

## **SECTION V**

### **TECHINICAL SPECIFICATIONS OF UNARMoured U/G FIBRE OPTIC CABLE**

This section describes the functional requirements, major technical parameters and Type and Factory Acceptance Testing requirements for underground fibre optic cable, Marking, Packaging and transportation requirements have also been described.

#### **2.1 General**

The Underground fibre optic cable shall be unarmoured and shall be suitable for underground installation in pipes. The cable should be of low weight, small volume and high flexibility. The mechanical design and construction of each unit shall be inherently robust and rigid under all condition of operation, adjustment, replacement, storage and transport.

#### **2.2 Applicable Standards:**

The cable shall conform to the standards named below and the technical specifications described in the following sections.

- (i) ITU-T Recommendations G-652.
- (ii) Electronic Industries Association, EIA/TIA 455-78A, 455-3A, 455-62A, 455-164A/167A/174. 455-168A/169A/175A, 455-176, 455-59, EIA/TIA 598, EIA 455-104.
- (iii) International Electro technical Commission standards, IEC 60304, IEC 60794-1-2, IEC 60811-5-1. (iv)

Bell Core GR-20.

### 2.3 Fibre Type (S) and Counts.

The cable shall contain 24 Dual window single Mode (DWSM) fibres conforming to G.652 as per the bill of the quantity and the technical parameters stipulated in the following sections. The BOQ for each type of cable has been provided in the appendices.

### 2.4 Optical Characteristics:

The attenuation coefficient for wavelength between 1525nm and 1575nm shall not exceed the attenuation coefficient at 1550nm by more than 0.25dB/km. The attenuation coefficient between 1285nm and 1330nm shall not exceed the attenuation coefficient at 1310nm by more than 0.35 dB/Km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.1db. The fibre attenuation Characteristics specified in table 2-1 shall be guaranteed fibre attenuation of any & every fibre reel. Further the average cabled fibre attenuation, averaged over 100 Kms of cabled fibre, (as measured during the factory acceptance testing) shall be as specified in 2.6.1.

**Table 2-1**

**DWSM Optical Fibre Characteristics**

Fibre Description:	Dual window Single-Mode
Mode Field Diameter:	8.6 to 9.5nm um (K10% of the nominal value)
Cladding Diameter:	125.0 um K 2um
Mode Field concentricity error:	=1.0um
Cladding non-circularity	=2%
Cable cut off wavelength	=1260nm
1550 loss performance	As per G.652
Proof Test Level	=0.35Gpa
Attenuation coefficient Max	@1310nm = 0.35 db/Km @1550nm = 0.25 db/Km
Tube	Base tube
Fiber Type	High performance -ATø
Giga Bit Ethernet Distance	10,000Mtrs (1310nm)
10 Giga Bit Ethernet Distance	5,000Mtrs (1310 nm) 30,000Mtrs (1550nm)
Connector loss Splice loss	0.75dB } 0.1dB for both 1310 & 1550nm type
Outer jacket	0.65ms polymide -12 (orange)
Rip cord	to be provided.

Chromatic Dispersion: Maximum:	20ps/(nm x km) 1550nm
Zero dispersion wavelength:	3.5ps/(nm x km) 1288-1339nm
Zero Dispersion Slope	5.3ps/(nm x km) 1271-1360nm
	1300 to 1324 nm
	-0.093ps/(nm <sup>2</sup> x km) maximum
Polarization mode dispersion coefficient	=0.5 ps/km <sup>1</sup> / <sub>2</sub>
Bend performance	@1310nm (75=2nmdia Mandrel), 100 turns
	Attenuation rise <0.05 db/km
	@1550nm (75=2nmdia Mandrel), 100 turns
	Attenuation rise <0.10 db/km
	@1550nm (32=0.5 dia Mandrel), 1 turn:
	Attenuation rise <0.50 db/km

## 2.5 General Construction:

The Optical cable shall consist of a central fibre optic unit protected by one or more layers of helically wound anti-hygroscopic tape or yarn. The central fibre optic unit shall be designed to house and protect the fibres from damage due to forces such as crushing, bending, twisting, tensile stress and moisture, wide temperature variations, hydrogen evolution etc. The fibre shall be of loose tube construction. The inner polyethylene jacket and outer sheath packets shall be free from pinholes, joints, splits or any other defects. All fibre optic cable shall have a minimum service life span of 25 years.

### 2.5.1 Colour Coding & Fibre Identification:

Individual optical fibre within a fibre unit, and fibre units shall be identifiable in accordance with EIA/TIA598 or IEC 60304 or Bellcore GR-20 Colour ó coding scheme. The colour coding system shall be discernible throughout the design life of the cables. Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogeneous. The

colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing. Each cable shall have tracibility of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibre shall be suitably bundled, tagged and identified at the factory by the vendor.

#### 2.5.2 Strength Members

The Central fibre optic unit should include a central strength member of Fibre Reinforced Plastic (FRP) or other suitable material. Peripheral strength members and aramid yarns are also acceptable. The Central FRP strength member may be of slotted type with SZ lay (reverse oscillation lay) of fibre units or it may be cylindrical type with helical lay of fibre units.

#### 2.5.3 Filling Compound:

The interstices of the central fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any longitudinal water migration within fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC60794-1-2F5. The filling compound used shall be a non-toxic homogeneous water proofing compound that is free of dirt and foreign matter, anti-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable. The filling compound shall remain stable for ambient temperature 40 to 670 deg C and shall not drip, flow or leak with age or at change of temperatures reference method to measure drip point shall as per IEC 60811-5-1 and drip point shall not be less than 70deg C.

#### 2.5.4 The Sheath /Inner Jacket:

The sheath shall be black, smooth, concentric, and shall be free from holes, splits, blisters and other surface flaws. The sheath shall be extruded directly over the central fibre optic unit and shall also be non-hygroscopic. The cable sheath design shall permit easy removal without damage to the optical fibres or fibre units. The sheath shall be made from good quality of weather resistant polyethylene compound (Black High Density Polyethylene-HDPE) and thickness shall be = 1.8mm. code -AØ for polyethelene.

#### **2.5.5 The Outer Jacket /Termite Protection**

The circular jacket of not less than 0.65mm Polymide 612 (orange Nylon 612) material should be applied over the sheath as an outer jacket. The outer jacket shall have smooth finish and shall be termite resistant.

- 2.5.6 RIP Cord: Suitable rip cord(s) shall be provided to open the outer sheath of the cable. The rip cord (s) shall be properly waxed to prevent wicking action and shall not work as a water carrier.

#### **2.6 Mechanical parameters & Tests**

- a. Tensile strength: The cable shall be of sufficient strength to withstand a load of value  $T(N) = 9.81 \times 2.5 \times W$  Newton or 2670 N whichever is higher (Where W is the mass in Kg of 1 Km cable). The load shall be sustained for 10 minutes and the strain of the fibre monitored. The load shall not produce a strain exceeding 0.25% in the fibre and shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation during or after the application of the compressive load shall not exceed 0.05dB/Km both 1310nm and 1550nm wavelength. The attenuation shall be noted before and after the test for all the fibres.
- b. Crush test (Compressive Strength): The cable shall withstand a compressive force of at least 2000N applied for at least 60 seconds between two plates of 100mm x 100mm in accordance with IEC60 794-

1-2 E3 procedure. This compressive load applied in accordance with IEC60 794-1-2-E3 shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation during or after the application of the compressive load shall not exceed 0.05dB/Km both 1310nm and 1550nm wave length. The attenuation shall be noted before and after the test for all the fibers.

- c. Bend Radius: The cable bend radius under no load shall be less than or equal to 20 times the cable diameter. The test method shall be according to the IEC 60794-1-2-E11 (Procedure-I). The fibres and 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 of 20 times to the cable diameter. The change in optical attenuation after the test shall not exceed 0.05dB/Km both for 1310nm and 1550nm wavelength. The attenuation shall be noted before and after the test for all the fibres. Outer jacket shall not show any cracks visible to the naked eye when examined whilst still wrapped on the mandrel.
- d. Cable Bending test (Repeated bending): The cable shall withstand repeated bending when tested in accordance with EIA-455-104 and shall not cause any permanent damage to any constituent part of the cable. The cable sample shall be at least 5 meters or more. The change in optical attenuation during or after the application of the repeated bending test shall not exceed 0.05dB/KM for all the fibres. The attenuation shall be noted before and after the test for all the fibres. The test requirement shall be as mentioned below:-

Weight	5Kg
Minimum distance from pulley center to holding device	216 mm
Minimum distance for weight to pulley center	457mm
Pulley diameter	20 times to the cable dia
Angle of turning	90°
No. of cycles	30
Time required for 30 cycles.	2 min.

- e. Impact Test: The cable shall withstand at least 10 impacts of 50 N load from a 0.5 meter height with impacting surface radius of 300mm. This impact load applied at the same place in accordance with IEC 60794-1-2-E4 shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation during or after the application of the impact load shall not exceed 0.05db/Km. The attenuation shall be noted before and after the test for all the fibres.
- f. Torsion Test: The cable shall withstand 10cycles of  $\pm 180^\circ$  torsion with 100N load applied on a 2m sample. This load cycle applied in accordance with IEC 607694-1-2-E7 shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation during or after the application of the torsion load shall not exceed 0.05Db/km for all the fibres. The attenuation shall be noted before and after the test.
- g. Kink test (Resistance): When a cable of sample length 10 times the minimum bend radius as defined above is subjected to kinking, it shall not result in any fibre breakage and the kink shall disappear after normalizing the cable. The change in optical attenuation after the application of the kink in accordance with IEC60794-1-2-E10 shall not exceed 0.05 db/km for all the fibres.
- h. Water penetration test (Resistance to water ingress): The resistance to water ingress of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-2 F5 method F5B. Before applying the water tight sleeve at one end the outer jacket shall be stripped. A water soluble fluorescent dye shall be used for testing. The duration of tests shall be 7 days. In addition after the test the cable shall be ripped open and distance up to which water has seeped shall be noted.
- i. Drip test (Seepage of Filling Compound): For testing, a sample of 30 cm length of the cable with one end sealed by the end cap will be taken and outer jacket, sheath, binder tapes shall be removed by 5 cms from open

end of the sample. The filling compound will be wiped thoroughly and the sample be kept vertically with open end down ward in the oven for 24 hours at 70°C temperature with a filter paper under the sample. The filter paper should not indicate any sign of drip or oily impression. The reference test specification shall be as per IEC 60811-5-1 to measure drip point.

- j. Environmental Test: Temperature cycling test shall be carried out on one drum length of the cable to ensure stability of attenuation parameter of the cable when subjected to temperature change which may occur during storage, transportation, and operation. The permissible temperature range for storage and operation will be from -20°C to -70 °C. The rate of change of temperature during test shall be 1°C per minute. The cable shall be kept for 12 hours at each of the following temperature and should follow the specification IEC 60794-1-2-F1. Two cycles shall be performed.

TA2	: -20°C
TA1	: -10-°C
TB1	: +60°C
TB2	: +70°C

The attenuation shall be measured at the end of each temperature range both at 1310nm&1550nm. The change of attenuation of fiber used shall be=0.05dB both for 1310nm&1550nm for entire range of temperature for all the fibers in each cycle.

- k. Termite Resistance Test: The outer jacket shall be demonstrated to be termite resistant. The exact procedure for the test shall be mutually agreed between the Contractor and the Employer and shall generally be in line with test procedures followed by reputed test laboratories.
- l. Abrasion Test: To be conducted as per IEC 60794-1-E2 or equivalent international test method.
- m. Flexure Rigidity Test: To be conducted as per ASTM D-790. The test shall not cause any permanent damage to any constituent part of the



cable. The change in optical attenuation after the test shall not exceed 0.05dB/km. The attenuation shall be noted before and after the test for all the fibres.

- n. Figure of Eight Test: 1000m of cable shall be uncoiled from the drum and arranged in figure of eight, each loop having a maximum, dimension of 2 m. It shall be possible to arrange cable in figure of 8 with relative ease and the cable shall not show any visible damages.
- o. Cable Ageing Test: After Environmental test the cable shall be subjected to a temperature of  $85 \pm 2^\circ \text{C}$  for 168 hours. Cable shall then be brought to ambient temperature and stabilized for 24 hours. The change in optical attenuation after the test shall not exceed 0.05dB/Km. For 1310 as well as 1550nm wavelengths. The attenuation shall be noted before and after the test for all the fibres.
- p. Embrittlement Test of Loose Tube: The minimum length of the test sample depend of the outside diameter of the loose tube and should be 85mm for tubes upto 2.5mm outside dia. The length of the bigger tubes should be calculated by using the following equation:

$$L_o > 100 \times ((D^2 + d^2)/4)^{1/2}$$

Where

$L_o$  = 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 which exert a constant rate of movement. The movable jaw may move at a rate if 50mm 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. The tube should not get embrittled. No ink should appear on the tube upto the safe

bend dia. of tube ( $20D$ ) where  $D$  is the outside diameter of the loose tube. There should not be any physical damage or mark on the tube surface.

- q. Kink Resistance test on the loose tube: 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.,  $20D$  (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.
- r. Drainage test for loose tube: A tube length to 40Cm 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 5cm from each end so that the finished length of the sample is 30Cm. 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 breaker. It is left in the oven at a temperature of  $70\text{ }^{\circ}\text{C}$  for a period 24 hrs. At the end of the 24 hrs period the breaker is checked and weighed to see if there is any gel in beaker. There shall be no gel or oil in the beaker.
- s. Check of easy removal of sheath: The sheath shall be cut in circular way using a sheath removal tool and about 300mm 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. It shall be possible to remove the sheath easily. Easy removal of both the outer jacket and the inner sheath shall be checked separately.
- t. Effect of aggressive media on the cable surface (Acidic and alkaline behaviour): The test shall be conducted as per method No. ISO-175. The two test samples of the finished cable each of 600mm 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 cable. The sample

should not show any effect of these solution of the sheath and other marking of the cable.

## 2.7 Cable drums, Marking, Packing and Transport:

All optional fibre cable shall be supplied on strong wooden drums provided with lagging with adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. The cable drum shall be suitable to carry underground fibre optic cable of length 2KM +/- 10% and 4KM +/- 10%. The contractor may offer higher cable drum length in straight routes subject to transportation handling and installation limitations. However, the exact lengths for drums to be supplied for each link shall be determined by the contractor during detailed engineering/survey. Drum schedule shall be got approved by the Employer before manufacturing FO cable. Both cable ends in the drum shall be sealed and shall be readily accessible. The drum shall be marked with arrows to indicate the direction of rotation, both the ends of the cable shall be provided with pulling eye. The pulling eye and its coupling system should withstand the same tensile load as applicable to the cable. The following marking be done on each side of the cable drums.

- i) Drum No.
- ii) Consignee's name and address.
- iii) Contractors name and address.
- iv) Type of cable
- v) Number of fibres
- vi) Type of fibres
- vii) Year of Manufacturing, month & batch No.
- viii) Name of Manufacturer.
- ix) Total cable length
- x) Inner end marking and outer end marking.

Packing list supplied with each drum shall have all the information provided on marking on the respective cable drum and following additional information: OTDR length measurement of each fibre and ratio of fibre and cable length.

### 2.7.1 Optical Fibre Cable marking:

A suitable marking shall be applied in order to identify this cable from the other cables. Marking on the cable shall be indelible of durable quality, shall last long and shall be applied at regular interval of one ómeter length.

Marking shall be imprinted and must clearly contrast with the surface and colors used must withstand the environmental influences experienced in the field.

The accuracy of the sequential marking must be within  $\pm 0.5\%$  of the actual measured length. The sequential length marking must not rub off during normal installation. In case laser printing is used the marking shall not exceed 0.15mm depth. The optical fibre cable shall have the following marking in every meter.

- i) Type of cable
- ii) Running meter length
- iii) No. of fibres
- iv) Type of fibre
- v) Laser symbol & caution notice
- vi) Year of manufacture and batch No.
- vii) Manufacturer's name
- viii) DTL

### **2.7.2 Operating Instructions:**

Complete technical literature in English with detailed cable construction diagram of various sub-component with dimensions and test data of the cable shall be provided. All aspects of installations shall also be covered in the handbook.

### **2.8 Test and Inspection:**

The general conditions for Type and Factory Acceptance Testing shall be as per section 6. Type test shall be as section 6.3. Sampling plan for FAT shall be as per section 6.4.1.

**2.8.1** Type testing the test mentioned in Section 2.6 shall be carried out as type test for fibre optic cable & the tests listed in table 2-2 shall be carried out as type tests for fibres.

**Table 2-2**

Sl. No.	Test Name	Acceptance criteria	Test Procedure.
1.	Attenuation	TS Table 2-1	EIA/TIA 455-78A
2.	Attenuation Variation with wavelength	TS Table 2-1	EIA/TIA 455-78A
3.	Attenuation of Water Peak	TS Table 2-1	EIA/TIA 455-78A
4.	Temp. Cycling		EIA/TIA 455-3A

	(Temp. dependence of Attenuation)		2 cycles
5	Attenuation with Bending (Bend Performance)		
	Table 2-2: Type Tests	For Optic Fibres	
Sl. No.	Test Name	Acceptance Criteria	Test Procedure
6.	Mode Field dia.		EIA/TIA 455 ó 164A/ 167A/174
7.	Chromatic Dispersion		EIA/TIA 455 ó 168A/ 169A/175A
8.	Cladding Diameter		EIA/TIA 455 ó176
9.	Point Discontinuities of attenuation		EIA/TIA 455 ó59
10.	Core ó clad Concentricity error		EIA/TIA 455 ó176

### 2.8.2 Factory Acceptance Testing:

The tests listed in Table 2-3 shall be carried out as Factory Acceptance Test for underground fibre optic cable.

**Table 2-3**  
**Factory Acceptance Tests on Underground Fibre Optic Cable**

Sl. No.	Factory Acceptance Test
1	Attenuation Co-efficient (1310, 1550 and water Peak)
2	Point discontinuities of attenuation
3	Chromatic Dispersion
4	Visual Material Verification and Dimensional Checks as per approved drawings
5	Resistance to water Ingress test
6	Tensile Strength test/Strain Test
7	Impact test
8	Kink test

## QUALITY ASSURANCE PROGRAMME

To ensure that the equipment and services under the scope of contract, whether manufactured or performed within the contractors work or at his sub contractors premises or at the owners site or at the other place of the work are in accordance with the specifications, the contractors shall adopt suitable quality assurance programme to control such activities at all points, as necessary. Such programme shall be outlined by the contractor and finally accepted by the owner/authorize representative after discussion before the award of contract. The QA programme shall be in line with ISO 9001/IS-14001.

## GENERAL REQUIREMENTS QUALITY ASSURANCE

All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all stages, as per comprehensive quality assurance programme. An indicated programme of the inspection/tests to be carried out by the contractor for some of the major items is given in the respective technical specifications. This is however, not intended to form a comprehensive programme as it is the contractor responsibility to draw up and implement such programme duly approved by the owner. The detailed quality plans for manufacturing and field activities should be drawn by the bidder and will be submitted to owner for approval. Schedule of finalization of such quality plans will be finalized before award. Manufacturing quality plan will detail out for all the components and equipments, various tests/inspection, to be carried out as per the requirement of this specification and standards mentioned therein and quality practices and procedure followed by contractors quality control organization, the relevant reference documents and standards, acceptance norms, inspection documents raised etc during all stages of material procurement, manufacturer, assembly and final testing performance testing. Field quality plans will detail out for all the equipment the quality practices and procedures etc, to be followed by the contractors site quality control organization, during various stages of site activities from receipt of materials/equipment at site. The contractor shall also furnish copies of reference documents/plant standards/acceptance norms/tests and inspection procedure etc, as referred in quality plans alongwith quality plans. These quality plans and reference documents/standards etc will be subject to Owner's approval without which manufacture shall not proceed. These approved documents shall form a part of the contract. In these approved quality plans Owner shall identify Customer Hold Points (CHP), i.e., test/checks which shall be carried out in presence of the Owner's engineer or his authorized representative and beyond which the work will not proceed without consent of Owner/authorized representative in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Owner along with technical justification for approval and dispositioning. No materials shall be dispatched from the manufacturer's work before the same is accepted subsequent to pre-dispatch final inspection including verification of records of all previous tests, inspection by Owner's engineer/authorized representative, and duly authorized for dispatch insurance of MDCC. All materials used for equipment manufacture including casting and forging etc shall be tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties, chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and or agreed details.