

# Optical fibre cables —

## Part 1-2: Generic specification — Basic optical cable test procedures

The European Standard EN 60794-1-2:2003 has the status of a British Standard

ICS 33.180.10

# National foreword

This British Standard is the official English language version of EN 60794-1-2:2003. It is identical with IEC 60794-1-2:2003. It supersedes BS EN 60794-1-2:1999, which is withdrawn. Together with BS EN 60794-1-1:2002, it supersedes BS EN 187000:1994, which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/1, Optical fibres and cables, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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**Part 1-2: Generic specification –**  
**Basic optical cable test procedures**  
(IEC 60794-1-2:2003)

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Partie 1-2: Spécification générique -  
Procédures de base applicables  
aux essais des câbles optiques  
(CEI 60794-1-2:2003)

Lichtwellenleiterkabel  
Teil 1-2: Fachgrundspezifikation -  
Grundlegende Prüfverfahren  
für Lichtwellenleiterkabel  
(IEC 60794-1-2:2003)

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## **Foreword**

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Annexes designated "normative" are part of the body of the standard.  
In this standard, annex ZA is normative.  
Annex ZA has been added by CENELEC.

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## **Endorsement notice**

The text of the International Standard IEC 60794-1-2:2003 was approved by CENELEC as a European Standard without any modification.

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## OPTICAL FIBRE CABLES –

### Part 1-2: Generic specification – Basic optical cable test procedures

#### 1 Scope and object

This part of International Standard 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.

The object of this standard is to define test procedures to be used in establishing uniform requirements for the geometrical, transmission, material, mechanical, ageing (environmental exposure) and climatic properties of optical fibre cables, and electrical requirements where appropriate.

#### 2 Normative references

**2.1** The following referenced documents are indispensable for the application 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 60068-2-14:1984, *Environmental testing – Part 2: Tests – Test N: Change of temperature*

IEC 60227-2:1997, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*

IEC 60544 (all parts): *Electrical insulating materials – Determination of the effects of ionising radiation*

IEC 60793-1-22:2001, *Optical fibres – Part 1-22: Measurement methods and test procedures – Length measurement*

IEC 60793-1-32:2001, *Optical fibres – Part 1-32: Measurement methods and test procedures – Coating strippability*

IEC 60793-1-40:2001, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-46:2001, *Optical fibres – Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance*

IEC 60793-1-54\_\_\_\_<sup>1)</sup>, *Optical fibres – Part 1-54: Measurement methods and test procedures – Gamma irradiation*

IEC 60794-1-1:2001, *Optical fibre cables – Part 1-1: Generic specification – General*

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<sup>1)</sup> To be published.

IEC 60794-3:2001, *Optical fibre cables – Part 3: Duct, buried and aerial cables – Sectional specification*

IEC 60794-4, *Optical fibre cables – Part 4: Sectional specification – Aerial optical cables along electrical power lines* <sup>2)</sup>

IEC 61931:1998, *Fibre optic – Terminology*

**2.2** References herein to the detail specification for cable attributes and parameters are intended to include the applicable other parts of this specification, the applicable family specifications contained therein and the detail specification. Annex A of IEC 60794-1-1 contains such requirements for short-distance links.

### **3 General and guidance**

Under consideration.

#### **3.1 Introduction**

#### **3.2 Test procedure format**

The standard order of each test method is as follows. Additional clauses may be inserted, whilst maintaining this general order.

Object

Sample

Apparatus

Procedure

Requirement

Details to be specified

#### **3.3 Definitions**

#### **3.4 Standard atmospheric conditions**

#### **3.5 Numerical value of quantity**

#### **3.6 Graphical symbols and terminology**

See IEC 61931/TR.

#### **3.7 Safety**

#### **3.8 Calibration**

##### **3.8.1 Calibration**

The process of calibration may be defined as the set of operations which establish, under specified conditions, the relationship between values indicated by a measuring system and the known values of a reference material. Once established, this relationship may be used to adjust the measuring system to correct for statistically significant bias. Adjustment of the system may take the form of, for example, a hardware or a software adjustment if a deterministic relationship is known to exist.

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<sup>2)</sup> To be published.

Ensure the apparatus is calibrated and adjusted in accordance with the manufacturer instructions before use, in order to minimize measurement uncertainty.

Record relevant information of the calibration process, such as the calibrated value and uncertainty of the reference material or test equipment used.

### 3.8.2 Assessment of uncertainties<sup>3</sup>

Measurement uncertainty may be defined as the range within which the true value of a measured quantity (the measurand) is estimated to lie, within a given likelihood (or confidence level). The measurement uncertainty normally comprises several components, some of which may be estimated using statistical techniques (known as Type A uncertainties) whilst others may be estimated on the basis of experience or other information (known as Type B uncertainties). Components of uncertainty, or variance, are additive, and a confidence interval may be calculated for the measurements based on the sum of the variance components.

A typical build-up of uncertainty may include the following sources of uncertainty:

- calibration uncertainty of reference materials or equipment used – normally stated on the calibration certificates of the standards;
- transfer uncertainty – estimated changes in the certified values of reference materials or equipment since they were calibrated;
- operational uncertainty – estimated effects of environmental conditions, such as temperature and humidity.
- statistical (random) uncertainty in the measurement of the specimen and the calibration standard – due to, for example, electrical noise, vibration, data quantization, etc.

### 3.9 Launch conditions

## 4 Optical cable tests

The following measurement procedures describe mechanical and environmental tests for optical cables and cable elements. Some of the tests are under consideration.

As this standard is a revision of an earlier specification, some tests have been superseded by other tests or have been determined to be otherwise not applicable. Therefore, several numbers in the test numbering sequence are missing. They are E9, E16, F2 and F4.

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<sup>3</sup>) See ISO/IEC Guide to the expression of uncertainty in measurement.

## **5 Method E1: Tensile performance**

### **5.1 Object**

This measuring method applies to optical fibre cables which are tested at a particular tensile strength in order to examine the behaviour of the attenuation and/or the fibre elongation strain as a function of the load on a cable which may occur during installation. This method is intended to be non-destructive (the tension applied shall be within the operational values).

Two measuring methods are described below:

- method E1A: procedure for determining attenuation changes;
- method E1B: procedure for determining fibre elongation strain.

Method E1B can provide information on both the maximum allowable pulling force for field installation and the strain margin of the cable.

One method or the other, or both, either separately or in combination, shall be used according to the detail specification or upon agreement between user and manufacturer.

### **5.2 Sample**

A length of cable under test, sufficient to achieve the desired accuracy, is removed from the reel or coil.

A flat endface shall be prepared at both ends of the test fibre.

### **5.3 Apparatus**

The apparatus consists of:

- 1) an attenuation measuring apparatus for the determination of attenuation changes (see IEC 60793-1-40) for method E1A, and/or
- 2) a fibre elongation strain measuring apparatus (see IEC 60793-1-22, method C: Fibre elongation measurement method) for method E1B;
- b) 1) a tensile strength measuring apparatus which is able to accommodate the minimum length to be tested. Transfer devices may be used (see Figure 2),
- 2) a load cell with a maximum error of  $\pm 3$  % of its maximum range,
- 3) a clamping device: care should be taken that the specific method of capturing the cable components does not affect the results;
- c) if required, mechanical or electrical means for measuring the cable elongation shall be provided.

Examples of suitable apparatus are shown in Figures 1 and 2.

### **5.4 Procedure**

- a) Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.
- b) Load the cable onto the tensile rig and secure it. At both ends of the tensile rig, a method of securing the cable shall be used which uniformly locks the cable so that all components of the cable are restricted in their movement. For most cable constructions (e.g. stranded type cables), clamping on cable elements, except the fibres, is practical and sufficient to obtain attenuation changes and/or both the maximum allowable pulling load and the strain margin of the cable. However, for certain cable constructions (e.g. single loose tube), it may be

necessary to prevent the fibres from slipping in order to obtain the correct strain margin figures.

NOTE For aerial cable types, if required by the detail specification, the fixing of the cable should be made by means of the anchoring devices relevant to the type of cable considered. For certain heavily armoured cables, a clamping device involving a stocking grip or similar anchoring device may be used.

- c) Connect the test fibre of the cable under tensile test to the measurement apparatus. For method E1B, and when using the Pulse delay (time of flight) technique of method C (Fibre elongation method) of IEC 60793-1-22, care shall be taken that, during the pulling of the sample, the reference length does not change.
- d) The tension shall be continuously increased to the required value(s) given in the detail specification.
- e) The change of attenuation and/or fibre strain shall be recorded, preferably as a function of cable load or elongation.
- f) For cables with a large number of fibres, a multiple attenuation and/or fibre strain measuring device can be used.
- g) A representative number of fibres and/or a number of test cycles (typically one) shall be agreed between manufacturer and customer.

### 5.5 Requirements

The attenuation and/or fibre strain of the sample shall not exceed the values given in the relevant detail specification.

For method E1B:

If required by the detail specification, the fibre elongation versus load, including residual elongation after the load removal, shall be evaluated.

The set of data presented with the results shall include the calibration curve or factor of the measured phase shift, or the pulse delay versus fibre elongation of the relevant fibre.

An example of presentation of the cable and fibre elongation is given in Figure 3.

If required, the load value where the beginning of fibre strain occurs is defined, on the plot of fibre strain versus load, as the intersection of the linear portion of the curve with the load axis.

NOTE As a first approximation, the length of fibre under elongation strain is taken as equal to the length of cable under tensile load. It should be noted, however, that the calculated value of the fibre elongation strain is affected by the accuracy of the value of this cable length and also by the excess length of fibre in the cable, which depends on the cable design.

### 5.6 Details to be specified

The detail specification shall include the following:

- a) length of the cable and length under tension;
- b) end preparation;
- c) load cell;
- d) launching conditions and attenuation measuring device;
- e) fibre strain measuring device, if applicable;

- f) change of attenuation and/or fibre strain at a specified wavelength as a function of the load;
- g) rate of tension increase;
- h) minimum accuracy for the measurement of the cable length, if applicable;
- i) temperature, if different from that indicated for standard atmospheric conditions.

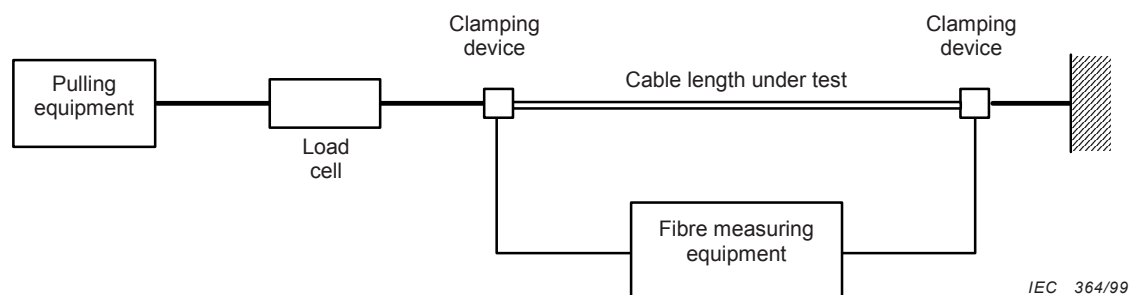


**Figure 1 – Tensile performance measuring apparatus**

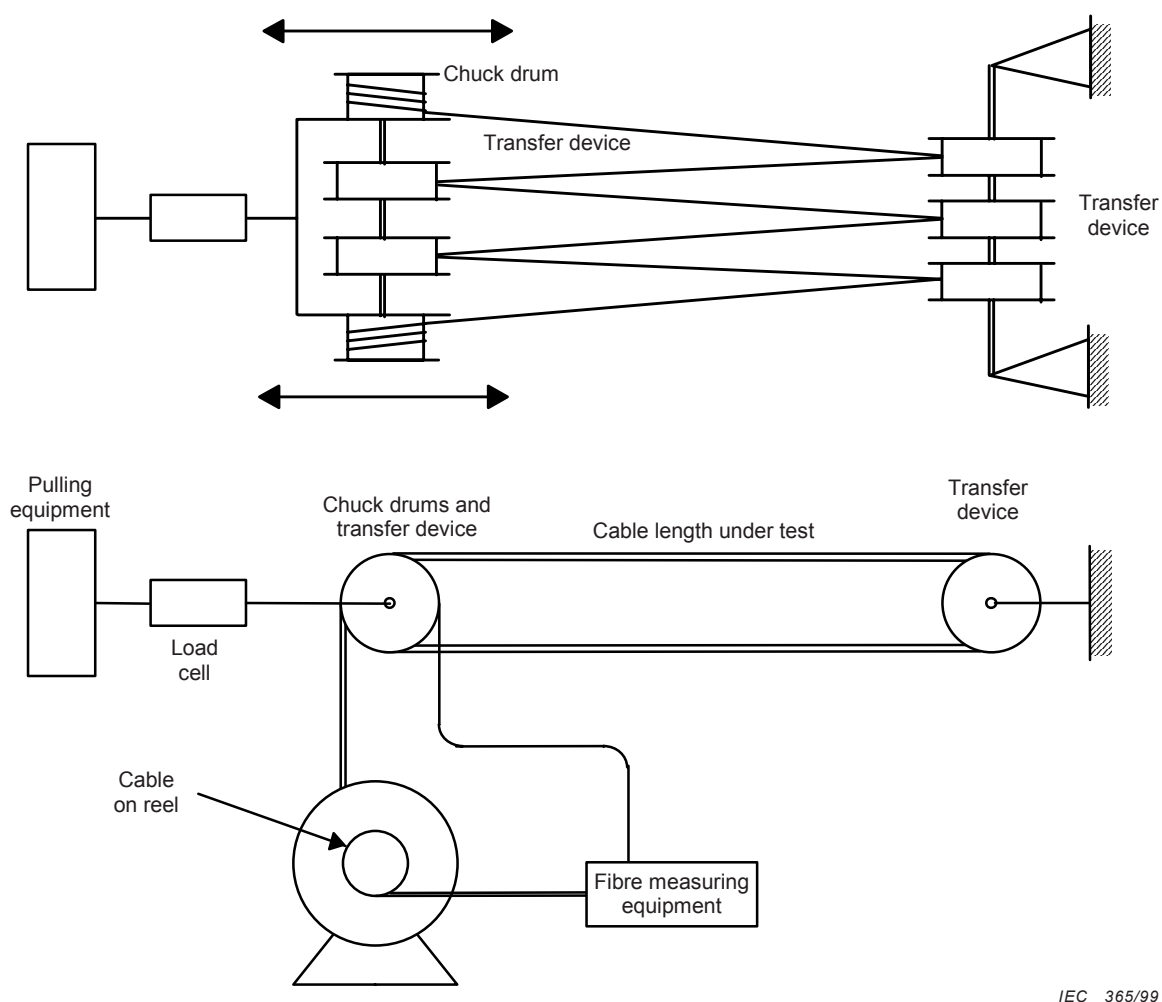
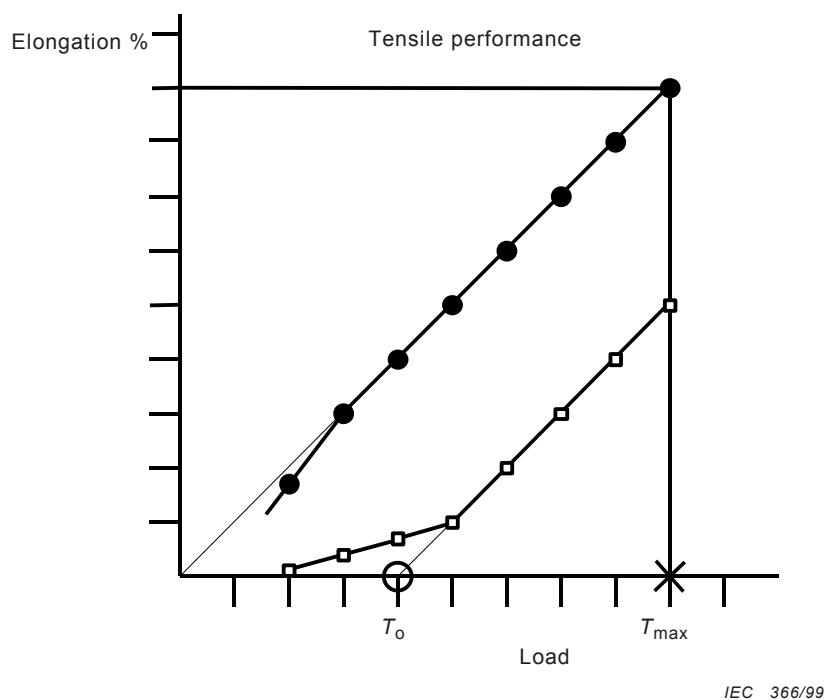


**Figure 2 – Example of tensile performance measuring apparatus using transfer devices and chuck drums**



Key

- Cable elongation (optional)
- Fibre elongation
- $T_o$
- ×  $T_{max}$

NOTE  $T_o$  corresponds to the load at which the fibre becomes under strain.  
 $T_{max}$  corresponds to the maximum specified pulling load.

**Figure 3 – Example of fibre and cable elongation as a function of load**

## 6 Method E2: Abrasion

### 6.1 Method E2A: Abrasion resistance of optical fibre cable sheaths

#### 6.1.1 Object

The abrasion resistance of optical fibre cables has two aspects:

- a) the ability of the sheath to resist abrasion;
- b) the ability of cable markings to resist abrasion.

The purpose of this test is to determine the ability of an optical fibre cable sheath to resist abrasion. Abrasion testing of cable markings is method E2B.

#### 6.1.2 Sample

The sample shall be of a length sufficient to carry out the specified test. A typical length is 750 mm.

#### 6.1.3 Apparatus

The abrasion test rig consists of a device designed to abrade the surface of the cable in both directions parallel to the longitudinal axis of the cable over a length of  $10 \text{ mm} \pm 1 \text{ mm}$  at a frequency of  $55 \text{ cycles/min} \pm 5 \text{ cycles/min}$ . One cycle consists of one abrading edge movement in each direction.

The abrading edge shall be a steel needle with a diameter as specified in the detail specification.

A typical apparatus is shown in Figure 4.

#### 6.1.4 Procedure

- a) Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.
- b) Securely attach the cable sample, measuring approximately 750 mm in length, to the supporting plate by means of cable clamps. The abrading edge shall be loaded with the mass necessary to provide the force stated in the detail specification whilst avoiding shock on the cable.

Four tests shall be made on each sample, with the sample moved forwards 100 mm between tests and rotated through an angle of  $90^\circ$ , always in the same direction.

#### 6.1.5 Requirements

There shall be no perforation of the sheath and optical continuity shall be maintained after performing the number of cycles specified in the detail specification.

#### 6.1.6 Details to be specified

The detail specification shall include the following:

- a) number of cycles;
- b) diameter of needle (method 1);
- c) force applied.

## **6.2 Method E2B: Abrasion resistance of optical fibre cable markings**

### **6.2.1 Object**

The abrasion resistance of optical fibre cables has two aspects:

- a) the ability of the sheath to resist abrasion;
- b) the ability of cable markings to resist abrasion.

The purpose of this test is to determine the ability of markings of optical fibre cables to resist abrasion. Abrasion testing of cable sheaths is method E2A.

Depending on the kind of marking and as indicated in the detail specification, one of the following two methods shall be used:

- method 1, suitable for rigid marking types like embossing, indenting and sintering;
- method 2, applicable to marking types other than embossing, indenting and sintering.

### **6.2.2 Sample**

The sample shall be of a length sufficient to carry out the specified test. A typical length is 750 mm.

### **6.2.3 Apparatus**

#### **6.2.3.1 Method 1**

A typical apparatus is shown in Figure 4.

The device is designed to abrade the marking of the cable parallel to the longitudinal axis of the cable over a length of 40 mm, at a frequency of 55 cycles/min  $\pm$  5 cycles/min. One cycle consists of one abrading edge movement in each direction.

The abrading edge shall be a steel needle with a diameter of 1 mm or as specified in the detail specification.

#### **6.2.3.2 Method 2**

The apparatus consists of:

- a) a test set-up, to apply a force to the wool felt. A typical example is shown in Figure 5;
- b) a wool felt, colour white;
- c) masses to apply a force to the sample.

### **6.2.4 Procedure**

Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.

#### **6.2.4.1 Method 1**

Securely attach the cable sample, measuring approximately 750 mm in length, to the supporting plate by means of cable clamps. Carry out the test with the sample mounted so that the marking is directly under the abrading edge. The abrading edge shall be loaded with the mass necessary to provide the force specified in the detail specification whilst avoiding shock on the cable.

#### **6.2.4.2 Method 2**

A sample of cable containing markings shall be laid between the two parts of the wool felt.

The wool felt shall be thoroughly impregnated with water.

The normal force ( $F$ ) given in the detail specification shall be applied to the markings on the sample which is moved back and forth over a length of 100 mm. The number of cycles shall be specified in the detail specification.

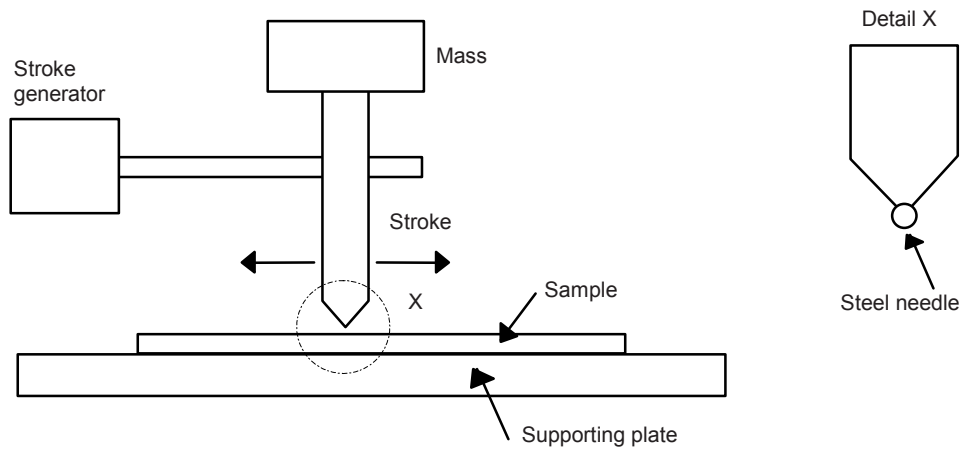
#### **6.2.5 Requirement**

The marking shall be legible at the completion of the test after the number of cycles specified in the detail specification.

#### **6.2.6 Details to be specified**

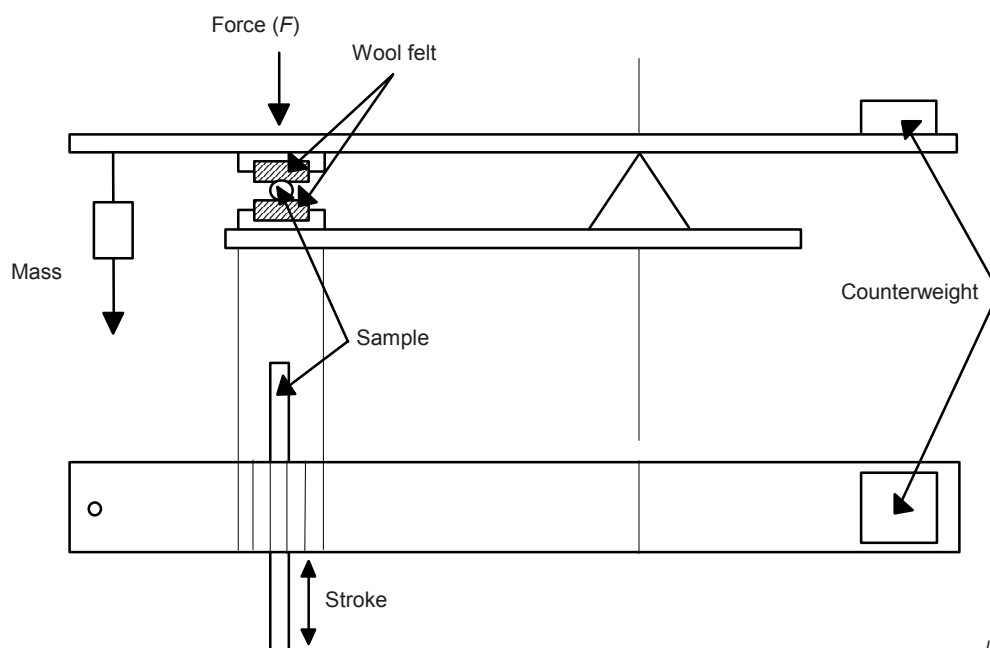
The detail specification shall include the following:

- a) number of cycles;
- b) method used;
- c) diameter of needle (method 1);
- d) force applied.



IEC 367/99

Figure 4 – Typical test set-up for tests E2A and E2B, method 1



IEC 368/99

Figure 5 – Typical test set-up for test E2B, method 2

## 7 Method E3: Crush

### 7.1 Object

The purpose of this test is to determine the ability of an optical fibre cable to withstand crushing.

### 7.2 Sample

The sample shall be of a length sufficient to carry out the specified test.

### 7.3 Apparatus

The apparatus shall allow a sample of cable to be crushed between a flat steel base plate and a movable steel plate which applies the crushing force uniformly over a 100 mm length of the sample.

The edges of the movable plate shall be rounded with a radius of about 5 mm. The edges are not included in the 100 mm flat part of the plate. A suitable apparatus is shown in Figure 6.

### 7.4 Procedure

The cable sample shall be mounted between the plates so that lateral movement is prevented, and the force shall be applied gradually without any abrupt change. If the force is applied in incremental steps, these shall not exceed a ratio of 1,5:1.

Unless otherwise specified in the detail specification, the test shall be performed three times, the force being applied on the specimen at three different places not less than 500 mm apart, without rotating the cable.

If requested in the detail specification, an additional or alternative test may be performed by inserting one or more steel mandrels (25 mm in diameter, unless otherwise specified in the detail specification) perpendicular to the sample, to represent particular operational conditions.

Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.

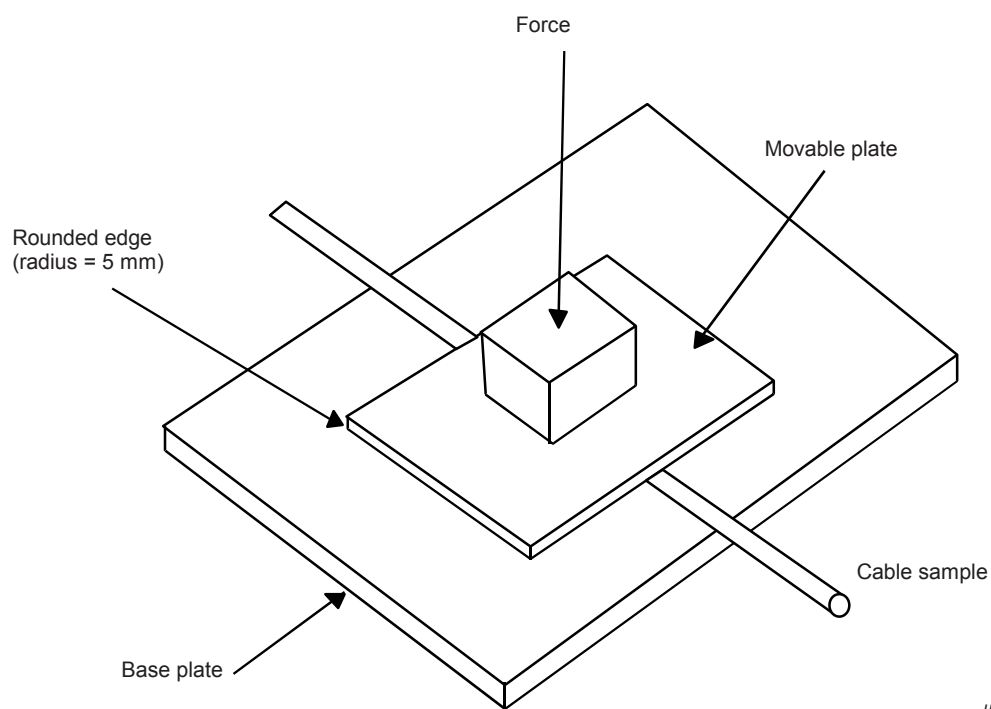
### 7.5 Requirements

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.

### 7.6 Details to be specified

The detail specification shall include the following:

- a) total force applied;
- b) duration of application of the force;
- c) number of tests;
- d) spacing between test places;
- e) configuration of mandrels, if used.



IEC 369/99

**Figure 6 – Crush test**

## 8 Method E4: Impact

### 8.1 Object

The purpose of this test is to determine the ability of an optical fibre cable to withstand impact.

### 8.2 Sample

#### 8.2.1 Sample length

The sample length shall be sufficient to carry out the specified test. When only physical damage is to be evaluated, the length may range from 1 m (for example for small diameter jumper cords or duplex cables) to 5 m (for larger diameter cables). Longer lengths may be necessary to permit optical measurements.

#### 8.2.2 Termination

The sample shall be terminated at each end in a connector, or in a manner such that the fibres, sheathings and any strain members are clamped together in a representative manner. The clamps on the impact apparatus may be adequate, or the sample may be long enough so that no restraint is needed.

### 8.3 Apparatus

The apparatus shall allow an impact to be imparted to the cable sample which is fixed to a flat substantial steel base. When a single or only a few impacts are required, a suitable apparatus, as shown in Figure 7a, is used. This allows a weight to drop vertically onto a piece of steel which transmits the impact to the cable sample. When repeated impacts are required (say, more than five), a more practical apparatus, as shown in Figure 7b, is used, which allows multiple impacts by a drop hammer.

In both cases, other equivalent apparatus may also be used.

The striking surface contacting the sample shall be rounded, either as a hemisphere (Figure 7c, A) or a cylinder (Figure 7c, B). The radius  $R$  of the surface shall be specified in the detail specification.

The apparatus shall include any optical test equipment needed to measure the changes in optical performance as required in the detail specification, and specified in method A (Transmitted power) of IEC 60793-1-46.

### 8.4 Procedure

Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions. If necessary, the sample shall be pre-conditioned at standard atmospheric conditions for 24 h.

The mass of the weight or drop hammer and the height from which it falls shall be adjusted to give the value of impact energy shown in the detail specification. The number and rate of impacts, and their location on the sample shall be as specified in the detail specification.

## **8.5 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.

## **8.6 Details to be specified**

The detail specification shall include the following:

- a) number of impacts;
- b) impact energy;
- c) test temperature;
- d) radius of the striking surface;
- e) frequency of multiple impacts (if any);
- f) location of impacts on the sample;
- g) if optical continuity or change in transmittance is to be measured.

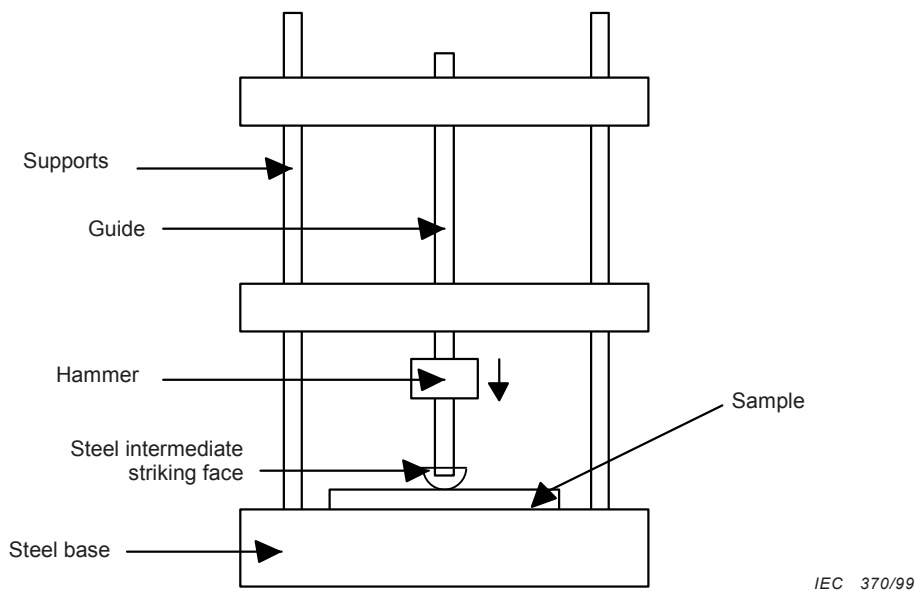


Figure 7a – Apparatus for a few impacts

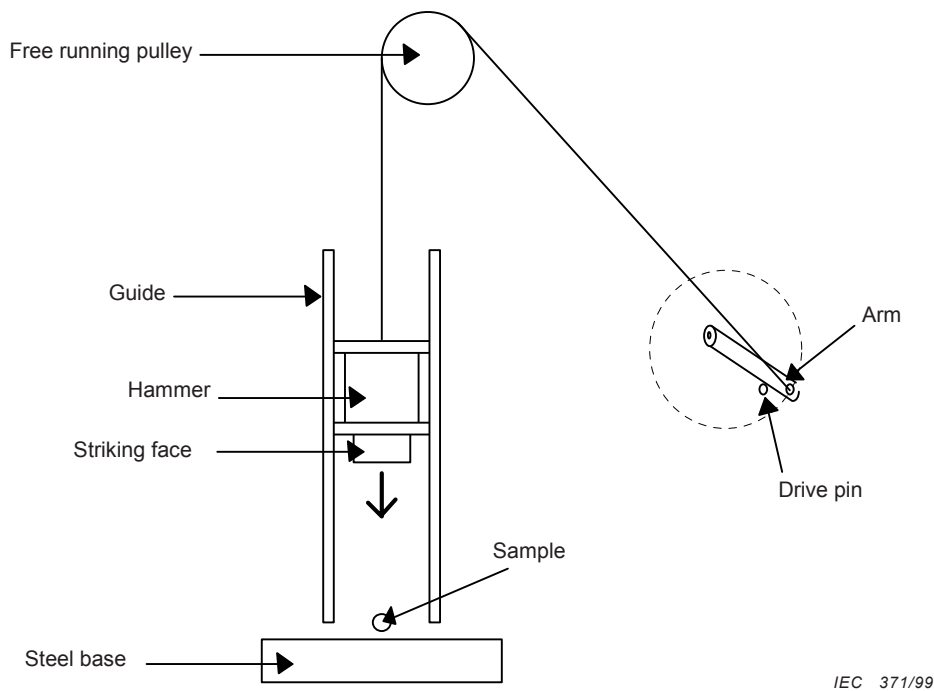


Figure 7b – Apparatus for multiple impacts

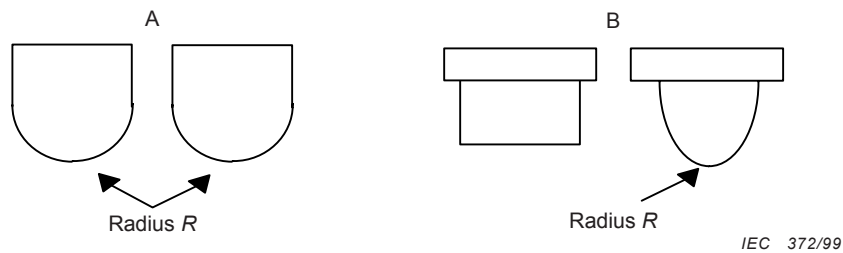


Figure 7c – Details of striking surface

Figure 7 – Impact test

## **9 Method E5: Stripping force stability of cabled optical fibres**

### **9.1 Object**

This test determines the stability of the stripping force of the coating of cabled fibres by measuring the change in fibre strippability after exposure to various environmental conditions.

### **9.2 Sample**

#### **9.2.1 Sample length**

The length of the cable or fibre sample shall be sufficient to carry out the specified test.

#### **9.2.2 Sample preparation**

The cable from which the fibres shall be taken is preconditioned, as specified in the detail specification, prior to withdrawal of the fibres.

The test shall be carried out on fibres taken from a sample of cable which is further divided into two lengths (minimum 2 m). One length is for testing and the other for reference measurements.

Sufficient samples shall be provided to allow tests to be carried out on 10 test pieces of fibre, conditioned as specified in the detail specification, and compared with test results for fibres taken from the reference cable length.

After withdrawal, any filling compound adhering to the fibres shall be carefully removed (e.g. by wiping with a soft tissue).

Cable environmental conditioning requirements should be agreed between user and manufacturer.

### **9.3 Apparatus**

The apparatus consists of conditioning equipment (if necessary) and a fibre strippability apparatus (see the strippability test method of IEC 60793-1-32).

### **9.4 Procedure**

The optical fibre strippability shall be measured on the environmentally conditioned samples using the strippability method of IEC 60793-1-32, after the recovery time and reconditioning as given in the detail specification. The same method shall be used to measure the strippability of fibre samples taken from the reference cable length and the change in stripping force shall be determined from a comparison of the results.

### **9.5 Requirements**

The change in stripping force shall meet the requirements specified in the detail specification.

### **9.6 Details to be specified**

The detail specification shall include the following:

- a) cable preconditioning;
- b) fibre conditioning;
- c) recovery time and reconditioning;
- d) permissible change in stripping force.

## 10 Method E6: Repeated bending

### 10.1 Object

The purpose of this test is to determine the ability of an optical fibre cable to withstand repeated bending.

### 10.2 Sample

#### 10.2.1 Sample length

The sample length shall be sufficient to carry out the specified test. When only physical damage is to be evaluated the length may range from 1 m (for example for small diameter jumper cords or duplex cables) to 5 m (for larger diameter cables). Longer lengths may be necessary to permit optical measurements.

#### 10.2.2 Termination

The sample shall be terminated at each end in a connector, or in a manner such that the fibres, sheathings and any strain members are clamped together in a representative manner. The clamps on the bending apparatus may be adequate, or the sample may be long enough that no restraint is needed.

### 10.3 Apparatus

The apparatus shall permit a sample to be bent backwards and forwards through angles up to 180°, the two extreme positions making an angle of 90° on both sides of the vertical, whilst the sample is subjected to a tensile load. For testing cable, a suitable apparatus is shown in Figure 8. For testing a cable/connector assembly, a suitable apparatus is shown in Figure 9. Other equivalent apparatus may be used.

The bending arm shall have an adjustable clamp or fixture to permit holding the cable securely during the entire test, without crushing the optical fibres or inducing optical loss. For connectorized cables, a connector may be used to hold the cable on the bending arm.

The apparatus shall be capable of cycling. Displacing the sample from the vertical position to the extreme right position, then oscillating to the extreme left position and returning to the original vertical position is considered to be one cycle. Unless otherwise specified in the detail specification, the bending rate shall be approximately one cycle in 2 s.

The apparatus shall include any optical test equipment needed to measure the changes in optical performance as required in the detail specification, and specified in method A (Transmitted power) of IEC 60793-1-46.

### 10.4 Procedure

- a) Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.
- b) The procedure can be defined by six steps:
  - step 1: precondition the sample at standard atmospheric conditions for 24 h;
  - step 2: fix the sample to the apparatus, as shown in Figures 8 and 9;
  - step 3: apply the weight, as shown in the detail specification;

- step 4: measure acceptance criteria parameters to establish baseline values;
- step 5: carry out repeated bending for the number of cycles specified in the detail specification;
- step 6: carry out acceptance criteria parameter measurements. If necessary, the sample may be removed from the apparatus for visual examination.

### **10.5 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.

### **10.6 Details to be specified**

The detail specification shall include the following:

- a) number of cycles;
- b) mass of the weight;
- c) bending radius  $R$ .