GENERAL FIBRE OPTIC CABLES INSTALLATION INSTRUCTIONS

Complete installation of Fibre Optic cables involves the following processes :

1.Transport, Storage, FO Cable Protection and Reel Handling

All optical cables are sensitive to damage during shipping, handling, and installation. Proper handling of cable reels/drums decreases the probability of accidental damage of cable, material & personnel. Such damage can degrade cable performance to the extent that replacement becomes necessary. Optical Fibre Cable is a valuable product. If handling is not done properly, the drum and in turn the cable may get damaged. At times, damage might not be discovered until the installation process, where repairing the cable gets extremely difficult and also expensive.

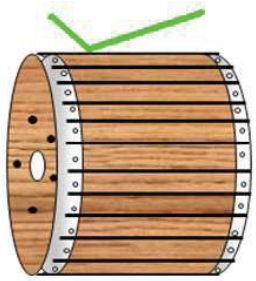
The drums with the cables cannot be thrown from any heights! The drums with optical cables have to always stand on the edges of the head, secured with a wedge to prevent movement. The only time when it is not necessary to secure the drums with a wedge is when the drums are mutually secured between each other by standing them crosswise.

It is possible to store simplex and duplex type cables and coils with cables up to 4 mm in diameter by laying them on the head. However, the cable has to be fastened by shrink wrap to prevent the loosening of individual cable coils. **Indoor Cables** can only be stored in closed areas without humidity.

Cables for **universal and outdoor** use, can be stored in outdoor conditions. However, the cable ends have to be waterproof. However, if the cable is on a plywood spool, it has to be stored in such a manner to prevent the effects of water on the spool.

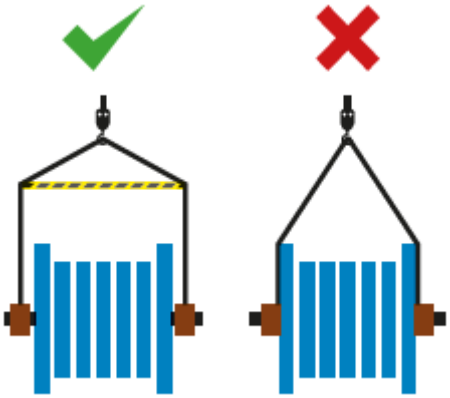
Keep the cable drum/reel protected with outer covering till the time it is used on site

Drum covered with wooden lags



Lift the drums without damage

When lifting the drum; use a shaft through the centre of the drum and a spreader beam. In case spreader is not used the rope may damage the flanges of the drum which can cause cable damage.



Handling with Forklift

Ensure the drums to be moved in the upright position and the fork must be longer than the width of the drum.

Keep the Drum in the upright position

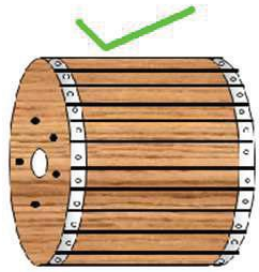
The drum is designed to be handled in the upright position. It may not sustain if lifted laying flat. When stored in the upright position, the cable-layers do not get entangled during uncoiling.

Note: Always store and move the drums in upright position. In no case, should the drums be stored 'on the flat' that is with flange horizontal.

Roll the drums only as per the direction marked on the drum flanges

When the drums need to be rolled due to some reason, always roll the drums in the direction of the arrow marked on the drum flanges. This way the cable over the drum will not loosen. However, this does not mean that the drum can be rolled freely for any distance. Limit rolling distance 5-10 meters. Once placed in position, use a proper stopper to prevent drums from rolling.

Drum on flange edge



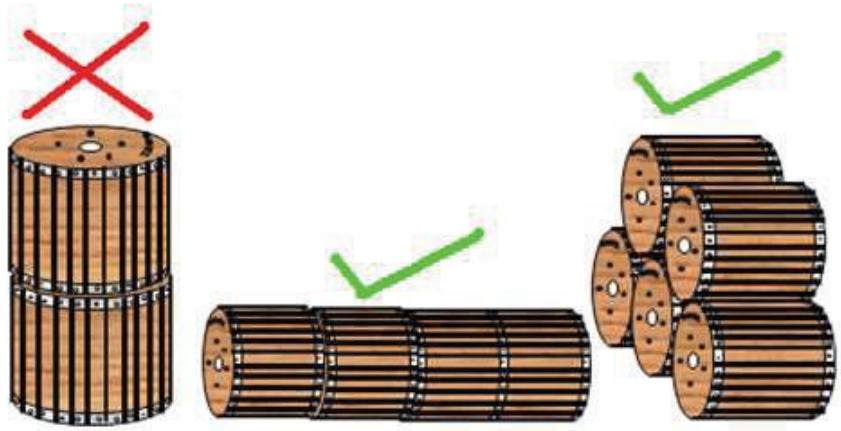
Drum transportation, Storage and cable handling

During transportation, the cable drums should not be kept in Flat position; it crushes the down the layer of the cable, resulting in fibre breakage.
The cable drums should always be kept in the upright position and be tied with a Chain or Belt with wooden blocks should be kept in between the flanges of each drum to avoid any jerks/movements during transportation.

While unloading the truck, it is important that the cable drum should not be dropped directly on the floor. The weight of Drum & cable may cause deflection of Drum flange resulting flattening, deformation or damage of cable. The drum must be rolled from the truck on to receiving platform, which should be in the same height as the tailgate of the truck. An alternate is to use a forklift to unload drums from the truck.

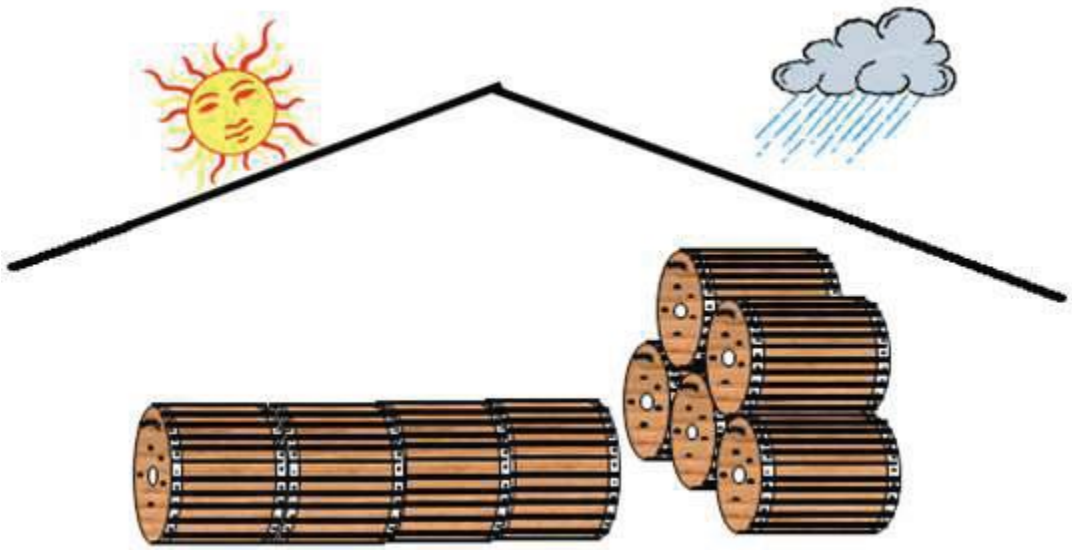
Note: If inclined ramps are used, roll the drums over it; but don't allow them to roll out of control. Roll each drum away from the bottom of the ramp before handling the next drum.

The drums should always be stored in an upright position. Storage of drums in an alternative position can lead to winding defects.



If storage place is limited and it becomes necessary to stack, then stack the completely wrapped on their flanges. Stacking is allowed only for the drums whose flange diameter is 125 cm or less. Do not store drums on flat flanges

The cable on the reel should be covered at the factory with a UV/thermal wrap until just before installation to protect it from exposure to the sun and high temperatures.



There are six principle installation methods. Operators can choose from FO direct buried cable, Aerial FO cable, FO cable-in-duct, blown fibre cable, pulled FO cable, or pushed deployments – their determination will be based on landscape, cost and installation speeds.

Cable pre-installed in duct provides greater protection from accidental damage than buried cable. If a duct is struck by a digger, for example, it may collapse in on itself without necessarily damaging the fibre. Unlike direct buried cable, cable installed in a duct can also be replaced relatively easily. Both duct and cable can be purchased separately or together from manufacturers and re-installed in the ground.

FIBRE OPTIC CABLE INSTALLATION INSTRUCTIONS

This procedure describes general information for installation of optical fibre cable in HDPE ducts. There are two basic methods of installation of duct cable, i.e. pulling method & blowing method, which should be selected based on route length, site condition & accessibility of required equipment, etc. Planning the actual installation should take place only after a thorough route survey. The installation method to be used will be largely dictated by the cable route.

2. Route survey and pre-installation :

The pre-installation survey of the route is recommended to identify the problem areas, fix them and define an installation plan before the start of installation.

For smooth operation of installation work, it is very important to make necessary arrangements of tools/machineries, managing route & manpower etc.

When a drum is received at site, inspect it for any physical damage. Properly fix bottom end of the cable so that it will not damage & make inconvenience for rolling drum . Load optical fibre cable drum on pay off so that cable can be pulled from the top of the drum. Which helps proper straightening of the cable when it pays out and prevents it from rubbing in the ground?

Placing operations in all types of plant (aerial, buried, and underground) usually is easier when done downhill. Try to configure the placing operation downhill.

Rewinding and unwinding of fibre optic cables

The rewinding and unwinding of cables are only possible in temperature above 5°C. If for any reason, it is necessary to unwind the cable at a lower temperature, the cable has to be left at a minimum temperature of 20°C for at least 24 hours beforehand. For rewinding the cable, the winding (bending) direction of the cable has to be maintained and unwinding cannot form an “S” shape.

When unwinding the cable, it is necessary to maintain continuous pull without variation. Unwinding without pull can then lead to the loosening of individual rolls and to the consequent mutual under the pull, possibly to the uncontrolled, sharp tugging of the cable, resulting in the damaging of the optical fibres.

Before starting installation ensure that all cable pathways are completely & thoroughly cleaned.

Choice of Cable Laying Technique :

1. The Pulling method is used when the blowing machinery is not available. Further, when the route length is small, this technique is useful. To use this method, it is necessary to have preinstalled rope inside the HDPE duct.

2. The Blowing method is used when route length is more & blowing machine can be accessible at duct/chamber points.

Installation process

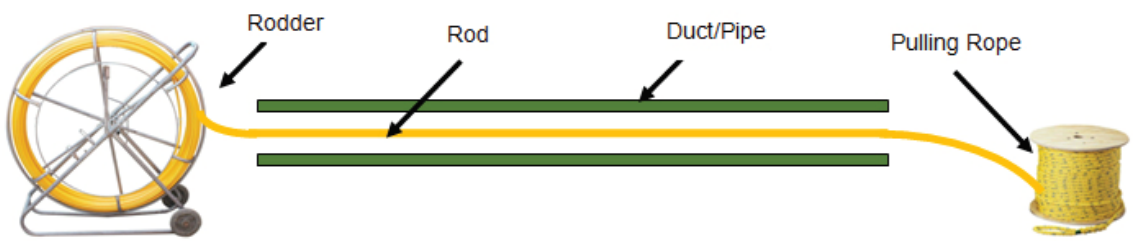
Practically installation of cable starts with the step of pulling /blowing and is the most important step in the installation completion.

To avoid any damage to the cable, follow the general instructions given below :

3. Cable pulling

The basic approach to pulling optical fibre cable differs a little from techniques used to pull the copper or aluminium power cables. In this method, the Optical Fibre Cable can be pulled by hand or using a cable-pulling winch at every chamber location.

Ensure that there is a pulling rope available in the duct. If pulling rope is not available inside the ducts then first install the pulling rope with the help of rodder as shown in Figure below. Push the rodder rod through one end of the duct/pipe and as the rodder rod reaches to other end of the duct/pipe, tie the pulling rope with the rodder rod at other end and reel back the rodder rod.



Pulling Procedure :

Shift the cable drum at the centre location of pulling the route length so that bi-directional pulls are possible by laying the cable into large figure-8 shapes loops on the ground. Thus it could be fed from both ends for both directions.

Load the cable drum on Jacks/drum pay off so that the cable can be pulled straight from the top of the drum. Check for cable upper layer for any cross winding & before start pulling. Tighten the cable pulling grip end with the anti-twisting device. Connect this pulling grip to the preinstalled rope.

While pulling the cable through the duct, always watch the cable entry & exit point and ensure that the cable should not bend below specified minimum bending radius, which may create permanent damage to cable & fibres. If the cable is pulled continuously for its whole length then put a person at every 200 m intervals/chamber location (or maximum possible length for which cable tension will not increase above its rated load) for pulling cable so that pulling tension will not exceed rated strength .

Make Figure 8 at every 200 m intervals/chamber location. Take extreme care while making Figure 8 & pulling it for the next span. This is the most sensitive place for cable bending. Always pull the cable in a straight direction.

Ensure that the pulling force is kept below the specified limit and also be kept uniform. Whenever the cable is pulled by cable-pulling winch, tension monitoring equipment must used to monitor uniform tension.

Cable pulling Tension:

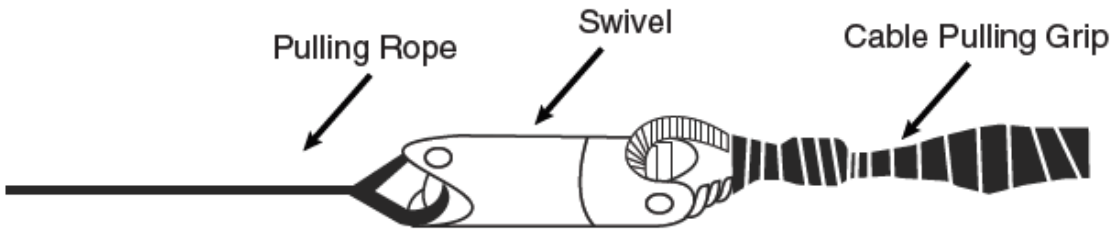
Do not pull the cable above its rated pulling tension. Pull maximum cable length so that it does not exceed its rated tension. The pull length depends on the cable weight, friction between cable & duct, duct cleanliness & bends in duct, etc. Use pulling grips with swivel to attach the pull rope. Use proper lubricants compatible with cable jacket & ducts. Connect proper pulling grip with a swivel between pulling rope & cable.

Pushing fibre optic cable

With pushing, the selected cable should be flexible enough to push around corners, yet stiff enough not to buckle in long routes where high levels of friction are generated. In many respects, pushing is much simpler – there is only one step in the process. In addition, pushing the cable into a microduct or conduit applies zero tensile load to the cable, reducing the instances of damaged cable or strained fibre. When rodding/ pulling seems like the only option, pushing can be a viable alternative solution, provided the cable has the right characteristics.

Cable Twisting :

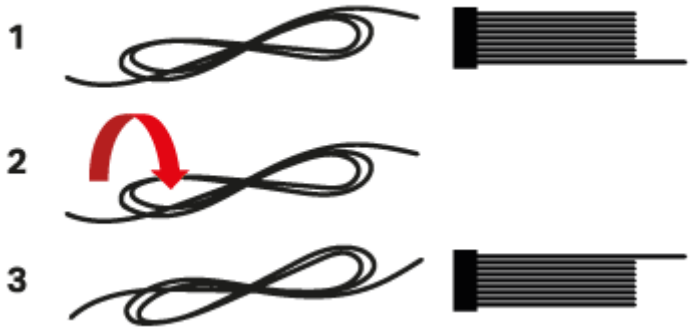
Cable twist can develop stress on the fibres and therefor need to be avoided. Tension on the cable and pulling ropes can cause cable twisting. Use a swivel pulling eye to connect the pulling rope to the cable prevents pulling tension causing twisting forces on the Cable.



Avoid twisting the cable during installation because this can cause stress to the fibre. If you install a cable longer than 30m and you are pulling it through a narrower section (for example, underground), unwind the cable beforehand.

Place cables freely in an eight-shape figure on the floor. Placing cables in a loop prevents twisting. The diameter of the loop should be 2–4m, depending on the rigidity of the cable. The length of the figure “8” is 8-10m. It is recommended to place for example, cardboard paper between individual rolls.

Prior to taking the cable from the figure 8, tilt it by 180°, with the aid of other persons, so that the beginning of the cable is facing upward. After pulling it through, **do not wind it back up onto the drum**, but place it back in a figure "8" for further laying.

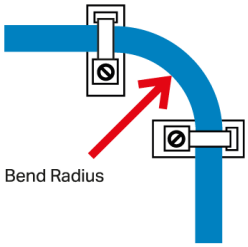


Cable Lubricants

Use of cable lubricants to reduce co-efficient of friction between cable outer surface and duct inner surface is recommended to pull cable in a duct route having multiple bends, elevation and undulations. The lubricant material should not react with the outer cable sheath (don't use soap water, kerosene, diesel).
Putting twist in cable increases much your chance of breaking the fibre.

Minimum Bending radius :

Optical fibre cables are designed with a minimum bending radius and maximum tensile strength. The cable should never be bent below its minimum bending radius. Doing so can result in bending losses and/or breaks in the cable's fibres. Generally the minimum bending radius of a fibre cable under load is 20 × D, where D is the diameter of cable; the minimum bending radius of a fibre cable under no load is 15 × D.

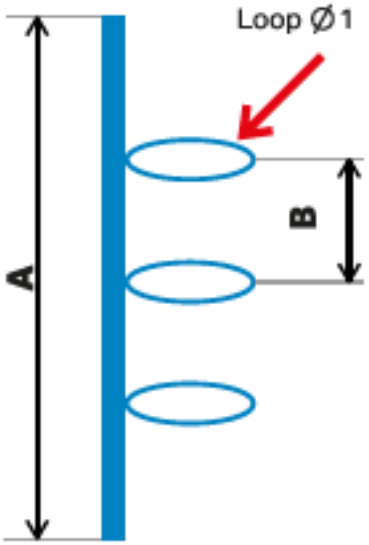


Vertical Installation

A gel, resistant to dripping up to 70°C for a period of 24 hours, is used in some fibre optical cables. This gel doesn't contain oil and maintains its characteristics for the entire lifetime of the cable. Therefore, it is possible to install optical cables with independent secondary protection, a gel-filled central tube, vertically.

This does not apply for multi-tubes, where the inner cable tube (the space between the individual tubes) is filled with gel. We do not recommend installing such cables vertically. Conditions for the bend radius of the pull strength and other parameters are the same as for any common horizontal installation. The procedure applies for installation outdoors as well as indoors, sewage systems, etc.

The vertical placement of cables has to be fastened by clamps, to prevent sliding. The maximum distance between individual clamps has to be such, where the weight of the cables between the clamps exceeds the pull strength and does not strain the fibres in the cable. Horizontal loops will form on vertically running cable as a relief element and protection against the possible movement of the cable in case of vibration of the load-bearing construction against fixed mounting in the lower part of the cable. The distance of the loops depends on the inner diameter of the tubes in the cable.



Tube Diameter	≤1,7 mm	1,8–2,6 mm
A	500 m	300 m
B	20	20

If the cable in the lower part directly enters into the connector panel, it should enter by three loops. The purpose of this is to compare the change in the lengths of cables given the change in temperatures. This is from the lower part of the panel.

4. Blowing Method

Cable blowing is an advance technique for cable installation in duct. This process is very fast comparative to traditional pulling and very effective for longer distance route.

Cable blowing is the process of blowing optical fibre cable through a duct while simultaneously pushing the cable into the duct. Compressed air is injected at the duct inlet and flows through the duct and along the cable at high speed.

Blowing Procedure

Load cable drum on Jacks so that the cable can be blown from the top of the drum. Properly fix bottom end of the cable so that it will not damage & make inconvenience for rolling drum before pulling cable. Check any cross winding of cable present if it is there remove it & then proceed for further blowing.

Start blowing very slowly to avoid whipping up & jerks on the drum. The blowing speed can be gradually and steadily increased. Set blowing pressure as per requirements of machine, cable & ducts.

While blowing cables threw duct always watch the cable entry point so that cable should not bend below its bending diameter .this may cause permanent damage to cable & fibres. Set machine for proper pressure so that no cable or duct component will damage. While pulling cable may get stuck due to the bending of ducts and /or couplers joint. Don’t increase the rated pressure. Find out cable stuck point in duct. Take the cable out at these points make figure 8 for further blowing from these points. Take extreme care to avoid bending while blowing next to these ducts.

4.1 Installation techniques of blown fibre Multiduct

Laying instruction

This section discusses various multiduct installation options in general terms and should not be interpreted as a step-by-step guide or “operations manual.” The user should contact the equipment manufacturer for more detailed instruction, as operating procedures will vary with equipment.

NOTE: The consequences of striking gas or power lines (above and below ground) during installation can be dangerous, possibly deadly. Before digging, it is critical to ensure that all existing underground service lines (gas, water, power, etc.) in the vicinity are located and marked. It is recommended to contact the local “Call before You Dig” agency to ensure these provisions are made. Furthermore, prior to installation, consult any applicable local codes.

Trench quality

- The trench should be dug as straight, level and rock-free as possible.
- Avoid curves smaller than the conduit’s allowable bend radius.
- Undercut inside corners to increase the radius of the bend.

Should there be a rapid grade change, use back-fill to support the conduit.
Excavate the trench to the desired depth (follow your local standards and authorities, but never less than freezing depth), and remove all rocks and large stones from the bottom of the trench to prevent damage to the conduit. Push some clean fill (fine material, without stones) into the trench to cushion the conduit as it is installed in the trench.

Supplemental trenches should be made to all offset enclosure locations. Trench intersections should be excavated to provide adequate space to make sweeping bends in the multiduct conduit. Fill the trench and compact as required. Tamp the trench to provide compaction that will prevent the trench backfill from settling.

Any rock or stones can cause damage to the multiduct. Therefore, if the soil is rocky then sand bed and a cover are necessary to protect the conduit against damage.

Uniformity of support and proper alignment of the pipe requires a trench bottom of stable soils and free of protruding rocks. Good practice often requires over-excavation and replacement of the foundation material with a suitably-graded soil mixture to inhibit migration of fines and subsequent loss of pipe support.

Bedding is required to establish line and grade and to provide a firm, but not hard, pipe support. Compacted granular material over a flat trench foundation should be spread evenly and compacted.

Placing Multiduct into an open trench

An important consideration for open-trench installations of multiducts is that the conduit should be straightened to remove any residual “shape memory” from the coil, which can create a tortuous path for the cable and cause significant challenges to cable installation afterwards.

Conduit placement can be accomplished by pulling the conduit into the trench from a stationary reel or by laying the conduit into the trench from a moving reel, usually attached to a trailer.

Spacers should be used when placing multiple multiducts in a trench. Spacers prevent the ducts from twisting over and around each other. By keeping the ducts in straight alignment, cable-pulling tensions are reduced. When water is present in the trench, or when using extremely wet concrete slurry, floating of the conduit can be restricted through the use of the spacers.

Multiducts can be delivered on-site either in coil or on a wooden drum.

The coil must be placed on a vertical/Horizontal de-coiler to unwind the multiduct into the open trench. Once the trench is ready in all respects for placement of multiduct into it, straps on the coil are cut appropriately and de-coiler is slowly rotated to unwind the multiduct along the trench plane.

Preferably, the multiduct is delivered on a wooden drum.

Installing multiduct into an open trench from a drum, following basic rules should be followed :

- conduit should be uncoiled from the bottom and not from the top of the reel.
- during uncoiling process, decoiler should be rotated slowly to avoid over-spining of reel which can result in damage to the multiduct
- Multiduct can be placed into an open trench either directly from the coil or temporarily laid alongside the trench and placed later on to eliminate shape memory.

Horizontal Directional Drilling (H.D.D)

When multiduct is installed by H.D.D where open trenching is not possible or permitted, the operator that is executing the laying of the multiduct by H.D.D machine should refer and abide to the product specifications for the maximum allowable pulling force that can be exerted on the multiduct for safe installation.

Tensile strength

Regardless of the installation method, mechanical stress is of great concern during conduit placement. Exceeding the maximum allowable pulling tension or the minimum allowable bending radius can damage the multiduct. Read carefully the specifications corresponding to your multiduct configuration for allowable pulling tensions.

During conduit pulling placement, attention should be given to the number of sweeps, bends or offsets and their distribution over the pull. Tail loading is the tension in the cable caused by the mass of the conduit on the reel and reel brakes. Tail loading is controlled by two methods. Using minimal braking during the pay-off of the conduit from the reel at times can minimize tension; no braking is preferred. Rotating the reel in the direction of pay-off can also minimize tail loading.

Breakaway swivels should be placed on the conduit to ensure that the maximum allowable tension for that specific conduit type is not exceeded. The swivel is placed between the winch line and pulling grip. A breakaway swivel is required for each conduit.

Ambient temperature

The multiduct bundles can be handled and buried at temperatures between -10°C and +50°C. When the temperature is below -10°C the ducts get brittle and under stress, especially under impact stress, they can crack. Storing the ducts without handling them under temperatures common in our climate (up to -30°C) no damage or deterioration of mechanical properties of the ducts will occur.

When the ducts are buried the inner wall has to be kept dry and clean. Any moisture, earth, sand and other impurities can increase the coefficient of friction between the inner wall of the duct and the cable sheath, which may cause a significant reduction of the cable installation distances.

Bending radius

The minimum bending radius is always connected with the size of your multiduct bundle. See the appropriate datasheet of your configuration for reference.
Anyway there is a basic rule – never exceed the limits of :

Minimal bend radius > 10 x MAX OD
Also ambient temperature makes a difference.
The lower temperature is the bigger bending radius has to be used for safe installation.

NOTE: The bigger the bending radius was applied, the bigger the blowing distance will be later when blowing cable in. Also, any vertical offsets should be avoided or made as smooth as possible.

Labelling/Marking

If required, the microduct, protected microduct, microduct optical fibre cable and microduct fibre unit shall be marked for identification purposes as agreed between the customer and supplier.

It is recommended to put labels at least at :

- each access point (duct ends, manholes, handholes, distribution points etc.)
- every 3-5 meters if there is no marking on the ducts itself
- connection and branching points

Trench back fill

It is best to place the best quality soil directly on and around the conduit.

- **DO NOT place any rocks directly on the conduit.**
- Allow at least 5 – 10 cm of clean, uniform soil to cushion the conduit.
- If possible, utilize sand for padding the conduit.
- warning tape should be placed typically 20-30 cm above the multiduct conduit.

It provides a more stable environment for the multiduct conduit, prohibiting damage from rocks and allowing water to drain away from conduit easily. More importantly is the protection it can provide during a future excavation near your facilities. The apparent change in soil condition provides warning that there is a utility buried there. This should not replace the practice of placing warning tape, but rather should serve as a supplement.

Not only is backfill utilized to fill the trench, but it also serves a very specific design function. The main purpose of the backfill material is to provide adequate support and protection for the multiduct conduit. By ensuring the backfill is solid and continuous, damage can be prevented from surface traffic, falling rock or lifting due to the trench filling with water.

It is important that the initial backfill is consolidated to ensure continuous contact and support of the conduit.

All trenches should be backfilled as soon as practicable, but not later than the end of each working day. Also, care should be taken to protect excavated soil from collecting moisture while the trench is prepared and pipe is laid. Uniformity of the underlying soil that forms the trench bottom will avoid stress concentrations and associated irregular pipe deformations.

Summary – basic steps to follow for blown fibre ducts

The successful performance of buried pipelines of all materials is dependent on the interest, care and attention to detail on the part of the contractor. Installation contractors should have a basic understanding of the pipe/soil composites structure. This will enable the contractor to anticipate problems that may arise from poor construction practice not otherwise recognized as such. The following are the key areas of consideration:

- Proper excavation and preparation of the trench will inhibit unanticipated longitudinal and cross-sectional strains and stresses in the pipe.
- Use only fine soil as a backfill
- Warning tape above the conduit
- Work within material limits – respect technical specs (min. bend radius, tensile strength, ambient temperature etc.)
- Always follow your local safety rules

5. Aerial FO Cable (Facade & ADSS)

Working with optical fibre requires specific skills and training - and performing that work at height is no exception. Aerial linemen should not only be competent and safe at height work, but they should also have permits for working near electricity cables and in a range of weather environments. Having a good understanding of the nature of the aerial environment and the additional precautions it demands will also stand them in good stead.

Some of these factors include cable sag, strain, tension, galloping and aeolian vibration – but they are not limited to this list.

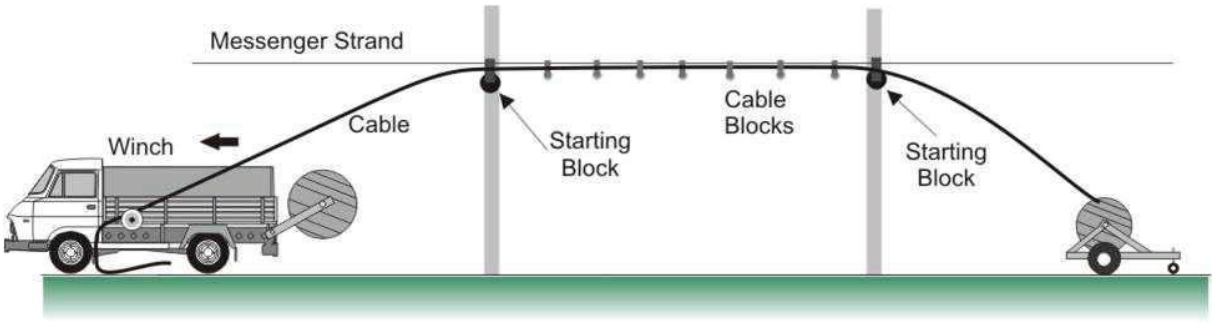
Stationary reel placing method

Providing permission is granted, the operator can move to the next stage of installation. At this point, they will need to decide whether they want to install the cable using moving reels or fixed reels.

The stationary reel placing method is generally used when the cable is installed above the existing lateral cable and other obstructions. The choice may also depend on the types of vehicles and placing equipment that is available to the installer.

First of all, a series of temporary cable supports, chutes or tangent blocks are installed at each pole along the route. Next, a pull line is threaded through the cable supports and attached to the outside of the cable using a breakaway swivel and a cable pulling grip. The pull line is then used to pull the cable through the cable blocks into position.

If the cable is pulled with a winch, the pulling rope or winch line must be installed through the cable supports. A non-metallic rope or winch line should then be used to pull the cable.



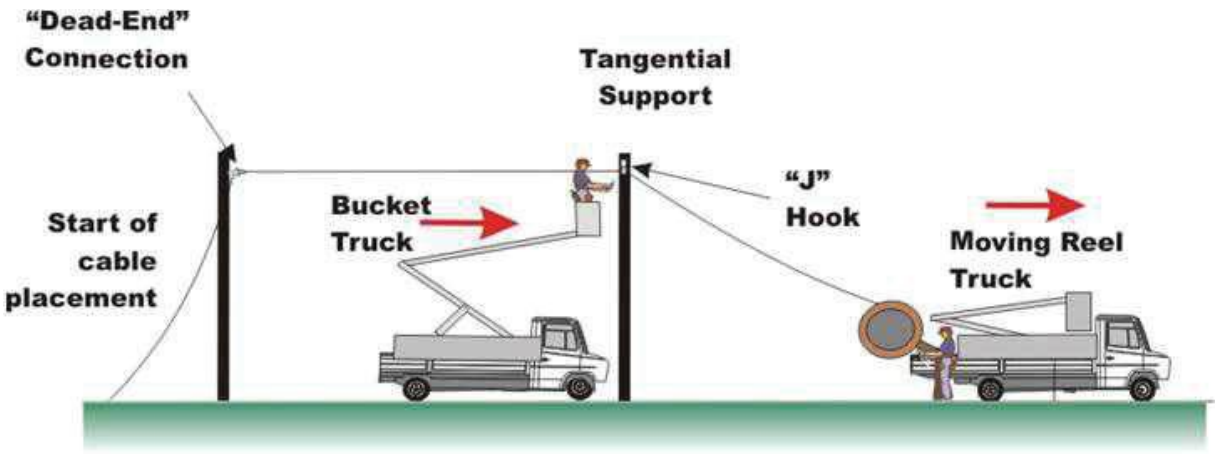
It is vital that the pulling winch is calibrated to stop the operation when the installation tension exceeds the maximum rated cable load (MRCL). If this type of winch isn't available, a dynamometer can be used to monitor installation tension. The dynamometer must be equipped with an audible alarm or visual display that allows the pulling operation to be stopped when the installation tension reaches the MRCL.

After the cable has been pulled into its final position with slack for building access or for splicing, the cable should be tensioned until the correct sag level is reached. It should then be terminated at each dead-end pole along the route.

Moving reel placing method

The moving reel method can be used in situations where a cable reel trailer or aerial lift truck can be moved along the pole line and there are no obstructions to prevent raising the cable. It should be noted that the moving reel method is a one-pass operation and does not require the use of cable blocks or pull lines.

In the first place, the cable reel should be mounted on a reel carrier off a cable trailer or aerial line truck. Next, the reel carrier should be driven along the cable route. As it advances along the route, the cable ought to be paid off the reel with no back tension on the reel, guided to the pole, and supported with appropriate hardware.



When using the moving reel method, operators must ensure that the aerial line truck or cable truck is about 10 to 15 metres ahead of the first pole position. This ensures that there is sufficient slack cable available for splicing and slack storage.

During the operation, the installer should fit the appropriate dead-end support to the cable, raise it to the correct support level and mount the dead-end to the pole.

The placing vehicle must then be driven parallel to and as close to the pole line as possible, while maintaining constant speed and tension. Once the cable pay-off is 10-15 metres past the next pole in the route, the cable should be raised to the required pole height and placed into a J hook or temporary support.

The cable installation should then continue span by span until the entire run is completed and the final dead-end pole has been reached. At this point the cable should be tensioned to the correct sag level using suitable chain hoist equipment at the "free" end of the cable, before it is dead-ended to the pole.

Once this has been done, the cable can be lifted out of the temporary J hooks or temporary supports and permanently fixed using tangent assemblies.

The moving reel method is a one-pass operation and does not require the use of cable blocks or pull lines. The selection of attachment hardware for aerial cable is vast and solutions exist to reduce vibration, coil excess cable, to provide mid-span drops and tangent support. Perhaps the most widely used hardware though, will be the dead-end attachments. Broadly speaking, this category can be split between a formed wire design and the wedge anchor clamp type.

The formed wire dead-ends function by gripping the cable uniformly over the length of the support, typically two to four feet in length. For this reason they are often seen as the strongest solution for long spans. The alternative wedge clamp dead-end works by anchoring the cable between opposing wedge blocks, gripping a shorter distance of cable; perhaps only 15 to 30 cm. Wedge supports are perhaps better suited to scenarios where strain is less of an issue and spans and below 100 m.

Aerial cable is no different from other fibre cables when it comes to termination, and can be field spliced or deployed pre-terminated. Each method has its pros and cons. For the last drop especially, many network operators choose to use pre-terminated aerial cable because it eliminates the need for time-consuming and expensive fusion splicing.

The main drawback to using a pre-terminated cable is that there is almost always excess cable left over from installations. Fusion splicing offers a high-quality connection and little excess cable is left over once the process is complete. However, it is a time-consuming process and specialist equipment and experienced engineers are needed to carry it out. The whole process of preparing and splicing the fibres is made more difficult when the network access point is mounted at pole height.

As previously noted, aerial cables are subject to tensile loads, static fatigue and fibre strain. In a bid to counteract these factors, some manufacturers have produced cables with

integrated strength members. Incorporating tensile reinforcing rods often mean that the cable design is “flat”, or with a central reinforcing element, separate to the cable sheath.

This adds new challenges to fibre termination and supporting the cable. Thankfully, some manufacturers have incorporated the strength rods inside the sheath wall (jacket), allowing the cable to be suspended using standard “round” termination and supporting accessories. Cable and duct designs with this feature are not prone to splitting; where the strength element becomes detached from the main sheath and the tensile integrity is compromised.

6. Fibre safety rules at installation

- Keep all food and beverages out of the work area. If fibre particles are ingested they can cause internal hemorrhaging.

- Wear disposable aprons to minimize fibre particles on your clothing. Fibre particles on your clothing can later get into food, drinks, and/or be ingested by other means.

- Always wear safety glasses with side shields, suitable safety helmet, safety belts and protective gloves. Handle the fibre optic splinters similar to glass splinters.

- Never look directly through the end of fibre cables till you ensure that there is no light source at the other end. Use a fibre optic power meter to make sure that fibre is dark. When using an optical tracer or continuity checker, look at the fibre from an angle at least 6 inches away from your eye to determine if the visible light is present. Only work in well-ventilated areas.

- Do not touch your eyes while working with fibre optic systems until they have been thoroughly washed.

- Keep all combustible materials away from the curing ovens.

- Dispose the fibre scraps properly.

- Thoroughly clean your work area after completion of installation.

- Do not smoke while working with fibre optic systems to avoid dust problems and explosion from gas.

7. Jointing, Termination and Labelling

The optical fibre cables are joined by Fusion splicing process by following colour code or sequence of buffer tubes and fibres in the cable and secure it in joint closure box at every joint location. Optical fibres may be connected to each other by connectors or by splicing, i.e. joining two fibres together to form a continuous optical waveguide.

The generally accepted splicing method is arc fusion splicing, which melts the fibre ends together with an electric arc.

Mechanical fibre splices are designed to be quicker and easier to install, but there is still the need for stripping, careful cleaning and precision cleaving. The fibre ends are aligned and held together by a precision-made sleeve, often using a clear index-matching gel that enhances the transmission of light across the joint. Such joints typically have a higher optical loss and are less robust than fusion splices, especially if the gel is used. All splicing techniques involve installing an enclosure that protects the splice.

At both ends of the link, the fibres of the cable are terminated in connectors that hold the fibre end precisely and securely and fixed in FDMS (Fibre Distribution Management System) or ODF (Optical Distribution Frame)

Dirt, dust and other contaminants are the enemies of high-speed data transmission over optical fibre, as even the most minor of scratches or defects can present problems further down the line.

Optical fibre connectors are used to join optical fibres wherever a connect/disconnect ability is required. Connectors are most commonly comprised of a spring-loaded ceramic ferrule, which aligns two mating connectors in a circuit. However, before they can be used in FTTx applications, the connector ferrules first need to be polished to achieve the required angle and end-face geometry.

Applying the right polishing process, or 'recipe,' ensures the connector end-faces are free of defects or scratches. While this process is generally managed within a manufacturing facility, there are occasions where assembly and polishing operations need to be undertaken in the field.

Microscope Inspection

Most operators will demand connector performance in line with the IEC (**International Electrotechnical Commission**) standard - the technical authority on connector performance that provides tables of parameters for defects and scratches on the connector interface.

Adhering to these strict guidelines ensures connectors meet quality standards in the field, which will have a direct impact on optical signal performance and on the efficiency of the entire network. The fibre core zone, for example, is especially important as it's where the light is transmitted and is very sensitive to contaminants.

If your connector passes the microscope inspection, but still has more scratches than you feel comfortable with, a good option is to run through the polishing process again. Having just a few scratches or defects can cause problems further down the line, and even previously acceptable scratches can fail over time, so it's vital these are identified from the outset. You might choose to repeat the entire 'recipe', or perhaps just the last two or three steps to re-finish. It's also worth checking to see if your fibre optic sensor (FOS) has reached the end of its life, as this can directly impact your inspection results.

Cleaning of fibre connectors

While there is a broad range of connector cleaning products on the market, it's always advisable to use the minimum materials necessary. Your microscope inspection results will be your best guide as to what level of cleaning is required.

Depending on how dirty the connector end-face is, sometimes a simple wipe with a lint-free towel is all that's needed. In other circumstances, it's better to use a click-cleaner, which will remove dust and oil from fibre end-faces without the use of alcohol.

Connectors should always be clean and dry before inserting into sensitive test and measurement equipment. Another way to clean a connector is by using a can of air duster. When using an air duster, it's important to give the trigger a quick squeeze to expel any contaminants that may have settled between uses.

You can remove any moisture during the aerosol process by inverting the can. Many professional termination laboratories have a dry compressed air setup in place of an aerosol.

8. Testing of the fibre optical cable link

Optical cables are tested by their manufacturer at the factory during and after manufacture, again after delivery by the contractor or his agent, and finally after construction by the contractor, his agent, or the end-user.

A summary of the factory tests is usually provided by the cable manufacturer as part of a cable characterization packet accompanying each cable shipped.

Pre-construction Fibre Measurements

The cable on all reels need to be inspected for damage as they are received. As a precaution and to avoid costly extra cable removal operations, all fibres should be measured on the reel using an OTDR. Measurements on single-mode fibre cables should be made at user-specified wavelengths or both 1550 nm and 1300 nm.

1. Optical continuity in all fibres.
2. Length of each fibre.
3. The optical attenuation coefficient of each fibre at user-specified wavelengths.

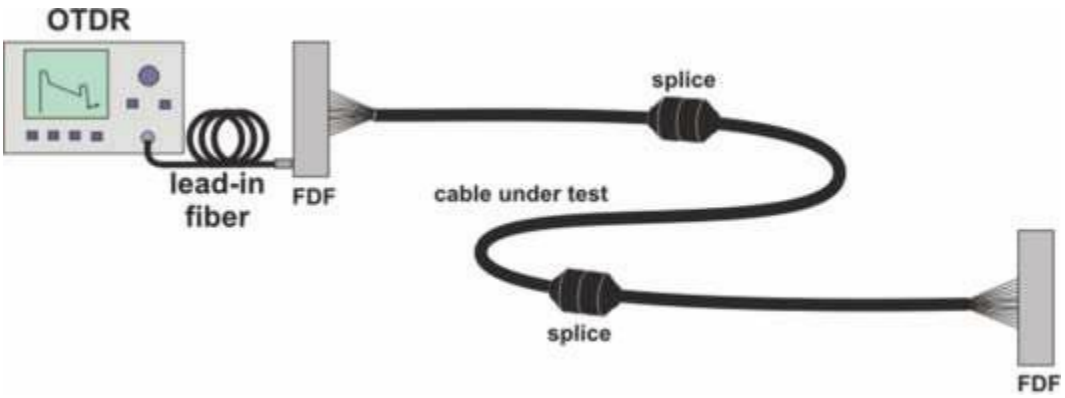
Post-construction measurements provide assurance that cable placing, splicing, and link construction activities have been completed that will enable the intended transmission system to function properly and to provide support for any future maintenance activities on the link. Most post-construction optical fibre loss measurements use the cut back method (TIA 455-78) or the back reflection method (TIA 455-8) to determine their measured quantity. The cutback method and the back reflection method are mainly used for testing at the manufacturing facility and the back reflection method is normally used in the field for most tests. An optical time-domain reflectometer (OTDR) is the back reflection, portable optical test set used in the field for pre- and post-construction fibre measurements.

The most common post-construction measurements include the following:

- Length of the fibre link
- Attenuation for fibre link
- Splice losses
- Optical return loss
- Reflectance or high loss in link

Post link measurements setup and Equipment Used

Figures below provide schematic drawings of the two primary setups that are commonly used to test new fibre links: first, using an **OTDR** with a lead- in fibre and second, using two optical loss test sets or a stabilized light source and optical power meter.

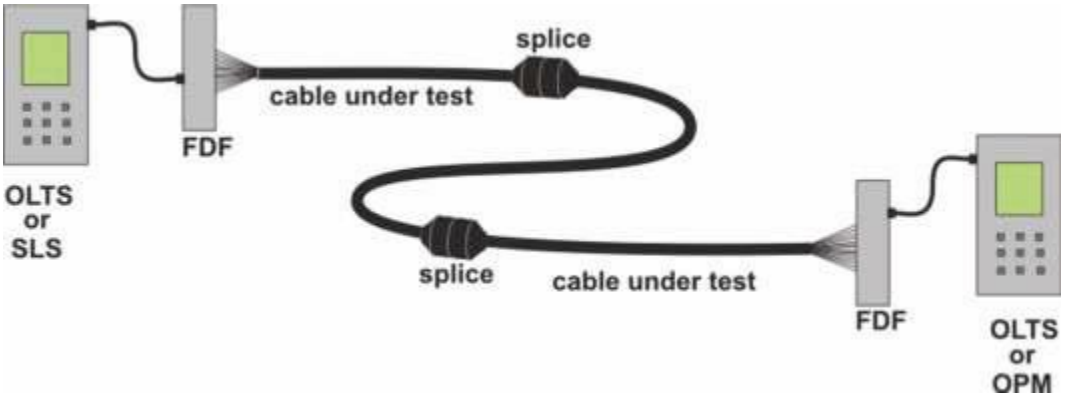


Schematic Setup of OTDR Used to Measure Link Loss of Fibre

Note: Following the OTDR manufacturer's instructions, set the fibre group index to 1.4670 for measurements at 1310 nm and 1.4675 for measurements at 1550 nm. The group index is used by the OTDR to convert time-of-flight of OTDR pulse to distance.

Fibre Link End-to-End Measurements Using an OLTS or SLS/OPM

This same measurement can be made between a SLS and an OPM at the preselected wavelengths that represent the working transmission wavelengths. These units must be zeroed at the start of the measurement process.



OLTS or SLS/OPM Measurement

While OTDRs may provide the most economical solution to post-construction measurement issues, many experts may argue that the end-to-end loss using an OTDR is an estimate of the actual end-to-end loss of the fibre link. Many companies may prefer to use a pair of **optical loss test sets (OLTSs**) or a stabilized **light source (SLS**) and an **optical power meter (OPM**) to make this measurement. Figure 2 shows a typical setup to measure the link loss of fibre using an OLTS or SLS/OPM.

OLTS testing requires access to both ends of the fibre link. A single unit has both a transmitter and receiver. It works with its partner unit positioned at the opposite end of the link to make loss measurements between units. The units communicate with each other and make measurements at several preselected wavelengths in both directions along the fibre link. They also provide a bidirectional average of the link-loss at each respective measurement wavelength.

Measurements tips :

Use an alcohol dampened wiper to clean the end of the mating connector ferrules used to connect the test sets to and from the fibre link. Canned air can also be used to blow off any ferrule or connector housing for dust both before and after cleaning with isopropylalcohol and a lint-free wiper.

Always make measurements with clean connectors. While there are a broad range of connector cleaning products on the market, it’s always advisable to use the minimum materials necessary. Your **microscope inspection** results will be your best guide as to what level of cleaning is required.

Depending on how dirty the connector end-face is, sometimes a simple wipe with a lint-free towel is all that’s needed. In other circumstances, it’s better to use a click-cleaner, which will remove dust and oil from fibre end-faces without the use of alcohol.

Connectors should always be clean and dry before inserting into sensitive test and measurement equipment. Another way to clean a connector is by using a can of air duster. When using an air duster, it's important to give the trigger a quick squeeze to expel any contaminants that may have settled between uses.

You can remove any moisture during the aerosol process by inverting the can. Many professional termination laboratories have a dry compressed air setup in place of aerosol cans which is extremely useful for high-termination volumes.

9. Recording of data :

This is a very important activity during and after completion of an optical fibre cable project Optical fibre cable life is more than 25 years but is sensitive to damage in Open environment. Proper selection of cable for aerial installation reduces chances of cable damage during its lifetime. Installation Data helps to find out the Fault location of cable very easily. Data recording saves time of cable maintenance & restoration. This document explains how to select cable & record data.

During operation condition of the cable, due to external factors cable can get damaged or faults may occur. To attend such faults, permanent documentation of cable route is required.

This document must record the following data :

Geographical map of the cable route
Table with the following information
Area name
Permanent sign at different places
Cable code name
Joint, Termination, Dropping details
Events on OTDR (at the time of Acceptance Test)
Manhole/Pole number & location
Meter marking at each manhole/pole/joint/termination