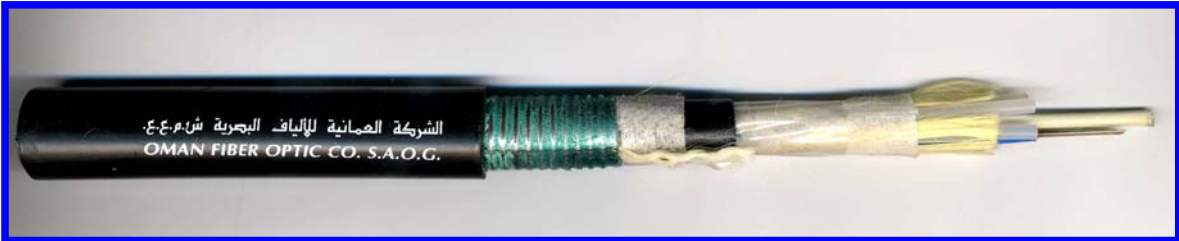




OMAN FIBER OPTIC, S.A.O.G.

General Installation Guidelines for Duct & Direct Buried Optical Cables

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PURPOSE & SCOPE

This document supercedes previous installation guidelines published by OFO.

The purpose of this document is to provide general guidelines for installation of optical cables in the following manner:

- ✓ Duct installation with pulling ropes, piston-type blowing or CableJet® method
- ✓ Direct buried by plowing or by trench & backfill method
- ✓ Aerial installation using messenger & lash method

Because it is impractical to cover all potential situations in the field, this document is not intended to be an exhaustive description of optical cable installation techniques. Rather, this document is intended to highlight the main concepts that are important to *prevent installation related cable damage and/or degradation of optical cable performance*. This document is not intended to supersede local practices, codes, laws or regulations.

As an additional preventive measure, Oman Fiber Optic Company (OFO) strongly recommends that the end user contact OFO with any cable installation related questions before beginning the installation work.

SAFETY ISSUES

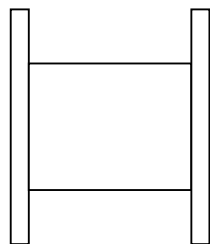
There are a number of key safety issues that are important to keep in mind while handling optical cables supplied by OFO or other supplier.

- ✓ Fire and safety regulations & laws limit the use of polyethylene-sheathed cables for indoor applications. Local fire codes must be consulted before deployment of cables.
- ✓ To prevent eye damage, never look into the end of an optical fiber unless a power meter is used to verify that no optical signal is present.
- ✓ All local government and end user regulations must be followed at all times.
- ✓ 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 OFO 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.

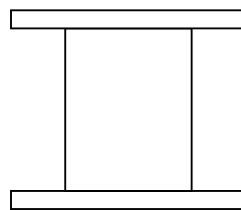


GENERAL RECOMMENDATIONS

- ✓ OFO strongly recommends a pre-survey of the route for all types of installations. Problem areas should be identified & fixed and an installation plan should be clearly defined prior to the start of the installation.
- ✓ For duct systems, the use of a main duct/innerduct system is strongly recommended by OFO. Use of innerduct provides additional physical protection of the cable as well as optimal use of main duct space and an individual low friction path for each cable. The duct should be placed so that it is straight. Waviness of the duct causes an undesired increase in cable tension.
- ✓ All ducts should be inspected prior to cable installation. Damage sections should be repaired and blockages cleared prior to removal.
- ✓ For direct burial of cables in difficult soil, a pre-rip (in the same direction as the installation) is recommended to improve plowing conditions. Vibratory plowing is the preferred method to static plowing because of its lower drawbar force.
- ✓ Use figure-8's 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 should be at least 5 meters long with each loop at least 2 meter minimum diameter.
- ✓ Petrol (gasoline) must NOT be used as a cable cleaner for any type of optical cable, including OFO. OFO recommends the use of Polywater optical cable cleaner (see www.polywater.com) or other effective orange-oil based cleaner.
- ✓ Always seal the end of the cable to prevent ingress of moisture and contaminants.
- ✓ Use of warning tapes is recommended.
- ✓ Special care should be taken during lashed aerial installation to assure the cables minimum bend radius is not exceeded when the cable is routed around the pole or into underground facilities.
- ✓ Roll drums only in the direction indicated by the arrow on the flange.
- ✓ Remove wood battens just prior to installation. For pre-installation tests, use the 3 meter inside end (routed through the flange).
- ✓ For long term storage of reels, it is advisable not to expose the reel to direct sunlight or excessive levels of moisture.
- ✓ Drums must not be laid flat for installation or storage.



OK



Not acceptable!



EQUIPMENT & MATERIALS

For all types of installation, the equipment in use **MUST** be capable of installing the cable without exceeding the maximum pulling tension or minimum bend radius.

OFO recommends the CableJet method for duct installation. When done correctly, the CableJet method provides the lowest friction, lowest tension method of installing optical cables into sealed duct system. OFO also strongly recommends the use of an after-cooler for all CableJet installation, particularly when the cable is to be installed in high ambient temperatures (such as those common in the Middle East). The use of an un-cooled compressed air source can cause a dramatic increase in the coefficient of friction between the duct and the cable sheath.

For duct pulling installations, a properly sized wire grip & swivel must be used for all cable pulling operations. A wire grip is designed to temporarily attach between a cable & pulling rope. OFO recommends Kellems® grips manufactured by Hubbell (www.hubbell.com). A swivel is a device that will spin to relieve torsional stresses that might build up in the cable or pulling rope during installation. The swivel can be a separate piece or it can be integrated with the wire grip.

Proper lubrication is vital for optical cable duct installation. For rope pulling of PE sheathed cables, a water based lubricant specifically designed for optical cables must be used. OFO recommends Polywater F for duct installation and Polywater Prelube 2000 for installation by CableJet. (see www.polywater.com). Bentonite, wax lubricants or liquid detergent must **NOT** be used as a pulling lubricant.

For plowing, the equipment in use must be capable of maintaining even & consistent cable tension and radii above the minimum bend radius of the cable. Particular importance should be paid to the plow itself. OFO cautions that some plows are not designed for use with optical cables.

For trench & backfill installation, a suitable amount of clean backfill should be used above & below the cable to prevent impact or compression damage to the cable.

For aerial installation by lashing method, all hardware fittings and pulling equipment must be able to complete the installation without exceeding the minimum bend radius and maximum pulling tension of the cable.



COMMUNICATIONS

Communications between installation personnel is vital to assure proper cable handling. Installation, splicing & testing crews must be equipped with radios, mobile phones, talk sets, order wires or other communication devices during the entire installation period to avoid accidental over-tensioning or other cable damage.

MAXIMUM PULLING TENSION (MPT)

All OFO optical cables have a rated maximum tension that is typically based on customer specifications. The MPT is clearly shown on cable specification sheet issued by OFO to the cable purchaser. If the MPT is unknown, contact OFO for details.

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. For questions regarding this important issue, please contact OFO.

MINIMUM BEND RADIUS (MBR)

Most OFO optical cables have the following minimum bend radius. Specific MBR is shown on cable specification sheet.

- ✓ 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 fibers.

REELS

OFO cables are normally supplied on wooden reels. These reels must be handled properly to assure optimum payoff control of the cable. Prior to installation, the installation crew must inspect the condition of the reel. If there is any evidence of reel damage, the damage must be repaired prior to installation to avoid damage or over-tensioning of the cable. Special attention must be paid to ensure there are no protruding nails or other sharp objects that can damage the cable sheath during payoff.



For cable payoff, the reels must be supported on a straight & sturdy axle through the central (arbor) hole. The payoff stand or payoff trailer must be located on firm & level ground. The payoff equipment must include a suitable back-tensioning device. Backtension pressure must NOT be applied to the drum flange. Do not lay reels on their side during installation or storage.

Also, when lifting the reel from above with a crane or other lifting device, a **spreader bar** must be used above the reel to prevent inward pressure on the top of the reel flanges. The proper technique is shown in the photo below.



SPLICE CLOSURES

The Raychem FOSC-400 series of closures are verified to be compatible with OFO optical cables and are the authorized joint closures for use with all types of PE sheathed cables supplied by OFO. The closure must be installed according to the instructions provided by Raychem. For specific questions regarding the proper assembly of the FOSC-400 series of closures, please contact OFO.

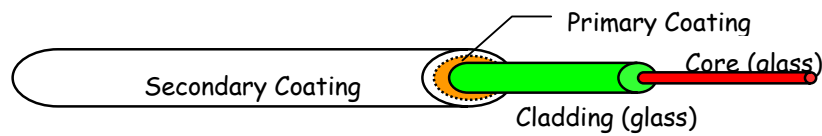
OFO cables are compatible with optical cable closures made by 3M, Lucent and other reputable manufacturers. For specific confirmation, please contact OFO.



SPLICING

The importance of splicing to long term cable reliability cannot be overstated. To provide the optimum performance and reliability, OFO strongly recommends fusion splicing. Following are important considerations for low-loss, reliable fusion splices.

- ✓ Use a quality, well-maintained cleaver that is capable of consistent, low angle cleaves.
- ✓ Maintain cleanliness and temperature/humidity/dust control of the splicing area
- ✓ Use a quality fusion splicer and maintain it according to the manufacturer recommendations.
- ✓ Perform an arc test periodically to verify splicer performance.
- ✓ Set the fusion splicer arc settings according to local temperature, humidity and altitude conditions.
- ✓ 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. See the drawing below.



SITE ACCEPTANCE TEST

OFO provides a test report for each drum of cable. The test report contains test data from the final inspection at the OFO factory. OFO recommends that the end user or installation contractor perform a site acceptance test prior to installation. OFO recommends a bi-directional OTDR test at 1310 & 1550 nm for singlemode fibers or bi-directional OTDR test at 850 & 1300 nm for GI multi-mode fibers.

OFO can provide site acceptance testing services to cable users, if desired. Please contact OFO for a quotation.

COMMISSIONING

OFO considers the following commissioning tests to be necessary to assure long service life and maximum upgradability.



- ✓ Bi-directional OTDR test at 1310 & 1550 nm for singlemode fibers or bi-directional OTDR test at 850 & 1300 nm for GI multi-mode fibers.
- ✓ Unidirectional "end to end" laser source/power meter test.
- ✓ Where high TDM bit rates (≥ 2.5 Gbps) are required at initial startup or for future expansion, a test of PMD (polarization mode dispersion) is necessary before and after cable installation.
- ✓ Microscopic inspection of all connectors (tails or jumpers).

PERIODIC MONITORING OF CABLE PERFORMANCE

OFO recommends detailed records be kept of commissioning measurements and that these measurements be used as a baseline to monitor the cable for any changes over its design lifetime.

OFO further recommends a cable-monitoring scheme to identify problems before they result in BER or LOS alarms. Typical cable-monitoring schemes include a periodic OTDR test and comparison against the baseline commissioning test values. Be sure to consider any measurement instrument bias between the baseline and test measurements.

TRACEABILITY

Each length of cable shipped by OFO has a unique cable number. The unique cable number is shown on the side of the shipping reel. In addition, because OFO is an ISO-9001 registered company, it has a complete system of material and process traceability tied into this cable number. Those involved with installation & use of cable should maintain this traceability by recording the location of each cable number because OFO needs the cable number to respond fully to questions, comments or complaints.

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