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Foreword

This Interim European Telecommunication Standard (I-ETS) has been produced by the Transmission and Multiplexing (TM) Technical Committee of the European Telecommunications Standards Institute (ETSI).

An ETSI standard may be given I-ETS status as it is regarded either 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, at first, to three years after which it can be converted into a European Telecommunication Standard (ETS), have its life extended for a further two years, be replaced by a new version of the I-ETS or, finally, be withdrawn.

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Introduction

This I-ETS concerns the functional requirements for single-mode optical fibre used in underwater cables. References are made to test methods and acceptance criteria in various CECC and ITU-T documents which are normative to this I-ETS (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 will be 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-mode optical fibre cables to be used as underwater cables.

Types of cables included in this I-ETS are "underwater cables" for lakes, river crossings etc. and are for cable systems without power feeding requirements. This specification does not cover repair capability.

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 reference 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 (1995): "Family Specification: Single-mode dispersion shifted (B2) optical fibre".

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

[4] 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 (1st edition 1990)".

[5] ISO/IEC 811-5-1 (1990): "Common test methods for insulating and sheathing materials of electric cables, Part 5: Methods specific to filling compounds (1st edition 1990)".

[6] ISO/IEC 708-1: "Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath, Part 1: General design details and requirements".

[7] EN 187000: "Generic specification: Optical fibre cables".

[8] EN 188000: "Generic specification: Optical fibres".

[9] ISO/IEC 794-1: "Optical fibre cables, Part 1: Generic specification".

[10] EN 188100 (1995): "Sectional Specification: Single-Mode (SM) optical fibre".

3 Symbols

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

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 fibre strain increase should occur in the tensile performance 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 performance test
T_{A1}	Temperature cycling lower limit for acceptance criteria 1

T_{A2} Temperature cycling lower limit for acceptance criteria 2

T_{B1} Temperature cycling upper limit for acceptance criteria 1

T_{B2} Temperature cycling upper limit for acceptance criteria 2

t_1 dwell time used in the temperature cycling test

4 Optical fibre

4.1 General

Single-mode optical fibre shall be used which meets 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 0,45 dB/km and at 1 550 nm it is 0,30 dB/km. Particular values shall be agreed between the user and the manufacturer.

The attenuation coefficient shall be measured in accordance with EN 188000 [8] test method 301, 302 or 303.

4.2.2 Attenuation uniformity

4.2.2.1 Attenuation discontinuities

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

4.2.2.2 Attenuation linearity

The functional requirements are under consideration.

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 IEC Publication 304 [3]. 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 under consideration.

5 Secondary protection

The material(s) used for the secondary protection shall be selected to be compatible with the other elements in contact with it. An appropriate compatibility test method is defined in IEC Publication 811-4-2 [4]. If fibres are in contact with a filling compound, the filling material shall be easily removable.

5.1 Tight secondary coating

If a tight secondary coating is required it shall consist of one or more layers of polymeric material. The coating shall be easily removable for splicing. The nominal overall diameter of the secondary coating shall be between 800 μm and 900 μm. The value, which shall be agreed between the user and the manufacturer, shall have a tolerance of ±50 μm. The fibre/secondary coating eccentricity shall not exceed 75 μm unless otherwise agreed between the user and the manufacturer.

The colour of the tight secondary coating shall be readily identifiable throughout the lifetime of the cable.

The macrobending performance of the tight secondary coated fibre shall be determined generally in accordance with EN 188000 [8] test method 318 for 1 dB with a 60 mm mandrel diameter when tested at a temperature in the range -10°C to -45°C in accordance with particular user requirements. The applicability of the test method for this temperature range needs further clarification.

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.

One aspect of the suitability of the tube shall be determined by an evaluation of its kink resistance in accordance with EN 187000 [7] test method 512.

The bleeding performance of the filling compound from the tube shall comply with EN 187000 [7] test method 608.

If required the macrobending performance of the fibre in loose tube shall be determined in accordance with EN 188000 [8] test method 318 for 1 dB with a 60 mm mandrel diameter, when tested at a temperature in the range -10°C to -45°C in accordance with particular user requirements. The applicability of the test method for this temperature range needs further clarification.

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:

- the number of fibres is between 2 and 12 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 the manufacturer;

- if additional mechanical tests are required, other than those already specified in the generic specifications (EN 187000 [7] and EN 188000 [8]), 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.

The number of fibre splices, if any, in a delivery length shall be agreed between the user and the manufacturer.

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

Consideration shall be taken concerning cable elongation during cable installation and operation.

6.2 Lay up of the cable elements

Secondary protected optical units as described in clause 5 may be laid up as follows:

a) single 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

The cable core, in addition to the filled unit, shall be continuously filled with a water blocking compound.

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

If required a hydrogen absorbing material may be used to prevent degradation due to the presence of hydrogen in the cable.

The blocking material used shall be compatible with the relevant cable elements. Where the blocking material is water swellable, 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 in IEC Publication 811-5-1 [5];

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

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 IEC Publication 811-5-1 [5];

d) increase in weight shall be tested as specified in clause 11 of IEC Publication 811-4-2 [4]. 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, repair and service conditions so that the fibres are not subjected to strain in excess of limits agreed between the user and the manufacturer.

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 protection

If specified, moisture protection shall be provided either by a continuous metallic sheath (hermetic protection) or by a metallic tape applied over the cable core with a longitudinal overlap and bonded to the sheath. Alternatively, other constructions may be adopted by agreement between the user and the manufacturer.

In the case of the continuous metallic sheath, the material and its thickness shall be agreed between the user and the manufacturer.

In the case of the metallic moisture barrier tape the amount of overlap and thickness of the metallic tape shall be in accordance with IEC Publication 708-1 [6]. The metallic tape may have a reduced nominal thickness with agreement between the user and the manufacturer.

The adhesion of the metallic tape to the sheath shall comply with subclause 19.2 of IEC Publication 708-1 [6]. A sample of sheath taken from each end of a finished cable shall be examined to ensure the overlap of the moisture barrier tape is closed and that it meets the requirements of this subclause.

The effectiveness of the moisture protection may be proved by an alternative test with agreement between the user and the manufacturer.

6.6 Cable sheath and armouring

6.6.1 Inner sheath

A cable inner sheath may be applied by agreement between the user and the manufacturer.

6.6.2 Armouring

Where additional tensile strength or protection from external damage is required, armouring shall be provided.

6.6.3 Outer protection

The outer protection may be either a layer of polypropylene roves or an outer sheath of polyethylene or other appropriate materials. The outer sheath constructions shall be agreed between the user and the manufacturer.

If required the underwater cable shall have a contrasting colour incorporated in the outermost layer to facilitate visibility of cable movement during any installation and maintenance operations.

6.7 Sheath marking

If required, the cable shall be marked as agreed between the user and the manufacturer.

7 Installation and operation conditions

Installation and operation conditions shall be agreed between the user and the manufacturer.

The range of conditions commonly experienced in Europe is given below:

Storage temperature: low temperature -45°C to high temperature (+60°C to +70°C);

Installation temperature: -10°C to +60°C;

Operating temperature: In water: 0°C to +30°C;

On shore: -45°C to +60°C;

Minimum cable bending diameter: 0,5 m to 3 m;

Maximum water depth: less than 500 m.

The following design parameters shall be indicated for the specific cable construction:

- cable weight and diameter;
- maximum installation load;
- breaking load.

8 Optical fibre cable tests

The parameters specified in this specification 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 standard shall be less 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 and the minimum fibre length tested shall be representative of the cable design and shall be agreed between the user and the manufacturer.

8.1 Tensile performance

The cable shall be tested in accordance with the method specified in EN 187000 [7], test method 501, and fibre strain to IEC 794-1 [9] and the following conditions:

Length under tension: Not less than 30 m taking into account the measurement accuracy and end effects.

Tensile load [N]:

Load 1: ≥ 2,5 x water depth (in [m]) x weight of cable in water (in [N/m]).

Other values may be agreed between the user and the manufacturer.

Load 2: ≥ water depth (in [m]) x weight of cable in water (in [N/m]).

A minimum value shall be agreed between the user and the manufacturer.

Duration of load: 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:
- Under load 1 there shall be no change in attenuation and/or the fibre strain shall not exceed 1/3 of the proof test strain which shall be reversible within the uncertainty of measurement;
- Under load 2 there shall be no fibre strain;
- Under visual examination, without magnification, there shall be no damage to the outer protection or to the cable elements.

NOTE: Load 1 represents installation load and load 2 represents operational load after installation.

8.2 Installation capability

Compatibility with particular installation conditions may be demonstrated by selecting from the following tests:

8.2.1 Repeated bending

The cable shall be tested in accordance with the method specified in EN 187000 [7], test method 507. Then the following conditions shall apply:

Bending radius R: 20 d to 30 d, where d is the specified cable diameter.

Load: Sufficient to keep cable in place during the test.

Number of cycles: ≥ 30.

Duration of cycles: ≥ 10 s.

Acceptance criteria: Under visual examination without magnification there shall be no damage to the outer protection or to the cable elements.

8.2.2 Impact

The cable shall be tested in accordance with the method specified in EN 187000 [7], test method 505, and the following conditions:

Anvil surface radius: 10 mm or 300 mm.

Anvil diameter: ≥ 50 mm.

Impact energy: ≥ 50 J.

Number of impacts: One in 3 different places spaced not less than 500 mm apart.

Acceptance criteria:
- Under visual examination without magnification there shall be no damage to the outer protection or to the cable elements;
- The imprint of the anvil on the sheath is not considered as mechanical damage;
- There shall be no change in attenuation after the test.

8.2.3 Torsion

The test method and acceptance criteria are under consideration.

8.2.4 Temperature cycling

The cable shall be tested in accordance with the combined test procedure of the method specified in EN 187000 [7], test method 601 and the following conditions:

Sample length: Cable length of at least 500 m. Taking into account the measurement accuracy shorter lengths may be used by agreement between the user and the manufacturer.

High temperature, T_{B2}: +60°C to +70°C.

High temperature, T_{B1}: +30°C to +60°C.

Low temperature, T_{A1}: -10°C.

Low temperature, T_{A2}: -10°C to -45°C in accordance with particular user conditions.

Dwell time, t_1: Time for the cable to reach, and stabilise to, the specified temperature, minimum 6 hours.

Rate of heating cooling: Slow enough to ensure that the change of temperature does not cause and temperature shock.

Number of cycles: Two, but additional cycles may be required in accordance with particular user requirements.

Acceptance criteria:
- For T_{A1} to T_{B1}, there shall be no change in attenuation;
- For (T_{A2} to T_{A1}) and (T_{B1} to T_{B2}), the change in attenuation shall be $\leq$ 0,10 dB/km and shall be reversible to $\leq$ 0,05 dB.

8.2.5 Hydrostatic pressure (for water depths > 100 m)

Length: To be agreed between the user and manufacturer.

Pressure: 11 kPa x (maximum water depth in m).

Test time: $\geq$ 24 hours.

Acceptance criteria:
- No attenuation increase;
- Under visual examination without magnification there shall be no damage to the outer protection.

8.2.6 Coiling performance (for armoured cables)

Diameter: Minimum specified coiling diameter.

Number of turns: 10.

Temperature: 10°C $\pm$ 5°C unless otherwise agreed between the user and manufacturer.

Acceptance criteria:
- No permanent increase in attenuation;
- The cable shall form a smooth circle and shall stay in contact with the ground all the way around the circumference.

8.3 Bending under tension

The test method and acceptance criteria are under consideration.

8.4 Cable bend

The cable shall be tested in accordance with Procedure 2 of the method specified in EN 187000 [7] test method 513 and the following conditions:

Diameter of mandrel: Minimum cable bending diameter.

Number of cycles: 3 to 6 depending on user requirements.

Acceptance criteria:
- There shall be no change in attenuation;
- The same acceptance criteria shall apply when the bend test is carried out at low temperatures in accordance with particular user conditions.

8.5 Crush

The cable shall be tested in accordance with the method specified in EN 187000 [7], test method 504 and the following conditions:

Load (plate/plate): $\geq$ 10 kN.

and/or

load (mandrel/plate) $\geq$ 2,5 kN.

Duration of load: 15 minutes.

Acceptance criteria:
- Under load there shall be no increase in attenuation.
- Under visual examination there shall be no damage to the outer protection or to the cable elements. The imprint of the anvil on the sheath is not considered as mechanical damage.

NOTE: It is recommended that additional testing considerations, such as the number of positions that the load is applied to the test specimen are defined.

8.6 Ageing

8.6.1 Fibre coating compatibility

When the fibres are in contact with a filling compound, the compatibility of the filling compound with the fibre 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 [7], test method 609;
- stability of the colour of the coating for fibre identification; and

if required for:

- dimensional stability;
- coating transmissivity.

8.6.2 Finished cable

The test method and acceptance criteria are under consideration.

8.7 Water penetration

The test procedure and the acceptance criteria shall be agreed between the user and the manufacturer.

8.8 Hydrogen gas

The test method and acceptance criteria are under consideration.

8.9 Sheath abrasion resistance

The abrasion resistance of the outer sheath shall be determined in accordance with EN 187000 [7], test method 502.

Details of the information to be provided to carry out the test and acceptance criteria are under consideration.

History

Document history			
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