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Guidance for the selection of drop cables

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National foreword

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colour inside

Guidance for the selection of drop cables

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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GUIDANCE FOR THE SELECTION OF DROP CABLES

FOREWORD

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62901, which is a Technical Report, has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86A/1676/DTR	86A/1707/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

GUIDANCE FOR THE SELECTION OF DROP CABLES

1 Scope

This Technical Report defines the term "drop cable", describes the application spaces and the performance requirements as a consequence of the different applications. Cable design options which result from specific applications which are not yet described in the existing product specifications will be explained.

This technical report also gives some guidance on cable testing with focused attention on cable performance requirements which are not covered by existing standards yet.

This technical report is not intended to be used as a product standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

None

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
drop cables
cables closing the gap between distribution cables (starting at the Network Access Point or NAP) and the single user´s home (Multi Dwelling Units or MDUs), or other premises

Note 1 to entry: Drop cables are deployed in aerial, in duct, direct-buried, on facades as well as indoor/outdoor cables.

Note 2 to entry: Drop cables end either outside the building or inside the building. Therefore, often so-called indoor/outdoor cables are needed to provide the appropriate fire performance.

Note 3 to entry: The Network access point (NAP) or Access Point is connected to the user´s house by aerial drop cables or underground drop cables, as shown in Figure 1.

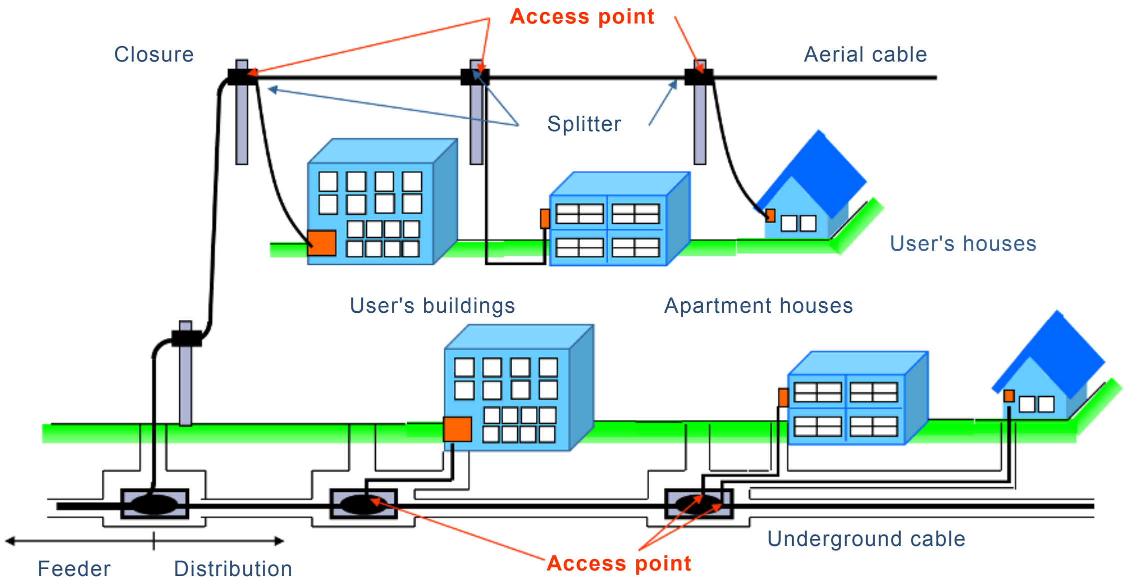

Figure 1 – Configuration of a typical FTTH network

3.2 Abbreviations

ADSS All Dielectric Self-Supporting Cable
ARP Aramid Reenforced Plastic
EFL Excess Fibre Length
FRNC Flame Retardant Non Corrosive
FTTH Fiber To The Home
GRP Glass Fibre Reinforced Plastic
HDPE High Density PE
LDPE Low Density PE
LSZH Low Smoke Zero Halogen
MCC Metal Cable Clamp

NOTE MCC are not made of metal anymore.

MDPE Medium Density PE
NAP Network Access Point
PE Polyethylene
PP Polypropylene
FR Flame Retardant
TB Tight Buffered Fibre or Tight Buffer

4 Application spaces

4.1 General

Clause 4 describes most of the different ways commonly used to connect the end user to the distribution cable.

4.2 Installation between poles

4.2.1 General

In some countries, the installation of fibre optic aerial drop cable is the most preferred option because of the relatively low effort compared to other methods like installation in ducts, direct burying, etc. Especially when the distribution cable has been installed between poles, it is common practice to also use an aerial installation for the last few meters from the NAP to the building. The connection to the NAP can either be done by splicing individual fibres to the NAP, or using field-installable connectors, or using preconnectorized cables when the NAP is designed to access the branched fibres via already installed connectors. Normally, only lower fibre counts (e.g. 1 to 8 optical fibres) are required. The distances are short (typically between 20 m and 100 m), thus the span lengths between the poles are also short (15 m to 50 m). Depending on the preferred installation method, fibre optical cables can be installed as self-supporting cables, lashed cables or suspended cables.

Even though the span length is short, ice and wind loads have to be taken into account especially when stringent sag requirements are to be fulfilled.

Cables with a black sheath are typically used for outdoor installations. The black colour is the result of the addition of "carbon black". A concentration of approximately 2,5 % ensures the long term stability against UV radiation. When other sheath colours are used (e.g. for a better appearance) UV stabilizers have to be added. The functionality of those stabilizers has to be demonstrated by appropriate test procedures.

4.2.2 Self-supporting cables

A self-supporting cable contains all required strain carrying elements; thus it can be directly fixed to the poles with the appropriate equipment. A widely used method which is also appropriate for the installation of long length self-supporting cables is the use of metallic spirals (dead ends, see Figure 2).

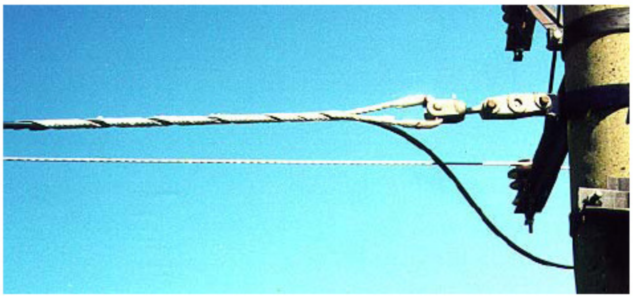

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Figure 2 – Dead ends to be used for the installation of long length self-supporting cables

For shorter length of cable, lower tension cable clamps can be used (see Figure 3, Figure 4 and Figure 5). More examples of commonly used clamp systems are shown in Annex C.

Self-supporting cables can contain metallic strength members which may need to have a good connection to ground. ADSS cables (see also IEC 60794-3-20) do not need this precaution.


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Figure 3 – P-clamp


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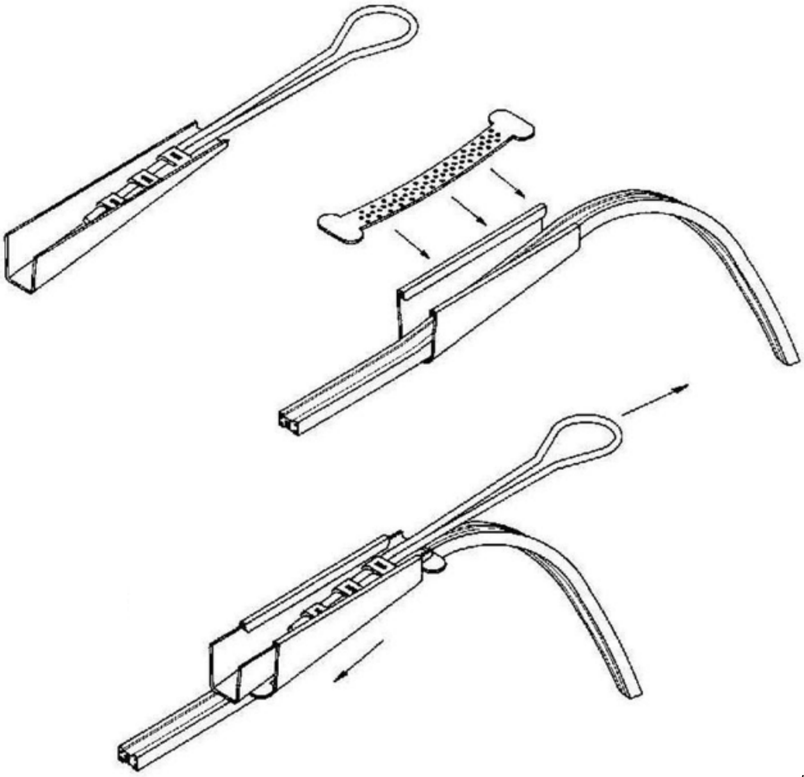
Left: open

Right: closed

Figure 4 – MCC



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NOTE A wedge clamp is a clamp with one end contacting the cable below its surface and the other end butting against a crosspiece so that the tightening of a bolt passing through its center causes the clamp to wedge the cable in position.

Figure 5 – Wedge clamp

4.2.3 Lashed and suspended cables

Lashed cables do not represent a specific class of cables. Almost all outdoor cable designs can be installed by that "lashing" technique. A prerequisite is a so-called messenger wire which needs to be installed up-front between the poles. The cable will be attached to the messenger wire by either winding a "band" or thread made of a metal or a dielectric material helically around the messenger and fibre optic cable. The winding process can be done with the help of a machine pulled from the ground or automatically driven by a motor (see Figure 6).

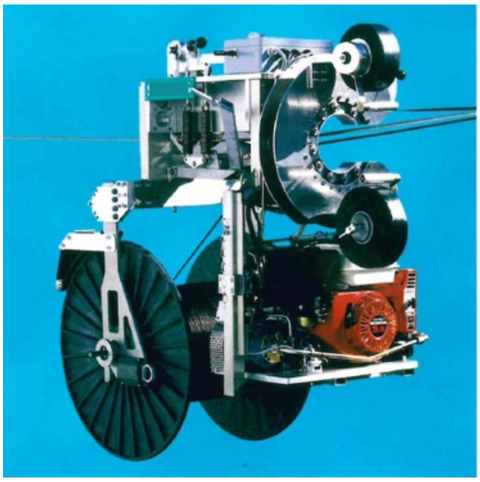

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Figure 6 – Motor-driven lash machine

Alternatively, the cable can also be fixed to the messenger wire with metallic crimps (see Figure 7).

Figure 7 – Crimp used to fix a cable to the messenger wire

The cable can also directly be wound around the messenger wire. No further "lash band" is required. However, the installation process is more difficult because the cable (and reel), which has a relatively high mass, has to be moved around the messenger wire. These cables may be suitable for mid-span access.

4.3 Installation in ducts

Cable installation in ducts is the most reliable installation method. Normally, the duct consists of a polymeric tube with a diameter of up to 100 mm. The duct can be regarded as an additional protection of the fibre optic cable. As a consequence, the strength of a cable (e.g. lateral crush resistance) can be smaller than the one for direct-buried cables.

A duct may be further sub-divided using sub-duct and/or micro-ducts. Cables may be installed by pulling, blowing or jetting. More detail is given in IEC TR 62691.

Care has to be taken that the ducts are not deformed at any point along their length. Before installing the cables (e.g. by blowing, jetting or pulling), the diameter of the duct has to be checked by means of an appropriate test method (see IEC TR 62691, IEC 60794-5-20:2014, 6.9 and Annex E and IEC 60794-1-21:2015, Clause 28).

4.4 Installation in sewer, water and gas pipes

Cable deployment is normally the most expensive part of the network. Especially, digging is very labour intensive. Therefore, it would be very beneficial to use already existing infrastructure, for example sewer, gas and water pipes, for the installation of fibre optical cables. Even though every household is connected via these (service-) pipes, this practice is not yet largely used. The main invoked reasons are: the access to these pipes is not allowed by the owner, the more sophisticated technology needed to enter and exit the pipe system is either too expensive or seems to be too complicated.

Nevertheless, the technology exists and is described in IEC 60794-3-40, IEC 60794-3-50, IEC 60794-3-60 and IEC TR 62691.

4.5 Direct-buried cables

Direct-buried cables are cables which are deployed in the soil without any additional external protection. To withstand the mechanical stress as well as possible chemical contamination, the cables may need additional protection, for example thicker sheath than a duct cable, steel tape or steel wire armouring, special sheathing materials. Figure 8 shows an example of cable with additional protection.

Cables used for direct deployment in the soil are described in IEC 60794-3-10, and details of the installation methods are given in IEC TR 62691.

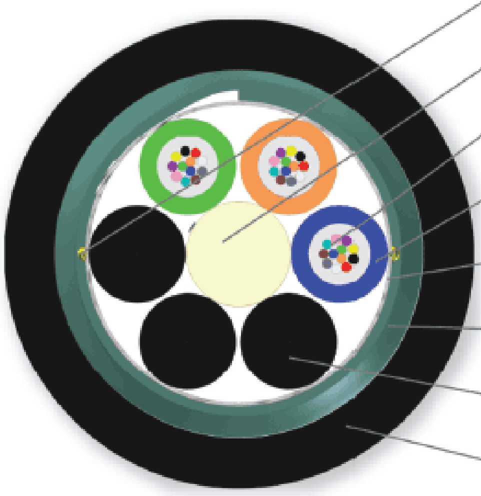
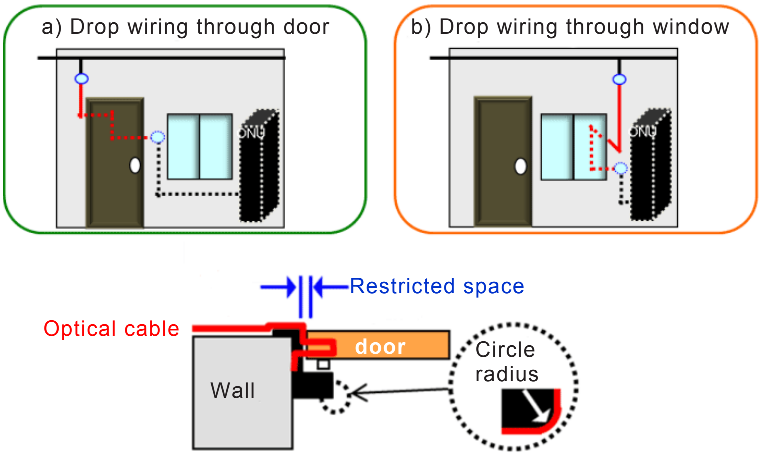


Figure 8 – Tape armored cable

4.6 Installation on facades

During the last years when FTTH deployment became more popular, more and more fibre optical cables were installed directly at the house walls to access the individual apartments from the outside by just drilling a hole through the wall and guiding the cable through it to the interior of the home. Often, aerial drop cables are used to connect the NAP with the building. On top of the building, a closure could be installed to connect the incoming cable (many fibres) to the different cables (e.g. 1 to 8 fibres) needed to access the end user´s apartment. Annex A describes some of the common practices used for the installation on facades. The main driver for the installation on facades is the relatively low deployment effort. The cable can easily be installed vertically just by tensioning it between some anchors fixed to the wall (see Annex A). No special regulations have to be fulfilled with respect to fire protection. However, care has to be taken to avoid sheath damage caused by vibration. Wind induced vibration can cause the cable to swing and successively scratch across the rough outer surface of the house wall. The resistance of the cable against this kind of load shall be tested if agreed between customer and supplier (see 60794-1-21:2015, 4.4; the felt shall be replaced by a rough surface similar to a facade surface). Test parameters (force, mass and number of cycles) need to be determined. Cables with a black sheath are typically used for outdoor installations. The black colour is the result of the "carbon black" additive included in a concentration of approximately 2,5 % to ensure the long term stability against UV radiation. When other sheath colours are used (e.g. for a better appearance), UV stabilizers shall be added. The functionality of those stabilizers has to be demonstrated by appropriate test procedures.

In case that the drop cable is installed into the house, the path of cable is required from outside to inside the residence. Although the existing duct for wiring or puncturing the facade is often used, a resident can refuse puncturing the facade. In this case, the cable can be installed into the restricted space through the door or window as shown in Figure 9.



Restricted space	2 ~ 3 mm
Circle radius	About 2 mm
Bend angle	90 degrees

IEC

Figure 9 – Puncture-free installation of drop cable

5 Installation options

5.1 General

Typical installation conditions for drop cables will be described in Clause 5. It will be shown that for most application spaces, already existing cable standards (e.g. IEC 60794-2, IEC 60794-3) can be referenced.

Because of the short lengths of drop cables, the ease of termination becomes a more prominent criteria for selection. Pre-connectorized solutions or use of field-installable connectors will speed up the installation process remarkably. However, other methods like fusion splicing or the use of mechanical splices can be used if appropriate.

5.2 Installation between poles

5.2.1 General

Cables to be installed between poles are described in IEC 60794-3-20. Two types of installation are currently in use: installation of self-supporting cables which include all the load carrying elements within the cable, and so-called lashed cables which is a technique based on standard cables which are attached to a load carrying element (see 5.2.2 and 5.2.3). The tensile load on the cable depends on the cable weight, length of the span and the required sag. In addition to that, ice and wind loads shall be taken into account. They depend on the cross section (diameter, shape) of the design, the amount of ice attached to the cable and the speed of wind. They contribute remarkably to the tensile load of the cable. Software tools are available to estimate the resulting loads on the cable.

5.2.2 Self-supporting cables

5.2.2.1 General

Cable designs according to IEC 60794-3-20 include sufficient strength elements to ensure that the optical fibres do not experience excess fibre strain (typically $< 0,2$ % long term) during operation when installed, for example between poles. However, higher strain levels might be acceptable when drop cables are installed in relatively short cable spans (e.g.

< 100 m). Glaesemann [4][1] has theoretically shown that under the assumption of the same failure probability, a shorter fibre length (e.g. 100 m) can be tensioned to a remarkably higher strain (approximately 0,3 % long term) than a fiber with a length of for example 1 km (approximately 0,2 % long term). The maximum short term load (2 h to 8 h) can be estimated to be 0,51 % [4, figure 63]. By using the appropriate tensioning assemblies, the cable can be directly installed between poles and fixed at each end by the appropriate hardware (spirals, clamps etc.). In case of low diameter central tube cables, special care has to be taken to ensure that the installation method does not negatively impact the optical properties, for example the attenuation. Thus, it should be verified that the tensioning devices do not lead to any attenuation increase when tensioned to the required load (see 5.3.3). Because of the small diameter, there is a certain risk that the cable is crushed locally by the tensioning device (e.g. clamps) or the bend radii are too small which also could result in some attenuation increase.

Cables in Figure 10 do not suffer from that issue because of the separation of the load carrying strength member (metallic rope) and the fibre optic cable.

Self-supporting cables with a central tube design must address fibre coupling in the design or deployment procedures to prevent fibre retraction issues associated with cable elongation caused by ice and/or wind load.

It is known that a biological attack may induce serious problems on the telecommunication cable and plants (for example, as described in ITU-T L.46). In particular, there is a risk of damaging the drop cable when cicadas lay eggs by inserting the ovipositor in the cable, as illustrated in Figure 10. It is important to select the appropriate material for cable sheath to avoid this problem taking into account the local fauna.

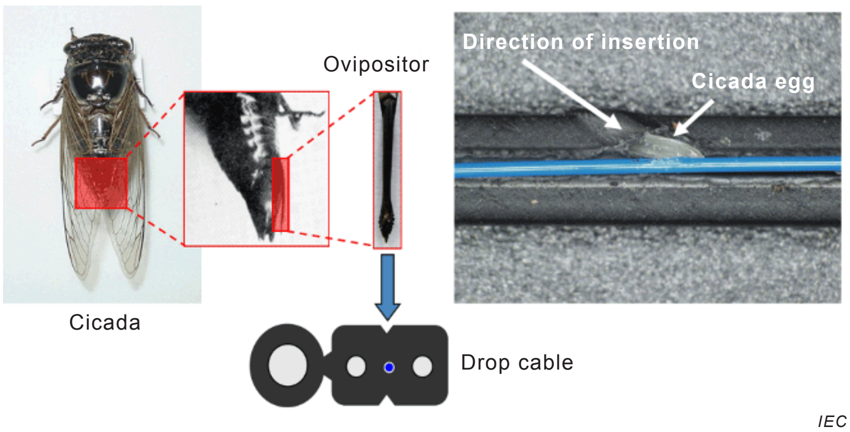


Figure 10 – Attack of drop cables by cicada

5.2.2.2 Specific installation options

Very often, installation of central tube design cables by using clamps (see Figure 3) is performed. The suitability of a cable design can be tested by a modified tensile test (see 6.3.3).

Bend insensitive fibres (e.g. B6 fibres as specified in IEC 60793-2-50) will give some advantage when clamps are used in cases the cable is tightly bent (see Figure 4). In general, the use of bend optimized fibers is recommended.

1 Numbers in square brackets refer to the Bibliography.

5.2.3 Lashed cables

5.2.3.1 General

Cables suitable for lashing or overlashing are described in IEC 60794-3-10. Also, the lashing procedure is described in the same standard. Because of the relatively short spans (typically around 50 m for drop applications), almost no tensile elements are needed in the cable design. However, it has to be ensured that a minimum of tensile elements is included in the cable to reduce the cable elongation during unwinding from the cable reel. Forces can easily go up to 50 N. Low diameter cables (e.g. 2,5 mm to 5 mm) are less susceptible against wind load because of the relatively low cross section. The lashing wire can be made of steel or dielectric material, for example aramid yarns.

5.2.3.2 Specific installation option

Metallic lashing wire is recommended in areas where bird attacks are likely.

5.2.4 Suspended cables

Cables according to IEC 60794-3-10 can also be fixed to a messenger wire or another already installed cable by using crimps which are applied along the length of the span.

5.3 Cables in ducts

5.3.1 General

Installation of fibre optic cables in ducts is the most common practice for a safe deployment. The ducts are typically made of a polymeric material like HDPE or PP. Typical duct diameters range from a few millimeters (5 mm, e.g. for microcables) up to 100 mm for typically 3 subducts. The subducts can be filled individually with cables of different diameters. Cables suitable for the installation in ducts are described in IEC 60794-3-10.

5.3.2 Pulling

5.3.2.1 General

Pulling of cables into ducts is still common practice. With the help of metallic spiral a pulling rope is attached to one cable end. Then the cable is pulled through the duct with the help of a winch. The procedure and the equipment needed is described in IEC TR°62691.

5.3.2.2 Specific installation options

During cable pulling, the maximum force acts at the point where the rope is fixed to the cable. Depending on the total length of the duct the force can easily go up to several hundreds of Newtons. Therefore the cable has to have sufficient strength elements (e.g. aramid yarns, glass yarns, metallic or non-metallic rods) to withstand the relatively high pulling tension. However, for drop applications it is very unlikely that the duct length is longer than 100 m. Thus the pulling force only should be in the order of 200 N. Additional tensile load can built up when the duct is deployed around corners with small bend radii. Because of the short distances and the deployment in safe ducts designs which are light weight and low diameter are to be preferred.

5.3.3 Jetting

Even though jetting with the help of an incompressible liquid (e.g. water) is a common method to install cables in ducts, it seems to be not efficient taken the short deployment distances into account. Jetting requires sophisticated equipment which is not needed for the installation of short length cables.

5.3.4 Blowing

5.3.4.1 General

As jetting (see 5.3.3), blowing is a method which minimizes the strain on the cable during installation. The driving force is distributed along the cable length. Thus, this method does not require cables to withstand high tensile force. A family of cables which is optimized for blowing is described in IEC 60794-5-10. Alternatively, blowing of fibre units into micro ducts can be considered (see IEC 60794-5-20).

5.3.4.2 Specific installation options

Cables and fibre units described in IEC 60794-5-10 and IEC 60794-5-20 are optimized for the use in low diameter ducts (typically less than 16 mm outer diameter, with examples being 14 mm outer diameter and 10 mm inner diameter, or smaller, for blown cables, and 5 mm outer diameter and 3,5 mm inner diameter, for microduct fibre units). Nowadays blowing equipment is small in size, thus it can also be used efficiently for the installation of short length drop cables.

5.3.5 Pushing

5.3.5.1 General

When the distances are short and the duct route is almost straight, cables can easily be installed by pushing the cables manually or supported by an appropriate caterpillar through the preinstalled duct. Cables according to IEC 60794-3-10 and IEC 60794-5-10 are suitable to be pushed into short ducts. However, normally no information about the total length which could be reached is specified in the product specification.

5.3.5.2 Specific installation options

To be able to push a cable through a duct, it needs to have a certain stiffness to minimize buckling which increases the friction of the cable to the inner wall of the duct. Up to now, no data about the stiffness and thus the friction increase due to buckling for different duct diameters are given in the product specifications. With the help of the coefficient of friction and the known cable stiffness, the expected pushing force can be estimated for a given duct length (see Annex B). From a practical point of view, the supplier should be asked to estimate the pushing length for a maximum pushing force (e.g. 100 N) for a straight duct configuration.

5.4 Installation in sewer, water and gas pipes

5.4.1 General

Deployment of fibre optic cables in routes guided through sewer, water and gas pipes is based on cable designs described in IEC 60794-3-10 and IEC 60794-3-20.

5.4.2 Specific deployment options

Special requirements have to be met with respect to chemical resistance and compatability with drinking waterl (see IEC 60794-3-60:2008, Clause 1). Because of the short distances for drop cables, special effort has to be undertaken to analyse the effort for implementation.

5.5 Direct-buried cables

When the overall situation requires the installation of cables directly into the soil, the cables should fulfill the requirements given in the standard IEC 60794-3-10. No additional requirements are to be expected.

5.6 Installation on facades

5.6.1 General

The requirements to be fulfilled by drop cables to be installed at facades are mainly determined by the selected installation method.

The following installation methods were observed in the field (Annex A):

Method 1: Tensioning the cable using clamps between anchors

Method 2: Attaching the cable using crimps on the wall

Method 3: Installing a duct (e.g. fixed by crimps) and pushing the cable through the duct

Method 4: Using alternative routes through the restricted space of windows and doors (see Figure 9)

Because of the low fibre count (1 to 8) which is normally needed for that application, the cable diameter can be as low as a few millimeters. Cables to be installed according to Method 1 need to have sufficient strength elements to withstand the applied tensions. When the cables are manually tensioned by the installers, the maximum tension is around 250 N. At the maximum specified tensile load, the fibre strain should not exceed 0,2 % (higher values have to be agreed between customer and supplier). To simplify the installation procedure, clamps as shown in Figure 3, Figure 4 and Figure 5 are often used. These clamps require cables which are very flexible: bend radii of ≤ 15 mm are typical. To avoid attenuation increase due to macrobending effects, bend insensitive fibres are recommended. The distance between the position of the clamps can easily reach 15 m to 25 m. Such a configuration is prone to vibrate when wind is blowing. When the cable vibrates, it can happen that parts of the cable frequently touch the rough surface of the facade which could lead, on a long term, to abrasion of the polymeric cable sheath. Abrasion may be tested as described in 4.6. The principle design of cables to be used for that application are described in IEC 60794-3-20.

5.6.2 Specific installation options

Because of the most common installation procedure for these cable (see Method 1 in 5.6.1), the cable has to withstand a combination of tensile strain under bent condition and should not show an attenuation increase higher than specified. The specific requirements depend on the specific conditions, for example length, clamps to be used. An appropriate test procedure is described in 6.3.3.

Wind induced vibration can lead to a frequent abrasive load due to scratching across the rough surface of the house wall.

The resistance of the cable sheath against that kind of mechanical load needs to be tested.

6 Testing

6.1 General

The cables used as drop cables are typically tested according to the standard cable test procedures (see 6.2). Additional performance requirements may need additional tests which are not standardized yet. These tests are described below.

6.2 Standard test procedures

Cable testing necessary to proof the cable specifications described in the product standards is done according to IEC 60794-1-20, IEC 60794-1-21, IEC 60794-1-22, IEC 60794-1-23, IEC 60794-1-24.

6.3 Additional test methods

6.3.1 General

The application of standard outdoor cables as drop cables may require additional features addressing the specifics of the installation method to be used.

6.3.2 Abrasion resistance against wind induced vibration in contact with rough surface

Observations in the field have shown that the fibre optic cable can be forced to touch frequently the rough surface of a house wall. When installed according to Method 1 in 5.6.1, anchors the amplitude of wind induced vibrations can become that big causing cable erosion due to repeated touch with the rough surface of the house wall. Because that can happen over years, the impact of that abrasive load on the cable sheath should be known. Currently, no test method is available to test this specific failure mode. Existing tests (e.g. in IEC 60794-1-21, Method E2A: Abrasion resistance of optical fibre cables, as described in 4.6) could be applied to get some confidence in the suitability of the selected drop cable. The specifics of the test have to be agreed between the supplier and the customer.

Alternative test methods which simulate the impact of that kind of vibrating abrasive load are under consideration.

6.3.3 Tensioning performance test

6.3.3.1 Principle

This test should be used to check if commonly used installation equipment, for example cable clamps or fixing spirals, results in any optical or mechanical deterioration of the selected drop cable. The requirements for the cable are different depending on the specific fixing devices used. In the case of the use of MCC (see Figure 4) the cable is bent to a radius of approximately 15 mm. During installation, the cable has to withstand the lateral deformation caused by the applied tensile load. In case of the P-clamp (see Figure 3) and the wedge clamp (see Figure 5) the critical load results from the localized clamping load caused by the applied tension.

NOTE IEC 60794-1-21, Clause 3, could also be used when the clamping device (see 60794-1-21:2015, 3.3, d)) is selected as described in 6.3.3.1.

6.3.3.2 Experimental set-up

So far, no specific test procedures exist which are suitable to predict the cable performance when these installation methods (see Annex A, Method 1) are used. Thus, the best approach is to use the specific fixation devices, to install them according to the instructions and to perform a tensile test.

A method of securing the cable shall be used, which uniformly locks the cable elements so that all the components of the cable are restricted in their movement, included optical fibres. One end of the cable sample is attached to the cable fixture (e.g. clamp, spiral, etc., see Figure 3, Figure 4 and Figure 5) according to the installation instructions of the supplier. The location of the fixture has to be marked on the cable. The other cable end should be wound around a mandrel with a radius of around 50 mm. Radius R should be big enough to avoid any attenuation increase due to macro bending when wound around the mandrel (see Figure 11).

The fixture and the mandrel should be attached to the standard tensile test equipment. The cable length under tension should be in the order of 0,5 m to 1 m.

The fibre(s) should be connected to an attenuation change measurement set-up (typical wavelengths of 1 310 nm and 1 550 nm).

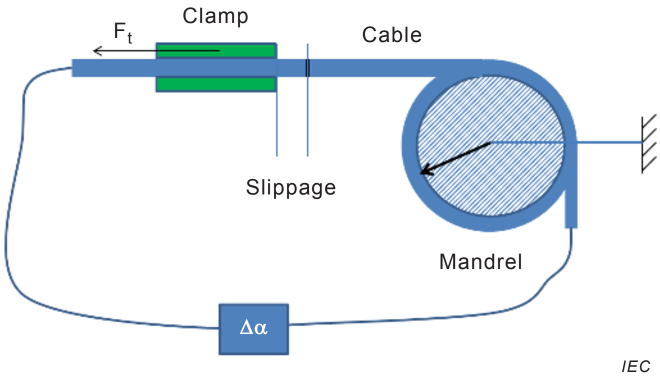


Figure 11 – Tensioning performance test set-up

6.3.3.3 Procedure

Once the cable sample is installed in the apparatus, the tensile force should be increased slowly up to the maximum specified tensile load F_t (typically in the order of 250 N). Once the maximum tensile load is reached, this force should be maintained for a longer period of time (typically 24 h). The change of the optical attenuation should be continuously monitored. The position of the fixing device (clamp, spiral) should be marked on the cable before tension is applied.

6.3.3.4 Typical requirements

No attenuation change should be observed during ramping up the tensile load and during the time period of constant tensile force.

No slippage of the cable should occur, no damage to be observed on the sheath and the cable components

7 Examples of commonly used drop cable designs

7.1 General

Clause 7 contains examples of cable designs which are commercially available right now and used as drop cables. This selection does not represent all constructions available on the market. However, it highlights some design criteria which make the cable suitable for a specific application space (see Tables 1 to 11 for the characteristics). Even though no designs with micro modules are presented, it does not rule out their use for drop cables. The most striking features of micromodules (high flexibility and stripability with bare fingers) can be of advantage during cable installation.

7.2 Designs to be used for the installation between poles

7.2.1 Self-supporting cables

7.2.1.1 Aerial cables

Figure 12 shows a typical cross section of a all dielectric self-supporting aerial cable based on a central tube design. For the application as aerial drop cable, only low diameter tubes (e.g. 3 mm) are required because of the low fibre count (e.g. 1 to 8 fibres). Depending on the specific installation conditions (e.g. span between 15 m and 50 m, allowed sag approximately 0,5 m), only a small amount of tensile elements (normally aramid yarns) is required (e.g. 9 600 dtex). Thus, the overall diameter can be as small as 6 mm. Also stranded designs (see Figure 13) could be used. However these designs result in much larger diameters and thus are not cost efficient, especially for low fibre counts.

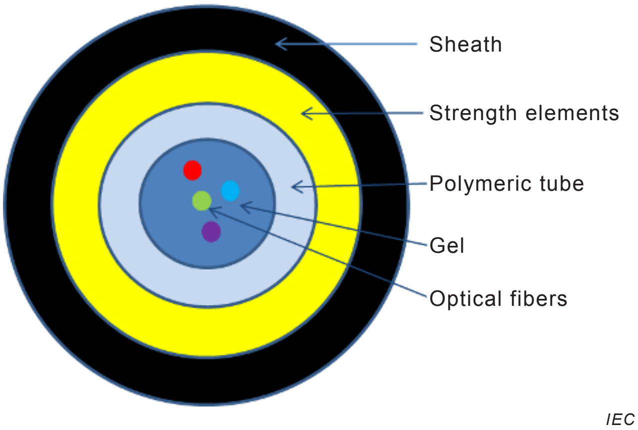


Figure 12 – Self-supporting dielectric aerial cable

Table 1 – Self-supporting dielectric aerial cables

Characteristics	Data	Remark
Typical design data	Cross section aramid: 5,4 mm^2 Outer diameter: 9,6 mm Central tube diameter: 4,2 mm Nominal sheath thickness: 2 mm Water blocking: gel filling Optical fibres: up to 12 f	
Typical performance data	Max. tensile load: 1,6 kN Min. bend radius: 140 mm Cable weight: 7,8 kg/100 m Thermal expansion coeff.: $-2,0 \times 10^{-6}$/°C Young´s modulus: 120 kN/mm^2	The maximum tensile load corresponds to the everyday stress which describes the long term tensile load without any ice and wind load.
Striking features	Low diameter	
	Fully dielectric	
	No preferential bend	

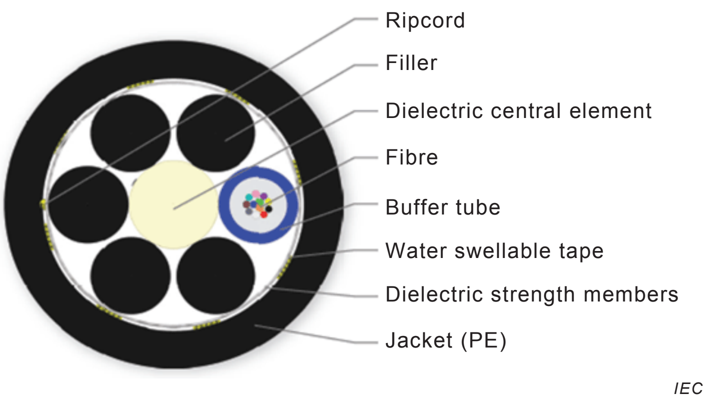


Figure 13 – Stranded self-supporting dielectric aerial cable

Table 2 – Stranded self-supporting dielectric aerial cables

Characteristics	Data	Remark
Typical design data	Outer diameter: 11 mm Buffer tube diameter: 2,5 mm Max. 12 f/tube	
Typical performance data	Tensile performance: 0,5 m sag at 500 N for 50 m span Min. bend radius (operation): 109 mm Gel filled buffer tubes Cable weight: 9,2 kg/100 m	
Striking features	EFL well defined by design	
	Larger diameter for small fibre counts (e.g. 1 to 8 f) than central tube design	

7.2.1.2 Cables with strength members embedded in the jacket

Alternatively, steel wires or GRP rods can be used as strength members. Because of the relatively stiff strength, elements bend performance is reduced compared to the yarns self-supporting dielectric aerial cable.

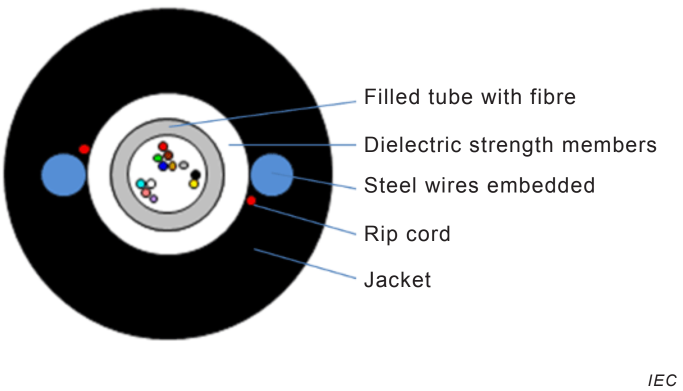


Figure 14 – Self-supporting aerial cable with non concentrically-arranged strength members

Table 3 – Self-supporting cable with non concentrically-arranged strength members

Characteristics	Data	Remark
Typical design data	Outer diameter: 8 mm Metallic: 1,2 mm Polymeric tube: 3 mm, up to 12 f	
Typical performance data	Tensile strength (short term): 2 700 N Weight: 6,3 kg/100 m	
Striking features	Low diameter	
	Easy installation	
	Reduced flexibility, preferential bend, not dielectric (if metallic strength element is used)	If metallic strength members are used correct grounding has to be considered

7.2.1.3 Flat designs

Other popular designs to be used for aerial installations are flat designs with strength members at the edges, as shown in Figure 15.

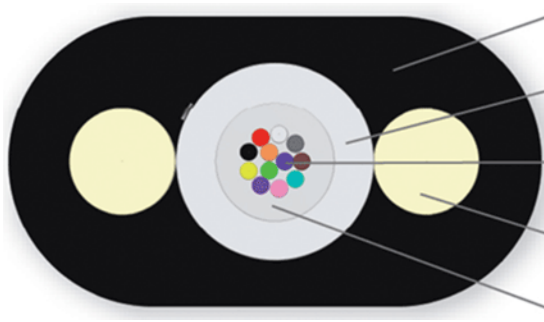


Figure 15 – Flat self-supporting aerial cable with strength members on both sides

Table 4 – Flat self-supporting aerial cable with strength members on both sides

Characteristics	Data	Remark
Typical design data	Buffer tube diameter: 3 mm Fibre count: up to 12f Dimensions: 8,1 × 4,5 mm^2 2 GRP strength members Sheath: PE or FRNC	Metallic strength members also possible
Typical performance data	Tensile strength (short term): 1 350 N Tensile strength (long term): 400 N Min. bend radius: 80 mm Weight: 3,0 kg/100 m	
Striking features	Dielectric or metallic strength members, high tensile strength, easy installation with P-clamps, also very small versions possible	
	Preferential bend	

7.2.1.4 Rectangular designs

Figure 16 shows rectangular design up to 12 fibres are embedded in an almost rectangular body made of Flame Retardant material or PE (depending on its use) in the centre between thin GRPs/ARPs/steel wires at the edges. This core is attached to a messenger wire which is embedded in a cable sheath. To avoid the insect risk such as egg-laying by cicada, it is important to select the appropriate material for the cable sheath (e.g. FR Polyamide, see Figure 14).

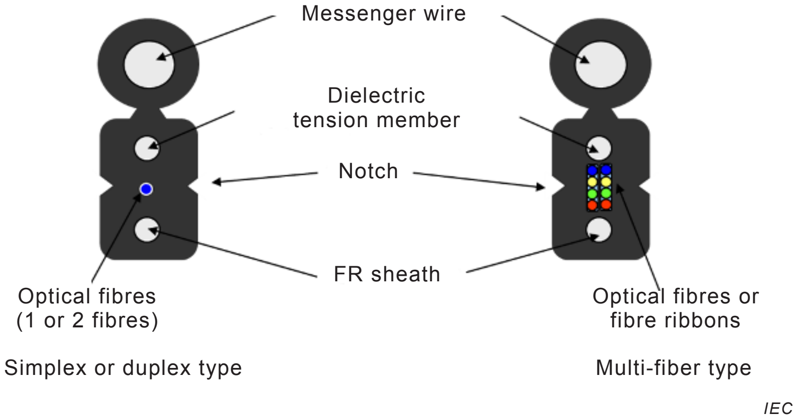


Figure 16 – Rectangular design with one integrated messenger wire and strength members

Table 5 – Rectangular design with one integrated messenger wire and strength member

Characteristics	Data	Remark
Typical design data	To be determined	
Typical performance data	To be determined	
Striking features	Easy to install by use of e.g. P-clamps (see Figure 3), low weight, low cross sectional area	
	Easy to separate	
	Easy access to fibre(s)	
	Preferential bend	

7.2.1.5 Cables with removable outer sheath

A version of aerial drop cable with a removable outer sheath is described in Figure 17. The outer sheath of that cable design consists of black Polyethylene which has excellent UV resistance. The outer sheath can be easily removed. The inner subunit is suitable to be deployed in house because its sheath consists of FRNC.

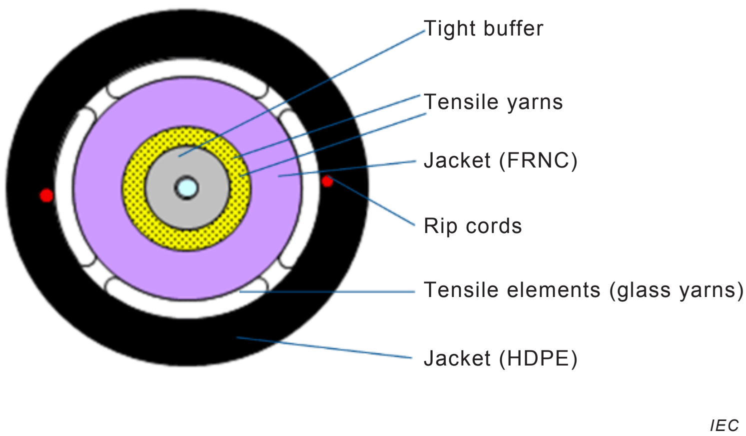


Figure 17 – Indoor / outdoor aerial drop cable with removable sheath

Table 6 – Indoor / outdoor aerial drop cable with removable sheath

Characteristics	Data	Remark
Typical design data	Outer diameter: 3,8 mm Subunit diameter: 2,4 mm Tight buffered fibre: 900 µm Outer sheath: HDPE Inner Sheath: FRNC	Outer sheath can be removed when cables enters the building
Typical performance data	Tensile strength (short term): 400 N Weight cable: 1,5 kg/100 m Min. bend radius cable: 25 mm Crush: 2 000 N/100 mm UV resistant	
Striking features	Low diameter, low weight, high tensile force, excellent bend and crush performance (thus suitable for the use with clamps), buffer tube reduces temperature shrink, can also be deployed indoors	
	Only 1 fibre	

7.2.2 Lashed and suspended cables

Aerial cables to be lashed on messenger wires do not require strong tensile elements. The maximum forces occur most likely during unreeling when the cable is being installed. Figure 18 shows an example of a lashed cable.

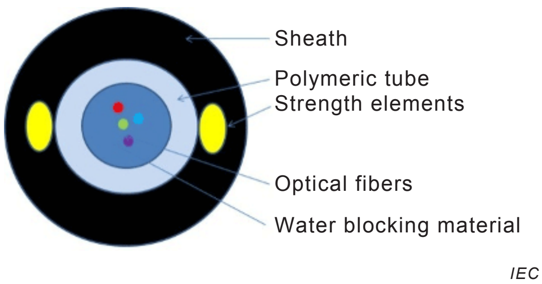


Figure 18 – Lashed cable

Table 7 – Lashed cable

Characteristics	Data	Remark
Typical design data	Outer diameter: 5,9 mm Buffer tube: 4,1 mm Fibre count: up to 24	
Typical performance data	Min. bend radius: 130 mm Cable weight: 2,8 kg/100 m Max. tensile force: 50 N	Tensile force applied during unwinding from the reel during the lashing process
Striking features	Low diameter, low weight	
	Lash tape susceptible to bird attack	Metallic lash tape shows better resistance against bird attack

7.3 Designs to be used for the installation in ducts

Traditional installation in ducts is done by pulling, jetting or blowing. These procedures are described in detail in IEC TR 62691. If these methods are to be applied, all types of standard duct cables can be used (see e.g. IEC 60794-3-11). In the context of drop cables, the installation distance is normally short (50 m to 100 m). Thus, alternate methods like pushing can be applied. Cables to be suitable for pushing are described in Figure 19.

The important feature is the stiffness of the cable, thus it does not buckle if pushed from one end when inserted into a duct.

Also, the friction to the inner surface of the duct and/or to other cables which are already deployed in the duct should be as low as possible.

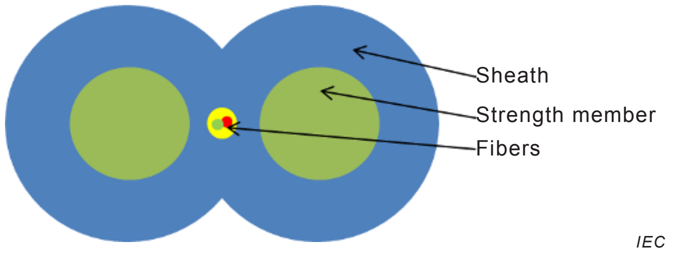


Figure 19a – Cable with high stiffness

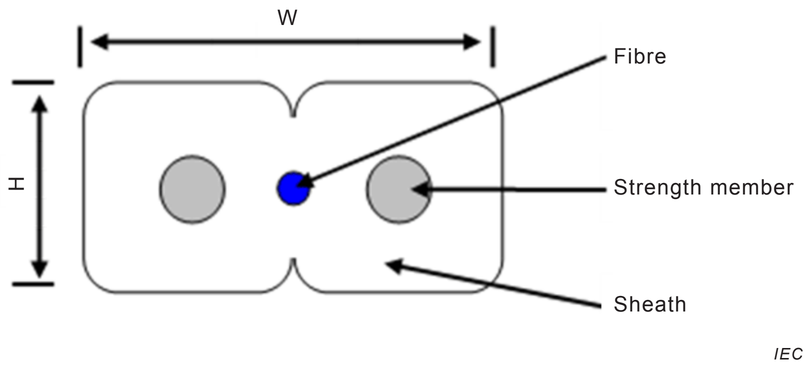


Figure 19b – Cable with thin low friction surface

Figure 19 – Cables suitables for pushing

Cables with flame retardant sheath material (e.g. LSZH) can also be installed indoors by pushing into ducts. The LSZH sheath allows the cable to be deployed in one single piece from the NAP straight into the house without the need of an additional cabinet for the transition from outdoor to indoor installation.

Table 8 – Designs to be used for the installation in ducts

Characteristics	Data	Remark
Typical design data	Dimensions (H × W): 3 × 5,4 mm^2 Dimensions (H × W): 1,6 × 2 mm^2	1 fibre or 1 tight buffered fibre
Typical performance data	min bend radius: 63 mm Max. tensile strength (short term): 1 350 N Min tensile strength (long term): 400 N Weight: 1,5 kg/100 m Min. bend radius: 15 mm Crush (long term): 1 960 N/100 mm Max. tensile load (short term): 200 N Cable weight: 0,7 kg/100 m	
Striking features	Low cross sectional area High stiffness, low friction (e.g. when HDPE is used), easy access	This cable design also can be used for the installation between poles
	Direct connectorization more difficult because cross section is not round Preferential bend	

7.4 Designs to be used for the installation in sewer, water and gas pipes

The cable types and installation procedures to be used for the application in sewer, water and gas pipes are described in detail in IEC 60794-3-40, IEC 60794-3-50, IEC 60794-3-60. Even though that technology can also be used for the installation of drop cables (short distance only), the complexity of these methods has to be taken into consideration. The access and exit into the pipes require special sealing technology which is commercially available but technically more challenging. Thus, a careful comparison of the effort has to be made before one of these methods is applied.

7.5 Designs to be used for direct-buried cables

All cable designs described in IEC 60794-3-10 and in IEC 60794-3-11 can principally be used for the application as drop cable. As the fibre counts are normally low (e.g. up to 12 fibres), central tube designs are preferred because of their smaller diameter compared to stranded designs. A robust design with a corrugated steel armoring is shown in Figure 20.

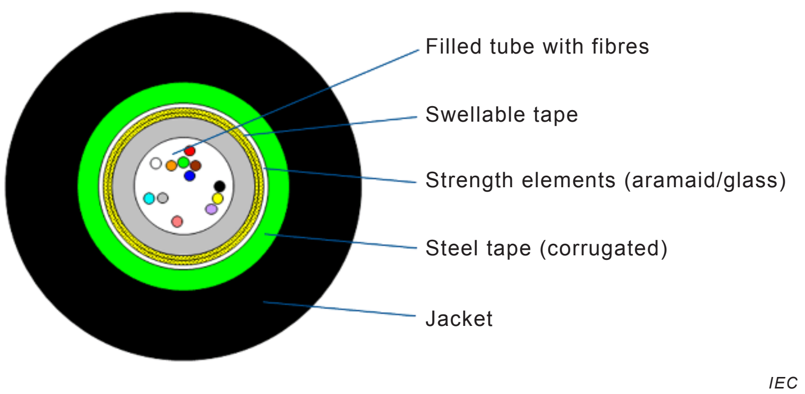


Figure 20 – Robust direct-buried cable with low diameter

Table 9 – Robust direct-buried cable with low diameter

Characteristics	Data	Remark
Typical design data	Outer diameter: 7,5 mm Buffer tube diameter: 3,0 mm Sheath thickness: 1,5 mm Sheath material: FRNC/LSZH	
Typical performance data	Min. bend radius (operation): 110 mm Weight 7,6 kg/100 m Max. tension during installation: 1 000 N Crush: 2 000 N/10 mm Temperature range: –20 °C to +70 °C	
Striking features	Robust design	
	High weight	

7.6 Designs to be used for the installation at facades

The design shown in Figure 21a can be used for the installation on facades. It provides enough strength (depending on the amount of tensile elements, e.g. aramid/glass yarns) to be tensioned between fixations, for example clamps (see Figure 4), or just guided through guiding rings or fixed by crimps. Because of the use of a FRNC sheath, it can also be guided directly through the house wall into the building without the need of an additional splice. The low diameter of the cable in combination with the ruggedized protection of the TB by the buffer tube enables the use of clamps without significant attenuation increase after installation.

A design which allows the installation into the restricted spaces through doors or windows to avoid puncturing the facades is shown in Figure 21b. The steel wire that is applied to restricted spaces at doors can remain bent. It is appropriate to select the bending-loss insensitive type optical fibre (such as ITU-T G.657.B3, or IEC 60793-2-50 B6_b3) to avoid bending loss by the tight bends.

A design which allows higher fibre counts is shown in Figure 21c, where 4 TB are stranded around a swellable yarn. Depending on the use of sheath material, the cable can be used as outdoor (sheath material PE) or indoor/outdoor version (sheath material FRNC).

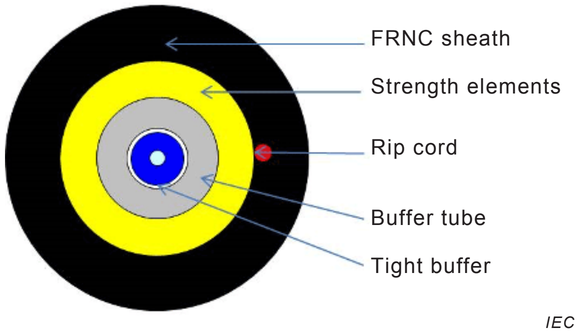


Figure 21a – Facade cable suitable for the installation between fixations using clamps

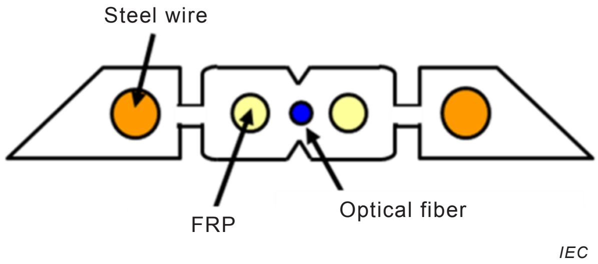


Figure 21b – Facade cable suitable for installation into restricted spaces through doors or windows

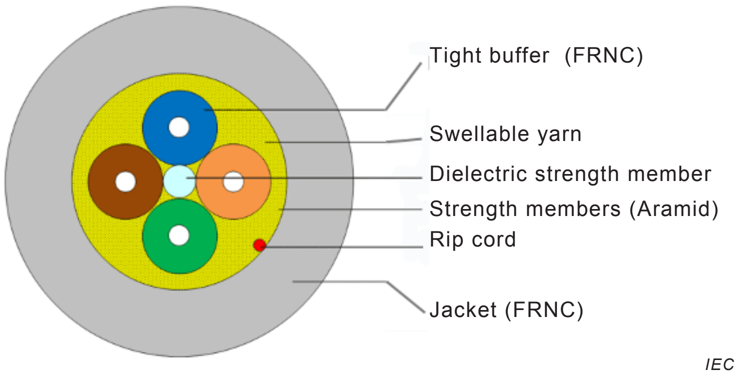


Figure 21c – Facade cable for fibre counts up to 4 fibres

Figure 21 – Facade cables

Table 10 – Designs to be used for the installation at facades

Characteristics	Data	Remark
Typical design data	Outer diameter: 5,0 mm Tight buffered fibre: 900 µm Outer sheath: FRNC	
Typical performance data	Tensile strength (short term): 1 000 N Weight of cable: 3,0 kg/100 m Min. bend radius cable: 15 mm UV resistant Crush: 800 N	
Striking features	Low diameter, low weight, high tensile force, excellent bend and crush performance (thus suitable for the use with clamps), buffer tube reduces temperature shrink, can also be deployed indoors	Can also be used as aerial drop cable
	Only 1 fibre	

Table 11 – Facade cable for fibre counts up to 4 fibres

Characteristics	Data	Remark
Typical design data	Outer diameter: 4,5 mm Tight buffered fibres: 4 Diameter TB: 0,9 mm	
Typical performance data	Cable weight: 2 kg/100 m Min. tensile load: 600 N Min. bend radius: 23 mm Crush (100 mm plate): 2 000 N Temperature range: –20 °C to 60 °C	 During operation
Striking features	Higher fibre count, low diameter, low weight, high tensile force	

Annex A
(informative)

Installation of fibre optic drop cables along facades

A.1 Method 1: Tensioning the cable using clamps between anchors

In some countries, it is common practice to install the fibre optic cable along the facade of building to be able to access the individual homes. In that case, clamps are fixed to anchors which are attached to the facade (see Figure 3, Figure 4 and Figure 5). The typical distance between these anchors is 6 m to 8 m. The cables are tensioned manually. The applied tensile force is in the order of 250 N. The distance between the cable and the surface of the wall is typically between 5 cm and 10 cm. Thus, wind induced vibration can cause the cable to swing and frequently touch the surface of the wall, which can cause abrasion of the cable.

A.2 Method 2: Attaching the cable with using crimps on the wall

The cable to be installed is fixed by crimps which are put in a distance between each other of typically 60 cm to 100 cm into the facade. No tensioning of the cable is required.

A.3 Method 3: Installing a duct (e.g. fixed by crimps) and pushing the cable through the duct

The installation of empty polymeric ducts (e.g. diameter between 8 mm to 10 mm) enables an easy deployment of an optical cable to a later point in time. Because of the short distances (typically 10 m to 40 m), a low diameter optical cable can easily be inserted by pushing it into the preinstalled duct.

A.4 Method 4: Using of alternative routes through the restricted space of windows and doors

In case a resident refuses to puncture the facade to install an optical cable inside a residence, the cable in Figure 21b can be used for wiring in the restricted space around a door or a window. The cable is connected with another cable and fixed along a corner of the door or the window as shown in Figure 9. The corner of the door or the window having typically a circle radius of 2 mm, the cable should have sufficiently low bending loss and high reliability for such a bend.

NOTE The installation methods listed above will be part of the next revision of IEC TR 62691.

Annex B
(informative)

Estimation of the pushing length

Pushing of a cable into a duct is governed by two effects: the friction between the cable and the inner surface of the duct and the buckling force (F_b).

The force caused by friction (F_f) can be described as

$$F_f = \mu \times L \times w$$

where

μ is the coefficient of friction;

L is the length of the cable;

w is the normal force caused by the cable mass in N.

The buckling force can be estimated using the Euler Formula:

$$F_b = \frac{\pi^2 \times E \times I}{(K \times L)^2}$$

where

E is the Young´s modulus;

I is the area moment of inertia in m^2;

L is the cable length in m;

K is 0,5 to 2.

The correct selection of the factor K depends on the boundary conditions:

- When the cable ends are fixed, K = 0,5
- When one cable end can freely move laterally and the other end is fixed, K = 2,0
- When both ends are pinned (hinged, but freely rotate), K = 1,0

Based on these formulae, F_f and F_b can be estimated as follows:

If

b(width) = 5,4 mm

h(height) = 3 mm

μ = 0,2

K = 0,5

w = 1,5 kg/100 m (cable weight/length)

$$A = (3 \times 5{,}4 \times 10^{-6}) m^2 \text{ (cross section)}$$

Tension at 0,6 % cable elongation = 1 350 N (short term load)

Estimates:

$$E = \frac{U}{A \times EL} = 1{,}38 \times 10^{10} \text{ N/m}^2$$

where

E is the Young's modulus;

U is the tension;

A is the cross section;

EL is the cable elongation.

$$I_1 = \frac{b \times h^3}{12} \text{ or } I_2 = \frac{h \times b^3}{12}$$

I_1 = 5,4 × 27/12 = 12,15 mm^2

I_2 = 3 × 157,4/12 = 39,4 mm^2

Thus:

$F_b = \pi^2 \times 1{,}38 \times 10^{10} \times 12{,}15 \times 10^{-6}/(0{,}5 \times 0{,}5 \times 100 \times 100) = 662$ N for I_1

$F_b = \pi^2 \times 1{,}38 \times 10^{10} \times 39{,}4 \times 10^{-6}/(0{,}5 \times 0{,}5 \times 100 \times 100) = 2\,146$ N for $I2$

$F_f = 0{,}2 \times 1{,}5 \times 9{,}81 \times 100 = 294$ N

The pushing force needed for the cable design (see Figure 19a) is approximately 300 N.

This force is still much lower as the estimate buckling force of approximately 662 N.

Please be aware that this estimate is only valid for a straight duct. As soon as bends are included, additional friction is created which remarkably increases the pushing force.

Annex C
(informative)

Additional clamp types for optical drop cables

Figures C.1 to C.4 show more examples for clamp systems to be used for the installation of fibre optic drop cables.


IEC


IEC

Left: open droplet type clamp

Right: droplet type clamp with round drop cable

Figure C.1 – Droplet type clamp


IEC


IEC

Left: open fish type clamp

Right: fish type clamp with round drop cable

Figure C.2 – Fish type clamp

IEC IEC

Left: open clamp

Right: clamp with round drop cable

Figure C.3 – P-clamp

IEC IEC

Left: open wedge type clamp

Right: wedge type clamp with flat drop cable

Figure C.4 – Wedge type clamp

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