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Foreword

This final draft Interim European Telecommunication Standard (I-ETS) has been produced by the Transmission and Multiplexing (TM) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now submitted for the Voting phase of the ETSI standards approval procedure.

An ETSI standard may be given I-ETS status either because it is regarded as a provisional solution ahead of a more advanced standard, or because it is immature and requires a "trial period". The life of an I-ETS is limited to three years after which it can be converted into an ETS, have its life extended for a further two years, be replaced by a new version, or be withdrawn.

Proposed announcement date	
Date of latest announcement of this I-ETS (doa):	3 months after ETSI publication

Introduction

This I-ETS concerns the functional requirements for single-mode optical fibre to be used in cables for indoor applications. Normative references are made to test methods and acceptance criteria in various CEN and ISO/IEC documents (see clause 2).

NOTE: The content of this I-ETS is the subject of an agreement between ETSI STC TM1 and CENELEC/TC CECC SC86A and is covered by a formal CENELEC/CECC - ETSI co-operation agreement.

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1 Scope

This Interim European Telecommunication Standard (I-ETS) specifies the requirements of single fibre and multi-fibre single-mode optical fibre cables to be used for indoor application. This I-ETS is intended to be used to prepare the relevant detail specifications for indoor cable to cover the different conditions experienced in Europe.

This I-ETS does not cover cable assemblies, such as connectorized jumper cable, or the functional requirements for cable break-out.

2 Normative references

This I-ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this I-ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] EN 188101 (1995): "Family Specification: Single-mode dispersion unshifted (B1.1) optical fibre".

[2] EN 188102 (1996): "Family Specification: Single-mode dispersion shifted (B2) optical fibre".

[3] EN 187000 (1995): "Generic specification: Optical fibre cables".

[4] EN 188000 (1995): "Generic specification: Optical fibres".

[5] CENELEC HD 624.7 (1994): "Materials used in communication cables; Part 7: Halogen free flame retardant thermoplastic sheathing compounds".

[6] ISO/IEC 304 (1982): "Standard colours for insulation for low-frequency cables and wires".

[7] ISO/IEC 332-1 (1993): "Tests on electric cables under fire conditions; Part 1: Test on a single vertical insulated wire or cable".

[8] ISO/IEC 332-3 (1992): "Tests on electric cables under fire conditions; Part 3: Tests on bunched wires or cables".

[9] ISO/IEC 754-2 (1991): "Test on gases evolved during combustion of electric cables; Part 2: Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity".

[10] ISO/IEC 811-4-2 (1990): "Common test methods for insulating and sheathing materials of electric cables; Part 4: Methods specific to polyethylene and polypropylene compounds; Section 2: Elongation at break after preconditioning - Wrapping test after preconditioning - Wrapping test after thermal ageing in air - Measurement of mass increase - Long-term stability test (Appendix A) - Test method for copper-catalysed oxidative degradation (Appendix B)".

[11] ISO/IEC 811-5-1 (1990): "Common test methods for insulating and sheathing materials of electric cables; Part 5: Methods specific to filling compounds; Section 1: Drop-point - Separation of oil - Lower temperature brittleness - Total acid number - Absence of corrosive components - Permittivity at 23°C - D.C. resistivity at 23°C and 100°C ".

[12] ISO/IEC 1034-1 (1990): "Measurement of smoke density of electric cables burning under defined conditions; Part 1: Test apparatus".

[13] ISO/IEC 1034-2 (1991): "Measurement of smoke density of electric cables burning under defined conditions; Part 2: Test procedure and requirements".

[14] ISO/IEC 754-1 (1994): "Test on gases evolved during combustion of electric cables; Part 1: Determination of the amount of halogen acid gas evolved during the combustion of polymeric materials taken from cables".

3 Symbols

For the purposes of this I-ETS, the following symbols apply:

CECC	CENELEC Electronic Components Committee
CENELEC	Comité Européen de Normalisation Electrotechnique
λ_{cc}	Cabled fibre cut-off wavelength
SZ	A technique in which the lay reverses direction periodically
T_0	Threshold below which no attenuation and/or fibre strain increase should occur in the tensile strength test
T_m	The acceptable amount of transient stress that can be applied to the cable without permanent degradation of the characteristics of the fibres in the tensile strength test
T_{A1}	Temperature cycling test temperature limit
T_{A2}	Temperature cycling test temperature limit
T_{B1}	Temperature cycling test temperature limit
T_{B2}	Temperature cycling test temperature limit
t_1	Temperature cycling test dwell time

4 Optical fibre

4.1 General

Single-mode optical fibres shall be used which meet the requirements of EN 188101 [1] or EN 188102 [2].

4.2 Attenuation

4.2.1 Attenuation coefficient

The typical maximum attenuation coefficient of a cable at 1 310 nm is 0,50 dB/km and/or at 1 550 nm it is 0,40 dB/km.

Particular values shall be agreed between the user and the manufacturer.

The attenuation coefficient shall be measured in accordance with EN 188000 [4] test method 301, 302 or 303.

4.2.2 Attenuation uniformity

4.2.2.1 Attenuation discontinuities

The local attenuation shall not have point discontinuities in excess of 0,1 dB. The test method best suited to provide the functional requirements is for further study.

4.2.2.2 Attenuation linearity

The functional requirements are for further study.

4.3 Cut-off wavelength

The cabled fibre cut-off wavelength (λ_{cc}) shall be less than the operational wavelength.

4.4 Fibre colouring

If the primary coated fibres are coloured for identification, the coloured coating shall be readily identifiable throughout the lifetime of the cable and shall be a reasonable match to ISO/IEC 304 [6]. If required, the colouring shall let sufficient light be transmitted through the primary coating to allow local light injection and detection. Alternatively the colour may be removed for this application.

A test for the resistance of the colour to cleaning agents is for further study.

5 Secondary protection

The material(s) used for the secondary protection shall be selected to be compatible with the other elements with which it is in contact. An appropriate compatibility test method is defined in ISO/IEC 811-4-2 [10].

If the fibres are in contact with a filling compound, the filling compound shall be easily removable.

5.1 Secondary coating

If a tight or semi-tight secondary coating is required, it shall consist of one or more layers of inert material. The nominal overall diameter of the tight secondary coating shall be between 800 µm and 900 µm with a tolerance of ±50 µm. The nominal overall diameter of the semi-tight secondary coating shall be between 800 µm and 1 100 µm with a tolerance of ±100 µm.

The fibre/secondary coating eccentricity shall not exceed 75 µm unless otherwise agreed between the user and the manufacturer.

The colour of the secondary coating shall be readily identifiable throughout the lifetime of the cable. The macrobending sensitivity of the secondary coated fibre shall be determined in accordance with EN 188000 [4] test method 318 for 1 dB with 60 mm mandrel, when tested at a temperature in the range -10°C to -45°C in accordance with particular user requirements.

Values for the coating removal force for tight and semi-tight secondary coated fibres are for further study.

The semi-tight secondary coating shall be easily removable, in one operation, over a length of 0,3 m - 2,0 m, depending on user requirements. For tight secondary coated fibres, the primary and secondary coatings shall be easily removable, in one operation, over a length of 15 mm to 25 mm, depending on user requirements.

5.2 Slotted core

The slotted core is obtained by extruding a suitable material (for example polyethylene or polypropylene). A cylindrical core containing a defined number of slots, with helical or SZ configuration along the core, is obtained. One or more primary coated fibres are located in each slot which may be filled.

The slotted core usually contains a central element which may be either metallic or non-metallic. In this case, there shall be adequate adhesion between the central element and the extruded core in order to obtain the required temperature stability and tensile behaviour for the slotted core element.

The profile of the slot shall be uniform and shall ensure the optical and mechanical performance required of the optical cable.

5.3 Loose tube

One or more primary coated fibres are packaged in a loose tube construction which may be filled. The loose tube may be reinforced with a composite wall.

One aspect of the suitability of the tube shall be determined by an evaluation of its kink resistance in accordance with EN 187000 [3] test method 512.

The bleeding performance of the filling compound from the tube shall comply with EN 187000 [3] test method 608.

If required, the macrobending sensitivity of the fibre in loose tube shall be determined in accordance with EN 187000 [3] test method 318 for 1 dB with a 60 mm mandrel, when tested at a temperature in the range -10°C to -45°C in accordance with particular user requirements.

5.4 Ribbon

The fibre ribbon consists of a "ribbon like" linear array of a defined number of individually coated optical fibres.

In this I-ETS, the details and characteristics of the ribbon construction shall be defined as follows:

- the number of fibres is between two and twelve according to user requirements;

- the colours of the fibres and ribbons if any, shall be agreed between the user and the manufacturer;

- if required, the ribbon shall be capable of being divided into sub-units or individual optical fibres. If the ribbon is divided into sub-units, the coating layer shall remain intact and preserve the integrity of the sub-units;

- if the ribbon is divided into individual coloured optical fibres, these shall remain easily identifiable and the colour coated layer and the primary coating shall remain undamaged;

- the coating of the single fibres, as well as the coating(s) of the ribbon, shall be easily removed. The method shall be agreed between the user and manufacturer;

- if additional mechanical tests are required, other than those already specified in the generic specifications EN 187000 [3] and EN 188000 [4], they shall be specified in the detail specification;

- fibre alignment and planarity shall be in accordance with the detail specification. More stringent requirements may need to be agreed between the user and the manufacturer, depending on the splice or the connector technique employed;

- additional environmental requirements, if any, shall be agreed between the user and the manufacturer.

6 Optical fibre cable construction

6.1 General

The cable shall be designed and manufactured for a predicted operating lifetime of at least 20 years. In this context, the attenuation of the installed cable at the operating wavelength(s) shall not exceed values agreed between the user and the manufacturer. The materials in the cable shall ensure that the increase in attenuation shall not exceed the specified value.

All the fibres in the cable shall be of the same type and origin.

There shall be no fibre splice in a delivery length unless otherwise agreed by the user and the manufacturer.

It shall be possible to identify each individual fibre throughout the length of the cable.

6.2 Lay up of the cable elements

6.2.1 Single fibre cables

The indoor single fibre cable may consist of a secondary coated fibre surrounded by strength members (see subclause 6.4) and protected by an oversheath (see subclause 6.6). It may also be sheath marked (see subclause 6.7).

6.2.2 Multi-fibre cables

Secondary protected optical units as described in clause 5, and/or single fibre cables as described in subclause 6.2.1, may be laid up as follows:

a) single or multiple optical unit(s) without a stranding lay (for a single tube its kink resistance shall be evaluated only if required);

b) a number of homogeneous optical units using helical or SZ configurations (ribbon units may be laid up by stacking two or more units);

c) a number of hybrid configurations in slotted core such as: tight coated, slotted core, ribbon, or loose tube;

d) a number of hybrid configurations in loose tube such as tight coated or ribbon.

If required, insulated copper conductors in single, pair or quad construction may be laid up with the optical units.

With the cable set at its minimum bend radius the maximum fibre strain due to the bending of the fibre shall be agreed between the user and the manufacturer.

6.3 Cable core filling

Cables used for indoor purposes are typically unfilled.

However, if agreed between the user and the manufacturer, the cable core may be continuously filled with water blocking compound, water blocks may be applied at regular intervals or water blocking materials may be introduced to prevent water seepage through the cable.

The material shall be non-toxic, free from bad smell and it shall not provide a health hazard. The material shall be easily removed without the use of materials considered to be hazardous or dangerous.

The blocking material used shall be compatible with the other relevant cable elements. Where the blocking material swells in water compliance shall be agreed between the user and the manufacturer. Where a filling compound is used its suitability shall be demonstrated by the use of the following test methods:

a) the amount of oil separation from the filling compound shall meet the requirements of clause 5 of ISO/IEC 811-5-1 [11];

b) for cables containing metallic elements the filling compound shall be tested for the presence of corrosive compounds in accordance with clause 8 of ISO/IEC 811-5-1 [11];

c) the filling compound shall not be liquid at temperatures lower than a specified value. The determination of the drop point shall be in accordance with clause 4 of ISO/IEC 811-5-1 [11];

d) increase in weight shall be tested as specified in clause 11 of ISO/IEC 811-4-2 [10]. The increase in weight shall not exceed the value specified for the particular material.

6.4 Strength member

The cable shall be designed with sufficient strength members to meet installation and service conditions so that the fibres are not subjected to excessive strain and/or excessive attenuation increments at low temperature.

The strength member may be either metallic or non-metallic and may be located in the cable core and/or under the sheath and/or in the sheath.

6.5 Moisture barrier

If required, the cable shall contain a moisture barrier. The material and functional requirements of the moisture barrier shall be agreed between the user and the manufacturer.

6.6 Cable sheath

The cable shall have a seamless "limited fire hazard" sheath in accordance with CENELEC HD 624.7 [5], unless otherwise agreed between the user and the manufacturer.

The sheath thickness and the overall diameter shall be agreed between the user and the manufacturer. The overall diameter shall take into account the installation conditions and shall be determined by agreement between the user and the manufacturer.

The small size of an optical fibre cable makes it more vulnerable to rodent attack. Where rodents cannot be excluded suitable protection shall be provided.

The type of rodent protection shall be agreed between the user and the manufacturer.

6.7 Sheath marking

If required, the cable shall be marked by a method agreed between the user and the manufacturer. Common methods of marking are embossing, sintering, imprinting, hot foil and surface printing.

7 Optical fibre cable tests

The parameters specified in this I-ETS may be affected by measurement uncertainty arising either from measurement errors or calibration errors due to the lack of suitable standards. Acceptance criteria shall be interpreted with respect to this consideration. The total uncertainty of measurement, for this I-ETS shall be less than or equal to 0,05 dB for attenuation.

The attenuation shall be measured in the 1 550 nm region or at the operational wavelength when specified by the user.

The expression of no change in attenuation means that any change in measurement value, either positive or negative, within the uncertainty of measurement shall be ignored.

The number of fibres tested shall be representative of the cable design and shall be agreed between the user and the manufacturer. For certain designs of two fibre cable, such as "figure eight" constructions, the cable may be tested with the same test conditions as for single fibre cable, in agreement between the user and the manufacturer.

7.1 Tensile performance

The cable shall be tested in accordance with the method specified in EN 187000 [3] test method 501 and the following conditions:

length under tension: not less than 50 m.
Taking into account the measurement accuracy and end effects, shorter lengths may be used by agreement between the user and the manufacturer;

fibre length: finished cable length;

tensile load: 20 N to 400 N for single fibre cables.
200 N to 2 000 N for multiple fibre cables.
Other loads may be applied in accordance with particular user conditions;

duration of load: 1 minute to 10 minutes, unless otherwise agreed between the user and the manufacturer;

diameter of test pulleys: 1 m or not less than the minimum dynamic bending diameter specified for the cable;

acceptance criteria:

a) multiple fibre cables: under load there shall be no change in attenuation (≤ 0,05 dB) and/or the fibre strain shall not exceed one third of the fibre proof strain which shall be reversible to within the uncertainty of measurement;

b) single and multiple fibre cables: after removal of the load, the fibre cables change in attenuation shall be reversible within the uncertainty of measurement and/or the residual fibre strain shall be < 0,1 % (provisional value).

Consideration is being given to introducing T_o and T_m values. Under visual examination without magnification there shall be no damage to the sheath or the cable elements.

7.2 Installation capability

Compatibility with particular installation conditions may be demonstrated by selecting from the tests given in subclauses 7.2.1 to 7.2.11.

7.2.1 Bending under tension

In order to demonstrate the ability of the cable construction to withstand the stresses of installation, it is recommended that the cable is subjected to a factory test involving a moving bend method or a field trial introducing both normal and reverse bends.

7.2.2 Repeated bending

The cable shall be tested in accordance with the method specified in EN 187000 [3] test method 507 and the following conditions:

bending radius: 5 x to 20 x specified cable diameter;

load:

single fibre cable: 20 N unless otherwise agreed between the user and the manufacturer;

multi-fibre cable: 100 N unless otherwise agreed between the user and the manufacturer;

number of cycles:

single fibre cable: 1 000 cycles unless otherwise agreed between the user and the manufacturer;

multi-fibre cable: 100 cycles unless otherwise agreed between the user and the manufacturer;

duration of cycle: approximately 2 s;

acceptance criteria: under visual examination without magnification there shall be no damage to the sheath or the cable elements.

7.2.3 Impact

The cable shall be tested in accordance with the method specified in EN 187000 [3] test method 505 and the following conditions:

Impact energy:

single fibre cable: 1 J with anvil surface radius of 12,5 mm or 2 J with anvil surface radius of 300 mm depending on particular user conditions;

multi-fibre cable: 1 J to 10 J with anvil surface radius of 12,5 mm or 2 J to 25 J with anvil surface radius of 300 mm depending on particular user conditions;

anvil diameter: 20 mm to 50 mm;

number of impacts: one at three different places spaced not less than 500 mm apart;

acceptance criteria: under visual examination without magnification there shall be no damage to the sheath or the cable elements. The imprint of the anvil on the sheath is not considered mechanical damage. The change in attenuation after the test may be agreed between the user and the manufacturer.

7.2.4 Kink

The cable shall be tested in accordance with the method specified in EN 187000 [3] test method 511.

The minimum diameter shall be agreed between the user and the manufacturer.

7.2.5 Torsion

The cable shall be tested in accordance with the method specified in EN 187000 [3] test method 508 and the following conditions:

length under test: 1 m;

load:

single fibre cable: 20 N unless otherwise agreed between the user and the manufacturer;

multi-fibre cable: 50 N unless otherwise agreed between the user and the manufacturer;

number of turns: ±1 turn unless otherwise agreed between the user and the manufacturer;

number of cycles: 5 cycles unless otherwise agreed between the user and the manufacturer;

acceptance criteria: Under visual examination without magnification there shall be no damage to the sheath or the cable elements.

The variation in attenuation shall be ≤ 0,10 dB.

There shall be no permanent change in attenuation after the test.

7.2.6 Crush

The cable shall be tested in accordance with the method specified in EN 187000 [3] test method 504 and the following conditions:

load (plate/plate):

single fibre cable: 0,3 kN to 1 kN unless otherwise agreed between the user and the manufacturer;

multi-fibre cable: 0,3 kN to 3 kN unless otherwise agreed between the user and the manufacturer;

and/or load (plate/mandrel):

single fibre cable: 50 N to 500 N unless otherwise agreed between the user and the manufacturer;

multi-fibre cable: 100 N to 1000 N unless otherwise agreed between the user and the manufacturer;

duration of load: 15 minutes unless otherwise agreed between the user and the manufacturer;

acceptance criteria: under load there shall be no increase in attenuation.

Under visual examination, there shall be no damage to the sheath or the cable elements. The imprint of the anvil on the sheath is not considered mechanical damage.

In accordance with particular user conditions, the test may be carried out with the load applied via one or more mandrels. In this case, the acceptability criteria shall be agreed between the user and the manufacturer.

7.2.7 Flexing

The cable shall be tested in accordance with the method specified in EN 187000 [3] test method 509 and the following conditions:

pulley diameter: 100 mm;

load: 20 N unless otherwise agreed between the user and the manufacturer;

number of cycles: 1 000 cycles unless otherwise agreed between the user and the manufacturer;

carrier speed: 10 cycles/minute;

acceptance criteria: under visual examination without magnification there shall be no damage to the sheath or the cable elements.

7.2.8 Cable bend

The cable shall be tested in accordance with procedure 1 of the method specified in EN 187000 [3] test method 513 and the following conditions:

diameter of mandrel: 12 D to 40 D depending on user requirements where D is the specified cable diameter;

number of turns per helix: 5 turns or a higher number of cycles may be applied in accordance with particular user conditions;

number of cycles: 3 cycles;

acceptance criteria: there shall be no change in attenuation unless otherwise agreed between the user and the manufacturer.

In accordance with particular user conditions, the test may be carried out at low temperature (typically -15°C minimum). In this case the acceptability criteria shall be agreed between the user and the manufacturer.

7.2.9 Sliding coefficient

For further study.

7.2.10 Stiffness/flexibility

For further study.

7.2.11 Water penetration

If required, the cable shall be tested in accordance with the method specified in EN 187000 [3] test method 605B.

7.3 Temperature cycling

The cable shall be tested in accordance with the combined test procedure of the method specified in EN 187000 [3] test method 601 and the following conditions:

sample length: finished cable length of at least 500 m;

high temperature, T_{B2}: +60°C to +70°C depending on user requirements;

high temperature, T_{B1}: +30°C to +60°C depending on user requirements;

low temperature, T_{A1}: - 10°C to -15°C depending on user requirements;

low temperature, T_{A2}: - 10°C to - 45°C depending on user requirements;

dwell time, t_1: time for the cable to reach and stabilize to the specified temperature;

number of cycles: 2 cycles but additional cycles may be required in accordance with particular user requirements;

rate of heating and cooling: sufficiently slow so that the effect of changing the temperature does not cause temperature shock;

acceptance criteria: for T_{A1} to T_{B1}, the change in attenuation shall not be > 0,10 dB/km and shall be reversible (≤ 0,05 dB).

for (T_{A2} to T_{A1}) to (T_{B1} to T_{B2}) the change in attenuation shall not be > 0,50 dB/km and shall be reversible (≤ 0,05 dB).

NOTE: The minimum handling temperature of cables with a halogen free flame retardant thermoplastic sheathing compound is > -15°C.

7.4 Tests under fire conditions

Depending upon particular user requirements, the fire performance of the cable may be demonstrated by selecting from the following tests. Other test methods may be agreed between the user and the manufacturer.

7.4.1 Flame propagation for a single (vertical) cable

The test shall be carried out in accordance with ISO/IEC 332-1 [7].

7.4.2 Flame propagation for multiple (vertical) cables

The test shall be carried out in accordance with ISO/IEC 332-3 [8]. Category C shall be used unless otherwise agreed between the user and the manufacturer.

7.4.3 Smoke emission

The test shall be carried out in accordance with ISO/IEC 1034-2 [13]. The test apparatus shall be in accordance with ISO/IEC 1034-1 [12]. The acceptance criteria of ISO/IEC 1034-2 [13] shall apply, unless otherwise agreed between the user and the manufacturer.

7.4.4 Corrosive and acid gases

7.4.4.1 Conductivity and pH

The test shall be carried out in accordance with ISO/IEC 754-2 [9]. The acceptance criteria of ISO/IEC 754-2 [9] shall apply. If the acceptance criteria is not fulfilled the test in subclause 7.4.4.2 shall be made.

7.4.4.2 Halogen

The test shall be carried out in accordance with ISO/IEC 754-1 [14]. Acceptance criteria shall be agreed between user and manufacturer.

7.5 Ageing

7.5.1 Fibre coating compatibility

When the fibres are in contact with a filling compound, the compatibility of the filling compound with the coating shall be demonstrated by testing after accelerated ageing, either the cabled fibre or the fibre in filling compound for:

- coating adhesion stability in accordance with EN 187000 [3] test method 609;

- stability of the colour of the coating for fibre identification;

and, if required, for:

- dimensional stability;

- coating transmissitivity.

7.5.2 Finished cable

For further study.

7.6 Sheath abrasion resistance

For further study.

History

Document history			
January 1996	Public Enquiry	PE 100:	1996-01-22 to 1996-05-17
March 1997	Vote	V 9720:	1997-03-18 to 1997-05-16