BS EN 50290-4-2:2014

BSI Standards Publication

# Communication cables

## Part 4-2: General considerations for the use of cables — Guide to use

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**National foreword**

This British Standard is the UK implementation of EN 50290-4-2:2014. It supersedes BS EN 50290-4-2:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/46, Cables, wires and waveguides, radio frequency connectors and accessories for communication and signalling.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.



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**Compliance with a British Standard cannot confer immunity from legal obligations.**

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## Communication cables - Part 4-2: General considerations for the use of cables - Guide to use

Kommunikationskabel - Teil 4-2: Allgemeine Betrachtungen für die Anwendung der Kabel - Leitfaden für die Verwendung

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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## Foreword

This document (EN 50290-4-2:2014) has been prepared by CLC/TC 46X "Communication cables".

The following dates are fixed:

| | | |
|---|---|---|
| • latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2015-06-05 |
| • latest date by which the national standards conflicting with this document have to be withdrawn | (dow) | 2016-09-16 |

This document supersedes EN 50290-4-2:2008.

EN 50290-4-2:2014 includes the following significant technical change with respect to EN 50290-4-2:2008:

– Subclause 5.3 was revised.

This standard should be read in conjunction with EN 50290-1-1 and is completed by generic, sectional, family and detail specifications, as appropriate, to describe in a detailed manner each type of cable with its specific characteristics.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

This standard covers the Principle Elements of the Safety Objectives for Electrical Equipment Designed for Use within Certain Voltage Limits (LVD - 2006/95/EC).

EN 50290-4, *Communication cables — General considerations for the use of cables*, is divided into the following sub-parts:

– *Part 4-1: Environmental conditions and safety aspects*;

– *Part 4-2: Guide to use* [the present document].

## 1 Scope

The scope of this European Standard is to help installers and cabling designers to understand the range of communication metallic cables available. To help this choice the fundamental and practical rules on how to use these cables are established.

The related cables are specified in the documents issued by CLC/TC 46X and its sub-committees.

These cables are:

– telecom cables used in access network,

– data communication twisted pairs cables,

– coaxial cables used in CATV.

## 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.

EN 50083 (all parts), *Cable networks for television signals, sound signals and interactive services*

EN 50090 (all parts), *Home and Building Electronic Systems (HBES)*

EN 50117 (all parts), *Coaxial cables*

EN 50173 (all parts), *Information technology — Generic cabling systems*

EN 50174 (all parts), *Information technology — Cabling installation*

EN 50200, *Method of test for resistance to fire of unprotected small cables for use in emergency circuits*

EN 50288 (all parts), *Multi-element metallic cables used in analogue and digital communication and control*

EN 50289-1-3, *Communication cables — Specifications for test methods — Part 1-3: Electrical test methods — Dielectric strength*

EN 50289-3-9, *Communication cables — Specifications for test methods — Part 3-9: Mechanical test methods — Bending tests*

EN 50289-4-16, *Communication cables — Specifications for test methods — Part 4-16: Environmental test methods — Circuit integrity under fire conditions*

EN 50290 (all parts), *Communication cables*

EN 50406 (all parts), *End user multi-pair cables used in high bit rate telecommunication networks*

EN 50407 (all parts), *Multi-pair cables used in high bit rate digital access telecommunication networks*

EN 50441 (all parts), *Cables for indoor residential telecommunication installations*

EN 50575, *Power, control and communication cables — Cables for general applications in construction works subject to reaction to fire requirements*

## 3 Communication cable basics

Communication cables are the highways and arteries that provide a path for telecommunications devices. There is a general tendency to say that one transmission medium is better than another. In fact, each transmission medium has its place in the design of any communication system. Each has characteristics that will make it the ideal medium to use based on a particular set of circumstances. It is important to recognize the advantages of each and develop a system accordingly.

Factors to consider when choosing communication cable include:

– efficiency of transmission,

– cost,

– ease of installation and maintenance,

– availability.

# 4 Types of cables

## 4.1 General

When working with communication cables, an installer will deal with two basic types:

– balanced,

– unbalanced.

Balanced cabling involve twisted-pair and/or twinaxial twisted cables that are composed of one or more pairs of copper wires (see Figure 1).

Unbalanced cabling involves coaxial cable, that has only one centre conductor of either solid or stranded inner conductor and an outer concentric conductor. Most data and voice networks use twisted-pair cabling. Coaxial cable is now used primarily for CATV, satellite and video connections (see Figure 2).

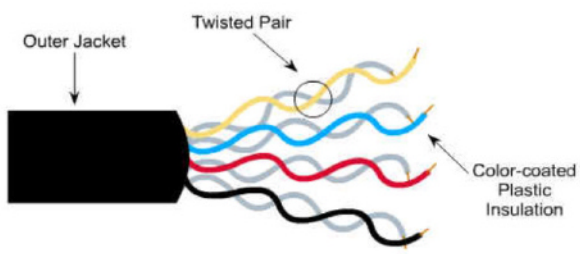



**Figure 1 — Balanced cabling**

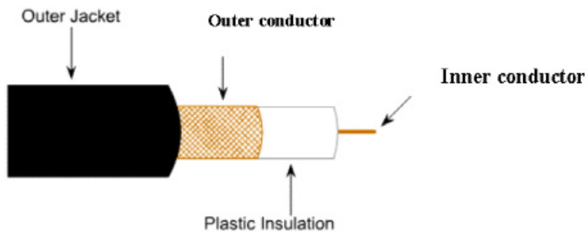



**Figure 2 — Unbalanced cabling**

## 4.2 Twisted pairs cables

### 4.2.1 Pair construction

There are two different pairing constructions:

– a pair made of two insulated wires twisted together (wire A and B in Figure 4);

– a quad made of four insulated wires twisted together, providing two pairs from a star formation (first pair wire A and B and second pair wire D and C in Figure 3);

– a pair made of two insulated wires twisted together;

– a quad made of four insulated wires twisted together, providing two pairs.

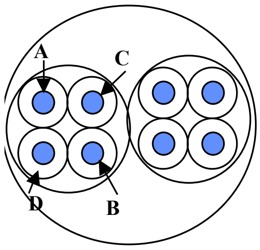



**Figure 3 — Starquads**

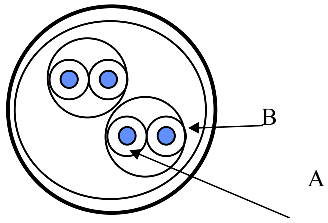



**Figure 4 — Pairs**

### 4.2.2 Pair counts

Telecommunications cable comes in many sizes, starting with a single pair of wires, up to and perhaps more than 4 200 pairs of wires. These pairs may be arranged in concentric layers or in bundles. A data communication terminal is fed normally with a maximum of 4 pairs, so the last part of the network is built with cables having 1 to 4 pairs. As the other parts of the network aggregate several terminal cables, they have a larger number of pairs. The highest number of pairs is encountered at the main communication switch. The main communication switch is then connected to global systems by satellite, fibre, radio, waveguide and coaxial (CATV).

The identification of each pair in the cable is made through an appropriate colour code that is given in the relevant standard or may be agreed between customer and manufacturer (see Example in Figure 5).

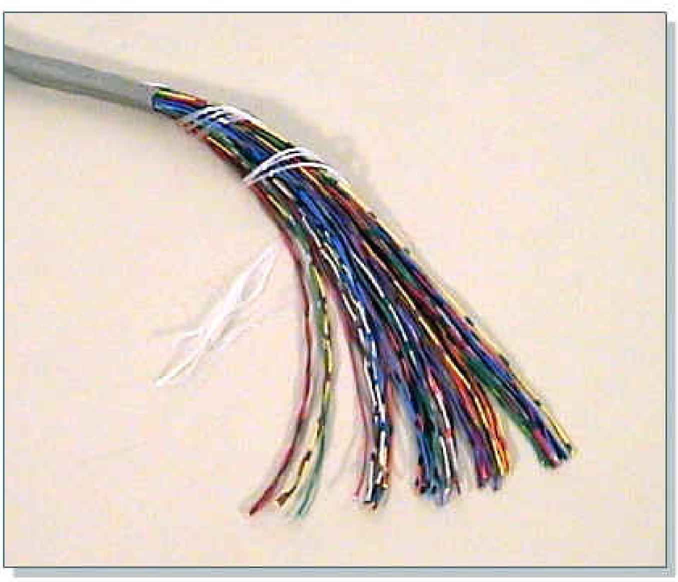


**Figure 5 — Example of pair arrangement in a telecommunication cable**

## 4.3 Coaxial cable (unbalanced)

Coaxial cable is called ‘coaxial’ because it includes one conductor surrounded by a layer of insulation, itself surrounded by a concentric conductor (a metallic foil or braid or a combination of both) and an outer sheath (see Figure 6).

Coaxial cable is the primary type of communication cable used by cable TV companies for signal distribution between the community antenna (CATV, normally 75 Ω) and user’s homes and businesses. The WWW is now accessible through such communication mediums making possible all types of connections. It was once the primary medium for Ethernet and other types of local area networks because of its ability to transmit high frequencies. With the development of standards for Ethernet over twisted-pair, new installations of coaxial cable for this purpose have all but disappeared.

Coaxial cable is still used for connecting CCTV cameras to monitors, antenna's and video switches. Cables for radio communication (mobile telephone) antenna's are also coaxial, these are feeder cables and are normally 50 Ω.

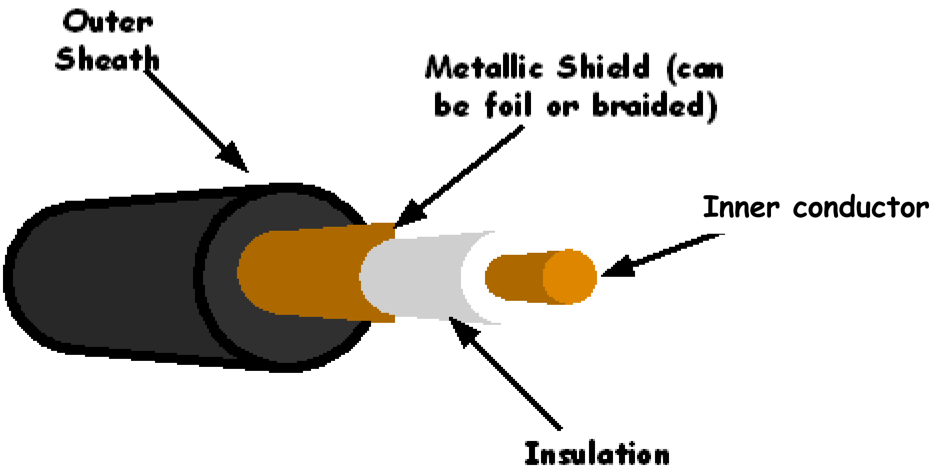



**Figure 6 — Coaxial cable illustration**

There are several variations. Triaxial (Triax) is a form of cable that uses a single centre conductor with two shields (one could be tape and one braid). This is important when considering EMC (electromagnetic compatibility). This composition affords a greater transmission distance with less loss due to interference from outside electrical signals. Twinaxial (Twinax) is two coaxial systems packaged within a single concentric outer conductor and jacket to form the cable.

### 4.4 Flexible cables versus rigid cables

Communication infrastructure includes different sections. Some sections are installed, indoor or outdoor, permanently (i.e. fixed) so the cables are static (once installed, do not move) for their lifetime. Some other sections are subjected to continuous movement and different mechanical behaviour is required for the cable (see 7.6).

Copper is inherently rigid and leads to build cables with a certain degree of stiffness suitable for permanent installations. However, copper is one of the most malleable of the rigid metals and so cannot be unsupported. Nonetheless, cable construction includes design to allow appropriate bending radius to be performed without degradation of mechanical and transmission properties.

For some applications there is a need for smaller bending radius, multiple bending, or less stiffness while keeping requested transmission properties (i.e. work area cables or cables used in lift machinery). Specific designs to achieve this target use stranded conductors instead of one-solid-conductor; also with insulation material having specific mechanical properties are used. These cables, named "flexible cables", are often used in cord assemblies and are specified for a given number of mechanical cycles.

In order to provide more flexibility to cables used in cords, stranded conductors are used instead of solid conductors. Not only does this improve flexibility but also allows the cable to be repeatedly flexed many times; this can be useful in robotic systems.

The relevant cable standards identifies whether the cable is either flexible or rigid, depending on how the cable will be used in its life cycle i.e. look for properties such as simulated installation, torsion and twisting or flexing performance tests.

These basic principles, along with avoiding already known stresses and misuses of installations, will ensure the cable does not irreversibly degrade below the performance criteria. There are many situations already known that will change the performance criteria below that of the specified limits.

# 5 Cables and regulations

## 5.1 General

In addition to functional requirements cables have to meet the essential requirements of European Directives like the LVD (Low Voltage Directive) and the CPD (Construction Products Directive) and may have to contribute to the compliance of systems versus other directives like the EMCD (Electromagnetic Compatibility Directive).

EN 50290-4-1 gives the relationship between cables and main European Directives by detailing the related cable characteristics and associated tests.

## 5.2 Low voltage

Cables that are described into the documents issued by CLC/TC 46X and its sub-committees are tested for voltage withstanding.

The test is performed between conductors and between the conductors or screen and the outer surface of the sheath.

When constructed in accordance with EN 50290-2-1 and submitted to spark testing, communication cables may be installed together with Low Voltage cable.

Moreover the tests are performed after environmental and ageing tests. In addition the raw materials of these cables are defined in the EN 50290 series. This ensures sufficient stability of the cable related to this characteristic for its life cycle.

Thus these cables are considered safe when:

– they are used for their intended purpose and applications;

– they are used under voltages and currents that do not exceed the limits given in the relevant specification.

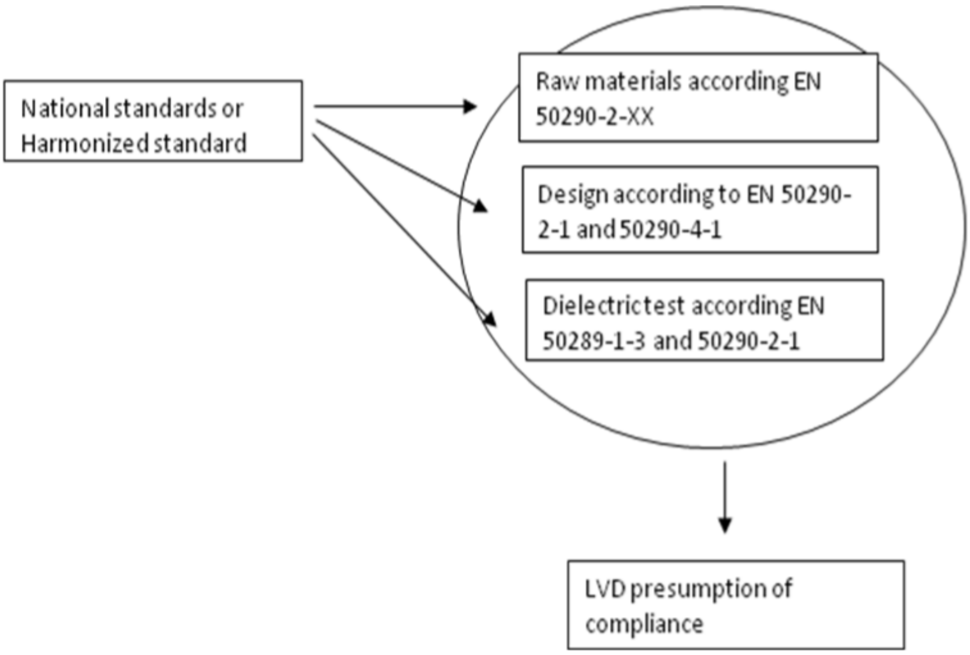



**Figure 7**

## 5.3 Fire reactions and Euroclasses

Cables that are installed in construction works are governed by the “Construction Product Regulation”; thus they shall be “CE” marked according to EN 50575.

Moreover, in each country, regulations may exist that explain the use of cables according to a given Euroclass versus the type of building that is considered.

Regulations as well as standards give only the minimum requirement and it is therefore always recommended to choose cable that fulfill or better exceed these requirements. This is particularly true when the requirement is safety related.

The designer/installer is invited to consider the relevant regulation related to safety in case of fire. A choice of cables that strictly comply to the requirements will give greater safety margin (especially in the case where the public or individuals are involved).

The EN 50288, EN 50441 and EN 50117 product standards series refer to the EN 50290 series to describe how a cable behaves in fire. This is achieved through EN 50290-4-1 that gives the relationship between the Euroclasses and the related test methods and limits.

Some local regulations/customer-requirements are stricter than the Euroclassification tables and therefore can and should be designed by discussions between the producer and customer.

During a building fire, a cable that runs in a wall, up an elevator shaft, or through an air-handling plenum could become a wick that carries the flame from one floor, or one part of the building, to the next. The standards, among other things, enable engineers to calculate the time that it will take for a cable to become a hazard once it is exposed. Evacuation times and building safety management can now be engineered to ensure complete safety for the occupants.

Additionally, because the outer coverings of cables and wires are typically plastic, they can create smoke when they burn. They also describe the amount of smoke and the type of gasses a burning cable can generate. This is important because cables often run in ventilation system return spaces above ceilings or below floors.

## 5.4 Electromagnetic behaviour

### 5.4.1 General

A cable's path may pass through many stray electric fields. Some of these may come from motors used in heating, ventilation, and air conditioning (HVAC). Florescent lights, radio transmitters, and power transformers may generate others. These stray fields are called ‘electromagnetic interference’ (EMI) if they originate from electrical sources and ‘radio frequency interference’ (RFI) if they come from radios, mobile phones, radars, or microwave ovens.

There are electrical environments in which EMI and RFI are so strong that induced voltage in the cable affects the integrity of the transmitted signals thus additional shielding is a requirement to make communication possible. An expensive way to supply this shielding might be to route the cabling through small pipes, called conduit, and then to make sure that the conduits are grounded (to make sure that any stray fields picked up by the conduits are passed to ground and do not induce interference into the data cables). However, conduit is expensive and difficult to work with.

### 5.4.2 Coaxial cables

The EN 50117 series that describes coaxial cables defines two classes of shielding effectiveness. The EN 50117 series that describes coaxial cables defines multiple classes of shielding effectiveness. The most commonly used, Class A, implies the use of a “foil+braid” outer conductor that would provide a sufficient immunity to the cable. The use of Class A cables gives assurance that the cabling system will work satisfactorily under normal conditions. Other shielding methods such as foil-braid-foil or foil-braid-foil-braid may also be used and higher shielding classifications may also be considered.

### 5.4.3 Twisted pairs cables

The coupling attenuation and/or the transfer impedance that is given in the relevant cable specification describe electromagnetic behaviour of twisted pairs cables. The coupling attenuation is the resultant of twist effect and screening effect.

The actual signal on the twisted pair version is applied to both the ‘a’ leg and ‘b’ leg simultaneously. However, the actual signal voltage level in each leg is opposite, 180’ out of phase, and therefore any emissions are naturally cancelled. The result is that in twisted-pairs, interference such as EMI and RFI tends to be cancelled out when the signal is reconstituted in a comparator.

On an other hand, keeping the cable twisted means that both of the wires in the pair are likely to be affected equally by the interference.

Installers shall preserve the twist of the pairs in these cables when mating the connectors to avoid introducing performance-degrading problems. When the immunity provided by the twist is not sufficient, it is better to use cable that carries its own screening when extra shielding is needed.

Two kinds of extra shielding may be provided:

– the first is an overall foiled screen (FTP) – (F/UTP);

– the second involves individually screened pairs within a cable with (SFTP) – (SF/UTP), (SSTP) or without (STP) an overall screen.

EN 50174-2 describes well the mechanisms of each of the kind of twisted pair cables.

A short summary for governing the choice of cables twisted pairs telecom cables would be:

– use unscreened cables whenever it is possible;

– use unscreened pairs cable with overall screen (FTP) if you cannot control the electromagnetic environment or to preserve your cable to be influenced by the installation conditions;

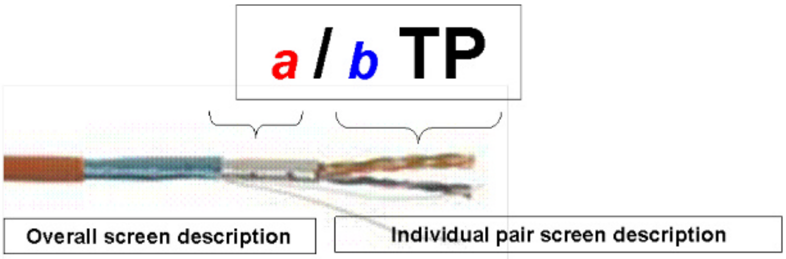
– use multiple screens cables (individually screened pairs SFTP or SSTP or specific cables) in case of harsh environment and when it is required by the transmission performances.

There are reasons why STP/FTP are not employed everywhere:

- The shielding layers shall be properly grounded in order to minimize signal degradation. If there is a difference in ground potential at different parts of the network, perhaps because problems exist with the ground system, or different areas are fed from different power sources, the shields will conduct these ground differences. These currents are called ground loops. Ground loops can become sources of interference, and they can even become shock hazards.

- STP is less flexible than UTP because of the shielding and is more difficult to install.

As a rule of thumb that applies to any telecommunication cable, one may consider that the use of a closed metallic continuous pathway (EN 50174-2) is roughly equivalent to a cable screen that gives 20 dB screening effectiveness.




TP = twisted pair

*a* = global screen :
- U unscreened
- F single foil
- FF double foil
- S Tinned Copper braid
- SF Tinned copper braid + foil

*b* = pair screen :
- U unscreened
- F individual foil per pair

| New | Old | Description |
|---|---|---|
| U/UTP | UTP | unscreened |
| F/UTP | FTP | Overall single foil |
| FF/UTP | F²TP | Overall double foil |
| SF/UTP | SFTP | Overall braid + foil |
| U/FTP | | No overall screen individual foil per pair |
| S/FTP | STP | Overall braid individual foil per pair |
| F/FTP | | Overall foil individual foil per pair |

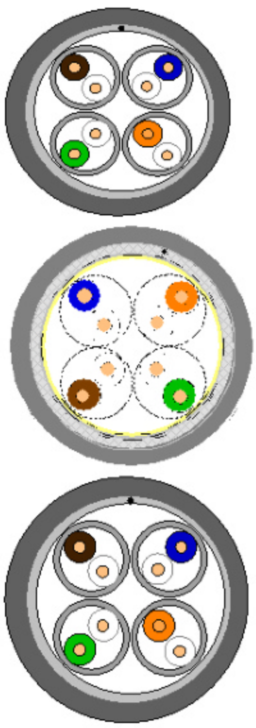


**Figure 8 — Twisted pairs cables — Screen description**

# 6 Criteria for the choice of the cables

## 6.1 Cable construction

### 6.1.1 General

Regardless of the construction, all cables contain certain common elements that are detailed in EN 50290-2-1:

- insulation to prevent short circuits between the individual conductors;
- spacers (dielectric) to preserve the electrical properties of the cable;
- a sheath for protection.

A copper conductor in a cable can be composed of a single solid copper core or a bundle of thin strands. The advantages and disadvantages of each been discussed next.

Some parts of the EN 50288 and EN 50117 series describe flexible cables manufactured with “stranded conductors”.

EN 50290-2-1 gives tools to get the cable attenuation depending upon the size of conductors and their nature (stranded or not).

### 6.1.2 Cable insulation/spacers

Insulation is used as a high resistance material that is extruded onto the conductor to resist the flow of current between conductors. This is sometimes referred to as the dielectric/insulation. This material also impinges on the transmission properties of the cable (especially in high frequencies as detailed in EN 50290-2-1).

There are several types of materials used for insulation, each having its advantages and disadvantages. Insulation materials are characterized using their loss angle (High Frequency) and their relative permitivity. For a suitable cable behaviour both of them should be low and stable.

There are several primary categories of insulators:

**Table 1**

| | | | |
|---|---|---|---|
| Polyvinylchloride (PVC) | PVC easy to strip<br>Flame retardant | Low frequency | High loss angle and high permitivity |
| Polyethylene | Flammable<br>Halogen free | High frequency | Good loss angle and low permitivity |
| Fluoropolymers | High temperature applications,<br>Flame retardant | High frequency | Low loss angle and low permitivity |

The type of insulation used depends on the intended application of the cable:

- EN 50290-2-23 describes suitable polyethylene;
- EN 50290-2-30 describes suitable fluoropolymers;
- for low frequency cables, PVC according to EN 50290-2-21 may be used.

### 6.1.3 Cable sheath

There are several types of materials used for sheathing, each having its advantages and disadvantages:

**Table 2**

| | | | |
|---|---|---|---|
| Polyvinylchloride (PVC) | PVC easy to strip<br>Flame retardant | PVC allows for bright colors.<br>Can be made flexible | Depending upon the detail specification resists to UV, ozone, oil and solvents |
| Polyethylene | Flammable<br>(Outdoor applications) | Water proofed | Depending upon the detail specification resists to UV, ozone, oil and solvents |
| Halogen free sheathing compound | Flame retardant<br>Low smoke emission<br>Halogen free | | Depending upon the detail specification resists to UV, ozone, oil and solvents |
| Fluoropolymers | High temperature applications<br>Flame retardant | Water proofed | Resists to UV, ozone, oil and solvents, acid, contaminating fluids |

The type of sheathing used depends on the intended application of the cable:

- EN 50290-2-22 describes suitable polyvinylchloride;
- EN 50290-2-24 describes suitable polyethylene;
- EN 50290-2-27 describes suitable halogen free sheathing compound;
- EN 50290-2-30 describes suitable fluoropolymers.

### 6.1.4 Armouring/additional protections

Some cables are manufactured with a metallic (or non-metallic) armour to provide added strength and protection against rodents and mechanical damage, usually required when burying direct.

Cable that is used in outside plant or underground, may be filled with a waterproof gel compound and may have a water blocking tape between the inner and outer sheaths.

Both outer and inner sheaths are made of materials designed to withstand immersion and resist corrosion.

The environment, the cable complies with is given in the relevant specification. Specific environment (i.e. industrial environment) may require customized cables that are built against a detailed specification agreed between the customer and the manufacturer based on EN 50288-11-3[1)].

## 6.2 Cabling

'Cabling' is more than a collection of individual cables. As the term indicates, cables are installed in accordance with a well-conceived design. Sometimes, however, it is useful to differentiate cables that run inside the protective environment of buildings from those that are exposed to the weather.

Indoor cables run inside buildings, they need to be flame or fire retardant.

They often have smoke requirements (density, opacity, acidity, halogen contents).

Some specific applications related to Human Hazards or Data Hazards may require the cables to be fire resistant. In this case the cable would have to be tested in accordance to EN 50200 and EN 50289-4-16.

Outdoor cables are usually manufactured with a stronger, denser sheath material.

They have improved resistance to moisture and water penetration as well as enhanced mechanical and electromagnetic properties.

1) Under development.

They may be provided with an aluminium shield under the outer sheath. They may be filled with water-resistant gel and covered with a layer of armouring.

**Table 3 — Types of cabling according to applications**

| Application | Indoor cabling | Outdoor cabling |
|---|---|---|
| LAN | EN 50288 series | EN 50288 series PE sheathing |
| Access network | EN 50407 series | EN 50406 series |
| Residential cabling | EN 50441 series | |
| Residential cabling (coaxial) | EN 50117-2-1<br>EN 50117-2-4 | EN 50117-2-2<br>EN 50117-2-5 |
| CATV (Drop cables) | EN 50117-2-1<br>EN 50117-2-4<br>EN 50117-4-1 | EN 50117-2-2<br>EN 50117-2-5 |
| CATV (Trunk cables) | EN 50117-2-3 | EN 50117-2-3 |

### 6.3 Transmission performance

Transmission efficiency is generally viewed as the amount of signal degradation created by the use of a particular transmission medium. The transmission medium presents a "barrier" to the communication signal. The "barrier" can be measured by many different factors. However, one common question is asked about all communication media. How far will the communication signal energy travel before it becomes too weak (or distorted) to be considered usable? There is equipment available to extend the distance for transmitting a signal, but that adds to the overall cost and complexity of deployment.

Data transmission is sensitive to pair quality. Each of the CLC/TC 46X specifications defines cables up to a given frequency thus implies a specific pair construction. Therefore poor quality pairs allow noise from neighboring wires as well as from outside the cable to interfere with the data transmission. When data is unintelligible due to attenuation or other causes, the missing data shall be retransmitted. Improving the quality of the media results in fewer missed messages, fewer retransmissions, and less unnecessary traffic on the network.

Cables standards have been developed in support of the cabling described in the EN 50083 and the EN 50173 series as well as in the ETSI recommendations and to ensure that the targeted applications will work satisfactorily when the cables installation fulfills the requirements of the EN 50174 series.

The EN 50117 series, the EN 50288 series and the EN 50441 series sort the cables according to their maximum frequency and thus are suitable for well known existing applications.

**Table 4 — Cables for CATV / MATV / TV and Video distribution**

| | F max | Cabling spec. | Application |
|---|---|---|---|
| EN 50117-2-1 | 1 000 MHz | EN 50083 series | Indoor drop cabling |
| EN 50117-2-4 | 3 000 MHz | EN 50083 series | Indoor drop cabling |
| EN 50117-2-2 | 1 000 MHz | EN 50083 series | Outdoor drop cabling |
| EN 50117-2-5 | 3 000 MHz | EN 50083 series | Outdoor drop cabling |
| EN 50117-2-3 | 1 000 MHz | EN 50083 series | Trunk cabling |
| EN 50117-4-1 | 3 000 MHz | EN 50173-4 | Indoor drop cabling |

**Table 5 — Cables for access network**

| | F max | Cabling spec. | Application |
|---|---|---|---|
| EN 50407-1 | 10 MHz | | Adsl/POTS |
| EN 50406-1 | 60 MHz | | XDSL/POTS |
| EN 50406-2 | 60 MHz | | XDSL/POTS |

**Table 6 — Cables that might be used for some given applications**

| | F max | Cabling spec. | Application | |
|---|---|---|---|---|
| EN 50288-2-1 | 100 MHz | EN 50173-2 | 100 Base T2/1 000 Base T4 | Screened |
| EN 50288-3-1 | 100 MHz | EN 50173-2 | 100 Base T2/1 000 Base T4 | Unscreened |
| EN 50288-4-1 | 600 MHz | EN 50173-2 | 10 GBase-T | Screened |
| EN 50288-5-1 | 250 MHz | EN 50173-2 | 100 Base T2/1 000 Base T4 | Screened |
| EN 50288-6-1 | 250 MHz | EN 50173-2 | 100 Base T2/1 000 Base T4 | Unscreened |
| EN 50288-7 | | | Instrumentation and control cables | Screened |
| EN 50288-8 | 2 MHz | EN 50090 series | Type 1 cables characterized up to 2 MHz | Unscreened |
| EN 50288-9-1 | 1 000 MHz | EN 50173-2 | 10 GBase-T | Screened |
| EN 50288-10-1 | 500 MHz | EN 50173-2 | 10 GBase-T | Screened |
| EN 50288-11 (all parts) | 500 MHz | EN 50173-3 | 10 GBase-T | Unscreened |
| EN 50441-1 [a] | 100 MHz | Residential | 100 Base T2/1 000 Base T4 | Unscreened |
| EN 50441-2 [a] | 100 MHz | Residential | 100 Base T2/1 000 Base T4 | Screened |
| EN 50441-3 [a] | 1 000 MHz | Residential | Cable sharing 100 Base T2+VHF/UHF+DSL | Screened |
| EN 50441-4 | 1 200 MHz | EN 50173-4 | Cable sharing 100 Base T2+VHF/UHF+DSL | Screened |
| [a] These cables are optimized for 50 m residential cabling. | | | | |

## 7 Installation practices

### 7.1 Delivery

Before laying the different cable sections, all reels should be visually inspected for possible transportation damage.

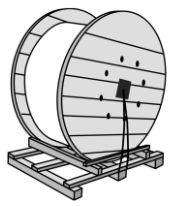


**Figure 9 — Reel of cables**

### 7.2 Storage

Never forget to place a wedge under the flange to avoid reels rolling away.

When cable is stored outside, a cap shall be placed at both ends to avoid water infiltration.

Storage temperature range is specified for each cable and shall be respected.

Indoor cables shall not be stored outside to prevent water infiltration and UV damages.

If several reels are stored at the same place, take care that flanges of a reel don’t collide with cable of another reel.

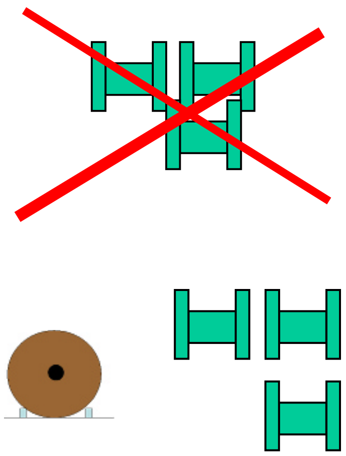


**Figure 10 — Reel storage**

### 7.3 Pre-installation procedure

Unless otherwise specified by the cable manufacturer, never install a cable if temperature is below – 5 °C. Be aware that in cold environment the cable sheaths are stiffer and more sensitive to bending and pulling. The range of recommended installation temperatures of cables is much smaller than the operating temperature ranges.

Before pulling the cable, ensure the stability of the pay-off:

To avoid possible damage from a sudden stop, the pay-off shall be equipped with a progressive braking system. Under no circumstances should the reel be stopped by hand.

The route defined by the design should be accessible and available in accordance with the installation schedule. The users should be advised of all proposed deviations.

The installer should establish that the environmental conditions within the routes and the installation methods to be used are suitable for the cable to be installed (check the datasheet of the cable used). If the route contains sections where the cable is subject to high temperatures the necessary protection should be provided. Look out for heating pipes especially those that are not heated all the time.

Any measure necessary should be taken to prevent the cable experiencing direct stress following installation.

The installer should determine the locations at which reels are to be positioned during the installation program.

Where necessary, the minimum quantity of ceiling tiles, floor covers should be removed and always replaced.

### 7.4 Pulling of the cable

For reasons of safety, always unroll cable by the bottom side of the reel.

During the pay-off of the cable the off-loading of the reels should be monitored to ensure that no mechanical damage occurs (kinking, unravelling or twisting).

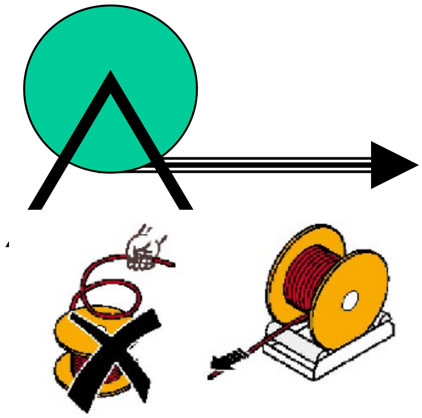


**Figure 11 — Advised way for pulling a cable**

### 7.5 Installation

At both cable ends, it is recommended to leave a few meters of cable for reserve; also leave some extra cable (approximately 5 m) at different places on the cable link (this makes it easier to repair in case of a broken cable).

Always cut first meters of cable off as this part can be damaged by pulling of the cable, bending, water, etc.

Ripcords are designed to make removal of the exterior cable sheath easier, preventing unnecessary stress to the core.

### 7.6 Mechanical considerations

#### 7.6.1 Tensile strength

One of the goals in any cable installation is to complete the installation with as little stress as possible to the conductors themselves.

For this reason, all cables are provided with a carefully calculated tensile loading value, which should never be surpassed. For cables, the tensile strength is the value that represents the highest load that can be placed upon a cable before any damage occurs to core characteristics. This is not the cable breaking strength but a realistic allowable limit.

Included are additional stresses caused by pulling cable through, over or around stationary objects such as ducts, corner and conduits. Many installers will carefully meter the force with which they are pulling the cable throughout the installation to avoid accidentally pulling on it too hard. After the cable has been installed it will be subject to lower loads. This value is referred to as the installed, long term, static or operating load.

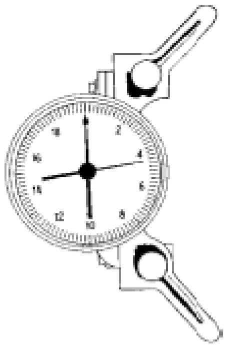


**Figure 12 — Tensile strength**

The tensile strength of the cable will depend upon the cable construction, and the application for which it is designed. You will find values in the relevant cable specification.

The EN 50288 series, the EN 50406 series, the EN 50407 series and the EN 50441 series give the maximum tensile strength as a function of the copper section in the cable. Unless otherwise specified in the customer specification that may involve additional strength members the value that is given in the EN 50288 series, the EN 50406 series, the EN 50407 series and the EN 50441 series should never be exceeded.

### 7.6.2 Bend radius

The minimum bend radius is the value determined by the cable manufacturer to be the smallest bend a cable can withstand. Bending the cable beyond recommended limits could cause impedance disturbances and/or Xtalk at this point.

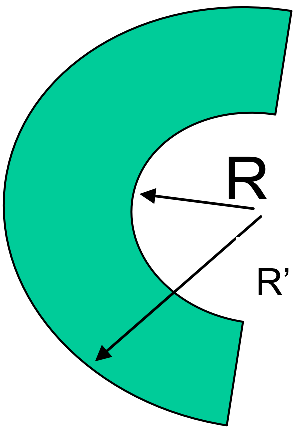
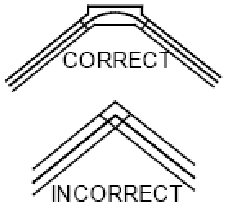


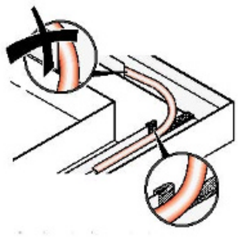

**Figure 13 — Shrinkage and elongation of internal and external element**

Like tensile strength, there are two values associated with bend radius, installation and long term.

The installation bend radius, again the higher value, is the amount of bending the cable can withstand while under the load of installation. After the cable has been installed and the stress of being pulled is removed, the cable may actually be bent to a smaller radius. These values will again depend on the size of the cable, its construction and intended application.




**a)**



**b)**

**c)**

**Figure 14 — Common handling mistakes when bending cables**

These are several common handling mistakes that lead to cable bend radii being exceeded. One of the most frequent errors is pulling cable through conduit with too small of a bend radius.

Similarly, cable shall never be over-bent going through trays, between tray sections, or when making transitions between locations.

Cables should be ‘swept’ to prevent sharp bends or corners (Figure 14 a)). Unfortunately, it is often tempting to bend the cables tightly over corners, to keep the cables closer to equipment. Bending cable over corners, sharp or not, can cause serious damage to the performance of the cable. Care shall also be taken to prevent wrapping the cable tightly around itself to be stuffed behind walls at the user end. Cables should never be kinked or knotted (Figure 14).

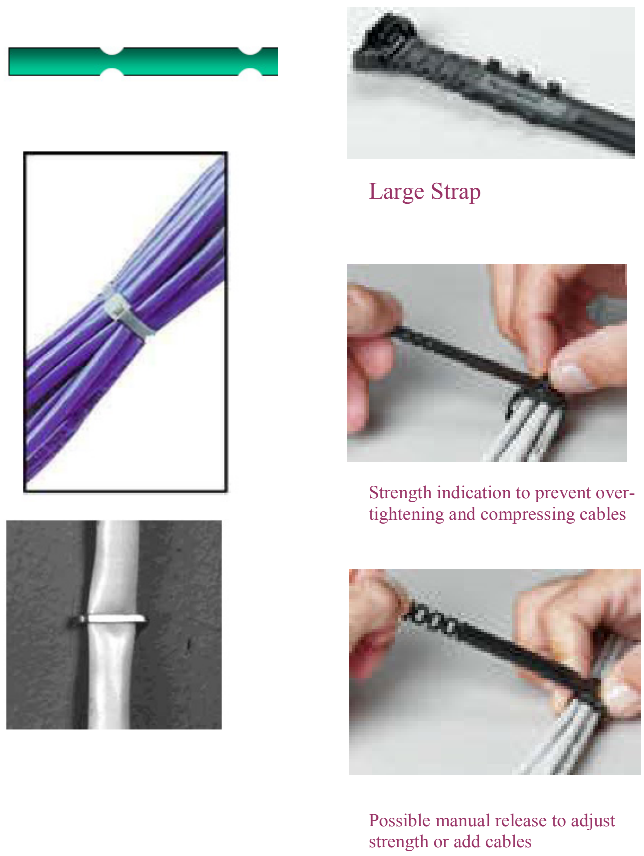
### 7.6.3 Crush and impact

#### 7.6.3.1 General

Cable crush and impact are often listed but rarely understood details of cables. They do however provide some legitimate guidelines for cable installation. EN 50289-3-9 details the crush test method of a cable. The intend of this document is to provide a standard means of testing cables to ascertain how well they either withstand or recover from a slow crushing or compressive action. It details the entire test procedure, which crushes a cable between two plates while measuring any power loss or impedance deviation.

Impact testing is documented with the intention of determination the ability of cable to withstand repeated impact loads, as they might be forced to encounter during installation in exposed or open access areas. Cables may be tested simply for changes in transmission characteristics. Crush and impact are important not as laboratory guidelines but as they apply to real-life installation situations.

It is highly advised to avoid placing excessive crushing forces on the cables (Figure 15 a)) by using dedicated products designed to prevent over tightening cables and readjusting cable fixation or bundle formation (Figure 15 b)).




a) b)

**Figure 15 — Crush and impact testing**

In office environment work area cables are often subjected to crushing (human step or worst rolling chairs). It should be noted that:

- ‘standard’ cables are designed to withstand to a human step; however it is recommended to avoid this stress using additional protective carpet;

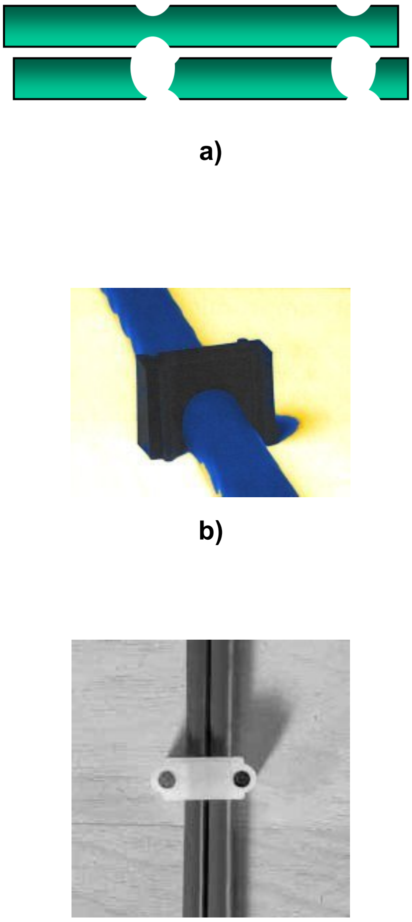
- ‘standard’ cables do not withstand to the stress of a rolling chair.

### 7.6.3.2 Stapling

In residential dwelling house, cabling may imply stapling of the cable. If the staple dimension is not well matched to the cable diameter there is a huge risk of crushing the cable.

The EN 50441 series describes cables that are tested for stapling.

To avoid transmission problems due to resonance phenomena, it is however strongly recommended to randomly space the staples along the cable.



**a)**

**b)**

**c)**

**Figure 16 — Cable stapling**

# 8 Cabling installation versus location

## 8.1 Outside plant

### 8.1.1 General

Much of the truly long-haul cable pulled is for trunk or telephony applications, and is installed by trained professionals using special and expensive equipment.

However, routine cable installations in many cases will see some amount of cable run outside. This can vary from campus application with many long outdoor runs to a simple 20 m segment connecting two buildings.

### 8.1.2 Direct burial

Cables can be manufactured in such a way as to be ideal for long haul buried applications. Designs make the cables particularly able to withstand certain stresses, while the gel filling prevents water migration. Specially selected sheath materials are abrasion and UV resistant. Outside plant cables have high tensile strengths to withstand environmental abuse and pressures of direct burial installations.

Trenching simply involves digging a hole, placing the cable in it, and refilling the hole. Trenches are often dug with backholes and visually inspected for rocks or debris that could potentially damage the cable. It is strongly recommended to fill the hole with 20 cm of sand under and over the cable (Figure 17).

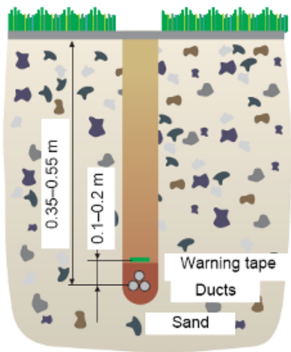



**Figure 17 — Cable buried in a trench**

This is not a quick process and is most effective for shorter distance applications. Cables directly buried in the ground should be placed deeply enough to provide adequate protection for the cable. This does seem obvious, but the depth for different cables may vary with their application, intended user and construction. It is usually beneficial to attempt to bury cable below the frost line for any given area. One of the major hazards a buried cable faces is the possibility of being dug up. It is usually desirable to place a marker tape over the cable but below the soil to warn future workers in the area that a cable lies below (Figure 18). Some taped armoured cables are rodent resistant.

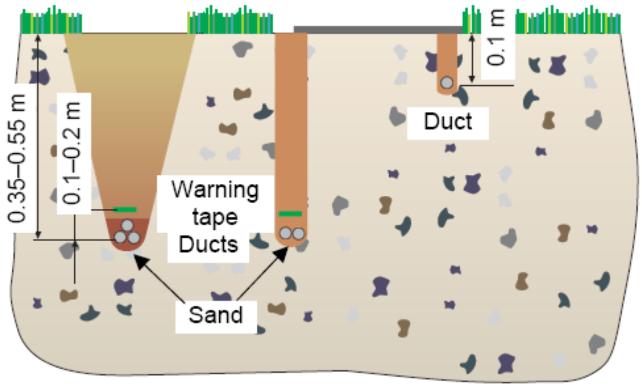



**Figure 18 — Cable buried in a trench with a warning tape**

### 8.1.3 Underground conduit

The conduit used in outside plant applications is designed to provide extra protection for the cables, but can also offer certain installation advantages. Duct or conduit for underground burial is manufactured using rigid, very rugged, abrasion resistant material. In many cities the “underground plant” is a series of ducts placed under the streets, accessible by utility vaults or manholes. Installed conduit is advantageous because it offers a route for new cable installation or old removal without damage to streets, pavements, edifices, etc.

Conduits should be placed with some sort of pull rope or tape already installed to ease future runs. Conduits are sometimes placed with direct burial cable in trenching operations, again for future use.

Inner duct or duct liner is slightly less sturdy plastic tubing designed to fit within larger conduits. Without providing the primary protection for the cable, inner duct serves several functions. Many manufacturers offer inner duct in diverse colours to assist in cable identification and maintenance. Inner duct affords a clean path for new cable installations. Where cables are already placed in duct it is difficult and often impossible to pull new cable in the same duct. Cables can, due to friction, sometimes block the conduit when new cable is installed along with the old. Inner ducts keep cables separate to prevent future installation cable damage.

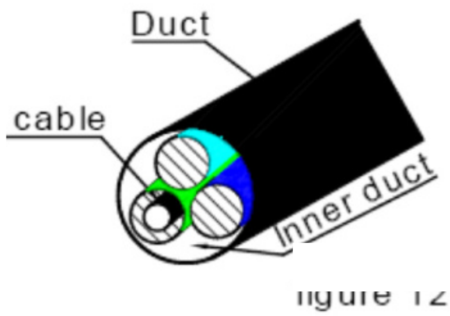



**Figure 19 — Conduit for underground burial**

Conduits can also serve, as rodent protection in these short-interbuilding installations where splicing to armoured cable is not a reasonable alternative. Conduits can economically be installed for applications where a second trenching operation would be impossible. Conduits may be placed under concrete banks, landscaping, farmland or private premises where it would be extremely undesirable to disturb the soil after some time has elapsed. Cables may be chosen, added and installed at a later time without disrupting the environment.

**Cable pulling** is the most used method to install a cable into conduit. First of all, a pulling tape is pulled in the conduit. The cable is attached to the pulling tape and then the cable is pulled through the conduit.

Cautions: Always respect the minimum bending radius and never exceed the maximum pulling force value specified in the cable data sheet.

#### 8.1.4 Aerial

The full details of aerial cable installations are too complicated for this discussion but a few key points should provide some critical guidelines. Like direct burial installations, aerial installations will often be executed by utility companies with specialized equipment for long haul runs. However, many campus or industrial environments do see shorter links between buildings that may most efficiently be run aerially.

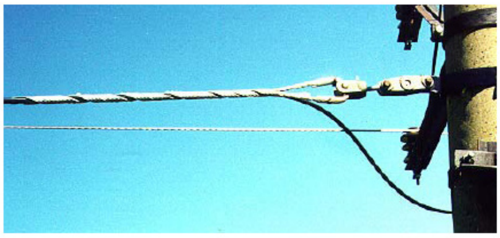


**Figure 20 — Example of an aerial cable installation**

**Figure 21 — Cable ‘messenger clamp/grip’**

Cables located in aerial runs can be affected by wind and ice, creating a situation that can cause the cable to stretch or sag. Under most conditions aerial cables should be supported by an external support member, suspension strand, or ‘messenger’.

Strong “wires” made of steel are positioned and secured to utility poles along the desired route. The cable is then placed along the route under the messenger, lifted into place and lashed or tied to the messenger with a steel or dielectric thread. Lashing can be accomplished using standard lashers designed for this purpose. Lashing strands should be chosen in accordance with guides associated with the lashing tool. As a general rule, there should be at least one wrap of the lashing wire per 30 cm.

Messenger wires are chosen by their tensile strength and size and the span distance per the requirements of each application. Charts for recommended messenger strands are readily available. Many variables have to be taken into account, and the inability to place a dedicated messenger shall outweigh the benefits of a known system.

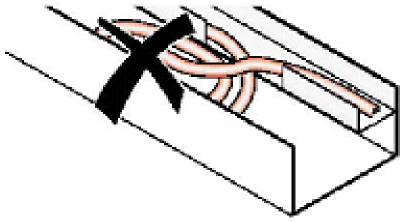
### 8.2 Intrabuilding

#### 8.2.1 General

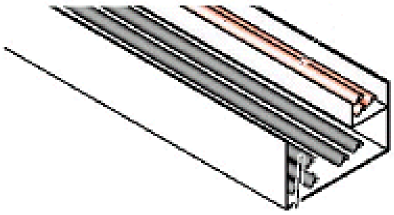
Inside a building it is strongly recommended to select a cable with a LSZH-FR sheath.

#### 8.2.2 Conduit applications

Intrabuilding conduit runs can be in ceilings, walls or under floors, with certain limits, as conduit systems are very flexible. Conduit systems should be used only when workstation outlet locations are permanent, no flexibility is required, and densities are low. Under-floor conduits are often embedded in concrete making it particularly difficult to do additions, changes or moves.



a)



b)

**Figure 22 — Examples of installation of intrabuilding conduits**

Pull cords should always be placed in the conduit to ease installation. Inner duct is an excellent tool for protecting cables and making future installations easier (Figure 22 b)).

### 8.2.3 Dropped ceiling and raised floor

Plenum or dropped ceiling/raised floor runs can sometimes be the easiest to install. Many dropped ceilings or raised floors have panels that are easily removed or opened to provide fast access to the area. Most new buildings have dropped ceilings, making this an extremely popular method of installing cables. Raised floors are usually found in computer rooms, although they can be used in many different conditions.

Suspended ceilings consist of low-weight panels supported by a system of metal frames or grids which are attached to the ceiling using struts or wires. Typically the panels are easily moved. When they are pushed up they are dislodged from the grid and may be pushed to the side. Although it is not particularly recommended, smaller cables can rest directly on the ceiling support grid. This is done at the discretion of the installer.

Cables should be supported in some manner, ideally in organized, easy-maintenance trays, wire ways or racks.

At the very least cables can be supported by bridle rings.

### 8.2.4 Cable in trays

Cable trays or "ladder racks" can often provide a convenient, safe, efficient method of cable installation. Trays can be installed in ceilings, below floors and even in riser shafts. Some trays are designed to be aesthetically pleasing, to be placed Below the ceiling, in the line of vision, while still supporting a multitude of cables. Frequently the tray installation precedes the cable installation, as trays can be used for many other cable types. This means that in many buildings a tray distribution system exists and if the plan can be followed the routes may be clear for the new cable installation.

Although the tray provides a sturdy support and basic protection for the cable, there are still stresses the cable will be subjected to. cable shall always be run in trays in a way to avoid as much tension, crush, and over-bending as possible. Routes should be inspected for possible sharp turns, snags (sometimes from other cables) or rough surfaces. Efforts should be made to run the cable without pulling it under or between heavier cables or multiple cables that will create added forces. The same holds true for moves and adds. It is desirable to secure the cable to the tray to avoid damage during future changes.

### 8.2.5 All pathways and spaces

Support the cable and avoid crushing, stressing and over-bending it. Every cable will have values attached for minimum bend radius and maximum.

In addition to monitoring the cable pulling tension, additional efforts to support and protect the cable will greatly lengthen its working life.

Cables should never be allowed to hang freely for long distances or be allowed to press against edges in any installation.

When pulling cable in conduit all transition points, such as going from conduit to a pull box, should be kept smooth. Sometimes adding a piece of conduit beyond the transition will keep the cable from resting on a sharp edge.

Bushings designed to fit the ends of conduit are also available.

Flexible conduits can also be placed within boxes or at interfaces to prevent pressure against the cable or scraping on rough edges. Flexible conduit can also be added in areas open to frequent access, such as raised computer room floors, when there is a higher potential risk to the cable.

Complying with the cable's minimum bend radius cannot be overstressed. Many applications will automatically present conditions wherein the bend radius of the equipment or its configuration will damage the cable if precautions are not taken.

Conduit bends pull boxes and joints shall be checked to verify that the radius is not too small. Inner duct or flexible conduit can be used to ease or sweep the cable around tight corners. The inside radius of conduit bends for cable should be at least 10 times the inner diameter of the conduit. Pulls through tightly bent elbow fixtures should be back-fed. The cable is not pulled from end to end, but out of the opened junction, coiled loosely on the ground, and fed through the rest of the run. In tray and rack installations the minimum cable bend radius shall also be monitored, as the cable will be routed around corners or through transitions.

Where raceway or rack transitions expose the cable a flexible conduit should be used for protection. The same critical observations shall be made when installing cable in vertical shafts or risers. Cable bend radii and tensile loading can never be exceeded. Cables in vertical runs should be supported as well as possible, in a reasonable number of locations.

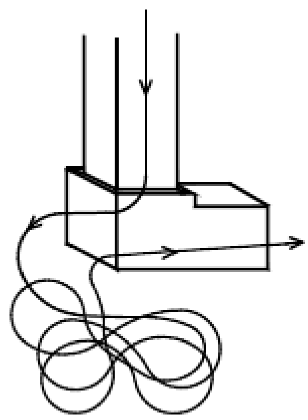


**Figure 23 — Example of mistake in pulling cables in conduits**

### 8.2.6 Compatibility with glue

Generally, cables with PE sheath cannot be glued.

### 8.2.7 Pulling cable

In many premises network cable installations the cable is going a short enough distance, in a straight enough path that it can be pulled in by hand without the use of special equipment. In any cable it is imperative that the load be applied to the strength bearing members of the cable.

When additional mechanical force is required to pull a cable there are several relatively standards tools available to aid in the installation of cable. External pulling grips (Figure 24) are designed to lock into and tighten around a cable as a tensile load is applied to the grip. The pulling end of the grip is a loop or eye for attachment of the pulling tape or rope.

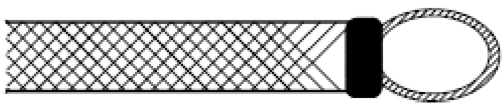


**Figure 24 — External pulling grip**

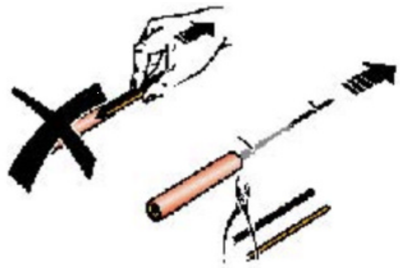


**Figure 25 — Advised way for pulling a cable**

A swivel should be used when pulling to make sure a twist in the pulling tape or rope is not translated to the cable. It is also important to monitor the tension being applied to the cable to be certain not to exceed the maximum specified cable installation load. Cutting a cable back 3 m from the pulling end should eliminate any portion of the cable, which might be damaged during installation.

Assuming the cable has been pulled and all of the restraints have been properly adhered to, the cable should now be ready for connectorization or termination. A reasonable amount of spare cable should be left at either end, and enough to reach the work area where the termination will take place. In some outside plant or factory-type environments the cable end may have to reach a special clean room this length shall be considered when planning the cable link length. Before termination, approximately 3 m of cable should be cut off to remove any piece that may have suffered stress from the pulling tape or grip.

After cable pulling, if the cable is not directly terminated, it is absolutely necessary to replace a cap at both ends of the cable in order to avoid water penetration.

In case of partial use of a cable, both ends of the remaining cable shall be fastened to a flange of the reel by means of a **'bridge nail'**.

Under no circumstances should the **'bridge nail'** be higher than the thickness of the flange in order to ensure that the **'nail nibs'** do not cause injury to people or damage the remaining cable on the spool.

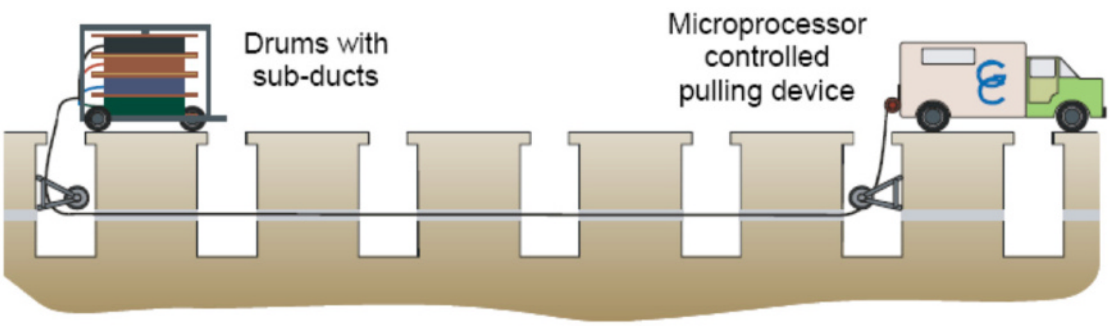



**Figure 26 — Example of cable pulling when a mechanical force is required**

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[1] Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits

[2] Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products

[3] Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC

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