

Standard Specification
for
Telecommunication Systems

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1. GENERAL

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

- a. Fiber Optic Transmission System (FOTS)
- b. DDF and Cabling
- c. Craft Terminal based Network Management System (NMS)
- d. Repeater Shelter
- e. FO Approach Cable
- f. FODP

The equipment supplied shall support existing communication network for Power system operational requirements.

The security related requirements of the equipment shall be as per CEA (Cyber Security in Power Sector) Guidelines, 2021 and all similar security requirements as amended by CEA on time-to-time basis shall be followed/complied by the vendor at no additional cost to Employer till the implementation of the project.

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

The contractor shall ensure that the supplied equipments have been got 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 27001/2, Power Control Systems – Security Requirements against IS 16335, Cyber Security for Industrial Control Systems against IEC 62443-4 etc. from an authorized and certified agency/lab. These mentioned standards shall be current with all amendments, if any and in case any standard is superseded, the new standard shall be applicable.

The Contractor shall ensure that all the Communicable Intelligent Equipments are sourced from the list of the “Trusted Sources” as and when drawn by MoP/CEA. In case, for any Communicable Intelligent Devices, if no Trusted Source has been identified, the Contractor in compliance with the provisions made in MoP order dated 2.07.2020 and any other relevant MoP order shall get the product cyber tested for any kind of embedded malware/Trojan/cyber threat and for adherence to Indian Standards at the designated lab.

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 may be dealt as per guidelines of CEA/Ministry of Power or any other Government department.

The primary function of the equipment is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS, RTUs & PMUs and for new technological requirements of Power System Operation such as Special Protection Scheme, Grid Security Expert System, Load Management, Advanced Protection System & Substation Automation System. A summary of the system requirements is as follows:

- a. High speed E1 channel support
- b. 64kbps & nx64kbps data channel support as required.

- c. Low speed (300 -1200 bps) data channel support as required.
- d. Voice (2 wires, 4 wires) channel support and integration with Employer's/RLDC's EPABX system. The details of EPABX System shall be provided during detailed engineering.
- e. Data transport supporting Network Management channels.
- f. The connectivity envisaged between Substation and Control Centre over TCP-IP using Ethernet interface for various services of data and voice such as for PMUs, RTUs, VOIP etc.

2. FIBRE OPTIC TRANSMISSION SYSTEM:

2.1 General Network Characteristics:

The SDH node shall be used for interconnection of terminal Substation to the fiber optic network and shall be based on the Synchronous Digital Hierarchy (SDH) having bit rate of STM-4/16 as specified in BOQ. The contractor shall follow numbering plan for the proposed voice communication system.

The transmission equipment to be supplied shall be a complete SDH node (add- drop multiplexer) providing all the features e.g. protection and performance monitoring.

This will be used for delivering E1 as per ITU-T G.703 and Giga/fast Ethernet services except repeater stations. In case other interface such as Asynchronous Sub- channel data card (RS232/V.24/V.28), Synchronous data card (V.36/X.21), 2 wire voice channel card or 4 wire (E&M) voice channel card as required, shall be supplied either in the same equipment or as independent PDH equipment.

The Contractor shall supply the equipment as per the technical specification. The deliverables shall include all installation materials necessary for successful installation and commissioning of the equipment viz. AC & DC power supply cabling, Krone type/75Ω BNC type Digital Distribution Frame (DDF) in enclosure, optical patch cords for FODP-to-equipment and equipment-to-equipment connection, optical attenuator (5dB/10dB), flexible conduits etc. as per site requirement. **Additionally, one (1) pair of optical patch cord per SDH node will be supplied as spare.** User Manual, System Guide shall be delivered with each equipment.

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

Table 1: Equipment Redundancy Requirements Summary

Fiber Optic Transmission Equipment	
Power Supply & Converters -----	1:1 APS or distributed power supply
Common Control* Cards -----	1:1 APS
* = Common control cards which are essentially required for operation of the equipment.	

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

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 signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

The offered transmission equipment (SDH node) shall support optical link of at least 250 km for STM-4 and 225Km for STM-16 without any repeater station in between. If required, wavelength translator/ optical amplifier shall be provided by the contractor.

2.2 Features of Transmission Equipment:

Aggregate interface shall be STM-4/16, with three (3)/Five (5) MSP protected directions (as required in BOQ). **If bidder 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, main and protection channel shall be terminated on separate cards. Aggregate interface of STM-4/16 shall have FC/PC. In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector is to be provided to connect with FODP.

All software and hardware shall support IPv4 and IPv6 simultaneously (dual stack).

SDH equipment shall support dual power feed with redundancies for Power supply unit and Control unit in each rack.

Minimum 16 nos. x 2 Mbit/s per card, 120Ω/75Ω tributary interface compliant to ITU-T G.703, G.704 with suitable connector

Ethernet interface shall have minimum 8 nos. per card of RJ-45 port for ingress and egress of Ethernet data (Ethernet over SDH) at 10/100/1000 Base-T speeds/standards (ITU-T G.7041GFP capsulation). Ethernet shall support LCAS feature. It shall support full throughput up to 1000 Mbps on Ethernet port by virtual concatenation of requisite no. of VC-12. There shall be the provision of “Auto Negotiation” and “Flow control” Enabling/disabling through NMS of the system. Also, there shall be provision of configuring the equipment for unrestricted nxVC12 bandwidth (up to 1000Mbps). The Ethernet interface shall support VLAN (IEEE 802.IP/Q), spanning tree (IEEE 802.ID) quality of service. The protection scheme for Ethernet traffic should be ERPS based.

Services channel shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. There shall be a facility to extend the line system order wire to any other system or exchange lines.

ADM configuration for traffic protection by using SNCP & MSP.

Synchronization: The substation GPS can be used for extending synchronization to

equipment. Alternately existing network Master Clock can be used for synchronization.

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.

Downloading of software shall be possible from remote.

Shall have Embedded Communication Channel (ECC), ports (Ethernet/RS232) for craft terminal and management interface and shall support DCC pass through.

DCN implementation through protected VC12. Support DCN grooming in VC12.

Pre-connectorized Optical patch cords shall be of G.625D fiber. 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. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop.

Manageable by Craft Terminal program. It shall support performance monitoring, remote software upgrade, configuration management from remote as well as local craft terminal.

Shall be operated with 48 V DC Power Supply (positive earthed). DC power interface shall be suitable to work on a nominal voltage of 48V DC \pm 20%. Compact design suitable for installation in 19" rack.

The bidder shall be required to provide only Optical Interface/SFP to be installed in the existing/third party SDH equipment at few locations, if any. The bidder has to ensure compatibility of the supplied Optical Interface/SFP for the same.

i. Network Monitoring (Craft Terminal based)

Manageable by Craft Terminal program. It shall support performance monitoring, remote software upgrade, configuration management from remote as well as local craft terminal. The craft terminal shall have minimum configuration of 2.4 GHz, 8 GB RAM, 256 MB Video Graphics Memory, 1 TB Hard Disk Drive, keyboard, mouse/trackball etc., serial/USB (2.0) ports to accommodate printers, IEEE 802.11a/b/g wireless LAN, Bluetooth, and a battery back-up of at least 3 hours. VDUs shall be 15" TFT active-matrix color LED with a minimum resolution of 1024 X 768. However, the configuration shall be finalized during detailed engineering as per the latest industrial standards.

Local Craft Terminal will be provided with requisite software for performing all element level management functions viz. configuration management, fault management, performance management etc.

Bidder shall provide the telecom equipment which can be integrated with the existing NMS server/s of the respective RLDC/ SLDC. The details of existing NMS server/s shall be provided during detailed engineering or to be ascertained by Bidder conducted during site survey.

2.3 Optical Link Budget Calculations:

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

- i. Fiber attenuation: The fiber attenuation shall be taken to be the guaranteed maximum fiber attenuation i.e. **0.21 dB/Km @1550nm and 0.35 dB/km @1310nm**.
- ii. Splice loss: **Minimum 0.05 dB per splice**. One splice shall be considered for every 3 kms.
- iii. Connector losses: Losses due to connectors shall be considered to be minimum **1.0 dB per link**.
- iv. 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.
- v. 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.
- vi. 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.
- vii. Other losses: Other losses, if any required specifically for system to be supplied, shall also be suitably considered.
- viii. Dispersion: The fiber 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 DWSM fibers**.
- ix. Bit Error Rate: The link budget calculations shall be done for a BER of 10⁻¹⁰.

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each fiber optic link during detailed engineering.

For finalizing the FOTS system design & BOQ, above methodology shall be adopted considering fiber 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.

2.4 Technical Requirement of Repeater Shelter (If Applicable)

The detailed requirements for Repeater Shelter are attached at Annexure – II.

3. FIBRE OPTIC APPROACH CABLE:

For purposes of this specification, a fiber optic approach cable is defined as the Armoured underground fiber optic cable required to connect Overhead Fiber Optic Cable (OPGW) between splice enclosure on the terminal gantry / tower and the Fiber Optic Distribution Panel (FODP) installed within the building. The estimated fiber optic approach cabling length requirements are

indicated in the appendices. However, the Contractor shall supply & install the optical fiber approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly. Approach Cable shall consist of G.652D DWSM Fibers.

3.1 Basic Construction

The cable shall be suitable for direct burial, laying in trenches, G.I. Pipes PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering, and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

3.2 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibers with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fiber support/bedding structure, core wrap/bedding, and an overall impervious jacket.

3.3 Installation Of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer's approval.

Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.

All required fittings, supports, accessories, ducts, inner ducts, conduits, risers, and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

At all locations, approach cable shall be laid within G.I. pipe along with necessary accessories. The bend radius of fiber optic approach cable during installation inside G.I. pipe must be within safe limits. Minimum technical specifications of G.I. pipe are brought out below:

Minimum Technical Specification of GI Pipe for Approach Cabling			
S. No.	Item	Parameter	Range
1.	GI Pipe	Material type	Galvanized Iron Round Tube
		Nominal Bore Diameter	32 mm
		Wall thickness	4 mm or better
		Manufacturing Process	Electric Resistance Welded
		Conformity to specification	IS 1239 OR BS 1378
		Series	Heavy
		Outer Diameter (Min.)	42 mm or better
		Outer Diameter (Max.)	42.9 mm or better

		Type	Screwed and socketed
		Weight (KG/m)	3.82 or better
		Make	Jindal/Tata/Surya/ Employer Approved
2	GI Elbow	Material type	Galvanized Iron
		Nominal Bore Diameter	32 mm
		Make	Employer Approved make
		Certification	NABL Test Certificate
3	GI Flexible	Material type	Galvanized Iron
		Nominal Bore Diameter	32 mm
		Make	Employer Approved make
		Certification	NABL Test Certificate

4. OPTICAL FIBRE TERMINATION AND SPLICING:

Optical fiber terminations shall be done in Fiber Optic Distribution Panels (FODP) designed to provide protection for fiber splicing of pre-connectorized pigtails and to accommodate connectorized termination and coupling of the fiber cables. The Contractor shall provide rack /wall mounted Fiber Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fiber optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

4.1 Fiber Optic Distribution Panel

All fibers within the cable shall be connectorized and terminated in Fiber Optic Distribution Panels irrespective of required termination, in a manner consistent with the following:

- All fiber optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibers within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fiber optic couplings.
- FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fiber terminations.
- FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement.
- The FODP shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs, and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.
- Flexible protection shall be provided to the patch cord bunches going out from FODP cabinet to other equipment cabinet.

5. ENVIRONMENTAL, EMI, POWER SUPPLY CABLING AND EARTHING REQUIREMENTS:

5.1 Equipment shall operate in accordance with the Environmental Operating limits as shown

in Table-2:

Table -2 Environmental Operating Limits

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

- 5.2 Equipment shall be properly shielded against radiation emissions at each location.
- 5.3 Power Distribution and Protection: Power supplies/converters for communications equipment shall use -48Vdc uninterrupted primary source power. The Employer will furnish only one power source.
- 5.4 Contractor shall provide equipment and rack safety earthing in full compliance with EMI/EMC requirements as per relevant international standards.
- 5.5 Equipment cabinet (enclosure) shall be designed 19-inch, free standing but shall be mounted on the floor. The dimensions of the cabinet shall be minimum **2200mm x 600mm x 600mm**. 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. Equipment cabinet (enclosure) shall be dust and moisture proof as per **IP41** specification or better (supporting certificates/documents shall be submitted during detailed engineering).
- 5.6 The Contractor shall provide all required minor civil works necessary for full connectivity as required in the Contractor's scope of work.
- 5.7 Any other miscellaneous items which may be required for successful interfacing for establishment of end-to-end communication is deemed to be included in the scope of the Contractor.

6. TESTING:

All materials furnished and all work performed under this Contract shall be inspected and tested. 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. 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.

All equipment being supplied shall conform to type tests as per Annexure-I of technical specification and the test reports shall be submitted as per clause 9.2 of section-GTR.

Equipments to be delivered shall be tested at factory before dispatch as per approved procedure. Factory Acceptance Test shall demonstrate the technical characteristics of the equipment in relation to this specification and approved drawings and documents. The Contractor shall provide procedures for installation and site acceptance test. The site acceptance testing will comprise of end- to-end testing between the terminal stations and RLDC/SLDC and CCR/other end.

The detailed requirements for Type Test, Factory Acceptance Test and Site Acceptance Test are attached at 'Annexure – I.

Standard Procedure for Type test, Factory acceptance test and Site acceptance test attached at 'Annexure-I (A)' (Test shall be applicable as per offered items)

7. TRAINING:

The Contractor will provide training of suitable duration on supplied SDH equipment for Employer's personnel to provide working knowledge of the equipment, operation and diagnostic tools, supervision and monitoring using local craft terminal. The training may be provided by the Contractor or its sub-vendor at the site itself, preferably prior to installation, and will include training materials, presentation equipment, and all associated expenses. No separate charges for training shall be payable to the Contractor.

8. 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 communication equipment for a minimum period of 15 years from operational acceptance by the employer or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. The Contractor shall review the Employer existing equipment make, integration & switch over recommendation and prepare a detailed field implementation plan.

8.1 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.

8.2 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 supplied equipment. The service shall begin at the time of contract award and shall continue for a minimum period of 15 years from operational acceptance by the employer

designed life of the equipment or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. 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.

8.3 Mandatory Spare Parts

The Contractor shall be required to supply spares for each subsystem as in BOQ. 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 (i.e. SDH equipment.).

8.4 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.

9. 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) Type test reports
- (f) Factory Test report
- (g) Manuals for each equipment
- (h) Schematic drawing
- (i) Numbering, Marking, labelling documents.
- (j) Synchronization plan
- (k) Test schedule.
- (l) Training manual
- (m) Configuration diagram
- (n) Transportation & handling Procedure
- (o) Installation Manuals
- (p) Maintenance Manuals

10. Annexure – I: Testing Requirement of Communication Equipment

10.1 List of type test to be conducted on Telecom equipment-

The type tests for Telecom Equipment with all types of cards are described below:

i. 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:

- 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.
- Degree of Severity: Test shall be done at 0°C
- 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:

- 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).
- Degree of Severity: Test shall be done at -10° C.
- Acceptance Criteria: Degradation of performance is allowable during the test, 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:

- 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.
- Degree of Severity: operation to specification range.
- 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:

- 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).

- Degree of Severity: Test shall be done at 55°C.
- Acceptance Criteria: Degradation of performance is allowable during the test, 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:

- 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.
- Degree of Severity: Test shall be done at $(40 \pm 2) ^\circ\text{C}$ & $(93 \pm 3) \% \text{ RH}$
- 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.

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

ii. Power Supply and EMI/EMC tests:

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

a. Immunity Tests: The list of Immunity tests is specified below in Table 1:

Table 1: Recommended Immunity Tests

S. No.	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parameters
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	
3	1.2/50 - 8/20µs surges	Yes	Yes	Yes	N/A	Table 12 of IEC 60870-2-1: 1995 - Level: 1
4	Fast transient bursts	Yes	Yes	Yes	Yes	Table 12 of IEC 60870-2-1: 1995 - Level: 4
5	Damped oscillatory waves	Yes	Yes	Yes	Yes	Table 12 of IEC 60870-2-1: 1995 - Level: 1
6	Electrostatic discharge	Yes				Table 13 of IEC 60870-2-1: 1995 - Level: 4
7	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-2-1: 1995 - Level: 4

b. Emission Tests: The list of Emission tests are specified below in Table 2

Table 2: Recommended Emission Tests

S. No.	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parameters
1	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	Table 17 of IEC 60870-2-1: 1995 - Class: B
2	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
3	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.

iii. 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 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 tests conditions are selected according to the vibration withstand requirements.

Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

b. Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semi- sinusoidal 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.

10.2 Type tests for Optical Fibers

The type tests listed below in Table 3 shall be conducted on DWDM fibers to be supplied as part of Approach cable. The tests specific to the cable type are listed in subsequent sections.

Table 3: Type Tests for Optical Fibers

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Standard	IEC 60793-1-40 Or EIA/TIA 455- 78A
2	Attenuation Variation with Wavelength	As per Standard	IEC 60793-1-40 Or EIA/TIA 455- 78A
3	Attenuation at Water Peak	As per Standard	IEC 60793-1-40 Or EIA/TIA 455- 78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455- 3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455- 62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455- 164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 Or EIA/TIA 455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 Or EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 Or EIA/TIA 455-176
11	Fiber Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455- 31B

10.3 Type tests for fiber Optic Approach Cable:

The type tests to be conducted on the Fiber Optic Approach cable are listed in Table 4: Type Tests for Fiber Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 4: Type Tests Fiber Optic Approach Cable

S.No.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration: 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning: 72 hours, Test duration: 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles

10.4 Factory Acceptance Test Requirement:

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 Approach Cable, FODP, Craft terminal, SDH Equipments, associated line & tributary cards, and all other items for which price has been identified separately in the BOQ.

Material 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 dispatch Clearance. 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 authorized representatives unless waiver for witnessing by Employer's representatives is intimated to the contractor.

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

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to these specifications and approved drawings and documents. List of factory acceptance tests for Fiber Optic Transmission system, Approach cable, Craft terminal, and FODP 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.

During FAT stage, the employer will verify all types of test reports/certificates including Communication Protocol and security conformance tests of the devices offered for FAT as part of essential cyber security tests. The equipment/system besides for functionality shall also be tested in the factory for vulnerabilities, design flaws, parts being counterfeit or tainted, so as to minimize problems during on-site testing and installation. Cyber security conformance testing is to be carried out in the designated lab as identified by GoI/MoP.

The following auditor report and audit recommendations are to be verified during FAT.

1. Vulnerability assessment
2. Risk assessment.
 - a. Network architecture validation with respect to design documents.
 - b. Penetration testing
 - c. System Hardening test.
- i. 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.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, and other similar items.

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.

ii. 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.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

Table 5: 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 test on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
11.	Simulation of failure conditions and failover of each redundant unit.
12.	VLAN (Layer-2 switching) feature testing configuration.
13.	Protection scheme for Ethernet Traffic (ERPS)
14.	Test of spare card slots
15.	Checks of power supply/converter voltage margins
16.	Random inspections to verify the accuracy of documentation
17.	Test of spare parts/modules/cards as per applicable tests
18.	Comprehensive Cyber Security Tests in compliance to latest cyber security guidelines issued by CEA/MoP or any other govt department.

Table 6: FAT on NMS (Craft Terminal)

1	Physical inspection of NMS hardware (Craft Terminal) for conformance to approved BoQ, DRS & drawing
2	Testing of NMS to demonstrate proper operation of all functions: Configuration Management, Performance Management, Fault Management and Security Management.

Table 7: Factory Acceptance Tests on Approach Cable

Factory Acceptance Test
Attenuation Co-efficient at 1310 nm and 1550 nm
Point discontinuities of attenuation
Visual Material verification and dimensional checks as per approved DRS/Drawings

Table 8 Factory Acceptance Test

Visual check of Quantities and Specific Component Number for each component of FODP and dimensional checks against the approved drawings.

10.5 Site Acceptance Tests:

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. 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.

i. Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

a. 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.

During Installation testing, the employer has to verify all type test reports/certificates including Communication Protocol and security conformance tests of the devices as part of essential cyber security tests.

The following auditor report and audit recommendations are to be verified during SAT.

1. Vulnerability assessment
2. Risk assessment.
 - a. Network architecture validation with respect to design documents.
 - b. Penetration testing
 - c. System Hardening test.

The minimal installation testing requirements for fiber optic transmission subsystem

are provided in the table below:

Table 9: Fiber Optic Transmission System Installation Testing

Item	Description:
1.	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	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 signaling earthing system and resistance to ground to be checked.
10.	Simulation of failure conditions and failover of protected components.
11.	Comprehensive Cyber Security Tests in compliance to latest cyber security guidelines issued by CEA/MoP or any other govt department.

b. 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 fiber 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:

- Ping test
- Throughput test
- Latency test
- Packet Loss

The links shall be tested for 12 Hour. 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 standards, 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.

c. Integrated Testing:

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the data and voice channel required to interconnect to control centers and other nodes in existing system. The integrated testing shall include end-to-end testing of communication. 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. The Integrated System Test shall include all fiber optic transmission equipment, the network management subsystem (Craft Terminal) 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) End to end testing of all individual voice circuits (VOIP) and to demonstrate proper operation of channels over wideband systems. Operation shall be checked in terms of quality of voice, call initiation and call termination processes.
- (3) End-to-end testing of all individual Data Circuits (Ethernet). Operation shall be checked in terms of monitoring of BER/packet loss.
- (4) Testing of NMS (Craft Terminal) to demonstrate proper operation of all functions. All the standard features of the NMS (Craft Terminal) shall be demonstrated for proper functioning.
- (5) All the standard features of the existing NMS server (at RLDC/ SLDC) shall be demonstrated for proper functioning with respect to supplied communication equipment/ Node.
- (6) Demonstration of Protection switching and synchronization of equipment.
- (7) Comprehensive Cyber Security Tests in compliance with the latest cyber security guidelines issued by CEA/MoP or any other govt department.