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Optical fibre cables – Guidance and installation technique

Air-assisted installation of optical fibre cables

Recommendation ITU-T L.156

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Air-assisted installation of optical fibre cables

Summary

Recommendation ITU-T L.156 describes air-assisted methods for installation of optical fibre cables in ducts. These methods can be used to install microcables into microducts, or larger cables into ducts or conduits. Installing conditions and equipment required should be different in each case.

History

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Introduction

Air-assisted installation is based on forcing a continuous high-speed airflow along the cable with an air source. The force of the moving air pushes the cable and makes it advance forward at a typical speed supported by the equipment.

Generally, the tensile load on the cable is an order of magnitude lower than the typical force involved with other installation methods, like pulling techniques, thus reducing installation hazards. Additionally, with this technique, bends in duct runs have somewhat less effect than with pulling techniques, so that installation speed increases and longer lengths of cable can be installed. Cables are installed virtually without stress, leaving the cable effectively relaxed in the duct upon completion of the installation.

There are several variants of air-assisted installation: with/without a piston at the front end of the cable, or with a leaking piston. For variants without a piston, there is no pulling force at the front end of the cable; airflow exerts a distributed force along the entire cable. In addition, the connection to a pulling cord is not needed.

Recommendation ITU-T L.156

Air-assisted installation of optical fibre cables

1 Scope

This Recommendation describes air-assisted methods for installation of optical fibre cables in ducts. These methods can be used to install microcables into microducts, or larger cables into ducts or conduits. Installing conditions and equipment required should be different in each case.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[IEC 60794-5-10] IEC 60794-5-10 (2014) *Optical fibre cables – Part 5-10: Family specification – Outdoor microduct optical fibre cables, microducts and protected microducts for installation by blowing*.

[IEC 60794-5-20] IEC 60794-5-20, *Optical fibre cables – Part 5-20: Family specification – Outdoor microduct fibre units, microducts and protected microducts for installation by blowing*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 blown-in element [b-ITU-T L.108]: A blown-in element consists of optical fibre(s), sheath and other materials and can be inserted into the microduct by continuous high-speed airflow force. Some of the characteristics of this element are described in clause 7.2 of [ITU-T L.108].

3.1.2 microcable [b-ITU-T L.162]: An optical fibre cable that is suitable for installation into a subducting microduct.

3.1.3 microduct [b-ITU-T L.108]: A small, flexible tube with enough wall thickness to provide the mechanical protection required by the application, with its outer and inner diameter defined according to the dimension and the condition of the existing duct and the diameter of the microcable.

3.1.4 micro fibre unit [b-ITU-T L.108]: This is a group of fibres (with a count starting at one) that can be installed in a microduct with the blowing technique.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 cable insertion machine: The main component of a blowing machine which pushes the cable into the duct with the help of compressed air.

3.2.2 leaking piston/open piston: A piston which allows the air stream to flow through its centre bore or other ports and exerts a low pulling force at the front end of the cable.

3.2.3 piston: A cylindrical part attached to the lead end of the cable, relatively tightly fitting and moving within A duct forced by compressed air.

3.2.4 shuttle: An alternative term for piston.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

HDPE High Density Polyethylene

OFC Optical Fibre Cable

5 Conventions

None.

6 Installation of jacketed cables in ducts

6.1 Considerations when installing cable

6.1.1 Cable duct

The combination of duct parameters and materials, critical in determining the installation requirements of specific cable designs when using air-assisted techniques (e.g., air tightness, circular shape, friction coefficient, wall thickness, pressure rating of duct, etc.), should be determined by prior testing. Maximum duct inner diameter depends on the type of machine used. See [IEC 60794-5-10] and [IEC 60794-5-20] for details of tests and criteria.

6.1.2 Cable

The bounds on maximum and minimum duct inner diameter, and criteria such as noncircularity, compression and obstructions are important for correct installation of cable.

Maximum installation length is influenced by the stiffness and weight of the cable. A very flexible cable can only be pushed with a low pushing force and it might be necessary to use an additional element at the front end of the cable, like an open shuttle, which allows the air stream to flow through its centre bore and exert a low pulling force at the front end of the cable. This element might also be necessary when the diameter of the cable is very small compared with the internal diameter of the duct.

When using a piston at the front end of the cable, a pulling force is exerted on the cable. In this case, maximum cable stress, which depends on the cable design, should not be exceeded.

Cable sheath friction coefficient and friction properties of the duct liner (low enough) are critical. It should be as low as possible. It could be influenced by the selection of the cable coating and duct characteristics. See [b-IEC TR 62470] for guidance on appropriate tests.

If necessary, the use of the appropriate lubricant is an important factor to obtain an optimum performance.

6.1.3 Cable route

Very tight bends in the cable route should be avoided because maximum installation length depends on the number of bends, their location in the route, the shape, gradient of the cable route, etc. Usually, the straighter the duct, the longer the permitted installation length.

Prior to blowing, the cable route should be "proved" to establish that the duct is clean and open, sufficiently round, and will allow passage of the cable or unit and any piston, if used. This can be accomplished by blowing a piston, ball or plug of appropriate size though the duct (see clause 6.3.1).

6.1.4 Compressed air

High-speed airflow that moves the cable into the duct is normally generated by a compressor on site. The maximum pressure of the compressor depends on the type of equipment used. Typically, this pressure it might be approximately 10 to 12 bar. Flow rate at the compressor output depends on the type of equipment and also on the internal diameter of the duct. Usually, the smaller the duct diameter, the lower the airflow rate and also the shorter the installation length for a specific cable design.

Compressed-air temperature has a great influence on the relevant parameters. At high temperatures, the material used in the cable jacket and duct begins to soften. This increases the friction between cable and duct, causing a reduction in the system performance. For ambient temperatures exceeding 30ºC, it is highly recommended to use an air cooler inserted between the compressor and the cable insertion machine.

6.1.5 Cable insertion machine

A cable insertion machine consists of a mechanical device that applies a force on the cable and controls its speed into the duct, together with the air-blowing nozzle. The mechanical element can be driven by an air or hydraulic motor with a manual and automatic run-stop device. This element is divided into two construction principles: pushing of the cable by a rubber block caterpillar drive belt or pushing by a notched wheel drive.

6.2 Variants of air-assisted installation

The choice of method, described in this clause, depends on several factors: type of cable (diameter, weight, stiffness), duct diameter, shape of the route (number of bends, location of the bends, gradient) and the equipment to be used. In the same manner, the installed lengths and laying speed depend on all of these factors. In all variants, the cable insertion machine may be used.

6.2.1 Installation method with a piston at the front end of the cable

In this method, a piston is attached at the front end of the cable. It transfers a defined pulling force to the cable which should not exceed the allowed tensile load. The piston exerts only a fraction of the maximum permissible pulling force on the cable.

If the piston gets to an oval section of the duct, it may become stuck. To avoid such a situation, the piston should have flexible cup sleeves or similar.

It is also possible to use a piston with a smaller diameter than the duct's internal diameter applied at the front end of the cable (also known as a *leaking piston*). It could be an open shuttle, which allows the air stream through its centre bore. In this case, the leaking level affects the level of stress suffered by the cable.

In all cases of this method, it is very important that the rated tensile strength of the cable is not exceeded. This is accomplished with a combination of the sizing of the duct, the sizing of the piston, the air leaking (leaking piston or shuttle) and the airflow/pressure.

6.2.2 Installation method without piston at the front end of the cable

In this method, the cable is inserted into the duct free of pulling force by means of a large and fast flowing air volume. The air streaming through the duct exerts a certain thrust on the cable sheath; this force is caused by friction between air particles and cable sheath. The compressor needs to provide sufficient capacity of air for the installation.

6.3 Operations

6.3.1 Precautions

When installing a cable using these methods, all precautions considered in other installation methods (reels handling, cables, personal security, cable storage in splice point, etc.), need to be taken into account.

Additionally, prior to the installation of the cable, the following are recommended:

– Plan the route and determine the best locations where the blowing-in machines should be placed, in order to achieve an optimum adaptation between the machine and the duct. This installation method allows the use of several blowing machines in series at different points of the same route, to obtain longer installation lengths or to solve complexity problems of the route. It may be possible to achieve installation lengths of 3 km, using only one blowing machine, depending on the characteristics of the route, the type of cable, duct and machine used.
– Check the continuity and integrity of the duct, in order to avoid losses of air pressure which may limit the performance of the system. At the points of discontinuity of the duct, the two duct ends should be joined by suitable duct coupler to ensure no air leakage.
– Check the inside of the duct, in the direction of installation, in order to ensure the absence of obstruction elements inside the duct, like water, dust or even stones. In the same manner, the absence of any flattening along the complete length of the duct should be checked (see clause 6.2.1).
– If required, a liquid lubricant can be added to the duct. To spread the lubricant uniformly along the duct, a sponge pushed by the airflow may be used. In some cases, the pouring of additional lubricant during the installation of the cable could be necessary.
– Clean the cable before inserting it into the cable-insertion machines.
– Take into account that a number of persons may be necessary in the installation process, in order that the following processes can be safely managed: handling the cable reel, handling the blowing machine, inserting the cable into the machine and receiving the cable at the far end.
– When required, the cable may be installed from an intermediate point. In this case, once the first part of the cable has been installed, it is recommended to lay the remaining part of the cable as a figure of eight or push it into a fleeting cage by means of the blowing-in machine.
– The maximum pressure the duct can support should not be exceeded.

6.3.2 Installation process

Once all precautions detailed in the previous clauses have been taken, and the blowing-in machines have been located in the correct places, the following are recommended:

– Prepare the front end of the cable. When using the installation method without piston, a light-weight cable guide should be fitted over the cable sheath to ease the movement of the cable around bends and through subduct connectors. When using the installation method with piston, the right cable grips should be prepared; they will be attached at the front end of the cable.
– Prepare the duct in order to adapt the blowing machine to the duct.
– If necessary, fit the cable pushing elements of the blowing machine to the cable diameter.
– Assure that the pushing elements of the blowing machine are set to avoid excessive buckling forces on the cable; a "crash test" should be performed.
– Put the cable into the insertion elements of the machine.
– Introduce the cable into the duct.

– Fix the cable to the insertion elements of the machine.

– Fix the duct to the blowing machine using an appropriate connector, in order to avoid air losses during the process.

– Start up the compressor and any auxiliary power for the pushing elements and connect it (them) to the blowing machine.

  Start the installation by pushing the cable into the duct to overcome initial friction. After an initial section of cable is inserted, the airflow through the duct will begin dragging the cable deeper inside the duct.

– At the distant end of the duct, the cable should be received. Care must be taken by operators because the cable may come out quite fast. If the installation process finishes at that point, a remaining length of cable, for cable splicing purposes, should be stored in the usual conditions.

– In case of several blowing machines being used in series, when the cable reaches the second installation point, it is necessary to stop the first machine and to introduce the cable into the second machine and duct, as previously detailed, and fix them to the cable. Afterwards, start up the first machine and then the second one. If any additional blowing machine is being used, proceed as detailed.

– When the cable is installed from an intermediate point, install the first length of the cable in one direction. Once completed, lay the remaining cable as a figure of eight or coil it into the special coiling apparatus by means of the blowing machine. Special care must be taken in order to prevent the cable from becoming dirty. Place the blowing machine in order to allow the installation in the opposite direction and proceed in a similar way as detailed previously.

7 Installation of microcables in microducts

Similar considerations, as previously detailed, should be taken into account when installing microcables in microducts. In this case, usually the diameter of the cables and ducts will be smaller. The characteristics of the ducts, materials and properties may be different. The blowing machines may also be different but precautions and installation process will be similar to those previously detailed. Further criteria for the installation of microducts and microcables are provided in [IEC60794-5-10] and [IEC 60794-5-20].

Appendix I

Indian experience: Installation of optical fibre cables by air blowing method

(This appendix does not form an integral part of the Recommendation.)

I.1 Products required for air-assisted installation of OFC

The liberalization of telecommunications, the advent of Internet and advances in optical fibre technology and have all led to increased need for efficient, fast and highly reliable methods for the installation of optical fibre cable (OFC). The lower weight of OFCs have led to the development of the air blowing technique for their installation. This technique essentially requires two main products: a duct and an air-blowing machine set.

I.2 Duct

The duct is made of high quality high density polyethylene (HDPE) pipe co-extruded with a special solid polymer lubricant as inner lining or ribbed inside surface. The important characteristics of this type of pipe are:

– low internal coefficient of friction with the outer sheath of the OFC. Additional lubricant (typically water based) can be used to reduce friction further at the time of blowing. The lubricant material should not react with cable outer sheath and duct materials;

– absence of coil-set;

– bending radius: minimum ten times the outer diameter of the duct;

– installation over wide range of temperature −5ºC to +50ºC;

– accurately controlled dimensions to enable leak-proof joints with suitable accessories;

– ability to withstand the air pressure required for OFC installation;

– expected life span typically 50 years for high quality HDPE (e.g., PE80 grade) duct. The lifetime estimate for a high-quality HDPE duct has been based on the pressure test from the standard [b-DIN 8075].

I.3 Air-blowing machine

The air blowing machine is capable of supplying a moisture-free air jet at pressure through a feed machine that introduces the OFC into the duct. It basically consists of:

– a compressor, capable of delivering air at 10 bar pressure continuously;

– an air cooler with facility to remove water vapour;

– a cable feed system fitted with a pneumatic/hydraulic motor to feed the cable continuously at a speed of up to 100 m/min. Generally, a speed of about 60 m/min is chosen.

I.4 Advantages of air-assisted installation of OFC

The advantages of the blowing method for OFC installation into the duct are:

– there is no stress on the OFC, as the inner surface of the duct is ultra-smooth. Typically, the coefficient of friction is less than 0.1 as determined by the method mentioned in the clause I.5. It is a pushing rather than pulling action of the cable;

– it allows a longer installation in a faster and more efficient way. A one-kilometre OFC can be laid in less than 20 min;

– the influence of bends and curves is minimized;

– there are a minimum number of joints in the duct and cable splices;

– the overall cost of installation and maintenance is reduced;

– future upgrading is facilitated.

I.5 Method to measure co-efficient of friction

This procedure outlines the method employed to determine coefficient of friction between duct inner surface and cable outer sheath as described in [b-TEC/GR/TX/CDS-008/03].

The required apparatus consists of an extensometer, a circular test fixture of diameter 750 mm, 25 kg weight, an OFC sample and a pulley wheel.

– A suitable length of the duct, pre-conditioned at 23± 2°C for 2 hours, to be secured to the text fixture such that the duct sample completes a 450° wrap, with one end extending vertically 200 mm towards the floor.

– A suitable length of OFC is inserted into the duct sample.

– The extensometer and the test fixture are aligned and secured from movement.

– The 25 kg tail weight is attached to the OFC extending from the 200 mm vertical extension of the sample such that there is a minimum free travel of 150 mm for the weight.

– The other end of the OFC is attached via a pulley, to the extensometer such that the planes of travel are in no direction diagonal and there is slack remaining in the OFC.

– The extensometer is operated, and the maximum load applied, in lifting the 25 kg weight to a minimum travel of 150 mm is noted.

– Extensometer conditions.

– Load: kg or N; Speed: 500 mm/min; Mode: Tension.

The coefficient of friction is calculated by the following equation:

$$\text{Coefficient of friction } = \frac{Ln(\frac{T_1}{T_2})}{Q}$$

Where:

T_1 = Pulling force in kg

T_2 = 25 kg

Q = Angle of the subtending between T_1 and T_2, in radians (i.e., 450° = 7.85398 radians)

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