

Optical fibres —

Part 1-33: Measurement methods and test procedures — Stress corrosion susceptibility

The European Standard EN 60793-1-33:2002 has the status of a British Standard

ICS 33.180.10

National foreword

This British Standard is the official English language version of EN 60793-1-33:2002. It is identical with IEC 60793-1-33:2001.

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;
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Partie 1-33: Méthodes de mesure
et procédures d'essai -
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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 86A/688/FDIS, future edition 1 of IEC 60793-1-33, prepared by SC 86A, Fibres and cables, of IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60793-1-33 on 2002-03-05.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2002-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2005-03-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, B, C, D, E and ZA are normative and annexes F, G and H are informative.

Annex ZA has been added by CENELEC.

Compared to IEC 60793-1:1989 and IEC 60793-2:1992, IEC/SC 86A has adopted a revised structure of the new IEC 60793 series: The individual measurement methods and test procedures for optical fibres are published as "Part 1-XX"; the product standards are published as "Part 2-XX".

The general relationship between the new series of EN 60793 and the superseded European Standards of the EN 188000 series is as follows:

EN	Title	supersedes
EN 60793-1-XX	Optical fibres -- Part 1-XX: Measurement methods and test procedures	Individual subclauses of EN 188000:1992
EN 60793-2-XX	Optical fibres -- Part 2-XX: Product specifications	EN 188100:1995 EN 188101:1995 EN 188102:1995 EN 188200:1995 EN 188201:1995 EN 188202:1995

EN 60793-1-3X consists of the following parts, under the general title: Optical fibres:

- Part 1-30: Measurement methods and test procedures – Fibre proof test
- Part 1-31: Measurement methods and test procedures – Tensile strength
- Part 1-32: Measurement methods and test procedures – Coating strippability
- Part 1-33: Measurement methods and test procedures – Stress corrosion susceptibility
- Part 1-34: Measurement methods and test procedures – Fibre curl

Endorsement notice

The text of the International Standard IEC 60793-1-33:2001 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

Publications in the IEC 60793-1 series concern measurement methods and test procedures as they apply to optical fibres.

Within the same series several different areas are grouped, as follows:

- parts 1-10 to 1-19: General
- parts 1-20 to 1-29: Measurement methods and test procedures for dimensions
- parts 1-30 to 1-39: Measurement methods and test procedures for mechanical characteristics
- parts 1-40 to 1-49: Measurement methods and test procedures for transmission and optical characteristics
- parts 1-50 to 1-59: Measurement methods and test procedures for environmental characteristics.

OPTICAL FIBRES –

Part 1-33: Measurement methods and test procedures – Stress corrosion susceptibility

1 Scope and object

This part of IEC 60793 contains descriptions of the five main test methods concerning the determination of stress corrosion susceptibility parameters.

The object of this standard is to establish uniform requirements for the mechanical characteristic stress corrosion susceptibility. Dynamic fatigue and static fatigue tests are used in practice to determine stress corrosion susceptibility parameters, dynamic n -value and static n -value.

Any fibre mechanical test should determine fracture stress and fatigue properties under conditions that model the practical application as close as possible. Some appropriate test methods are available:

- A: Dynamic n value by axial tension (see annex A);
- B: Dynamic n value by two-point bending (see annex B);
- C: Static n value by axial tension (see annex C);
- D: Static n value by two-point bending (see annex D);
- E: Static n value by uniform bending (see annex E).

These methods are appropriate for types A1, A2 and A3 multimode and type B1 single-mode fibres.

Static and dynamic fatigue test methods show comparable results if both tests are performed in the same effective measuring time. For dynamic fatigue tests this means a measuring time which is $(n + 1)$ times larger than the measuring time of static fatigue tests.

When using static fatigue test methods, it has been observed that for longer measuring times and consequently lower applied stress levels, the n -value increases. The range of measuring times of the static fatigue tests, given in this standard, approaches the practical situation better than that of the dynamic fatigue tests, which in general are performed in relatively short time-frames.

These tests provide values of the stress corrosion parameter, n , that can be used for reliability calculations according to IEC 62048.

2 Normative references

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 62048, *The law theory of optical fibre reliability* ¹

¹ To be published.

3 Apparatus

See annexes A, B, C, D, and E for each of the layout drawings and other equipment requirements for each of the methods respectively.

4 Sampling and specimens

These measurements are statistical in nature. A number of specimens or samples from a common population are tested, each under several conditions.

Failure stress or time statistics for various sampling groups are used to calculate the stress corrosion susceptibility parameters.

4.1 Specimen length

Specimen length is contingent on the test procedure used. See the respective annexes A, B, C, D and E for the length required for the test method. For tensile tests, the length ranges from 0,5 m to at most 5 m. For two-point bending tests, the actual length tested is less than 1 cm and for uniform bending tests about 1 m.

4.2 Specimen preparation and conditioning

All of the test methods shall be performed under constant environmental conditions. Unless otherwise specified in the detail specification, the nominal temperature shall be in the range of 20 °C to 23 °C with a tolerance of ± 2 °C for the duration of the test. Unless otherwise specified in the detail specification, the nominal relative humidity (RH) shall be in the range of 40 % to 60 % with a tolerance of ± 5 % for the duration of the test.

Unless otherwise specified, all specimens shall be pre-conditioned in the test environment for a minimum period of 12 h.

The use of stress corrosion susceptibility (and proof stress) parameters for reliability estimates is still under consideration. A method for extrapolating such parameters to service environments different from the default environment specified above has not been developed.

It has been observed that the value of n produced by these tests can change after even brief exposure of the fibre to elevated temperature and humidity. A guide for the use of these methods is documented in IEC 62048.

The observed value of stress corrosion susceptibility parameter, n , may differ between fatigue test methods. Influences on the results have been observed concerning the measuring time and the applied stress level. Care should be taken in the choice of test method. This should be agreed between the user and manufacturer.

5 Reference test method

Method A is the reference test method and shall be used to resolve disputes because it yields minimal values compared to the others and may be completed in a duration practical for dispute resolution.

6 Procedure

See annexes A, B, C, D and E, respectively, for the individual test methods.

Each of several samples (consisting of a number of specimens) is exposed to one of a number of stress conditions. For static fatigue tests, a constant stress is applied from sample to sample and time to failure is measured. For dynamic fatigue tests, the stress rate is varied from sample to sample and the failure stress is measured.

The following is an overview of the procedures common to all methods:

- complete pre-conditioning;
- divide the specimens into sample groups;
- apply the specified stress conditions to each sample group;
- measure time or stress at failure;
- complete calculations

7 Calculations

The calculations for each individual test method are found respectively in annexes A, B, C, D and E.

8 Results

8.1 The following information shall be reported with each test:

- fibre identification;
- test date;
- stress corrosion susceptibility parameter;
- test method.

8.2 The following information shall be provided upon request:

- specific information as required by the test method;
- any special pre-conditioning.

Clauses A.5, B.5, C.5, D.5, and E.5 have results that apply respectively for each specific method.

9 Specification information

The detail specification shall specify the following information:

- information to be reported;
- any deviations to the procedure that apply;
- failure or acceptance criteria.

Annex A (normative)

Dynamic n value by axial tension

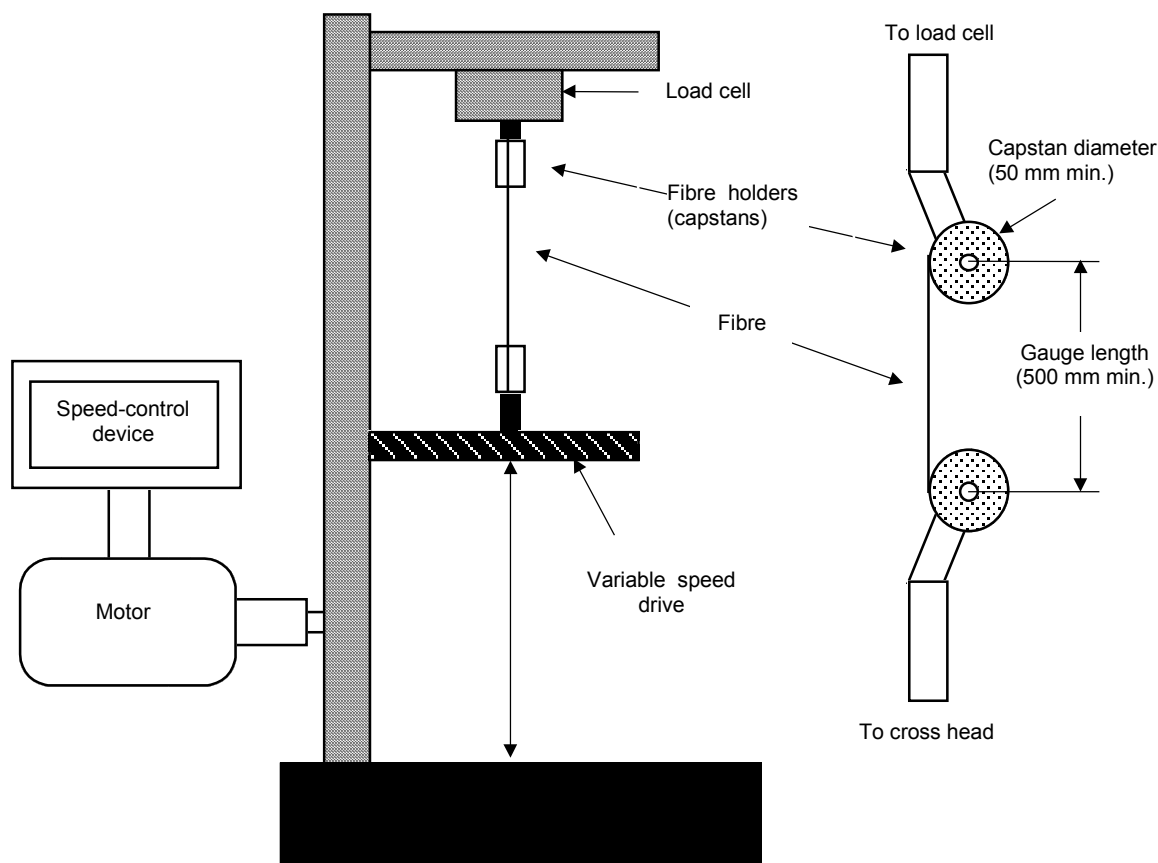
This method is designed for determining the dynamic stress corrosion susceptibility parameter (dynamic n value, n_d) of optical fibre at specified constant strain rates.

This method is intended only to be used for use with those optical fibres of which the median fracture stress is greater than 3 GPa at the highest specified strain rate. For fibres with median fracture stress less than 3 GPa, the conditions herein have not demonstrated sufficient precision.

This method is intended to test fatigue behaviour of fibres by varying the strain rate. The test is applicable to fibres and strain rates for which the logarithm of fracture stress versus the logarithm of strain rate behaviour is linear.

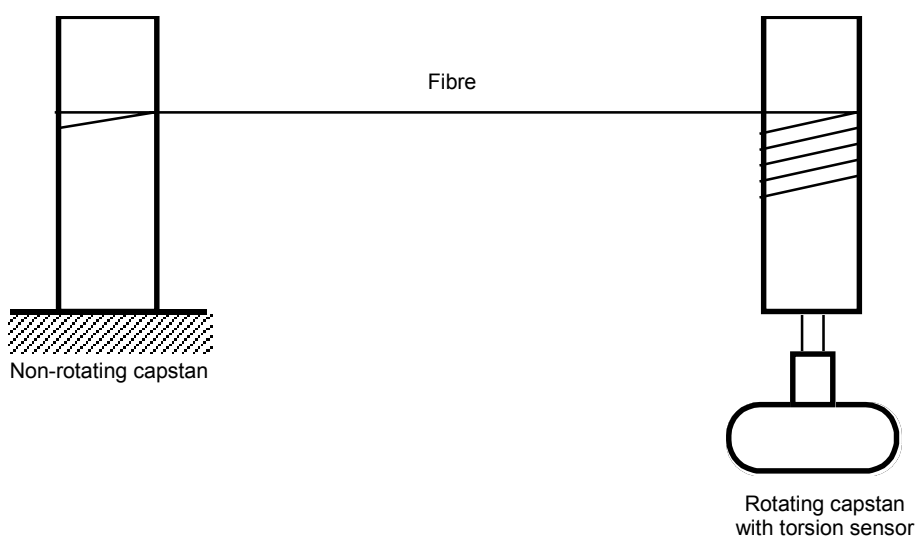
A.1 Apparatus

This clause describes the fundamental requirements of the equipment used for dynamic fracture stress testing. There are several configurations that meet these requirements. Examples are presented in figures A.1 to A.3. Unless otherwise specified in the detail specification, use a gauge length of 500 mm for tensile test specimens.



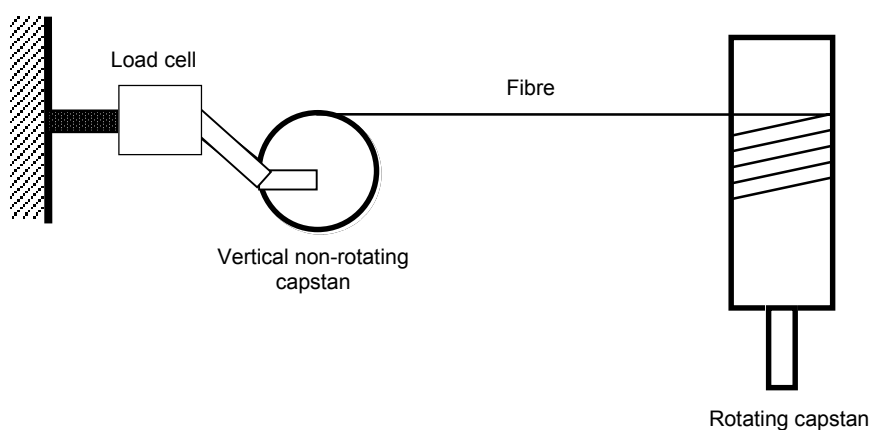
IEC 1385/01

Figure A.1 – Schematic of translation test apparatus



IEC 1386/01

Figure A.2 – Schematic of rotational test apparatus



IEC 1387/01

Figure A.3 – Schematic of rotational test apparatus with load cell

A.1.1 Support of the specimen

Grip the fibre length to be tested at both ends and subject the fibre to tension until fracture occurs in the gauge length section of the fibre. Minimize the fibre fracture at the grip by providing a surface friction that prevents excessive slippage.

Do not include breaks that occur at the grip in the sample or use them in the calculations.

Use a capstan, optionally covered with an elastomeric sheath, to grip the fibre. Wrap a section of the fibre that will not be tested around the capstan several times and secure it at the end with, for example, an elastic band or masking tape. Wrap the fibre with no crossovers. The gauge length is the length of fibre between the axes of the gripping capstans before it is stretched.

Use a capstan and pulley diameter so that the fibre is not subjected to a bending stress that causes the fibre to break on the capstan. For typical silica based fibres, the bending stresses shall not exceed 175 MPa when the fibre is wrapped as shown in the figures or traverses a pulley. (For 125/250 μm – cladding/coating – silica fibre, the minimum capstan diameter is then 50 mm.) Provide a capstan surface tough enough that the fibre does not cut into it when fully loaded. This condition can be determined by pre-testing.

A.1.2 Stressing application

Elongate the fibre at a fixed strain rate until it breaks. The rate of elongation is expressed as percentage per minute, relative to the gauge length. Two examples for doing this are as follows:

- a) increase the separation between the gripping capstans by moving one or both of the capstans at a fixed rate of speed, with the starting separation equal to the gauge length (figure A.1); or
- b) rotate one or both of the gripping capstans, to take up the fibre under test (see figures A.2 and A.3).

The strain rate is the change in length between the two locations, in per cent, divided by the time.

If method b) is used, ensure that the fibre on the capstan does not cross over itself as it is wrapped.

If fibres are tested simultaneously, protect each fibre from adjacent fibres so that whiplash at fracture does not damage other fibres under test.

A.1.3 Fracture force measurement

Measure the tensile stress during the test and at fracture for each test fibre by a load cell, calibrated to within 0,5 % (0,005) of the fracture or maximum load, for each range of fracture stress. Calibrate the load cell while oriented in the same manner as when testing the fibre under load. For method b), use a light, low-friction pulley (or pulleys) in place of the non-rotating capstan (see figure A.2), or the rotating capstan (see figure A.3), when calibrating load cells with a string and calibration weight.

Use a string, attached at one end to the load-measuring device (or its capstan), to duplicate the direction of an actual test fibre and be of a thickness or diameter comparable to that of a test fibre. A minimum of three calibration weights are recommended for load cell calibration which bracket the typical fracture or maximum load (50 % below maximum, maximum and 50 % above maximum).

Recording the maximum tensile load at the time of fracture may be obtained for example by a strip chart recorder. The response time shall be sufficient to report the fracture stress within 1 % of the actual value.

NOTE Frictional effects from the pulleys can lead to substantial errors in the load cell calibration of rotating capstan testers for horizontally mounted fibre.

A.1.4 Strain rate control

Determine the setting for the speed control unit by trial in order to meet the specified strain rates. Express the strain rate as a percentage of gauge length per unit time. Unless otherwise specified in the detail specification, the maximum strain rate shall be equal to or less than 100 %/min. Select the actual maximum strain rate by taking into account aspects of the test

method such as equipment considerations, material properties of the samples, etc. In addition to the maximum rate, use three additional strain rates, each reduced sequentially by roughly a power of 10 from the maximum.

It is possible to minimize test duration by using a faster strain rate in conjunction with a reduced load. For example, if a strain rate of 0,025 %/min is specified, test some specimens at the next fastest rate (0,25 %/min) to establish a range of fracture stress. Then pre-load to a level equal to or less than 80 % of the lowest fracture stress found for the initial trial specimens at the next fastest rate.

A.1.5 Stress rate characterization

The stress rate may vary with fibre type, equipment, breaking stress, fibre slippage, and strain rate. Characterize the stress rate, $\dot{\sigma}_a$, at each strain rate used in the fatigue calculation according to:

$$\dot{\sigma}_a = \frac{0,2 \times \sigma_f}{t(\sigma_f) - t(0,8 \times \sigma_f)} \quad (\text{A.1})$$

where

σ_f is the fracture stress;

$t(\sigma_f)$ is the time to fracture;

$t(0,8 \times \sigma_f)$ is the time at 80 % of the fracture stress.

A.2 Test sample

A.2.1 Sample size

Because of the variability of test results, test a minimum of 15 specimens for each strain rate, and drop the lowest breaking fracture stress data point for each strain rate. Alternatively, if the standard error of estimate of slope σ_f vs. $\dot{\sigma}_a$ is 0,0017 or greater (as explained in F.2), test a minimum of 30 specimens for each strain rate and drop the lowest two breaking fracture stress data points for each strain rate.

A.2.2 Sample size (optional)

As explained in clause A.2.1, additional specimens may be required for some applications in which the confidence interval on the estimate of the dynamic (tension) stress corrosion susceptibility parameter, n_d needs to be known. Refer to table F.1 for various sample sizes, depending upon the expected dynamic Weibull slope, m_d . Appropriate use of the algorithm in clause F2 is restricted to tests in which the same sample size is specified for each strain rate.

A.3 Procedure

This procedure describes how to obtain fibre fracture stress on a given sample set tested at a given strain rate. Calculations of population statistics are presented in clause F.2.

A.3.1 Set and record the gauge length (see A.1.2).