

OPTICAL FIBRE CABLES INSTALLATION GUIDE

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RECOMMENDATIONS FOR OPTICAL FIBRE CABLE INSTALLATION

The objective of this document is to be an optical fibre cable installation and laying guide, addressed to new installers, also being useful as a reminder to experienced installers. We should always consider the restrictions established by different administrations related to this matter.

1. General.

In any cable deployment, whether it is optical fibre or any other type of cable, it should be considered the considerable number of tasks related to the manipulation and laying of the cable. Cable laying needs to be preceded and followed by specific steps to have successful installation.

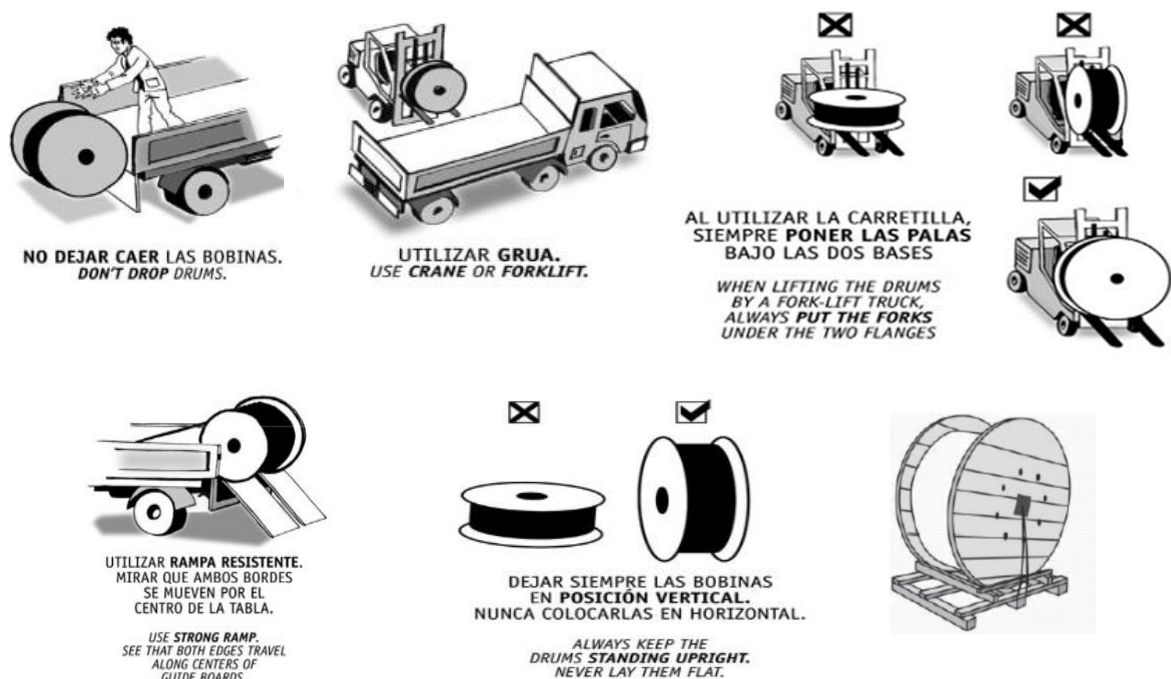
In general, the following steps and features are recommended for the optical fibre cable installation:

- Previous tasks: laying, splicing and cable connection require a previous study of each one of the cable sections to evaluate and recognize their needs and requirements.
- Main recommended features to be considered before laying cable are:
 - Laying method required in every section.
 - Amount and type of splices and segregations used in every section, specifying their location is well.
 - Amount and type of wrapping and protection elements (splice boxes, distributors, guide elements...) used in every section, with their specific location as well.
 - Drums and sections selected for each case.
 - Necessary material and machinery for cable laying.
 - Human team to execute the different tasks.
 - Security plan and measures as well as signaling systems, depending on the surroundings.
 - Methodology for cable laying supervision.
 - Environmental measures taken for each task.
- No tasks should be performed without a corresponding authorization from authorities and entities involved.

2. Work control. The assigned staff to the execution of the cable laying will be responsible for work control and the appropriate performance of each task. Therefore, cable should be manipulated in its format, drum, box or coil, so that it can be in good condition at all times. This way, we can avoid any damage before the cable laying, as well as during and after the performance of organization and connection tasks. The quality and good functioning of the whole installation will be the consequence of the appropriate performance of each task. The previous requirements of each product and their specifications should always be taken into account.

3. Supervision before and after cable laying. The following actions could be necessary before and after cable laying. The performance of each of these tasks is arranged during the supervision before cable laying:

- a. Cable reception. It will be verified that the material does not show signs of being transported in a wrong way, and do not shows any evidence of bumps or scratches that can diminish the quality of the product. To do that, the following areas should be supervised:
- Drums will be in perfect condition.
 - Drums will be appropriately protected upon receipt of the transport.
 - The cable will not present irregularities in its shape
 - The transport material will be removed with the care it deserves, always respecting the recommended:

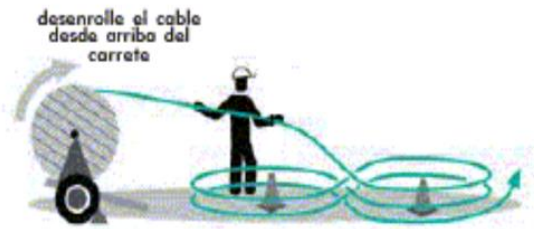


- b. Installation recognition. During the work prior to cable laying, conditioning and preparation of the work, manhole and optical fibre drum, at least the following aspects should be supervised:
- The work area will be properly signalled.
 - The manholes will be clean and identified.
 - The appropriate material will be available for handling drums and optical fibre cable.
 - The work area will be clear.
- c. Cable manipulation. Before the optical fibre cable installation, we will have to verify, at least, that the following aspects are met:

- i. The cable will not bend below the specified minimum bend radius under any circumstances.
 - ii. Any twisting on the cable will be avoided, nor will excessive efforts be made on the cable that exceed the specified values.
 - iii. Whenever considered appropriate, special cable lubricant will be used, which will not be abrasive in any case.
 - iv. Cable reserves will be left in the shape of an “eight” or circular.
 - d. Splices and connections. During the splicing, bleeding, and connection of the fibres, at least the following points will be supervised:
 - i. Specific and adequate elements will be available for the handling and stripping of the cable and optical fibre.
 - ii. Splice protectors will be used, and sufficient reserves will be left.
 - iii. Fibres that are not involved in the bleeding will be left behind.
 - iv. The connection in the distributor will be done with pigtails or direct connector mounting if possible.
 - v. The connections from the distributor to the equipment or the distributor itself will be made with patch cords.
 - e. Cleaning and finishing. During connectivity in the distributor, to verify that the following tasks are performed:
 - i. Previous cleaning of the connectors
 - ii. Cleaning and collection of leftover material and debris produced during the tasks.
 - iii. Finishing of the boxes and optical distributors.
 - iv. The reserves and junction boxes will be securely fastened in the superior part of the manholes.
 - v. The reserves will be left in the shape of an “eight” or in circles.
 - vi. The cable entries to the distributor will be securely fastened.
 - vii. The trays will be properly fixed.
 - viii. The excess cable in the distributor will be collected using cable ties.
- Compliance with the Work’s Occupational Risk Prevention Plan will be verified.

4. Work prior to cable laying

- a. General cable care. The cable must be handled carefully to avoid deteriorating neither its properties nor those of the fibre. The cable will not be twisted at any time, nor will it be deformed with clamps, cable ties, supports... In case of having to tie the cable, special care will be taken to avoid deforming the cover. We will also avoid applying non-homogeneous point pressures on the fibre.
- b. If stored, it will be left in the shape of an “eight” on a flat surface, making sure that the radii of curvature are greater than the minimum radius specified by the manufacturer.



- c. Signaling and dimensioning of work areas. The work areas must be properly dimensioned and signaled (warning and danger signs) in accordance with the authority in charge of the place where the work is carried out (institutions, town hall...)
- d. Checking for toxic gases and placement of protection elements in the manhole opening. Once the manhole is open and before the staff can access it, any presence of toxic gases should be checked. The next step will be to place the protection elements in the manhole in order to avoid any falls or access to it.
- e. Manhole cleaning. Whenever the installation involves a laying through outdoor ducting, the cleaning and draining of the manhole needs to be carried out if necessary.
- f. Pipeline conditioning for laying. Whenever the installation involves laying by duct, it might be necessary to drill the duct or carry out some tests in those situations in which the outdoor ducting does not present any accessibility.
- g. Cable loop's location identification. Before the laying, the manholes must be identified (in the case of outdoor pipeline laying) and the location where the cable loops will be placed.
- h. Drum conditioning for the installation. Before cable laying, drum must be transported to the work area and it must be conditioned for its posterior installation, always placing it properly to uncoil.

5. Cable laying techniques. Cable laying refers to deploying the optical fibre cable between the ends to be connected. There are several laying methods depending on the area where the cable laying needs to take place. The criteria chosen to carry out the laying depends on the section and the degree of occupation in the pipeline, with its criteria being determined in the stakeout prior to installation. Basically, there are two types of laying: outdoor laying and indoor laying. With outdoor laying, we can distinguish between:

- Laying in outdoor ducting.
- Facade laying.
- Aerial laying.

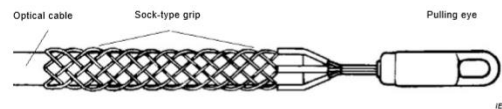


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Regardless of the laying method used, the following general indications must be followed:

- The minimum radius of curvature of the optical fibre cable to be installed is always met.
 - The drum is placed suspended on jacks or crane, so that it can rotate freely and so that the cable comes out of the drum from its upper part.
 - The cable must be pulled in its generatrix's direction. It should not be bent in order to obtain better support during its laying.
 - The people who are involved in the laying operation, especially those next to the drum, should carefully observe the cable as it comes out of the drum, making sure the cable does not get damaged. In the case any damage is detected, it needs to be communicated immediately to the superior who decides whether the process should be continued or not.
 - The cable should remain correctly immobilized. In order to do that, proper fastening systems are used, which can be screwed on, fastened with lags screws or clamps. The fibre properties should not be altered under any circumstances. We should also allow the installed fibre to expand if necessary.
- a. **Laying in outdoor ducting.** Optical fibre cable laying in external ducting are carried out by deploying the cable through one of the ducts or sub-ducts that make up the available pipeline infrastructure. In any of the available techniques for pipeline laying by manual pulling, we must make sure that the pipes to be used for the installation are drilled. The drilling action consists in checking the continuity of

the duct, for which we use a thread or cord with a tip of a certain length and diameter. Moreover, it is necessary to use the guide wire appropriate for the conduct chosen for the laying. This is due to the cable being prepared to be attached to the guide wire by the rotating knot. With this, the tip of the wire prepared for the pull cable is hooked to one of the ends of the rotating knot, for which the screw must be removed using a screwdriver. This way, the guide wire is tied to the other end of the rotating knot, making sure that the knot itself does not slip.

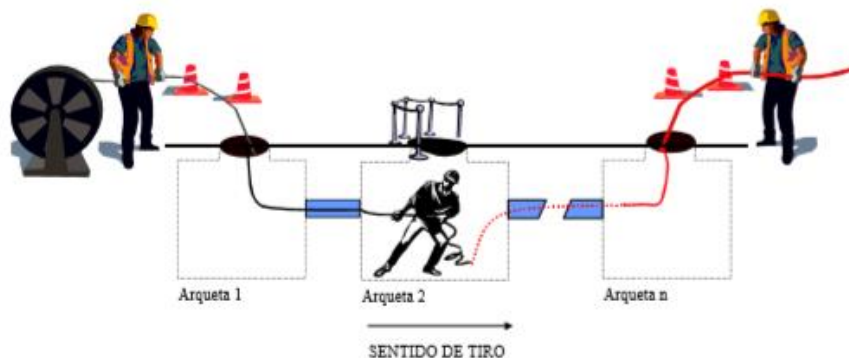


The knots are taped with plastic isolating tape from the end of the rotating knot to about 10cm after the last knot. Once these general aspects are clear, these three are the most popular types of laying in pipeline:

- i) Manual laying.
- ii) Laying by automatic winch.
- iii) Laying through "BLOWING".

- i) Manual laying. This technique is called "distributed manual" because the traction is done manually. This way, the total tension of the laying is independently distributed by piping sections between manholes, which means that in each manhole, the operator only has to overcome the tension generated by the weight of the cable, its friction and its corresponding sub-duct to the ducting section included between the previous manhole and its manhole. For the manual laying, an operator is permanently at the place where the cable drum is located. His job is to control the progress and stopping of the laying operation, according to the information received from all the manholes. Another operator recognizes the route as the cable progresses to solve any problem that can arise in any of the manholes. At least, the staff located at the tip and at the cable drum should be in radio contact continuously. The rest of the staff located in intermediate manholes can communicate by live voice continuously. In general, in those manholes with a change of direction in the cable route, there is an operator exerting the shot in the entry sub-duct, and another one drilling the cable in the outlet sub-duct to avoid cable loops or any axial deformation of the cable. The operators who intervene in the cable tip, in the outlet sub-ducts and in the pulling operation, control the length of the stored cable to decrease, if necessary, the laying pressure in the adjacent manhole to regulate the speed. As a result, we can ensure that the loop is not closed and that the minimum radius of curvature and the independence of

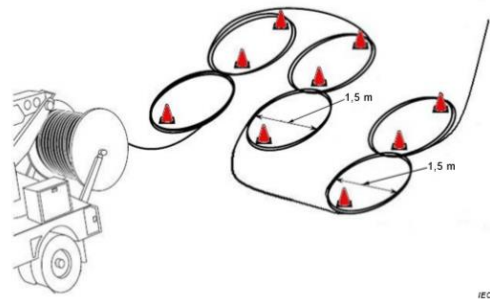
tensions between sections are widely maintained. The operator of the first intermediate manhole (manhole 2) pulls the guide wire of the entry sub-duct of the cable until this one arrives, which is the moment when it is connected to the manhole where the laying started (manhole 1) to stop the cable drum. Once the cable drum is stopped, the operator unties the guide wire used in that section and ties the rotating knot to the guide wire located in the cable outlet sub-duct towards the manhole 3, making sure that the tie is resistant. Manhole 1 is communicated to continue with the laying. In case that the manhole needs to change direction, the operator will untie the guide wire used in that section and previously creating a tie, with a radius as wide as the place where the manhole is located allows it to be, the guide wire located in the outlet sub-duct towards the manhole 3 will be tied to the rotating knot, as explained above. Once work has resumed, the operator of the next manhole (manhole 3) needs to perform the same tasks as the operator in the previous manhole (manhole 2). Meanwhile, it pulls the cable parallel to the axis of the latter, without twisting it, and leaving enough length of the stored cable in order to perform the operation as indicated. The laying rhythm is established by the operator who pulls the guide wire, which is the farthest one from the drum. If an intermediate operator cannot maintain the established rhythm, the cable will start losing its stored reservation, or in the case of a manhole with a change of direction, the ratio of curvature of the tie will start decreasing. Before that happens, an order to stop the process in the next manhole should be communicated until the operator recovers enough cable to continue with the process.



Once we are done with the laying, the next step is to install the cable in its route through the manholes. Since the previous process didn't leave the exact necessary cable for its final installation, we do not proceed to perform the task in every single one of them. Instead, we should start by the second-to-last. This way, if there is excess or lack of cable, it will be taken from the previous manhole. The cable will be installed in the manholes using this method, starting with the second-to-last and finishing with the second one. This process should be carried out carefully because the cable excess should be placed inside the manhole, always being over the minimum radius of curvature established. Finally, we will need to

cut the drum, leaving it stored and properly placed in its structure and with enough cable length to loosely reach the area where the splice is made. In the case that the laying, due to its significant length or a different reason, has to be divided in two subsections (in other words, the entry point is an intermediate manhole), the laying of the first section will be executed as it is explained above and the second section will have to follow these steps:

- The remaining drum wire is laid out, in the shape of “eights” on the ground and its laying will be done as it is explained above, making sure that the stored cable is recovered correctly, without creating any axial deformations, and always maintaining the minimum radius of curvature established.

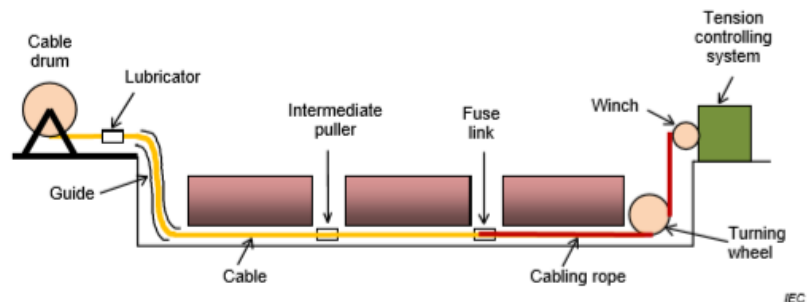


- If it were not like this, it would be communicated in order to stop the traction and solve the problem manually.

ii) Laying by automatic winch. Regarding laying by automatic winch, an automatic winch with tension control is required. The automatic winch, located at the exit manhole, is used to pull the optical fibre cable. To take the automatic winch pulling cable from the exit manhole to the entry manhole, we can use either manual techniques or an autonomous winch. For the optical fibre cable laying, we will need to use pulleys of the adequate size to meet the cable's minimum radius of curvature. In addition, lubricant is added to the cable feeder and to any intermediate position. The passage of the automatic winch pulling cable is carried out as follows:

- 1) The lubricating sling is placed between the pulling cable and the guide wire, connected to this last one through the rotating knot and protected by a thimble.
- 2) Next, 4 litres of lubricant are poured into the duct in front of the first sponge and 1 litre is poured between sponges.
- 3) Once the pulling process has begun, the speed is adjusted to the winding speed of the automatic winch, so that there are no jerks on the guide wire.
- 4) When it is approximately 50m before the end of the cable reaches the intermediate lubrication zones, if any, the operator located in that zone will pour 2 litres of lubricant into the duct, which drags the sponges from the lubricant sling. The laying of the optical fibre cable will be carried out as follows:

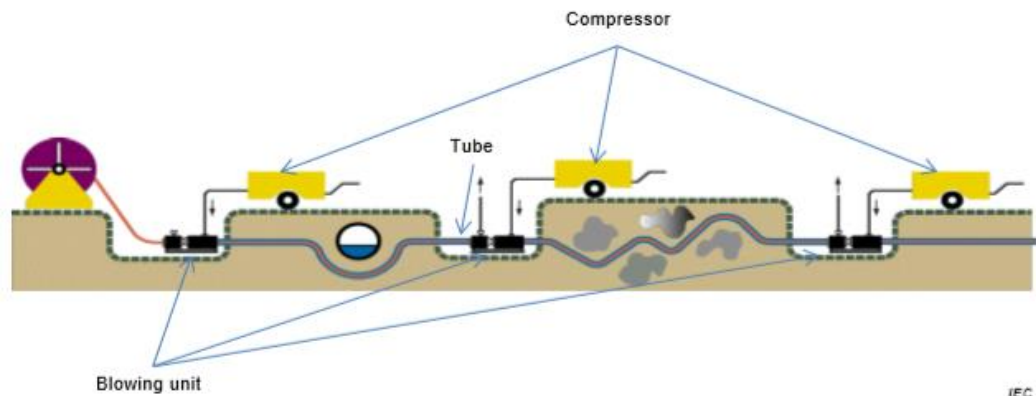
- 5) The winch must be far enough from the exit manhole to allow the necessary length of cable to exit without the fibre reaching the pull cable collection drum.
- 6) Once the winch pulling cable is passed, the guide wire is released, leaving the lubricating sling and the rotating knot installed.
- 7) The optical fibre cable pull sleeve connects to the lubricant sling through the rotating knot, and rollers are placed so that the cable does not touch the ground.
- 8) Before starting the pulling, 3 liters of lubricant must be poured in front of the sling, and the end of the cable can then be inserted into the duct.
- 9) The lubrication element for cable entry is attached to the end of the duct, pouring enough lubricant to completely cover it. As the cable progresses, an operator regulates the amount of lubricant.
- 10) With the automatic winch, we should control and check the tension and speed of the laying continuously. It is started programming it to an initial tension of 80% of the maximum cable tension. If the laying goes over these tensions, the process stops automatically.
- 11) The first 25m of the laying will be carried out at a low and progressive speed, until reaching a speed of 20m/min, which should not be exceeded.
- 12) At the same time, lubricant is poured, about 50m before the cable reaches the intermediate lubrication areas, so that the sponges can drag part of it.
- 13) When, in addition to the pulling sleeve, the necessary meters of cable protrude outside the duct of the exit point, the laying process has ended.
- 14) The last meters of cable must be entered carefully, making sure not to exceed the minimum radius of curvature, and always leaving the corresponding length of cable loop stored in the manholes.



- iii) Laying through "BLOWING". The cable laying method called "blowing" can be defined as a pneumatic laying used for ducting installations of telecommunication cables, which consists of inserting cables directly under pressure with the help of brown air, and the cable being able to be placed in a single operation. For this type of laying, it is necessary to use a cable track to increase the thrust (used to support the thrust force or energy during the "blowing" of optical fibre cables) with accessories adapted to the external diameter of the cable such as a compressor. It will be necessary that the ducts and tubes do not present any deformation. The procedure is as follows:

1. It must be checked and verified that the cable's diameter is regular enough to ease the passage of the caterpillar and the elements that ensure the air tightness.
2. Make sure that the duct's internal diameter and the its external diameter fit adequately in order to guarantee a volume occupation of around 65%.
3. Before the cable blowing, a probe must be inserted to check whether the condition of the duct is in perfect conditions for the passage of the cable or not, thus avoiding areas of crushing or unnecessary bending that would avoid cable passage and problems during the laying.
4. The probe is blown through the entire duct, and it is also impregnated with lubricant in order to lubricate its interior.
5. Whenever possible, the blowing should be done in a downward direction to ease the passage of the cable.
6. The process is started at a low speed, between 10-20m/min, increasing the speed according to the amount of cable to be blown.
7. This process allows the blowing of cable lengths of approximately 2 to 3 km in a single section.

Machinery must operate within the proper limits of use, after careful observation of the operative manual instructions and other inspection and maintenance guidelines.

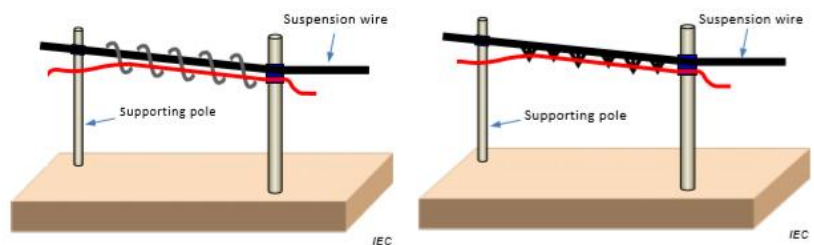


b. **Aerial laying.** To carry out the optical fibre cable laying by aerial route, the following precautions must be considered:

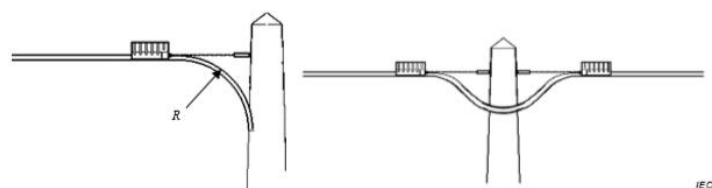
1. In general, the drum is placed next to the pole from which the laying will start, suspended from a crane, on a trailer or on jacks, so that it can freely rotate, and the cable always comes out at the top. We will always try to place the drum at the same level as the poles where the cable laying is to be carried out.
2. Aerial installation is performed between poles, tying the optical fibre cable to an existing steel fastener. The fibre optical cable is placed next to the sear by cable drum trucks and trailers. A cable guide and a cable tie are used to secure the cable

to the sear. Meanwhile, a truck follows the clamp to make sure that it is operating correctly and that the cable is properly adjusting to the line positions.

3. At the prepared end of the cable, we will add a rotating knot, tying a hemp rope to it. The way of performing the traction of the cable in the laying process, differentiates two forms of aerial laying: manual laying or winch laying.
4. Once the laying process is over, the cable is sewn to the messenger. The fastener is tied by sewing with 2mm steel wire. This sewing is done with the tying machine that sews the cable as it progresses along the suspension cable.

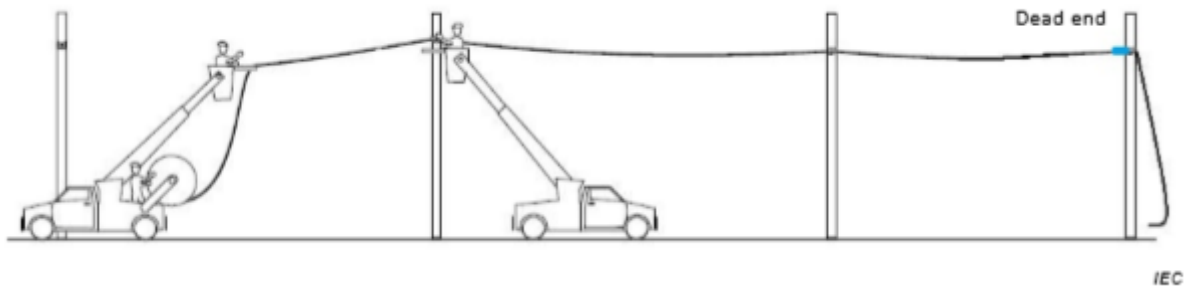


5. On each pole, the cable will form a turn of expansion to allow the messenger to dilate. Due to the optical fibre's properties, the cable expands or contracts very little when the temperature varies. Therefore, to reduce the strain on an optical fibre cable that has been attached to a steel messenger, a small turn of expansion will be added.
6. The curvature radius of the cable must be considered, so that the loop's length of the tie D must be two times greater than the minimum curvature radius of the cable.



ii. Manual cable pulling laying. Due to the low weight of the optical fibre cables and when the conditions of the line drawing advise it, we can use the method described below:

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- On the first pole, the hemp rope is passed through the guide pulley and the sliding hooks. The free end of the rope that connects the hooks to the cable pull head is tied, so that as the cable progresses the hooks can extend.
- Following the poles line, and in the direction of moving away from the drum, the hemp rope is pulled by the necessary operators, at the regular speed of a man's passage, until the cable reaches the next pole where it stops to pass the rope through the pulley and hooks again and repeat the previous operation.



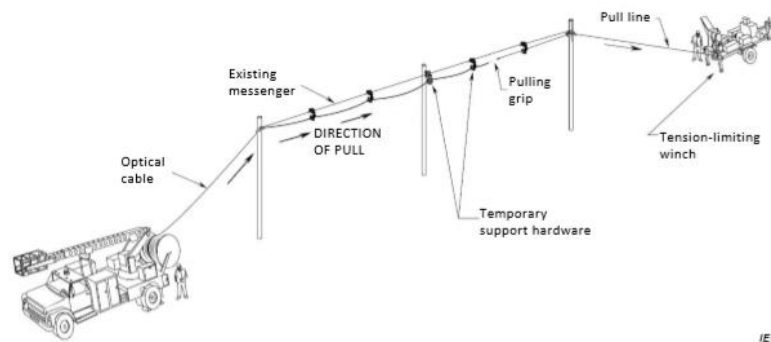
iii. Winch laying. In this method, a winch is used to control the laying speed and the pulling force, with automatic stop whenever the recommended value is exceeded. The tasks to be performed are the following:

- The winch is placed at the end of the line and the pull rope is manually extended, making its way through the sliding hooks and guide pulleys of each pole until reaching the drum.
- The winch is adjusted for maximum cable tension and a certain speed.
- Pulling is started slowly until the cable reaches the sliding hooks, where pulling stops to tie the rope connecting the hooks to the end of the cable.
- The traction process resumes until progressively reaching the corresponding speed and stops at the next pole to release the rope from the hooks, watch the cable go through the pulley and tie the rope of the next group of hooks.

c. Facade laying. Optical fibre cable laying on facade should be minimized due to the risk of the cable once installed. Here are some precautions to keep in mind:

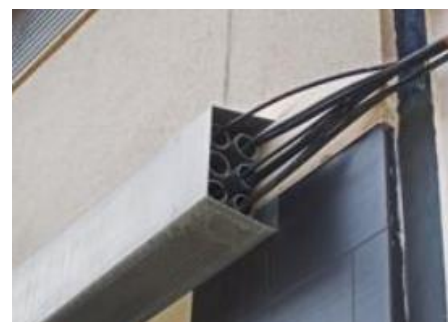
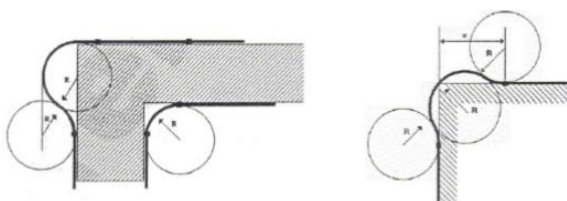
- 1) The laying must be maintained at a constant height, without any level change, the minimum height being 2,5m above the ground, and the cable being parallel to the ground or perpendicular always.
- 2) To minimize the aesthetic impact, architectural elements such as moldings, gutters, etc. are used. It is important that the optical fibre cable has difficult accessibility.

- 3) We should consider adapting the cable's route so that its exposure to deterioration due to bad weather is minimized.
- 4) The laying is done in such a way that the least number of materials is used, with the least number of angles possible and trying to overcome all of the potential obstacles.
- 5) The vertical paths are separated by at least 30cm from the projecting edges of the buildings.
- 6) We should be very careful with the cable's curvature radius and the edges of the facade, so that we can avoid any curvature below the minimum radius indicated in the technical instructions for the cable to be installed. We must have a cable installation template of the minimum curvature radius to avoid damaging it.



The procedure for the facade cable installation includes the following steps:

- 1) It begins with the tracing of the mark on the facade of the route to follow. This mark or signal can be done with a marker, or in other words, nothing more than a fine rope dipped in coloured powders. The ascents and descents of the cable for the aerial or underground passages are carried out by means of plumb and distinctive marking.
- 2) Once the marking/signalling task is completed, the task of placing the plugs and fixing clamps on the facade is carried out, following the marks.
- 3) Once this operation is completed, the cable drum is placed in position and the cable installation begins.
- 4) Once the facade cable laying process is over, we proceed to its final fixation, adjusting the fastening systems simultaneously to the perfect alignment of the cable on the facade, in order to avoid the installation with openings.
- 5) It is recommended to review any possible flaws, chips, holes or paint for its replacement.

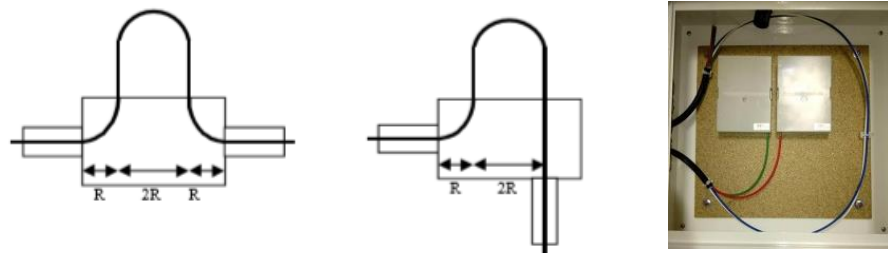


d. Indoor laying. Ducting and indoor laying will be carried out in accordance with the stakeouts made. Keep in mind following instructions when laying indoor cables:

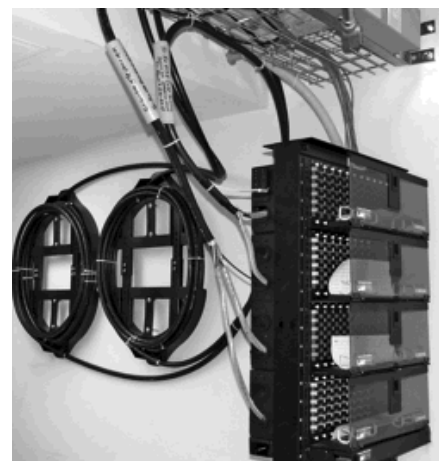
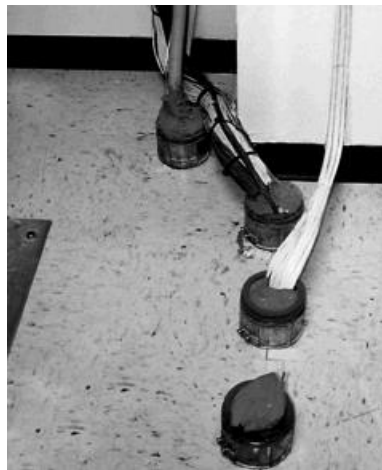
- 1) Cable installation without ducts will be avoided. If that is not possible, the fastening system must guarantee the perfect operation of the cable without being damaged.
- 2) Review the location of all the necessary elements to help and fix the cables on their route through the communication rooms of the centers: gutters, trays or selected support elements.
- 3) All equipment (cabinets and metal structures) should be connected with ground protection for safety.
- 4) All links should be properly identified. It is recommended to avoid any splice in the cables, except for the corresponding equipment access end hoses, when required.
- 5) It is necessary to make extra fibre length as reservation in a false ceiling or raised floor, long enough to allow future movements of the rack or the distribution panel, always respecting cable minimum bending radius.
- 6) In the case that the ducting is done through gutters, the optical fibre cables are fixed at the base of the gutter through cable ties every 300mm at the most, along its entire route, without exceeding the tightening.

In both cases, the following general laying methodology can be applied:

- 1) First, a connection panel at the cable entrance, splicing the fibre coming from the exterior cable with that of the interior cable.
- 2) Horizontal routes can be placed on suspended ceiling or under raised floors, while vertical routes are carried out in lifted cabinets. If these cabinets are not available, holes are drilled in the floor for cable or duct guidance.
- 3) To make the dragging of the cable inside the duct easier, we can use traction or laying boxes, preferably in long straight and curved sections. At least one pull box is used after the second 90-degree bend. The two types of boxes are seen in the following figure, where R represents the minimum curvature radius of the optical
- 4)



- 5) All pull boxes, ducts and cable trays are identified and inspected, making sure they are not obstructed.
- 6) A continuous section of traction tape is placed in the complete route and the laying hole and swivel are tied to the cable and then the traction tape is tied to the swivel. The use of cable guides with a smaller diameter is also recommended for indoor spaces.
- 7) The cable is pulled from the first pull box, winding the cable on the ground forming an "eight".
- 8) The traction box is fed with cable, continuing the procedure until the next box.
- 9) Indoor wiring in technical rooms often requires firebreak systems on each cable entries in the walls and ceilings. In addition, fire-fighting systems for telecommunications must comply with the applicable norms and standards. All cable accesses should be protected with approved systems.



6. Documentary references.

- <https://www.thefoa.org/tech/ref/contents.html>
- Eusko Jaurlaritza-Herrizaingo Saila – ANEXO-III
- Technical Report IEC TR 62691