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# ITU-T

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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

## Optical fibre cable installation by floating technique

ITU-T Recommendation L.61

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**Summary**

This Recommendation describes the floating technique to install optical fibre cables in ducts.

The floating process described in this Recommendation is always performed by means of water.

It provides considerations on the equipment to be used, and gives advice on steps to be performed, and on procedures and precautions to be taken during the cable installation.



**Source**

ITU-T Recommendation L.61 was approved on 29 July 2004 by ITU-T Study Group 6 (2001-2004) under the ITU-T Recommendation A.8 procedure.



**Keywords**

Air compressor, duct, floating, gradient pressure, water pump.

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## CONTENTS

# ITU-T Recommendation L.61

## Optical fibre cable installation by floating technique

### 1 Scope

This Recommendation:

- gives a general description of the machine and operations needed in performing the installation of optical cables as defined in ITU-T Rec. L.10 inside ducts or conduits by means of floating technique;
- provides considerations on infrastructure, floating equipment and setting needed in using such a technique;
- gives advice on the preliminary steps that should be performed;
- gives advice on procedures and precautions to be considered during the cable installation.

### 2 References

#### 2.1 Normative 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.

- ITU-T Recommendation L.1 (1988), *Construction, installation and protection of telecommunication cables in public networks*.
- ITU-T Recommendation L.10 (2002), *Optical fibre cables for duct and tunnel application*.
- ITU-T Recommendation L.35 (1998), *Installation of optical fibre cables in the access network*.
- ITU-T Recommendation L.57 (2003), *Air-assisted installation of optical fibre cables*.

#### 2.2 Informative references

- ITU-T Handbook on *"Construction, Installation, Jointing and Protection of optical fibre cables"*.
- ISO 7611:1985, *Gas chromatographic method on capillary columns*.

### 3 Definition

None.

### 4 Abbreviations

This Recommendation uses the following abbreviations:

EKE PolyEthylene – Aramidic Yarn – PolyEthylene

EVE PolyEthylene – Fibre Glass Yarn – PolyEthylene

HDPE High Density PolyEthylene

NPx x bar value of Nominal Pressure

## 5 Introduction

The floating technique is based on forcing along the cable route, by means of a pump, a suitable water flow. Moving water exerts a distributed action on the cable that pushes it forward at a speed in the range 30 ÷ 40 m/min.

There are no pulling forces applied at the front end of the cable: that extremity being completely free (with neither rope nor parachute attached).

Moreover, the water thrust minimizes the friction effect generated between the cable and the duct during the installation process.

Besides, because, with this technique, the applied forces on 1 m of cable element are around 0.10-0.15 N kg, the resultant forces applied on the cable are lower than those applied in the case of the use of pulling techniques, thus reducing the installation hazards.

Additionally, if the fluid speed is such as to cause, on each cable element, a force greater than that aforesaid, then the presence of bends along the cable route becomes a less significant affecting factor compared with the pulling technique. Fluid speeds of 1 m/s are advisable for heavy optical cables (around 300 kg/km).

Furthermore, since the density of the water is greater than that of the air, for a given type of cable (weight and diameter), a lower water pressure is requested with respect to the use of the Air-assisted technique. This also allows the laying of cables in ducts designed to withstand a working pressure (NP) of 6 bar (e.g., HDPE NP6 ducts) which would not be suitable in the case of the use of the Air-assisted technique.

Cables are installed without virtual stress, leaving the cable relaxed in the duct upon completion of the installation.

Finally, water floating does not cause a significant increase of the duct temperature, providing another advantage over those systems that use gas as a laying element.

## 6 Floating technique requirements

The choice of the floating technique depends mainly on:

- type of cable (diameter, weight, stiffness);
- duct diameter and duct characteristics vs. pressure;
- water availability;
- duct joints characteristics vs. inner pressure;
- shape of the route (number of bends, location of the bends, gradient).

The maximum length of installed cable, as well as the maximum speed of installation, depend on the aforesaid factors and the equipment used according to the theory shown in Annex A.

For uphill routes, the weight of the water pushing the cable towards the upper side should be taken into account. It is recommended increasing water pressure of about 1 bar per 10 m drop level.

If the drop is relevant, the water pressure or increase may be incompatible with maximum pressure to be used with the duct and joints; in such a case, it is convenient to proceed with a downhill laying using a limited water quantity in order to get the allowed range.

## 7 Infrastructures

### 7.1 Ducts

Material and thickness of the ducts and the watertight connectors fitting them should be suitable for the water pressure to be used. A reference value ≥ 6 bar is recommended.

In order to prevent unforeseeable friction between duct and cable sheath, it is important to ensure that the duct is in a sound condition (it should keep its circular shape during installation) and as clean and clear as possible.

Maximum duct diameter depends on the type of machine used. HDPE ducts with an external diameter of 40 ÷ 50 mm, have allowed the installation of cable lengths up to 6000 m.

NOTE – The use of HDPE ducts having a working pressure of less than NP6 degrees may be possible, but this has to be analysed considering the real application in the field (route length, cable type, route layout, duct inner diameter, duct characteristics vs. pressure).

### 7.2 Cable

The maximum of length cable that can be installed is influenced by the stiffness of the cable. A very flexible cable (minimum curvature radius during installation less than 300 mm) can be floated without resistance as long as the bends along the route are greater than this value. A rigid cable may encounter resistance during the laying in the duct if two consecutive bends are closely spaced, (e.g., 50 m).

Consequently, friction between the cable sheath and the inner duct surface may become another important parameter in case of rigid cable structures. Such a parameter should be as low as possible: a typical value of the dynamic friction coefficient is 0.1.

Moreover, according to Equation A.2, the lighter the cable is, the further it can be floated, but there is no linear relationship between the cable weight and the floating-in length.

In order to limit the friction forces between cable and duct, it is recommended to avoid two or more consecutive 90° bends spaced less than 20 m apart, otherwise, the cable stiffness could cause excessive friction corresponding to such bending points.

To minimize the friction effect, the cable diameter shall not be bigger than 50% of the internal duct diameter.

In Table 1, the relationships among cable weights, type of ducts and maximum cable length installable for a linear route are shown.

**Table 1/L.61 – Maximum cable length relative to cable and duct types**

| Cable weight (kg/km) | Duct types (HDPE ϕ ext 50 mm) | Maximum floating length (m) |
|---|---|---|
| 100 | NP6 | 4000 |
| 100 | NP10 | 6000 |
| 200 | NP6 | 3000 |
| 200 | NP10 | 4000 |
| 300 | NP6 | 2000 |
| 300 | NP10 | 3000 |

## 8 Equipment and settings in floating technique

The most important parts of the system are:

- water pump;
- water tank;
- cable pushing device (caterpillar);
- water stream/cable coupling device.

A communication system (usually a Radio link or mobile phone) shall be deployed for on site communications between the ends of the cable route.

Figure 1 shows how the parts of the floating machine are assembled.

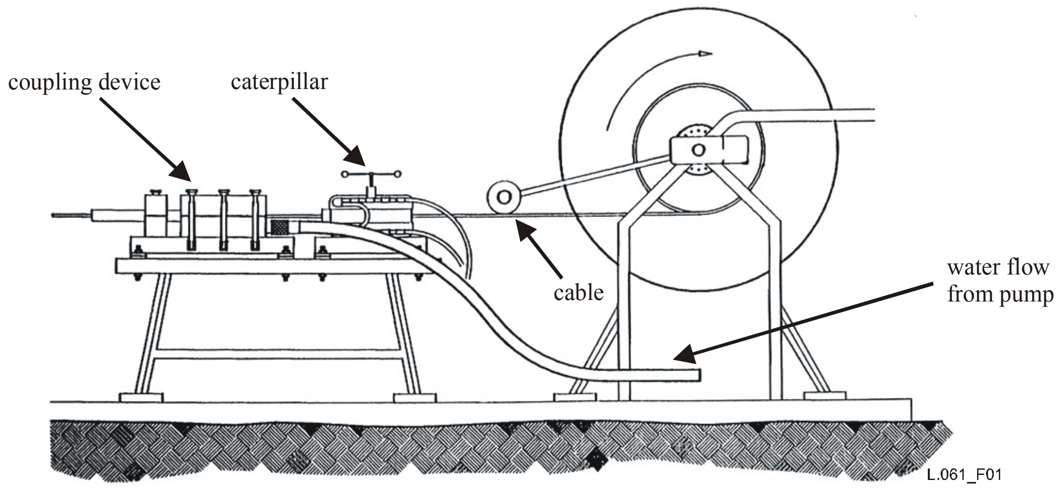


**Figure 1/L.61 – General assembly of the floating machine**

### 8.1 Water pump

It is a motive station mounted on a truck used to generate a high-pressure water flow through the duct route.

A pump generates a water flow that pushes the cable into the duct.

By means of Equation A.4, it is possible to calculate the correlation between the speed of the water flow and its pressure.

Maximum pressure to apply depends on the characteristics of the duct used (see ISO 7611).

Practical pressure values are in the range of 4 ÷ 10 bar. Pressure to be used has to be in accordance with the duct characteristics (see 7.1).

### 8.2 Water tank

The capacity of the tank shall be able to supply water for the maximum size of cable to be installed taking into account:

- duct inner diameter;
- duct length;
- cable diameter;
- cable installation speed;
- fluid speed.

For example, in a typical installation of 6000 m, about 6000 litres of water are necessary to fill the duct before starting the cable installation, and another 2000 litres are necessary for its laying.

A truck is then requested on which a water tank of about 8000 litres, assembled with the machinery controller and the cable reel, is loaded. A second tank may be used to recover the incoming water at the far end of the duct route.

According to local rules, the water inside the duct should be recovered at the end of the cable installation (i.e., by means of an air compressor).

### 8.3 Cable pushing device (Caterpillar)

The water flow and cable shall be directed inside a "flowing room" in order to exert the dragging force on the cable.

The Flowing Room System shall be used to couple both the cable and the high-pressure fluid flowing into the duct route. This system is positioned at the starting end of the cable laying and located as close as possible to the starting manhole in the duct route.

A caterpillar shall be used to trigger and regulate the cable installation speed. This is because the speed of cable installation, caused by the motive force of the water flow, is usually too high. The caterpillar makes it possible to stop the cable laying, restart it, and even to reverse the cable laying.

An example of the coupling mechanism process between the water stream and the cable is shown in Figure I.1.

### 8.4 Cable-speed control

The cable speed shall be controlled by means of a mechanical device (caterpillar) that applies a force on the cable and pushes it into the duct at a controlled speed. An example of a caterpillar is shown in Figure I.2.

It shall be driven by a motor, provided with a manual and automatic run-stop device.

A variable speed engine system shall also be used to match the speed of the cable reel to the required laying speed (the recommended laying speed is 40 m/min).

## 9 Preliminary phases

For installations using the floating technique, all precautions considered in other installation techniques such as reels handling, cables, personal security, cable storage in splice point, etc., shall be taken into account.

To achieve an optimum adaptation between the machine and the cable route, the best location for the placement of the floating machine should be determined. For instance, to minimize the friction effect of the closeness of bends to one end of the laying route, it would be preferable to start the cable installation from the other end. Considerations regarding the presence, along the cable route, of favourable gravitational gradients should also be taken into account. In some cases, the gradient pressure might be too extreme for the duct performance.

## 10 Installation issue

### 10.1 Duct setting

The duct shall be jointed at all the intermediate manholes/handholes by means of a piece of duct and watertight connectors with an adequate NP degree. It is recommended setting a piece of duct around the wall in order to leave it for future use, otherwise it has to be removed after laying.

The maximum pressure that the duct can support for short periods shall not exceed a value of three times the NP degree of HDPE duct (see ISO 7611). Of course, the duct joints shall be able to withstand such a maximum pressure too.

The duct route shall be controlled and checked by means of a system able to perform a "go/not go" test concerning the real inner diameter of the duct itself. Several methods may be used. The most widely used consists of blowing in the duct a piston or a ball of suitable diameter (around 80% of the inner nominal duct diameter).

In case of long routes with many bends, it is recommended pouring a proper lubricant into the duct before cable installation.

### 10.2 Cable setting

Before cable laying, the water flow shall be tested in order to control the continuity of the duct and the feasibility of the floating. The water shall completely fill the duct, eliminating any air-pockets.

The cable, closed at the end with a thermo-restricting sheath, is inserted into the duct free of pulling force by means of a large and fast flowing volume of water coupled to it in the flowing room.

The water streaming through the duct exerts the thrust on the cable sheath. This force is caused by friction between water particles and cable sheath.

To achieve good floating performances, the compressor shall have a capacity according to the duct size and its length (e.g., to fill a 4000 m duct having an inner diameter of 43 mm, according to Table 1, it is necessary to supply about 5800 litres of water).

## 11 Cable installation

It has to be taken into account that at least four persons are necessary to perform the installation process: one handling the cable reel and the floating machine; one inserting and controlling the cable into the flowing room, one at the cable reception point, and one to manage all the operations (see Figure 2).

Once all precautions detailed in the previous paragraphs have been taken and the floating-in machines have been located in the right places, the following is recommended:

- Preparation of the duct in order to adapt the floating to the duct.
- Checking that the water flow arrives to the remote end of the route, filling the remote end duct section.
- Fitting the cable pushing elements of the floating machine's capstan to the cable diameter.
- Putting the cable in the cable pushing elements of the machine (caterpillar).
- Putting the cable in the floating chamber.
- Introducing the cable in the duct.
- Fixing the cable pushing elements of the machine to the cable.
- Fixing the duct to the pushing in machine with the fitting connector. Making sure the right fitting connector is used in order to avoid water losses during the process.
- Starting up the machine. The water flow generated by the compressor will begin dragging the cable inside the duct.
- At the distant end of the duct, the cable will be received. A remaining length of cable, for cable splicing purposes, shall be stored and protected as usual.
- Installing the first length of the cable in one direction when the cable is installed from an intermediate point. Once it is finished, remove the remaining part of the cable from the drum and lay it on the ground in a figure-of-eight pattern. Special care must be taken in

order to prevent the cable getting dirty during this phase. Then, place the floating machine in order to allow the installation in the opposite direction and proceed in a similar way as detailed previously.

- When necessary, the cable may be installed from an intermediate point of the route.
- For difficult sites, the truck containing the floating apparatus shall be connected to the starting manhole by an appropriate length of duct.

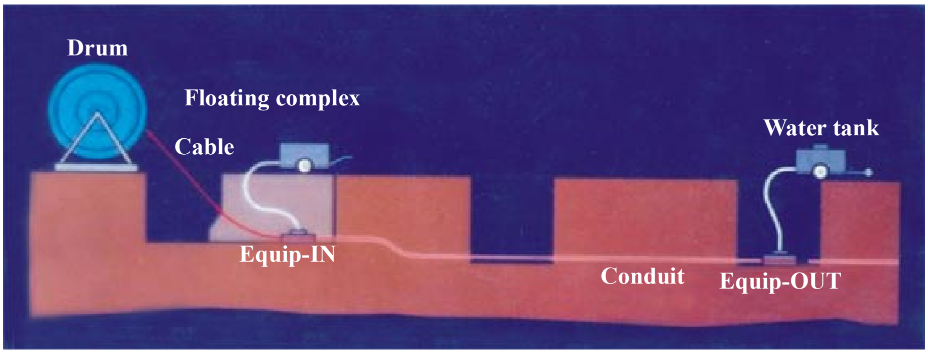


**Figure 2/L.61 – Schematic layout**

# Annex A

## Theory

The rate of water flow necessary to move a cable through a duct route depends on mechanical and physical characteristics of the duct and cable.

The vertical thrust (Fq) on a cable submerged in water is:

$$Fq = \gamma * \pi * (d/2)^2 * l * g \quad [N] \qquad (A.1)$$

where:

**d** = cable diameter (m)

**γ** = water density (kg/m³)

**l** = cable length (m)

**g** = gravitational acceleration = 9.8 m/s$^2$

The elementary pulling force (Ft) to move the cable is:

$$Ft = \mu * [(p * l * g) - Fq] \quad [N] \qquad (A.2)$$

where:

**μ** = coefficient of residual friction between cable sheath and duct

**p** = longitudinal mass of cable (kg/m)

Such a formula shows how water is more effective than a gas as laying fluid, being: **Fq** water >> **Fq** gas.

The horizontal thrust of the water on the cable is:

$$Fs = Q * (v - c) = S * \gamma * v * (v - c) \quad [N] \qquad (A.3)$$

where:

$\mathbf{Q}$ = rate of flow (kg/s)

$\mathbf{v}$ = water speed (m/s)

$\mathbf{c}$ = laying speed (m/s)

$\mathbf{S}$ = effective area (duct section minus cable section), ($m^2$)

The cable floats when: **Fs** = **Ft**

$$\mu * [(p * l * g) - Fq] = S * \gamma * v * (v - c) \quad \text{(A.4)}$$

by solving Equation A.4, it is possible to find the value of **v min** which allows the cable to float.

For example, using:

$\boldsymbol{\mu}$ = 0.1

duct inner diameter = 50 mm

cable diameter = 20 mm

$\mathbf{c}$ = 0.5 m/s

p = 0.200 kg/m

we find an effective minimum water speed:

$$v\ min = 0.61\ m/s$$

The floating system must be able to get a water flow with a speed greater than **v min.**

Using **v min = 0.61** m/s in Equation A.4 we find: **Fs** = **0.11** N

# Appendix I

## Italian experience

**I.1** By the end of 2003, around 6000 km of cables have been laid in Italy by using the floating technique.

The most important features for such installations were:

- Duct type: HDPE 50 mm external diameter duct with NP6 or NP10 degree;
- Cable type: diameter: 12 ÷ 20 mm; installation minimum curvature radius: 20 times diameter; weight: 0.1 ÷ 0.2 kg/m. Protection structures: EKE, EVE, etc.;
- Floating length (without figure eight procedure): 4000 m of cable;
- Steady applied pressure: < 6 bar for NP6 and < 10 bar for NP10 ducts;
- Short-term applied pressure: 10 bar for NP6;
- Pump max. pressure: >> 10 bar in order to have the possibility of applying a maximum effective pressure of 10 bar at the beginning of the duct;
- Floating Machinery and Devices.

An idea of the most important coupling mechanism, devices and floating system used are shown in Figures I.1, I.2 and I.3 respectively.

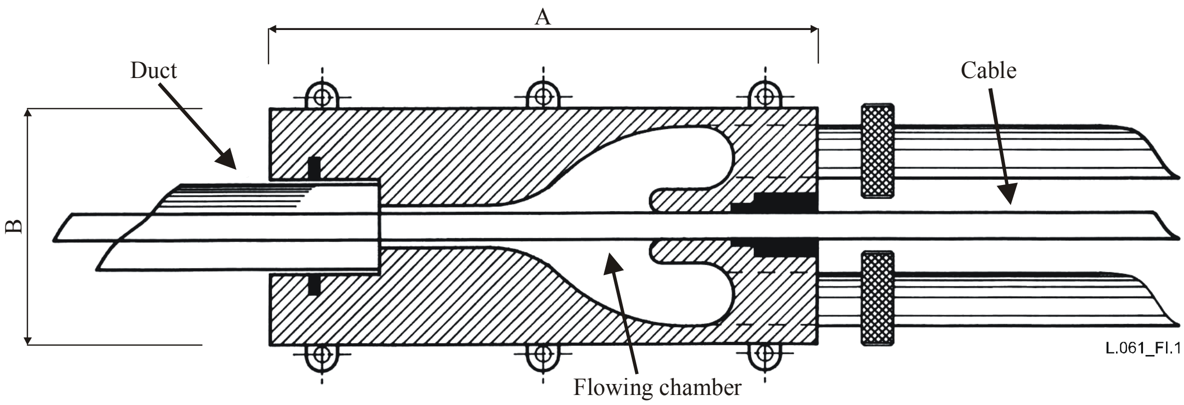


**Figure I.1/L.61 – Coupling mechanism process between the water stream and the cable**

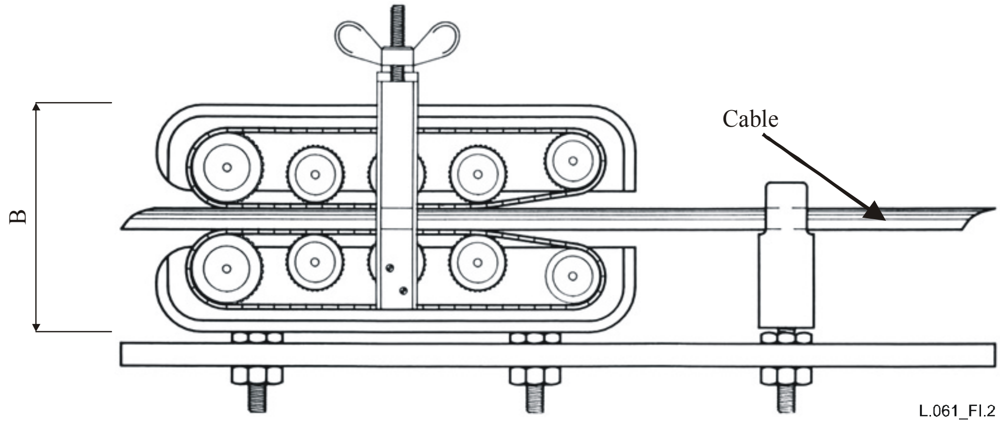


**Figure I.2/L.61 – Caterpillar that applies a force on the cable and pushes it into the duct**


**Figure I.3/L.61 – Floating system at near end**

## I.2 Bibliography

The installation processes have been performed following the guidelines by CIS "Procedimento de apparecchiatura per la posa di cavi entro tubi a mezzo di un fluido idraulico a pressione" (1991-1992).

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