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TECHNICAL REPORT

Guidance on techniques for the measurement of the coefficient of friction (COF) between cables and ducts

colour inside

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GUIDANCE ON TECHNIQUES FOR THE MEASUREMENT OF THE COEFFICIENT OF FRICTION (COF) BETWEEN CABLES AND DUCTS

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IEC TR 62470, which is a technical report, has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

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

Enquiry draft	Report on voting
86A/1407/DTR	86A/1417/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- withdrawn,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
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GUIDANCE ON TECHNIQUES FOR THE MEASUREMENT OF THE COEFFICIENT OF FRICTION (COF) BETWEEN CABLES AND DUCTS

1 Scope and object

This technical report describes three techniques to measure the coefficient of friction (COF) between cables and ducts. For a given technique, cable construction, installation method (pulling, pushing, or blowing), and duct size, the relative values of the COF can give some indication as to the relative ease of installation. The techniques can be used for traditional cables and ducts (see IEC 60794-3-10) as well as for microduct cables and microducts (see IEC 60794-5). A fibre or fibre unit may be evaluated in place of a cable in all techniques.

Methods A, B, and C are distinguished by the equipment used for measurements:

- method A – using a wheel around which the duct is wound, a cable with attached weight being pulled through the latter, while measuring the force needed for this;
- method B – using a device to clamp a duct specimen, a cable specimen placed inside, tilting both while measuring the angle at which the cable specimen starts to slide, or the angle which sustains sliding; and
- method C – using a device to clamp and straighten a cable specimen, a duct specimen placed around it, tilting both while measuring the angle at which the duct specimen starts to slide, or the angle which sustains sliding.

The COF when the cable is not moving with respect to the duct is the static COF, and will increase until sliding suddenly starts. The COF while the cable is sliding within the duct is the kinetic or dynamic COF. It should be noted that the static COF will generally be a higher value than the kinetic COF.

The results from the three methods can be compared qualitatively, but are not represented as being equivalent. None of the methods are represented as being the Reference Test Method. Method A will yield the kinetic COF; methods B and C will yield both static and kinetic COF.

Both the static and kinetic COF may be dramatically affected by lubrication of the cable and/or duct. While not specifically addressed herein, the intent of these methods may be used with lubricated cable/duct samples.

These methods do not constitute a routine test used in the general evaluation of the installation performance of cables in ducts. This parameter is not generally specified within a detail specification.

2 Reference documents

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 documents (including any amendments) applies.

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

IEC 60794-3-10: *Optical fibre cables – Part 3-10: Outdoor cables – Family specification for duct, directly buried and lashed aerial optical telecommunication cables*

IEC 60794-5: *Optical fibre cables – Part 5: Sectional specification – Microduct cabling for installation by blowing*

3 Test procedures

3.1 Method A: wheel test

3.1.1 General

This subclause describes a technique for the measurement of the COF between a cable specimen and a duct specimen, an important parameter for the installation performance (pushing, pulling, blowing, etc.) of the cable in the duct; see IEC 60794-1-1:2001, Annex C (to be IEC/TR 62691). This method particularly evaluates the friction seen when a cable travels around a curve in a duct.

In this method, a cable specimen with attached weight is pulled through a duct specimen wound around the wheel and the pulling force is measured.

Several variants of wheel tests are used with different weights, diameters, and angles over which the duct is pulled over the wheel. Sometimes a pulley is also used to direct the cable in line with the pulling/force-measuring device. One variant is given here as an example.

3.1.2 Sample

The test sample comprises a duct specimen and a cable specimen of the type under consideration. A new, clean, grease-free specimen of each is required for each test to avoid the effects of wear and contamination. Sometimes a dummy cable, with the same weight but a lower stiffness than the cable to be tested, is used to minimise stiffness effects at the ends of the ducts.

The duct specimen is of sufficient length to wrap around the wheel or segment (see 3.1.3) the number of times required by the detail specification, with an additional length for an entrance and exit end (see Figure 1 and 3.1.4). Typically, 1 wrap around the wheel is used.

The cable specimen shall be long enough to fit within the duct specimen, with additional length to accommodate attachments at each end (see 3.1.3 and 3.1.4) and gauge length(s) for all test runs (see 3.1.4).

3.1.3 Apparatus

A wheel with radius R per the detail specification (50 ± 2 cm is the suggested standard value) is placed before a tensile test machine, see Figure 1. A mass, M, is attached to the tail end of the cable specimen to provide the specimen with a counter-weight, W (see Figure 1). The weight serves to simulate the upstream functional force, as friction from a long length of cable. The arrangement allows the pulling force to be measured where a cable specimen is pulled through a duct specimen wound around the wheel.

In the case of installation by blowing the attached weight in the wheel test must be small in order to simulate the friction in blowing practice as closely as possible. In this case its mass M should be approximately equal to the mass of a length of 2 m of the cable specimen. The low forces involved in said case do not allow the use of (relatively small diameter) pulleys, where bending the cable, thus dissipating energy, results in extra forces that cannot be ignored.

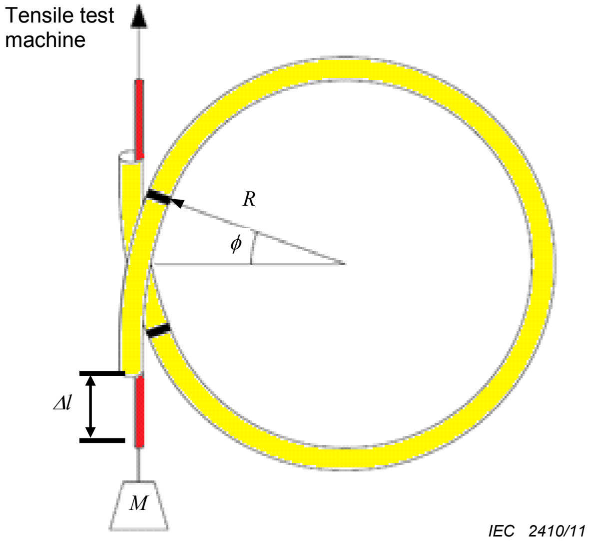

Figure 1 – Sketch of a wheel test

3.1.4 Procedure

The procedure follows the intent of the following steps, with variations as necessary for the specific test:

- Wind the duct specimen firmly around the wheel over the arc for the number of turns specified in the detail specification (360°, 1 wrap, is a common value). At each end of the duct specimen, a free angle, ϕ, of about 10° is provided (see Figure 1). This minimises the effect of bending a cable with stiffness from straight to curved.
- Insert the cable specimen into the duct by pushing or pulling, as appropriate. Take care to avoid damaging the inner surface of the duct.
- Attach a weight to the cable. The value of the mass is per the detail specification, mindful of the discussion in 3.1.3.
- Pull the cable through the duct at the specified speed for the specified length, continuously measuring the force. This sequence is the test run. A speed of 1,0 or 1,8 m/min is frequently used. A first length pulled is ignored in evaluating the force (typically 20 cm), thereafter, the force is measured for a gauge length (typically 50 cm).

  NOTE 1 The measured COF can be affected by the speed used in the test. The relationship of the measured COF to the effective COF in actual installations can therefore be affected. The actual installation speeds of interest could be used in the test, but this might lead to needing longer cable specimens in the test and modification of the test setup.

- Repeat the test run several times, as specified, and average the pulling force. Typically, about five test runs are performed. The data should be examined for outliers. Often, the first one or two test runs should be excluded from the averaging, best simulating the long length cable sliding found in a practical installation.

3.1.5 Calculations

The COF can be found from:

$$F = (Mg + W\Delta)\exp(2n\pi f) + \frac{2f}{1+f^2} WR\left[\exp(2n\pi f) - 1\right] \qquad (1)$$

where