

**Section 5**  
**Chapter-3**  
**Technical Specifications for Underground Fibre Optic Cable**

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.

This section describes the functional requirements, major technical parameters and Type testing and Factory Acceptance Testing requirements for underground fibre optic cables, HDPE pipes. Marking, packaging, transportation installation requirements have also been described. The distance of the underground FO cable route length has been specified in the BOQ. The payment will be made for the executed route length only. However, specified service loops and lengths for wastage, installation/working for FO cable & HDPE ducts shall be considered as required by the bidder for which no additional payment will be made. The unit rate (per Km) quoted shall include the required FO cable, **pair of HDPE** ducts and all other installation items/accessories including manholes, GI/Hume pipes for crossings, markers, duct jointing accessories etc. for one km of FO cable route irrespective of the type of soil along the route. Bidders are advised to survey at their own expenses to assess the requirement before bidding if desired by them.

### **3.1 Under Ground FO Cable**

#### **3.1.1 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.

#### **3.1.2 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, IEC60304, IEC60794-1-2, IEC60811-5-1.
- iv). Bellcore GR-20
- v) TEC-spec no-G/OFC-01/03. Aug 99 (including all amendments up to September 2000)

#### **3.1.3 Fibre Type(s) and Counts**

The cable shall contain at least 6 nos. of 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.

#### **3.1.4 Optical Characteristics**

The attenuation coefficient for wavelength between 1525nm and 1575nm shall not exceed the attenuation coefficient at 1550nm by more than 0.05dB/km. The attenuation coefficient between 1285nm and 1330nm, shall not exceed the attenuation coefficient at 1310nm by more than 0.05dB/km. The attenuation of the

fibres 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 3-1 shall be “guaranteed” fibre attenuation of any & every fibre reel.

DWSM fibres shall conform to the requirements specified in Table 3-1 below:

**Table 3-1  
DWSM Optical Fibre Characteristics**

<b>Fibre Description:</b>	Dual-Window Single-Mode
<b>Mode Field Diameter:</b>	8.6 to 9.5 $\mu\text{m}$ ( $\pm 10\%$ of the nominal value)
<b>Cladding Diameter:</b>	125.0 $\mu\text{m}$ $\pm 2\mu\text{m}$
<b>Mode field Concentricity Error:</b>	$\leq 1.0\mu\text{m}$ at 1310 nm
<b>Core-Clad concentricity error:</b>	$\leq 1.0\mu\text{m}$
<b>Cladding non-circularity</b>	$\leq 2\%$
<b>Cable Cut off Wavelength:</b>	$\leq 1260$ nm
<b>1550 loss performance</b>	As per G.652
<b>Proof Test Level</b>	$\geq 0.35$ Gpa (50.76 Kpsi )
<b>Attenuation coefficient</b>	@ 1310nm $\leq 0.35$ dB/Km @ 1550nm $\leq 0.23$ dB/Km
<b>Attenuation at water peak (1383nm)</b>	$\leq 2.1$ dB/Km
<b>Attenuation variation with wavelength</b> 1285 nm - 1330 nm 1525 nm – 1575 nm	Attenuation coefficient @ 1310 $\pm 0.05$ dB Attenuation coefficient @ 1550 $\pm 0.05$ dB
<b>Point discontinuities</b>	$\leq 0.1$ dB
<b>Chromatic Dispersion; Maximum:</b>  <b>Zero Dispersion Wavelength:</b> <b>Zero Dispersion Slope:</b>	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 <sup>2</sup> xkm) maximum
<b>Polarization mode dispersion coefficient</b>	$\leq 0.5$ ps/km <sup>1/2</sup>
<b>Temperature Dependence:</b>	Induced attenuation $\leq 0.05$ dB (-60°C - +85°C)
<b>Bend performance:</b>	@ 1310nm (75 $\pm$ 2 mm dia Mandrel), 100 turns; Attenuation rise $\leq 0.05$ dB @ 1550nm (75 $\pm$ 2 mm dia Mandrel), 100 turns; Attenuation rise $\leq 0.10$ dB @ 1550nm (32 $\pm$ 0.5 mm dia Mandrel), 1 turn; Attenuation rise $\leq 0.50$ dB
<b>End of Table</b>	

### 3.1.5 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 jackets 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.

#### 3.1.5.1 Colour Coding & Fibre Identification

Individual optical fibres within a fibre unit, and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme. The colour coding system shall be discernible throughout the design life of the cable. Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. 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 tracability 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 are 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. The colouring scheme shall be submitted along with the cable DRS/drawing for employer's approval.

#### 3.1.5.2 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.

#### 3.1.5.3 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 the 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 **IEC60794-1-2-F5**. The filling compound used shall be a non-toxic homogenous waterproofing 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 up to +70°C and shall not drip, flow or leak with age or at change of temperature. Reference method to measure drip point shall be as per **IEC 60811-5-1** and drip point shall not be less than 70°C.

#### 3.1.5.4 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  $\geq 1.8\text{mm}$ .

#### 3.1.5.5 The Outer Jacket/ Termite protection

A circular jacket of not less than 0.65mm Polyimide-12 (Orange Nylon-12) material should be applied over the sheath as an outer jacket. The outer jacket shall have smooth finish and shall be termite resistant.

**3.1.5.6 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.

### 3.1.6 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 of 1Km cable in Kg). 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 rated tensile load in accordance with **IEC60794-1-2-E1** procedure shall not exceed 0.05dB/Km both for 1310nm and 1550nm wavelength. The attenuation shall be noted before strain, during strain and after release of strain for all the fibres.

(B) **Crush test (Compressive Strength):** The cable shall withstand a compressive force of at least 2000 N, applied for at least 60 seconds between two plates of 100mm X 100mm in accordance with IEC60794-1-2-E3 procedure. This compressive load applied in accordance with **IEC60794-1-2-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 both for 1310nm and 1550nm wavelength. The attenuation shall be noted before, during and after the test for all fibres.

(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 **IEC60794-1-2-E11 (procedure-1)**. The fibres and component parts of the cable shall not suffer permanent damage when the cable is subjected to 10 cycles of wrapping and unwrapping of 4 complete turns around a mandrel of dia equal to 20 times the cable diameter. The change in optical attenuation after the test shall not exceed 0.05dB both for 1310nm and 1550nm wavelength. The attenuation shall be noted before and after the test for all 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. 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 centre to holding device	216mm
Minimum distance from weight to pulley centre	457mm
Pulley diameter	20 times to the cable dia
Angle of turning	90°
Number of cycles	30
Time required for 30 cycles	2 min.

(E) **Impact Test:** The cable shall withstand at least 10 impacts of 50N load from a 0.5 metre height with impacting surface radius of 300mm. The 10 impacts when applied at the same place in accordance with **IEC60794-1-2-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. The attenuation shall be noted before, during and after the test for all fibres.

- (F) **Torsion test:** The cable shall withstand 10 cycles of  $\pm 180^\circ$  torsion with 100N load applied on a 2m sample. This load cycle applied in accordance with **IEC60794-1-2-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 for all fibres. The attenuation shall be noted before, during 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 normalising the cable. The change in optical attenuation after the application of the kink in accordance with **IEC60794-1-2-E10** shall not exceed 0.05dB for all the fibres.
- (H) **Water ingress test (Resistance to water penetration):** The water ingress test of the cable shall meet or exceed the test performance criteria as per **IEC60794-1-2-F5** method B. Before applying the water tight seal at one end the outer jacket shall be stripped. A water-soluble fluorescent dye shall be used for testing. The duration of test shall be 7 days. In addition after the test the cable shall be ripped open and the 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 5cms 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  $70^\circ\text{C}$  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 **IEC60811-5-1** 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  $-20^\circ\text{C}$  to  $+70^\circ\text{C}$ . The rate of change of temperature during test shall be  $1^\circ\text{C}$  per minute. The cable shall be kept for 12 hours at each of the following temperature and should follow the specification **IEC60794-1-2-F1**. Two cycles shall be performed.

TA2	: $-20^\circ\text{C}$
TA1	: $-10^\circ\text{C}$
TB1	: $+60^\circ\text{C}$
TB2	: $+70^\circ\text{C}$

The attenuation shall be measured at the end of each temperature range both at 1310nm & 1550nm. The change of attenuation of the fibre used shall be  $\leq 0.05$  dB/km for 1310 & 1550nm for entire range of temperature for all the fibres in each cycle.

- (K) **Termite Resistance Test:** 3 (Three) Samples of optical fibre cables of 2(Two) meter length each shall be taken from the selected drums for Optical Fibre cable and the ends shall be sealed with metallic caps. These test samples will be sent to the reputed test lab for termite resistance test. The test Procedure and period shall be as per CAZRI, Jodhpur. All Samples shall be checked for any termite attack over the Nylone-12 jacket. The outer jacket shall be demonstrated to be termite resistant. Attack by termites shall be disregarded but termite should not penetrate or damage the Nylone-12 jacket of any sample.

Observation on any damage of the cable shall be recorded.

- (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 2m. 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  $^{\circ}$ C for 168 hours. Cable shall then be brought to ambient temperature and stabilised for 24 hours. The change in optical attenuation after the test shall not exceed 0.05dB/Km for 1310 as well as 1550 nm 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 depends 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 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. The tube should not get embrittled. No ink should appear on the tube upto 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.

- (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. 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.
  - (R) **Drainage test for 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  $^{\circ}$ 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.
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- (S) **Check of easy removal of sheath** : The sheath shall be cut in 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. 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. ISO175. 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.

### 3.1.7 Cable drums, Marking, Packaging and Transport

All optical 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 upto 4 Km  $\pm 10\%$  or 2 km  $\pm 10\%$ . 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 approved by the Employer before manufacturing the 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 shall be done on each side of the cable drums.

- i) Drum number
- ii) Consignee's name and address
- iii) Contractor's 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.

#### 3.1.7.1 Optical fibre cable marking

A suitable marking shall be applied in order to identify this cable from other cables. Marking on the cable shall be indelible, of durable quality, shall last long and shall be applied at regular interval of one-meter 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 0.15 mm depth. The optical fibre cable shall have the following markings in every meter.

- i) Type of Cable
- ii) Running meter length
- iii) Number of fibres
- iv) Type of fibre
- v) Laser symbol & caution notice
- vi) Year of manufacture and batch no.
- vii) Manufacturer's name
- viii) Owner's Name " "

### 3.1.7.2 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 installation shall also be covered in the handbook.

### 3.1.8 Test and Inspection:

The general conditions for Type and Factory Acceptance Testing shall be as per section 7.

#### 3.1.8.1 Type Testing

The cable to be supplied should have been type tested either as per the requirement specified in this section or relevant TEC specifications including latest amendments. The Bidder shall submit along with their bid the earlier carried out type test reports and/or TEC certificates for the offered fibre optic cable meeting the requirement. The fibre should have been type tested as per relevant International standards for the tests listed in Table 3-2 and the Bidder shall submit the test reports and certificates along with the bid. The Contractor shall submit the type test reports of fibres meeting the minimum requirement specified in Tables 3-2 below. If the test reports are not submitted or if the submitted test reports do not meet the requirement, the Contractor shall carry out the type testing on the fibres as per requirement specified in Table 3-2 and on the FO cable as per 3.1.6 of this chapter with no additional cost to the Employer.

**Table 3-2: Type Tests For Optical Fibres**

S.N.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	TS Table 3-1	EIA/TIA 455- 78A
2	Attenuation Variation with wavelength	TS Clause 3.1..4	EIA/TIA 455- 78A
3	Attenuation at Water Peak	TS Table 3-1	EIA/TIA 455- 78A
4	Point Discontinuities of attenuation	TS Table 3-1	EIA/TIA 455-59
5	Attenuation With Bending (Bend Performance)	TS Table 3-1	EIA/TIA 455- 62A Method/procedure A/B
6	Mode Field diameter	TS Table 3-1	EIA/TIA 455- 164A/167A/174
7	Chromatic Dispersion	TS Table 3-1	EIA/TIA 455- 168A/169A/175A



**Table 3-2: Type Tests For Optical Fibres**

S.N.	Test Name	Acceptance Criteria	Test procedure
8	Cladding Diameter	TS Table 3-1	EIA/TIA 455-176
9	Core -Clad concentricity error	TS Table 3-1	EIA/TIA 455-176

### 3.1.8.2 Factory Acceptance Testing

The tests listed in Table 3-3 shall be carried out as Factory Acceptance Test for Underground fibre optic cable meeting the requirements specified in this section.

**Table 3-3  
Factory Acceptance Tests on Underground Fibre Optic 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 per design/total project requirement.

## 3.2 PLB HDPE DUCT and ACCESSORIES

The following paragraphs describes the functional requirements & major technical parameters for Permanently Lubricant High Density Polyethylene (PLB HDPE) duct. PLB HDPE duct shall be suitable for underground fibre optic cable installation by blowing as well as conventional pulling. The PLB HDPE duct shall be suitable for laying in trenches by directly burying, laying through G.I./RCC hume pipe and laying through trench less horizontal directional drilling. The expected service life of HDPE duct and accessories shall not be less than 50 years.

The Bidder shall quote unit rates for each of the items mentioned in the price schedule. However, the quantities indicated in the BoQ are indicative only and the actual quantity will be governed by the quantity variation clause as defined in Conditions of Contract.

### 3.2.1 Construction of PLB HDPE duct

The PLB HDPE duct shall have two concentric layers viz. outer layer and inner layer. The outer layer shall be made of HDPE material and the inner layer of solid permanent lubricant. **These** concentric layers shall be co-extruded and distinctively visible in cross-section under normal lighting conditions and generally conform to IS-9938. The colour of the PLB HDPE duct shall be orange and uniform throughout. In the finished PLB HDPE duct, the co-extruded inner layer of solid permanent lubricant shall be continuous and integral part with HDPE outer layer and preferably be **white** in colour. The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the duct. The duct shall be supplied in a continuous minimum length of 1000 (one thousand) meters in coil form, suitable for transportation, installation and handling purposes.

Bidders may offer HDPE duct of a homogeneous construction (i.e. without a separate inner layer) as **an** alternative, meeting all the requirements of this specification.

The finished duct shall be of good workmanship such that the duct is free from blisters, shrink **holes**, flaking, chips, scratches, roughness, break and other defects. The duct shall be smooth, clean and in round shape, without eccentricity. The ends shall be cleanly cut and shall be square with axis of the duct.

### 3.2.2 General

The HDPE duct shall conform to the following standard and the technical specifications **described** in the following sections.

- (A) IS: 4984 - Specification for HDPE duct
- (B) IS: 2530 - Method for tests for polyethylene molding materials and compounds.
- (C) IS: 14151(part1) -Polyethylene pipes for sprinkler irrigation systems (part-1, pipes).
- (D) IS: 9938-Recommended colors for PVC insulation for LF wires and cables.
- (E) TEC-spec no G/CDS-08/01/Dec-99-HDPE duct for use as duct for optical fibre cable.
- (F) IS:7328 -HDPE material for moulding and extrusion
- (G) ASTM D 1693 -Test method for environmental stress cracking of ethylene plastics.
- (H) IS12235 (Para 9) - Method of tests for unplasticized PVC pipe for portable water supplies , impact strength at zero degree centigrade.
- (I) ASTMD 1505 -Test method for density
- (J) ASTMD 3895 - Method for Oxidation Induction test

### 3.2.3 Material

The raw material used for the PLB HDPE duct shall meet the following

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requirements:-

- (i) The anti-oxidant establisthers, color master batch and other additive used shall be physiologically harmless and shall be used only to minimum extent necessary to meet the specification.
- (ii) Usage of any additives used separately or together, should not impair the long-term physical and chemical properties of the PLB HDPE duct.
- (iii) Suitable Ultra Violet stabilizers may be used for manufacture of the PLB HDPE duct to protect against UV degradation when stored in open for a minimum period of Eight months.
- (iv) The base HDPE resin used for manufacturing outer layer of duct shall conform to any grade of IS-7328 or to any equivalent standard meeting the following requirement.

**Density** *940 to 958kg/m<sup>3</sup> at 27 °C*  
**Melt Flow Rate(MFR)** *0.2 to 1.1 g/10 minutes at 190 °C & 5 kg load*

- (v) In case of PLB HDPE duct of two concentric layer construction, the friction reducing, polymeric material to be used as the inner layer lubrication material shall be integral with HDPE layer. The lubricant materials shall have no toxic or dermatic hazards for safe handling.

### 3.2.4 Dimension of duct

The nominal size of the duct shall be 40mm and shall meet the following requirements.

- |       |   |  |
|-------|---|--|
| (i)   | Outside diameter  | 40 mm + 0.4 mm                                   |
| (ii)  | Wall thickness  | 3.5 mm (+0.2 mm/ -0.00 mm)                       |
| (iii) | Standard length   | 1000 meters ± 100 meter                          |
| (iv)  | Thickness of permanent lubricant,   | ≥ 0.4 mm   |
| (v)   | Maximum outer diameter of FO cable that can be installed by blowing technique | 16 mm or offered cable dia (whichever is higher) |

### 3.2.5 Accessories of PLB HDPE duct

The following accessories are required for jointing the duct and shall be supplied along with the duct. The manufacturers shall provide complete design details, procedure for method of installation and type of the material used for the accessories.

- i) Plastic coupler: The coupler shall be used to join two PLB HDPE ducts. The coupling shall be able to provide a durable water tight joint between two ducts without deteriorating the strength of the ducts. The strength of coupler shall match the primary strength of the PLB HDPE duct and threaded coupler is not acceptable.
- ii) End plug: This shall be used for sealing the ends of empty duct, prior to installation of FO cable and shall be fitted immediately after laying of the PLB

- HDPE duct, to prevent entry of any unwanted elements such as dirt, water, moisture, insects/rodents etc.
- iii) End cap: This cap is made of hard rubber, shall be fitted with both ends of PLB HDPE duct to prevent the entry of any unwanted elements such as dirt, water, moisture, insects/rodents during transportation and storage. No separate payment will be admissible for providing end caps with each piece of PLB HDPE duct supplied.
  - iv) Cable sealing plug: This is used to hold the cable and prevent entry of any unwanted elements, as specified above.
  - v) **Empty PLB HDPE duct with draw rope inside it** : A draw rope shall be provided in each PLB HDPE duct. The rope will have a braided multi-strand construction, 4mm diameter, polypropylene raw material and having breaking load strength of not less than 200kg. The PLB HDPE duct should be sealed at both ends with suitable sealing caps with hooks to tie the inner rope at both ends.
  - vi) Colour of each of the accessories shall be black or white.

### **3.2.6 Workmanship**

The duct shall be free of blisters, shrink holes, break and other defects. The PLB HDPE duct ends shall be cut as square as possible to longitudinal aspects. The internal and external PLB HDPE duct surfaces shall be smooth. The color should be uniform throughout.

### **3.2.7 Marking**

All the duct, shall be clearly marked at intervals of 1 meters with the following data which is not less than 5 mm high. The details of marking on duct shall be approved by Owner/Employer before commencement of manufacturing.

- i) "Name of utility" with logo
- ii) Manufacture's name or trade mark
- iii) Year of manufacturing
- iv) Type of PLB HDPE duct and size
- v) Running length marking .

### **3.2.8 Packing and condition of delivery**

The duct may be supplied in reels or coils after sealing both ends by end caps. The following marking shall be provided on each packing:-

- (a) Code of product
  - (b) Name of Manufacturer
  - (c) Date of manufacturing
  - (d) Length of PLB HDPE duct
  - (e) Dimension of Outer Dia and Inner Dia
  - (f) Owner's name "Name of utility"
-

### **3.2.9 Type Tests and Factory Acceptance Tests**

The Bidder shall enclose in the bid valid type approval certificate from Telecom Engineering Centre (TEC), New Delhi of Department of telecommunication according to TEC specification no. G/CDS-08/01 or latest TEC for the proposed PLB HDPE duct meeting the specified requirements. The cable is liable to be considered non-compliant to the technical specifications in absence of type approval certificates as stipulated above as no separate type testing is envisaged for the material to be supplied by the Contractor (i.e. the successful Bidder).

The dimensional and marking checks of each reel or coil of PLB HDPE duct and their accessories as per the approved DRS shall be carried out as Factory Acceptance Test (FAT) which may be witnessed by the Employer. However, visual inspection of 100% of the item/material may be carried out by Employer/Owner on receipt of material at site and any visual damage observed on site inspection on the supplied item/material would make the consignment liable for rejection.

### **3.3 INSTALLATION OF UNDERGROUND FIBRE OPTIC CABLE SYSTEM**

This section describes the installation procedures and methods including survey, clearances, excavation of trenches and pits, trenchless digging, installation of PLB HDPE pipes, installation of RCC hume pipes and GI Pipes, marking, backfilling, installation of underground cable, construction of manholes, splicing, termination and site acceptance testing requirements of the underground fibre optic cabling system.

#### **3.3.1 Survey**

The choice of route is most important aspect in planning an underground cable system. The correct choice is essential to reduce the cost of laying pipes, keeping the pipes safe from damage and to attain their maximum utilisation when they have been laid. The broad guidelines to be taken into consideration while choosing a route for the installation of underground fibre optic cable are given hereunder.

The Owner/Employer will provide the details of the existing PLB HDPE pipe routes to the extent possible. However, to carry out the fibre optic cable installation, the Contractor shall carry out the required survey of the routes at no additional cost to the Owner/Employer. The Contractor shall submit the survey report of these routes furnishing all details regarding position of joint boxes, manholes (existing and proposed), section distances etc.

##### **3.3.1.1 Survey for underground fibre optic cable links:**

The survey shall be carried out by the contractor for the proposed under ground FO cable routes defined in the Appendices for selection of most optimal route. The contractor shall arrange topographical maps and the details of facilities belongs to other utilities along the proposed route. The route shall be selected considering the following guidelines:

- a. The route shall be as straight and as short as possible.
  - b. The route shall have minimum obstacles in order.
-

- c. Clearances required from other authorities/bodies are minimum and that the clearances can be obtained expeditiously.
- d. Wet or unstable ground shall be avoided to the extent possible.
- e. The route for the pipes shall be away from the carriage-way of the road to the extent possible.
- f. The route shall be suitable for placing manholes wherever required.
- g. Future expansion of roads shall be taken into consideration.
- h. Road, rail, river, culvert (nallah) crossings.
- i. As far as possible underground fibre optic cable route shall be on the opposite side of the existing cables laid by DOT/BSNL or other utilities. Wherever both routes fall on the same side of the road, sufficient spacing shall be maintained, to the extent possible.
- j. Care must be taken to avoid choosing routes, roads, areas that are **rat infected** and prone to floods etc.

Trial pits shall be dug at suitably selected locations to assess the obstacles. It is necessary to locate the trial pits at proposed manhole locations for the pipe. If required, more trial pits shall be dug carefully to assess the existing underground facilities and the same shall be recorded in the inspection note of the trial pit along with suitable sketch. The type of soil condition is also recorded.

### 3.3.1.2 Survey Report

The Contractor shall submit the survey report with the most suitable routes for all the fibre optic links along with details described above for owner/employer's approval FO cable route. The owner/employer will give the preliminary approval for the route, subject to obtaining the required clearances. Up on approval Contractor shall carry out detail survey for the selected routes and submit the final survey report for approval before implementation. The final survey report shall include at least the following:

- a. A drawing of the proposed route indicating all details of the route including relevant details of soil strata, bridges, culverts, causeways, rail over/under bridges, defence area, underground gas / oil / water pipe line, power and communication cables routes, other important landmarks etc.
- b. The distance of the fibre optic cable route from the centre of the road/rail/river//bridge/culvert etc. shall be indicated on the route maps as well as documented in tables.
- c. Sections of the links where trenchless digging may be required.
- d. Sections where GI or RCC hume pipe may be required.
- e. Location and number of permanent and temporary manholes.
- f. Location of all turns, bends and major landmarks.
- g. Type, quantity and location of all the joint boxes. Care must be taken to minimise the number of splicing and joint boxes.
- h. Section lengths of the underground fibre optic cable, total length of each link and drum scheduling for all the links.
- i. List of authorities from which clearance shall be required to be obtained for each relevant section.
- j. **Sections of unavoidable rat infected areas along the proposed route, for which armored FO cable is required.**
- k. All the information required for obtaining clearance.
- l. It may be noted that the reinstatement of the facilities/properties damaged during the installation is the responsibility of the Contractor for which there will be no additional cost implication to the Owner/Employer.

It shall be the responsibility of the contractor to propose the alternate route, if the proposed route is not suitable for installation due to the condition of soil or non availability of clearances or any other reasons. The final survey report shall have to be approved by the Owner/Employer and requisite clearances need to be obtained before the cable installation work is commenced by the contractor..

The Contractor shall prepare and submit for approval by the Owner/Employer, specific construction drawings for all types of soil strata/crossings taking into consideration the guidelines given in this specification. The construction/implementation shall be carried out as per the approved drawings.

The construction drawings shall interalia include the longitudinal sectional diagram of the trench for different soil strata and detail arrangement of crossings, number of pipes, size of pipe, locations and position of manholes, other details as per the technical specifications. Route maps shall be drawn to the scale of 1:20,000. For convenient handling in the field, the map shall be made on 300mm(W) and lengths not exceeding 1190mm sheets with 30 mm overlap shown on subsequent sheets.

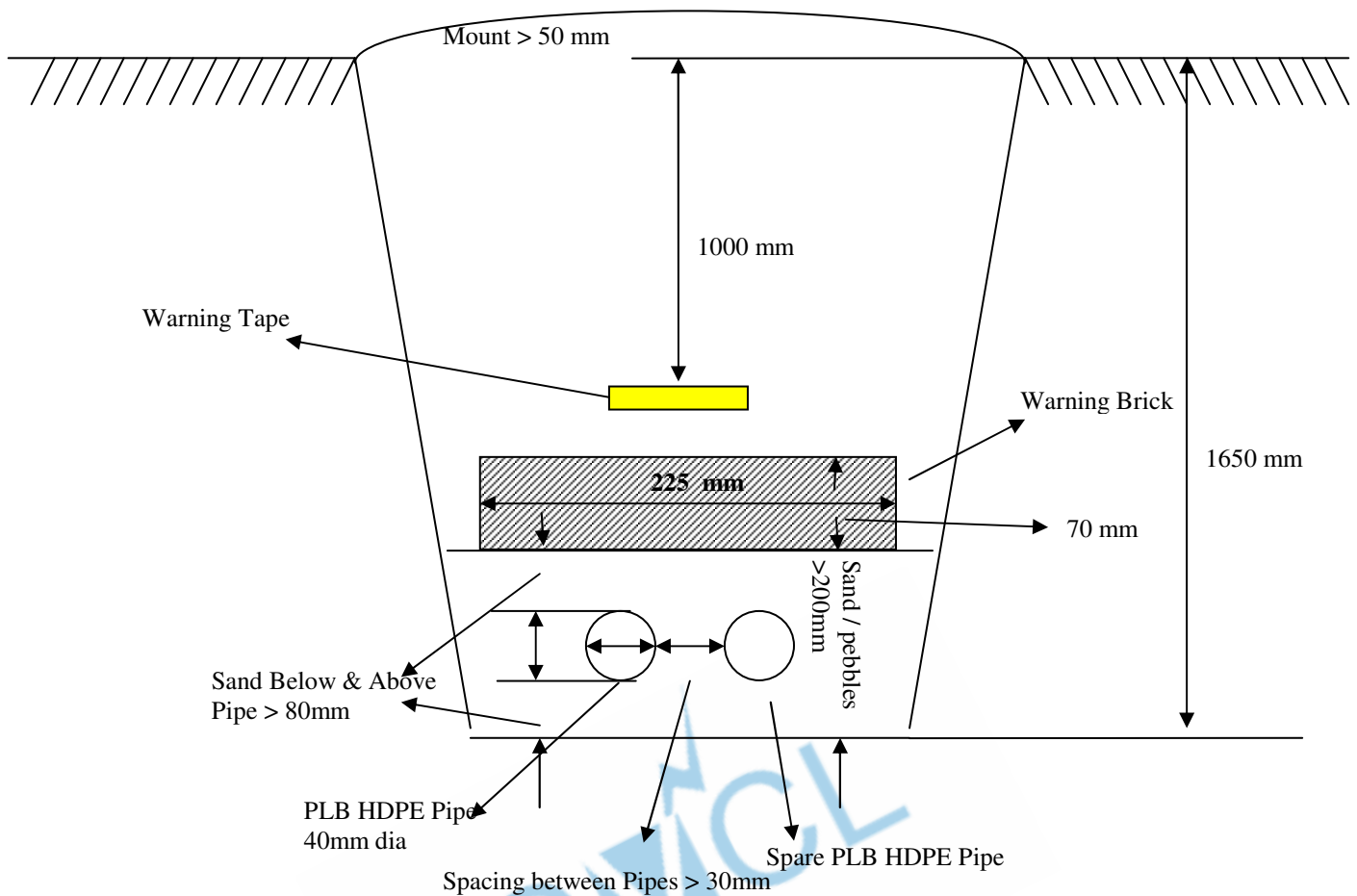
### **3.3.1.3 Clearances**

The Contractor shall be responsible for obtaining necessary clearances for excavation work from the authorities on behalf of the Owner and provide requisite copies of information, maps, survey report etc to the authorities. The Owner/Employer shall assist the Contractor in obtaining such clearances by providing the authority letter or any other relevant document. The Contractor shall make an all out effort with the concerned authority to get clearances expeditiously and to negotiate the least cost to the Owner/Employer. The Owner/Employer shall furnish all required bank guarantees and make payments to the concerned authorities directly based on the demand letter obtained by the Contractor from the concerned authorities. The Contractor shall ensure quick and speedy clearances in order to implement the project within stipulated schedule. In case the authorities have some objections on certain sections of routes proposed and are unwilling to provide clearances, the Contractor shall propose an alternate route, promptly carry out the survey and submit specific survey report for that and reapply for clearance after taking into account the comments/objections of the authority.

### **3.3.2 Excavation and Backfilling**

The Contractor shall carry out excavation and backfilling of trenches in all kinds of soil strata such as normal soil, soft rock, hard rock for laying PLB HDPE pipe, RCC hume pipe and GI pipe.

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**Figure 3-1: Trench in Normal Soil for 2 PLB HDPE pipes (Not To Scale)**

### 3.3.2.1 Excavation

The cable trenches shall be dug as per route plan and detail trench drawings (indicating the various dimensions and other details of the trench) approved by the Owner/Employer for each type of soil strata. The Contractor shall take due care and precaution during excavation to avoid possible damage of other underground plants/facilities in the proposed underground fibre optic cable route and shall indemnify the Owner/Employer for all damages and shall be solely responsible for all the damages and losses. The Owner/Employer shall not be liable for any damages/losses.

Fig 3-1 shows the dimensional view of excavation of trench and other details of installation in normal soil for 2 PLB HDPE pipes. For the purpose of this specification, soil strata types are defined below:

Normal Soil	All type of soil {i.e. dry, wet (partially or fully submerged)} except soft rock or hard rock as defined below.
Soft Rock	Lime stone, laterite, hard conglomerate or other fissured rock which can be quarried or split with crow bars, wedges or pickaxes. However, if required light blasting may be resorted to for loosening the material, but this will not in any way entitle the material to be classified as hard rock.
Hard Rock	Any rock excavation other than specified under Soft Rock, for which blasting, drilling, chiselling are required.

Depth of trench shall be at least 1650 mm in normal soil. However, for rail & road crossings the trench depth shall be at least **1000** mm. Depth of trench shall be at least 1000 mm in soft rock from the depth soft



rock is encountered i.e. in case soft rock is encountered at say 500 mm then the actual depth of the trench shall be  $500+1000 = 1500$  mm limited to a maximum depth of 1650mm. Depth of trench shall be at least 800 mm in hard rock from the depth hard rock is encountered i.e. in case hard rock is encountered at say 300 mm then the actual depth of the trench shall be  $300 + 800 = 1100$  mm limited to a maximum depth of 1650mm. For excavation in hard rock, controlled blasting can be resorted to. The Contractor shall obtain necessary permissions from the statutory authorities for blasting and the use of explosives for this purpose. No blasting is permitted near permanent work or dwellings. Blasting shall be so made that pits are as near to the designed dimensions as practicable. Jackhammers can also be used for the excavation. The width of trench at the top and bottom shall be adequate for proper installation of PLB HDPE pipes, RCC hume pipes, GI pipes Warning tape, route marker and joint markers. The contractor shall submit the construction drawing for approval. The trench depth shall be measured from the bottom of the trench. Trench shall be located at the lowest point of lower area if possible. Trench shall not be constructed at field boundary or any up-heap. In case of uneven ground, the Contractor ensure that the bottom of the trench is not uneven, the Contractor shall maintain minimum depth of the trench as per specifications and may be required to increase the depth at some locations and provide a suitable gradient in the trench.

During the construction of trenches, the Contractor shall be responsible for shoring and strutting the walls of the trench on either side by using suitable means such as wooden planks to avoid subsidence of soil. The Contractor shall also be responsible for supporting the exposed plant/facilities of other utilities such as water, gas and oil pipes, electric, telephone or fibre optic cables etc to avoid any possible damage. The Contractor shall also be responsible for any dewatering of the trench during digging and installation of pipes.

In case it is necessary to get around a large obstacle such as a boulder or an underground plant/facility, which has not been anticipated earlier the trench may be given a gentle bend within permissible radius or by construction of a manhole. Wherever possible, it is preferable to avoid additional manholes.

The **Owner/Employer's Project Manager or his/her authorized representative** will be the authority to decide the classification of the soil i.e. normal soil, soft rock or hard rock. In few cases where the required depth is not achievable, the Project manger may allow the lesser depth subject to providing the suitable protection such as providing the concrete casing of the installed ducts. For such cases, the contractor shall propose the suitable protection arrangement along with the reasons for non achievability of the required depth and obtain the specific approval of the project manager before execution of the work. The decision of the Project Manager shall be final and binding on the Contractor.

### **3.3.2.2 Backfilling**

After installation of PLB HDPE pipes, RCC hume pipes or GI pipes, the backfilling of the trench shall be done. The PLB HDPE pipes shall be sandwiched with sand as per the Figures 3-1. Backfilling shall normally be done with the excavated soil, unless it consists of large boulders/stone in which case the boulders/stone shall have to be broken to a maximum size of 80mm. The backfilling should be clean and free from organic matter or other foreign material. The earth shall be deposited in maximum 200 mm layers levelled and wetted and tamped properly before another layer is deposited. The earth filling is done with a suitable mount to allow for any shrinking of soil at the later date. In case of regular footpath, temporary reinstatement shall be done after backfilling. The left out earth if any has to be disposed by the Contractor to a suitable location as indicated by authorities at his own cost. It is advisable to start backfilling of the trench from one end or after padding of the pipe to avoid uplifting. In case of soft rock as well as hard rock, the PLB HDPE pipe shall be covered with 1:2:4 concrete. The cross section of the concrete shall be 100 mm (depth) x 200 mm (width). The Contractor shall properly cure the concrete for four days. The backfilling of the remaining portion shall be done as stipulated for normal soil.

Final inspection of the backfilling shall be done jointly by the Contractor and Owner/Employer

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immediately after first monsoon and the Contractor shall rectify the defects, if any, without any cost to the Owner/Employer.

### 3.3.3 Marking

The Contractor shall provide markers, warning bricks and warning tape as stipulated below for the routes where new PLB HDPE pipes are installed under this package.

#### A) Markers

Route markers made of RCC (1:2:4) of length 1450 mm and a bottom cross section of 150mmx200mm tapering to 75mmx125mm at top shall be provided. Route markers shall be provided at 500 mm from the trench and away from the road centre, at an average of 200 m. Markers shall also be provided at major directional changes in route (from straight) and at both sides of all types of crossings. 900 mm of the marker shall be underground and 550 mm shall be above the ground. The portion of route markers above ground shall be painted with brown synthetic enamel paint.

Joint Markers shall be provided at each joint location and shall be same as route markers except that they shall be blue in colour. In case joint markers and route markers fall at the same location, route marker shall not be installed and only joint marker shall be provided.

All Markers shall be Engraved vertically as "NAME OF UTILITY" in 500 mm portion above the ground area and filled with fluorescent white colour. The marking shall face the road.

#### B) Warning Bricks

Bricks class designation-5(50) of the actual size 225 mm (Length) x 111 mm (Width) x 70 mm (Thick) shall be laid breadth-wise as per Figure : 5-1(average 9 bricks per metre) in city area (municipality limits) immediately above the sand layer in which PLB HDPE pipe is installed. Stone slabs of suitable size may also be used in place of warning bricks with the approval of the Owner/Employer.

#### C) Warning Tape

A warning tape, made of HDPE or LDPE (Low Density Poly Ethylene) other suitable inert material, containing a printed message "**WARNING : Name of utility's Fibre Optic Cable below**" shall also be laid over the pipe, throughout the cable route at a depth of 1000mm in normal soil (the depth in soft rock and hard rock shall be proposed by the Contractor and approved by the Owner/Employer), for warning the person who is excavating the trench. The width of the tape shall be at least 100 mm and thickness of the tape shall be at least 500 micrometer. The life of the warning tape shall be at least 25 years.

### 3.3.4 Installation of PLB HDPE Pipe

Two PLB HDPE pipes two PLB HDPE pipes (**one spare for future use**) shall be laid. Two PLB HDPE pipes shall be laid side by side (minimum spacing 30 mm) at bottom of the trench after making the surface smooth and providing 80 mm of sieved, stone free sand bedding. After laying the pipe additional sieved sand shall be added to increase the height of the sand layer to a total of 200 mm hence positioning the PLB HDPE pipe in the middle of the layer. In case of unavoidable rat infected areas along the finalised route, pebbles of dia 20 mm (nominal) shall be used in place of the sand. Other important steps are described as under:

- a. PLB HDPE Pipe shall be laid in a flat bottom trench free from stones, sharp edged debris. Pipe shall not be laid in water filled trenches.
- b. The Pipe shall be placed in trenches as straight as possible. Minimum bending radius of pipe and fibre optic cable shall always to be taken into account.
- c. The ends of pipes shall always be closed with end plugs to avoid ingress of mud, water or dust i.e. all pipe opening shall be sealed to avoid entry of foreign material.
- d. The pipes shall be joined tightly & properly through plastic couplers and the joint shall be smooth and free from steps. The joints shall be made properly so that it passes the duct integrity test specified in section 3.3.12.4 . All joints shall be assembled with proper tools only.
- e. Coupler shall not be placed along the bend portion of the pipe and hacksaw shall never be used to cut the pipe.
- f. Cable sealing plugs shall be provided at all manhole locations and at locations cable is coming out of the pipe and empty pipe ends i.e. all pipe openings shall be sealed to avoid entry of foreign objects.
- g. PLB HDPE pipes shall be installed in a manner that fibre optic cable can be pulled, blown, de-blown without damaging the fibre optic cable due to stresses.

The Contractor shall get inspected, by a representative of Owner/Employer, all joints before carrying out the backfilling. Joints shall be visually inspected and checked for tightness.

### 3.3.5 Manholes

Manholes shall be provided at every joint location to house Joint Box and Optical Fibre cable service loops. The location for Joint boxes shall be decided during detailed engineering. The manhole shall be pre cast RCC Cylindrical pipe with minimum internal diameter of 1000 mm, minimum height of 1100 mm and minimum thickness of 80 mm. The height of the manhole where only the service loop of the cable to be kept at road/culvert/bridge crossings shall be minimum 500 mm. It shall be made by spun concreting method and shall include 8mm steel reinforcement. The base of the manhole shall be minimum 80 mm thick, RCC. The cover shall be pre cast RCC, minimum 50mm thick with a diameter suitable for the manhole. The cover shall include two permanently fixed iron hooks of sufficient size for reopening purpose. Minimum 3 mm thick GI strip rings shall be used inside and outside of the top edge of the manhole cylinder. To avoid direct concrete contact between manhole cylinder and top cover as well as for protection of the concrete edge, the outer edge and the edge having contact with inner side of the manhole cylinder shall also have minimum 3 mm thick GI strip rings. The above mentioned GI strip rings shall be suitably fixed with the reinforcements. The bottom of the manhole shall be at depth equal to the depth of the trench. The Manhole shall be able to withstand a live load of 20ton vehicle plus 30% for impact from moving vehicle. The Contractor shall propose a suitable procedure for **proto testing** of the manhole for approval by **Employer** & shall carry out the proto test if the offered manhole is not type approved earlier by the Owner/Employer. Manholes type approved by the Owner/Employer only shall be acceptable. The manhole shall include sufficient number of suitable entries for installing PLB HDPE Pipes. The manhole shall have two holes in each four perpendicular directions for PLB HDPE pipe entries and exits. Fixtures for placing cable and spliced Joint Box inside the manhole shall be provisioned. The joint box shall be mounted vertically on the wall of the manhole. The contractor shall carry out the required excavation and backfilling for the construction of the manhole. All PLB HDPE pipe entries including spare HDPE pipes, cable entries and spare holes shall be properly sealed. The Contractor shall submit construction drawings and installation procedures for the Manholes (all different configurations) for approval by the Owner/Employer.

The Contractor shall get inspected, by a representative of the Owner/Employer, all manholes before carrying out the backfilling. Pipe & cable sealing, installation of joint box and cable service loops as per approved drawings shall be visually inspected and checked for tightness.

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### **3.3.6 Reinstatement**

The contractor shall be required to carry out reinstatement of the excavated area in case the concerned authority requires so. Reinstatement shall include all works necessary (such as reconstruction of metalled/asphalt road, footpath etc) to restore the excavated area to original quality and shape.

### **3.3.7 Installation of GI Pipe**

The GI pipe of nominal bore of minimum 100 mm shall be laid wherever road crossings, bridge crossings, railway crossings are encountered on the route as well as on wall/floor crossings in a building. Both two PLB HDPE pipes shall be inserted into one GI pipe. Whenever it is not possible to install the FO cable underground due to non availability of the right of way or any other unavoidable reasons, the HDPE ducts along with FO cable shall be installed in GI pipe on the wall inside the sewerage pipe and or on the existing rock/concrete/brick wall/surface with suitable fixing arrangement and concreting, if necessary, with specific approval of the Owner/Employer in case to case basis. The GI pipe shall conform to at least medium class and conform to IS : 1239 (Part –I). In regard to bridge and culvert crossing, GI pipe may be installed by concreting the GI pipe along the bridge or by using supporting brackets or by laying underneath the existing footpath etc. The PLB HDPE pipes shall be installed through this GI pipe. Wherever underground fibre optic cable is required to be spliced to overhead fibre optic cable using the outdoor FODPs / Joint Boxes installed on towers/pole (at a height of 6 to 10 meters), GI pipes shall be used to protect the complete exposed portion of the cable and shall be extended in the ground up to suitable depth of the trench so that minimum bending radius of the cable is maintained. The GI pipe shall be properly clamped/fixed on the tower leg/pole. The Contractor shall supply and install all necessary accessories as part of the installation work.

The Contractor shall propose the exact methods and procedures for implementation of crossings taking into consideration the following guidelines, for approval by the Owner/Employer:

- a. The GI pipe shall be extended at least 5 meters on each side of crossing subject to availability of space and approval of the Owner/Employer.
- b. Two GI pipes shall be joined using proper tools, sockets and accessories etc.
- c. Proper arrangements shall be made to seal the ends of GI pipe after installation of PLB HDPE pipes.
- d. Minimum bending radius of optical fibre cable shall always be taken into consideration.
- e. 1:2:4 concrete shall be used.
- f. The floor of the trench shall be levelled by laying at least 50 mm of soft soil or sieved sand before installing the GI pipe.
- g. The GI pipes shall be supplied in standard lengths of 6m or as approved by Owner/Employer's Project Manager.
- h. The GI pipe shall be sealed at both ends.
- i. The GI pipe of suitable length shall be provided at road crossings, bridge crossings, railway crossings encountered on the route as well as on wall/floor crossings in a building.

### **3.3.8 Installation of RCC Hume Pipe**

Minimum inside diameter 100 mm, NP3 RCC hume pipe shall be laid wherever river, nallah crossing encountered on the route. The RCC pipe shall conform to IS:458. Both PLB HDPE pipes shall be inserted into RCC hume pipe. The Contractor shall propose the exact methods and procedures for implementation of crossings taking into consideration the following guidelines, for approval by the Owner/Employer.

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- a. The RCC hume pipe shall be extended at least 5 meters on each side of river, nallah subject to availability of space and approval of the Owner/Employer.
- b. Two RCC hume pipes shall be joined using RCC collar and properly cemented.
- c. Proper arrangements shall be made to seal the ends of RCC hume pipe after installation of PLB HDPE pipes.
- d. Minimum bending radius of optical fibre cable shall always be taken into consideration.
- e. 1:2:4 concrete shall be used.
- f. The RCC hume pipes shall be supplied in standard lengths of 2m or as approved by Owner/Employer's Project Manager.
- g. The RCC hume pipe shall be sealed at both ends.

### **3.3.9 Underground Fibre Optic Cable Installation**

The cable shall be installed inside one of the 40mm diameter PLB HDPE pipes installed under this package along the route(s). The cable shall be installed by compressed air blowing technique. The cable blowing machine shall be suitable for blowing the proposed section lengths of fibre optic cables.

As various utilities have already installed their fibre optic cables in the existing PLB HDPE pipe routes, the Contractor shall take due care and precaution during installation of fibre optic cable and the rectifications work to avoid possible damage of ducts / OFC of other utilities. The Contractor shall indemnify the Owner/Employer for all the damages and the Contractor shall be solely responsible for the damages and losses. The Owner/Employer shall not be liable for any such damages.

Bidder shall provide armored fibre optic cable (TEC approved design) in some of the sections, which are not suitable for unarmored cable installation in ducts (example: highly rat infested sections). The armored fibre optic cable shall also be installed inside the PLB HDPE pipe / GI pipe / RCC pipe, as applicable. The routes and types of installation shall be finalised during project execution based on the site survey report and actual requirements.

The Contractor shall propose the exact methods and procedures for installation taking into consideration the following guidelines, for approval by the Owner/Employer.

- a. The Optical Fibre Cable Drums shall be handled with utmost care. The drum shall not be subjected to shocks by dropping etc. They shall not be normally rolled along the ground for long distance and when rolled, shall in the direction indicated by the arrow. The battens shall be removed only at the time of actual laying.
- b. A blowing machine in association with an appropriate compressor shall be used for blowing.
- c. Temporary blowing chambers (if required) shall be constructed and then backfilled after blowing operation is completed.
- d. Locations along the route, which provide easy access points for blowing machine and compressor, shall be determined.
- e. Before starting the cable blowing, both PLB HDPE pipes installed under this package shall be checked for obstacles or damage. The already installed PLB HDPE pipe wherein cable are to be installed under this package shall also be checked for obstacles or damage. Checking shall be done by using a proper sized mandrel equipped with a transmitting device.
- f. Always blow downhill wherever possible.
- g. Multiple blowing machines may be used in tandem if so required.

Installation by pulling may be permitted by the Owner/Employer in specific cases where installation by blowing is not feasible. In case pulling is used, the pulling speed shall be determined considering the site condition. Care must be taken not to violate the minimum bending radius applicable for the fibre optic

cable. Tension in the cable during laying shall not exceed tension limit of the offered FO cable and the cable should not be damaged during or after the pulling.

While installing the cable, excess length of about 10 meters shall be stored at each joint location for each side. Excess length of 10 m shall be kept at one ends of a road crossing, culvert crossing and 20 meters at one end of bridges.

### **3.3.10 Trenchless Digging**

Trenchless digging may be used in short section for crossing National highways, important road or rail crossings etc, where the concerned authorities do not permit open cut method, for which no additional cost shall be provided by the Employer.

### **3.3.11 Optical fibre termination Splicing and Service**

Termination and splicing of optical fibre cables are described in chapter 2 of Section 5. Unless other wise specified in this chapter, service loop requirements specified in chapter 2 of section 5 shall be provided.

### **3.3.12 Site Acceptance Testing (SAT)**

General conditions for testing shall be as per Section 7 of this specification. The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment/material for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation s and Field Quality Plan documents.

#### **3.3.12.1 Underground Fibre Optic Cable**

SAT for optical fibre cable shall be carried out link by link from FODP to FODP.

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 cable segments that may have been damaged during shipment. Test requirements are as per table 3-1.

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 failure. The Contractor shall have to either replace the concerned cable span at its own cost or provide additional splicing, joint box and manholes required to rectify the fault at its own cost. The fibre attenuation shall be tested again after replacement or rectification of fault.

During the installation, spliced cable segments shall be tested and documented. In case it is found that the splices are bad (loss is unacceptable as per approved test procedures), the Contractor shall have to do re-splicing and provide new Joint Box wherever required at no additional cost to the Owner/Employer. After re-splicing the end to end testing shall be repeated. The splice testing requirements are indicated in table 3-2.

Upon completion of a continuous cable path (FODP to FODP locations), all fibres within the cable path shall be demonstrated for acceptance of the cable path. Test requirements are indicated in table 3-3 and in no case losses attributed due to other factors viz. extra splice, kinks, will be acceptable to the limit determine by the following formula:

Max attenuation @ 1550nm:  $0.23\text{dB/km} + 0.05\text{dB} \times \text{total no of splices} + 0.5\text{dB} \times \text{connector}$

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Max attenuation @ 1310nm: 0.35dB/km + 0.05dB x total no of Splices + 0.5dB x connector

As averaged over 100 km of fibre.

**Table 3-1:  
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 1550 nm

**Table 3-2:  
Fibre Optic Cable Splice Testing**

Item:	Description:
1.	Per splice attenuation with OTDR (bi-directional average) at 1550 nm
2.	Physical inspection of Joint Box for proper fibre routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

**Table 3-3:  
Fibre Optic Cable Commissioning Testing**

Item:	Description:
1.	Fibre continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fibre at 1310 & 1550 nm by OTDR
2.	Fibre continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fibre at 1310 & 1550 nm by Power Meter & Laser Source
3.	Average splice loss (bi-directional) for each splices and average splice loss for the link by OTDR at 1550 nm
-End of Table-	

### 3.3.13 SAT for Joint Box

20% Joint Box shall be tested for water penetration. Installed joint box shall be completely immersed in water for 1 hour under 1 meter head, then opened and observed for water/moisture ingress. The Joint Box shall then be sealed and installed again. In case any water/moisture is detected, test shall be declared failed and all the Joint Boxes shall be tested, all failed joint boxes shall have to be re spliced and resealed.

#### 3.3.13.1 SAT for PLB HDPE pipe

For the new PLB HDPE pipes to be installed under this package, duct integrity tests shall be carried out as described below. The **Duct cleaning (Sponge test)** test shall be carried out on all the ducts before blowing/pulling of the cable while all other tests shall be carried out on spare ducts only. If Duct cleaning (sponge) test fails in the duct in which cable to be laid then other tests may be carried out to clean and rectify the problem, if any. The tests as described below shall be carried out between two consecutive manholes on the PLB HDPE pipes.

##### a. Duct cleaning (Sponge test)

Compressed air should be blown through the PLB HDPE pipe in order to remove dirt and water, if any, with the help of suitable Air Compressor. A short blast of air about 2-3 Bar shall be blown through the PLB HDPE pipe for about 2 minutes. Sponge shall be blown through the duct to thoroughly clean the duct from inside.

**b. Crush and deformity test**

Place a shuttle of length <15cm and O.D. 80% of the inner diameter of the offered PLB HDPE pipe. Connect the compressor pipe with a suitable flexible wire grip at the other end to catch the shuttle and start blowing operation to the pipe and check if shuttle reaches at the other end. If shuttle gets stuck perform the Radio transmitter detection test.

**c. Radio Transmitter detection test**

For this test, a Radio shuttle shall be blown by a compressed air which shall also be stuck at the point of earlier shuttle. The place and position of the radio shuttle shall be identified with help of detector and obstruction (kink/deformation/ sharp bend) is removed and the test procedure shall be repeated, until the whole duct section is found cleaned for blowing.

**d. Pressure testing**

For this test, seal one end of the PLB HDPE pipe with end coupler and connect valve with coupler at the other end and then pressurise the pipe up to 5 Bar with a compressed air from valve end coupler. After 30 minutes pressure drop shall not exceed by 0.5 Bar.

**3.3.13.2SAT for other items**

Tests for other components such as FODP etc. shall be done as per approved Field Quality Plan.

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