Section-5
Chapter – 2

SELF SUPPORTING METAL FREE AERIAL FIBRE OPTIC CABLE

2 Introduction

Utility shall use Fiber optic leased line communication system provided telecom service provider in the project area. In case, the same is not available then utility may use Fiber optic option as envisaged in this section & may use the specification for self supporting metal free aerial fibre optic cable

This section describes the functional requirements, major technical parameters and all testing requirements for self supporting metal free aerial fibre optic cable and associated fittings for communication system and sub-systems to be provided under this package.

The fibre optic network (FO) network shall connect all the Substations & SCADA/DMS Control Centre The network connectivity is proposed to form loop covering most of the locations to provide the redundancy in the network wherever Possible.

2.1 Fibre Optic Network

The FO network comprises of the following major items:

(i) Self supporting metal free aerial/ under ground fibre optic cable along with necessary hardware & fittings/ HDPE ducts & accessories, splice Enclosure, Fibre Optic Distribution Panel etc.
(ii) Fibre Optic Transmission Equipment with user interface

The technical requirements for under ground FO cable & installation has been specified under chapter 3 of this section. The technical requirement for Fibre Optic Transmission Equipment is specified in Chapter-1 of this section.

2.2 Fibre Optic metal Free Aerial Cable

Self Supporting Metal Free Aerial Optical Fibre Cable shall be installed on existing 33/11 kV lines. The estimated cable route length requirements are indicated in the appendices. However, the Contractor shall supply & install the Self Supporting Metal Free Aerial Optical Fibre Cable as required based on detailed site survey to be carried out by the Contractor during the project execution. The Contract price shall be adjusted accordingly.

2.2.1 Basic Construction

The Metal Free Aerial Optical Fibre Cable shall be low in weight, and shall have small diameter, small volume and high flexibility. The Optical Fibre cable shall also have good mechanical protection with stable temperature performance conditions, as it will be exposed

to varying environmental conditions in the field like applicable wind and snow loading.

2.2.1.1 Secondary Protection

The secondary protection may be provided for the primary coated fibres may be protected by loose packaging within a tube or tubes and or in groove, which shall be filled with thixotropic jelly.

2.2.1.2 Number of fibres

Six (6) nos. of DWSM G.652 fibres shall be provided in the cable. The BOQ has been specified in the appendices.

2.2.1.3 Strength Member

The strength member (s) shall be provided for strength and flexibility of the cable. The strength member(s) shall be Solid FRP non-metallic and shall have anti buckling properties. These shall also keep the fibre strain within permissible values. The non-metallic strength member(s) may be in the cable core or embedded within the sheath.

2.2.1.4 Cable Core Assembly

Primary coated fibres in loose tube/tubes and/or in groove stranded together around a central strength member using helical or reverse lay techniques shall form the cable core. Alternatively multiple **units** of fibres may be placed loosely in a single tube with the strength members in the sheath.

2.2.1.5 Core Wrapping

The main cable core containing fibres shall be wrapped by layer/layers of Polyester foil/tape. The nylon/polyester binder tape or thread shall be used to hold the tape if required.

2.2.1.6 Moisture barrier (Protection)

The main cable core (containing fibres & core wrapping) shall be protected by flooding compound (jelly) have properties of non hygroscopic dielectric material and/or by water swellable tape. The core wrapping shall not adhere to the secondary fibre coating.

2.2.1.7 Filling compound

The filling compound used in the loose tube and in the cable core shall be compatible to fibre, secondary protection of fibre, core wrapping etc. The drip point shall not be lower than +70 degree C. The fibre movement shall not be constrained by stickiness & shall be easily removable for splicing. Reference material test method to measure drop point shall be as per ASTM D 556. The filling and the flooding jelly compound shall be as per the TEC specs GR no. G/ORM-01/02 MAR 99 and the subsequent amendment, if any.

2.2.1.8 Inner Sheath

A non-metallic moisture barrier sheath may be applied over and above the cable core. The core shall be covered with tough weather resistant High Density Polyethylene (HDPE) sheath black in colour and the colour shall conform to Munsell Colour Standards. Thickness of the sheath shall be uniform & shall not be less than 1.8 mm including the strength members if used in the sheath. The sheath shall be circular, smooth, free from pin holes, joints, mended pieces and other defects. Reference test method to measure thickness shall be as per IEC 189 para 2.2.1 and para 2.2.2.

2.2.1.9 Reinforcement

The aerial optical fibre cable shall be reinforced with Aramid Yarn in the periphery over the inner sheath. The Aramid Yarn shall be uniformly and equally distributed on the entire periphery (circumference) of the cable. The quantity of the Aramid Yarn used per kilometre length of the cable with its D-Tex value shall be indicated by the Contractor.

2.2.1.10 Outer jacket

Outer jacket shall be circular and uniform tough weather resistant & UV stabilised polyethylene compound HDPE material. Sheath/jacket black in colour shall be provided over and above the reinforcement of aramid yarn. The thickness of the outer sheath/jacket shall not be less than 2.0 mm. The sheath shall be free from pin holes, joints, scratches, mended pieces and other defects etc. and it shall have smooth finish.

2.2.1.11 Cable diameter and tolerance

The manufacturer shall define the cable diameter. The finished cable diameter shall be within ± 0.5 mm from the defined cable diameter.

2.2.1.12 RIP Cord

The two suitable (minimum) water blocking rip cords shall be provided which shall be used to open the inner and outer (HDPE) sheath of the cable. It shall be capable of consistently slitting the sheath without breaking for a length of 1 meter at the installation temperature. The rip cord(s) shall be properly waxed to avoid wicking action and shall not work as water carrier. The rip cord used in the cable shall be readily distinguishable from any other components (e.g. Aramid Yarn etc.) utilized in the cable construction.

Note : The Contractor may offer cable(s) of other design , however, the offered cable shall meet the specified technical and testing requirements. The Bidder shall submit details of cable design, test reports and customers certificates for successful operation of the offered cable, wherever alternate design has been proposed.

2.2.2 Raw Material

The cable shall use the raw materials approved against the TEC specs No. G/ORM-01/02 MAR.99 and the subsequent amendment issued if any.

The change in the design of the optical cable shall call for fresh type testing.

The HDPE Black in colour used for sheath shall be UV stabilized and shall withstand UV test for 2000 hrs (minimum).

The material used in optical fibre cable must not evolve hydrogen that will affect the fibre loss.

A test certificate from a recognised laboratory or institute may be acceptable.

2.2.3 Cable Material Compatibility

Optical fibre, buffers/core tubes, and other core components shall meet the requirements of the compatibility with buffer/core tube filling material(s) and/or water-blocking materials that are in direct contact with identified components within the cable structure as per clause no. 6.3.4 of GR-20-CORE issue 2, July 1998 and subsequent amendments, if any.

2.2.4 Safety Requirement

The material used in the manufacturing of the optical fibre cables and for use in splicing and maintenance shall be non-toxic and dermatologically safe in its life time and shall not be hazardous to health.

2.2.5 Operating requirement

The design and construction of aerial metal free optical fibre cable shall be inherently robust and rigid under all conditions of operation, adjustment, replacement, storage and transport.

The optical fibre cable shall be able to work in hilly area in snow loading conditions.

Life of cable shall be at least 25 years.

It shall be possible to operate and handle the aerial metal free optical fibre cable with tools as per TEC specs GR no. G/OFT-01/02 MAR 99 and subsequent amendment if any. If any special tool required for operating and handling the optical fibre cable, the one set of the same shall also be provided along with the supplied cable system.

It shall be possible to install the Aerial optical fibre cable with accessories and fixtures as per the TEC specs GR no. G/OAF-01/01 FEB 98 and subsequent amendments if any.

The Aerial optical fibre cable shall work satisfactorily in electrical field environment of 11 KV and shall not degrade with presence of electrical field. The cable shall be capable to be installed on 132 KV/66KV/33KV/11KV lines .

The Self Supporting Metal Free Aerial Optical Fibre Cable shall be designed and manufactured to meet the following minimum conditions of operation, installation & storage:

(a) Minimum Span length : 100 metres

(b) Maximum ice loading : As applicable for specified site.

(c) Operational wind pressure : min 45 Kgf/m^2

The supplied cable shall meet the span, wind loading and ice loading requirement of the specified location where the cable is to be installed.

2.2.6 Sag of the span lengths

(i) Maximum sag allowed without excess load **(i.e. with self weight and no wind & ice load condition)** : 1% of the span length.

(ii) Maximum sag allowed with excess load **(i.e. with all applicable loads)** : 2% of the span length

Temperature range

(i) Operation : -20° to +70°C
(ii) Installation : -15° to + 50°C
(iii) Storage : -50° to + 70°C

Tensile force design parameter : **As required to meet the specified requirement.**
Minimum bending Radius : **20** D (D is diameter of the cable)

2.2.7 FO Cable Link Lengths

2.2.7.1 The FO cable links lengths indicated in the BOQ are from gantry tower/pole to pole, pole to pole and from gantry towers/poles to FODPs. For purpose of payment cable route length shall be considered from gantry tower to pole, pole to pole (span lengths) and approach length from gantry towers/poles to FODPs.The actual cable length to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths and wastages etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price schedules shall take into account all such factors.

2.2.7.2 **Survey for Aerial cable :** The bidder is encouraged to make site visits (at their own expense), prior to bid submission. The successful bidder (Contractor) is required to visit all sites and the lines where the self supporting metal free aerial optical fibre cabling system is to be installed to perform the design and implementation functions. The Contractor shall submit the survey format for Employer's approval. The Contractor shall inform the survey schedule to the Employer well in advance and Employer may be associated with the Contractor during the survey activities. After survey, the Contractor shall submit the detailed survey report for Employer's approval for all the suggested links indicating the following as a minimum:

a. List of all spans and total link length.
b. Suitability of installation of the proposed cable on the proposed reoute.
c. Tower/Pole wise identification of type(s)_and numbers of fittings and accessories required.
d. If vibration dampers are required to be installed, the number and placement of dampers for each span shall be submitted alongwith the calculations.
e. Proposed splice locations and cable drum schedules.
f. Proposed routing of cables from the poles/towers up to the termination points in the buildings.
g. The installation arrangement of the joint boxes and the FODPs.
h. Height of installation of optical fibre cable in different poles/rotes.
i. Route for underground cable installation at Road crossings, if required.
j. Requirement of additional poles to meet sag/clearance/span at site.
k. Details and types of existing poles/towers and healthiness of the poles/towers.
l. Details of overhead cables/conductors presently string on the route.
m. Frequency and type of faults of towers/poles and cables/conductors of the route.
n. Snow fall period and snow load of the area as per Metrological departments data.

2.2.8 Cable Ends

Both cable ends (the beginning end and end of the cable reel) shall be sealed and readily accessible. Minimum 5 meter of the cable of the beginning end of the reel shall accessible for testing. Both ends of the cable shall be kept inside the drums and shall be located so as to be easily accessible for the test. The drum (confirming to GR No. G/CBD-01/02 Nov. 94 and subsequent amendments if any) should be marked to identify the direction of rotation of the drum. Both ends of cable shall be provided with cable pulling (grip) stocking and the anti twist device (free head hook).

Anti-twist device (Free head hook) shall be provided attached to the both end of the cable pulling arrangement. The arrangement of the pulling eye and its coupling system along with the anti twist system shall withstand the prescribed tensile load applicable to the cable.

2.2.9 The nominal drum length

Generally, the length of aerial optical fibre cable in each drum shall be **2 km ± 5 %**. However, the cable drum lengths shall be supplied as per the approved drum schedule. The drum shall be marked with arrows to indicate the direction of rotation. **Packing list supplied with each drum** shall have at least the following information: Drum no., Type of cables, Physical Cable length, No. of fibres, Length of each fibre as measured by OTDR, The cable factor – ratio of fibre/cable length, Attenuation per km. of each fibre at 1310 & 1550 nm, User's/consignee's name, Manufacturer's Name, Month, Year and Batch no., Group refractive index of fibres, Name of the route.

2.2.10 Optical Fibre Strain

The following shall be ensured:

(a) The Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is no fibre strain.
(b) The cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
(c) The maximum allowable tension (MAT) is defined as the maximum tension experienced at worst wind load and snow load conditions.
(d) The Cable everyday tension (EDT) is defined as the maximum cable tension at 32 degree C, no wind load and no ice load.
(e) The ultimate/ rated tensile strength test is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

The Contractor shall offer suitable aerial optical fibre cable and submit the sag-tension chart for various spans for the aerial FO cable meeting the following conditions for Employer's approval:

(i) The MAT / maximum strain shall be less than or equal to the MWT / strain margin of the cable.
(ii) The sag shall exceed the conditions specified in clause 2.5.5.
(iii) The MAT shall be less than or equal to 0.4 times the rated UTS of the cable.
(iv) The EDT shall not exceed 20 % of the rated UTS of the cable.
(v) The ground clearance shall be met for the actual site conditions.

2.2.11 Cable Marking

The cable marking shall be imprinted and indelible (indented). The marking on the cable shall be indelible of durable quality and at regular intervals of one meter length. The alternatively permanent printing with the laser shall also be acceptable. In case of laser printing method; the impression shall not exceed the depth of 0.15 mm. The accuracy of the sequential marking must be within –0.25% to +0.5% of the actual measured length. The markings on the cable must not rub off during normal installation.

The marking shall be of clearly contrast colour on the black HDPE sheath in case hot foil indentation method is used. The colour used must withstand the environmental influences experienced in the field.

Two orange colour (UV stabilized) lines of minimum 3 mm width diametrically opposite to each other, continuous over the length of the cable shall be applied (marked) for easy identification of this cable from other cables.

The type of legend marking on O.F. cable shall be as follows:

(i) Company Legend
(ii) Legend containing international acceptable Laser symbol

(iii) Type of cable i.e. Slotted or Loose Tube or Uni-tube (Central Tube)
(iv) Type of Fibre ie. DWSM
(v) Number of Fibres
(vi) Year of manufacturer
(vii) Sequential length marking
(viii) Owner's Name i.e. " "

2.2.12 Installation ,Accessories and Fixtures for Aerial Cable

The scope of supply of the Self Supporting Metal Free Aerial Optical Fibre Cable includes the assessment, supply and installation of all required installation accessories and fixtures. The Contractor shall provide documentation justifying the adequacy and suitability of the hardware used. To ensure their satisfactory performance, the Contractor shall determine the exact requirements of all accessories and fixtures used to install and secure the cable.

The cable hardware accessories and fixtures shall follow the general requirements regarding design, materials, dimensions & tolerances and markings etc. as specified in TEC spec. No. GR NO.G/OAF-01/01. FEB 98 and subsequent amendments, if any. The cable accessories & fixtures drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The required joint box shall also be provided by the Contractor and the details of which shall be submitted for Employer's approval. The joint box shall comply to ingress protection class IP 66 or better. The in-line splice support mechanical opening and closing.

The required strengthening of existing structures/towers/poles shall be carried out by the Contractor for installation of offered aerial cable. As the aerial cable is designed for 100 m span for self supporting condition and for the span greater than 100 m , the additional strength wire along with the clipping arrangement and/or poles to support the aerial cable for installation of aerial cable system shall also be provided by the Contractor at no additional cost to the Employer. However, the actual span lengths may vary at site and the fittings & accessories shall be provided as per site requirement.

The above requirement of additional poles, strength wires, strengthening of existing structure/poles/towers shall be submitted by the Contractor for Employer's approval and same shall be provided as per approval.

2.3 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur within facilities or on tower structures. All optical fibre splicing shall comply with the following:

(a) All fibre splices shall be accomplished through fusion splicing.

(b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(c) All splices and bare fibre shall be neatly installed in covered splice trays. No more than six (6) fibres shall be installed in each splice tray.

(d) For each link, bi-directional attenuation of single mode fusion splices measured at 1550 nm shall not average more than 0.05 dB. The bi-directional splice loss of each splices shall not exceed 0.1 dB when measured at 1550 nm.

(e) For in-line splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

2.4 Optical Fibre Termination and Splicing

All fibre optic cables shall be terminated in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP shall be proposed by the Contractor during the survey and shall be submitted for Employer's approval.

2.4.1 Fibre Optic Distribution Panels

At each location requiring the termination of fibres of a cable, all fibres within that cable shall be connectorised and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to preconnectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall support fibre terminations as well as pass-through splicing.

(c) FODPs shall be supplied in suitable wall mounted type enclosures or in sub racks which shall be mounted in SDH cabinets.

(d) In case of wall mounted FODP shall be corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Specific selection of the entry points shall be made at the time of installation. 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 IP51 specifications.

(e) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

2.4.2 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

2.5 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level. At least tower/pole height plus five meters length of FO cable is to be considered for service loop in each direction at splicing location. After splicing the extra length shall be coiled with the recommended bending radius and joint suitably fixed at top of the tower.

(b) Indoor Cable Service Loops: FODPs shall provide at least five (5) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least two (2) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops: Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least two (2) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops: At least 1 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

(f) Sufficient service loop is to be kept at all crossing location(railways, culverts, river etc.) through under ground installations (if applicable) in the overhead FO cable routes. At least 5 meters on each side of the crossing is to be considered for the same.

2.6 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in 2.5 .The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

2.7 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

(a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(b) Indoor 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 provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.

(c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review.

2.8 Required Optical Fibre Characteristics

This section describes the characteristics of optical fibre to be provided under this specification.

2.8.1 Physical Characteristics

Dual-Window Single mode (DWSM) optical fibres shall be provided in the quantities specified in the Appendices. DWSM optical fibres shall meet the requirements defined in Table 4-1(a).

2.8.2 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm, shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 2-1 shall be "guaranteed" fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm: 0.23dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors

Maximum attenuation @ 1310nm: 0.35dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors

Table 2-1
DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 µm (± 10% of the nominal value)
Cladding Diameter:	125.0 µm ± 2 µm
Mode field concentricity error	≤ 1.0µm at 1310 nm
Cladding non-circularity	≤ 2%
Cable Cut-off Wavelength	≤ 1260 nm
1550 nm loss performance	As per G.652
Proof Test Level	≥ 100 kpsi
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.23dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	20 ps/(nm x km) 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324nm -0.093 ps/(nm^{2}xkm) maximum
Polarization mode dispersion coefficient	≤ 0.5 ps/km^½

Table 2-1
DWSM Optical Fibre Characteristics

Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB/km @ 1550 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.10 dB/km @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB/km
End of Table	

2.9 Test and Inspection

2.9.1 Type Testing

The bidder shall submit earlier carried out type test reports for the offerd fibre optic cable, fibre, joint box and fittings. The Contractor shall submit the type test report as per the requirement specified below . Type Tests shall be performed for all equipment/cable types for which certification is not provided, or if it is determined by the Employer that the certification provided is not acceptable. If any of the type tests are required to be carried out, the same shall be carried out by the Contractor at no additional cost to the Employer.

2.9.1.1 Type Tests For Optical Fibres

The type tests listed below in Table 2.1 are applicable to all types of F.O. cables and shall be conducted on DWSM fibres. The tests specific to the cable type are listed in subsequent sections.

Table 3.1
Type Tests For Optical Fibres

S.No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	Table 2-1(a)	EIA/TIA 455- 78A
2	Attenuation Variation with Wavelength	Table 2-1(a)	EIA/TIA 455- 78A
3	Attenuation at Water Peak	Table 2-1(a)	EIA/TIA 455- 78A
4	Temp. Cycling (Temp dependence of Attenuation)		EIA/TIA 455- 3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		EIA/TIA 455- 62A
6	Mode Field diameter		EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		EIA/TIA 455-176
9	Point Discontinuities of attenuation		EIA/TIA 455-59

Table 3.1
Type Tests For Optical Fibres

S.No.	Test Name	Acceptance Criteria	Test procedure
10	Core -Clad concentricity error		EIA/TIA 455-176
11	Polarisation Mode Dispersion		
-End Of table-			

2.9.1.2 Type Testing on Aerial Optical Fibre Cable

The mechanical and testing parameters of the cable shall meet the requirements defined in Table 3.2 below:

Table 3-2

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
1	Tensile strength Test	To test the tensile strength Self Supporting Metal Free aerial Optical Fibre cable in order to examine the behaviour of the attenuation as a function of the load on a cable during installation and while the aerial optical fibre cable encounters the excess ice loading and the winds at high speed and to check its design parameters.	IEC 794-1-E1 The cable shall sufficient strength to withstand UTS load. The load shall be sustained for 10 minutes and the strain of the fibre and the attenuation shall be monitored at MWT, Max installation load & UTS. MWT & UTS shall be derived from SAG-TENSION data for aerial cable.	The load shall produce no strain (≤0.05% is to be treated as no strain) up to MWT and fibre strain shall not exceeding 0.25% in the fibre upto max installation load. At UTS fibre shall not break and shall not cause any permanent physical and optical damage to any component of the cable. The attenuation shall be noted before strain and after the release of strain. The change in attenuation of each fibre after the test shall be ≤ 0.05dB both for 1310 nm and 1550 nm wavelength.
2	Abrasion Test	To test the abrasion resistance of the sheath and the marking printed on the surface of the cable.	IEC-794-1-E2 or by any other international test method The cable surface shall be abraded with needle (wt. 150 gm) having diameter of 1mm	There shall be no perforation & loss of legibility of the marking on the sheath.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			with 500 grams weight (Total weight more than equal 650 gms.) No. of cycles : 100 Duration : One minute (nominal)	
3	Crush Test (Compressive Test)	The purpose of this test is to determine the ability of an optical fibre cable to withstand crushing.	IEC 794-1-E3 The fibres and component parts of the cable shall not suffer permanent damage when subjected to a compressive load of 2000 Newtons applied between the plates of dimension 100 x 100 mm. The load shall be applied for 60 Secs. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310 nm and 1550 nm wavelength.
4	Impact Test	The purpose of this is to determine the ability of an optical fibre cable to withstand impact.	IEC 794-1-E4 The cable have sufficient strength to withstand an impact caused by a mass weight of 50 Newtons, when falls freely from a height of 0.5 meters. The radius R of the surface causing impact shall be 300 mm. Ten such impacts shall be applied at the same place. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be ≤ 0.05 db both for 1310 nm and 1550 nm wavelength.
5	Repeated Bending	The purpose of this test is to determine the ability of an optical fibre cable to withstand repeated bending.	EIA-455-104 The cable sample shall be of sufficient length (5 m minimum to permit radiant power measurements as required by this test. Longer lengths may be used if required. Parameters : Weight : 5 kg Minimum distance from Pulley Centre:216mm	During the test no fibre shall break and the attenuation shall be noted before and after the completion of the test. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310 nm and 1550 nm wavelength.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			To holding device Minimum distance from Wt. To Pulley Centre : 457 mm Pulley Diameter: 20 D (D-cable diameter) Angle of Turning: 90° No. of cycles: 30 Time Required for 30 cycles : 2 min	
6	Torsion Test	The purpose of this test is to determine the ability of an optical fibre cable to withstand torsion.	IEC 794-1-E7 The length of the specimen under test shall be 1 meters and the load shall be 75 N. The sample shall be mounted in the test apparatus with cable clamped in the fixed clamp sufficiently tight to prevent the movement of cable sheath during the test. One end of the cable shall be fixed to the rotating clamp, which shall be rotated in a clockwise direction for one turn. The sample shall then be returned to the starting position and then rotated in an anti-clock wise direction for one turn and returned to the starting position. This complete movement constitutes one cycle. The cable shall withstand ten such complete cycles.	The cable shall be examined physically for any cracks, tearing on the outer sheath and for the damage to other component ports of the cable. The twist mark shall not be taken as damage. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wave length.
7	Kink Test	The purpose of this test is to verify whether kinking of an optical fibre cable results in breakage of any fibre, when a loop is formed of dimension small enough to induce a kink on the sheath.	IEC 974-1-E10 The small length shall be 10 times the minimum bending radius of the cable. The sample is held in both hands, a loop is made of a bigger diameter and by stretching both the ends of the cable in opposite direction, the loop is made to the minimum bend radius and no	The kink should disappear after the cable is brought to normal position. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wavelength.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			kink shall form. The cable is then normaled and attenuation reading is taken.	
8	Cable Bend Test	The purpose of this test is to determine the ability of an optical fibre cable to withstand repeated flexing. The procedure is designed to measure optical transmittance changes and requires an assessment of any damage occurring to other cable components.	IEC 794-1-E11 (Procedure-I) The fibre and the component parts of the cable shall not suffer permanent damage when the cable is repeatedly wrapped and unwrapped 4 complete turns of 10 complete cycles around a mandrel having diameter of 20 D, where D is the diameter of the cable. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wave length. Sheath shall not show any cracks visible to the naked eye when examined whilst still wrapped on the mandrel.
9	Snatch Test	This test is to determine the ability of the cable to withstand a sudden snatch load.	IEC 794-1-E9 The sample is terminated in a manner that the fibres, sheathing and any strength member/members are clamped together firmly. A hook of dimension ahs a shaft capable of bearing variable loads applied to it. The cable of 4.5 meters length is taken and firmly clamped at the two ends so that a sag of 300 mm., is formed. The attenuation is then measured. Testing load shall be 300 N and the radius of impacting surface of the crown of the hook shall be 12.5 mm. The hook with the mass attached, is held or supported over the cable so that the crown of the hook is centered over the lowest point of the cable at a height of 100 mm. The hook is then released so as to catch the cable after dropping from the height of 100	There shall be no permanent physical damage to the cable and the change in attenuation of the fibre after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wave length.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			mm. It shall be repeated ten times. The attenuation is measured. The load is then removed from the cable and attenuation is noted.	
10	Cable Bend Test at High & Low Temperature	To determine the ability of a optical fibre cable to withstand bending at low and high temperatures which might be encountered during cable placement.	EIA RS-455-37 Test Temperature : -30 ^{o}C to +70 ^{o}C Mandrel dia : 20D (D – dia of the cable) No of turns : 4 Conditioning time duration : 24 hours at each temperature.	Visual test for damage of the sheath shall be checked. The change in attenuation of the fibre after the test shall be ≤ 0.05 dB/Km both for 1310 nm and 1550 nm wave length. The attenuation shall be noted before and after the completion of the cycle.
11	Temperature Cycling	To determine the stability behaviour of the attenuation of a cable subjected to temperature changes which may occur during storage, transportation and usage.	IEC 794-1-F1 (To be tested on 2 Km ± 5% of cable) The permissible temperature range of the cable for storage shall be from –40 ^{o}C to +70 ^{o}C. The rate of change of temperature during the test shall be 1 degree/minute approx. The cable shall be subjected to temperature cycling for 12 hours at each temperatures as given below: TA2 : –20 ^{o}C TA1 : –10 ^{o}C TB1 : +60 ^{o}C TB2 : +70 ^{o}C The test shall be conducted for 2 cycles at the above temperatures.	The change in attenuation of the fibre under test after the test shall be ≤ 0.05 dB both for 1310nm and 1550 nm wave length for entire range of temperature.
12	Cable Aging Test	To check the cable material change dimensionally as the cable ages.	At the completion of temperature cycle test, the test cable shall be exposed to 85 ± 2 degree C for 168 hours. The attenuation measurement at 1310 & 1550 nm wavelengths to be made after stabilisation of the test cable at ambient temperature for	The increase in attenuation allowed : ≤ 0.05 dB at 1310 & 1550 nm wavelengths. *(Note: The attenuation changes are to be calculated with respect to the base line*

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			24 hours.	*attenuation values measured at room temperature before temperature cycling.)*
13	Water Penetration Test	To ensure that the installed optical fibre cable will not allow water passage in the cable.	IEC 794-1-F5 (Fig. B) 1992. A circumferential portion of the cable end shall face the water head. The water tight sleeve shall be applied over the cable. The cable shall be supported horizontally and one meter head of water, containing a sufficient quantity of water soluble fluorescent dye for the detection of seepage, shall be applied over the inner sheath for seven days at ambient temperature. No other colour dye is permitted.	No dye shall be detected when the end of the 3m length is examined with UV light detector.
14	Test of Figure of Eight on the cable	To check of easiness in formation of figure of 8 of the cable during installation in the field.	1000 meters (approx) length of the cable shall be uncoiled from the cable reel and shall be arranged in figure of 8. The diameter of each loop of the figure of 8 shall be maximum 2 meters.	It shall be possible to make figure of 8 of minimum 1000 meter length of the cable uncoiled from the cable reel without any difficulty. No visual damage shall occur.
15	Cable Jacket Yield Strength and Ultimate Elongation	To check the yield strength and elongation of polyethylene (HDPE) cable sheath.	FOTP –89 or ASTM D1248 Type III Class. (a) Sample shall be taken from the completed cable (The nylon to be removed for this test). The aged sample shall be conditioned at 100 ± 2 ^{o}C for 120 hours before testing. The cross-head speed shall be 50 mm per minute.	Refer Table E-6.2 below.
16	Drip Test	To determine the ability of jelly in the cable to withstand a temperature of 70 ^{o}C.	Take a sample of 30 cm length of cable with one end sealed by the end cap. Remove nylon jacket, black sheath binder tape for 5 cm from open end of the sample. Clean the jelly. Then the sample is kept vertically	There should be no jelly drip or oil impression on the paper.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			with open end downwards in the oven for 24 hours at 70 ^{o}C with a paper under the sample. Examine the paper placed below the cable sample inside the oven for dripping of the jelly after 24 hours.	
17	ECSR Test	To check the outer sheath of the cable for ECSR.	ASTM D 1693.	There should not be any visible cracks on the surface of the outer sheath, when examined with the help of a magnifying glass.
18	UV Resistance Test	To check the effect of UV radiation on the following: (i) On the outer sheath material (HDPE) (ii) On the Orange colour lines. (iii) On the meter and other legend marking.	ASTM G-53-96 Duration : 2000 hours Four test samples of the finished cable of required length (as per test chamber specifications) are to be prepared. 2 samples shall be kept inside and these test samples are to be compared after test with the other 2 samples kept outside.	There should not be any fading or change in the colour of the marking and that of sheath. *(Note: Earlier Carried out test certificates may be accepted for same raw material and similar design/construction of the cable).*
19	Embrittlement Test of Loose Tube	To check the embrittlement test of the loose tube	The minimum length of the test sample depends of the outside diameter of the loose tube and should be 85mm for tubes up to 2.5mm outside dia. The length of the bigger tubes should be calculated by using the following equation : $Lo > 100 \times ((D^2 + d^2)/4)^{1/2}$ Where Lo = Length of tube under test D = Outside dia of loose tube. d = inside dia of loose tube. Both the ends of a buffer tube test sample may be mounted in a tool which is clamped in jaws of a tensile machine	The tube should not get embrittled. No ink should appear on the tube up to the safe bend dia of tube (20 D) where D is the outside diameter of the loose tube. There should not be any physical damage or mark on the tube surface.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			which exert a constant rate of movement. The movable jaw may move at a rate of 50 mm per minute toward the fixed jaw. Under load the tube will bend, so that the tube is subjected to tensile and compressive stresses. The fixture for holding the tube should be designed in a manner that the tube might bend in all directions without further loading.	
20	Kink Resistance Test on the Loose Tube	To check the kink resistance of the loose tube during installation and in splicing operation	A longer length of the loose tube is taken (with fibre and gel), a loop is made and loop is reduced to the minimum bend radius of loose tube i.e. 20 D. (where D is the outside dia of the loose tube). This test is to be repeated 4 times on the same sample length of the loose tube.	No damage or kink should appear on the surface of the tube.
21	Drainage Test for Loose Tube	To check drainage of the loose tube	A tube length to 40 cm shall be cut and filled with filling gel ensuring there are no air bubbles and the tube is completely full. The filled tube is placed in a horizontal position on a clean worktop and cut 5 cm from each end so that the finished length of the sample is 30 cm. The filled tube shall be left in a horizontal position at an ambient temperature for 24 hrs. The sample tube is then suspended vertically in an environment heat oven over a weighed beaker. It is left in the oven at a temperature of 70 °C for a period of 24 hrs. At the end of the 24 hrs. period the beaker is checked and weighed to see if there is any gel in the beaker.	There shall be no gel or oil in the beaker.
22	Check of	To check the easy	The sheath shall be cut in	It shall be possible to

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
	Easy removal of Sheath	removal of sheath of the optical fibre cable by using normal sheath removal tool.	circular way using a sheath removal tool and the about 300 mm length of the sheath should be removed in one operation. It should be observed during sheath removal process that no undue extra force is applied and no component part of the cable is damaged.	remove the sheath easily. Easy removal of both the outer jacket and the inner sheath shall be checked separately.
23	Check of the effect of Aggressive Media on the Cable	To check the effect of aggressive media solutions of PH4 and PH10 on the cable.	ISO 175. The two test samples of the finished cable each of 600 mm in length are taken and the ends of the samples shall be sealed. These test samples are put in the PH4 and PH10 solutions separately. After 30 days these samples are taken out from the solutions and examined for any corrosion etc. on the sheath and other markings of the cables.	The sample should not show any effect of these solutions on the sheath and other marking of the cable. *(Note: Earlier Carried out test certificates may be accepted for same raw material and similar design/construction of the cable).*
---End of Table ----				

Table 2.2

Jacket material	Minimum Yield Strength		Minimum Elongation (%)
	(Mpa)	(psi)	
HDPE unaged	16.5	2400	400
HDPE aged	12.4	1800	375

2.9.1.3 **Type Tests on Aerial FO cable Accessories & fixtures**

The accessories and fixtures shall subject to the following tests. The applicability of the tests for the particular type of accessories and fixtures shall be as given below:

2.9.1.3.1 Visual examination : Applicable to all fittings

Objective: To check the quality and the workmanship.

Visual examination shall be carried out for all the accessories and fixtures for quality and workmanship which is required to be of the high order with super quality finish without any manufacturing defects.

2.9.1.3.2 Verification of dimensions : Applicable to all fittings

Objective: To check the dimensions of the accessories and fixtures : shall be checked as per approved DRS/drawings.

2.9.1.3.3 Tensile strength test : Applicable to tension & suspension clamp assemblies

Objective: To assess the mechanical performance of fixtures under ultimate tensile strength.
Requirement: Cable UTS with factor of safety 1.5

All the load bearing metal fittings except those of elastomer pads and helically formed fittings shall be tested to meet the above requirement.

2.9.1.3.4 Tensile strength test for helically formed product

This test shall be applicable to terminating Helix, Protective Helix and Armour grip suspension helix.

Objective : To check the tensile strength for the helically formed items.

Requirement : The tensile strength test shall be carried out to the method specified in the respective standards for wires and shall meet the requirements listed in earlier clauses.

2.9.1.3.5 Slip Strength Test

This test shall be applicable to the Terminating helix and Armoured grip suspension fittings.

Objective : To check the tensile load strength of the formed fittings to assess the performance for withstanding the guaranteed load.

Requirement : The helically formed terminating fittings shall not slip up to 90 % of the Cable UTS. The helically formed suspension fittings shall withstand the load up to a minimum of 25 % of cable UTS and shall slip before 50 % of cable UTS.

2.9.1.3.6 Resilience Test

This test shall be applicable to terminating Helix.

Objective : To check the resilience of the helically formed fittings (Terminating Helix)

Requirement : The helically formed fittings shall pass the resilience test while helically formed fittings are wrapped and unwrapped on a piece of optical fibre cable three times successfully. The helical fittings should not loose its resilience even after three applications and shall be able to pass the slip strength test after third application.

2.9.1.3.7 Galloping / Fatigue test

This shall be applicable to a complete assembly of one set of tension fittings together with one set of suspension fittings and spiral damper.

Objective : To assess the fatigue performance of fixtures and accessories and the performance of optical characteristics of the optical fibre cable under galloping conditions.

Requirement of test methods:

Length of the span : 25 – 30 meters
Minimum vibration cycles : 1 million
Frequency : > 30 Hz to 100 Hz.
Amplitude : Amplitude of vibration at antinodal points shall not be less than 100 % of the cable diameter.

Requirement : The accessories and fixtures shall pass the test when tested for the test conditions as above and shall meet the requirement given below:

1. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
2. No damage on the accessories and fixtures.
3. No physical damage to optical fibre cable.

2.9.1.3.8 Aeolian Vibration Test

Objective : To assess the fatigue performance of accessories and fixtures and the optical characteristics of the optical fibre cable under Aeolian vibration.

Requirement of test method :

Minimum length of span : 25 meters.
Minimum vibration cycles : 1 million
Frequency : 10 Hz to 100 Hz.
Amplitude : Free loop peak to peak antinode amplitude shall be maintained at a level equal to one half of the cable diameter.

Requirement :
1. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
2. No visual damage observed on the accessories and fixtures.
3. No physical damage to optical fibre cable.

2.9.1.3.9 Tension and Attenuation Test (Dead End Assembly)

Objective : To assess the attenuation and the optical characteristics of the optical fibre cable after fixing and installing dead end assembly on the optical fibre cable.

Requirement of test method :

Minimum length of span : 25 meters

The test shall meet the following:

a. Change is attenuation shall not exceed more than 0.1 dB after the recovery period.
b. Any visual damage observed on the accessories and fixtures.
c. No physical damage to optical fibre cables.

2.9.1.3.10 Wrapping Test

Objective : To check quality of the aluminum alloy wires.

Test Method : The formed fittings made of aluminum alloy wires shall by wrapped on a wire of its own diameter to form a close helix.

Requirement : The wires should not break or show fracture and shall meet the requirement specified above.

2.9.1.3.11 Galvanising Test

Objective : To check galvanized coating and the quality of galvanizing on accessories and fixtures

Test method : IS 2633-1972 for uniformity.

Requirement : The fittings shall meet the requirement of the specifications.

2.9.1.3.12 Hardness Test of Elastomer pad

Objective : To check the Ploychloroprene compounded elastomer pads of the suspension and cable jumper clamp.

Requirement : The Ploychloroprene compounded elastomer pads of the suspension unit shall be subjected for the test parameters as listed earlier in this specifications. The compounded material should meet the minimum properties specified therein.

2.9.1.4 Type Tests for In Line Splice Enclosure

Following Type tests shall be demonstrated on the In Line Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 794-1 procedures).

2.9.1.4.1 **Temperature Cycling Test**

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to +65°C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20/ IEC 794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

2.9.1.4.2 **Humid Heat test**

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55°C ±2°C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ±0.05dB, and the internal humidity rate measured, less than 2% .

2.9.1.4.3 **Rain Withstand Test**

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

2.9.1.4.4 **Vibration Test**

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

2.9.1.4.5 **Bending and Torsion test**

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

a) 3 torsion cycles of ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure.

2.9.1.4.6 **Tensile test**

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 Newton for a period of two minutes. No fissure shall be noted in the connections or on the box.

2.9.1.4.7 **Drop Test**

With 2 lengths of 10 metres of cable fixed to the box, it shall be dropped five times from a height of 1 metre. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test shall be carried out in accordance with procedure described in IEC-68-2-32.

2.9.2 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 Aerial fibre optic cable, Aerial FO cable accessories & fixtures, splice enclosures, FODP etc.

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 despatch Certificate. 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.

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. A list of factory acceptance tests for fibre optic cables and FO cable hardware fittings & accessories etc. are given below. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program.

For the FO cable **hardware fittings & accessories**, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The factory acceptance tests for the splice enclosures, FODP and 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, FAT tests shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

2.9.2.1 Factory Acceptance Tests On Fibre Optic Cables

The Factory acceptance tests shall be conducted on random sampling of fibre optic cable to be supplied for the present procurement, prior to any shipment.

2.9.2.1.1 FAT On Fibre: Optical Acceptance Tests

The Optical acceptance tests listed in table E-8.1 below are applicable for the fibres of all types of Fibre Optic Cables to be supplied. The listed tests follow testing requirements set forth in IEEE standards 1138 section 4.2.2.1 and section 5.2.2.1 . The referenced sections

specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standard unless specified otherwise in the technical specifications.

Table 3.5.1
Factory Acceptance Tests for Fibres of all FO cables: Optical Tests

S.No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	Table 2-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	Table 2-2(a)	EIA/TIA 455-59
3	Attenuation at Water Peak	Table 2-2(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core - Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding dia.		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		
-End Of table-			

The manufacturer carried out test certificates for fibres shall be produced during FAT on FO cable and the test reports shall be submitted along with the FO cable FAT reort.

2.9.2.1.2 Factory Acceptance Tests on Self-supporting metal free aerial optical fibre cable

The tests listed in Table 3.6 shall be carried out as Factory Acceptance Test for Self-supporting metal free aerial optical fibre cable meeting the requirements specified in this section.

Table 3.6
Factory Acceptance Tests on Self Supporting Metal Free Optical Fibre Cable

S. No.	Factory Acceptance Test
1	Attenuation Coefficient (1310, 1550): By EIA/TIA 455- 78A or OTDR
2	Point discontinuities of attenuation: By EIA/TIA 455- 78A or OTDR
3	Visual Material verification and dimensional checks as per approved drawings
4	Water Ingress test

5	Tensile strength test / Strain test
6	Impact test
7	Kink test
8	Environmental test
9	Crush Test
10	Drip test

Note : Sampling

For test sl. No. 1 & 2 (10% drums of the lot offered). Test shall be conducted on all fibres of the selected drums.
For test Sl. No. 3, 4, 5, 6, 7, 9 & 10 shall be one drum per lot.
For test No. 8 one drum for the design/total project requirement.

2.9.2.2 Factory Acceptance Tests on Aerial FO cable accessories & fixtures

The FAT on accessories & fixtures of Self-supporting metal free aerial optical fibre cable shall be carried out as specified in Table 3.6.2.

Table 3.6.2
Factory Acceptance Tests on Fittings for Self Supporting Metal Free Optical Fibre Cable

S. No.	**Factory Acceptance Test**
1	Visual and dimensional checks of all components
2	Tensile test
3	Slip test
4	Galvanising test
5	Wrapping test
6	Hardness test

2.9.2.3 **Factory Acceptance Test on In Line Splice Enclosures**

The factory acceptance tests for In Line Splice Enclosures as specified below in Table 7.1:

Table 3.7.1
Factory Acceptance Tests on In Line Splice Enclosures

S. No.	Factory Acceptance Test

1	Visual check Kit Quantities and Specific Component Number for each component of In Line Splice Enclosure and dimensional checks against the approved drawings.
End of Table	

2.9.2.4 Factory Acceptance Test on Fibre Optic Distribution Panel (FODP)

The factory acceptance tests for FODP as specified below in Table 3.8

Table 3.8
Factory Acceptance Tests on FODP

S. No.	Factory Acceptance Test
1	Visual check Kit Quantities and Specific Component Number for each component of FODP and dimensional checks against the approved drawings.
End of Table	

2.9.3 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), alongwith 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.

2.9.4 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, the Sampling rate for the Factory acceptance tests shall be 10% (Minimum 1) of the batch size. 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.

2.9.5 Site Acceptance Tests

The Contractor shall be responsible for the submission of all 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. A minimum Site Acceptance Testing requirement 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).

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 and Purchaser to demonstrate that it is entirely suitable for commercial operation.

2.9.5.1 **Minimum Site Acceptance Testing Requirement for FO Cabling**

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

2.9.5.2 **Phases of Site Acceptance Testing of FO cabling system**

SAT shall be carried out link by link from FODP to FODP.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and tension of Aerial cable shall generally be as per approved sag-tension chart and during installation, sag and tension of Aerial shall be documented. Upon completion of a continuous cable path (equipment to equipment locations), all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Tables 2-2 (a) through 2-2(c).

Table 2-2 (a):
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1310 /1550 nm

Table 2.2 (b): Fibre Optic Cable Splice Testing	
Item:	**Description:**
1.	Per splice bi-directional average attenuation with OTDR
2.	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.
Table 2-2 (c): Fibre Optic Cable Commissioning Testing	
Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3.	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4.	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.
-End of Table-	