IEC 60794-1-22

Edition 2.0 2017-10
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Optical fibre cables –
Part 1-22: Generic specification – Basic optical cable test procedures – Environmental test methods

IEC 60794-1-22:2017-10 RLV(en)

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OPTICAL FIBRE CABLES –

Part 1-22: Generic specification – Basic optical cable test procedures – Environmental test methods

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60794-1-22 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 2012. It constitutes a technical revision.

This second edition includes the following significant technical changes with respect to the previous edition:

a) new test method designation F16 – Compound flow (drip) [E14 in IEC 60794-1-21];
b) new test method F17 – Cable shrinkage test (fibre protrusion);
c) new test method F18 – Mid-span temperature cycling test.

NOTE Missing numbers in the test methods sequence are intentional. They can suggest a deleted test method or a test method that was never published.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
86A/1813/FDIS	86A/1827/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60794 series, published under the general title *Optical fibre cables*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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OPTICAL FIBRE CABLES –

**Part 1-22: Generic specification –
Basic optical cable test procedures –
Environmental test methods**

1 Scope

~~This part of IEC 60794 applies to optical fibre cables for use with telecommunication equipment and devices employing similar techniques, and to cables having a combination of both optical fibres and electrical conductors.~~

This part of IEC 60794 defines test procedures to be used in establishing uniform requirements for the environmental performance of

- optical fibre cables for use with telecommunication equipment and devices employing similar techniques, and
- cables having a combination of both optical fibres and electrical conductors.

Throughout this document, the wording "optical cable" ~~may~~ can also include optical fibre units, microduct fibre units, etc.

See IEC 60794-1-2 for a reference guide to test methods of all types and for general requirements and definitions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

IEC 60544-1, *Electrical insulating materials – Determination of the effects of ionizing radiation – Part 1: Radiation interaction and dosimetry*

IEC 60793-1-40, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-46, *Optical fibres – Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance*

IEC 60793-1-54, *Optical fibres – Part 1-54: Measurement methods and test procedures – Gamma irradiation*

IEC 60794-1-1, *Optical fibre cables – Part 1-1: Generic specification – General*

~~IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*~~

~~IEC 60811-502, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 502: Mechanical tests – Shrinkage test for insulations*~~

IEC 60811-503, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 503: Mechanical tests – Shrinkage test for sheaths*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 4892-3, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Method F1 – Temperature cycling

4.1 Object

This measuring method applies to optical fibre cables, which are tested by temperature cycling in order to determine the stability behaviour of the attenuation of cables submitted to temperature changes. This method can also be used for evaluation of buffer tubes or other elements independent of a cable construction, as defined by a detail specification.

Changes in the attenuation of optical fibre cables, which ~~may~~ can occur with changing temperature, are generally the result of buckling or tensioning of the fibres resulting from differences between their thermal expansion coefficient and the coefficients of the cable strength and sheath members. Test conditions for temperature-dependent measurements shall simulate the worst conditions.

This test can be used either for monitoring cable behaviour in the temperature range, which ~~may~~ can occur during storage, transportation and usage, or to check, in a selected temperature range (usually wider than that required for the above-mentioned case), the stability behaviour of the attenuation connected to a substantially microbend-free situation of the fibre within the cable structure.

NOTE 1 Method F12 is a specialized subset of this method, specifically addressing cables for use in patch cords.

NOTE 2 The ageing test, F9, uses method F1 as its pre- and post-test temperature cycle. Often these tests are done together.

NOTE 3 The cable shrinkage test, F17, uses method F1 as temperature cycling. These tests can be done together.

4.2 Sample

The sample shall be a factory length or a sample of sufficient length as indicated in the detail specification but, nevertheless, of length appropriate to achieve the desired accuracy of attenuation measurements. The sample is additionally defined as the cable sample as deployed for testing.

In order to gain reproducible values, the cable sample shall be brought into the climatic chamber in a manner such that the deployment does not affect the measurement. Such methods could be a loose coil or on a reel with large diameter coils, cushioned reels with a soft layer or a zero tension facility device.

The ability of the fibre(s) to accommodate differential expansion and contraction (e.g. by slipping within the cable) could be influenced by the bending radius of the cable. Sample conditioning should, therefore, be realized as close as possible to normal usage conditions. The bend diameter of the cable sample shall not violate the minimum bend diameter of the cable, tube or other unit as specified by the detail specification.

Potential problems are due to an actual difference between the expansion coefficients of the test sample and of the holder (e.g. reel, basket, plate) which can induce, during thermal cycles, a significant effect on the test result if "no effect" conditions are not completely fulfilled. The intent is to simulate the installed condition, in which the cable is generally straight for the majority of its length.

Parameters of influence are mainly the details of conditioning, the type and materials of the holder, and the diameter of the sample coil or reel.

General recommendations include the following.

a) The winding diameter shall be large enough to keep the ability of the fibre to accommodate differential expansion and contraction. A winding diameter substantially greater than the value selected for cable delivery ~~may~~ can be necessary.

b) Any risk of cable expansion (or contraction) limitation created by conditioning shall be suppressed. In particular, special care should be taken to avoid residual tension on the cable during the test. For example, a tight winding on a drum is not recommended as it can limit cable contraction at low temperature. On the other hand, a tight multilayer winding can limit expansion at high temperature.

c) The use of loose winding is recommended with large diameter coils and cushioned reels with a soft layer or zero tension facility device.

d) The number of fibres tested shall conform to IEC 60794-1-1~~:2011, Annex B~~.

e) The fixed cable ends as well as connection to the equipment shall be outside of the temperature chamber to avoid negative influences.

When necessary, in order to limit the length of the cable under test, it is permissible to concatenate several fibres of the cable and to measure the concatenated fibres. The number of connections shall be limited and they should be located outside the climatic chamber.

4.3 Apparatus

The apparatus shall consist~~s~~ of the following.

a) An appropriate attenuation measuring apparatus for the determination of attenuation change (see the test methods of IEC 60793-1-40 and 60793-1-46).

b) a climatic chamber of a suitable size to accommodate the sample and whose temperature shall be controllable to remain within ±3 °C of the specified testing temperature. One example of a suitable chamber is given in Clause 8 of IEC 60068-2-14:2009~~: Test Nb: Change of temperature with specified rate of change~~.

c) A temperature sensing device to measure the temperature of the sample, when applicable. Samples with a large thermal mass ~~may~~ can require measurement to verify temperature stability rather than utilizing a specified exposure period, t_1 (see Table 1).

4.4 Procedure

4.4.1 Initial measurement

The sample shall be visually inspected and a basic value for attenuation at the initial temperature shall be determined.

4.4.2 Pre-conditioning

Pre-conditioning conditions shall be agreed between customer and supplier.

4.4.3 Conditioning

Figure 1 and Figure 2 show graphically the initial cycle(s) and the final cycle. Together, they illustrate the temperature cycle sequence to be used. If only one ~~cycle~~ high and low temperature is specified, use Figure 1; for cycles with multiple high and/or low temperature steps, use Figure 2.

NOTE The language of the conditioning procedure is written in reference to Figure 1, for clarity. If Figure 2, with multiple low and/or high temperatures, is used, the appropriate steps are repeated for each temperature. That is, steps (2) to (4) would be repeated for each additional low temperature and/or steps (5) to (7) would be repeated for each high temperature.

1) The sample at ambient temperature shall be introduced into the climatic chamber which is also at that temperature.
2) The temperature in the chamber shall then be lowered to the appropriate low temperature T_{A2} at ~~the appropriate~~ a rate of cooling not to exceed 60 °C per hour, unless otherwise specified.

   NOTE The initial cycles use the temperature extremes, T_{A2} and T_{B2}, regardless of whether the cycle Figure 1 or Figure 2 is being used.
3) After temperature stability in the chamber has been reached, the sample shall be exposed to the low temperature conditions for the appropriate period t_1 (see (4), below).
4) A minimum soak time is given in Table 1; however, the soak time, t_1, ~~must~~ shall be sufficient to bring the complete cable to equilibrium with the specified temperature.
5) The temperature in the chamber shall then be raised to the appropriate high temperature T_{B2} at ~~the appropriate~~ a rate of heating not to exceed 60 °C per hour, unless otherwise specified.
6) After temperature stability in the chamber has been reached, the sample shall be exposed to the high temperature conditions for the appropriate period t_1.
7) The temperature in the chamber shall then be lowered to the value of the ambient temperature at the appropriate rate of cooling. This procedure constitutes one cycle (see Figure 1 or Figure 2). If this is the intermediate step in a series of cycles, no soak is required, but no measurements shall be taken.
8) Continue to the next cycle, using steps 2) through 7). The sample shall be subjected to at least two cycles unless otherwise required by the relevant detail specification. The initial cycle(s) shall comprise one low temperature and one high temperature, as per Figure 1. The ~~last~~ final cycle shall comprise one ~~or more~~ low temperature~~s~~ and one ~~or more~~ high temperature~~s~~, as per Figure ~~2~~ 1, as required by the relevant detail specification. If multiple low or high temperature steps are required, the final cycle shall comprise two or more low temperatures and two or more high temperatures, as per Figure 2. On the last cycle, if multiple temperatures are specified, the sample shall be held at each intermediate temperature (T_{A1} or T_{B1}) for the appropriate time t_1. At the end of the cycling sequence, hold the sample at ambient temperature for the appropriate period t_1.
9) The attenuation shall be measured at ambient temperature at the start of the first cycle, at the end of the soak time t_1 at each of the specified temperature steps (T_{A1}, T_{A2}, T_{B1}, T_{B2}) in the ~~last~~ final cycle, and at ambient temperature at the end of the ~~last~~ final cycle. If measurement at intermediate cycles is required by the detail specification, the measurements shall be performed in the same manner.

10) Before removal from the chamber, the sample under test shall have reached temperature stability at ambient temperature.

Table 1 – Minimum soak time t_1

Minimum soak times for a given sample mass	
Sample mass kg	**Minimum soak time, t_1** h
Under 0,35	0,5
0,36 to 0,7	1
0,8 to 1,5	2
1,6 to 15	4
16 to 100	8
101 to 250	12
251 to 500	14
Over 501	16
NOTE It is the responsibility of the tester to assure that the soak time is long enough to bring the cable to equilibrium with the specified temperature.	

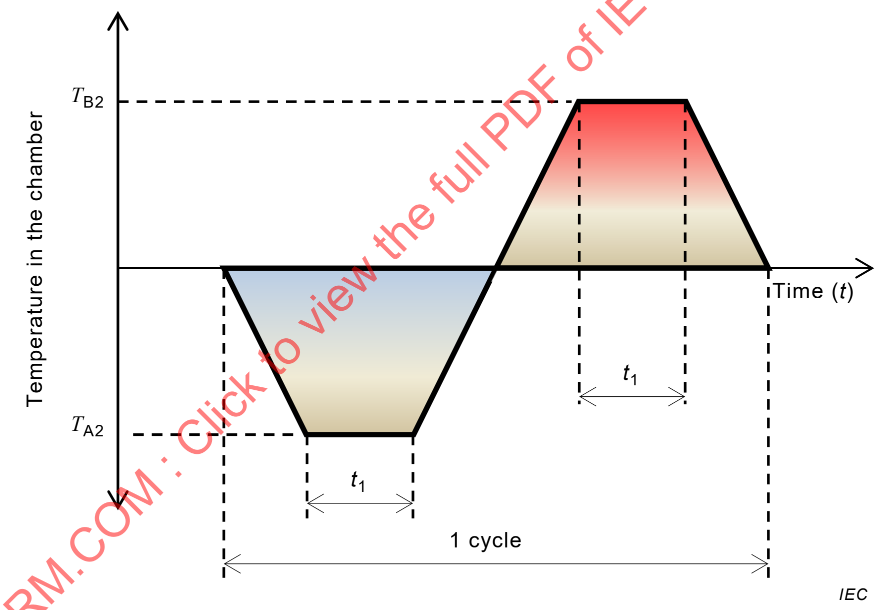


Figure 1 – ~~First~~ Initial cycle(s) procedure

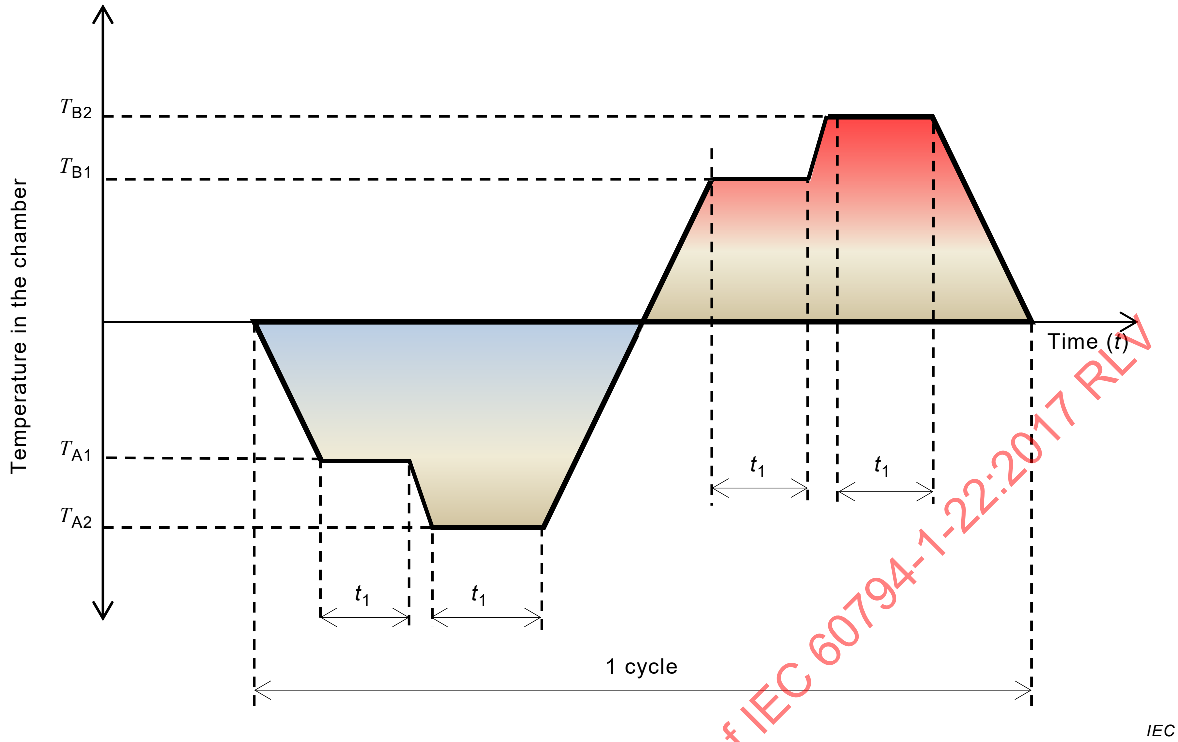


Figure 2 – ~~Last~~ Final cycle procedure

4.4.4 Recovery

If the ambient temperature is not the standard atmospheric condition to be used for testing after removal from the chamber, the sample shall be allowed to attain temperature stability at this latter condition.

The relevant detail specification ~~may~~ can call for a specific recovery period for a given type of sample.

4.5 Requirements

The acceptance criteria for the test shall be as stated in the detail specification. Typical failure modes include loss of optical continuity, degradation of optical transmittance or physical damage to the cable. Unless otherwise specified, the change in attenuation shall be calculated with respect to the attenuation value attained at ambient conditions prior to the start of the temperature cycling test (4.4.1).

4.6 Details to be specified

The detail specification shall include the following:

a) cable sample length;

b) number of fibres tested if different from 4.2;

c) length of the fibre under test ~~typically 1 km minimum, unless otherwise specified~~;

d) type of connection between concatenated fibres (~~if any~~ optional);

e) temperature limits:

   i) T_{A2} and T_{B2} (Figure 1), or

   ii) T_{A1}, T_{A2}, T_{B1} and T_{B2} (Figure 2);

f) number of cycles;

g) humidity levels at each temperature extreme (if ~~any~~ specified);

h) maximum change of attenuation (see 4.5) at a specified wavelength as a function of temperature cycling.

4.7 Details to be reported

Type of winding:

a) coil, reel, other (to be stated, in case of a cushioned reel, the type of cushioning and material used);
b) winding diameter;
c) single or multilayer;
d) winding tension and zero tension facility device (if any).

Soaking time, t_1, if different, as specified in Table 1.

~~4 Method F2 – Contamination (test deleted)~~

~~5 Method F3 – Sheath integrity (test deleted)~~

~~6 Method F4 – External static pressure (test deleted)~~

5 Method F5 – Water penetration

5.1 Object

This test applies to continuously water-blocked cables. The purpose is to determine the ability of a cable to block water migration along a specified length.

- F5A evaluates radial ingress of water due to sheath damage.
- F5B evaluates longitudinal ingress of water down the entire cable cross-section designed to be water-blocked, from an undefined water exposure at a cable end.
- F5C also evaluates longitudinal ingress of water from cable end and is applicable for cables with swellable water blocking material.

Compliance shall be checked on samples of cable using one of the three following methods (F5A, F5B or F5C), as stated in the detail specification. Method F5A tests for water migration between the outer interstices of the optical core and the outer sheath, whereas methods F5B and F5C test for water migration over the entire cross-section designed to be water-blocked. Method F5C includes a precondition step, a restricted-flow apparatus, or longer sample to simulate gradual water exposure at a location along the length of a cable or at a cable end.

~~NOTE~~ Multiple sheath designs, for example armoured cables, are not necessarily designed to be water blocked. If so, then remove the outer layers before application of the seals.

5.2 Sample

5.2.1 Method F5A

A circumferential portion of sheath and wrapping 25 mm wide shall be removed 3 m from one end of a sample length of cable and a watertight sleeve shall be applied over the exposed core so as to bridge the gap in the sheath and allow a 1 m height of water to be applied.

The opposite end of the sample shall be capped to block any water leakage in that direction.

The sample shall be long enough to include the test end length, the length of removed sheath, and length sufficient to cap the opposite end. Generally, 3,1 m should be sufficient.

5.2.2 Method F5B

A cable sample that shall not exceed 3 m is used.

A watertight seal shall be applied to one end of the sample to allow a 1 m height of water to be applied.

NOTE 1 If the armour in armoured cables is not designed to be water-blocked, the armour ~~may~~ can be removed at the end before the application of the seal.

NOTE 2 Water pressure ~~may~~ can force the fibre and filling compound out of the core tubes of filled cables. Such an occurrence would be a "test void" result. Therefore, the core ~~may~~ can require that the fibres be restrained at the exit end – as with a screen or cloth covering. Since the filled tubes exhibit robust water blocking ability, testing ~~may~~ can focus on the water penetration characteristics of the rest of the cable. In this case, it is ~~recommended~~ suggested that the core tube(s) be plugged at either end to avoid this problem.

5.2.3 Method F5C (for cables with swellable water blocking material)

A cable sample, which shall not exceed 3 m, is used for pre-soak or orifice procedure. Unless one of these procedures is selected, a longer cable sample, which shall not exceed 40 m, can be used.

A watertight seal shall be applied to one end of the sample to allow a 1 m height of water to be applied.

NOTE 1 If the armour in armoured cables is not designed to be water-blocked, the armour ~~may~~ can be removed at the end before the application of the seal.

NOTE 2 Water pressure ~~may~~ can force the fibre and water-blocking material out of the core tubes of filled cables. Such an occurrence would be a "test void" result. Therefore, the core ~~may~~ can require that the fibres be restrained at the exit end – as with a screen or cloth covering.

5.3 Apparatus

5.3.1 Test fixtures and set-up

Suitable test arrangements are shown in Figures 3 to 8: for method F5A – Figure 3; method F5B – Figure 4, and method F5C~~, respectively~~ – Figures 5 to 8. Unless otherwise specified in the detail specification, the sample shall be supported horizontally.

5.3.2 Water

Water shall be potable water, either common tap water or deionized or distilled water, at the option of the cable manufacturer.

A water soluble fluorescent dye or other suitable colouring agent may be used to aid in the detection of water seepage at the option of the cable manufacturer. Care should be taken in choosing a fluorescent dye that does not react with any of the cable components.

NOTE Fluorescent dyes inhibit the action of many swellable water blocking materials to some degree, which ~~may~~ can bias test results.

If required by the detail specification, water simulating sea water (or other) may be used for the test. Note that special design considerations and test limits should apply to cables designed for salt water or brackish water exposure.

5.3.3 Orifice (method F5C)

An orifice may be placed in the tube connecting the water source to the sample to limit the water flow rate.

The orifice, if used, shall be 1,50 mm ± 0,25 mm diameter, and a maximum length of 30 mm (see Figure 7).

5.4 Procedure

5.4.1 Method F5A and F5B

1 m height of water shall be applied for 24 h.

5.4.2 Method F5C

5.4.2.1 Pre-soak (alternative)

If the pre-soak procedure is used, one end of the sample shall be pre-soaked in a bucket of water to a depth of 100 mm ± 10 mm for 10 min. After the pre-soak and at the same end, a watertight seal shall be applied to allow a 1 m height of water to be applied.

After the pre-soak procedure, 1 m height of water shall be applied for 24 h.

5.4.2.2 Orifice (alternative)

The orifice, if used, may be placed in any part of the tube connecting the water head source to the sample.

1 m height of water shall be applied for 24 h ~~(see Figure 8)~~.

5.4.2.3 Longer sample (alternative)

1 m height of water shall be applied for 24 h.

5.5 Requirements

For methods F5A, F5B and F5C, no water shall be detected at the unsealed end of the sample. If a fluorescent dye is used, an ultraviolet light may be used for the examination.

NOTE The test procedure 5.4 is a basic compliance requirement. For process evaluation, test samples of shorter lengths ~~may~~ can be tested for a shorter time.

5.6 Details to be specified

The detail specification shall include the following:

a) method used – F5A, F5B, or F5C (see Figures 3 to 8);
b) any alternative test length, water head, water type, or test duration;
c) alternative test lengths, preconditioning or leakage requirements if salt water (or other) is to be used.

5.7 Details to be reported

~~Orifice if used:~~

- If method F5C is used, which alternative procedure was used – pre-soak, orifice, or longer length.
- Details of dye, if used.
- Test length, if different.
- Duration of test, if different.

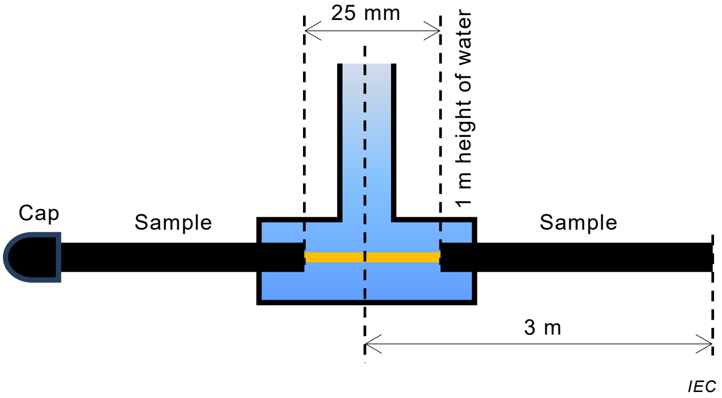


Figure 3 – Test arrangement for method F5A

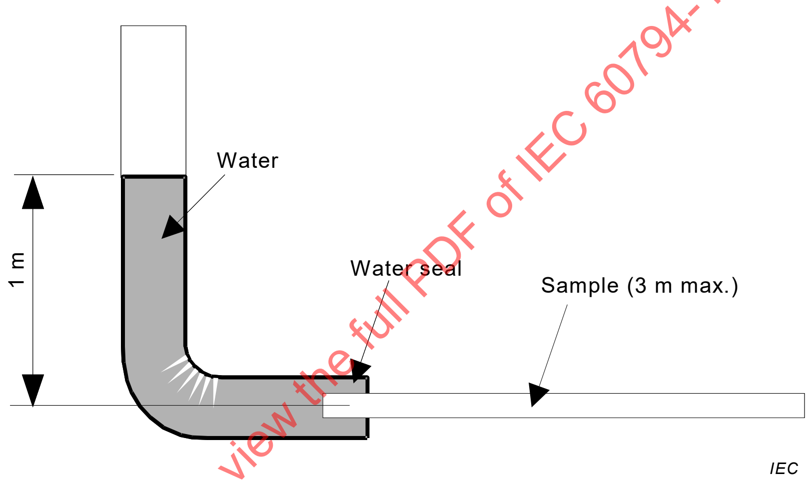


Figure 4 – Test arrangement for method F5B

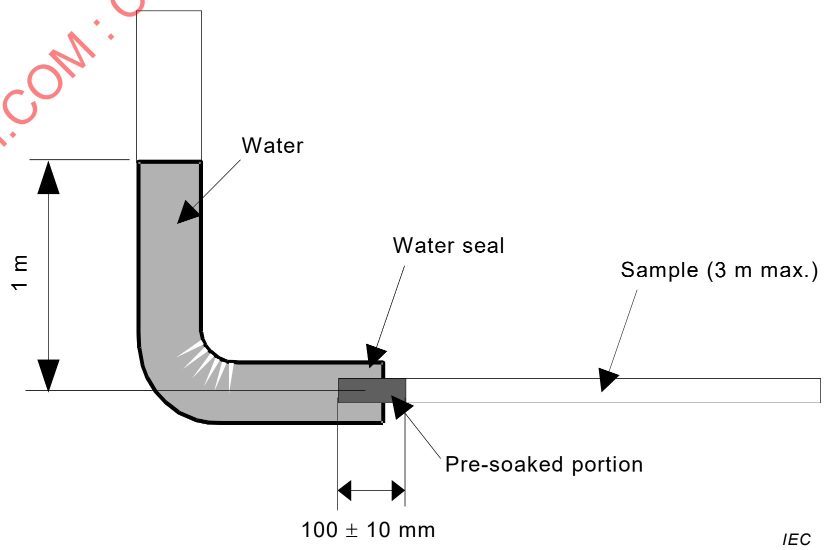


Figure 5 – Test arrangement for method F5C: pre-soaked sample

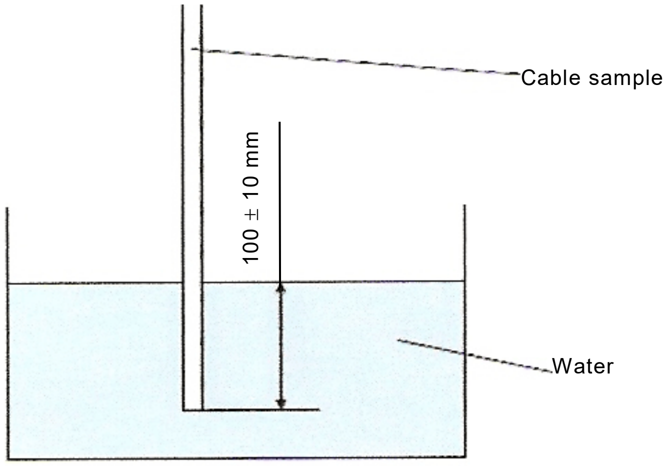


Figure 6 – Test arrangement for method F5C ~~Alternative~~: pre-soak procedure

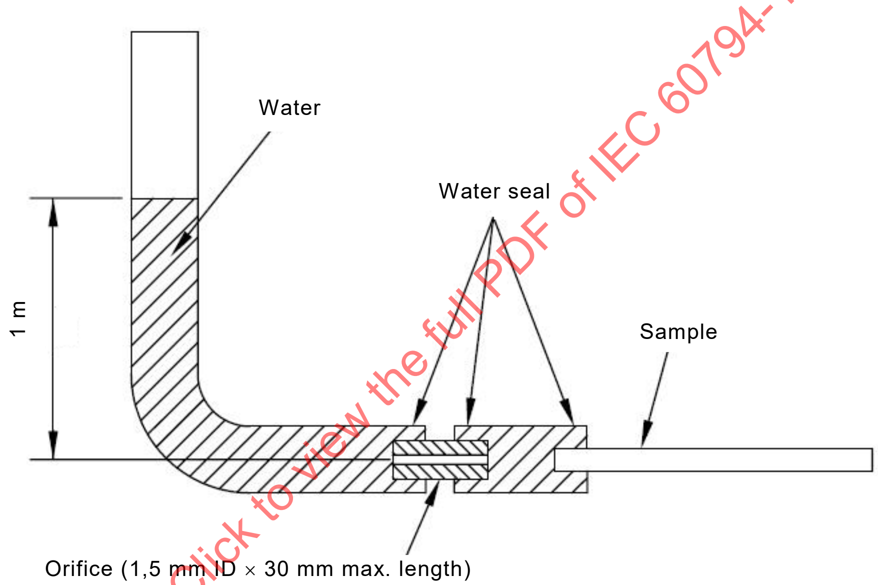


Figure 7 – Test arrangement for method F5C: orifice

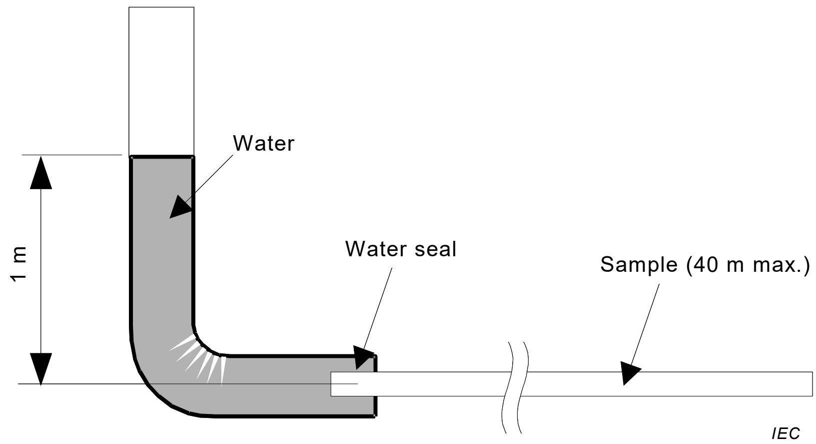


Figure 8 – Test arrangement for method F5C: longer sample

~~8 Method F6 – Unknown (test deleted)~~

6 Method F7 – Nuclear radiation

6.1 Object

Exposure of optical fibre cables to nuclear radiation can cause a change in the attenuation of the fibres and a change in the physical characteristics of the materials used in the cable construction. Typically, attenuation is more sensitive than change in the physical characteristics.

The attenuation of fibres and cabled ~~and uncabled~~ optical fibres generally increases when exposed to radiation, due mainly to the trapping of radiolytic electrons and holes at defect sites in the glass. Exposure of polymeric materials to radiation generally produces degradation in properties such as tensile strength, elongation at break and impact performance as the material becomes brittle (although some materials can show an initial improvement at relatively low levels of exposure due to crosslinking).

In special cases where the cable operational environment includes exposure to nuclear radiation, for example military applications and cables for use in certain areas in nuclear power stations and nuclear laboratories, fibres and materials with an appropriate radiation response can be chosen, and cable constructions incorporating metal sheaths or composite screens can be considered.

6.2 Sample

The sample shall be as defined in IEC 60793-1-54.

6.3 Apparatus

The apparatus description is given in IEC 60793-1-54.

6.4 Procedure

6.4.1 Fibres

For the radiation response of fibres, including cabled fibres, use the nuclear radiation method of IEC 60793-1-54.

6.4.2 Materials

For the radiation response of materials, ~~use~~ the methodology given in IEC 60544-1 shall be used.

6.5 Requirements

The nuclear radiation resistance shall comply with the maximum value given in the detail specification.

6.6 Details to be specified

Details to be specified are given in IEC ~~60794-1-54~~ 60793-1-54.

7 Method F8 – Pneumatic resistance

7.1 Object

This test applies only to unfilled cables which are protected by gas pressurization. The purpose is to measure the pneumatic resistance to gas flow of such cables.

~~NOTE~~ The pneumatic resistance of pressurized cables is required to assure adequate functioning of the gas pressurization process and systems. The results obtained using dry air ~~may~~ can be used to calculate the performance using other gases.

7.2 Sample

The sample of finished cable shall have a length sufficient to carry out the test specified.

7.3 Apparatus

The apparatus shall consist~~s~~ of the following:

a) pneumatic equipment to supply a regulated pressure of air to the sample;
b) a flow-meter;
c) a barometer;
d) a thermometer.

7.4 Procedure

The ambient temperature and barometric pressure shall be measured.

The length of finished cable shall have one end connected to a steady state ~~flow~~ source of dry air to be measured by the flow-meter, supplied by a pressure regulated source providing air with a dryness of 5 % RH or lower, at +20 °C. The other end of the cable shall be open to the atmosphere.

The pressure applied across the cable should be 62 kPa with a relative tolerance of ±2 %, and the steady state air flow shall be recorded using a flow-meter calibrated to ±10 %. Other pressures may be applied in accordance with particular user requirements and specified in the detail specification.

Only those air paths which access the interior of the sheath shall be used in the measurement.

A second measurement shall be made with the air flow direction reversed, and the results shall be recorded separately.

The pneumatic resistance is derived from the following formula:

$$R = \frac{3\,720}{f \times L} \quad \text{kPa} \times \text{s}/\left(\text{m}^3 \times \text{m}\right)$$

where

L is the sample length, in metres (m);

f is the flow, in cubic metres per second (m^3/s).

7.5 Requirement

The pneumatic resistance shall comply with the maximum value given in the detail specification.

7.6 Details to be specified

The detail specification shall include the following:

a) maximum pneumatic resistance;

b) sample length;

c) pressure, if different from 62 kPa.

8 Method F9 – Ageing

8.1 Object

This test method applies to optical fibre cables which are tested by high temperature exposure and temperature cycling in order to ~~determine~~ simulate life-time behaviour of the attenuation of cables, or physical attributes specified in the detail specification.

End of life performance is not predicted by this test. However, the data may be useful in modelling performance over the lifetime of the cable.

8.2 Sample

The sample shall be the same as for method F1: Temperature cycling. If this ageing method is used in series with method F1, and F1 is performed first, the same sample may be used for this ageing test.

8.3 Apparatus

The apparatus shall be as described in method F1.

8.4 Procedure

~~This test shall be carried out after the temperature cycling test described in Method F1.~~

~~The cable shall be exposed to +85 °C for 168 h. Other ageing conditions are allowed if agreed between customer and supplier. Optical measurements are not required during this phase.~~

Method F9 is frequently used as part of an overall procedure with method F1. If this is the case, method F9 shall be carried out after the temperature cycling test described in method F1. In this case, the initial attenuation value for F9 shall be that measured at the last ambient point per step 9) of F1. If method F9 is not used in conjunction with method F1, measure the attenuation at the ambient temperature.

The cable shall be exposed to the temperature and during the time specified in the detail specification. Optical measurements are not required during this phase.

After the ageing steps, perform a temperature cycling test according to method F1. Perform two cycles. At the end of the last cycle, the temperature shall be lowered to ~~+23 °C~~ ambient temperature, which shall be maintained for 24 h, and the attenuation shall be measured.

8.5 Requirement

~~At the final +23 °C temperature, attenuation measurements shall be performed.~~ Calculate the change in attenuation from the initial measurement (8.4). Unless otherwise agreed between customer and supplier, the maximum allowable attenuation increase shall be

a) for single-mode fibre, tested at 1 550 nm: 0,25 dB/km, maximum, and 0,10 dB/km, average, and

b) for multimode fibre, tested at 1 300 nm: 0,6 dB/km, maximum, and 0,4 dB/km, average.

After measuring attenuation, an appropriate section of the cable shall be dissected. Any elements of the cable which are colour coded (fibres, buffer tubes, sheath) shall be examined as per Annex A.

8.6 Details to be specified

The detail specification shall include the following:

a) the exposure temperature~~, if other than +85 °C~~;

b) the exposure time~~, if other than 168 h~~;

c) the maximum change in attenuation allowed, if other than as in 8.5;

d) any tests of physical attributes in addition to those of 8.5.

9 Method F10 – Underwater cable resistance to hydrostatic pressure

9.1 Object

The purpose of this test is to determine the ability of an underwater optical fibre cable to withstand hydrostatic pressure, by measuring the attenuation or by monitoring changes in optical transmission.

9.2 Sample

The sample shall be of a sufficient length to be terminated outside each end of the pressure tube vessel.

9.3 Apparatus

The test apparatus shall consist of the following:

a) appropriate attenuation measuring apparatus for determination of attenuation change (see test procedure of IEC 60793-1-40 or IEC 60793-1-46);

b) pressure tube vessel: the size of the pressure tube vessel shall be sufficient to accommodate the minimum length required by the detail specification.

9.4 Procedure

The test is to be carried out at ambient temperature. The pressure shall be maintained for 24 h or a period agreed between the user and the manufacturer.

The cable shall be installed in the pressure vessel. The water pressure in the pressure vessel during the test shall be 1,1 times higher than the water pressure at the seabed where the cable shall be installed.

The attenuation shall be measured before, during and after the test.

Special care should be taken for the tube end seals not to affect the results.

9.5 Requirements

Unless otherwise specified in the detail specification, there shall be no increase in attenuation during or after the test.

Other requirements may be agreed between the manufacturer and the user.

9.6 Details to be specified

The detail specification shall include the following information:

a) sample length;

b) pressure;

c) application period of pressure.

10 Method F11 – Sheath shrinkage (cables intended for patch cords)

10.1 Object

The purpose of this test is to measure the shrinkage behaviour of the sheath due to ageing of simplex and duplex optical fibre cables intended for use in patch cords.

~~13.2 General~~

This test method ~~is based on~~ IEC 60811-503 shall be used with modifications related to the sampling and measuring method.

10.2 Sample

A 2 m length of cable shall be removed from the supply reel and disposed of, before cutting the test sample lengths. Five test samples ~~each with a length of 1 050 mm ± 5 mm~~ of the length specified in the detail specification shall be cut from the cable.

- For test samples of a nominal 1 m length, cut 1 050 mm ± 5 mm.
- For test samples of a nominal length of 150 mm, cut 160 mm ± 5 mm.

10.3 Apparatus

A container (with typical dimensions 0,5 m × 0,5 m) into which the test sample is placed. The base of the container shall be covered with talc or paper to minimise frictional forces on the test sample and to permit free movement of the sheath.

A temperature chamber able to accommodate the test sample container and maintain the specified temperature within ±3 °C, as described in Clause 8 of IEC 60068-2-14:2009~~, Method Nb: Change of temperature~~.

A length measuring device with a minimum resolution of ~~0,5 mm~~ 0,1 %.

~~13.4 Conditioning~~

10.4 Procedure

The cable on the supply reel shall be conditioned for 24 h at ~~a room~~ ambient temperature of ~~+23 °C ± 5 °C~~ before cutting the test samples.

Two marks separated by ~~a distance of 1 000 mm~~ the distance of the nominal test length per the detail specification, ± 0,5 mm, shall be applied to each test sample. ~~The marks shall be located at approximately 25 mm from each end of the test sample.~~

The distance (L_1) between the ~~sheath~~ marks on each test sample shall be measured and recorded.

A test samples ~~coil is then~~ are placed approximately horizontally in the container. When space allows, the sample also can be placed into the chamber in a straight configuration. If the samples shall be coiled, the test samples shall be coiled with a radius of not less than 150 mm and in such a manner as to permit free movement of the sheath.

The temperature chamber shall be heated up to the specified temperature.

The container with horizontally positioned samples is then placed in the temperature chamber.

After the specified ~~heating~~ exposure time (~~typically 3 h~~ minimum 1 h, if not otherwise specified), the container with samples shall be removed from the chamber and allowed to cool to room temperature for a period of 1 h, if not otherwise specified.

A minimum of four such cycles shall be carried out.

After each cycle (preferably more than one sample has to be measured), the distance (L_2) between the ~~sheath~~ marks on each test sample shall be measured and recorded. If the samples have been coiled, straighten them for this measurement. If the coiled samples cannot be effectively straightened for measurement, the test is rendered invalid.

The sheath shrinkage of each test sample is calculated after each cycle as:

$$\Delta L_{x,i} = (L_1 - L_{2x,i})\ \text{mm} \qquad \cancel{, x = 1, 2, 3, 4, i = 1, 2, 3, 4, 5}$$

where

L_1 is the initial distance measured between the ~~sheath~~ marks;

$L_{2x,i}$ is the distance measured between the ~~sheath~~ marks ~~of sample no. i (i = 1 to 5) after the *x*th cycle~~;

i is the sample number (i = 1 to 5);

x is the cycle number (x = 1 to 4).

The average value $\Delta L_x = 1/5\ (\Delta L_{x,1} + \Delta L_{x,2} + \Delta L_{x,3} + \Delta L_{x,4} + \Delta L_{x,5})$ should be calculated after each temperature cycle.

Continue the test cycles until the shrinkage exhibits a variation less than ~~that specified in 12.7~~ ±1 mm.

10.5 Requirements

~~The final sheath shrinkage ΔL = 1/3 × ((ΔL)n-2 +(ΔL)n-1 +(ΔL)n) (n = 4, unless more cycles have to be carried out) after the last 3 T cycles should show only a variation of ± 0,5 mm. In case of ΔL varies more than ± 1 mm further T cycles should be performed until a stable value is reached.~~

~~ΔL~~ The sheath shrinkage shall not exceed the value given in the relevant detail specification.

10.6 Details to be specified

The detail specification shall include the following information:

a) details of temperature chamber and exposure high temperature;

b) duration of exposure to high temperature, if other than 1 h;

c) method of ~~sheath~~ marking and length measurement;

d) sample configuration and fixing in the container;

e) number of cycles.

10.7 Details to be reported

The test report shall include the following information:

a) individual shrink values of all samples ~~after every T cycle~~;

b) average sheath shrinkage;

c) any deviations from this test method.

11 Method F12 – Temperature cycling of cables ~~used for patch cords~~ to be terminated with connectors

11.1 Object

The purpose of this test is to examine the attenuation behaviour (change in attenuation) when optical fibre cables ~~for use in patch cords~~ that are terminated with connectors are subjected to temperature cycling.

NOTE Method F1 is a general temperature cycling test for cables.

11.2 Sample

The sample shall be taken from a finished cable length. The sample length ~~situated in the chamber~~ shall be as specified in the detail specification, typically 10 m.

11.3 Apparatus

The apparatus shall consist~~s~~ of the following:

a) a temperature chamber suitable to accommodate the sample and to maintain the specified temperature within +3 °C, as described in Clause 8 of IEC 60068-2-14:2009~~, Method Nb~~;

b) attenuation monitoring equipment according to IEC 60793-1-40 and IEC 60793-1-46.

11.4 Procedure

The sample shall be placed in the test chamber with a method of storage that shall not affect the optical fibre with respect to ~~extension~~ expansion or contraction. At both ends of the sample inside the chamber, all components of the cable shall be fixed together to avoid any relative movement between the cable elements at the fixing point. The fixing may be by means of clamps, or adhesive injection, or attachment with connectors, for example. Such fixing shall not affect the attenuation of the test sample. The optical fibre ends (outside the chamber) may be temporarily joint to ~~connectorised~~ pigtails. The deployment of the sample outside the chamber shall not affect the results.

Preconditioning procedures, if any, shall be performed as agreed between the customer and the supplier.

The temperature cycling shall be performed in accordance with method F1: Temperature cycling with the first cycle procedure as follows:

- the temperature of the chamber shall be decreased to the lower temperature ~~TA~~ T_{A1}/T_{A2} at an appropriate cooling rate;
- as soon as the temperature in the chamber has reached stable condition, the sample shall be exposed to the lower temperature during an appropriate time interval t_1;

- the temperature in the chamber is then increased to the specified high temperature ~~T_B~~ T_{B1}/T_{B2} at an appropriate heating rate;
- as soon as the temperature in the chamber has reached stable condition, the sample shall be exposed to the high temperature during an appropriate time interval t_1;
- the temperature in the chamber is then decreased to ambient temperature.

This procedure corresponds to one cycle. The cooling and heating rate ~~should be about 1°C/min~~ shall not exceed 60°C/h.

11.5 Requirements

The maximum increase in attenuation during and after the test shall be as shown in the relevant detail specification. As in method F1, the change in attenuation shall be calculated relative to the initial attenuation at ambient before the start of the test.

11.6 Details to be specified

The detail specification shall include:

a) method of sample storage in the temperature chamber;

b) preconditioning procedures;

c) method of fixing cable ends;

d) data of test equipment including method of measurement and launching conditions;

e) number of cycles;

f) values of ~~T_A, T_B~~ T_{A1}/T_{A2}, T_{B1}/T_{B2} and t_1.

12 Method F13 – Microduct pressure withstand

12.1 Object

The purpose of this test is to verify that the microduct is capable of withstanding the maximum internal pressure used for blowing the microduct cable or fibre unit.

~~15.2 General~~

This test ensures safe operation over a range of temperatures. The test pressure is chosen to be either the maximum working pressure of the microduct or a multiple of this as stated in the detail specification. The controlled area is a heating/cooling chamber in the event that the detail specification requires testing above or below ambient temperatures. Typical ranges are –20 °C to +60 °C. In general, polymer microducts will have a reduced tolerance to pressure as the temperature is increased.

12.2 Sample

Equal lengths L of microduct approximately 1 m long are cut from a production length. The ends shall be cut carefully, ensuring that they are not crushed. This will prevent air leaks from around the connectors. This test ~~must~~ shall be conducted in a controlled area so that there is no danger from flying fragments should the microduct fail.

The microduct samples shall be conditioned at the test temperature for a minimum of four hours before testing.

12.3 ~~Test equipment~~ Apparatus

The pressure source shall be agreed between customer and supplier. Typically, it is a compressor or gas bottle. Personal protective equipment (PPE) is recommended (goggles or full-face mask and gloves).

12.4 Procedure

One end of the microduct is inserted into the pressurizing device. A fully blocking end cap (usually metal) is fitted to the opposite end. The pressurizing device is activated and the pressure slowly increased to the specified level. The sample is left pressurised for 30 min (unless otherwise stated in the detail specification).

The sample is observed for leaks at all times; it ~~may~~ can be useful to place the microduct in a container of water to look for leaking air bubbles. After 30 min (unless otherwise stated in the detail specification), the air source is disconnected and the sample removed. PPE should be worn when entering the test area.

Ten samples shall be tested, unless otherwise stated in the detail specification.

12.5 Requirements

All samples shall withstand the applied pressure with no leakage during test and no visible damage after test.

12.6 Details to be specified

a) sample length: 1 m (unless otherwise specified);

b) test pressure: according to the detail specification;

c) duration: ~~according to the Detail Specification~~
30 minutes (unless otherwise specified);

d) number of samples: 10 (unless otherwise specified in the detail specification).

13 Method F14 – Cable UV resistance test

13.1 Object

This test evaluates the ability of cable sheath materials to maintain their integrity when exposed to ultraviolet (UV) radiation due to sunlight or fluorescent light, as applicable. This maintenance of integrity is evaluated by measuring the retention of tensile strength and elongation in the sheath of cable samples.

The test methods ~~to be utilized are addressed in~~ ISO 4892-2 and ISO 4892-3 shall be used.

The test of ISO 4892-2 is applicable to outdoor cables and other cables which have significant exposure to sunlight. The test of ISO 4892-3 is applicable to indoor cables which are exposed to fluorescent lighting.

13.2 Sample

Prepare samples and test specimens (six specimens and six as control specimens) as described in ISO 4892-2 or ISO 4892-3, as applicable.

13.3 Apparatus

The apparatus to be used is described in ISO 4892-2 or ISO 4892-3, as applicable.

In addition to the UV exposure apparatus, a tensile testing apparatus appropriate for testing the sheath specimens shall be used.

13.4 Procedure

13.4.1 General

Prior to conditioning, measure the control specimens for tensile strength at break and ultimate elongation in the tensile testing machine.

Condition the test specimens as described in 13.2, as applicable. ~~For method ISO 4892-2, applicable to outdoor cables, expose the test specimens for a minimum duration of 4 000 h.~~

After exposure, test the test specimens for tensile strength and elongation in the same manner as for the control specimens.

13.4.2 Conditioning for outdoor cables (weatherometer test)

Six test specimens shall be suspended vertically so that the external surface is uniformly exposed to the action of the actinic rays. During the test, the temperature indicated by the black-panel or the black-standard thermometer shall remain in the range +60 °C ± 3 °C and the relative humidity shall remain in the range 50 % ± 5 % (only in the dry period in the case of a test for outdoor application). The rotating drum carrying the test specimens shall turn at a speed of 1 r/min ± 0,1 r/min.

Test specimens are cycled through periods of UV exposure, followed by periods of no radiation during which temperature changes occur. The periods of each cycle, total time of 120 min, are the following: 102 min of dry UV exposure at a temperature of +60 °C ± 3 °C, followed by 18 min of rain exposure, without radiation, at a temperature of +50 °C ± 5 °C.

The overall duration of the test shall be 4 000 h (2 000 cycles), unless otherwise defined in the relevant product standard.

NOTE The MICE (mechanical, ingress, climatic, chemical and electromagnetic) table contains three classifications, ranging from 500 h to 6 000 h.

For coloured compounds, a black panel temperature of +60 °C ± 3 °C shall be used.

After the exposure, the exposed test specimens shall be removed from the equipment and conditioned at ambient temperature for at least 16 h.

The six other test specimens shall be kept at ambient temperature and protected from direct sunlight during the UV treatment and tested at the same time as the exposed test specimens.

13.4.3 Conditioning for indoor cables (QUV test)

Conditioning details for QUV test are to be determined. Refer to ISO 4892-3 for guidance. For method ISO 4892-3, applicable to indoor cables, expose the test specimens for a minimum duration of 720 h.

13.5 Requirements

After exposure, the average tensile and elongation of the test specimens shall be a minimum of 80 % of the original value.

13.6 Details to be specified

The detail specification shall include the following:

a) which method to use – ISO 4892-2 for outdoor cables or ISO 4892-3 for indoor cables;
b) any different exposure conditions or duration from those specified;

c) any compliance requirements different from those specified herein.

14 Method F15 – Cable external freezing test

14.1 Object

This test determines the ability of a cable to withstand the effects of freezing water (ice) that ~~may~~ can immediately surround the optical fibre cable sheath by observing any changes in the physical appearance of the sheath, or in the measured cable optical attenuation.

NOTE The external freezing test simulates freezing of the medium surrounding a buried cable, as in wet earth or water. It is not intended to simulate freezing of a cable in a duct or pipe. This external freezing test has little use for evaluating an outdoor cable, since such cables rarely fail the test. The aggregate of other requirements for outdoor cables results in a cable that is sufficiently robust to easily withstand this test. Evaluation of microcables in microducts using this test is under consideration. It ~~may~~ can be useful for evaluating cables not normally intended for outdoor installation. Users are encouraged to refer to national standards in effect in applicable regions.

14.2 Sample

A 50 m minimum length of cable shall be loosely coiled in the water to be frozen. Contact between the cable coil and the water tank wall shall be random. Additional length sufficient to make the required optical measurements and to connect the cable from the apparatus to the measuring equipment shall be provided.

14.3 Apparatus

The apparatus shall be a water tank suitable to contain the sample gauge length covered with water.

The water shall be common tap water.

~~NOTE~~ This procedure is written in view of the use of tap water. Other types of water, such as sea water or the like, shall be as specified by the detail specification. In these cases, the detail specification ~~may need to~~ can prescribe temperatures other than those specified herein.

The water tank shall be positioned in an apparatus suitable for freezing the water and maintaining it at the specified temperature ±3 °C. An environmental chamber is a common example. Optionally, a temperature monitoring device may be used to monitor the cable temperature. In this case, the device shall be in close proximity to the sample under test.

14.4 Procedure

1) Place the cable gauge length in the water tank, either as a coil or by coiling it into the tank. Cover the cable with water.
2) Perform initial attenuation measurements as indicated by the detail specification.
3) If the optional temperature monitoring device is used, the chamber temperature may be lowered so far as to –40 °C until the ice is completely frozen and the ice temperature is –10 °C or lower.
4) Raise the chamber temperature to –2 °C and hold this temperature for 1 h.

   NOTE This is the temperature at which pure water experiences its greatest volume expansion as ice.

5) Measure the attenuation as indicated by the detail specification.
6) If the optional temperature monitoring device is used, the chamber temperature may be raised so high as to +65 °C, in order to accelerate the ice melting. Maintain the high temperature until the water reaches +15 °C. Then, return the chamber temperature to +23 °C and hold this temperature until the water reaches +23 °C ± 5 °C.
7) Measure the attenuation as indicated by the detail specification.
8) Remove the cable from the water tank and examine the exterior of the gauge length for any physical damage.

14.5 Requirements

After exposure, there shall be no visible cracks or other openings in the cable sheath. ~~The attenuation increase, if specified, shall be:~~

~~– 0,15 dB for single-mode fibre at 1 550 nm,~~

~~– 0,30 dB for multimode fibre at 1 300 nm,~~

The maximum increase in attenuation during and after the test shall be as shown in the relevant detail specification, when frozen and no change after thawing.

14.6 Details to be specified

The detail specification shall include the following:

~~a) if attenuation measurement is required ;~~

a) change of attenuation

b) any deviations from the criteria specified herein.

15 Method F16 – Compound flow (drip)

15.1 Object

This test (E14 in IEC 60794-1-21) is intended to verify that filling and flooding compounds will not flow from a filled or flooded fibre optic cable, at stated temperatures.

15.2 Sample

a) Number and type of specimens

Unless otherwise specified in the detail specification, prepare two cable specimens for testing from each cable sample to be evaluated. Each cable specimen shall be representative of the cable type specified by the detail specification.

b) Specimen length

Unless otherwise specified in the detail specification, each specimen shall be 200 mm ± 5 mm in length.

c) Specimen preparation

Prepare each cable specimen as follows, making any modifications as required in item d).

1) Remove a 100 mm ± 2,5 mm section of the outer sheathing material from one end.

2) Remove all remaining non-intrinsic cable elements (e.g. armour, screens, inner sheaths, helically applied strength elements, water blocking tapes, other core wraps, etc.) for a length of 80 mm ± 2,5 mm from the same cable end. Do not disturb the remainder of the cable (e.g. the final buffer tubes which contain the optical fibres or fillers used for roundness).

3) Remove loosely adhered quantities of filling or flooding material disturbed in 1) or 2), but ensure that the specimen remains essentially coated by the filling or flooding material (i.e. do not wipe clean).

4) For cable designs containing components such as fibre bundles or ribbons which might move under their own weight during the test, secure such components at the unprepared end of the specimen in a manner which does not disturb the remainder of the specimen. Such components may be secured by clamps, epoxy plugs or other means meeting the objectives of the procedure.

5) When permitted by the detail specification, the upper ends of buffer tubes or loose tubes may be sealed to simulate long length cable sections.

d) Specimen termination

If allowed by the detail specification, terminate the lower end of the cable specimen according to the manufacturer's recommendations for terminating the cable in actual use. Parts of item c) procedure may be affected by this termination, but the objective of item c) is to be followed.

15.3 Apparatus

The following apparatus and equipment are required to perform this test.

a) Chamber

A temperature chamber large enough to hold the specimens in a vertical position, with sufficient thermal capacity to maintain the specified temperatures for the duration of the test. If the temperature chamber is of a circulating air type, the air shall not blow directly on the test specimens.

b) Container

A non-hygroscopic container to catch dripping material.

c) Analytical balance

15.4 Procedure

The following steps shall be taken.

a) Preheat the chamber to the temperature specified in the detail specification.
b) Place each prepared specimen in the oven, suspended in a vertical position with the prepared end down. Place a pre-weighed clean collection container directly under (but not contacting) the suspended specimen.
c) If permitted by the detail specification, preconditioning may be performed as defined in 1) to 3) below; otherwise, continue with d) below.
   1) Stabilize the chamber temperature and, unless otherwise specified in the detail specification, precondition each specimen for a period of 1 h.
   2) At the end of the specified preconditioning time, replace the collection container with another pre-weighed clean collection container. Weigh the preconditioning collection container to measure the quantity of filling or flooding compound which may have dripped out of the cable during the preconditioning. A measured quantity greater than the specified preconditioning limit shall constitute a failure. Unless otherwise specified in the detail specification, the preconditioning limit shall be 0,5 % of the total cable specimen weight or 0,5 g, whichever is the smaller;
   3) Continue testing for 23 h, unless otherwise specified in the detail specification, and continue with e).
d) Stabilize the chamber temperature and, unless otherwise specified in the detail specification, test for a period of 24 h.
e) At the end of the specified time, remove and weigh the collection container to calculate the quantity of filling or flooding compound which may have dripped out of the cable.
f) Record this as the quantity of dripped filling or flooding compound for each cable specimen. Unless otherwise specified in the detail specification, report "no flow" for measured quantity changes less than or equal to 0,005 g.

15.5 Requirements

Unless otherwise specified in the detail specification, the cable specimens shall be permitted a maximum flow quantity of 0,050 g. If the flow quantity from one of the cable specimens exceeds 0,050 g, but is less than 0,100 g, prepare two additional cable specimens in accordance with item c) of 15.2, and test as per items a) to f) of 15.4. The test shall be considered successful if neither of the second set of specimens has flow quantities which exceed 0,050 g.

15.6 Details to be specified

The detail specification shall include the following:

a) test temperature;
b) preconditioning details (if permitted):
   – statement that preconditioning is permitted (if permitted);
   – exceptions to default preconditioning procedure as defined in 15.4 c);
   – preconditioning pass/fail criteria if other than above.
c) any exceptions to be applied to the requirements of this procedure;
d) acceptance (pass/fail) criteria, if other than default.

16 Method F17 – Cable shrinkage test (fibre protrusion)

16.1 Object

The purpose of this test is to measure the fibre protrusion compared against the cable elements and cable sheath due to temperature changes.

Low shrinkage of cable elements and cable sheath is important in most cable installations. The effect of fibre protrusion may occur when cables are used in areas with large temperature changes. Cable designs with poor stabilization elements and high material shrinkage may cause excessive fibre protrusion that can lead to an attenuation increase, cable fixing and sealing weakening and in worst cases fibre breakage.

16.2 Sample

The test sample shall have a minimum length of 10 m.

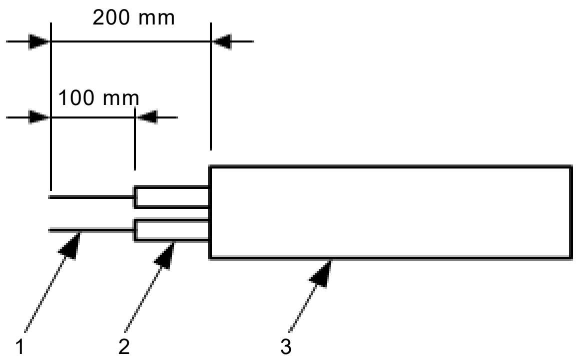
16.3 Apparatus

According to method F1.

16.4 Conditioning

The cable test sample shall be coiled in loose windings with a minimum diameter of 0,6 m, unless otherwise specified. The cable coils shall be loosely fixed at two opposite places in a way that the cable elements are free to move (expand and shrink). The coiled cable shall be put in the chamber.

The cable outer sheath shall be removed over a length of 200 mm from the cable end as shown in Figure 9. Also the strength members, inner sheath and other cable elements should be stripped closely to the end of the cable outer sheath. The secondary fibre protection or fibre tubes shall be removed over a length of 100 mm from the end of the cable outer sheath as shown in Figure 9, so that the fibres are bare over a length of 100 mm as shown in Figure 9. This preparation shall be done at both cable ends.



Key

1 fibre or bundle of fibres

2 secondary fibre protection or fibre tube

3 cable

Figure 9 – Preparation of the cable ends

The initial fibre protrusion shall be measured from the edge of the secondary fibre protection or fibre tube and from the edge of the cable sheath of all secondary fibre protection or fibre tubes at both ends (see Figure 10).

The prepared cable sample shall be temperature cycled in accordance to test method F1 and the following parameters:

– high temperature, T_{B1} and T_{B2}: high operation temperature as defined in the relevant detail specification

– low temperature, T_{A1} and T_{A2}: low operation temperature as defined in the relevant detail specification

– minimum soak time, t_1: according to method F1.

A minimum of four cycles shall be carried out.

After the last cycle, the cable sample shall recover for a minimum period of 1 h at ambient temperature, unless otherwise specified in the relevant detail specification.

The fibre protrusion shall be measured at both ends (see Figure 10).

The maximum change of fibre protrusion lengths are calculated as:

$$\Delta L1 = \max(L1_{ai} - L1_{bi})$$

$$\Delta L2 = \max(L2_{ai} - L2_{bi})$$

where

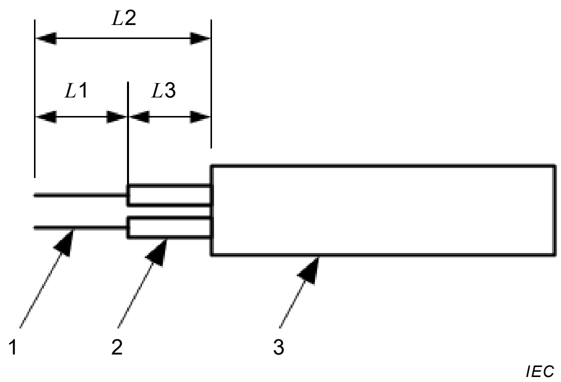
$L1_{ai}$ is the fibre protrusion length from the edge of the secondary fibre protection of fibre tube after temperature cycling of element number i;

$L1_{bi}$ is the fibre protrusion length from the edge of the secondary fibre protection of fibre tube before temperature cycling of element number i;

$L2_{ai}$ is the fibre protrusion length from the edge of the cable sheath after temperature cycling of element number i;

$L2_{bi}$ is the fibre protrusion length from the edge of the cable sheath before temperature cycling of element number i.

NOTE The measured values $L1$ and $L2$ give no information about which cable element expands or shrinks, because the reference point of the fibre end is not fixed.



Key

1 fibre or bundle of fibres

2 secondary fibre protection or fibre tube

3 cable

NOTE The protrusion of the secondary fibre protection or fibre tube is represented as length $L3$, that can be calculated as $L2$ minus $L1$.

Figure 10 – Fibre protrusion measurement

16.5 Requirements

The calculated maximum change of fibre protrusion lengths ($\Delta L1$ and $\Delta L2$) shall not exceed the values given in the relevant detail specification.

NOTE The change of protrusion of the secondary fibre protection or fibre tube is represented as length $\Delta L3$, that can be calculated as $\Delta L2$ minus $\Delta L1$.

16.6 Details to be specified

The detail specification shall include the following:

a) high and low exposure temperature;

b) permissible maximum change of fibre protrusion length.

16.7 Details to be reported

a) coiling diameter of cable;

b) soak time;

c) number of cycles;

d) recovery period;

e) maximum change of fibre protrusion of all secondary fibre protection or fibre tubes;

f) any deviations from this test method.

17 Method F18 – Mid-span temperature cycling test for exposed buffer tubes

17.1 Object

The mid-span temperature cycling test evaluates the environmental effects on unopened buffer tubes from a loose tube cable exposed in a mid-span entry (expressed) and stored in a pedestal, closure or similar. The test measures the change in attenuation caused by thermal contraction and expansion of the unopened tubes of a mid-span entry when exposed to temperature cycles in the stored configuration.

The method applies to loose tube type outdoor cables having fibre bundles in buffer tubes with diameters of 2,0 mm OD, or larger. The method may be used for other outdoor cables using criteria as agreed between manufacturer and customer.

The method uses a generic simulation assembly, but can also be used to evaluate the optical performance in a pedestal, closure, or any other device with mid-span access.

The temperature cycle as described in method F1 is used as the basis of this test.

17.2 Sample

The cable sample shall be long enough to enter and exit the climatic test chamber, supply the section of exposed buffer tube(s), and provide a coupling length of cable.

The length of exposed buffer tubes shall be as specified in the detail specification, reflecting the installation practise. There shall be at least 6 m of cable at each end of the exposed section to prevent the tubes and fibres from moving in or out of the sample during the test. At least one fibre of each type, if applicable, per loose tube shall be selected.

17.3 Apparatus

The generic apparatus, which may vary depending on cable design, is intended to test the cable in a representative manner independent of the influence of a particular closure or similar. A closure, pedestal, splice case or another device may be used as agreed between manufacturer and user.

The generic apparatus shall be configured to terminate the cable in a manner consistent with the installation practices. The exposed buffer tube(s) shall be stored in loops within a basket or other area of 75 mm to 300 mm width and 200 mm to 600 mm length. The specified minimum bend radii of the cable and the buffer tube(s) shall not be violated.

The climatic test chamber shall be in accordance with method F1.

17.4 Procedure

a) If available, follow the cable manufacturer`s instructions for cable preparation.

b) Open the cable to expose the buffer tube(s). Remove the cable sheaths and cut the strength members if present.

c) Strip/prepare the cable ends.

d) Install the cable with exposed buffer tubes on the generic assembly (e.g. basket per 16.3) or closure as specified and install both in the climatic chamber. If closures or similar are used, remove lids, domes or covers. The buffer tubes shall be loosely coiled. The tubes shall be straightened during coiling and not stay in the stranding form.

e) Measure the attenuation of the specified fibres.

f) Cycle the cable and assembly per method F1, with the following exceptions.

   i) The temperature range shall be per the detail specification. The default temperature range is –40 °C to +70 °C.

   ii) Use the following soak times: the time period t_1 for the first hot soak shall be 14 h; unless otherwise specified, the time periods t_1 for the other cycle steps shall be 3h.

   iii) Perform at least 2 cycles; the maximum number is not specified herein.

g) Measure the attenuation of the specified fibres at the low and high temperatures of the final cycle and and at the final ambient temperature, per method F1. Calculate the change in attenuation from the initial value, as in F1.

17.5 Requirements

Unless otherwise specified, the maximum change in attenuation for single-mode fibres measurements at 1 550 nm is given in the detailed specification.

The criteria for multimode fibres are under study.

17.6 Details to be specified

The detail specification shall specify the following:

- type of cable and number of tubes to be expressed.

The following shall be specified, if different from the default values above:

- length of cable with exposed tubes;
- sample length;
- deviation in the stored loop size;
- cycling temperature range;
- number of cycles;
- soak time(s).

If an actual closure, pedestal or similar is being tested, complete details of the apparatus and test criteria shall be specified as agreed between the customer and manufacturer.

Annex A
(normative)

Colour permanence

Colours used in optical fibre cables ~~are~~ shall be as those defined in IEC 60304. Other colours may be defined, as necessary, by subordinate or detail specifications.

A colour for fibres, tubes, sheaths or other components shall be discernible as the colour intended, as manufactured. All components for which colour is a significant attribute (e.g. fibre or tube colours necessary for identification) shall remain discernible as being the intended colour after any ageing tests. It is not intended that the colours will be identical before and after ageing.

Bibliography

IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Cross reference table for optical cable test procedures*

IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*

IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*

IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable elements tests methods*

IEC 60794-1-24, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical tests methods*

IEC 60794-1-22

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IEC 60794-1-22:2017-10(en-fr)

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OPTICAL FIBRE CABLES –

Part 1-22: Generic specification – Basic optical cable test procedures – Environmental test methods

FOREWORD

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International Standard IEC 60794-1-22 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This bilingual version (2018-04) corresponds to the monolingual English version, published in 2017-10.

This second edition cancels and replaces the first edition published in 2012. It constitutes a technical revision.

This second edition includes the following significant technical changes with respect to the previous edition:

a) new test method designation F16 – Compound flow (drip) [E14 in IEC 60794-1-21];
b) new test method F17 – Cable shrinkage test (fibre protrusion);

c) new test method F18 – Mid-span temperature cycling test.

NOTE Missing numbers in the test methods sequence are intentional. They can suggest a deleted test method or a test method that was never published.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
86A/1813/FDIS	86A/1827/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60794 series, published under the general title *Optical fibre cables*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC 60794-1-2:2003 has been split into five new documents:

- IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures – General guidance*
- IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*
- IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*
- IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable elements tests methods*
- IEC 60794-1-24, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical tests methods*

OPTICAL FIBRE CABLES –

**Part 1-22: Generic specification –
Basic optical cable test procedures –
Environmental test methods**

1 Scope

This part of IEC 60794 defines test procedures to be used in establishing uniform requirements for the environmental performance of

- optical fibre cables for use with telecommunication equipment and devices employing similar techniques, and
- cables having a combination of both optical fibres and electrical conductors.

Throughout this document, the wording "optical cable" can also include optical fibre units, microduct fibre units, etc.

See IEC 60794-1-2 for a reference guide to test methods of all types and for general requirements and definitions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60304, *Standard colours for insulation for low-frequency cables and wires*

IEC 60544-1, *Electrical insulating materials – Determination of the effects of ionizing radiation – Part 1: Radiation interaction and dosimetry*

IEC 60793-1-40, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-46, *Optical fibres – Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance*

IEC 60793-1-54, *Optical fibres – Part 1-54: Measurement methods and test procedures – Gamma irradiation*

IEC 60794-1-1, *Optical fibre cables – Part 1-1: Generic specification – General*

IEC 60811-503, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 503: Mechanical tests – Shrinkage test for sheaths*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 4892-3, *Plastics – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Method F1 – Temperature cycling

4.1 Object

This measuring method applies to optical fibre cables, which are tested by temperature cycling in order to determine the stability behaviour of the attenuation of cables submitted to temperature changes. This method can also be used for evaluation of buffer tubes or other elements independent of a cable construction, as defined by a detail specification.

Changes in the attenuation of optical fibre cables, which can occur with changing temperature, are generally the result of buckling or tensioning of the fibres resulting from differences between their thermal expansion coefficient and the coefficients of the cable strength and sheath members. Test conditions for temperature-dependent measurements shall simulate the worst conditions.

This test can be used either for monitoring cable behaviour in the temperature range, which can occur during storage, transportation and usage, or to check, in a selected temperature range (usually wider than that required for the above-mentioned case), the stability behaviour of the attenuation connected to a substantially microbend-free situation of the fibre within the cable structure.

NOTE 1 Method F12 is a specialized subset of this method, specifically addressing cables for use in patch cords.

NOTE 2 The ageing test, F9, uses method F1 as its pre- and post-test temperature cycle. Often these tests are done together.

NOTE 3 The cable shrinkage test, F17, uses method F1 as temperature cycling. These tests can be done together.

4.2 Sample

The sample shall be a factory length or a sample of sufficient length as indicated in the detail specification but, nevertheless, of length appropriate to achieve the desired accuracy of attenuation measurements. The sample is additionally defined as the cable sample as deployed for testing.

In order to gain reproducible values, the cable sample shall be brought into the climatic chamber in a manner such that the deployment does not affect the measurement. Such methods could be a loose coil or on a reel with large diameter coils, cushioned reels with a soft layer or a zero tension facility device.

The ability of the fibre(s) to accommodate differential expansion and contraction (e.g. by slipping within the cable) could be influenced by the bending radius of the cable. Sample conditioning should, therefore, be realized as close as possible to normal usage conditions. The bend diameter of the cable sample shall not violate the minimum bend diameter of the cable, tube or other unit as specified by the detail specification.

Potential problems are due to an actual difference between the expansion coefficients of the test sample and of the holder (e.g. reel, basket, plate) which can induce, during thermal cycles, a significant effect on the test result if "no effect" conditions are not completely fulfilled. The intent is to simulate the installed condition, in which the cable is generally straight for the majority of its length.

Parameters of influence are mainly the details of conditioning, the type and materials of the holder, and the diameter of the sample coil or reel.

General recommendations include the following.

a) The winding diameter shall be large enough to keep the ability of the fibre to accommodate differential expansion and contraction. A winding diameter substantially greater than the value selected for cable delivery can be necessary.
b) Any risk of cable expansion (or contraction) limitation created by conditioning shall be suppressed. In particular, special care should be taken to avoid residual tension on the cable during the test. For example, a tight winding on a drum is not recommended as it can limit cable contraction at low temperature. On the other hand, a tight multilayer winding can limit expansion at high temperature.
c) The use of loose winding is recommended with large diameter coils and cushioned reels with a soft layer or zero tension facility device.
d) The number of fibres tested shall conform to IEC 60794-1-1.
e) The fixed cable ends as well as connection to the equipment shall be outside of the temperature chamber to avoid negative influences.

When necessary, in order to limit the length of the cable under test, it is permissible to concatenate several fibres of the cable and to measure the concatenated fibres. The number of connections shall be limited and they should be located outside the climatic chamber.

4.3 Apparatus

The apparatus shall consist of the following.

a) An appropriate attenuation measuring apparatus for the determination of attenuation change (see the test methods of IEC 60793-1-40 and 60793-1-46).
b) a climatic chamber of a suitable size to accommodate the sample and whose temperature shall be controllable to remain within ±3 °C of the specified testing temperature. One example of a suitable chamber is given in Clause 8 of IEC 60068-2-14:2009.
c) A temperature sensing device to measure the temperature of the sample, when applicable. Samples with a large thermal mass can require measurement to verify temperature stability rather than utilizing a specified exposure period, t_1 (see Table 1).

4.4 Procedure

4.4.1 Initial measurement

The sample shall be visually inspected and a basic value for attenuation at the initial temperature shall be determined.

4.4.2 Pre-conditioning

Pre-conditioning conditions shall be agreed between customer and supplier.

4.4.3 Conditioning

Figure 1 and Figure 2 show graphically the initial cycle(s) and the final cycle. Together, they illustrate the temperature cycle sequence to be used. If only one high and low temperature is specified, use Figure 1; for cycles with multiple high and/or low temperature steps, use Figure 2.

NOTE The language of the conditioning procedure is written in reference to Figure 1, for clarity. If Figure 2, with multiple low and/or high temperatures, is used, the appropriate steps are repeated for each temperature. That is, steps (2) to (4) would be repeated for each additional low temperature and/or steps (5) to (7) would be repeated for each high temperature.

1) The sample at ambient temperature shall be introduced into the climatic chamber which is also at that temperature.
2) The temperature in the chamber shall then be lowered to the appropriate low temperature T_{A2} at a rate of cooling not to exceed 60 °C per hour, unless otherwise specified.

   NOTE The initial cycles use the temperature extremes, T_{A2} and T_{B2}, regardless of whether the cycle Figure 1 or Figure 2 is being used.
3) After temperature stability in the chamber has been reached, the sample shall be exposed to the low temperature conditions for the appropriate period t_1 (see (4), below).
4) A minimum soak time is given in Table 1; however, the soak time, t_1, shall be sufficient to bring the complete cable to equilibrium with the specified temperature.
5) The temperature in the chamber shall then be raised to the appropriate high temperature T_{B2} at a rate of heating not to exceed 60 °C per hour, unless otherwise specified.
6) After temperature stability in the chamber has been reached, the sample shall be exposed to the high temperature conditions for the appropriate period t_1.
7) The temperature in the chamber shall then be lowered to the value of the ambient temperature at the appropriate rate of cooling. This procedure constitutes one cycle (see Figure 1 or Figure 2). If this is the intermediate step in a series of cycles, no soak is required, but no measurements shall be taken.
8) Continue to the next cycle, using steps 2) through 7). The sample shall be subjected to at least two cycles unless otherwise required by the relevant detail specification. The initial cycle(s) shall comprise one low temperature and one high temperature, as per Figure 1. The final cycle shall comprise one low temperature and one high temperature, as per Figure 1, as required by the relevant detail specification. If multiple low or high temperature steps are required, the final cycle shall comprise two or more low temperatures and two or more high temperatures, as per Figure 2. On the last cycle, if multiple temperatures are specified, the sample shall be held at each intermediate temperature (T_{A1} or T_{B1}) for the appropriate time t_1. At the end of the cycling sequence, hold the sample at ambient temperature for the appropriate period t_1.
9) The attenuation shall be measured at ambient temperature at the start of the first cycle, at the end of the soak time t_1 at each of the specified temperature steps (T_{A1}, T_{A2}, T_{B1}, T_{B2}) in the final cycle, and at ambient temperature at the end of the final cycle. If measurement at intermediate cycles is required by the detail specification, the measurements shall be performed in the same manner.
10) Before removal from the chamber, the sample under test shall have reached temperature stability at ambient temperature.

Table 1 – Minimum soak time t_1

Minimum soak times for a given sample mass	
Sample mass kg	**Minimum soak time, t_1** h
Under 0,35	0,5
0,36 to 0,7	1
0,8 to 1,5	2
1,6 to 15	4
16 to 100	8
101 to 250	12
251 to 500	14
Over 501	16
NOTE It is the responsibility of the tester to assure that the soak time is long enough to bring the cable to equilibrium with the specified temperature.	

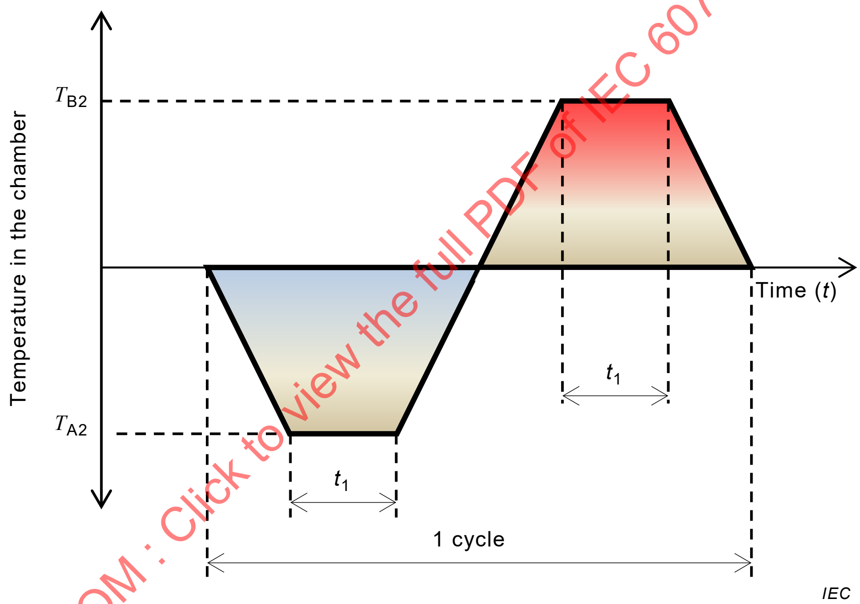


Figure 1 – Initial cycle(s) procedure

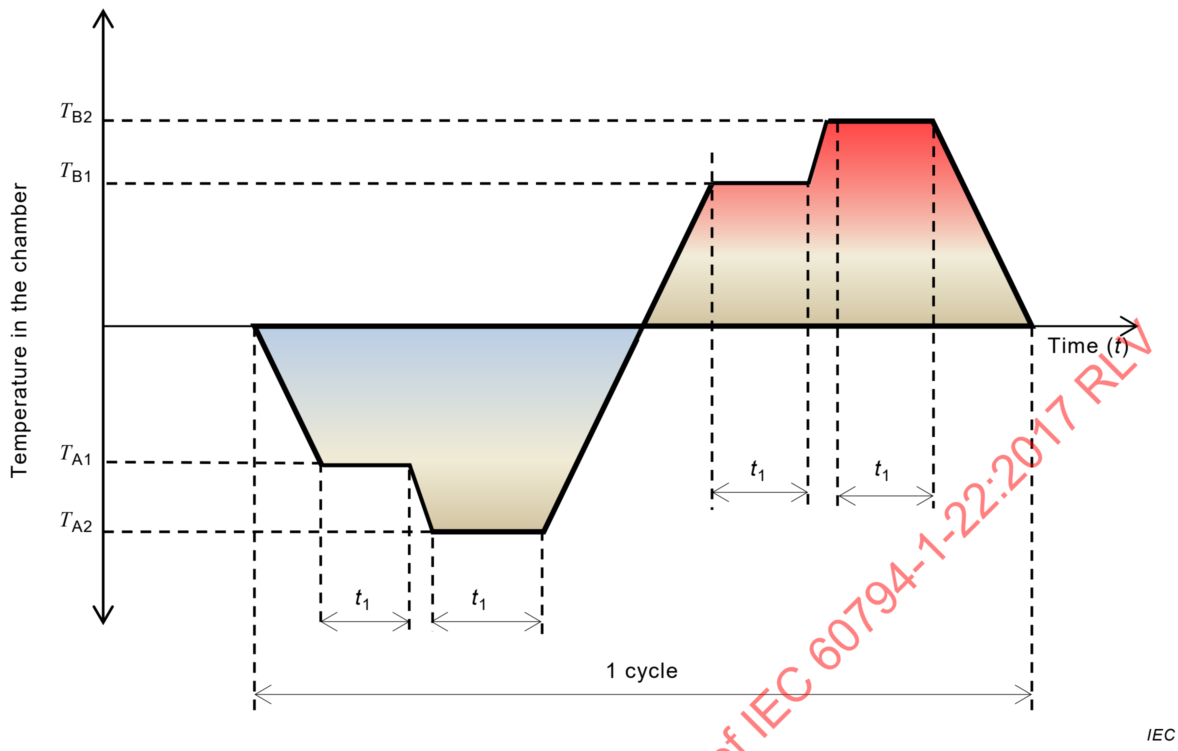


Figure 2 – Final cycle procedure

4.4.4 Recovery

If the ambient temperature is not the standard atmospheric condition to be used for testing after removal from the chamber, the sample shall be allowed to attain temperature stability at this latter condition.

The relevant detail specification can call for a specific recovery period for a given type of sample.

4.5 Requirements

The acceptance criteria for the test shall be as stated in the detail specification. Typical failure modes include loss of optical continuity, degradation of optical transmittance or physical damage to the cable. Unless otherwise specified, the change in attenuation shall be calculated with respect to the attenuation value attained at ambient conditions prior to the start of the temperature cycling test (4.4.1).

4.6 Details to be specified

The detail specification shall include the following:

a) cable sample length;

b) number of fibres tested if different from 4.2;

c) length of the fibre under test;

d) type of connection between concatenated fibres (optional);

e) temperature limits:

   i) T_{A2} and T_{B2} (Figure 1), or

   ii) T_{A1}, T_{A2}, T_{B1} and T_{B2} (Figure 2);

f) number of cycles;

g) humidity levels at each temperature extreme (if specified);

h) maximum change of attenuation (see 4.5) at a specified wavelength as a function of temperature cycling.

4.7 Details to be reported

Type of winding:

a) coil, reel, other (to be stated, in case of a cushioned reel, the type of cushioning and material used);
b) winding diameter;
c) single or multilayer;
d) winding tension and zero tension facility device (if any).

Soaking time, t_1, if different, as specified in Table 1.

5 Method F5 – Water penetration

5.1 Object

This test applies to continuously water-blocked cables. The purpose is to determine the ability of a cable to block water migration along a specified length.

- F5A evaluates radial ingress of water due to sheath damage.
- F5B evaluates longitudinal ingress of water down the entire cable cross-section designed to be water-blocked, from an undefined water exposure at a cable end.
- F5C also evaluates longitudinal ingress of water from cable end and is applicable for cables with swellable water blocking material.

Compliance shall be checked on samples of cable using one of the three following methods (F5A, F5B or F5C), as stated in the detail specification. Method F5A tests for water migration between the outer interstices of the optical core and the outer sheath, whereas methods F5B and F5C test for water migration over the entire cross-section designed to be water-blocked. Method F5C includes a precondition step, a restricted-flow apparatus, or longer sample to simulate gradual water exposure at a location along the length of a cable or at a cable end. Multiple sheath designs, for example armoured cables, are not necessarily designed to be water blocked. If so, then remove the outer layers before application of the seals.

5.2 Sample

5.2.1 Method F5A

A circumferential portion of sheath and wrapping 25 mm wide shall be removed 3 m from one end of a sample length of cable and a watertight sleeve shall be applied over the exposed core so as to bridge the gap in the sheath and allow a 1 m height of water to be applied.

The opposite end of the sample shall be capped to block any water leakage in that direction.

The sample shall be long enough to include the test end length, the length of removed sheath, and length sufficient to cap the opposite end. Generally, 3,1 m should be sufficient.

5.2.2 Method F5B

A cable sample that shall not exceed 3 m is used.

A watertight seal shall be applied to one end of the sample to allow a 1 m height of water to be applied.

NOTE 1 If the armour in armoured cables is not designed to be water-blocked, the armour can be removed at the end before the application of the seal.

NOTE 2 Water pressure can force the fibre and filling compound out of the core tubes of filled cables. Such an occurrence would be a "test void" result. Therefore, the core can require that the fibres be restrained at the exit end – as with a screen or cloth covering. Since the filled tubes exhibit robust water blocking ability, testing can focus on the water penetration characteristics of the rest of the cable. In this case, it is suggested that the core tube(s) be plugged at either end to avoid this problem.

5.2.3 Method F5C (for cables with swellable water blocking material)

A cable sample, which shall not exceed 3 m, is used for pre-soak or orifice procedure. Unless one of these procedures is selected, a longer cable sample, which shall not exceed 40 m, can be used.

A watertight seal shall be applied to one end of the sample to allow a 1 m height of water to be applied.

NOTE 1 If the armour in armoured cables is not designed to be water-blocked, the armour can be removed at the end before the application of the seal.

NOTE 2 Water pressure can force the fibre and water-blocking material out of the core tubes of filled cables. Such an occurrence would be a "test void" result. Therefore, the core can require that the fibres be restrained at the exit end – as with a screen or cloth covering.

5.3 Apparatus

5.3.1 Test fixtures and set-up

Suitable test arrangements are shown in Figures 3 to 8: for method F5A – Figure 3; method F5B – Figure 4, and method F5C – Figures 5 to 8. Unless otherwise specified in the detail specification, the sample shall be supported horizontally.

5.3.2 Water

Water shall be potable water, either common tap water or deionized or distilled water, at the option of the cable manufacturer.

A water soluble fluorescent dye or other suitable colouring agent may be used to aid in the detection of water seepage at the option of the cable manufacturer. Care should be taken in choosing a fluorescent dye that does not react with any of the cable components.

NOTE Fluorescent dyes inhibit the action of many swellable water blocking materials to some degree, which can bias test results.

If required by the detail specification, water simulating sea water (or other) may be used for the test. Note that special design considerations and test limits should apply to cables designed for salt water or brackish water exposure.

5.3.3 Orifice (method F5C)

An orifice may be placed in the tube connecting the water source to the sample to limit the water flow rate.

The orifice, if used, shall be 1,50 mm ± 0,25 mm diameter, and a maximum length of 30 mm (see Figure 7).

5.4 Procedure

5.4.1 Method F5A and F5B

1 m height of water shall be applied for 24 h.

5.4.2 Method F5C

5.4.2.1 Pre-soak (alternative)

If the pre-soak procedure is used, one end of the sample shall be pre-soaked in a bucket of water to a depth of 100 mm ± 10 mm for 10 min. After the pre-soak and at the same end, a watertight seal shall be applied to allow a 1 m height of water to be applied.

After the pre-soak procedure, 1 m height of water shall be applied for 24 h.

5.4.2.2 Orifice (alternative)

The orifice, if used, may be placed in any part of the tube connecting the water head source to the sample.

1 m height of water shall be applied for 24 h.

5.4.2.3 Longer sample (alternative)

1 m height of water shall be applied for 24 h.

5.5 Requirements

For methods F5A, F5B and F5C, no water shall be detected at the unsealed end of the sample. If a fluorescent dye is used, an ultraviolet light may be used for the examination.

NOTE The test procedure 5.4 is a basic compliance requirement. For process evaluation, test samples of shorter lengths can be tested for a shorter time.

5.6 Details to be specified

The detail specification shall include the following:

a) method used – F5A, F5B, or F5C (see Figures 3 to 8);

b) any alternative test length, water head, water type, or test duration;

c) alternative test lengths, preconditioning or leakage requirements if salt water (or other) is to be used.

5.7 Details to be reported

- If method F5C is used, which alternative procedure was used – pre-soak, orifice, or longer length.
- Details of dye, if used.
- Test length, if different.
- Duration of test, if different.

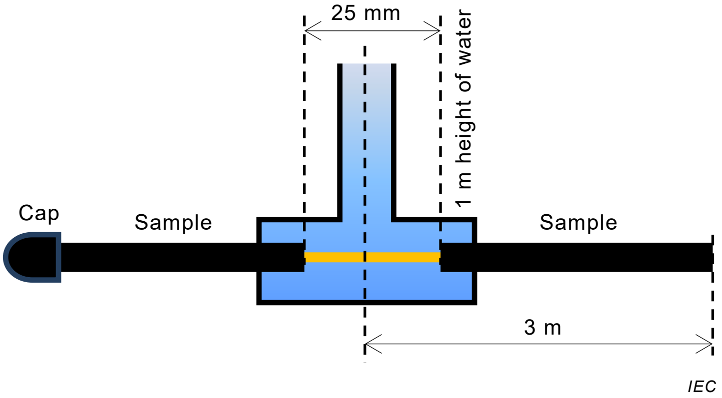


Figure 3 – Test arrangement for method F5A

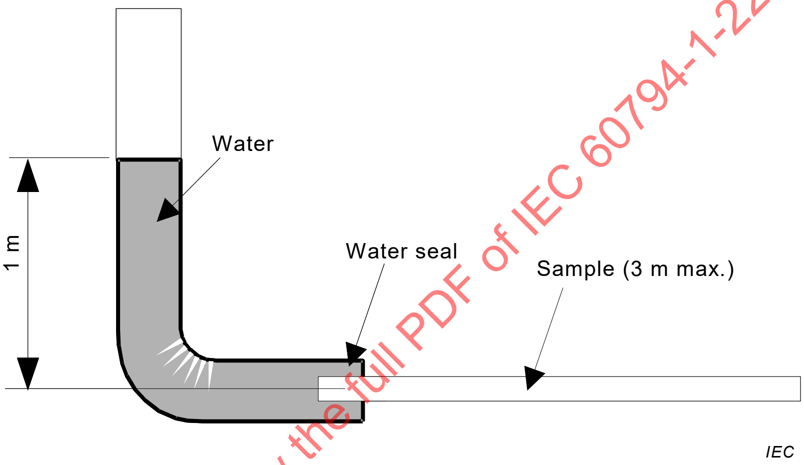


Figure 4 – Test arrangement for method F5B

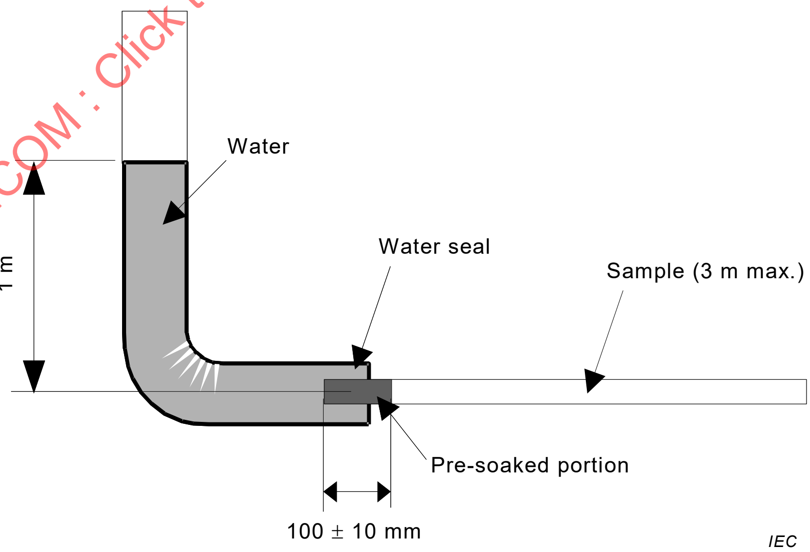


Figure 5 – Test arrangement for method F5C: pre-soaked sample

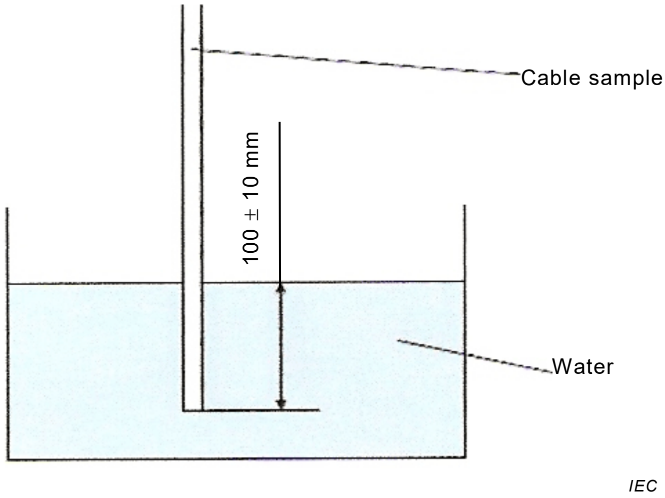


Figure 6 – Test arrangement for method F5C: pre-soak procedure

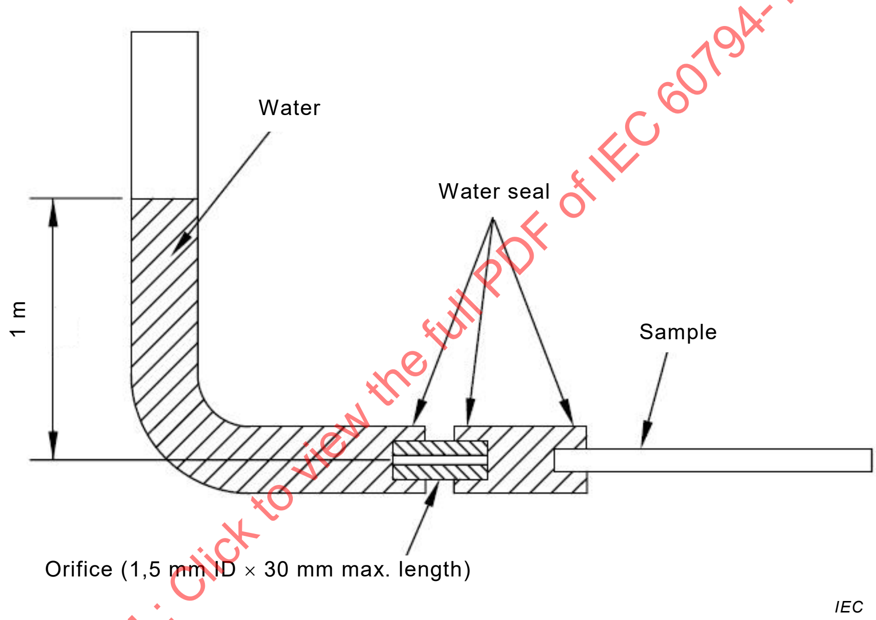


Figure 7 – Test arrangement for method F5C: orifice

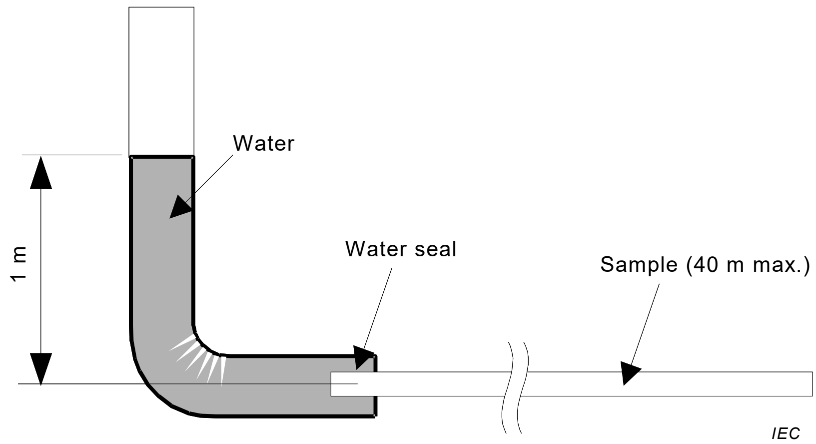


Figure 8 – Test arrangement for method F5C: longer sample

6 Method F7 – Nuclear radiation

6.1 Object

Exposure of optical fibre cables to nuclear radiation can cause a change in the attenuation of the fibres and a change in the physical characteristics of the materials used in the cable construction. Typically, attenuation is more sensitive than change in the physical characteristics.

The attenuation of fibres and cabled optical fibres generally increases when exposed to radiation, due mainly to the trapping of radiolytic electrons and holes at defect sites in the glass. Exposure of polymeric materials to radiation generally produces degradation in properties such as tensile strength, elongation at break and impact performance as the material becomes brittle (although some materials can show an initial improvement at relatively low levels of exposure due to crosslinking).

In special cases where the cable operational environment includes exposure to nuclear radiation, for example military applications and cables for use in certain areas in nuclear power stations and nuclear laboratories, fibres and materials with an appropriate radiation response can be chosen, and cable constructions incorporating metal sheaths or composite screens can be considered.

6.2 Sample

The sample shall be as defined in IEC 60793-1-54.

6.3 Apparatus

The apparatus description is given in IEC 60793-1-54.

6.4 Procedure

6.4.1 Fibres

For the radiation response of fibres, including cabled fibres, use the nuclear radiation method of IEC 60793-1-54.

6.4.2 Materials

For the radiation response of materials, the methodology given in IEC 60544-1 shall be used.

6.5 Requirements

The nuclear radiation resistance shall comply with the maximum value given in the detail specification.

6.6 Details to be specified

Details to be specified are given in IEC 60793-1-54.

7 Method F8 – Pneumatic resistance

7.1 Object

This test applies only to unfilled cables which are protected by gas pressurization. The purpose is to measure the pneumatic resistance to gas flow of such cables. The pneumatic resistance of pressurized cables is required to assure adequate functioning of the gas pressurization process and systems. The results obtained using dry air can be used to calculate the performance using other gases.

7.2 Sample

The sample of finished cable shall have a length sufficient to carry out the test specified.

7.3 Apparatus

The apparatus shall consist of the following:

a) pneumatic equipment to supply a regulated pressure of air to the sample;
b) a flow-meter;
c) a barometer;
d) a thermometer.

7.4 Procedure

The ambient temperature and barometric pressure shall be measured.

The length of finished cable shall have one end connected to a steady state source of dry air to be measured by the flow-meter, supplied by a pressure regulated source providing air with a dryness of 5 % RH or lower, at +20 °C. The other end of the cable shall be open to the atmosphere.

The pressure applied across the cable should be 62 kPa with a relative tolerance of ±2 %, and the steady state air flow shall be recorded using a flow-meter calibrated to ±10 %. Other pressures may be applied in accordance with particular user requirements and specified in the detail specification.

Only those air paths which access the interior of the sheath shall be used in the measurement.

A second measurement shall be made with the air flow direction reversed, and the results shall be recorded separately.

The pneumatic resistance is derived from the following formula:

$$R = \frac{3\,720}{f \times L} \quad \text{kPa} \times \text{s} / \left(\text{m}^3 \times \text{m}\right)$$

where

L is the sample length, in metres (m);

f is the flow, in cubic metres per second (m^3/s).

7.5 Requirement

The pneumatic resistance shall comply with the maximum value given in the detail specification.

7.6 Details to be specified

The detail specification shall include the following:

a) maximum pneumatic resistance;
b) sample length;
c) pressure, if different from 62 kPa.

8 Method F9 – Ageing

8.1 Object

This test method applies to optical fibre cables which are tested by high temperature exposure and temperature cycling in order to simulate life-time behaviour of the attenuation of cables, or physical attributes specified in the detail specification.

End of life performance is not predicted by this test. However, the data may be useful in modelling performance over the lifetime of the cable.

8.2 Sample

The sample shall be the same as for method F1: Temperature cycling. If this ageing method is used in series with method F1, and F1 is performed first, the same sample may be used for this ageing test.

8.3 Apparatus

The apparatus shall be as described in method F1.

8.4 Procedure

Method F9 is frequently used as part of an overall procedure with method F1. If this is the case, method F9 shall be carried out after the temperature cycling test described in method F1. In this case, the initial attenuation value for F9 shall be that measured at the last ambient point per step 9) of F1. If method F9 is not used in conjunction with method F1, measure the attenuation at the ambient temperature.

The cable shall be exposed to the temperature and during the time specified in the detail specification. Optical measurements are not required during this phase.

After the ageing steps, perform a temperature cycling test according to method F1. Perform two cycles. At the end of the last cycle, the temperature shall be lowered to ambient temperature, which shall be maintained for 24 h, and the attenuation shall be measured.

8.5 Requirement

Calculate the change in attenuation from the initial measurement (8.4). Unless otherwise agreed between customer and supplier, the maximum allowable attenuation increase shall be

a) for single-mode fibre, tested at 1 550 nm: 0,25 dB/km, maximum, and 0,10 dB/km, average, and

b) for multimode fibre, tested at 1 300 nm: 0,6 dB/km, maximum, and 0,4 dB/km, average.

After measuring attenuation, an appropriate section of the cable shall be dissected. Any elements of the cable which are colour coded (fibres, buffer tubes, sheath) shall be examined as per Annex A.

8.6 Details to be specified

The detail specification shall include the following:

a) the exposure temperature;

b) the exposure time;

c) the maximum change in attenuation allowed, if other than as in 8.5;

d) any tests of physical attributes in addition to those of 8.5.

9 Method F10 – Underwater cable resistance to hydrostatic pressure

9.1 Object

The purpose of this test is to determine the ability of an underwater optical fibre cable to withstand hydrostatic pressure, by measuring the attenuation or by monitoring changes in optical transmission.

9.2 Sample

The sample shall be of a sufficient length to be terminated outside each end of the pressure tube vessel.

9.3 Apparatus

The test apparatus shall consist of the following:

a) appropriate attenuation measuring apparatus for determination of attenuation change (see test procedure of IEC 60793-1-40 or IEC 60793-1-46);

b) pressure tube vessel: the size of the pressure tube vessel shall be sufficient to accommodate the minimum length required by the detail specification.

9.4 Procedure

The test is to be carried out at ambient temperature. The pressure shall be maintained for 24 h or a period agreed between the user and the manufacturer.

The cable shall be installed in the pressure vessel. The water pressure in the pressure vessel during the test shall be 1,1 times higher than the water pressure at the seabed where the cable shall be installed.

The attenuation shall be measured before, during and after the test.

Special care should be taken for the tube end seals not to affect the results.

9.5 Requirements

Unless otherwise specified in the detail specification, there shall be no increase in attenuation during or after the test.

Other requirements may be agreed between the manufacturer and the user.

9.6 Details to be specified

The detail specification shall include the following information:

a) sample length;

b) pressure;

c) application period of pressure.

10 Method F11 – Sheath shrinkage (cables intended for patch cords)

10.1 Object

The purpose of this test is to measure the shrinkage behaviour of the sheath due to ageing of simplex and duplex optical fibre cables intended for use in patch cords.

This test method IEC 60811-503 shall be used with modifications related to the sampling and measuring method.

10.2 Sample

A 2 m length of cable shall be removed from the supply reel and disposed of, before cutting the test sample lengths. Five test samples of the length specified in the detail specification shall be cut from the cable.

- For test samples of a nominal 1 m length, cut 1 050 mm ± 5 mm.
- For test samples of a nominal length of 150 mm, cut 160 mm ± 5 mm.

10.3 Apparatus

A container (with typical dimensions 0,5 m × 0,5 m) into which the test sample is placed. The base of the container shall be covered with talc or paper to minimise frictional forces on the test sample and to permit free movement of the sheath.

A temperature chamber able to accommodate the test sample container and maintain the specified temperature within ±3 °C, as described in Clause 8 of IEC 60068-2-14:2009.

A length measuring device with a minimum resolution of 0,1 %.

10.4 Procedure

The cable on the supply reel shall be conditioned for 24 h at ambient temperature of before cutting the test samples.

Two marks separated by the distance of the nominal test length per the detail specification, ± 0,5 mm, shall be applied to each test sample.

The distance (L_1) between the marks on each test sample shall be measured and recorded.

A test samples are placed approximately horizontally in the container. When space allows, the sample also can be placed into the chamber in a straight configuration. If the samples shall be coiled, the test samples shall be coiled with a radius of not less than 150 mm and in such a manner as to permit free movement of the sheath.

The temperature chamber shall be heated up to the specified temperature.

The container with horizontally positioned samples is then placed in the temperature chamber.

After the specified exposure time (minimum 1 h, if not otherwise specified), the container with samples shall be removed from the chamber and allowed to cool to room temperature for a period of 1 h, if not otherwise specified.

A minimum of four such cycles shall be carried out.

After each cycle (preferably more than one sample has to be measured), the distance (L_2) between the marks on each test sample shall be measured and recorded. If the samples have been coiled, straighten them for this measurement. If the coiled samples cannot be effectively straightened for measurement, the test is rendered invalid.

The sheath shrinkage of each test sample is calculated after each cycle as:

$$\Delta L_{x,i} = (L_1 - L_{2x,i}) \text{ mm}$$

where

L_1 is the initial distance measured between the marks;

$L_{2x,i}$ is the distance measured between the marks;

i is the sample number (i = 1 to 5);

x is the cycle number (x = 1 to 4).

The average value ΔL_x = 1/5 ($\Delta L_{x,1}$+ $\Delta L_{x,2}$ +$\Delta L_{x,3}$ +$\Delta L_{x,4}$ +$\Delta L_{x,5}$) should be calculated after each temperature cycle.

Continue the test cycles until the shrinkage exhibits a variation less than ±1 mm.

10.5 Requirements

The sheath shrinkage shall not exceed the value given in the relevant detail specification.

10.6 Details to be specified

The detail specification shall include the following information:

a) details of temperature chamber and exposure high temperature;
b) duration of exposure to high temperature, if other than 1 h;
c) method of marking and length measurement;
d) sample configuration and fixing in the container;
e) number of cycles.

10.7 Details to be reported

The test report shall include the following information:

a) individual shrink values of all samples;
b) average sheath shrinkage;
c) any deviations from this test method.

11 Method F12 – Temperature cycling of cables to be terminated with connectors

11.1 Object

The purpose of this test is to examine the attenuation behaviour (change in attenuation) when optical fibre cables that are terminated with connectors are subjected to temperature cycling.

NOTE Method F1 is a general temperature cycling test for cables.

11.2 Sample

The sample shall be taken from a finished cable length. The sample length shall be as specified in the detail specification, typically 10 m.

11.3 Apparatus

The apparatus shall consist of the following:

a) a temperature chamber suitable to accommodate the sample and to maintain the specified temperature within +3 °C, as described in Clause 8 of IEC 60068-2-14:2009;
b) attenuation monitoring equipment according to IEC 60793-1-40 and IEC 60793-1-46.

11.4 Procedure

The sample shall be placed in the test chamber with a method of storage that shall not affect the optical fibre with respect to expansion or contraction. At both ends of the sample inside the chamber, all components of the cable shall be fixed together to avoid any relative movement between the cable elements at the fixing point. The fixing may be by means of clamps, or adhesive injection, or attachment with connectors, for example. Such fixing shall not affect the attenuation of the test sample. The optical fibre ends (outside the chamber) may be temporarily joint to pigtails. The deployment of the sample outside the chamber shall not affect the results.

Preconditioning procedures, if any, shall be performed as agreed between the customer and the supplier.

The temperature cycling shall be performed in accordance with method F1: Temperature cycling with the first cycle procedure as follows:

- the temperature of the chamber shall be decreased to the lower temperature T_{A1}/T_{A2} at an appropriate cooling rate;
- as soon as the temperature in the chamber has reached stable condition, the sample shall be exposed to the lower temperature during an appropriate time interval t_1;
- the temperature in the chamber is then increased to the specified high temperature T_{B1}/T_{B2} at an appropriate heating rate;
- as soon as the temperature in the chamber has reached stable condition, the sample shall be exposed to the high temperature during an appropriate time interval t_1;
- the temperature in the chamber is then decreased to ambient temperature.

This procedure corresponds to one cycle. The cooling and heating rate shall not exceed 60 °C/h.

11.5 Requirements

The maximum increase in attenuation during and after the test shall be as shown in the relevant detail specification. As in method F1, the change in attenuation shall be calculated relative to the initial attenuation at ambient before the start of the test.

11.6 Details to be specified

The detail specification shall include:

a) method of sample storage in the temperature chamber;
b) preconditioning procedures;
c) method of fixing cable ends;
d) data of test equipment including method of measurement and launching conditions;
e) number of cycles;
f) values of T_{A1}/T_{A2}, T_{B1}/T_{B2} and t_1.

12 Method F13 – Microduct pressure withstand

12.1 Object

The purpose of this test is to verify that the microduct is capable of withstanding the maximum internal pressure used for blowing the microduct cable or fibre unit.

This test ensures safe operation over a range of temperatures. The test pressure is chosen to be either the maximum working pressure of the microduct or a multiple of this as stated in the detail specification. The controlled area is a heating/cooling chamber in the event that the detail specification requires testing above or below ambient temperatures. Typical ranges are –20 °C to +60 °C. In general, polymer microducts will have a reduced tolerance to pressure as the temperature is increased.

12.2 Sample

Equal lengths L of microduct approximately 1 m long are cut from a production length. The ends shall be cut carefully, ensuring that they are not crushed. This will prevent air leaks from around the connectors. This test shall be conducted in a controlled area so that there is no danger from flying fragments should the microduct fail.

The microduct samples shall be conditioned at the test temperature for a minimum of four hours before testing.

12.3 Apparatus

The pressure source shall be agreed between customer and supplier. Typically, it is a compressor or gas bottle. Personal protective equipment (PPE) is recommended (goggles or full-face mask and gloves).

12.4 Procedure

One end of the microduct is inserted into the pressurizing device. A fully blocking end cap (usually metal) is fitted to the opposite end. The pressurizing device is activated and the pressure slowly increased to the specified level. The sample is left pressurised for 30 min (unless otherwise stated in the detail specification).

The sample is observed for leaks at all times; it can be useful to place the microduct in a container of water to look for leaking air bubbles. After 30 min (unless otherwise stated in the detail specification), the air source is disconnected and the sample removed. PPE should be worn when entering the test area.

Ten samples shall be tested, unless otherwise stated in the detail specification.

12.5 Requirements

All samples shall withstand the applied pressure with no leakage during test and no visible damage after test.

12.6 Details to be specified

a) sample length: 1 m (unless otherwise specified);

b) test pressure: according to the detail specification;

c) duration: 30 minutes (unless otherwise specified);

d) number of samples: 10 (unless otherwise specified in the detail specification).

13 Method F14 – Cable UV resistance test

13.1 Object

This test evaluates the ability of cable sheath materials to maintain their integrity when exposed to ultraviolet (UV) radiation due to sunlight or fluorescent light, as applicable. This maintenance of integrity is evaluated by measuring the retention of tensile strength and elongation in the sheath of cable samples.

The test methods ISO 4892-2 and ISO 4892-3 shall be used.

The test of ISO 4892-2 is applicable to outdoor cables and other cables which have significant exposure to sunlight. The test of ISO 4892-3 is applicable to indoor cables which are exposed to fluorescent lighting.

13.2 Sample

Prepare samples and test specimens (six specimens and six as control specimens) as described in ISO 4892-2 or ISO 4892-3, as applicable.

13.3 Apparatus

The apparatus to be used is described in ISO 4892-2 or ISO 4892-3, as applicable.

In addition to the UV exposure apparatus, a tensile testing apparatus appropriate for testing the sheath specimens shall be used.

13.4 Procedure

13.4.1 General

Prior to conditioning, measure the control specimens for tensile strength at break and ultimate elongation in the tensile testing machine.

Condition the test specimens as described in 13.2, as applicable. After exposure, test the test specimens for tensile strength and elongation in the same manner as for the control specimens.

13.4.2 Conditioning for outdoor cables (weatherometer test)

Six test specimens shall be suspended vertically so that the external surface is uniformly exposed to the action of the actinic rays. During the test, the temperature indicated by the black-panel or the black-standard thermometer shall remain in the range +60 °C ± 3 °C and the relative humidity shall remain in the range 50 % ± 5 % (only in the dry period in the case of a test for outdoor application). The rotating drum carrying the test specimens shall turn at a speed of 1 r/min ± 0,1 r/min.

Test specimens are cycled through periods of UV exposure, followed by periods of no radiation during which temperature changes occur. The periods of each cycle, total time of 120 min, are the following: 102 min of dry UV exposure at a temperature of +60 °C ± 3 °C, followed by 18 min of rain exposure, without radiation, at a temperature of +50 °C ± 5 °C.

The overall duration of the test shall be 4 000 h (2 000 cycles), unless otherwise defined in the relevant product standard.

NOTE The MICE (mechanical, ingress, climatic, chemical and electromagnetic) table contains three classifications, ranging from 500 h to 6 000 h.

For coloured compounds, a black panel temperature of +60 °C ± 3 °C shall be used.

After the exposure, the exposed test specimens shall be removed from the equipment and conditioned at ambient temperature for at least 16 h.

The six other test specimens shall be kept at ambient temperature and protected from direct sunlight during the UV treatment and tested at the same time as the exposed test specimens.

13.4.3 Conditioning for indoor cables (QUV test)

Conditioning details for QUV test are to be determined. Refer to ISO 4892-3 for guidance. For method ISO 4892-3, applicable to indoor cables, expose the test specimens for a minimum duration of 720 h.

13.5 Requirements

After exposure, the average tensile and elongation of the test specimens shall be a minimum of 80 % of the original value.

13.6 Details to be specified

The detail specification shall include the following:

a) which method to use – ISO 4892-2 for outdoor cables or ISO 4892-3 for indoor cables;
b) any different exposure conditions or duration from those specified;
c) any compliance requirements different from those specified herein.

14 Method F15 – Cable external freezing test

14.1 Object

This test determines the ability of a cable to withstand the effects of freezing water (ice) that can immediately surround the optical fibre cable sheath by observing any changes in the physical appearance of the sheath, or in the measured cable optical attenuation.

NOTE The external freezing test simulates freezing of the medium surrounding a buried cable, as in wet earth or water. It is not intended to simulate freezing of a cable in a duct or pipe. This external freezing test has little use for evaluating an outdoor cable, since such cables rarely fail the test. The aggregate of other requirements for outdoor cables results in a cable that is sufficiently robust to easily withstand this test. Evaluation of microcables in microducts using this test is under consideration. It can be useful for evaluating cables not normally intended for outdoor installation. Users are encouraged to refer to national standards in effect in applicable regions.

14.2 Sample

A 50 m minimum length of cable shall be loosely coiled in the water to be frozen. Contact between the cable coil and the water tank wall shall be random. Additional length sufficient to make the required optical measurements and to connect the cable from the apparatus to the measuring equipment shall be provided.

14.3 Apparatus

The apparatus shall be a water tank suitable to contain the sample gauge length covered with water.

The water shall be common tap water. This procedure is written in view of the use of tap water. Other types of water, such as sea water or the like, shall be as specified by the detail specification. In these cases, the detail specification can prescribe temperatures other than those specified herein.

The water tank shall be positioned in an apparatus suitable for freezing the water and maintaining it at the specified temperature ±3 °C. An environmental chamber is a common example. Optionally, a temperature monitoring device may be used to monitor the cable temperature. In this case, the device shall be in close proximity to the sample under test.

14.4 Procedure

1) Place the cable gauge length in the water tank, either as a coil or by coiling it into the tank. Cover the cable with water.

2) Perform initial attenuation measurements as indicated by the detail specification.
3) If the optional temperature monitoring device is used, the chamber temperature may be lowered so far as to –40 °C until the ice is completely frozen and the ice temperature is –10 °C or lower.
4) Raise the chamber temperature to –2 °C and hold this temperature for 1 h.

   NOTE This is the temperature at which pure water experiences its greatest volume expansion as ice.
5) Measure the attenuation as indicated by the detail specification.
6) If the optional temperature monitoring device is used, the chamber temperature may be raised so high as to +65 °C, in order to accelerate the ice melting. Maintain the high temperature until the water reaches +15 °C. Then, return the chamber temperature to +23 °C and hold this temperature until the water reaches +23 °C ± 5 °C.
7) Measure the attenuation as indicated by the detail specification.
8) Remove the cable from the water tank and examine the exterior of the gauge length for any physical damage.

14.5 Requirements

After exposure, there shall be no visible cracks or other openings in the cable sheath. The maximum increase in attenuation during and after the test shall be as shown in the relevant detail specification, when frozen and no change after thawing.

14.6 Details to be specified

The detail specification shall include the following:

a) change of attenuation during and after the test;
b) any deviations from the criteria specified herein.

15 Method F16 – Compound flow (drip)

15.1 Object

This test (E14 in IEC 60794-1-21) is intended to verify that filling and flooding compounds will not flow from a filled or flooded fibre optic cable, at stated temperatures.

15.2 Sample

a) Number and type of specimens

   Unless otherwise specified in the detail specification, prepare two cable specimens for testing from each cable sample to be evaluated. Each cable specimen shall be representative of the cable type specified by the detail specification.
b) Specimen length

   Unless otherwise specified in the detail specification, each specimen shall be 200 mm ± 5 mm in length.
c) Specimen preparation

   Prepare each cable specimen as follows, making any modifications as required in item d).

   1) Remove a 100 mm ± 2,5 mm section of the outer sheathing material from one end.
   2) Remove all remaining non-intrinsic cable elements (e.g. armour, screens, inner sheaths, helically applied strength elements, water blocking tapes, other core wraps, etc.) for a length of 80 mm ± 2,5 mm from the same cable end. Do not disturb the remainder of the cable (e.g. the final buffer tubes which contain the optical fibres or fillers used for roundness).

3) Remove loosely adhered quantities of filling or flooding material disturbed in 1) or 2), but ensure that the specimen remains essentially coated by the filling or flooding material (i.e. do not wipe clean).

4) For cable designs containing components such as fibre bundles or ribbons which might move under their own weight during the test, secure such components at the unprepared end of the specimen in a manner which does not disturb the remainder of the specimen. Such components may be secured by clamps, epoxy plugs or other means meeting the objectives of the procedure.

5) When permitted by the detail specification, the upper ends of buffer tubes or loose tubes may be sealed to simulate long length cable sections.

d) Specimen termination

If allowed by the detail specification, terminate the lower end of the cable specimen according to the manufacturer's recommendations for terminating the cable in actual use. Parts of item c) procedure may be affected by this termination, but the objective of item c) is to be followed.

15.3 Apparatus

The following apparatus and equipment are required to perform this test.

a) Chamber

A temperature chamber large enough to hold the specimens in a vertical position, with sufficient thermal capacity to maintain the specified temperatures for the duration of the test. If the temperature chamber is of a circulating air type, the air shall not blow directly on the test specimens.

b) Container

A non-hygroscopic container to catch dripping material.

c) Analytical balance

15.4 Procedure

The following steps shall be taken.

a) Preheat the chamber to the temperature specified in the detail specification.

b) Place each prepared specimen in the oven, suspended in a vertical position with the prepared end down. Place a pre-weighed clean collection container directly under (but not contacting) the suspended specimen.

c) If permitted by the detail specification, preconditioning may be performed as defined in 1) to 3) below; otherwise, continue with d) below.

1) Stabilize the chamber temperature and, unless otherwise specified in the detail specification, precondition each specimen for a period of 1 h.

2) At the end of the specified preconditioning time, replace the collection container with another pre-weighed clean collection container. Weigh the preconditioning collection container to measure the quantity of filling or flooding compound which may have dripped out of the cable during the preconditioning. A measured quantity greater than the specified preconditioning limit shall constitute a failure. Unless otherwise specified in the detail specification, the preconditioning limit shall be 0,5 % of the total cable specimen weight or 0,5 g, whichever is the smaller;

3) Continue testing for 23 h, unless otherwise specified in the detail specification, and continue with e).

d) Stabilize the chamber temperature and, unless otherwise specified in the detail specification, test for a period of 24 h.

e) At the end of the specified time, remove and weigh the collection container to calculate the quantity of filling or flooding compound which may have dripped out of the cable.

f) Record this as the quantity of dripped filling or flooding compound for each cable specimen. Unless otherwise specified in the detail specification, report "no flow" for measured quantity changes less than or equal to 0,005 g.

15.5 Requirements

Unless otherwise specified in the detail specification, the cable specimens shall be permitted a maximum flow quantity of 0,050 g. If the flow quantity from one of the cable specimens exceeds 0,050 g, but is less than 0,100 g, prepare two additional cable specimens in accordance with item c) of 15.2, and test as per items a) to f) of 15.4. The test shall be considered successful if neither of the second set of specimens has flow quantities which exceed 0,050 g.

15.6 Details to be specified

The detail specification shall include the following:

a) test temperature;

b) preconditioning details (if permitted):
   - statement that preconditioning is permitted (if permitted);
   - exceptions to default preconditioning procedure as defined in 15.4 c);
   - preconditioning pass/fail criteria if other than above.

c) any exceptions to be applied to the requirements of this procedure;

d) acceptance (pass/fail) criteria, if other than default.

16 Method F17 – Cable shrinkage test (fibre protrusion)

16.1 Object

The purpose of this test is to measure the fibre protrusion compared against the cable elements and cable sheath due to temperature changes.

Low shrinkage of cable elements and cable sheath is important in most cable installations. The effect of fibre protrusion may occur when cables are used in areas with large temperature changes. Cable designs with poor stabilization elements and high material shrinkage may cause excessive fibre protrusion that can lead to an attenuation increase, cable fixing and sealing weakening and in worst cases fibre breakage.

16.2 Sample

The test sample shall have a minimum length of 10 m.

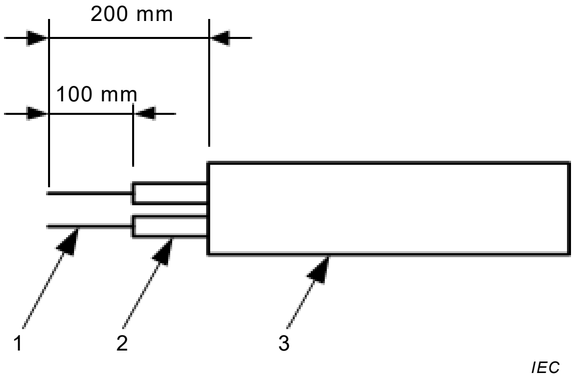
16.3 Apparatus

According to method F1.

16.4 Conditioning

The cable test sample shall be coiled in loose windings with a minimum diameter of 0,6 m, unless otherwise specified. The cable coils shall be loosely fixed at two opposite places in a way that the cable elements are free to move (expand and shrink). The coiled cable shall be put in the chamber.

The cable outer sheath shall be removed over a length of 200 mm from the cable end as shown in Figure 9. Also the strength members, inner sheath and other cable elements should be stripped closely to the end of the cable outer sheath. The secondary fibre protection or fibre tubes shall be removed over a length of 100 mm from the end of the cable outer sheath as shown in Figure 9, so that the fibres are bare over a length of 100 mm as shown in Figure 9. This preparation shall be done at both cable ends.



Key

1 fibre or bundle of fibres

2 secondary fibre protection or fibre tube

3 cable

Figure 9 – Preparation of the cable ends

The initial fibre protrusion shall be measured from the edge of the secondary fibre protection or fibre tube and from the edge of the cable sheath of all secondary fibre protection or fibre tubes at both ends (see Figure 10).

The prepared cable sample shall be temperature cycled in accordance to test method F1 and the following parameters:

– high temperature, T_{B1} and T_{B2}: high operation temperature as defined in the relevant detail specification

– low temperature, T_{A1} and T_{A2}: low operation temperature as defined in the relevant detail specification

– minimum soak time, t_1: according to method F1.

A minimum of four cycles shall be carried out.

After the last cycle, the cable sample shall recover for a minimum period of 1 h at ambient temperature, unless otherwise specified in the relevant detail specification.

The fibre protrusion shall be measured at both ends (see Figure 10).

The maximum change of fibre protrusion lengths are calculated as:

$$\Delta L1 = \max(L1_{ai} - L1_{bi})$$

$$\Delta L2 = \max(L2_{ai} - L2_{bi})$$

where

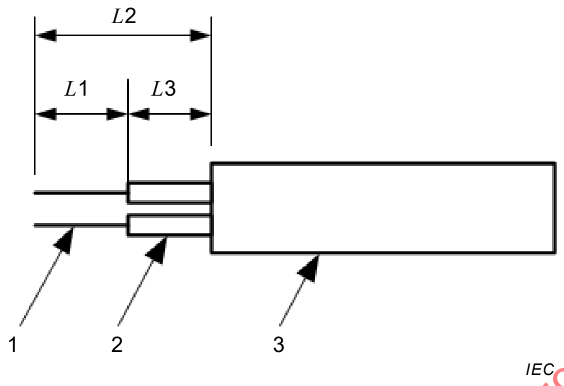
$L1_{ai}$ is the fibre protrusion length from the edge of the secondary fibre protection of fibre tube after temperature cycling of element number i;

$L1_{bi}$ is the fibre protrusion length from the edge of the secondary fibre protection of fibre tube before temperature cycling of element number i;

$L2_{ai}$ is the fibre protrusion length from the edge of the cable sheath after temperature cycling of element number i;

$L2_{bi}$ is the fibre protrusion length from the edge of the cable sheath before temperature cycling of element number i.

NOTE The measured values $L1$ and $L2$ give no information about which cable element expands or shrinks, because the reference point of the fibre end is not fixed.



Key

1 fibre or bundle of fibres

2 secondary fibre protection or fibre tube

3 cable

NOTE The protrusion of the secondary fibre protection or fibre tube is represented as length $L3$, that can be calculated as $L2$ minus $L1$.

Figure 10 – Fibre protrusion measurement

16.5 Requirements

The calculated maximum change of fibre protrusion lengths ($\Delta L1$ and $\Delta L2$) shall not exceed the values given in the relevant detail specification.

NOTE The change of protrusion of the secondary fibre protection or fibre tube is represented as length $\Delta L3$, that can be calculated as $\Delta L2$ minus $\Delta L1$.

16.6 Details to be specified

The detail specification shall include the following:

a) high and low exposure temperature;

b) permissible maximum change of fibre protrusion length.

16.7 Details to be reported

a) coiling diameter of cable;

b) soak time;

c) number of cycles;

d) recovery period;

e) maximum change of fibre protrusion of all secondary fibre protection or fibre tubes;

f) any deviations from this test method.

17 Method F18 – Mid-span temperature cycling test for exposed buffer tubes

17.1 Object

The mid-span temperature cycling test evaluates the environmental effects on unopened buffer tubes from a loose tube cable exposed in a mid-span entry (expressed) and stored in a pedestal, closure or similar. The test measures the change in attenuation caused by thermal contraction and expansion of the unopened tubes of a mid-span entry when exposed to temperature cycles in the stored configuration.

The method applies to loose tube type outdoor cables having fibre bundles in buffer tubes with diameters of 2,0 mm OD, or larger. The method may be used for other outdoor cables using criteria as agreed between manufacturer and customer.

The method uses a generic simulation assembly, but can also be used to evaluate the optical performance in a pedestal, closure, or any other device with mid-span access.

The temperature cycle as described in method F1 is used as the basis of this test.

17.2 Sample

The cable sample shall be long enough to enter and exit the climatic test chamber, supply the section of exposed buffer tube(s), and provide a coupling length of cable.

The length of exposed buffer tubes shall be as specified in the detail specification, reflecting the installation practise. There shall be at least 6 m of cable at each end of the exposed section to prevent the tubes and fibres from moving in or out of the sample during the test. At least one fibre of each type, if applicable, per loose tube shall be selected.

17.3 Apparatus

The generic apparatus, which may vary depending on cable design, is intended to test the cable in a representative manner independent of the influence of a particular closure or similar. A closure, pedestal, splice case or another device may be used as agreed between manufacturer and user.

The generic apparatus shall be configured to terminate the cable in a manner consistent with the installation practices. The exposed buffer tube(s) shall be stored in loops within a basket or other area of 75 mm to 300 mm width and 200 mm to 600 mm length. The specified minimum bend radii of the cable and the buffer tube(s) shall not be violated.

The climatic test chamber shall be in accordance with method F1.

17.4 Procedure

a) If available, follow the cable manufacturer`s instructions for cable preparation.
b) Open the cable to expose the buffer tube(s). Remove the cable sheaths and cut the strength members if present.
c) Strip/prepare the cable ends.
d) Install the cable with exposed buffer tubes on the generic assembly (e.g. basket per 16.3) or closure as specified and install both in the climatic chamber. If closures or similar are used, remove lids, domes or covers. The buffer tubes shall be loosely coiled. The tubes shall be straightened during coiling and not stay in the stranding form.
e) Measure the attenuation of the specified fibres.
f) Cycle the cable and assembly per method F1, with the following exceptions.
   i) The temperature range shall be per the detail specification. The default temperature range is –40 °C to +70 °C.

ii) Use the following soak times: the time period t_1 for the first hot soak shall be 14 h; unless otherwise specified, the time periods t_1 for the other cycle steps shall be 3h.

iii) Perform at least 2 cycles; the maximum number is not specified herein.

g) Measure the attenuation of the specified fibres at the low and high temperatures of the final cycle and and at the final ambient temperature, per method F1. Calculate the change in attenuation from the initial value, as in F1.

17.5 Requirements

Unless otherwise specified, the maximum change in attenuation for single-mode fibres measurements at 1 550 nm is given in the detailed specification.

The criteria for multimode fibres are under study.

17.6 Details to be specified

The detail specification shall specify the following:

- type of cable and number of tubes to be expressed.

The following shall be specified, if different from the default values above:

- length of cable with exposed tubes;
- sample length;
- deviation in the stored loop size;
- cycling temperature range;
- number of cycles;
- soak time(s).

If an actual closure, pedestal or similar is being tested, complete details of the apparatus and test criteria shall be specified as agreed between the customer and manufacturer.

Annex A
(normative)

Colour permanence

Colours used in optical fibre cables shall be as those defined in IEC 60304. Other colours may be defined, as necessary, by subordinate or detail specifications.

A colour for fibres, tubes, sheaths or other components shall be discernible as the colour intended, as manufactured. All components for which colour is a significant attribute (e.g. fibre or tube colours necessary for identification) shall remain discernible as being the intended colour after any ageing tests. It is not intended that the colours will be identical before and after ageing.

Bibliography

IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Cross reference table for optical cable test procedures*

IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*

IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*

IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable elements tests methods*

IEC 60794-1-24, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical tests methods*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

CÂBLES À FIBRES OPTIQUES –

Partie 1-22: Spécification générique – Modes opératoires de base applicables aux essais des câbles optiques – Méthodes d'essais d'environnement

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La Norme internationale IEC 60794-1-22 a été établie par le sous-comité 86A: Fibres et câbles, du comité d'études 86 de l'IEC: Fibres optiques.

La présente version bilingue (2018-04) correspond à la version anglaise monolingue publiée en 2017-10.

Cette deuxième édition annule et remplace la première édition parue en 2012. Cette édition constitue une révision technique.

Cette deuxième édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) nouvelle désignation de la méthode d'essai F16 – Ecoulement (égouttement) des matériaux de remplissage [E14 dans l'IEC 60794-1-21],

b) nouvelle méthode d'essai F17 – Essai de rétraction du câble (excroissance des fibres),

c) nouvelle méthode d'essai F18 – Essai de cycles de température à mi-portée.

NOTE L'absence de certains numéros dans la séquence de numérotation des méthodes d'essai est intentionnelle. Elle peut correspondre à une méthode d'essai supprimée, ou bien une méthode d'essai qui n'a jamais été publiée.

Le texte anglais de cette norme est issu des documents 86A/1813/FDIS et 86A/1827/RVD.

Le rapport de vote 86A/1827/RVD donne toute information sur le vote ayant abouti à l'approbation de cette norme.

La version française de cette norme n'a pas été soumise au vote.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60794, publiées sous le titre général *Câbles à fibres optiques*, peut être consultée sur le site web de l'IEC.

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INTRODUCTION

L'IEC 60794-1-2:2003 a été scindée en cinq nouveaux documents:

- IEC 60794-1-2, *Câbles à fibres optiques – Partie 1-2: Spécification générique - Procédures fondamentales d'essais des câbles optiques – Lignes directrices générales*
- IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods* (disponible en anglais seulement)
- IEC 60794-1-22, *Câbles à fibres optiques – Partie 1-22: Spécification générique – Modes opératoires de base applicables aux essais des câbles optiques – Méthodes d'essais d'environnement*
- IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable elements tests methods* (disponible en anglais seulement)
- IEC 60794-1-24, *Câbles à fibres optiques – Partie 1-24: Spécification générique – Méthodes fondamentales d'essais applicables aux câbles optiques – Méthodes d'essais électriques*

CÂBLES À FIBRES OPTIQUES –

Partie 1-22: Spécification générique – Modes opératoires de base applicables aux essais des câbles optiques – Méthodes d'essais d'environnement

1 Domaine d'application

La présente partie de l'IEC 60794 définit les modes opératoires d'essai à utiliser pour définir des exigences harmonisées pour les performances environnementales

- des câbles à fibres optiques destinés à être utilisés avec les équipements et dispositifs de télécommunications employant des techniques similaires, et
- des câbles combinant fibres optiques et conducteurs électriques.

Dans la présente norme, le terme «câble optique» peut également englober les unités de fibres optiques, les unités de fibres en microconduit, etc.

Se reporter à l'IEC 60794-1-2 comme guide de référence des méthodes d'essai de tous types, et pour consulter les exigences générales et les définitions.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-14:2009, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60304, *Couleurs de référence de l'enveloppe isolante pour câbles et fils pour basses fréquences*

IEC 60544-1, *Matériaux isolants électriques – Détermination des effets des rayonnements ionisants - Partie 1: Interaction des rayonnements et dosimétrie*

IEC 60793-1-40, *Fibres optiques – Partie 1-40: Méthodes de mesure et procédures d'essai – Affaiblissement*

IEC 60793-1-46, *Fibres optiques – Partie 1-46: Méthodes de mesure et procédures d'essai – Contrôle des variations du facteur de transmission optique*

IEC 60793-1-54, *Fibres optiques – Partie 1-54: Méthodes de mesure et procédures d'essai – Irradiation gamma*

IEC 60794-1-1, *Câbles à fibres optiques – Partie 1-1: Spécification générique – Généralités*

IEC 60811-503, *Câbles électriques et à fibres optiques – Méthodes d'essai pour les matériaux non-métalliques – Partie 503: Essais mécaniques – Essai de rétraction des gaines*

ISO 4892-2, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 2: Lampes à arc au xénon*

ISO 4892-3, *Plastiques – Méthodes d'exposition à des sources lumineuses de laboratoire – Partie 3: Lampes fluorescentes UV*

3 Termes et définitions

Aucun terme n'est défini dans le présent document.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

4 Méthode F1 – Cycles de température

4.1 Objet

Cette méthode de mesure s'applique aux câbles à fibres optiques soumis à essai selon des cycles de température, afin de déterminer la stabilité de l'affaiblissement des câbles lorsqu'ils sont soumis à des variations de température. Cette méthode peut également être utilisée pour l'appréciation de tubes de protection ou d'autres éléments indépendants de la structure d'un câble, tels que définis par une spécification particulière.

Une modification de l'affaiblissement des câbles à fibres optiques, qui peut se produire avec la variation de la température, résulte généralement du gondolage ou de la traction des fibres, du fait d'un écart entre leur coefficient de dilatation thermique et le coefficient des éléments de renfort et des éléments de gainage du câble. Les conditions d'essai pour les mesures en fonction de la température doivent simuler les conditions les plus défavorables.

Cet essai peut être utilisé pour surveiller le comportement du câble dans la plage de températures, qui peut correspondre aux conditions de stockage, de transport et d'utilisation, ou bien pour vérifier, au sein d'une plage de températures sélectionnée (généralement plus étendue que celle exigée pour le cas susmentionné), la stabilité de l'affaiblissement dans une situation substantiellement exempte de microcourbures au sein de la structure du câble.

NOTE 1 La méthode F12 constitue un sous-ensemble spécialisé de cette méthode, qui traite spécifiquement des câbles destinés aux cordons de brassage.

NOTE 2 L'essai de vieillissement décrit dans la méthode F9 utilise la méthode F1 pour définir son cycle de température avant et après l'essai. Ces essais sont donc souvent réalisés simultanément.

NOTE 3 L'essai de rétraction du câble décrit dans la méthode F17 utilise la méthode F1 pour définir ses cycles de température. Ces essais peuvent donc être réalisés simultanément.

4.2 Echantillon

L'échantillon doit présenter une longueur de fabrication standard en sortie d'usine, ou une longueur suffisante telle qu'elle est indiquée dans la spécification particulière, cette longueur devant quoi qu'il en soit être appropriée pour atteindre la précision souhaitée dans les mesures d'affaiblissement. L'échantillon est en outre défini comme l'échantillon de câble déployé pour les essais.

Afin d'obtenir des valeurs reproductibles, l'échantillon de câble doit être introduit dans l'enceinte climatique de telle sorte que le déploiement n'affecte pas la mesure. Ces méthodes de déploiement peuvent consister en une couronne enroulée librement, ou bien une bobine avec des boucles de grand diamètre, une bobine avec matelas amortisseur en couche molle, ou un dispositif de relâchement des contraintes.

La capacité de la ou des fibres à accepter la dilatation et la contraction différentielles (par exemple par glissement à l'intérieur du câble) peut être influencée par le rayon de courbure du câble. Il convient donc que le conditionnement de l'échantillon soit aussi proche que possible des conditions d'utilisation normales. Le diamètre de courbure de l'échantillon de câble ne doit pas contrevenir au diamètre de courbure minimal du câble, du tube ou d'une autre unité, tel qu'il est indiqué dans la spécification particulière.

Les problèmes potentiels sont dus à une différence effective entre les coefficients de dilatation de l'échantillon d'essai et du support (par exemple enrouleur, panier, plateau) qui peuvent induire durant les cycles thermiques un effet significatif sur le résultat d'essai, si les conditions «effet nul» ne sont pas complètement remplies. Le but recherché est de simuler la condition d'installation, dans laquelle le câble est généralement droit sur l'essentiel de sa longueur.

Les paramètres ayant une influence sont principalement les détails du conditionnement, le type et les matériaux constitutifs du support, et le diamètre de la couronne échantillon ou de l'enrouleur.

Les recommandations générales sont les suivantes.

a) Le diamètre d'enroulement doit être suffisamment grand pour laisser à la fibre la possibilité de s'adapter à la dilatation et à la contraction différentielles. Un diamètre d'enroulement substantiellement supérieur à la valeur retenue pour la livraison du câble peut être nécessaire.
b) Tout risque de limitation à la dilatation (ou à la contraction) du câble créé par le conditionnement doit être supprimé. Il convient plus particulièrement de veiller à éviter toute tension résiduelle sur le câble durant l'essai. Par exemple, un enroulement serré sur touret n'est pas recommandé, car il peut limiter la contraction du câble à basse température. D'autre part, un enroulement multicouche serré peut limiter la dilatation à température élevée.
c) L'utilisation d'un enroulement lâche est recommandée dans le cas d'une couronne formant des boucles de grand diamètre, d'une bobine avec matelas amortisseur en couche molle, ou d'un dispositif de relâchement des contraintes.
d) Le nombre de fibres soumises à essai doit être conforme à l'IEC 60794-1-1.
e) Les extrémités de câble fixes ainsi que les raccordements aux équipements doivent être situés en dehors de l'enceinte thermostatique, afin d'éviter tout effet négatif.

S'il est nécessaire de limiter la longueur du câble soumis à essai, il est admis de concaténer plusieurs fibres du câble et de mesurer les fibres concaténées. Le nombre de raccordements doit être limité et il convient que ceux-ci soient situés en dehors de l'enceinte climatique.

4.3 Appareillage

L'appareillage doit être composé des éléments suivants.

a) Appareillage de mesure de l'affaiblissement approprié pour déterminer la variation de l'affaiblissement (voir les méthodes d'essai de l'IEC 60793-1-40 et de l'IEC 60793-1-46).
b) enceinte climatique de dimensions permettant de recevoir l'échantillon et dont la température doit pouvoir être régulée afin de rester à ±3 °C de la température d'essai spécifiée. Un exemple d'enceinte adaptée est donné dans l'Article 8 de l'IEC 60068-2-14:2009.
c) Dispositif de détection de température pour mesurer la température de l'échantillon, s'il y a lieu. Les échantillons présentant une masse thermique importante peuvent exiger une mesure de vérification de la stabilité en température, plutôt que d'utiliser une période d'exposition spécifiée, t_1 (voir Tableau 1).

4.4 Mode opératoire

4.4.1 Mesure initiale

L'échantillon doit être examiné visuellement et une valeur de référence de l'affaiblissement doit être déterminée à la température initiale.

4.4.2 Préconditionnement

Les conditions de préconditionnement doivent faire l'objet d'un accord entre client et fournisseur.

4.4.3 Conditionnement

La Figure 1 et la Figure 2 fournissent une représentation graphique du ou des cycles initiaux et du cycle final. Elles représentent à elles deux la séquence de cycles de température à utiliser. Si une seule température haute et une seule température basse sont spécifiées, utiliser la Figure 1; pour les cycles présentant plusieurs paliers de températures hautes et/ou basses, utiliser la Figure 2.

NOTE À des fins de lisibilité, le mode opératoire a été rédigé en prenant pour référence la Figure 1. Lorsque plusieurs paliers de températures hautes et/ou basses doivent être utilisés, et que donc la Figure 2 s'applique, les étapes appropriées doivent être répétées pour chaque température. C'est-à-dire que les étapes (2) à (4) sont à répéter pour chaque température basse supplémentaire et/ou que les étapes (5) à (7) sont à répéter pour chaque température haute.

1) L'échantillon, étant à la température ambiante, doit être introduit dans l'enceinte climatique, celle-ci étant également à la température ambiante.
2) La température dans l'enceinte doit ensuite être abaissée à la température basse appropriée, T_{A2}, à une vitesse de refroidissement n'excédant pas 60 °C par heure, sauf indication contraire.

   NOTE Les cycles initiaux utilisent les températures extrêmes, T_{A2} et T_{B2}, quel que soit le cycle utilisé, celui de la Figure 1 ou de la Figure 2.
3) Lorsque la stabilité en température dans l'enceinte est atteinte, l'échantillon doit être exposé aux conditions de basse température pendant la durée appropriée t_1 (voir étape (4) ci-après).
4) Une durée d'exposition minimale est donnée dans le Tableau 1. Cependant, la durée d'exposition, t_1, doit être suffisante pour permettre au câble complet d'atteindre l'équilibre avec la température spécifiée.
5) La température dans l'enceinte doit ensuite être élevée à la température haute appropriée, T_{B2}, à une vitesse de chauffe n'excédant pas 60 °C par heure, sauf indication contraire.
6) Lorsque la stabilité en température dans l'enceinte est atteinte, l'échantillon doit être exposé aux conditions de haute température pendant la durée appropriée t_1.
7) La température dans l'enceinte doit ensuite être abaissée jusqu'à la température ambiante, à la vitesse de refroidissement appropriée. Ce mode opératoire constitue un cycle (voir Figure 1 ou Figure 2). S'il s'agit de l'étape intermédiaire d'une série de cycles, alors il n'est pas exigé de ménager une durée d'exposition, mais aucune mesure ne doit être effectuée.
8) Passer au cycle suivant en appliquant les étapes 2) à 7). L'échantillon doit être soumis à au moins deux cycles, sauf exigence contraire dans la spécification particulière applicable. Le ou les cycles initiaux doivent inclure une température basse et une température haute, conformément à la Figure 1. Le cycle final doit inclure une température basse et une température haute, conformément à la Figure 1 et selon ce qui est exigé par la spécification particulière applicable. Si plusieurs paliers de température basse ou haute sont exigés, le cycle final doit inclure au moins deux températures basses et au moins deux températures hautes, conformément à la Figure 2. Sur le dernier cycle, si plusieurs températures sont spécifiées, l'échantillon doit être maintenu à chaque température intermédiaire (T_{A1} ou T_{B1}) pendant la durée appropriée t_1. A la fin de la

séquence de cycles, maintenir l'échantillon à la température ambiante pendant la durée appropriée t_1.

9) L'affaiblissement doit être mesuré à la température ambiante au début du premier cycle, à la fin de la durée d'exposition t_1 pour chacun des paliers de température spécifiés (T_{A1}, T_{A2}, T_{B1}, T_{B2}) lors du cycle final, et à la température ambiante à la fin du cycle final. Si la spécification particulière exige des mesures à des cycles intermédiaires, ces mesures doivent être effectuées en procédant de la même manière.

10) Avant d'être retiré de l'enceinte, l'échantillon soumis à essai doit avoir atteint la stabilité en température à température ambiante.

Tableau 1 – Durée d'exposition minimale t_1

Durée d'exposition minimale pour un échantillon de masse donnée	
Masse de l'échantillon kg	**Durée d'exposition minimale, t_1** h
Moins de 0,35	0,5
0,36 à 0,7	1
0,8 à 1,5	2
1,6 à 15	4
16 à 100	8
101 à 250	12
251 à 500	14
Plus de 501	16
NOTE Il appartient au responsable des essais de s'assurer que la durée d'exposition est suffisante pour amener le câble à l'équilibre pour la température spécifiée.	

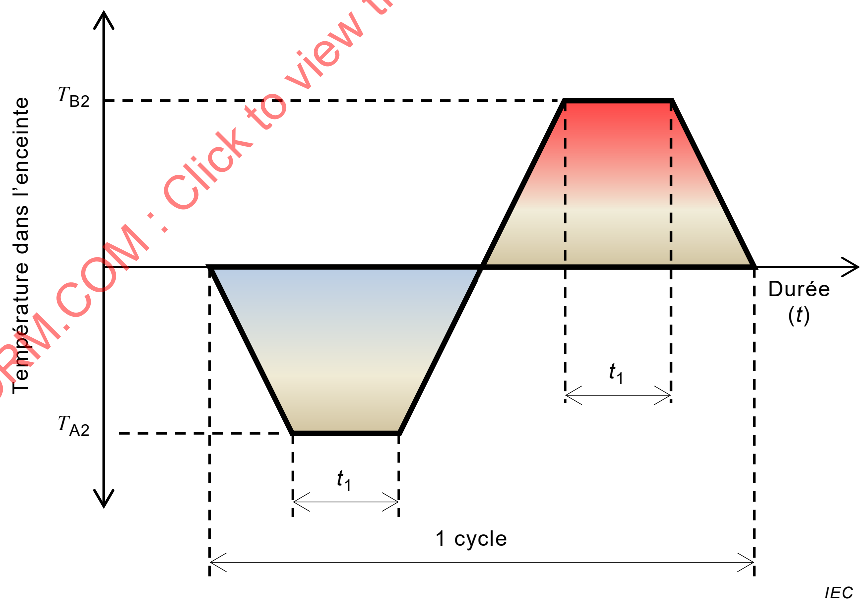

Figure 1 – Mode opératoire pour le ou les cycles initiaux

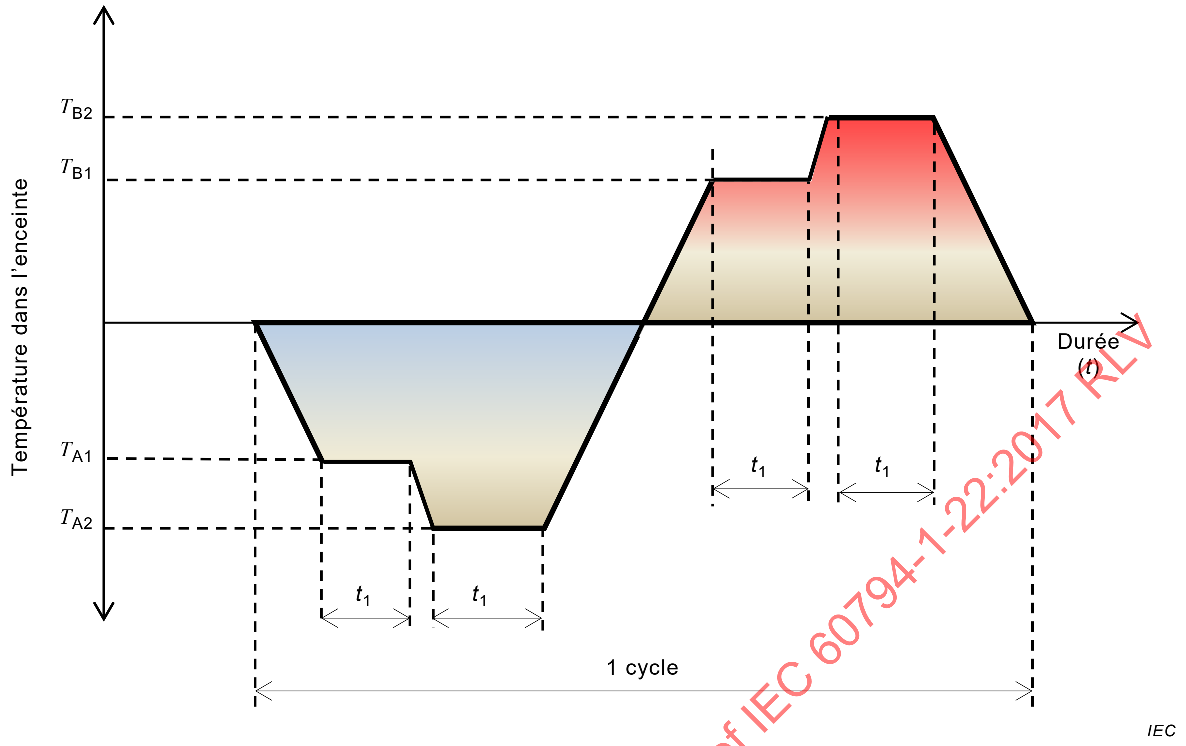

Figure 2 – Mode opératoire pour le cycle final

4.4.4 Période de repos

Si la température ambiante ne correspond pas aux conditions atmosphériques normales à appliquer pour soumettre l'échantillon à essai après son retrait de l'enceinte, l'échantillon doit être laissé au repos de manière à atteindre la stabilité en température à ces dernières conditions.

La spécification particulière applicable peut indiquer une période de repos spécifique pour un type d'échantillon donné.

4.5 Exigences

Les critères d'acceptation pour l'essai doivent être ceux indiqués dans la spécification particulière. Les modes de défaillance types incluent la perte de continuité optique, la dégradation du facteur de transmission optique ou la détérioration physique du câble. Sauf indication contraire, la variation de l'affaiblissement doit être calculée en fonction de la valeur d'affaiblissement atteinte dans les conditions ambiantes, avant le début de l'essai de cycles de température (4.4.1).

4.6 Détails à spécifier

La spécification particulière doit indiquer les éléments suivants:

a) longueur de l'échantillon de câble;

b) nombre de fibres soumises à essai, s'il diffère de celui donné en 4.2;

c) longueur de la fibre soumise à essai;

d) type de connexion entre fibres concaténées (facultatif);

e) limites de température:

   i) T_{A2} et T_{B2} (Figure 1), ou

   ii) T_{A1}, T_{A2}, T_{B1} et T_{B2} (Figure 2),

f) nombre de cycles,

g) taux d'humidité à chaque valeur extrême de température (si spécifiée),

h) variation d'affaiblissement maximale (voir 4.5) à une longueur d'onde spécifiée, en fonction des cycles de température.

4.7 Détails à consigner

Type d'enroulement:

a) couronne, bobine, autre (à spécifier, dans le cas d'une bobine avec matelas amortisseur, type de matelas amortisseur et matériau utilisé);

b) diamètre d'enroulement;

c) enroulement à couche unique ou multicouche;

d) tension d'enroulement et dispositif de relâchement des contraintes (le cas échéant).

Durée d'exposition, t_1, si elle diffère de celle spécifiée dans le Tableau 1.

5 Méthode F5 – Pénétration d'eau

5.1 Objet

Cet essai s'applique aux câbles empêchant de manière continue la progression de l'eau. Le but est de déterminer la capacité du câble à bloquer la migration de l'eau sur une longueur spécifiée.

- La méthode F5A apprécie les entrées d'eau sur le plan radial, dues à une détérioration de la gaine.
- La méthode F5B apprécie les entrées d'eau sur le plan longitudinal, sur l'ensemble de la section de câble conçue pour empêcher la progression de l'eau, à partir d'une exposition à l'eau indéfinie en extrémité de câble.
- La méthode F5C apprécie également les entrées d'eau sur le plan longitudinal à partir d'une extrémité de câble, et s'applique aux câbles dotés d'un matériau gonflant empêchant la progression de l'eau.

La conformité doit être vérifiée sur les échantillons de câble en utilisant l'une des trois méthodes suivantes (F5A, F5B ou F5C), selon ce qui est indiqué dans la spécification particulière. Les essais de la méthode F5A portent sur la migration d'eau entre les interstices extérieurs du cœur optique et la gaine extérieure, tandis que les essais des méthodes F5B et F5C portent sur la migration d'eau sur l'ensemble de la section conçue pour empêcher la progression de l'eau. La méthode F5C intègre une étape de préconditionnement, un appareillage à débit limité, ou un échantillon de plus grande longueur, afin de simuler une exposition progressive à l'eau en un emplacement donné le long du câble, ou à une extrémité du câble. Les différentes conceptions de gaines, par exemple les câbles armés, ne sont pas nécessairement conçues pour empêcher la progression de l'eau. En pareil cas, retirer les couches extérieures avant d'appliquer les presse-étoupes.

5.2 Echantillon

5.2.1 Méthode F5A

Une portion circonférentielle de la gaine et du revêtement de 25 mm de largeur doit être enlevée à 3 m d'une extrémité d'un échantillon de câble et un manchon étanche doit être appliqué par-dessus le cœur dénudé de manière à relier les bords de la coupure dans la gaine et permettre l'application d'une colonne d'eau de 1 m.

L'extrémité opposée de l'échantillon doit être obturée afin d'empêcher toute fuite d'eau dans cette direction.

La longueur de l'échantillon doit être suffisante pour englober la distance entre la portion circonférentielle et l'extrémité de câble, la largeur de gaine retirée et la longueur permettant d'obturer l'extrémité opposée. Un échantillon de 3,1 m devrait être adapté à la majorité des usages.

5.2.2 Méthode F5B

Un échantillon de câble ne devant pas dépasser 3 m de longueur est utilisé.

Un presse-étoupe étanche doit être appliqué à une extrémité de l'échantillon, pour permettre l'application d'une colonne d'eau de 1 m.

NOTE 1 Si l'armature des câbles armés n'est pas conçue pour empêcher la progression de l'eau, l'armature peut être enlevée à l'extrémité du câble avant l'application du presse-étoupe.

NOTE 2 La pression exercée par l'eau peut contraindre la fibre et le matériau de remplissage à sortir des tubes des câbles remplis. En pareil cas, le résultat de l'essai serait invalide. Il peut par conséquent être exigé qu'au niveau du cœur, les fibres soient contraintes en sortie de câble, par exemple en obturant l'extrémité par une membrane ou un tissu. Comme les tubes remplis présentent de bonnes capacités pour empêcher la progression de l'eau, les essais peuvent se focaliser sur les caractéristiques de pénétration d'eau du reste du câble. Il est suggéré en pareil cas, pour éviter ce problème, que le ou les tubes du cœur soient bouchés à l'une ou l'autre des deux extrémités.

5.2.3 Méthode F5C (pour les câbles avec matériau gonflant empêchant la progression de l'eau)

Un échantillon de câble ne devant pas dépasser 3 m de longueur est utilisé pour le mode opératoire par prétrempage ou par insert réducteur. Si aucun de ces deux modes opératoires n'est retenu, un échantillon de câble plus long, mais ne devant pas dépasser 40 m, peut être utilisé.

Un presse-étoupe étanche doit être appliqué à une extrémité de l'échantillon, pour permettre l'application d'une colonne d'eau de 1 m.

NOTE 1 Si l'armature des câbles armés n'est pas conçue pour empêcher la progression de l'eau, l'armature peut être enlevée à l'extrémité du câble avant l'application du presse-étoupe.

NOTE 2 La pression exercée par l'eau peut contraindre la fibre et le matériau empêchant la progression de l'eau à sortir des tubes des câbles remplis. En pareil cas, le résultat de l'essai serait invalide. Il peut par conséquent être exigé qu'au niveau du cœur, les fibres soient contraintes en sortie de câble, par exemple en obturant l'extrémité par une membrane ou un tissu.

5.3 Appareillage

5.3.1 Dispositifs et configuration d'essai

Les montages d'essai appropriés sont représentés aux Figures 3 à 8: Figure 3 pour la méthode F5A, Figure 4 pour la méthode F5B et Figures 5 à 8 pour la méthode F5C. Sauf indication contraire dans la spécification particulière, l'échantillon doit être soutenu horizontalement.

5.3.2 Eau

L'eau doit être de l'eau potable (eau du robinet, eau déionisée ou eau déminéralisée), le choix étant laissé à la discrétion du fabricant de câbles.

Un colorant fluorescent soluble dans l'eau ou un autre agent colorant approprié peut être utilisé pour faciliter la détection de l'infiltration d'eau, le choix étant laissé à la discrétion du fabricant de câbles. Il convient de veiller à choisir un colorant fluorescent qui n'entre en réaction avec aucun des organes du câble.

NOTE Les colorants fluorescents inhibent dans une certaine mesure l'action de nombreux matériaux gonflants empêchant la progression de l'eau, ce qui peut biaiser les résultats d'essai.

Si cela est exigé par la spécification particulière, de l'eau simulant l'eau de mer (ou autre) peut être utilisée pour l'essai. Il convient que des considérations de conception et des limites d'essai spécifiques s'appliquent aux câbles conçus pour une exposition à l'eau salée ou à l'eau saumâtre.

5.3.3 Insert réducteur (méthode F5C)

Un insert réducteur peut être inséré dans le tube reliant la source d'eau à l'échantillon, afin de limiter le débit d'eau.

S'il est utilisé, l'insert réducteur doit présenter un diamètre de 1,50 mm ± 0,25 mm et une longueur maximale de 30 mm (voir Figure 7).

5.4 Mode opératoire

5.4.1 Méthodes F5A et F5B

Une colonne d'eau de 1 m doit être appliquée pendant 24 h.

5.4.2 Méthode F5C

5.4.2.1 Prétrempage (variante)

Si le mode opératoire par prétrempage est utilisé, l'une des extrémités de l'échantillon doit être prétrempée dans un seau d'eau pendant 10 min à une profondeur de 100 mm ± 10 mm. Un presse-étoupe étanche doit ensuite être appliqué sur l'extrémité ayant fait l'objet du prétrempage, pour permettre l'application d'une colonne d'eau de 1 m.

Après le mode opératoire par prétrempage, une colonne d'eau de 1 m doit être appliquée pendant 24 h.

5.4.2.2 Insert réducteur (variante)

Si l'insert réducteur est utilisé, il peut être inséré dans une quelconque partie du tube reliant la source de pression hydrostatique à l'échantillon.

Une colonne d'eau de 1 m doit être appliquée pendant 24 h.

5.4.2.3 Echantillon de plus grande longueur (variante)

Une colonne d'eau de 1 m doit être appliquée pendant 24 h.

5.5 Exigences

Pour les méthodes F5A, F5B et F5C, aucune présence d'eau ne doit être détectée au niveau de l'extrémité non scellée de l'échantillon. Si un colorant fluorescent est utilisé, un rayonnement ultraviolet peut être utilisé pour l'examen.

NOTE Le mode opératoire d'essai donné en 5.4 constitue une exigence de conformité de base. Pour l'appréciation du processus, des échantillons d'essai plus courts peuvent être soumis à essai pendant une durée plus courte.

5.6 Détails à spécifier

La spécification particulière doit indiquer les éléments suivants:

a) méthode utilisée: F5A, F5B ou F5C (voir Figures 3 à 8);
b) une quelconque donnée en variante (longueur de l'échantillon d'essai, pression hydrostatique, type d'eau ou durée de l'essai);

c) les exigences en variante relatives à la longueur de l'échantillon d'essai, au préconditionnement ou aux fuites si de l'eau salée (ou de l'eau d'un autre type) doit être utilisée.

5.7 Détails à consigner

- Si la méthode F5C est utilisée, le mode opératoire en variante retenu (prétrempage, insert réducteur ou échantillon de plus grande longueur).
- Détails concernant le colorant, le cas échéant.
- Longueur de l'échantillon d'essai, si elle est différente.
- Durée de l'essai, si elle est différente.

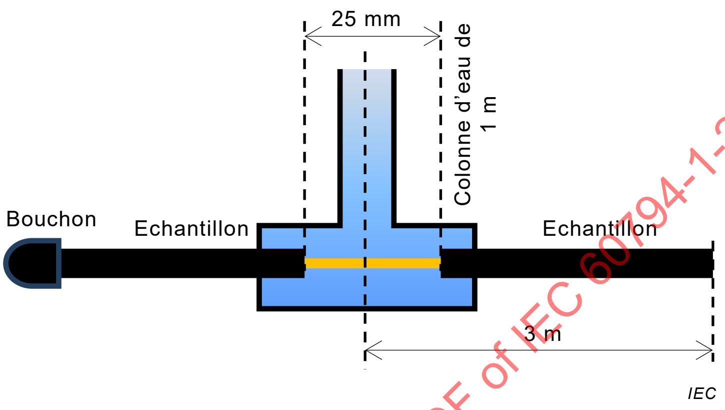

Figure 3 – Montage d'essai pour la méthode F5A

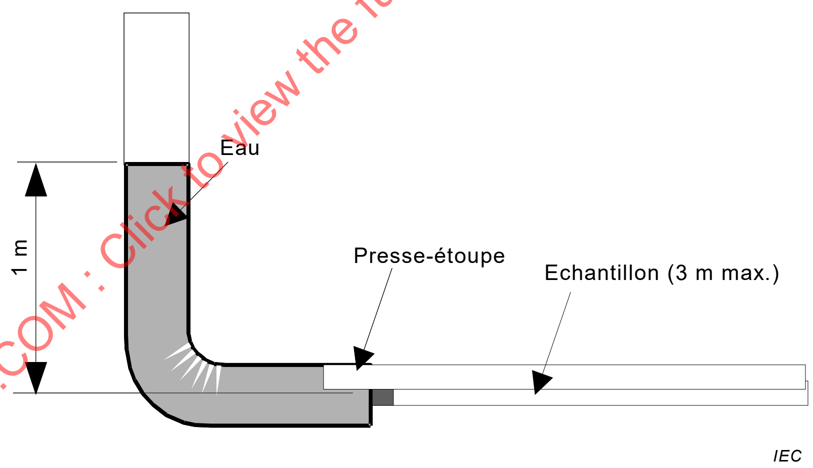

Figure 4 – Montage d'essai pour la méthode F5B