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Europacable
Technical newsletter
Fibre to the Home
Indoor Optical Fibre Cables

March 2023

1. Introduction

Optical fibres cables are used for data transmission in different environments:

Outdoor: as direct buried cables or duct cables, cables to be installed between poles (aerial cables), as well as deployments in lakes, rivers or in the sea (submarine cables).

Finally the optical fibre has to be deployed in buildings / premises to get closer to the end user. This requires cable designs which differ considerably from those used for outdoor applications. For outdoor use the cables have to withstand very severe environmental conditions related to mechanical impact, temperature changes, UV radiation and to certain extend also chemical attacks. Thus the cables are generally designed to provide high tensile strength, crush resistance and to withstand temperature changes between -40°C and +70°C with attenuation changes as low as possible. Since these cables are very often installed as trunk cables the fibre count can go easily up to approx. 432f. Long cable lengths in the order of several 10th of km are common practice.

The cable design of indoor optical cables reflects the application space typically inside of buildings: the cables are not exposed to severe environmental attacks, the tensile requirements are less severe, the normal temperature range lies between -5°C and +60°C. Cable connections are short (typically around 100 m). However flexibility, bend performance and not to forget very stringent requirements related to burn performance have to be fulfilled. Also fibre handling as well as fast and easy installation is becoming more important because of increasing number of terminations. The required fibre counts per cable are normally much lower than for outdoor cables. The typical requirement ranges between 1f up to 24f/cable. However especially in the so called "riser application" also cables with much higher fibre count (up to e.g. 72-144f) are in use.

This document is part of a suite of Newsletters published by EUROPACABLE: We encourage the reader to read all of them and also the white paper entitled "**Expected lifetime of Passive Optical Infrastructure**".

Application spaces

FttH indoor optical fibre cables are used for the following applications [10,11]:

a. Distribution of optical signals in the vertical direction e.g. between the floors of a building. These cables are known as Riser cables.
b. Distribution of optical signals in the horizontal direction within a floor e.g. to connect the different appartements or offices. These cables are known as drop cables.
c. Connection of ports within e.g. Optical Distribution Frames (ODF) by patch cords which typically consist only of one fibre with a length of only a few meters and connectors on each side.

Note: Designs to be used in an industrial environment as well as installations in Data Centers are not covered in this article.

2. Design criteria for indoor cables

Since the indoor optical fibre cables are installed in a protected environment, the requirements related to the impact of temperature, irradiation as well as chemical attacks are less stringent. UV stability is normally not required.
Normally the cables are subjected to a temperature variation from -5°C (cold cellar) up to 60°C (cabinet with active equipment) which corresponds to the definition of so called "controlled environment" (see ISO/IEC 11801-3:2017 Mice-Table). Thus the cables do not always require strong anti-buckling elements to mitigate the effect of cable contraction and expansion due to the coefficient of thermal expansion (CTE). Depending on the application indoor cables are less stiff and thus can be bent in small diameters down to approx. 2 cm which makes them suitable to be routed through the cabinets to connect the transmission equipment.
Indoor installation will very often push the cable to the limit of the bending performances: sharp corners are a common reality and connection boxes will be reduced in size. The type of fibres must reflect those difficulties and it makes also sense to avoid a fibre type change between outdoor drop cables and indoor cables.

All indoor cables can consist of single mode fibres as well as multimode fibres depending on the bandwidth requirements and the selection of the transmission wavelength. For more information regarding optical fibres see references [13, 14 and 15].

Another major general design criteria is the required protection of the cables against the fire. The requirements for the fire performance varies between countries. In the European Union the indoor cables have to be classified according to the Construction Product Regulation (CPR). The relevant standard is the EN 50575 "Power, control and communication cables - Cables for general applications in construction works subject to reaction to fire requirements" [6]. According to their performance the classification for indoor cables ranges between Fca (no fire protection) and B2ca (high fire protection).

3. Indoor distribution cables

After the fibre optic trunk cable has entered the building (typically in the base of the building) the incoming cable will be split in a central patch panel into several indoor riser distribution cables which will connect the different floors with the base.

Depending on the numbers of end-users the fibre count can vary remarkably. For single user homes the minimum recommended fibre count is 6 (4 per user + 2 “for the building”, German Broadband Concept). In France minimum fiber count is 1 to 4 (French Regulation Authority concept)

3.1 High fibre count indoor distribution cables

3.1.1 Stranded loose tube

The cables with high fibre count can have a similar design than stranded loose tube outdoor cables. A typical cable design is shown in fig 1. Six units of twelve fibres (12f) are stranded around a central element and surrounded by a jacket which results in a cable outer diameter of approximately 8.3mm. The 12f units contain bare fibres.
The individual units can be separated and guided horizontally to the floor distribution boxes.

Fig.1 Stranded multi unit design: 6x12f

3.1.2 Easy access cables

Another solution consists in using an easy access cable (see fig. 2), allowing straight midspan access anywhere along its path (also known as extractable pull back cable).

This consist of a jacket surrounding either tight buffered fibres or micromodules containing typically 4-12 bare fibres each. This last solution enabling up to 144 optical fibers per cable.
Fibres are typically spliced at the floor distribution box to connect end user.

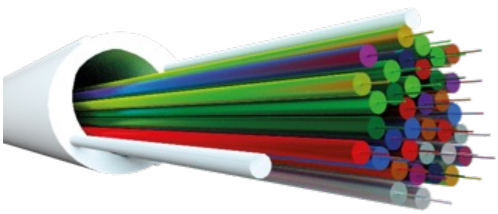

Fig. 2 Example of easy access cable with tight buffered fibres

Connection procedure:
Two opening windows are performed with a dedicated tool in the sheath to allow and easy access to micromodules or tight buffered fibres (see fig 3). These extracted micromodule or tight buffered fibers are then connected to end user or spliced in a floor distribution box.

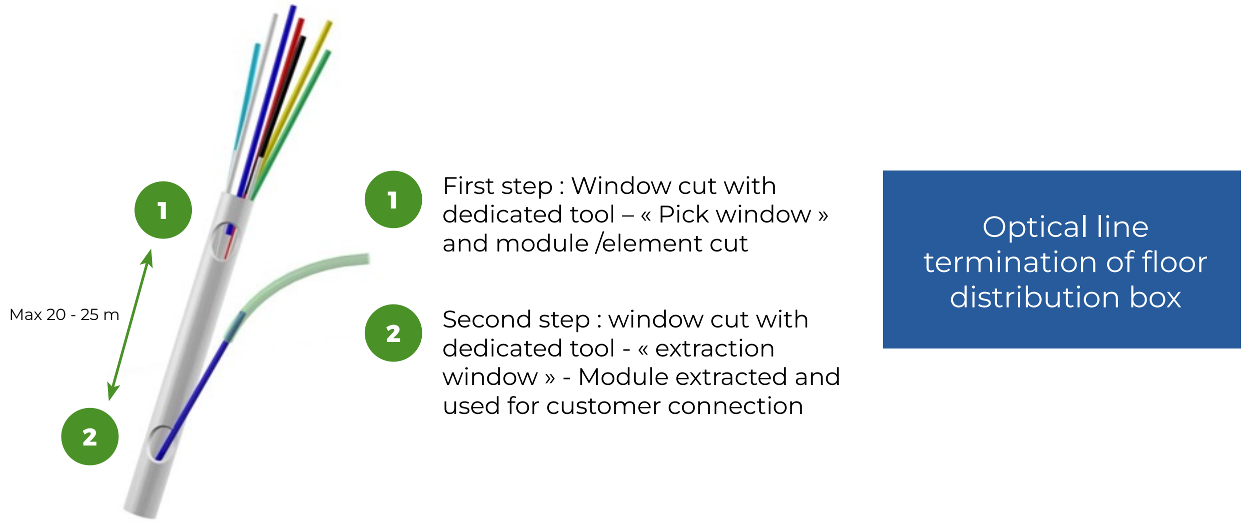

Fig. 3 Procedure to extract tight fibres or micromodules

3.2 Low and medium fiber count distribution cables

3.2.1 Mini-break out cables

A common design to be used in riser installations with low and medium fiber count cables is shown in fig 4. Six units consisting of one tight buffered fibre are stranded around a central element.
To simplify the fibre handling and on site connectorization, the so called Tight Buffered Fibres (TB) have been introduced. These elements typically have a diameter of 900 µm and consist of a single fibre (diameter 250µm) surrounded with a secondary coating made of an appropriate thermoplastic material. These buffered fibres are more ruggedized because of the thicker coating and thus handling on site and connectorization, done in the field, is easier.

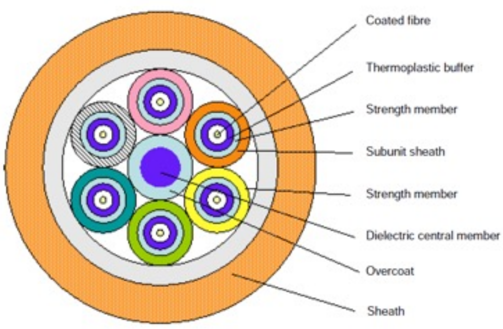

Fig. 4 Riser mini break out cable: 6 TB units

These units can be routed individually as part of the horizontal cabling of a building. To increase the fibre count either more single tight buffers can be stranded around the central element or units made of 6 stranded TB can be used.

3.2.2 Central tube cables

Alternate cable designs are based on the so called central tube concept. The optical elements (bare fibres or tight buffered fibres) are put into a polymeric tube which is surrounded by strength elements and a jacket (fig 5) made of a flame retardant material..

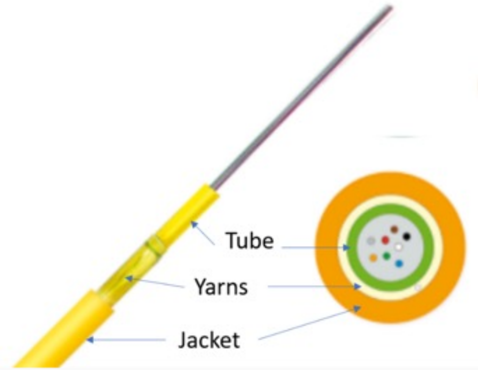

Fig. 5 Central tube design with bare fibres. Cable outer diameter: 6.2mm

3.2.3 Multi tight buffered fiber cables

These multifiber indoor cables are based on up to 12f tight buffered fibers embedded in yarns which provide the needed tensile strength and surrounded by a flame retardant jacket (see fig. 6) which fulfills the fire performance requirements according to the CPR [7]. Since no stiff central strength member is used the minimum bend diameter is as low as a few centimeters.

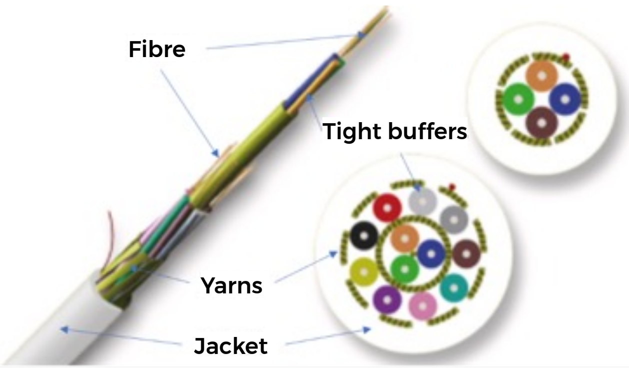

Fig. 6 Tight buffered fibers (TB) embedded in yarns and surrounded by a jacket. Cable outer diameter: 6.2mm for 12 TBs, 4.2mm for 4 TBs.

3.3 Pre-terminated distribution cables

Since the installation time of an optical link is one of the biggest contributors to the overall indoor network cost, so called pre-terminated solutions (see fig. 7) become more and more popular. The connectorization of the fibre optic cables is critical and requires a high level of precision. Thus performing this step in a well defined controlled and clean lab environment also increases the product quality. At one end pre-terminated cables, can easily be installed within the building with standard installation methods, e.g. pushing and or pulling through pre-installed ducts.

Fig. 7a Trunk cable, pre-connectorized with LC-PC connectors. Prepared for pulling through a duct.

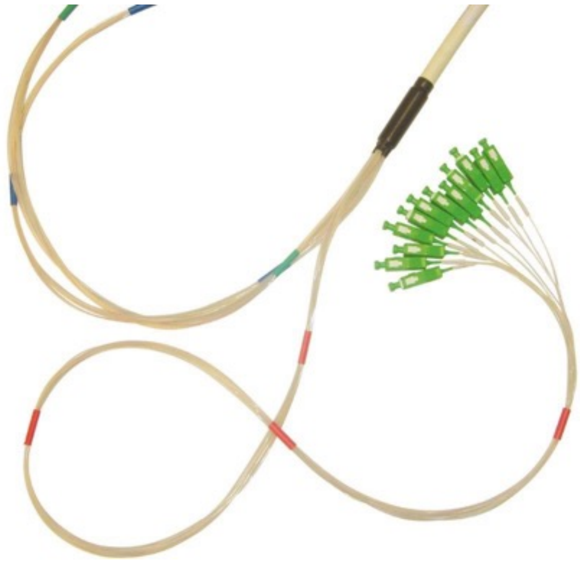

Fig. 7b Preterminated easy access cables based on micromodules

4. Drop cables

4.1 Standard Indoor drop cables

These cables can be used for horizontal as well as vertical connection, e.g. from a floor distribution box to the individual appartement. The fiber count is typically 1 – 2 fibres. The cable diameter is around 2mm.

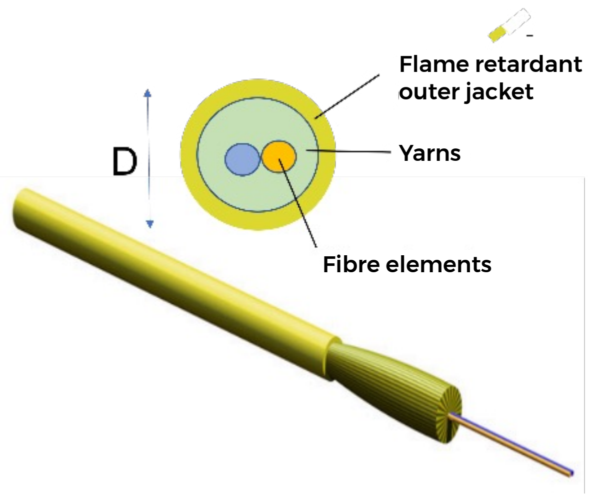

Fig. 8) Standard indoor drop cable with 1 or 2 tight buffered fibres or bare fibres. The outer diameter D ranges from approx. 1.6mm to 2.8mm when TB are included and 1.4mm to 2.0mm when bare fibres are used.

4.2 Reinforced indoor drop cables

Fig. 9 shows an example of a single fibre reinforced drop cable. The strength elements provide enough strength for longer vertical or horizontal installation as well as enough rigidity to be pushed through ducts which are often preinstalled and already used in buildings. The optical fibre (tight buffer) is well protected in the center against e.g. lateral loads. The fibre can be easily access by tearing the strength elements apart.

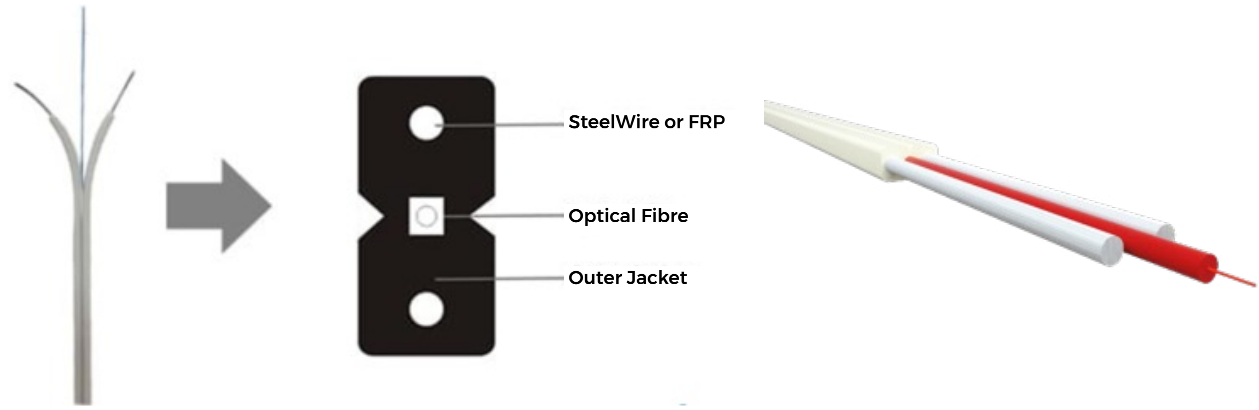

Fig. 9 Indoor drop cable with strength elements which makes the cable also suitable for longer vertical or horizontal installations as well as installation by pushing into preinstalled ducts.

5. Patchcord cables

Indoor cables made of only 1 tight buffered fibre (see fig. 12) are mainly used to connect the many ports in distribution frames, racks of switches and other hardware. The typical diameter of these cables is only 1.2mm to 2.0mm and thus the minimum bend diameter is in the order of 24mm - 40mm which makes them ideal for being routed in confined space. Normally these cables have only short lengths: 3m, 5m, 10m. For the purpose described both ends are pre-terminated with different kind of connectors to build a patch cord. However this kind of cable can also be used as distribution cable from the floor distribution point to an individual apartment.

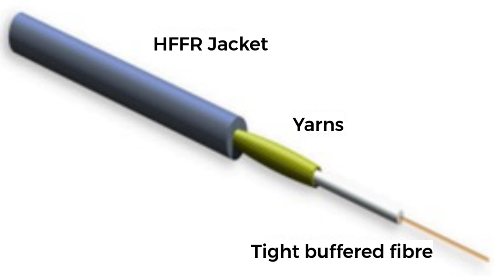

Fig 12 Simplex cable: to be used in patchcords as well as floor distribution cable

Note: Since these cables need to be connectorized care should be taken to select cables made of a low shrink cable jacket. The shrinkback of the jacket should be as low as possible but at least should be known to avoid issues during the connectorization process. The characterization of the jacket shrinkback is described in an appropriate IEC standard [12].

6. Indoor Cable performance

Indoor cables are installed in a protected environment. Therefore cable expansion and contraction due to thermal effects and resulting attenuation changes are minimal. The cables do not require a strong armoring against lateral forces and local impact. The tensile requirements are determined by the installation methods to be used. The cables have to withstand the loads needed for installation by e.g. pulling them vertically / horizontally through ducts or cable conduits. These loads are typically in the order of 200N – 500N (typically the "weight" of 1 km cable) for riser cables. Since the cable diameters of some indoor designs can go down to 1.2mm the achievable minimum cable bend diameters are in the order of 25mm (min bend diameter = 20 x cable outer diameter). A detailed description of the indoor cable specification can be found in the standards series IEC 60794-2 [1,2,3,4,5]. Premises cabling is described in detail in the series EN 50173 [9,10,11].
One of the most important performance criteria for indoor cables is their fire behaviour. In 2017 the Construction Product Regulation became effective in Europe. According to this regulation every cable product supposed to be permanently installed in buildings has to be certified according to the procedure described in EN 50575 [6]. Tests according to EN 50399 will finally provide a CPR classification in classes B2ca to Fca described in the classification standard EN 13501-6 (see fig. 13)

	classification	**B2**$_{ca}$	**C**$_{ca}$	**D**$_{ca}$	**E**$_{ca}$	**F**$_{ca}$
Standard		**FIPECScen1**	**FIPECScen1**	**FIPECScen1**	**-**	**-**
EN 60332-1	**H** / mm	**≤425**	**≤425**	**≤425**	**≤425**	
EN 50399	**FS** / m	**≤1,5**	**≤2,0**			
	THR$_{1200s}$ / MJ	**≤15**	**≤30**	**≤70**		
	HRR / kW	**≤30**	**≤60**	**≤400**		
	FIGRA / Ws-1	**≤150**	**≤300**	**≤1300**		
	additional classification					
EN 61034	smoke production	s1a, s1b,s2,s3	s1a, s1b,s2,s3	s1a, s1b,s2,s3	no	no
EN 60754-2	aciditiy	a1,a2,a3	a1,a2,a3	a1,a2,a3	no	no
EN 50399	flaming droplets	d0,d1,d2	d0,d1,d2	d0,d1,d2	no	no

Fig. 13 Euroclasses according to EN 13501-6

Parameters like Flame Spread (FS), Heat Release Rate (HRR), Smoke Production (TSP) and others are taken into account. Sensitive areas like hospitals, schools, should be equipped with cables of highest performance B2ca to minimize the risk of fire.
It is the duty of each national appropriate authority to define which cable can be installed in which building. The installation requirements must be respected by installers and must be documented in such a way that the traceability is in place up to the manufacturer.

Patchcords as described before are assemblies and thus not "permanently installed" in the network. Formally they do not fall under the CPR and cannot be certified. Nevertheless it is common practice that customers also require a certificate for the cables to be used for manufacturing of those cords.

References

[1] IEC 60794-2-10 Indoor cables – Family specification for simplex and duplex cables

[2] IEC 60794-2-20 Indoor cables – Family specification for multi-fibre optical cables

[3] IEC 60794-2-30 Indoor cables – Family specification for optical fibre ribbon cables for use in terminated cable assemblies

[4] IEC 60794-2-40 Indoor optical fibre cables – Family specification for A4 fibre cables

[5] IEC 60794-2-50 Indoor cables – Family specification for simplex and duplex cables for use in terminated cable assemblies

[6] EN 50575:2014 "Power, control and communication cables - Cables for general applications in construction works subject to reaction to fire requirements"

[7] EN 50399 "Common test methods for cables under fire conditions – Heat release and smoke production measurement on cables during flame spread test - Test apparatus, procedures, results"

[8] EN 13501-6 "Fire classification of construction products and building elements — Part 6: Classification using data from reaction to fire tests on electric cables"

[9] EN 50173-1: "Information technology – Generic cabling systems – Part 1: Generic requirements"

[10] EN 50173-2: "Information technology – Generic cabling systems – Part 2: Office premises"

[11] EN 50173-4: "Information technology – Generic cabling systems – Part 4: Homes"

[12] IEC 60794-1-22-F17: "Optical fibre cables – Part 1-22: Generic specification – Basic optical test procedures – Environmental test methods, Method F17 – Cable shrinkage test"

[13] Europacable Newsletter "Understanding an optical fibre datasheet"

[14] Europacable Newsletter "Optical fiber standards"

[15] Standard document IEC 60793-2 series: "Optical fibres – Product Specifications"

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March 2023 – Ed1