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TECHNICAL REPORT

colour inside

Optical fibres – Measurement methods – Microbending sensitivity

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CONTENTS

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OPTICAL FIBRES – MEASUREMENT METHODS – MICROBENDING SENSITIVITY

FOREWORD

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IEC 62221, which is a technical report, 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, and constitutes a technical and editorial revision.

The main changes with respect to the previous edition are listed below:

a) updates related to B6 (bend-insensitive) category single-mode fibres;
b) inclusion of a definition for microbending and general properties;
c) expansion of general considerations;

d) more details given for each method;

e) addition of an Annex A.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
86A/1460/DTR	86A/1470/RVC

Full information on the voting for the approval of this technical report 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.

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- withdrawn,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.

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OPTICAL FIBRES –
MEASUREMENT METHODS –
MICROBENDING SENSITIVITY

1 Scope

IEC 62221, which is a technical report, describes four methods (A, B, C and D) for the measurement of microbending sensitivity of optical fibres.

These four methods are distinguished by the equipment being used for measurements and their applications:

- method A using an expandable drum and applies to category A1 and class B fibres;
- method B using a fixed diameter drum and applies to category A1 and class B fibres;
- method C using a plate and applied loads and applies to category A1 and class B fibres;
- method D using a "basketweave" wrap on a fixed diameter drum, and applies to category A1 and class B fibres

Methods A and B may also be used to measure the microbending sensitivity of optical fibre ribbons.

Methods A and C offer the capability to measure the microbending sensitivity over a wide range of applied linear pressure or loads. Method B may be used to determine the microbending sensitivity for a fixed linear pressure.

Methods A, B and D can also be used at different temperatures (temperature cycling) provided special low thermal expansion materials (e.g. quartz drums) are used.

The results from the four methods can only be compared qualitatively. These methods are considered characterization type tests.

It shall be understood that the microbend results from any method, could have significant variation between laboratories.

These methods do not constitute a routine test used in the general evaluation of optical fibre. This parameter is not generally specified within a detail specification.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-1-1:2008, *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance*

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

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 and test procedures – Monitoring of changes in optical transmittance*

IEC 62614, *Fibre optics – Launch condition requirements for measuring multimode attenuation*

3 General properties of microbending loss

Added loss due to microbending occurs when localized lateral forces along the length of the fibre appear. These may be caused by manufacturing and installation strains, as well as dimensional variations in the cable materials due to temperature changes. Sensitivity to microbending is a function of the difference of refractive index of the core and the cladding, and diameters of the core and cladding. Coating structure and material property may also have an influence.

The effect of microbending in single-mode fibres is increased optical loss at 1 310 nm, 1 550 nm and 1 625 nm wavelength ranges as opposed to macrobend effects in single-mode fibres that primarily is present in the longer wavelengths 1 550 nm and 1 625 nm.

In category A1 multimode fibres, microbending manifests itself in general nearly equally over a wide wavelength range (e.g. 850 nm – 1 320 nm).

To reduce microbending losses, the cable structure has to protect the optical fibres from lateral forces. Loose tube cable construction should be optimized to prevent buckling of the fibre in the tube during temperature changes leading to possible macrobending as well as microbending loss.

Cable components such as the cable sheath and the strength member are important because they also help to reduce the microbending caused by the external mechanical forces on the cable and by temperature changes.

Microbending losses may also be introduced in aerial cables subjected to excessive elongation (e.g. heavy ice loading).

4 General considerations

4.1 Launch condition for multimode fibres

Concerning multimode fibres, reference is made to the launching technique described in IEC 62614, as done for the macrobend test method.

4.2 Sample lengths

This technical report lists several methods to evaluate microbend sensitivity for optical fibres. One key difference is the sample length requirements for the different methods. Though the exact sample lengths may vary, a list with lengths that have been typically used is given here below:

Method	Length
A	300 m
B	400 m
C	2 m – 3 m
D	2,5 km

4.3 Winding tension

When using methods A, B or D, the control of the winding tension should be mentioned and carried out with a calibrated device. Added loss due to microbending is reasonably linear over a winding tension range from 1 N to 3 N, but different winding tensions could yield different normalised microbending sensitivity results. For methods A and B, careful winding is required with no crossovers in order to avoid negative influence on the correct winding force.

4.4 Relaxation time

Information about relaxation time should be given. Almost all fibres show some kind of coating relaxation effect, most probably dependant on the mechanical properties of the secondary layer of the primary coating. If no fixed relaxation time is used (time between ending the winding and starting the attenuation measurement) less repeatable results may be obtained. This relaxation time needs to be investigated by each user (depending on the particular coating system tested).

Other mechanical relaxation issues (such as humidity and temperature) have been observed such as the difference in storage temperature of the fibre spool and the winding/measurement conditions. This requires some description of the measurement conditions. Temperature cycling is an additional option in microbending testing.

4.5 Material used for fixed roughness

For methods A and B a fixed roughness material is required that is single wide with only one single seam such as wire mesh or adhesive sandpaper (e.g. a sandpaper/lapping film PSA – grade 40 μm – mineral Al_2O_3).

Reference measurements with known fibre are recommended to control quality of the measurement.

4.6 Drum materials

Any kind of material may be used for the drum used in methods B and D. The barrel shall uniform (seamless, smooth surface, constant diameter).

The drum shall be of material showing high strength with a relaxation modulus that remains in the glassy plateau region for the time duration of the test.

4.7 Drum material for temperature cycling

Methods A, B and D can be used for temperature cycling tests. This requires a low thermal expansion material (e.g. quartz drum).

The size of the drum doesn't need fixed dimensions. It is recommended that the drum diameter be at least 200 mm to minimize macrobending effects.

5 Test procedures

5.1 Method A: expandable drum

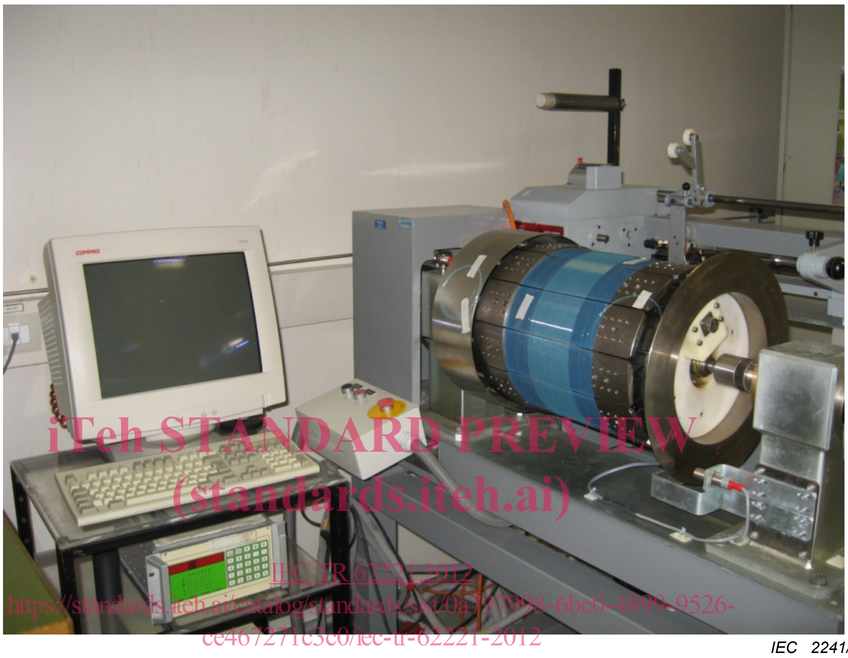
5.1.1 General

This subclause describes a technique for the measurement of the loss increase due to microbending effects induced by the application of linear pressure to category A1 and class B fibres. This method may also be used to measure the microbending sensitivity of optical fibre ribbons.

5.1.2 Apparatus

The apparatus is an expandable drum, the diameter of which can be changed continuously. In order to avoid any loss contribution due to macrobending effects a minimum drum diameter of 200 mm is recommended, see Figure 1. The curvature at any edges of the expanded segments of the drum also exceeds 200 mm diameter. The drum surface is coated with a material of fixed roughness (see subclause 4.5). The length under test should fit onto the expandable drum. The winding pitch is controlled to prevent the fibre/ribbon turns from overlapping.

While expanding the drum, the fibre elongation is measured using the phase-shift method (Method E of IEC 60793-1-22: 2001). The attenuation measurement is conducted using either the cut back technique (method A of IEC 60793-1-40: 2001), the backscatter technique (method C of IEC 60793-1-40: 2001) or by the direct transmitted power measurement technique (method A of IEC 60793-1-46: 2001).



IEC 2241/12

Figure 1 –Set-up for expandable drum method used in an optical fibre testing facility

5.1.3 Procedure

The fibre to be tested is carefully wound onto the coated drum with minimal tension (e.g. 0,4 N to 0,5 N) in one single layer avoiding any crossing or overlapping. The fibre is fixed to avoid any relative slipping. While expanding the drum the changes in attenuation coefficient and phase are recorded.

5.1.4 Calculations

The fibre elongation (ε) can be found from:

$$\varepsilon = \frac{\Delta\theta}{f \times L} \times V \qquad (1)$$

where

$\Delta\theta$ is the phase shift (degrees);

f is the modulation frequency (Hz);

L is the length of the sample (km);

V is the constant depending on the photo-elastic coefficient (k), the speed of light in vacuum (c) and the group index (N_g):