in account the whole current requirement of a single source of feed.

The feeder cables and the jumper cables shall be sized to provide for environmental derating corresponding to the laying method and maximum overload and short-circuit currents.

The cable terminations shall be suitably designed for adequate insulation, mechanical strength, low resistance and against fraying of strands, developing cracks or getting loosened with vibrations, wear and tear.

The interrupters and isolators meant for sectioning shall be located in the station area in a room close to the sections required to reduce length of cables.

Connection of feeder cables to OCS conductor rail shall be through flexible jumper and terminal connectors and shall be of bolt fixing type. Details shall be submitted for review of Engineer.

The feeder cable jumpers shall be flexible to accommodate rigid conductor rail movement due to temperature variations.

Due care should be taken to lay and connect the cables to switchgear and to OCS to ensure that the current carrying capacity of the system is not de-rated. All connectors shall be robust and of proven types.

### 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 finalised by EMC simulation study. The Conductor shall conform to Indian Railway's RDSO specification**

10.6.2.2 Earth Conductor

Earth Conductors shall be made of flexible Aluminium conductors of adequate size to be finalised by EMC simulation study. The Earth Conductor shall conform to Indian Railway's RDSO specification for IS: 398.

Suitable bimetallic connectors to be provided between any copper and aluminium connections in earthing system.

## 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, random check of components; electrical and mechanical clearances, air gaps and general alignment.

b) Continuity test of each joint in traction and return current circuit.

c) Insulation resistance of 25 kV ac overhead contact system shall be as per international standards.

d) Physical examination of rail bonds.

e) Checking of construction gauge

f) Return current continuity test, testing of joints.

g) Earth resistance test.

### 10.10.2 Partial Acceptance Tests

10.10.2.1 **Not used**

10.10.2.2 Tests

After physical verification and measurements, tests as indicated below but not limited to these, shall be carried out.

10.10.2.2.1 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.

10.10.2.2.2 High voltage ac test.

Meggering of OCS sections at 2.5 kV and record results.

10.10.2.2.3 Pantograph tests will be performed using a self-powered transit vehicle in order to identify any locations where arcing may occur.

10.10.2.2.4 The Contractor shall be responsible for all adjustments required as a result of these tests.

### 10.10.3 System Acceptance Tests

10.10.3.1 Energisation

10.10.3.1.1 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.

10.10.3.1.2 Short circuit tests shall be carried out as per a detailed test protocol, which shall be submitted for review by Engineer.

### 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.

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 – JP/EW/1B/E2

# CHAPTER – 11

## I/O list for underground switching station breakers

**9**

| | | Type of signal | | |
|---|---|---|---|---|
| **S.no** | **Description** | **DI** | **DO** | **AI** |
| 1 | CB close command | | 1 | |
| 2 | CB open command | | 1 | |
| 3 | CB close status | 1 | | |
| 4 | CB open Status | 1 | | |
| 5 | Isolator Close Command | | 1 | |
| 6 | Isolator open Command | | 1 | |
| 7 | Isolator open status | 1 | | |
| 8 | Isolator Close status | 1 | | |
| 9 | Earth switch close status | 1 | | |
| 10 | Earth switch open status | 1 | | |
| 11 | Control supply fail alarm | 1 | | |
| 12 | L/R Mode in local | 1 | | |
| 13 | SCADA permissive for local control | | 1 | |
| 14 | Spring discharged | 1 | | |
| 15 | CB stuck | 1 | | |
| 16 | Current | | | 1 |
| 17 | Voltage | | | 1 |
| 18 | SF6 gas pressure low alarm Stage-I | 1 | | |
| 19 | SF6 gas pressure low trip stage-II | 1 | | |
| 20 | Lock out relay operated | 1 | | |
| 21 | Lock out relay reset | | 1 | |
| 22 | PT MCB trip | 1 | | |

| | | | | |
|---|---|---|---|---|
| 23 | Trip circuit unhealthy | 1 | | |
| 24 | Under voltage tripping of Paralling interrupters | | 1 | |

# CONTRACT PACKAGE – JP/EW/1B/E2

# CHAPTER – 12

# NOT USED

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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

The list of relevant contractors/ DDC's is as under:

1) Civil Contractor
2) S&T Contractor
3) Power Supply (RSS), SCADA & Elevated line Traction Contractor
4) Track Contractor
5) Rolling Stock Contractor
6) DDCs
7) E&M Contractor
8) VAC Contractor
9) Any other associated with the work

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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.

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 Installation validation & auditing after installation of ROCS, other for design validation & auditing. Final validation report should cover installation & design of 25 KV ROCS, the reports should clearly certify that design/installation has been done according to applicable standards and international safe practices. The contractor shall submit the reports for review of Engineer.

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

Five 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.

14.1.5 Factory Acceptance Tests

14.1.5.1 FAT shall comprise Sample Tests, Routine Tests, and any additional tests required by the Engineer. FAT plan as per GS should be submitted for approval of 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.

Contractor shall certify the matching of all components of ROCS.

## 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 additional/special tests as directed by Engineer should be done by 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, allinstruments, 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 approvedtesting 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 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 2.5 kV insulation tester.

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 Batteries and Chargers.

Discharge tests and charging tests shall be carried out to verify the capacity of the batteries and all functions available on the charger

The operation of the boost charge facility and the effect of the voltage dropping diodes shall also be demonstrated.

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.

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 The Contractor shall prepare operation safety rules and procedures for the review of the Engineer before Energisation.

14.6.1.2 The Contractor shall carry out all necessary checks to ensure safe Energisation.

14.6.1.3 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.

14.6.1.4 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 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) Rolling stock regenerative braking tests.

e) Measurement of step & touch potential to validate the result obtained by Simulator study.

f) Current Collection Test

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 Technical Specification, the Contractor shall make every effort to rectify the deviation in the shortest possible time, and to the satisfaction of the Engineer.

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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 Jaipur 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 Jaipur 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

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

15.4.4.1 Necessary precautions shall be taken during shipping, handling and storage as per manufacturer's recommendations

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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 TS and clause 3.6.1 of the GS, installation details and methods of all activities equipments 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.

16.4.3 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 exhaust pollution norms of minimum EURO-II.

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.

16.7.1.1 Details of Health and Safety requirements at Site are described in Chapter 18 of the GS and Safety & Health Manual.

#### 16.7.2 Quality Management

16.7.1.2.1 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 TS are achieved.

16.7.1.2.2 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.

16.7.1.2.3 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.

16.7.1.2.4 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.

16.7.1.2.5 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.

16.7.1.2.6 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.

## 16.8 Installation of Cables

### 16.8.1 Laying of Cables

16.8.1.1 The Contractor shall co-ordinate with the Civil Contractors for the installation of cables in cable galleries, trenches, ducts, troughs, risers and shafts.

16.8.1.2 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.

16.8.1.3 Should it prove necessary to cut any cable during installation, all cut ends shall be properly sealed.

16.8.1.4 The maximum pulling force of any cable during installation shall not exceed the design force of cables.

16.8.1.5 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.

16.8.1.6 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 Workmanship

### 16.9.1 General

16.9.1.1 All the installation shall be carried out according to the instructions shown in this Specification and Employer's Drawings.

16.9.1.2 All assemblies of equipment and their components and parts shall be completely interchangeable if they are of similar type

16.9.1.3 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.

16.9.1.4 All parts, which are subject to, wear or damage by dust shall be completely enclosed in dust proof housings.

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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 TS.

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 theContractor 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 – JP/EW/1B/E2

# 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

18.2.1 The Contractor shall supply quantity of spare parts in accordance with clause 13.3 of GS.

18.2.2 Notwithstanding clause 13.3.5 and 13.3.6 of GS, the Contractor shall supply a minimum quantity of the following items of Spares as given below in Table 18.2-1.The price of below quantity of spare should be quoted in the item provided in cost centre C-spares of pricing document. The evaluation of the tender shall be done considering this price of spares. Upon approval of the Engineer the procurement of spares should be done by contractor.

**Table 18.2-1 Minimum Quantity of Contract Spares ***

| Sr. No. | Item | Quantity | |
|---|---|---|---|
| **A** | **Rigid OCS Spares** | | **For JP/EW/1B/E2** |
| 1 | Rigid OCS with all its components, fittings and fixtures including contact wire, OPC, TEW, RC and any other material required for installation. | | 0.5track kilometres |
| 2 | 25kV cable | | 0.5 km (in appropriate number of drums) |
| 3 | 25kV cable straight joints | | 5 Nos. |
| 4 | 25kV cable termination kits | | 2of each type |
| **B** | **27.5 kV GIS Spares** | | |
| 7 | Vacuum Circuit Breaker 2000 A consisting of 2 Vacuum Chambers in series | | 1nos |
| 7.1 | Vacuum Circuit Breaker 1250 A | | 1 no. |
| 8 | Drive motor for VCB | | 1no. |
| 9 | Drive Motor for Disconnector | | 1no. |
| 10 | Metal enclosed Voltage Transformer (VT) | | 1no. |
| 11 | Closing Coils | | 2nos. |

| Sr. No. | Item | Quantity | |
|---|---|---|---|
| 12 | Tripping Coils | | 2nos. |
| 13 | Blocking Diodes | | 2nos. |
| 14 | SF6 leakage detector | | 1 no. |
| 15 | One light weight assembling type ladder trolley | | 1 no. |
| 16 | Gas Analyzer (Dew point meter of latest specifications) | | 1 no. |
| 17 | Conductor mounting trolley – Aluminium type | | 1 no. |

Conductor mounting trolley shall be capable of safely installation and dismantling of all ROCS components (e.g. conductor rail etc.). The trolley should be capable of running on both tracks as well as ground section of tunnels.

G Spare shall be procured only after the approval from the engineer. The quantity of spares given can be increased or decreased by the engineer. The equipments/kits supplied should be as per latest specifications/models and should be compatible with the system (ROCS & ASS) being installed in this contract. Approval for the specifications should be taken from engineer before placement of the order.

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. The special tools, testing and diagnostic equipment and measuring instruments shall also include apart from the other necessary items.

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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 TS 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, abroad, 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 in Appendix K 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) 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 JMRC 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 Bidder 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
- Traction Power Supply equipment

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.

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# 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 provided in English and Hindi language both. The Contractor shall provide the Operation and Maintenance manuals in soft copy also (4 set).

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 five 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 **Working model for training**

The Contractor shall develop a working model for the training institute which will be used as a reference for producing a working prototype. This model shall represent the key physical characteristics of the selected ROCS system or process by having different types of switching stations, cable connections, OCS sections, transition arrangements, overlaps etc.

The model shall be minimum 10 meter in length and shall depict all the key information about the ROCS system so that the same can be simply understudied by the engineers.

The working model shall be provided indoor as well as outdoor for training of staff. The model will as per architectural, technical working models. The model should be designed to provide all the details and sections required for understanding the ROCS. The design of models shall be submitted to Engineer for approval.

END OF CHAPTER

# CONTRACT PACKAGE – JP/EW/1B/E2

# CHAPTER – 21

# PROGRAMME REQUIREMENTS

The programme requirements (Key Dates) for JP/EW/1B/E2 Lot 1 and JP/EW/1B/E2 Lot 2 have been defined in the Appendix-1A of Form of Tender

# CONTRACT PACKAGE – JP/EW/1B/E2

# CHAPTER – 22

# SITE FACILITIES

## 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:

- Fax & Phones (Telephone P&T line)
- Photocopier
- Computer with coloured A4 size printer & other
- Peripheral CS Writer, CD, Floppy
- Plotter
- Digital Camera

END OF CHAPTER