

CHAPTER 29: SPECIFICATIONS FOR COMMUNICATION EQUIPMENT FOR ESTABLISHMENT OF FIBRE OPTIC COMMUNICATION SYSTEM

29.0 Introduction, General Information and General Requirement

This Chapter describes the technical specifications for Communication Equipment for Establishment of Fibre Optic Communication System under the contract. This specification describes the functional and performance requirements of the system.

29.1 Scope and General Requirements

The broad scope of the procurement of this part include the survey, planning, co-ordination with other suppliers' equipment, design, engineering, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for

- (i) SDH Equipment along with suitable optical line interfaces & tributary cards.
- (ii) Integration with existing NMS at SLDC.
- (iii) All cabling, wiring, Digital Distribution Frame patch facilities and interconnections to the supplied equipment at the defined interfaces.
- (iv) System integration of the supplied subsystems and also integration with existing communication equipment such as SDH
- (v) Integration of supplied system with the User equipment such as RTUs, SCADA system SAS etc.
- (vi) Maintenance of the supplied system
- (vii) Integration/Interfacing with PLCC/DPC

All other associated works/items described in the technical specifications for a viable and fully functional communication network.

The network shall comprise multi input and multi output fibre optic equipment complete for speech communication in dialling mode and or through express telephone, data communication, fibre optic based power system protection, suitable for multi point to multi point fibre optic network. The terminal optical communication equipment shall be installed in the Sub Stations to be constructed under this Package (only for 400kV Voltage Level).

The responsibility of connecting the optical terminal equipments with the FODP of the respective substation shall rest with this contract. Also, the connection of OLTE with FODP is within the scope of this contract..

29.2 General Requirements

29.2.1 It should be noted that preliminary design information and bill of quantity (BOQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BOQ as required for ultimate design & system performance.

29.2.2 The Tenderer's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

29.2.3 An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items and services such that a viable and fully functional communication equipment system is implemented that meets or exceeds

the capacity, and performance requirements specified. Such materials and services shall be considered to be within the scope of the contract. To the extent possible, the Tenderers shall identify and include all such additional items and services in their proposal.

29.2.4 All telecom equipment provided shall be designed to interface with existing telecom equipment and shall be capable of supporting all present requirements and spare capacity requirement identified in this specification.

29.2.5 The communication equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation, including adding and removing circuits. The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

29.2.6 The Tenderer is supposed to make necessary survey for integration of the SDH Equipment with the existing NMS at SLDC, Kahilipara. For this if any traffic routing to SLDC is required through other Utilities; AEGCL will arrange the same. However, during interfacing with the existing telecom equipment if any hardware/software is required (at SLDC or Remote end), the Bidder has to offer the same with no cost implication to AEGCL.

29.2.7 The Tenderers are advised to visit sites (at their own expense), prior to the submission of a proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful tenderer (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer may be associated with the Contractor during their site survey activities. After the site survey, the Contractor shall submit to the Employer a survey report

on each link and site. This report shall include at least the following items:

- (a) Proposed layout of Equipment in the existing rooms and buildings.
- (b) Proposed routing of power, earthing, signal cables and patch cords etc.
- (c) Confirmation of adequacy of Space and AC/DC Power supply requirements
- (d) Proposals for new rooms/buildings if required
- (e) Identification of facility modifications if required
- (f) Identify all additional items required for integration for each site/location.

29.2.8 Synchronization of the Communication Network

The Contractor shall be responsible for synchronization of new communication equipment with existing network utilizing the existing GPS clock. The Contractor shall make an assessment of additional clock requirement for synchronization of the communication equipment.

29.3 General Responsibilities and Obligations

This section describes the general responsibilities and obligations of the Contractor and the Employer.

29.3.1 Responsibilities for the Implementation Plan

The Tenderer's technical proposal shall include a project implementation plan and schedule that is consistent with the implementation plan detailed in this specification. The implementation plan shall be modelled such that it provides fibre optic cabling system support for the activation of this Project. The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones and clearly identifying the nature of all information and project support expected from the

Employer. The Employer and Contractor shall finalise the detailed Implementation plan following award of the contract.

29.3.2 Contractor's Responsibilities and Obligations

The Contractor shall be responsible for all cables and wiring associated with the equipment provided, both inside and outside buildings in accordance with technical specifications. The Contractor shall also be responsible for determining the adequacy of the local power source for the equipment and for wiring to it, with adequate circuit protective breakers. In addition, the Contractor shall be responsible for shielding equipment and cabling to eliminate potential interference to or from the equipment, and for earthing all cabinets and shields.

Contractor's obligations include, but are not limited to, the following:

- (1) Site visits, and surveys, necessary to identify and provide all equipment needed to implement the network.
- (2) Equipment Engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.
- (3) Overall integration of communication equipments/subsystem procured in present with existing User equipments such as SDH, RTUs, SCADA, SAS system with SLDC, Kahilipara etc.
- (4) All cabling, wiring including supply, laying and termination etc of the cables, and distribution frame at wideband nodes required for full interconnectivity and proper operation of the telecommunications network including equipment supplied under this package and the connectivity and interfacing of user equipment.
- (5) Installation and integration of network management software, hardware and firmware.
- (6) Project management, project scheduling, including periodic project reports documenting progress, review meeting during the contract period.
- (7) Engineering and technical assistance during the contract and warranty period.
- (8) Implement all minor civil works and identify any major civil works i.e. expansion or construction of rooms, trenches necessary for installation of proposed equipment and provide the details of such work to the Employer.
- (9) Factory and site testing of all hardware, software, and firmware provided.
- (10) Provide documented evidence of satisfactory Type Test performance to the Employer and if required by The Employer, conduct type test.
- (11) Provide a Quality Assurance Plan, ensuring the Employer access to the manufacturing process.
- (12) Training of the Employer personnel.
- (13) Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment through out the warranty period.
- (14) Availability of service, spare and expansion parts for the supplied items for the designed life of the equipment or seven (7) years after the declaration of withdrawal of equipment from production, whichever is earlier. However, the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

Detailed descriptions of the Contractor's obligations, in relation to individual items and services offered, are delineated in other sections of this specification.

29.3.3 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

- (1) Overall project management of the project
- (2) Review and approval of the Contractor's designs, drawings, and recommendations.
- (3) Communication network configuration data, including:
 - (a) Channel assignments for voice and data
 - (b) Interconnection drawings for existing equipment
- (4) Review and approval of test procedures.
- (5) Participation in and approval of "Type", factory and site acceptance tests where testing is required.
- (6) Review and approval of training plans.
- (7) Providing support and access to facilities at the sites.
- (8) Implement the major civil works such as expansions or construction of rooms, trenches etc. as required for the equipment to be provided by the Contractor.
- (9) Coordination of the Contractor's activities with the Employer's and constituents' concerned departments.
- (10) Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned.
- (11) Approval of the key personnel for the project

29.4.0 Applicable Standards

The applicable standards are mentioned in the respective technical section. The offered equipment shall conform to the standards mentioned in the specification except to the extent modified by this specification. In case of any discrepancy between the description given in the specification and the standards, the provisions of the technical specification shall be followed. The parameters not specifically mentioned in this specification shall conform to the standard mentioned in this specification.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the

contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

29.5.0 Network Configuration and Equipment Characteristics

29.5.1 Introduction

This section describes the Fibre Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

- (1) Fibre Optic Transmission System (FOTS)
- (2) Craft Terminal based Network Management System (NMS)
- (3) DDF and Cabling

The requirements described herein are applicable to and in support of network requirements.

29.5.2 The security related requirements of the equipment shall be as per DOT (Department of Telecommunication)/ MEITY (Ministry of Electronics and Information Technology) guidelines and all similar security requirements as amended by DoT on time to time basis shall be followed/complied by the vendor at no additional cost to employer till the implementation of the project..

29.5.3 The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security /threat check any time during the supplies of equipment.

29.5.4 The contractor shall ensure that the supplied equipment have been tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. From 1st April, 2013, the certification shall be done from authorized and certified agency/lab in India.

29.5.5 The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. Supplied and implemented in the project shall be given for use by the Employer.

29.5.6 The contractor shall get the Employer's equipment audited from security point of view once a year from a network audit and certification agency as identified by DoT. The audit of the equipment shall be carried once in a financial year till the maintenance service contract in the tender.

29.5.7 In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Contractor as per guidelines of DoT and any other Government department.

29.6.0 General Network Characteristics

29.6.1 Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH). The network shall consist of overhead fibre optic links with a minimum bit rate of

Synchronous Transport Module-STM-16 (STM-16). The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in appendices. The fibre optic network shall also be able to integrate with existing STM-1 network.

29.6.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTUs/SAS. The communications support requirement for SCADA/EMS/RTUs/SAS system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

- (a) High speed E1 channel support
- (b) 64kbps & nx64kbps data channel support
- (c) Low speed (300-1200 bps) data channel support
- (d) Voice (2 wire, 4 wire) channel support
- (e) Network Management channels either through (Data Communication Channel(DCC) or through data channel as may be suitable as per site requirement.
- (f) The connectivity envisaged for RTUs and SAS with Control Centre (SLDC, Kahilipara) over TCP-IP is Wide Area Network on TCP-IP using IEC 60870-5-104 and IEC 60870-5-101 protocol.
- (g) Tele-protection interface for simultaneous transmission and reception of trip (tele-protection) signal from/to one station to/from another two three or more stations. Tele-protections unit should be capable of communicating with remote end tele-protections directly or through fibre with 64kbps or E1 as back up path through fibre optic equipment.

29.6.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

29.6.3.1 System Synchronization

The Contractor shall synchronize the existing equipment and all the new equipment under the contract

using existing Master clock. The Contractor shall provide the additional clocks as required under the set of clock indicated in BOQ. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of

ITU-T G.803. The synchronization plan shall clearly indicate the requirement of additional clocks with full justification.

The system equipment requiring “clock” shall be connected to the master clock using external clocking. For this purpose, appropriate interface(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

29.6.3.2 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under NMS control with graphical user interface. Such testing shall not affect the functional operation of the system.

29.6.3.3 System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies and NMS shall be sized for maximum equipped system capacity.

29.6.3.4 Equipment Availability

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. The average per link subscriber to subscriber availability shall be at least 99.97%. The per link subscriber to subscriber availability is defined as the availability between any two data or voice subscribers between SAS/RTU to reporting Control Centres and between control centres.

The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the meantime- to-repair (MTTR) of the components and subsystems comprising the FOTS. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations.

In order to ensure that the equipment and configuration proposed by the Tenderers shall capable of demonstrating the specified availability figures it is required that the Tenderer shall include in their proposal a calculated availability analysis for the proposed equipment/sub system. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided by the Contractor during detailed engineering. The analysis shall be based on an availability block diagram and shall include the mean-time-between-failure (MTBF) and mean-time-to-repair (MTTR) of all the components on the link. The Tenderer shall indicate in the analysis the MTBF and MTTR and the resulting availability of each point-to-point link. For this analysis, an MTTR of at least 4 hours shall be assumed.

The Tenderer shall carry out the survey at respective Sub-Stations and other linking Sub-Stations to assess the requirements. The required wiring and cabling for the integration with new & existing OPGW systems, new & existing Fibre Optic System, new and existing EPAXs, space requirements, power supply requirements. Placing of proposed FOTS equipment with FODP shall also be assessed by the Tenderer during the Site Survey.

29.6.3.5 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

29.6.3.6 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BOQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion. Data communications channelization required to support the NMS subsystems specified in Technical Specifications (TS) are not identified in the appendices. Therefore, the Contractor is required to size and equip the system to include all channelization and channel cards required to support the NMS function.

29.6.3.7 Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 2-1. The failure of one element shall not prevent the use of any other that has not failed.

**Table 2-1
Equipment Redundancy Requirements Summary**

Fiber Optic transmission Equipment : SDH equipment	
Power Supply & Converters -----	1:1 APS
Common Control* Cards -----	1:1 APS
Common control cards which are essentially required for operation of the equipment.	1:1 APS
DACS(Cross Connect)-----	1:1 APS
Power Supply-----	1:1 redundant
Multiplexer power supply-----	1:1 APS

The offered equipment shall support at least SNCP **as per standard ITU-T G.841**. In case the equipment offered by the Tenderer does not support the above mentioned minimum protection methods, the tenderer shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The tenderers shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

29.6.3.8 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment,

rack and monitoring levels and normal operation indications restored and reported if applicable.

29.6.3.9 Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer.

29.6.3.10 General Site Considerations

In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wave length translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored by centralized NMS.

29.6.3.11 Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table-2-2:

Table-2-2 Optical Fibre Characteristics	
Fibre Description:	Dual-Window Single-Mode (DWSM)
Mode Field Diameter:	8.6 to 9.5 μm ($\pm 0.6 \mu\text{m}$)
Cladding Diameter:	125.0 μm + 1 μm
Mode field Concentricity Error:	$\leq 0.6\mu\text{m}$
Core-Clad concentricity error:	$\leq 1.0\mu\text{m}$
Cladding non-circularity	$\leq 1\%$
Cable Cut off Wavelength:	$\leq 1260 \text{ nm}$
1550 loss performance	As per G.652D
Proof Test Level	$\square\square 0.69 \text{ Gpa}$
Attenuation coefficient	@1310nm $\leq 0.35 \text{ dB/Km}$ @1550nm $\leq 0.21 \text{ dB/Km}$
Attenuation variation with wavelength 1285 nm - 1330 nm 1525 nm – 1575 nm	Attenuation coefficient @1310 $\pm 0.05 \text{ dB}$ Attenuation coefficient @1550 $\pm 0.05 \text{ dB}$
Point discontinuities	$\leq 0.1\text{dB}$
Chromatic Dispersion; Max.:	18.0 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) @ 1288-1339nm 5.3 ps/(nm x km) @ 1271-1360nm
Zero Dispersion Wavelength: Zero Dispersion Slope:	1300 to 1324nm 0.092 ps/(nm ² xkm) maximum
Polarization mode dispersion coefficient	$< 0.2 \text{ ps/km}^{1/2}$
Temperature Dependence:	Induced attenuation $< 0.05 \text{ dB}$ (-60 deg C - +85 deg C)

Bend performance:	@1310nm (75+2 mm dia Mandrel), 100 turns; Attenuation rise □□0.05 dB @1550nm (30+1 mm dia Mandrel), 100 turns; Attenuation rise □□0.10 dB @1550nm (32+0.5 mm dia Mandrel), 1 turn; Attenuation rise □□0.50 dB
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29.7.0 Fibre Optic Link Lengths

The fiber optic route lengths are as specified in appendices/Section Project/BoQ. The lengths specified in appendices are the transmission line route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to sag, jointing & splicing, approach cabling etc. For bidding purposes the Contractor may assume an additional cable length of 5% of given route length + 1Km towards approach cable for calculating the link length. The exact cable lengths shall be determined by the Contractor during the survey. The same shall be used by the Contractor for final link design during the detailed engineering of the project.

29.7.1 Fibre Optic Transmission System

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-16 and equipped with 2 nos. Of minimum 63 port E1 interface (G.703) card, two no. of minimum 8 port Ethernet interface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE802.1P/Q), spanning tree (IEEE 802.1D) quality of service. Protection scheme for Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032..

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided for each equipment connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

29.8.0 SDH Equipment

29.8.1 Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The Price schedule shall be referred for BOQ. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If tenderer is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements

of the specifications. Further, control card shall not be equipped with more than one optical interface/SFP and optical base card shall not be equipped with more than two optical interface/SFPs.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

29.8.2 SDH ADM

The aggregate interfaces shall be STM-16 towards at least 5 (five) protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 2 nos., min. 63 E1 port electrical tributary cards & one no., min. 8 port Ethernet interface card as tributaries. The equipment shall provide access to full STM16 payload. The equipment shall provide non blocking cross connect capability of 64 STM-1 (bi-directional) at high order VC-4 level and as well as low order VC-12 level. Cross connection (VC4) capability of offered SDH equipment shall be provided according to STM-16 equipment.

29.8.3 Redundancy and Protection

Two fibre rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibres shall be implemented.

29.8.4 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: 8 voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and 4 data channel with optical coupler interface for V.24/V.28 interface. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

29.8.5 Supervision and Alarms

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the NMS.

29.8.6 Synchronisation

The equipment shall provide synchronisation as per Table 2-2. One 2MHz synchronisation output from each equipment shall be provided.

29.8.7 Electrical and Optical I/O Characteristics and General Parameters

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Table 2-3	
Electrical and Optical I/O Characteristics and General Parameters	
Optical Wavelength NOTE (1)	1310/1550nm
Optical Source NOTE (2)	Laser

Optical Source Lifespan	Better than 5 X10 ⁵ hours
Optical Fibre Type	G.652 D
Optical Connectors	Type FC-PC
Transmission Quality	Per ITU-T G.821, G.823, G.826
Source Primary Power	-48 Vdc
Equipment Specifications	Per ITU-T G.783
Tributary, Electrical Interface	Per ITU-T G.703, 75 Ω
Ethernet Interface	10/100 Mbps
SDH Bit Rates	Per ITU-T G.703
Optical Interfaces	Per ITU-T G.957, G.958
Frame and Multiplexing Structure for SDH	Per ITU-T G.707
Synchronization	Per ITU-T G.813
Management Functions	Per ITU-T G.774, G.784
Protection Architectures	Per ITU-T G.841
Built In Testing and Alarms	Per ITU-T G.774, G.783, G.784

NOTE (1) Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

NOTE (2) Eye Safety for Laser Equipment: To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

NOTE (3) In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

29.9.0 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

29.9.1 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

- (1) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.
- (2) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.
- (3) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.
- (4) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed "End of Life (EOL)" parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.
- (5) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.
- (6) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWDM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of 10^{-10} . The tenderers shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link during detailed engineering.

For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

29.9.2 Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.

FOTS equipments shall be provided with in-built loopback capabilities : Each FOTS transceiver pair shall be able to provide local(manual) and remote on demand loopbacks of the composite baseband and each E-1 port.

29.10.0 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP(to be provided under separate contract) and the SDH equipment. The Contractor shall provide FC PC coupled patch cords of suitable length as per requirement. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

29.11.0 DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities to the wideband telecommunications system. Equipment and material components for DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

29.12.0 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

- (i) "Normally thru" circuit routing
- (ii) Circuit rerouting via patch cord assemblies
- (iii) Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

29.12.1 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

29.13.0 Telecommunication Management Network / Network Management System

The Contractor shall provide Craft Terminal based Telecommunications Management Network System (NMS) for operational support to the FOTS subsystems (if required). This NMS shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network with the help of a portable personal computer to be known as craft terminal. The Contractor shall submit for Employer's approval the NMS architecture describing in detail the following subsystems/features:

- (a) Database used in NMS
- (b) Peripherals and hardware
- (c) Software and operating system
- (d) Craft Terminals

29.14.0 Management Functions

The NMS shall support following Management functions:

29.14.1 Configuration Management

Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

- a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.
- b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.
- c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.
- d. Provide verification testing to support new equipment installation.

29.15.0 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

- a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.
- b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.
- c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms and minor alarms with different colours.

- d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.
- e. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.
- f. Track network equipment failure history.

29.16.0 Performance Management

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

- a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link, together with other data measured at each node, shall be available on operator request.

- b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources. Specifically provide displays to permit the operator to:
 - 1. Select/deselect network equipments, events, and threshold parameters to monitor
 - 2. Set monitoring start time and duration or end time
 - 3. Set monitoring sampling frequency
 - 4. Set/change threshold values on selected performance parameters
 - 5. Generate alarm events when thresholds are exceeded.
 - 6. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
 - 7. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.
 - 8. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
 - 9. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

29.17.1. Security Management

The NMS shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only, and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the NMS system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control. Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

29.17.2. Communication Channel Requirement and Integration

Communication requirements for NMS system have not been considered in Appendices and the Contractor shall provide these as a part of NMS system. The Contractor shall provide all required interface cards / devices etc. The NMS data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible.

29.18 Craft Terminal

Each equipment on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

- a. Change the configuration of the station & the connected NEs.

- b. Perform tests
- c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices

29.19 Hardware Requirements

29.19.1 Craft Terminal

The craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, IBM, HP, Compaq make shall be supplied. The Craft Terminal shall be a laptop. The craft terminal shall have the following minimum configuration:

Parameter	Specification
Compliance	MIL-STD 461F, MIL-STD 810 G
Display	14.0" FHD (1920 x1080)
	1000 nits DynaVue® sunlight readable display with capacitive multi-touch screen
	User selectable touch mode for Finger/Water, Glove, or Stylus programmable function
Operating System	Windows® 10 Pro 64-bit
Processors	Intel® Core™ i7-1185G7 vPro™ (11th Gen) 3.0GHz processor with Turbo Boost Technology up to 4.8GHz, 12MB cache
Memory	2 slots 8GB (3200MHz DDR4)
Storage	Main: 1TB NVME PCIE SSD
Graphics	Intel® Iris® Xe Graphics
Camera	Integrated 2.0 MP web-cam with shutter design
	Optional IR camera for Windows Hello1
Audio	Integrated microphone
	Intel® High Definition Audio Compliant
	Integrated speaker x 2
	Keyboard volume and mute controls
Media Bay (One Option Only)	Optional DVD super Multi Optional 2nd battery Optional SATA SSD
Expansion Box	Optional PCI-Express 3.0 (2 slots)1,6

	Optional discrete VGA1,6
	Optional storage extension with RAID 0/1/5/101,6
	Optional military-grade connectors1
I/O Ports	Thunderbolt 4 (type C) x 1
	USB 3.2 Gen2 (type C) x 1 (support DP)
	USB 3.2 Gen2 (type A) x 1
	USB 3.2 Gen1 (type A) x 1
	USB 2.0 (type A) x 1
	Audio in/out (combo jack) x 1
	microSD card (microSDXC) x 1
	10/100/1000 Ethernet (RJ45) x 2
	VGA port (D-sub,15-pin) x 1
	HDMI port (type A) x 1
	Serial port (RS232 : D-sub,9-pin) x 25
	Docking connector (41-pin Pogo) x 1
	SIM card x 1
	Smart card reader x 1
	DC-In jack x 1
	ExpressCard 54 x 1 (default) or PCMCIA Type II x 1
	Optional RF antenna pass-through for GPS, WWAN, and WLAN
Keyboard & Pointing Device	2 user-definable keys (P1/P2)
	RF signal slide-switch
	Standard membrane keyboard with LED backlight
Communications	Integrated 10/100/1000 Ethernet
	Intel® Wi-Fi 6 AX201 (802.11 ax)
	Bluetooth® V5.2
	Optional dedicated GPS module (UBLOX-NEO-M8N)
	Optional 4G LTE multi-carrier mobile broadband
	Optional RF antenna pass-through for GPS, WWAN, and WLAN
Security	Intel® vPro™ Technology (per CPU options)
	TPM 2.0
	NIST BIOS compliant
	Easy removable SSD
	Smart card reader
	Stealth mode
	Night vision mode
	Kensington lock
	Optional Windows Hello1
	Optional fingerprint scanner

	Optional HF/LF RFID reader ¹
Power	AC adapter : 100-240V, 50Hz-60Hz, 90W
	Optional AC adapter (100-240V, 50Hz-60Hz, 120W), with NVIDIA® VGA
	Main battery Li-Ion, 10.8V, 7800mAh, 16 hours ²
	Optional 2nd battery Li-Ion 10.8V, 4700mAh, 9 hours ²
	Optional bridge battery : 5 minutes swap time ³
Dimension & Weight	356 mm (L) x 280 mm (W) x 50 mm (H) ⁴
	3.6 kg
Warranty	3-year limited warranty standard

29.19.2 Power Supplies

The NMS system shall use 220 volts 50 Hz A.C or -48 volt D.C as available at site for its operation as available at site.

29.20 General Software/Firmware Requirements

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

29.20.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources, and manage communications among the system processors. The contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

29.20.2 Applications Software

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The contractor shall make no modifications to the applications program except as provided as USER development tools.

29.20.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

29.20.4 Revisions, Upgrades, Maintainability

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

All software shall be easily user expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly recompilation or revision upgrades

of the software or components of the software, shall not be necessary to accommodate full system expansion.

Software provided shall be compliant with national and international industry standards.

20.5 Database(s)

The contractor shall develop all the databases for final wideband network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of NMS system.

NMS operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

29.20.6 Help

All applications shall be supported by USER accessible HELP commands that shall assist the user in the performance of its tasks. HELP commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.

29.21 Environment, EMI, Power Supply, Cabling and Earthing

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

29.21.1 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

29.21.1.1 Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 4-1.

**Table 4-1
Environmental Operating Limits**

Temperature Range: Specification	(Un Controlled Environment) 0 to 45°C
Operation without damage	-10 to 55°C
Shipping/storage	-40 to 60°C
Relative Humidity, non- condensing	Upto 90%
Elevation: Operating	to 3,000 m
Non-operating	to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

29.21.2 EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location. Specifications provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

29.21.3 Vibration and Shock Resistance

As per testing requirements indicated in this specification.

29.21.4 Tropicalization

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

29.21.5 Contaminants

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

29.22.0 Primary Source AC/DC Power Requirements

Facilities will be required to support both AC and DC power load requirements of telecommunications equipment as specified below:

29.22.1 Primary Source AC Power

It will be the Employer's responsibility to provide required Primary AC source Power for communications equipment installed under this specification. The Primary AC Power supplied will be 240 VAC $\pm$ 10%, 50Hz with a frequency variance between 46 and 55 Hz. Harmonic distortion will not exceed five (5) percent. All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 240 VAC supply. The Contractor shall provide in their Bid as well as in the survey report to the Employer the projected 240 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification. The Contractor shall provide suitable UPS for communication equipment/module etc. requiring AC power supply at locations other than control centre.

29.22.2 -48V DC Power

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 240 VAC) provided under this specification, shall use -48Vdc uninterrupted primary source power. **The 48V SMPS battery charger and 48V battery bank for all the 220KV and 132KV substations that fall under this network shall be supplied by the contractor.** The power supply may vary normally within the voltage range -42 to -58 Vdc and the supplied equipment shall operate satisfactorily within this range.

29.22.3 TECHNICAL SPECIFICATION 48V BATTERY BANK FOR FOTE (If Required)

29.22.3.1 TYPE AND RATING

- i) Stationary type, sealed, valve regulated lead acid battery tank suitable for operation on 48 Volts D.C. system to meet loads like emergency lighting, control and signaling circuits, relays, breaker operations, indicating circuits, etc. shall be required. The stationary battery shall comply with the provisions of IEC 896, Part 2 / ANSI T1.330.
- ii) The Ampere-hour capacity of the battery bank at 27°C at 10 hours discharge rate shall be 100/200 AH.
- iii) The nominal voltage of the battery bank shall be 48 Volts D.C.
- iv) The number of cells in a complete battery bank set shall be 24 plus 2 spares.

29.22.3.2 **PLATES**

Positive plates shall be made of flat pasted type using lead-cadmium antimony alloy for durability, high corrosion resistant, maintenance free, long life both in cyclic as well as in float applications. Negative plates shall be heavy duty, durable flat plate using lead calcium alloy pasted box grid. Negative plates shall be designed to match the life of positive plates and combination of negative and positive plates shall ensure long life, durability and trouble free operation of battery. PLC operated equipment should be deployed for preparation of paste to ensure consistency in paste quality. Conventional / manual type of paste preparation is not allowed.

29.22.3.3 **CONTAINER AND LID**

The containers and lids shall be made of a special grade polypropylene copolymer plastic material. They shall be sufficiently robust and not liable to deformation under internal operating pressures and within the temperature range naturally encountered, leak proof, non-absorbent and resistant to the acid with low water vapour permeability.

29.22.3.4 **VENT PLUGS**

Each cell shall be equipped with one-way safety valve with opening pressure of 5 ± 1 psi and closing pressure 4 ± 1 psi. The vent plug shall be made with suitable grade of fire retardant plastic material. Each valve opening shall be covered with flame barrier capable in preventing the ingress of flame into the cell interior when the valve opens and hydrogen / oxygen gas mixture is released.

29.22.3.5 **SEPARATORS**

Separator shall be made of spun glass, micro porous matrix and shall be resistant to Sulphuric Acid. It shall be capable of keeping the entire electrolyte and shall be electrically insulated. Sufficient separator overlap and PVC shield protection to top and bottom edges of the plates is to be provided to prevent short circuit formation between the edges of adjacent plates.

29.22.3.6 **CONNECTORS**

The connectors shall be lead coated copper of suitable size to join the cells. The connectors shall be suitably designed and coated to withstand corrosion due to sulphuric acid. The coating should be adequate and tenacious. All the copper inter cell connectors shall be provided with heat shrinkable sleeves except at the connecting points.

29.22.3.7 **ELECTROLYTE**

The electrolyte shall be prepared from the battery grade Sulphuric Acid confirming to ISS: 266. The batteries shall be supplied in factory filled and charged condition.

29.22.3.8 **WATER**

Water required for preparation of electrolyte shall conform to IS: 1069.

29.22.3.9. **PLATE CONNECTION**

Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be cast with lead alloy. The positive and negative terminal posts shall be clearly marked for unmistakable identification.

29.22.3.10 **BOLTS AND NUTS**

Nuts and Bolts for connecting the cells shall be of superior grade passivated Stainless steel.

29.22.3.11 **TERMINALS**

Terminals shall be of integral lead terminal with solid copper core with M6 threading for fastening. The junction between terminal posts and cover and between the cover and container shall be hermetically sealed

29.22.3.12 **BATTERY RACKS ...**

Batteries shall be installed on MS racks to be supplied by the Contractor to fit in the battery room. Racks/Trays shall be powder coated with anti-corrosive paint. Rack shall accommodate 55 cells plus 2 spares. Racks/Tray shall be suitably treated before painting for protection against fungus growth and other harmful effects due to tropical environment. The colour of the supporting racks shall conform to RAL 7032 shade.

29.22.3.13 **CAPACITY REQUIREMENTS:**

When the battery is discharged at 10 hour rate, it shall deliver 80% of Rated Capacity (corrected at 27°C) before any of the cells in the battery bank reaches 1.85 V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75 V/cell) within 10hrs upto 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

The capacity (corrected at 27°C) shall also not be less than Rated capacity & not more than 120% of Rated capacity before any cell in the battery bank reaches 1.75 V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at a rate of 1/10th of the Rated Capacity:

- (a) After SIX hours of discharge: 1.92V/cell
- (b) After EIGHT hours of discharge: 1.85V/cell
- (c) After TEN hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35°C for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall

be within 0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt-hour efficiency shall be better than 80%. However, the battery to be manufactured and to be delivered at site in such a way that load can be connected with the battery within 15 days from the date of installation. Date of initial charging is to be mentioned on the battery.

29.22.3.14 ASSOCIATED EQUIPMENTS & ACCESSORIES (For each set of battery) :

- a) Best quality metallic stand/frame as per Clause 9.12.
- b) Stand insulators +5% extra
- c) Inter row connectors :Appropriate quantity
- d) Inter tier connectors
- e) Centre-zero (3-0-3) volts DC Voltmeter : 1 No
- f) Torque wrench/ Spanners : 1 No
- g) Connection hardwares, such as strips, bolts, nuts(with 5% extra)
- h) Cable clamps with hardware
- i) Cell numbering tags with fixing arrangement
- j) Two sets of special tools and tackles for connecting terminals of the battery
- k) Any other accessories not specified but required for satisfactory operation.

29.22.3.15 TYPE TEST OF BATTERY:

The Tenderer/ Supplier shall supply type tested battery as per IS 15549:2004/ IEC 60896-21 & 22 over the range of at least one capacity per design. The Tenderer/ Supplier shall submit necessary evidences enclosed along with tender documents.

SI No	DESCRIPTION
1	Gas Emission
2	High Current Tolerance
3	Short Circuit Current & DC Internal resistance
4	Protection against Internal Ignition from External Spark source
5	Protection against Ground Short Propensity
6	Content & Durability of required marking
7	Material Identification
8	Valve Operation
9	Flammability Rating of Material
10	Intercell Connector Performance
11	Discharge Capacity
12	Charge Retention during Storage
13	Float Service with Daily Discharge for reliable mains power
14	Recharge behaviour
15	Service Life at an operating temperature of 40°C for brief duration exposure time

16	Impact of Stress Temperature of 60°C for brief duration exposure time with 3hrs discharge test
17	Abusive Over Discharge
18	Thermal Runaway Sensitivity
19	Low Temperature Sensitivity
20	Dimensional Sensitivity at Elevated Internal Pressure & Temperature
21	Stability against Mechanical abuse of units during installation

29.22.3.16 Routine Test:

- (i) Physical Examination Test
- (ii) Visual Inspection
- (iii) Dimensions, Mass & Layout
- (iv) Marking & Packing

29.22.3.17 ACCEPTANCE TEST OF BATTERY

- (i) Polarity Marking
- (ii) Verification of Dimensions
- (iii) Open Circuit Voltage of each Cell & Total Open Circuit voltage of the battery bank
- (iv) Test of AH Capacity

29.22.3.18 LIST OF FACTORY & SITE TESTS FOR BATTERY

Sl. No.	TEST	FACTORY TESTS	SITE TESTS
1	Physical Verification	YES	YES
2	Capacity Test on the cell at 1/10th of Rated Capacity, corrected at 27°C	YES	
3	8hrs Charge & 15mins Discharge Test at Full Rated Load	YES	

29.22.4 48V BATTERY CHARGER

29.22.4.1 General:

This section covers the general requirement of 48 V DC SMPS Based Power Plants, based on High Frequency Switch Mode Techniques using switching frequencies of 20KHz and above for use in AEGCL.

29.22.4.2 SMPS Based Power Plants is intended to be used in **Auto Dual Float Rectifier cum Boost Charger (FR-BC)** mode as a regulated DC Power Source.

29.22.4.3 Power System Configuration:

The configuration of 48 V DC Power Plants with FR-FC & FRBC Modules shall be as under:

SI No	Basic SMR Module	Configuration	Permissible Ultimate Capacity
1	25 A FR-FC	(n+1)	75 Amp
2	50 A FR-FC	(n+1)	150 Amp
3	25 A FR-BC	(n+2)	75 Amp
4	50 A FR-BC	(n+2)	150 Amp

The FR-FC or FR-BC modules shall be housed in (n+1) or (n+2) parallel configuration in a single rack where 'n' is the actual required number of FR-FC, FR-BC modules for meeting the particular load requirement.

AEGCL shall indicate the Type, Number and Configuration of SMR Modules, depending upon the load requirement. AEGCL shall also indicate Ultimate Expandable Capacity considering future expansion requirement.

29.22.4.4. The Battery Charger of 48V/25A (Ultimate capacity 150A) or 48/50A (Ultimate capacity 150A) N+1 configuration shall be of SMPS type and shall be chosen as per load demand of communication equipments of the substations. The system shall consist of DSA and Float Rectifier –cum-Charger (FR/FC) in a steel rack in a modular type. It should have menu driven microprocessor control technique for DSA as well as module for control, monitoring and alarm to achieve better reliability of the system.

29.22.4.5 Rack Configuration :

Rack is composed of following units accommodated in sub racks

- Dual Float Rectifier cum Boost Charger (FR-BC) Modules.
- Distribution-Switching-Control-Alarm Arrangement (DSCA)
- The number and rating of FR-FC, FR-BC Modules shall be provided as per purchaser's requirement. The Distribution-Switching-Control-Alarm Arrangement (DSCA) shall be provided for the Ultimate Expandable Capacity. All factory wirings for the rack shall be for the Ultimate Expandable Capacity so that only plugging-in of FR-FC or FR-BC module shall enhance the DC Power output.

29.22.4.6 Parts & Components

The Parts & Components including Fuses and Circuit Breakers for manufacturing of the SMPS Based Power Plants shall be of Industrial Grade. These Parts & Components shall be procured from reputed manufacturers to ensure prompt and continuous service and delivery of spare parts.

Power Transformers and Chokes shall use Class B or Higher Grade of insulation. The Transformers and Chokes shall be wound with copper wire provided with adequate insulation.

Component mounting and fixing methods shall be secured.

29.22.4.7 Wiring:

All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current voltage during fault and overload.

All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part of Metal Panel or Cover, the hole through which they pass shall be suitably bushed with rubber grommet.

29.22.4.8 Bus Bars:

Bus bars shall be of high conductivity electrolytic copper strips capable to with-stand 1.5 times the maximum load current. The Bus bar shall be capable to carry current density of 2 Amps/mm² but shall not be less than 25mmx5mm in any case. The size of bus bars chosen for battery and load path shall be capable to take care of the current of maximum power plant capacity for which it is designed.

Bus-bar Riser height wherever applicable shall be 250mm for both load and battery.

Earthing: All non-current carrying metal parts shall be bonded together and earthed. An earth terminal suitable for taking minimum 4 mm dia wire and with suitable marking shall be provided

The SMPS Based Power Plants shall be designed & manufactured for continuous operation at rated load in the ambient temperature range of 0°C to 55°C.

Insulation Resistance and Voltage Proof

The insulation resistance of a fully wired FR-FC and FR-BC Modules when tested with a 500V DC Megger shall be as given below:

- a) AC input and Earth - Greater than 2 Mega Ohm
- b) DC Output and Earth - Greater than 1 Mega Ohm
- c) AC input and DC output - Greater than 5 Mega Ohm.

29.22.4.9 Lightning Protection :

The SMPS Based Power Plants shall have modular type Type I/Class B and Type II/Class C type surge protection in TT configuration of wiring. Both the Type I/Class B and Type II/Class C arrestors should be from the same manufacture and shall be mounted as per the specific installation recommendations of the manufacturer to achieve perfect coordination.

Radio Frequency Interference Suppression: The module shall be designed to minimize the level of electromagnetic interference (EMI), both conducted and radiated, detected in its vicinity and generated by Switch Mode Power Conversion Equipment operating within the rack.

29.22.4.10 Name plate :

A name plat etched/engraved/anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each rack/module and contain following information.

1. Specification Number

2. Type of Unit
3. Manufacturer's name and identification
4. Model No.
5. Unit Serial No.
6. Input Voltage and phase
7. Output Voltage and current
8. Year of manufacture
9. Suitable for battery capacity

29.22.4.11 AC input supply: The Power Plant using FR-FC or FR-BC modules of 25 Amps shall operate from single phase AC input and FR-FC or FR-BC modules of 50A capacity may operate from single phase or 3 phase 4 wire AC input. The nominal input frequency is 50Hz which may vary from 48-52Hz. The input voltage range shall be as given below:

a) Single Phase (nominal 230V) :

For Power Plant to be used at stations having reasonable power supply regulation, incoming power supply range shall be from 165 V AC to 260 V AC.

b) Three Phase/4 Wire 400V+10%/ - 15% (Nominal 400V)

29.22.4.12 There shall be an automatic arrangement for shutting off the FR-FC or FR-BC Modules wherever the input voltage is beyond the specified operating limits with suitable alarm indication. It shall resume normal working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the FR-FC or FR-BC Modules. A tolerance of $\pm 5V$ may be acceptable for protection & alarm operation. All the FR-FC or FR-BC Modules shall switch OFF simultaneously.

29.22.4.13 FR-FC or FR-BC Modules working from 3 phase/4 wire input shall work satisfactorily for unbalance of $\pm 10\%$ of nominal input. The module shall be isolated (if required for the protection of the unit) in the event of unbalance beyond 10% and shall restore when the input is within limits.

29.22.4.14 The SMPS battery charger shall be capable of continuous operation with float voltage 2.23 to 2.25 Volt per cell and 2.3 Volt per cell for charge voltage while supplying the constant DC load.

29.22.4.15 The SMPS battery charger shall have constant voltage characteristics throughout the range (from zero to full load) at floating value of the voltage so as to keep the VRLA batteries fully charged but without harmful overcharge.

29.22.4.16. The float cum boost charger works on 415 V AC, 50 Hz supply (or 230 V AC, 50 Hz supply). The battery charger should be capable of delivering the full rated load at the specified voltage at the output terminals. The set output voltage is maintained for AC input variation of + 10% and load variation from 0-100% of rated full load.

29.22.4.17 The charger voltage in float mode of operation is normally be set at 54 V DC and the same shall be adjustable between 48 and 54 V DC through variable potentiometer. When the charger is selected to boost mode, it should supply charging at the rated current maximum. This shall be adjusted from 20% to 100% of rated current through potentiometer.

29.22.4.18 All these circuits are housed in freestanding cabinet of folded sheet steel (thickness of sheet steel should not be less than 2.5mm) construction finished in stove enamel light gray colour conforming to shade of 631 of IS: 5. The cabinet is provided with front and back doors for easy accessibility. All meters, meter selector switches, control switches and LCD display (Microprocessor unit) etc are to be provided on the front panel. The AC input and DC output MCCB'S and control switches are provided on middle inside of the breaker panel. The cable terminations are provided on front side of the cubicles.

29.22.4.19 PARTICULARS

<u>Type</u>		FLOAT CUM BOOST CHARGER	
		Hot swappable rectifier modules 25A/48V, N+1 configuration.	
<u>Rating</u>		48 V (Capacity as per Battery Sizing Calculation) Dual float cum boost charger (suitable for MF-VRLA battery)	
<u>AC INPUT</u>			
A	Voltage	415 V AC+ 10% (230V AC +10%)	
B	Phase	3 phase, 3 wire (single phase)	
C	Frequency	50 Hz+5% (50Hz+2Hz)	
D	Power factor	(Better than 0.7 lagging)	
<u>DC OUTPUT</u>			
A	Float voltage	:	48 V- 54 V DC
B	Boost voltage	:	48 V-55.2 V DC
C	Output current	:	35A
D	Voltage regulation	:	Better than + 1% of set value
E	Ripple	:	Less than 1% r m s
F	Efficiency	:	(Better than 90%)
G	System output voltage	:	55.2V DC+1%(at load terminal)
<u>METERS</u>		The microprocessor based controller should have metering facilities namely (a) Load Voltage (b) Load Current, (c) Battery Voltage (d) Battery Current (e) Battery Temperature, (f) Voltage and current of individual module.	
<u>PROTECTION</u>			
Over voltage trip at the output	:	Over voltage cutback	56.5+ 0.5 V DC
DC under voltage at battery input	:		42+ 0.5 V(1.75 V X 24)
Fuse at AC input	:	Fast acting semiconductor fuse	Fast acting semiconductor fuse
Fuse at DC out put to load	:	MCCB	Fast acting semiconductor fuse
Reverse polarity at	:	Protected	Protected

battery input			
Out put current limiting	:		Battery charging current limit
AC input MCCB	:	Required	Required
Blocking diode	:	Required	Required
Charger over load	:	Required	Required
<u>INDICATION</u>			
AC input ON	:	Required	
DC output ON	:	Required	
Float ON	:	Required	
Boost ON	:	Required	
AC under voltage	:	Required	
AC over voltage	:	Required	
DC over load	:	Required	
DC over voltage	:	Required	
Short circuit	:	Required	
Reverse polarity	:	Required	
Mains fail		Required	
Charger fuse fail		Required	
Battery over voltage		Required	
<u>CONTROLS AND SWITCHES</u>			
AC input MCCB		ON/OFF switch at input	
DC output MCCB		Three way switch to select auto / manual float / manual boost operation	
Auto/manual float/boost mode selector switch		Two way switch to read charger output current or battery charge / discharge current	
Auto /manual voltage regulator selector switch		Single tern potentiometer for float voltage adjust	
Float and boost voltage variable potentiometer		Single tern potentiometer for boost voltage adjust	
Manual voltage adjust variable potentiometer		Single tern potentiometer for charger total current adjust	
Battery current adjust potentiometer		Single tern potentiometer for battery current adjust	
Heaters power supply switch			
Socket power supply switch			
<u>ADDITIONAL FEATURES</u>			
Soft start on DC side		Auto float / boost operation	

29.22.4.20

- a). The Battery Charger shall have Dual Source AC Input (AC Input 1 and AC Input 2) with individual MCCB and shall be provided with Auto Changeover arrangement.
- b). The Battery Charger shall have an IP Rating of IP42 or better. The Charger shall be type tested for IP42 or better rating.

29.22.5 Power Distribution and Protection

The Employer will furnish only one source primary 240 VAC. It shall be the Contractor's responsibility for the connection and distribution of all Primary AC and 48V dc source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall supply & install Primary AC and -48Vdc feeder cables to Contractor-furnished distribution panels.

The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor shall also be responsible for Load Balancing.

The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

Partially equipped subsystems shall be installed with provision for expansion. Equipment power supplies provided under this specification, shall be sized to support fully equipped subsystems. Primary power distribution protection shall be sized to support and protect maximum operating load potential whether or not the actual projected load shall meet that maximum load potential.

The Contractor shall provide equipment and rack safety earthing in compliance with this specification.

29.23.0 Equipment Construction, Assembly and Installation

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

2.23.1 Identification

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable as per the following:

2.23.2 Equipment

Each equipment component to the level of printed circuit card, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture and revision level. Changes to components shall be identified by an unambiguous change to the marked revision level. The Contractor shall be responsible for maintaining the master revision level list until the Contractor has complied with all requirements of this specification. Where custom components and parts are provided, each component/part shall be marked to specifically identify that component/part. Printed circuit card cages are defined as an equipment component and as such, shall be clearly identified as stated within this specification. Equipment chassis and printed circuit card cages having wired back-planes, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture, revision level and an additional identifier corresponding directly to the applicable backplane wiring diagram/list.

2.23.3 Power Distribution

Power distribution panels shall be clearly marked with their unique identifier, source feed information, and remote source feed emergency disconnect location and identity. Power distribution panel "Main Disconnect" and circuit breakers shall be clearly marked with a unique identifier. Circuit breaker feed lists shall be clear, accurate and the feed list information shall be posted inside each distribution panel door.

Inter-rack and intra-rack (enclosure) power distribution shall be clearly identified with source feed, voltage and power rating information. All power feed cabling shall be clearly identified near the point of termination.

All power distribution identification shall utilize heat-resistant permanent marking techniques such as stamped non-metallic tags, embossed labels, etc. Marking techniques are subject to approval by the Employer. Power distribution identifiers and information shall agree with the Contractor's power cable plant drawings.

2.23.4 Signal Cabling

Connectorised signal cabling/wiring requires marking with a unique identifier at each connectorised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations.

Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fanout point.

All signal cable, wiring and terminations shall be clearly labelled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

2.23.5 Equipment Racks and Enclosures

All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labelled with unique identifiers consistent with Contractor supplied floor plans and rack elevations.

2.24.0 Installation Hardware

Equipment racks, enclosures, cable raceways and installation hardware shall, at a minimum, comply with the following requirements:

2.24.1 Equipment Sub-Racks and Cabinets (Enclosures)

All equipment provided under this specification, shall be physically mounted in sub-racks and cabinets (enclosures). The Contractor shall determine and propose for the Employer approval, the type, size, weight and manner of installation for each location. Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

(A) Equipment Sub Rack Construction

Equipment Sub Racks provided for installation in environmentally controlled facilities, shall meet the following minimum requirements:

- (1) Equipment Sub Racks shall be steel/aluminium fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.
- (2) Equipment covers shall be provided for exposed components mounted in equipment sub Racks.
- (3) Dust and moisture protection shall meet or exceed IP20 standards.

(B) Equipment Cabinet (Enclosure) Construction

- (1) Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.
- (2) Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secure fitting, lockable, full-length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.
- (3) All doors and removable panels shall be fitted with long life rubber beading. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet.
- (4) Equipment cabinets (enclosures) shall be dust and moisture-proof as per IP41 specification, or better.

29.24.2 Cable Raceways

The Contractor is required to provide and install all additional necessary indoor and outdoor cable raceways. The cable raceways shall be in conformance with the following:

- (1) Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required.
- (2) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- (3) Outdoor cable raceways shall be of corrugated construction and shall be fitted with solid covers overlapping all sides of the cable raceways.
- (4) Outdoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be taken. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.
- (5) Indoor cable raceways fabricated of aluminium or galvanized iron, shall not normally need special finishing or painting, unless otherwise stipulated by the Employer. Steel fabricated raceways shall require a red oxide primer coat at a minimum.

29.24.3 Signalling Distribution

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:

- (1) All signal wiring connections to the communications equipment shall be via Krone type or equivalent terminal blocks.
- (2) The Contractor shall provide subscriber level wiring and patching wherever required.

29.24.4 Lightning and Transient Voltage Protection

The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:

- (1) At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.

- (2) All equipment installed under this specification that requires 240VAC primary power, shall be surge protected.

29.24.5 Station Safety Earthing and Signal Grounding

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

- (1) All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards.
- (2) Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.
- (3) Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sq mm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.
- (4) The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.
- (5) The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall extend the existing station earth to the equipment room using suitable G.I. earthing strip (50 x 6 mm), wherever required.

The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer's approval.

The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract. In case existing earthing arrangement at the site is not adequate, the Contractor shall either make improvement in the existing earthing arrangement or make new earthing as per requirement.

29.25.0 Interconnections

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor supplied as-built drawings.

The Contractor shall supply and install all primary power cords, power-strips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution cabling, and power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded.

Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks.

Plug-type connectors with captive fasteners (ie. DB-25, etc) shall be used for the interconnection of all inter and intra-enclosure signalling cable.

29.26.0 Finish Colors

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss medium grey enamel on the outside. Only brushed aluminum trim shall be used. Employer reserves the right to approve the proposed color scheme.

29.27.0 Location of Equipment, Cable Routes and Associated Civil Works

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the Employer and the Contractor regarding equipment siting, intra and inter facility interconnectivity and necessary associated civil works.

29.27.1 Locations for Supplied Equipment

All transmission equipment and associated DDFs, shall generally be co-located in the same communications room located in the Control Building whenever possible.

29.29 Inspection, Test and Availability

- i) All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.
- ii) Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.
- iii) The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.
- iv) Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.
- v) All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.
- vi) Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

- vii) The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance. All security related features shall be demonstrated during FAT/SAT as required by the Employer.

29.29.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

- (a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.
- (b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.
- (c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.
- (d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.
- (e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

29.29.2 Test Plans and Procedures

- a) Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall ensure that each factory and site test is comprehensive and verify all the features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.
- b) The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test
- c) schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.
- d) The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the

corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

29.29.3 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 4-1.

Table 4-1
Factory & field Test Plan Requirements

Items	Description
1	Test Schedule
2	Record-keeping assignments, procedures and forms
3	Procedures for monitoring, correcting and retesting variances
4	Procedure for controlling and documenting all changes made to the communications equipment after the start of testing.

29.29.4 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 4-2.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

Table 4-2
Test Procedure Requirements

Item:	Description:
1	Test Title and Revision Level, if applicable
2	List of Standard(s) complied with
3	Function(s) / parameter(s) to be tested
4	Purpose of each test segment
5	List of required test equipment
6	Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test.

7	Test setup including test configuration block diagrams and/or illustrations.
8	Test procedures to be followed.
9	Required inputs and expected outputs for each test segment
10	Acceptance criteria for each test segment.
11	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
12	Format of test reports.

29.29.5 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 4-3.

Table 4-3
Test Record Requirements

Item:	Description:
1	Test Title and Revision Level, if applicable; contract references
2	Date and time for test start and test completed
3	Test title and reference to the appropriate section of the test procedures
4	Description of any special test conditions or special actions taken (Includes test case data).
5	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6	Test procedure modifications made during testing.
7	Variance Report(s) tracking information and copies (if variance(s) was detected).
8	Contractor's test engineer(s) identification, signature and remarks
9	Employer's test witness identification, signature and remarks
10	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

29.29.6 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary. Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

29.30.0 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

- (a) All equipment being supplied shall conform to type tests as per technical specification.
- (b) The test reports submitted shall be of the tests conducted within last five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the purchaser.
- (c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.
- (d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.
- (e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.
- (f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
- (g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

29.30.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are

selected a random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

29.30.2 List of Type Tests

The type testing shall be conducted on the following equipment

- (a) SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)

29.30.2.1 List of type test to be conducted on Telecom equipment

The type tests for SDH Equipment with all types of cards, Primary Multiplexer & Drop-Insert Mux with subscriber interface card and DACS are described below:

29.30.2.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

(a) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.
- (2) Degree of Severity: Test shall be done at 0°C
- (3) Acceptance Criteria: No degradation of performance during and after the test.

(b) Low Temperature Test : Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*)
- (2) Degree of Severity: Test shall be done at -10° C
- (3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(c) Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours.
- (2) Degree of Severity: As per table 5-1: operation to specification range.
- (3) Acceptance Criteria: No degradation of performance during and after the test.

(d) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).
- (2) Degree of Severity: Test shall be done at 55°C.
- (3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(e) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.
- (2) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

(f) Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

- (1) Number of cycles required is five (5)
- (2) The degree of severity: temperature TL:0°C, TH: As per table 5-1 (Operation to specification range)
- (3) Cycle duration for each temperature is three (3) hours.
- (4) Ramp : 1 °C/minute.
- (5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

29.30.2.2 Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

Immunity Tests

The list of Immunity tests are specified below in Table 4-4:

Table 4-4: Recommended Immunity Tests

SI No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
1	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 60870-2-1: 1995 - Level : 1
2	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	

SI No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
3	100/1300 μs surge	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995
4	1.2/50 - 8/20 μs surges	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995 - Level : 4
5	Fast transient bursts	Yes	Yes	Yes	N/A	
6	Damped oscillatory waves	Yes	Yes	Yes	Yes	
7	10/700 μs surges	N/A	N/A	N/A	Yes	
8	Electrostatic discharge	Yes				Table 13 of IEC 60870-2-1: 1995 - Level : 4
9	Power frequency magnetic field	Yes				Table 14 of IEC 60870-2-1: 1995 - Level : 4
10	Damped oscillatory magnetic field	Yes				
11	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-2-1: 1995 - Level : 4
12	Power Frequency voltage on control and signal lines	N/A	N/A	Yes	Yes	IEC 61000-4-16 : 2002-07 Level : 4
13	DC voltage on control and signal lines	N/A	N/A	Yes	N/A	IEC 61000-4-16 : 2002-07 Level : 4

(a) **Emission Tests:**

The list of Emission tests are specified below in Table 4-5

Table 4-5:
Recommended Emission Tests

S. NO	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
1	LF disturbance voltages CCITT	N/A	Yes	N/A	N/A	Table 17 of IEC

	Recommendation P.53					60870-2-1: 1995 - Class : B
2	Transient disturbance voltages	Yes	Yes	N/A	N/A	
3	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
4	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
5	RF radiated fields CISPR 22	Yes				

(c) Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class : VW1 of Table 18.

29.30.2.3 Mechanical Tests

(a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements. Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semisinusoidal shape (clause 3.1.1.2).

The recommended severity shall be $A = 294 \text{ m/s}^2$, $D = 18 \text{ ms}$. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

29.30.2.4 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on

SDH Equipments, associated line & tributary cards, Termination Equipments (Primary Mux, Drop/Insert, DACS, associated Subscriber Line Interface Cards etc), Network Management System etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer's representatives is intimated to the contractor

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system and NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

29.30.2.5 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures

and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

29.30.2.6 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along-with information such as sampling frequency, applicable standards, acceptance criteria etc.

Table 4-6:
Factory Acceptance Testing for Fibre Optic Transmission System

Item	Description
1	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2	Optical output power
3	Transmitter lightwave spectral analysis
4	Low receive level threshold
5	Generation of bit error rate curve
6	Measurement of analog and digital service channel parameters as well as service channel functionality
7	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.
8	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for multiplexers
9	At a minimum tests on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
10	Simulation of failure conditions and failover of each redundant unit.
11	Test of spare card slots
12	Checks of power supply/converter voltage margins
13	Random inspections to verify the accuracy of documentation
14	Test of spare parts/modules/cards as per applicable tests

2.30.2.7 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate. The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for Telecom equipment, NMS etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for Telecom equipment installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

29.30.2.8 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

29.30.2.9 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense. In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated. The minimal installation testing requirements for fiber optic transmission subsystem, Termination equipment sub-system and NMS are provided in respective Tables in this section.

29.30.2.10 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated

as per RFC 2544:

- a) Ping test
- b) Throughput test
- c) Latency test
- d) Packet Loss

10% of the total links (Chosen by the Employer, generally to cover links from all configurations used)

shall be tested for a duration of 12 Hours. Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects. This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

29.30.2.11 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the channels required to interconnect the various User's

interfaces. The integrated testing for batch shall include end-to-end testing of backbone network included in that batch. Integrated testing for last batch shall include testing of the entire backbone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all fibre optic transmission equipment, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

- (1) Equipment configuration shall be checked to establish that it supports the channel routing.
- (2) Testing of Craft Terminal to demonstrate proper operation of all functions: Configuration Management, Performance Management, Fault, Management and Security management. All the standard features of the Craft Terminal based NMS shall be demonstrated for proper functioning.
- (3) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

Table 4-7
Fibre Optic Transmission system Installation Testing

Item	Description
1	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2	Station power supply input and equipment power supply (DC-DC converter) output voltage measurements
3	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
4	Service channel performance
5	Craftsperson interface, alarm and control functional performance
6	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional
7	Network management interface and supervision performance
8	Correct configuration, level setting & adjustments and termination of Input/output interfaces
9	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
10	Simulation of failure conditions and failover of protected components.

29.31 Training and Support Services

This section describes the requirements for Contractor-supplied training, support services, and maintenance of the FOTS. The intent of the training and support program is to ensure a smooth transfer of systems and technologies from the Contractor to the Employer, and to ensure that Employer staff is fully trained to operate, maintain and expand the integrated telecommunication network.

29.31.1 Training

The Contractor shall provide a comprehensive training program that prepares the Employer's personnel for on-site installation support, operation, and maintenance of the telecommunication network.

Training may be conducted by the Contractor, the Contractor's subcontractors, and/or original equipment manufacturers (OEMs). The training requirements of this Specification shall apply to all such courses.

Training courses shall be conducted by personnel who speak understandable English and who are experienced in instruction. All necessary training material shall be provided by the Contractor. The training charges quoted by the Contractor shall include training materials and all associated expenses. However, for all training courses in India or abroad, the travel (e.g., airfare) and per diem expenses covering fooding and Lodging of the participants will be borne by the Contractor. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangement.

Hands-on training shall be provided with equipment identical to that being supplied to the Employer. The schedule, location and detailed training contents shall be submitted by the Contractor to the Employer for approval.

29.31.2 System Design & Overview Training

This training shall provide a functional description of the fibre optic transmission system and a discussion of the failover and alternate routing schemes inherent in the configuration. The training shall include an overview of the network configuration and indicate the functional responsibilities of all major subsystems including the network monitoring system hardware and software. The training shall highlight all significant methodologies or concepts utilized by the hardware and software to perform the required functions. High-level hardware configuration block diagrams and network/sub-network block/flow diagrams shall be included to enhance the understanding of the overall capability incorporated into all network and sub-network equipment.

The training shall be oriented to a user's point of view. The Employer/Owner users will include managers, design & planning personnel, communication support staff and maintenance personnel. As part of the proposal, the Contractor shall identify the number of days deemed appropriate for this training.

The overview training shall be customized for the specific functions, features, and equipment purchased by the Employer; it shall not be a general presentation of the Contractor' standard equipment repertoire. Personnel assigned by the Contractor to implement the Employer's system shall conduct this overview training. The Employer shall review and approve the contents of the overview training at least four (4) weeks prior to the course.

29.31.3 Installation & Maintenance Training

There shall be separate modules of the installation & maintenance training for the FO Transmission System.

The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive & restorative maintenance of the respective communications subsystems purchased by the Employer. **In addition to that the Bidder shall provide Video Tutorials or necessary documentation for maintenance and trouble shooting.**

29.31.4 Network Management Training

The Network Management training shall familiarize the Employer's telecommunication personnel with the concepts and techniques for configuring, programming, maintaining,

and troubleshooting the Contractor supplied NMS and its associated database. The Network Management training course shall provide the course participants with hands-on experience using the actual system being supplied.

29.31.5 Training Course Requirements

This section describes general requirements that apply to all training courses

29.31.5.1 Class Size

The Employer plans to send a number of participants to the training courses for a specified duration as described in Appendices.

29.31.5.2 Training Schedule

The Contractor shall provide training in a timely manner that is appropriate to the overall project schedule. All training courses shall be available to the Employer for a minimum of five years after final acceptance of the communication system. The training courses shall be offered in one cycle, such that none of the courses within the cycle overlap. The Contractor shall take the above requirements into account in developing the preliminary training schedule. Contractor shall develop a final training schedule in consultation with the Employer after contract award.

29.31.5.3 Manuals and Equipment

The Contractor, subcontractor, or OEM shall prepare training manuals and submit them to the Employer for review at least one month prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids; reference manuals, maintenance manuals, and user's manuals may be used as supplementary training material. Principal documents used for training shall be tailored to reflect all the Employer requirements specified.

Each course participant shall receive individual copies of training manuals and other pertinent material at least two weeks prior to the start of each course. The Employer shall retain the master and two additional copies of all training manuals and materials as reference documentation. A complete set of instructor's manuals and training aids shall also be provided. Upon completion of each course, instructor's manuals, training manuals, and training aids shall become the property of the Employer. As part of the delivered system documentation and the final documentation, the Contractor shall supply the Employer with all changes and revisions to the training manuals and other training documentation. The Employer reserves the right to copy all training manuals and aids for use in the Employer-conducted training courses. The Contractor shall furnish for use during training courses all special tools, equipment, training aids, and any other materials required to train course participants.

29.32 Support Services

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required. The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test. After final acceptance of the communications equipment, the Contractor shall offer continuing technical support and spare parts for the designed life of the equipment or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. However the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

29.32.1 Technical Support

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the telecommunication network upon expiration of the warranty period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above

29.32.2 Contractor's Future Hardware/Software Changes

The Employer shall be informed of all alterations or improvements to the hardware supplied under this Specification. The Employer shall be placed on the Contractor's mailing list to receive announcements of the discovery, documentation, and solution of hardware/software problems as well as other improvements that could be made to supply equipment. The service shall begin at the time of contract award, and shall continue for 10 years. The Contractor shall also include a subscription to the hardware subcontractors' change notification service from the time of contract award through the warranty period, with a Employer renewable option for extended periods.

29.32.3 Spare Parts and Test Equipment

The spare parts and test equipment shall be provided for each subsystem as described below.

29.33 Mandatory Spare Parts

Appendices provides the Mandatory Spare Parts Requirements described in **subsystem sets**. The mandatory spare parts table represents the minimum spares the Contractor shall be required to supply. The **subsystem set** of spare parts is defined to include all equipment modules, subunits and parts required to effect replacement, repair and restoration to full operational status of a defined unit of a subsystem.

29.33.1 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipments are enumerated in Table 6.2 below and shall be as per the Chapter "spares and tools"

Table 6.2		
Sl. No.	Test equipment	
	SDH Analyser	
	Handheld 2Mbps BER Tester	
	Digital Multimeter	
	Ethernet Tester (with dual port, 10/100 ports Mbps Ethernet option, layer-1 & layer-2 functionality)	

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer.

The Contractor shall provide in their bid, additionally recommended test equipment list necessary to support system availability figures specified in technical specifications. These lists shall include all relevant technical descriptions and recommended minimum quantities based upon the guidelines consistent with the telecommunications resource management hierarchy and continuing maintenance concept. The recommended test equipment shall not be considered for evaluation and may be included in the final scope of supply.

29.34 System Maintenance

As per DoT guidelines, operation and maintenance of the network shall be entirely by Indian engineers and dependence on foreign engineers shall be minimal within a period of two years from the date of LoA. The contractor shall be responsible to maintain the confidentiality of the Employer's System Information that Employer shares with the contractor for maintenance period.

29.34.1 Warranty Period

The one year period commencing immediately after the operational acceptance is called the Warranty Period/Defect liability Period. In addition to the responsibilities covered under Vol I Condition of Contracts during Defect Liability Period, the Contractor shall also be responsible for maintenance of the Fibre Optic Transmission System supplied under this Package. The specification for the maintenance of the system after Operational Acceptance is enclosed at Annexure-I.

29.34.2 Contractor's Maintenance Responsibility

The Contractor shall be responsible for carrying out "Non-Comprehensive Maintenance" of the Communication System for a period of six years after warranty period for ensuring the successful operation of the system. The Contractor shall be responsible for achieving the system availability and the response time mentioned in technical specifications. The tenderer shall quote the Annual Maintenance Charges for six years after Warranty Period which shall be considered in the bid evaluation. Tenderer shall submit the detailed procedure for achieving above in the bid. The specification for the maintenance of the system is enclosed at Annexure-I. Upon expiry of the six years AMC period Employer may, at its discretion, extend this Maintenance for additional one year at the same price & terms and conditions.

29.34.3 Miscellaneous Supplies

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor at no additional cost.

29.35 Documentation

The Contractor shall submit following documents during detailed engineering:

- (a) Data Requirement sheets
- (b) Link Budget calculations
- (c) MQP, FQP
- (d) Bill of Quantity including mandatory spares
- (e) Previous Type test reports
- (f) Factory Test report

- (g) Manuals for each equipment
- (h) Schematic drawing
- (i) Numbering, Marking, labelling document
- (j) Synchronization plan
- (k) Test schedule
- (l) Training manual
- (m) Configuration diagram
- (n) Transportation & handling Procedure
- (o) Installation Manuals
- (p) Maintenance Manual

APPENDIX-D

**BILL OF QUANTITIES OF FIBRE OPTIC TERMINAL COMMUNICATION EQUIPMENT
(REFER PRICE SCHEDULE FOR BOQ FIBRE OPTIC TERMINAL COMMUNICATION
EQUIPMENT)**

APPENDIX-E**(The following data shall be furnished for each of the manufacturer)**

DRS Form 01

**DATA REQUIREMENTS SHEETS for
OPTICAL LINE TERMINATION EQUIPMENT (OLTE)****GENERAL OLTE FEATURES**

SI No	Parameter:	As per Technical Specification	As per Tenderer Offering
1	SDH hierarchy level: Capacity Aggregate Bit-rate: CEPT E-1 Ports: SDH Hierarchy Level: STM-16	STM-16 620 Mbps 252 x E1	
2	Minimum No. of protected (MSP) directions	Five	
3	No. of E1 ports in E1 tributary Cards	minimum 63	
4	No. of ethernet ports in Ethernet interface tributary cards	minimum 8	
5	Service Channel provision a) Voice Channel b) Data Channel	Yes Minimum 8 Minimum 4	
6	Power Supply cards of SDH Equipment Common Control* Card of SDH equipment	1:1 APS 1:1 APS	

GUARANTEED TECHNICAL PARTICULARS FOR VALVE REGULATED LEAD ACID BATTERY

(To be filled in and signed by the Tenderer)

1	Type/ Designation	48V, 200AH battery bank
2	Manufacturer's type designation	
3	Ampere-Hour capacity 10hrs rate of discharge to 1.75V	
4	Total No. of Plates per cell	
5	Nominal Cell Voltage (V)	
6	No. of Cells in each Bank	
7	No. of Spare Cell, if any, in each Bank	
8	Internal Resistance for each Cell	
9	Resistance of the Battery including Inter-connection between the	
10	Cell Discharge rate in Ampere (from rated Voltage to final discharge rate in Ampere (i) 5hrs Discharge rate in Amp (ii) 2hrs Discharge rate in Amp (iii) 1hr Discharge rate in Amp (iv) 30min Discharge rate in Amp (v) 10min Discharge rate in Amp (vi) 1min Discharge rate in Amp (vii) 30sec Discharge rate in Amp (viii) 1sec Discharge rate in Amp (Please furnish a graph showing Amps against time for the type of battery offered)	
11	Short Circuit Current (Amps)	
12	(i) Material of Cell Containers (ii) Material used for Battery Box (iii) Trays	
13	Thickness, Type & Material of Separators	
14	Constructional details and dimension: Surface area plates of (i) Positive Plate (ii) Negative Plate in Sq.mm.	
15	(i) Ampere Hour efficiency (%) (ii) Watt Hour efficiency (%)	
16	(i) Recommended Float Charge Current & Voltage (ii) Recommended Boost Charge Current & Voltage	
17	Time required for Boost Charging from Discharged condition	
18	(i) Max. Charging Current/Cell (ii) Nominal Charging Rate	
19	(i) Whether explosion proof or vent plugs provided (ii) Whether vent is spill proof	
20	Type of Inter Cell connection & whether they are covered with plastic sleeves	
21	(i) Dimensions of each 2V Block/Cell a. Length (mm) b. Width (mm) c. Height (mm) (ii) Thickness of Container (mm)	