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Technical newsletter
Optical cable material selection and aging

November 2022

Summary

Passive optical infrastructure includes optical fibre cables and connectivity components and is expected to have a very long service lifetime. Field experience shows that these networks will work well for more than 30 years, even as long as 50 years.
How is this possible? By selecting right cable designs with high quality raw materials for the right application. Relevant test programs ensure long term performance and it is always important that the right principles and methods of installation are followed.
This document is part of a suite of Newsletters published by EUROPACABLE: We encourage the reader to read all of them and also the white paper entitled **"Expected lifetime of Passive Optical Infrastructure"**.

Designs and Materials

Faults noted in passive optical networks have different origins. In some cases the initial installation fails with fibre breaks or high optical attenuation as a result of damage due to incorrect installation procedure. During operation, faults can relate to renovations or construction work where the passive network components obviously can be damaged.
Aging must be considered as a normal process, the challenge is to avoid unexpected degradation of the cable performance and characteristics over a period of 30 to 50 years. This requirement can only be achieved by the selection of the right materials and "State of the Art" processing conditions.
Correct and reliable products are the result of very long R&D activities and more than 50 years' experience. R&D engineers must integrate many parameters and execute many tests, including long-term aging tests, to be able to demonstrate that the targeted lifetime is achievable. A wide range of competence and expertise on design, materials, processes and qualification procedures is required to develop the right products for the right applications. This competence is the result of exhaustive technical tests that very often goes beyond the well-known test standards. It is also important to consider the structure of the optical cables in order to choose the most suitable design with respect to environmental conditions and the required long-term performance.

The optical fibre must be of high quality which is verified through different qualification tests including long-term aging such as temperature aging, water aging, sunlight aging and color stability. To protect the optical fibres, a variety of different cable designs are available for different applications. Usually different types of strength elements are used in the cable design to reduce the fibre elongation during installation and operation but also achieve good optical performance during temperature variations. Different protective polymeric materials are used as mechanical protection.
For long distance applications, optical fibres are generally well protected in robust cable designs. These cables are installed with a lot of care so that the fibres within are not subjected to excessive bending effects. Consequently, conventional single mode fibres will work well with good performance.

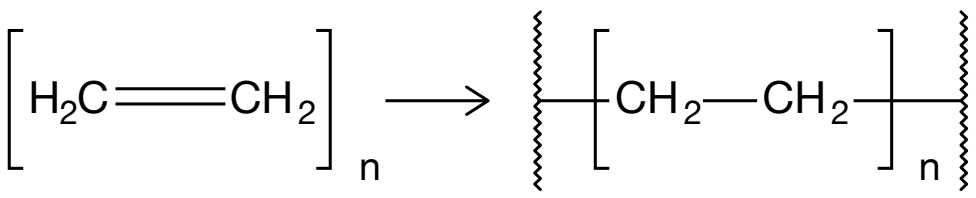
For FTTx or 5G applications, the situation is different: cables and fibres are subjected to macro- and microbending as both cables and components are smaller in size. Moreover, installers frequently perform new cable installations or repairs and maintenance along the existing network. Each time the optical fibre must support new stresses and strains. Compared to long distance networks, the installation is executed with less care. In such an environment, bend insensitive fibres are used to enhance the network reliability.

It is important to note that cable design and application goes together. As an example, microcables in microducts require different properties than an aerial solution. Microcables will be installed by blowing which can require a sheath designed for good blowability. Microcables are usually not subjected to a lot of tensile strain and, when installed, protected mechanically through microducts. Aerial installation require high tensile strength cable designs the fibre elongation and good UV-resistance.
The important point is to understand how the choice of materials is essential to produce high quality products. High quality raw materials are mandatory to produce high quality optical cables.

To produce optical cables, a large variety of materials will be used, for example:
- Metals
- Glass
- Polymers

Again, it is impossible in a few lines to explore this wide scientific sector. The important point is to understand how the choice of materials is important to produce high quality hardware. To make a parallel with the cooking activity, chefs will tell you “high quality of basic food” is mandatory for “high quality cooking”. In the cable industry, it’s the same story: high quality raw materials are mandatory to produce high quality optical cables.

Let us illustrate this point with a well-known material in the cable industry: Polyethylene.



Ethylène Polyéthylène

If the basic formulation is simple, the production of polyethylene blend with the right macromolecular weight, the right poly-dispersion index, the right stabilization with appropriate antioxidants such as phenolic antioxidants BHA, BHT, AO 2246, AO 425, Ethanox 330, Irganox 1010, Irganox 1076 or others and with the right concentration is a lot more complex.

The different grades of polyethylene (LDPE, LLDPE, HDPE, copolymers) do not present the same extrudability and during the extrusion process the polymer may be damaged by the use of the wrong process. The material reliability may also be affected.
On top of these different parameters that influence the expected life time, there are a lot of other characteristics to take into account. The friction coefficient is an important parameter to keep under control the pulling force of cables in ducts or to optimize blowing properties.
The UV resistance of jacketing materials is also very important, particularly for aerial cables. Here also the expected lifetime of these polyethylene jacketing materials will strongly depend on the carbon black concentration, quality of the dispersion in the PE matrix, size of carbon black particles.
We can see that for just one material it requires many studies, tests and long term aging to understand if the targeted long-term lifetime will be achieved.
Any kind of polymeric materials used to produce optical cables requires the same care as the one presented above for the polyethylene as an example, to be sure that the final reliability of the optical cable will be in line with expectations.
On top of the material quality, any possible interaction between materials included in the cable but also between the jacketing material and the cable environment must be carefully investigated. This is another very important activity of the R&D teams.

Test Program and International Standards

A newsletter has been prepared **to understand an optical fibre cable datasheet**; but very important tests results are not always presented in a datasheet. To ensure expected service lifetime and high reliability it is important to always perform mechanical and temperature qualification tests of the optical fibre and optical fibre cables following applicable international standards taking into account local environmental conditions. IEC and CENELEC standards (i.e. IEC 60793, 60794 and 60811 suites) provide relevant guidance on the performances to achieve and the tests to perform:

- **Optical fibre**
  - **Mechanical characteristics**
    - IEC 60793-1-30 Fibre Proof Test
    - IEC 60793-1-31 Tensile strength
    - IEC 60793-1-32 Coating strippability (compatibility with filling compound if any)
    - IEC 60793-1-33 Stress corrosion susceptibility
  - **Environmental characteristics**
    - IEC 60793-1-50 Damp heat
    - IEC 60793-1-51 Dry heat
    - IEC 60793-1-52 Change of temperature
    - IEC 60793-1-53 Water immersion
  - **Some of these tests are also useful to validate the long term stability of the color identification (including ring markings).**

· **Polymeric material**
  - **Thermal stability of protective tubes**
  - **Compatibility with filling compound and elements coatings (if any)**
  - **Stress cracking of sheath materials**
  - **UV resistance of the outer sheath material**

Conclusions

To enable and build high-quality, reliable and long lasting networks it is imperative to ensure:

a) Detailed product and hardware specifications and qualification processes, taking into account their future proof capability and reliability during the expected lifetime.

b) The network owner, installer and maintenance crew have adequate competence.

c) The network owner must be able to set standards in terms of the right products being used and the right methods of installation as well as procedures for maintaining the network.

d) High quality and reliable civil works as well as installation. The installers shall be certified for the task and make sure that installation instructions are followed.

e) Accurate final inspection to guarantee that any of the above mentioned points are totally under control.

For more information, refer to Europacable technical newsletter « FttH-and-Optical-distribution-network-reliability »

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