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BID DOCUMENTS

FOR

DEDICATED FREIGHT CORRIDOR PROJECT
(Western Corridor, Phase : 1 Rewari – Makarpura (Vadodara)

ELECTRICAL AND MECHANICAL WORKS

CONTRACT PACKAGE - 4
ICB No. EM P-4 :Rewari – Makarpura (Vadodara) Section

Volume III :Employer's Requirements
Power Supply, OHE and SCADA Systems

Section 9: Particular Specification

Engineer:
Dedicated Freight Corridor Corporation of India
(A Government of India Enterprise)

Consultants
NK Consortium
NK – JARTS – PBJ – NKI
Consulting Engineers

28TH MARCH, 2013

BID DOCUMENTS

FOR

ELECTRICAL AND MECHANICAL WORKS

Contract Package 4
for
ICB No. EM P-4: Rewari – Makarpura (Vadodara) Section

(Traction Power Supply, OHE and SCADA)

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1 General

1.1 Objective

1.1.1 This specification defines the objectives, guidelines and requirements for the design,supply, installation, testing and commissioning of the, traction power supply system, traction substations (TSSs), sectioning and paralleling post (SP), sub sectioning and paralleling post (SSP), auto transformer stations (ATS),supervisory control and data acquisition (SCADA),overhead line equipment (OHE), auxiliary transformers at level crossings, signal &telecom huts and emergency supply at stations on the Western Dedicated Freight Corridor included in phase-I; Makarpura (Vadodara) – Rewari Section(915 RKm).

1.1.2 The works to be executed under the Contract include but not limited to, system and equipment design, manufacture, procurement, verification, delivery, installation, testing including integratedtesting &commissioning, supervision of maintenance, training of Employer's staffand documentation for a complete System necessary to deliver the requirements of this Specification and enable Employer's maintenance set-up to take up preventive, predictive and directed maintenance upto the defect notification period.

END OF CHAPTER

2 Overview of the Project

2.1 Western Dedicated Freight Corridor

2.1.1 Ministry of Railways (MOR), Government of India has planned to construct a High Axle Load Dedicated Freight Corridor (DFC) covering about 3325 RKM on two corridors, known as the Eastern and Western Corridors.

2.1.2 The Western Corridor is planned from JawaharlalNehru Portat Nhava Sheva (JNPT), Mumbai to Tughlakabad/Dadri near Delhi. The Western Corridor of DFC Project covers a length of about 1,480 RKM (JNPT – Ahmadabad – Palanpur – Rewari – Asaoti - Dadri). Western Corridor is planned to be implemented in two Phases. The first phase envisages construction of about 915 RKM between Makarpura (Vadodara) and Rewari.

2.1.3 This specification applies only to the first phase of the Western Corridor.

2.1.4 The Project entails construction of double-track electrified railway lines capable of handling 25 ton axle load, trains of 750m, with single haul or 1500m with two coupled trains as long haul. Accordingly,loop lines in yards will be 1500m long capable of servicing two trains of 750m long each. In the first phase, although yard lines will be 1500 m long, crossing stations will have 750 m long loops with provision to extend them in future. The bridges and other structures will be designed to allow movement of 32.5 ton axle load, while the track structure will be initially designed for 25 ton axle load, operating at maximum train speed of up to 100 km/hr. The Overhead Equipment Design will provide for movement of double stack container on flat wagons and the contact wire shall be provided at a height of normal 7.54m above rail at support. The overhead electrification shall be designed with clearances as provided in the Standard Schedule of Dimension for Dedicated Freight Corridor Jan. 2013 for maximum speed of 120 kmph and shall permit raising of the tracks by 275 mm to allow ultimately axle loads to be increased to 32.5 tonnes in future.

2.1.5 The Western DFC Phase-I route has 10 junction and 20 crossing stations, as under:

TABLE 2.1-1

List of Junction and Crossing Stations on Rewari- Makarpura (Vadodara) Section

Rewari Junction	**Bangurgram Junction**	**Palanpur Junction**
AteliJunction	Haripur	Malosana
Dabla	Chandawal	**Mahesana Junction**
Bhagega	**MarwarJunction**	Ghumasan
Pacharmalikpur	Jawali	**Sabarmati Junction (N)**
Phulera Junction	Birolyia	**Sabarmati Junction (S)**
Sakun	Keshavaganj	Timba
Kishangarh	Banas	Changa
Saradhna	Swarupganj	Vasad
Srimadopur	Sriamirgarh	**Makarpura Junction**

Note: (1) Junction Stations are the interchange stations with Indian Railways& are indicated in bold letters.
(2) Junction stations are indicated in bold letters.

2.1.6 Trains will be hauled by 9000HP, 3 phase electric locomotives.

2.1.7 The formation of single trains shall be either 4500t container trains or 6000t bulk carrier trains. Trains may be coupled in formation of twin trains hauling 12000t bulk and 9000t containers with one engine in the middle of the train.

2.1.8 The section shall; be capable of haulage of peak traffic expected in the year 2031.

2.1.9 DFC Locomotive Depot will be located at Rewari. The Depot will serve as a maintenance centre for Rolling Stock (electric locos) running on the Western DFC.

2.1.10 The Freight Corridor will utilise 25 kV AT feeding system.

2.1.11 The first section of the Western Dedicated Corridor from Rewari to Makarpura is to be opened for commercial services in 190 weeks from date of commencement of Contract.

2.1.12 Out of the entire length of Phase-I, the priority section is Rewari to Dabla, which should be commissioned earlier to enable trial testing of 9000 h.p. locomotives for the corridor.

2.2 Description of Corridor

2.2.1 The route is to be constructed with the section being split in 3 portions for managing the civil engineering works and laying the tracks,as per following packages:

2.2.2 ICB No. CT P-1 & P-2 of the Corridor consists of a two track railway: from Rewari to Iqbalgarh. The corridor is approximately 626km long.

2.2.3 ICB No. CT P-3 of the Corridor consists of a two track railway: from Ikbalgarh to Makarpura. The corridor is approximately 289 km long

2.2.4 Besides there will be two more packages as described hereunder.

2.2.5 ICB No. S&T – 5 provides for contract forFour aspect colour light signalingwith permissive block signal spacing at approximately 2km intervals for the entire route.

2.2.6 ICB No. RS P-7 provides for contract for procurement of 9000hp, six axle locomotives for the entire route, construction of a depot at Rewari alongwith tracks, signalling & OHE inside the depot.

2.3 Salient Features of the Western Dedicated Freight Corridor System

2.3.1 The salient features of the Western Dedicated Freight Corridor are as follows:

(I)	Gauge	1676mm
(II)	No. of tracks	2
(III)	Shortest radius of curve	700m on main lines and 200m on Depot and yard lines
(IV)	Maximum gradient	0.5%, with one stretch of 1120 mtrs of 0.55%
(V)	System of current collection.	Overhead Equipment
(VI)	On Main Line	25kV AT feeding system, regulated poly-gonal type
(VII)	Rewari Depot	25kV ac regulated polygonal type OHE system
(VIII)	Crossing and Junction Stations	25kV ac regulated polygonal type OHE system

(IX)	Design Speed Main Line Depot Access Line Depot Test Track Depot Other Tracks Crossovers	 120 km/h 50 km/h OHE inside depot will be designed and erected by the Other Contractor (RS P-7)

2.4 Operation Control Centre

2.4.1 The operations control centre (OCC) for corridor shall be located inNational Capital Region.

2.5 Power Supply for Western Freight Corridor

2.5.1 Power supply shall be received at the Traction Substations (TSS) from the State Power Companies of Rajasthan, Haryana and Gujarat through 220/132kV, 3phase, double circuit transmission lines,while 14 TSS will be fed at 220kV, two will be at 132kV.

2.5.2 The power supply shall be stepped down at each TSS as follows:

(1) 54kV a.c. single phase,converted to 2 x 27kV by the TSS AT, which shall be distributed between feeder wire / catenary – contact wires / earth.
(2) 240 V, ac for auxiliary supplies.

2.6 Key Challenges

2.6.1 The traction, auxiliary power supply and SCADA systems for Western Dedicated Freight Corridor shall be designed following good Engineering Practices. The following are the Key Challenges presented to the Contractor.

a) Thetraction, OHE and SCADA systems shall be designed by the Contractor to support a 12minute headway operation in different operation modes of two single haul followed by one double haul (two trains coupled together) while offering speedy recovery from various perturbations.

b) 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 described in clause 14 of this specification and 1.12 of Section 8 (General Specification).

c) The Contractor shall carefully study the space envelopes (as per the Standard Schedule of Dimensions for Dedicated Freight Corridor, Western Jan- 2013) allocated for the installation of overhead line equipment to ensure that all relevant safety clearances and rules are complied with and performance requirements are fully met. The Contractor shall pay particular attention to the design of overhead line structures and foundations due to increased structure heights requiring a normal contact wire heights of 7.54 m to accommodate double stack containers and the presence of black cotton soil along the route at certain locations.

d) The layouts of TSS, SP, SSP, and ATS etc. shall be contained within either the existing land procurement or the right of way by resorting to longitudinal layout, if required.

e) Various interfacing issues with Other Contractors are required to be resolved to ensure timely completion of the Works. Whilst some of the interface issues have already been included in this document, some of them are yet to be identified and finalized. It is the Contractors responsibility to ensure that all interface issues are clearly defined and agreements sought from all relevant Other Contractors and State Power Companies in accordance with Chapter 17 of thisSpecification and interface matrix.

f) Need for interface with Other Contractors of the project, Indian Railways and other independent authorities such as Power Supply agencies for timely and successful completion of the project.

g) The System Design shall meet the specified performance and operational requirements stipulated in this Particular Specification. The Contractor shall conduct Simulation Studies in early design stage, to ensure that the system capacity and equipment design meet the Employer's Requirements.

h) EMI control including ensuring safe touch and step potential of the tracks and all metal work on the installation of the corridor of the route including the adjacent Indian Railway tracks and other outside agencies.

i) The traction equipment, the cable feeders, overhead equipment, auxiliary power supply, SCADA -, and other system components shall be designed and rated to withstand the atmospheric pollution and ambient conditions furnished in Chapter 19, Part - III of this Specification, relevant to the location, where they shall be installed.

j) The entire Scope of Works shall generally meet design requirements of safety and Protective provisions including Fire safety in accordance with National Building Code and Indian Electricity Rules.

END OF CHAPTER

3 Scope of Works

3.1 General

3.1.1 The scope of work to be performed under the Contract shall includebut not limited to system simulation of train operation for the projected traffic in the year 2031 to be run over the section, design, complete supply specifications for procurement of components, manufacture, verification, delivery, construction, installation of equipment, testing, including integrated testing, commissioning, technical support, supervision of maintenance, training of Employer's staff and Documentation for a complete system necessary to provide traction power supply from 220/132 kV traction substations, through 25 kV AT Feeding System traction overhead contact lines (OHE) capable of running bulk loaded double stack containers on flat wagons, complete with a central supervisory control and data acquisition system (SCADA) for running trains hauled by 9000 h.p. electric locomotives, a proportion of which shall also be in long haul (two train) formation. The scope also includes 240V single phase a.c. supply for auxiliary services of the route at level crossings, signal and telecom installations along the route and emergency stand by power supply at the stations.

3.1.2 This shall include any associated Works relating to satisfactory completion of the Work defined above on design-build lump sum price basis.

3.2 Design by Computer Simulation

3.2.1 The proposed capacities, ratings, number and locations of equipment as a basic requirement of the design development shall be demonstrated by a proper design, calculation and traction simulation study. This shall be got approved by the Engineer before proceeding to workout the detailed system designs.

3.2.2 The Contractor shall satisfy himself that the indicative minimum capacities, ratings and quantities of equipment as specified herein meet the operational requirements of the Western Dedicated Freight Corridor. Otherwise the Contractor shall adopt higher capacities,ratings,quantities as per outcome of simulation study conducted by him with the approval of Engineer. Any modifications in the specifications/technical details of equipment as specified in this PS shall be advised by the Contractor to the Engineer for his approval.

3.2.3 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, operable and maintainable traction power supply system for the phase I of the Western Dedicated Freight Corridor SCADA System at OCC shall however be capable of the taking care of additional requirements of phase-II(Makarpura – JNPT) having tentatively 10 nos of TSSs, 10 nos of SPs and a total of 34 SSPs and 4 stand alone ATs (to be installed at a later date) in the OCC architecture.

3.3 Scope

The Contract shall include but not be limited to the following Works:-

a) Provison of sixteen (16) Traction Substations (220kV 14 locations, 132kV – 2 locations) ac 3 Ph/ 50kV for 25kV AT Feediing System) For the purpose of adequate redundancy alongwith economy alternate TSS shall be equipped with one transformer, with provision to install the second transformer at a later date. All civil works and ancilliary structural works for the second transformer for these TSSs are included in the scope of this contract.
All TSSs shall be outdoor type located at surface level.

b) **Sixteen** Sectioning and Paralleling Posts (SP) of outdoor type located at surface level.

c) **Sixty** Sub Sectioning and ParallelingPosts (SSP) located at each end of all stations (Junction and Crossing) opposite the cross-overs between Up and Down Main Tracks. In addition there are **17** (Seventeen) SSPs in mid-sections totaling **Seventy Seven SSPs**. Details of sectioning requirements are indicated in General Traction Supply Diagram (Vol. V)

d) According to the indicative study, Auto Transformers shall be provided at each TSS and SP and in between, to ensure their interval remains within 13 -17 km. Accordingly 17 midsection SSPs will have at midsection SSP.In addition, at some of the Station SSPs Auto Transformers while there will be five standalone AT Stations. shall be required to be provided. However, ATs positioning along the mainline shall be derived from System Simulatin Study. At Five locations only stand alone outdoor Auto Transformer Station shall be located in midsection.

e) These locations shall be reviewed during Traction Simulation Study and final Traction General Supply Diagram shall be designed to be approved by the Engineer.

f) 240Va.c. single phase auxiliary low voltage supply shall be drawn from 25kV traction circuit at all supply control posts and Auto Transformer Stations.

g) 240 V single phase a.c. auxiliary supply from OHE, shall also be provided along the alignment to:

- Crossing and JunctionStations, as emergency supply for essential loads.
- Signal & Telecom Control huts along the entire route at approx 7 km intervals
- Manned level crossings on DFC

h) Capacities and indicative numbers of auxiliary transformers to be provided for the project at each of the location are furnished in the Table below:

Table 3.3-1 Capacities & Number of Auxiliary Transformers To be provided

	Minimum Capacity in (kVA)	Nos. at each location	Locations	Total Number of Aux. Trans-former
Traction Sub-station	100	2	16	32
Sectioning Posts	10	2	16	32
Sub-Sectioning Posts	10	2	77	154
Auto Transformer Stations	10	2	5	10
Crossing + Junction Stations	25	2	30	60
Signal + Telecom Huts	10	2	154	308
Level Crossings	10	2	2	4

Total Auxiliary Transformers : 100 kVA -32
: 25kVA -60
: 10 kVA - 540

Note (1) : The scope of work for Low Voltage Supply from traction supply
a) Crossing and Junction Stations
b) Signal & Telecom Huts
c) Level Crossings
shall be limited to terminating the supply at the changeover switch between two auxiliary Transformers on up and down tracks.

i) The Contractor based on the ground survey and the Traction Power Simulation Study shall prepare a General Traction Power Supply Diagram for acceptance by the Engineer as a basic design for finalizing the Construction drawings for the Traction Power Supply Installation.

j) "Complete Cable and cross-feeder network and cable support system" including the following:

- 25 kV ac cable/ overhead connection from TSSs, SPs, SSPs and ATSto overhead feeder and current collection system.

- Return current cabling and bonding along the alignment, andin yards.

- Auto transformer connections to the rail.

- All connections for traction bonds, including exothermic welding or any other approved process for connection with the head hardened rails.

k) 25kV AT Feeding System ofoverhead equipment (OHE) on main lines of Western Dedicated Freight Corridor including optimum conductor type, sizes, tensions based upon simulation study.Besides,temperature rise of conductors & uplift of contact wire under static and dynamic conditions should also be covered.

l) 25kV overhead equipment (OHE) system in junction & crossing stations including the connecting routesto Indian Railways.

m) Provision of swivelling type OHE for about 750 m on one of the ballast sidings at - Bhagega crossing station in consultation with the Civil and Track Works Contractor to ensure adequate implantation of traction structures to facilitate top loading and unloading of consignments from wagons.

n) Provision of split anchor for catenary and contact wires either on the same mast or two separate masts through different regulating equipment for at least one tension length of the OHE.

o) Protective provisions relating to electrical safety and earthing, which include earthing and bonding of equipment, cables and non-current carrying metallic components, etc. Protective provisions include protective earth conductors mounted on masts with earth connections at regular intervals including connections to the buried earth conductors, Earthing and bonding plans for the Contract, as required for Indian Railway tracks or any other adjacent metallic structures for other independent authorities to help them provide for protective provisions against EMI from 25kV traction currents of the DFC.

p) All joints, where galvanishing has been damaged, shall be appropriately protected against corrosion through protective painting including that of bituninus painting for joints in the ground.

q) All civil works or modifications required for installation of the equipment and restoring to final finishes. This shall include but not limited to preparation and leveling of ground, ground investigation, hydrological studies, earth filling to lift the land 0.5 m above highest flood lowest point in the installation such as the bottom of the cable trenches or ducts in the building, construction of the building, cable trenches, access roads, fences, drainage, OHE and otherfoundations, traction equipment/ component foundations and containments.

r) All overhead equipment structure foundations along the alignment of the Western Dedicated Freight Corridor (including stations and connections to Indian Railways).

s) Spare parts, special tools, testing, diagnostic equipment and measuring instruments.

t) Documentation

u) Supervision of Maintenance

v) Furniture, shock treatment charts, rubber mats, fire fighting, first aid boxes and danger notice plates etc.

w) Site facilities for the Engineer's Representative

x) Signs, labels and notices

y) Installation of check meters on the 220kV/132kVpower supply incoming side in a separate cubicle foreach TSS, which should have communication with OCC through SCADA.

Supervisory Control and Data Acquisition System for the entire works

3.4 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) Interface management (Chapter 17 of this PS)

d) Ground Investigation including,survey, design, identification of locations and installation for foundations for trackside equipment and for any other equipment in TSS, SSP, ATP and SP.

e) System operations and maintenance support services;

f) Training for Engineer's training instructors, operators, maintenance and engineering officials;

g) Decommissioning, removal and/or responsible for disposal of Temporary Works;

h) Prototype and Factory Acceptance Testing as per test plan

i) Defects liability of Permanent Works after commissioning as stipulated in the General Conditions (GC),

j) Assist in obtaining statutory clearances and submittal of information asked for by statutory bodies (e.g., Government of India, Ministry of Railways, Commissioner of Railway Safety, Electrical Inspector to Govt. of India (EIG) etc. as directed by Engineer).

k) Provision of integration test plans for commissioning of the electrification works including power supply and SCADA.

3.5 Documentation

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

3.5.1 Following Contract document shall be approved by Engineer with the consent of Employer:

a) Design Manual
b) Earthing and Bonding Management Plan
c) General Traction Power Supply Diagram and Sectioning Diagram
d) Pollution Map of the Section
e) Protection System Scheme and its calculations
f) SCADA System
g) EMC Control and Management Plan
h) Interface Management Plan
i) Prototype Test Plan
j) Power Quality and Power Correction Methods

k) Installation and Commissioning Plan

l) List of items for which specifications are to be drawn by the Bidder based on functional requirements.

3.5.2 Following Contract document shall be approved by Employer to be submitted through Engineer:

a) Type Tests
b) Factory Acceptance Test
c) Training Plan
d) Operation and Maintenance Plan

3.5.3 Technical Design Stage

a) Design philosophy adopted

b) Multi train simulation study for determination of :

1. Traction power supplies requirements to ensure optimum voltage regulation at the Sectioning and Paralleling Posts or adjacent TSS (for emergency feed conditions).
2. Demonstrating the number and location of ATs along the track to provide satisfactory voltage level.
3. The simulation shall determine the EMI including telecom interferences. Fault level and short-circuit calculations;
4. Normal and peak currents in various feeders
5. Short time peak RMS current and corresponding maximum permissible currents in various feeders
6. Ultimate location and distribution of TSSs with double / single HV transformers.
7. Feeding arrangements under various supply failure scenarios;
8. Equipment ratings, specifications with schedule of guaranteed performance (SOGP);
9. Conductor sizes including those for the Overhead Equipment, (if required), the 25 kV feeder and the - Aerial Earth Conductor and or Buried Earth Conductor;
10. Designs of TSS, SSP, SP and ATS suitable to the size and shape of the land available for them;
11. Design of connection for 220/132kV intake including control and protection strategy between the TSS and the State Power Company's equipment;
12. Design of protection systems and their calculations;
13. Proposed design of Power quality correction equipment;
    Estimate and indicate the Voltage unbalance and THD imposed at point of common coupling (PCC) with power supply authorities
14. Rail accessible and touch potential under normal and fault conditions, which shall remain within safe limits. (EN -50122)

15. Earthing requirements and calculations of safe touch and step potentials for the entire system; including those on adjacent structure and IR lines running parallel to DFC alignment; (EN-50122)
16. Intervals of interconnection between earth conductors both overhead and buried and their connection to earth mats/rails.
17. Lightning protection measures;
18. Contact Wire and pantograph interface study.

c) Detailed Design & Tests
1. Type test reports for equipment or component selected;
2. Detailed design drawings and reports;
3. Detailed interface reports and interfacing design drawings;
4. Hazard identification and control documentation;
5. Earth Resistivity Measurement;
6. Project wide EMC control and management plan;
7. Project wide earthing and bonding plan and its management;
8. Protective system proposed alongwith automatic fault location (AFL) with its suitable algorithm to isolate the faulty section on OHE and feeder with high degree of accuracy of a maximum error of 200m.
9. Pollution mapping for identification of polluted zones warranting use of higher creepage path insulators;
10. System reliability, availability, maintainability and safety evaluation reports (RAMS);
11. Systems integration plan and proposed tests;
12. Designer's guarantee;
13. Project wide integration testing plan;
14. Equipment, conductor & fitting specifications and their schedule of guaranteed performance.

The system shall be designed in such a manner that all future proposed additions & alterations shown on approved plans are provided for in the Design and erection of equipments so that with minimum modification / reconstruction, these additions are incorporated in future requiring minimum shut down to the installation.

d) The Design Manual

3.5.4 Construction Stage

a) Construction and Installation Plan;

b) Factory acceptance test plan for equipment;

c) RAMS plans;

d) Operation and maintenance manuals covering, installation, operation and maintenance instruction of all equipment;

e) Records and drawings of equipment to be installed;

f) Inter connection drawings;

g) Site test report of equipment;

h) Earthing and bonding plans;

i) Updated EMC control plan and certificates

j) Updated traction simulation model verified against testing data;

k) Site access control system proposed to the Engineer;

l) Testing and commissioning documents, as required by the Engineer.

m) As built drawings including interface drawings;

n) All other records of construction, including hidden parts;

o) Other documentation as required, by the Engineer.

The drawings and documents to be submitted for each stage of construction shall be proposed to the Engineer for his approval and subsequently used for construction.

3.6 Furniture

3.6.1 The Contractor shall provide requisite furniture at TSS,

3.6.2 The Contractor shall submit the details of the furniture to the Engineerfor review and approval.

3.6.3 The Contractor shall provide shock treatment charts, rubber matting, fully equipped first aid boxes, eyewash kits, danger plates, fire fighting system & equipment, etc. being statutory requirements in adequate number. The safety instructions and danger plates shall be exhibited at conspicuous locations.

3.7 Provision of Work Sites

3.7.1 The Contractor shall be responsible for setting up and managing storage and logistics at sites along the route of the Dedicated

Western Freight Corridor to ensure speedy coordinated construction work.

3.7.2 All work sites that are not part of the Works shall be remediated to their original condition on completion of construction.

3.8 Items of Work Excluded from Contract

3.8.1 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 parties and Other Contractors, as required. These items are detailed below and also covered in Chapter 17 of this Employer's Requirements.

a) 220/132kV transmission line from State Company's Grid Substation to the 220/132kV incoming gantry at each TSS. The incoming gantry shall be provided by the Contractor;
b) Construction of OCC buildings will be by Other Contractor
c) Fiber Optic Cables for SCADA between OCC and TSS, SP, SSP, andAuto Transformer Post (ATP). These will be the activities of contractor for package ST-P5;
d) SCADA video wall at the OCC shall be provided by ST P-5. The point of common coupling between the Contractors for EM P-4 and ST P-5 will be at the connections to the video matrix.
e) Furniture in OCC Room.
f) Low Voltage power supply from changeover switch onwards.

END OF CHAPTER

4 Design and Functional Requirements

4.1 General

4.1.1 The design, supply, installation, testing and commissioning of the Traction power supply OHE, SCADA systems and auxiliary power supply – shall meet the design and performance requirements within the design environments specified in this PS and the GS.

4.1.2 Further the Contractor shall carry out all investigations necessary for the design of the Permanent Works and to enable the determination of the methods of construction and the nature, extent and design of Temporary Works.

4.1.3 The Contractor shall investigate environmental factors to determine suitable methods of manufacture and installation, both for Temporary and Permanent Works. In particular the Contractor shall ensure that the dusty environment,rocky terrain and earth resistivity having detrimental effect to the functionality, reliability or long term maintainability of the Permanent Works.

4.2 Design Environment

4.2.1 The traction overhead equipment and auxiliary power systems shall be fully operable and maintainable without deterioration, in the climatic and atmospheric conditions as indicated in –Chapter 19 of this Employer's Requirements.

4.3 Functional Requirement

4.3.1 The traction power supply systems with control through SCADA System on the Western Dedicated Freight Corridor shall deliver safe, adequate and reliable 25kV AT Feeding System (25kV ac in the yards) to the electric trains via overhead equipment and single phase 240 V ac supply for S & T installation on the route, emergency supply at stations and at level crossings.

4.3.2 The Contractor shall prepare and submit specifications, which shall 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 environment condition stipulated in Chapter 19 of this Employer's Requirements. The Contractor shall identify by manufacturer model and part number of each system equipment, which he plans to install. The Schedule of Guaranteed Performance (SOGP) shallbe provided by the Contractor for each vital/major equipment and shall be approved by Engineer.

4.3.3 Unless specific authorization to the contrary is given in writing by the Engineer in all design shall conform to the latest applicable standards as indicated Chapter 19 of this document.

4.4 Basic Design Philosophy and Requirementsfor Design

4.4.1 Conformity with Governing specification and Statutory requirements

The works shall be carried out in accordance with the following governing specifications and other statutory rules as per the priority given below:

a) Indian Electricity Rules – 1956 with latest amendments
b) Indian Electricity Act – 2003 with latest amendments
c) Regulations laid down by Chief Electrical Inspector to the Govt.
d) Rules and Regulations prescribed by local authorities as applicable
e) Relevant Indian standards,
f) Standard Schedule of Dimensions (SOD) for DFCC - 2013 and the Indian Railways Schedule of Dimensions (2004) for the works concerning Indian Railways and connecting tracks,
g) RDSO Specifications and Drawings,
h) Design Manual for Electric Traction (Indian Railways)
i) Indian Railways AC Traction Manual
j) Electrical Safety Code and National Building Code
k) EN-50122-1 Railway Application, fixed installation – electrical safety, earthing and retrun circuits
l) EN – 50119 Electric Traction overhead contact lines
m) IEC Standards, British Standards and other national / international standards; a list of such standards is given in Parts IV, V, VI, VII and VIII of clause 19, provided always that these meet or exceed the requirements of the standards mentioned at (a) to (l) above.

4.4.2 Proven Design& Cross Acceptance Criteria

4.4.2.1 The Contractor shall develop the design based on this specification by using proven and reliable engineering practices. The design details shall be submitted with technical data and calculations to the Engineerfor review and approval.

4.4.2.2 The Contractor shall undertake multi train simulations of the whole route using a fully validated computer based multi train simulation package. The simulation study shall model normal operations, first failure and second failure conditions and perturbations.

4.4.2.3 The System, including all sub-systems and Equipment shall be of approved RDSO design/ specifications, wherever applicable and shall be subjected to prototype testing as per relevant RDSO Specifications.

4.4.2.4 . The Contractor has to develop design and specifications for these items based on draft specification/ functional requirement, if available, and prepare detailed specification for approval of the Engineer with the consent of Employer.

4.4.2.5 Cross acceptance criteria will be applicable on following;

a) Items not covered by RDSO specification OR
b) Items being adopted for the first time in Indian railways (though RDSO specification may exist).

4.4.2.6 The cross acceptance criteria shall be as under:

a) THREE years satisfactory performance on AC Traction System prior to date of tender opening.

b) The manufacturer should have supplied the equipment of minimum 70% rating of equipment offered. Certificate from the user railway to be submitted in this regard.

c) The manufacturer/s should have supplied at least 20% quantity to be used in this Contract in last seven years OR they can supply, maximum five times the quantities supplied in last seven years.

d) Prototype test certificate for such items, if carried out in last Three (3) years to be submitted, otherwise fresh prototype test certificate shall be carried out.

e) Manufacturer shall have to support maintenance in India and supply spares till the design life of the material.

f) The manufacturer (OEM) may transfer technology to any Indian company for manufacture and supply 30% quantity used in the project provided original equipment manufacturer (OEM) has technology tie up with the Indian manufacturer and the OEM signs bank guarantee in this regard as per proforma appearing at Part XIII of Chapter 19 of this specification.

In order to ensure satisfactory transfer of technology, the OEM shall provide:

a) Design Drawings
b) Manufacturing Drawings
c) Process Sheets for Manufacture
d) Inspection and Quality Management Procedures
e) Complete Material Specifications
f) Jigs and fixtures
g) List of Machinery and Plants alongwith their functional specifications, which are need for manufacture
h) Manufacturing Supervision
i) Inspection by OEM's representative
j) Any other assistance, that may be reasonably required.

These equipment shall be guaranteed for satisfactory performance for a minimum period of THREE years.

4.4.2.7 Any approval to the prototype tests by the Employer in no way would absolve the Contractor of his responsibility under the terms of the contract for the equipment.

4.4.3 The design philosophy shall meet the following criteria:

a) Service proven design;
b) Minimum life cycle cost;
c) Low maintenance cost;
d) Use of interchangeable, modular components;
e) Extensive and prominent labeling of parts, cables and wires;
f) Use of unique serial numbers for traceability of components;
g) High reliability;
h) Low energy loss;
i) Fail safe design;
j) Adequate redundancy in system;
k) Fire and smoke protection;
l) Use of fire retardant materials;
m) Environment friendly;
n) Compliance with noise regulations;
o) Adherence to operational performance requirements;
p) Maximum utilization of indigenous materials and skills, subject to quality conformity;
q) Compliance with relevant standards;
r) Maintainable throughout the design life;
s) Use of open systems;
t) Use of substation automation and smart grid technology at TSS, SP, SSP & ATS to enable optimize performance with due economy;
u) Design for mechanized delivery, construction, installation, maintenance and inspection;
v) Compliance with all statutory regulations.
w) System shall be designed to meet the peak requirement of traffic

4.4.3.1 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.

4.4.3.2 The Contractor shall demonstrate, to the satisfaction of the Engineer, that appropriate insulation co-ordination for all electrical equipment is incorporated in the design of the Traction Power, OHE and SCADA system. The study shall take into account the installation of surge arresters at appropriate locations.

4.5 Design Submission Requirements

4.5.1 The Contractor shall perform his designs for the Contract in accordance with the requirements of Employer's Requirements (Sections 8 and 9). The Contractor shall submit to the Engineer's Representative for his review, relevant design information as identified under each stage. Such submissions shall incorporate the relevant Standards applicable.

4.5.2 The design submission schedules and their stages as detailed in Vol. I (2/2) Section 6.

4.5.3 Stages of Design Submissions

4.5.3.1 There are Five crucial design submissions viz. Inception Report, Train and traction Simulation Report , and its conclusions, Basic Designs of the System and the Sub-systems (traction Power, Over Head equipment and SCADA), The Construction Design and finally the As-Built Document and

4.5.3.2 One additional submissions viz.

4.5.3.3 "Design Plan Submission" containing the various programmes / plans / procedures and

4.5.3.4 Technical Designs containing the various reports / drawings etc.

4.5.3.5 The items to be submitted in the six design submissions (five crucial submissions and one additional submission).

4.5.4 Inception Report and Traction Simulation Report:

4.5.4.1 Based on the Contractor's Bid Design and Technical proposals during the bidding process, the Inception Report submission shall provide the approach to the design and execution of 25 kV AT Feeding System, based on a study of heavy haul freight or high speed passenger systemsaround the world and the approach the Contractor wishes to take so as to provide a most cost effective and reliable system designs for Freight Corridor with adequately detailed drawings and documents for the purpose of review of the Employer's Requirements. This shall be reviewed through the Computer based Train Operation and the Traction Power Simulation, on the Engineers data and approved by the Engineer. Based on the approval of the Engineer, the technical Design shall be developed in the Design Phase.

4.5.4.2 The Inception Report shall be sufficiently detailed to show the requirements for the main elements of the design such as capacities of the traction transformers, the Auto transformers, the ratings of the switchgear and the conductor sizes, earth conductor sizes and their fittings.etc so that all items necessary to develop the basic component designs and their assemblies, their installation and testing are provided.

4.5.4.3 Basic and detailed Designs of the System and the Subsystems: Subsequent to the study conducted as detailed above,the Contractor shall develop his basic designs of the System and the Sub-systems for traction Power Supply to the Locomotives finalizing the Ratings of the Equipment, the switchgear, the conductors of the Traction Overhead System, including the Control and Protection Systems and SCADA. The Safety of the entire Railway Network including the work to be done by Other Contractors (Civil Engineering, Signal Engineering, and the communications) for earthing and bonding shall be an important document to be prepared for approval by the Engineer. Works of Earthing and Bonding required on the adjacent Railway network of the Indian Railways of both electrified and non-electrified systems running parallel to the Freight Corridor against induced current from 25 kV AT Feeding System shall also be prepared so as to provide a safe environment. The works of the Other Contractors shall be monitored through interface coordination. The Basic and detailed Design Report submission shall also provide details for but not limited to the following:

4.5.4.4 The design shall be coordinated fully with the requirements of the signaling and train control system, and with the final track-work, the Civil and Track Works design, including drainage and service roadways, and any specified design requirements that those systems or facilities may dictate for the operation and management of the railway. The alignment of storm drains along the track shall be co-ordinated with civil contractors (CT-P1, CT-P2 and CT-P3) to ensure that the alignment of the OHE structures and storm drains do not obstruct each other. The OHE final design shall be engineered by the Contractor in accordance with the design criteria, specifications, codes and standards contained or referenced in the Employer's Requirements (Section 8 and 9).

4.5.4.5 The design of OHE supports, on two long bridges (on rivers Sabarmati and Mahi) and their earthing shall be coordinated with CT-P3A Contractor

4.5.4.6 In addition, the Contractor shall submit during the design stage the following:

(1) The first 4 month's Rolling Programme as described in Sub Clause 1.8 of G.S. [Project Programme Requirements] ;

(2) The project organization plan.

(3) A review of the General Arrangement and the General Supply Diagram provided by the Engineer.

(4) A review of the Final Alignment Drawing for assessing the type and quantum of Traction Overhead Erection work required. and for planning the supply of materials and execution of the work within the time frame finalized in accordance to with the Coordinated Events and key milestones available for access to the site of Works.

(5) A review of Right of Way (ROW) , and land in the station yards and of the Site Plans for the land acquired for TSS,

SPs and SSPs and AT Stations where traction installation may need to be located. .

(6) The preliminary Construction Method Statement giving Method of Construction work including that for foundations, mast erection, bracket erection, wiring and adjustments for OHE.

(7) A proposal of the Work Areas outside (e.g. proposed locations and design of Contractor's Temporary Works i.e. construction depots, plants, steel, fittings and other component stock pile areas, storage, workshops, camping areas etc required to execute the Work according to the time frame;

(8) Preliminary typical main line and Station Yard OHE Layout Plans and their sectioning .

(9) General Arrangement of equipment at Traction Power Supply and Control Posts.

(10) Slewing plan for Indian Railways tracks infringing location of Masts, if any.

(11) Preliminary design of OHE structures on bridges (Important and Major Bridges, and viaducts longer than 50 m.

(12) Preliminary design of OHE under Overline structures such as ROBs, Rail Fly Overs, through girder bridges, Foot Over bridges etc.

(13) Preliminary earthing and bonding diagram for structures and metal work along the track & in vicinity.

(14) Proposed location for setting up of material testing laboratories;

(15) Proposed construction methods and installation of equipment and structures at TSS, SSPs and SPs.

(16) Proposed Construction machinery and equipment to be used for foundation work, Mast erection, Bracket ejection, Wiring, adjustments etc

(17) Proposed software's to be used for design activities;

(18) The preliminary Design Manual including the identification of design codes and standards (ref.chapter 19 of this Specification);

(19) two original sets of the full edition of the publication / technical standards including Codes & Standards and other documents that the Contractor proposes to use for the Work

(20) An updated Design Submission Programme (ref. sub-clause 1.8.10 of Clause 1.8 of G.S. and Table 1.10-1 of Clause 1.10 of [Requirements on Documents and Drawings] Employer's Requirements–General Specification);

(21) Preliminary Combined Services Drawings (CSD);

(22) Preliminary structural drawings with finish schedule for the Building Works at TSS and SSPs and SPs.;

(23) Preliminary MEP drawings for the Building Works;

(24) The preliminary Traffic Management Plan for working of the OHE Construction Train.

(25) The detailed and comprehensive SHE plans including ESMP (ref. clause 1.2.2.2 & 1.2.2.3 of Appendix 2 Project SHE Manual to Employer's Requirements – General Specification);

(26) The Project Quality Assurance Plan;

(27) Proposed on site and off site testing arrangements for testing and quality control of input materials; and

(28) Manufacture, Installation and Construction Methods

(29) Procurement Programme for Manufactured Items (ref. sub-clause 1.8.14 of Clause 1.8 of Employer's Requirements – General Specificaton;

(30) Proposal for physical progress report & basis for measuring the progress of the Work.

(31) Master list of technical documents, which Contractor proposes to prepare and submit to the Engineer for his approval(ref. sub clauses 1.10.1 & sub clause 1.10.12 of Employer's Requirements – General Specificaton;

(32) RAM specifications and studies expected during the Project to demonstrate the achievement of specified targets Chapter 7 of Employer's Requirements – General Specificaton;

(33) Design Warranty Format.

4.5.5 Design Submission Plan

Subsequent to the Inception Report, within 28 days after the Commencement Date, the Contractor shall submit the "design plan Submission" containing the following plans and programmes to the Engineer for consent to commence the respective activities and with which he executes the subsequent submissions in a consistent and organized manner. Those are:

(a) the Contractual Construction Programme as described in sub Clause 1.8.6 of Clause 1.8 of – General Specificaton;and sub clause 1.10.25 of [Requirements on Documents and Drawings] Employer's Requirements–General Specification);

(b) Validation of Data including Geotechnical Investigation and drawings provided by the Engineer and additional Surveys required to be carried out by the Contractor

(c) the CAD and Document Control Procedure as described in sub clause 1.10.1 of and Clause 1.1 of Appendix 1 to Employer's Requirements - General Specificaton;

(d) the SHE policy as described in Clause 1.2.2 of - Appendix 2 Project SHE Manual to Employer's Requirements - General Specificaton.

4.5.6 Design Manual

4.5.6.1 The Design Manual shall incorporate all design requirements including standards, codes, loading cases, permissible movements and deflections, limit states, design stresses and strains, electrical and mechanical properties of materials and all other documents or matters which are relevant to and govern the design. The Design Manual shall refer to all materials, codes and standards used, making clear their specific applications. The Design Manual shall be produced so that it can be used by those involved in the preparation or review of the design of the Works as a comprehensive reference text and efficient working document.

4.5.6.2 The initial submission of the Design Manual shall be soon after finalization of equipment and ancillary component ratings and designs and be further developed during the Design Phase.

4.5.6.3 The Contractor shall supply two copies of single user train operation and traction power supply simulation software.

4.5.7 Document Control Procedure

The Document Control Procedure shall include CAD standards and the document/ drawing requirements including their format and numbering systems as detailed in Clause 1.10.1 of [CAD and Document Standards] Employer's RequirementsGeneral Specificaton and also include the procedural requirements described in Clause 1.10 of [Document Submission and Response Procedure] of the Employer's Requirements – General Specification.

4.5.8 Technical Design

4.5.8.1 Based on the Contractor's Bid Design and Technical proposals during the bidding process and supplemented by the Inception Report, the design of the Works shall be developed to the Technical Design by the Contractor. The developed and updated drawings and documents shall be submitted in the Technical Design Submission.

4.5.8.2 In the course of the Technical Design Development, the Contractor shall submit the Site Location plans of all the installation.

4.5.8.3 These drawings shall finally be converted to Layout Plans as a part of As Built Drawings after construction, duly corrected.

4.5.8.4 The Technical Design Submission may be divided into multiple submissions as consented by the Engineer. In such a case, submittals which are commonly applicable to the subsequent submissions such as Employment Schedules of structures and bracket tubes, shall be submitted in the initial submission and each submission shall include correlated and interdependent submittals so as that each submittal is logically independent and consistent. The all divided Technical Design Submission shall be integrated and compiled into one package at the time when the final submission is made and the compiled documents and drawings shall be submitted to the Engineer for consent and issue of Notice of No Objection and will be collectively referred to as the Technical Design.

4.5.8.5 The Technical Design Submission shall be a coherent and complete set of documents, properly consolidated and indexed and shall fully describe the proposed Technical Design. In particular, and where appropriate, it shall define but not limited to :

(1) the dimensions of all major features, structural elements and members;

(2) All components and their specifications.;

(3) location, geometry and setting-out of all main elements and features;

(4) The OHE Pre-pegging and Pegging Plan and the Cross Section Drawing.

(5) OHE profile Drawings shall be drawn for all locations where the contact wire height is altered,

(6) provisions and proposals for construction interfacing with the Other Contractors and Interfacing parties;

(7) uncharted utilities to be diverted including charted utilities of 33kV & below overhead power lines along with all the documentation for their physical diversion as per the consented procedure

(8) Indian Railway tracks infringing DFC tracks and to be dismantled / remodeled; and

(9) Traffic Management

4.5.9 In the Technical Design Submissions of the Design Submission Programme, the Contractor shall not, without the prior written consent of the Engineer**:**

(1) revise or alter the content of any document and / or drawings in the design package which have been submitted to and approved by the Engineer. The Technical design shall be developed based upon the previous submission(s) unless otherwise the Engineer approves the change in the contents;

(2) reduce the periods provided for review by the Engineer of any submission of design, design data and materials as set out in the Design Submission Programme;

(3) revise the sequence of submissions of design, design data and material as shown in the Design Submission Programme.

(4) Any non-conformity to the design development and the Design Submission Programme as stated in the above requirements shall have no effect whatsoever under the Contract.

4.5.10 Technical Drawings and Documents

The Technical Design Submission shall include, where appropriate and without limitation, the following documents:

(1) List of Technical Drawings to be submitted

The Technical Drawings based on the technical design shall be in part a set of drawings which describe integral feature of the Permanent Works strictly in compliance with the Employer's Requirements including, but not limited to, general arrangements, layouts of structures, all materials with associated fittings, all machinery and equipment with associated fittings and drawings which supplement the above. The Contractor shall submit including but not limited to the following drawings as a Technical Drawings submission:

(A) OHE

(i) the OHE lay out of the Traction Overhead equipment on the Final Alignment Plan of main and the yard plans [including but not limited to offsets from the parallel IR tracks,

(ii) OHE profile Drawings through Overline structures, bridges & viaducts.

(iii) general arrangement, location plan, geometry, and setting out drawings;

(iv) the Cross Section Alignment Drawings at all OHE structures

(v) the Structural Drawings for Masts and Portals for OHE and Switchyards of Traction Supply Posts.;

(vi) Earthing and Bonding Plans.

(vii) OHE Sectioning Diagrams of main lines and yards;

(viii) Details of connections with Indian Railways including the details of sectioning and traction control switching.

(ix) OHE Structural Steel –masts and portal structures for support of the Overhead Conductor. Head spans shall not be used except at locations where the Contractor has received permission from the Engineer.

(x) Small part steelwork Fabrications – galvanized small part steelwork (SPS) assemblies required to support OHE, some of which may be special structural assemblies.

(xi) The fittings, structures and conductors as far as reasonably practicable standardized throughout the whole length of the Western Dedicated Freight Corridor. The Contractor shall interface with Contractor EM-P7 in regard to ensuing the similarity of OHE equipment, fittings etc. between main line and depot OHE for provision of Overhead equipment in the Depot.

(xii) Foundation layout of structures and equipment

(B) TRACTION POWER SUPPLY

(a) Cross section drawings at TSS, SP, SSP and AT stations

(ii) Level & filling cross section drawings of TSS, SP & SSP

(iii) Incoming EHV transmission lines at the terminal Tower of Supply Authority and the TSS Gantry

(iv) Gantry for 25kV AT outgoing feeder to the OHE.

(v) Position and layout of control Room in TSS and Control Huts and Cubicles, SP and SSP and at AT stations.

(vi) Layout of Earthing system

(vii) Lightning Protection System

(viii) Fencing Layout

(ix) Equipment Layout

(x) Cable trenches.

(xi) Drainage of TSS Yard including that for Cable trenches.

(xii) Outdoor yard layout, Busbar supports

(xiii) Outdoor yard Illumination Lay Out .

(xiv) Clearance drawings of outdoor equipment, bus bars and conductors

(xv) Cable Run Layout

(xvi) Connection of TSS to Adjacent Track

(xvii) Switch Yard Scope and Drainage Drawings

(xviii) Soil Bearing Capacity and Soil Resistivity.

(2) Design Manual

The Design Manual initially submitted in the Inception Report shall be developed during the Design Phase and shall be included in the Technical Design submission.

(3) Design Submission Programme

One of the Works Programmes as described in Clause 1.8.10 of Employer's Requirements – General Specification.

(4) Technical Design Report

a) The report shall be a narrative report describing the Design Submission including its extent and relationship with other submissions. It shall include, a guide to all relevant technical data used and outline the design approach, standards used, design calculations & analysis particularly in respect of Traction Power Supply, Traction OHE, OHE sectioning, the protection scheme and the interlocking provided for a safe and reliable traction system. The design Report shall specify the limitations for the first failure and the second failure situations as a part of the reliability study.

b) Structural analysis report including loading diagram and input & output files of the approved software used for the design of traction structures.

c) For traction Power Supply System complete design document in respect of all the systems viz. earthing, HT/LT panels, interlocking arrangements, cabling layout, internal wiring, conduiting, illumination, HVAC, UPS, yard lighting etc. and shall also cover the illumination level at various location.

(ii) SCADA control

(iii) Contractor shall incorporate adequate standardization to ensure minimum variety and sizes of equipment, accessories, sub-assemblies, system and practices.

d) The report shall also include design submissions in regard to developing working EMI Mitigation/ EMC control and earthing and bonding codes for approval by the Engineer so as to execute the work by the Contractor and Other Contractors to ensure appropriate execution of these safety works, the completion of which is a necessary pre-requisite for completion of the project.

(5) Scale of rating of UPS, and battery supply details

(6) Interface Report on Other Contractors

The Report shall detail coordination and cooperation with the Other Contractors and specifically demonstrate provisions for them, indicating arrangements for safe earthing and bonding of metallic structures against induced currents for 25kV traction supply system. The Contractor shall refer the prepared Combined Services Drawings (CSD) with narrative clarifications.

(7) Testing and Commissioning Report

Details of proposals for testing and commissioning procedures for all relevant elements and equipment contained in the Works.

4.5.11 Works Management Plans

The Contractor shall submit the Works Management Plans with which he plans to execute the Works in compliance with the Employer's Requirements in terms of SHE provisions, Quality Assurance and other construction management and monitoring practices as part of the Technical Design Submission. The Works Management Plans shall include but not limited to:

(1) The Traffic Management Plan , as described in clause 2.9 and Appendix 2 - Project SHE Manual ofEmployer's Requirements – General Specification.

(2) The Site Quality Assurance Plan (as detailed in Clause 1.11 [Quality Assurance] of Employer's Requirements - General Specification;

(3) TheManufacturing Management and Quality Plans (as detailed in Clause 1.11 [Quality Assurance] of Employer's Requirements - General Specification.

(4) The On-site Inspection Plan for Resources Procurement (as detailed in Clause 1.11 [QualityAssurance] of Employer's Requirements - General Specification;

(5) Comprehensive Procurement, Testing and commissioning Programme (as detailed in Employer's Requirements – manufacturing, Installation, Testing & Commissioning and sub-clause 1.8.16 of Employer's Requirements - General Specification.

(6) Environment impact correction measures

(7) Temporary Works Design Report

A report which provides sufficient information on the design of the Temporary Works, including but not limited to construction depots, workshops , site offices, structural storage area, secure storage areas for non-ferrous components cables and conductors and their managements, temporary roads, labour camps etc. and other temporary construction works, if any, (as detailed in Clause 4.3 ofEmployer's Requirements - General Specification to allow the Engineer to assess their effects on the Works and to enable these to be taken into account in the review of the technical design.

(8) Construction Method Statement

A report which provides sufficient information on the methods of construction of the Works and Contractor's resources applied to his construction including labour deployment, accessibility, availability and deployment of construction equipment and work trains etc, to allow the Engineer to assess their effects on the Works and to check and monitor the quality and workmanship of the Works. The proposed methods shall have no adverse effects on partially completed works during the construction stage and shall ensure that the Works are statically and aerodynamically stable.

(9) Signage requirements and their design

(10) Manufacturing Management and Quality assurance plan in respect of each plant and equipment and manufactured material and shall contain all the data as specified in clause 5 of Employer's Requirements – General Specificaton Manufacturing, Installation, Testing & Commissioning.

(11) Anti-theft Charging of erected conductors and their management Plan

(12) Inspection Programme and Testing Proposals defining quality assurance and controls.

(13) Comprehensive Testing Programme (ref. clauses5.4 & 5.5 [Installation, Testing & Commissioning] of Engineer's Requirements – General Specification.

4.5.12 Technical Literature

Technical literature shall include detailed manufacturers' specifications and original catalogues or catalogue, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy the Engineer that proposed equipment and systems are suitable and adequate.

(1) Proposed Manufacturers

List of proposed Manufacturers of all equipment and materials, including all the other items for which choice of manufacturer is at the discretion of the Contractor, is to be submitted to the Engineer for approval. Proven track record in the Railways sector shall be the governing criteria.

(2) Labeling Schedule

The Contractor shall submit for approval, prior to installation, a schedule of all equipment and devices to be labeled and the suggested details, lettering, position and fixing methods of each label indicating its application

(3) Samples

The Contractor shall submit samples of all fittings and small components materials for approval. Major items of equipment are subject to type and other tests and are to be demonstrated in existing installations or by manufacturer's information, test certificates and reports.

4.5.13 The Construction Design:

Based on the Basic designs and the general arrangement designs and drawings, the Construction Drawings shall be prepared by the Contractor for approval and construction.

4.5.14 Construction Design

4.5.14.1 The Construction Design shall be the latest revisions of the documents and drawings comprised in the Technical Design, taking account of agreed responses to any comments appended to Notices of No Objection. The Construction Design shall also include the latest addition to the documents and drawings in the Technical Design to facilitate the construction execution.

4.5.14.2 The Construction Design Package shall be a coherent and complete set of documents in line with the Technical Design which has received "Notice of No Objection" from the Engineer, properly consolidated and indexed and shall fully describe the proposed Construction Design.

4.5.14.3 Contents of Construction Design Package
The Construction Design Package is a set of the documents and drawings which is defined as the above mentioned Construction Design and is a combination of two elements:

(1) Those produced by the Design Team of the Contractor from the consented Technical Design and incorporating any comments with the Notice of No Objection.

(2) Those produced by the Contractor to supplement the design and to show further details for construction.

4.5.14.4 The Construction Design Package shall be fully checked by the Chief Design Engineer in the Contractor's Design Team and by the Contractor's Representative in the Contractor's Construction Team and submitted by the Contractor to the Engineer for consent as described in Clause 1.11 [Quality Assurance] of Employer's Requirements - General Specification.

4.5.14.5 The contents of each of these two elements are listed below;

(a) Produced by the Design Team of the Contractor

(i) the Updated Technical Drawings;

(ii) the Updated Works Specification;

(iii) the Updated Technical Design Report; and

(iv) the Interface Report on Other Contractors.

(b) Produced by Construction Team of the Contractor

(c) Working Drawings as described in the Employer's Requirements - Design and as further detailed below.

(i) the Site Drawings: these are supplementary detail drawings which expand and explain the information shown on the Construction Technical Drawings based on the site conditions and dimensions existing there.;
(ii) the Fabrication Drawings: These are supplementary drawings of specific elements of the works such as for the switchyards, portal structures shown on the Construction Technical Drawings for the purpose of manufacture or fabrication of those element and erection.
(iii) All other drawings as deemed necessary by the Contractor for the accurate and safe construction of the Works in accordance with the Contract.

(d) Construction Documents as below shall be submitted:

(i) the Updated Construction Method Statement;
(ii) the Construction Sequence Statement: The document illustrates the sequence of one cycle of particular construction implementation in which such sequence is critical to maintain the quality, safety and/or any other important factors of the construction implementation.
(iii) the Updated Construction Programme; and
(iv) the Safety Risk Assessment: The analysis describes and evaluates the risks associated with the construction implementation anticipated in the course of the construction.

(e) Works Management Plans as described in the Employer's Requirements - Design and as further detailed below:

(i) the updated Project Organization Plan;
(ii) the updated Traffic Management Plan;
(iii) the updated SHE Plans;
(iv) the updated Site Quality Assurance Plan;
(v) the updated Manufacturing Quality Plan;
(vi) the updated On-site Inspection Plan for Resources Procurement

4.5.15 As-Built Documents

4.5.15.1 The As-Built Documents shall contain the As-Built Drawings and Documents, the Operation and Maintenance (O&M) Manuals and all other records included in the list below:

4.5.15.2 As-Built Drawings and Documents showing all changes from the Construction Technical Drawings of the Permanent Works. The as-built information shall include, but not be limited to the following;

(a) Changes to dimension and detail from the Construction Technical Drawings;

(b) Changes due to variation orders.

All As-Built Drawings and Documents for different category of structures and equipment shall be signed off by the Contractor's respective Construction Superintendent and the Contractor's Representative:

(1) Operation and Maintenance (O&M) Manuals

(2) Official letters regarding the design change acceptance;

(3) Certificates of acceptance between the Contractor and the Engineer;

(4) A construction diary;

(5) Design Certificate (as specified in Clause 1.11 [Quality Assurance] of Employer's Requirements - General Specification for all Internal Authorizations carried out.

4.5.16 Definition of Works Segments

4.5.16.1 The Works Segments shall be that used in subdividing the design of the Works of each installation of traction Power Supply, or each stretch of the traction Overhead Equipment, or each items of the any special works such as those on bridge structure or under over-line structure. It also includes major elements of the Work to be procured by sub-contract and the same includes the designs.

4.5.16.2 The Contractor shall use the Works Segment Table to determine the types of Works Segments and the type of design work to be included in each.

4.5.16.3 The size of the Work Segment for construction purpose shall be proposed by the Contractor and consented by the Engineer and approved by the Engineer.

4.5.17 Manufacture, Installation and Construction Methods

4.5.17.1 The Contractor shall submit complete documents and information pertaining to the methods of manufacture, installation and construction which the Contractor proposes to adopt or use, with details as applicable. The Engineer will then check to see whether, if such methods are adhered to, the Works can be executed in accordance with the Contract and without detriment to the Works (when completed) and to other works comprising the project and in a manner which minimizes such risk.

4.5.17.2 The Engineer shall inform the Contractor in writing within 21 days after receipt of the above information:

(1) that the Contractor's proposed methods of manufacture, installation and construction have the consent of the Engineer; or

(2) in what respects, in the opinion of the Engineer, the Contractor's proposed methods of manufacture, installation and construction**:**

(a) fail to comply with the Employer's Requirements and/or the Definite Design and/or the Final Design;

(b) would be detrimental to the Works and/or to the other Works comprising the project'

(c) do not comply with the other requirements of the Contract; or

(d) as to the further documents or information, which are required to enable the Engineer to properly assess the proposed methods of manufacture, installation and construction.

4.5.17.3 In the event that the Engineer does not give his consent, the Contractor shall take such steps or make such changes in the said methods or supply such further documents or information as may be necessary to meet the Employer's Requirements and to obtain his consent. The Contractor shall not change the methods of manufacture, installation and construction which have received the Engineer's consent without further review and consent in writing of the Engineer.

4.5.17.4 Notwithstanding the foregoing provisions or that certain of the Contractor's proposed methods of manufacture, installation and construction may be the subject of the consent of the Engineer, the Contractor shall not be relieved of any liability or obligation under the Contract.

4.5.18 Design Changes and Variation Procedure

4.5.18.1 In the event that the Contractor identifies a problem or other cause for a change in his design after the Construction Design has been submitted and consented by the issue of Notice of No Objection during the Construction Phase, then the Contractor shall propose in writing a solution and procedure either a Field Change Notice (FCN) or a Design Change Notice (DCN) depending on the severity of the change within the Contract.

4.5.18.2 A major design shall warrant a Design Change Notice and shall go through the full process of the Design Review Procedure as described in the Employer's Requirements – Design and Clause 1.11 [Quality Assurance] of Employer's Requirements - General Specification. Whenever site changes may be agreed at site level by producing a Field Change Notice, the Engineer shall decide whether the proposal shall be DCN or FCN.

4.5.19 Design Variation

4.5.19.1 Design Variation including Value Engineering may be initiated at any time prior to issuing the Taking-over Certificate for the Works. It shall be based on the provisions as stipulated in Clause 13 [Variations and Adjustment] of the Conditions of Contract. A design variation shall not comprise the omission of any the Works.

END OF CHAPTER

5 Performance Requirements of Traction Power Supply System

5.1 General

5.1.1 Traction power supply system shall be capable of meeting the entire demand of the service headway of 12minutes permanently with one adjacent TSS out of service. Each alternate TSSshall be equipped with one traction transformer. However, all associated fixed structures and bus-bars shall be erected so that the transformers and their connecting switchgear of HV and LV sides can be added at a later stage without any additions/modifications to the structures.

5.1.2 Normal feeding : is defined as "all traction equipment in service, with TSS supplying power upto the neutral section at the adjacent SP."

5.1.3 Emergency feeding: is defined as "a first failure condition that either:-

- Requires the by-pass interrupters to be closed at an SP and the supply from one TSS to be extended to the circuit breakers of the adjacent TSS.
- Requires the bypass coupling interrupter to be closed between the up and down lines and a supply to be extended onboth lines from one feeder circuit breaker as far as the adjacent SP.
- The isolation of a single auto transformer.

5.1.4 Under all emergency feeding conditions; full designed headway service shall be feasible without any loss of performance.

5.1.5 **First failure conditions (N-1) –** Under first failure of any one item of equipment in the TSS, SP, SSP andATS,full designed headway train service shall be maintained without any loss of performance.

5.1.6 **Second failure conditions –** Under second failure conditions, the traction power systems shall allow for a reduced train service/may consider extended headway /reduced speed of trains to operate in the affected section supported by train simulation study This would have to be approved by Engineer and provision should exist with the operator to choose a combination of above or any one of the above.

5.1.7 Traction power supply system shall meet the requirements given below in Table 5.1-1, 5.1-2 and 5.1-3 in respect of maximum and minimum voltages at any overhead current collection point.

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

5.1.9 Rolling stock characteristics and train operation data.

- Traction power supply shall be designed taking into consideration the rolling stock characteristics and train operation data given below in Table 5.1-1 and Table 5.1-2

Table 5.1-1 Rolling stock characteristics and train operation data

Item	**Western Dedicated Freight Corridor**
Maximum design speed	120 km/h
Maximum service speed	100 km/h
Adhesion	40% starting 30% Continuous
Continuous rated power at the rail	7 MW(Indicative only)
Acceleration 0-30 km/h for fully loaded train on tangent track	0.11 m/s/s
Service braking rate from 80 Km/h to standstill (fully loaded train on tangent track)	1.0 m/s/s (Loco) (Indicative only)
Emergency braking rate from 80-0 km/h	1.3 m/s/s (Loco) (Indicative only)
Type of rolling stock	Locomotive hauling flat wagons, well wagons and bulk wagons.
Type of Braking	Electro-pneumatic service friction brake, Electric regenerative brake
Design headway between trains	12. minutes
Maximum gradient	0.5% with only one section of more than 1 km at 0.55%
Max starting current per train	Approx. 360 A Peak
Efficiency of propulsion system	89% on full load

Note: Some trains are proposed to be operated in coupled pairs in heavy haul mode.

Table 5.1-2 Vehicle weights

Type of Vehicle	**Weight**
Locomotive	135.6 to 150 Tonnes
Flat & Well Wagons Laden	4500 tonnes(single haul)
Bulk Wagons Laden	6000 tonnes (single haul)
Flat & Well Wagons Laden	9000 tonnes (double haul)
Bulk Wagons Laden	12000 tonnes (double haul)

- The rolling stock characteristics are subject to confirmation from Rolling Stock Contractor under contract RS P-7 (Electric Locomotive and Maintenance Depot). The Contractor shall confirm the rolling stock characteristics with the RS P-7 as part of the EM P-4 design process.

5.1.10 Further details such as power & harmonics drawn versus time and distance characteristics for level of services at design headway shall be ascertained from the Rolling Stock contractor working under Contract RS P-7 Electric Locomotive and Maintenance Depot.

Table 5.1-3 Voltage Requirements
(Reference: IEC 60850)

Item	Freight Corridor
Nominal voltage	25 kV ac
Minimum Voltage	19 kV ac
Maximum Voltage	27.5 kV ac
Instantaneous Minimum Voltage (as specified IEC standards)	17 kV ac
Instantaneous maximum Voltage	29 kV ac

- The design of traction power supply system shall provide a voltage range of 19kV to 27kV ac with normal feed & one adjacent TSS going out of service with the designed headway.
- Contractor shall provide built-in diagnostics and remote monitoring functions to identify and locate faults in the equipment, OHE and 25kV feeder conductors, with an accuracy of ± 200m. This information shall be available within a short time of occurrence at OCC through SCADA.

5.2 Performance Features:

5.2.1 The systems shall meet or exceed the requirements for safety and reliability as specified in national or International Standards for heavy haul freight or a high current railway system with similar environmental conditions. 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. This requirement has been elaborated in Chapter 14 of this document.

5.2.2 Achieve integration between Protection, SCADA System, Maintenance System and Asset Data Base.

5.2.3 Access control and maintenance locking off shall follow the latest smart card technology.

5.3 System Requirements

5.3.1 Train Operations

The system shal be designed to fully satisfy the operational requirement for horizon year 2031-32.The system shall be capable of hauling following traffic each way:

In the horizon year 2031-32, 5 trains per hour with an average load of 5350 Tonnes per single haul train (Trains at 12 minute interval) with one double haul followed by two single haul.Single Haul trains are 750 m long with one 9000 hp engine at the head.

Double Haul trains are two single haul trains coupled together with one leading and one middle locomotive.Double haul are two Trains coupled.

The train resistance and locomotive resistance data as followed by IR is given below:

i) Train resistance (of BOX N wagon excluding Locomotive)

a) Main starting resistance on level tangent track (including acceleration reserve) = 4.0 (in kg/tonne)

b) Main running resistance on level tangent track = $0.6438797 + 0.01047218\ V + 0.00007323\ V^2$ (in kg/tonne), where V is speed in Kmph

ii) Grade resistance = I/G x 1000 (in kg/Tonne), where G is gradient (e.g. G =200 in case of 1 in 200 gradient)

iii) Curvature resistance = 0.4 x curvature in degree (in kg/tonne)

iv) Locomotive resitance

a) Starting resistance on level tangent track = 6.0 (in kg/tonne)

b) Running resitance on level tangent track = $0.647 + 13.17/W + 0.00933V + 0.057/WN \times V^2$ (in kg/tonne)

Where W = Axle load of the locomotive in tonne

N= Number of Axle

V = Speed in km/ph

The signaling of the route is Automatic Signals located every 2 kms.

The design should take in account bunching of trainsallowing 10% extra power demand. For failure of one TSS, the system shall be able to support 100% Train service under normal condition.For failure of consecutive TSS reduction of train service shall be acceptable.

5.3.2 System Wide EMI Mitigation/EMC, Earthing and Bonding strategy

Based on the simulation studies for the traction supply carried out by the Contractor, he shall develop an EMI Mitigation/ EMC strategy for the entire system and develop Earthing and Bonding scheme for the entire system to ensure safe touch and step potentials for the the traction installation and those of track and metal work of other installations of the corridor. This strategy shall also include installations of other parties affected by the traction currents. The strategy shall be developed in a work execution design for incorporation in the System Installation of track, bridges, viaducts and other adjacent metallic structures, protective works for electrical circuits, signal and telecom installations including similar works required for the adjacent Indian Railway route running parallel to the DFC and also include any installation of other parties which may be affected.

The Contractor shall ensure that step and touch potentials shall not exceed the voltage limits as stipulated in table of EN 50122-1 (reproduced below) for failure of Overhead equipment and locomotive fault having duration of 300 ms.as a minimum, subject to backup protection clearing the fault within this period to be confirmed by the Contractor which, the Contractor shall demonstrate through design calculations.

Table 5.3.-1 — Maximum permissible body voltages $U_{b,\ max}$ in a.c. traction systems as a function of time duration (Ref. EN 50122-1)

t	*Ub, max*
s	V
> 300	60
300	65
1	75
0,9	80
0,8	85
0,7	90
0,6	100
0,5	120
0,4	150
0,3	230
0,2	295
0,1	345
0,05	360
0,02	370
t time duration $U_{b,\ max}$ permissible body voltage	

Table 5.3.-2 — Maximum permissible effective touch voltages $U_{te,\ max}$ in a.c. traction systems as a function of time duration (Ref. EN 50122-1)

t	*Ute, max* **long-term**	*Ute, max* **short-term**
s	V	V
> 300	60	-
300	65	-
1	75	-
0,9	80	-
0,8	85	-
0,7	90	-
< 0,7	-	155
0,6	-	180
0,5	-	220
0,4	-	295
0,3	-	480
0,2	-	645
0,1	-	785
0,05	-	835
0,02	-	865

t time duration
$U_{te,\ max}$ permissible effective touch voltage

The Contractor shall simulate the worst condition by considering failure of insulator, failure of locomotive and earthing of broken conductors.

The Contractor shall furnish information asked for by statutory bodies (e.g., Government of India Ministry of Railways, Ministry of Power, State Power Companies, Commissioner of Railway Safety, etc.) in such format as directed by Engineer.

END OF CHAPTER

6 Design Criteria & Performance Specification for Traction Power Supply

6.1 Conceptual Power Supply Arrangement

6.1.1 Conceptual schematic power supply arrangement diagram of typical TSS/SSP/SP/ATP and preliminary system design are furnished in the Engineer's drawings, Vol.V. Based on these, the Contractor may review/ improve layouts/arrangements to effect economy and ensuring the requirement for RAMS.

6.1.2 Traction Substations (TSSs)

6.1.2.1 For Western Dedicated Freight Corridor, power supply from state power company shall be received at each TSS location througha minimum of two incoming 220/132kV supply circuits, which shall be arranged by the Employer

6.1.2.2 Traction substation shall include, but not limited to provision of:

- 220/132 kV AC/54kV traction transformers complete with all accessories,
- 220/132kV ac circuit breakers,
- 50kV circuit breakers
- 25kV circuit breakers,
- 25kV interrupters,
- 25kV isolators, (motor operated)
- Lightning arrestors,
- Auto transformers for converting 50kV to 25kV,
- Auxiliary transformers,
- Single core and multi core copper cables,
- Return current circuit cabling
- Provision of cross track rail and its bonding to the tracks in close coordination with Other Contractors for civil and track works &signaling and telecom. contractor (ST P-5).
- Earthing and Bonding system including Buried rail for traction return current
- Protection relays, CTs and PTs
- Metering complete with all measuring CTs and PTs
- Batteries and chargers
- Power quality improvement
- RTU and Control Equipment
- Automatic fault locator

6.1.3 Sectioning and Paralleling Posts (SP)

6.1.3.1 Theseshallinclude, but not limited to provision of:

- 25kV circuit breakers,
- 25kV interrupters,
- 25kV isolators,
- Auto Transformers,
- Auxiliary transformers
- Single core and multi core copper cables,
- Return current circuit cabling,
- Earthing & Bonding system,
- Protection relays and associated CTs and VTs,
- Measuring instruments including CTs and VTs as deemed necessary
- Batteries and chargers,
- RTU and control equipment

6.1.4 Sub Section Posts (SSP)

6.1.4.1 Sub-section post along the Western Dedicated Freight Corridor shall include, but not limited to provision of:

- 25kV interrupters,
- 25kV isolators,
- Auto transformers,
- Auxiliary transformers
- Single core and multi core copper cables,
- Return current circuit cabling,
- Earthing & Bonding system
- Protection relays and CTs and VTs,
- Batteries and chargers,
- RTU and control equipment

6.1.5 Auto Transformer Stations (ATS)

6.1.5.1 Auto transformer stations along the Western Dedicated Freight Corridorshall include, but not limited to provision of:

- 25kV isolators, (motorized)
- Auto transformers,
- Auxiliary transformers
- Single core and multi core copper cables,
- Return current circuit cabling,
- Earthing & Bonding system,
- Protection CTs,
- Batteries and chargers,
- RTU and control equipment

6.2 Design of the Power Supply System

6.2.1 The Contractor shall propose to the Engineeraproven multitrain system simulation software to be used taking in account the data for rolling stock, train loads, speeds, track alignment and the electrification system in the model of the simulator, which has been successfully accepted as stipulated in sub para nos 3.2.1 and 3.2.2 of this specification.The Contractor shall propose the various simulation runs to be undertaken, for Engineer's approval.

6.2.2 This study shall also be used to finalize the capacity of 220/132kV ac circuit breakers, the rating of the 25kV ac circuit breakers, isolators and interruptors, ratings of both the traction transformers and auto transformers, all substation traction power conductors and number and size of 25kV ac contact wires, catenary wires, feeder wire, Aerial Earth and Buried Earth Conductors (AEC and BEC) in the overhead line equipment and confirm the ratings of all traction equipment.

6.2.3 The software shall produce output data as a minimum for the following, both during normal feed i.e. all TSS in service and one TSS out of service;

- Voltage profile at pantograph of each train under normal and worst condition,
- Current output at each TSS both Peak and RMS and conductor temperature rise including feeder wires,
- Capacity of traction transformer,
- Spacing between traction sub-stations,
- Spacing of auto transformers,
- Capacity of auto transformers,
- Sizes of contact, catenary, feeder wires, earth wires (both Aerial and buried)
  (Considering 30% wear of contact wire) and jumper wires.
- Touch and step potential of traction rail and interval of grounding of Aerial Earth Wire (AEC), and Buried Earth Conductors (BEC) to rails either directly or through impedance bonds.

6.2.4 Anticipated short circuit levels are given in Table 6.7-1 .Based on the traction power system requirements and load flow studies,the system and fault analysis, the power supply system shall be designed. Sizesand ratings of all equipment, cables of different voltages 25kV ac and 240V ac auxiliarysupply, earth bus and conductors, joints, jumpers, as well as ancillary equipment and instrument transformers shall be firmed up.

6.2.5 The details of calculations and specifications finalized shall be submitted for approval of the Engineer.

6.2.6 The multi-train simulation study shall be used to verify the adequacy of number and location of traction substations and evolve a design so that the traction power demand, voltage requirements and RAMS requirements for full peak services are satisfactorily met.

- Normal feed conditions, with one adjacent TSS out of commission under normal headway and perturbed operation.
- One line feeder breaker failed and the paralleling interrupter closed under normal headway and perturbed operation.
- To specify the optimum interval between rail to earth connections to ensure that the rail voltages are within permissible limits as per IEC 62128-1, and EN 50522.
- Max power demand in case of extended feed condition and minimum voltage at pantograph under worst condition.
- Catenary current & temperature rise in conductors under extended feed conditions,

6.2.7 Alternative TSS shall be provided with two transformers, one being standby. Rest of the TSSs shall have single traction transformer. In the latterTSSs, the bus-bar shall be configured such that in future when the (second) standby transformeris installed, thatalong with the ancillary equipment can be directly installed with no modification to the TSS layout. The foundations including all Civil and Track Works covering baffle wall shall be constructed initially by the Contractor.

6.2.8 This specification gives indicative details of power supply arrangements envisaged for traction for Dedicated Freight Corridor. The Contractor is expected to examine the entire scope of work and scrutinize the specified system, the specification of cables &equipment and work out the ratings based on his own designs of entire system.

6.3 Design of Earth System

6.3.1 System protective earthing for providing electrical safety on entire system including earthing of non-current carrying metallic components, cable supports, transformer neutrals, lightning arrestors, etc shall be designed. The earthing system shall conform to relevant provisions of EN 50122-1, EN-50522, IS 3043-1987, Earthing Manual 311 issued by CBIP and IEEE 80.

6.3.2 The earth system shall consist of: -

a) Earth mat and earthing conductorsin traction substations.
b) Earth systems in sub sectioning and paralleling posts.
c) Earth system in sectioning posts.
d) Earth systems at auto transformer stations.
e) BuriedEarth conductors (BEC)
f) Buried rail and its connections
g) Aerial Earth Conductor (AEC)
h) Structure Bond& Rail Continuity and Cross Bond

6.3.3 Inall traction power supply control posts, GI flats and pipes, allowingadequate margin against corrosion shall be used as per IS-3043, EN-50522 and manual on sub stations issued by Central Board of Irrigation and Power. The earth rods below the mat shall be copper clad steel as per ASTM 460-11. The connections shall be maintenance free, self gripping type. Wherever the earthing bonds pass along or across the tracks, it shall be routed along the sleepers using proper fastners and clamps so as to avoid damages/ disconnection during ballast screening or tei-tamping of the track.

6.3.4 The maximum earth resistance of entire system shall meet the following requirements:

Table 6.3-1 Maximum Earth Resistance

Location	**Total earth resistance system (in ohms)**
TSS	0.5
SSP	0.5
SP	0.5
Other locations	To meet the requirements of EN50122-1

6.3.5 The signaling system mainly will be axle counter based signal and metallic liners shall be provided between rail and sleepers under both the rails of sixty kg. The rails shall be available for traction return currents.

6.4 Surge Arresters and Lightning Protection

6.4.1 Surge arresters shall be installed at each location of TSS,SP, SSP, ATP and Auxiliary Transformer Locations.

6.4.2 Each surge arrester shall incorporate an individual earth which shall be connected to a ground rod or rods and shall also be connected to the earth system in vicinity.

6.4.3 Each earth connection shall have earth resistance as specified by the surge arrester manufacturer for the type of unit supplied, and shall be tested individually in accordance with testing procedures as approved by the Engineer.

6.4.4 Bonding cable connections between the surge arrester and the OHE, and between the surge arrester and the grounding system, shall be installed with a minimum number of bends.

6.4.5 The connection of surge arresters to OHE shall be such that in case of breakage of the surge arrester, the connector does not create an earth fault in the OHE.

6.5 Lightning Protection

6.5.1 The entire sub-station shall be protected against lightning strikes by providing earth screen conductors on tower peaks and/or by means of lightning protection masts suitably spaced to cover the entire area.

6.5.2 The height and locations of the lightning masts shall be designed appropriately with due consideration to the equipment layout in the TSS, to ensure that all the equipment required to be protected against lightning are within protective zone provided by the lightning conductor.

6.5.3 The lightning conductor shall consist of

- Lightning receiver projecting above the object to be protected
- The earthing grid
- The conductor which connects the receiver with the earthing grid and is meant to carry the lightning current away safely to the ground.

6.5.4 The lightning protection designs shall be based on a well recognized practice to provide a fail safe protection to the TSS building and switchyard.

6.6 Capitalisation of Transformer Losses

6.6.1 The traction supply transformers and auto transformers (ATs) shall be low loss type. The value of losses shall be guaranteed.

6.6.2 Following formula shall be used for the purpose of calculating the present worth of the transformer after taking into account capitalization of its losses, when comparing different bids capitalized cost of the losses in the transformer shall be added to the bid value for evaluation purposes.

$$K = \frac{D\{(1+i)^N - 1\}}{i(1+i)^N}$$

Where,
K= Present worth of transformer in Rupees.
D= Annual cost of combined no-load and load losses in Rupees.
i= Rate of compound interest on unit price of transformer @ 12% per annum.
N = Life of transformer in years

Substituting value of D, which is:

$$D = \frac{\{(I+F^2 C)\ 365 \times 24 \times T\}}{1000}$$

Where,
I = Maximum no-load loss in watt
C= Maximum load-loss in watt
T= Tariff
F= Load factor, value for different type of transformers to be taken is furnished below:

Traction transformer	=	40%
Auto Transformer	=	25%

For main traction transformer, assuming values of N as 25 years, F as 40% and T as Rupee 5.00 per kWh, the value of K is.

$$K_{traction} = \frac{30.66 \times 16\ (I+0.16C)\ \{(1+0.12)^{25} - 1\}}{0.12\ (1+0.12)^{25}}$$

For auto-transformer, assuming values of N as 25 years, F as 60% and T as Rupee 5.00 per kWh, the value of K is.

$$K_{auto} = \frac{30.66 \times 196\ (I+0.36C)\ \{(1+0.12)^{25} - 1\}}{0.12\ (1+0.12)^{25}}$$

The value of K for traction transformer and auto-transformer shall be calculated considering load factor as indicated above.

If the guaranteed values are not achieved by the Contractor, the Contractor shall be penalized four times of excess factor of capitalization of losses i.e. $K_{traction}$ andK_{auto}

6.7 Short Circuit Capacity

6.7.1 The Contractor shall ensure that traction and substation auxiliary power supply system including cables installed shall be capable of withstanding the state power company fault levels at the points of common coupling and downstream with an allowance to cater for possible future increases. The fault levels to be catered for generally are given in table 6.7-1 below. Specific requirements (if they are different) are furnished in the equipment/sub-system specifications.

Table 6.7-1 Design Short Circuit Levels

System Voltage(kV)	Breaking Capacity in MVA	Fault Current in kA	Fault Duration in Seconds
220	20000	40	1
132	10000	30	1
25	30	12	3

6.8 EHV Power Supply Design Data

6.8.1 Insulation coordination

6.8.1.1 The nominal voltages and corresponding maximum voltages shall be as follows (IEC 60850):-

Nominal Voltage	Maximum Voltage
25kV	29kV
132 kV	145kV
220kV	245kV
240V	250V

6.8.1.2 The 220/132kVac, 25kV ac and 240V equipment shall meet the insulation coordination requirements of IS2165 (Part I and Part II) with latest amendments.

6.8.1.3 25kV ac equipment shall have insulation levels according to the European Standards EN 50124, Railway Applications – Insulation co-ordination and EN 50152 series, Railway Applications – Fixed Installations, Particular Requirements for ac switchgear.

6.8.2 Power Quality

Power Quality shall keep the voltage and current unbalance, reactive power and harmonic contents within the prescribed limit in normal and extended feed conditions.

For connectivity to the grid sub-station of power supply authorities, following power quality limits have been laid down at the point of common coupling (PCC):

6.8.2.1 Voltage unbalance

The limit of voltage unbalance permitted according to Central Electricity Authority (CEA) standards are as follows based on lowest short circuit MVA at the grid sub-station:

Voltage of supply	Maximum permissible unbalance
132 kV	3%
220kV	2%

6.8.2.2 Harmonics Generated at the PCC

Harmonics generated	(%) Not more than
THD for voltage	5%
Any individual harmonic	3%
THD for current	8%

Based on the characterstic of the traction supply demand and the locomotives proposed to be run on the system, a suitable system of power quality correction network with fixed and variable capacitor banks including correction to power factor 0.95 shall be proposed and installed at each TSS.

Suitable active and passive feature shall be provided to reduce harmonic content for third , fifth and other multiple thereof. The Contractor shall prepare a detailed document and obtain prior approval of the same from Engieer. The power quality equipment shall be able to afford maximum tarrif advantage to the Employer. Harmonic resonance in feeding circuit shall be determined and suitable harmonic compensating equipment shall be provided at system points.

6.9 Switchgear and panels

6.9.1 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 where necessary. Protection Class at a minimum shall be IP 54.

6.9.2 The switchgear shall be designed such that a failed circuit breaker can be taken out and replaced within 4 hour maintenance period.

6.9.3 Switchgear shall have appropriate terminations to suit the locations and electrical clearances. Where the size of available land is small the Contractor shall use cable box terminations to maximize the electrical clearances to the operational railway.

6.9.4 All switchgear shall be suitable for operation, control, interlocking and protection via a substation automation system complying with IEC 61850.

6.10 Protection Scheme

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 computerized logic protection scheme. All types of faults on overhead equipment covering faults among conductorsfor 25 kV feeder, OHE, and earth shall be identified, to facilitate isolation within ± 200m accuracy.The traction switchgear and cables / feeders on supply side and the catenary on railway side must have sufficient protection. It shall have overcurrent protection for traction feed transformers with inverse definite time relays set to the rated load, earth fault protection, buckholtz relays winding and coolent temperature detection, - differential protection for transformer and the distance protection with atleast three zones with back up protection shall be provided for feeders.

6.10.2 The impact of trains with regeneration shall be taken by the Contractor while designing protection scheme. Definite time over-current and back up over current shall be provided. Breaker re-closiing facility shall be provided and after first reclosure on the persistence of fault, breaker shall not be closed. Detailed scheme shall be put up for approval of the Engineer at design stage. Thermal protection for catenary shall also be provided. The catenary heating and cooling time constent shall be specified. The scheme of protection shall be fully co-ordinated with the state power companies.

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

6.10.4 All protection functions available in the manufactures specification shall be available for use of the Engineer, without having to purchase any passwords or unlocking codes. Any such passwords or unlock codes shall be available to the Engineer free of cost during and post contract.

6.10.5 The Contractor shall design protection system for power supply equipment to ensure:

i) Adequate coordination with the Power Supply Authorities.
ii) Satisfaction of Power Supply Authorities
iii) Adequate discrimination between load and fault conditions.

6.11 Galvanisation of All Outdoor Steel Works

6.11.1 Steel structures for outdoor TSS, SSP, ATP and SP and those required for support of overhead equipment, all small part steel works (SPS) shall be hot dip as per RDSO's specification No.ETI/OHE/13 (4/84 or latest)

6.11.2 The galvanization shall be done only after cutting and drilling work is over. Galvanized bolts, nuts and spring washers shall be used for assembly work.

6.11.3 Wherever galvanizing 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 only after examination and no objection from the Engineer.

6.12 Modular Equipment and Components

6.12.1 All components shall be modular in construction to facilitate easy troubleshooting and replacement of components to minimize down time of the system. Design shall be such that it facilitates interchangeability.

6.12.2 Equipment along the length of the Western Dedicated Freight Corridor shall be selected from a common palette of materials to ensure that equipment is interchangeable between sites, spares and training on different equipment and systems is kept to a minimum.

6.13 Outdoor Switchyard for TSS, SSP & SP

The layout shall be designed and constructed based on manual for outdoor grid sub-station publication 299 of 2006 by Central Board of Irrigation and Power (CBIP), Delhi.

6.14 Electromagnetic Compatibility (EMC) Requirements

6.14.1 General

6.14.1.1 The requirements stated below shall be read in conjunction with the EMC requirements in the General Specification.

6.14.1.2 The Project Wide EMC manager shall prepare a Project Wide EMC management plan for the processes to be followed by all Western DFC contractors including the EM P-4 Contractor.

6.14.1.3 An EMC control plan shall be submitted for review by Engineerthroughproject wide EMC manager.

6.14.1.4 The project wide EMC project manager shall integrate the EMC control plans from all Western DFC contractors and combine them into one integrated Project Wide EMC control plan. The EM P-4 Contractor shall fully comply with the project wide EMC control plan.

6.14.1.5 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.

6.14.1.6 The plan shall analyze EMI/EMC impacts on the design of the train, all other train-borne equipment and trackside equipment as well as the general environment. Particular attention shall be paid to additional requirements in grounding, bonding, and shielding, filtering, and cabling arrangements.

6.14.1.7 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	Railway Applications Electromagnetic Compatibility – General
EN50121-2	Railway Applications Electromagnetic Compatibility – Emissions of the whole railway system to the outside world
EN50121-5	Railway Applications – Electromagnetic Compatibility - Emissions and immunity of fixed power supply installations and apparatus.
EN50152	Railways Applications – Fixed Installations – Particular requirements for ac switchgear. (All parts)

b) Specific standards:

i) Immunity

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

ii) Emission:

EN50121-5	Radiated emission
EN50121-4	Conducted emission
IEC61000-2-6	Electromagnetic Compatibility Part 2: Environmental Section 6: Assessment of the emission levels in the power supply of industrial plants as regards low-frequencyconducted disturbances.

IEC61000-3-2	Electromagnetic Compatibility Part 3: Limits for harmonic current emissions.
IEC61000-3-3	Electromagnetic Compatibility Part 3: Limits Section 2: Limitation of voltage fluctuations and flicker in low-voltage supply for equipment with rated current 16A.
IEC61000-3-5	Electromagnetic Compatibility Part 3: Limits Section 2: Limitation of voltage fluctuations and flicker in low-voltage supply for equipment with rated current greater than 16A.

6.14.1.8 The Contractor shall identify all EMC tests to be undertaken in the EMC control plan and the where appropriate in the integration testing plan. The test plan shall make clear the pass / fail criteria prior to any testing taking place. All tests shall be conducted at severity levels specified by EN50121 and/or the Engineer, whichever are more stringent. The test plans shall be approved by the Engineer prior to any testing being undertaken.

6.14.2 Intra-System EMC

6.14.2.1 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.

6.14.3 Inter-System EMC

6.14.3.1 The Contractor shall ensure that all 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, EN50152, EN50155, IEC60571 and IEC61000 or equivalents, to ensure proper functioning. Consideration shall be given to the EMC of the complete Dedicated Freight Corridor. All applicable standards shall be identified in the EM P-4 EMC control plan.

6.14.3.2 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 document for safety audit shall be maintained by the Contractorto demonstrate EMC compliance.

6.14.4 Non-Safety-Related Systems Interference

6.14.4.1 The Contractor shall take appropriate measures to ensure that EMC is achieved between the power supply equipment and all other system equipment. The transformer shall be designed with particular attention to the suppression of harmonic voltages, especially the third and fifth or any other values as specified by the latest version of the EN 50121 and other relevant International Standards or by the Engineer.

6.14.4.2 All radiated emissions, either via the power cables, transformers or any other system components, shall be minimized such that they conform to the appropriate international standards. Special reference shall be made to the compliance of EN50121-5, EN50152, and IEC61000-2.

6.14.4.3 All power cables shall be properly shielded where applicable. Reference shall be made to IEC61000-4-6 and IEC61000-4-16.

6.14.4.4 The Contractor shall ensure that all conducted emissions, including but not limited to harmonics, shall not interfere with telephone, communications, supervisory and control, train protection and control, and other railway equipment via the 25kV systems. Reference shall be made to EN50121-5, EN50152, and IEC61000-2.

6.14.4.5 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.

6.14.5 Environment EMC

The Contractor shall ensure that radiated emissions from the power supply cable are maintained at an internationally acceptable level. The Contractor shall also ensure that the power cables are protected from RF radiations from all telephone network operators and radio networks.

6.14.6 Installation and Mitigation Guidelines

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

6.14.7 Earthing and Bonding

6.14.7.1 The Contractor shall prepare an earthing & bonding management plan which shall detail the EM P-4 approach for delivering and integrated earthing scheme for EM P-4. This shall be submitted to the Project Wide Earthing& Bonding Manager who will integrate the EM P-4 Earthing& Bonding Plan into a Project Wide Earthing& Bonding Plan. This plan shall apply to the Permanent Works by all the Other Contractors on the Project to ensure the structures and equipment are safe from EMI due to 25 kV traction effects and for touch voltages and shall be an important interface requirement for the project.

The Contractor shall update the EM P-4 earthing and bonding plan to reflect any consequential changes imposed by the project wide earthing & bonding plan.

The project wide earthing & bonding plan and the EM P-4 Earthing and Bonding Plans shall be the basis of design for all earthing& bonding on traction, OHE and SCADA infrastructure.

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

6.14.8 Bonding

6.14.8.1 Bonding all exposed metallic parts of all equipment and connecting them to the earth.

6.14.8.2 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 and EN 50122-1.

a) Low bonding resistance from DC to at least 2 GHz.
b) Low bonding inductance from DC to at least 2 GHz.
c) Proper bonding procedure, including appropriate surface treatment before and after the bonding process, is adopted.
d) Proper use of bond material to minimize electrolytic corrosion.

6.14.9 Cabling

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

6.14.9.2 A cable routing plan shall be designed to minimize likelihood of coupling between parallel cables. The Contractor shall refer to guidelines recommended by IEC61000-5-2,

Table 6.14-1 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 &control lines, and long bus &control lines	
Test	**Severity level**
RF common mode	0.15-80 MHz, 20 V, 80%AM at 1kHz source impedance 150 ohms
Fast transients	4 kV, 5/50 Tr/Th nanoseconds, PRF 5 kHz
Transients common/diff modes	1.2/50 Tr/Th□sec, 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	4kV, 5/50 Tr/Th nanoseconds, PRF 5 kHz
Transients common/diff modes	1.2/50 Tr/Th□sec, 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	2/50 Tr/Th□sec, 2 kV (c), 1 kV (d)
Earth port	
Test	**Severity level**
RF common mode	0.15-80 MHz, 20 V, 80%AM at 1kHzsource impedance 150 ohms

6.14.10 Bonding of conduits & cable armour :

Proper bonding & cross bonding of metallic conduits armour& screening conductor shall be made to ensure that the induced voltage in them during fault conditions are within safe limits.

6.15 Provision for Future Additions and Alterations

In this Project, it is proposed to provide stand by traction transformers only at alternate Traction Sub-Stations. It shall be ensured that the designs and execution of works for the TSS where standby transformers are to be installed at a later date, shall include completion of all civil engineering works such as foundations and cable ducts etc. and all structural works excluding electrical equipments and components in these sub-stations.

END OF CHAPTER

7 Proposed Locations ofSwitching Stationsand Details of Equipment

7.1 Scope of Works

7.1.1 System Wide - Scope of Works includes following installations: - 16 Traction Sub-Stations (TSSs), 16 –Sectioning & Paralleling Posts (SPs), 77 – Sub-Sectioning & Paralleling Posts (SSPs) and 6 – Stand Alone Auto-TransformerStations (ATSs). The arrangements shown are indicative only. The Contractor shall make his own General Traction Supply Diagram based on the indicated locations of Supply Control Posts.

7.1.2 The details of locations of TSS and traction supply posts including ATSs are shown in the EMP4/PS/201(in Volume V). Auto transformer stations have been located at intervals in between 13 to 17 kms. At some locations, where SSPs are not required from Sectioning aspects, stand alone Auto-Transformer Stations have been indicated in the drawing. These are at 6 locations.

7.1.3 The Contractor is advised to note that the neutral section opposite the TSS and SPs will have to be located at sites, where single trains of 750m length with one locomotive and also long haul trains 1500 m length with two single hauls with one locomotive on the head and one in the middle will be required to coast through, accordingly their locations will have to be judiciously selected with close interface with ST P-5 contractor, to ensure that even on restrictive aspect of signals the engine coast through.

7.1.4 Location of TSSs, SPs and SSPsis as shown in the tables 7.1-1,7.1-2 and 7.1-3.These locations were selected at outline stage of the project, where details of the alignment, track levels and location of stations (crossing and junction were yet to be firmed up.) Accordingly, the position of availability of land for the Supply Control Posts is as follows:

a) The locations of TSS had been finalized and frozen as final locations. At some locations, the provison of neutral section on the OHE opposite the TSS may not be practicable in view of the TSS being too close to a station signals for a locomotive to permit coasting through the neutral section without the risk of being stalled. Accordingly, the neutral section will have to be located away with feeders being run within the ROW to a suitable location coordinated with the automatic signals being provided.

b) The locations of SPs, SSPs and ATPs require review by the Contractor on considerations indicated below:-

c) In regard to SPs, their locations may also need a review with respect to stations and signals as stated above. The land for SPs has been acquired at the locations indicated in Table no. 7.1-2. However, in case the land acquired does not suit the Contractor may review the design of switchgear & equipment to reduce the footprint to be able to accommodate in the location of SP in the ROW by using modular or linear layout or pole mounted switchgear may be adopted for installation. The most economical solution of locating it in the acquired land and running feeders to the neutral section or providing modular layout as mentioned above may be selected.

7.1.5 In regard to SSPs,the General Power Supply diagram,provides for appropriate sectioning, so as to permit trains to take alternative paths through stations during traffic and power blocks minimizing traffic delays. This calls for location of SSPs opposite main line cross-overs of each station: Junction and Crossing. Accordingly,60 SSPs opposite 30station cross-overs become necessary. In addition SSPs are provided in between to locate the ATs, wherever a station with its SSP are close by and ATs are to be provided, if these are shown as stand alone. These are shown in the Traction General Supply Diagram. The auto transformer posts, which are stand alone types shall be located in the ROW.

Table 7.1-3 indicates the tentative location of the SSPs based on Sectioning Arrangements. The Contractor may review all these locations and prepare his own designs to provide the best sectioning of the overhead equipment for ease in maintenance and operation. In regard to availability of land for SSPs, in most cases of SSPs at stations, land will be available within the land boundary of the stations. In case this is not so, switching station may be designed so as to accommodate them within the ROW in a most economical manner by usinglinear layout, Pole Mounted type of switchgear and / or running of along feeders.

7.1.6 The proposal for final designs of General Supply Diagram clearly indicating the type of Post being provided at each of the location, may be made to the Engineer for his approval.

Table 7.1-1 List of Proposed Traction Substations (TSS)

Nos.	TSS Name	Chainage	DFC		
	Name	Continuous (from Rewari)	CPM	Section	Chainage
1	Ateli (132kV)	35.754	Jaipur	15	21.742
2	Maonda	89.100	-do-	14	75.520
3	Ringus	143.220	-do-	14	21.400
4	Phulera	210.43	-do-	13	35.800
5	Kishangarh	263.267	-do-	12	85.400
6	Mangliyawas	315.867	Ajmer	12	32.800
7	Haripur	375.791	-do-	11	77.000
8	Marwar Junction	432.991	-do-	11	18.800
9	Falna	492.278	-do-	10	62.550
10	Sirohi Road	551.928	-do-	10	2.900
11	Sriamirgarh	610.674	-do-	9	42.240
12	Dharewada	670.767	Ahmedabad	8 (N)	89.780
13	Jornang	730.452	-do-	8 (N)	29.645
14	Sanand	785.017	-do-	6	79.460
15	Heranje (Vaso)	835.212	-do-	6	29.265
16	Bhayali (132kV)+	896.794	Vadodara	5	149.150

Table 7.1-2 List of Proposed Sectioning Posts (SPs)

Nos.	SPs Name	Chainages	DFC		
	Name	Continuous (from Rewari)	CPM	Section	Chainage
1	Gumina	7.940	Jaipur	16	7.560
2	Amarpura Jorasi	58.820	-do-	14	105.800
3	Kanwat	120.180	-do-	14	44.440
4	Renwal	177.403	-do-	13	68.800
5	Sakun	234.803	-do-	13	11.400
6	Madar	286.167	Ajmer	12	62.500

Nos.	SPs Name	Chainages	DFC		
	Name	Continuous (from Rewari)	CPM	Section	Chainage
7	Amarpura	347.307	-do-	12	1.360
8	Bagdi Nagar	403.491	-do-	11	49.300
9	Jawali	465.388	-do-	10	89.440
10	Mori Bera	519.493	-do-	10	35.335
11	Bhimana	578.774	-do-	9	74.100
12	Chitrasini	637.874	-do-	9	15.000
13	Jetalvasna	698.547	Ahme-dabad	8 (N)	62.000
14	Piyaj	756.647	Ahme-dabad	8 (N)	3.900
15	Meiroli	805.177	Ahme-dabad	6	59.300
16	Napavanto	867.113	Vado-dara	5	178.913

Table 7.1-3 List of Proposed Sub Sectioning Posts (SSP)
(As provided in General Traction Supply Diagram EM P-4/PS/201)

Sl. No.	SSP Name	Chainage (Continuous from Rewari)	CPM	Section	Chainage
1	Rewari Stn (N)	1.261	Jaipur	16	14.239
2	Rewari Stn (S)	3.848	-do-	16	11.652
3	Kund	22.596	-do-	15	34.900
4	Ateli Stn N	28.871	-do-	15	28.625
5	Ateli Stn S	31.310	-do-	15	26.186
6	Narnaul	46.696	-do-	15	10.800
7	Dabla (N)	69.025	-do-	14	95.595
8	Dabla (S)	70.787	-do-	14	93.482
9	Bhagega N	103.939	-do-	14	60.947
10	Bhagega S	106.058	-do-	14	58.562
11	Hanspur	133.020	-do-	14	31.600

Sl. No.	SSP Name	Chainage (Continuous from Rewari)	CPM	Section	Chainage
12	Srimadhopur N	140.687	-do-	14	23.933
13	Srimadhopur S	142.868	-do-	14	21.752
14	Kishan Manpur	161.613	-do-	14	3.007
15	PacharMilikpur N	170.061	-do-	13	76.142
16	PacharMilikpur S	172.174	-do-	13	74.029
17	Sanodia	193.770	-do-	13	52.433
18	Phulera N	217.763	-do-	13	28.440
19	Phulera S	220.441	-do-	13	25.762
20	Sakun N	237.540	-do-	13	8.663
21	Sakun S	239.679	-do-	13	6.524
22	Gehlota	247.867	-do-	12	100.800
23	Kishangarh N	271.295	-do-	12	77.375
24	Kishangarh S	273.408	-do-	12	75.262
25	Sardhana N	299.21	-do-	12	49.457
26	Sardhana S	301.350	-do-	12	47.317
27	Bangur Gram N	334.311	-do-	12	14.356
28	Bangurgram S	337.185	-do-	12	11.482
29	Sendra	360.041	Ajmer	11	92.750
30	Haripur N	376.009	-do-	11	76.782
31	Haripur S	378.146	-do-	11	74.645
32	Chandawal N	395.166	-do-	11	57.625
33	Chandawal S	397.279	-do-	11	55.512
34	Sojat	420.591	-do-	11	32.200
35	MarwarJn N	431.603	-do-	11	21.188
36	MarwarJn S	434.042	-do-	11	18.749
37	Bhinwala	451.728	-do-	10	103.100
38	Jawali N	467.282	-do-	10	87.546
39	Jawali S	469.422	-do-	10	85.406
40	Bhagwanpura	479.179	-do-	10	75.649
41	Biroliya N	500.929	-do-	10	53.899

Sl. No.	SSP Name	Chainage (Continuous from Rewari)	CPM	Section	Chainage
42	Biroliya S	503.043	-do-	10	51.785
43	Keshavganj N	540.445	-do-	10	14.383
44	Keshavganj S	543.303	-do-	10	11.525
45	Banas N	559.632	-do-	9	93.242
46	Banas S	561.778	-do-	9	91.096
47	Swarupganj N	570.683	-do-	9	82.191
48	Swarupganj S	572.823	-do-	9	80.051
49	Morthala	594.304	-do-	9	58.570
50	Sriamirgarh N	610.674	-do-	9	42.639
51	Sriamirgarh S	612.349	-do-	9	40.525
52	Sarotra Road	622.035	-do-	9	30.839
53	Palanpur N	639.211	Ahmedabad	9	13.258
54	Palanpur	642.234	-do-	9	10.877
55	Malo San N	658.989	-do-	8 (N)	101.793
56	Malo San S	660.539	-do-	8 (N)	99.558
57	Maktupur	686.337	-do-	8 (N)	74.210
58	Mehsana N	701.610	-do-	8 (N)	58.937
59	Mehsana S	703.219	-do-	8 (N)	56.320
60	Heduva Hanumat	715.547	-do-	8 (N)	45.000
61	Ghumasan N	741.986	-do-	8 (N)	18.567
62	Ghumasan S	744.096	-do-	8 (N)	16.444
63	Sabarmati (North) N	772.460	-do-	7	99.488
64	Sabarmati (North) S	775.621	-do-	7	97.056
65	Sabarmati (South) N	782.550	-do-	6	81.758
66	Sabarmati (South) S	785.083	-do-	6	79.175
67	Timba N	806.817	-do-	6	58.021
68	Timba S	808.009	-do-	6	55.871
69	Nakia	819.727	-do-	6	44.750

Sl. No.	SSP Name	Chainage (Continuous from Rewari)	CPM	Section	Chainage
70	Changa N	848.247	Vadodara	6	197.710
71	Changa S	850.357	-do-	6	195.587
72	Vasad N	850.267	-do-	5	169.287
73	Vasad S	878.780	-do-	5	167.164
74	Makarpura N	911.471	-do-	5	134.36
75	Makarpura S	914.413	-do-	5	131.530

Table 7.1-4 List of Proposed (standalone)Auto Transformer Stations (ATS) (As provided in General Traction Supply Diagram EM P-4/PS/201)

Sl. No.	ATS Name	Chainage (Continuous from Rewari End)	CPM	Section	Chainage of CPM
1	Dabla ATS	74.220	Jaipur	14	90.400
2	Bangurgram ATS	332.067	Ajmer	12	16.600
3	Chandawal ATS	389.283	Ajmer	11	63.508
4	Keshavaganj ATS	535228	Ajmer	10	19.600
5	Banas ATS	565.585	Ajmer	9	87.289
6	Umardashi ATS	654.767	ADI	8 (N)	105.780
7	Ambali ATS	882.426	Vadodara	4	163.600

Note :1) The location or supply control posts are shown in the tables 7.1-1 to 7.1-4 Theircontinuous chainages from Rewari End shown are those derived from the DFC Chainage as prepared by Respective Chief Project Managers. Those are based on the indicative alignment. The Contractor shall prepare his own General Supply diagram based on the indicative locations. The Contractor shall then verify and propose his own General Supply Diagram on the final Alignment Plan for the construction Designs and Drawings

2) The location of Neutral Sections on the OHE opposite TSS & SP may not be most suitable for passage of locomotives. This may call for short lengths of feeder wires to be run between TSS/SP and the corresponding Neutral Sections.

3) At four locations SSPs/ATs are to be located in ROW at following chainages:

a. Umardashi ATS Section 8(N) (DFCC-105.78, Continuous Chainage 654.767)
b. Chandawal ATS Section 11 (DFCC-63.508, Continuous Chainage 389.283),

c. Sanodia SSP Section 13 (DFCC-52.433, Continuous Chainage 193.770),
d. Kishan Manpur SSP Section 14(DFCC-3.007, Continuous Chainage 161.613).

Cross-Section Drawings of the ROWs at these chainages are shown at drawing no. EM P-4/PS/SSP/ATS/208. (Vol. V).Table of Traction Supply Control Posts are given in Vol. IV Data Book (2/2) at S.No. 4

7.2 Equipment ratings and their specifications

The specifications and minimum ratings of various equipmetns are given in Chapter 19 (Part VI to XII)

7.3 Extra High Voltage Power Supply to TSS by State Power Companies:

7.3.1 The Contractor shall provide all requirements for EHV at the TSS to enable the State Power Companies to complete their design.

7.3.2 The Contractor shall provide with prior agreement of the Engineer the state power companies with any reasonable status and indications from the TSS. The Contractor shall make allowance in his design to provide these indications and controls.

7.3.3 The Contractor shall make provision to house any protection relays, Remote Terminal Units, programmable logic arrays (PLCs), protection relays and meters that the state electricity companiesmayrequire. This equipment shall be installed in a suitable separate cubicle, which shall be made accessible to state power personnal for regular inspection as may be required. The contact telephone numbers of the authorities shall be exhibited in the control room and also available with the traction power controller.

7.3.4 Check Metering Equipment including all associated CTs and VTs for measuring power consumption shall be installed on the GSS side of EHV Isolators G1 and G2.

7.4 Traction Transformers

7.4.1 The TSS shall be designed such that both traction transformers can be in service and coupled to the same busbar, whilst load is transferred from one transformer to the other. The traction transformers shall be manufactured and supplied as per particulars furnished in Part XI of clause 19 of this specification.

7.4.2 Transformer estimated ratings are as follows. However these are to be confirmed by the system simulation study by the Contractor subejct to the approval ofthe Engineer:-

Table 7.4-1
Salient Features of Traction Transformers

Parameter	**Rating**
Power Rating	60/84MVA (Minimum)
Cooling	ONAN/ONAF/OFAF
Connection type	Scott Connected
Number of secondary windings	Two, Main and teaser
Rated secondary voltage	55kV
Rated secondary current	602A
Phase difference between main and teaser windings	90^{o}
Rated Primary voltage Un	220/132kV,
Highest system voltage Um	245kV
Percentage Impedance at 60 MVA	11%
Non-cumulative overload capacity after the transfor-mer has reached steady temperature on continuous operation at rated power	150% rated load for 15 min 200% rated load for 5 min

Each transformer shall be designed to comply with IEC - 60076.

7.4.3 The transformers shall be designed so that they can be delivered by rail as well as road. The transformer shall be designed such that it is within IR SOD.Radiators, accessories and conservators may be removed for transport. The insulation oil may be removed for transport and a nitrogen cushion employed during transportation.
Further, the design shall incorporate provision OFAF cooling at a later stage, when load increases.

7.4.4 The transformers shall be installed on a suitable foundation that can withstand the transformers static and dynamic load. The foundation shall be able to support the loads during installation and removal.

7.4.5 The substation transformer bays shall be provided with suitable pulling eyes to allow the transformer to be moved and positioned.

7.4.6 Each transformer shall be located in its own bund (liquid containment). The bund shall contain stone metal soaking pits with voids of capacity adequate to contain at least 110% of total quantity of oil.

7.4.7 If there is a requirement to store spare transformer oil at the TSS, the oil drums shall be stored on their own bund to prevent spillage. The bunds used for oil storage barrels shall be positioned so that they do not fill with rain water.

7.4.8 There shall be a bafflewall between adjacent transformers. The wall shall be sufficient to protect adjacent transformers in the event of a catastrophic failure of one of the traction transformers.

7.4.9 In urban areas, the traction transformers shall be enclosed in acoustic barriers where the operational noise contravenes the requirements of the "The Noise Pollution Regulation and Control) Rules, 2000 or later".

7.4.10 The design of the substation shall be such that one transformer can be removed by road or rail without disturbing the operation of the railway and allowing the remaining transformer to continue to supply the railway and operate a full headway service.

7.5 Auto Transformers

7.5.1 Auto Transformers shall be manufactured and supplied as per particulars furnished in Part XII clause 19 of this specification. The rating and its short circuit capacity shall be as per the following Table.

	TSS	SSP and SP
Rating	8MVA (min)	8 MVA (min)
Short Circuit Capacity	35 times	25 times

7.6 25 kV Circuit breakers

7.6.1 Where gas is used as an insulation medium, the circuit breaker shall be fitted with a pressure monitoring device that will detect the reduction in pressure and provide a signal via SCADA to the electrical control room.

7.6.2 The command and control signals shall enter the enclosure via pressure tight plug and sockets to provide simple and quick connection and disconnection.

7.6.3 Each circuit breaker shall have a control cabinet with an IP rating54.

7.6.4 The poles shall be able to be operated locally electrically or by a control handle manually from the local control cabinet.

7.6.5 The circuit breaker shall have the minimum of 3 normally open and 3 normally closed auxiliary contacts that are directly driven from the parts of the circuit breaker / interrupter.

7.6.6 The control cabinet shall be equipped with the following functions:-

- Local and remote operation switch
- Open and close buttons
- Open and close indications
- Operations counter.
- Control indication monitor
- Capacitor charge indicator

7.7 Batteries and Chargers

7.7.1 There shall be two battery chargers at each TSS, SP, SSP and auto transformer station.

7.7.2 Each battery charger shall be capable of supporting the total substation 110V dc operational load.

7.7.3 The substation batteries shall support the substation 110V dc loads for a minimum of 10 hours following 400V ac power or failure of all battery chargers.

7.7.4 The designs of the batteries and battery charger shall be prepared and their capacities and ratings got approved by the Engineer:

7.7.5 The 110V battery charger shall be fed from the essential services distribution board that itself will be fed from substation auxiliary transformer.

7.7.6 The battery charger shall be located inside a water tight, environmentally controlled structure. The batteries shall be located in their own battery room or compartment, which is vented to outside air.

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

7.8 Control and Power Cables

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

7.8.2 Power and Control cables shall be installed in separate cable containments.

7.8.3 All cable shall be suitable for the environmental conditions as defined in Chapter 19 of this Employer's Requirements, where cables are installed in trenches or ducts the cable shall be designed to function without any deterioration in fully immersed in water or insulation oil.

7.8.4 Cabling & ducting shall be designed and supplied to be vermin proof.

7.8.5 Cables shall be indelibly marked along their whole length with the following information as a minimum:

- Manufacturer's name
- Insulation material
- Number of cores
- Cable conductor size
- Cable nominal voltage
- Batch no.
- Year of manufacture
- Country of origin

7.8.6 Cable joints shall not be formed in ducts or trenches. Where joints are needed in duct or trenches separate joint bays shall be constructed.

7.8.7 All cables and ducts shall have identification plates fitted at the following locations as a minimum: -

- At all terminations.
- Every 100m along the length.
- At entries/exits through walls or obstructions.
- Entry and exits to ducts or trenches
- At cable joints

7.8.8 All cable joints shall be allocated cable joint numbers and each joint shall be physically labelled. The location and joint numbers shall be shown on the as built record drawings.

7.8.9 25kV a.c. single core cables shall be XLPE and armoured.

7.8.9.1 Cables of sizes & types required on the project have been indicated in table below:

S. No.	Voltage		Short Circuit Capa-city – 1 second	Minimum current carrying capacity (in Amps)	Duty	Core Material	Number of cores	Brief Description	Remarks
	Normal (kV)	Maximum (kV)							
1	25 ac	52.5 ac	12 kA	2000	Traction power	Copper 630 sq.mm.	Single Core	FRLS standard armoured XLPE insulated	Cables laid in parallel as required by system design
2	25 ac return current	3.3 ac			Traction power	Aluminium – 400 sq.mm.	Single Core	FRLS outer sheath, armoured XLPE insulated	-Do-
3	0.240 ac	1.1 ac			Power Supply to Equip-ment		2	FRLS outer & inner sheath, Armoured PVC insulated	
4	0.240 ac and 0.110 dc	1.1 ac			Protec-tionand Control	Copper	As required	FRLSOH	
5	0.240 ac and 0.110 dc	1.1 ac			Alarm &Emer-gency Circuits	Copper	As required	PVC insulated FRLSOH rated 3hours rated	

7.8.9.2 The sizes as indicated are tentative and should be verified for the duties required of them. The cable design and installation shall meet the regulations of IEEE and Fire Safety Regulations of National Building Code.

7.8.9.3 Compounds of additives to the cable over sheath shall be anti termite and resistance and shall comply with internationally acceptable regulations.

7.9 Civil Works &Illumination at TSS, SP, SSP and AT Stations

7.9.1 The Contractor shall perform the Civil and Structural design including all calculations and preparation ofdrawings, specification and other documents but not limited to for the following:

- General arrangement (Layout and elevation)
- Structures and sub-structures
- Foundations
- Drainage (Covered type)
- Networks (Water Sewage etc.)
- Baffle wall
- Boundary wall / Fencing.

The structure shall be of RCC framed structure based on BIS Codes.

7.9.2 The Contractor shall be required to prepare detailed design of civil, structural, architectural and electrical works. All applicable building regulations shall be observed and the rules for good building practices shall be followed. After obtaining the Engineer's approval, the Contractor shall construct the building alongwith auxiliary works in accordance with approved drawings, designs and best engineering practices.

7.10 Earth Work

7.10.1 The Earth work shall be based on final layout plan for the premises giving also the rail level of the final surface as approved by the Engineer.

(a) Before the earth work is started, the area coming under filling shall be cleared of shrubs, rank vegetation, grass, bush, wood trees and samplings of girth upto adequate depth as required as per site condition and rubbish removed outside the periphery of the areaunder clearance. The roots of the trees and samplings shall be removed to a depth, as per site conditions. The required holes or hollows filled up with the earth ramped and levelled.

(b) The trees of girth shall be cut only after the permission of the Engineer.

(c) Earth work in cutting or embankment for the premises of switching station yard and buildings is included in the scope of construction of building. The building will be adequately levelled with earth duly consolidated in the premises or as directed by the Engineer.

(d) Mechanical Compaction:-

Depending upon the height of the embankment, the type of soil, time available for completing the embankment and other relevant factors, Engineer shall decide whether mechanical compaction is to be done for the full or part height of embankment. Suitable method for compaction as decided by Engineer shall be adopted. Suitable drainage in the yard shall be provided to drain away rain water.

(e) Excavation:
All cutting shall be taken down carefully to the precise level as ordered by the Engineer. In case, the bottom of the cutting is taken down deeper than is necessary by oversight or neglect of the contractor, the hollow must be filled up to true depth with selected material and rammed, if approved by Engineer. Cuttings with the formation in rock will be excavated [to 15cm] below the true formation and filled upto true level with cutting spoil to ensure that no lumps of solid rock project above formation level.

(f) Drainage of cuttings:
In excavating cuttings, special precautions are to be taken to ensure that the excavations drain themselves automatically. To ensure this, the central block of earth or gullet is to be excavated first. This will be done in such a manner that the bottom of the excavation shall where possible, slope downwards from the center of the cutting towards the ends. It will be made in such cuts or steps as may from time to time, be directed. Generally, in deep cuttings the first cut or step will approximately follow the surface of the ground where this will secure the necessary slope for drainage, and will be excavated to such depth as may be ordered, with perpendicular sides leaving pathways for workmen along the sides of the cut parallel to the central line the gullet may be cut out at once to formation level.

7.11 Cable Trench

7.11.1 Cable Trench shall be provided in the yard. It will have a gradient to discharge the water. Cable trench provided in the control room may not have any gradient as it will not discharge any water.

7.12 Drainage

7.12.1 Drainage of the substation and switching posts shall be provided as per the best engineering practices, so as to prevent surface flooding and pooling of water. In addition precaution shall also be taken to prevent transformer insulating oil from being discharged into the environment in the event of a ruptured transformer tank. This shall be ensured by a retention tank for each transformer of the size to be able to contain the whole transformer oil. This shall be constructed below the transformer and shall be covered by a suitable net to maintain a 5 cm width stone bed on which the oil might fall fitted with an extraction pit to be used for oil or rain water pumping.

7.12.2 Wall, Ceiling and Floors

Wall, ceiling and floors shall be sound proof and two hours fire rating. The inside surface of the walls shall be as smooth as possible to prevent dust deposits. The ceiling shall be finished in such a way that the equipment are not endangered by fall of plaster. The floor surface must be easy to clean, pressure resistant non slip, wear-resistant. Concrete floor with adequate strength to withstand movement of equipment / panels, wear-resistant, protective coating with ceramic tiles shall be used for the TSS control room. Attention shall be paid to floor loadings when taking the equipment in and out. In front and back of control panels and switchgear panels, insulated mats of adequate deigns and latest IS specifications shall be provided. The internal walls and ceiling shall be finished with plastic emulsion in control room.

7.12.3 Doors and windows

7.11.3.1 Windows in each room shall be of an area, not less than 20% of the floor area. Windows must be so arranged that they can be opened and closed without any personnel coming dangerously close to any live parts. All windows shall be fitted with burglar bars firmly fixed to the structure of the building. The windows shall be of aluminum frame of appropriate section and fitted with locks.

7.11.3.2 Internal doors shall be fitted with door closure, lever latches and arrangement for locking the same.

7.11.3.3 External doors shall have barrel bolts both at top and bottom of one leaf and a Yale type lock on the other leaf, they shall be equipped with an anti-panic system permitting urgent door opening by a means of a bar located at about 0.7 m high from floor level. External doors shall be of solid external quality and secured with heavy duty hinges.

7.13 Yard lighting

7.13.1 The lighting of the TSS and switching posts yards shall be adequate to permit circulation in the external and yard areas. A lighting level of 30 lux at 1 m from ground level shall be ensured for the entire TSS and switching post compound.

7.13.2 The lighting fixtures shall be installed on the main masts over the conductors with adequate clearances. The clearances shall not be less than 3m from the conductor. When the mast is inside the compound, each face of the mast shall be fitted with one luminaire. When the mast is at one border, only three or two sides of the mast facing towards the yard shall be fitted with one luminaire each. All yard lights shall be provided with astro-timers.

7.13.3 Complete lighting fixture shall have an IP code of IP 55 to ensure protection against dust and water. The luminaries shall be high pressure sodium vapor type of suitable power to ensure the required illumination level. The life of the luminare shall be at least 24000 burning hours.

END OF CHAPTER

8 LV Supply at TSS, SP, SSP & AT Stations, L-Crossings and S&T Huts

8.1 Source of Supply

8.1.1 240 V, LV supply at TSS, SP, SSP and auto transformer stations shall be obtained by suitably installing 25kV/240V single phase aux. transformer of the following rating:

a) TSS- 100kVA 2 nos. connected to 25kV bus bar of Up and Dn lines by independent jumpers.

b) SP , SSP and Auto Transformers stations - 10kVA connected to 25kV bus bar of Up and Dnlines by independent jumpers.

c) The connection shall be such that in case of power block or failure of power supply on any one of the lines the LV power shall be automatically switch over to the other line. The arrangement will be similar to the schematic diagram for stations, S&T huts and level crossings as indicated in the tender drawing vol. V.

d) AT installed for S&T installations shall be provided with energy meters and small RTUs shall be provided to monitor status of supply through SCADA System and OCC. Suitable data communication cable shall be provided by the Contractor from nearest OFC Hut.

8.2 LV Supply at Stations, Level Crossings and S&T Huts

8.2.1 Station Buildings, shall be supplied 240V electric power from local supply authorities, DG set with an option of solar power shall also be installed. The normal Power supply shall be arranged by the Other Contractors (CTP 1, 2and 3) However, emergency power shall be made available for essential loads by EMP-4 contractor by installing 25kV/240V, 25kVA step dn transformers.

8.2.2 For level crossings,Other Contractors (CTP-1, 2 and 3) shall provide solar power and auto change over switch. EM P-4 Contractor shall install 25kV/240 V auxiliary transformers of 10 kVA and terminate the L.T. Supply at the ACO switch as per drawing no. EMP4/OHE/106.

8.2.3 For S&T Huts, supply from 25kV/240 V Auxiliary Transformers shall be the main source of supply and shall be provided by EM P-4 upto the terminal board.

8.2.4 The details of 2 core cables shall be as under:

Item	Railway Station	Signalling Huts	Level Crossing
Size of 2 core cables	70 sq mm	25 sq mm	25sqmm

8.2.5 The Auxiliary Transformers shall conform to specification no. ETI/PSI/15(8/03) and mounting arrangement shall be similar to ETI/PSI/0312 (Mod. B). The efficiency of the auxiliary transformer shall be governed by the total loses at 50% and 100% loading as per the formula given below:

$$Y_0 50\% = \left[\frac{\mathrm{Kxo} - \mathrm{Kx1}}{\mathrm{Kx2} - \mathrm{Kx1}}\right] x \left[\mathrm{L2} - \mathrm{L1}\right] + M_1 X_1$$

$$Y_0 100\% = \left[\frac{\mathrm{Kxo} - \mathrm{Kx1}}{\mathrm{Kx2} - \mathrm{Kx1}}\right] x \left[\mathrm{L2} - \mathrm{L1}\right] + M_1 X_1$$

Where :

K = kVA rating of transformer
L = losses
M_1 = Maximum losses for a given star rating
X_o = kVA rating of Standard Rating Transformer
X_1 = kVA rating of Standard Rating Transformer below X_o
X_2 = kVA rating of Standard Rating Transformer above X_o
L_2 = Maximum losses for a given star rating Standard Rating Transformer above X_o@ a particular loading
L_1 = Maximum losses for a given star rating Standard Rating Transformer below X_o@ a particular loading

M_1 X_1= Maximum losses of X1@ a particular loading for a given star rating

END OF CHAPTER

9 Design Criteria & Performance Requirement - Overhead Equipment

9.1 General Requirements

9.1.1 Scope of Work

This specification covers complete design, supply, installation, testing and commissioning of traction overhead equipment (OHE) for 25 kV AT Feeding System of traction for the tracks on the Western Dedicated Freight Corridor, including main lines, yards, connecting tracks to Indian Railways and depot access lines to provide traction power to rail vehicles.

The principal components of the scope of work shall include but not be limited to the following:

a) The Contractor shall provide 25kV AT Feeding System, auto-tensioned overhead equipment on the sections.

b) The nominal height of contact wire shall be about 7.54 m above rail level for the passage of double stack containers mounted on flat wagons.

c) Complete 25 kV ac flexible polygonal Overhead Equipment (OHE) including parallel reinforcing conductors along the track, foundations, steel structures, protective conductors, 25 kV feeder and cross track feeders, earth and associated insulators and hardware, jumpers and isolators (other than those located in TSS, SSP and SP).

d) +25kV and -25kV cable/Overhead cross-track feeders and flexible cable feeder connections from track-side bus to the tracks.

e) Track bonding and earthing.
Survey and safety earthing of all other adjacent steel structures alongside including those of Indian Railways alignment running alongside, if required.

9.1.2 Scope of OHE Wiring

a) Main Up and Down tracks as below:

	From	To
Station	Rewari Junction	Makarpura Junction
Continuous chainage	00.00	914.943
CPM : Section Chainage	16/15.500	5/131

b) All running loops and crossovers at crossing and junction stations as furnished in the Wiring Cum Sectioning Diagrams for all the 30 stations included in volume V of the Bid Document.

c) All Electric Locomotive sidings and brake-van sidings. Electric Locomotive sidings will be provided with a short neutral section with one manually operated double pole isolator with earthing heel.

d) All Ballast sidings and hot axle sidings through a single pole earthing switch.

e) The connecting up and down tracks from Makarpura Junction yard of DFC to Makarpura yard of Western Railway over the chainages indicated below:

	From Chainage	To chainage	Length (Km)	Total (Km)
Up Track	134/191	136/544.34	2.353	8.518
	0/00	6/165.30	6.165	
Down Track	134/178.5	135.658.34	1.480	7.983
	0/00	6/502.97	6.503	
			Total	16.501

f) On other connecting tracks from DFCC yard to un-electrified tracks of Indian Railway, the tracks shall be wired for 200m from the crossover point to facilitate shunting of Electric Locomotives

g) Diesel stabling sidings, Machine sidings and Tower Wagon sidings shall not be wired.

9.1.3 The Contractor shall be responsible for design and construction of Traction Overhead Equipment, civil and protective works. The Contractor shall be responsible for coordinating and cooperating with the Other Contractors so that the design and installation of all components of the railway are compatible as a whole.

9.1.4 The design and installation of all the other railway infrastructure and operating equipment, including track and Civil and Track Works , signals and signalling cables, general power supply, telecommunication links, etc. that are required for the railway will be undertaken by the Other Contractors. Accordingly, the work will be carried out on basis of access and necessary space shall be earmarked and provided for laying of the cables and equipment on both sides of the DFC alignment by the Other Contractors (general power, telecom and signalling).

9.1.5 The Contractor shall coordinate his design Works with the Works to be carried out by Other Contractors and execute his works as planned and programmed for access during the design phase.

9.1.6 The extent and details of such provisions are to be determined by the Contractor(s) making due enquiries, during the design coordination period, from the Other Contractors engaged (or from the Engineer in case of absence of the Other Contractor(s)) to provide railway operating equipment as stated above.

9.1.7 The extent of provision of overhead equipment for the tracks shall be determined in coordination with the Other Contractors and with the Engineer for ensuring that the design incorporates suitable fixings byOther Contractors.Accordingly, the modifications to bridge piers, viaducts, or any other structures for the provision of OHE shall be subject of interface at the initial stage of design so that they are incorporated in the permanent works by the Other Contractors.

9.2 Factors Governing Design of OHE

9.2.1 Track Structure

9.2.1.1 Highlights of the Track Work Specifications' as finalized for Civil and Track works Contract CTP-1, CTP-2 and CTP-3 are furnished below:

Following technical parameters in respect of track structure corresponding to 25 tonne axle load will be adopted. In future the track structure shall be upgraded to 32.2 tonne axle load by increasing the track level by 275 mm, provision for which shall be made while designing the OHE.

Table: 9.2-1– Track Structure

	Points &Crossings	
a)	Main line and auxiliary main tracks and running Loops	60 kg Rail, 1 in 12 curved thick web switches with CMS crossings on fan shaped PSC sleepers layout
b)	Minor loops and non-running lines /Sidings	60 kg Rail, 1 in 8 1/2 curved thick web switches with CMS crossings on fan shaped PSC sleepers layout
	Ballast Cushion below the bottom of the sleeper at the rail seat	
a)	Main line.	350 mm.

b)	Loop line & sidings	250 mm
	Sleepers	
a)	Sleeper	PSC Mono-block, 60 Kg with 1 in 20 cant for the rail seat (The rail seat of PSC sleeper will be able to cater to 68 Kg/m and 60 Kg/m rail sections by providing suitable liners.)
	Formation Width	
a)	Embankment	a) For double track : 13.5 meter b) For single track : 7.5 meter
b)	Cutting excluding side drains	a) For double track : 12.9 meter b) For single track : 6.9 meter

The relevant part of the design criteria to be followed by the Other Contractors for the track construction is attached for information only for the Contractor to suitably design the Overhead Equipment structures for the tracks of the route.

9.2.1.2 Earth Work

The main features of the geometric parameters of the earth work are furnished in the table below:

Table 9.2-2 : Geometric Parameter of Earthwork

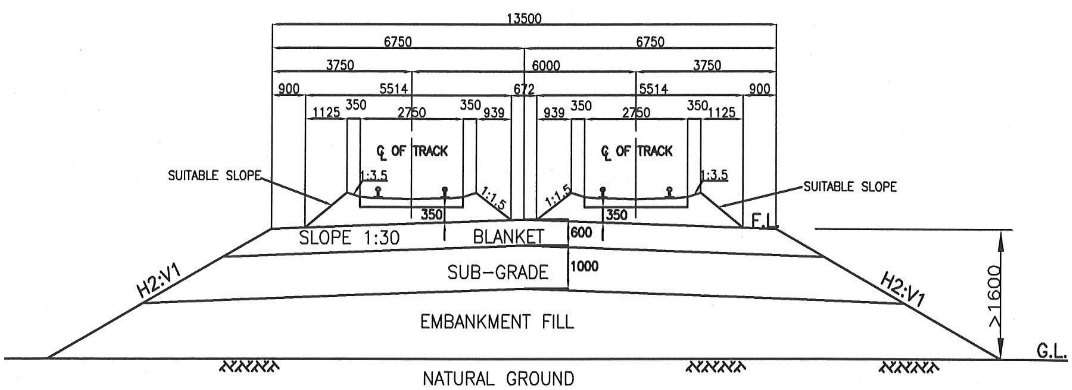
S. No.	Parameter	Value
1.	Formation Width (a) Embankment (b) Cutting	 i) For double track : 13.5 m ii) For single track : 7.5 m i) For double track : 12.9 m ii) For single track : 6.9 m
2.	Slope gradient for embankment	2H : 1V
3.	Slope gradient for cut	1H : 1V
4.	Thickness of blanket	600mm
5.	Thickness of prepared sub-grade	1,000mm (if the existing soil conditions satisfy the conditions of the prepared sub-grade for the embankment height up to 1.6 meter, the same shall be treated as sub-grade)
6.	Width of berm	1,500mm (Minimum)
7	Width of cess	900mm (Minimum)
8.	Cross slope at top of blanket	1 : 30 or 3.0% with tolerance

S. No.	Parameter	Value
		of 0.5%
9.	Cross slope at top of prepared sub-grade	1 : 30 or 3.0% with tolerance of 0.5%
10.	Cross slope at top of embankment fill	1 : 30 or 3.0% with tolerance of 0.5%
11.	Cross slope at berm	1 : 30 or 3.0% with tolerance of 0.5%

9.2.1.3 Embankment

Typical cross-section at an embankment is shown in the sketch attached below:

TYPICAL X-SECTION OF EARTHWORK STRUCTURE (EMBANKMENT)



9.2.1.4 Curves

(1) The minimum radius shall comply with the requirements as follows:
   (i) Minimum radius for the Main Line : 700 meters (2.5 degreecurve)
   (ii) Minimum radius for other than Main Lines 438 meters (4 degree curve)

Where degree of the curve is the angle subtended at the center by a chord of 30.5m (refer Para 401 of Indian Railway Permanent Way Manual).

9.2.1.5 Cant and Speed as specified (As per DFCC-SOD-2013):

The curve speed and cant relationship shall be based on the following equations:

Actual CantCa = $GV^2/127R$

Where Ca:Actual cant [mm]

G: Dynamic Gauge in mm i.e. 1750 [mm]

V: Equilibrium Speed in km/hr i.e. 85 [km/hr]

R: Radius of the curve [m]

The standard speed for actual cant shall be defined by considering the maximum permissible speed (100 km /hr.), speed restriction, gradient and train operation plan. The equilibrium speed of actual cant setting for general section is 85 km/hr. The cant computed shall be rounded off nearest 5mm. The allowable applied cant shall not be over 140mm and the cant deficiency shall be limited to 75mm.

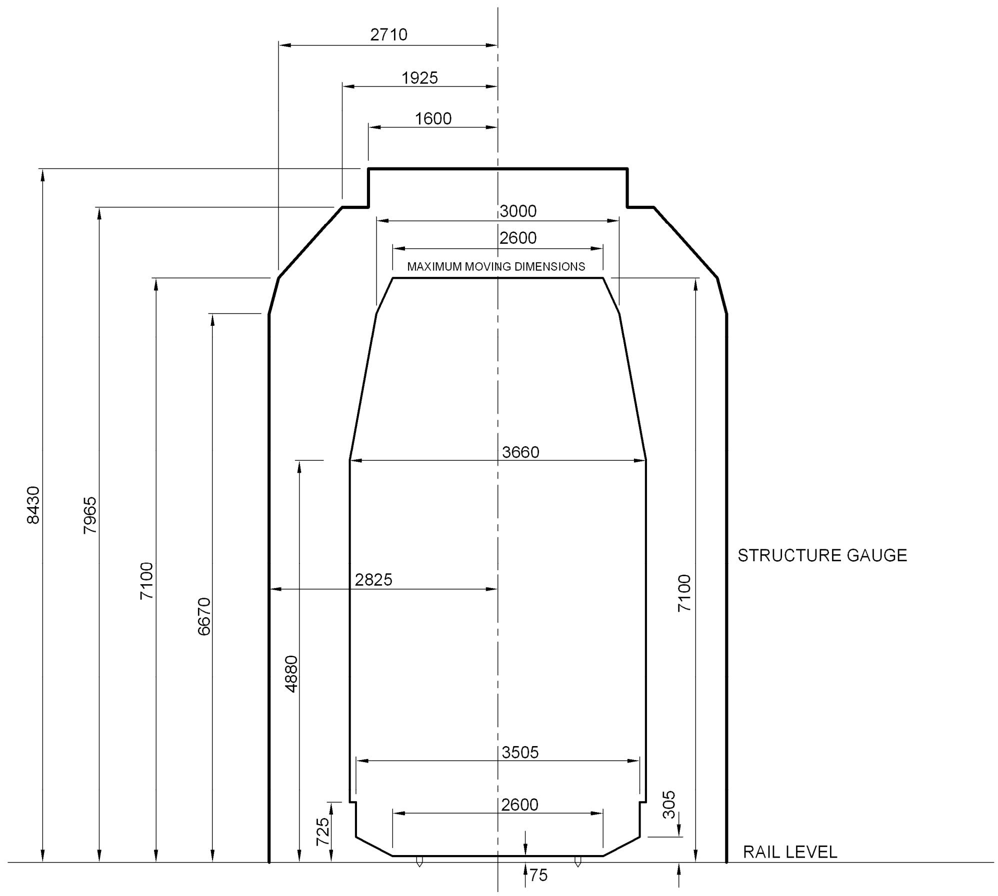
Cant transition shall be straight ramp. Cant excess shall be limited to 75mm.

For OHE design purposed to be used for Construction drawings the actual cant provided, shall be obtained from the relevant Civil Contractor (CT-P1, CT-P2 andCT-P3).

9.2.1.6 Maximum Moving Dimensions (MMD) and Structure Gauges

Double stack containers on flat wagons are proposed to be run on the route. The MMD and Structure Gauges Drawingsare shownbelow(Figure No. 8.3-1), as per the details given in DFCC-SOD-2013. The Contractor shall ensure that the proposed size and location of Works including Contractor's works are outside the Structure Gauge.

Figure9.2-1: Maximum Moving Dimension and Structure Gauges



9.2.1.7 Headroom clearances:

With regard to headroom clearance, the following exceptions are added to the requirements above. Minimum height above rail level for a distance of 1,600 mm on either side of the centre of the track shall be as under:

1) When lower track line is DFC tracks
   (i) Light overhead structure such as foot over bridges8,430 mm
   (ii) Heavy overhead structure such as road over bridge or flyover8,050mm
   (iii) Heavy overhead structure at turnout etc. 8,430 mm

2) When DFC tracks are crossing over IR Lines, the vertical clearances to be observed (as per IR Schedule Of Dimensions) shall be:

(i) Light overhead structure such as FOB 6250 mm
(ii) Heavy overhead structure such as Flyover or ROBs 5870 mm

In case IR track is nominated for Double Stack Container (DSC), vertical clearance shall be provided as per the requirement specified above.

9.2.1.8 Provision in the designs for Low joints in the track:
For low or loosely packed joints a difference of 10 mm in the opposite rail shall be taken as the basis for estimating the displacement of the Pantograph with respect to its normal position.

9.2.1.9 Displacement of track due to slewing:

The slewing allowance shall be taken as100 mm.

9.2.1.10 Height of Rolling Stock:
Maximum height of the rolling stock with Double Stacked Container, above Rail level 7.10m. This height of the Rolling Stock above rail level shall result in contact wire height above rail level as follows:

Normal at the support	:	7.54 m
Minimum (anywhere in the span)	:	7.47m
Minimum under Overline structure		7.41 m

9.2.1.11 Maximum Span of OHE
Maximum Span to be adopted on this route: 63 m. All spans shall in multiples of 4.5 m

9.2.1.12 Motive Power Pantograph Characteristic
(1) The Pantograph details, used DFCC rolling stock, are as follows:

a)	Overall width (Including Horns)	2040mm
b)	Number of collector strips	2
c)	Collector material	Metalized carbon strips
d)	Working width of the head	1040 m
e)	Static contact force	7 ± 0.4 kg on OHE
f)	Working range (above rail level)(m)	4.58 to 7.55

9.2.1.13 Over-line structures with restricted Overhead Clearance:

The list of over-line structures such as RoadOver-Bridges and Rail Flyovers with restricted Overhead Clearance has been furnished inVolume IV (Data Book) Part 1. The overhead equipment profile through these structures shall be designed to pass through them with adequate electrical and mechanical clearance without any speed restrictions on this account as per DFCC-SOD-2013.

9.2.1.14 A list of major and important bridges with spans above 50 m is in Volume IV (Data Book) Part 1. Structures to support traction overhead equipmentmay be required to be provided on the bridge piers.

9.2.1.15 On long bridges and long viaduct OHE anchors and supports may also be required on bridge/structures itself. On through girder bridges, the overhead conductors and pantograph swept path shall have to be provided with adequate electrical and mechanical clearances. These will need special designs.

9.2.1.16 The design and erection of OHE structures on these bridges and earthing& bonding of all structures shall be carried out in close co-ordination with the other (Civil and track work) contractor.

9.2.1.17 The overhead equipment which shall be of simple sagged polygonal type shall be designed for a maximum line speed of 120 km/h, and a normal operating speed of 100 km/h.

9.2.2 Minimum clearances to be adopted:

Table 9.2-3 Minimum E & M Clearance (mm)

Item	Dimension
25kV Live metal to earth - Static - Dynamic (passing)	 250 200
25kV Live Metal to Vehicles -Static - Dynamic (passing)	 290 220
Phase Difference (47.6kV) - Static - Dynamic (passing)	 530 350
Between conductors of different electrical sections Gap at Insulated Overlap Gap at Uninsulated Overlap	 500 200

9.2.2.1 The minimum clearances betweenlive conductors (including thepantograph) and any grounded fixed structure shall be in accordance with DFC-SOD-2013.

9.2.2.2 Mechanical clearance from the pantograph to any fixed structure, excluding the registration assembly, steady arm or registration pipe of the cantilever, shall be not less than 200 mm. except at locations where a locomotive is expected to halt as a matter of normal operation. Clearance to steady arms and registration assemblies or tubes used for registration purpose, shall be not less than 35mm under worst case operating conditions including dynamic displacement of the vehicle, the pantograph as well as track and maintenance tolerances.

9.2.3 The Aerial Earth Conductor (AEC) level at the lowest point shall not fall below the contact wire level at the maximum temperature.

9.2.4 The following design features of OHE as on Indian Railways may be adopted:

(a) Normal Encumbrance:(Axial Distance between Contact wire and the Catenary wire in a vertical plane) :1.4m
(b) Standard spans in multiples of 4.5 m from a minimum of 27 m
(c) Stagger of Contact Wire:
- On straight :200 mm
- On curved track : 300 mm

(d) The maximum distance between anti-creep to the anchor structure is 750m on Indian Railways. The Contractor may propose longer lengths upto 1000 m in view of the need to provide taller masts to support contact wire at height of 7.54 m based on his design calculations for acceptance by the Engineer. This should be submitted with detailed calculations for movement of cantilevers from their normal position to extreme temperature conditions.

9.3 Structural Design of the Overhead Equipment Support

9.3.1 The structural design of overhead equipment adopted by the Contractor shall follow the method of RDSO as applicable to the special parameters of DFC (WC) requiring increased height of contact system to permit passage of double stack containers of flat wagons as well as the sizes and number of conductors required for the 25 kV AT Feeding System of traction. These sizes and numbers will be confirmed through the computer simulation of traffic needs of the route and shall need approval by the Engineer. It is to be noted that the designs shall continue to be safe for the ultimate raised height of the contact wire plus 275 mm for future needs, when the axle load permitted on the route is increased to 32.5 tonnes.

9.4 Sectioning of Overhead Equipment

9.4.1 Introduction

Stations are generally 30km to 40km apart with crossing stations for giving precedence to trains and junction stations providing exchange with IR route. With reduced manning for operation, it is proposed to make the switching of OHE for main lines and yard sections through remote control from the Operations Control Centre.

9.4.2 The OHE shall be sectionalized through remote controlled switching, so as to maximize the amount of operational track in the event of :

a) An overhead equipment failure
b) An isolation required for routine maintenance
c) Isolation required for emergency work.

The sectioning shall be minimum to provide for flexibility of operation in consonance with reliability of equipment.

The indicative sectioning layout for the Western Dedicated Freight Line is shown in the Traction Power Supply and Sectioning Diagram in Drawing EMP4/PS/201.

9.4.3 Sub-sectioning Posts (SSP)

9.4.3.1 To enable speedy issue of maintenance and emergency power blocks, outer most crossovers between up and down main tracks shall have an SSP located at each entrance of Junction and Crossing stations. Additional SSPs shall be provided to sectionalize the route, if required.

9.4.3.2 The SSP sectionalization shall be arranged such that movement to various lines and yard line is maintained, isolating the smallest portion of tracks for maintenance or breakdowns. Portions of station yard can be made dead whilst the rest of the mainline and yard is energized and vice versa.

9.4.3.3 At Junction stations, there shall also be an isolation point at the boundary between the Western Dedicated Freight Corridor infrastructure and Indian Railways infrastructure through a neutral section. The IR sections are fed by conventional 25 kV system, while DFC is on 25 kV AT Feeding System and these two need to be isolated. The isolation shall also allow the 25 kV ac traction supply from Indian Railways to feed the Junction station exchange yard lines when the Western Dedicated Freight Corridor main lines are un-energized.

9.4.4 Section Posts (SP) and Traction Substations (TSS)

9.4.4.1 At SP and TSS locations, there shall be sectionalization to allow one section to be isolated from the next section. The section isolations shall be arranged such that safe isolation can be made for maintenance purposes, whilst the adjacent section remains alive. The location of SP and TSS shall be subject of interface with the Other Contractors for signaling, to ensure there are no stop signals in the vicinity of the neutral section.

9.4.5 Auto-transformer Stations:

9.4.5.1 Auto-transformers shall be provided in each TSS, SSP and SP at every 15 km apart and an average 13 to 17 km apart at a SSP location. Additional ATS shall be provided in case there are no switching stations in the vicinity to ensure that the accessible voltage does not exceed the limits laid down in International Standards. To isolate faulty autotransformers, each autotransformer will be connected through double pole motor operated Isolators controlled by SCADA.

9.4.6 Indicative Sectioning Diagrams

9.4.6.1 The indicative sectioning and wiring of lines is shown in Drawing No. EM P-4/PS/201.

9.4.6.2 The Contractor shall verify the drawing in regard to the indicated wiring &sectioning provided and shall submit his own proposal for the sectioning diagram to the Engineer for approval. The Contractor shall not commence construction until the OHE layout plan along with the sectioning diagram has received the statement of “no objection” from the Engineer.

9.4.7 Locomotive Maintenance Depot:

9.4.7.1 There shall be sectionalization at the entrance to the locomotive maintenance depot at Rewari. There shall be an SSP that shall be used to supply main line power to the Depot. The sectionalization at this location shall allow safe isolation of the depot lines whilst the main and Rewari yard lines remains energized.

9.5 OHE Conductors

9.5.1 Indicative Sizes of Conductors

The indicative sizes of conductors for the main lines are furnished in the Table No. 9.5-1below: The Contractor has to design system in such a way that the conductors are sized to meet the power requirement fortraffic to be hauled in the year 2031-32.

TABLE: No 9.5-1
OHE Conductors for Main Lines for each track

Conductor	Minimum Size(mm^2)	Material	Remarks
Catenary	125	Copper alloy	Material having temperature range up to 100^{0}C as per EN 50119
Contact wire	150	Copper alloy	
25 kV Feeder	To be determined	AAAC	Material having temperature range up to 80^{0}C as per EN 50119
Aerial Earth Conductor	To be determined	ACSR	
Buried Earth Conductor	To be determined	GS	Material having temperature range up to 80^{0}C shall be used

Note: Conductors for yard lines shall be as per para 9.6.14

9.5.2 Contact Wire

The contact wire shall be Silver bearing copper of 150mm^2. Contact wire of less than 150mm^2 shall not be used. The contact wire shall be grooved and conform to RDSO Spec. No. TI/SPC/OHE/CW(Cu-Ag)/0100 or any copper alloy as per EN 50149.

9.5.3 The contact wire shall be continuous, that is, splicing or jointing of the conductors is not permitted between terminations or between cut-in insulators. Splices are primarilyfor use during maintenance and shall not be used in the contact and/or catenary wires by way of installation or repair, unless approved by the Engineer.

9.5.4 Catenary (Messenger) Wire

The catenary wire, where provided, shall be 125mm^2 copper alloy, conforming to RDSO Spec. No. TI/SPC/OHE/Cat(Mg-Cu)/0120 or DIN 48201 - T_1 & T_2 or EN 50149, EN 50119.

9.5.5 Aerial Earth Conductor

A aerial earth conductor of adequate size if required shall be provided. It shall be of steel reinforced aluminium strands with fixed termination shall be erected parallel to the OHE system and be simultaneously utilized as a common aerial earth condcutor (AEC) and as a continuous path for normal current return and fault current return.

9.5.6 Splices, Clamps and other Tension Fittings for the Conductors

9.5.6.1 The performance of fittings designed to terminate or splice stranded or individual wires is critical to the efficient operation and maintenance of the OHE.

9.5.6.2 The fittings shall be tested in tension, in a special rig to simulate the load characteristics experienced in service and Contractor shall demonstrate its suitability by FEM Analysis.

9.5.6.3 The tensile failing load of the fitting shall exceed the failing load of the wire or stranded wire with which it shall be assembled and used.

9.5.6.4 When the fitting is tested and assembled to the allocated wire or stranded wire the assembly shall achieve 85% or greater than the specified tensile failing load of the wire or stranded wire.

9.5.6.5 Applicable factors of safety shall be derived from the European standard EN 50119.

9.5.6.6 Unless otherwise specified in this PS, all bolts, studs, nuts, washers and pins used for the current carryingconductors shall be of stainless steel or high tensile copper alloy. However, for all other applications, galvanized steel may be used with particular reference to the prevention of corrosion.

9.5.6.7 All fittings, components and materials to be used on the Project shall be subject to prototype tests. If prototype sample of the item has, in the past, been approved in connection with a previous electrification project on Indian Railways for identical purpose at least two years prior to this project work, such item shall be exempt from prototype test. Any approval to the prototype tests by the Engineer in no way would absolve the Contractor of his responsibility under the terms of the contract for the equipment, fitting, component and materials provided and used on the project. Supply of bulk quantity shall not, however, commence unless a 'No Objection' to its supply has been obtained in writing from the Engineer.

9.6 Electrical Connections

9.6.1 The connections shall be robust, to withstand both static and dynamic loads, wind, along track movement. (temperature variation in conductors and operational vibrations).

9.6.2 Design of fittings and connections shall ensure no localized temperature rise at the connection to prevent any damageor deformation or adversely affect the mechanical capacity of the conductors or their electrical performance.

9.6.3 Where dissimilar connecting materials are used appropriate measures shall be employed to mitigate the risk of bimetallic corrosion.

9.6.4 Protective bimetallic tapes and shells shall be installed at clamps and terminals used with aluminum and copper conductors and cables.

9.6.5 Nominal working pressure shall be kept up to compensate the permanent temperature deformations and generation of local overheats.

9.6.6 The tapes and shells shall envelope 10mm outside of clamps on both sides.

9.6.7 General requirement

9.6.7.1 All wires including feeders, earth wires shall all be preferably located on the inside (side closest to the railway track) of the OHE mast for convenience of wiring from the wiring train, and to minimize EMI effects.

9.6.7.2 The sizes of contact, catenary wires,any proposed reinforcing parallel feeders and the 25 kV feeder and any other protective conductors shall, however, be verified based on current to be handled by the OHE under worst conditions as determined in the Simulation Report and accepted by the Engineer.The wires shall be sized on the worst case practical of feeding arrangements under say, one TSS breaker failure occurring when extended emergency feed is enforced due to a previous adjacent TSS Failure. The conductors shall not suffer any permanent damage or deterioration under normal train operation. These calculations shall be undertaken for every electrical section.

9.6.7.3 In assessing the conductor sizes, tensions and current carrying capacity, an allowance for manufacturers permitted cross-sectional area loss due to wear of the contact wire to 70% shall be taken into consideration.

9.6.8 Buried Earth Conductors

Buried Earth Conductors shall be laid on both sides of the alignment by theContractor. The Contractor shall connect BEC, AEC and running rails of both the tracks at regular intervalsas per the result of simulation study to keep the rail touch and step potentials under acceptable limits both for normal and fault conditions. It shall be the responsibility of the Contractor to verify the sizes of the buired and overhead earth conductors, distances of their connection to rails/earth so as to ensure a safe system both under normal and fault conditions as per EN-50122-1. For the calculation purpose time duration for clearance of fault may be considered as 300 ms.

9.6.9 The Contractor shall where practical, optimize on the number of parallel feeders and shall install them where necessary. The multi-train simulations shall be used to prove the optimization of conductors.

9.6.10 The Contractor shall install a minimum of two feeder wires for the auto transformer feeders.

9.6.11 The clearance between feeders and the catenary system should remain adequate under adverse wind and temperature ambient conditions.

9.6.12 The multi train simulations shall be used to prove that the wire temperatures are within design limits as stipulated in EN-50119 under all practical operational configurations. The Contractor shall identify any operational limits in the design report.

9.6.13 Jumpers and Feeders

9.6.13.1 Flexible Jumper wire shall be fabricated from soft or annealed, high conductivity copper with stranded conductors. The relevant RDSO specification for annealed stranded copper conductor for jumper wire is ETI/OHE/3(Latest).

9.6.13.2 Flexible jumpers of adequate cross-section, suitable material and standard construction shall be provided at un-insulated overlaps (air gaps), points and crossings to carry and maintain the anticipated load and short circuit currents.

9.6.13.3 Feeder connections shall have the full copper equivalent cross sectional area of the combined contact and catenary conductors.

9.6.13.4 In-span potential equalizing jumpers may be fitted between catenary and contact wires, to ensure that burning of dropper components does not occur

9.6.13.5 All conductors shall be above contact level in design and jumpers shall be connected to contact wire in such a way that if it comes out of contact wire P G Clamp, it does not infringe with pantograph movement.

9.6.13.6 Wherever the clearances as stipulated are not obtained, special insulation arrangements shall be proposed to the Engineer for his acceptance.

9.6.14 Conductors for the Yard Lines

The size of catenary and contact wires for yard lines shall be 107mm^2 HDGC copper and 65 mm^{2}catenary to RDSO's specifications.

9.6.15 Flexible Droppers

Each bronze dropper shall consist of suitable size (minimum 10mm^2)bronze strands and two dropper clamps, one of which is connected to the contact wire, and the other to the catenary wire. Flexible dropper shall conform to DIN 482. The maximum resistance at the joint between the bronze dropper wire and the clamp, and at the contact point between the clamp and the catenary and contact wire, shall be less than the resistance of the conductor of the same length. The maximum temperature rise at the joint and at the contact surface shall not be higher than that of the conductor. The tensile breaking load of the complete joint shall not be less than 90% of the failure tension of the dropper wire.

9.7 Cantilever Assemblies

a) The Contractor shall adopt modular cantilever system (MCS) on DFCC. These shall be easy to install and field adjusted to account for the effects of future track settlements or movements.
b) The MCS chosen shall be light weight, rust free, the tube being of aluminum alloy and the fittings stainless steel, gun metal, bronze or copper alloy to make them rust free.Copper alloy components and fittings are desirable, dis-similar materials with potential bi-metallic corrosion defects shall be avoided.
c) The number of components and their sizes shall be as few as possible.
d) The Contractor shall ensure that the range of cantilever frame components are suitable for the loadings and applications shown in the Drawings and these Specifications.
e) The proposed cantilever frames will sustain the normal and worst case loading conditions with a factor of safety not less than 2.5.

f) The cantilevers shall be designed such that they can be pre-assembled off site for delivery to site. FEA (Finite Element Analysis) of the cantilever assemblies shall be carried out and got approved.

g) The Contractor shall demonstrate that his choice of design and material for cantilever assemblies and components fulfill the following criteria:
1. Economically advantageous
2. Robust to withstand static, dynamic loads and vibrations under all operational and survival loading conditions.
3. Efficiently, fully and freely rotating at the hinges, due to continuous along track movement.
4. Compliant with the design specifications approved for the project.
5. Simple to assemble with low maintenance.
6. Having safe rigid connections and fittings.
7. Standard re-usable parts and fittings.
8. Compliant with the required life expectancy.

h) The contact wire registration profile shall accommodate the permissible extremes of uplifted and swayed pantograph movement in addition to the effects of track tolerances and include allowance for mechanical and electrical clearances and to be in accordance with the stipulations of DFC-SOD-2012.

i) Fittings connected to the in-running contact wire shall utilize the wire groove and shall be shaped to maximize clearances to the pantograph head when uplifted by the extreme operating running conditions and shall take account of pantograph and contact wire wear and to be in accordance with the EN/IEC standards.

j) Assemblies shall allow for the adjustment of contact wire stagger and the equivalent catenary adjustment by 75mm either side of the designed position without changing components.

9.8 OHE Assemblies, Fittings and Hardware

9.8.1 The fittings, tubes and hardware shall confirm to RDSO (Indian Railways) specifications for these items subject to their suitability for the ratings and situation applicable for use on the dedicated freight corridor (Western). Where the Contractor offers components of different ratings, design or configuration conforming to other National and International specifications or proven design, details of the specifications and performance elsewhere shall be furnished.

9.8.2 Fasteners and Fixing for structures

(1) All threaded fasteners, washers, headed pins and locking pins etc., shall generally conform to appropriate Indian standards applicable to

materials, form, threads and protective coatings, these requirements shall include, but not be limited to, the following:

a) Hot dipped galvanized bolts shall have a minimum diameter of 16 mm, bolts below this diameter shall be stainless steel.

b) Hot-dipped galvanized fasteners with male threads shall normally be spun, immediately after removal from the galvanizing bath to remove excess zinc from the threads.

c) Brushing of the threads is not permitted.

d) Hot-dipped galvanized nuts shall have threads cut after galvanizing.

e) The bare metal shall be protected from corrosion with an inhibiting oil or suitable grease.

f) All other bolted joints shall have a minimum of 2 threads showing.

g) All bolted joints for greater than 12mm in diameter shall be by a single flat washer and double nuts application.

h) Structures or brackets required to be fixed to masonry or rock shall be attached by approved anchor bolts inserted into pre-drilled holes, filled with an approved chemical fixing product, which sets rapidly to firmly fix the anchor bolts in position.

i) In each case the location of the fixing shall be subject to the approval of the Engineer, and shall subsequently demonstrate the efficacy of the fixing to the satisfaction of the Engineer, who may require sample pull-test or torque tests to be performed.

j) In the case of chemical fixings, the Contractor shall be expected to adhere to the manufacturer's instructions for installation, and shall bring these to the attention of the Engineer before installation commences.

k) The Contractor shall prepare and submit for the Engineer's approval a list of all applicable specifications for threaded fasteners, washers, headed pins and locking pins.

l) Locking pins, washers and fasteners shall be of stainless steel.

9.9 Auto Tensioning Devices:

9.9.1 The tension in the contact and catenary conductors of the flexible overhead equipment shall be Regulated at all temperatures by auto-tensioning devices of proven design. The Auto Tensioning Device shall be of 3/5 pulley type as per RDSO specification NO. TI/SPC/OHE/WR/1060 or latest .

9.10 25 kV Cables

9.10.1 25kV ac single core cables shall be insulated with XLPE and shall be armoured. The outer sheath of the cables shall be protected against ultra violet radiation.

9.10.2 In order to protect the insulated cables and associated equipment from atmospheric voltage surges on the OHE located outdoors, TSS and traction switching station feeder cable connections to the OHE shall be provided with gap less lightning (surge) arrestors.

9.10.3 Conduits and Cables
Cables shall be placed in protective metallic conduits up to 1.5m above the ground, these being encased in concrete up to the plinth level of structure.

9.11 Structure/Uprights and their Foundations

9.11.1 Overhead equipment structuresfor the main line tracks shall be mechanically and electrically independent and shall not be located between Up and Down tracks except where specifically approved by the Engineer. The structure uprights shall generally be embedded in concrete. In station yards,generally portals spanning over 4 tracks shall be erected. In junction stations, portals with larger number of tracks may also be required. For this purpose, adequate track centres shall be provided by the other (Civil and Track Work contractor). Designs for steel structures shall comply with IS 800- Indian Standard Code of Practice for use of structural steel in general building construction. Design method as adopted in Indian Railway Design Manual for Electric Traction (Volumes 3 and 4) may be followed for guidance. Pre-stressed concrete structures shallnot be adopted.

9.11.2 For methods of designs of structures and foundations, Indian Railways Design Manual for Electric traction shall be followed. The Concrete for the foundations shall be of Mix M15 with proportion as given in IS456. For grouting, muffing, and embedment of structures in concrete the nominal mix of the concrete shall be M20. Volume of batching shall be adopted as per clause 9.2.2 of IS 456.Cylindrical foundations mechanically augured may be proposed as compared to regular rectangular foundation design in view of faster installation requirements. Precast foundation shall not be used.

9.11.3 The Contractor shall examine the details of geotechnical survey supplied by the Engineer followed by that verified and/or carried out by the Other Contractor for civil engineering and track-work and also validate it through his own geo technical survey wherever found necessary. This data should form the basis for his design for foundations. The Contractor shall undertake sufficient geo-technical investigation to demonstrate that the foundation designs are adequate.

9.11.4 Location and Setting distance of Structures

a) Location of structures shall be selected after ensuring that there are no infringements and they do no obstruct roadways, pathways, run of cables, drains, or the sighting of DFC or IR signals etc.

b) Setting distance of structures (distance from centre line of track to face of mast) shall normally be 3.0 m plus curve allowance as required. Setting distance of portal upright, multiple OHE structure, anchor structures shall normally be 3.5 m. Where such distances are not possible, maximum possible clearance, but not less than that required by the Schedule of Dimensions for Western Dedicated Corridor for fixed structure shall be adopted. This is subject to review by the Engineer. The setback of location of traction mast shall be such that visibility of signals is not obstructed and shall be as indicated in the ACTM.

c) To ensure provision of safe current collection under adverse conditions the deflection of masts on top of the OHE structure shall not exceed 8 cm and the mast shall be erected such that it becomes vertical on application of permanent loads, The mast shallnot further deflect more than 8 cm under the wind load. Torsional deflection under permanent loads shall not exceed 0.1 radian.

The value of setting distance of masts/structures shall be painted on each mast/structures. The figures shall be 25mm in size in white on a red background. In addition, the track level shall also be marked on the mast/structure by a horizontal red painted stroke.

d) Extra clearance on Curves
The minimum setting of structures on curves shall be increased by adding to the above minimum figures of extra clearances on account of the kinematic profile of the locomotive and wagons and super elevation, the figures for curve allowance being taken from Schedule of Dimensions for DFC Western Corridor.

- Structures with Counter Weights
  Structures carrying counter-weight assemblies, the term "setting" shall refer to the minimum distance of the mast including the counter-weight from the track centre.The minimum and maximum travel of counter weight shall be marked on the mast.

- Numbering of Structures Carrying Overhead Equipment
  Structures shall be numbered in accordance with the standard numbering given in the finalized overhead equipment layout

plans. Enameled number plates at eye level from a locomotive driving cab (approx. 3m above rail level) shall be provided on each mast or structure. Details to be submitted for review by Engineer. Retro-reflective number plates shall be provided 500m in approach of neutral sections, approach to up/ down gradient and the first number plate of each kilometer.

9.11.5 Construction design shall include the construction employment schedules for structures and the foundations for different situations of loading expected to be encountered on the route.

9.11.6 Field work shall only be commenced when the Contractor has received a letter of no objection to the proposed mast and foundation designs and construction methodology from the Engineer.

9.11.7 Tolerance in erection:

1	Span lengths shall not vary more than	+/- 200 mm
2	Cumulative error in all spans in one km shall not exceed	+/- 1000 mm
3	Height of contact wire	+/- 20 mm
4	Dropper length	+/- 5 mm
5	Dropper location	+/- 100 mm

9.11.8 For OHE masts to be erected on long bridges and viaducts, the Civil Contractor (CTP-1, 2, 3 and CTP-3A) shall provide fixing arrangement for the masts with base plates. EM P-4 Contractor shall interface with Civil Contractor so that masts with base plate are ordered and fabricated at the suppliers works and duly galvanized after welding and drilling holes in the base plate.

9.12 Outdoor Steel parts

All the steel structures and small part steel for carrying overhead equipment shall be galvanized.

All the steel structures and small part steel for carrying overhead equipment are to be fully galvanized after drilling and fabrication to RDSO Specification ETI/OHE/13 (Latest). Painted structures shall not be used.

In case of need to use non standard SPS at special locations to be fixed to the steel structure, these shall be with clamps to avoid drilling of galvanized mast sections.

9.12.1 Anti- Climbing Guards

a) Anti-climbing guards shall be provided for all structures to supporting Auxiliary Transformers.

b) Screens and anti-climbing guards shall be provided on OHE supports at locations where any person can either touch or gain access to live overhead conductors.

c) Where deemed necessary the equipment and critical points shall be clearly identified with warning and danger signs positioned at appropriate intervals, distance and heights.

d) All safety critical items shall be secured by bolts, clamps, etc., and shall be fitted with shake proof, self-locking washers or secured with split pins behind the nuts.

e) The device shall be clamped to the structure that it protects, and no drilling of the structure shall be acceptable.

f) The guards shall be positioned to allow unimpeded access to maintenance staff during the normal course of their duties.

9.13 Insulators and Section Insulators

9.13.1 Insulators

All insulators shall be suitable for use in tropical environment. At locations subject to pollution longer creepage path, composite polymer insulators shall be provided.

9.13.1.1 For this purpose, the Contractor shall undertake a survey to categorize levels of pollution along the route in order to provide insulators suitable for polluted zones, structure protection and other protective measures for the OHE. The governing specification to determine the level of pollution for insulation and corrosion resistance shall be EN 50119.

9.13.1.2 All insulators shall be, anti-tracking, solidly bonded with weatherproof seals to appropriate end caps.

9.13.1.3 Porcelain Insulators as per RDSO specification No.TI/SPC/OHE/INS/0070 shall be provided at all locations except at polluted locations,where Polymer insulators as per RDSO Specification No. TI/SPC/(OHE)/INCOM/0070(04/07) shall be used.

9.13.2 Section Insulators

9.13.2.1 Section insulators shall not be installed in main line equipment and shall operate at the required speeds in either direction.

9.13.2.2 The section insulator shall be compatible with the mechanical and electrical characteristics of the contact wire, and the system power and electrical clearance requirements for the overhead contact system.

9.13.2.3 Type test validation shall be required for the section insulators proposed for the contract.

9.13.2.4 The section insulator offered by the Contractor shall be of a proven design with proven service in mechanical, electrical and environmental conditions similar to those specified in this design specification. The section insulators shall be designed to withstand arcing caused by the passing of pantographs with no reduction in mechanical and electrical integrity even if a pantograph runs into an isolated section for a period of 3 secs.

9.13.2.5 The specification shall be used initially for tender purposes and later on, for adjudication, purchase and inspection of material.

9.13.2.6 The governing specifications for the electrical and mechanical testing requirements for insulators shall be according to EN50151, EN50124-1, IEC 61109 and EN50119.

9.14 Design of Neutral Sections

9.14.1 The route shall be provided with automatic colour light signaling. Also the route is undulating with 0.5% grade. The location of neutral section for the TSS and the SP is to be judiciously selected such that trains are able to coast through the TSS and SP with power off with least risk of stalling. Accordingly their location shall be judiciously selected and shall be subject matter for interface coordination with contractors for contract packages ST P-5 (Signalling) and RS P-7(locomotives).The neutral sections shall be short PTFE type to RDSO Design.

9.15 Interface Coordination by the Contractor

9.15.1 Design Coordination and Interface

The Contractor shall be responsible for design coordination for EMI and safety works related to rendering the whole installation safe from EMI interference and from unsafe touch potential from induction effects of AC traction currents with all the Contractors viz: CT–P1& CT-P2, CT-P3, CT-

P3A, ST–P5, and RS–P7 and through the Engineer with adjacent Indian Railway system of both electrified and non electrified section.

9.15.2 The Contractor shall be responsible for coordinating the final OHE design and installation at different stages of deisgn and construction in co-ordination with CT-P1&CT-P2, CT-P3, CT-P3A and ST-P5 contractors.

9.15.3 The Contractor shall interface with ST P-5, Signaling and RS P-7 Electric locomotive Contractorsand also co-ordinatefor positioning of masts in respect of signal sighting and locating automatic signals near TSS and SP such that long twin trains with pantographs 750 m apart can negotiate the neutral sections located opposite the traction supply installations.

9.15.4 The Contractor shall interface with RS-P7 contractor for the co-ordination of rolling stock issues and the interface of the depot overhead line systems that is to be developed by the RS-P7 contractor, to permit loading and trailing locomotives powering down, opening of circuit breakers and again closing of circuit breakers sequentially after crossing the neutral section and resumption of traction with highest degree of reliability.

9.15.5 The Contractor shall also interface with Indian Railways through the Engineer as follows:-

- For the design, construction, testing and commissioning of the overhead line interface between Indian Railways and the Western Dedicated Freight Corridor at Junction Stations.
- To ensure that the design and construction of the OHE does not affect the signal sighting on Indian Railways.
- To ensure that the construction of the OHE does not interfere with train operation on Indian Railways nor damage any Indian Railway assets.
- To ensure that the design and construction does not impede the operation and maintenance for Indian Railways in any way.

9.15.6 The Contractor shall also interface with the civil and track work contractors for CT-P1& CT-P2 and CT-P3 to ensure that they provide the statutory signage and height gauges on the roads and Highways crossing the tracks (Level crossings and the road over-bridges) to ensure that Railway and Statutory warning signs are installed warning of the hazards caused by the 25kV AT Feeding traction system provided on the rail system.The Contractor shall further coordinate laying of buried earth conductors on both sides of the track.

9.15.7 The Contractor shall also interface with bridge contractor CT-P3A, in order to ensure smooth flow of traction return and fault current flow back to TSS and safe touch and step potential of rails under all conditions.

9.15.8 In addition to what has been stated above, interface requirements to be met by the Contractor, have been clearly defined in Chapter 17 of this Employer's Requirement.

9.16 Earthing and Bonding Systems for OHE

9.16.1 Work shall be taken up according to the approved earthing and bonding management plan by the Contractors, and those also by the Indian Railways as stipulated in theinterface coordination documents and a certificate to that effect shall befurnishedto the Engineer. Only on completion of such works, tests prior to commissioning may be taken up.

9.16.2 The work includes the earthing and bonding of steelwork.

a) Connectors,Clamps and lugs shall be bolted to structures with bolts, washers and lock nuts.

b) Earth Electrodes: shall be at least 1.5 m away from any structure so as not to interfere with its foundation. These shall consist of 50mm diacopper clad steel pipes driven into the earth up to a depth not less than 3.5m

c) Connectors: Exposed and buried earth connections shall be of type and in conformity with IS 3043 - Code of practice for earthing. Details to be submitted for review by Engineer.

d) Stipulations of clause 6.3 of this Employer's Requirement relating to Earthing are applicable.

e) The earthing connections shall be through fastners or shall use exothermic welding procedure.

9.17 Return Current Connections at AT

9.17.1 Return Current passing through the rails to the ATshall be routed through the buried rail at each location of Auto Transformer.

9.17.2 For this purpose, an industrial steel rail of minimum 52 kg/m andminimum length of 15 m shall be buried near the track at the above locations at a depth of about 1 m to form a part of the earthing system. The buried shall also be connected by means of at least fourseparate distinct connections made with steel armoured PVC insulated cables of adequate size to the traction rails. In cases where the feeding post is located separately away from the traction substation, the buried rail shall be provided at the feeding post (where the mid point of the auto-transformer winding at the substation is grounded).

9.17.3 The connections shall be maintenance free, self gripping type. Wherever, such bonds pass along or across the tracks, it shall be routed along the sleepers using proper fastners and clamps so as to avoid any damage/disconnection during ballast screening or tie-tamping of the track.

9.18 Provision for Future Additions and Alterations

The civil engineering station yard plans indicate works of additions and alterations to the yard lines in future such as provision of additional crossovers between main line tracks and or replacement of cross overs amongst loop lines. Further, some loop lines are proposed to be constructed in future. The design of over head equipment, traction installations should be take in account the complete layout which includes the future additions / alterations while designing the system. The works should be completed such that minimum modification are required in future for such works.

END OF CHAPTER

10 Supervisory Control & Data Acquisition (SCADA) System

10.1 General

10.1.1 ThisChapter of the Particular Specification defines the objectives, guidelines and requirements for the Contractor's design, verification, specification, supply, installation, testing and commissioning of the Supervisory Control and Data Acquisition (SCADA)alongwith associated cable works, and Power Asset Management System on the Western Dedicated Freight Corridor.

10.1.2 Scope of works

The works to be executed under the Contract include but not limited to the design, manufacture, verification, delivery, installation, testing, including integrated testing and commissioning of traction SCADA, asset management system, technical support, supervision of maintenance, training of Engineer's staff and documentation for a complete system necessary to deliver the requirements of the Specification.

Broadly, the scope of works include but limited to the following:-

- Remote monitoring and control of Sixteen Traction Substations (TSS). All TSSs shall be outdoor type.
- Remote monitoring and control of Sixteen Section Posts (SP) of outdoor type.
- Remote monitoring and control of Seventy Seven Sub Section Posts (SSP).
- Remote monitoring and control of Fiveoutdoor Auto Transformer Stations (ATS).
- Control and monitoring of all switches including Circuit Breakers, Interrupters of TSS, SP, SSP,ATSand Auxilliary Transformer (AxT)locations including the connection chords to Indian Railways and to the proposed depot(s).
- Monitoring fault locations as triggered by Fault Locators and reporting to the OCC.
- Complete Cable network and cable support system at the following locations:
  a) All Control and Data Acquisition wiring within TSS, SP, SSP,ATS and Auxilliary Transformer (AxT) locations.
  b) All SCADA low voltage ac and dc power supply wiring at TSS, SP, SSP, ATS and Auxilliary Transformer (AxT)locations.
  c) All Traction Power SCADA control and power supply cabling within the OCC.
  d) Where cables cross the track or are in any part external to cable trough routes, then they shall be suitably protected through FRP/ hume pipe conduits encased in concrete. The Contractor

shall coordinate with the Civil Contractors, to incorporate under track crossings into the basic construction of the concrete structures and the track formations.

e) Provision of cable termination boxes at RTU locations and at OCC for OFC cables , where cables enter and leave equipment rooms.

- Interfacing with the State Power Companies for the coordination of the exchange of analogue, digital status, measurands and protection. The Contractor shall be responsible for agreeing a control strategy with the State Power Company and provision of control and authorisation for the operation of interfacing the power supply equipment at the TSS and GSS. Supply installation and commissioning of RTU/BCU/Relay/IED required for this purpose.

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

- All Civil and Track Works or modifications required for installation of the equipment and restoring to final finishes. This shall include but not limited to preparation and levelling of ground, ground investigation, trenches, drawings, cable trenches & ducts in both buildings and with the right of way, buildings, access roads, fences, drainage, and containments.

- Provision of parallel redundant UPS at the OCC for supply of power to all traction SCADA equipment.

- Fully equipped training centre with simulator for OCC Traction Power SCADA Operators and Traction Power SCADA maintenance technicians.

- Provision of hot stand-by server at OCC.

- Provision of all documentation relevant to the Design. Construction, Testing, Operations and Maintenance in both paper and electronic form including but not limited to:
  (i) Catalogues,
  (ii) Operation and maintenance manuals,
  (iii) Data sheets,
  (iv) Release notes,
  (v) Version control documents,
  (vi) Guarantee and,
  (vii) Licence certificates.

- Supervision of Maintenance upto DLP.

- Supply, installation, commissioning and bringing in service the complete SCADA system.

10.1.3 A conceptual system configuration for the SCADA system for WDFC is attached at in Vol. V of the Bid Documents.

10.1.4 The Contractor shall undertake the Works & Services described in this document such that Phase I Works do not prejudice the design, construction, commissioning, operation and maintenance of the Phase II Works.(JNPT – Vadodara and Rewari to Dadri) of Western Dedicated Fright Corridor.

10.2 Services

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

a) Design, verification, supply, installation, testing including integrated testing ,commissioning andsetting up of quality management system as brought out above;

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

c) Interface management as specified in Chapter 17 and other stipulations of this Particular Specification;

d) System operations and maintenance support services;

e) Training for Engineer's operations and maintenance staff;

f) Decommissioning, removal and/or responsible disposal of temporary works;

g) type testing;

h) Defects liability of Permanent Works after commissioning as stipulated in the General Conditions (GC);

i) Preparation of integrated test plans for commissioning of the DFCC;

j) Ensure availability of spare components during life time (20 yrs.) of the SCADA.

k) Assisting Engineer in obtaining clearances/ sectioning from Statutory Bodies/ Agencies.

10.3 Documentation

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

- System Architechture
- Description of general design philosophy
- System reliability, availability, maintainability and safety evaluation report.
- Automatic fault identification and isolation system.
- Determination of equipment rating and space requirement
- Design and proving protection system and its calculations.
- Type test planand report of equipment selected.
- Detailed design, drawings and reports
- Interfacing design drawings
- Hazard identification and control documents
- Construction and installation plan
- Site test report of equipment
- As Built drawings and interface drawings

10.3.2 Works excluded from Scope of the Contract

10.3.2.1 The following items of work associated with the system will be provided by Other Contractors and are excluded from the scope of this contract. However, the Contractor shall provide timely inputs such as necessary drawings,instructions, hardware and materials to the relevant Other Contractors as specified in Interface Documents.

10.3.2.2 The provision of the SCADA between the state power company's grid substation and the incoming gantry at each TSS.

10.3.2.3 The provision of SCADA equipment within Rewari Depot which will be provided by the RS –P7 Contractor. However, the control & monitoring of the circuit breakers to the Rewari Loco Depot SSP shall remain the responsibility of the Contractor.

10.3.2.4 The provision of OFC communication cable, which shall be done by ST P-5 up to individual Switching Post. Any equipment required at RTU level shall be provided by EM P-4.

10.3.2.5 Construction at OCCbuildings will be by the Other Contractor.

10.3.2.6 Following items will be procured by ST P-5 Contractor:

(i) Provision of telecom fibres at SSP, SP, TSS, ATSand Auxilliary Transformer (AxT) locations.

(ii) Fibre optic cable links for SCADA between OCC, TSS, SSP, SP, ATS and Auxilliary Transformer (AxT) locations from station control room.

(iii) SCADA video wall at the OCC. The point of common coupling between the Contractors for EM P-4 and ST P-5 shall be at the connections to the video matrix.

10.4 Design and Performance Requirements

10.4.1 Basic Design Philosophy and Requirements

10.4.1.1 The Contractor shall develop the design based on this specification and the relevant standards based upon good engineering Practices. The design details shall be submitted with technical data and calculations to the Engineerfor review.

10.4.1.2 The system, including all sub-systems and equipments shall be of proven design.

10.4.1.3 The servers in the control centres shall be designed to cater to further addition of RTUs to be installed under Phase-II of Dedicated Freight Corridor (Western)

10.4.1.4 The design philosophy shall meet the following criteria:

- Use of interchangeable and , modular components;
- Extensive and prominent labelling of parts, cables and wires;
- Use of unique serial numbers for traceability of components;
- System safety;
- Adequate redundancy in system such that any single point failure shall not degrade the system availability or performance in any way;
- Fire prevention, detection and extinction systems
- Ergonomically designed to ensure no long term fatigue or cumulative injury to the operators;
- Adherence to operational performance requirements;
- Compliance with standards;
- The minimum design life of equipment shall be as follows:-
  - Remote Terminal Units 15 years.
  - Keyboards including printer - 5 years
  - UPS Units 10 years
  - UPS Batteries 06 years
  - Master Stations Terminal Computers 6 years
  - Master Station Main Processors 15 years.
- Use of open systems and platforms;
- Integration with other systems.

10.4.1.5 The SCADA system equipment shall be designed to suit the environment in which it is to be installed. It shall meet the environmental conditions as specified in Pt. III of Chapter 19 of this Specificaiton.

10.4.2 Design Stages of the System

10.4.2.1 The Contractor shall design the system in two stages i.e. design stage and construction stage.

10.4.2.2 Stage wise documentation to be delivered by the Contractor shall include but not limited to the following items:-

i) **Design Stage**

(a) Description of general design philosophy;
(b) Arrangements under various supply failure scenarios;
(c) Restrictions, if any individual RTU suffers failure conditions;
(d) Determination of equipment ratings;
(e) Determination of Conductor sizes and core numbers for all control and fibre optic cables;
(f) Identification of the bandwidth required from the ST P-5 Contractor;
(g) Earthing requirements for the SCADA equipment and calculations of safe touch and step potentials for the entire SCADA System;
(h) Design requirements for the OCC including Human Factors Reports and Work Load Assessments;
(i) Type test reports for equipment or component selected;
(j) Detailed design drawings and reports;
(k) Detailed interface reports and interfacing design drawings;
(l) Hazard identification and control documentation;
(m) EMC Control Plan for SCADA;
(n) Earthing and Bonding Plan for SCADA;
(o) Systems integration plan;
(p) Design of control and protection strategy between the TSS and the State Power Company's equipment for intake power connection at 220/132kV.
(q) Design of Control & protection strategy at junction stations with I.R. with their 25kV system.
(r) Designer's Guarantee
(s) Design for the Asset Management including Traction Power and OHE maintenance planning systems.
(t) The system shall be designed to achieve at least the following levels of system availability.
   - The complete SCADA system shall be designed to meet 99.99% hardware availability.

- The availability figures for Traction Power functionality and the Traction power decision support facilities shall be 99.97%.
- The availability figures for other SCADA subsystems viz. Software Development and Training Simulator shall be 99.7%.
- In determining the availability of the Delivered System, Reliability Block Diagrams using expected failure rates for commercial off the shelf equipment shall be produced.

(u) Any equipment manufactured by the Contractor shall have its failure rate determined strictly in accordance with its appropriate operating environment.

(v) Any degraded mode of operation or re-configuration functions provided by the Delivered System shall not be included in the determination of the Delivered System availability.

(w) Redundant design
In rare instances failure of a single item of equipment can be tolerated for a short period of time, say 10 minutes provided that only a small part of the overall system is affected and the occurrence does not take place more than once per year. However, redundancy shall be incorporated where failure cannot be tolerated even for short periods.

(x) The system shall therefore be designed around small autonomous items of equipment but shall be commensurate with an economical overall solution.

(y) Failure of any equipment node on the network shall not affect the local operation nor prevent communication between any other connected equipment node.

(z) Noise
All SCADA system equipment shall operate satisfactorily in the very high "electrical noise" environment normally associated with Metro systems due to electrical fields created by traction supplies and strong magnetic fields. Equipment shall be immune to the effects of conducted and radiated electrical interference.

(aa) Time to Repair
The SCADA system shall have an MTTR of 30 minutes. This time shall not include the time taken for a technician to arrive at the initial reported failure site.

(bb) **Lightning Strikes / Power Supply Surges and Disturbances**
The Contractor shall ensure that all SCADA system and equipment are fully protected against the effects of mains surges and direct and indirect lightning strikes. Protection shall be applied to incoming mains power supplies and to input and output signal lines to externally located sensors, transducers, actuating equipment, etc. or to any other equipment likely to be affected.

(cc) Lightning protection systems shall be in accordance with BS 6651 – "Lightning Protection" or an equivalent Indian/international standard.

(dd) All surge suppression equipment shall be self-contained and self-resetting.

(ee) The suppression equipment shall be so selected that the let-through voltage specification does not exceed the absolute maximum voltage specified for the particular equipment being protected.

(ff) Signal lines from external sensors at risk from the effects of lightning shall have surge suppressers fitted at both ends of each line and shall be installed and connected in accordance with the manufacturer's recommendations.

ii) **Construction Stage**

(a) Construction and Installation Plan;
(b) Factory Acceptance Test Plan for equipment;
(c) Quality Plans and RAMS Plans;
(d) Installation, operation and maintenance instruction of all equipment;
(e) Records and drawings of equipment installed;
(f) Inter-connection drawings.
(g) All other records of construction, including hidden partsas required, by the Engineer;
(h) Site test report of equipment;
(i) As built drawings including interface drawings;
(j) Earthing and Bonding plans;
(k) Updated EMC Control Plan and certificates;
(l) Site access control system proposed to the Engineer.

10.4.3 Design Service of the Works

10.4.3.1 The Contractor shall be responsible for the design service of the SCADA works and shall satisfy himself that the indicative capacities, ratings and quantities of equipment as specified herein meet the operational requirements of the Western Dedicated Freight Corridor.

10.4.3.2 Contractor shall include any necessary additional equipment, equipment of higher capacities and higher ratings for the systems and sub-systems necessary for the complete, safe, reliable, operable and maintainable SCADA system for the traction power supply system for the Western Dedicated Freight Corridor Phase I and also be able to support the services for Equipment for phase II added later.

10.4.3.3 The proposed capacities, ratings and number of equipment as a result of the design development shall be demonstrated by a proper design, calculation to review by the Engineer's Representative.

10.4.3.4 The SCADA System as designed for installation should have the capability of being extended, if required, by addition of extra modules, to cover the requirement of Phase II of the Project to be implemented later. For this purpose, the Contractor shall include a chapter in his operation and maintenance manual a user friendly diagrammatic instruction to be followed to enable the Engineer to add SCADA requirements for additional traction substation, supply control, auto-transformer posts at a later date for Phase-II work of the Dedicated Freight Corridor (Western).

10.4.3.5 The design, supply, installation, testing and commissioning of the SCADA system, traction power asset management system and the tractionpower maintenance planning system shall meet the design and performance requirements within the design environments specified in this PS and the GS.

10.4.4 Design Submission Requirements

10.4.4.1 The Contractor shall perform his design for the contract in accordance with the requirements of this PS and the GS. The Contractor shall submit to the engineer for his review and approval, relevant design information as identified under each stage. Such submissions shall incorporate the relevant Standards.

10.4.4.2 The design submissions have been detailed in the Engineers Requirements, Chapter - 4..5.18 and 4.5.19 and clause 3 of Vol II (Section 8 of the Bid Document).

10.4.4.3 The Contractor shall develop and submit a detailed concept plan of SCADA system for approval of the Engineer.

10.4.5 Operation Control Centre (OCC)

10.4.5.1 The OCC will be located at within NCR region to be decided in a purpose built structure. The OCC control room will be multi-functional and will house the traction power SCADA, signalling control, telecoms control and rolling-stock monitoring equipment. In addition, the OCC control room will be supervised by a chief controller who will oversee all operations on the railway.

10.4.6 Traction Power Supply Facilities to be controlled and monitored

10.4.6.1 The architecture of the power SCADA systems for phase-I shall allow expansion to control and monitor the traction power supply for both Phase I and II for the Western Dedicated Freight Corridor. This PS details the scope of supply and installation for Phase I only. The addition of the Phase II SCADA equipment shall not impact or reduce the performance of the Phase 1 SCADA system in any way.

10.4.6.2 The SCADA system shall have adequate number of workstations, which will include the requirement of both PhaseI& II. This shall be proposed through the Contractor's work load assessment report and shall be subject to approval by the Engineer.

10.4.6.3 The Phase 1 SCADA system shall monitor and control the following as a minimum:-

- Sixteen Tractions Substations;
- Sixteen Sectioning and Paralleling Posts;
- Seventy Seven nos of Sub-Sectioning & Paralleling Posts – sixty at stations and seventeen in mid-section,
- Five Auto Transformer Stations;

(**According to indicative designs, the location of the principal sites to be controlled and Monitored is shown in drawing no. EMP4/PS/201 in Vol. V**).

10.4.6.4 The Contractor shall confirm the exact number and configuration of each type of switching station as part of the works described in this Particular Specification and Engineer's drawing no. EM P4/PS/201.

10.4.6.5 The Contractor shall make passive provision for the Phase II extension within the SCADA system architecture it should essentially include any licensing for SCADA software, protocols, I/O points, workstations etc. The number of sites to be monitored & controlled under Phase-II as expected to be approximately:-

- TenTraction Sub-Stations
- Ten Sectioning & Paralleling Posts
- Thirty SevenSub- Sectioning Posts
- FourAuto Transformer Station

10.4.6.6 After final design the number of posts / stations my alter by not more than 25% of the above indicated figures.

10.4.7 Indicative List of Equipment to be Monitored and Controlled at Remote Locations

Table 10.1-1 provides an indicative overview of the typical items of major plant that will be required in each Installation on phase I of the Western Dedicated Freight Corridor.

Table 10.1-1

Equipment		**Quantity**					
	TSS	**SSP (open route)**	**SSP at Jn Stn.**	**SP**	**ATS**	**AxT**	**OCC**
Traction Transformers	2	0	0	0	0		0
Auto Transformers	4	2	2 *	4	2		0
25kV Circuit Breakers	10	1	0	2	0		0
25kV Interruptors	2	4	8	2	0		0
25kV Isolators	18	12	18	12	2		0
220/132kV Circuit Breakers	2	0	0	0	0		0
220/132kV Isolators	5	0	0	0	0		0
Power Factor Correction Equipment	2	0	0	0	0		0
Battery Chargers	2	1	1	1	1		0
Auxiliary Transformers	2	2	2	2	2	504	0
Low Voltage Distribution Boards	1	1	1	1	1		0
(Current and Potential Transformers)	24	2	**$**	8	0		0
Doors and gate contacts	3	2	2	2	0		0
Gate locks, Intruder Alarm	2	1	1	1	2		0
Fire alarm system	1	1	1	1	0		0
UPS	0	0	0	0	0		2

(Reference General Traction Power Supply Diagram open route and station drawing no. EM-P4/PS/202/203/204/205/206)

* Auto Transformers may be provided, if required.
$ PT may be provided, if required.

10.4.8 SCADA System Performance Requirements

10.4.8.1 The SCADA systems shall continue to be able to function should there be a mass trip of all equipment at every TSS, SP, SSP and ATS. The OCC shall continue to function normally in such an event.

10.4.8.2 Complete SCADA system with servers, workstations, and full communication with all RTU's shall be ready within 30 seconds of a cold restart of complete system. All software shall automatically start up on system restart and system shall be ready for the operator after entering the password.

10.4.8.3 The SCADA system shall be able to initiate a change of state at the output of an RTU within 3 seconds of initiation by the control room operator. If this change has not occurred in the field for any reason, the operator shall be notified that the command was unsuccessful.

10.4.8.4 The SCADA system shall indicate the change of state or change in alarm status within 3 seconds of receiving the signal at the input to an RTU.

10.4.9 Asset Management including Maintenance Planning System Performance Requirements

10.4.9.1 The asset management system (AMS) shall be able to track every asset and component part of equipment that forms part of the traction power supply, OHE and SCADA system on the Western Dedicated Freight Corridor.

10.4.9.2 The AMS shall have sufficient capacity to hold asset data for assets on both Phase I and II of the Western Dedicated Corridor electrification assets plus 100% redundant capacity.

10.4.9.3 The AMS shall be able to provide description of each asset throughout its whole life cycle, including maintenance and fault history.

10.4.9.4 The AMS shall provide hyperlinks to relevant drawings and operations and maintenance manuals.

10.4.9.5 Fault, tripping and operations counters shall be automatically updated by the SCADA system for each equipment.

10.4.9.6 The AMS shall be able to produce user defined reports and graphs. e.g. top 10 Items of equipment that failed in a rolling 12 months. The maintenance system shall be able to produce user defined reports e.g. assets that are overdue maintenance by ½ weeks or items being repaired frequently.

10.4.9.7 The AMS shall be able to track asset and component history including failures and repairs over whole life.

10.4.9.8 The AMS shall be able to track the change of location of assets and components e.g. if tap changer is taken off of one transformer, repaired and installed on a transformer at another location.

10.4.9.9 The AMS shall be able to track the stores holding and trend the rate of use of components issued.

10.4.9.10 The maintenance planning shall be capable of manual entry of maintenance schedule.

10.4.9.11 The maintenance system shall be able to generate job cards, based on information from SCADA on predetermined thresholds. E.g. circuit breaker maintenance following either on number of trips or time Lapse since, last attention.

10.4.9.12 The maintenance system shall be able to schedule operation of equipment that has not been operated during predetermined period. E.g. If a 220/132kV circuit breaker has not operated in 6 months then a schedule of plant not normally operated shall be generated for maintenance attendance and operation by the SCADA engineer.

10.4.9.13 The maintenance systems shall be able to issue job cards, lists of materials required and drawings and operations & maintenance manuals required. records shall be available to the maintenance staff via laptop or tablet computers at site.

10.4.9.14 The maintenance systems shall be able to issue job cards to maintenance gangs when they are mobile this shall be done via tablet PC or laptop computers.

10.4.9.15 The Contractor shall prepare concept for developing asset management software and submit the same for approval of the Engineer.

10.4.10 RAMS Requirements

The RAMS shall conform to EN 50126 (IEC 6278) and IEC 61508.

10.4.11 Reliability Requirements

10.4.11.1 The SCADA system shall be of the highest reliability. The communication links and OCC equipment shall have 100% redundancy as a minimum.

10.4.11.2 In event that the SCADA system fails then the traction power and its protection system shall continue to operate autonomously, until either the SCADA system comes on line or until the switching station is placed into local control.

10.4.11.3 All OCC equipment shall be supplied power from two independent sources of supply. If one supply is lost then the remaining healthy supply shall be able to maintain the full load.

10.4.11.4 All UPS equipment at the OCC for the SCADA system shall be online UPS. The SCADA UPS shall only supply power to the SCADA Equipment and SCADA operator emergency task lighting.

10.4.11.5 The design shall consider security and backup storage of data in SCADA, AMS and maintenance planning system.

10.4.12 Availability Requirement

10.4.12.1 Quantitative targets have been set for the system availability to ensure that SCADA system does not jeopardise the reliability of services for the Freight Railway.

10.4.12.2 The System shall be designed to ensure that failure of any major equipment, caused by external accident or negligence of the internal staff or malicious damage by external influences or fire will not lead to unavailability of the whole system, other than a temporary outage of the failed equipment. For this purpose the SCADA system shall provide through pre-determined algorithm the steps to be adopted by the Controller to retain the system in healthy condition to the extent feasible.

10.4.12.3 The SCADA system at the OCC shall be designed to a reliability level of minimum N-1Communications between the OCC and the outstations in the field shall be to a minimum reliability of N-1.

10.4.12.4 In event of communications failure at the controlled Post, that particular post shall record changes within the switching station until communications are restored and RTU shall update current status and change history shall be transferred to the master station for recording in the logs of Events.

10.4.12.5 The Contractor shall prepare a detailed maintenance strategy for the SCADA system, detailing how system availability will be maintained.

10.4.12.6 The Contractor shall ensure that the SCADA system fully supports the availability requirements as identified in Section 4.12 and 4.13 of this PS.

10.4.13 Maintainability Requirement

10.4.13.1 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 risk of maintenance-induced faults have been mitigated in design.

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

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

10.4.13.4 The SCADA equipment along the length of the Western Dedicated Freight Corridor shall be selected from a common palette of materials to ensure that equipment is interchangeable between sites, spares and training on multiple systems is kept to a minimum.

10.4.13.5 To optimise speedy corrective attention or maintenance, techniques employing automatic diagnostics test points, and rapid repair facilities for the SCADA and traction system as a whole shall be provided. To this end expert system algorithm to identify location of OHE faults based on auto – transformer neutral Current & voltage shall be provided to the controller.

10.4.14 Safety Requirements

10.4.14.1 The installation design shall incorporate measures to avoid presenting safety hazards to people.

10.4.14.2 The Systems design shall incorporate measures to provide for its safe management and operation. The system shall ensure that there is no inadvertent operation of any SCADA controlled equipment.

10.4.14.3 The Systems shall not give rise, or be subjected to, dangerous interactions within the railway or with other systems through fail safe interlocks.

10.4.14.4 The design of the earthing system shall conform to IS 3043: 1987 and EN 50122-1. The Contractor shall incorporate the SCADA earthing design requirements in the earthing and bonding management plan and design as described in this Particular Specification.

10.4.15 Safety Targets

10.4.15.1 The Contractor shall satisfy the Engineerthat the SCADA system meets the safety integrity level (SIL-2) in continuous demand mode of operation.

10.4.15.2 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.

10.4.15.3 The Contractor shall show that the systems can be operated and maintained safely. The Contractor shall prepare a quantified risk assessment (QRA) to model the risk to (a) public (b) maintenance and operations staff (c) public and staff on the adjacent Indian Railways line. The QRA may be based on a comparison of System features and operating practices with other high current main line railways and heavy haul railway systems for which risk levels are known. Accidental charging of dead section due to problem with SCADA or wrong indication causing issue of permit to work on charged section posing safety hazard shall also be prevented.

10.4.15.4 Following types of interlocks shall be possible:

(i) Interlock between any number of items of equipment through OCC such as n-1 interlock.

(ii) Interlock locally within equipments reporting to single RTU. This shall be possible without intervention of OCC server.

(iii) Interlock between equipments reporting to different RTU's on same LAN/TCP/IP connectivity. This shall be possible without intervention of OCC server.

10.4.16 Specific Safety Requirements

10.4.16.1 In addition to the Engineer's safety rules which shall apply for the entire system, the operation and maintenance of equipment inside the TSS, SSP, ATS and SP shall satisfy the safety rules and system operation requirements of state power companies.

10.4.16.2 The system shall comply with all the relevant safety documentation of the Engineer, including, but not limited to 'Project Safety Manual' and any update thereof provided by the Engineer's representative

10.4.17 Conformity with Governing Specifications and other Statutory Requirements

10.4.17.1 The works shall be carried out in accordance with the list of governing acts, regulations, (Indian,International and RDSO Standards)climatic conditions, as appearing in Chapter 19 of this Paticular Specification of the Engineer's Requirement (GS),regulations laid down by Chief Electrical Inspector to the Government and rules and regulations prescribed by local authorities.

10.5 Functional Requirements

10.5.1 General

10.5.1.1 The Contractor shall design, manufacture, install and commission the SCADA System to provide a safe, efficient and effective means of monitoring and /or controlling the connected equipment as required for the operations of the project.

10.5.1.2 The SCADA system shall comprise of three basic elements:

a) Interface with SCADA workstations and SCADA maintenance terminals for displaying the status of connected equipment to operators and providing control facilities for operators for connected equipment;
b) Data communication links with the connected equipment to be controlled and / or monitored within the Project including use of the Data Transmission System.
c) Processing equipment information that allows:

i) The information received from the connected equipment to be displayed in a consistent format.

ii) The controls entered by operators to be converted into a form that shall be understood and correctly acted upon by the connected equipment.

iii) The storage of all controls, events, alarms and measurands of current & voltage readings including transients to facilitate analysis of data and system behaviour, including trend.

10.5.1.3 The SCADA system shall have sufficient levels of redundancy in its equipment and configuration as necessary to meet the System Performance Targets.

10.5.1.4 As a minimum, the central servers shall have dual redundancy with one set of servers located at the OCC equipment room interconnected with multiple redundant and spatially diverse data communication links.

10.5.1.5 Multiple, redundant configurations shall be used where necessary to ensure adequate operational safety and availability for all the SCADA equipment, SCADA System interconnections and SCADA interfaces to equipment to be controlled and /or monitored.

10.5.1.6 Redundancy shall be achieved either with hot standby equipment where only one unit is in use at a location or by utilising several functionally identical units with an overall capacity such that one of the units may be taken out of use without loss of overall functionality.

10.5.1.7 The SCADA System shall have a distributed architecture with the majority of I/O being transmitted via high speed data communication links.

10.5.1.8 The SCADA system architecture shall be arranged to minimise the requirement for marshalling large quantities and long lengths of metallic control cable to data collection points.

10.5.1.9 Primary control and monitoring of connected systems shall be from the SCADA workstations in the central control room combined with playback and training functionality.

10.5.1.10 Additionally, the SCADA system shall include a data link to a maintenance management system (MMS). This link shall enable the SCADA System to forward fault information to the MMS from all connected equipment to identity the location and nature of faults

10.5.1.11 The mechanism of control and monitoring shall ensure that the connected equipment shall continue to function correctly and in a safe manner in the event of malfunction of parts or all of the SCADA System.

10.5.1.12 Control capacity, status and alarm messages displayed at each SCADA Workstation shall be limited / filtered according to the login privileges of the user.

10.5.1.13 The SCADA System shall be configured to permit phased commissioning of the project.

10.6 Design Criteria and Performance Specification

10.6.1 General

10.6.1.1 The SCADA system shall be designed such that no single point failure of SCADA component results in failure of OCC or of the SCADA System.

10.6.1.2 The Contractor shall design the switching station control, protection and interlocking system based on a substation automation system.

10.6.1.3 The SCADA system shall display information on the video wall provided by ST P5 Contractor.

10.6.1.4 The Contractor shall design and submit all SCADA screens to the Engineer for review and approval.

10.6.1.5 The Contractor shall design and submit all the pages and fields that will be stored in the AMS to the Engineer / Engineer for review and approval.

10.6.1.6 The Contractor shall submit the design for standard reports to be made available in the AMS and Maintenance Planning System. These shall be reviewed and approved by the Engineer / Engineer.

10.6.1.7 The Contractor shall examine the whole scope of work and scrutinise the specified system, specification for cables and equipments and work out the ratings and capacities based upon his own designs, for approval of the Engineer/ Engineer.

10.6.1.8 The list of "I-O" requirements giving details of event type, alarm class and event text for TSS, SP, SSP and AT stations shall be submitted and approval obtained from the Engineer/ Engineer.

10.6.1.9 A typical requirement of I/O list which is not exhaustive is furnished in table no. 10.6-1 below. The Contractor shall finalize the list in consultation wih the Engineer at the Design finalization stage.

Table No. 10.6-1 Typical requirement for I/O List

Telecommands, Telesignals and Measurands

(General Guidance : The list is not exhaustive covering all the features required)

S.NO.	Description	
1.0	220/132 kV C.B.	Telecommand
1.1	25 kV C.B.	Telecommand
1.2	25kV Interrupters	Telecommand
1.3	Auto recloser release with lock out indication	Telecommand
1.4	Transformer tap changer	Telecommand
1.5	Interlock release request at boundary post	Telecommand
1.6	To by passpanto flashover relay	
1.7	Lock of entrance gate of TSS, SP, SSP, and ATS	Telecommand
2.1	110 V D.C. low / Battery charger fail	Telesignal
2.2	240 V a.c. Fail	Telesignal
2.3	Transformer and feeder CB trip circuit failure	Telesignal
2.4	Feeder CB operated on Distance Protection Relay	Telesignal
2.5	Feeder CB operated on Over Current Relay	Telesignal
2.6	Feeder CBs operated on Delta-I Relay	Telesignal
2.7	Feeder CB operated on Wrong Phase Coupling	Telesignal
2.8	Feeder CBs operated on Panto Bridging	Telesignal
2.9	Feeder-PT fuse fail	Telesignal
2.10	Transmission line PT fuse failure (if applicable)	Telesignal
2.11	Transformer tap positions	Telesignal
2.12	Auto recloser locked out	Telesignal
2.13	Panto Flashover Protection Relay By-passed	Telesignal
2.14	Status of fault locator	Telesignal
2.15	OHE power failure in any sections	Telesignal

2.16	Winding temperature for ATs and main transformer	Telesignal
2.17	Oil levels in tanks	Telesignal
2.18	Transformers fan ON/OFF	Telesignal
2.19	Power factor correction equipment	Telesignal
3.1	Position of lock at entrance gate of TSS, SP, SSP, and ATS	Telesignal
3.2	25 kV bus / OHE voltage	AnalougeMeasurand
3.3	Feeder Currents	AnalougeMeasurand
3.4	Power factor	AnalougeMeasurend
3.5	220/132kV incoming feeder kWh/kVA,	AnalougeMeasurand
3.9	Information from fault locator	AnalougeMeasurand
3.7	240 V Supply failure at level crossings, S&T huts, switching stations and station buildings	Telesignal only

10.6.2 Systems Integration

10.6.2.1 The systems integration process is set out in Section 4.5 of this Particular Specification.

10.6.3 Modular Equipment and Components

10.6.3.1 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. Where equipment is of the same rating, equipment shall be interchangeable.

10.6.3.2 Equipment along the length of the Western Dedicated Freight Corridor shall be selected from a common palette of materials to ensure that equipment is interchangeable between sites, spares and training on different equipment and systems is kept to a minimum.

10.6.3.3 Open systems shall be employed such that if items from one supply becomes economically unviable or non-available, products from other suppliers will be available and compatible.

10.6.3.4 Compliance with Directives:

All works shall comply with directives and requirements below:

- Compliance with electromagnetic compatibility as per requirements of Section 6.14 of this PS.
- Development and implementation of a quality management plan.

- Preparation and finalization of schematic general arrangement, detailed construction drawings through to "As-Built Drawings".

10.6.4 Contractor responsibilities

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

- Provision and maintenance in good condition sufficient number of tools and diagnostic equipment, mechanical equipment and apparatus necessary to complete the work within the agreed schedule.
- Transporting and storage in safe and satisfactory condition all materials brought to their depot.
- Provision of temporary AC construction power and testing power at work sites and other areas where such power is not provided by civil contractor.
- Security of all work sites

10.7 Performance Specification for IP Based SCADA Software

10.7.1 General

10.7.1.1 The software shall be compatible for working on IEC 60870-5-104 companion standard protocol based on IEC 60870-5-1 to 5 series of standards. It shall also support multiple channels for communication to all RTUs as per TCP/IP based IEC60870-5-104 communication protocol;

10.7.1.2 The software shall fully support file transfers between RTU & OCC as defined by different IEC 60870-5 series of standards;

10.7.1.3 The software shall give fast response to operator actions and system events. SCADA system stability should be sustained during event bursts. The software should be capable to support system working at high speed data transfer rates achievable over OFC communication networks;

10.7.1.4 Software/system performance shall not degrade or drift due to generation of temporary files etc. which the software shall clean/delete automatically

10.7.1.5 Only the valid licensed copies (CD/DVD's) of complete SCADA application, commercial and peripheral software shall be supplied;

10.7.1.6 SCADA vendor shall provide all necessary run time utilities for successful running of the SCADA application. The utilities supplied by the Contractor along with operating system should be sufficient to independently execute the SCADA software without any problem.

10.7.2 Functional Details Of Master Station Software

10.7.2.1 Acquisition of measurands

a) The SCADA system shall be capable of acquiring measurands i.e. analogue inputs from the TSS and SP including transients. The measurand data shall be time tagged at OCC.

b) Software shall have capability for Analogue value scaling, processing and conversion to engineering values, limit settings of parameters.

c) Software shall be fully configurable to analyze the analogue data received from RTU e.g. energy parameters (active, reactive and apparent power & energy), voltage, current and power factor in the form of displays (graphs as well as tabular), trends, alarms to operator in case of set limit violations and historical interpretations.

d) Software shall also be able to analyse the transients analogue data for detection of faults and their corrective measures

e) There shall be facility to transfer the data to spreadsheet applications like MS-Excel in .xml formats.

10.7.2.2 Acquisition of telesignals

a) The software shall support the acquisition of telesignals (bi-state devices) for each RTU.

b) There shall be dependent and independent points in the traction power supply system. For example if a feeder Circuit Breaker Trips, there shall be associated telesignals for catenary and 230 V ac fail. All such events shall be reported by RTU to OCC with time stamp.

10.7.2.3 Execution of tele-commands

a) The Software shall be capable of issuing tele-commands to open or close a switching device. All the commands shall follow select – check – execute and report back execution procedure.

b) The tele-commands shall receive the highest priority. The normal communication between RTU & OCC shall get interrupted for sending the tele-command.

c) Operator shall be able to cut off power to a sub-sector by selecting it and giving the command. The system shall open all the associated switching devices automatically in appropriate order with confirmation for each device as an event.

d) Option to abort a command shall be available with the operator till it has not been acknowledged for execution at the switching station. In case the command is issued to more than one RTUs and acknowledgement for execution is not received at OCC from any one RTU, the command shall be automatically aborted within 3 seconds as a fail-safe measure. Any command which does not get executed within the specified time of 3 seconds,shall be automatically cancelled and confirmation to this effect communicated to operator.

e) All the operator commands shall be logged as events. after a control command is issued by the operator, and if the command is not executed, then a message shall be displayed indicating reason(s) for it.

f) The tele-command once selected, if not sent to RTU due to communication failure or otherwise, shall be aborted after a predefined period of say 30Secs. and shall not remain in queue.

10.7.2.4 **Parameter loading to RTU**

a) The OCC software shall be capable of parameter loading to the RTU in line with IEC 60870-5-104 & other basic standards of IEC 60870-5 series. Some configurable parameters are as under:

(i) Dead band for RBE (Report By Exception) of an Analogue value.
(ii) Pulse duration of control commands.
(iii) Used point of each type in an RTU. (Number of point used of a particular type of point)

(iv) Event reporting details which include windows time and de-bouncing time.

b) The de-bouncing time, dead band for measurands and the clock synchronisation time period shall be settable and so selected that the optimum use of data communication channel is made.

10.7.2.5 **SCADA software configuration**

a) The software shall provide menu driven and user-friendly configuration. The configuration shall define the various devices, their attributes and the traction system specific details. The configuration of the software shall be carried out to cover all details/address/nodes of traction supply operation e.g. Interlocking, locked out signals, protection relays & elements, alarms with attributes, power blocks, parameter settings and display/picture screen properties etc.

10.7.2.6 **Time Synchronisation**

a) The master clock installed by ST-P5 in OCC shall be used to synchronize the Host computer clock and the clocks of the RTUs.

10.7.2.7 **Test Procedure & Diagnostics**

a) The software shall support basic test procedure and diagnostic checks for RTU as per IEC 60870-5-104 & basic standards of IEC 60870-5 series. As in IEC 60870-5- 104, there is no periodic polling for Class1/Class2 event from the master and all events shall be reported by exception from the RTU. The only periodic poll from the master shall be the general interrogation, at intervals not exceeding 10minutes . Apart from this, master shall send a TESTER packet 10-15 seconds, to check the health of the RTU and communication media.

b) SCADA application software shall have minimum following inherent features to check its own sub functions and report status to the operator:

(i) Online/standby /offline state of SCADA server/communication front ends.
(ii) State of all RTUs.
(iii) State of printers.
(iv) Connection status of all the operator workstation.
(v) Diagnostics shall use standardOS tools to be provided as part of the administrator tools.

10.7.2.8 Block/De-block of RTU

a) The operator shall be able to block/de-block the RTU that is not responding to optimise the channel capacity.

10.7.2.9 Communication Failures

a) Time out of the RTU and the cyclic redundancy check(CRC) errors shall be progressively counted and displayed in a tabular report as "Communication failures" for each RTU. The tabular report shall be generated at 4.00hrs every day for the preceding calendar day of 24 hours.

10.7.2.10 System security and access levels

a) The system shall provide three security levels for access for different functions:

   (i) Traction Power Controller (TPC): - To view and Control.
   (ii) OCC Engineer – To edit configuration information .
   (iii) System Engineer- Able to do everything.

b) The Contractor shall liaise with the Engineer as to which facilities each security level is given. This shall be undertaken in coordination with the Engineer developing the Electrical Control Room rule book.

c) There shall be no remote/email/internet access, user access codes/passwords in the master station software and hardware so that any possibility of a cyber-intrusion or attacks is eliminated. Reasonable precaution, by way of installing fire-wall, and blocking ports for connecting external devices like pen drives, CD drives etc shall be ensured.

d) There shall be means to indicate & give alarm in case an intrusion event occurs either through a connection or a peripheral device.

e) In addition backup and recovery procedures for the SCADA system shall be well defined by the Contractor. The Contractor shall train the Employer's staff on the security threats and vulnerabilities involved with IP based systems.

f) The Contractor shall provide in OCC, aworkstation with a general purpose computer for non SCADA applications. E.g. internet browsing and word processing. The general purpose computer will be connected to the general office LAN and NOT to the SCADA LANs.

10.7.2.11 **Manual Input**

a) Facility for marking (manual input) shall be provided for any alarms, equipment status including manually operated isolators, measurands and limit-settings, through keyboard.

10.7.2.12 **Status Information**

a) The SCADA system shall be able to display status information for switching station equipment such as device name and its' current value/status, scans status (on/off scan), override status and block status shall be displayed.

10.7.2.13 **Breaker Operation Counter**

a) The system shall monitor operation counter of the breakers. The operation counter shall segregate normal operations and fault trippings after analysing the associated trip relay data. it shall generate alarms after a predefined limit of normal & fault operations is reached. If a pre-determined limit is reached then a maintenance flag shall be sent to the maintenance planning system. The operations counter data shall also be sent to the asset management system at a predetermined time each day.

10.7.2.14 **Block/Un-block control for devices**

a) Facility shall be provided to block / deblock a control point (circuit breaker, interrupter and other controllable equipment or a set of controlled equipment at the controlled station). the block or unblock command shall disable/enable control operations from the OCC. The blocked condition of any equipment or a set of equipment shall be suitably indicated on the monitor.

10.7.2.15 **Boundary post operation:**

a) The design shall be such that it shall be possible to provide interlocks in future between two control centres , if required for each equipment, of a part at the end of its zone of control. For example, when a post separates the zones controlled by two adjacent OCCs, control of breakers/interrupters at this post shall be so arranged that the breakers/interrupters can be closed by one OCC only when an interlock is released from the other OCC. However, opening shall be possible from any of the OCC, in such cases there shall be visual alarm indicating that the opening was initiated by another OCC.

10.7.2.16 **Alarm Processing and displays:**

a) Blinking Visual and audio alarms shall get generated whenever the state of device is found to be in the abnormal condition or any measurands' set limit is violated, with facility with the operator to silence the audio part of the alarm and the blinking visual alarm is changed to steady state once for every alarm generation.

b) In the event of failure of RTU or any equipment at RCC such as Host or HMI, an equipment alarm shall appear. When both the auxiliary contacts of a device are either in open or in closed condition, such faults shall be detected and identified as "Complementary Faults". Such conditions shall be logged in alarm and event list. The alarm list shall be of two kinds – current and historic.

- **Current alarm list** shall contain minimum 400 entries. The list shall be ordered chronologically. Acknowledgement status of an alarm shall be indicated in the current alarm list.

- **Historical alarms list** shall consist of all alarms for the last one month.

c) Operator shall be able to request for display of the alarms in chronological order starting from any given time. Provision for sorting of historic alarms on various options such as a geographical area, station-wise, or tag wise, and in chronological order shall be supported. Alarm list shall be printable on user's request or downloadable in a format compatible by commercially available spreadsheet software, clearly separating original & consequent alarm such as circuit breaker trip &consequent loss of voltage

10.7.2.17 **Alarm acknowledgement**

a) Page wise facility for alarm acknowledgement with a single click and confirm shall be provided in addition to one by one acknowledgement.

b) There shall be facility to define certain alarms with audible sound or pre-recorded voice to attract the attention of the operator as per user requirement.

c) There shall be facility for time delayed alarm operation e.g. alarm for tripped capacitor bank cicuit breaker closing reminder.

d) There shall be a facility to label a post under maintenance & to disable the audio alarm for particular post/rtu equipment by the operator. For scenariossuch as contact chattering, it shall be alarmed as a failure and; visual indication of the discrepancy shall however remain active till its resolution . The list of disabled alarms shall be reported on the daily log each day until the alarm is reinstated.

10.7.2.18 **Events display**

a) Events shall be logged separately for all commanded and for unusual un-commanded changes in equipment status, acknowledgement of alarms, limit violations of analogue points, successful and unsuccessful user login and markings done by operator from HMI shall be logged clearly with different heads

b) The event list shall be of two kinds – current and historic, same as explained in 10.7.3.16 and 10.7.3.17above and same facilities for sorting, displaying and printing of event reports shall be available.

c) **Processed alarms:** It shall be possible to create Processedalarms in the system. For example, There are two events, event A and event B, which are not classified as alarms, however if they occur both together an alarm shall be generated. It shall be possible to apply any booleanoperation or time delay to any number of events to create or process an alarm.

d) **Searching and sorting:** The alarms and event lists shall be fully searchable and sortable, in a similar fashion to commercially available spreadsheet software.

e) **Event list security:** The list shall be protected by a password & authorisation by the Engineer, so that it shall not be possible for any unauthorized operator or person to edit or delete the event lists.

f) It shall be possible to view a historical view as a video on the SCADA operator screen.

10.7.2.19 **Power Block Identification**

a) Power block for maintenance or inspection shall be granted by the operator / controller in the OCC through a foolproof system of parties identification of (both persons granting the block i.e.(the controller of the authorized person requesting the block through a system of passwords& interlocks). The block shall not be able to be cancelled & section energised unless the block is cancelled by the person who has taken the block. In case a tele-command is attempted for energising the device/ section under block, the command shall be aborted and a hazard message at the OCC and the RTU shall be generated.

b) **Granting the power block:** Thesoftware shall havefacility to select the device/section to be brought under power block and kept under, power block or to be taken out of power block.

c) **It shall be possible to** select a number of circuit breakers/ Interruptors required to be operated for making a section dead and a group command shall possible to be issued. The system shall be open all devices, which are put under power block by the operator. The operation shall be confirmed for each device as an event. The operator shall be able to modify/create such predefined sequences and save. Such operator created programs shall be available only to the creator and not to the other operators. There shall be function to allow the system engineer to copy user created programs for other operators.

d) Operator shall be able to cut off power to a sub-sector by selecting it and giving and confirming the command. The system shall open all the associated switching devices automatically with confirmation for each device as an event.

e) The operator shall have to enter the details of the power block like the operator's code number, and time duration of power block. All power block details like operator's identity, time of imposition and section shall be recorded along with system time.

10.7.2.20 **Cancelling the power block:**

a) Only on authorisation of the field supervisor having been granted power block, the operator shall be able to select the device or the section on which the block has to be cancelled and give power block cancellation command. With this the power block of the devices/section shall be removed.

b) If a power block is not cancelled at the end of the permitted duration, a suitable alarm shall be generated to attract the attention of the operator. System shall not permit the operator to charge until cancellation of the power block.

c) It shall be possible to display or print the information of all power block details giving clear details regarding operator's identity, time of imposition and its cancellation. Power block details shall be stored in the database for later use and the switching events.

10.7.2.21 **Under-voltage tripping of SP Bridging interrupters**

a) Under extended feed conditions, if a low voltage at SP persists for more than a specified time (both of these shall be configurable), an alarm shall be sent to the operator. If the voltage continues to be in the low range even after this time (i.e. operator has not taken any action within specified time to restore normalcy) then the bridging device shall be opened by the concerned RTU through close loop action. Closed loop action on voltage limit violation" shall be implemented using ladder logic or IEC 61131-2 control logic. Any override operation shall be possible only through authentication by an administrative head nominated for the purpose.

10.7.2.22 **Printers**

a) The SCADA software shall support a minimum of two data-logging printers (one laser other dot matrix) connected on LAN. The data logging printers shall be in a secure room which the operators have no access to.

b) Each operator shall have one laser printer for the production of logs and reports.

c) For the avoidance of doubt an additionalprinter shall be provided for the general purpose computer connected to the office lan.

10.7.2.23 **Message pad:**

a) One page shall be provided for the operator to record/add important messages. The messages shall be able to be edited and removed by the operator. The messages shall be retained by the system even if the HMI has been shutdown. When the HMI is brought up again, the last entered message shall be viewable by the operator.

10.7.2.24 **Data logging and Reports generation:**

a) All alarms and events shall be logged by the system. Average minimum + maximum values of selected analog parameters shall be stored. The duration of this logging shall be settable and logged data shall be stored automatically with date (year, month and day) and time (hours and minutes) stamp in a file. The software shall be capable of generating different types of reports.

b) Some of the reports which may be required are: -

(i) Summary of circuit breaker's tripping during a specified period including the relay(s) which caused the tripping;

(ii) Power block availed report;

(iii) Event and their durations during the month when the voltage went beyond permissible levels at the TSS and SP respectively;& parameters of excesses

(iv) Duration during the month when the current exceeded nominal full load capacity of the transformer;

(v) Energy data interpretation, MD violation.

(vi) Morning reports of all the abnormal incidences in the last 24 hours.

10.7.2.25 **Help functions:**

a) On-line help and tutoring guide shall be provided for all major functions in the HMI using the HELP option. The help optionshall guide the operator for any specific help for carrying out certain tasks.

b) A keyboard shortcut shall be provided which can directly take to the current highlighted section help.

10.7.2.26 **Tabular displays, Current & Historical trends diagrams/ graphs:**

a) The software shall be capable of providing tabular display of data of a controlled station e.g. equipment status, alarms and measurands.

b) The time versus value plot of measurands in a separate colour including the arithmetic values on the measurands such as multiplication shall be displayed in a trend diagram. The trending shall include both historical trending and dynamic trending of current data.

c) The dynamic (current values) trending shall be for duration of one hour. For historical trend, average value of data shall be logged at the interval of 5 min duration.

d) It shall be possible to permit the dynamic values in the forms of graphs to anaccuracy of 5%

e) It shall be possible to store historical data of 5 years. If required a separate server may be provided at backend to store historical data.

f) However all data shall be accessible from the main screen where operator normally watch the recent data.

10.7.2.27 **Switch over to hot-standby systems:**

a) Hot standby systems shall be designed to improve the reliability of SCADA system by having back-up machines that automatically takes over when the primary fails.

b) The standby systems for the main server shall ensure that there will be no loss of data, alarms, event etc. due to the failure of primary server and data shall be updated normally after the failure occurs.

10.7.2.28 **Switch over of cold-standby systems:**

a) In the event of failure of primary server, the system shall ensure that the stand by server computer system automatically takes over including the data acquisition and the communication with RTUs over the existing channels. In any case the changeover from main to standby computer shall not take more than 30secs from the point of view of SCADA system working. The failure of primary server shall be displayed on all HMI's along with suitable alarm indication.

b) The system shall be configured on dualeEthernet LAN wherein each computer and server shall have two LAN interfaces. From each computer, one LAN interface shall be connected to first network switch and the second interface to the other switch. After achieving this connectivity, it shall be ensured that any failure of one LAN interface of computer, any one LAN wire, any one LAN switch shall not cause permanent break in LAN connection between any two machines. In any such condition, the system shall be able to restore alternate LAN route within 30 seconds. None of the equipment shall be declared offline/disconnected during LAN failure. Server hot standby switch over shall not be initiated due to a single LAN card failure.

10.7.2.29 **Overall screen design & real time display**

a) The MMI screen shall generally comprise of title bar, menu bar, tool bars, status bars etc for real time depiction & control of traction power system. This interface shall provide for all interactions between the operator and the SCADA system.

b) The MMI shall have features for alerting the operator with audio/visual supports on occurrence of critical alarms and events.

c) The audio alarms shall include play back of pre-recorded voice files in .wav or any other standard formats to be agreed by the Engineer. It shall be possible to play at least 20 different pre-recorded alarms based on criticality of alarm or any other alarm classification.

d) Full graphic, coloured displays of controlled stations shall be provided by the software. The display shall include ON/OFF status of equipment, (such as feeder CB trip, ac and dc voltage fail/low, RTU fail, communication fail, machine down etc.), alarms, measurands and names of the controlled stations.

e) There shall be facility for viewing display of full section, suitably condensed to fit screen size. This condensed picture shall be displayed on the MMI when called by the operator. Condensed diagram shall have fewer details as compared to the normal display but operator shall be able to control any of the devices and accept / acknowledge any alarm. The display shall support de-cluttering, zooming and panning through mouse.

10.7.2.30 **Simulator:**

a) A Simulator workstation/server setup shall be provided at OCC location with identical replica/snapshots of the actual system available to SCADA Operators. It shall be possible for the trainer to:

(i) Create fault scenarios for the trainees;

(ii) Pre-program simulator with timed faults so as to create live like scenarios;

(iii) If the trainer has created an earth fault in any elementary section, then the relevant breakers shall trip. If the trainee tries to charge that section the closing shall be aborted.

(iv) So that the trainee can learn to identify the fault as he would be required to find on live system;

(v) The simulator shall generate alarms and events as it would generate in a live system;

(vi) The simulator shall not be connected to any RTU (Other than a test RTU) or any other field equipment.

(vii) Grant / cancel Power blocks

(viii) Evaluate performance of trainees

10.7.2.31 **Safety Tagging:**

a) Tagging facility shall be provided on each item equipment for operator to put his comment and inhibit the command for that equipment. After this tag has been enabled, issuing of command shall not be possible from any operator or other control rooms until this tag has been, over-ridden by the chief SCADA operator. If the chief SCADA operator does override the Inhibit then he shall have to enter his password and this shall be counter signed by the operator who requested the removal of the tag only then shall the tag be removed.

b) The tag shall not be lost on system restart or any such scenario.

c) The over riding authority to the chief SCADA operator shall be delegated in writing by an administrative grade officer empowered to do so.

10.7.2.32 **Database creation:**

a) Database creation for the complete system shall be possible through microsoft excel based tools or similar. Small addition and deletions of I/O points shall be possible online with minimal disturbance to the Operators.

b) Complete system restarts shall not be required for such minor operations.

10.7.2.33 **Bus Bar Coloring:**

a) The SCADA software proposed shall support necessary busbar colouring feature by which the dynamic status of the busbar can be depicted during charged and dead (discharged) conditions.

b) Earthed equipments, blocked equipments, faulty equipments, faulty status, communication failures shall be displayed in separate colours.

c) The colouring shall be provided on all screens (overview / individual or sub-picture) at all times.

d) The status change shall be reflected through colour change within 2 seconds on the display.

e) It shall be possible to give a specific colour to any section based on an intelligent rule.

10.7.2.34 **Application Programming Interfaces (APIs) :**

a) Since other applications for which interfaces with SCADA data may not have been defined at time of tendering (e.g

GIS and Fault Call Management etc) the SCADA, system shall provide open APIs that can be configured at a later date to suit future interface requirements.

(i) ODBC support for data interchange between MS-Windows clients like Excel and the real-time/historical databases.
(ii) A generic library of services for database access and activation of SCADA procedures and services from external applications.
(iii) Support of all APIs in heterogeneous computer environments and to be network transparent.
(iv) Standard Utility Protocols as TASE.2 for inter-control center communication.

b) A wide range of remote terminal communication protocols for interfacing RTUs and substation control systems from different vendors.

10.7.2.35 **Integrated Graphical &Data Engineering Tool:**

a) The integrated graphical & data engineering tool shall provide as a minimum following functions:

(i) Automatic linking of station and network pictures with the SCADA data as part of the data engineering function;
(ii) Support for mass data entry through deep copy and paste, or excel export import.
(iii) Incremental loading of real-time database.
(iv) Rapid fail-over to new database without data loss.
(v) Drag anddrop support for linking to data base and pictures.

10.7.2.36 **IT Hardware**

a) The Contractor shall include the IT hardware specifications in his design for review and approval by Engineer. Industry proven IT hardware shall be used.

b) Achieving the performance parameters listed this PS shall be the responsibility of the Contractor.

c) The following points shall be complied as minimum requirement:

(i) Server and workstation hardware shall be platform independent.

(ii) All servers shall be industrial grade servers;
(iii) Power supply units of the servers, switches, and routers shall be redundant and fed from redundant UPS;
(iv) All monitors shall be minimum 21" diagonal, TFT/LCD/LED type and mouse & keyboard shall be cordless.;
(v) All servers and networking equipments shall be rack mountable;
(vi) Server hard disks shall be in RAID 5 configuration and hot swappable;
(vii) As a precaution against security level, USB ports/CD/DVD drives and other removable media shall not be available on operator workstation or shall be suitably disabled such that operator shall not be able to use portable flash or removable media drives on the workstations.
(viii) A general office PC shall be provided on each workstation for word processing etc. This shall be connected to the office LAN and can have all of its USB ports and data drives unblocked.

10.7.3 Remote Terminal Unit

10.7.3.1 General

a) As a minimum, the RTU shall support the following;
(i) Remote Terminal Unit (RTU) shall be installed at all TSS, SP, SSP, and ATS on main lines, in yards, at the OCC. It serves as single point interface between switching stations (All TSS, SP, SSP and ATS) and master station (OCC);
(ii) RTU shall be able to perform both data acquisition and local data processing. In the case of a communication path failure, the RTU shall operate as an independent intelligent unit and acquire and store data without interruption. On resumption of normal communication, the data shall be transmitted to the SCADA system;
(iii) The RTU shall support remote programming facility using RTU programming utility software from the master control centre. A port on the RTU shall be dedicated to the master control centre via one separate non redundant Ethernet communication channel;

(iv) In case of failure of communication between control posts and OCC/BCC, the local protective relays shall continue to function with all their protective features, including the lock out features on a persistent fault. All information in regard to the occurrence including data shall be stored in the RTU and shall be transmitted the OCC on resumption of normalcy.

(v) LCC shall continue to operate relay implementation and all safety features during failure of SCADA channel to OCC.

(vi) The RTU shall be capable to handle analogue input, digital input, and control output signals.

(vii) For each substation, the RTU shall be equipped to handle all the I/O points specified inTable 10.6-1. In addition, the RTU shall include fully configured spare I/O points available for the purchaser's use;

(viii) The RTU shall have an internal clock for data collecting coordination and time tagging. The internal clock shall be completely independent of the synchronization source so that the RTU shall continue to properly handle its time related application in case of source and communication failure.

(ix) RTU shall support maximum demand (apparent power) calculation based on 5 to 30 minutes window periods based on inputs received from energy/power transducers. The value of MD shall be reported to OCC after each window period;

(x) It shall be possible to reset the CPU of RTU from OCC in case it halts due to any reason;

(xi) High-resolution sequence-of-events (SOE) processing and reporting capability shall be as follows;

(xii) Detect changes in the state of SOE points;

(xiii) Record the date and time of change with a resolution of ±1 ms;

(xiv) Ability to retransmit stored SOE data if requested by the system Master Station in order to ensure that SOE data are neither lost nor overwritten until the RTU acknowledges the receipt of the data. A buffer capable of storing at least 1024 events shall be provided;

(xv) Ability to communicate with the local user interface (LUI) for maintenance purposes in case of communication path failure;

(xvi) It shall be possible to increase the number of communication ports in the RTU by addition of suitable cards, if required in future;

(xvii) RTU firmware shall be capable of being reconfigured (under password control) locally from the laptop/portable programming device and from the central master station by using IP based RTU maintenance software. Contractor shall furnish authentic copies of RTU firmware in CD/DVD to the purchaser;

(xviii) The RTU shall have self monitoring/diagnostic for fault conditions. This shall provide various details such as status of ROM, data bus, RAM check, battery low, defective cards etc. The RTU should generally support the test procedures as per standard protocol IEC 60870-5-101 & 104;

(xix) The RTU address shall be configurable. The RTU address shall not be lost in case of power swings or surges. It shall be possible for the Engineers' Staff to reconfigure the address for the remote station. (The Contractor shall train the Engineers' staff in the setting, configuring of the RTU's.)

(xx) In case additional RTUs are to be configured, configuration manual shall be provided by the Contractor and the Engineer's Staff should be trained to configure additional RTUs as per requirement of the Engineer.

10.7.4 RTU Cabinets

10.7.4.1 The RTU installations shall be dust, rodent and vermin proof with doors. The doors shall have proper rubber gaskets & locking arrangement. The cabinets shall have facility for bottom entry of incoming/outgoing cables for operation of the equipment. The stainless steel sheets of thickness not less than 1.6 mm as per IS: 6911- 1992 with mill finish of number 1 shall be used for making the cabinets. Suitable reinforcements shall be provided wherever necessary.

10.7.4.2 The RTU shall be floor mounted. The Contractor shall offer as small a cabinet as possible without compromising on maintainability and serviceability of the RTU equipment. There shall preferably be only one RTU cabinet housing all equipment. All enclosures shall conform to minimum protection class IP 64 as per IEC 60 529. The interior of the panel shall be lit on opening, using a CFL/LED lamp by a door controlled switch .

10.7.4.3 Modular type of construction shall be adopted to facilitate unit replacement of devices wherever required. Surface mounted technology or better (SMT) shall be used for higher level of reliability. Standard plug-in and connector arrangement shall be made for the printed cards.

10.7.5 RTU Wiring

10.7.5.1 All internal RTU control circuits and wiring of DI/DO & other signal circuits between C & R panel and RTU shall be with at least 0.75 sq mm, 1100 Vac/ 1500Vdc grade PVC insulated copper conductors conforming to IS 694.

10.7.5.2 RTU shall be wired with 1.5 sq mm XLPE insulated copper conductors conforming to IS 1554 Part-I, 1998 1100V ac/ 1500Vdc grade (screened wherever necessary) only for main incoming 110Vdc & 240 V ac power supply (4 sq mm only for CT wiring).

10.7.5.3 Harnesses of wires/cables shall be neatly dressed, laid in metallic and supported suitably. Separate wire bunches shall be run for ac, dc, control and data circuits. Caution plates and name labels shall be provided in keeping with good engineering practice.

10.7.6 RTU Software

10.7.6.1 The term "RTU software" used in this Particular Specification means software or software implemented through firmware. All Software shall be implemented according to the Contractor's established design and coding standards. Complete and comprehensive documentation shall be provided for all software to the extent that it is used in any way to configure or manage the system.

10.7.6.2 The RTU software shall provide automatic restart of the RTU upon power restoration, memory parity errors, hardware failures, and manual request. It shall initialize the RTU and begin execution of the RTU functions without intervention by the OCC. All restarts shall be reported to the system Master Station.

10.7.6.3 In order to provide for easy upgrading and/or correction, the RTU software shall be stored on a removable flash memory card. In addition, it is required for the RTU to perform the following tasks remotely:

- RTU software and database maintenance
- RTU diagnostics
- Configuration of RTU parameters and programmable logic functions.

10.7.6.4 The RTU software shall also support an easy, user-friendly human interface enabling an authorized operator to perform local supervision, control and/or maintenance of the RTU. There shall be a context sensitive interactive help window, e.g., a pop up text window displaying relevant help information.

10.7.6.5 The System Functions to be supported by the RTU Software shall be as follows:

- Equipment control;
- Equipment indications;
- Equipment alarm and event handling facilities;
- System configuration and database maintenance;
- Manual and automatic control function configuration;
- Protocol management;
- Measurement values and computations;
- Automatic self diagnostic;
- Help information;
- Archiving.

10.7.7 Local User Interface (LUI). (Only in TSS RTU's)

10.7.7.1 The RTU shall support a LUI for use by the Engineer's maintenance engineers and shall allow local operation.

10.7.7.2 As a minimum, the LUI shall perform the following functions:

- View remote station data and alarm information on graphical and tabular displays. This function shall include one-line diagram displays of the associated substation for viewing dynamically updating data and alarms.
- Initiate control actions, such as opening and closing circuit breakers. This function shall operate on a Select-Check-back-Before-Operate (SCBO) basis, and shall include appropriate security to prevent inadvertent and unauthorized control actions.
- Store historical information such as alarms, events and analog measurement.
- Maintain LUI and RTU software, database, and displays.
- Execute LUI and RTU diagnostic programs. The diagnostic programs are installed in the RTU-Software, thus no special installation shall be necessary on the computers/laptops used to present the LUI.
- Configure RTU system parameters.
- Configure RTU programmable logic functions.

10.7.8 RTU Environment Conditions:

10.7.8.1 RTUs shall be subjected to severe temperature variations and vibration conditions produced by moving rolling stock. The amplitude of these vibrations is expected to be in the range of 30 to 150 microns, with rapidly varying time periods in the range of 15 to 70 ms and occasional peaks of 350 microns. The Contractor shall confirm these values with the Other Contractors designing rolling-stock and the track alignment prior to commencing his design.

10.7.8.2 The track side cubicles shall not be air-conditioned and are liable for exposure to polluted, dusty and corrosive atmosphere. The Contractor shall take care of these aspects in his design. The RTU hardware shall meet the following environmental requirements:

a) Electrical Interferences:

(i) Power Supply and insulation applying to IEC 60255-5,IEC 60870-2-1 and IEEE C37.90-1989

(ii) Electro-magnetic compatibility(EMC)

- Immunity applying to EN 50121, IEC 60255,IEC 60870-2-1, IEC 61000-6-2, IEC 61000-6-5, IEC 61850-3 and IEEE C37.90.1-2002
- Emission applying to IEC 61000-6-4.

b) Environmental Conditions:

- Temperature and humidity parameters applying to IEC 60870-2-2 and IEEE C37.90-1989
- Mechanical Influences applying to IEC 60255-21 and IEC 60870-2-2
- The RTU hardware shall meet the following requirement of Electrical parameters:-

c) Power Supply and Insulation:

Sl. No.	Parameters	Accuracy/range	Standards
1	AC voltage tolerances of power supply	-20%...+15%	IEC 60870-2-1
2	Frequency tolerances of power supply	± 5%	IEC 60870-2-1

Sl. No.	Parameters	Accuracy/range	Standards
3	DC voltage tolerances of power supply	-20%...+15%	IEC 60870-2-1
4	Immunity of Voltage interruption	-100%:50ms	IEC 61000-4-29
5	AC power frequency withstand	2.5kV AC, 50Hz, 1 min	EN60255-5
6	Impulse Voltage withstand	5kV DC, 1.2µs/50µs	EN60255-5
7	Insulations Resistance	> 100MΩ at 500 V DC	EN60255-5

d) Electro-magnetic compatibility (EMC):

- **EMC Emission :**

S.No	Parameters	Range	Standard
1	Enclosure radio interference field strength	30dB (30—230 MHz) 37dB (230—1000 MHz)	IEC/CISPR 11 /EN 50011
2	Power supply radio interference voltage	79dB (0.15—0.5 MHz) 37dB (0.5—30 MHz)	IEC/CISPR 11 / EN 50011

- **EMC Immunity :**

S.No.	Parameters	Range	Standard
	Electrostatic discharge	Cubicle 15/8 kV	IEC 61000-4-2 Level 4
1	Radiated electromagnetic field	10 V/m	IEC 61000-4-3 level 3
2	Electrical fast transient / Burst	4 kV	IEC 61000-4-4 level 4
3	Surge	2 kV 4 kV	IEC 61000-4-5 level 3 IEC 61000-4-5 level4

4	Conducted disturbance included by	10V	IEC 61000-4-6 level 3
5	Power frequency magnetic field	30A/m	IEC 61000-4-8 level 4
6	Damped oscillatory wave	2.5kV/1kV	IEC 61000-4-12 level 3
7	Mains frequency interference 50 Hz	30/ 300 V	EN 61000-4-16 level 4
8	AC ripple on DC power supply	12%	EN 61000-4-17 level 3
9	Voltage dips on DC power supply	-30%, 100 ms -60%, 100 ms	IEC 61000-4-29
10	Voltage short interruptions on DC power supply	-100%, 50 ms	IEC 61000-4-29

10.7.9 UPS

10.7.9.1 The UPS for providing uninterrupted power supply to the SCADA equipments shall be installed at OCC. The UPS shall comprise:

- two AC/DC converter (battery charger)
- one Ni-Cd battery bank
- two inverters
- static bypass switches
- emergency switch
- two AC output protection circuitbreaker

10.7.9.2 The output shall not be affected by the quality of input source. It should be capable of running the SCADA system if the UPS input is fed from a diesel generator set.

10.7.10 Technical characteristics of UPS:

10.7.10.1 The UPS shall comply with following characteristics

Standards		**IEC 60146**
Electrical Characteristics		
Type		Dual Power, with auto changeover
Rated power (at cos ϕ = 0.8)	KVA	10 (Or higher if required)
Input voltage	V	415
Input voltage variations	%	+10, -15
Input frequency	Hz	50

Permitted variations of frequency	%	±3
Output voltage	V	240
Output voltage variations	%	±0.5
Output frequency	Hz	50
Output frequency tolerance	%	0.5
Harmonic content of output voltage	%	≤3
System efficiency	%	>90
Minimum time of emergency supply	h	4

10.7.11 Test Sheet of OCC UPS

10.7.11.1 The test sheets include type tests, routine tests, after shipment tests and on site tests.

10.7.11.2 The tests shall be performed in accordance with the IEC standards defined into the technicalSheets:

INDICATIONS	TYPE of TEST		
	Type	**Routine**	**On site**
Temperature rise	X		
Rated short duration power frequency withstand voltage		X	
Floating operation mode test		X	
Direct operation mode test		X	X
Protection devices operation		X	
Battery discharge duration			X
Setting test		X	
Visual inspection		X	X
Emergency switch operation			X

10.7.12 Protection against Surges

10.7.12.1 The power supply unit/DC-DC converter of RTU shall have internal protections against under voltage, over voltage, overload and short circuits in addition to adequate protection against surges and lightening in compliance of IEC-61643-12, 61312 & 61024 and DIN VDE-0100-534 as applicable.

10.7.12.2 In signalling line surge protection device of class D type shall be provided as per IEC 61643-21 & DIN VDE 0675 Pt 6.

10.7.13 Earths

10.7.13.1 Contractor shall provide a separate maintenance free low resistance earth for RTU. The RTU body/frame shall be suitably connected to the separate earth

10.7.13.2 Overall responsibility to ensure suitable design of RTU earthing arrangement to avoid failures of electronic cards etc. in RTU shall be that of the Contractor.

10.7.14 Electrical Protection for Power Supply

10.7.14.1 The Contractor shall ensure proper electrical protection by providing MCBs. There shall be one MCB per supply circuit.

10.7.15 Redundancy

10.7.15.1 The Power supply cards for the RTU system shall work in (1+1) hot standby mode. Failure of one supply card and its switchover to the standby card shall not cause any interruption to the functioning of SCADA. All failures shall be recorded as an event and stamped with date and time in OCC.

10.7.15.2 The RTU shall communicate with the Master SCADA server through redundantcommunicationchannels. The RTU communication cards and the server shall be accordingly configured. Redundant data channel of adequate bandwidth shall be provided by ST-P5.

10.7.15.3 Processing Cards for the RTU shall be provided in (1+1) hot stand by mode. Switchover from main to standby, card shall be transparent to the system functioning i.e. there will be no loss of function during the change over period.

10.7.16 PLC Programming Facility:

10.7.16.1 To enable programming for logic functions as required for the traction power supply distribution application, the RTUs shall support PLC in compliance with IEC 61131-3. The required programming tool shall be within the scope of the work.

10.7.17 Central Processing and communication unit:

10.7.17.1 The Central processing unit shall employ at least a 32 bit microprocessor and a dedicated peripheral bus controller for handling IO functions and adequate RAM - flash memory and high processing power. Features shall be identical in the redundant CPU. The CPU module shall have non volatile memory. The CPU module shall support the following ethernet and serial port requirements in one or more CPU modules;

10.7.17.2 It shall have necessary communication ports for communication with at least 3 control centres i.e. one main control centre and one two futurecontrol centreson IEC 870-5-104 protocol.

10.7.17.3 It shall support data acquisition from energy meters.

10.7.17.4 The Central RTU shall include serial port using RS232/ RS485 interface to communicate with IEDs by using the IEC61850/IEC60870-5-103/DNP 3.0 protocol.

10.7.17.5 The RTU shall have one MMI port which may also be used for configuration purpose.

10.7.18 Analog Input

10.7.18.1 The analogue inputs module shall have minimum 8 channels per module and shall support dual slope integration A/D conversion.

10.7.18.2 The RTU analogue-to-digital (A/D) converters shall have a digital resolution of at least 11 bits plus sign.

10.7.18.3 The analogue module shall support the following signal :

a) Unipolar Measured Values
b) Bipolar Measured values

10.7.18.4 It shall be configured for the following measurement ranges:

- 0 … 2.5 mA
- 0 … 5.0 mA
- 0 … 10 mA
- 0 … 20 mA
- 4 … 20 mA
- 0 … 1.0Vdc
- 0 ... 10 Vdc

The accuracy shall be min ± 0.1% on full scale.

10.7.18.5 Following Programmable parameters shall be supported:

a) Live zero conversion coefficient Cyclic;
b) Transmission or threshold value Forced;
c) zero pint conversion coefficient Limit;
d) Values Smoothing factor Threshold;

e) Values Cyclic duration;

f) Priority of transmission.

10.7.18.6 Other parameters:

a) Inputs shall be configurable for 4 to 20 mA / bipolar or live zero
b) Accuracy- </= 0.25 %
c) Common Mode Voltage : +/- 8 V DC
d) Line Interference suppression : > 100 d for =50 or 60 Hz

10.7.19 Transducers:

10.7.19.1 The independent transducers converter/ multi function transducers (MFT) required for acquiring Analogue inputs from CT/PT shall be supplied by the Contractor.

10.7.19.2 The transducers shall be selected for nominal 110 V ac (Ph-Gr voltage) and 1A/5A CT/PT inputs. The transducers shall withstands input voltages upto 120% of the nominal voltage and shall be suitable for 20% continuous over load and 20 times the normal current rating for a period of one second.

10.7.19.3 Transducers shall provide at least the following parameters as a minimum with the specified accuracies.

Sl. No.	Parameters	Accuracy
(i)	Voltage (Each phase to neutral and phase to phase)	±0.5%
(ii)	Current (each phase)	±0.5%
(iii)	Active Power, Reactive power, Apparent Power	±0.5% / ±1%
(iv)	Import & Export Energy (active/reactive)	±1% / ± 2%
(v)	Power Factor (measuring range)	0.5 lag to 0.5 lead
(vi)	Auxiliary Power supply	110 V dc

10.7.19.4 Temperature and pressure monitoring transducers shall be similarly rated and provided with the independent power supply drawn from local LT supply.

10.7.20 Digital Input Module:

10.7.20.1 The Digital input module shall have at least 16 optically isolated channels per module and shall support time stamping with time resolution of 1 ms. The digital input module shall support configuration of inputs for the following options:

- Single Indications
- Double Indications
- Digital Measurands

10.7.20.2 The digital input module shall support the following features:

a) Programmable parameters including but not limited to:
  - Bounce Filter (Suppression Time);
  - Settling time for reliable digital measured value;
  - Chatter suppression;
  - Suppression of intermediate position;
  - With / without time tagging shall be a configurable feature;
  - Configurability of message transmission priority.

b) Indication processing of
  - Group or Common alarms shall be configurable from Individual alarms by Boolean operations;
  - Acquisition of events in chronological order with a time resolution of 1 ms - Buffering up to 3 changes per input.

10.7.21 Digital Output

10.7.21.1 The Digital Output module shall support at least 16 digital output channels per module. The output module shall support time stamping with time resolution of 1ms and the following features:

10.7.21.2 Programmable Parameters shall includes
- Duration of output pulse
- Release disconnection delay time at response indications
- Select before execute
- Cyclic duration
- Priority of transmission

10.7.21.3 Interposing contactors/relays for operating the closing and tripping circuits shall form part of the SCADA equipment. The contactors/relays shall be suitable for 110 V dc supply varying from + 10 % to -20 %. The contacts of relays shall have a continuous current carrying capacity of 5 A, making capacity of minimum 10 A and breaking capacity of 2 A inductive load. Suitable spark quenching circuit shall be provided to take care of breaking inductive loads

10.8 Functional Interface with Others

10.8.1 Interface with the State Power Companies 220/132kV system

10.8.1.1 The Contractor shall liaise with State Power Companies to establish the requirement for SCADA, between the Engineers' Equipment and that of State Power Company and vice-versa. The Contractor shall provide any necessary interfacing SCADA equipment.

10.9 Testing, Commissioning and Verification

10.9.1 General

10.9.1.1 Tests shall be performed in accordance with Chapter 5 of Employer's Requirements (GS).

10.9.1.2 The Contractor shall develop a full test plan including integrated test and commissioning and performance verification and submit for review by the Engineer at least one month before any on site tests are to be performed.

10.9.1.3 On receipt of no objection by the Engineer the on site tests as indicated therein shall be performed. The tests mentioned herein are indicative and minimum requirement.

10.9.1.4 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's Representative in accordance with the specifications relating to the item,, component or equipment of this contract. These test records and certificates shall be supplied for all tests, whether or not the Engineer's Representative has witnessed them. The information given on such test certificates shall be sufficient to identify the materials or equipment to which the certificate refers.

10.9.2 Testing of SCADA System

10.9.2.1 Factory Acceptance Tests:

a) Complete SCADA system shall be offered for factory acceptance tests before dispatch. These tests shall as a minimum comprise of but not limited to the following:

(i) Communication Protocol Test: All the important services as per IEC 60870-5-104 and 61850 shall be verified. Vendor shall also supply the necessary test certificates issued from reputed testing agencies for IEC 60870-5-104 and 61850 compliance for the complete SCADA system;

(ii) The Master station with RTU simulator tool shall be used to test the communication interfaces of Master station, RTU and Protection relays. The Master station simulator tool shall be capable of emulating the master station for IEC 60870-5-104 and IEC 60870-5-103 protocols.

(iii) The RTU simulator shall be capable of emulating the slave protocols for both the IEC 60870-5-104, and IEC 60870-5-103 protocols for Protection relays. It shall also be possible to prepare illegal messages for transmission, such as messages having invalid checksum;

(iv) The protocol analyser shall be used to monitor all communication traffic on a channel (between Master station & RTU and between RTU & protection relays without interfering channels operation. Channel traffic captured in the active or passive modes of operation shall be displayed;

(v) The Master station simulator and protocol analyser tool shall also have following features:

- Each received message shall be checked for validity, including the check sum.
- The tool shall maintain and display error counters so that the number of errors during a period of unattended testing can be determined.
- All fields of a message shall be displayed. A pass/fail indication for the message shall be included.

(vi) RTU functionality Test:

- Visual Examination: RTUs shall be inspected for the features indicated in the specification and the Engineer's Representative approved drawings.
- Detailed Architecture and features: Verification of requirements as stipulated in section 5, Design Criteria & Performance Specification shall be covered.

- Functional testing on all communication devices including media converters, LAN equipment etc. shall be carried out to verify their operational parameters.
- Transducers accuracy shall be verified over the entire range for linearity and accuracy.
- Functional tests shall be conducted on the power supply unit
- Stability of output voltages with the variation of input DC (94-121V) voltage. 2. With 120% of the normal designed rated load, the voltage regulation and the ripple factor.
- Insulation resistance Tests: Insulation resistance of cables shall be checked without connecting electronic circuits between various circuits, contacts, and terminals with a 500 V megger. It shall not be less than 5 mega Ohms.

(vii) SCADA Software functionality tests:

- All SCADA Software functional features mentioned in this specifications shall be verified
- Sample SLD's for one station of each type shall be made available and verified for look and feel, ergonomics, symbols used, interlinking of various Pictures and operation mechanisms.
- Command execution time verification with minimum four online RTU's.
- Status update time verification with minimum four online RTU's.
- Bus bar coloration performance verification. with minimum four online RTU's.
- Verification of various authorisation levels and password protections in the system.
- hot and standby switchover, self check and diagnostic features etc. shall be verified
- PC/Servers/Printers for OCC etc shall be checked as per approved drawings

10.9.3 Environment and EMI test on RTU:

10.9.3.1 The following tests shall be conducted on the RTU sub assemblies (cards/modules) or reports of type tests carried out at Government test labs/institutions/NABL accredited testing labs or any other lab acceptable to Engineer's engineer shall be produced.

Sr. No.	Title	Standard No.
1	High Frequency test	: IEC 60255-22-1, class – III : Frequency : 1MHz Damped Oscillatory : Longitudinal :5 kVp : Duration: 2 sec. : Between input current Terminals
2	Electrostatic discharge (Direct application) Indirect application	: IEC 60255-22-2 Class III and IEC 61000-4-2 class III. : Contact discharge: 6kV, : Air discharge: 8kV : Polarity: both +ve and –ve polarities. : IEC-61000-4-2, Class-III
3	Fast transient disturbance	: IEC 60255-22-4 and IEC 61000-4-4, class A : 1.2kV; 5/50ns; 5kHz burst duration = 15ms. : Repetition rate 300ms; Both polarities; Ri = 50Ω; duration 1 min.
4	Surge immunity test	: IEC 60255-22-5 / IEC 61000-4-6 class 4 : Differential Mode = 2kV : Common Mode = 4kV : 1.2/50uS , 5 surges of each polarity
5	Power frequency immunity test	: IEC 60255-22-7, Class-A
6	Power frequency	: IEC 61000-4-8, Class-V
7	Radiated electromagnetic field disturbance	: IEC 60255-22-3 : EN 61000-4-3 : Frequency 80MHz – 1GHz
8	Conducted Disturbance induced	: IEC 60255-22-6 / IEC 61000-4-6:

	by Radio Frequency field	1996. : Freq. 150kHz – 80MHz, Amplitude 10 V, : Modulation 80% AM @ 1 kHz
9	ac Ripple in dc supply Test	: IEC 60255-11
10	Radiated emission:	: IEC 60255-25
11	Dry heat test at 70^{o}C in operational condition for 96 Hours.	
12	Damp heat test at 40 ^{o}C and 95 % RH in operational condition for 10 hours.	
13	Cold test at 0^{o} C operational condition for 16 Hours.	
14	Cyclic heat test at high temperature at 50^{o}C and low temperature at 0^{o}c; Dwell time in high or low temperature for 3 Hours. Transition of 10^{o}c per minute, and for 5 such cycles in operational condition.	

The vibration test specified as under shall be conducted on the complete assembled

1	Vibration test with severity of weight centered endurance by sweep frequency 10-50 Hz, displacement of 0.15 mm acceleration of 2 g and of duration of 2 Hours in each axis. (total 6 Hours).

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10.9.4 Site Acceptance Tests

a) Tests shall be carried out during erection/commissioning of the equipment at site on the complete system in the presence of the Engineer's Representative to check the proper erection and successful commissioning of the equipment. These tests shall be carried out to check the compliance of the SCADA system with the stipulations made in the specification drawings.

b) SCAN time, cyclic update time and command operation time shall be measured.

c) Complete SCADA system working after full configuration shall be verified.

d) System response to abnormal conditions shall be verified.

10.9.5 Re-Testing

a) When defects are detected in the equipment accessories, etc during the commissioning tests, the Contractor shall ensure that adequate spares are kept on site to promptly attend to these defects.

b) 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's Representative shall be carried out in a similar manner by the Contractor.

c) 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's Representative may reject the item or defective component thereof, whichever is considered necessary and after adjustment or modification as directed by the Engineer's Representative, the Contractor shall submit the item for further inspection and/or test.

d) 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 shall be replaced by the Contractor at his own expense, after carrying out the tests as per the relevant specifications. for the acceptance by the Engineer's Representative.

END OF CHAPTER

11 DFC Traction Installation Handover

11.1 DFC Traction Installation handover

11.1.1 The conditions for handover of the Traction installation Hand Over are as follows:

(1) The Contractor shall hand over the Railway sections of the traction installation to the Engineer on the Co-ordination Dates as defined in the Conditions of the Contract. From this date any access to the Railway Installation by the Contractor shall be in accordance with any procedures, requirements and conditions laid down by the Engineer as defined under sub-clause 11.1.2.

(2) At the time of handover, the Contractor shall have executed all necessary works on the structure, all safety works, screens , barriers from High Voltage and affixed all Safety and Warning Signboards and all other works provided by the Contractor within the Railway Envelope, the installation of all equipment and fixings defined under sub-clause 11.2 and shall ensure that the Envelope is complete, secure, safe for the operation of trains, and has the Engineer's and Engineer's approval for effective handover.

11.1.2 The conditions for access to the DFC Railway Envelope after handover are as follows:

(1) Access to the Railway Envelope after handover will be controlled by the Engineer and priority will be given to the testing and trial running of rolling stock and other operating components associated with the railway. Access will be given to the Contractor and to Other Contractors by the Engineer for inspecting, maintaining, adjusting and repairing, by prior arrangement and for limited periods. The work on High Voltage sections will be subject to Permit to Work procedure.

(2) At the time of handover, the Contractor shall provide the Engineer with the name of, and twenty-four (24) hour contact person for, the individual charged in liaison with the Engineer. The Contractor shall give two weeks notice of his desired track and /or High Voltage equipment possessions, and, when requested, at the appropriate meetings track possession and or Traction Installation possession allocations will be made by the Engineer. It may be necessary for the Contractor's work to be carried out intermittently or at night if suitable possessions cannot be given during its preferred hours. During all such operations the Contractor will be fully responsible for safety of men, equipment and Works.

(3) After the handover, and prior to the issue of Taking Over Certificate, the Engineer will be undertaking the following activities:

(a) testing traction and signalling equipment together with other equipment and facilities required for operation of the railway: during this period the Engineer and/or his contractors will be running work trains through the Railway Envelope;

(b) undertaking acceptance tests, Integrated System Tests and test running: during this period the Engineer and/or its contractors will be running trains through the Railway Envelope on a regular basis;

(c) undertaking trial running: during this period the Engineer will be operating trains and equipment on a trial basis, the frequency of which will increase as the trials proceed until full operating frequencies are reached.

11.1.3 The Contractor shall take account of the Engineer's activities and train operations in planning and programming its Works.

(1) The conditions for access to the Railway Envelope on the Work Site after issue of Taking Over Certificate on completion will be administered by the Engineer.

(2) Prior to the substantial completion of the Works the Contractor will be given extended possessions of the Railway Envelope for the purposes of final adjustment, tightening, touching up or cleaning up prior to the final inspection of the Works. Such possessions shall be agreed with the Engineer.

11.2 Railway Equipment

(1) Non-structural items

Safe Earthing and Bonding of the Traction Installation, screens and access barriers against exposure to 25 kV ac for public and unauthorized personnel etc as required in terms safety provisions of Indian Electricity Act and rules shall be supplied and installed by the Contractor before the handover of the Traction Installation to the Engineer.

11.2.1 Electrical and Mechanical Equipment

(1) All Traction installation equipment and services shall be complete properly enclosed and secured for safe and reliable operation.

END OF CHAPTER

12 Supervision and Planning of Maintenance

12.1 General

12.1.1 The scope and requirements of supervision and planning of maintenance are stipulated in Vol. II Section 8 of Engineer's Requirement (General Specification) Manufacturing, Installation, Testing and Commissioning".

12.1.2 The following outlines the Engineer's maintenance strategy, different levels of maintenance, the maintenance management system and the arrangement for maintenance.

12.1.3 The Contractor shall make use of all relevant information to provide supervision of maintenance.

12.2 Engineer's Maintenance Strategy

12.2.1 Maintenance Strategy

12.2.1.1 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) Unforeseen design errors in the System;
b) operational changes;
c) environment changes; and
d) changes in infrastructure.

12.2.1.2 According to the maintenance strategy, all equipment and infrastructure supplied for the 'Project' shall be designed for minimum or no maintenance.

Maintenance activities required shall 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.

Where practicable where major items of plant fail and cannot be fixed quickly then modular design is preferred for quick change of modules, then the faulty equipment can be repaired in factory conditions in the maintainersworkshop.

12.2.1.3 During the Defects Liability Period (DLP) maintenance of all Works will be conducted by the Engineer under the supervision of the Contractor.

12.2.1.4 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. The addresses and 24 hour telephone numbers (Land and Mobile line) shall be available with the Engineer for this purpose.

12.2.1.5 The Contractor, upon being advised of or on 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's Representative for review.

12.3 Different Levels of Planned Maintenance

12.3.1 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.

12.4 Supervisory Staff

12.4.1 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) Traction substation (220/132kV, 25kV/ac) including SSP, SP and OHE switches
b) Auxiliary power
c) Power Factor Correction equipment
d) 25kV flexible OHE
e) SCADA
f) Electrical Protectionand earthing

END OF CHAPTER

13 Supply of Spares, Tools & Measuring Instruments

13.1 General

13.1.1 The Contractor shall supply spare parts, special tools and test equipment in accordance with the requirements of "Manufacturing, Installation, Testing and Commissioning - Clause 5.8 of General Specification Section 8".

13.2 Contract Spares, Instruments, Toolsand Plants

13.2.1 The Contractor shall supply a minimum quantity of the following items of Spares as given below in Table 13.2-1.

Table 13.2-1 Minimum Quantity of Contract Spares

S. No	Spares	Quantity
	A. OHE Spares	
1	Complete overhead equipment along with Conductors, Fittings and Jumpers: Main Lines	30 km
2	Complete set of overhead equipment along with conductors : yard lines	5 km
3	25 kV Feeder Conductor	10 km
4	Protective Earth Conductor	10 km
5	25kV Cable Termination Fitting	10 sets
6	25kV Cables	1 km
7	Cantilever Brackets with top and Bottom insulators, 5 Tonne and 9 Tonne Insulators	100 nos. each
8	OHE Section Insulators	20 sets
9	OHE Auto-tensioning device sets	20 sets
10	Counter weights for ATD	6 sets
11	Stainless steel wire rope for ATD	20 sets
12	Jumper Cables	1 km each type
13	Height and Stagger Gauges (mechanical)	20 sets
14	Height and Stagger gauge(instrument laser based)	9 sets
	B. Sub-Station Spares	
1	Traction transformers	1 nos
2	Auto- Transformers	2 Nos
3	220 kV switch gear, lightning arrestors	2 sets

4	25 kV switchgear , surge arrestors	5 sets
5	Protective Relays	2 sets of all types
6	Control Auxiliary Relays	5 sets
7	Bus Bar Conductors & Fittings	1 TSS Set
8	25 kV circuit breaker – 2 pole	2 sets
9	25kV Interrupter – 1 pole	2 sets
10	25kV Current Transformer	5 nos.
11	25kV Potential Transformer	5 nos.
12	Post and String Insulators	1 TSS Set
13	25kV Insulator – 2 pole (motorized)	2 sets
14	25kV Insulator – 1 pole (motorized)	2 sets
15	Buckholtz Relay	1 set of each type
16	220/132kV isolator	2nos.of each type
17	220/132kV Lightning Arrestor	3 nos.
18	25kV Lightning Arrestor	5% of each type
19	AC Power Line Analyser	1 No.
20	Acoustic Level Test Set (Suitable Range)	1 No.
	C– SCADA Spares	
1	RTU SET - TSS	2 sets
2	RTU SET - SSP	2 sets
3	RTU SET - SP	2 sets
4	Printer	1 set
5	Modules and cards of RTUs	3 % of each type
	D – Instruments, Test Kits, Tools & Plant	
1	Lap Top Computer for diagnostic checks	3
2	Signal level meters	3
3	Dual Trace oscilloscope: 12 channel, 25 MHz bandwidth, sampling rate 20 ms/s	2 sets
4	Cable Fault Locator	4 sets
5	AC Power Line Analyser	1 set
6	Earth Leakage Detector	10 sets
7	Earth Megger	10 sets
8	Manual Megger 1000 V	20 sets
9	Primary injection test kit	3 sets
10	Secondary injection test kit	3 sets
11	Relay Testing Kits	3 sets
12	Infra-red remote temperature sensor	15 sets
13	Oil dielectric test kit	8 sets
14	Thermal Imaging Camera	15 sets

15	Video Camera	5 sets
16	Dissolved Gas Analyzer Set	5 sets
17	Digital Multi Meters Megger M 7027 / Fluke 27/Yokogawa 732 series only.	4 sets
18	Multipurpose Screw driver sets Small and Big	24 sets
19	Vehicle mounted single phase centrifulgal transformer oil filteration plant of 300 liters per hour capacity	3 sets

Ref. clause 13.2 Section 9 – Particular Specification

The above items in good condition shall be handed over to the nominated official of the Engineer at locations indicated by the Engineer.

13.3 Second Sourcing

13.3.1 The Contractor shall identify principal and second-source suppliers that can supply the Contract Spares

13.3.2 The Contractor shall ensure that second-source supplier information is maintained up to date up to a period of 10 years after taking over of whole works. The Contractor will provide support to the Engineer to a reasonable extent regarding the second-source supplier information throughout the service life of the system.

13.3.3 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.

13.4 Long Lead Times

13.4.1 The Contractor shall identify the lead times for all spare parts. Parts with long lead times shall be identified in the spares list.

13.5 Routine Change

13.5.1 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 Engineertogether with the routine change interval.

13.6 Shelf Life

13.6.1 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.

END OF CHAPTER

14 Reliability, Availability, Maintainability & Safety Requirements

14.1 General

14.1.1 The project is to be designed with a high degree of reliability and availability, in order to provide a dependable service thereby increasing patronage and revenues from the system.

14.1.2 The optimization of the system with respect to reliability, availability and maintainability shall be planned and shall form an integral part of the project from its inception through to its operational life as the 'life cycle cost' of a major system is an aspect which in the long term can affect the financial viability of the project.

14.1.3 The Contractor shall demonstrate that the issues of RAM will be managed during all phases of the project.

14.1.4 The RAM management process shall address all aspects of the System and shall be demonstrably integrated into the project as a whole and this is to be achieved through the development of a process that as a minimum shall address the following:

a) Definition of RAM requirements.
b) Planning and implementation of RAM tasks for all project phases.
c) Assessment and control of impacts and threats to RAM requirements.
d) Demonstration of compliance with RAM requirements.
e) Program of on-going monitoring of compliance.
f) Applying of the Indian Standards, norms, regulations, instructions and the Employer's Requirements / Specifications.
g) Operational compatibility with the neighbouring railway systems and electrical locomotives.

14.2 Reliability

14.2.1 A fault study shall be prepared for the Various Systems, identifying the System failure modes which contribute to reliability and quantitative estimates prepared of the likelihood of failure. The system and the components shall comply to EN 50126/IEC 62278.

(1) The Contractor shall demonstrate the reliability of the proposed design and material for OHE equipment within the DFCC operating environment.

(2) For all critical items of the equipment offered the Contractor shall state the mean time to failure, the mean time to repair, and the mean time to preventative maintenance and details of preventative maintenance required to maintain full operational performance.

(3) Where equipment has novel features or where insufficient operational data is available, the Contractor shall state the methods used to determine reliability performance.

(4) All consumable and/or bought-out items shall have a high level of reliability in particular where they shall remain continuously energized and in service e.g. insulators.

(5) In the event that a feeder circuit breaker fails at a TSS, SSP, or SP it shall be possible to close an interrupter to parallel the up and down lines together.

(6) Each TSS, SSP, ATP and SP shall have two battery chargers for provision of power to the control and protection equipment.

(7) The battery sets at TSS, SSP, ATP and SP shall have the capacity to operate all plant for a minimum of 10 hours following failure of the battery chargers. This failure alarm shall be tele-signalled to the OCC through SCADA system.

14.2.2 Dynamic Validation

(1) Dynamic validation shall be undertaken to ensure compliance with the specified current collection criteria of all relevant parts of the project including track work, rolling stock and catenary interfaces.

(2) If the technology for measuring by force is not available, then the criteria for measurement shall be loss of contact with measurable arcs lasting longer than 10ms (maximum 25ms) shall not occur more than once in 100m.

(3) The Contractor shall agree with the Engineer the selection of a suitable method and equipment, which determines compliance with the current collection standard within the range of operating conditions.

(4) The system dynamic performance shall comply with the requirements of pr EN 50119.

14.3 Availability

(1) The overhead contact system design, arrangement and component design shall be chosen to ensure that the railway shall have high service availability.

(2) The OHE design shall have mechanical independence of support and registration,for main line & where practicable on other lines.

(3) The arrangement of tension lengths and wire runs shall minimize the effect of overhead equipment damage in a station or crossover, on neighbouring sections, in the event of overhead contact or catenary wire failure.

(4) Equipment positioning and equipment access shall consider ease of maintenance and continued service availability during maintenance.

(5) Quantitative targets have been set for the System availability to ensure that the reliability of the Systems does not jeopardize the reliability of services of the Freight Railway.

(6) The Systems shall be designed to ensure that failure of any major equipment, caused by an external accident or negligence of internal staff or malicious damage by external influence, will not lead to unavailability of the whole System, other than temporary outage of the failed equipment.

(7) TSS, SSP, ATP and SP shall be designed to an availability level of N-1(First failure).

(8) The traction power and overhead line systems and all other associated equipment shall be designed for scheduled/routine maintenance of each TSS and all allied equipment downstream within one four hour maintenance block. Maintenance shall not interfere with freight services at any other time.

(9) Electrification of Junction and Crossing Stations:-

(10) Circuit breakers shall be provided to operate on definite fault or over current conditions, and to isolate only the faulty part or equipment ensuring healthy system is not affected.

(11) It shall be possible to automatically re-energize the overhead line immediately following the occurrence of transient faults such as lightning, or bird strike causing a momentary short circuit. The auto-reclosure shall be of one shot only.

(12) No single point failure of TSS, SSP, ATP or SP equipment shall lead to prolonged traction failure to any part of the system. Loss of any single external supply shall not affect full peak traction power being supplied to any part of the system.

(13) The traction power supply shall interface with the SCADA system to allow control and monitoring remotely from the OCC. The System shall provide diagnostic information to the operator in the event of fault affecting the power supply.

(14) Save and except where specifically approved, failures of the overhead line, or support equipment shall not cause loss of traction supply to more than one line. 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.

(15) The Contractor shall define maintenance and test procedures of various equipment to ensure reliable availability of the traction power,auxiliary power supply and SCADA.

(16) Surge arrestors shall be with dedicated earths and compatible for condition monitoring.

(17) Indoor components and cabling shall be so located as to prevent exposure to water and moisture.

(18) Mechanical joints of conductors, which may be susceptible to failure, shall, where practicable, not be located in close proximity to locations where there is an interface where the public have access. e.g. Adjacent Indian Railways Stations and level crossings. Locations where the public have reasonable access may be inspected by the Engineer's representative prior to energization of the electrical section.

(19) Overhead line over each track on mainlines shall be supported independently and shall be robust for normal and abnormal operation. The design of supports shall be of sufficient robustness so that an impact by a train pantograph shall not cause a failure affecting other running lines.

14.4 Maintainability

(1) The Contractor shall identify and document the maintenance requirement for the overhead contact equipment.

(2) The maintenance commitment in terms of frequency, number of personnel and specialist equipment shall be worked out by the Contractor.

(3) Equipment design should balance these requirements with the reliability and maintenance benefits offered by the new design.

(4) OHE maintenance in terms of work level, work frequency, personnel numbers, varieties of status, types and numbers of specialist items and spares, shall be minimum.

(5) The Contractor shall undertake maintainability analysis to assess the preliminary maintainability targets of the systems.

(6) 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.

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

(8) Routine/Preventive Maintenance periods shall be limited to non-operational 4 hour maintenance blocks or if essential during periods of light traffic.

(9) Equipment along the length of the Western Dedicated Freight Corridor shall be selected from a common Group of materials to ensure that equipment is interchangeable between sites, spares and training on multiple systems is kept to a minimum.

(10) Where ever possible the layout of each TSS, SSP, ATP and SP shall be standard to avoid confusion and ensure interchangeablity of equipment.

(11) To optimize speedy corrective maintenance, techniques employing automatic diagnostics test points, and rapid repair facilities shall be provided. In addition, especially the OHE 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.

(12) The Contractor shall provide a facility for anti theft charging of the OHE equipment prior to commissioning.

(13) All OHE components including tensioning devices shall be installed with sufficient lubrication to prevent mechanical failure in service.

14.5 Safety

14.5.1 General

(1) Items relating to safety, contained within this Design Criteria and Standards, do not necessarily cover the full safety requirements.

(2) The Contractor shall be responsible for addressing all of the issues relating to safety, compliant with Indian Railway safety regulations.

(3) The design, construction, maintenance and monitoring of safety critical items, must be such as to guarantee safety at a level determined by the Contractor and presented to the Engineer for approval.

14.5.2 Safety Requirements

All safety hazards shall be mitigated at the design stage where permissible.

a) The installation design shall incorporate measures to avoid presenting safety hazards.

b) The Systems design shall incorporate measures to provide for its safe management and operation.

c) The Systems shall not give rise, or be subject to, dangerous interactions within the railway or with other systems. Particular attention shall be paid by the Contractor to the interface with the adjacent Indian Railways infrastructure.

d) The Traction installation shall meet the fire safety requirements as per Indian Electricity Rule & National Building Code.

e) The design of the earthing system shall conform to IS 3043: 1987 (including latest amendments) and EN 50122-1, EN 50522 and IEEE 80. Most onerous conditions shall apply where there is conflict between standards.

14.5.3 System Safety Plan

(1) The Contractor shall develop a System Safety Plan as an integral part of the design.

(2) The Plan shall address the general safety aspects associated with the OHE design and peripheral features.

(3) The Plan shall include, Hazard Operability Studies (HAZOP) and Fault Tree Analysis (FTA) which shall fall into the following three categories:

a) Subsystem hazard analysis (SSHA).

b) Interface hazard analysis (IHA).

c) Operating and support hazard analysis (O & SHA).

(4) Each of the above shall identify four degrees of risk:

a) Catastrophic.

b) Critical.

c) Marginal.

d) Negligible.

(5) The above items related to safety do not necessarily cover the full requirements.

(6) It is the Contractor's responsibility to address all aspects of safety and comply with legislation.

14.5.4 Quantified Risk Assessment

- The Contractor shall prepare a Quantified Risk Assessment (QRA) to model the risk to (a) public (b) maintenance and operations staff (c) public and staff on the adjacent Indian Railways Line and other third party infrastructure. The QRA shall address the risk of electrocution from the OHE and other equipment. 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, falls during maintenance, electrocution or injury due to crossing into Indian Railways territory. Accidental charging of dead section due to problem with SCADA and Interlocking 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 are adopted to mitigate the consequence of such error.

- The Contractor shall demonstrate that risk to public, including trespassers is low as reasonably practicable.

14.5.5 Risks on Functional Safety

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

a) Explosion or fire at TSS, SSP, ATS and SP and SCADA equipment room;

a) Equipment safety;

b) Damage to overhead conductors;

c) Damage to overhead current collection system equipment;

d) Damage to 25kV feeder and return cables;

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

f) Safety of the Engineer's staff and public, including trespassers as far as is reasonably practicable.

g) Occupational repetitive injuries.

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

14.5.6 Minimum Factors of Safety

(1) The mechanical design of contact wire, catenary wire and other conductors shall take into account the permissible tensile stress, maximum temperature, allowable wear, wind loads, efficiency of tensioning devices, termination fittings, welded or soldered joints, additional vertical load in accordance with EN 50119 to allow adequate factor of safety under all conditions.

(2) Cantilever support frames, and main structures and SPS, in combined tension/compression and bending, shall have safety factors in compliance with the appropriate design codes.

END OF CHAPTER

15 Training

15.1 General Requirements

15.1.1 The Contractor shall provide comprehensive training to the Employer's staff in accordance with the requirements contained in this PS and in the GS"Chapter on Manufacturing, Installation, Testing and Commissioning paragraph no. 5.9".A central training school may be planned by DFCCIL for this purpose.

15.1.2 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 theEmployer.

15.1.3 The training courses and/or sessions shall include system performance requirements and all major equipment and works designed, by the Contractor.

15.1.4 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 Employerfor review at least three months before any course is conducted.

15.1.5 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 The training manuals shall be submitted in original plus five hard copies and in electronic format.

15.1.6 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.

15.1.7 The training courses shall be delivered to all relevant Employer's staff, including instructors, operation and maintenance engineering staff.

15.1.8 The proposed training requirements are to be developed for next issue of this Particular Specification.

15.1.9 The foreign training of 300 mandays and 30 instructor man days and 300 mandays training in India shall be arranged by bidder in the different fields. The boarding,lodging and transportation charges for trainees shall be arranged and borne by the Employer.

15.2 Mock Up for Training

15.2.1 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.

15.2.2 The training mock up shall include but not limited to the following: -

a) OHE system components
b) Contact, messenger and protective 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 and Interrupters and their component assemblies;
g) Isolators;
h) SCADA training Aids such as RTU, PCU and OCC.
i) Cut Sections of Circuit breakers, cables
j) Cut sections of Gas Insulated switchgear
k) Clear photographs of various equipment such as transformers, their windings, rectifier and inverter sets;
l) Samples of various clamps and fitting used;
m) Control panel, protection schemes, earthing and bonding arrangement.

15.2.3 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 Employerreview in accordance with clauses 13.2.1, 13.2.2 and 13.7 of this Specification.

15.2.4 The Contractor for training purposes shall also supply any special tools and equipment required to be used.

15.3 Training Plan

15.3.1 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:

- Details of the Contractor's ability to carry out the necessary training.
- Details of the proposed approach to structuring and providing the courses required.

- Course details including duration, maximum number of trainees, ratio of trainees to trainers, facilities required or available and prerequisites for attending the course.
- Recommendations for additional training or alternative means by which the Engineer's training objectives may be met.

15.3.2 The Training Plan shall be submitted for review by the Employer'sRepresentative 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.

15.4 Training of Employer's Training Instructors (ETI)

15.4.1 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 Engineer.

15.4.2 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 State Power Company supply system at the infeed 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 220/132kV, 25kV, 400 V circuit breakers, isolators, voltage and current transformers, OHE 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) SCADA System; and
g) Earthing and bonding arrangement, covering safety aspects of touch and step potential safety to personnel, passengers and outsiders.

15.5 Operations Staff Training

15.5.1 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.

15.5.2 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.

15.6 Maintenance Staff Training

15.6.1 The objective of the training is to enable the Employer's maintenance 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.

15.7 Computer Based Training (CBT)

15.7.1 The Contractor shall submit, for the Employer's review, the following CBT information documents:

a) Operation of the TSS, SSP and SP power systems;
b) Maintenance of TSS, SSP and SP power systems;
c) Operation of SCADA system;
d) Maintenance of SCADA system.

15.7.2 The CBT Information Document on Operation of individual system shall contain, but not be limited to, the following:

a) General introduction of the System, its functionalities and objectives (including the RAMS requirement);
b) Single line diagrams;
c) Description of the System operation principles, for both normal and emergency operation conditions;
d) An overview on the system configuration, including interface with other agencies;
e) General description of the functions of each key equipment and components of the system with photographs showing the appearance of each of them;
f) Where they are located throughout the DFC;
g) List of potential hazards that may arise in operating the system;
h) Any specific points to note in operating the System to ensure safety to personnel (the Employer's staff and members of the public) and equipment, and ;
i) Electric shock treatment.

15.7.3 The CBT Information document on maintenance of individual system shall contain, but not be limited to, the following:

a) General description of the functions of key components of the System, with photographs showing the appearance of each of them;
b) A general description of the proposed maintenance strategy of the System and major components;
c) The maintenance plan and procedures proposed for the System and major components in accordance with the MMS;
d) A general description of the 1st, 2nd and 3rd line maintenance activities required for the System and major components;
e) An introduction to the special tools and equipment required for maintaining the System and major components;
f) A description of the symptoms of the common faults found on the System;
g) Simulation of faults on the entire System, and how to promptly restore the system; and
h) Other points to be noted in effectively maintaining the System.

15.8 Training and Transfer of Technology

15.8.1 Training of DFCC Staff

15.8.1.1 The Contractor shall train five Personnel of the Employer free of cost at manufacturer's works. The total duration of training shall be 30 man days at manufacturer's work and 5 man days at site. The cost of travel & stay shall be borne by the Employer. Any other training requirement shall be specifically mentioned by the Employer.

15.8.1.2 The training shall broadly cover following aspects.

a) Identification of the various cards & components of a RTU.
b) Erection, commissioning and wiring of RTU's and trouble shooting of the RTU.
c) Configuration of addresses of the RTU's, future expansions of the RTU and setting up of additional tele-signals and tele-commands.
d) Using the test instruments to check the communication cable performance parameters.
e) Training in operation of SCADA software and HMI display functions.
f) Training in configuration of SCADA software, changing the setting of the software, generating various reports etc.

g) Formatting of hard disk, loading of the Operating system, loading of the basic SCADA application software and taking back up of files.

h) Operation & maintenance instructions recommended by OEM's of different SCADA sub-systems.

i) Training in manufacture and special aspects of repair and maintenance of traction and auto-transformers.

j) Training in manufacture and special aspects of repair and maintenance of 220/132 and 25kV swtichgear.

15.8.1.3 Further, stipulations contained in Chapter 17 of Part I of this specification and clause 1.12.4 and 1.18 and 5.7 of General Specification shall apply.

END OF CHAPTER

16 Operation and Maintenance Documentation

16.1 General

16.1.1 The Contractor shall provide Operation and Maintenance manuals, for use by supervisory, operating and technical staff of Engineer.

16.1.2 Requirements of submission have been furnished in Section 8 Chapter nos. 3 and 5 of General Specification. (To check from GS).

16.1.3 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 Engineer' Representative. The binding shall allow for all subsequent changes and additions to be readily effected.

16.1.4 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.

16.1.5 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.

16.1.6 For the avoidance of doubt operations and maintenance manuals shall be specifically written for the Western Dedicated Freight Corridor describing the equipment as installed and modified and shall NOT be a collection on manufactured catalogues.

16.1.7 Operations and Maintenance Manuals shall be supplied in English and Hindi versions.

16.1.8 The Operations and Maintenance Manuals shall be supplied in electronic format loaded on ruggedized tablet computers. These will be taken to site by the site maintenance teams.

16.2 Operation Manuals

16.2.1 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.

16.3 Maintenance Manuals

16.3.1 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.

16.3.2 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.

16.3.3 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 with the consent of Employer.

16.3.4 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.

16.3.5 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

16.3.6 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.

16.3.7 And the third an indicative price list which shall list in alpha-numeric sequence the part number with the price, lead time and vendor.

16.4 Quantity of Manuals

16.4.1 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 format.

16.4.2 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.

16.4.3 The Documents Management System and Language used shall be subject to Engineer's Representative's review.

END OF CHAPTER

17 Contractor's Coordination With Others (Interface Management)

17.1 General

The entire construction of Dedicated Freight Corridor (Western Corridor, Phase 1) is to be implemented through nine (9) Contracts as defined:

CT P-1	Civil/Building/Track Works Rewari – Ajmer Section;
CT P-2	Civil/Building/Track Works Ajmer –Ikbalgarh Section;
CT P-3	Civil/Building/Track Works Ikbalgarh – Vadodara Section;
CT P-3A	Special Steel Bridges across rivers Mahi & Sabarmati;
EM P-4	Traction Power Supply and SCADA
ST P-5	Signal & Telecommunication;
PE P-6	Plant and Equipment for operation and Maintenance; and
RS P-7	Electric Locomotive and Maintenance Depot.
Unknown	The Contractor for construction of OCC

For the purpose of this clause the term "Contractor" shall denote EM P4 Contractor and the Other Contractors which are engaged in completing other parts of the complete Project, as Other Contractors.

17.1.1 Contractor's Coordination with Others

The Contractor shall take in to account the interface coordination requirements of Other Contractors, who will be working at site and or duly constituted authorities who will be employed or required by the Employer to execute the work within or adjacent to site in connection with or ancillary to the works. In this regard, the Employer/Engineer shall organize coordination meetings to sort out any interfacing issues amongst the interfacing Contractors. In addition, the Contractor may also arrange his own coordination meetings with the Other Contractors.

17.1.2 The Contractor shall fully integrate and coordinate the design and construction of the Works with Other Contractors, Interfacing Parties and related bodies parties and entities including but not limited to Indian (Zonal) Railways, Railway Board, RDSO, State Electricity Authorities for Supply of Traction Power, as well as the designated contractors / consultants / service providers, other than Other Contractors who are engaged in part of the Works, relevant statutory authorities, relevant public utility agencies and adjacent contractors who are or may be working adjacent to the Site and may be affected physically or through Electromagnetic Induction Effects from Traction currents.

17.1.3 The Contractor shall be responsible for keeping Other Contractors fully informed on all matters of progress which may affect the progress of Other Contractors and for all coordination with such Other Contractors during stages of survey, design, work execution, as well as finally during tests and commissioning stages.

17.1.4 Interfacing Parties and Related Parties
The Contractor shall fully coordinate the design of the Works with Other Contractors and Interfacing Parties, all relevant bodies, parties and entities, in particular government authorities, departments and regulatory bodies, public utility companies, Power Supply Authorities and the consultants, and contractors of adjacent projects whether ongoing or planned, as advised by the Employer/Engineer. The Contractor shall identify all such related parties, bodies and entities including but not limited to those included in the Table: Matrix of Interface requirement for System Design & Construction of Traction Power Supply Contract (EM P4) with Other Contractors at Appendix 17-1 given at the end of the chapter.

17.1.5 The Contractor shall actively seek out solutions to integration issues, and to anticipate, to plan for, and to comply with the needs of these related parties, which are properly required and consistent with the obligations under the Contract. The Contractor shall comply in this respect with the Design and Construction requirements with the other related entities and parties identified by him.

17.1.6 In case the Other Contractor is not in place, the Contractor shall co-ordinate with the Engineer for the Interfacing issues.

17.1.7 The Engineer shall actively facilitate in drawing up the Interface Management Plan amongst the interfacing contractors

17.2 Interface requirements

The careful coordination of all technical and programming matters between the relevant parties isa critical element in achieving a fully coordinated design and construction. This clause describes the Contractor's responsibilities with regard to interface management and coordination with those who are considered to be related with the Work. The Contractor's responsibility for interface coordination shall not only include interfacing with the Other Contractors and Other independent parties such as local authorities, statutory bodies, public utility companies including Power Supply Authorities, Indian Railways but also others who may be identified in future. such as private service providers, consultants or contractors whether or not specifically mentioned in the Contract. This responsibility is not limited to a particular number of interfacing parties but includes all interfaces required required for successful completion of the Contract which is the sole responsibility of the Contractor.

17.3 General Responsibility of the Contractor

17.3.1 The Contractor shall not impede but shall afford the Other Contractors and the Interfacing parties with all reasonable opportunities& facilities, access to the site and / or services to any related parties in the Contract including Other Contractors, Interfacing Parties and the Engineer / Employer so as to ensure the whole project including envisaged Other Contractor's works as well as his Works be executed in the most efficient manner for the best interest of the Employer as a whole.

17.3.2 The Contractor shall, in accordance with the Employer's Requirements, coordinate and integrate the Contractor's own Works under the Contract with works of the Other Contractors and Interfacing Parties. In addition, the Contractor shall take all necessary means and steps to ensure that the Works are coordinated and integrated with the works of the Other Contractors and Interfacing Parties, and shall comply with any directions which the Engineer may give. Such responsibilities shall neither be mitigated nor in any way affected by virtue of similar responsibilities being placed on Other Contractors.

17.3.3 The Contractor is responsible for the detailed co-ordination of his design, manufacturing, installation, construction, testing and commissioning activities. The lead part to be taken by the Contractors of the Project has been indicated in the Matrix Chart. The Enginner may decide to direct Contractor and the Other Contractors to abide by it or modify it to be coordinated by anOther Contractor if the progress of Works demands. The Engineers decision shall be finalhe Contractor shall carefully review pertinent information made available by the Engineer relating to the nature and programming of the related parties' contracts and use such information in his planning of the Works.

17.3.4 The Contractor shall communicate, coordinate and exchange information directly with the Other Contractors and Interfacing Parties, on initial authorization by the Employer and under intimation to the Engineer. Information necessary to fulfill the Contractor's interface obligations shall be directly requested and obtained from the Other Contractors and Interfacing Parties under intimation to the Engineer and receipt acknowledged. Conversely, the Contractor shall provide directly to the Other Contractors and Interfacing Parties with the information within the Contractor's scope that is required by them to meet their contractual obligations and proceed with their co-ordination under intimation to the Engineer. The Independent Interfacing Parties such as The Power Supply Authorities and the Adjacent Indian Railway Organization shall be coordinated through the Engineer / Employer.

17.3.5 The Contractor shall ensure that the Contractor's requirements are provided to all the related members of the Other Contractors and the Interfacing Parties before the cut off dates as identified in the Overall Interface Management Plan to be developed by the Lead Contractor/ Co-ordinating Contractor and approved by the Engineer.

17.3.6 Where the other contracts requiring interface are yet to be awarded, the Contractor shall proceed with the coordination activities with the Engineer, until such time the related parties including Other Contractor / Interfacing Party is engaged by the Employer.

17.3.7 The Contractor shall take all reasonable steps to ensure that the Works are coordinated and integrated with the design, manufacture, installation, execution and testing of such other works and shall in particular (but without limitation) to:

(a) comply with any direction which the Engineer may give for the integration of the design of the Works with the design of any other part of the Project;
(b) consult, liaise and co-operate with those responsible for carrying out such other works, including where necessary, in the preparation of the respective designs and drawings, the preparation of coordinated programmes, method statements, co-ordination drawings and specifications together with arrangements of service priorities and zoning; and
(c) participate in Integrated Testing and Commissioning of the system with the Other Contractors and Interfacing Parties and demonstrate to the satisfaction of the Engineer that the Works have been designed and constructed in a manner compatible with the works of the Other Contractors and Interfacing Parties

17.3.8 As soon as the Contract is Awarded the Contractor shall undertake design and Work in co-ordination with Other Contractors, who shall be carrying out works forming part of this project. There will be a continuous requirement of coordination amongst all the Contractors in respect of, but not limited to the Items shown in the Interface Matrix Chart (Appendix 17-1). Other interface requirement which may crop up during Design and construction phase shall be promptly resolved and informed to the Engineer.

17.3.9 At the end of each such co-ordination period, the Contractor, Other Contractors and Interfacing Parties with whose works the interface period refers, shall jointly state in writing that their design co-ordination activities are complete and that their respective designs are integrated and can be finalized without interference with each other's designs or the designs with which their designs have already been integrated. A copy of this joint written statement shall be provided to the Engineer within 7 days of the end of the said design co-ordination period. Unless and until copies of all relevant and necessary design co-ordination statements have been submitted to the Engineer, the Engineer shall be entitled to suspend any review or further review of the Contractor's or the Other Contractor's and Interfacing Party's design submissions. Such suspension shall not be grounds for any claim by the Contractor nor the Contractor shall be entitled to receive an extension of time or additional payments. The interface coordination with independent parties such as the Power Supply Authorities and adjacent Indian Railways alignments of NWR and WR the interface coordination will be through the Engineer/Employer.

17.3.10 During construction the Civil and Track Works (Other) Contractor shall provide within the Site, staging, storage and unloading and temporary storage areas for structural steel, insulators etc. and enclosed for secured high value items and space for tracks for sidings for Traction Overhead Construction trains for the temporary use of the Contractor to a reasonable extent during construction, erection and commissioning process. Separate locations at different points of the route as required by logistics of timely construction completion of the work shall be provided for each of the Other Contractors.. Specific details shall be coordinated and agreed during the design interface period amongst the Contractors.

17.3.11 Any other contract which depends for its execution on the Contract or upon which the Contract is dependent for its own execution shall be identified by the Engineer as a "Interface Contract". The Contractor shall provide attendance on Other Contractors and Interfacing Parties (if necessary) on meetings and correspondences in this regard in accordance with the Employer's Requirements and / or as instructed by the Engineer. The identity of the Other Contractor(s) for the Interface Contract may not be known before the execution of the Contract but this shall not be a ground for the Contractor to object to the subsequent appointment of an Other Contractor.

17.3.12 The Contractor shall in accordance with the requirements of the Contract and instructions of the Engineer coordinate his own Works with the works of Other Contractors strictly adherent to the Coordinated Construction Programme as detailed in clause 1.8 [Project Programme Requirements] stated in the Employer's Requirements, (General Specifications) and shall afford the Other Contractors all reasonable opportunities for carrying out their works.

17.3.13 The Contractor shall, while carrying out his co-ordination responsibilities, provide sufficient information for the Engineer to decide on any disagreement between the Contractor and the Other Contractors / Interfacing Parties as to the extent of services or information required to pass between them.

17.3.14 If the Contractor suffers delay by reason of failure caused by any Other Contractor/ Interfacing Parties to meet the specified installation interfacing, co-ordination, and / or completion dates resulting in delay beyond the extent which could be reasonably foreseen by an experienced contractor at the time when the Coordinated Construction Programme is formulated and consented by the Engineer , then the Engineer shall take such delay into account in determining any extension of time to which the Contractor is entitled under the Contract.

17.3.15 If any act or omission of the Contractor whether directly or indirectly results in the delay in execution of the works of the Other Contractor and / or Interfacing Parties associated with the execution of the project, the matter will be settled by the Engineer under clause 3.5 [Determination] and clause 2.5 [Employer's Claim] of the Conditions of Contract.

17.3.16 The Civil and Track Works(Other) Contractor shall co-ordinate the access and delivery routes and ensure that all provisions for access and delivery of the, materials, components and plant of the Contractor is co-ordinated with and reflected in the delivery route drawings of the all Contractor and Interfacing Parties to the work sites on all .. Other Contractors and Interfacing Parties shall furnish the details with to be provided for access to work site or passage for their construction materials, plant & equipment in accordance with Coordinated Construction Programme.

17.3.17 All requests for information (RFI), acknowledgement of receipt of information and any official communication between the Contractor and the Other Contractors and Interfacing Parties shall be made in writing with a copy to the Engineer for information.

17.3.18 The Contractor shall advise the Engineer in writing of any problems encountered in obtaining necessary information and/or lack of cooperation from the Other Contractors. In the event that the Engineer considers that the resolution of the interface is not proceeding satisfactorily, the Engineer will review the matter and establish a coordinated plan directing the Contractor and the Other Contractor / Interfacing Parties as to the required action. In such a case, the decision of the Engineer shall be final and binding.

17.3.19 For the items of Co-ordination for which the Contractor is the Co-ordinating Agency as shown in the Table: Matrix for Interface Requirement (Appendix 17-1), the Contractor shall conduct regular meetings with the Other Contractors and Interfacing Parties, under intimation to the Engineer to clarify particular aspects of the interface requirements of the Works.

17.3.20 The Co-ordinating Party who convenes the meeting shall prepare minutes recording all matters discussed and agreed at the meeting. The Contractor shall advise the Engineer in advance the date, time and location of such meetings as he may decide to attend.

17.3.21

17.3.22 The work required to be done by other independent parties or those independent parties affected by the work to be done by the Contractor shall be interfaced and coordinated by the Engineer.

17.3.23 For the Items of Coordination for which the Contractor is The Coordinator the Contractor shall ensure that copies of all correspondence, drawings, meeting minutes, programmes, etc. relating to amongst the Contractors / Interfacing Parties to the coordination, are issued to all concerned parties and the Engineer no later than two calendar days from the date of such correspondence and meetings.

17.3.24 All interfacing Contractors shall note that the information exchange is an iterative process requiring the exchange and up-dating of information at the earliest opportunity and shall be carried out on a regular and progressive basis in order for the process to be completed for each design and construction stage.

17.3.25 The Contractor shall for the Items of Coordination for which the Contractor is The Coordinator establish a detailed Interface Management System and participate in the activities with the Other Contractors and Interfacing Parties. The Contractor shall include in his coordination activities but not limited to the following:

(a) provide an Interface Co-ordinator who has the responsibility, and authority with substantial experience to resolve interface matters to the satisfaction of the Engineer, and provide the necessary support team for the Interface Co-ordination;
(b) respond to, confirm and make written agreements with regard to interfaces;
(c) attend interface meetings that may be arranged by the Engineer, with a representative empowered to make agreements on interfaces. The Engineer may arrange regular meetings to monitor the status of interfaces, and may require special meetings as may be necessary to resolve specific issues. The Contractor may request assistance from the Engineer to arrange meetings on particular subjects;
(d) provide the Engineer with regular status information and/or details of interfaces, including copies of relevant correspondence and material; and
(e) provide the Engineer with access to information for the purpose of conducting audits on interface compliance and for confirming that interface coordination is proceeding consistently with the Employer's Requirements.
(f) For other items for which the Contractor is an interfacing party the Interface coordinator shall provide an authorized Contractor's Representative's attendance to conclude a meaningful interface.

17.3.26 Should it appear to the Engineer that the Work Programme or three month rolling programme does not conform with the Coordinated Construction Programme, the Contractor shall be required to revise all such programmes so as to conform to Contractual Construction Programme.

17.4 Dedicated Co-ordination Team

17.4.1 The Contractor shall establish a dedicated co-ordination team led by an Interface Co-ordinator reporting to the Contractor's Representative. The primary function of the team is to provide a vital link between the Contractor's design & construction teams and the Other Contractors / Interfacing Parties.

17.4.2 The Interface Co-ordinator shall assess the progress of the co-ordination with Other Contractors / Interfacing Parties by establishing lines of communications as per pre-defined co-ordination model and promote regular exchange and updating of the information so as to maintain the Contractor's Programme.

17.4.3 The complexity of the project and importance of ensuring that the work is executed within the time limitations, requires detailed programming and monitoring of the progress so that early programme adjustments can be made in order to minimize the effects of potential delays.

17.4.4 The Interface Co-ordinator in conjunction with the Other Contractors and Interfacing parties shall identify necessary provisions in the Works for plant, equipment and facilities of the Other Contractors and Interfacing Parties. These provisions shall be allowed by the Contractor in his design of the Works

17.5 Design Interface

17.5.1 General

(1) The Co-ordination Dates shown in Conditions of Contract are critical to the timely completion of the project and the dates have been determined to create a time frame during which design interactions with the Other Contractors and Interfacing Parties on the project have to be completed in order for every interface activity to streamline through the time schedule.

(2) The Contractor shall commence the design interface with the the Other Contractors / Interfacing Parties as soon as possible after the award of the Contract. Also whenever he has been notified by the Engineer that an Interfacing Contract has been awarded by the Employer. The various issues of interface which will require coordination during Design Stage and subsequently during the installation of all the equipment of the Other Contractors are included but not limited to these items as shown in the Table of Matrix of Interface .

(3) In the case of utility agencies, Indian Railways, Power Supply Authorities and other statutory bodies, interfacing shall commence as soon as practicable

(4) The Contractor shall, immediately upon award of the Contract, gather all necessary information and develop his design to a level where meaningful interaction can take place.

17.5.2 The Contractor shall support the Other Contractors and Interfacing Parties and process the achievement of a fully coordinated design for the Works, including undertaking the following:

(1) providing timely information to the Other Contractors when requested by Other Contractors and Interfacing Parties;

(2) Providing OHE Layout Plan for the entire length on a continuous Chainage prepared on the Final Approved Route Alignment plans of

the (Other) Civil and Track Contractors on different nominated layers of the same soft copy of the Plans, as finalized at a coordination meeting amongst all the Contractors of the Project, to be developed by each contractor of the project providing their installations including OHE Lay Out Plans, the Earthing and Bonding Plans, signaling and telecom installations on the route alignment of the tracks showing also the relevant other metallic and concrete structures, bridges and viaducts on the route. This plan shall derive from the original Final Alignment Plans Continuous chainage be used for common project working chainages by all the Other Contractors and other Interfacing Parties;

(3) anticipating the information needs of the Other Contractors / Interfacing Parties and transmitting such information as soon as it is available;

(4) pro-actively keeping the Other Contractors and Interfacing Parties informed of any development of the Works and the works of the Other Contractors related to the interfaces;

(5) advising the Other Contractors and Interfacing Parties on potential problems related to the interfaces, together with proposed solutions likely to be acceptable to them and which meet the needs of the Contract; and

(6) Requesting Other Contractors / Interfacing Parties for arranging and/or attending coordination meetings convened by the Engineer with the Other Contractors and Interfacing Parties as necessary to resolve interface issues. The party who convenes the meeting shall prepare the minutes recording all the issues discussed and agreements reached.

17.5.3 While complying with the Contract requirements, the Contractor's programme shall allow for the timing of availability of necessary interface information from the Other Contractors and Interfacing Parties. If necessary, the design of a particular element shall be programmed on a "late-start" basis to allow receipt of necessary interface information. If a design activity is programmed earlier than necessary and without sufficient interface information, this activity shall be proceeded entirely at the Contractor's own risk.

17.5.4 The Contractor shall allow for the fact that many of the design activities for the Other Contractors and Interfacing Parties will be proceeding concurrently. Specific dates for the delivery of the design output and other required information shall be confirmed between the Contractor and the Other Contractors and Interfacing Parties.

17.5.5 In order to achieve a fully coordinated design, the Contractor should also note that the level of information provided to and requested from the Other Contactors and Interfacing Parties should be appropriate for the particular Design Stage. The Contractor shall also recognize and allow for times when it may be necessary to modify the Contractor's design process to accommodate the timing of information availability from the Other Contractors and Interfacing Parties in order to achieve a fully coordinated design. Similarly at times it will be necessary for the Contractor to modify the Contractor's design process to allow information needed by Other Contractors and Interfacing Parties to be expedited for them to achieve timely completion of the coordinated design of the Other Contractors and Interfacing Parties.

17.5.6 The Contractor's attention is drawn to the need to undertake and develop the design in such a way as to ensure that interface issues are resolved satisfactorily and in time. Design schemes that impose unnecessary or unreasonable construction challenges for Other Contractors will not be considered suitable for a statement of no objection.

17.5.7 For the purpose of design coordination, the Contractor shall use the Coordination Drawings, and other drawings as necessary.

17.5.8 In advance of each Design Stage, the Contractor shall:

(1) request in writing and obtain from the Other Contractors and Interfacing Parties, interface information required for that Design Stage.

(2) review the interface information received and agree in writing to the Other Contractors and Interfacing Parties that the interface information is adequate for that design stage.

17.5.9 In advance of the design stages of the Contractor and Other Interfacing Parties' Design Stages, the Contractor shall when requested by them:

(1) provide to the Other Contractors / Interfacing Parties interface information needed for their impending design stages; and

(2) confirm in writing that the interface information suitably represents the Contractor's interface requirements for that Design Stage.

Interface with independent parties such as the Power Supply Authorities and adjacent Indian Railways alignments of NWR and WR. interface with independent parties such as the Power Supply Authorities and adjacent Indian Railways alignments of NWR and WR The Contractor shall submit together with each of his design submissions a joint statement with the relevant Other Contractor / Interfacing Parties confirming that they have jointly reviewed the drawings and documents to ensure a consistent design that has no interference with each others design and that their designs are already integrated. Unless all the relevant and necessary joint coordination statement has been submitted to the Engineer, the Engineer will be entitled to suspend any reviews or further review the Contractor's design submission. Such suspension shall not be the ground for the Contractor to claim any extension of time or additional payment.

17.5.10 The Contractor shall ensure that the information he requires from Other Contractors / Interfacing Parties is made known at the outset of each design interface and vice a versa so that the information can be provided in time for the Contractor and Other Contractors / Interfacing parties to complete their design to meet their various design submission stages.

17.5.11 At the completion of each Design Stage of the Contractor, the Contractor shall:

(1) transmit those portions of the design relevant to interface to the Other Contractors and Interfacing Parties for review and.

(2) agree in writing to the Other Contractors and Interfacing Parties on the incorporation of applicable review comments.

17.5.12 At the completion of each design stage of the Other Contractors and Interfacing Parties, upon receipt of the designs from them for review, the shall

(1) review those portions of the design relevant to interface and transmit comments to the Other Contractors and Interfacing Parties and.

(2) agree in writing that subject to the incorporation of the applicable comments.

17.5.13 Design coordination the Contractor shall include definition, approach and agreement with the Other Contractors and interfacing Parties of interface areas, contract limits, shared loads and sequence of design activities and the definition and design approach for type, size and location of equipment, access thereto, cable routing and protection, agreement of installation programming, preparation of Interface Documents.

17.5.14 The Contractor shall liaise with the Engineer in developing a uniform identity code system which shall be used to uniquely identify each item of equipment and software components provided under the Contract. Such identity codes shall be used for labeling each item of equipment and shall also be used in design reports, drawings and operations and maintenance manuals. This identity code system shall be generally compatible with principles to be established by the Engineer and shall specifically be compatible with the use of the Engineer's defined names, mnemonics and codes for stations.

17.6 Construction Interface

17.6.1 Construction interfacing will be necessary throughout the duration of the Works commencing from the time the Contractor mobilizes on the site to the completion of the Works. Construction interface will overlap the design interface and involve all Contractors' and Interfacing Parties' requirements for provision of cables ,foundations, buried conductors, cables and fixtures for Traction components in the Civil and Track Contractor's Works etc as noted in the Interface Matrix covering all the Other Contractors. up to provision of attendance during the testing and commissioning stage.

17.6.2 The Contractor shall coordinate with the Other Contractors / Interfacing Parties to allow the efficient execution of the respective construction activities.

17.6.3 The Contractor shall coordinate and cooperate with Other Contractors and Interfacing Parties on all site- related matters including but not limited to site access and occupation, safety, verification of work compatibility and survey control etc. The Contractor shall advise the Other Contractors and Interfacing Parties in advance when a construction item is ready for field inspection to verify compatibility with the Other Contractors and Interfacing Parties' needs, and shall facilitate access to the site for the interfacing parties.

17.6.4 The Contractor shall ensure that there is no interference with the works of the Other Contractors / Interfacing Parties' and shall maintain close co-ordination with them to ensure that his Work progresses in a smooth and orderly manner.

17.6.5 The Contractor shall carry out and complete the Works, or any part thereof, in such order as may be agreed by the Engineer or in such revised order as may be instructed by the Engineer from time to time. The Contractor shall, be liable for and shall indemnify the Employer against all costs, charges, expenses etc resulting from the failure of the Contractor to co-ordinate the Works as specified.

17.6.6 The Contractor shall prepare a Coordinated Construction Programme for each segment of the Work on a works element basis covering the period of the Interfacing Contract access. It shall fully conform to the Contractual Construction Programme as specified in clause 1.8 [Project Programme Requirement] as stated in Employer's Requirements (General Specification).

17.6.7 The Coordinated Construction Programme shall allow adequate time periods for all the Contractors / Interfacing Parties to install their plant and equipment in the designated areas and interfacing components such as earthing and Bonding.

17.6.8 The Coordinated Construction Programme shall be agreed with and signed off by the concerned all Other Contractors / Interfacing Parties and then submitted to the Engineer no later than six (6) months before the earliest access date to the Site.

17.6.9 At or near the completion of the construction of any interface-related element of the Contractor's Work, the Contractor shall:

(a) advise Other Contractors and Interfacing Parties that the as-constructed interface-related Work can be inspected, and provide the necessary access to the Site and its occupation.

(b) agree in writing to the Other Contractors and Interfacing Parties and as consented by the Engineer on the adoption of any applicable comments on the constructed Work.

(c) On erection of Overhead equipment Conductors prior to their commissioning these conductors will need to be charged with 2.2 kV power to prevent their being stolen. During this period and until commissioning of the route the members of the construction teams of the Contractor and those of the Other Contractors will need to be regulated to prevent risk of electrocution if they come within 2 metres of the charged live lines. For this purpose the Contractor will propose a system of Permit to Work on discharged line during working periods. These rules will be finalized in consultation with the Interfacing Other Contractors and approved by the Engineer.

17.6.10 On advice from the Other Contractors and Interfacing Parties that an as-constructed interface-related element is ready for inspection, the Contractor shall:

(a) conduct on-site inspections of the Work elements, and give comments in writing to the Other Contractors and Interfacing Parties.

(b) agree in writing to the Other Contractors and Interfacing Parties that the as-constructed Work meets the interface requirements.

17.6.11 Prior to applying for a Taking-Over Certificate, the Contractor shall obtain written confirmation from each applicable Other Contractors and Interfacing Parties, that the interface elements meet the requirements of the Other Contractors and Interfacing Parties. If any Other Contractor and Interface Party withholds such confirmation, the Engineer will decide on further action, as requested by the Contractor prior to the issue of a Taking-Over Certificate.

17.6.12 Where Contractor's Works are identified as failing to meet the requirements of the Contract and which will impact the Other Contractors' and Interfacing Parties' works, the Contractor shall submit the proposed remedial measures to the Engineer for review and shall copy the same to the Other Contractors and Interfacing Parties.

17.7 Preparation of Interface Documents and Drawings

17.7.1 For Items of Interface for which the Contractor is the Co-ordinating Agency, the Contractor shall prepare as required the following interface documents which shall be used to completely define the Contractor's interface coordination details relating to:

(1) Interface Matrix;

(2) Coordinated Construction Programme (as specified in clause 1.8 [Project Programme Requirements]; contained in Employer's Requirement (General Specification)

17.7.2 Combined Services Drawings (CSD) covering Traction Installations, earthing and Bonding Conductors, Ground earths and other installations of all the Other Contractors to the Project on the common base of the Approved Final Route Alignment Plans on different designated layers of the Soft Copy of the Plans developed by the (Other) Civil and Track Contractor as Working Drawing. This Drawing will automatically delimit the jurisdiction of each Contractor based on the Layers on the Drawing allotted to them in the Drawing interface arrangements. The Construction Plans shall be based on these drawings signed by each Contractor to the Interface and shall be accepted at each stage of completion of each stage provided in the layers used by the interfacing Contractors.

17.8 Coordinated Construction Programme

17.8.1 The Contractor shall prepare and submit a Coordinated Construction Programme in accordance with the requirements of clause 1.8 [Project Programme Requirements] to the Employer's Requirements (General Specification) and / or as instructed by the Engineer.

17.9 Interface Management Plan (IMP)

17.9.1 Based on the Interface Matrix but not limited to it, the Contractor shall develop and submit to the Engineer within the specified schedule, an IMP for all the interface issues that may arise during the design, construction, testing and commissioning of the project in consultation with the Other Contractors and/or Interfacing Parties. The Contractor shall prepare an Interface Management Plan (IMP) for each segment of the Work on a works element basis covering the period of Interfacing Contract access. The IMP shall allow adequate time periods for each of the Other Contractor / Interfacing Party and the Contractor to install their structure, plant and equipment in the station area and the route alignment including on the bridges and viaducts.

17.9.2 The IMP shall be agreed with and signed off by each of the Other Contractor / Interfacing Party and then submitted to the Engineer no later than six (6) months before the earliest Coordination Dates as defined in Conditions of Contract.

17.9.3 The IMP shall:

(1) identify all the systems and sub-systems including the civil construction, bridges, viaducts, traction and signaling and Telecom works, earthing and bonding and facilities with interfacing requirements;

(2) define the authority and responsibility of the Contractor's and the Other Contractor's and Interfacing Party's (and any relevant sub-contractors') staff involved in interface management and development;

(3) identify the information to be exchanged, together with the management and technical skills required for the associated development of the works, at each phase of the Contractor's and the

Other Contractor's and Interfacing Party's (and any relevant sub-contractors') project life-cycles;

(4) address the Works Programme of theContractor to meet the Coordination Dates of the of the Other Contractors and Interfacing Parties and highlight any programme risks requiring the Engineer's attention;

(5) include considerations of the requirements of the System Safety Management;

(6) specify the configuration and version control procedures in accordance with the Contractor's and Other Contractors' and Interfacing Parties' (and any relevant sub-contractors') quality management system;

(7) address the design, supply, installation, testing and commissioning programmes of the Contract to meet the coordination dates of Other Contractor's and Interfacing Party's contract, and highlight any programme risks requiring management attention;

(8) indicate dates for commencement and completion of each principal activity by the Contractor and those of the Other Contractor and Interfacing Party, and delivery and installation of equipment.

17.9.4 In case of any disagreement between the Contractor and Other Contractors / Interfacing Parties on the interface issues, the decision of the Engineer shall be final and binding; and

17.9.5 After the review of the IMP with No Objection certified by the Engineer, all the Contractors shall strictly execute the Works accordingly.

17.9.6 These interface documents shall be submitted for review and consent to the Engineer. For all subsequent updates, these documents shall be submitted to the Engineer for information, review and comment. A summary of principal issues shall be included in each Monthly Progress Report.

17.9.7 The Interface Matrix which describes relations between Contractor and Other Contractors and Interfacing Parties and their roles and responsibilities as a key document and should be submitted to the Engineer for consideration as an overview of all subsequent interface related documents and drawings.

17.10 Employer's / Engineer's Input

17.10.1 The Engineer will coordinate the activities of all the Contractors with reference to interfacing with third parties during all the phases of the Contract.

17.10.2 The Employer/Engineer, within the scope of the relevant Contract provisions, will support and assist all the Contractors in the following fields:

(1) Interfacing Indian Railways, Power Supply Authorities, execution of interfacing works by them and state and local authorities for timely receipt of the required permits, certificates and approvals related to the design and construction process;

(2) Interfacing state and local tax authorities for the Value Added Tax (VAT) reimbursement arrangements;

(3) Interfacing state and local authorities for implementation of the additional land acquisition procedures; and

(4) Any other fields of activities related to the Contract as may be required with the purpose of facilitating all the Contractor's performance.

17.10.3 This support and assistance of the Employer/Engineer shall not release the Contractors of any of their obligations under this Contract.

17.10.4 The Contractor shall coordinate with the Engineer / Employer on all matters relating to the Works that may affect the existing Indian Railway (IR) operations. Such Works shall be carried out as per IR rules and regulations in close coordination and under the directions of Engineer/Employer.

17.11 Cost relating to the Interface Activities

17.11.1 Accepted Contract Price and Contractual Construction Programme shall be deemed to have included the provision in respect of the obligations relating to coordination and interface management activities. No separate payment will be made with regard to the activates as described herein above.

Appendix 17.1:MATRIX OF INTERFACE REQUIREMENT FOR SYSTEM DESIGN & CONTRUCTION OF TRACTION SUPPLY CONTRACT (EM-P4) with OTHER CONTRACTS and INTERFACING PARTIES

(over leaf)

REV. 1

Appendix 17.1

MATRIX OF INTERFACE REQUIREMENT FOR SYSTEM DESIGN & CONTRUCTION OF TRACTION SUPPLY CONTRACT (EM-P-4) & OTHER CONTRACTS

S.No.	Item of work	DFCC Contractors						Independent Authorities						Coordinating Contractor/ Agency	Remarks
		Civil building and Track work			Signal & Telecom ST P-5		Loco	Traction Power Supply			Indian Railway		Other		
		CTP-1 & 2	CTP-3	CTP-3A	Signal	Telecom	RSP7	GEB	RSEB	HSEB	NWR	WR			
1	Access to worksite (Embankment, Cess, Tracks, Bridges, viaducts, Tunnel & Depot	✓	✓	✓										CTP-1 & 2 CTP-3 CTP-3 A	
2	Site Facilities, Temporary Storage Sites, Siding for Traction Construction Trains	✓	✓	✓	✓	✓	✓						(As applicable)	-do- Employer & Engineer	
3	Design & Drawings Coordination	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		CTP-1 & 2 CTP-3 CTP-3 A	Based on final approved route alignment plan on nominal layers of soft copies of drawings
4	EMI Mitigation Measures (Earthing & Bonding : Track, Bridges, viaducts, tunnels, Buried Earth Conductors, Structures, Fencing, continuous metal work	✓	✓	✓	✓	✓	□				✓	✓	Dependent on Site Survey (Pipes, Wires, etc.)	EM P4-4	Work to be done by NWR & WR on their installations Coordination through Employer/Engineer
5	Traction Return Current connection to tracks at each AT Stations	✓	✓	✓	✓									EM P-4	
6	Location of Signals vis-à-vis (OHE Neutral Sections)				✓	□	✓							EM P-4	
7	Location of Signals vis-à-vis (OHE Structures)				✓	□								-do-	
8	Power Supply to S&T Installation on open route				✓	✓								-do-	

S.No.	Item of work	DFCC Contractors						Independent Authorities						Coordinating Agency	Remarks
		Civil building and Track work			Signal & Telecom ST P-5		Loco	Traction Power Supply			Indian Railway		Other		
		CTP-1 & 2	CTP-3	CTP-3A	Signal	Telecom	RSP7	GEB	RSEB	HSEB	NWR	WR			
9	Telecom facilities for SCADA : OFC Terminals at on Route (TSS & Switching posts and stations) and at OCC					✓								EM P-4 Employer & Engineer	
10	Video wall in OCC				✓	□	□							EM P-4	-
11	Traction Power Supply from Electricity Boards at 220/132kV							✓	✓	✓				Employer & Engineer	Coordination through Employer/Engineer
12	Traction Supply & Sectioning to Loco Depot						✓							RS P-7	
13	OHE configuration and Sectioning to IR Electrified Sections											✓		EM P-4	Coordination through Employer/Engineer
14	Traction Power Cable across the Tracks at Traction Supply control Posts	✓	✓	✓	□	□	□							CTP-1 & 2 CTP-3 CTP-3 A	
15	Execution of Construction work after anti-theft charging of OHE Conductors prior to test & commissioning	✓	✓	✓	✓	✓	✓				✓	✓	✓	EM P-4	In formulation of Rules for safe working Employer & Engineer in framing Rules for Operation - EM P-4 Contractor for day to day operation
16	System Integration, Testing and Commissioning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	(As applicable)	EM P-4	Coordination through Employer/Engineer

END OF CHAPTER

18 Possession Management

18.1 General

18.1.1 The definition of the "Possession" to be applied herein is the 'Possession of the segment / stretch of Works and / or Indian Railway (IR) tracks/ and /or Traction Power Blocks required by the Contractor from the Engineer and / or IR during construction of the Works and / or after Taking Over Certificate and during the Defects Notification Period for maintenance / rectification of the defects in the Works'.

18.1.2 The Contractor shall comply with the possession management system operated by DFCC or Indian Railways (IR) as the case requires.

18.1.3 The Contractor shall appoint a responsible person who shall coordinate with Engineer / IR and Other Contractors as applicable and who shall act as the possession coordinator for the Contractor only. The person appointed shall have experience of IR operations and shall be fully aware of IR Rules and Regulations related to possession of track for construction of railway works and in accordance with IR regulations to issue possession requests. For the purpose he shall be duly certified in accordance with the said rules.

18.2 Possession Periods

18.2.1 The Contractor may use possessions on the line as follows:

a) For each particular possession and depending on the duration and the location of the possession, alternative route / mode of transport may be required, and where provided this alternative route / mode of transport will be at the Contractor's cost.

b) The normal alternative mode of transport will be by IR Tracks / road and the route and timings of this alternative transport is to be agreed with the Engineer / IR (as the case may be) prior to obtaining the Possessions. Engineer shall however provide necessary assistance to the Contractor for arranging alternative mode of transport..

c) The Engineer reserves the right to use the Possession Periods for works by Other Contractors for Defects Notification Period maintenance / rectification of the defects in the Works ensuring that the segment allotted to the Other Contractors do not interefer with or cause obstruction to the work of the Contractor.

18.2.2 Line closures may be agreed subject to approval of the Engineer and IR (as the case may be).

18.2.3 The Engineer gives no guarantee that line closures and possession periods will be available during the period as requested by the Contractor. No claim shall be entertained by the Engineer on this account

18.2.4 The Engineer will however provide any assistance necessary to the Contractor to enable him to obtain the line closures and possessions required by him but will not be responsible if any possession requests are refused by IR. No claim shall be entertained by the Engineer on this account

18.2.5 The Contractor shall prepare technological and organizational schedule for construction and submit the same to the Engineer for his consent.

18.2.6 Should the Contractor, for the safe and proper execution of the works, require to take a temporary possession of IR tracks he shall, not later than 56 days prior to the proposed possession date, submit a request for track possession to the Engineer. The Contractor's request shall detail the purpose, proposed duration and any other such particulars as may be reasonably requested by the Engineer. The Engineer, through the Engineer shall make provisional arrangements with the DFCC/Zonal Railway for the possession to be taken. Not later than 7 days in advance of the provisional possession, the Contractor, Engineer, Engineer and the designated officer of the DFCC/Zonal Railway shall meet to confirm the detailed arrangements for the possession and the possession shall be confirmed. The cost of arranging such possessions shall be borne by the Engineer.

18.2.7 If any confirmed possession cannot be given up by the DFCC/Zonal Railway at the agreed date & time, the Engineer will bear the cost and time incurred by the Contractor for such possession failure.

18.2.8 If the Contractor fails to take up a confirmed possession or fails to hand back the tracks to the DFCC/Zonal Railway at the agreed time, the Contractor shall bear the costs incurred by the Engineer and the DFCC/Zonal Railway.

END OF CHAPTER

19 Abbreviations, Governing Specs, Climatic Conditions

INDEX

Part– I

Abbreviation:

A	Amperes
AC (or ac)	Alternating Current
ABS	Automatic Block Signaling
ACSR	Aluminum Conductor Steel Reinforced
ACTM	Alternating Current Traction Manual
AF	Audio Frequency
AFTC	Audio Frequency Track Circuit
ALARP	As Low As Reasonably Practicable
AN	Normal Air-cooled Transformer
ANSI	American National Standards Institute
APFC	Automatic Power Factor Correction
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AT	Auto Transformer
ATC	Automatic Train Control
ATD	Auto Tensioning Device
ATF	Autotransformer Feed
ATS	Auto Transformer Station
Aux	Auxiliary
AWG	American Wire Gauge
AxT	Auxiliary Transformer
BCC	Back up Control Centre
BG	Broad Gauge
BIS	Bureau of Indian Standards

BMS	Building Management System (Rail System)
BS	British Standard
BS EN	British Standard Euro Norm
BWA	Balance Weight Assembly
C	Celsius or Centigrade
CAD	Computer Aided Design
CB	Circuit Breaker
CBN	Common Bonding Network
CBT	Computer Based Training
CEA	Central Electricity Authority – Government of India
CLS	Colour Light Signal
Cm or cm	Centimeter
CMS	Control and Monitoring System
CO2	Carbon Dioxide
COM	Communications (Rail Subsystem)
CORE	Central Organization for Railway Electrification
CPM	Critical Path Method
CPU	Central Processing Unit
Cr.	Crores
CRCA	Cold Rolled Closed Annealed
CRS	Commissioner of Railway Safety
CT	Current Transformer
DB	Distribution Board
DC (or dc)	Direct Current
DCC	Depot Control Centre

DFCCIL	Dedicated Freight Corridor Corporation of India Limited
DG	Diesel Generator
DIN	Deutsche Industries Norm
DLP	Defect Liability Period
DOL	Direct On Line
DPR	Detailed Project Report
DSC	Double Stack Container
E&M	Electrical and Mechanical
EI	Electronic Interlocking
ELCB	Earth Leakage Circuit Breaker
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	European Norm
ENV	European Pre-standard
EP	Electro Pneumatic
FA	Fire Alarm
FM	Frequency Modulation
FOB	Foot Over Bridge
FP	Feeding Post
FR	Fire Resistant
FRC	Fault Reporting Centre
FRLS	Fire Retardant Low Smoke
FRP	Fire Rated Proof
GC	General Consultant (to DFCC)
GCC	General Conditions of Contacts

GETCO	Gujarat Energy Transmission Corporation Limited
GHz	Giga Hertz
GL	Ground Level
GOI	Government of India
GPS	Global Positioning System
GR	General Rules (for Train Operation on Indian Railways)
GS	General Specification
GSEB	Gujarat State Electricity Board
GSM	Global System for Mobile Communication
GSM-R	Global System for Mobile Communication for Railway applications
GSS	Grid Substation
HF	Human Factors
HFIP	Human Factors Integration Plan
HMI	Human Machine Interface
HO	Head Office
HRC	High Rupturing Capacity
HSCB	High Speed Circuit Breaker
HT	High Tension
HV	High Voltage
Hz	Hertz
I/O	Input/ output
IBJ	Insulated Block Joint
ICD	Interface Coordination Document
ID	Identification
IDMT	Inverse Definite Minimum Time

IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers Inc.
IER	Indian Electricity Rules, 1956
IPR	Intellectual Property Rights
IPS	Integrated Power Supply
IR	Indian Railways
IRS	Indian Railway Standards
IS	Indian Standards
ISO	International Standards Organisation
ITU	International Telecommunication Union (Formerly CCITT)
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards (Japan)
JS	Japanese Standard
JV	Joint Venture
K	Kilo
kA	kilo Ampere
Kg	Kilogram
kV or KV	Kilo Volt
kVA	Kilo Volt-Amp
kW	Kilowatt
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LRU	Line Replaceable Unit
LSOH	Low Smoke & Zero Halogen

LSZH	Low Smoke Zero Halogen
LT	Low Tension
LV	Low Voltage
LWR	Long Welded Rail
M or m	Meter
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MDBF	Mean Distance Between Failures
MIL	Military Standard (DoD)
MLDB	Main Lighting Distribution Board
mm	Millimeter
MMD	Maximum Moving Dimension
MMI	Man Machine Interface
MMIS	Maintenance Management Information System
MOR	Ministry of Railway
MOU	Memorandum of Understanding
MPDB	Main Power Distribution Board
MS	Mild Steel
MTBF	Mean Time Between Failures
MTBR	Mean Time Between Repairs
MTTR	Mean Time To Repair
N	Neutral
NBC	National Building Code of India
NC	Normally Closed
NCR	North Central Railway

NCT	Neutral Current Transformer
NEMA	National Electrical Manufacturers' Association (USA)
NF	Negative Feeder
NFPA	National Fire Protection Association (USA)
NMS	Network Management System
NO	Normally Open
NTP	Notice To Proceed
O&M	Operation and Maintenance
OCC	Operations Control Centre
OCS	Overhead Contact System
OEM	Original Equipment Manufacturer
OFC	Optical Fibre Cable
OHE	Overhead Equipment
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
PCB	Poly Chlorinated Biphenyls
PDF	Portable Document Format
PETS	Preliminary Engineering cum Traffic Survey
PF or pf	Power Factor
PFC	Power Factor Controller
Ph	Phase
PLC	Programmable Logic Controllers
POH	Periodical Overhaul
PS	Particular Specification
PSC	Pre-stressed Concrete

PTR	Playback and Training Room
PVC	Polyvinyl Chloride
RAM	Reliability, Availability and Maintainability
RAMS	Reliability, Availability, Maintainability and Safety
RCCB	Residual Current Circuit Breaker
RCD	Residual Current Device
RDSO	Research Design and Standard Organization (under the Ministry of Railways)
RFI	Request for Information
RITES	Rail India Technical and Economic Services
RL	Rail Level
rms	Root Mean Square
ROB	Road Over Bridge
ROW	Right of Way
RS	Rolling Stock (Rail System)
Rs.	Rupees (Indian Currency)
RSEB	Rajasthan State Electricity Board
RTU	Remote Terminal Unit
RUB	Road Under Bridge
SAP	System Assurance Plan
SAT	System Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SCP	Supply Control Post
SHE	Safety Health and Environment
SF_6 CB	Sulphur Hexafluoride Circuit Breaker
SIG	Signalling (Rail System)

SM	Station Master
SOD	Schedule of Dimension (of IR)
SOR	Station Operations Room
SOR	Schedule of Rates
SP	Sectioning and Paralleling Post(s)
SPS	Small Part Steelwork
SQE	Safety, Quality and Environment
SSAT	Subsystem Acceptance Tests
SSP	Sub-Sectioning and Paralleling Post(s)
SWA	Steel Wire Armoured
T&P	Tools & Plant
TBA	To be advised
TC	Track Circuit
TEL	Telephone (Rail Subsystem of COM)
TOR	Terms of Reference
TOT	Transfer of Technology
TPS	Traction Power Substation(s)
TPSS	Traction Power Supply System
TPWS	Train Protection and Warning System
TSS	Traction Substation
UIC	International Union of Railways
UPS	Uninterruptible Power Supply
V	Volt
V_{acc}	Accessible Voltage
VCB	Vacuum Circuit Breaker

VDU	Visual Display Unit
XLPE	Cross Linked Polyethylene

Part -II

Definitions:

Terminology	Explanation/definition
Accessible Voltage (Vacc)	The part of the rail potential under operating conditions that can be bridged by persons, the conductive path being conventionally from either hand to both feet through the body, or from hand to hand.
Autotransformer	A transformer with a single winding that is centre tapped to provide a zero potential traction return connection. The +25kV terminal is connected to the catenary and the -25kV terminal is connected to the autotransformer feeder or negative feeder.
Autotransformer Station (ATS)	A building or compound containing electrical switchgear, equipment and autotransformer(s) which is arranged to connect together a number of sections of overhead line equipment.
Bonding	The electrical connection of two or more conductive parts to ensure a continuous path for electric current, or to maintain the connected parts at substantially the same potential.
British Standard	A standard published by the British Standards Institution. Its alphanumeric identity is prefixed by BS.
Common Bonding Network(CBN)	The CBN is the principle means for effecting bonding and earthing inside a building. It is the set of metallic components that are intentionally or incidentally interconnected to form the principal bonding network in a building. These components include: structural steel or reinforcing rods, metallic plumbing, AC power conduit, cable racks and bonding conductors.
Cross-Bond	In addition to self-bond in each tunnel, the two tracks are bonded together via Traction Spider Plates.
Earth	The conductive mass of the earth, whose electric potential at any point is conventionally taken as equal to zero.
Earth Electrode	A conductive part or a group of conductive parts in intimate contact with and providing an electrical connection to earth.
Earth Mat	A group of conductor rods connected together as a grid, with or without earthing electrodes normally connected at the grid points.
Earth Wire	A conductor electrically connecting together the steelwork of two or more overhead line structures or a number of overhead line small-part steelwork assemblies and bonded to a traction return rail or to the centre tap of an impedance bond.
Electrical Section	A length of overhead line equipment between switching stations or between a switching station and a terminal end.
Electrification System	Electric power distribution system along track which can be on side rails or overhead and distributes power from Feeder Stations to the train's current collection system.

Terminology	Explanation/definition
Equipotential Bonding	Electrical connections ensuring that exposed conductive parts and extraneous conductive parts are maintained at substantially equal potential.
European Standard	A standard published by the European Committee for Standardization or by the European Committee for Electro-technical Standardization. Its alphanumeric identity is prefixed by 'EN'.
Fault Current	The current that flows as a result of a unintentional electrical fault on the electrification system, such as a short circuit or flashover.
Feeding Section	A feeding section is defined as the section of overhead line between successive TSS/SP on either side of a feeder station.
First Emergency Feeding	The feeding arrangement when one of two feeder circuits to the feeder station has failed (in the case where the feeder station is fed by two feeder circuits). For feeder stations with one feeder circuit, the feeder circuit shall be used to T-feed the sections in both directions. In the latter case, normal and first emergency feeding arrangements are the same.
International Standard	A standard published by the International Electro-technical Commission. Its alphanumeric identity is prefixed by 'IEC'.
Load Current	The current that flows as a result of the operation of electric trains.
Metallic Service	A service having an exposed metallic surface, such as a gas or water pipe, a conduit, or a metal-sheathed cable.
Normal Feeding	The feeding arrangement when both 220/132kV feeder circuits to the Traction Sub-station are healthy and available for service. All feeder circuits shall be used to radial feed their respective sections with a neutral section between them.
Overhead Contact Line Zone	The zone whose limits are not exceeded, in general, by a live or broken overhead line conductor. The term applies to out-of-running overhead line conductors but not to those conductors that are not mechanically strained by pantographs, because the probability of breakage is too small. The profile and dimensions of the zone are defined in EN 50122-1.
Pantograph Zone	The zone whose limits are not exceeded, in general, by a live, broken or de-wired pantograph. Its profile and dimensions are defined in BS EN 50122-1.
Rail Potential	The voltage occurring between the traction return rails and earth under operating conditions and or under fault conditions.
Return Conductor	A conductor connected in series with the secondary windings of booster transformers, and bonded to the traction return rails to carry traction return current back to a feeder station independently of the running rails.

Terminology	Explanation/definition
Second Emergency Feeding	The feeding arrangement when both the feeder circuits to the feeder station have failed (in the case where the Feeding Station is fed by two feeders circuits), or when the single feeder to the feeding station has failed (in the case where the Feeding Station is fed by a single feeder circuit). The affected sections are fed by the adjacent feeder stations.
Self-Bond	In open air: One Traction Earth Wire, two running rails via traction rail spider plate, one Protective Earth Wire and HV cable sheaths (at joint) within the same track (or same tunnel) are bonded to two Traction Spider Plates, one on each side of a track.
Simultaneous Touching Distance	The distance which can be bridged by a person. In general a minimum horizontal dimension of 2m and a minimum vertical dimension of 2.5m are adopted.
Stray Current	Electric current that follows paths other than intended paths. Stray currents occur in ac traction systems but only d.c. stray current is corrosive to steel structures.
Sub-Sectioning and Paralleling Post	A building or compound containing electrical switchgear, equipment and autotransformer(s) which is arranged to connect together a number of sections of overhead line equipment. There is also a section overlap.
Switching Station	Generic term for TSS,SSP, SP and ATP.
Touch Potential, Touch Voltage (V_{touch})	The electrical potential difference between two parts at different electrical potentials under fault conditions that is experienced when touched.
Traction Power Supply System	The Traction Power supply System is defined as the Infrastructure between the points of common coupling with State Power Companies.
High Voltage	Where the voltage does not exceed 33,000 volts under normal conditions subject, however, to the percentage variation allowed as per the IE Rule 1956.
Low Voltage	where the voltage does not exceed 250 volts under normal conditions subject, however, to the percentage variation allowed as per the IE Rule 1956.
Phase 1	The section of the Western Dedicated Freight Corridor between Rewari chainage (0km) and Vadodara chainage (922km)
Phase 2	The phase 2 section of the Western Dedicated Freight Corridor falls between Vadodara to JawaharLal Nehru Port (JNPT) and Rewari to Dadri.
Project	Western Dedicated Freight Corridor Phase-I Rewari to Vadodara
Project	Eastern Dedicated Freight Corridor from New Karwandiya to Durgaoti (approx. 66 km)

Terminology	Explanation/definition
Project Wide	Project Wide is defined as Western Dedicated Freight Corridor Project Phase-I and includes Scope of Work on CT-P1, CT-P2, CT-P3 CT-P3A, EM-P4, ST-P5, & RS –P7
Project Wide	Project Wide is defined as Eastern Dedicated Freight Corridor Project
Proven	The proposed System/Equipment to be used should be of proven performance and record and should have been satisfactorily in use in adequate numbers (at least 70% of the estimated quantities) in Metros, Railways or Airports during the last 3 years. The Contractor shall submit necessary proof in this regards.

Part –III

Climatic and atmospheric conditions:

1. The system is expected to be used in varying atmospheric and climatic conditions. The environmental factors are expected to vary in the range as tabulated below:

i)	Ambient air temperature	-2.5^0C to $+50\ ^0$C
ii)	Maximum temperature of metallic object under sun.	70^0C
iii)	Solar radiation	1 kW/m^2
iv)	Horizontal Seismic Level	0.3 g
v)	Maximum relative humidity	100%
vi)	Annual rainfall (Most of the rainfall may be expected in the monsoon seasons)	Dry Arid regions and also heavy monsoon affected regions with rainfall ranging from 1750 to 6250mm
vii)	Maximum number of thunder storm days per annum	45
viii)	Maximum number of dust storm days per annum	35
ix)	Number of rainy days per annum.	120
x)	Basic wind pressure 1. Rewari – Makarpura Section – 200kgf/m^2	150 - 200 kgf/m^2, as per wind map based on BIS - 875. For long bridges (more than 150 m) and within 100 m from their abutments on either side and on banks, where the height of catenary above surrounding mean retarding surface is more than 20 meters, the specified 25% reduction in wind pressure shall not be reckoned for purposes of design.
xi)	Altitude	Not exceeding 500m
xii)	Creepage distance for (i) Extreme pollution condition (ii) Polluted conditions (Normal and Light)	 31mm/kV 20mm/kV

Part –IV

List of Indian Standards (IS):

1.	226-1969, 814-1974, 816-1969, 823-1964 , 6227-1971	Code of practice for electric welding of mild steel structures.
2.	269-1989 (4th rev.)	Specification for 33 grade ordinary Portland cement.
3.	335-1993/BS-148, D-1473, D-1533-1934, IEC Pub 296-1969	New Insulating Oils.
4.	371-1999 (3rd rev)	Ceiling Rose specification.
5.	383-1970 &515-1959	Fine & coarse aggregates for concrete.
6.	432-1982	Specification for mild steel and medium tensile steel bars and hard drawn steel wires for concrete reinforcement.
7.	456-2000	Code of practice for plain and reinforced concrete for general building construction.
8.	694-1990/IEC 60227	PVC Insulated cables for working voltages up to and including 1100 Volts.
9.	732-1989	Code of Practice of Electrical Wiring Installations (System Voltage not exceeding 660 V).
10.	800-1984	Code of practice for use of structural steel in building construction.
11.	875-1987	Code of Practice for Design Loads for Building and Structure – Part 3- Wind Loads.
12.	1239-2004	Steel Tubes, Tubular and other Wrought Steel Fittings.
13.	1248-2003	Direct Acting Electrical Indicating Instruments.
14.	1255-1983	Code of Practice for Installation and Maintenance of Power Cables up to and Including 33kV Rating.
15.	1271-1958	Classification of Insulating Materials.
16.	1293-1988/ IEC 60884-1 (2002)	Plugs and socket outlets of rated voltage up to and including 250 volts and rated current up to and including 16 amperes.
17.	1393-1984	Criteria for earthquake resistance design of structure.
18.	1554-1988/IEC 60502	PVC Insulated (Heavy Duty) Electric Cables
19.	1646-1997	Code of Practice for Fire Safety of Building.
20.	1753-1967	Aluminium conductors for insulated cables.

21.	1777-1978	Industrial Luminaries with Metal Reflectors.
22.	1866-2000	Code of practice for maintenance and supervision of mineral insulating oil in equipment.
23.	1905-1980	Code of practice for structural safety of building masonry walls.
24.	1913-1978	General Safety Requirements for luminaires.
25.	1964-1966	Code of practices for structural safety of building foundations.
26.	2026-1977/ IEC76	Specification for Power Transformer.
27.	2062-2006	Steel for general structural purpose.
28.	2099-1986	Bushing for Alternating Voltages Above 1000V (2nd Revision).
29.	2175-1988	Heat Sensitive Detectors for Use in Automatic Fire Alarm System.
30.	2189-1999	Code of Practice for Installation of Automatic Fire Alarm System.
31.	2208-1962	HRC cartridge fuses links up to 650 volts.
32.	2309-2005	Code of practice for the protection of buildings and allied structures against lightning.
33.	2312-1976	Propeller type AC ventilating fans.
34.	2412-1975	Link clips for electrical wiring.
35.	2502 -1963	Code of practice for bending & fixing of bars for concrete reinforcement.
36.	2667-1988	Fittings for Rigid Steel Conduits for Electrical Wiring.
37.	2675-1983	Enclosed distribution fuse boards, cut outs for voltage not exceeding 1000 V AC & 1200 V DC.
38.	2705-1992	Current Transformers.
39.	2834-1986	Shunt Capacitors for Power Systems
40.	3024-2006	Electrical sheet steel (oriented).
41.	3043-1987	Code of Practice for Earthing.
42.	3156-1992/4146-1983	Voltage Transformers/Application guide for Voltage Transformers.
43.	3202-1965	Code of Practice for Climate Proofing of Electrical Equipment.
44.	3231	Electrical Relays for Power System Protection.
45.	3347-1967/ DIN 42531,23, 3	Dimensions for Porcelain Transformer Bushings for Use in Lightly Polluted Atmospheres.
46.	3401-1992	Specification for Silica Gel.
47.	3427-1997	Metal Enclosed Switchgear & Control Gear for Voltages Above 1000V up to and Including 52000V.

48.	3528-1966	Water Proof Electric Light Fitting.
49.	3553-1983	Specification for Watertight Electric Lighting Fitting.
50.	3639-1966	Fittings and accessories for power transformers.
51.	3646-1992	Code of Practice for Interior Illumination.
52.	3696-1993	Safety Code for Scaffolds and Ladders.
53.	3764-1992	Excavation work- code of safety.
54.	3837-1976	Accessories for rigid steel conduit for electrical wiring.
55.	3842	Application guide for electrical relays for ac systems
56.	3854-1997/ IEC 60669-1	Switches for domestic and similar purposes.
57.	3961-1968 (Part III)	Recommended current ratings for cables.
58.	3975-1999	Mild Steel Wires, Strips and Tapes for Armouring of Cables.
59.	4160-1967/ IEC 60884-2-6 (1997)	Interlocking switch socket outlet.
60.	4253 (Part II)	Rubber and cork.
61.	4615-1968	Switch socket outlets (non-interlocking type).
62.	4876-1979	Specification for hot dipped for galvanized coatings on ground steel wires.
63.	4889/BS-269	Rules for Method of Declaring Efficiency and Electrical Machines.
64.	4984-1985	High Density Polyethylene Pipes
65.	5082-1998	Wrought Al. and Aluminium Alloys, Bars, Rods, Tube and Sections for Electrical Purposes.
66.	5133-1969 (Part-I & II)	Boxes for the Enclosure of Electrical Accessories.
67.	5138-1978	Enclosure construction with single sheet sturdy frame construction.
68.	5216	Recommendations on Safety Procedures and Practices in Electrical Work.
69.	5561-1970	Electrical power connectors.
70.	5578-1984	Guide for marking of insulated conductors.
71.	5613	Code of Practice for Design, Installation and Maintenance of Overhead Power Lines.
72.	5819-1970	Recommended short circuit ratings of high voltage PVC cables.
73.	5831-1984	PVC insulation and sheath of electric cables.
74.	5891-1970	Recommended Short Circuit Rating of High Voltage XLPE Insulated PVC Cables.
75.	6313-1981	Anti-termite treatment.

76.	6380-1984	Specification of Elastomeric Insulation & Sheath of Electric Cables.
77.	6474-1984	Polyethylene insulation and sheath of electric cables.
78.	6600-1972 / IEC 76	Guide for Loading of Oil Immersed Transformers.
79.	6655-1972	Code of Practice for Industrial Lighting.
80.	6792-1992/IEC 60156	Method for Determination of Electric Strength of Insulating Oils.
81.	7098-1988 (Part-I & II)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto 33kV.
82.	7671-2001	Requirements for Wiring Installations. IEEE Wiring Regulations – 16th Edition.
83.	8112-1489	Cement grade 43/ 53 (OPC/PPC).
84.	8130-1984 (1st rev.)	Conductor for insulated electric cables & flexible cords.
85.	8468-1977	On-load tap changers.
86.	8478-1977	Application guide for Tap- Changers.
87.	8623-1993	Low-Voltage Switchgear and Controlgear Assemblies.
88.	8632-1977	Method for identification of test-piece axes.
89.	8826-1978	Guidelines for design of large earth and rockfill dams.
90.	9537-1980 (Part 1)/ IEC 60614-1 (1978)	Conduits for electrical installations.
91.	9900-1981/IEC 188	High Pressure Mercury Vapour lamps.
92.	9974-1981/IEC 662	High Pressure Sodium Vapour Lamps.
93.	10028	Code of Practice for Selection, Installation and Maintenance of Transformers.
94.	10118 (Parts 1-4)	Code of Practice for Selection, Installation and - 1982, Maintenance of Switchgear.
95.	10322	Specification for Luminaries.
96.	10418-1982	Drums for Electric Cables.
97.	10561-1983/IEC 606	Application Guide for Power Transformers.
98.	10593-2006	Mineral Oil-impregnated electrical equipment in services - Guide to the interpretation of dissolved and free gases analysis.
99.	10810	Methods of Tests for Cables.
100.	11353-1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals.
101.	12021-1987	Control Transformers for Switchgear and Control gear for Voltages not Exceeding 1000 V ac.

102.	12676-1989	Oil impregnated paper insulated condensers bushings-dimensions and requirements.
103.	12943-1990	Brass glands for PVC cables.
104.	13021-1991/IEC 60928	AC Supplied Electronic Ballasts for Tubular Fluorescent Lamps.
105.	13032-1991	AC Miniature Circuit-Breaker Boards for Voltages not Exceeding 1000 V.
106.	13118-1991	High-Voltage Alternating-Current Circuit-Breakers.
107.	13340-1993	Power Capacitor of Self-healing Type for AC Systems Having Rated Voltage up to 650 Volts.
108.	13341-1992	Requirements for Ageing Test, Self-healing Test and Destruction Test on Shunt Capacitors.
109.	13707-1993	Reliable transfer in text communication for information processing systems.
110.	13779-1999/ IEC 62056	AC static watt hour meter class 1 and 2.
111.	13925-1998	Shunt Capacitor for Power System.
112.	13947	Specification for low voltage switchgear & control gear.
113.	15787-2008/ IEC 60884-2-3 (1989)	Switch-Socket outlets (Non-Interlock Type).
114.	60309-2002	Plugs, socket outlets & couplers for industrial purpose.

Part -V

List of International Standards (EN/BS/IEC/IEEE/ENV/ISO/UL etc.):

	Standard Number	Description
1.	BS 5308	Instrumentation cables – Part 1 Specification for polyethylene cables
2.	BS 6724	Specification for 600/1000 V and 1900/3300 V armoured electric cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire
3.	BS 7211	Specification for thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire
4.	BS 7430	Code of Practice for Earthing.
5.	BS 7671	Requirements for Electrical Installations.
6.	BS 7835	Specification for cables with cross-linked polyethylene or ethylene propylene rubber insulation for rated voltages from 3800/6600 V up to 19000/33000 V having low emission of smoke and corrosive gases when affected by fire.
7.	BS 7846	Electric cables 600/1000V armoured fire resistant cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire.
8.	BS EN 50082-1	Electromagnetic compatibility - Generic immunity standard Part 1: Residential, commercial and light industry.
9.	DD ENV 50121 (All parts)	Railway applications - Electromagnetic compatibility.
10.	DIN 43668	Key for the doors of electrical switchgear cubicles and cabinets; double-bit key.
11.	DIN 43671	Copper bus bars; design for continuous current.
12.	DIN 43761	Temperature Sensors.
13.	DIN 53481/1.2 (36)	Dielectric strength.
14.	DIN 53504	Tensile strength.
15.	DIN53577	Compressive strength.
16.	DIN EN 13601	Copper rod, bar and wire for general electrical purposes.
17.	DIN EN ISO 1798	Flexiblecellular polymeric materials.
18.	EN ISO 1856	Flexiblecellular polymeric materials.
19.	EN ISO 9001	Quality systems: Model for quality assurance in design, development, production, installation and

	Standard Number	Description
		servicing.
20.	EN 50119	Railway Applications - Fixed installations- Electric traction overhead lines.
21.	EN 50121	Railway applications - Electromagnetic compatibility.
22.	EN 50122	Railway Application - Fixed Installations, Electrical Safety, Earthing and return circuit.
23.	EN 50124-1	Insulation Co-ordination in Traction Systems.
24.	EN 50125-2	Environmental Conditions for Fixed Installations.
25.	EN 50126	Railway applications: The specification and demonstration of dependability, reliability, availability, maintainability and safety (RAMS).
26.	EN 50149	Railway applications. Fixed installations. Electric traction. Copper and copper alloy grooved contact wires.
27.	EN 50152	Railway Applications- Fixed Installations - Particular requirements for AC Switchgear. (All parts).
28.	EN 50522	Earthing of Power System exceeding 1 kV/ac
29.	EN 50163	Railway Application - Supply Voltages of traction systems.
30.	EN 50267	Common test methods for cables under fire conditions. Tests on gases evolved during combustion of materials from cables.
31.	EN 50272 (Part 2)	Safety requirements for secondary batteries and battery installations - Stationary batteries
32.	EN 50327	Railway applications. Fixed installations. Harmonization of the rated values for converter groups and tests on converter groups.
33.	EN 50328	Railway applications. Fixed installations. Electronic power convertors for substations.
34.	EN 50329	Railway applications. Fixed installations. Traction transformers.
35.	EN 50388	Railway applications: Power supply and rolling stock – technical criteria for the coordination between power supply (substation) and rolling stock to achieve operability.
36.	EN 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
37.	EN 60073	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators.
38.	EN 60076	Power Transformers / Reactors

	Standard Number	Description
39.	EN 60137	Insulated Bushings for Alternating Voltages above 1kV.
40.	EN 60146	Semiconductor converters.
41.	EN 60214	On-load tap-changers.
42.	EN 60255	Electrical relays.
43.	EN 60269	Low-voltage fuses.
44.	EN 60270	High voltage test techniques - Partial discharge measurements.
45.	EN 60296	Fluids for electro technical applications. Unused mineral insulating oils for transformers and switchgear
46.	EN 60332	Tests on electrical and optical cables under fire conditions. Test for a vertical flame propagation for a single insulated wire or cable.
47.	EN 60417	Graphical symbols for use on equipment.
48.	EN 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system.
49.	EN 60507	Artificial pollution tests on high-voltage insulators to be used on ac systems.
50.	EN 60529	Specification for the degree of protection provided by enclosures (IP code).
51.	EN 60721	Classification of environmental conditions. Environmental parameters and their severities.
52.	EN 60726	Dry type power transformers.
53.	EN 60896-2	Stationary lead-acid batteries. General requirements and methods of test. Valve regulated types.
54.	EN 60947	Specification for low-voltage switchgear and control gear.
55.	EN 61034	Measurement of smoke density of cables burning under defined conditions.
56.	EN 61138	Cables for Portable Earthing and Short Circuiting Equipment.
57.	EN 61140	Protection against shock – Common aspects for installation and equipment.
58.	EN 61230	Live Working – Portable Equipment for Earthing or Earthing and short circuiting.
59.	EN 61325	Insulators for Overhead Lines with Nominal Voltages above 1000 V.

	Standard Number	Description
60.	EN 61508	Functional safety of electrical/electronic/ programmable electronic safety related systems.
61.	EN 61952	Insulators for overhead lines. Composite line post insulators for alternating current with a nominal voltage.
62.	EN 62271	High-voltage switchgear and control gear.
63.	IEC Hand Book for Temperature Index	Cable in fire regarding temperature Index Chapter-6.
64.	IEC 68	Arrangements for the recognition and acceptance of conformity assessment results.
65.	IEC 112	Guide on the safety of multimedia equipment.
66.	IEC 137	Bushings for alternating voltages above 1000 Volts.
67.	IEC 185	Current Transformers.
68.	IEC 1508	Functional Safety – Safety related systems.
69.	IEC10333	Cable joints and terminations.
70.	IEC 60044	Instrument transformers.
71.	IEC 60050	International Electro technical Vocabulary.
72.	IEC 60076	Power Transformers/Reactors.
73.	IEC 60081	Tubular fluorescent lamps for general lighting service.
74.	IEC60228	Conductors of insulated cables.
75.	IEC 60255	Measuring Relays and Protection Equipment.
76.	IEC 60269	Low Voltage Fuses.
77.	IEC 60287	Calculation of the continuous current rating of cables.
78.	IEC 60298	AC metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 72kV.
79.	IEC 60332	Tests on electric and optical fibre cables under fire conditions Part 1-2: Test for vertical flame propagation for a single insulated wire or cable Procedure for 1 kW pre-mixed flame.
80.	IEC 60364	Electrical installations of buildings.
81.	IEC 60376	Specification of technical grade Sulphur Hexafluoride (SF6) for use in electrical equipment.
82.	IEC 60439	Type-test low-voltage switchgear and control gear assembly.
83.	IEC 60479	Effects of current on human beings and livestock.
84.	IEC 60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.
85.	IEC 60517	Gas-insulated metal-enclosed switchgear for rated

	Standard Number	Description
		voltages of 72.5 kV and above.
86.	IEC 60598	Luminaires: General Requirements and Tests.
87.	IEC 60616	Terminal and tapping markings for power transformers.
88.	IEC60694	Common specification for high voltage switchgear and control gear standards.
89.	IEC 60754	Test on gases evolved during combustion of electric cables.
90.	IEC60815	Guide for the selection of insulators in respect of polluted conditions.
91.	IEC 60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 150 kV) Test methods and requirements.
92.	IEC 60850	Railway applications – Supply voltages of traction systems.
93.	IEC 60853	Cyclic & emergency current rating of cable.
94.	IEC 60898	Circuit-breakers for over current protection for household and similar installations.
95.	IEC 60929	AC supplied electronic ballasts for tubular fluorescent lamps - Performance requirements.
96.	IEC 60947-2	Low-Voltage Switchgear and control gear.
97.	IEC 61000	Electromagnetic compatibility.
98.	IEC 61024	Protection of Structures against Lightning, Part 1: General Principles.
99.	IEC 61243	Voltage Detecting Systems.
100.	IEC 61312	Protection against lightning electromagnetic impulse (LEMP).
101.	IEC 61439	Low-voltage switchgear and control gear assemblies.
102.	IEC 61443	Short Circuit Temp. limits for cables with rated voltage above 36kV.
103.	IEC 62128	Railway applications-Fixed installations-Part 1: Protective provisions relating to electrical safety and earthing.
104.	IEC 62236	Railway Applications – Electromagnetic Compatibility.
105.	IEC 62271	High Voltage Switchgear and Control Gear.
106.	IEEE 80	Guide for safety in ac substation grounding.
107.	IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grid System.

	Standard Number	Description
108.	IEEE 446	IEEE Recommended Practice for Emergency and Standby Power Systems.
109.	IEEE 485	IEEE Recommended Practice for Sizing of Large Lead Storage Batteries for generating Station and Substations.
110.	IEEE738	Standard for Calculating Current-Temperature of Bare Overhead Conductors.
111.	IEEE980	Guide for Containment and Control of Oil Spills in Substations.
112.	IEEE1187	Recommended Practice for Installation Design and Installation of Valve-regulated Lead acid Storage batteries for Stationary Applications.
113.	IEEE 1188	IEEE Recommended Practice for Maintenance, Testing and Replacement of valve-regulated Lead Acid (VRLA) Batteries for Stationary Applications.
114.	IEEE 1189	IEEE Guide for Selection of Valve-regulated Lead Acid (VRLA) Batteries for Stationary Applications.
115.	IEEE 1313.1	Standard for Insulation Coordination
116.	IEEE 1427	Guide for Recommended electrical Clearances and Insulation Levels in Air-insulated Electrical Power Substations.
117.	IEEE C2	National Electrical Safety Code.
118.	IEEE C37.14	Low-voltage DC Power Circuit Breakers used in Enclosures.
119.	IEEE C37.16	Standard for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors used in Enclosures
120.	IEEE C37.20.1	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
121.	IEEE C37.30	Standard requirements for High-Voltage Switches.
122.	IEEE C37.32	HV switches, Bus Supports and Accessories, Schedule of Preferred Ratings, Construction Guidelines and Specifications.
123.	IEEE C37.34	Standard Test Code for HV Air Switches, Insulators and Bus Supports.
124.	IEEE C37.35	Guide for Application, Installation, O&M of HV Air Disconnecting and Load Interrupter Switches.
125.	IEEE C37.37	Standard Loading Guide for AC HV Air switches (in excess of 1000V).
126.	IEEE C37.20.2	Standard for Metal-Clad Switchgear.
127.	IEEE C37.100	Definition of Power Switchgear.

	Standard Number	**Description**
128.	IEEE C57.93	Guide for Installation of Liquid Immersed Power transformers.
129.	IEEE C57.12.00	Standard General Requirements for Liquid Immersed Distribution, Power and Regulating Transformers.
130.	IEEE C57.12.80	Standard Terminology for Power and Distribution Transformers.
131.	IEEE C95.1	Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
132.	IEEE C95.6	Standard for Safety Level with respect to Human Exposure to Electromagnetic Fields 0-3 kHz.
133.	IEEE PC37.2/D 2.2	Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations.
134.	ISO 3864	Graphical symbols -- Safety colours and safety signs.
135.	ISO 17398	Safety colours and safety signs.
136.	NEC 300-21	Spread of Fire or Products of Combustion.
137.	NEMA 250	Enclosures for Electrical Equipment.
138.	NEMA AB1	Moulded Case Circuit Breakers and Moulded Case Switches.
139.	NEMA BU1	Bus ways.
140.	NEMA SG5	Power Switchgear Assemblies.
141.	NEMA SG6	Power Switching Equipment.
142.	NEMA TR208	Disconnect Switchgear Insulators.
143.	NEMA WC70	Standard for Non-shielded Power Cables Rated 2000V or Less for the Distribution of Electrical Energy
144.	NFPA	National Fire Protection Association.
145.	NFPA 70	National Electrical Code.
146.	UL 6	Rigid Metal Conduit.
147.	UL 924	Emergency Lighting and Power Equipment.
148.	UL 925	Fluorescent lamp Ballasts.

Part - VI

List of RDSO Specifications:

Sl. No.	Specification No.	Description
1.	ETI/OHE/3	Technical specification for Annealedstranded copper conductors for jumper wirefor Electric Traction.
2.	ETI/OHE/11	Specification for steel tubes.
3.	ETI/OHE/13	Specification for Hot dip zinc galvanizationof steel masts (Rolled & Fabricated), tubesand fittings used on 25kV ac OHE.
4.	ETI/OHE/16	Specification for 25kV ac single pole and double pole isolators for Railway Electrification.
5.	ETI/OHE/18	Specification for Steel and stainless steel bolts, nuts and washers.
6.	ETI/OHE/21	Aluminium alloy section and tubes for 25kV Traction Overhead Equipment.
7.	ETI/OHE/27	Section Insulator assembly without sectioning insulator.
8.	ETI/OHE/33	Specification for Enamelled steel plates.
9.	ETI/OHE/33A	Provisional specification for "retro-reflective structure Number plates."
10.	ETI/OHE/36	Specification for Galvanized steel wire rope.
11.	ETI/OHE/42	Technical specification for hard drawngrooved contact wire for electric traction(jointed/welded contact wire).
12.	ETI/OHE/48	Technical specification for Winch typeregulating equipment for 25kV ac traction.
13.	ETI/OHE/49	Technical specification for Fittings for 25 kV ac OHE.
14.	ETI/OHE/50	Technical Specification for cadmium copperconductors for overhead Railway traction.
15.	ETI/OHE/51	Specification for Discharge/earthing poleassembly for 25kV ac traction.
16.	ETI/OHE/52	Specification for Interlocks for ac tractionswitchgears.
17.	ETI/OHE/53	Principles for OHE layout plans andsectioning diagrams for 25kV ac traction.
18.	ETI/OHE/54	Specification for 19/2.79mm all aluminium alloy, stranded catenary wire.
19.	ETI/OHE/55	Specification for Bimetallic (aluminium-copper) strip.
20.	ETI/OHE/58/1	Specification for hand operated lifting andswivelling platform.
21.	ETI/OHE/64	Specification for solid core cylindrical postinsulators for systems with nominal voltagesof 220kV,132kV,110kV& 66kV.
22.	ETI/OHE/65	Specification for continuous cast copper wirerods.

Sl. No.	Specification No.	Description
23.	ETI/OHE/71	Code of bonding and earthing for 25kV ac 50Hz single phase traction system.
24.	ETI/OHE/76	Technical Specification for hard drawn groovedcontact wire for electric traction drawn out ofcontinuous cast copper (ccc) wire rods.
25.	ETI/PSI/1	Battery charger for 110 volt battery, 40Ah.
26.	ETI/PSI/14	Technical specification for 25kV drop out fuse switch and operating pole for use with 110kVA and 100kVA,25k/230V LT supply transformers.
27.	ETI/PSI/15	Specification for 25kV/240V, 5 kVA, 10kVA, 25kVA &50kVA, 50 Hz, single phase, oil filled auxiliary transformers for Railway AC traction system.
28.	ETI/PSI/15A	25kV/240V L.T. supply Transformer,100kVA.
29.	ETI/PSI/24	Battery charger for 110V Battery, 200 AH.
30.	ETI/PSI/29	Low tension Distribution panels for Railway A.C traction sub-stations.
31.	ETI/PSI/31	Standard for drawings for power supply Installations.
32.	ETI/PSI/63	Low tension distribution panels.
33.	ETI/PSI/71	Metal oxide gapless type lightning arrester for use on 25 kV. side of Railway traction substations and switching stations.
34.	ETI/PSI/90	25 kV ac 50 Hz single phase oil filledcurrent transformers with ratio of (i) 1000-500/5A, (for general purposes), (ii) 1500-750/5 (for heavy duty).
35.	ETI/PSI/117	Technical specification for current transformers: I. 220kV. 200-100/5A, II. 132kV. 400-200/5A, III. 110kV.400-200/5A, IV. 66kV.800-400/5A for Railway A.Ctraction substations.
36.	ETI/PSI/120	Code of practice forearthingofpowersupply installations for 25kV ac, 50 Hz, single phase traction system.
37.	ETI/PSI/122	Technical Specification for 245 kV, 145 kV, 123 kV, 72.5 kV, Double Pole & Triple Pole Isolator for Railway Traction Sub-Stations.
38.	ETI/PSI/123	8MVA, 54kV 50Hz Auto Transformer for Railway 2 x 25kV AT Feeding System.
39.	ETI/PSI/124	54MVA, 220/2 x 27kV Scott connected Traction Power Transformer for 27kV AT feeder system for Railway ac Traction Sub-station.

Sl. No.	Specification No.	Description
40.	ETI/PSI/132	25 kV double pole outdoor, vacuum interrupters for Railway switching stations for 2x25 kV 'AT' feeding system.
41.	ETI/PSI/133	25kV ac Double Pole Isolators for 2 x 25kV AT feeding system.
42.	ETI/PSI/137	Metal oxide gapless type lightning arresters for use of 220/132/110/66 kV side of railway ac traction substation.
43.	ETI/PSI/167	25kV AC 50Hz single pole, outdoor interrupter forRailway traction switching stations.
44.	RE/30/OHE/5	Specification for Copper bus bar.
45.	RE/OHE/25	Standard for drawings for TractionOverhead equipment.
46.	RDSO/PE/SPEC/AC/0100,(Rev.'1') - 2011	Technical Specification for Doublecapped tubular T5 Fluorescentlamps, T5 luminaire & Electronicballast.
47.	RDSO/PE/SPEC/TL/0040-2003(Rev-0)	Specification for low maintenance lead acid batteries for 40 Amp hour and 200 Amp hour cells for traction distribution system.
48.	TI/SPC/LWTSI/0060	Specification for light weight section insulator assembly.
49.	TI/SPC/OHE/ATD/0060	Specification for Three pulley type regulating equipment (3:1 Ratio).
50.	TI/SPC/OHE/FRPNP/INS/COM/1070	Technical specification for silicon composite insulators for 25kV ac 50Hz single phase overhead traction lines.
51.	TI/SPC/OHE/GALSTB/0040	Technical specification for galvanized steel stranded wire for traction bonds for 25kV ac Electric traction systems.
52.	TI/SPC/OHE/GATD/0080	Technical specification for gas auto tensioning device.
53.	TI/SPC/OHE/GSSW/0090	Schedule of technical requirements for manufacture of Galvanized steel stranded wire (GSSW).
54.	TI/SPC/OHE/HDCSCF/0030	Technical specification for 37/2.25mm Hard Drawn Stranded copper conductor.
55.	TI/SPC/OHE/INS/0070	Specification of solid core porcelain insulators for 25kV A.C 50 Hz single phase overhead traction lines.
56.	TI/SPC/OHE/INS/0700	Specification for stainless steel wire rope.
57.	TI/SPC/OHE/INSCAT/0000	Insulated Cadmium Copper Catenary 19/2.1mm. Diameter for provision under overhead line structures in the 25kV ac Electric Traction.
58.	TI/SPC/OHE/INSTEST/0090	Specification for Testing load testing machine 25kV Porcelain & Composite insulator before installation.

Sl. No.	Specification No.	Description
59.	TI/SPC/OHE/POST/0100	Specification for solid core porcelain cylindrical post insulator for systems with nominal voltage of 66kV, 110kV, 132kV & 220kV.
60.	TI/SPC/OHE/SNS/0000	Specification for short Neutral section assembly (Phase Break).
61.	TI/SPC/OHE/WR/1060	Specification for solid porcelain insulators for 25kV ac 50hz single phase overhead traction lines.
62.	TI/SPC/PSI/CB/0000	Outdoor Circuit Breaker for Railway ac Traction Sub-stations.
63.	TI/SPC/PSI/FC&SR/0100	Technical specification for shunt capacitor & series reactor equipment for traction sub-station.
64.	TI/SPC/PSI/ISOLTR/1060	25kVac Single Pole and Double Pole Motorized Isolators for Railway Traction.
65.	TI/SPC/PSI/MOGTLA/0100	42 KV Metal oxide gapless type lightningarrester for use on 25 KV side & Railway Traction substation and Switching Station.
66.	TI/SPC/PSI/PROTCT/1982	Specification for Delta-I type HighResistive fault selective relay for 25 kVac traction systems.
67.	TI/SPC/PSI/PROTCT/2983	Specification for Panto Flashover Protection relay for 25 kV ac tractionSystem.
68.	TI/SPC/PSI/PROTCT/6070	Control and relay panel for 25kV acTSS including specification fornumerical type protection relays fortraction transformer, 25kV shuntcapacitor bank and transmission line for25kV AC TSS on Indian Railways.
69.	TI/SPC/PSI/PROTECT/7100	Technical specification for control and relay panel including numerical type protection relays for scott-connected/single phase traction transformers, OHE protection and shunt capacitor bank protection for 2x25 kV traction sub-station.
70.	TI/SPC/PSI/PTs/0990	Technical specification for 220kV or 132kV or 110kV or 66kV or 25kV potential transformer.
71.	TI/SPC/PSI/VACINT/0040	Magnetic actuator type 25 kV ac, 50 Hz, single pole, outdoor vacuuminterrupter for railway traction switchingStation.

Part –VII

List of RDSO Drawings:

Sl. No	Brief Description	Drawing Series	Drawing Number	Mod. No.
1.	Typical location & schematic connection diagram for a three interrupter switching station.	ETI/PSI	003	C
2.	Typical general arrangement of a three interrupter switching station.	ETI/PSI	004	F
3.	Typical location plan &general arrangement for sectioning & paralleling station.	ETI/PSI	005	F
4.	Typical location plan and general arrangement for a feeding station.	ETI/PSI	006	E
5.	Details of foundation for fencing upright.	ETI/C	0032	B
6.	Details for pre-cast cable trench for switching station.	ETI/C	0038	E
7.	Remote Control Cubical at station, Foundation, RCC Slab, building plant and steel door.	ETI/C	0067	B
8.	Protective screen of foot-over bridge and road over-bridge.	ETI/C	0068	G
9.	Typical fencing and anti-climbing arrangement at switching stations.	ETI/PSI	104	E
10.	Typical fencing layout at TSS (Details of Fencing panel, door, anti-climbing device etc.).	ETI/PS2	121	F
11.	General arrangement & details of fencing panels & gate for switching stations.	ETI/C	0186 Sh.I& II	E
12.	Typical earthing layout of sub- sectioning and paralleling station.	ETI/PSI	201	B
13.	Typical Cable trench layout and foundation layout of 132/ 25kV TSS.	ETI/C	0210	F
14.	Details of baffle wall at TSS (WP-112.5 Kg f/m2 and WP-75 kg f/m$^{2)}$.	E TI/C	0213	D
15.	Details of RCC baffle wall at TSS (WP-150kgf/m$^{2)}$.	ETI/C	0214	B
16.	Transformer oil drainage arrangement at substations.	ETI/C	0216	B
17.	Arrangement for false catenary under over	ETI/OHE/SK	446	--

	line structure.			
18.	Special arrangement of OHE under over line structure.	ETI/OHE/SK	529	--
19.	Arrangement of overlap.	ETI/OHE/SK	566	-
20.	Typical arrangement of OHE with insulated copper catenary under over line structure.	ETI/OHE/SK	570	--
21.	Schematic arrangement of un-insulated over Lap (type-I) (3 & 4 Span overlaps).	RE/33/G	02121 Sh.1	F
22.	Schematic arrangement of un-insulated overlaps (3 & 4 span overlaps).	ETI/OHE/G	02121 Sh.4	A
23.	Schematic arrangement of insulated overlap.	ETI/OHE/G	02123 Sh.3	A
24.	Schematic arrangement of insulated overlap.	ETI/OHE/G	02131 Sh.1	
25.	General arrangement of regulated OHE at turn-outs (overlaps & crossed type).	ETI/OHE/G	02141	C
26.	General arrangement of regulated OHE at cross over(overlap & crossed type).	ETI/OHE/G	02151	-
27.	Arrangement of neutral section.	ETI/OHE/G	02161 Sh.1	C
28.	Arrangement of short neutral section.	ETI/OHE/G	02161Sh.2	-
29.	Arrangement of neutral section assembly (PTFE Type) at SWS.	ETI/OHE/G	02162	-
30.	Standard termination of OHE (Regulated & un-regulated).	ETI/OHE/G	03121 (All parts).	E
31.	General arrangement of connections to OHE by copper cross feeder (150).	ETI/OHE/G	05121 Sh.1	C
32.	General arrangement of connections at switching station on double track section by copper cross feeder.	ETI/OHE/G	05122 Sh.1	C
33.	General arrangement of connections at switching station on multiple track section by copper cross feeder.	ETI/OHE/G	05123 Sh.1	C
34.	Arrangement of suspension of double spider 25 kV feeder and return feeder between sub-station and feeding station.	RE/33/G	05152	C
35.	General arrangement of earth wire onOHE mast.	ETI/OHE/G	05201	A
36.	Arrangement of transverse bonds.	ETI/OHE/G	05251	A

Part -VIII

List of CORE Drawings:

Sl. No.	TITLEOFDRAWINGS	DRAWINGNO.
1.	Structural layout of 132/25 kV traction sub-stations.	ETI/C/0200, SH.No.-1 (Mod-H); SH.No.-2 (Mod-D)
2.	Typical cable trench and foundation lay out of132/25kv TSS.	ETI/C/0210 (Mod.F)
3.	Line Diagram of Structural layouts of 220/25kV Traction sub-station.	ETI/C/0222
4.	Structural layout of 220/27kV traction sub-station (Type-I).	ETI/C/0222-I
5.	Characteristics of conductors/ bus bar for 25kV AC traction.	ETI/OHE/G/05600 (Mod.A)
6.	Typical earthing, cable trench & foundation layout of 132/25kv TSS.	ETI/PSI/ 224 (Mod.E)
7.	Typical layout of Remote Control cubicle at a switching station.	ETI/PSI/0010 (Mod. E)
8.	Typical location plan and general arrangement for a feeding station.	ETI/PSI/006 (Mod.E)
9.	Typical return current connection to buried rail at 132/25kv Traction sub-station.	ETI/PSI/0212-1(Mod.NIL)
10.	Typical layout for 25kv Shunt capacitor with series reactor to be installed at 132/25kv TSS.	ETI/PSI/0223 (Mod.E)
11.	Typical general arrangement of earth screenwire termination at Traction substation.	ETI/PSI/0225 (Mod.C)
12.	Typical schematic diagram of protection for single transformer traction sub-station.	ETI/PSI/0228-1 (Mod-NIL)
13.	High speed auto reclosing scheme for feeder circuit breaker at 25kV A.C TSS.	ETI/PSI/0231-I (Mod A)
14.	Typical layout of 220/27kV traction substation(Type-I).	ETI/PSI/0240-1 (Mod.NIL)
15.	Typical schematic diagram of protection for double Transformer traction substation.	ETI/PSI/024-1 (Mod. NIL)
16.	Typical return current connection to buried rail at 220/25kV Traction sub-station.	ETI/PSI/0242 (Mod.A)
17.	Typical general arrangement of earth screen wire termination at 220/25kV traction sub-station.	ETI/PSI/0244
18.	Typical earthing layout of a feeding station	ETI/PSI/203 (Mod.B)
19.	Typical earthing arrangement for equipment/ structure at TSS.	ETI/PSI/228 (Mod-A)

20.	Schematic inter connection diagram for remote control of power gear & supervision equipments at TSS.	ETI/PSI/644 (Mod.C)
21.	Schematic inter connection diagram for remote control of power gear and supervision equipments at controlled station (SP & SSP).	ETI/PSI/645(Mod.C)
22.	General scheme of supply for25 kV 50 Hz single phase AC traction system.	ETI/PSI/702-1 (Mod.D& E)&
23.	Control desk arrangement for 2 work stations of SCADA system.	ETI/PSI/SK/337
24.	Arrangement of suspension of double spider 25kV feeder and return feeder between substation and feeding station	RE/33/G/05152(Mod.C)
25.	Standard plan of control room at traction sub-station (General arrangement and RCC details)	RE/Civil/S-144/06
26.	Typical schematic diagram for TSS, FP, SSP and SP with 21.6 MVA or 30 MVA transformers for three lines.	TI/DRG/PSI/3L-TSS/RDSO/00001/07/1 (Mod-NIL)
27.	Typical layout of Control Room at traction sub-station.	TI/DRG/PSI/CPROOM/RDSO/ 00001/01/0
28.	Typical layout of 132 /27kV Traction sub-station.	TI/DRG/PSI/TSSLO/RDSO/ 00001/01/0

Part - IX

Power supply design data:

<table>
<tr><td>Electric Supply interface & power quality parameters</td><td colspan="2">Power Supply Utilities define the limits of various parameters in their supply codes, grid codes and regulations issued by respective regulatory commissions. General limits are also defined in Central Electricity Authority (CEA) technical standardsforconnectivity to grid available at http://www.cea.nic.in/reports/regulations/grid_connect_reg.pdf.</td></tr>
<tr><td>Frequency</td><td colspan="2">50 Hz ± 3%</td></tr>
<tr><td>Supply voltages</td><td colspan="2">HV side nominal system voltages of 66, 132 and 220 kV are prevalent. Variation of + 10 % and - 15 % are permitted as per IE Rules-1956 (unless otherwise specifically confirmed by utility/regulatory commission). Traction side voltage levels as per IEC 60850 shall be :
Nominal voltage - 25 kV
Max value of voltage likely to be sustained on continuous basis - 27.5 kV. Min value of voltage - 19 kV.
Max value of voltage likely for not > 5 minutes- 29kV, occasional peak of 30 kV.
All equipment on 25 kV side shall be of 52 kV class</td></tr>
<tr><td>Unbalance</td><td colspan="2">The unbalance for all 3- phase connections above 33 kV shall not exceed 3% (as per CEA standard mentioned above).</td></tr>
<tr><td>Harmonics</td><td colspan="2">(a) Number of utilities has stipulated limits on Harmonics at PCC as per IEEE 519 guidelines, however CEA standard stipulates the following:
THD for Voltage at PCC — Not > 5 %
Harmonic Distortion for Voltage for any individual harmonic at PCC — Not > 3 %
THD for current at PCC — Not > 8 %</td></tr>
<tr><td rowspan="6">Fault level (likely values of phase earth fault levels)</td><td>Highest system voltage kV</td><td>Short circuit apparent power MVA</td></tr>
<tr><td>52</td><td>300</td></tr>
<tr><td>72.5</td><td>3500</td></tr>
<tr><td>123</td><td>6000</td></tr>
<tr><td>145</td><td>10000</td></tr>
<tr><td>245</td><td>20000</td></tr>
<tr><td></td><td colspan="2">Higher fault levels can be expected for TSS locations very close to generating station for which actual fault levels may be worked out and switchgear shall have to be selected accordingly</td></tr>
</table>

Part -X

List of Governing Acts, Regulations and Specifications:

Indian Electricity Rules	1953 with latest amendments
Indian Electricity Act	2003
General Specifications for electrical works Part-1 internal (CPWD)	2005
IRSOD- (Revised) with updated correction slips	2004
DFC SOD	2012
CBIP Manual	
TNEB Engineers hand book	
Westinghouse T & D book	
ITU-TStandards & guidelines for limits of interference with telecom circuits	
All BIS & IEC standards mentioned in the document or relevant/applicable to the subject	
Latest AC Traction Manual with updated correction slips	
All latest rules, regulations, guidelines and codes issued by statutory bodies and regulatory commissions pertaining to Electrical interface with utilities, interference to telecommunication circuits and other emission requirements.	

Part -XI

Specification for 60/84 MVA, 220/132 kV/54 kV SCOTT-CONNECTED TRACTION POWER TRANSFORMER FOR 2x25 kV AT FEEDING SYSTEM

1. Scope

1.1 This document applies to 60/84 MVA, ONAN/ONAF, 220/132/54kV Scott-connected traction power transformers for Auto Transformer (AT) feeding system for installation in DFCC, an infrastructure providing company of Indian Railways.

1.2 The transformer shall be complete with all parts, fittings and accessories whether specifically mentioned herein or not, necessary for its efficient operation in an unattended traction substation.

2. Governing specification

2.1 In the preparation of this document, assistance has been taken from the following National and International standards, wherever applicable.

Table No. 2.1-1

Standard		Description
Equivalents	IS	
IEC 60076 (all parts)	IS:2026 (all parts)	Power transformers.
IEC 60044-1	IS:2705	Instrument transformer – Part 1: Current transformer.
IEC 60137	IS:2099	Bushing for alternating voltages above 1000V
IEC 60214	IS:8468	Tap changers.
IEC 60296	IS:335	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear/ New insulating oils.
	IS:5	Colours for ready mix paints and Enamels.
IEC 60502-1	IS:1554 (Part 1)	PVC insulated (heavy duty) Electric cables: Part 1 For working voltages up to and including 1100V
	IS:1570	Schedules for Wrought Steels - Part 5: Stainless and heat resisting steels.
	IS:1576	Solid pressboard for electrical purposes
IEC 60422	IS:1866	Code of practice for electrical maintenance and supervision of mineral insulating oil in equipment
	IS:2927	Brazing alloy
JIS C 2553	IS:3024	Grain oriented electrical steel sheets and strips
	IS: 3637	Gas operated relays
	IS:3639	Fittings and accessories for power transformers

	IS:4253	Cork composition sheets : Part 2 Cork and Rubber
	IS:5561	Electrical power connectors
IEC 60909	IS:13234	Guide for short circuit calculations in 3Phase a.c. systems.
IEC 60270	IS: 6209	High-voltage test techniques - Partial discharge measurements.
	IS:6600	Guide for loading of oil-immersed transformers
	IS:10028 (all parts)	Code of practice for selection, installation and maintenance of transformers
	IS:10593	Mineral Oil-impregnated electrical equipment in services - Guide to the interpretation of dissolved and free gases analysis
IEC 60137	IS: 12676	Oil impregnated paper insulated condensers bushings – dimensions and requirements
	DIN 7733	Laminated products, pressboard for electrical engineering, types.
		Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2010, part-III, Sec.4, 2010 Rule no. 44 (2) (ix).

2.2 In case of any conflict between the contents of the above standards and this document, the latter shall prevail.

2.3 Any deviation, proposed by the bidder, calculated to improve the performance, utility and efficiency of the equipment, will be given due consideration; provided full particulars of the deviation with justification are furnished. In such a case, the bidder shall quote according to this document and the deviations, if any, proposed by him shall be quoted as alternative/alternatives.

3. Climatic and Atmospheric Conditions

3.1 The transformer shall be suitable for outdoor use in moist tropical climate and in areas the limiting weather conditions which the equipment has to withstand in service are given in Part-II of the Particular Specification.

3.2 The transformer would also be subjected to vibrations on account of trains running on nearby railway tracks.

3.3 The amplitude of these vibrations which occur with rapidly varying time periods in the range of 15 to 70 ms lies in the range of 30 to 150 microns at present, with instantaneous peaks going up to 350 microns. These vibrations may become more severe as the speeds and loads of trains increase in future.

4. Traction Power Supply Systems 2x25kV AT Feeding System

4.1 General Scheme

4.1.1 The electric power for railway traction is supplied in ac 50 Hz, single-phase through 2x25 kV AT feeding system, which has a feeding voltage (2x25 kV) from the traction substation (TSS) two times as high as the catenary voltage, which is 25 kV with respect to earth/rail. The power fed from the TSS through catenary and feeder wire is stepped down to the catenary voltage by means of autotransformers (ATs) installed about every 13 to 17 km along the track, and then fed to the locomotives. In other words, both the catenary and feeder voltage are, 25 kV with respect to the earth/rail, although the substation feeding voltage between catenary and feeder wires is 50 kV. The catenary voltage is therefore, the same as that in the conventional 25 kV system.

4.1.2 The power supply shall be obtained from the 220 kV/132 kV, three-phase, effectively earthed transmission network of the State Power Utilities to the Scott-connected transformer installed at the TSS, whose primary winding is connected to the three phases of the transmission network. The spacing between adjacent substations is normally 60 km.

4.1.3 One outer terminal of the secondary windings of the traction transformer is connected to the catenary and the other outer terminal is connected to the feeder.

4.1.4 ATs connect the 25 kV catenary to 25 kV return feeder, with mid-point connected to rail and earth (25 kV return OHE and earth). Two adjacent AT's share power to feed trains at 25 kV/2x25 kV system feeds 50 kV supply from traction transformer terminal to the ATs. The load current (current drawn by electric locomotives) from the TSS flows through the catenary and returns to the TSS through the feeder. For a train in an AT-cell (distance between two consecutive ATs), most of the current is fed to the electric locomotive by the ATs of that AT-cell; the, current returns in the rails/earth and is boosted up to the feeder through the neutral terminals of the autotransformers. The current in OHE, therefore, is an algebraic sum of 25 kV current feed to locomotives from AT and the 50 kV supply to ATs from the TSS.

4.1.5 Approximately midway between adjacent TSSs, a sectioning and paralleling post (SP) is provided. In order to prevent wrong phase coupling of power supply, a dead zone known as 'Neutral Section' is provided in the OHE opposite the TSS as well as SP. At the TSS, there are two-feeder circuit breakers for either side of the TSS for controlling the power fed to the OHE, in a double track section. Out of the two feeder circuit breakers for one side, one feeds the OHE of that side while the other remains (open) as standby. There is also a paralleling interrupter, which is normally closed, for either side of the TSS for paralleling the OHE of the UP and DOWN tracks. In case of fault in the OHE, the feeder circuit breaker of the TSS trips to isolate it. The Bridging Interrupter is used to feed one TSS up to the next TSS, in case the adjacent TSS is temporarily out of order.

4.1.6 For maintenance work and keeping the voltage drop within limit, one or more sub-sectioning and paralleling post (SSP) are provided between the TSS and SP. The supply control Posts are on an average located every 13-17 km interval. An SSP has four sectioning interrupters and one paralleling interrupter, whereas an SP has two bridging circuit breakers (which remain open under normal feeding condition) and two paralleling interrupters.

4.2 Protection System

4.2.1 The protection system of the traction transformer comprises the following:

1	Differential protection
2	Instantaneous and IDMT over-current, and earth fault protection on the primary side
3	Protection against phase-failure on the secondary side (i.e. to detect malfunction of feeder/transformer circuit breaker)
4	Buchholz Relay
7	Thermistor/Optical hot spot sensor. The Transformer should have built-in hottest spot temperature device to indicate and record the hot test spot temperature as per IEC-60076-2 (Ed. 3.0).

4.2.2 The protection systems for the OHE comprise the following:

1	Distance protection
2	Delta I type fault selective protection
3	Instantaneous over current protection
4	Under-voltage protection to avoid wrong phase coupling
5	Fault locating expert system based on AT voltage neutral current.

4.3 OHE General data

4.3.1 The OHE shall consists of (i) Contact wire of minimum 150 mm^2 cross section suspended directly from catenary of wire of minimum 125 mm^2 cross section by a number of vertical dropper wires, usually at regular intervals and (ii) a feeder wire of stranded all aluminium conductor.

4.4 Traction Transformer General Data

4.4.1 The transformer shall have 60/84 MVA power rating based on ONAN / ONAF cooling. For the normal service, the transformer will operate in ONAN mode. However, fans shall be mounted at initial stage, so that when the load increases, such as during emergency feed extensions, the transformer will be ready to feed the demand, if required, in ONAF mode.

4.5 Nature of traction loads and faults on the OHE system

4.5.1 The traction load is a frequently and rapidly varying one; between no load and overload. The TSS equipment is subject to frequent earth faults/short circuits caused by failure of insulation, snapping of OHE touching earth, wire dropped by bird connecting the OHE to earth/ over line structure, and miscreant activity. On an average, the number of faults/ short circuits per month could be as high as 40. The magnitude of the fault current may vary between 40% and 100% of the dead short circuit value. These faults are cleared by the feeder circuit breaker on operation of the distance, delta I and instantaneous over-current relays associated with the concerned feeder circuit breaker. In 2x25 kV system faults can occur with: feeder-earth; feeder-OHE and OHE-earth faults or a combination of them.

4.5.2 The existing Indian Railways ac electric locomotives are silicon rectifiers or with dc motors or GTO/IGBT based power converter fed 3-phase Induction Motors and the average power factor generally varies between 0.7 and 0.85 lagging, without reactive power compensation, which introduces harmonic currents in the 25kV power supply system.

4.5.3 On DFCC (Western) Locomotives are proposed to have VVVF drives and improved power factor closer to 0.98 and negligible harmonics. The traction supply may therefore be at higher power factor than those on IR.

4.6 Short-Circuit Apparent Power of the system

4.6.1 The short-circuit apparent power at the transformer location for various system voltages is as under:

Highest system voltage (kV)	Short circuit apparent power (MVA)
72.5	3,500
123	6,000
145	10,000
245	20,000

4.7 Auxiliary power supplies at TSS

4.7.1 The following auxiliary power supplies are available

1	110V dc from a battery
2	240 V ac, 50 Hz, single-phase from a 25/0.24 kV auxiliary transformer feed from Traction supply.

5. Rating and General Data

5.1 The rating and general data of the transformer shall be as follows:

SN	Item	Description
1	Type	ONAN/ONAF cooled, Scott-connected (3 phase/ 2 phase), step down power transformer, double limb wound, core-type for outdoor installation.
2	Windings	Primary windings shall be T-connected for three phase supply. Two secondary windings, one per phase, Main-phase (M-phase) and Teaser-phase (T-phase), with a phase difference of 90 degree. The primary and secondary windings shall be uniformly insulated.
3	Rated Frequency (Hz)	50 $\pm$ 3%
4	Rated 3-phase primary voltage between phases Un (kV)	220
5	Highest 3-phase system voltage between phases Um (kV)	245
6	Rated 2-phase	54 per phase

	secondary voltage (at no load), (kV)	
7	Rated power, (MVA)	60/84 MVA ONAN/ONAF (Each secondary winding shall have a rated power of 30/42 MVA)
8	Rated current at the principal tapping: i. Rated primary current (A) ii. Rated secondary current (A)	 157.6 / 220.7 556 / 840 (for each secondary winding)
9	Percentage of impedance voltages, main/primary winding and teaser/primary winding at 30 MVA based at principal tapping.	%Z = 11-13% %Zt = 12 $\pm$ 1.2% %Zf = 12 $\pm$ 1.2% %Zn = -0.2 to 3.5%
10	Non-cumulative overload capacity on ONAN rating.	1) 150% rated load for 15 minutes 2) 200% rated load for 5 minutes
11	Polarity	Subtractive
12	Tapping (off - circuit)	Separate tapped winding on primary winding to give rated secondary voltage for variation in primary voltage of +10% to -15%, in steps of 5% each.
13	Temperature rise	1) Winding: 50K at rated load, and 60K for overloads as specified in Clause 5.1(10) (temperature measured by resistance method). 2) Top oil: 45K (temperature rise measured by thermometer). 3) Current carrying parts in air. 40K (temperature rise measured by thermometer).
14	Maximum permissible total load losses at the principal tapping including core, windings, frame parts, tank and auxiliary requirements.	250 kW at 60 MVA ONAN
15	Ability to withstand short circuit: 1. Thermal ability 2. Dynamic ability	 5s 0.5s
16	Flux density at rated voltage and	Shall not exceed either 1.55 T; when the tapped coils are on the secondary windings or 1.71 T;

<table>
<tr><td></td><td>frequency at principal tapping.</td><td colspan="3">when the tapped coil is on the primary winding.</td></tr>
<tr><td>17</td><td>Current density in the windings.</td><td colspan="3">Shall not exceed 2.5A/mm^2 at 60MVA for ONAN.</td></tr>
<tr><td>18</td><td>Acoustic sound level when energized at rated voltage and at no-load.</td><td colspan="3">Not more than 75dB at 1m distance.</td></tr>
<tr><td rowspan="5">19</td><td rowspan="5">Bushing</td><td>Item</td><td>Secondary</td><td>Primary</td></tr>
<tr><td>Type</td><td>OIP condenser</td><td>OIP condenser</td></tr>
<tr><td>Highest voltage for equipment Um(kV)</td><td>54</td><td>245</td></tr>
<tr><td>Rated current(kV)</td><td>1250</td><td>800</td></tr>
<tr><td>Minimum creepage distance in air (mm)</td><td>1300</td><td>6125</td></tr>
<tr><td rowspan="9">20</td><td rowspan="9">Busing type current transformers for differential protection of transformer</td><td>Item</td><td>Secondary</td><td>Primary</td></tr>
<tr><td>Highest voltage</td><td>52</td><td>245</td></tr>
<tr><td>CT Ratio</td><td>1000/5</td><td>300/5</td></tr>
<tr><td>Frequency(Hz)</td><td>50 +/- 3%</td><td>50 +/- 3%</td></tr>
<tr><td>Class of accuracy as per IEC60044-1.</td><td>PX</td><td>PX</td></tr>
<tr><td>Minimum knee-point emf,(V)</td><td>150</td><td>125</td></tr>
<tr><td>Maximum excitation current at knee-point voltage (V)</td><td>0.25</td><td>0.75</td></tr>
<tr><td>Maximum resistance of the secondary winding, (Ω)</td><td>0.5</td><td>0.25</td></tr>
</table>

6. Salient design features

6.1 Overall dimensions

6.1.1 The overall dimensions of the transformer shall be kept as low as possible and in any case shall not exceed the transportation limit in India.

(Transportation dimension)

1	Length x Width (in mm)	14,000 x 6,500
2	Height of topmost point of primary bushing terminal	7,500 mm
3	Height of topmost point of secondary bushing terminal	5,500mm

6.1.2 The manufacture shall, where practical, design the transformer so that with the bushings & accessories removed, the transformer shall fit within Indian Railway loading gauge, in case it is transported through rail, MMD to be enclosed with the offer.

6.1.3 The transformer should be designed nitrogen filled, such that it can be transported without the insulation oil inside the tank. The transformer shall be designed such that it can be transported with tank under pressure with nitrogen and other protective measures that the Manufacturer recommends, so that no moisture can enters the housing.

6.2 Tank

6.2.1 The tank for the transformer shall be of the top cover jointed with bolted connection. The bottom plate of main tank shall be firmly welded to the main body and the top cover is a plate reinforced with ribs. The winding and core shall fully exposed when the bell tank cover is lifted. A pressure gauge along with a hygrometer shall be provided so that the status of dryness of the winding can be assessed in the transformer prior to its heat run before commissioning.

6.2.2 The tank shall be constructed from mild steel of a quality that allows welding without any defect/flaw, with a single tier construction, shaped so as to reduce welding to the minimum. The welded joints shall be made using good engineering practices. The tank shall be adequately strengthened for general rigidity to permit hoisting of the transformer filled with oil by crane. The tank body shall be designed to withstand against the full vacuum degree.

6.2.3 The tank shall be fitted with four lifting pads at the lower end to enable lifting of the transformer filled with oil by means of lifting jacks.

6.2.4 The tank shall be fitted with an under carriage and mounted on eight bi-directional swiveling type flanged rollers for being rolled on 1676mm (5' 6") gauge track, on which it shall also rest in the final position.

The rollers shall be provided with detachable type locking arrangement to enable their locking after installing the transformer in the final position, to hold the transformer fixed on foundation and to prevent any accidental movement of the transformer.

6.2.5 There shall be at least five inspection covers of suitable size on the tank to enable inspection of the lower portions of bushings, and the leads as well as the various connections of the manual off-circuit tap-changer.

6.2.6 The gaskets with groove NBR (NITRILE BUTADIENE RUBBER) shall be provided for oil sealing points. The rubberized cork gasket may be used for other general portion.

6.2.7 All valves used in the transformer shall be capable to withstand full vacuum degree. The manufacturer shall ensure that suitable anti-theft measures like locked use of blanking plates are provided on these valves, so as to prevent pilferage/theft of oil during transit and service.

6.3 Marshalling box

6.3.1 A vermin proof, weatherproof and well ventilated, marshalling box with IP class 55, made up of sheet steel of thickness not less than 2 mm, strengthened with adequate stiffeners, shall be provided on the left hand side of the transformer tank as viewed from the secondary terminals side.
It shall have a hinged door, with provision for padlocking the door opening outward horizontally.

6.3.2 The marshalling box shall have a sloping roof. The top of the marshalling, box shall be at a height of about 2 m from the transformer rail level.

6.3.3 The marshalling box, shall house the winding and oil temperature indicators and terminal board. To prevent condensation of moisture in the marshalling box, metal clad space heater controlled by an associated thermostat and switch shall be provided. Cable glands shall be provided for the incoming and outgoing cables.

6.3.4 The temperature indicators shall be so mounted such that their dials are at a height of not more than 1.6 m from the rail level. Transparent windows of tough acrylic plastic or similar non-fragile transparent material shall be, provided on the marshalling box, so as to enable reading of the temperature indicators without opening the door of the marshalling box

6.3.5 All cables from the bushing current transformers, Buchholz relay, magnetic oil level gauge, pressure relief device and, temperature indicators shall be run up to the marshalling box. The cables shall be of 1100 V grade, XLPE insulated, XLPE sheathed, steel wire armored, stranded copper conductor conforming to IEC 60502-1. The cables shall, be adequately insulated for heat from the tank surface and the sun.

6.3.6 All wiring in the marshalling box shall be clearly identified by lettered/figured ferrules of the interlock type, preferably of yellow colour with-black letters/figures. The ac and dc circuits shall be clearly distinguished and well separated from each other.

6.3.7 Suitable legend and schematic diagram plates made of anodised aluminium with black lettering and lines shall be fixed on the inside surface of the marshalling box door.

6.4 Core

6.4.1 The core shall be built-up of high permeability cold rolled grain oriented silicon steel laminations conforming to JIS C2553 or equivalent IS as indicated in Table No. 2.1-1. The flux density in any part of the core and yokes at the principal tapping with primary winding excited at the rated primary voltage and frequency shall not exceed either 1.55 T, when the tapped coils are on the secondary windings or 1.71 T when the tapped coils are on the primary windings. The successful bidder / manufacturer shall furnish calculations to prove that this value shall not be exceeded.

6.4.2 The lamination for the core shall be free from waves, deformations and signs of rust. Both sides of the laminations shall be coated with suitable insulation capable of withstanding stress relief annealing. In assembling the core, air gaps shall be avoided. Necessary cooling ducts shall be provided in the core and yoke for heat dissipation. The core clamping frame shall be provided with lifting eyes for the purpose of tanking and un-tanking the core and winding of the transformer.

6.4.3 The core shall be electrically solidly connected to the tank.

6.4.4 Design of the Core shall be boltless and it shall be tightened by binding the laminations using resin glass type. Core laminations shall be tested after completion of the core assembly to ensure that they withstand a voltage of 2 kV r.m.s with respect to core for duration of 60 seconds.

6.4.5 The transformer is required to be continuously in service, preferably without requiring any attention from the date of its energization, up to the periodical overhaul (POH), which is generally done after 10-12 years of service. The successful bidder/ manufacturer of the transformer shall, take this aspect into account during core assembly/manufacture and indicate measures taken by them to ensure suitable clamping to permit the above frequency and cover this in their instruction manual.

6.5 Windings

6.5.1 The winding shall be of disc/interleaved/inter-shield type for the primary and of disc/helical/cylindrical type for the secondary windings. The primary and secondary windings shall be uniformly insulated. The four terminals of both secondary windings of 'M' and 'T' phases shall be brought out separately through 54 kV OIP condenser bushings, for cascade connection externally. The QAP of the manufacturing process is to be submitted along with the bid.

6.5.2 The workmanship shall be of high quality in keeping with Good Engineering Practices and as for insulation, insulating materials of class A or higher should only be used.

6.5.3 No joint shall be used in the winding conductor, in principle, except for inter-leave joint.

6.5.4 Separate tapped coil shall be provided for either each primary winding or each secondary winding for connection of the manual off-circuit tap-changer. The tapped coils shall be distributed in multi-sections in order to reduce the imbalance in ampere turns to the minimum at any tap position.

6.5.5 Separate tapped winding shall be provided for each primary winding. The transformer windings shall be designed for the following rated withstand voltages:

	Item	Secondary	Primary
1	Highest voltage for equipment Um(kV)	52	245
2	Rated short duration power frequency withstand voltage (kV)	95	395
3	Rated lightning impulse withstand voltage (kV peak)	250	950

6.5.6 The windings shall be so designed that the transfer of lightning and switching surges from primary to secondary windings and vice-versa is kept to the minimum level.

6.5.7 The axial pre-compression on the windings shall not be less than the double the calculated axial thrust that may be set up under dead short-circuit condition so; as to ensure that the windings do not become loose due to frequent short circuits in service.

6.5.8 During short circuits, the stresses set up in conductors, spacers, end blocks, clamping, rings and such other parts of the transformer; shall not exceed one third of the maximum permissible values.

6.5.9 Pre-compressed spacers shall be used between disc shaped coils of the windings to transmit the axial forces generated due to the short circuits.

6.5.10 A uniform shrinkage shall be ensured during the drying of the individual coils or assembly of coils by providing a uniform clamping force with the help of hydraulic jacks or similar devices.

6.5.11 Inorder to keep unbalanced axial force due to non-uniform shrinkage/unequal height of the coils to the minimum, wedges of pre-compressed wood or similar such material shall be used.

6.5.12 The successful bidder/ manufacturer shall ensure that there is no further shrinkage of the coil assembly in any additional cycle after the final curing.

6.5.13 The separate winding compression structure suitable shall be provided apart from the core clamping structure in order to not causing any loose. The equal axial force compression system shall be applied on to each assembled windings throughout the drying process and fixing with the high tension self tightening structure to eliminate any loose unbalanced face due to non uniform shrinkage of windings. To prevent displacement of the radial spacers used in the windings, closed slots shall be provided.

6.5.14 The vertical locking strips and slots of the radial spacers shall be so designed as to withstand the-forces generated due to short circuits.

6.5.15 The vertical locking strips and radial spacers shall be made of pre-compressed pressboard conforming to grade PSP: 3052 of DIN 7733.

6.5.16 To prevent end blocks from shifting, pre-compressed pressboard ring shall be provided in between the two adjacent blocks. Coil clamping rings made of densified wood or mild steel shall be located in position with pressure screws.

6.5.17 Leads from the windings to the terminals, from the tap switch to the tappings of the primary windings and other interconnections shall be properly supported and secured.

6.5.18 The following particulars/ documents in respect of the radial spacer blocks (winding blocks), vertical locking strips (axial ribs), end blocks, insulating cylinder, angle rings, paper insulation of the conductor and coil clamping plates used in the manufacture of the windings shall be furbished.

1. Reference to specification-and grade of material.
2. Source(s) of supply,
3. Test certificates.

7. INSULATING OIL

7.1 The transformer shall be supplied with new insulating oil conforming to IEC60296. In addition, 10% extra oil by volume, shall be supplied in non-returnable steel drums. The characteristics of the insulating oil before energisation of service shall conform to IEC 60296.

8. BUSHINGS AND TERMINAL CONNECTORS

8.1 Both the primary and secondary side bushings shall conform to IEC 60137. On the primary, side, sealed draw lead type Oil Impregnated Paper (OIP) condenser bushings shall be used. On the secondary side, sealed solid stem type OIP condenser bushings shall be used.

8.2 The bushings shall have a non-breathing oil expansion chamber. The expansion chamber shall be provided with an oil level indicator, which shall be so designed and dimensioned that oil level is clearly visible from ground level.

8.3 A test tap shall be provided for dielectric or power factor measurement.

8.4 The bushings shall be designed for the following insulation level:

1	Highest voltage for equipment Um (kV)	52	245
2	Rated short duration wet power frequency withstand voltage (kV)	95	460
3	Rated lightning impulse withstand voltage (kV peak)	250	1050

8.5 Adjustable arcing horns shall be provided on both the primary and secondary bushings. The horn gap setting shall be variable as indicated below:

1.	Highest voltage for equipment Um, kV	52	245
2.	Horn gap setting variable between, mm	150 and 300	1200 and 1500

8.6 The design and construction of the bushing shall be such that stresses due to expansion and contraction in any part of the bushings shall not lead to its deterioration breakage. The bushings shall be free from corona and shall not cause radio interference.

8.7 The bushing terminals shall be provided with terminal connectors of bimetallic type and shall be such that there is no hot spot formation even during the extreme over load condition of ONAN rating with 200% over loading.

8.8 The terminal connectors shall conform to IS: 5561. The design shall be such as to be connected to the equipment terminal stud with a minimum of four 12 mm diameter bolts, nuts, spring and flat washers.

9. BUSHING TYPE CURRENT TRANSFORMERS

9.1 The 52 kV and 245 kV bushings shall be so arranged as to accommodate bushing type current transformers (BCTs) for the biased differential protection of the transformer. The BCTs shall conform to IEC 60044-1 and meet with the stipulations in Clause 5.1(20) of this document.

9.2 The BCTs shall be so designed as to withstand thermal and mechanical stresses resulting from frequent short circuits experienced by the transformer on which these are fitted.

9.3 Apart from the BCTs required for the biased differential protection, BCT of accuracy class 5 and conforming to IEC 60044-1, with suitable tappings, shall be mounted inside one bushing of the left-hand side (as viewed, from the. secondary; terminals, side) of each secondary winding 'M' and 'T' phases for use with the-winding temperature indicators.

9.4 The BCTs and the bushings shall be so mounted so that removal of a bushing can be achieved without disturbing the current transformers, terminals and connections or pipe work is easy and convenient.

9.5 The leads from the BCTs shall be terminated in terminal boxes provided on the bushing turrets. Suitable links shall be provided in the terminal boxes for shorting the secondary terminals of the BCTs, when not connected to the external measuring circuits.

9.6 The leads from the secondary winding of the BCT terminated in the terminal box on the bushing turret up to the marshalling box shall be of 1100 V grade, XLPE insulated, XLPE sheathed, steel wire armoured, stranded copper cable of cross section not less than 4 mm^2 to IEC 60502-1.

9.7 Cable glands of proper size shall be provided in the terminal boxes to lead in/lead out the cables.

10. CLEARANCES

10.1 The relative orientation in space of the bushings fitted with terminal connectors the main tank, radiators, conservator, pressure relief device, oil piping and other parts when mounted on the transformer shall be such that the various clearances in air from bushing live parts shall not be less than the appropriate values given here under:

1	Highest voltage for equipment Um(kV)	52	245
2	Minimum clearance (mm)	500	1900

The same distance shall apply for clearances phase-to-earth (including oil piping work, conservator, pressure relief device and such other parts), phase-to-phase and towards terminals of a lower voltage winding.

11. Manual OFF-LOAD TAP-CHANGER

11.1 The transformer shall be fitted with a manual off circuit tap-changer, to cater for the voltage, range specified in Clause 5.1(12) of this document. Visibility of the tap position should be such that display is legible from a distance of 6 m. The manual off circuit tap-changer shall be installed in a weather and corrosion proof adequately ventilated cubicle made of sheet steel not less than 2 mm thick with adequate stiffeners to prevent deformation during transit and handling. The cubicle shall have a sloping roof. The top of the cubicle shall be at a height of about 1.5 m from the rail level. The cubicle shall be so positioned that the hinge of the operating handle for manual operation is at a height of about 1.1 m from the rail level.

11.2 Suitable legend and schematic diagram plates made of anodised aluminium with black lettering and lines shall be fixed on the inside surface of the cubicle door.

11.3 A tap position indicator shall be provided to indicate the tap position which shall be clearly visible to an operator standing on the ground.

12. Cooling Equipment

12.1 The transformer shall be designed to be ONAN/ONAF. The transformer shall be designed such that in case of emergency feed extension, it shall be capable of delivering 40% more of the ONAN rating following the installation and commissioning of forced cooling.

12.2 The fans shall be designed with 50% redundancy.

12.3 The fans shall be fitted with fan failure alarms. These alarms shall be routed back to the marshalling box, for connection to the SCADA system. There shall be visual indication in the marshalling box as to which fan group has failed.

12.4 The radiators shall consist of a pressed steel plate assembly formed into elliptical oil channels as per IEEMA Standard. The radiators shall be designed in such a manner that the temperature-rise limits specified under Clause 5.1 (13) of this document are not exceeded.

12.5 The radiators shall be removable (after isolating the same from the main tank) to facilitate transportation of the transformer. A drain plug of size 19 mm and an air-release plug of size 19 mm shall be provided at the bottom and at the top of each radiator bank for draining and filling of oil respectively. Each radiator bank shall also be provided with shut-off valves. If radiators are supplied as a separate unit, then body bellows type flexible joints shall be provided on the oil headers.

12.6 The radiators shall preferable be supported directly on the transformer tank. Each radiator bank shall be fitted with lifting lugs.

13. Parts, Fittings and Accessories

13.1 Apart from the parts, fittings and accessories specifically detailed in the foregoing Clauses, the parts, fittings and accessories detailed hereunder shall be supplied with each transformer.

13.1.1 **Conservator Tank**: It shall be of adequate capacity and complete with supporting bracket or structure, oil filling cap and drain valve of size 25 mm. The cylindrical portion of the conservator tank shall be of single piece construction without any gasket joint.

13.1.2 **Oil Level Gauge**: It shall be of magnetic type having a dial diameter of 200 to 250 mm. The gauge shall have markings corresponding to minimum oil level, maximum oil level and oil level corresponding to oil temperature of 30oC, 45oC and 85oC. The oil level indicator shall be so designed and mounted that the oil level is clearly visible to an operator standing on the ground. The oil level gauge shall be fitted with two SCADA readable contacts. The first contact shall provide a warning that the oil level is at 25% above the minimum level. The second contact shall indicate when the minimum oil level has been reached.

13.1.3 **Silica Gel Breather**: It shall be complete with oil seal and connecting pipes. The connecting pipes shall be secured properly. The container of the silica gel breather shall be of transparent flexi glass or similar material suitable for outdoor application.

13.1.3.1. Orange silica gel (round balls 2 to 5 mm) with quantity of two DT-8 silica gel connecting with flanged mounting two pipes control through different valves as per DIN: 42567 & IS: 6401 to be provided.

13.1.4 **Pressure Relief Device**: It shall operate to release internal pressure at pre-set value without endangering the equipment or operator and shall be of instantaneous reset type. There shall be two pressure sensor installed with the pressure relief valve. The first sensor shall provide indication that pressure within the transformer has increased to a point 25% below where the pressure relief device will operate. The second sensor shall indicate when the pressure within the transformers has become unacceptable. Both sensors shall have two contacts that can be read by the SCADA system.

13.1.4.1. Shroud Pressure Relief Device will be used and have provision of discharge of oil from PRD to safe place by closed pipeline. This avoida hazards of fire and it is safe to persons working near Transformer & it is environment friendly.

13.1.5 **Filter Valves**: The bottom and upper filter valves shall be of 50 mm size and suitably baffled to reduce aeration of oil. The valves shall be flanged to seat 40 mm adopter threaded to thread size P 1-1/2 for connection to oil filtration plant.

13.1.6 **Drain Valve**: It shall be of size 80 mm fitted with an oil sampling device of size 15mm.

13.1.7 **Earthing Terminals**: Two earthing terminals of adequate size shall be provided on the tank for its earthing with the help of 3 mild steel flats, each of size 75 mm x 8 mm. The terminals shall be clearly marked for earthing.

13.1.8 **Buchholz Relay**: It shall be of double float type, with two shut-off valves of 80 mm size, one between the conservator tank and the Buchholz relay and the other/between the transformer tank and the Buchholz relay. The relay shall have one alarm contact and one trip contact, none of the contacts being earthed. The contacts shall be of mercury/micro switch type, electrically independent and wired up to the marshalling box. A testing petcock shall be brought down through a pipe for the purpose of sampling the gas, if any, collected in the Buchholz relay.

13.1.9 **Oil temperature indicator (OTI)**: It shall have one alarm contact, one trip contact and two normally open spare contacts none of the contacts being earthed. The contacts shall be electrically independent.

13.1.10 **Winding temperature indicator (WTI)**: Two WTIs shall be provided, one for the M-phase and the other for the T-phase. Each WTI shall have one alarm contact, one trip contact and two normally open spare contacts, none of the contacts being earthed. The contacts shall be electrically independent.
The windings shall also be fitted with analogue temperature sensors/thermistors/optical sensors that are suitable for being remote read via the SCADA system.

13.1.11 **Thermometer Pockets**: A separate thermometer pocket with cap shall .be provided on the tank for measuring the top oil temperature in the tank. The thermometer shall indicate hot spot temperature.

13.1.12 **Rating Plate**: The rating plate shall indicate the following:

- The ratings of the transformer
- The connection diagram of the windings
- The particulars of the bushing current transformers
- Weight without oil
- Weight with oil
- Kind of transformer (I.e. Scott Connected traction transformer)
- Manufacturer
- Date of manufacture
- Serial number

- Rated Voltages in (kV) and tapping range
- Rated primary and secondary currents
- Short circuit impedance
- Type of cooling
- Other details as per IEC 60076-1.

The rating plate shall be both in English and Hindi version.

13.2 All valves shall be of the double flange type and fitted with suitable blanking plates on the outer face of the exposed flange.

13.3 The capillary tubes for temperature indicators shall be able to withstand normal bending. They shall be supported properly without sharp or repeated bends or twists.

13.4 Fibre Optic Hot Winding Temperature Monitor:

Fibre optical winding hot spot temperature monitor to be provided with the transformer windings, connected in addition to the winding temperature indicator in parallel to measure transformer winding hot spots in real time and activate control of the cooling system. The fibre to be given high strength casing through rugged jacketing and fibre to be securely routed till the tank wall plate. The application of fibre optic shall be governed by IEC-60076-2 (Ed. 3.0).

<u>Specification for Fibre Optic Temperature Measurement System</u>

Fibre optic based temperature measurement of Oil and windings shall be done using Fibre Optic Sensors meetings following broad criteria:

13.4.1 System shall be of proven technology. The temperature sensing tip of the fiber optic shall be ruggedized. The probes shall be directly installed in each winding of power transformer to measure the winding hot spot and at the top oil temperature. There shall be at least 4 probes inside the transformer.

13.4.2 Out of the 4 probes one probe shall be used for top oil temperature measurement and the balance 3 will be placed in the LV, HV and Tap Changer winding (One probe per winding) of one limb.

13.4.3 Probes shall be able to be completely immersed in hot transformer oil. They shall withstand exposure to hot vapour during the transformer insulation drying process, as part of Vacuum Phase Drying (VPD). The probes shall meet the requirement to eliminate the possibility of partial discharge in high electric stress areas in the transformer. Probes shall preferably have certified Weidman testing for electrical parameters as per ASTM D-3426 and ASTM D-149 that is current (no more than 1 year old). Test results and studies to be submitted by the transformer manufacturer along with the first unit of a certain type of traction power transformer.

13.4.4 Temperature range of the system should be up to +200°C without any need of recalibration. Probes must connect to the tank wall plate with threaded connectors containing a Viton O-ring to prevent against oil leakage.

13.4.5 Probes shall be of material inert to mineral and ester oils, multiple jacketed (Kevlar preferred), perforated out jacket to allow complete oil filling and mechanical strength.

13.4.6 System should include analog outputs for each measurement channel. Temperature resolution of the analog outputs shall be ±0.1℃ and precision of ±0.5℃ and the system shall offer user programmable temperature alarm outputs with 8 relays. The cooling system (Fans & Pumps) should be operated through these relays. The temperature settings for the relays shall be made as per the end-user request.

13.4.7 All inputs and outputs of the system shall meet the requirements of surge test of IEEE C37.90.1-2002 in which a 4000 V surge is applied to all the inputs and outputs without permanent damage to the instrument. The system should electronically store testing records of components and allow for on board diagnostics and instructions, including a signal strength reading to verify integrity of fiber optic connections. System should contain a battery for date/time stamp of data readings. The system should comply with IEC61850 protocol, along with DNP 3.0, Modbus, TCP/IP and ASCII.

13.4.8 The transformer manufacturer should submit details showing that the probes are located in the hottest point of the winding, while submitting drawings for approval. The manufacturer are free to use more than 4 probes if design so required.

13.4.9 The controller shall be housed in cooler cubicle or in a separate enclosure having ingress protection IP 56.

13.4.10 Temperature Rise Test Measurements shall be made with the Fiber Optic Thermometers.

The equipment shall be operational during temperature tests and be demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified and temperature data for all probes recorded and reported in the test report.

13.5 The manufacturers of Part, Fittings & Accessories for the transformer shall be mentioned in the SOGP/BOM & got approved. During prototype test, the accessories will be tested & performance monitored by either at Customer Hold Point (CHP) or by Test Certificate (TC) Verification as categorised in Annexure 6.

Henceforth, while ordering Traction Power Transformer, a copy of Employer approved SOGP should be called by the users. This document shall form basis for ordering accessories in the future.

In case manufacturers desire to change a particular make of accessory, prior approval of Employer would be required and SOGP as well as Bill of Material (BOM) shall have to be got approved from Employer.

In case of make of accessories approved under Customer Hold Point (CHP) for regular production, the Employer's approval would be required separately on SOGP and BOM. The Traction Power Transformer manufacturer shall be responsible for availability of compatible accessories for the equipment approved.

14. Fasteners

14.1 All fasteners of 12 mm diameter and less exposed, to atmosphere shall be of stainless steel and those above 12 mm diameter shall preferably be of stainless steel or of, mild steel hot dip galvanised to 610g/m of zinc. The material of the stainless steel fasteners shall conform to IS: 1570 (Part-V), Grade 04Cr17Ni12Mo2 or equivalents

15. PAINTING

15.1 Shot blasting/ sand blasting shall be done on the transformer tank to remove all scales rust and other residue, before applying the paint inside the tank. All steel surfaces which are in contact with insulating oil shall be painted with heat resistant oil-insoluble insulating varnish. All steel surfaces exposed to weather shall be given, one primer coat of zinc chromate and two coats of anti corrosion grey paint. The touch-up of gray paint shall be applied at site by, the manufacturer.

16. TESTING OF TRANSFORMER

16.1 General

16.1.1 The designs and drawings of transformer together with detailed calculations & the Quality Assurance Plan (QAP) shall be furnished to the employer, within the period stipulated in the contract. Only after all the designs and drawings as well as the QAP have been-approved for prototype tests and a written advice given to that effect, shall the successful bidder/manufacturer take up manufacture of the prototype of the transformer. It is to be clearly understood that any change or modification required by the above authorities to be done in the prototype shall be done expeditiously, not withstanding approval having already been given for the, designs and drawings. Such change or modification shall be incorporated in the drawings.

16.1.2 Prior to giving a call to the Employer for inspection and testing of the prototype, the successful bidder/manufacturer shall submit a detailed test, schedule consisting of schematic circuit diagrams, for each of the tests and the number of days required to complete all the tests at one stretch. Once the schedule is approved, the tests shall invariably be done accordingly. In case any dispute or disagreement arises between the successful bidder/manufacturer and representative of the Employer during the process of testing as regards the procedure for type tests and/or the interpretation and acceptability of the results of type tests, it shall be brought to the notice of the Employer, as the case may be, whose decision shall be final and binding. Only after the prototype transformer is completed and ready in each and every respect, shall the successful bidder/manufacturer give the actual call for the inspection and testing.

16.1.3 The type tests shall be carried out on the prototype transformer at the works of the successful bidder/manufacturer or at reputed testing laboratory in the presence of the representative of the Employer, in accordance with the relevant specifications and as modified or amplified by this document.

16.2 Tests during manufacture

16.2.1 Though the tests described below shall form part of the type tests, the manufacturer shall carry out these tests on each unit during the process of manufacture and submit the test reports to the Employer deputed for witnessing the routine tests:

- Oil leakage test.

- Vacuum test.
- Pressure test.
- Test for pressure relief device.
- Measurement of capacitance and tan-delta values.

16.2.1.1 **Oil Leakage Test**: The transformer with its radiators, conservator tank and other parts, fittings and accessories completely, assembled shall be tested for oil leakage by being filled with oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure corresponding to twice the normal static oil head or to the normal static oil head plus 35 kN/m^2 (0.35 kgf/cm^2) whichever is lower, the static oil head being measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hr, during which time no leakage shall occur.

16.2.1.2 **Vacuum Test**: The transformer tank only shall be tested at a vacuum of 3.33 kN/m^2 (0.0333 kgf/cm^2) for 60 min. The permanent deflection of flat plates after release of vacuum shall not exceed the values specified below:

Horizontal length of flat plate	Permanent deflection (mm)
Up to and including 750mm	5.0
751mm to 1250mm	6.5
1251mm to 1750mm	8.0
1751mm to 2000mm	9.5
2001mm to 2250mm	11.0
2251mm to 2500mm	12.5
2501mm to 3000mm	16.0
Above 3000mm	19.0

16.2.1.3 **Pressure Test**: Every transformer tank, radiator and conservator tank shall be subjected to an air pressure corresponding to twice the normal static head of oil or to normal static oil head pressure plus 35 kN/m^2 (0.35 kgf/cm^2) whichever is lower as measured at the base of the tank. The pressure shall remain constant for 1 hour to indicate that there is no leakage.

16.2.1.4 **Test of Pressure Relief Device**: Every pressure relief device shall be subjected to gradually increasing oil pressure. It shall operate before the pressure reaches the test .pressure specified in Clause 16.2.1.3 hereof and the value; at which it has operated shall be recorded.

16.2.1.5 **Measurement of capacitance and Tan-Delta values**: The measurement of capacitance and tan-delta (dielectric loss factor) of the transformer windings shall be made by Schering Bridge.

16.3 Type Tests

16.3.1 General

The type tests shall be carried out on' the prototype transformer at the works of the successful bidder/manufacturer or at any reputed laboratory in the presence of the representative of the Employer and in accordance with the relevant specifications and as altered, amended or supplemented by this document. Amongst others, the following shall constitute the type tests:

1) Temperature-rise test

2) Lightning impulse test.
3) Test with lightning impulse stopped on the tail
4) Short circuit test.
5) Measurement of acoustic sound level.
6) Measurement of partial discharge quantity.
7) Measurement of harmonics of no-load current.

16.3.2 **Temperature-rise test**:

16.3.2.1. The temperature rise test shall be done with the tap changer on the lowest tap position (-15%). in accordance with IEC60076-2 except as modified hereunder.

1	At rated load
2	At 150% rated load for 15min after continuous operation at rated load for 1hr.
3	At 200% rated load for 5 minutes after continuous operation at rated load for one hour.

The tests shall be undertaken at transformers ONAN as well as on ONAF. The tests shall be done continuously without any power supply interruption. In case interruptions of power supply do take place for some reason, then the entire test shall: be repeated after steady state conditions are attained.

16.3.2.2. The points to be ensured during the temperature rise test shall be:

1	The ambient temperature shall be measured using calibrated thermometers only
2	The winding temperature shall be determined by the resistance method only.
3	The temperature of the top oil shall be measured calibrated thermometer placed in an oil-filled thermometer pocket.
4	The average oil temperature shall be calculated as the difference between the top oil temperature and half the temperature drop in the cooling equipment (radiators)
5	The temperature of the hot-spot in the winding shall be the sum of the temperature of the top oil and 'H' times the temperature rise of the winding above the average oil temperature, where 'H' is the hot spot factor as per IEC 600076-2 and 60076-7.

16.3.2.3. The test shall be carried out as described below:

16.3.2.3.1. **100% load**

1	A quantum of power equal to the sum of the measured losses viz. no-load and load losses measured at minus 15% tap position,/corrected to 75^0C plus 10% of such sum shall be fed to the primary winding of the, transformer with the secondary windings short-circuited.
2	The power so fed to the transformer shall be continuously maintained till such time as the steady stats temperature is reached i.e. the top oil temperature

	rise does not vary by more than 1^{0}C during four consecutive hourly readings
3	On attaining the steady state temperature, the current in the primary winding of the transformer shall be brought to the rated current which shall-be maintained for one hour. At the end of the period the power supply to the transformer shall be switched of and the time of Switching off recorded
4	The measurement of resistance shall commence as soon as is possible after switching off. The first reading of the resistance shall be taken as soon as possible, before the expiry of 90 seconds from the instant of switching off and the first ten readings shall be taken at intervals of l5s apart. Thereafter, another ten readings shall be taken at intervals of 30s apart.
5	The time at which each of the resistance values is read shall also be recorded.
6	The temperatures of the ambient, top oil, the top and bottom radiator header oils shall also be recorded at half-hourly intervals throughout the test starting from the instant power supply is; switched on to commence the if test till it is switched off.
7	The WTI and OTI readings shall also be recorded at half hourly intervals right from the instant the power supply is switched on to commence the test till it is switched off
8	After power supply is switched off the readings of OTI and WTI shall be recorded at intervals of 1 min apart for 30 min

16.3.2.3.2. **150% load**

1	After completion, of the test at 100% load, the transformer shall be fed with power which shall be a value so as to cause circulation of the rated current in the primary, winding with secondary windings short circuited. This current shall be circulated for 1h.
2	The current shall thereafter be increased to 150% of the rated current and maintained-for a" period of 15min. At the end of the 15 min period the power supply shall be switched off and the time of switching off recorded.
3	Thereafter the readings as indicated in Clause 16.3.2.3.1(4) to (8) shall be recorded.
4	The temperatures of ambient, top oil, the top and bottom radiator header oil and the temperatures indicated by OTI and WTI shall also be recorded at the time of switching on 150% load as well as at the time of switching off the power supply.

16.3.2.3.3. **200% Load**

1	After completion of the test at 150% load, the transformer shall be fed with power which shall be a value so as to cause circulation of rated current in the primary with the secondary windings short circuited. This current shall be circulated for 1hour.
2	The current shall thereafter be increased to 200% of the rated current and be maintained for 5minute period. At the end of the 5minute period the power supply shall be switched off and the time of switching off recorded.
3	Thereafter the readings as indicated in clause 16.3.2.3.1(4) to (8) shall be

	recorded.
4	The temperatures of ambient, top-oil, top and bottom radiator header oils and temperatures indicated by OTI and WTI shall also be recorded at the time of switching on the 200% load as well as the time of switching of the power supply.

16.3.2.4. **Determination of thermal time constant of the windings**: The thermal time constant of the primary and secondary windings under both rated load and overloads shall be verified during the temperature rise tests. This test shall be completed for ONAN and ONAF rating.

16.3.2.5. The temperature rise of the oil, windings and current carrying parts in air under both the overload conditions stipulated in clauses 16.3.2.3.2 and 16.3.2.3.3 above shall not exceed the values stipulated in clause 5.1(13) of this document. The windings hot-spot temperature under the overload conditions shall not exceed 115 ^{0}C.

16.3.2.6. **Testing and calibration of the temperature indicators**: The functioning of the OTI and WTI shall be verified during the tests described above. Both the OTI and WTI shall be recalibrated, where necessary, to reflect the respective temperatures correctly. In particular, the reading of the WTI shall be the same as the calculated value of the hot-spot temperature of the winding.

16.3.2.7. **Determination of the thermal time constant of the WTI**: The thermal time constant of the WTI shall be determined for comparison with the thermal time constant of the windings of the transformer, with respect to the transformer oil. For this purpose, the indications of the WTI and the OTI shall be recorded every minute during the first 1 hour from the instant the transformer is loaded. From the slope of the curve plotted with time on the x-axis and the difference between the readings of the WTI and the OTI at particular time on the y-axis, the thermal time constant of the WTI shall be determined.

16.3.3 **Lightning Impulse Test**

16.3.3.1. This test shall be done in accordance with IEC 60076-3. Each of the terminals of the primary and secondary windings shall be tested with the following:

1	Highest voltage for equipment Um (kV)	52	245
2	Lightning impulse withstand voltage (kV peak)	250	950

16.3.4 Test with lightening impulse, chopped on the tail

16.3.4.1 This test shall be done in accordance with IEC60076-3 with appropriate test voltage as stipulated in Clause 16.3.3.1 above.

16.3.5 **Short Circuit Test**

16.3.5.1 The short circuit test shall be conducted in accordance with IEC 60076-5 with the following schedule:

1. Insulation resistance of the windings with respect to the earth and the windings.
2. No load current
3. No load loss

4. Resistance of windings
5. Percentage impedance voltages.
6. Load loss
7. Voltage ratio
8. Di-electric test comprising:
   - Separate source voltage withstand test
   - Induced over voltage withstand test
9. Recording of Surge frequency Response Analysis (SFRA) at the highest (+10%), lowest (15%) and principal tapping as per IEC 60076-18.

16.3.5.2 The test will be done with secondary side short-circuited and energizing the primary side of the transformer at its rate voltage.

16.3.5.3 The transformer shall be subject to a total of seven shots in the following sequence:

1st Shot	Asymmetrical and symmetrical currents in M-phase and T-phase respectively at highest tap (+10%)
2nd Shot	Symmetrical and asymmetrical currents in the M-phase and T-phase respectively at the highest tap (+10%)
3rd Shot	Asymmetrical and symmetrical currents in M-phase and T-phase respectively at principle tap
4th Shot	Symmetrical and asymmetrical currents in the M-phase and T-phase respectively at the principle tap
5th Shot	Asymmetrical and symmetrical currents in M-phase and T-phase respectively at lowest tap (-15%)
6th Shot	Symmetrical and asymmetrical currents in the M-phase and T-phase respectively at the lowest tap (-15%)
7th Shot	Symmetrical currents in M-phase and T-phase at lowest tap (-15%)

16.3.5.4 The duration of each shot shall be 0.25s as per IEC 60076.

16.3.5.5 Measurements shall be done after each shot for the following:

1	Percentage impedance voltage
2	No-load current
3	No-load loss

16.3.5.6 Further testing and inspection of the transformer subjected to the short-circuit test shall be carried out as per IEC 60076-5 with the modification that:

1	The dielectric routine tests shall be at 100% of the original test value
2	The percentage impedance voltages measured after the short circuit test shall not vary by more than 2% from those measured before the sort circuit test.

16.3.5.7 On completion of the short circuit test the transformer shall be un-tanked for inspection of the core and windings. In case the inspection of the core and windings do not reveal any apparent defects and the results of the short circuit test, the values of percentage impedance voltages as also the results

of the route tests done after the short circuit test are in order the transformer will be deemed to have passed the short circuit.
If any of the results of the tests are not in order or the inspection of the core and winding reveals any defects, then the transformer shall be dismantled for detailed inspection.

16.3.6 **Measurement of acoustic sound level**

16.3.61 Measurement of acoustic sound level of the transformer energized at rated voltage and frequency shall be carried out either as per Indian Electrical Rules & IEC60076-10.

16.3.7 **Measurement of Partial discharge quantity**

16.3.7.1 Partial discharge quantity of the windings shall be measured in accordance with IEC 60076-3.

16.3.8 Measurement of harmonic of no-load current.

16.3.8.1 The magnitude of harmonics of no-load current, as expressed in percentage of the fundamental, shall be measured by means of a harmonic analyser, in accordance with IEC 60076-1.

16.3.9 **Test with lightening impulse, chopped on the tail**:

16.3.9.1 This test shall be done in accordance with IEC 60076-3 with appropriate test voltage as stipulated in Clause 16.3.3.1 above.

16.4 Type tests on parts, fittings and accessories

16.4.1 **General**

16.4.1.1 Though there are no Indian Standards Specifications at present for manual off-circuit tap-changer, the following test shall be carried out thereon in accordance with IEC 60214.

16.4.1.2 **Tests for temperature rise of contacts**: The test shall be carried out at rated current of 1250A. The temperature rise shall not exceed the limit specified in IEC 60214.

16.4.1.3 **Mechanical endurance test**: With the tap changer in oil, 1000 operations shall be done manually. An operation shall comprise moving the tap changer from one tap position to the next higher or low tap position. All the taps of the tap changer i.e. 10% position tap through to the 15% tap shall be covered during the test.

16.4.1.4 **Milli Volt drop tests**: The test shall be done both before and after the mechanical endurance test to access the condition of contacts. The variation in millivolt drop values shall not be more that 20%.

16.4.1.5 **Short Circuit current test**: The test shall be done in accordance with IEC60214 with short circuit currents of 4 kA r.m.s, each 5s duration.

16.4.1.6 **Dielectric tests**: The test shall be done in accordance with IEC 60214.

16.4.2 **Condenser Bushings**

16.4.2.1 The type tests shall be carried out in accordance with IEC 60137 on porcelain housing of the condenser bushings. The following shall constitute the type test:

1. Visual inspection
2. Verification of dimensions

3. Electrical routine test
4. Porosity test
5. Temperature cycle test
6. Bending test

16.4.2.2 The type tests shall be carried out in accordance with IEC 60137 on prototype of the condenser bushing. The following shall constitute the type test:

1. Wet power frequency withstand voltage test
2. Dry lightning impulse voltage test
3. Thermal stability test
4. Temperature rise test
5. Thermal short time current withstand test
6. Dynamic current withstand test
7. Cantilever load withstand test
8. Tightness test
9. Test of tap insulation
10. Tightness at flange or other fixing device
11. Measurement of partial discharge quantity.

16.4.3 **Bushing type current transformers**

16.4.2.1 The bushing type current transformers shall be tested in accordance with IEC60044-1.

16.4.4 **Buchholz relay**

16.4.4.1 The Buchholz relay shall be tested in accordance with IS: 3637

16.4.5 **Terminal connector**

16.4.5.1 The terminal connectors shall be tested in accordance with IS: 5561

16.4.6 **Temperature indicators**

16.4.6.1 The following tests shall be conducted on prototypes of OTI and WTI:

1	Accuracy with reference to a standard instrument
2	Calibration of the indicators to reflect the actual temperature of the oil/ windings
3	Dielectric test at 2.5kV for 60s.
4	Vibration test.
5	Dust and water splash test to IP55 degree of protection.

16.4.7 **Pressure Relief Device**

16.4.7.1 The following tests shall be conducted on the prototype of the pressure relief device:

1. Air pressure test.
2. Leakage test
3. Contact rating and operation test
4. Dielectric test on contacts at 2.5 kV for 60s.

16.4.8 **Radiators**

16.4.8.1 The radiators shall be tested for air leakage at a pressure of 2.5 kg/cm^2. The pressure shall remain constant for 1h to indicate that there is no leakage.

16.5 Insulating Oil

16.5.1 The following tests shall be carried out in accordance with IEC60296 on the sample of new insulating oil for use in the prototype transformer:

1. Density at 27 ^{0}C
2. Kinetic viscosity at 27 ^{0}C
3. Interfacial tension at 27 ^{0}C
4. Flash point.
5. Neutralisation value (acidity)
6. Electric strength (with 2.5mm gap)
7. Dielectric dissipation factor (tan-delta)
8. Specific resistance at 27 ^{0}C and at 90 ^{0}C
9. Oxidation stability
10. Water content.

16.6 Routine tests

16.6.1 The following routine tests shall be undertaken on each transformer including the prototype unit in accordance with IEC 60076-1:

1. Visual examination
2. Insulation resistance measurement
3. Measurement of no load current
4. Measurement of no load loss
5. Measurement of resistance of the windings
6. Measurement of percentage impedance voltages
7. Measurement of load loss
8. Polarity test
9. Voltage ratio test.
10. Dielectric tests comprising:
    - Separate-source voltage with stand test
    - Induced over voltage with stand test.
11. Recording/ submission of SFRA as per IEC 60076.
12. Recurrent Surge Oscillogram (RSO) Test

16.6.2 **Visual examination**: A general examination shall be made to check that the transformer conforms to the approved drawings, various items are accessible for maintenance, the quality of workmanship and finish are of acceptable standards and all parts, fittings and accessories\are provided.

16.6.3 **Insulation resistance test**: The insulation resistance of the windings with respect to the earth and between the windings shall be measured using a 5 kV Megger.

16.6.4 **Measurement of no-load current**: Measurement, load current referred to the primary side shall be done at:

1. 90%, 100% and 110% of the rated voltage at the principal tapping, and

2. The appropriate tap voltage at the +10% and -15% tap positions.

16.6.5 **Measurement of no-load loss**: Measurement of no-load loss referred to the primary, side shall be done at:

1. 90%, 100% and 110% of the rated voltage at the principal tapping, and
2. The appropriate tap voltage at the +10% and -15% tap positions.

16.6.6 **Measurement of resistance of windings**: The resistance of the windings shall be measured at all tappings and computed at 75^0C.

16.6.7 **Measurement of percentage impedance voltages**: The percentage impedance voltages at 'principal', +10% tap and -15% tap positions shall be measured at rated current and at ambient temperature and computed at 75^0C.

16.6.8 **Measurement of load loss**: Load losses at rated current shall be measured at principal, +10% and -15% tap positions at ambient temperature and computed at 75^0C.

16.6.9 **Polarity test**: The polarity (subtractive) and marking of the terminals for the polarity shall be verified.

16.6.10 **Voltage ratio test**: Voltage ratio shall be measured at all tap positions.

16.6.11 **Dielectric tests**:

16.6.11.1 **Induced over voltage withstand test**: The test shall be done by applying the test voltage across the entire secondary winding as per IEC 60076-3.

16.6.12 **Separate source voltage withstand test**: The test voltage to be applied as under:

1	Highest voltage for equipment Um (kV)	52	245
2	Rated short duration power frequency withstand voltage (kV)	95	395

16.6.11.2 Recording of Surge Frequency Response Analysis (SFRA) as per IEC 60076-18.

16.6.13 **Tests on off-load tap-changer**: The tests shall be conducted in accordance with IEC 60214.

16.6.14 During the routine tests of any unit if it is found that the sum of the measured losses (i.e. no-load and load losses) measured at the principal tapping (corrected to 75^0C) exceeds the maximum guaranteed value defined in Clause 5.1 (14), the transformer shall be rejected.

16.7 If the prototype of a transformer conforming to this document and rating has already been approved in connection with previous supplies to Indian Railways, fresh type testing may be waived at the discretion of the Employer, provided that no changes whatsoever in the design or materials used or the process of manufacture have been made.

However, the Employer reserves the right to conduct type tests, if he deems, it necessary to do so in the light of experience gained from previous supplies.

16.8 Only after approval of the original tracings of drawings incorporating changes, if any, as a result of the prototype tests and clear written approval of the results of. the tests on the prototype is communicated by the Employer, to the successful bidder/manufacturer, shall he take up bulk manufacture of the transformer which shall be strictly with the same materials and process of manufacture as adopted for the prototype. In no circumstances shall materials other than those approved in -the design/drawings and/or during the prototype testing be used for bulk manufacture-on the plea that they had been obtained prior to the approval of the prototype.

16.9 The bidder may quote his charges for short-circuit and temperature rise tests. No charges shall be payable, for any other type and routine tests.

16.10 Transformer before dispatch should be filled with Nitrogen/ dry air and provided with a gauge clearly visible for monitoring the pressure inside the tank.

17. TECHNICAL DATA

The following shall be furnished by the Tenderer:

17.1 **Calculations for**:

1. Temperature rise of winding at rated current.
2. Hot-spot temperature of the winding at 150% and 200% rated loads for 15 min and 5 min respectively.
3. Thermal withstand capacity of the windings for a short circuit of 5 s duration.
4. Mechanical forces in respect of the following as per IEEMA (Indian Electrical & Electronic Manufacturer's Association) formulae:
   a) Asymmetrical short-circuit current.
   b) Hoop stress in primary and secondary windings.
   c) Compressive pressure in the radial spacers.
   d) Internal axial compressive force.
   e) Axial imbalance force.
   f) Radial bursting force.
   g) Resistance to collapse.
   h) Bending stress on clamping ring and densified wood.
   i) Maximum allowable torque on pressure screws for coil clamping bolts at the time of tightening, if any.
5. Flux density with the characteristic curve.
6. Maximum value of inrush current.

17.2 **Drawings for**:

1. Outline general arrangement drawing giving complete details of the transformer.
2. Arrangement of the core, windings and magnetic path.
3. Magnetizing characteristic of CRGO sheet steel.

17.3 The successful bidder/ manufacturer shall submit to employer for approval the following detailed dimensioned drawings as per Indian Railways standard in sizes of 210 mm x 297 mm or any integral multiples thereof.

1. Outline general arrangement of the transformer indicating plan, front elevation, side elevation with all parts, fittings and accessories, electrical, clearances as well as salient guaranteed particulars.
2. Internal arrangement of the transformer indicating primary and secondary bushing lead connections, core to clamp to core-base bolting, and the locking arrangement of the core assembly with the tank.
3. Cross sectional view of the core and windings with material specifications and makes.
4. Detail of the pressure screws/oil dash-pot/coil clamping bolts or other devices and their location with materials specification.
5. Schematic view of the valves used on the transformer and the anti theft device so as to prevent theft of oil.
6. Transport outline dimensions.
7. General arrangements of the odd-circuit tap changer assembly with salient technical parameters.
8. Tap changer cubical layout.
9. Schematic diagram for driving of manual off circuit tap changer via SCADA.
10. Name and rating plate of manual off circuit tap changer.
11. General arrangement of marshalling box indicating protection and control equipment.
12. Wiring diagram of the marshalling box.
13. Schematic diagram of protection and control circuits in marshalling box with cable schedule.
14. Legend plate showing protection and control circuits for fitment into the marshalling box.
15. OIP condenser bushing for primary side including cross-sectional view, shed profile and salient electrical and mechanical characteristics.
16. OIP condenser bushing for secondary side including cross-sectional view, shed profile and salient electrical and mechanical characteristics.
17. Dimensional drawing, V-I characteristic and rating plate for bushing type current transformers.
18. Rigid terminal connectors for primary side bushing terminal
19. Rigid terminal connectors for secondary side bushing terminal
20. Rating plate with diagram of connections, both in English and Hindi versions.
21. Details of radiators
22. Details of breather
23. External cable-run with cable schedule.
24. Any other drawings which the successful bidder considers necessary.

17.4 After approval, six copies of each of the approved drawings along with two sets of reproducible prints for each drawing shall be supplied to each consignee(s).

17.5 Two copies of the “Operations and Maintenance manual” for each transformer shall be supplied to the consignee(s) two copies of the manual shall be supplied to the employer.

18. Capitalisation of Transformer Losses

18.1 The traction transformers shall be low loss type. The value of losses shall be guaranteed. The formula given in Clause 6.6 of the Particular Specification shall be used for the purpose of calculating the present worth of the transformer after taking into account capitalization of its losses, when comparing different bids capitalized cost of the losses in the transformer shall be added to the bid value for total quantity of transformers required for this Project in the lump sum form for evaluation purposes.

19. Spares

19.1 The bidder shall supply the following essential spares for every lot of up to 5 transformers or part thereof:

1. One primary bushing complete with parts, fitting and bushing type current transformer.
2. One secondary bushing complete with parts, fitting and bushing type current transformer.
3. One complete set of gaskets of all sizes required for use in the transformer.
4. One breather unit with silica gel.
5. One piece of radiator.
6. This clause left blank
7. One each of terminal connectors for primary and secondary side bushing terminals
8. One set of valves
9. One pressure relief device.

20. ERECTION, TESTING AND COMMISSIONING

20.1 The transformer shall be erected and commissioned by the successful bidder. The manufacturer shall invariably make available at site the services of an engineer of his to ensure, by his continued presence, that the process of erection, testing and commissioning of the transformer is in accordance with established and recommended practices. For this purpose, prior intimation regarding the dates/period and locations at which the transformers are to be erected and testing/commissioning done shall be given by the bidder to the manufacturer.

21. SCHEDULE OF GUARANTEED PERFORMANCE, TECHNICAL AND OTHER PARTICULARS (GUARANTEED PARTICULARS ARE TO BE ESTABLISHED BY ACTUAL TESTS/ TEST REPORTS)

SN		DESCRIPTION	UNIT OF MEASUREMENT	VALUE/ INFORMATION
1		2	3	4
A		**RATINGS/PARTICULARS**		
1.		Name of the Manufacturer		

2.		Country of manufacture		
3.		Reference to specification based on which performance data is prescribed		
4.		Rated power	MVA	
5.		Primary current at:		
		a) Rated load	A	
		b) 150% rated load for 15 min	A	
		c) 200% rated load for 5 min	A	
6.		Secondary current at:		
		a) Rated load	A	
		b) 150% rated load for 15 min	A	
		c) 200% rated load for 5 min	A	
7.		Rated voltage :		
		a) Primary	kV	
		b) Secondary (at no-load)	kV	
8.		Rated frequency	Hz	
9.		Temperature rise above ambient temperature of 50 ^{0}C :		
	(i).	Oil :		
		a) At rated load	^{0}C	
		b) At 150% rated load for 15 min	^{0}C	
		c) At 200% rated load for 5 min	^{0}C	
	(ii)	Winding :		
		a) At rated load ^{0}C		
		b) At 150% rated load for 15 min.	^{0}C	
		c) At 200% rated load for 5 min	^{0}C	
10		Hot-spot temperature of winding over ambient temperature of	^{0}C	
		a) At rated load	^{0}C	
		b) At 150% rated load for 15 min.	^{0}C	
		c) At 200% rated load for 5 min	^{0}C	
		Interval of time between two successive overloads after continuous working at full load, at maximum ambient temperature of 50℃:		
		a) Between two consecutive over min.	min.	

		loads of 50% for 15 min		
		b) Between two consecutive min overloads of which one is of 50% for 15 min and the other of 100% for 5 min.	min.	
12		No-load current referred to primary side at rated frequency and at:		
		a) 90% rated voltage A		
		b) Rated voltage A		
		c) 110% rated voltage A		
13		Power factor of no-load current at rated voltage and rated frequency		
14		Value of the inrush current at rated voltage on primary side, the secondary side being open circuited		
15		Losses:		
	(i)	No-load loss at rated frequency and at:		
		a) 90% rated voltage at the principal tapping.	kW	
		b) rated voltage at the principal tapping.	kW	
		c) 110% rated voltage at the primary tapping.	kW	
		d) Appropriate voltage at the 15% tapping. -	kW	
		e) Appropriate voltage at the +10% tapping/	kW	
	(ii)	Load loss (at 75 ^{0}C) at rated current and frequency	kW	
		a) Principal tapping	kW	
		b) -15% tapping	kW	
		c) +10% tapping	kW	
	(iii)	Total losses at rated current and frequency		
		a) Principal tapping	kW	
		b) -15% tapping	kW	
		c) +10% tapping	kW	
16		Resistance voltage (at 75 ^{0}C) at rated current	%	
17		Reactance voltage (at 75 ^{0}C) at rated current and frequency	%	

18		Impedance voltage (at 75 ^{0}C) at rated current and frequency	%	
19		Resistance (at 75 ^{0}C) of primary winding	ohm	
20		Resistance (at 75 ^{0}C) of secondary winding	ohm	
21		Reactance of winding :	H	
	i)	Primary	H	
	ii)	Secondary at	H	
		a). Principal tapping	H	
		b). +10% tapping	H	
		c). -15% tapping	H	
22		Regulation (at 75 ^{0}C) with rated current and at power factor of:		
		a) Unity	%	
		b) 0.8 lagging	%	
23		Efficiencies:		
	(i).	Efficiency (at 75 ^{0}C) at unity power factor at:		
		a). 100% load	%	
		b). 75% load	%	
		c). 50% load	%	
		d). 25% load	%	
	(ii).	Efficiency (at 75^{0}C) at 0.8 power factor lagging at:		
		a). 100% load	%	
		b). 75% load	%	
		c). 50% load	%	
		d). 25% load	%	
	(iii)	Percentage of rated load at which maximum efficiency occurs.	%	
24		Ability to withstand short-circuit:		
		a). Thermal	s	
		b). Dynamic	s	
25		Thermal time constant (calculated):		
	(i)	for winding with respect to oil at:		
		a). rated current	min	

		b). 150% rated current	min	
		c). 200% rated current	min	
	(ii)	Complete transformer at rated current	min	
26		Temperature gradient between oil and winding at:		
		a). Rated current	^{0}C	
		b). 150% rated current for 15 min	^{0}C	
		c). 200% rated current for 5 min.	^{0}C	
27		Temperature rise of oil:		
	(i).	Calculated average temperature rise of oil at:		
		a). Rated current	^{0}C	
		b). 150% rated current for 15 min	^{0}C	
		c). 200% rated current for 5 min	^{0}C	
	(ii)	Estimated temperature rise of top oil at:		
		a). Rated current ^{0}C		
		b). 150% rated current for 15 min ^{0}C		
		c). 200% rated current for 5 min ^{0}C		
28		Details of core:		
	(i)	Type of core		
	(ii)	Flux density at rated voltage and frequency	tesla	
	(iii)	Flux density at 110% rated voltage and frequency	tesla	
	(iv)	Thickness of steel stampings	mm	
	(v)	Grade of core material and conforming specification		
	(vi)	Exciting VA/kg for core stampings at:		
		a) Flux density of 1.55 tesla	VA/kg	
		b) Flux density at rated voltage	VA/kg	
		c) Flux density at 110% rated voltage	VA/kg	
	(vii)	Exciting VA/kg for assembled core at:		
		a) Flux density of 1.55 tesla	VA/kg	
		b) Flux density at rated voltage	VA/kg	

		c) Flux density at 110% rated voltage	Va/kg	
	(viii)	Type of insulation between core laminations.		
	(ix)	Type of joint between the core limbs and yoke.	kV	
	(x)	Core bolt Insulation withstand voltage	kV	
	(xi)	Core bolt insulation flashover voltage	kV	
		Details of windings:		
	(i)	Type of winding		
		(a) Primary		
		(b) Secondary		
		(c) Number of turns of primary winding		
		(d) Number of turns of secondary winding		
		(e) Number of parallel paths in primary winding		
		(f) Number of parallel paths in secondary winding.		
		(g) Is interleaving/inter shielding of the winding adopted to ensure better impulse voltage distribution?	Yes/No	
		(i) Primary		
		(ii) Secondary		
		(h) Is the insulation of end turns of winding reinforced?	Yes/No	
	(i)	Primary		
	(ii)	Secondary		
		(i) Type of coil		
	(ii)	Mode of connection (i.e. in series or in parallel) of the portions of the windings on the two limbs of the core, if applicable.		
	(iii)	Dimensions of the copper conductor used in the winding:		
		a) Primary	mm x mm	
		b) Secondary	mm x mm	
		c) Tapped winding.	mm x mm	

	(iv)	Current density at rated current.		
		a) Primary	A/mm^2	
		b) Secondary	A/mm^2	
	(v)	Insulation used over the conductor (details of material and specification there for)		
	(vi)	Type of joints, if any, in the windings		
	(vii)	Dielectric strength of windings:		
		a) Full wave lightning impulse withstand voltage:		
		i) Primary winding	kV peak	
		ii) Secondary winding.	kV peak	
		(b) Lightning Impulse chopped on the tail withstand voltage:	kV	
		(i) Primary winding		
		(ii) Secondary winding		
		(c) Separate source power frequency withstand voltage	kV	
		(i) Primary		
		(ii) Secondary		
		(d) Induced over voltage withstand value		
	(viii)	Minimum flashover distance to earth in oil of :		
		a) Secondary winding to core		
		b) Primary winding to yoke		
		c) Primary winding to tank		
	(ix)	Material used for coil clamping rings and specification there for		
	(x)	Magnitude of axial pre-compressive force on the winding		
		(a) Primary	kV peak	
		(b) Secondary	kV peak	
	(xi)	Calculated maximum axial thrust in the winding due to dead short circuit at the terminals		
		(a) Primary		

		(b) Secondary		
	(xii)	Calculated short circuit forces:		
		a) Hoop stress in primary winding	kgf/cm^2	
		b) Hoop stress in secondary winding	kgf/cm^2	
		c) Compressive pressure in the radial spacers		
		d) Internal axial compressive force	kgf/cm	
		e) Axial imbalance force		
		f) Resistance to college	kgf	
		g) Bending stress on clamping	kgf/cm^2	
		h) Radial bursting force		
	(xiii)	Arrangement to maintain constant pressure on the windings		
	(xiv)	Maximum permissible torque on pressure screws for coil clamping at the time of tightening, if any.	N.m	
	(xv)	Can either end of each secondary winding (25 kV) be connected directly to earth?	Yes/No.	
30		Motorised off-circuit tap changer:		
		a) Name of the manufacturer		
		b) Country of origin.		
		c) Type designation		
		d) Governing specification.		
		e) Is a separate taped winding provided on each secondary?		
		f) Number of tappings:		
		i) Plus tappings		
		ii) Minus tappings		
		g) Percentage variation of voltage on different tapping.		
		h) Minimum contact pressure between moving and stationery contacts	kgf	
		i) Maximum rated through current	A	
		j) Voltage class	kV	
		k) Rated voltage of control circuit	V(dc)	

		l) Tap changer motor particulars:		
		i) Make and type		
		ii) Rated voltage	V(dc)	
		iii) Rated current	A	
		iv) Rated power	kW	
		v) Speed	rpm.	
		vi) Class of insulation		
31		Bushings:		
	(i).	Primary side:		
		a) Name of the manufacturer		
		b) Country of origin		
		c) Governing specification		
		d) Type designation (specify as to whether it is OIP condenser bushing)		
		e) Voltage class	kV	
		f) Rated current	A	
		g) Visible power frequency discharge voltage	kV	
		h) Wet one minute power frequency withstand voltage	kV peak	
		i) Lightning impulse withstand voltage	mm	
		j) Creepage distance		
		k) Weight of assembled bushing	Kg	
	(ii)	Secondary side		
		a) Name of the manufacturer		
		b) Country of origin		
		c) Governing specification		
		d) Type designation		
		e) Voltage class	kV	
		f) Rated current	A	
		g) Visible power frequency discharge voltage	kV	
		h) Wet one minute power frequency withstand voltage	kV	

		i) Lightning impulse withstand voltage	kV peak	
		j) Creepage distance	mm	
		k) Weight of assembled bushing	kgf	
32		Bushing type current transformers:		
	(i).	Primary side:		
		a) Name of the manufacturer		
		b) Governing specification		
		c) Transformation ratio		
		d) Accuracy class and rated accuracy limit factor		
		e) Rated current	A	
		f) Rated output	VA	
		g) Exciting current at the rated knee point emf	mA	
		h) Rated knee point emf	V	
		i) Secondary winding resistance corrected to 75^0C	ohm	
		j) Short time thermal current and duration.	kA, s	
	(ii)	Secondary side:		
		a) Name of the manufacturer		
		b) Governing specification		
		c) Transformation ration		
		d) Accuracy class		
		e) Rated current	A	
		f) Rated output	VA	
		g) Exciting current at the rated knee point emf	mA	
		h) Rated knee point emf	V	
		i) Secondary winding resistance corrected to 75^0C.	ohm	
		j) Short time thermal current and duration	kA, s	
33		Insulating oil :		
		a) Governing specification		

		b) Grade of oil		
		c) Source of supply		
		d) Specific resistance at:		
		i) 27 ^{0}C	ohm-cm	
		ii) 90 ^{0}C	ohm-cm	
		e) Dielectric, dissipation factor (tan-delta) at 90 ^{0}C		
		f) Dielectric strength	kV	
		g) Water content	ppm	
		h) Interfacial tension	N/m	
		i) Neutralisation value	mg KOH/gm	
		j) Flash point	℃	
34		Type of transformer tank		
35		Details of radiators:		
		a) Make and type		
		b) Type of mounting		
		c) Overall dimensions (LxWxH)	mmx mm x mm	
36		Details of Buchholz relay:		
		a) Make and type		
		b) Governing specification		
		c) Provision of shut-off valves on either side of the relay	Yes/No	
		d) Provision of alarm contact	Yes/No	
		e) Provision of trip contact	Yes/No	
		f) Rated current of contacts	A	
37		Details of winding temperature		
		Indicator.		
		a) Make and type		
		b) Governing specification		
		c) Number of contacts provided		
		d) Rated current of contacts	A	
		e) Dielectric withstand value of contacts	kV	
38		Details of oil temperature indicator		

		a) make and type		
		b) Governing specification		
		c) Number of contacts provided		
		d) Rated current of contacts	A	
		e) Dielectric withstand value of contacts	kV	
39		Details of Magnetic oil level gauge:		
		a) Make and type		
		b) Governing specification		
		c) Diameter of dial mm		
		d) Number of contacts provided		
		e) Rated current of contact	A	
		f) Dielectric withstand value of contacts	kV	
40		Details of pressure relief device:		
		a) Make and type		
		b) Governing specification		
		c) Does it reset itself	Yes/No	
41		Bimetallic terminal connectors:		
	(i)	Primary side:		
		a) Source of supply		
		b) Governing specification		
		c) Type		
		d) Rated current	A	
		e) Temperature rise over an ambient temperature of 45℃ while carrying rated current.	℃	
		f) Short time current and duration	kA, s	
	(ii).	Secondary side:		
		a) Source of supply		
		b) Governing specification		
		c) Type		
		d) Rated current	A	
		e) Temperature rise over an ambient temperature of 45^0C while current rated	℃	

		current		
		f) Short time current and duration	kA, s	
42		Acoustic sound level at a distance dB of 1 m, when energised at rated voltage and rated frequency without load.	dB	
43		Partial discharge value at 1.5Um/ 3 kV r.m.s.	pC	
44		Weights and dimensions:		
	(i)	Net weight of core		
	(ii)	Net weight of cooper:		
		a) Primary winding	kg	
		b) Secondary winding	kg	
	(iii)	Net untanking weight of core frame and coils	kg	
	(iv)	Net weight of insulating oil	kg	
	(v)	Volume of insulating oil	l	
	(vi)	Total weight of cooling equipment	t	
	(vii)	Total weight of transformer without oil	t	
	(viii)	Total shipping weight of complete transformer including all detachable parts, fittings and assemblies	t	
	(ix)	Shipping weight of largest package	t	
	(x)	Crane lift (excluding slings) for un-tanking core and coils	mm	
	(xi)	Crane lift (excluding slings) for removal of primary side bushings.	mm	
	(xii)	Dimensions of the complete transformer including all parts, fitting and accessories:		
		a) Overall length	mm	
		b) Overall breadth	mm	
		c) From rail level to the topmost point	mm	
	(xiii)	Minimum thickness of steel plate/ sheet used:		
		a) Bell tank mm		
		b) Tank bottom mm		

		c) Conservator mm		
		d) Radiator mm		
		e) Marshalling box. mm		
	(xiv)	Overall shipping dimensions of the largest package (Length x width x height)	mm x mm x mm	
	(xv)	Mode of transportation of transformer unit (filled with oil/nitrogen gas.)		
		Other particulars		
45		Is the transformer tank fitted with lifting pads? If yes, what is the number of pads	Yes/ No	
46		What is the number of inspection covers provided?		
47		Are comfits/ trays provided for cable run?	Yes/ No	
48		Is the core electrically connected with the tank?	Yes/No	
49		Will the gaskets to be used in the transformer give trouble free service for at least 7 years? If not, indicate the life.	Yes/No	
50		Is the core construction without core bolts?	Yes/No	
51		Are the core bolts grounded, and if so, how?	Yes/ No	
52		What is the number of radial spacers used in the winding?		
53		What is the number of joints provided in the winding?		
54		Are the spacers/blocks/angle rings of pre-compressed press boards? If no, indicate the material with specification.		
55		Are arrangements made for ensuring automatic constant pressure on the coils? If no. give the reasons.	Yes/ No	
56		Are closed slots provided on outer most winding for locking the vertical strips? If no, give the reason.	Yes/ No	
57		What is the periodicity for tightening of coil clamping arrangement?	Years	
58		What are the designed values of short-circuit current for:		
		a) Symmetrical :		

		i) Primary winding A		
		ii) Secondary winding A		
		b) A symmetrical:		
		i) Primary winding A		
		ii) Secondary winding A		
59		What is the over flux with stand capability of the transformer (Maximum permissible limit of flux density) ?	Tesla	
60		Are windings pre-shrunk?	Yes/No	
61		Have the details of drying cycles of the coils/coil assembly including final tightening values of pressure, temperature and degree of vacuum at various stages of drying been furnished?	Yes/ No	
62		Are arcing horns provided for line and neutral bushings?	Yes/ No	
63		Is a test tap provided in the line bushing?	Yes/ No	
64		Is the porcelain housing of the bushings of single piece construction?	Yes/ No	
65		Is the shed profile of porcelain housing of the bushing free from under-ribs but has a lip?	Yes/ No	
66		Is the bushing type current transformer of low reactance type?	Yes/ No	
67		Is Clause by Clause "Statement of compliance" attached?	Yes/ No	
68		Is "Statement of deviation", if any, attached?	Yes/ No	
69		Does the tap changer have snap action? If not, give reason.		
70		Is the Buchholz relay provided with two shut-off valves, one on either side?	Yes/ No	
71		Is separate conservator tank & Buchholz relay provided for tap changing equipment?	Yes/ No	
72		Are fasteners of 12 mm diameter and less exposed to atmosphere of stainless steel to Grade 04Cr17 Ni12Mo to IS 1570 Part-V?	Yes/ No	

73		Are the fasteners of more than 12 mm diameter exposed to atmosphere of stainless steel or MS hot dip galvanised?	Yes/ No	
74		Are test certificates for tests as per Clause 15.0 attached?	Yes/ No	
75		Are all the calculations required as	Yes/ No	
76		Are all the drawings required as per clause 16.3.2 attached?	Yes/ No	
77		(a) Are all the parts, fittings and accessories from Employer's approved manufacturers?	Yes/ No	
		(b) If not, list the items which are to be type tested in the presence of Employer's representative.	Yes/No	
78		Is adequate space provided in the marshalling box for housing the wiring and components?	Yes/ No	
79		Is warranty as per clause 22.0?	Yes/ No	
80		Is the list of spares furnished or no?		

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Annexure - I

TECHNICAL SPECIFICATIONS FOR NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM FOR OIL FILLED TRANSFORMER

1.0 GENERAL DESCRIPTION:

Nitrogen injection fire protection system designed for oil filled transformers shall prevent tank explosion and the fire during internal faults resulting in an arc, where tank explosion will normally take few seconds after arc generation and also extinguish the external oil fires on transformer top cover due to tank explosion and/or external failures like busing fires, OLTC fires and fire from surrounding equipment's.

The system shall drain a pre-determined quantity of oil from the tank top through outlet valve to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and deduce the temperature of top oil surface below flash point to extinguish the fire.

Conservator tank oil shall be isolated during busing bursting, tank explosion and oil fire to prevent aggravation of fire.

Transformer isolation shall be an essential pre-condition for activating the system. The system shall be designed to operate automatically. However, it shall be designed for manual operation, in case of failure of power supply.

The system shall consist of following equipment:

1. Fire extinguishing cubicle placed on a plinth at about 5-10 meter away from the transformer.
2. Control box placed in the control room.
3. Necessary valves in the conservator pipe.
4. Suitable fire sensing components to be provided preferably in/on the tank cover.
5. Signal box suitably placed.

2.0 SCOPE

The scope of this document covers design, engineering, supply testing at works before dispatch; erection, testing and commissioning and performance demonstration of "fire protection and extinguishing system by nitrogen injection method".

The necessary civil work which will be required for construction of oil soak – pit for the storage of oil coming out from the transformer and plinth for extinguishing cubicle is outside the scope of this document. However, laying of oil pipe, nitrogen pipe, electrical cables, control boxes, extinguishing cubicle, nitrogen cylinder, necessary vales, fire detectors and other equipments& accessories required for erection, testing, commissioning and performance demonstration of the complete fire protection system is in the scope of the tenderer. It will be the responsibility of the tenderer, i.e.

transformer manufacturer to coordinate with the supplier of the Fire Protection System for all the arrangements for the complete erection, testing, commissioning and performance tests. Notwithstanding the technical specifications and requirements mentioned herewith any modification can be incorporated for correct operation of nitrogen injection fire protection system without extra cost. The full details of the same are required to be submitted to Employer for approval, when first unit is implemented on a transformer of specific make & rating.

3.0 OPERATIONAL CONTROLS:

The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control, remote electrical push button control on control box and local manual control in the fire-extinguishing cubicle shall be provided. The fire protection system will take signal from HV/LV circuit breaker.

4.0 SYSTEM ACTIVATING SIGNALS:

4.1 Transformer isolation shall be an essential pre-condition for activating the system. Provision shall be provided to isolate the Traction Power Transformer through Master trip relay or circuit breaker (HV and LV side in series) before Nitrogen injection and after oil depressurization.

4.2 There shall be two modes of operation of Fire Protection System i.e. Fire Prevention Mode & Fire Extinction Mode. In these mode the safety equipment to be involved are tabulated below. The logic of their operation shall be finalized during design approval.

Mode of Operation	Safety Equipment to be used
Fire Prevention Mode	• Differential relay/Over current/Restricted earth fault relay. • Pressure relief valve
Fire Extinction Mode	• Fire sensing components • Buchhloz relay

5.0 SYSTEM EQUIPMENT:

5.1 Fire Extinguishing Cubicle (FEC), placed on plinth at about minimum 5 meter away from the transformer shall consist of:

5.1.1 Nitrogen gas cylinder with pressure reducer/regulator and falling pressure electrical contact manometer.
5.1.2 Oil drain pipe with mechanical quick drain valve;
5.1.3 Electro mechanical control equipment for oil drain and pre-determined regulated nitrogen release.
5.1.4 Pressure monitoring switch for backup protection, pressure reducer with solenoid valve in the cabinet for operation of nitrogen gas release, which will be IP-65, protected and leak proof for nitrogen release.
5.1.5 Limit switches for monitoring of the system.
5.1.6 Flanges on top panel for connecting oil drain and nitrogen injection pipes for transformer.
5.1.7 Panel lighting
5.1.8 Oil drainpipe extension of suitable sizes for connecting pipes to oil pit.

5.1.9 The Nitrogen gas cylinder should be of sufficient (not less than 50 liter) capacity and should be filled at a pressure of not less than 150 bars with falling pressure electrical contact manometer, suitable design measures to prevent leakage of gas to be taken.

5.1.10 The nitrogen valve shall have IP-65 protection. The nitrogen shall be contained within the cylinder and released from the cylinder valve only upon activation of the fire protection system. Nitrogen purity shall 99.99%

5.1.11 Proper approvals and certificates should be provided with each cylinder. No used nitrogen bottle will be accepted.

5.2 Control box with activating, monitoring devices and line faults indicators to be placed in control room. It should have audiovisual alarm indication and push button switches for tests response.

5.3 Necessary valves to be fitted in the conservator pipeline between conservator and Buchholz relay operating mechanically on transformer oil flow rate with electrical signal for monitoring.

5.4 Suitable fire sensors to be fixed on transformer tank top cover and off circuit tap changer for sensing fire.

5.5 Signal box to be fixed on transformer side will for terminating cable connection from sensors and conservator shutter/signal box to be suitably placed.

5.6 All other consumables necessary for operation of complete system.

5.7 Control box should be microprocessor based and compatible to be interfaced with existing RTU for Railway Traction SCADA system available at the control room. For communication, Control box shall have provision for interfacing with SCADA in this regards details Digital Input & Output required for operation monitoring through SCADA should be furnished.

6.0 OTHER REQUIREMENTS FOR SYSTEM INSTALLATION:

6.1 Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations.

6.2 Flanges with dummy piece in conservator pipe between Buchhloz relay and conservator tank for fixing.

6.3 Brackets on transformer top cover for sensing equipment, valves to enable operation of the system.

6.4 Spare potential free contacts for system activating signals i.e. differential relay, Buchholz relay, pressure relief valve, transformer isolation (master trip relay).

6.5 Pipe connections between transformer to fire extinguishing cubicle and fire extinguishing cubicle to oil pit.

6.6 Cabling on transformer top cover all sensors to be suitably connected for reliable fire sensing and inter cabling between signal box to control box and control box to fire extinguishing cubicle.

6.7 Plinth for fire extinguishing cubicle. Oil pit with capacity as 10% of total oil quantity of transformer.

7.0 TECHNICAL DETAILS:

Fire extinction period:

On commencement of Nitrogen injection	:	Maximum 30 seconds
On system activation up to post cooling	:	Maximum 3 minutes
Heat sensing area	:	140± 2°C

Seating for operation to isolate conservator : Min.60 Ltr. per minute

Power Source:

Control Box : 110 V DC

Fire extinguishing cubicle for lighting : 240 V AC

8.0 CABLING:

8.1 Fire survival cables, able to withstand 750℃, 1.5 mm² with necessary no. of conductors for connection of fire detectors in parallel shall be used. The test certificates for the cables shall be submitted.

8.2 Fire retardant low smoke (FRLS) cable 1.5 mm² with necessary no. of conductors for connection between transformer signal box/marshalling box to control box and control box to fire extinguishing cubicle shall be used.

8.3 Fire retardant low smoke (FRLS) cable 1.5 mm² with necessary no. of conductors for connection between control box to DC supply source and fire extinguishing cubicle to AC supply source, signal box/marshalling box to transformer shall be used.

9.0 PREVIOUS EXPERIENCE FOR QUALIFYING SUPPLIER:

The supplier shall have a minimum experience of two years in the design, manufacturing, erection, testing and commissioning of Nitrogen Injection Fire Protection System on power transformers of similar or higher rating. At least 2 sets of the system shall be in successful operation for a minimum period of the 2 years. The supplier shall furnish the details of Nitrogen Injection Fire Protection System supplied by them so far, giving order reference, name and address of the customer, indicating the dates of commissioning as well as performance certificate of successful and satisfactory operation for minimum two years from the customers.

10.0 TESTS

10.1 **Type Tests**

Type test reports including that for detectors along with declared response time as per test approval certificate letter shall be submitted along with the tender.

The system shall be tested by international or a national testing body (NABL accredited recognized laboratory. Tariff Advisory Committee (TAC's) approval, if any, shall be submitted with the tender.

10.2 **Factory Test**

Tests will be carried out on individual equipment of the system and the total system in the supplier's workshop in presence of purchaser's representative.

10.3 **Performance Test**

Performance test of the complete system shall be carried out after complete erection at site by the supplier's representative. These tests shall include simulation and verification of the response of the complete system without actual draining of the oil and injection of the nitrogen gas.

In addition to above, additional tests as required necessary shall be conducted.

11.0 DRAWINGS AND MANUALS

Detailed layout drawing along with the equipment drawing to be given in the tender along with complete bill of materials. After awarding of contract, detailed dimensional drawing of the system complete bill of materials including location and size of plinth for cubicle and recommended capacity of oil soak-pit shall be submitted for purchaser's approval. After approval 10 (ten) sets of all above drawings and 5 (five) sets of operation and Maintenance Instruction Manual (bound) shall be submitted for purchaser's use.

12.0 SPARES:

One full set of spare nitrogen gas filled cylinder, one set of the installed no. of fire sensors shall be provided in addition to additional other recommended spares. The list of recommended spares is to be submitted along with the tender.

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Part -XII

Specification for8 MVA, 54 kV, 50Hz AUTO TRANSFORMER FOR 2 X 25 kV AT FEEDING SYSTEM

1 SCOPE

1.1 This document applies to 8 MVA, ONAN, 54 /27 kV Autotransformer for Auto Transformer (AT) feeding system for Installation in DFCC, an infrastructure providing company of Indian Railway's.

1.2 The transformer shall be complete with all parts, fittings and accessories whether specifically mentioned herein or not, necessary for its efficient operation in an unattended traction substation.

2 GOVERNING SPECIFICATION

2.1 In the preparation of this document, assistance has been taken from the following National and International Standards, wherever applicable.

Table No.: 2.1-1

Standards		Description
Equivalents	IS	
IEC 60076 (all parts)	IS:2026 (all parts)	Power transformers.
IEC 60044-1	IS:2705	Instrument transformer – Part 1: Current transformer.
IEC 60137	IS:2099	Bushing for alternating voltages above 1000V
IEC 60214	IS:8468	Tap changers.
IEC 60296	IS:335	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear/ New insulating oils.
	IS:5	Colours for ready mix paints and Enamels.
IEC 60502-1	IS:1554 (Part 1)	PVC insulated (heavy duty) Electric cables: Part 1 For working voltages up to and including 1100V
	IS:1570	Schedules for Wrought Steels - Part 5: Stainless and heat resisting steels.
	IS:1576	Solid pressboard for electrical purposes
IEC 60422	IS:1866	Code of practice for electrical maintenance and supervision of mineral insulating oil in equipment
	IS:2927	Brazing alloy
JIS C 2553	IS:3024	Grain orient electrical steel sheets and strips
	IS:3637	Gas operated relays
	IS:3639	Fittings and accessories for power transformers

	IS:4253	Cork composition sheets : Part 2 Cork and Rubber
	IS:5561	Electrical power connectors
	IS:5621	Hollow insulators for use in electrical equipment
IEC 60909	IS:13234	Guide for short circuit calculations in 3Phase a.c. systems.
IEC 60270	IS: 6209	High-voltage test techniques - Partial discharge measurements.
IEC 60076	IS:6600	Guide for loading of oil-immersed transformers
	IS:10028 (all parts)	Code of practice for selection, installation and maintenance of transformers
	IS:10593	Mineral Oil-impregnated electrical equipment in services - Guide to the interpretation of dissolved and free gases analysis
IEC 60137	IS: 12676	Oil impregnated paper insulated condensers bushings – dimensions and requirements
	DIN:7733	Laminated products, pressboard for electrical engineering, types
		Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2010, part-III, Sec.4, 2010 Rule no. 44 (2) (ix).

2.2 In case of any conflict between the contents of the above standards and this document the latter shall prevail.

2.3 Any deviation from this document, proposed by the bidder calculated to improve the performance, utility and efficiency of the equipment, will be given due consideration; provided full particulars of the deviation with justification therefore are furnished. In such a case, the bidder shall quote according to this document and the deviations. If any proposed by him shall be quoted as alternative/alternatives.

3 Climatic and Atmospheric Conditions

3.1 The transformer shall be suitable for outdoor use in moist tropical climate and in areas the limiting weather conditions which the equipment has to withstand in service are given in Part-II of the particular Specification.

3.2 The transformer would also be subjected to vibrations on account of trains running on nearby Railway tracks.

The amplitude of these vibrations which occur with rapidly varying time periods in the range of 15 to 70 ms lies in the range of 30 to 150 microns at present, with the instantaneous peaks going up to 350 microns. These vibrations may become more severe as the speeds and loads of trains increase in future.

4 TRACTION POWER SUPPLY SYSTEM (2x25 kV AT FEEDING SYSTEM)

4.1 General Scheme

4.1.1 The electric power for railway traction is supplied in ac 50 Hz, single-phase through 2x25 kV AT feeding system, which has a feeding voltage (2x25 kV) from the traction substation (TSS) two times as high as the catenary voltage, which is 25 kV with respect to earth/rail. The power fed from the TSS through catenary and feeder wire is stepped down to the catenary voltage by means of autotransformers (ATs) installed about every 13 to 17 km along the track, and then fed to the locomotives. In other words, both the catenary and feeder voltage are, 25 kV with respect to the earth/rail, although the substation feeding voltage between catenary and feeder wires is 50 kV. The catenary voltage is therefore, the same as that in the conventional 25 kV system.

4.1.2 The power supply shall be obtained from the 220/132 kV, three-phase, effectively earthed transmission network of the State Power to the Scott-connected transformer installed at the TSS, whose primary winding is connected to the three phases of the transmission network. The spacing between adjacent substations is normally 60 km.

4.1.3 One outer terminal of the secondary windings of the traction transformer is connected to the catenary and the other outer terminals are connected to the feeder.

4.1.4 ATs connect the 25 kV catenary to 25 kV return feeder, with mid-point connected to rail and earth (25 kV return OHE and earth). Two adjacent AT's share power to feed trains at 25 kV/2x25 kV system feeds 50 kV supply from traction transformer terminal to the ATs. The load current (current drawn by electric locomotives) from the TSS flows through the catenary and returns to the TSS through the feeder. For a train in an AT-cell (distance between two consecutive ATs), most of the current is fed to the electric locomotive by the ATs of that AT-cell; the, current returns in the rails/earth and is boosted up to the feeder through the neutral terminals of the autotransformers. The current in OHE, therefore, is an algebraic sum of 25 kV current feed to locomotives from AT and the 50 kV supply to ATs from the TSS.

4.1.5 Approximately midway between adjacent TSSs, a sectioning and paralleling post (SP) is provided. In order to prevent wrong phase coupling of power supply, a dead zone known as 'Neutral Section' is provided in the OHE opposite the TSS as well as SP. At the TSS, there are two-feeder circuit breakers for either side of the TSS for controlling the power fed to the OHE, in a double track section. Out of the two feeder circuit breakers for one side, one feeds the OHE of that side while the other remains (open) as standby. There is also a paralleling interrupter, which is normally closed, for either side of the TSS for paralleling the OHE of the UP and DOWN tracks. In case of fault in the OHE, the feeder circuit breaker of the TSS trips to isolate it. The Bridging Interrupter is used to feed one TSS up to the next TSS, in case the adjacent TSS is temporarily out of order.

4.1.6 For maintenance work and keeping the voltage drop within limit, one or more sub-sectioning and paralleling post (SSP) are provided between the TSS and SP. The supply control Posts are on an average located every 13-17 km interval. An SSP has four sectioning interrupters and one paralleling interrupter, whereas an SP has two bridging circuit breakers (which remain open under normal feeding condition) and two paralleling interrupters.

4.2 Protection System

4.2.1 The Protection system of the traction transformer comprises the following:

1	Differential protection
2	Instantaneous and IDMT over-current, and earth fault protection on the primary side
3	Protection against phase-failure on the secondary side (i.e. to detect malfunction of feeder/transformer circuit breaker)
4	Buchholz Relay
7	Thermistor/Optical hot spot sensor. The Transformer should have built-in hottest spot temperature device to indicate and record the hot test spot temperature as per IEC-60076-2 (Ed. 3.0).

4.2.2 The protection system for the OHE comprises the following:

1	Distance protection
2	Delta I type fault selective protection
3	Instantaneous over current protection
4	Under-voltage protection to avoid wrong phase coupling
5	Fault locating expert system based on AT voltage neutral current.

4.3 OHE General data

4.3.1 The OHE shall consists of **(i)** Contact wire of minimum 150 mm^2 cross section suspended directly from catenary of wire of minimum 125 mm^2 cross section by a number of vertical dropper wires, usually at regular intervals and **(ii)** a feeder wire of stranded all aluminium conductor.

4.4 Auto Transformer General Data

4.4.1 The transformer shall have 8 MVA power rating based on ONAN cooling.

4.5 Nature of traction loads and faults on the OHE system

4.5.1 The traction load is a frequently and rapidly varying one, between no load and overload. The TSS equipment is subject to frequent earth faults/short circuits caused by failure of insulation, snapping of OHE touching earth, wire dropped by bird connecting the OHE to earth/ over line structure, and miscreant activity. On an average, the number of faults/ short circuits per month could be as high as 40. The magnitude of the fault current may vary between 40% and 100% of the dead short circuit value. These faults are cleared by the feeder circuit breaker on operation of the distance, delta I and instantaneous over-current relays associated with the concerned feeder circuit breaker. In 2x25 kV system faults can occur with: feeder-earth; feeder-OHE and OHE-earth faults or a combination of them.

4.5.2 The existing Indian Railways ac electric locomotives are silicon rectifiers, with dc motors or GTO/IGBT based power converter fed 3-phase Induction Motor and the average power factor generally varies between 0.7 and 0.85 lagging, without reactive power compensation, which introduces harmonic currents in the 25 kV power supply system.

4.5.3 On DFCC (Western) Locomotives are proposed to have VVVF drives and improved power factor closer to 0.98 and negligible harmonics. The traction supply may therefore be at higher power factor than those on IR.

4.6 Short-circuit apparent power of the system

4.6.1 The short-circuit apparent power at the transformer location for various system voltages is as under:

Highest system voltage (kV)	Short circuit apparent power, (MVA)
72.5	3,500
123	6,000
145	10,000
245	20,000

4.7 Auxiliary power supplies at TSS

4.7.1 The following auxiliary power supplies are available

1	110V dc from a battery
2	240 V ac, 50 Hz, single-phase from a 25/0.24 kV auxiliary transformer feed from Traction supply.

5 RATING AND GENERAL DATA

5.1 The rating and general data of the auto transformer shall be as follows:

SN	Item	Description
1.	Type	ONAN cooled, single-phase autotransformer with centre tapping (neutral terminal), double limb wound, core-type for outdoor installation
2.	Winding	One winding with centre tapping, uniformly insulated, shall be provided.The outer (line) terminals of the winding shall be brought out through 54 kV class bushings, whereas the neutral terminal (centre tapping) through 12 kV class bushing.
3.	Rated frequency, Hz	50 $\pm$3%
4.	Rated primary voltage, kV	54
5.	Maximum primary voltage, kV	60
6.	Rated secondary voltage (at no-load), kV	27
7.	Rated power, MVA	8 MVA ONAN
8.	Rated current	
	1) Rated primary current, A	148
	2) Rated secondary current, A	296
9.	Maximum leakage impedance as seen from secondary side	0.45 ohm
10.	Non-cumulative overload capacity after the transformer has reached steady temperature on continuous operation at rated load (i.e.at rated power)	150% rated load for 15 min 200% rated load for 5 min
11.	Temperature rise	1. Winding: 50K at rated load, and 60K for overloads as specified in Clause 5.1(10) (Temperature measured by resistance method). 2. Top oil: 45K (temperature rise measured by thermometer) 3. Current carrying parts in air: 40K (temperature rise measured by thermometer).
12.	Maximum permissible losses	
	1. No-load loss, kW	6.5 kW
	2. Load loss, kW	24 kW
13.	Short circuit current (symmetrical)	25 (Twenty five) or 35 (Thirty five) times of the rated current.
14.	Ability to withstand short	

<table>
<tr><td rowspan="3"></td><td>circuit current of 25 (Twenty five) or 35 (Thirty five) times of the rated current</td><td colspan="3"></td></tr>
<tr><td>1. Thermal ability</td><td colspan="3">5s</td></tr>
<tr><td>2. Dynamic ability</td><td colspan="3">0.5s</td></tr>
<tr><td>15.</td><td>Flux density at rated voltage and frequency</td><td colspan="3">Shall not exceed 1.55 Tesla.</td></tr>
<tr><td>16.</td><td>Current density in the windings at rated current</td><td colspan="3">Shall not exceed 2.5 A/mm^2</td></tr>
<tr><td>17.</td><td>Acoustic sound level when energized</td><td colspan="3">Not more than 75 dB at a distance of one meter</td></tr>
<tr><td rowspan="5">18.</td><td rowspan="5">Bushing</td><td>Item</td><td>Line terminals</td><td>Neutral terminals</td></tr>
<tr><td>Type</td><td>OIP condenser</td><td>Solid or Liquid filled porcelain</td></tr>
<tr><td>Highest voltage for equipment Um(kV)</td><td>52</td><td>12</td></tr>
<tr><td>Rated current(kV)</td><td>800</td><td>800</td></tr>
<tr><td>Minimum creepage distance in air(mm)</td><td>1300</td><td>300</td></tr>
<tr><td rowspan="10">19.</td><td>Busing type current transformer on neutral transformer for fault locator:</td><td colspan="3"></td></tr>
<tr><td>1. Highest voltage for equipment Um, kV</td><td colspan="3">12</td></tr>
<tr><td>2. CT ratio</td><td colspan="3">500/5</td></tr>
<tr><td>3. Frequency, Hz</td><td colspan="3">50 ± 3%</td></tr>
<tr><td>4. Rated output, accuracy class and accuracy limit factor as per IEC60044-1</td><td colspan="3">30VA Class 5P15</td></tr>
<tr><td>5. Minimum knee-point emf, V</td><td colspan="3">125</td></tr>
<tr><td>6. Maximum excitation current at knee-point voltage, A.</td><td colspan="3">0.25</td></tr>
<tr><td>7. Maximum resistance of the secondary winding When corrected to 75 ℃, ohm</td><td colspan="3">0.25</td></tr>
<tr><td>8. Rated short-time thermal current</td><td colspan="3">25 kA for one second</td></tr>
<tr><td>9. Rated dynamic current</td><td colspan="3">62.5 kA (peak)</td></tr>
</table>

6 SALIENT DESIGN FEATURES

6.1 Overall dimensions

6.1.1 The overall dimensions of the transformer shall be kept as low as possible and in any case shall not exceed the transportation limit.

(Transportation dimension)

1	Length x Width (in mm)	14,000 x 6,500
2	Height of topmost point of primary bushing terminal	7,500 mm
3	Height of topmost point of secondary bushing terminal	5,500mm

6.1.2 The manufacture shall, where practical, design the transformer so that with the bushings & accessories removed, the transformer shall fit within Indian Railway loading gauge, in case it is transported through rail, MMD to be enclosed with the offer.

6.1.3 The transformer should be designed nitrogen filled, such that it can be transported without the insulation oil inside the tank. The transformer shall be designed such that it can be transported with tank under pressure with nitrogen and other protective measures that the Manufacturer recommends, so that no moisture can enters the housing.

6.2 Tank

6.2.1 The tank for the transformer shall be of the top cover jointed with bolted connection. The bottom plate of main tank shall be firmly welded to the main body and the top cover is a plate reinforced with ribs. This is subject to quality and life of windings which does not require any retightening after energized in field. A pressure gauge along with a hygrometer shall be provided so that the status of dryness of the winding can be assessed in the transformer prior to its heat run before commissioning.

6.2.2 The tank shall be constructed from mild steel of a quality that- allows welding without any defect/flaw, with a single tier construction, so shaped as to reduce welding to the minimum. The welded joints shall be made using the latest welding techniques. The tank shall be adequately strengthened for general rigidity to permit hoisting of the transformer filled with oil by crane. The tank body shall be designed to withstand full vacuum degree.

6.2.3 The tank shall be fitted with four lifting pads at the lower end to enable lifting of the transformer filled with oil by means of lifting jacks.

6.2.4 The tank shall be fitted with an under carriage and mounted on eight bi-directional swiveling type flanged rollers for being rolled on 1676mm (5'6") gauge track on which it shall also rest in the final position..

The rollers shall be provided with detachable type locking arrangement to enable their locking after installing the transformer in the final position, to hold the transformer fixed on foundation and to prevent any accidental movement of the transformer.

6.2.5 There shall be at least five inspection covers of suitable size on the tank to enable inspection of the lower portions of bushings, and the leads as well as the various connections of the motorized off-circuit tap-changer.

6.2.6 The gaskets with groove NBR (NITRILE BUTADIENE RUBBER) shall be provided for oil sealing points. The rubberized cork gasket may be used for other general portion.

6.2.7 All valves used in the transformer shall be capable to withstand full vacuum degree, conform to IS-3639. The manufacturer shall ensure that suitable anti-theft measures like locked use of blanking plates are provided on these valves, so as to prevent theft of oil during transit and service.

6.3 Marshalling box

6.3.1 A vermin proof, weatherproof and well ventilated, marshalling box with IP class 55, made up of sheet steel of thickness not less than 2 mm, strengthened with adequate stiffeners, shall be provided on the left hand side of the transformer tank as viewed from the secondary terminals side. It shall have a hinged door, with provision for padlocking the door opening outward horizontally.

6.3.2 The marshalling box shall have a sloping roof. The top of the marshalling, box shall be at a height of about 2m from the transformer rail level.

6.3.3 The marshalling box, shall house the winding and oil temperature indicators and terminal board. To prevent condensation of moisture in the marshalling box, metal clad space heater controlled by an associated thermostat and switch shall be provided. Cable glands shall be provided for the incoming and outgoing cables.

6.3.4 The temperature indicators shall be so mounted such that their dials are at a height of not more than 1.6 m from the rail level. Transparent windows of tough acrylic plastic or similar non- fragile transparent material shall be provided on the marshalling box, so as to enable reading of the temperature indicators without opening the door of the marshalling box.

6.3.5 All cables from the bushing current transformers, Buchholz relay, magnetic oil level gauge, pressure relief device and temperature indicators shall be run up to the marshalling box. The cables shall be of 1100 V grade, XLPE insulated, XLPE sheathed, steel wire armored, stranded copper conductor conforming to IEC 60502-1. The cables shall be adequately insulated for heat from the tank surface and the sun.

6.3.6 All wiring in the marshalling box shall be clearly identified by lettered/figured ferrules of the interlock type, preferably of yellow colour with-black letters/figures. The ac and dc circuits shall be clearly distinguished and well separated from each other.

6.3.7 Suitable legend and schematic diagram plates made of anodised aluminium with black lettering and lines shall be fixed on the inside surface of the marshalling box door.

6.4 Core

6.4.1 The core shall be built-up of high permeability cold rolled grain oriented silicon steel laminations conforming to JISC 2553 or equivalent IS as indicated in Table No. 2.1-1. The flux density in any part of the core and yokes with primary winding excited at the rated primary voltage and frequency; shall not exceed 1.55T. The successful bidder / manufacturer shall furnish calculations to prove that this value shall not be exceeded.

6.4.2 The lamination for the core shall be free from waves, deformations and signs of rust. Both sides of the laminations shall be coated with suitable insulation capable of withstanding stress relief annealing. In assembling the core, air gaps shall be avoided. Necessary cooling ducts shall be provided in the core and yoke for heat dissipation The core clamping frame shall be provided with lifting eyes for the purpose of tanking and un-tanking the core and winding of the transformer.

6.4.3 The core shall be electrically solidly connected to the tank.

6.4.4 Design of the Core shall be boltless and it shall be tightened by binding the laminations using resin glass type. Core laminations shall be tested after completion of the core assembly to ensure that they withstand a voltage of 2 kV r.m.s with respect to core for a duration of 60 seconds..

6.4.5 The transformer is required to be continuously in service, preferably without requiring any attention from the date of its energization, up to the periodical overhaul (POH), which is generally done after 10-12 years of service. The successful bidder/ manufacturer of the transformer shall take this aspect into account during core assembly/manufacture and indicate measures taken by them to ensure suitable clamping to permit the above frequency and cover this in their instruction manual.

6.5 Winding

6.5.1 The winding shall be of disc/concentric/interleave/multilayer type. The winding shall be uniformly insulated. The two outer terminals of the winding shall be brought out through 54 kV OIP condenser bushings whereas the neutral terminal (Centre tapping) through a 12 kV oil-filled porcelain bushing. The QAP of the manufacturing process is to be submitted along with the bid.

6.5.2 The winding shall be made of continuous electrolytic copper conductor, paper insulated to class-A insulation. The conductor shall not have sharp edges which may damage the insulation.

6.5.3 The workmanship shall be of high quality in keeping with Good Engineering Practices.

6.5.4 No joint shall be used in the winding conductor, in principle, except for inter-leave joint.

6.5.5 The transformer winding shall be designed for the following rated withstand voltages:

1	Rated short duration power frequency withstands voltage kV	95
2	Rated lightning impulse withstand voltage kV peak	250

6.5.6 The axial pre-compression on the winding shall preferably be double the calculated axial thrust that may be set up under dead short-circuit condition, so as to ensure that the winding do not become loose due to frequent short circuits in service.

6.5.7 During short circuits the stresses set up in conductors, spacers and blocks, clamping rings and such other parts of the transformer, shall not exceed one third of the maximum permissible values.

6.5.8 Pre-compressed spacers shall be used between disc shaped coils of the winding to transmit the axial forces generated due to the short circuits.

6.5.9 Wood insulation, if used on the core and winding shall be seasoned, dried and well compressed and shall have adequate strength.

6.5.10 A uniform shrinkage shall be ensured during the drying of the individual coils or assembly of coils by providing a uniform clamping force with the help of hydraulic jacks or similar devices.

6.5.11 The separate winding compression structure shall be provided apart from the core clamping structure in order not causing any loose. The equal-axial force and continuous compression system shall be applied onto each assembled windings throughout the drying process and fixed with the high-tension, self-tightening structure to eliminate any loose, unbalanced force due to non-uniform shrinkage of windings. No re-tightening of winding after the production is prohibited.

6.5.12 The successful bidder / manufacturer shall furnish details of various stages of drying of coils, coil assembly up to and including oil impregnation and final tightening of the coil assembly, values of pressure, duration, temperature and degree of vacuum maintained at various stages of drying shall also be indicated.

6.5.13 To prevent displacement of the radial spacers used in the winding, closed slots shall be provided and a vertical locking strip shall be passed through these slots.

6.5.14 The vertical locking strips and slots of the radial spacers shallbe so designed as to withstand the forces generated due to short circuits.

6.5.15 The vertical locking strips and radial spacers shall be made of pre-compressed pressboard conforming to grade PSP:3052 of DIN 7733.

6.5.16 To prevent end blocks from shifting, pre-compressed pressboard ring shall be provided in between the two adjacent blocks. Coil clamping rings made of densified wood or mild steel shall be located in position with pressure screws.

6.5.17 Leads from the winding to the terminals and other interconnections shall be properly supported and secured.

6.5.18 The following particulars / documents in respect of the radial spacer blocks (winding blocks), vertical locking strips (axial ribs), end blocks, insulating cylinder, angle rings, paper insulation of the conductor and coil clamping plates used in the manufacture of winding shall be furnished:

a) Reference to specification and grade of material.

b) Source(s) of supply.

c) Test certificates.

7 INSULATING OIL

7.1 The transformer shall be supplied with new mineral insulating oil conforming to IEC 60296/ IS: 335. In addition, 10% extra oil by volume, shall be supplied in non-returnable steel drums. The characteristics of the insulating oil before energization of the new transformer and during its maintenance and supervision in service shall confirm to IEC 60296.

8 BUSHINGS AND TERMINAL CONNECTORS

8.1 Both the line and neutral bushings shall confirm to IEC 60137. On the line side, 54 kV class, sealed solid stem type Oil Impregnated Paper (OIP) condenser bushings shall be used. On the neutral side, 12 kV class oil-filed porcelain bushing shall be used. The dimensions of the bushings shall confirm to IEC 60137.

8.2 The OIP condenser bushings shall have a non-breathing oil expansion chamber. The expansion chamber shall be provided with an oil-level indicator, which shall be so designed and dimensioned that oil level is clearly visible from ground level. A test tap shall be provided for dielectric or power factor measurement.

8.3 The bushings shall be designed for the following insulation level:

1	Highest voltage for equipment Um, kV	52	12
2	Rated short duration wet power frequency withstand voltage, kV	95	28
3	Rated lightning impulse withstand voltage, kV peak	250	75

8.4 The design and construction of the bushing shall be such that stresses due to expansion and construction in any part of the bushings shall not lead to its deterioration / breakage. The bushings shall be free from corona and shall not cause radio interference.

8.5 The bushing terminals shall be provided with rigid type terminal connectors of Bimetallic type and shall be such that there is no hot spot formation even during the extreme over load condition of ONAN rating with 200% over loading.

8.6 The terminal connectors shall confirm to IS: 5561. The design shall as to be connected to the equipment terminal stud with a minimum of four 12 mm diameter bolts, nuts, spring and flat washers.

9 BUSHING TYPE CURENT TRANSFORMERS

9.1 The neutral bushing shall be so arranged as to accommodate bushing type current transformer (BCT) for connection to the AT neutral current ratio type fault locator. The BCT shall conform to IEC 60044-1 and meet with the stipulations in Clause 5.1(19) of this document.

9.2 The BCT shall be so designed as to withstand thermal and technical stresses resulting from frequent short circuits experienced by the transformer on which these are fitted.

9.3 Apart from the BCTs required for the biased differential protection, BCT of accuracy class 5 and conforming to IEC 60044-1, with suitable tappings, shall be mounted inside a line bushing for use with the winding temperature indicator.

9.4 The BCTs and the bushings shall be so mounted that removal of a bushing can be achieved without disturbing the current transformers, terminals and connections or pipe work is easy and convenient.

9.5 The leads from the BCTs shall be terminated in terminal boxes provided on the bushing turrets. Suitable links shall be provided in the terminal boxes for shorting the secondary terminals of the BCTs, when not connected to the external measuring circuits.

9.6 The leads from the secondary winding of the BCTs terminated in the terminal box on the bushing turret up to the marshalling box shall be of 1100V grade PVC insulated PVC sheathed, steel wire armoured, stranded copper cable of cross-section not less than 4 mm^2 to IEC 60502-1.

9.7 Cable glands of proper size shall be provided in the terminal boxes to lead in / lead out the cables.

10 CLEARANCES

10.1 The relative orientation in space of the bushings fitted with terminal connectors, the main tank radiators, conservator, pressure relief device, oil piping and other parts when mounted on the transformer, shall be such that the various clearances in air from live parts of bushing shall not be less than the appropriate values given hereunder:

1	Highest voltage for equipment Um, kV	52	12
2	Minimum clearance, mm	500	200

The same distance shall apply for clearance of phase-to-earth (including oil piping work, conservator, pressure relief device and such other parts), phase-to-phase and towards terminals of a lower voltage winding.

11 COOLING EQUIPMENT

11.1 The transformer shall be designed for ONAN type of cooling.

11.2 The radiators shall consist of a pressed steel plate assembly formed into elliptical oil channels or a series of separate elliptical tubes. The radiators shall be designed in such a manner that the temperature-rise limits specified under Clause 5.1(11) of this document are not exceeded.

11.3 The radiators shall be removable (after isolating the same from the main tank) to facilitate transportation of the transformer. A drain plug of size 19 mm and an air-release plug of size 19 mm shall be provided at the bottom and at the top of each radiator bank for draining and filling of oil respectively. Each radiator bank shall also be provided with shut-off valves. If radiators are supplied as a separate unit then body bellows type flexible joints shall be provided on the oil headers.

11.4 The radiators shall preferably be supported directly on the transformer tank. Each radiator bank shall be fitted with lifting lugs.

12 PARTS, FITTINGS AND ACESSORIES

12.1 Apart from the parts, fittings and accessories specifically detailed in the foregoing Clauses, the parts, fittings and accessories detailed hereunder shall be supplied with each transformer:

12.1.1 **Oil level gauge**: It shall be of magnetic type having a dial diameter of 200 to 250 mm. The gauge shall have markings corresponding to minimum oil level, maximum oil level and oil level corresponding to oil temperature of 30^0C, 45^0C and 85^0C. The oil level indicator shall be so designed and mounted that the oil level is clearly visible to an operator standing on the ground. The oil level gauge shall be fitted with two SCADA readable contacts. The first contact shall provide a warning that the oil level is at 25% above the minimum level. The second contact shall indicate when the minimum oil level has been reached.

12.1.2 **Silica gel breather:**It shall be complete with oil seal and connecting pipes. The connecting pipes shall be secured properly. The container of the silica gel breather shall be of transparent flexi glass or similar material suitable for outdoor application.

12.1.2.1 Orange silica gel (round balls 2 to 5 mm) with quantity of two DT-8 silica gel connecting with flanged mounting two pipes control through different valves as per DIN: 42567 & IS: 6401 to be provided.

12.1.3 **Pressure relief device**: It shall operate to release internal pressure at a pre-set value without endangering the equipment or operator and shall be of instantaneous reset type. There shall be two pressure sensor installed with the pressure relief valve. The first sensor shall provide indication that pressure within the transformer has increased to a point 25% below where the pressure relief device will operate. The second sensor shall indicate when the pressure within the transformers has become unacceptable. Both sensors shall have two contacts that can be read by the SCADA system.

12.1.3.1 Shroud Pressure Relief Device will be used and have provision of discharge of oil from PRD to safe place by closed pipeline to avoid hazards of fire.

12.1.4 **Filter valves**: The bottom and upper filter valves shall be of 50 mm size and suitably baffled to reduce aeration of oil. The valves shall be flanged to seat 40 mm adopter threaded to thread size P 1½ for connection to oil filtration plant.

12.1.5 **Drain valve**: It shall be of size 80 mm fitted with an oil sampling device of size 15 mm.

12.1.6 **Earthing terminals**: Two earthing terminals of adequate size shall be provided on the tank for its earthing with the help of 3 mild steel flats, each of size 50 mm x 6 mm. The terminals shall be clearly marked for earthing.

12.1.7 **Oil temperature indicator (OTI)**: It shall have one alarm contact, one trip contact and two normally open spare contacts none of the contacts being earthed. The contacts shall be electrically independent.

12.1.8 **Winding temperature indicator (WTI)**: It shall have one alarm contact, one trip contact and two normally open spare contacts, none of the contacts being earthed. The contacts shall be electrically independent. The windings shall also be fitted with analogue temperature sensors/thermistors/optical sensors that are suitable for being remote read via the SCADA system.

12.1.9 **Thermometer pockets**: A separate thermometer pocket with cap shall be provided on the tank for measuring the top oil temperature in the tank. The thermometer shall indicate hot spot temperature.

12.1.10 **Rating plate**: The rating plate shall indicate the following:

- The ratings of the transformer
- The connection diagram of the windings
- The particulars of the bushing current transformers
- Weight without oil
- Weight with oil
- Kind of transformer (I.e. Scott Connected traction transformer)
- Manufacturer
- Date of manufacture
- Serial number
- Rated Voltages in (kV) and tapping range
- Rated primary and secondary currents
- Short circuit impedance
- Type of cooling

Other details as per IEC 60076-1.. The rating plate shall be both in English and Hindi version.

12.2 All valves shall be of the double flange type and fitted with suitable blanking plates on the outer face of the exposed flange.

12.3 The capillary tubes for temperature indicators shall be able to withstand normal bending. They shall be supported properly without sharp or repeated bends or twists.

12.4 **Fibre Optic Hot Winding Temperature Monitor:**

Fibre optical winding hot spot temperature monitor to be provided with the transformer windings, connected in addition to the winding temperature indicator in parallel to measure transformer winding hot spots in real time and activate control of the cooling system. The fibre to be given high strength casing through rugged jacketing and fibre to be securely routed till the tank wall plate. The application of fibre optic shall be governed by IEC-60076-2 (Ed. 3.0).

Specification for Fibre Optic Temperature Measurement System.

Fibre optic based temperature measurement of Oil and windings shall be done using Fibre Optic Sensors meetings following broad criteria:

13.4.11 System shall be of proven technology. The temperature sensing tip of the fiber optic shall be ruggedized. The probes shall be directly installed in each winding of power transformer to measure the winding hot spot and at the top oil temperature. There shall be at least 4 probes inside the transformer.

13.4.12 Out of the 4 probes one probe shall be used for top oil temperature measurement and the balance 3 will be placed in the LV, HV and Tap Changer winding (One probe per winding) of one limb.

13.4.13 Probes shall be able to be completely immersed in hot transformer oil. They shall withstand exposure to hot vapour during the transformer insulation drying process, as part of Vacuum Phase Drying (VPD). The probes shall meet the requirement to eliminate the possibility of partial discharge in high electric stress areas in the transformer. Probes shall preferably have certified Weidman testing for electrical parameters as per ASTM D-3426 and ASTM D-149 that is current (no more than 1 year old). Test results and studies to be submitted by the transformer manufacturer along with the first unit of a certain type of traction power transformer.

13.4.14 Temperature range of the system should be up to +200°C without any need of recalibration. Probes must connect to the tank wall plate with threaded connectors containing a Viton O-ring to prevent against oil leakage.

13.4.15 Probes shall be of material inert to mineral and ester oils, multiple jacketed (Kevlar preferred), perforated out jacket to allow complete oil filling and mechanical strength.

13.4.16 System should include analog outputs for each measurement channel. Temperature resolution of the analog outputs shall be ±0.1°C and precision of ±0.5°C and the system shall offer user programmable temperature alarm outputs with 8 relays. The cooling system (Fans & Pumps) should be operated through these relays. The temperature settings for the relays shall be made as per the end-user request.

13.4.17 All inputs and outputs of the system shall meet the requirements of surge test of IEEE C37.90.1-2002 in which a 4000 V surge is applied to all the inputs and outputs without permanent damage to the instrument. The system should electronically store testing records of components and allow for on board diagnostics and instructions, including a signal strength reading to verify integrity of fiber optic connections. System should contain a battery for date/time stamp of data readings. The system should comply with IEC61850 protocol, along with DNP 3.0, Modbus, TCP/IP and ASCII.

13.4.18 The transformer manufacturer should submit details showing that the probes are located in the hottest point of the winding, while submitting drawings for approval. The manufacturer are free to use more than 4 probes if design so required.

13.4.19 The controller shall be housed in cooler cubicle or in a separate enclosure having ingress protection IP 56.

13.4.20 Temperature Rise Test Measurements shall be made with the Fiber Optic Thermometers.

The equipment shall be operational during temperature tests and be demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified and temperature data for all probes recorded and reported in the test report.

12.5 The manufacturers of Part, Fittings & Accessories for the transformer shall be mentioned in the SOGP/BOM & got approved. During prototype test, the accessories will be tested & performance monitored by either at Customer Hold Point (CHP) or by Test Certificate (TC) Verification as categorised in the relevant Annexure.

Henceforth, while ordering Traction Power Transformer, a copy of Employer approved SOGP should be called by the users. This document shall form basis for ordering accessories in the future.

In case manufacturers desire to change a particular make of accessory, prior approval of Employer would be required and SOGP as well as Bill of Material (BOM) shall have to be got approved from Employer.

In case of make of accessories approved under Customer Hold Point (CHP) for regular production, the Employer's approval would be required separately on SOGP and BOM. The Traction Power Transformer manufacturer shall be responsible for availability of compatible accessories for the equipment approved

13 FASTENERS

13.1 All fasteners of 12 mm diameter and less exposed to atmosphere shall be of stainless steel and those above 12 mm diameter shall preferably be of stainless steel or of mild steel hot dip galvanized to 610 g/m^2 of zinc. The material of the stainless steel fasteners shall confirm to IS: 1570 (Part-V) Grade O4Cr17Ni12Mo22 or equivalents.

14 PAINTING

14.1 Shot blasting / sand blasting shall be done on the transformer tank to remove all scales, rust and other residue, before applying the paint inside the tank. All steel surfaces which are in contact with insulating varnish. All steel surfaces exposed to weather shall be given, one primer coat of zinc chromate and two coats of grey anti corrosion paint. The touch-up of gray paint shall be applied at site by, the manufacturer.

15 TESTING OF TRANSFORMER

15.1 General

15.1.1 The designs and drawings together with the Quality Assurance Plan (QAP) shall be furnished to the employer, within the period stipulated in the contract.

Only after all the designs and drawings as well as the QAP have been approved for prototype tests and a written advice given to that effect shall the successful bidder / manufacturer take up manufacture of the prototype of the transformer. It is to be clearly understood that any change or modification required by the above authorities to be done in the prototype shall be done expeditiously, not withstanding approval having already been given for the designs and drawings.

15.1.2 Prior to giving a call to the Employer for inspection and testing of the prototype, the successful bidder/ manufacturer shall submit diagrams for each of the tests and the number of days required to complete all the tests at one stretch. Once the schedule is approved, the tests shall invariably be done accordingly. In case any dispute or disagreement arises between the successful bidder/manufacturer and representative of the Employer during the process of testing as regards the procedure for type tests and/or the interpretation and acceptability of the results of type tests, it shall be brought to the notice of the Employer, as the case may be, whose decision shall be final and binding. Only after the prototype transformer is completed and ready in each and every respect, shall the successful bidder/manufacturer give the actual call for inspection and testing.

15.1.3 The type tests shall be carried out on the prototype transformer at the works of the successful bidder/manufacturer or at a reputed testing laboratory in the presence of the representative of the employer in accordance with the relevant specifications and as modified or amplified by this document.

15.2 Tests during manufacture

15.2.1 Though the test described below shall form part of the type tests, the manufacturer shall carry out these tests on first and every unit during the process of manufacture and submit the test reports to the Employer's Inspector deputed for witnessing the routine tests:

a) Oil leakage test.
b) Vacuum test.
c) Pressure test.
d) Test for pressure relief devise.
e) Measurement of capacitance and tan-delta values.

15.2.1.1 **Oil leakage test**: The transformer with its radiators, conservator tank and other parts, fittings and accessories completely assembled shall be tested for oil leakage by being filled with oil conforming to IEC 60296 at the ambient temperature and subjected to a pressure corresponding to twice the normal static oil head or to the normal static oil head plus 35 kN/m^2(0.35 kgf/cm^2), whichever is lower, the static oil head being measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 h, during which time no leakage shall occur.

15.2.1.2 **Vacuum test**: The transformer tank only shall be tested at a vacuum of 3.33 kN/m^2 (0.0333 kgf/cm^2) for 60 min. The permanent deflection of flat plates after release of vacuum shall not exceed the values specified below:

Horizontal length of flat plate	Permanent deflection. mm
up to and including 750 mm	5.0
751 mm to 1250 mm	6.5
1251 mm to 1750 mm	8.0
1751 mm to 2000 mm	9.5
2001 mm to 2250 mm	11.0
2251 mm to 2500 mm	12.5
2501 mm to 3000 mm	16.0
above 3000 mm	19.0

15.2.1.3 **Pressure test**: Every transformer tank, radiator and conservator tank shall be subjected to an air pressure corresponding to twice the normal static head of oil or to the normal static oil head pressure plus 35 kN/m^2 (0.35 kgf/cm^2), whichever is lower, as measured at the base of the tank. The pressure shall remain constant do 1 hour to indicate that there is no leakage.

15.2.1.4 **Test for pressure relief devise**: Every pressure relief device shall be subjected to gradually increasing oil pressure. It shall operate before the pressure reaches the test pressure specified in Clause 15.2.1.3 hereof and the value at which it has operated shall be recorded.

15.2.1.5 **Measurement of capacitance and tan-delta values**: The measurement of capacitance and tan-delta (dielectric loss factor) of the transformer windings shall be made by Schering Bridge.

15.3 Type Tests

15.3.1 The type tests shall be carried out on the prototype transformer at the works of the successful bidder/manufacturer or at any reputed laboratory in the presence of the representative of the Employer and in accordance with the relevant specifications and as altered, amended or supplemented by this document.Amongst others, following shall constitute the type tests:

1. Temperature-rise test.
2. Lightning impulse test.
3. Test with lightning impulse, chopped on the tail.
4. Short-circuit test.
5. Measurement of acoustic sound level.
6. Measurement of partial discharge quantity.
7. Measurement of harmonics of no-load current.

15.3.2 Temperature-rise test

15.3.2.1 The temperature-rise test shall be done in accordance IEC 60076-2 except as modified hereunder.

1	At rated load
2	At 150% rated load for 15min after continuous operation at rated load for 1hr.
3	At 200% rated load for 5min after continuous operation at rated load for 1hr.

The tests shall be done continuously without any power supply interruption. In case interruptions of power supply to take place for some reason, then the entire rest shall be repeated after steady state condition are attained.

15.3.2.2 The points to be ensured during the temperature-rise test shall be:

1	The ambient temperature shall be measured using calibrated thermometers only
2	The winding temperature shall be determined by the resistance method only.
3	The temperature of the top oil shall be measured calibrated thermometer placed in an oil-filled thermometer pocket.
4	The average oil temperature shall be calculated as the difference between the top oil temperature and half the temperature drop in the cooling equipment (radiators)
5	The temperature of the hot-spot in the winding shall be the sum of the temperature of the top oil and 'H' times the temperature rise of the winding above the average oil temperature, where 'H' is the hot spot factor as per IEC 600076-2 and 60076-7.

15.3.2.3 The test shall be carried out as described below:

15.3.2.3.1 **100% load**

1	A quantum of power equal to the sum of the measured losses viz. no-load and load losses measured at minus 15% tap position/ corrected to 75^0C plus 10% of such sum shall be fed to primary winding of the transformer with the secondary winding short-circuited.

2	The power so fed to the transformer shall be continuously maintained till such time as the steady stats temperature is reached i.e. the top oil temperature rise does not vary by more than 1^0C during four consecutive hourly readings
3	On attaining the steady state temperature, the current in the primary winding of the transformer shall be brought to the rated current which shall be maintained for 1 hour. At the end of the period the power supply to the transformer shall be switched of and the time of Switching off recorded
4	The measurement of hot resistance shall commence as soon as is possible after switching off. The first reading of the resistance shall be taken as soon as possible, before expiry of 90 seconds from the instant of switching off and the first ten readings shall be taken at intervals of l5s apart. Thereafter, another ten readings shall be taken at intervals of 30s apart.
5	The time at which each of the resistance values is read shall also be recorded.
6	The temperatures of the ambient, top oil, the top and bottom radiator header oils shall also be recorded at half-hourly intervals throughout the test starting from the instant power supply is; switched on to commence the if test till it is switched off.
7	The WTI and OTI readings shall also be recorded at half hourly intervals right from the instant the power supply is switched on to commence the test till it is switched off
8	After power supply is switched off the readings of OTI and WTI shall be recorded at intervals of 1 min apart for 30 min

15.3.2.3.2 **150% load**

1	After completion, of the test at 100% load, the transformer shall be fed with power which shall be a value so as to cause circulation of the rated current in the primary winding with secondary windings short circuited. This current shall be circulated for 1 hour.
2	The current shall thereafter be increased to 150% of the rated current and maintained-for a period of 15 min. At the end of the 15 min period, the power supply shall be switched off and the time of switching off recorded.
3	Thereafter, the readings as indicated in Clause 15.3.2.3.1(4) to (8) shall be recorded.
4	The temperatures of ambient, top oil, the top & bottom radiator header oil and the temperatures indicated by OTI and WTI shall also be recorded at the time of switching on 150% load as well as at the time of switching off the power supply.

15.3.2.3.3 **200% load**

1	After completion of the test at 150% load, the transformer shall be fed with power which shall be a value so as to cause circulation of rated current in the primary with the secondary windings short circuited. This current shall

	be circulated for 1 hour.
2	The current shall thereafter be increased to 200% of the rated current and be maintained for 5minute period. At the end of the 5 minute period the power supply shall be switched off and the time of switching off recorded.
3	Thereafter, the readings as indicated in clause 15.3.2.3.1(4) to (8) shall be recorded.
4	The temperatures of ambient, top-oil, top & bottom radiator header oils and temperatures indicated by OTI and WTI shall also be recorded at the time of switching on the 200% load as well as the time of switching of the power supply.

15.3.2.3 **Determination of thermal time constant of the winding**: The thermal time constant of the winding under both rated load and overloads shall be verified during the temperature-rise tests.

15.3.2.4 The temperature rise of the oil, winding and current carrying parts in air under both the overload conditions stipulated in Clauses 15.3.2.3.2 and 15.3.2.3.3 above shall not exceed the values stipulated in Clause 5.1(11), of this document. The winding hot-spot temperature under the overload conditions shall not exceed 1150C.

15.3.2.5 **Testing and calibration of the temperature indicators**: The functioning of the OTI and WTI shall be verified during the tests described above. Both the OTI and WTI shall be recalibrated, if necessary, to reflect the respective temperatures correctly. In particular, the reading of the WTI shall be the same as the calculated value of the hot-spot temperature of the winding.

15.3.2.6 **Determination of the thermal time constant of the WTI**: The thermal time constant of the WTI shall be determined for comparison with the thermal time constant of the winding of the transformer with respect to the transformer oil. For this purpose, the indications of the WTI and the OTI shall be recorded every 1 or 2 min during the first 1 h from the instant the transformer is loaded. From the slope of the curve plotted with the time on the X-axis and the difference between the readings of the WTI and OTI at the particular time on the Y-axis, the thermal time constant of the WTI shall be determined.

15.3.3 Lightning impulse test

15.3.5.1 This test shall be done in accordance with IEC 60076-3. The line and neutral terminals of the winding shall be tested with the following:

1	Highest voltage for Equipment Um, kV	52	12
2	Lightning impulse withstand voltage kV peak	250	75

15.3.4 Test with lightning impulse, shopped on the tail

15.3.4.1 This test shall be done in accordance with IEC 60076-3 with the appropriate test voltage as stipulated in Clause 15.3.3.1 above

15.3.5 Short-Circuit Test

The short-circuit test shall be conducted in accordance with IEC60076-5 with the following schedule:

15.3.5.1 Prior to commencement of the test, the following measurements/ tests shall be made:

a) Insulation resistance of the winding with respect to the earth.
b) No-load current.
c) No-load loss.
d) Resistance of windings.
e) Percentage impedance voltage.
f) Load loss.
g) Voltage ratio.
h) Di-electric tests comprising :
  - Separate – source voltage withstand test, and
  - Induced overvoltage withstand test.
i) Recording of Surge Frequency Response Analysis (SFRA) as per IEC 60076-18.

15.3.5.2 The test will be done with secondary side short-circuited and energizing the primary side of the transformer at its rate voltage.

15.3.5.3 The transformer shall be subjected to a total of seven shots in the following sequence:

1st Shot	Symmetrical current
2nd Shot	Asymmetrical current
3rd Shot	Asymmetrical current
4th Shot	Symmetrical current
5th Shot	Symmetrical current
6th Shot	Asymmetrical current
7th Shot	Symmetrical current

15.3.5.4 The duration of each shot shall be 0.25s as per IEC 60076.

15.3.5.5 Measurement shall be done after each shot for the following:

1	Percentage impedance voltage
2	No-load current
3	No-load loss

15.3.5.6 Further testing and inspection of the transformer subjected to the short-circuit test shall be carried out as per IEC 60076-5 with the modification that:

1	The dielectric routine tests shall be at 100% of the original test value
2	The percentage impedance voltages measured after the short circuit test shall not vary by more than 2% from those measured before the sort circuit test.

15.3.5.7 On completion of the short-circuit test the transformer shall be un-tanked for inspection of the core and windings. In case the inspection of the core and winding do not reveal any apparent defects and the results of the short-circuit test, the values of percentage impedance voltage as also the results of the routine tests done after the short-circuit test are in order, the transformer shall be deemed to have passed the short-circuit test.

If any of the results of the tests are not in order or the inspection of core and windings reveals any defect, then the transformer shall necessarily have to be dismantled completely for detailed inspection.

15.3.6 Measurement of acoustic sound level

15.3.6.1 Measurement of acoustic sound level of the transformer energized at rated voltage and frequency shall be carried out either as per Indian Electrical Rules & IEC 60076-10.

15.3.7 Measurement of Partial discharge quantity

15.3.7.1 Partial discharge quantity of the windings shall be measured in accordance with IEC 60076-3.

15.3.8 Measurement of harmonics of no-load current

15.3.8.1 The magnitude of harmonics of no-load current as expressed in percentage of the fundamental shall be measured by means of a harmonic analyzer, in accordance with IEC 60076-1.

15.4 Type tests on part, fittings and accessories

15.4.1 Bushings

15.4.1.1 The type tests shall be carried out in accordance with IEC 60137 on porcelain housing of the bushings. The following shall constitute the type tests:

a) Visual inspection.
b) Verification of dimensions
c) Electrical routine test.
d) Porosity test.
e) Temperature cycle test.
f) Bending test.

15.4.1.2 The type tests shall be carried out in accordance with IEC 60137 on the prototype of the bushings. The following shall constituted the type test:

a) Wet power frequency withstand voltage test.
b) Dry lightning impulse voltage withstand test.
c) Thermal stability test.
d) Temperature-rise test.
e) Thermal short time current withstand test.
f) Dynamic current withstand test.
g) Cantilever load withstand test.
h) Tightness test.
i) Test of tap insulation.
j) Tightness test at flange or other fixing device.
k) Measurement of partial discharge quantity.

15.4.2 Bushing type current transformers

15.4.2.1 The bushing type current transformers shall be tested in accordance with IEC60044-1.

15.4.3 Terminal connectors

15.4.3.1 The terminal connectors shall be tested in accordance with IS: 5561.

15.4.4 **Bucholz Relay**: The Buchholz relay shall be tested in accordance with IS:3637.

15.4.5 Temperature indicators

15.4.5.1 The following tests shall be conducted in prototypes of OTI and WTI:

1	Accuracy with reference to a standard instrument
2	Calibration of the indicators to reflect the actual temperature of

	the oil/ windings
3	Dielectric test at 2.5kV for 60s.
4	Vibration test.
5	Dust and water splash test to IP 55 degree of protection.

15.4.6 Pressure relief device

15.4.6.1 The following tests shall be conducted on the prototype of pressure relief device:

a) Air pressure test.
b) Leakage test.
c) Contact rating and operation test.
d) Dielectric test on contacts at 2.5kV for 60 s.

15.4.7 Radiators

15.4.7.1 The radiators shall be tested for air leakage at a pressure of 2.5 kg/m^2. The pressure shall remain constant for 1 h to indicate that there is no leakage.

15.5 Insulating oil

15.5.1 The following tests shall be carried out in accordance with IEC 60296 on the sample of new insulating oil for use in the prototype transformer

a) Density at 270C
b) Kinematic viscosity at 270C
c) Interfacial tension at 270C
d) Flash point.
e) Neutralisation value (acidity)
f) Electric strength (with 2.5 mm gap)
g) Dielectric dissipation factor (tan-delta)
h) Specific resistance at 27^{0}C and at 90^{0}C
i) Oxidation stability
j) Water content

15.6 Routine tests

15.6.1 The following routine tests shall be performed on each transformer including the prototype unit in accordance with IEC 60076-1:

a) Visual examination
b) Insulation resistance test
c) Measurement of no-load current
d) Measurement of no-load loss
e) Measurement of resistance of the windings
f) Measurement of percentage impedance voltage
g) Measurement of load loss
h) Voltage ratio test
i) Dielectric tests comprising

- Separate-source voltage withstand test, and
- Induced overvoltage withstand test

j) Recording of SFRA as per IEC 60076.

15.6.2 **Visual examination**: A general examination shall be made to check that the transformer conforms to the approved drawings, various items are accessible for maintenance, the quality of workmanship and finish are of acceptable standards and all parts, fittings and accessories are provided.

15.6.3 **Insulation resistance test**: The insulation resistance of the winding with respect to the earth shall be measured using a 5 kV megger.

15.6.4 **Measurement of no-load current**: Measurement of no-load current referred to the primary side shall be done at 90%, 100%, and 110% of the rated voltage.

15.6.5 **Measurement of no-load loss**: Measurement of no-load loss shall be done at 90%, 100% and 110% of the rated voltage.

15.6.6 **Measurement of resistance of windings**: The resistance of the windings between the line and neutral terminals shall be measured and computed at 75^0C.

15.6.7 **Measurement of percentage impedance voltage**: The percentage impedance voltage shall be measured at rated current and at ambient temperature and computed at 75^0C.

15.6.8 **Measurement of load loss**: Load loss at rated current shall be measured at ambient temperature and computed at 75^0C.

15.6.9 **Voltage ratio test**: The voltage ratio shall be measured.

15.6.10 **Dielectric tests**

15.6.10.1 **Induced overvoltage withstand test**: The test shall be done as per IEC 60076-3.

15.6.10.2 **Separate source voltage withstand test**: A test voltage of 28 kV shall be applied between the winding and tank.

15.6.11 Recording of Surge Frequency Response Analysis (SFRA) as per IEC 60076-18.

15.6.12 During the routine tests of any unit, if it is found that the sum of the measured losses (i.e. no-load and load losses) measured at the15% tap position (corrected to 75^0C) exceeds the value defined in Clause 16.3.2.3.1(1), or if the no-load loss/ load loss at the principal tapping exceeds the maximum guaranteed value defined in Clause 5.1 (12), the transformer shall be rejected.

15.7 If the prototype of a transformer conforming to this document and rating has already been approved in connection with previous supplies to Indian Railways, fresh type testing may be waived at the discretion of the Employer, provided that no changes whatsoever in the design or materials used or the process of manufacture have been made. However, the Employer reserves the right to conduct type tests if he deems it necessary to do so in the light of experience gained from previous supplies.

15.8 Only after approval of the original tracings of drawings incorporating changes, if any, as a result of the prototype tests and clear written approval of the results of. the tests on the prototype is communicated by the Employer, to the successful bidder/manufacturer, shall he take up bulk manufacture of the transformer which shall be strictly with the same materials and process of manufacture as adopted for the prototype. In no circumstances shall materials other than those approved in -the design/drawings and/or during the prototype testing be used for bulk manufacture-on the plea that they had been obtained prior to the approval of the prototype.

15.9 The bidder may quote separately his charges for short-circuit and temperature rise tests. No charges shall be payable for any other type and routine tests.

15.10 Transformer before dispatch should be filled with Nitrogen / dry air and provided with a gauge clearly visible for monitoring the pressure inside the tank.

16 TECHNICAL DATA AND DRAWINGS

16.1 The bidder shall furnish along with his offer in the proforma, at Annexure-2, the Schedule of Guaranteed Performance Technical and Other Particulars (SOGP) for the transformer. The particulars shall be complete in all respects. If there is any entry like shall be furnished later or a blank us left against any items, the offer is not likely to be considered as the evaluation of the offer is rendered difficult and cannot be compared with other offers, if any.

16.2 The bidder shall specifically indicate in a "Statement of Compliance" attached with the offer his compliance with each and every Clause of this document. In case the bidder wishes to deviate from any Clause(s) of this document, he may do so by giving reference to the Clause(s) with the reasons/justification for the deviation. This shall be in the form of a separate statement called the "Statement of Deviations".

If there is no deviation at all a specific "NIL" "Statement of Deviations" shall be attached with the offer. If the "Statement of Compliance" and "Statement of Deviations" are not attached with the offer, it is not likely to be considered for the reason that it is an incomplete offer which cannot be properly evaluated and compared with other offers, if any.

16.3 The bidder shall furnish the following information along with his offer:

16.3.1 **Calculations for**:

a) Temperature rise of winding at rated current.
b) Hot-spot temperature of the winding at 150% and 200% rated loads for 15 min and 5 min respectively.
c) Thermal withstand capacity of the windings for a short circuit of 5s duration.
d) Mechanical force in respect of the following as per IEEMA (Indian Electrical & Electronic Manufacturer's Association) formulas given in

Annexure-3:

i) Hoop stress in primary and secondary windings.
ii) Compressive pressure in the radial spacers.
iii) Internal axial compressive force.
iv) Axial imbalance force.
v) Radial bursting force.
vi) Resistance to collapse.
vii) Bending stress on clamping ring and densified wood.
viii) Maximum allowable torque on pressure screws for coil clamping bolts at the time of tightening, if any

e) Flux density with the characteristic curve.
f) Maximum value of inrush current.

16.3.2 Drawings for:

a) Outline general arrangement drawing giving complete details of the transformer
b) Arrangement of the core, winding and magnetic path
c) Magnetizing characteristic of CRGO sheet steel.

16.4 The successful bidder/manufacturer shall submit to the employer for approval the following detailed dimensioned drawings as per Indian Railways standard in sizes of 210 mm x 297 mm or any integral multiples thereof:

a) Outline general arrangement of the transformer indicating plan, front elevation, side elevation, with all parts, fittings and accessories, electrical clearances as well as salient guaranteed particulars.
b) Internal arrangement of the transformer indicating line and neutral bushing lead connections core to core-clamp earthing, core-clamp to tank earthing, core-clamp to Core-base bolting, and the locking arrangement of the core & coil assembly with the tank.
c) Cross sectional view of the core and winding with material specifications and makes.
d) Details of the pressure screws/ oil, dash-pot/ coil clamping bolts or other devices and their location with materials specification.
e) Schematic view of the valves used on the transformer and the antitheft device so as to prevent theft of oil.
f) Transport outline dimensional diagram.
g) General arrangement of marshalling box indicating protection and control equipment.
h) Wiring diagram of marshalling box.
i) Schematic diagram of protection and control circuits in marshalling box with cable schedule.
j) Legend plate showing protection and control circuits for fitment in the marshalling box.
k) OIP condenser bushing for line terminal including cross-sectional view,

shed profile and salient electrical and mechanical characteristics.

l) Oil-filled porcelain bushing for neutral terminal including cross-sectional view shed profile and salient. Electrical and mechanical characteristics

m) Dimensional drawing, V-I characteristics and rating plate for bushing type current transformers.

n) Rigid type terminal connector for line bushing terminal.

o) Rigid type terminal connector for neutral bushing terminal.

p) Rating plate with diagram of connections both in English and Hindi versions.

q) Details of radiator

r) Details of breather.

s) External cable run with cable schedule.

t) Any other drawings considered necessary by the successful bidder/ manufacturer and / or Employer.

16.4.1 The format of the title sheet to be adopted for preparation of the drawings is attached at Appendix-2.

16.4.2 After approval, six copies of each of the approved drawings along with two sets of reproducible prints for each drawing shall be supplied to each consignee(s).

16.4.3 Two copies of the "Operations and Maintenance manual" for each transformer shall be supplied to the consignee(s) two copies of the manual shall be supplied to the employer.

17 CAPTALISATION OF TRANSFORMER LOSSES

17.1 The capitalized value of transformer losses shall be as low as possible and commensurate with optimum no-load and load losses. The formula given in Clause 6.6 of the Particular Specification shall be used for the purpose of calculating the present worth of the transformer after taking into account capitalization of its losses, when comparing different bids capitalized cost of the losses in the transformer shall be added to the bid value for total quantity of transformers required for this Project in the lump sum form for evaluation purposes.

18 SPARES

18.1 The bidder shall quote separately for the following essential spares for every lot of up to 5 transformers or part thereof:

a) One line bushing complete with parts, fittings and bushing type current transformer.
b) One neutral bushing complete with parts, fittings and bushing type current transformer.
c) One complete set of gaskets of all sizes required for use in the transformer.
d) One piece of radiator.
e) One terminal connector each for line and neutral side bushing terminals.
f) One set valves.
g) One pressure relief device.

19 ERRECTION TESTING AND COMMISSIONING

19.1 The transformer shall be erected and commissioned by the Employer. The successful bidder/manufacturer shall invariably make available at site the services of an engineer of his to ensure, by his continued presence, that the process of erection, testing and commissioning of the transformer is in accordance with established recommended practices. For this purpose prior intimation regarding the dates/period and locations at which the transformers are to be erected and testing/commissioning done shall be given by the Employer to the successful bidder/manufacturer. No charges shall be payable by the employer to the successful bidder/manufacturer for the services of his engineer in this regard.

20 SCHEDULE OF GUARANTEED PERFORMANCE, TECHNICAL AND OTHER PARTICULARS (GUARANTEED PARTICULARS ARE TO BE ESTABLISHED BY ACTUAL TESTS/ TEST REPORTS)

SN		DESCRIPTION	UNIT OF MEASUREMENT	VALUE/ INFORMATION
1		2	3	4
A		**RATINGS/PARTICULARS**		
1.		Name of the Manufacturer		
2.		Country of manufacture		
3.		Reference to specification based on which performance data is prescribed		
4.		Rated power	MVA	
5.		Primary current at:		
		a) Rated load	A	
		b) 150% rated load for 15 min	A	
		c) 200% rated load for 5 min	A	
6.		Secondary current at:		
		a) Rated load	A	
		b) 150% rated load for 15 min	A	
		c) 200% rated load for 5 min	A	
7.		Rated voltage :		
		a) Primary	kV	
		b) Secondary (at no-load)	kV	
8.		Rated frequency	Hz	
9.		Temperature rise above ambient temperature of 50 ^{0}C :		
	(i).	Oil :		
		a) At rated load	^{0}C	
		b) At 150% rated load for 15 min	^{0}C	
		c) At 200% rated load for 5 min	^{0}C	
	(ii)	Winding :		
		a) At rated load ^{0}C		
		b) At 150% rated load for 15 min.	^{0}C	
		c) At 200% rated load for 5 min	^{0}C	

10		Hot-spot temperature of winding over ambient temperature of	^{0}C	
		a) At rated load	^{0}C	
		b) At 150% rated load for 15 min.	^{0}C	
		c) At 200% rated load for 5 min	^{0}C	
		Interval of time between two successive overloads after continuous working at full load, at maximum ambient temperature of 50℃:		
		a) Between two consecutive over min. loads of 50% for 15 min	min.	
		b) Between two consecutive min overloads of which one is of 50% for 15 min and the other of 100% for 5 min.	min.	
12		No-load current referred to primary side at rated frequency and at:		
		a) 90% rated voltage A		
		b) Rated voltage A		
		c) 110% rated voltage A		
13		Power factor of no-load current at rated voltage and rated frequency		
14		Value of the inrush current at rated voltage on primary side, the secondary side being open circuited		
15		Losses:		
	(i)	No-load loss at rated frequency and at:		
		a) 90% rated voltage at the principal tapping.	kW	
		b) rated voltage at the principal tapping.	kW	
		c) 110% rated voltage at the primary tapping.	kW	
		d) Appropriate voltage at the 15% tapping. -	kW	
		e) Appropriate voltage at the +10% tapping/	kW	
	(ii)	Load loss (at 75 ^{0}C) at rated current and frequency	kW	
		a) Principal tapping	kW	
		b) -15% tapping	kW	

		c) +10% tapping	kW	
	(iii)	Total losses at rated current and frequency		
		a) Principal tapping	kW	
		b) -15% tapping	kW	
		c) +10% tapping	kW	
16		Resistance voltage (at 75 ^{0}C) at rated current	%	
17		Reactance voltage (at 75 ^{0}C) at rated current and frequency	%	
18		Impedance voltage (at 75 ^{0}C) at rated current and frequency	%	
19		Resistance (at 75 ^{0}C) of primary winding	ohm	
20		Resistance (at 75 ^{0}C) of secondary winding	ohm	
21		Reactance of winding :	H	
	i)	Primary	H	
	ii)	Secondary at	H	
		a). Principal tapping	H	
		b). +10% tapping	H	
		c). -15% tapping	H	
22		Regulation (at 75 ^{0}C) with rated current and at power factor of:		
		a) Unity	%	
		b) 0.8 lagging	%	
23		Efficiencies:		
	(i).	Efficiency (at 75 ^{0}C) at unity power factor at:		
		a). 100% load	%	
		b). 75% load	%	
		c). 50% load	%	
		d). 25% load	%	
	(ii).	Efficiency (at 75^{0}C) at 0.8 power factor lagging at:		
		a). 100% load	%	
		b). 75% load	%	

		c). 50% load	%	
		d). 25% load	%	
	(iii)	Percentage of rated load at which maximum efficiency occurs.	%	
24		Ability to withstand short-circuit:		
		a). Thermal	s	
		b). Dynamic	s	
25		Thermal time constant (calculated):		
	(i)	for winding with respect to oil at:		
		a). rated current	min	
		b). 150% rated current	min	
		c). 200% rated current	min	
	(ii)	Complete transformer at rated current	min	
26		Temperature gradient between oil and winding at:		
		a). Rated current	^{0}C	
		b). 150% rated current for 15 min	^{0}C	
		c). 200% rated current for 5 min.	^{0}C	
27		Temperature rise of oil:		
	(i).	Calculated average temperature rise of oil at:		
		a). Rated current	^{0}C	
		b). 150% rated current for 15 min	^{0}C	
		c). 200% rated current for 5 min	^{0}C	
	(ii)	Estimated temperature rise of top oil at:		
		a). Rated current ^{0}C		
		b). 150% rated current for 15 min ^{0}C		
		c). 200% rated current for 5 min ^{0}C		
28		Details of core:		
	(i)	Type of core		
	(ii)	Flux density at rated voltage and frequency	tesla	
	(iii)	Flux density at 110% rated voltage and frequency	tesla	

	(iv)	Thickness of steel stampings	mm	
	(v)	Grade of core material and conforming specification		
	(vi)	Exciting VA/kg for core stampings at:		
		a) Flux density of 1.55 tesla	VA/kg	
		b) Flux density at rated voltage	VA/kg	
		c) Flux density at 110% rated voltage	VA/kg	
	(vii)	Exciting VA/kg for assembled core at:		
		a) Flux density of 1.55 tesla	VA/kg	
		b) Flux density at rated voltage	VA/kg	
		c) Flux density at 110% rated voltage	Va/kg	
	(viii)	Type of insulation between core laminations.		
	(ix)	Type of joint between the core limbs and yoke.	kV	
	(x)	Core bolt Insulation withstand voltage	kV	
	(xi)	Core bolt insulation flashover voltage	kV	
		Details of windings:		
	(i)	Type of winding		
		(a) Primary		
		(b) Secondary		
		(c) Number of turns of primary winding		
		(d) Number of turns of secondary winding		
		(e) Number of parallel paths in primary winding		
		(f) Number of parallel paths in secondary winding.		
		(g) Is interleaving/inter shielding of the winding adopted to ensure better impulse voltage distribution?	Yes/No	
		(i) Primary		
		(ii) Secondary		
		(h) Is the insulation of end turns of winding reinforced?	Yes/No	
	(i)	Primary		

	(ii)	Secondary		
		(i) Type of coil		
	(ii)	Mode of connection (i.e. in series or in parallel) of the portions of the windings on the two limbs of the core, if applicable.		
	(iii)	Dimensions of the copper conductor used in the winding:		
		a) Primary	mm x mm	
		b) Secondary	mm x mm	
		c) Tapped winding.	mm x mm	
	(iv)	Current density at rated current.		
		a) Primary	A/mm^2	
		b) Secondary	A/mm^2	
	(v)	Insulation used over the conductor (details of material and specification there for)		
	(vi)	Type of joints, if any, in the windings		
	(vii)	Dielectric strength of windings:		
		a) Full wave lightning impulse withstand voltage:		
		i) Primary winding	kV peak	
		ii) Secondary winding.	kV peak	
		(b) Lightning Impulse chopped on the tail withstand voltage:	kV	
		(i) Primary winding		
		(ii) Secondary winding		
		(c) Separate source power frequency withstand voltage	kV	
		(i) Primary		
		(ii) Secondary		
		(d) Induced over voltage withstand value		
	(viii)	Minimum flashover distance to earth in oil of :		
		a) Secondary winding to core		
		b) Primary winding to yoke		

		c) Primary winding to tank		
	(ix)	Material used for coil clamping rings and specification there for		
	(x)	Magnitude of axial pre-compressive force on the winding		
		(a) Primary	kV peak	
		(b) Secondary	kV peak	
	(xi)	Calculated maximum axial thrust in the winding due to dead short circuit at the terminals		
		(a) Primary		
		(b) Secondary		
	(xii)	Calculated short circuit forces:		
		a) Hoop stress in primary winding	kgf/cm^2	
		b) Hoop stress in secondarywinding	kgf/cm^2	
		c) Compressive pressure in the radial spacers		
		d) Internal axial compressive force	kgf/cm	
		e) Axial imbalance force		
		f) Resistance to college	kgf	
		g) Bending stress on clamping	kgf/cm^2	
		h) Radial bursting force		
	(xiii)	Arrangement to maintain constant pressure on the windings		
	(xiv)	Maximum permissible torque on pressure screws for coil clamping at the time of tightening, if any.	N.m	
	(xv)	Can either end of each secondary winding (25 kV) be connected directly to earth?	Yes/No.	
30		Motorised off-circuit tap changer:		
		a) Name of the manufacturer		
		b) Country of origin.		
		c) Type designation		
		d) Governing specification.		
		e) Is a separate taped winding provided on each secondary?		

		f) Number of tappings:		
		i) Plus tappings		
		ii) Minus tappings		
		g) Percentage variation of voltage on different tapping.		
		h) Minimum contact pressure between moving and stationery contacts	kgf	
		i) Maximum rated through current	A	
		j) Voltage class	kV	
		k) Rated voltage of control circuit	V(dc)	
		l) Tap changer motor particulars:		
		i) Make and type		
		ii) Rated voltage	V(dc)	
		iii) Rated current	A	
		iv) Rated power	kW	
		v) Speed	rpm.	
		vi) Class of insulation		
31		Bushings:		
	(i).	Primary side:		
		a) Name of the manufacturer		
		b) Country of origin		
		c) Governing specification		
		d) Type designation (specify as to whether it is OIP condenser bushing)		
		e) Voltage class	kV	
		f) Rated current	A	
		g) Visible power frequency discharge voltage	kV	
		h) Wet one minute power frequency withstand voltage	kV peak	
		i) Lightning impulse withstand voltage	mm	
		j) Creepage distance		
		k) Weight of assembled bushing	Kg	
	(ii)	Secondary side		
		a) Name of the manufacturer		

		b) Country of origin		
		c) Governing specification		
		d) Type designation		
		e) Voltage class	kV	
		f) Rated current	A	
		g) Visible power frequency discharge voltage	kV	
		h) Wet one minute power frequency withstand voltage	kV	
		i) Lightning impulse withstand voltage	kV peak	
		j) Creepage distance	mm	
		k) Weight of assembled bushing	kgf	
32		Bushing type current transformers:		
	(i).	Primary side:		
		a) Name of the manufacturer		
		b) Governing specification		
		c) Transformation ratio		
		d) Accuracy class and rated accuracy limit factor		
		e) Rated current	A	
		f) Rated output	VA	
		g) Exciting current at the rated knee point emf	mA	
		h) Rated knee point emf	V	
		i) Secondary winding resistance corrected to 75^0C	ohm	
		j) Short time thermal current and duration.	kA, s	
	(ii)	Secondary side:		
		a) Name of the manufacturer		
		b) Governing specification		
		c) Transformation ration		
		d) Accuracy class		
		e) Rated current	A	
		f) Rated output	VA	

		g) Exciting current at the rated knee point emf	mA	
		h) Rated knee point emf	V	
		i) Secondary winding resistance corrected to 75^{0}C.	ohm	
		j) Short time thermal current and duration	kA, s	
33	Insulating oil :			
		a) Governing specification		
		b) Grade of oil		
		c) Source of supply		
		d) Specific resistance at:		
		i) 27 ^{0}C	ohm-cm	
		ii) 90 ^{0}C	ohm-cm	
		e) Dielectric, dissipation factor (tan-delta) at 90 ^{0}C-		
		f) Dielectric strength	kV	
		g) Water content	ppm	
		h) Interfacial tension	N/m	
		i) Neutralisation value	mg KOH/gm	
		j) Flash point	℃	
34	Type of transformer tank			
35	Details of radiators:			
		a) Make and type		
		b) Type of mounting		
		c) Overall dimensions (LxWxH)	mmx mm x mm	
36	Details of Buchholz relay:			
		a) Make and type		
		b) Governing specification		
		c) Provision of shut-off valves on either side of the relay	Yes/No	
		d) Provision of alarm contact	Yes/No	
		e) Provision of trip contact	Yes/No	
		f) Rated current of contacts	A	

37		Details of winding temperature		
		Indicator.		
		a) Make and type		
		b) Governing specification		
		c) Number of contacts provided		
		d) Rated current of contacts	A	
		e) Dielectric withstand value of contacts	kV	
38		Details of oil temperature indicator		
		a) make and type		
		b) Governing specification		
		c) Number of contacts provided		
		d) Rated current of contacts	A	
		e) Dielectric withstand value of contacts	kV	
39		Details of Magnetic oil level gauge:		
		a) Make and type		
		b) Governing specification		
		c) Diameter of dial mm		
		d) Number of contacts provided		
		e) Rated current of contact	A	
		f) Dielectric withstand value of contacts	kV	
40		Details of pressure relief device:		
		a) Make and type		
		b) Governing specification		
		c) Does it reset itself	Yes/No	
41		Bimetallic terminal connectors:		
	(i)	Primary side:		
		a) Source of supply		
		b) Governing specification		
		c) Type		
		d) Rated current	A	
		e) Temperature rise over an ambient temperature of 45℃ while carrying	℃	

		rated current.		
		f) Short time current and duration	kA, s	
	(ii).	Secondary side:		
		a) Source of supply		
		b) Governing specification		
		c) Type		
		d) Rated current	A	
		e) Temperature rise over an ambient temperature of 45^0C while current rated current	°C	
		f) Short time current and duration	kA, s	
42		Acoustic sound level at a distance dB of 1 m, when energised at rated voltage and rated frequency without load.		
43		Partial discharge value at 1.5Um/ 3 kV r.m.s.	pC	
44		Weights and dimensions:		
	(i)	Net weight of core		
	(ii)	Net weight of cooper:		
		a) Primary winding	kg	
		b) Secondary winding	kg	
	(iii)	Net untanking weight of core frame and coils	kg	
	(iv)	Net weight of insulating oil	kg	
	(v)	Volume of insulating oil	l	
	(vi)	Total weight of cooling equipment	t	
	(vii)	Total weight of transformer without oil	t	
	(viii)	Total shipping weight of complete transformer including all detachable parts, fittings and assemblies	t	
	(ix)	Shipping weight of largest package	t	
	(x)	Crane lift (excluding slings) for un-tanking core and coils	mm	
	(xi)	Crane lift (excluding slings) for removal of primary side bushings.	mm	
	(xii)	Dimensions of the complete transformer including all parts, fitting and accessories:		

		a) Overall length	mm	
		b) Overall breadth	mm	
		c) From rail level to the topmost point	mm	
	(xiii)	Minimum thickness of steel plate/ sheet used:		
		a) Bell tank mm		
		b) Tank bottom mm		
		c) Conservator mm		
		d) Radiator mm		
		e) Marshalling box. mm		
	(xiv)	Overall shipping dimensions of the largest package (Length x width x height)	mm x mm x mm	
	(xv)	Mode of transportation of transformer unit (filled with oil/nitrogen gas.)		
		Other particulars		
45		Is the transformer tank fitted with lifting pads? If yes, what is the number of pads	Yes/ No	
46		What is the number of inspection covers provided?		
47		Are comfits/ trays provided for cable run?	Yes/ No	
48		Is the core electrically connected with the tank?	Yes/No	
49		Will the gaskets to be used in the transformer give trouble free service for at least 7 years? If not, indicate the life.	Yes/No	
50		Is the core construction without core bolts?	Yes/No	
51		Are the core bolts grounded, and if so, how?	Yes/ No	
52		What is the number of radial spacers used in the winding?		
53		What is the number of joints provided in the winding?		
54		Are the spacers/blocks/angle rings of pre-compressed press boards? If no, indicate the material with specification.		
55		Are arrangements made for ensuring automatic constant pressure on the coils? If no. give the reasons.	Yes/ No	

56		Are closed slots provided on outer most winding for locking the vertical strips? If no, give the reason.	Yes/ No	
57		What is the periodicity for tightening of coil clamping arrangement?	Years	
58		What are the designed values of short-circuit current for:		
		a) Symmetrical :		
		i) Primary winding A		
		ii) Secondary winding A		
		b) A symmetrical:		
		i) Primary winding A		
		ii) Secondary winding A		
59		What is the over flux with stand capability of the transformer (Maximum permissible limit of flux density) ?	Tesla	
60		Are windings pre-shrunk?	Yes/No	
61		Have the details of drying cycles of the coils/coil assembly including final tightening values of pressure, temperature and degree of vacuum at various stages of drying been furnished?	Yes/ No	
62		Are arcing horns provided for line and neutral bushings?	Yes/ No	
63		Is a test tap provided in the line bushing?	Yes/ No	
64		Is the porcelain housing of the bushings of single piece construction?	Yes/ No	
65		Is the shed profile of porcelain housing of the bushing free from under-ribs but has a lip?	Yes/ No	
66		Is the bushing type current transformer of low reactance type?	Yes/ No	
67		Is Clause by Clause "Statement of compliance" attached?	Yes/ No	
68		Is "Statement of deviation", if any, attached?	Yes/ No	
69		Does the tap changer have snap action? If not, give reason.		

70		Is the Buchholz relay provided with two shut-off valves, one on either side?	Yes/ No	
71		Is separate conservator tank & Buchholz relay provided for tap changing equipment?	Yes/ No	
72		Are fasteners of 12 mm diameter and less exposed to atmosphere of stainless steel to Grade 04Cr17 Ni12Mo to IS 1570 Part-V?	Yes/ No	
73		Are the fasteners of more than 12 mm diameter exposed to atmosphere of stainless steel or MS hot dip galvanised?	Yes/ No	
74		Are test certificates for tests as per Clause 15.0 attached?	Yes/ No	
75		Are all the calculations required as	Yes/ No	
76		Are all the drawings required as per clause 16.3.2 attached?	Yes/ No	
77		(a) Are all the parts, fittings and accessories from Employer's approved manufacturers?	Yes/ No	
		(b) If not, list the items which are to be type tested in the presence of Employer's representative.	Yes/No	
78		Is adequate space provided in the marshalling box for housing the wiring and components?	Yes/ No	
79		Is warranty as per clause 22.0?	Yes/ No	
80		Is the list of spares furnished or no?		

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Annexure - I

TECHNICAL SPECIFICATIONS FOR NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM FOR OIL FILLED TRANSFORMER

13.0 GENERAL DESCRIPTION:

Nitrogen injection fire protection system designed for oil filled transformers shall prevent tank explosion and the fire during internal faults resulting in an arc, where tank explosion will normally take few seconds after arc generation and also extinguish the external oil fires on transformer top cover due to tank explosion and/or external failures like busing fires, OLTC fires and fire from surrounding equipment's.

The system shall drain a pre-determined quantity of oil from the tank top through outlet valve to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and deduce the temperature of top oil surface below flash point to extinguish the fire.

Conservator tank oil shall be isolated during busing bursting, tank explosion and oil fire to prevent aggravation of fire.

Transformer isolation shall be an essential pre-condition for activating the system. The system shall be designed to operate automatically. However, it shall be designed for manual operation, in case of failure of power supply.

The system shall consist of following equipment:

6. Fire extinguishing cubicle placed on a plinth at about 5-10 meter away from the transformer.
7. Control box placed in the control room.
8. Necessary valves in the conservator pipe.
9. Suitable fire sensing components to be provided preferably in/on the tank cover.
10. Signal box suitably placed.

14.0 SCOPE:

The scope of this document covers design, engineering, supply testing at works before dispatch; erection, testing and commissioning and performance demonstration of "fire protection and extinguishing system by nitrogen injection method".
The necessary civil work which will be required for construction of oil soak – pit for the storage of oil coming out from the transformer and plinth for extinguishing cubicle is outside the scope of this document. However, laying

of oil pipe, nitrogen pipe, electrical cables, control boxes, extinguishing cubicle, nitrogen cylinder, necessary vales, fire detectors and other equipments& accessories required for erection, testing, commissioning and performance demonstration of the complete fire protection system is in the scope of the tenderer. It will be the responsibility of the tenderer, i.e. transformer manufacturer to coordinate with the supplier of the Fire Protection System for all the arrangements for the complete erection, testing, commissioning and performance tests. Notwithstanding the technical specifications and requirements mentioned herewith any modification can be incorporated for correct operation of nitrogen injection fire protection system without extra cost. The full details of the same are required to be submitted to Employer for approval, when first unit is implemented on a transformer of specific make & rating.

15.0 OPERATIONAL CONTROLS:

The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control, remote electrical push button control on control box and local manual control in the fire-extinguishing cubicle shall be provided. The fire protection system will take signal from HV/LV circuit breaker.

16.0 SYSTEM ACTIVATING SIGNALS:

16.1 Transformer isolation shall be an essential pre-condition for activating the system. Provision shall be provided to isolate the Traction Power Transformer through Master trip relay or circuit breaker (HV and LV side in series) before Nitrogen injection and after oil depressurization.

16.2 There shall be two modes of operation of Fire Protection System i.e. Fire Prevention Mode & Fire Extinction Mode. In this mode the safety equipment to be involved are tabulated below. The logic of their operation shall be finalized during design approval.

Mode of Operation	Safety Equipment to be used
Fire Prevention Mode	• Differential relay/Over current/Restricted earth fault relay. • Pressure relief valve
Fire Extinction Mode	• Fire sensing components • Buchhloz relay

17.0 SYSTEM EQUIPMENT:

17.1 Fire Extinguishing Cubicle (FEC), placed on plinth at about minimum 5 meter away from the transformer shall consist of:

17.1.1 Nitrogen gas cylinder with pressure reducer/regulator and falling pressure electrical contact manometer.

17.1.2 Oil drain pipe with mechanical quick drain valve;

17.1.3 Electro mechanical control equipment for oil drain and pre-determined regulated nitrogen release.

17.1.4 Pressure monitoring switch for backup protection, pressure reducer with solenoid valve in the cabinet for operation of nitrogen gas release, which will be IP-65, protected and leak proof for nitrogen release.

17.1.5 Limit switches for monitoring of the system.

17.1.6 Flanges on top panel for connecting oil drain and nitrogen injection pipes for transformer.

17.1.7 Panel lighting

17.1.8 Oil drainpipe extension of suitable sizes for connecting pipes to oil pit.

17.1.9 The Nitrogen gas cylinder should be of sufficient (not less than 50 liter) capacity and should be filled at a pressure of not less than 150 bars with falling pressure electrical contact manometer, suitable design measures to prevent leakage of gas to be taken.

17.1.10 The nitrogen valve shall have IP-65 protection. The nitrogen shall be contained within the cylinder and released from the cylinder valve only upon activation of the fire protection system. Nitrogen purity shall 99.99%

17.1.11 Proper approvals and certificates should be provided with each cylinder. No used nitrogen bottle will be accepted.

17.1.12 Control box with activating, monitoring devices and line faults indicators to be placed in control room. It should have audiovisual alarm indication and push button switches for tests response.

17.1.13 Necessary valves to be fitted in the conservator pipeline between conservator and Buchholz relay operating mechanically on transformer oil flow rate with electrical signal for monitoring.

17.1.14 Suitable fire sensors to be fixed on transformer tank top cover and off circuit tap changer for sensing fire.

17.1.15 Signal box to be fixed on transformer side will for terminating cable connection from sensors and conservator shutter/signal box to be suitably placed.

17.1.16 All other consumables necessary for operation of complete system.

17.1.17 Control box should be microprocessor based and compatible to be interfaced with existing RTU for Railway Traction SCADA system available at the control room. For communication, Control box shall have provision for interfacing with SCADA in this regards details Digital Input & Output required for operation monitoring through SCADA should be furnished.

18.0 OTHER REQUIREMENTS FOR SYSTEM INSTALLATION:

18.1 Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations.

18.2 Flanges with dummy piece in conservator pipe between Buchhloz relay and conservator tank for fixing.

18.3 Brackets on transformer top cover for sensing equipment, valves to enable operation of the system.

18.4 Spare potential free contacts for system activating signals i.e. differential relay, Buchholz relay, pressure relief valve, transformer isolation (master trip relay).

18.5 Pipe connections between transformer to fire extinguishing cubicle and fire extinguishing cubicle to oil pit.

18.6 Cabling on transformer top cover all sensors to be suitably connected for reliable fire sensing and inter cabling between signal box to control box and control box to fire extinguishing cubicle.

18.7 Plinth for fire extinguishing cubicle. Oil pit with capacity as 10% of total oil quantity of transformer.

19.0 TECHNICAL DETAILS:

Fire extinction period:

On commencement of Nitrogen injection	:	Maximum 30 seconds
On system activation up to post cooling	:	Maximum 3 minutes
Heat sensing area	:	140± 2°C
Seating for operation to isolate conservator	:	Min.60 Ltr. per minute

Power Source:

Control Box	:	110 V DC
Fire extinguishing cubicle for lighting	:	240 V AC

20.0 CABLING:

20.1 Fire survival cables, able to withstand 750°C, 1.5 mm² with necessary no. of conductors for connection of fire detectors in parallel shall be used. The test certificates for the cables shall be submitted.

20.2 Fire retardant low smoke (FRLS) cable 1.5 mm² with necessary no. of conductors for connection between transformer signal box/marshalling box to control box and control box to fire extinguishing cubicle shall be used.

20.3 Fire retardant low smoke (FRLS) cable 1.5 mm² with necessary no. of conductors for connection between control box to DC supply source and fire extinguishing cubicle to AC supply source, signal box/marshalling box to transformer shall be used.

21.0 PREVIOUS EXPERIENCE FOR QUALIFYING SUPPLIER:

The supplier shall have a minimum experience of two years in the design, manufacturing, erection, testing and commissioning of Nitrogen Injection Fire Protection System on power transformers of similar or higher rating. At least 2 sets of the system shall be in successful operation for a minimum period of the 2 years.

The supplier shall furnish the details of Nitrogen Injection Fire Protection System supplied by them so far, giving order reference, name and address of the customer, indicating the dates of commissioning as well as performance certificate of successful and satisfactory operation for minimum two years from the customers.

22.0 TESTS

22.1 Type Tests

Type test reports including that for detectors along with declared response time as per test approval certificate letter shall be submitted along with the tender.

The system shall be tested by international or a national testing body (NABL accredited recognized laboratory. Tariff Advisory Committee (TAC's) approval, if any, shall be submitted with the tender.

22.2 Factory Test

Tests will be carried out on individual equipment of the system and the total system in the supplier's workshop in presence of purchaser's representative.

22.3 Performance Test

Performance test of the complete system shall be carried out after complete erection at site by the supplier's representative. These tests shall include simulation and verification of the response of the complete system without actual draining of the oil and injection of the nitrogen gas.
In addition to above, additional tests as required necessary shall be conducted.

23.0 DRAWINGS AND MANUALS

Detailed layout drawing along with the equipment drawing to be given in the tender along with complete bill of materials. After awarding of contract, detailed dimensional drawing of the system complete bill of materials including location and size of plinth for cubicle and recommended capacity of oil soak-pit shall be submitted for purchaser's approval. After approval 10 (ten) sets of all above drawings and 5 (five) sets of operation and Maintenance Instruction Manual (bound) shall be submitted for purchaser's use.

24.0 SPARES

One full set of spare nitrogen gas filled cylinder, one set of the installed no. of fire sensors shall be provided in addition to additional other recommended spares. The list of recommended spares is to be submitted along with the tender.

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Part -XIII

JOINT DEED OF UNDERTAKING BY THE QUALIFIED EQUIPMENT MANUFACTURER ALONGWITH THE CONTRACTOR AND INDIAN EQUIPMENT MANUFACTURER/INDIAN PARTNER

THIS DEED OF UNDERTAKING executed this ……………. day of ………………….. Two Thousand and ………… by

M/s. ……………………, a Company incorporated under the laws of …………. and having its Registered Office at ………………………… (hereinafter called the *"Qualified Equipment Manufacturer"*, which expression shall include its successors, executors and permitted assigns),

And

M/s. ……….…………….., a Company incorporated under the Indian Companies Act of 1956 and having its Registered Office at ……………………………….. (hereinafter called the *"Indian Equipment Manufacturer/Indian Partner"*, which expression shall include its successors, executors and permitted assigns),

Through

M/s. ……….…………….., a Company incorporated under the laws of …………………… and having its Registered Office at ……………………………….. (hereinafter called the *"Contractor"*, which expression shall include its successors, executors and permitted assigns),

in favour of M/s Dedicated Freight Corridor Corporation of India Limited (DFCCIL), a Company incorporated under the Indian Companies Act of 1956 and having its registered office at Room No. 101/A, Rail Bhavan, Raisina Road, New Delhi – 110001, India (hereinafter called the *"Employer"* which expression shall include its successors, executors and permitted assigns).

WHEREAS:

1. The *"Employer"* has invited a bid as per its Tender Specification No. ………………….. for the execution of …………… *(Insert name of the package along with project name).*

2. The *"Contractor"* at the time of bidding has submitted its bid to the *"Employer"* vide proposal No. ………dated……………..for the said package and accepted by the *"Employer"*, resulting into a contract (hereinafter called the *"Contract"*).

3. The *"Contractor"* has selected *"Qualified Equipment Manufacturer"* along with its *"Indian Equipment Manufacturer/Indian Partner"*, for the supply of Equipment, who is the qualified manufacturer of transformers in line with the Clause No. …......, Section ………, of Volume………… forming part of the contract.

4. Under the provisions of the contract for the supply of the Equipment,, the "*Qualified Equipment Manufacturer"* will supply _______ Nos. of Equipment, *Indian Partner"* will supply _______ Nos. of equipment.

NOW THEREFORE THIS UNDERTAKING WITNESSETH as under:

1.0 Without in any way affecting the generality and total responsibility in terms of this Deed of Undertaking, the Contractor, Indian Equipment Manufacturer/Indian Partner and the Qualified Equipment Manufacturer to ensure:

(i) Design of the Equipment manufactured in India shall be identical to the design of equipment to be manufactured and supplied by the Qualified Equipment Manufacturer.

(ii) Adequate up gradation of the facilities including quality systems at Indian works.

(iii) Training to staff of Indian Equipment Manufacturer/Indian Partner and certification to its trained personnel to carry out each activity.

(iv) Active involvement of Qualified Equipment Manufacturer expert in various stages of manufacturing such as for transformer winding manufacturing, core assembly, complete assembly, quality assurance and testing for the first unit of the Equipment at Indian Partner's works.

(v) MQP of Indian Equipment Manufacturer/ Indian Partner shall be same as that of Qualified Equipment Manufacturer.

(vi) Specification of raw material / major bought out components shall be same as that of Qualified Equipment Manufacturer.

(vii) Timely supply of the said equipment. In the event, the development takes time and does not meet the time schedule, Qualified Equipment Manufacturer shall supply all the equipment from their works to meet the completion schedule without any additional liability to the Employer.

(viii) If necessary the Qualified Equipment Manufacturer shall advise the Indian equipment manufacturer/Indian Partner and/or Contractor suitable modifications of designs and implement necessary corrective measures to discharge the obligations under the Contract.

(ix) The prototype tests shall be conducted for the equipment manufactured at the works of both i.e. Qualified Equipment Manufacturer as well as Indian equipment manufacturer/Indian Partner.

3.0 This Deed of Undertaking shall be construed and interpreted in accordance with the laws of India and the Courts in Delhi shall have exclusive jurisdiction in all matters arising under the Undertaking.

4.0 We, the Qualified Equipment Manufacturer/Contractor and/or The Indian Equipment Manufacturer/Indian Partner agree that this Undertaking shall be irrevocable and shall form an integral part of the Contract and further agree that this Undertaking shall continue to be enforceable till the Employer discharges it.

IN WITNESS WHEREOF the Qualified Equipment Manufacturer, The Indian Equipment Manufacturer/Indian Partner and/or the Contractor have through their Authorised Representatives executed these presents and affixed Common seals of their respective Companies, on the day, month and year first above mentioned.

WITNESS

Signature …………………….

Name ………………………..

Office Address ……………….

(For Qualified Equipment Manufacturer)

(Signature of the authorized representative)

Name ……………………..

Common Seal of Company …...…………….

WITNESS

Signature …………………….

Name ………………………..

Office Address ……………….

(For Indian Equipment Manufacturer/ Indian Partner)

(Signature of the authorized representative)

Name ……………………..

Common Seal of Company …...…………….

WITNESS	**(For Contractor)**
Signature …………………….	(Signature of the authorized representative)
Name ………………………..	Name ……………………..
Office Address ……………….	Common Seal of Company …...…………….

Note:

1. The non-judicial stamp papers of appropriate value shall be purchased in the name of executants parties and the date of purchase should not be later than six months of date of execution of the Undertaking.

2. The Undertaking shall be signed on all the pages by the authorised representatives of each of the partners and should invariably be witnessed.

3. In the event the Contractor is an Indian transformer Manufacturer/Indian Partner and the Collaboration is between Qualified Transformer Manufacturer and the Contractor, then the Joint deed of undertaking shall be modified accordingly.