OMAN WASTEWATER SERVICES COMPANY S.A.O.C

الشركة العمانية لخدمات الصرف الصحي ش.م.ع.م

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OMAN WASTEWATER SERVICE COMPANY

TECHNICAL STANDARD SPECIFICATIONS FOR FIBRE OPTIC NETWORK

SECTION 05-05

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PROGRAMMABLE LOGIC CONTROLLER (PLC)

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1.0 SCOPE, STANDARDS AND DEFINITIONS

1.1. Scope of this Document

This specification covers the general requirements to be applied to all Control & Automation systems and equipments to be installed within Oman Wastewater Services Company projects.

This document is a guide to the design, installation and testing of different types of fibre optic cables including buried, ducted and blown. The Installation of fibre optic cables shall be governed by, but not limited to, the provisions specified, and shall be undertaken to high standards of workmanship and in a safe manner. This specification shall be utilised with one or more of the referenced international standards to complete the COMPANY requirement for installation Works. However, it remains the contractor responsibility to ensure the complete installation of FOC. This specification shall be used in conjunction with the separate related sections of the Electrical Standard Specifications as follows:

1.2. Applicable Standards, Specifications and Codes

The design of the projects shall comply with the following codes and standards

1.2.1. British Standards:

- BS 89 - Direct acting indicating analogue electrical measuring instruments and their accessories.
- BS 381C - Colour for Identification, Coding and special purposes
- BS 4794 - Control Switches
- BS 6231 - PVC Insulated cables for switchgear
- BS 381C - Colour for Identification, Coding and special purposes

1.2.2. International Standards

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- EIA-455 -Standard Test Procedures for Fibre Optic Fibres, Cables, Transducers, Connecting andTerminating Devices.
- EIA-598 -Optical Fibre Colour Coding
- IEC 529 - Environmental protection
- IEC 793-1 -Generic Specification for Optical Fibres
- IEC 794-1 -General Specification for Optical Fibre Cables
- IEC 794-2 -Product Specifications for Optical Fibre Cables
- IEC 874 - Connector for Optical Fibres and Cables
- IEC 1073 - Splices for optical fibres and cables.
- IEC 1218 - Fibre optic - Safety guide
- ITU-T G.652 International Telecommunication Union-Telephony: Characteristic of Single mode Optical Fibre Cable

1.2.3. Omani Electrical Standards.

All relevant local and Omani regulations shall be complied with. Any item not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.

1.2.4. Company HSE Standards

All Company Health Safety and Environmental Protection Standards shall be complied with. Refer the Document: **Construction Safety Standards -CSS 01**, for further details

1.3. Compliance with Standards

All requirement of this specification shall apply except where the manufacturer's standards are more stringent and then the latter shall apply. If a standard becomes old and a latest issue of the same standard is available then the latest issue shall be followed. For any deviation from these standards, the written agreement of the Company shall be obtained prior to commencing associated engineering or construction work

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1.4. Service and Environmental Conditions

1.4.1. Temperature:

Recorded of extreme of site ambient temperature are: +5°C to +50°C

1.4.2. Altitude:

Height above Sea level: 0 - 2000m

1.4.3. Relative humidity:

Highest: 95%

Lowest: 40%

1.4.4. Atmosphere:

The equipment and material are to be suitable for installation in coastal industrial plant where the atmosphere is subject to dust storms.

Mean annual rain fall: 100mm

Daily average wind speed: 4-5 m/sec

1.5. Priority

Standards shall take the following priority (in order of highest to lowest):

-The project related technical specification (Shall be attached as Annexure)

-This document (**Standard Specifications**)

-International Standards

-Industry Standards

1.6. Safety regulations

Safety is the most important aspect of a fibre optic cable installation and highest priority shall be assigned to the safety issues. These safety recommendations are meant to supplement, not to replace, relevant local & national laws, company-specific safety practices and other codes and regulations. Some of the key points are:

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- To prevent eye damage, never look into the end of an optical fibre unless a power meter is used to verify that no optical signal is present.
- Testing for explosive gases and proper ventilation of underground facilities is vital.
- Capable ventilation equipment must be used according to local regulations & practices prior to installation of FOC cables in underground facilities.
- A running ground must be used whenever there is the possibility that a voltage may be somehow applied to the cable. The use of compressors for cable blowing requires careful attention be paid to the safety instruction for the compressor and all compressed air fittings.

1.7. Definitions

1.7.1. Technical Terminology

Macro bend loss

A relatively large-radius bend in an optical fibre, such as might be found in a splice organiser/enclosure tray or a fibre-optic cable that has been bent. The definition of "sufficiently large" depends on the type of fibre. Single-Macro bend mode fibres have a low numerical aperture, typically less than 0.15, and are therefore are more susceptible to bend losses than other types. Normally, they will not tolerate a minimum bend radius of less than 6.5 to 7.5 cm (2.5 to 3 inches).

In an optical fibre, the loss attributable to macro bending. If a loss found from OTDR test at 1550nm wavelength is greater than 0.05 dB comparing with loss found at 1310nm wavelength for the same point then this considered to be a macro bend loss contributed to damages and bents done during installation or objects (e.g. stones) damaged the fibre. In an optical waveguide, sharp curvatures involving local axial displacements of a few micrometers and spatial wavelengths of a few millimetres. Note: Micro bends can result from waveguide coating, cabling,packaging, and installation. Micro bending can cause significant radiative loss and mode coupling. In an optical fibre, the optical power loss caused by a micro bend. If a loss found from OTDR test at 1310 nm loss to be greater then 0.03 dB at a point, where there is no splice then this is considered to be micro bend loss.

Macro bend

Macro bend

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1.7.2. Abbreviations

AC	Alternating Current
ADSS	All Dielectric Self Supporting
BS	British Standard
CCIR	Committee Consultative International Radio
CCITT	Committee Consultative International Telegraphy and Telephony
Db	Decibel
DC	Direct Curren

2.0 FOC NETWORK ENGINEERING REQUIREMENTS

2.1. Design Stages and Submissions

In the design stage, the following shall is mandatory:

a. A pre-survey of the route shall be conducted for all types of installations.

b. Optical power loss budget shall be calculated for any FOC link.

c. Problem areas shall be identified & fixed and an installation plan should be clearly defined prior to the start of the installation.

In addition, the Contractor shall submit the followings:

1. Catalogue Data: Catalogue data on conduit system, manholes, conduit fittings, conduit plugs, pull rope, identification tape, and warning signs.
2. Detailed bill of materials.
3. Drawings indicating the routes, total layout and locations of all manholes.
4. Catalogue data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.
5. In case of pressure blowing, detailed methodology of blowing FOC.
6. In case of HDPE duct installation, detailed installation methodology of the duct.
7. In case of cable pulling, pulling calculations for all conduit runs.

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8. A cable pulling and splicing work plan shall be submitted. Work plan shall include the following. The name and qualifications of the supervisory personnel that will be directly responsible for the installation of the cable and/or conduit system.

2.2. Route survey

The Contractor shall make a physical survey of the project site for the purpose of establishing the exact cable routing, termination points, jointing locations and cutting lengths prior to the commencement of any work or committing any materials. The Contractor shall conduct the detailed survey and confirm the line route. If a change in route is required for any practical reason, prior approval should be obtained from the Company. The contractor shall ensure that clearances are maintained from the fibre optic cable to any part of the line or surroundings.

2.3. Optical Power Loss Budget

The optical Power Budget presents the optical budget calculations. The link calculations (OLTE - OLTE) shall be designed to give a bit error rate of better than 1×10^{-9}, based on the average expected joint loss. Table 1 shows the parameters to be included for calculating the required System margin.
than 1×10^{-9}, based on the average expected joint loss. Table 1 shows the parameters to be included for calculating the required System margin.

System Margin	dB
Equipment Degradation (ageing of Laser	3
Lifetime	
Design Noise	1
Operation Margin (Safety Margin)	1 5
Future Splice Margin (The system shall allow at 0.1 per splice lease 10 additional joints)	

Table 1. Required System Margin

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The fibre optic link shall accommodate up to additional 10 joints (5 repairs) without exceeding the error performance. Table 2 shows the recommended parameters to be included for calculating the link losses.

Link losses	**dB**
Cable loss (G.652)	0 4 dB/km
Splice loss (G.652)	0.1
Connector Loss	0.5
FDF loss (Connector loss + Jumper loss)	0.75

Table 2. Recommended link losses parameters

2.4. Testing

The Contractor shall perform pre-installation and post-installation FOC tests. The Company Site Representative shall be notified a minimum of 10 days in advance so that these tests are witnessed. The Contractor shall carry out all the Site Acceptance Tests (SAT) required to prove that the FOC is free from damage, installed according to the Company specifications and requirements and functioning properly. The contractor shall provide a detailed Integration acceptance test document with the following information as a minimum for approval by the Company before the scheduled test. The Company at its own discretion shall ask the contractor to include (or waive) any tests to ensure proper functionality of the network

- Test Plan
- Schedule
- Procedures
- Equipment setup diagrams

3.0 SPECIFICATIONS FOR FOC NETWORK MATERIALS AND ACCESSORIES

The following sections comprise guidelines for the mostly used materials for FOC network and its specifications. However, it remains the Contractor responsibility to identify and procure all the required materials for the complete FOC installation work

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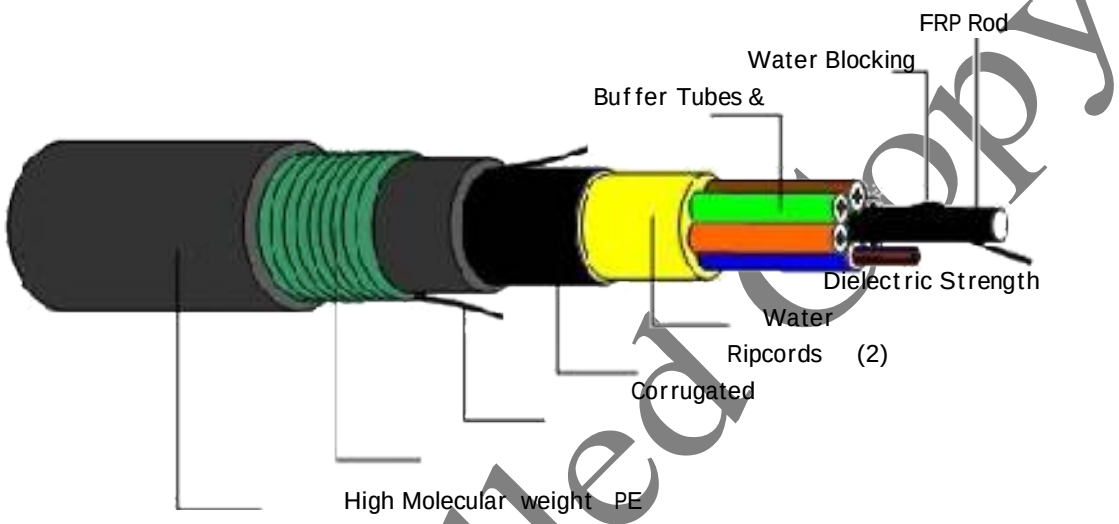
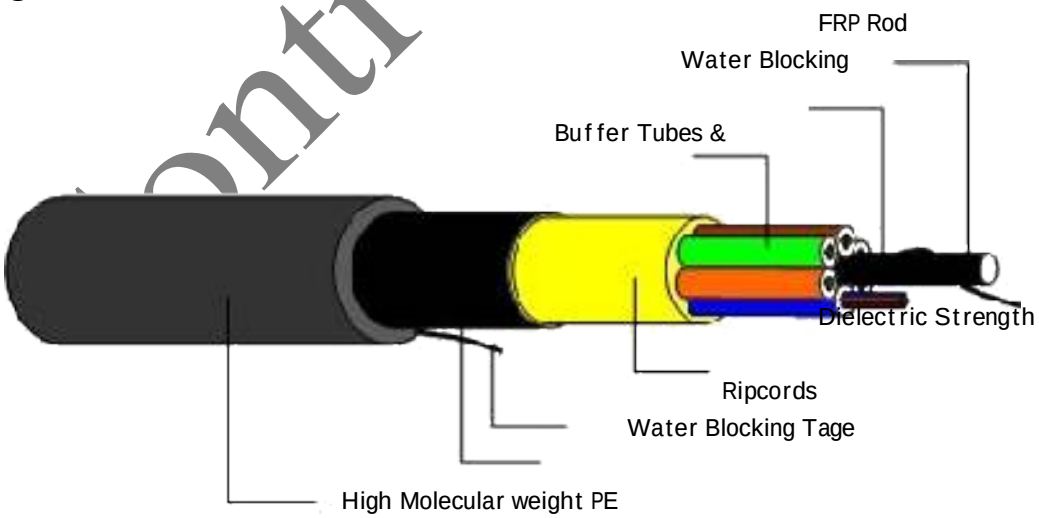
3.1. Fibre Optic Cable.

It describes the construction, performance, acceptance criteria, and installation of polyethylene sheathed armoured optical cables ("PSA") and polyethylene sheathed dielectric optical cables ("PSD").

Design "PSA": Armoured Cable



Design "PSD": Dielectric Cable



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For PSA cable, applications include pulling/blowing into ducts and direct burial by plowing or by "trench & backfill method". PSA designs should be well protected against attack by rodents & termites and have excellent crush & impact resistance to provide protection against the rigors of direct burial installation. For PSD cable, deployments are limited to duct installation by pulling or blowing. The cables described herein have a stranded loose buffer tube construction that is designed so that no net axial fibre strain occurs at maximum pulling tension.

3.1.1. Cable Construction

The required cable is comprised of the following components listed radially from the centre.
-A central strength & anti-buckling member made of 2.5 mm GRP.
-Super absorbent polymer yarns wrapped around the central member
(or super absorbent polymer binders suitably located elsewhere in the cable structure)
- SZ stranded loose buffer tube containing optical fibres and a thixotropic filling compound.
-Optionally, filler rods may be used in lower fibre count cables to keep the structure round.
-A layer of aramid yarn that is engineered to provide the required level of tensile strength.
-A super absorbent polymer tape wrapped around the aramid yarn
-One or two ripcords
-A PE inner sheath
-A corrugated steel armour tape (PSA only)
-A PE outer sheath (PSA only)

3.1.2. General Requirements

The cables must be circular in cross section and free from pinholes, joints, repairs and other defects. Materials used in the construction of the cable shall not affect the physical or optical properties of the fibres and shall be compatible with each other. The fibre and stranded loose tubes shall be colour coded as specified below to provide easy identification at either cable end.

The cable must be of stranded loose buffer construction where fibres are contained in a series of tubes (6 or more). The fibres must have enough free space inside the tube to provide the required level of mechanical and environmental performance. The inside of the tubes must be filled with a thixotropic gel to prevent moisture ingress. The buffer tube-filling compound must be non-toxic and dermatologically safe. It must free from foreign matter, chemically and mechanically compatible with all cable components, non-nutritive to fungus, non-hygroscopic, and electrically non-conductive.

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For lower fibre counts, filler rods may be placed into any unused positions in the stranded fibre optic core. The filler material must be made of a material compatible with other core components. Each buffer tube in the finished cable is distinguishable from the others by means of colour coding as follows:

TUBE NUMBER	BUFFER TUBE COLOUR
1	BLUE
2	ORANGE
3	GREEN
4	BROWN
5	GRAY
6	WHITE

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3.1.2.1.Optical Fibres

All optical fibres must meet the requirements set forth in ITU-T Recommendation G.652 and the detail specifications below. Each optical fibre must be protected with a dual layer acrylate coating. The inner layer shall be optimised for adhesion to the cladding glass, strippability and temperature performance while the outer coating shall be a harder material optimised for abrasion performance. Each cable must have traceability of the optical fibre back to the original fibre ID number and test parameters as provided by the fibre manufacturer.

Optical fibres shall have a high level of splice compatibility with optical fibres from other manufacturers. No fibre splices are allowed in any continuous length of cable. Each fibre in a tube must be distinguishable from other fibres in the same tube by means of colour coding ink discernible throughout the design life of the cable. Required fibre colour sequence is as follows

Fiber Number	Fiber Colour	Fiber Number	Fiber Colour
1	Blue	**4**	Brown
2	Orange	**5**	Gray
3	Green	**6**	White

3.1.2.2.Super-absorbent Polymer Materials

Cables must be water blocked with superabsorbent polymer water blocking yarns, tapes and/or binders. The superabsorbent polymer materials must be safe, easy to remove and require no special handling or solvents.

3.1.2.3.Inner Sheath

The sheath must be made of a high molecular weight linear PE meeting the requirements of ASTM-1248, type III, Class C, Category 5, Grade J3. The inner sheath thickness should be nominally 1.0 mm or to meet the required cable mechanical and environmental performance characteristics.

3.1.2.4.Strength Yarns

The strength yarns for PSA and PSD cables shall be aramid yarns.

3.1.2.5.Outer Sheath

The sheath must be made of a high molecular weight linear PE meeting the requirements of ASTM-1248, type III, Class C, Category 5, Grade J3. The nominal outer sheath thickness shall be 1.8 mm. The average thickness of any
cross section shall not be less than 90% of the specified thickness. The minimum spot thickness shall not be less than 80% of the specified thickness.

3.1.2.6.Sheath Markings

The outer sheath shall be marked with the following:

-The words "Oman Wastewater Services Company S.A.O.C - Fibre Optic Cable".The manufacturer name.

- The year of manufacture (for example: "Year 2007").
- The fibre count (for example: "24 F").
- Meter marks at a one meter interval with arrowhead indicating upward direction of meter markings.

3.1.3. Cable Performance Requirements

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Mechanical Characteristics

PARAMETER	REQUIREMENTS
Maximum pulling tension (MPT)	3500N for PSA 2700N for PSD
Minimum bend radius, no load	10 times the cable outside diameter
Min bend at max pulling tension	15 times the cable outside diameter
Compressive Load	5000N/10 cm for PSA 2500N/10 cm for PSD
Impact Load	25 N-m for PSA 15 N-M for PSD

Optical performance for G.652 Single Mode Fibres

PARAMETER	REQUIREMENT
Attenuation variation with wavelength (1285 – 1330 nm)	< 0.1 dB/km
Attenuation at water peak	≤ 2.1 Db/km
Attenuation with bending (100 turns on a 75 mm dia mandrel)	≤ 0.1dB/km at 1550 nm
Attenuation coefficient at 1310 nm	≤ 0.38 dB/km
Attenuation coefficient at 1550 nm	≤ 0.25 dB/km
Optical discontinuities at 1310 and 1550 nm	< 0.1 dB
Chromatic dispersion between 1285 and 1330 nm	≤ 3.5 ps/nm·km
Chromatic dispersion at 1550	≤ 18 ps/nm· km
Cable cutoff wavelength	≤1260 nm
PMD Coefficient	≤ 0.5 ps/√km

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Optical Performance for with 62.5/125 GI Multimode fibres

PARAMETER	REQUIREMENT
Attenuation coefficient at 850 nm	≤ 3.0 dB/km
Attenuation coefficient at 1300 nm	≤ 0.7 dB/km
Optical discontinuities at 1310 and 1550 nm	< 0.1 dB
Bandwidth Dist Product at 850 nm	≥ 160 MHz·km
Bandwidth Dist Product 1300 nm	≥ 500 MHz·km

Environmental Performance of Cable

PARAMETER	REQUIREMENT
Operating Temperature	-20 to +70 ºC
Allowable change in attenuation	≤ 0.05 dB/km
Installation Temperature	-20 to +55 ºC
Storage Temperature	-20 to +55 ºC

3.2. HDPE Duct Material

The raw material used for HDPE ducts shall meet the following requirements:

a. The anti-oxidants used shall be physiologically harmless

b. Single pass rework material of the same composition produced from the manufacturer's own production shall be used and it shall not exceed 10% in any case.

c. The raw material used for extrusion shall be dried to bring the moisture content to less than 0.1%.

d. Suitable UV stabilizers shall be used for manufacture of the duct to protect against UV degradation, when stored in open for a minimum period of 8 months.

e. The raw material used in the manufacture of the duct shall be such that the service life of the duct and all its accessories can be expected to bemore than 50 years including the life of permanent lubricant.

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3.2.1. HDPE Standards

HDPE Ducts shall conform to the following standards & Specifications

A. IS: 4984	**Specifications for HDPE Pipes**
B. IS: 2530	**Method for tests for polyethylene moulding materials and compounds.**
C.IS: 9938	**Recommended colours for PVC insulation for LF wires and cables.**
D.TEC Specs no. G/CDS-08/01/Dec.99	**HDPE Ducts for moulding and extrusion cable**
E.IS: 7328	**HDPE material for moulding and extrusion**
F.ASTM D 1693	**Test method for environmental stress cracking of ethylene plastics.**
G.ASTM D 1505	**Test method for density**

3.2.2. HDPE Requirements

Visual Inspection: The ducts shall be checked visually for ensuring good workmanship that the ducts shall be free from blisters, shrink holes, flaking, chips, scratches, roughness, break and other defects. The ducts shall be smooth, clean, round. The ends shall be cleanly cut and shall be square with axis of the duct. The ducts shall be of different colours and for further identification, contrast striping shall be provided. These stripes shall be co-extruded during the duct manufacturing. The material of the stripes shall be same as that of base compound for the duct.

Identification Markings: The duct shall be prominently marked with indelible ink, with the following information at intervals every meter to enable identification of the pipe. The size of ink markings shall be distinct, clearly and easily visible.

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§ Manufacturer's name (Also can be in abbreviated form)
• Oman Wastewater Services Company S.A.O.C
• Name of the duct with size
• Specific serial number of the duct
• Date of manufacture
• Sequential length marking at every meter with Arrow mark in ascending order.

3.3.HDPE Duct Accessories

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

a. **Plastic Coupler:** The coupler shall be of **Push-fit type** having Push-Lock mechanism, which enables them to be installed on ducts without pre-dismantling. The design of this shall be simple, easy to install and shall provide air tight and water tight leak proof joint between the two ducts. It shall withstand the air pressure test of 15 Kg/cm^2 for a minimum period of 2 hours without any leakage.

b. **End Plug:** This is for sealing the ends of empty ducts, prior to installation of O.F. cable and shall be fitted immediately after laying of duct, to prevent the entry of any dirt, water, moisture, insects/rodents etc into ducts.

c. **Cable Sealing Plug:** This is used to seal the ends of ducts perfectly, after the cable is installed in the duct, to prevent the entry of dirt, water, moisture, insects/rodents etc into ducts.

d. **End Cap:** These caps, made of hard rubber/plastics, shall be fitted on each end of duct coil after manufacturing. These shall avoid ingress of dust, mud, rain water etc. into ducts, during transit and storage.

3.4.Cable Markers

The markers shall be made from Aluminium with width of 100mm, height of 30mm and thickness of 1mm. The text shall be engraved on the Aluminium marker. The text shall provide details of the FOC type, the route, manhole number, start and end locations.

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3.5.Duct or Conduit Seals

The Duct Sealing Kit prevents water and gas from entering a manhole through a cable duct.

3.6.Pull Rope

Low friction, polyethylene jacketed polypropylene rope with 1800 psi tensile strength.

3.7.Fan-Out Termination for Loose Tube Cables

Individual fibres within the loose tube cable require handling protection inside the termination cabinets. Fan-out kits shall be installed in the patch panel enclosures to transition the loose tube fibres to ruggedized tight-buffered fibre pigtail cables. Fan-out tubes or furcation kits shall not be used. Optical fusion splices shall connect the loose tube fibres to the tight-buffered pigtail cables. The optical splice loss shall comply with the specifications for optical splices. Splice protection sleeves shall be employed on all splices to protect the splices.

3.8.Pigtail Cable Specifications

Optical characteristics shall comply with the optical fibre performance specifications.
- Buffer material: Thermoplastic
- Buffer O.D.: 900 um
- Strength Member: Kevlar
- Jacket Material: PVC
- Jacket O.D.: 3.0 mm
- Temperature Range: -20 to + 70 C

3.9.Fibre Optic Termination Patch Panels

The contractor shall supply the required quantities of pig tails, patch cords and patch panels. The fibre optic cable shall terminate inside a communications cabinet on a termination patch panel. All single mode fibre sub-cables or cores within the cable shall be terminated with E-2000 compatible connectors. All Multimode fibre sub-cables or cores within the cable shall be terminated with ST2 compatible connectors.
The patch panel shall have a fibre capacity equal to the total number of fibres (connected and spares) for all cables to be connected. All unused couplings shall have protective dust covers. All panels shall be furnished with front removable door or cover, Factory-terminated, tight-buffered, agamid-reinforced fibre optic jumper assemblies or interconnect cables, standard 3.0 mm O.D., shall connect the optical cable terminations to the patch panel couplings. The termination patch panel shall be equipped with a suitable means for routing and securing of

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cables and shall provide a suitable means of protection for the mounted fibre connectors to prevent damage to fibres and connectors during all regular operation and maintenance functions. All cables shall be provided with strain relief. Bend diameters on cable fibres and jumpers must be greater than four (4) inches at all times to ensure optical and mechanical integrity of the optical fibres.

3.10. Optical Connectors

All connectors shall be field-installable and perfectly matched to the cable used. The connectors shall provide tight fitting termination to the cladding and buffer coating. Epoxy based or "hot melt "adhesives shall be used to bond the fibre and buffer to the connector ferrule and body prior to polishing the end face. No dry-termination or "quick crimp" connectors are allowed.

Connectors shall have a maximum allowable connection loss of 0.3 dB per mated pair, as measured per EA.-455-34. No index-matching gel is to be used, dry interfaces only. Single mode connectors shall be capable of field installation on 9/125 micron fibres with 900 micron buffers (OD).

Each connector shall be of the industry standard E-2000 or ST2 type compatible, designed for single mode or multimode tolerances, respectively, and shall meet or exceed the applicable provisions of EIA.-455-5, 455-2A, and 455-34, and shall be capable of 100 repeated matings with a maximum loss increase of 0.1 dB. Connectors shall incorporate a key-way design and shall have a zirconia ceramic ferrule. Connector bodies and couplings shall be made of corrosion-resistant and oxidation-resistant materials, such as nickel plated zinc, designed to operate in humid environments without degradation of surface finishes.

3.11. Manholes

The manhole shall have the followings:

- Minimum size of 600 x 600mm (LxW) and a depth of 600 mm
- Ductile iron covers with a galvanised steel frame. The covers will be tested to the European standard EN124 B125. Security: Special "penta head" bolts shall be fitted. These can only be opened & locked with a special socket, which is also available.
- Duct Entry
- Internal Cable furniture

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4.0 INSTALLATION GUIDELINES FOR FOC NETWORK

4.1. Clearances between conduits and other structures

4.1.1. Separation from non-Electrical Installations/Structures

For non-Electrical structures or installation, a minimum separation between FOC and the structure shall be 300 mm, while running parallel. While crossing the structure, the minimum separation shall be 200 mm. The structure can be a pipe for gas, oil, water, sewage or other non- Electrical installation.

4.1.2. Separation from Electrical Installations/Structures

When installing a buried optical fibre cable near existing HV infrastructure, maintain a 3 metre separation between the fibre optic cable and poles, stays and existing HV electrical cables. Where cable is being installed in the same trench with other electrical cables, the minimum separation is given as follow:

- Minimum separation from electrical cables is 750mm (LV), 1000mm (11kV) and 1500mm (33kV).

- Note the requirements for vertical tiles between HV cables and the fibre optic cable.

4.2. Markers

Cable route markers will be installed at the completion of the cable installation and generally after the cable trench has been back filled and compacted. To enable the use of machines to complete this backfilling operation, temporary “off set” pegs will be placed in the ground with a recorded measurement to the cable. This measurement will then be used to establish the cable route marker; 1 metre from the cable after the machines has finished their activities. The cable markers shall be installed in accordance with the followings:

- Along FOC independent route, at every 100m.
- At every change in direction.
- At both ends of every conduit.
- At each joint or/and manhole.

The distance to the cable is to be recorded on each marker, together with the cable depth at each point. The supply and installation shall include the route markers including plates, posts and all the necessary materials required for installation

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4.3. Direct Buried FOC/HDPE Duct

Normal soil trench shall be excavated up to 750mm deep. The trench shall be filled with clean and soft sand up to 150mm from the bottom of the trench with the surface levelled (flattened). The trench shall be backfilled up to 500mm from the bottom of the trench with excavated material (with no stones larger than 4mmx4mmx4mm size). A mesh filter shall be used to remove big stones and sharp materials from the excavated material prior to backfilling. The trench shall be backfilled with remaining excavated material with big and sharp stones removed up to the normal ground level. The Contractor shall inform OWSC regarding backfilling schedule to enable quality verification/inspection of cable installation and backfilling for different layers.

The HDPE duct/conduit shall be of corrugated construction with a plain internal wall of LDPE (low-density polyethylene) and an external corrugated wall of HDPE (High Density Polyethylene). External colour shall be blue. Manufacturing shall be according to STD. EN50086-1 and EN 50086-2-4. Conduit shall withstand 450N with maximum deflection of 5% of internal diameter and 750N with maximum deflection of 15%. Conduit shall withstand impact test specified in EN 50086-2-4- sect. 10.3. Suitable jointing tubes with indented rings, which mate with external corrugations, shall be utilised for all joints. Joints shall provide a watertight seal.

During construction the ends of the conduit shall be closed to prevent foreign objects. Upon completion the ends shall be sealed to prevent ingress of water and sand using a plug. Sealing shall be achieved without use of glues, sealing compounds or foams. After its installation, the conduit shall be cleaned on the inside from any kind of material (earth, stones, etc.). A puling rope shall be provided in the conduit for future use.

The cable/duct drum shall be installed on the cable carrier (trailer). This cable carrier shall move along the trench line with the cable being manually spooled off the drum. The drum shall be turned by hand and the cable laid without any tension, directly into the trench. At no stage is the cable to be pulled off the drum. The cable/duct shall not be over-stressed during the unwinding and laying process. In cases where the cable or duct is drawn off the cable reel a swivel joint and mechanical "fuse" of the correct capacity shall be used to avoid exceeding the designed maximum pulling force for the cable.

Figure-8's shall be used for backfeed pulling or other situation where removal of the cable from the drum is needed. The size of the figure-8 should be marked with cones or other suitable devices. The figure-8 shall be at least 5 meters long with each loop at least 2 meter minimum diameter.

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4.4. Maximum Pulling Tension (MPT)

All Fibre Optic cables have a rated maximum. The MPT is clearly shown on cable specification sheet issued by the Manufacturer. During installation, the tension applied to the cable MUST be monitored with a calibrated load cell or tensiometer (dynamometer). Once the cable tension reaches 90% of MPT, the installation must stop to troubleshoot the cause. All measures possible must be taken to assure the pulling tension does not exceed the MPT rating of the cable, otherwise damage to the cable performance may result.

4.5. Minimum Bending Radius (MBR)

Most fibre optic cables have the following minimum bend radius.

- MBR = 20 times the cable diameter at maximum pulling tension
- MBR = 10 times the cable diameter at no tension

It is absolutely vital to maintain the minimum bend radius of the cable at all times to avoid catastrophic damage to the cable components including the optical fibres.

4.6. Splicing

In order to provide the optimum performance and reliability, any splicing of fibre optic cable shall be by fusion splice only, no mechanical splices are permitted. The following shall be followed b the Contractor:

- The splicing shall be conducted by trained, authorized persons only.
- All fusion splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Cable preparation, closure installation and splicing shall be accomplished in accordance with accepted and approved industry standards.
- Following are important considerations for low-loss, reliable fusion splices.
    a. Use a quality, well-maintained cleaver that is capable of consistent, low angle cleaves.
    b. Maintain cleanliness and temperature/humidity/dust control of the splicing area
    c. Use a quality fusion splicer and maintain it according to the manufacturer recommendations.
    d. Perform an arc test periodically to verify splicer performance.
    e. Set the fusion splicer arc settings according to local temperature, humidity and altitude conditions.

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f. To maintain the strength of the optical fiber, the coating strippers must be able to remove the primary and secondary coatings without scratching or damaging the cladding glass

- The average splice loss shall be 0.1 dB or less per splice. The average splice loss is defined as the summation of the loss as measured in both directions using an optical time domain reflectometer (OTDR) through the fusion splice, divided by two. No individual splice loss measured in a single direction shall exceed 0.15 dB

4.7. Manholes Installation

Any FOC joint shall be housed inside the manhole. The following guidelines and procedures shall be followed for FOC Installation at Manholes:

- Excavate site to the depth required. Allow 150mm all around the wall for backfill and 150mm for the base.
- Manholes installed in soil areas shall be installed so that the top of the cover is at least 100 mm above the final grade level of the restored surface to prevent accumulation of dirt, silt and debris on the top of the hand hole cover.
- Manholes conduit entries shall be sealed with duct plugs to prevent the intrusion of water and debris into the manholes
- The pulling of the cable shall be hand assisted at each Manhole or hand hole. The cable shall not be crushed, kinked or forced around a sharp corner. Sufficient slack shall be left at each end of the cable to allow proper cable termination
- The cable shall be marked and labelled at each manhole and at all entry and end points of the fibre optic cables. When all cables at each manhole are securely racked, unused conduits and void areas around conduit containing cables shall be sealed.
- The area around the manhole shall be compacted. Upon final acceptance of the conduit/duct system all manholes shall be free of debris and water, and be ready for cable installation.

5.0 DRAWINGS AND DOCUMENTS

The documents are an integral part of the equipment required to maintain and restore a fibre optic system. The following information shall be included in the documentation package.

5.1. Test Results

Hard and electronic copy of test documentation shall be submitted to the Company. The documentation shall include the trace plot, index, dB/km loss, cable length, date and time of test, wavelength, pulse width, the test site, cable ID, fiber number and type, and operator's initials. The Contractor shall compare the pre-installation test results to the post-installation

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results. If a deviation of greater than one dB occurs, the Company shall be notified in writing by the Contractor.

5.2. Key Map

The key map is a geographical map showing the system route in relation to roads and highways. Its purpose is to provide quick access to key areas of the system, such as field splice points and major road crossings. Sheath metre marks should be indicated on the map for splice points, road crossings, etc. It shall also provide horizontal and vertical alignment of FOC.

5.3. Circuit Diagram

The circuit diagram is a schematic that identifies the actual fibre circuits, system number, working and protected fibres, fibre/buffer colours, priority sequence during restoration and other pertinent information such as transposed fibres.

5.4. Manufacturer provided documentation

The manufacturer provided documentation should include the cable data sheets of each cable reel, documentation provided on the fibre, results of calculations of the field strength levels relative to different structure types. The original copy should be maintained and handed over to the Company representative for record.

5.5. As-Built Documentation

The as-built drawings and documents shall identify the actual apparatus units at each structure and other information such as the structure type and dimensions, cumulative distance to each termination point from the structure, any grounding or bonding detail, etc. These drawings and documents are typically the construction detail sheets that have been corrected to reflect any changes during construction. As built drawing shall record all deviations, deletions and additions with respect to the original scope.

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