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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Optical fibre cables – Cable structure and characteristics

Optical fibre cable elements for microduct blowing-installation application

Recommendation ITU-T L.108

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ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Recommendation ITU-T L.108

Optical fibre cable elements for microduct blowing-installation application

Summary

Recommendation ITU-T L.108 (ex. L.79) describes the characteristics, construction and test methods for microduct fibre units and microduct cables that are used with the blowing installation technique. The cable characteristics required for a cable to perform appropriately are described. Also, a method is described for determining whether or not the cable has the required characteristics. The required conditions may differ according to the installation environment; detailed test conditions must be agreed upon between a user and a manufacturer for the environment in which a cable is to be used.

History

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Blowing installation, fibre unit, microcable, microduct, optical fibre cable.

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FOREWORD

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Introduction

Air blowing installation methods are based on viscous drag acting upon a cable within a duct by forcing a continuous high-speed airflow through the duct. The velocity of the moving air propels the cable and makes it advance at a typical speed supported by the blowing equipment. When using blowing techniques, there is generally no pulling force at the front end of the cable; the airflow exerts a distributed force along the entire cable. In addition, connection to a pulling cord is not needed.

Generally, the blowing force is an order of magnitude lower than the typical force involved in other installation methods, for example pulling techniques, thus reducing installation hazards. Additionally, with this technique, bends in a duct run are of less concern than with pulling techniques, so, generally, the installation speed increases and longer lengths of cable can be installed. Cables are installed with low stress levels, leaving the cable or other elements effectively relaxed in the duct once the installation has been completed.

Therefore, cables can be designed with lower tensile capabilities than cables to be pulled. And, elements without additional strength members, such as fibre units and single fibres, can also be considered.

New generation cabling techniques, based on microduct cables, microduct fibre units and microduct systems, offer the possibility of branching without the need for splices. These techniques are extremely flexible and make them possible to grow in accordance with demand. This gives rise to the concept of "fibre on demand", which involves the pre-installation of a multi-microduct system and then the subsequent, incremental installation of fibres based on individual customer demand.

To support this "fibre on demand" approach, a fibre cable product must allow the installation of only a few fibres at a time. These types of cable products should take up the smallest possible amount of the service provider's right-of-way (i.e., fit the smallest microduct) so that there is plenty of space to add fibres for future customers. Therefore, usually only a small number of the fibres that are installed are used immediately. Also, the latest fibre technology can be adopted when required.

Recommendation ITU-T L.108

Optical fibre cable elements for microduct blowing-installation application

1 Scope

This Recommendation:

– refers to microduct fibre units and microduct cables to be used for telecommunication networks with blowing installation techniques;

– deals with mechanical and environmental characteristics of microduct fibre units and microduct cables. The optical fibre dimensional and performance parameters, together with their test methods, should comply with [IEC 60793-5-10] or [IEC 60794-5-20] which deal with microduct cable and microduct fibre units, respectively. The optical fibre dimensional and transmission characteristics, together with their test methods, should comply with [IEC 60793-2-10] and with [ITU-T G.651.1], [ITU-T G.652], [ITU-T G.653], [ITU-T G.654], [ITU-T G.655], [ITU-T G.656] and [ITU-T G.657] which deal with multi-mode graded index optical fibres and single-mode optical fibres, respectively;

– acknowledges that some optical fibre cables may contain metallic elements, for which reference should be made to [b-ITU-T Technical Report] and other L-series Recommendations.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.650.1] Recommendation ITU-T G.650.1 (2018), *Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable*.

[ITU-T G.651.1] Recommendation ITU-T G.651.1 (2007), *Characteristics of a 50/125 µm multimode graded index optical fibre cable for the optical access network*.

[ITU-T G.652] Recommendation ITU-T G.652 (2016), *Characteristics of a single-mode optical fibre and cable*.

[ITU-T G.653] Recommendation ITU-T G.653 (2010), *Characteristics of a dispersion-shifted single-mode optical fibre and cable*.

[ITU-T G.654] Recommendation ITU-T G.654 (2016), *Characteristics of a cut-off shifted single-mode optical fibre and cable*.

[ITU-T G.655] Recommendation ITU-T G.655 (2009), *Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable*.

[ITU-T G.656] Recommendation ITU-T G.656 (2010), *Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport*.

[ITU-T G.657] Recommendation ITU-T G.657 (2016), *Characteristics of a bending loss insensitive single mode optical fibre and cable*.

[ITU-T L.100] Recommendation ITU-T L.100/L.10 (2015), *Optical fibre cables for duct and tunnel application*.

[ITU-T L.101] Recommendation ITU-T L.101/L.43 (2015), *Optical fibre cables for buried application*.

[ITU-T L.102] Recommendation ITU-T L.102/L.26 (2015), *Optical fibre cables for aerial application*.

[ITU-T L.103] Recommendation ITU-T L.103/L.59 (2016), *Optical fibre cables for indoor applications*.

[ITU-T L.162] Recommendation ITU-T L.162 (2016), *Microduct technology and its applications.*

[ITU-T L.400] Recommendation ITU-T L.400/L.12 (2008), *Optical fibre splices*.

[IEC 60189-1] IEC 60189-1 (2007), *Low-frequency cables and wires with PVC insulation and PVC sheath – Part 1: General test and measuring methods*.

[IEC 60793-1-1] IEC 60793-1-1 (2017), *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance*.

[IEC 60793-1-20] IEC 60793-1-20 (2016), *Optical fibres – Part 1-20: Measurement methods and test procedures – Fibre geometry.*

[IEC 60793-1-21] IEC 60793-1-21 (2001), *Optical fibres – Part 1-21: Measurement methods and test procedures – Coating geometry.*

[IEC 60793-1-32] IEC 60793-1-32 (2010), *Optical fibres – Part 1-32: Measurement methods and test procedures – Coating strippability.*

[IEC 60793-1-53] IEC 60793-1-53 (2014), *Optical fibres – Part 1-53: Measurement methods and test procedures – Water immersion tests.*

[IEC 60793-2-10] IEC 60793-2-10 (2017), *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres.*

[IEC 60794-1-1] IEC 60794-1-1 (2015), *Optical fibre cables – Part 1-1: Generic specification – General*.

[IEC 60794-1-2] IEC 60794-1-2 (2017), *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures – General guidance*.

[IEC 60794-1-21] IEC 60794-1-21 (2015), *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*.

[IEC 60794-1-22] IEC 60794-1-22 (2012), *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental test* methods.

[IEC 60794-1-23] IEC 60794-1-23 (2012), *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures –Cable element test methods*.

[IEC 60794-5] IEC 60794-5 (2014), *Optical fibre cables – Part 5: Sectional specification – Microduct cabling for installation by blowing.*

[IEC 60794-5-10] IEC 60794-5-10 (2014), *Optical fibre cables – Part 5-10: Family specification - Outdoor microduct optical fibre cables, microducts and protected microducts for installation by blowing.*

[IEC 60794-5-20] IEC 60794-5-20 (2014), *Optical fibre cables – Part 5-20: Family specification – Outdoor microduct fibre units, microducts and protected microducts for installation by blowing.*

[IEC/TR 62222]	IEC/TR 62222 (2012), *Fire performance of communication cables installed in buildings.*

3 Definitions

3.1 Terms defined elsewhere

For the purpose of this Recommendation, the definitions given in [ITU-T G.650.1] and [ITU-T G.651.1] apply.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 blowing duct: There are three kinds of blowing ducts: outer protective duct, protected microduct and composite protected microduct/cable.

3.2.2 blown-in element: A blown-in element consists of optical fibre(s), sheath and other materials and can be inserted into the microduct by continuous high-speed airflow force. Some of the characteristics of this element are described in clause 7.2.

3.2.3 composite protected microduct/cable: A composite protected microduct/cable is a bundle containing both microducts and optical fibre cable. They are combined and surrounded by a tight or loose protective sheath, perhaps with another optional protective layer such as a moisture barrier.

3.2.4 microduct: A small, flexible tube with enough wall thickness to provide the mechanical protection required by the application, with its outer and inner diameter defined according to the dimension and the condition of the existing duct and the diameter of the microcable.

3.2.5 microduct cable (also called microcable): An optical fibre cable that is suitable for installation into a subducting microduct.

3.2.6 microduct fibre unit: This is a group of fibres (with a count starting at 1) that can be installed in a microduct with the blowing technique.

3.2.7 micromodule: This is a thin walled tubing unit. These flexible modules have bending radii similar to the unbundled fibre and are easy to strip without a tool for easy splice preparation and mid-span access. They have no shape memory and may be used directly in an enclosure up to the splicing tray. Water-blocking material may be contained in the micromodule, if required. See Figure 1.

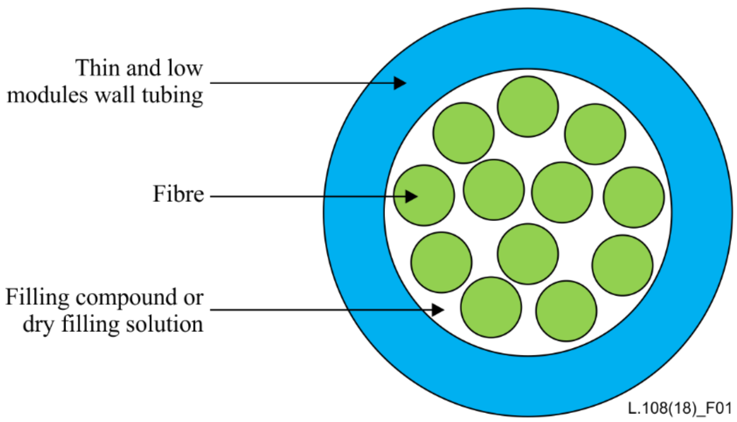

Figure 1 – Example of primary coated fibres protected by micromodule

3.2.8 protected microduct: This kind of duct comprises a number of microducts that are loosely or tightly packed together and jacketed, in much the same way as an optical cable without the fibre.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

FTTH Fibre To The Home

HDPE High Density Polyethylene

LSZH Low Smoke Zero Halogen

OD/ID Outer Diameter/Inner Diameter

OTDR Optical Time Domain Reflectometer

PE Polyethylene

PVC Polyvinyl Chloride

5 Conventions

None.

6 Environmental conditions

The required characteristics depend strongly on the environmental conditions at the location where the optical cables are installed. Therefore, it is important to know these conditions.

6.1 Underground

6.1.1 Conduits and tunnels

The environmental conditions of conduits and tunnels are described in [ITU-T L.100].

6.1.2 Direct buried

The environmental conditions for buried applications are described in [ITU-T L.101].

6.2 Aerial

The environmental conditions for aerial applications are described in [ITU-T L.102].

6.3 Indoor

The environmental conditions for indoor applications are described in [ITU-T L.103].

7 Construction and characteristics of microduct system and cable elements

7.1 Fibre

7.1.1 Primary coated fibre

Primary coated fibres must comply with the relevant ITU-T G.65x-series Recommendations.

7.1.2 Buffered fibre

When using a tight or semi-tight (loosely applied) buffer, the following characteristics are required:

– A tight buffer should be easily removable over a length of 15 to 25 mm for fibre termination or splicing.

– A semi-tight buffer should be easily removable over a length of 0.3 to 2 m for fibre termination or splicing, and without affecting the fibre coating.

– With a tight buffer, the nominal diameter should be between 300 and 1000 µm, based on an agreement between the user and supplier. The tolerance should be ±50 µm.

– With a semi-tight buffer, the nominal diameter should be between 300 and 1400 µm, based on an agreement between the user and supplier. The tolerance should be ±50 µm.

7.2 Blown-in elements

The key mechanical design issues related to the blown-in elements are diameter, weight, stiffness and elasticity, robustness, surface friction and element memory. Element memory is an attribute relating to the element's ability to return to its original shape, i.e., straight, after being bent. The relatively lower tensile force resulting from blowing in a microduct cable or microduct fibre unit generally results in a structure requiring lower tensile rating than that of ordinary optical fibre cables. Although the blown-in element is effectively pulled into the duct by an air stream during installation, there are circumstances under which compressive axial forces can occur, and hence the possibility of buckling the blown-in element. Buckling can cause jams in the duct and possible damage to the fibre being installed.

Therefore, these elements must also be able to bend around corners, as typical installations will contain bends. Thus, the element bending stiffness must be sufficiently high to minimize the risk of buckling, but not so high as to prevent cornering during installation.

Another key property of these elements is their surface characteristics. The goal is to maximize viscous air drag on these elements and minimize friction with the duct. Although these elements should be designed to minimize sliding friction inside the duct, its surface will contribute to drag.

Regarding the fibre itself, any of the current ITU-T Recommendations may be considered, from [ITU-T G.651.1] to [ITU-T G.657].

Different methods may be used to ensure correct fibre identification within the element (typically, by colouring fibres).

Finally, the element must be robust to the presence of gases or liquids (typically, water) in the duct.

7.2.1 Microduct cable

Microduct cables, often called microcables, may consist of fibres, groupings of fibres, strength members, water blocking materials, sheaths and other appropriate materials. Microduct cable construction and performance is described by [IEC 60794-5-10].

The attenuation of the installed cable at the operational wavelength(s) should not exceed the values of [IEC 60794-5-10] or as agreed between the customer and supplier.

There should be no fibre splice in a delivery length unless otherwise agreed by the customer and supplier.

It should be possible to identify each individual fibre throughout the length of the optical fibre microduct cable. Colour coding of fibres and units within the cable are common methods.

Microduct cables typically have fibre counts ranging from 4 to 288 or more, with a typical outside diameter of 1.5 mm to 10.0 mm or even larger diameters. The units within may consist of single fibres, fibre groupings such as tubes, micromodules or ribbons.

7.2.2 Microduct fibre unit

These units differ from microduct optical fibre cables in that they provide less protection to the fibres that they contain. Microduct fibre unit construction and performance is described by [IEC 60794-5-20].

Microduct fibre units do not utilize strength members as traditional fibre cables do, and therefore the stiffness and tensile strength of the entire element is achieved through the intrinsic stiffness of the fibre assemblage and the intrinsic tensile strength of the fibres themselves, as well as of the materials coating the fibres. Here the small cross-sectional geometry of the blown-in element plays a beneficial role in achieving a balance between flexibility and stiffness.

The attenuation of an installed microduct fibre unit at the operational wavelength(s) should not exceed the values of [IEC 60794-5-20] or as agreed between the customer and supplier.

There should be no fibre splice in a delivery length unless otherwise agreed between the customer and supplier.

It should be possible to identify each individual fibre throughout the length of the microduct fibre unit. Colour coding and positional coding are common methods.

Fibre units typically have fibre counts ranging from 1 to 24 fibres, and will typically have an outside diameter of between 1.0 mm and 3.2 mm. They may consist of single fibre, or an assembled bundle or a flat ribbon (made of two or four fibres). Bundles may be assembled using coating-like matrix, buffer material, binders or other methods meeting the design intent.

7.3 Microducts

The microducts should be able to resist the pressure differences needed during installation with a blowing technique. They should be circular and uniform in cross-section throughout their length and the inner surface should have a low friction coefficient either by the material used (silicone, etc.) or having profiled ribbing. The inner and outer diameters should be specified.

Microducts are intended for benign installation within ducts or as components within protected microducts as described in clause 7.4. In all cases it should be possible to identify each individual microduct throughout its length. Colour coding or marking are common methods for identification.

Microducts can also be put into the interstices of ducts containing other cables.

7.4 Protected microducts

Duct systems to install blown-in elements inside have been designed to optimize blowing distances and provide additional protection from the environment. Different kinds of protected microducts are considered, with alternative materials and properties, depending on the installation environment.

For example, if rodent protection is needed, fibreglass yarn or corrugated laminated steel can be used in the outer duct.

7.4.1 Outdoor protected microducts for duct installation

The outer duct of these microducts can be made of polyethylene, with an optional low friction anti-static inner surface. The surface may be ribbed or may be of a different material. For example, such a surface could be made of silicone rubber to reduce the friction or aluminium foil to deal with the presence of water.

Inner duct counts may vary from 1 to more than 20 microducts. These inner microducts are typically coloured to facilitate identification.

7.4.2 Outdoor protected microducts to be directly buried

Duct assemblies for direct burial should be more robust than those for duct installation. The outer duct of these microducts can be made of polyethylene: two sheaths of polyethylene (the outer one made of high density polyethylene), with a low friction anti-static inner surface. The surface may be ribbed or may be of a different material. For example, such a surface could be made of silicone to reduce the friction or aluminium foil to deal with the presence of water.

Alternatively, they can consist of a bundle of microducts loosely pre-installed in a protective duct of the type commonly used as an empty protected duct.

Inner microduct counts may vary from 1 to more than 20. These inner microducts are typically coloured to facilitate identification.

7.4.3 Aerial protected microducts for outdoor installations

These microducts, can either be used singly or enclosed in a larger outer duct. Either type is usually made of polyethylene. The ducts that are suspended are often self-supporting with a typical installation span of up to 70 m. Different reinforcing elements or materials such as steel, fibreglass or aramid yarns should be used to improve the mechanical characteristics. These protected microducts may be lashed to aerial suspension elements in the same manner as outdoor optical fibre cables. Inner microduct counts may vary from 1 to more than 12. These inner microducts are typically coloured to facilitate identification.

The suspension element can be metallic or dielectric, and the whole system should be waterproof.

7.4.4 Indoor protected microducts

These microducts are usually made of halogen-free, flame-retardant material, with a low friction anti-static inner surface. Usually, fire safety is required (see clause 8.5). Inner microduct counts may vary from 1 to more than 15. These inner microducts typically have individual markings or colour coding for identification.

7.5 Composite protected microduct/cable

Composite protected assemblies consist of microducts, optical fibre cables and protective sheaths, perhaps with some other optional protective layer such as a moisture barrier. The materials and configuration that can be used for microducts are described in clause 7.3. The requirements, configuration, characteristics and test methods of an optical fibre cable that is used for this unit are described in [ITU-T L.100], [ITU-T L.102], [ITU-T L.101] and [ITU-T L.103], and depend on the environment in which they are used.

8 Test methods

The tests and performance requirements recommended herein should comply with the applicable requirements of [IEC 60794-1-1] and the relevant ITU-T G.65x-series Recommendations.

8.1 Test methods for dimensions

[IEC 60793-1-20] and [IEC 60793-1-21] should be used for measuring fibre geometry parameters.

[IEC 60189-1] should be used for measuring buffered fibres, tubes and cable diameters. This method can be employed to measure the thickness of a cable sheath, buffer tube, or similar.

8.2 Test methods for cable elements

8.2.1 Tests applicable to optical fibres

This clause describes optical fibre test methods related to cabled fibre performance. Methods for testing the mechanical and optical characteristics of optical fibres are described in [ITU-T G.650.1], [ITU-T G.651.1] and [IEC 60793-1].

8.2.1.1 Coating strippability

[IEC 60793-1-32] should be used for measuring the strippability of primary or secondary fibre coatings.

8.2.1.2 Compatibility with filling material

When fibres come into contact with a filling material, the stability of the fibre coating and the filling material should be tested after accelerated ageing.

The stability of the coating stripping force after ageing should be tested in accordance with method E5A of [IEC 60794-1-21].

Dimensional stability and coating transmissivity should be examined by using a test method agreed upon between the manufacturer and the user.

8.2.2 Tests applicable to tubes

8.2.2.1 Tube kink

Method G7 of [IEC 60794-1-23] should be used for measuring the kink characteristics of a tube.

8.3 Methods for testing mechanical characteristics

The methods for testing the mechanical characteristics of each product are divided into two categories as shown in Table 1. This table is a general summary of the testing requirements of [IEC 60794-5-10] and [IEC 60794-5-20]. In the table, "recommended" means that a test should be performed. "Optional" means that a test will be performed if agreed between the manufacturer and the user. As regards the test methods, reference should be made to [IEC 60794-1-21], [IEC 60794-5] and [IEC 60794-5-10] for microduct cables or [IEC 60794-5-20] for fibre units.

Table 1 – Mechanical test methods applied for each product

	Protected microducts and microducts	Composite protected microduct/cable	Microduct fibre unit and microduct cable
Tensile strength	Recommended	Recommended	Recommended
Bending	Recommended	Recommended	Recommended
Crushing	Recommended	Recommended	Recommended
Torsion	Recommended	Recommended	Recommended
Impact	Recommended	Recommended	Recommended
Kink	Recommended	Recommended	Recommended
Repeated bending	Recommended	Recommended	Recommended
Bending at low temperature	Optional	Optional	Optional

NOTE – The mechanical test methods for protected microducts and microducts as well as the microducts in composite protected microduct/cable should be carried out as per [IEC 60794-5-10].

8.3.1 Tensile strength

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

Measurements are made to examine the behaviour of the fibre attenuation and fibre strain as a function of the load on a cable or other elements during installation.

The test should be carried out in accordance with method E1 of [IEC 60794-1-21].

For cable, the amount of mechanical decoupling of the fibre and cable can be determined by measuring the fibre elongation with optical phase shift test equipment, together with cable elongation.

This method may be non-destructive if the tension applied represents the operational values.

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.3.2 Bending

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

The purpose of this test is to determine the ability of microduct cables to withstand bending around a pulley, as simulated by a test mandrel. The applicability to microduct fibre units should be as agreed between the manufacturer and the user.

This test should be carried out in accordance with method E11A or E11B of [IEC 60794-1-21].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.3.3 Crushing

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

This test should be carried out in accordance with method E3A of [IEC 60794-1-21] (the plate/plate configuration).

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.3.4 Torsion

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

This test should be carried out in accordance with method E7 of [IEC 60794-1-21].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.3.5 Impact

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

This test should be carried out in accordance with method E4 of [IEC 60794-1-21].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.3.6 Kink

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

This test should be carried out in accordance with method E10 of [IEC 60794-1-21].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.3.7 Repeated bending

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

This test should be carried out in accordance with method E6 of [IEC 60794-1-21].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.3.8 Bending at low temperature

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

This test should be carried out in accordance with method E11A or E11B of [IEC 60794-1-21].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units and at the minimum installation temperature, as T_{A1}.

8.4 Test methods for environmental characteristics

This clause recommends appropriate tests and test methods for verifying the environmental characteristics of optical fibre cables.

8.4.1 Temperature cycling

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

Testing involves temperature cycling to determine the stability of the attenuation of a microduct element in the presence of ambient temperature changes, which may occur during storage, transportation, installation and operation.

This test should be carried out in accordance with method F1 of [IEC 60794-1-22].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.4.2 Ageing

This test method applies to microduct cables, microduct fibre units installed under all environmental conditions.

Testing involves extended high temperature exposure after temperature cycling to determine the stability of the attenuation of a cable after simulated ageing.

This test should be carried out in accordance with method F9 of [IEC 60794-1-22].

The test conditions should be identical to those of [IEC 60794-5-10] for microduct cables and [IEC 60794-5-20] for microduct fibre units.

8.4.3 Water penetration for microduct cables

This test method applies to microduct cables installed under all environmental conditions.

Testing involves exposure of a cable specimen to a water head at one end to evaluate the ability of the microduct cable to inhibit the longitudinal flow of water.

This test should be carried out in accordance with method F5B or F5C, as appropriate to the cable design, of [IEC 60794-1-22].

The test conditions should be identical to those of [IEC 60794-5-10].

8.4.4 Water immersion for microduct fibre units

This test method applies to microduct fibre units installed under all environmental conditions.

Testing involves soaking a microduct fibre unit specimen in water (or other fluid, as agreed) to evaluate the integrity of the fibre unit after such exposure.

This test should be carried out in accordance with [IEC 60793-1-53].

The test conditions should be identical to those of [IEC 60794-5-20].

8.4.5 UV exposure testing

These tests apply to any elements of this Recommendation installed so that they are exposed to ultraviolet (UV) radiation. Elements for indoor applications may be exposed to UV radiation from fluorescent lights. Elements for outdoor application may be exposed to UV radiation from sunlight. UV exposure can cause degradation of the outer surface and of the material characteristics of the exposed element.

Testing differs for indoor and outdoor exposure because of the different spectrums and intensity of UV radiation, and requires different test methods and attribute values. These differences are specifically addressed in the standard test method for cable UV resistance.

Testing should be carried out in accordance with method F14 of [IEC 60794-1-22].

The exposed outer material of the element should retain at least 80% of the elongation and tensile strength before exposure.

8.5 Test methods for fire safety

The user is advised that local fire codes are predominant in this subject area. [IEC/TR 62222] provides guidance and recommendations for the requirements and test methods for the fire performance of communication cables when installed in buildings. The recommendations relate to typical applications and installation practices, and an assessment of the fire hazards presented. Account is also taken of applicable legislation and regulation.

[IEC/TR 62222] references several IEC fire performance test methods and also other test methods that may be required by local or national legislation and regulation. The tests to be applied, and the requirements, should be agreed between the manufacturer and the user taking into account the fire hazard presented by the end use application in which the cable is intended to be used.

8.6 Test methods for installation performance

This clause recommends appropriate tests and test methods for verifying that a microduct cable and microduct fibre unit can be installed in a microduct in the manner intended. The microduct installation test should refer to methods E23 and E24 in [IEC 60794-1-21].

Appendix I

Chinese experience

(This appendix does not form an integral part of this Recommendation.)

I.1 Product types of microducts

Product types of microduct include outer protective ducts, microducts, microduct bundles, protected microducts, composite protected microduct/cable, etc.

Their main specifications are shown in Table I.1.

Table I.1 – Main specifications and arrangements of microduct

Duct type			Example of maximum capacity of sub-ducts or microcables	Layout purpose
Duct type	**Outer/inner diameter (mm)**	**Material**		
Underground telecommunication ducts	110/100	PVC PE	3 × 40/33 outer protective ducts, 4 × 34/28 outer protective ducts	Backbone conduit, or conduit from telecom central office.
	100/90	PVC PE	2 × 40/33 outer protective ducts, 3 × 34/28 or 32/26 outer protective ducts	Backbone conduit.
	75/65	PVC PE	2 × 32/26 outer protective ducts	Branching conduit to distribution point, or feeder conduit to a great number of users.
Outer protective ducts	63/54	HDPE	10 × 10/8 microducts, 20 × 7/5 microducts	Placed inside underground telecommunication ducts/ rainwater pipelines, or used directly.
	50/41	HDPE	7 × 10/8 microducts, 14 × 7/5 microducts	
	46/38	HDPE	6 × 10/8 microducts, 12 × 7/5 microducts	
	40/33	HDPE	5 × 10/8 microducts, 7 × 8/6 microducts, 10 × 7/5 microducts, 4 groups of 4/3 microduct bundles	
	34/28	HDPE	3 × 10/8 microducts, 7 × 7/5 microducts	
	32/28	HDPE	3 × 10/8 microducts, 7 × 7/5 microducts	
	32/26	HDPE	3 × 10/8 microducts, 6 × 7/5 microducts	

Table I.1 – Main specifications and arrangements of microduct

Duct type			Example of maximum capacity of sub-ducts or microcables	Layout purpose
Duct type	**Outer/inner diameter (mm)**	**Material**		
Microducts	20.0/16.0	HDPE		
	16.0/14	HDPE	Could accommodate the microduct cable, and the ratio of the cross-sectional area of the microduct cable to the inner aperture area of the microduct is generally not more than 60%.	Placed inside the outer protective ducts.
	14.0/10.0**	HDPE		
	12.0/10.0*	HDPE		
	10.0/8.0*	HDPE		
	8.0/6.0	HDPE		
	7.0/5.5*	HDPE	Could accommodate microduct cable or microduct fibre unit, and the ratio of the cross-sectional area of the microduct cable or microduct fibre unit to the inner aperture area of the microduct is generally not more than 60%.	
	5.0/3.5*	HDPE		
	4.0/3.0	LSZH		
	3.5/2.5	LSZH		
	3.0/2.1	LSZH		
Microduct bundles	Main types are 1, 2, 4, 7, 12, 19, 24 apertures.			Placed inside underground telecommunication ducts/ rainwater pipelines, or used directly.
NOTE 1 – The microducts noted with * are often used and ** are ducts with larger wall thickness. NOTE 2 – The choice of duct diameter should be based on the most commonly used specifications, reducing the size of duct, and improving the air-blowing performance. NOTE 3 – If necessary, the ratio of the cross-sectional area of the microduct cable to the inner aperture area of the microduct can be expanded to 70%. In this case, the blowing distance may decline.				

I.2 Microduct inner clearance verification

Test method: As shown in Figure I.1, fix the microduct on a plate to make it remain horizontal, and then put the experimental object into the sample to see if it could reach the other end of the microduct.

NOTE 1 – If the microduct is flat enough, the plate is not required.

Sample length: A short segment of the microduct is used, usually 2 m length.

NOTE 2 – If longer microduct is tested, refer to method E23 of [IEC 60794-1-21].

Test apparatus: a) An experimental object, either a small steel ball or a short segment of microduct cable or microduct fibre unit to be installed (for example, 100 mm long). The outer diameter of the experimental object should not be less than 85% of the nominal inner diameter of the microduct under test. b) A piece of flat plate; this helps to make the microduct remain flat.

Performance guidance: The experimental object should pass through the microduct.

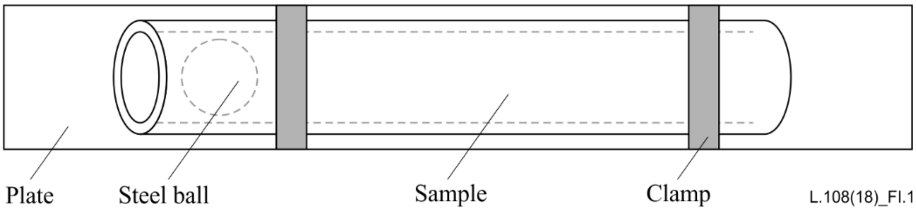

Figure I.1 – Test set-up for microduct inner clearance verification

I.3 Blowing performance test for microcables or fibre units in microduct

I.3.1 Method A: Blowing test through microduct on drum

Test method: as shown in Figure I.2.

Sample length: not less than 500 m.

Microduct drum diameter: to be 1000 mm for microcables; to be 500 mm for fibre units.

Microduct diameter when sample is a microcable: To be determined according to the ratio of the cross-sectional area of the microcable to the inner aperture aera of the microduct. Generally, 45% to 65% are specified as reasonable ratios. (Lower limit is possible)

Microduct diameter when sample is fibre unit: to be determined according to the dimension of the fibre unit and the maximum blowing force that it can support. Generally, the reasonable microduct diameter range is from 2.5 mm to 6.0 mm.

Blowing pressure: generally, 15 bar max. for microduct cables and 10 bar max. for microduct fibre units. Lower pressure may be agreed upon between the customer and supplier.

Relative humidity of air in microduct: 40% to 60%.

Number of tests: 3 times.

Performance guidance: In order to evaluate the blowing performance of blowing products, in the test process the installation length, installation speed and blowing pressure should be recorded corresponding to installation time. Generally speaking, as for microduct cables, the average installation speed should be not less than 25 m/min, installation length in 20 minutes should be not less than 500 m. As for fibre units, the average installation speed should be not less than 20 m/min, installation length in 25 minutes should be not less than 500 m.

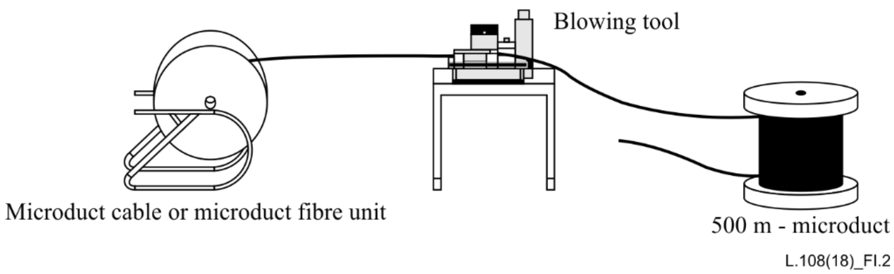

Figure I.2 – Test set-up for blowing performance on drum

I.3.2 Method B: Blowing test through microduct on field (simulated)

Test method: Besides method E24 of [IEC 60794-1-21], the microduct can be laid out according to one of a), b) and c) in Figure I.3. Sufficient access to both ends of the microduct should be provided. The microduct should then be positioned for the duration of the tests. Air should then be blown into the microduct through the blowing head for 20 minutes to condition the reference test route. Then the microduct cable or microduct fibre unit should be installed into the microduct at up to the maximum speed specified, until the microduct cable or microduct fibre unit is blown out of the other end of the microduct.

Sample length: not less than 1000 m for microduct cables; 500 m for microduct fibre units.

Microduct diameter when sample is a microduct cable: to be determined according to the ratio of the cross-sectional area of the microduct cable to the inner aperture area of the microduct. Generally, 45% to 65% are specified as reasonable ratios (lower limit is possible).

Microduct diameter when sample is a microduct fibre unit: To be determined according to the dimensions of the microduct fibre unit and the maximum blowing force that it can support. Generally, reasonable values for the microduct diameter are 2.5 mm to 6.0 mm.

Blowing pressure: Generally, 15 bar max. for microduct cables and 10 bar max. for fibre units. Lower pressure may be agreed upon between the user and supplier.

Relative humidity of air in microduct: 40% to 60% (only relevant for microduct fibre units).

Number of tests: 3 times.

Performance guidance: In order to evaluate the blowing performance of blowing products, in the test process the installation length, installation speed and blowing pressure should be recorded corresponding to installation time. Generally speaking, for microduct cables, the average installation speed should be not less than 35 m/min, installation length in 30 minutes should be not less than 1000 m. For microduct fibre units, the average installation speed should be not less than 25 m/min, installation length in 20 minutes should be not less than 500 m.

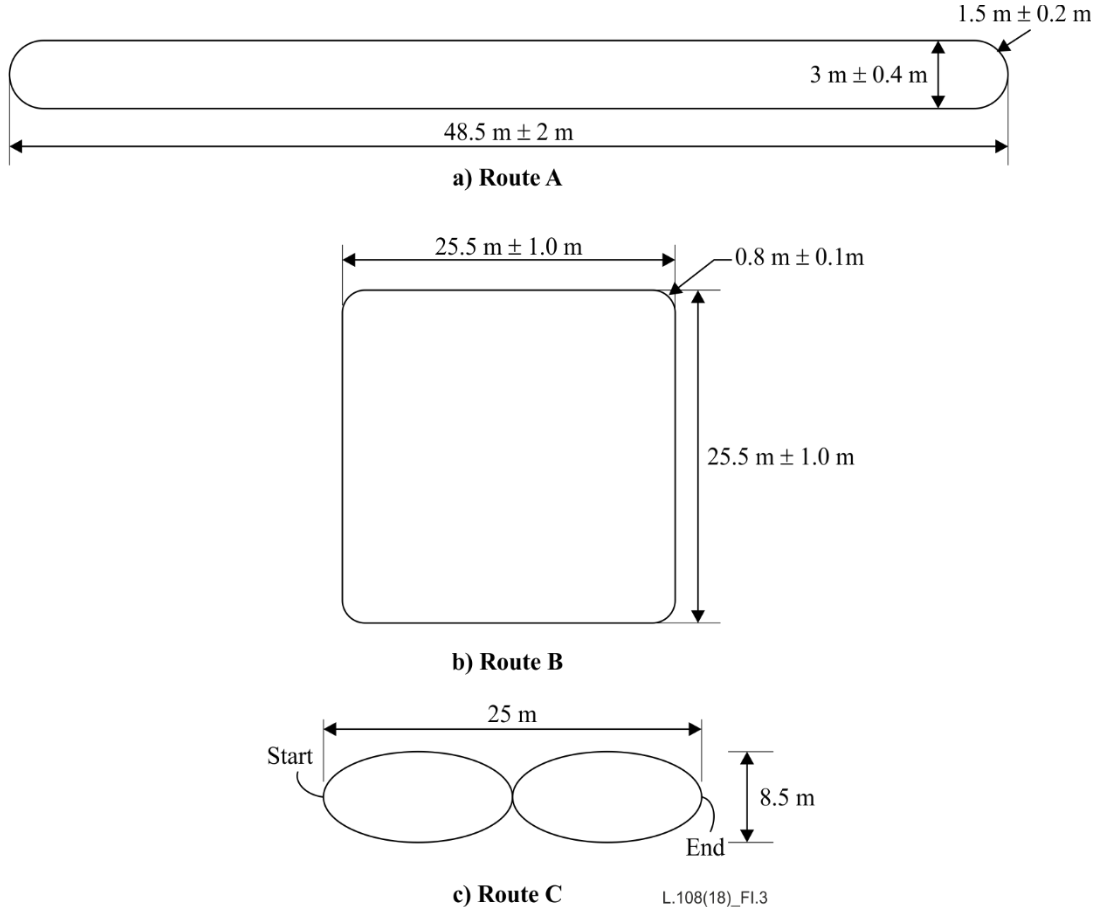

Figure I.3 – Test set-up for blowing performance in the field (simulated)

I.4 Layout location selection for microduct

The best layout location should be selected according to Table I.2, taking local conditions into account.

Table I.2 – The priority of layout location selection for microduct

Sequence number	Layout region	Layout location for microduct
1	Super highway	1) Central reservation (median strip) 2) Road shoulder 3) Inside safety guardrail 4) Roadside ditch
2	Ordinary highway	1) Invariable highway: road shoulder, the belt between the roadside ditch and the edge of highway, the roadside ditch 2) Variable highway: within 200 m of the highway; avoiding the influence of inclines, changes in direction or width, etc.
3	City street	1) Footway footpath (sidewalk) 2) Slow lane 3) Fast lane
4	Other region	1) Suitable topography and consistent geology 2) Convenient access for blowing machines

Burying depth

The burying depth for protected microduct should be determined according to the characteristics of the soil and environment around layout regions. The main specifications are shown in Table I.3.

Table I.3 – Guidance on burying depth for protected microduct

Number	Characteristics of soil and layout regions	Burying depth (m)
1	Ordinary soil, hard soil	≥1.0
2	Half stone-like soil (for example stonebrash and efflorescent stone, etc.)	≥0.8
3	Full stone-like soil and quicksand	≥0.6
4	Suburb, village and small town	≥1.0
5	City street	≥0.8
6	Through railroad or highway from underside	≥1.0 (from roadbed)
7	Central reservation (median strip) and road shoulder of highway	≥0.7 (pavement) and ≥0.8 (road)
8	Groove, ditch and pond	≥1.0

Appendix II

Chinese experience on effects of freezing conditions on microduct air-blown cables

(This appendix does not form an integral part of this Recommendation.)

II.1 Introduction

With the development of fibre to the home (FTTH) network construction, microduct air-blown cables are more frequently used, even in some cold regions. In this case, the water permeated into the microduct will be frozen under such low temperatures. In order to study the effects of freezing conditions on the transmission performance of optical fibres, freezing tests to simulate the cold climate with the aid of temperature cycling chambers have been designed. During the tests, the attenuation change of the fibres is monitored and also the appearance of the cable is checked.

II.2 Freezing test

II.2.1 Test details

Microduct air-blown cable: stranded loose tube structure containing 96 G.652D fibres with an outer diameter of 6.1 mm.

Microduct: HDPE duct with OD/ID: 10/8 mm.

Cycles: 2.

II.2.2 Impact on fibre attenuation with water frozen in microducts

A 1.8 km long microduct air-blown cable and an 80 m long microduct are used.

First, soak the 80 m long microduct (with cable inside) in water for 24 hours to fill the duct completely with water. Seal the duct with end caps. Then take the cable as well as the duct out and put them into the temperature cycling chamber. Then record the attenuation of each fibre at room temperature (23°C).

Temperature cycling programme

1. Lower the temperature from 23°C to 3°C within 30 minutes and hold this temperature for 8 hours. Record the attenuation of each fibre.
2. Then lower the temperature to −40°C within 30 minutes and hold it until the water is completely frozen and the ice temperature is −10°C or lower (by using a temperature monitoring device).
3. Raise the temperature to −2°C and hold this temperature for 1 hour. Record the attenuation of each fibre.
4. Raise the temperature to 65°C. Maintain the temperature until the water reaches 15°C. Then, return the temperature to 23°C and hold the temperature until the water reaches 23°C±5°C. Record the attenuation of each fibre.

Results and analysis

1. During the test, attenuation changes of all fibres are really small. The largest attenuation values at −2°C are shown in Figure II.1, at 1310 nm and 1550 nm wavelengths respectively.

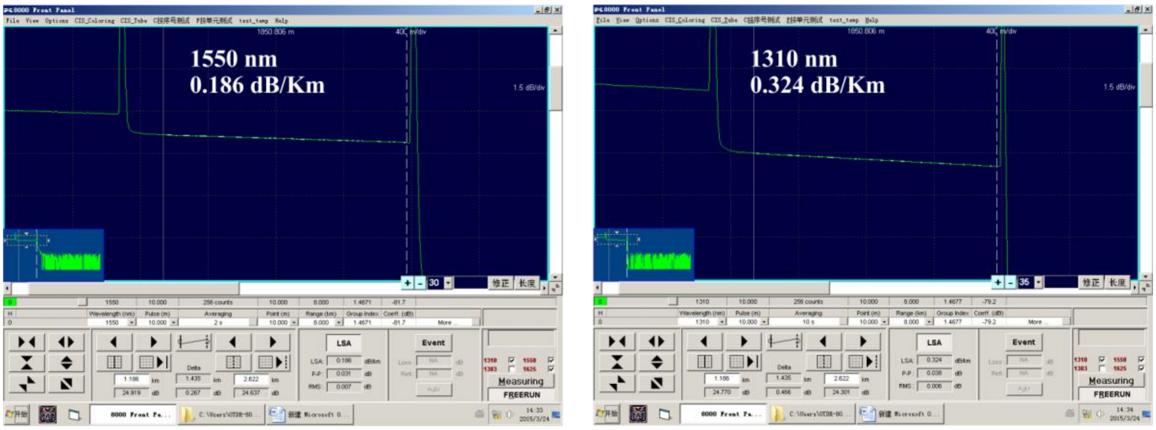

Figure II.1 – OTDR graphs of the fibre with largest attenuation values at −2°C

2. Considering the microduct is rarely full of water and the actual temperature change rate is much slower than that in the experiment, the impact of ice in microducts on air-blown cables can be regarded as insignificant.

Additional test (for extreme weather conditions)

When considering extreme cold weather conditions, the temperature cycling programme is changed and the above test repeated.

Temperature programme (for extreme weather conditions)

1. Lower the temperature from 23°C to −40°C within 30 minutes and hold this temperature for 12 hours. Perform attenuation measurement.
2. Raise the temperature to 65°C within 30 minutes and hold it for 12 hours. Perform attenuation measurement.
3. Return the temperature to 23°C within 30 minutes and hold this temperature for 12 hours. Perform attenuation measurement.

Results and analysis (for extreme weather conditions)

1. During the test, attenuation changes of all fibres are really small and the optical time domain reflectometer (OTDR) curves are very smooth. The test results at −40°C should be the worst. Therefore, the largest attenuation values at −40°C are displayed in Figure II.2, at 1310 nm and 1550 nm wavelengths respectively.

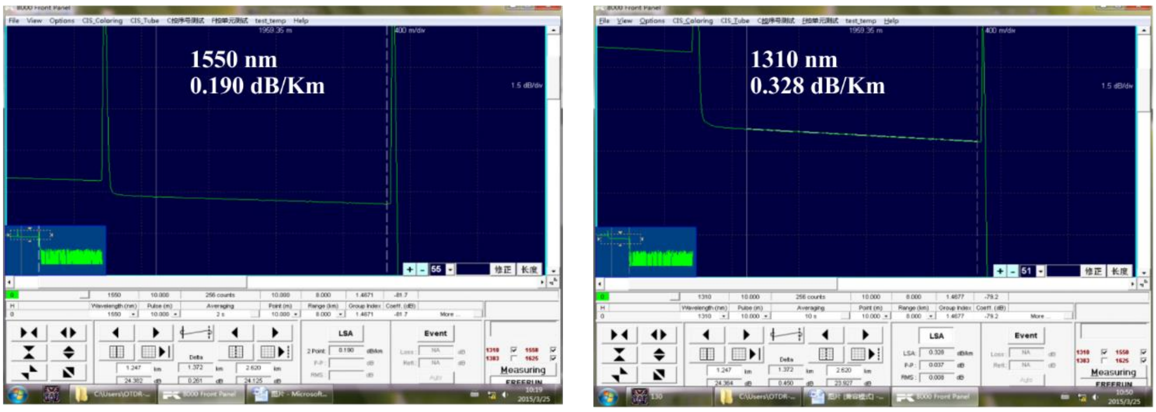

Figure II.2 – OTDR graphs of the fibre with largest attenuation values at −40°C

2. The largest fibre attenuation values in each loose tube at different temperature points during the above test and the additional test are shown in Figure II.3, at 1310 nm and 1550 nm wavelengths respectively. During this extreme weather condition test, attenuation changes of all fibres are really small.

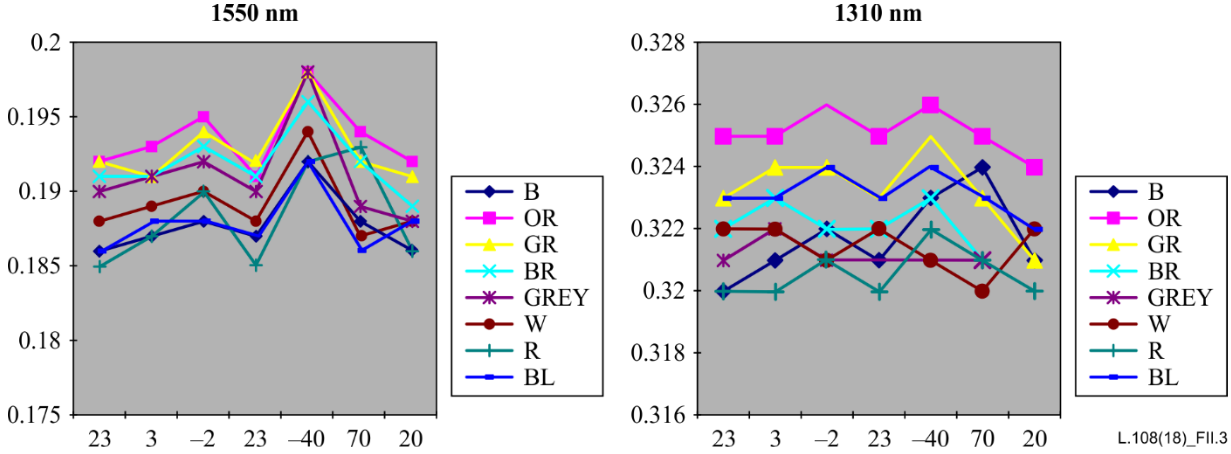

Figure II.3 – Largest attenuation values in each loose tube at different temperature points

3. Until all the above tests have been finished, the cable is blown out of the duct by compressed air. It shows that the blowing performance of the cable is still good and no visual damage to the cable sheath has been found.

II.2.3 Impact on fibre attenuation with water frozen around end caps

A 1.8 km long microduct air-blown cable and 6 m long microduct are used in this test. Move the microduct to the middle of the cable and record the distance from the test end to the microduct.

First, seal one end of the microduct with an end cap and fill water into the duct till it is full of water. Then seal the other end of the duct with another end cap and keep the two end caps at the same height.

Before the experiment, record the attenuation of each fibre. Then put the cable into the temperature cycling chamber and set the temperature programme as below:

1. Lower the temperature from 23°C to −40°C within 30 minutes and hold this temperature for 12 hours. Perform attenuation measurement.
2. Raise the temperature to 70°C within 30 minutes and hold it for 12 hours. Perform attenuation measurement.
3. Return temperature to 23°C within 30 minutes and hold this temperature for 12 hours. Perform attenuation measurement.

Results and analysis

1. Check the end caps at −40°C. Some ice can be found around them. Therefore, the situation where water freezes around end caps, as shown in Figure II.4, is successfully simulated.

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Figure II.4 – Water frozen around end caps

2. Note the positions where the end caps are located on the attenuation curve during measurement. The OTDR curves are very smooth.
3. During the test, attenuation changes of all fibres are really small and no visual damage to the cable sheath has been found.

II.3 Conclusion

When microduct air-blown cables are used in cold areas, the influence of freezing conditions on optical fibre transmission should be taken into consideration. In order to study this subject, two experiments are designed to evaluate this influence. Based on the test results, it can be concluded that the effects of frozen water on microduct air-blown cables are insignificant. However, the long-term effects during a cable's lifetime should be also considered. Thus, protective measures to avoid the penetration of water into microducts should not be ignored.

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