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Optical fibres –
Part 1-31: Measurement methods and test procedures – Tensile strength

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CONTENTS

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OPTICAL FIBRES –

Part 1-31: Measurement methods and test procedures – Tensile strength

FOREWORD

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International Standard IEC 60793-1-31 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 2001. This edition constitutes a technical revision.

The main change with respect to the previous edition is the addition of comprehensive details, such as examples of fibre clamping as given in Annexes A, B and C.

The text of this standard is based on the following documents:

CDV	Report on voting
86A/1285/CDV	86A/1308/RVC

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

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

A list of all parts of the IEC 60793-1series, published under the general title *Optical fibres – Measurement methods and test procedures*, can be found on the IEC website.

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

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- withdrawn,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

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

INTRODUCTION

Failure stress distributions can be used to predict fibre reliability in different conditions. IEC/TR 62048 shows mathematically how this can be done. To complete a given reliability projection, the tests used to characterize a distribution shall be controlled for the following:

- Population of fibre, e.g., coating, manufacturing period, diameter
- Gauge length, i.e., length of section that is tested
- Stress or strain rates
- Testing environment
- Preconditioning or aging treatments
- Sample size

This method measures the strength of optical fibre at a specified constant strain rate. It is a destructive test, and is not a substitute for prooftesting.

This method is used for those *typical* optical fibres for which the median fracture stress is greater than 3,1 GPa (450 kpsi) in 0,5 m gauge lengths at the highest specified strain rate of 25 %/min. For fibres with lower median fracture stress, the conditions herein have not demonstrated sufficient precision.

Typical testing is conducted on “short lengths”, up to 1 m, or on “long lengths”, from 10 m to 20 m with sample size ranging from 15 to 30.

The test environment and any preconditioning or aging is critical to the outcome of this test. There is no agreed upon model for extrapolating the results for one environment to another environment. For failure stress at a given stress or strain rate, however, as the relative humidity increases, failure stress decreases. Both increases and decreases in the measured strength distribution parameters have been observed as the result of preconditioning at elevated temperature and humidity for even a day or two.

This test is based on the theory of fracture mechanics of brittle materials and on the power-law description of flaw growth (see IEC TR 62048). Although other theories have been described elsewhere, the fracture mechanics/power-law theory is the most generally accepted.

A typical population consists of fibre that has not been deliberately damaged or environmentally aged. A typical fibre has a nominal diameter of 125 µm, with a 250 µm or less nominal diameter acrylate coating. Default conditions are given for such typical populations. Atypical populations might include alternative coatings, environmentally aged fibre, or deliberately damaged or abraded fibre. Guidance for atypical populations is also provided.

OPTICAL FIBRES –

Part 1-31: Measurement methods and test procedures – Tensile strength

1 Scope

This part of IEC 60793 provides values of the tensile strength of optical fibre samples and establishes uniform requirements for the mechanical characteristic – tensile strength. The method tests individual lengths of uncabled and unbundled glass optical fibre. Sections of fibre are broken with controlled increasing stress or strain that is uniform over the entire fibre length and cross section. The stress or strain is increased at a nominally constant rate until breakage occurs.

The distribution of the tensile strength values of a given fibre strongly depends on the sample length, loading velocity and environmental conditions. The test can be used for inspection where statistical data on fibre strength is required. Results are reported by means of statistical quality control distribution. Normally the test is carried out after temperature and humidity conditioning of the sample. However, in some cases, it may be sufficient to measure the values at ambient temperature and humidity conditions.

This method is applicable to types A1, A2, A3, B and C optical fibres.

Warning – This test involves stretching sections of optical fibre until breakage occurs. Upon breakage, glass fragments can be distributed in the test area. Protective screens are recommended. Safety glasses should be worn at all times in the testing area.

2 Normative references

The following referenced documents are indispensable for the application of this document. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-1-20, *Optical fibres – Part 1-20: Measurement methods and test procedures – Fibre geometry*

IEC 60793-1-21, *Optical fibres – Part 1-21: Measurement methods and test procedures – Coating geometry*

3 Apparatus

3.1 General

This clause prescribes the fundamental requirements of the equipment used for dynamic strength testing. There are many configurations that can meet these requirements. Some examples are presented in Annex A. The choice of a specific configuration will depend on such factors as:

- gauge length of a specimen
- stress or strain rate range
- environmental conditions
- strength of the specimens.

3.2 Gripping the fibre at both ends

Grip the fibre to be tested at both ends and stretch it until failure occurs in the gauge length section. The grip shall not allow the fibre to slip out prior to failure and shall minimize failure at the grip.

Record a break that occurs at the grip, but do not use it in subsequent calculations. Since fibre strain is increasing during the test, some slippage occurs at the grip. At higher stress levels, associated with short gauge lengths, slippage can induce damage and cause gripping failures that are difficult to ascertain. The frequency of such failures can often vary with stress or strain rate. Careful inspection of the residual fibre pieces, or other means, is required to prevent the possibility of including gripping failures in the analysis.

Use a capstan, typically covered with an elastomeric sheath, to grip the fibre (see Figure A.1). Wrap a section of fibre that will not be tested around the capstan several times and secure the fibre at the ends with, for example, an elastic band. Wrap the fibre with no crossovers. The capstan surface shall be tough enough so that the fibre does not cut into it when fully loaded. The amount of slippage and capstan failures depends on the interaction of the fibre coating and the capstan surface material, thickness, and number of wraps. Careful preliminary testing is required to confirm the choice of a capstan surface.

Design the diameter of the capstan and pulley so that the fibre does not break on the capstan due to bend stress. For typical silica-clad fibres, the bend stresses shall not exceed 0,175 GPa. (For typical 125/250 µm silica fibre, the minimum capstan diameter is then 50 mm.) A particular gripping implementation is given in Annex B.

3.3 Sample support

Attach the specimen to the two grips. The gauge length is the length of fibre between the axes of the gripping capstans before it is stretched. To reduce the space required to perform the test on long gauge lengths, one or more pulleys may be used to support the specimen (see Figure A.4). The pulleys shall be designed, and their surfaces kept free of debris, so the fibre is not damaged by them. The remainder of the fibre, away from pulleys and capstans, shall not be touched.

When multiple fibres are tested simultaneously, as in Figure A.5, a baffle arrangement is required to prevent a broken fibre from snapping into, or otherwise perturbing the other fibres under test.

3.4 Stretching the fibre

Stretch the fibre at a fixed nominal strain rate until it breaks. The nominal strain rate is expressed as the percent increase in length per minute, relative to the gauge length.

There are two basic alternatives for stretching the fibre:

– Method A: Increase the separation between the gripping capstans by moving them apart at a fixed rate of speed, with the starting separation equal to the gauge length (Figure A.2 of Annex A).

– Method B: Rotate a capstan at a fixed rate to take up the fibre and strain the section between capstans (Figures A.3 to A.5 of Annex A). The rotation shall not result in crossovers on the capstan.

Calibrate the strain rate to within ±10 % of the nominal strain rate. Some equipment configurations are computer-controlled and allow dynamic control of the capstan motion to produce a constant stress rate. A particular implementation of this is given in Annex C.

The strain rate shall be agreed between customer and supplier. A strain rate range of either 2,5 % to 5 % or 15 % to 25 % is typically used.

3.5 Measuring the force at failure

Measure the tensile load (force in tension) at failure for each specimen by a calibrated load cell, to within ±1 % of the actual load. This can be done with a variety of methods:

- strip chart recorder
- peak and hold meter
- computer sampling.

Provide a means of measuring the tensile load as a function of time to determine the stress rate. This is not required for each individual test, but shall be done occasionally.

Calibrate the load cell to within 0,5 % of the failure, or maximum load, for each range of failure loads, while it is oriented in the same manner as when testing a fibre. Do this by substituting a string attached to a known weight for the test specimen. For method B, a light, low-friction pulley can be used in place of the capstan that is not attached to the load cell. The string, with one end attached to the load cell capstan and the other end attached to a known weight, shall duplicate the direction of a test specimen and be of a diameter comparable to that of a test specimen. A minimum of three calibration weights, bracketing the typical failures, is recommended.

3.6 Environmental control equipment

Measured failure stress and fatigue characteristics are known to vary with temperature and humidity of the fibre, both of which shall be controlled during both preconditioning and test. Many equipment configurations might be used to provide the required controls, including controls on the entire room in which testing is conducted.

Typical control requirements are:

- Temperature: 23 ± 2 °C
- Relative Humidity: 50 ± 5 %.

Alternative test environments, such as high non-precipitating humidity, can be achieved by enclosing the test specimen and injecting water vapour into the enclosure. Figure A.5 shows a ganged tester that includes an enclosure over a circulating water bath.

4 Sample preparation

4.1 Definition

A sample is one or more fibres from a population. Each sample provides a result by cutting it into smaller lengths called specimens. Testing results on these specimens are combined to yield an overall result for the sample. The term "sample size" is used to indicate the number of specimens tested in rest of this standard.

For ribbonized fibre, select the specimens uniformly across the ribbon structure. Exercise caution in removing fibre from the ribbon to avoid inadvertent strength reduction.

4.2 Sample size and gauge length

The result of testing is a statistical distribution of failure stress values. Hence all reported parameters are statistical in nature, with inherent variability that is a function of the sample size and the variability of flaw size within the sample. The weakest site, or largest flaw, within a specimen will fail, and the typical failure stress decreases as gauge length increases.