IEC 61753-111-09

Edition 1.0 2021-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Fibre optic interconnecting devices and passive components – Performance standard –
Part 111-09: Sealed closures – Category S – Subterannean

Dispositifs d'interconnexion et composants passifs fibroniques – Norme de performance –
Partie 111-09: Boîtiers étanches pour la catégorie S – Souterrains

IEC 61753-111-09:2021-09(en-fr)

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – PERFORMANCE STANDARD –

Part 111-09: Sealed closures – Category S – Subterannean

FOREWORD

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IEC 61753-111-09 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics. It is an International Standard.

This first edition cancels and replaces IEC 61753-111-9 published in 2009. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 61753-111-9:

a) terms and definitions updated according to IEC 61753-1:2018 and IEC 61756-1:2019;
b) detailed test severities added for UV light and fungus resistance tests of materials;
c) test severities updated according to IEC 61753-1:2018;
d) laboratory test conditions harmonized with IEC 61300-1 to +23 °C ± 5 °C, unless otherwise specified;

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e) addition of B-657 fibre types with minimum bending radius of stored fibres according to IEC 61756-1:2019;

f) vibration sealing test changed to 10 Hz, 3 mm amplitude and 1 000 000 cycles;

g) reduced loads added in cable retention test for small diameter cables and tubes;

h) reduced loads for cable axial compression test for small diameter cables and tubes;

i) duration of the cycles in torsion and bending test added;

j) free fall test removed (is covered now by the optical shock test);

k) assembly and disassembly test duration reduced to 5 cycles;

l) resistance to solvents and contaminating fluids: changed duration of immersion in diesel to 1 h and 24 h drying time and removed immersion in kerosene;

m) duration of the change of temperature reduced to 12 cycles.

The text of this International Standard is based on the following documents:

Draft	Report on voting
86B/4494/FDIS	86B/4515/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts of IEC 61753 series, published under the general title *Fibre optic interconnecting devices and passive components – Performance standard*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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INTRODUCTION

Performance standards for sealed closures define the requirements for standard optical performance under a set of specified conditions. This subpart of the IEC 61753-111 series contains a series or a set of tests and measurements with clearly stated conditions, severities and pass/fail criteria. The set of tests is intended to be a basis to prove the product's ability to satisfy the requirements of a specific application, market sector or user group.

A product that has been shown to meet all the requirements of this performance standard may be declared as complying with this performance standard. Products having the same classification from one manufacturer that satisfy this performance standard will operate within the boundaries set by the performance standard. There is no guarantee that products from different manufacturers, having the same classification and which conform to the same performance standard, will provide an equivalent level of performance when they are used together.

Conformance with IEC environmental policy according to IEC Guide 109 and concerning the need to reduce the impacts on the natural environment of fibre optic closures during all phases of their life – from acquiring materials to manufacturing, distribution, use, and end-of-life treatment (i.e. re-use, recycling – recovery and disposal) – is not part of this document, but will be covered in the generic specification.

Conformance to a performance standard demonstrates that a product has passed a design verification test. It is not a guarantee of lifetime assured performance or reliability. Reliability testing is the subject of a separate test schedule, where the tests and severities selected are such that they are truly representative of the requirements of this reliability test programme. Consistency of manufacture should be maintained using a recognised quality assurance programme whilst the reliability of product should be evaluated using the procedures recommended in IEC 62005 (all parts).

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS – PERFORMANCE STANDARD –

Part 111-09: Sealed closures – Category S – Subterannean

1 Scope

This part of IEC 61753 contains the minimum tests, test severities and measurement requirements which a sealed fibre optic closure need to meet in order to be categorised as meeting the IEC standard for category S – Subterannean, as defined in Table A.15 of IEC 61753-1:2018.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-10, *Environmental testing – Part 2-10: Tests – Test J and guidance: Mould growth*

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 61300-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 1: General and guidance*

IEC 61300-2-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-1: Tests – Vibration (sinusoidal)*

IEC 61300-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fibre or cable retention*

IEC 61300-2-5, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-5: Tests – Torsion*

IEC 61300-2-9, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-9: Tests – Shock*

IEC 61300-2-10, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-10: Tests – Crush and load resistance*

IEC 61300-2-11, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-11: Tests – Axial compression*

IEC 61300-2-12, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-12: Tests – Impact*

IEC 61300-2-22, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-22: Tests – Change of temperature*

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IEC 61300-2-23, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-23: Tests – Sealing for non-pressurised closures of fibre optic devices*

IEC 61300-2-26, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-26: Tests – Salt mist*

IEC 61300-2-33, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-33: Tests – Assembly and disassembly of fibre optic mechanical splices, fibre management systems and closures*

IEC 61300-2-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-34: Tests – Resistance to solvents and contaminating fluids of interconnecting components and closures*

IEC 61300-2-37, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-37: Tests – Cable bending for fibre optic closures*

IEC 61300-2-38, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-38: Tests – Sealing for pressurized fibre optic closures*

IEC 61300-3-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-1: Examinations and measurements – Visual examination*

IEC 61300-3-3, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-3: Examinations and measurements – Active monitoring of changes in attenuation and return loss*

IEC 61300-3-28, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-28: Examinations and measurements – Transient loss*

IEC 61753-1:2018, *Fibre optic interconnecting devices and passive components – Performance standard – Part 1: General and guidance*

IEC 61756-1:2019, *Fibre optic interconnecting devices and passive components – Interface standard for fibre management systems – Part 1: General and guidance*

ISO 4892-3, *Plastics – Methods of exposure to laboratory light sources – Fluorescent UV lamps*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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3.1
distribution joint
protective housing that allows the splicing of the fibres from a feeder cable to the fibres of multiple smaller drop cable and that allows easy fibre access, maintenance, re-arrangement and addition of fibre circuits or passive optical components

Note 1 to entry: Storage of uncut fibres and fibre cable elements is allowed.

Note 2 to entry: A distribution joint is typically used in access and distribution networks.

3.2
excursion loss
change in optical attenuation during the slow variations of environmental parameters

Note 1 to entry: Excursion loss is the ± deviation from the original value of the transmitted power at the start of the test.

3.3
fibre management system
system to control, protect and store splices, connectors, passive optical components and fibres from incoming to outgoing cables

Note 1 to entry: A fibre management system is intended for installation within a protective housing.

Note 2 to entry: A fibre management system is often called an "organiser".

[SOURCE: IEC 61756-1:2019, 3.1.2]

3.4
intervention
gain access to modify, add, remove or repair fibre circuits, splices, connectors or other components between the incoming and outgoing cables of an existing closure

3.5
installation
activities and handling operations to establish and install a protective housing including the cables or by adding new circuits, splices, connectors and other components

3.6
installation conditions
circumstances that shall be fulfilled for an installation, which includes environmental conditions, size interface between the closure and the fibre management system, optical performance, additional/special conditions and safety requirements

3.7
multiple element
physical fibre separation level consisting of more than one single element

Note 1 to entry: This separation level has fibres from multiple cable elements on one splice tray and is also called mass storage. It is the lowest (worst) degree of physical circuit separation.

[SOURCE: IEC 61756-1:2019, 3.1.3]

3.8
multiple ribbon
multiple element consisting of multiple optical fibres (circuits) arranged in ribbons (fibres in parallel) which are also arranged (for example, in stacks)

[SOURCE: IEC 61756-1:2019, 3.1.5]

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3.9
residual loss
change in optical power between initial and final measurements

3.10
sealed closure
watertight and dust-tight housing that can hold a varying overpressure or underpressure caused by temperature changes or atmospheric pressure changes

Note 1 to entry: There is no exchange of air with the outside environment when exposed to temperatures over the specified operating temperature range.

Note 2 to entry: Although sealed closures are often referred to as hermetic sealed closures, humidity can enter the inner closure by diffusion.

[SOURCE: IEC 61753-1:2018, 3.17, modified – Note 2 to entry has been rephrased, and Note 3 to entry and Note 4 to entry have been deleted.]

3.11
single circuit
physical fibre separation level where the optical circuit consists of one fibre (single fibre), or more than one fibre, providing all services for one subscriber

Note 1 to entry: This fibre separation level has the fibre(s) of only one customer on one splice tray. It is the highest (best) degree of physical circuit separation.

[SOURCE: IEC 61756-1:2019, 3.1.7]

3.12
single element
physical fibre separation level in the cable subassembly comprising one or more optical fibres inside a common covering for example in a tube or inside one groove of a grooved cable (slotted core cable)

Note 1 to entry: A single element provides services to more than one subscriber.

Note 2 to entry: This fibre separation level has all fibres from a cable element (e.g. loose tube) on one splice tray. It is an intermediate degree of physical circuit separation (between single circuit and multiple element).

[SOURCE: IEC 61756-1:2019, 3.1.9]

3.13
single ribbon
single element designed to carry all fibres of one ribbon

Note 1 to entry: Depending on the fibres deployment, a single ribbon can contain all the fibres of one circuit (single circuit) or the fibres of more than one circuit (single element).

[SOURCE: IEC 61756-1:2019, 3.1.11]

3.14
splice tray
structure that organises and controls storage of fibre splices in an orderly manner, together with the associated excess uncabled fibre length

Note 1 to entry: It can be a part of a fibre management system.

[SOURCE: IEC 61756-1:2019, 3.1.12]

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3.15
track/spur joint
protective housing that allows the splicing of all the fibres of at least three cables

Note 1 to entry: The track/spur joint acts as a reinstatement of the cable length. It will not be re-entered except for repair or reinstatement of damaged cables.

Note 2 to entry: This closure configuration is typically used in trunk and junction networks to connect the cable sections from various cable reels or to split one cable into at least two smaller cables.

3.16
transient loss
short term (ms) reversible change of optical transmission characteristics arising from optical discontinuity, physical defects and modifications of the attenuation (e.g. bending loss) normally caused by mechanical stress

3.17
uncut fibre
fibres from a continuous cable with the cable sheath removed over a defined length without cutting the fibres or tubes

Note 1 to entry: The uncut tubes or fibres are stored e.g. in a space saving loop. When required, the fibres are cut and spliced or connected.

[SOURCE: IEC 61756-1:2019, 3.1.14]

4 Abbreviated terms

FMS	fibre managementsystem
ME	multiple element
MR	multiple ribbons
NA	not applicable
SC	single circuit
SE	single element
SR	single ribbon
UV	ultraviolet

5 General requirements

5.1 Storage, transportation and packaging

The classes of environmental conditions and their severities to which sealed closures may be exposed during storage and transportation are defined in IEC 60721-3-1 and IEC 60721-3-2. Normal transportation time is considered to be 30 days or less.

The product, in its original packaging, shall be suitable for normal public or commercial transportation and storage in weather protected non-temperature controlled storage environments and, after installation, meet the requirements as specified in Table 1, Table 2 and Table 3.

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5.2 Installation and intervention

The minimum and maximum temperatures at which a closure may be installed (installation conditions) or re-entered (intervention) are not necessarily equal to the maximum temperature excursion of the environment in which it will reside, once installed. Accessing fibres and the fibre management system inside the closure is typically done in a more controlled environment. Closures and the fibre management system shall be installable in the temperature range between −5 °C and +45 °C. Closure and cable handling alone shall be possible at temperatures between −15 °C and +45 °C.

Typically, the following operations are carried out during an intervention:

– handling of closure;
– opening closure;
– getting access to fibres and splices (e.g. hinging, pivoting, sliding, removal of splice trays, or other FMS components);
– breaking a splice, rerouting fibres and connecting to another fibre end;
– cutting one or more uncut fibres, rerouting and connecting to another fibre end;
– disconnecting a connector and mating with another connector (when applicable);
– adding FMS elements/components and connecting the fibres;
– closing and sealing the closure.

5.3 Marking and identification

Product marking and identification shall survive the storage and transportation.

Each test sample should contain the following information at a minimum:

– manufacturer's identification mark or logo;
– product designation, model or type;
– one of the following: lot number, batch number, date (at least month and year) of production or serial number;
– expiry date (at least year) if the product contains components with a limited shelf-life.

5.4 Materials

For all applied materials, a material safety data sheet shall be made available upon request.

All materials that are likely to come in contact with personnel shall meet appropriate health and safety regulations.

The materials of the sealed closure and fibre management system shall be compatible with the other materials or solvents that can come into contact with it during installation and operation, for example water (humidity), cable filling compounds and degreasing agents. Exposure to these solvents shall not adversely affect the product's performance.

The effect of ultraviolet (UV) light on all polymeric materials that are directly exposed to the environment shall not adversely affect the product's performance. UV test shall be according to ISO 4892-3, lamp type 1A (UVA-340), cycle 1, duration 2 160 h. The effect of UV light shall be determined by measuring a suitable property (e.g. tensile strength at yield and elongation at yield) both before and after exposure of the material slabs. The average change in mechanical characteristics of the tested material slabs shall be less than 20 %.

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Polymeric materials shall not support mould growth causing mechanical degradation of the materials. Mould growth shall be tested according to IEC 60068-2-10, test variant 1, severity 1. The effect of mould growth shall be determined first by a visual rating based on examination per IEC 60068-2-10. When a rating 0 is obtained, the material is considered fungus resistant and no further testing is required. When a rating 1 or 2 is obtained, the effect of mould growth shall be evaluated by measuring a suitable property (e.g. tensile strength at yield and elongation at yield for thermoplastic polymers, a compression set, a Shore A hardness for elastic materials, or any other test which checks a relevant property) both before and after exposure of the material slabs. The average change in mechanical characteristics of the tested material slabs shall be less than 20 %. A rating of more than 2 is not allowed.

Metallic elements shall be corrosion resistant. Dissimilar metals should not be used in contact with each other unless they are suitably finished to prevent electrolytic corrosion.

Materials which are not specified or which are not specifically described are left to the discretion of the manufacturer.

5.5 Safety

Special attention should be taken when opening sealed closures that are carrying an overpressure. Overpressure can build up in sealed closures due to temperature differentials, atmospheric pressure changes over a period of time, flash testing of the seals after installation or incorrect installation techniques. Care should be taken when opening a sealed closure. Provisions shall be made that overpressure is exhausted when opening the closure prior to complete removal of the cover.

6 Test

6.1 General

The mechanical and environmental performance of a closure is vital to the optical cabling system. The purpose of testing is to demonstrate that the closure can survive under defined environmental conditions, without irreversible or reversible failures and perform according to the requirements.

The performance test procedure of a closure shall

– evaluate the product for 3 basic acceptance criteria: sealing, mechanical integrity by visual inspection and optical transmission requirements,
– simulate the effects of exposure to the environment in which it will be installed, and
– simulate installation and intervention conditions.

Optical performance testing is accomplished by subjecting the test sample to a number of mechanical and environmental conditions and measuring any optical performance deviations at prescribed intervals during and after completion of each test.

6.2 Test sample preparation

Sealing performance test samples shall be provided with an air pressure test access valve. The length of the cables extending the closure shall be long enough to perform the tests. The free ends of the cables shall be sealed. Each applicable cable type with minimum and maximum cable dimensions shall be represented in the test program. When applicable, open closure ports shall be sealed with a cap or a plug.

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Optical test samples shall be constructed in such a way that they will cover all allowed functions as specified by the manufacturer, being "track/spur joint" configuration or "track/spur joint and distribution joint" configuration. This shall be realised by building optical circuits for each fibre separation level (typical SC, SE, SR, ME or MR splicing and uncut fibre storage). The minimum bend radius for installed and stored fibres in a FMS depends on the fibre type and is given by IEC 61756-1. The type of fibre for the optical test samples and the test sample preparation are single-mode fibres as described in Annex A. Only stable optical fibre fusion splices shall be used in the optical circuits.

6.3 Test and measurement methods

All tests and measurements shall be selected from IEC 61300 (all parts).

All optical losses indicated are referenced to the initial attenuation at the start of the test.

No deviation from the specified test method is allowed.

Since only optical fusion splices are used, the optical effects of other passive optical components are not considered for the evaluation of the closure system.

Closures under test shall be mounted and connected in accordance with the manufacturer's guidelines.

Unless otherwise specified, tests shall be carried out under standard atmospheric conditions according to IEC 61300-1.

6.4 Sample size

Separate test samples for sealing performance and optical evaluation may be used.

The sample size used for each test is intended to be composed of randomly selected and previously unstressed new samples. Due to the complexity of the optical test sample, consecutive testing on the same optical sample is allowed.

The sample size for each test can be found in Table 2 and Table 3.

6.5 Pass/fail criteria

A product meets the requirements of this document provided no failures occur in any test. The pass/fail criteria for sealed closures are specified in Table 1.

In the event of a failure occurring on a sealing performance test sample, the test shall be re-run using a sample size double that of the original.

Due to the complexity of the optical test samples, consecutive testing on the same optical sample is allowed. In case of a failure during the consecutive testing, a new sample shall be prepared and the failed test shall be re-done.

6.6 Test report

Conformance to a performance standard shall be supported by a test report. The test report shall clearly demonstrate that the tests were carried out in accordance with the requirements of the performance standard and provide full details of the tests together with a pass/fail declaration. An analysis of the cause of the failure shall be undertaken and any corrective actions taken shall be described.

If design changes are made, a risk assessment should be carried out to determine whether full or partial requalification should be done.

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7 Performance requirements

7.1 Sealing, optical and visual examination pass/fail criteria

The sealing, optical and visual examination pass/fail criteria are described in Table 1.

Table 1 – Sealing, optical and visual examination pass/fail criteria

No.	Examinations and measurements	Requirement	Details	
Criterion 1	Sealing for pressurised closures of fibre optic devices – sealing performance after test	No emission of air bubbles indicating a leak	Method: Test temperature: Test pressure: Immersion depth: Duration: Pressure detector: Pre-conditioning procedure:	IEC 61300-2-38, method A +23 °C ± 5 °C Internal overpressure 40 kPa ± 2 kPa Just below the surface of the water 15 min Minimum resolution 0,1 kPa Sample conditioned to room temperature for at least 4 h
Criterion 2	Pressure loss during test	Difference in pressure before and after test shall be less than 2 kPa. Measurements taken at same atmospheric test conditions	Method: Test temperature: Test pressure: Pressure detector: Pre-conditioning procedure:	IEC 61300-2-38, method B As specified by individual test Internal overpressure 40 kPa ± 2 kPa sealed at test temperature Minimum resolution 0,1 kPa Sample conditioned to test temperature and test pressure for at least 4 h
Criterion 3	Visual examination	No defects which would affect functionality of the closure	Method: Examination:	IEC 61300-3-1 Product shall be checked with naked eye
Criterion 4	Active monitoring of change in attenuation[a] and return loss	Excursion losses: δ ≤ 0,2 dB at 1 310 nm and 1 550 nm per incoming fibre during test. δ ≤ 0,5 dB at 1 625 nm per incoming fibre during test. Residual losses: δ ≤ 0,1 dB at 1 310 nm, 1 550 nm and 1 625 nm per incoming fibre after test.	Method: Wavelengths[b]: Source stability: Detector linearity: Measurements required: Sampling rate:	IEC 61300-3-3, method 1 1 310 nm ± 30 nm 1 550 nm ± 30 nm 1 625 nm ± 30 nm Within ±0,05 dB over the measuring period Within ±0,05 dB over the dynamic range to be measured Before, during and after the test At least every 10 min
Criterion 5	Transient loss[a]	Transient losses: δ ≤ 0,5 dB at 1 550 nm per active circuit during test. δ ≤ 1 dB at 1 625 nm per active circuit during test. Residual losses: δ ≤ 0,1 dB at 1 550 nm and 1 625 nm per active circuit after test	Method: Wavelengths[b]: Source stability: Detector linearity: Measurements required: Active circuit:	IEC 61300-3-28 1 550 nm ± 25 nm 1 625 nm ± 25 nm Within ±0,05 dB over the measuring period Within ±0,05 dB over the dynamic range to be measured Before, during and after the test 10 incoming fibres in series

[a] The change in attenuation values refer to the ± deviation from the original value of the transmitted power at the start of the test.

[b] Testing at 1 625 nm is optional for enterprise applications but required for carrier applications.

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7.2 Sealing performance requirements

The sealing performance requirements are described in Table 2.

Table 2 – Sealing performance requirements

No.	Test	Requirement	Details	
1	Vibration (sinusoidal)	Sealing performance (criterion 1) Visual examination (criterion 3)	Method:	IEC 61300-2-1
			Frequency range:	10 Hz
			Amplitude:	3 mm
			Cable clamping distance:	500 mm from closure
			Number of cycles:	1 000 000 (about 28 h)
			Test temperature:	+23 °C ± 5 °C
			Test pressure:	Internal overpressure 40 kPa ± 2 kPa
			Pre-conditioning procedure:	Sample conditioned at room temperature for at least 4 h
			Sample size:	3
2	Cable retention	Sealing performance (criterion 1) Pressure loss (criterion 2) Visual examination (criterion 3)	Method:	IEC 61300-2-4
			Test temperatures:	–15 °C ± 2 °C and +45 °C ± 2 °C
			Load (N):	20 × $\varnothing_{Cable}$ (mm) for $\varnothing_{Cable}$ > 7 mm 10 × $\varnothing_{Cable}$ (mm) for $\varnothing_{Cable}$ ≤ 7 mm 10 N for tubes and cables with strength members that are not intended for attachment
			Load application:	The greater of 400 mm or 50 × cable diameter measured from the closure
			Duration:	1 h per cable
			Test pressure:	Internal overpressure 40 kPa ± 2 kPa sealed at test temperature
			Pre-conditioning procedure:	Sample conditioned at the specified test temperature and test pressure for at least 4 h
			Sample size:	3 per test temperature

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No.	Test	Requirement	Details	
3	Axial compression of cable	Visual examination (criterion 3) No movement of cable by more than 5 mm	Method: Test temperature: Load: Load application: Duration: Pre-conditioning procedure: Sample size:	IEC 61300-2-11 +23 °C ± 5 °C 10 N for $\varnothing_{Cable}$ < 3 mm 20 N for 3 mm ≤ $\varnothing_{Cable}$ < 6 mm 50 N for 6 mm ≤ $\varnothing_{Cable}$ < 10 mm 100 N for 10 mm ≤ $\varnothing_{Cable}$ < 20 mm 200 N for $\varnothing_{Cable}$ ≥ 20 mm 10 N for tubes and cables without strength member attachment At maximum twice the cable diameter measured from closure 30 min per cable Sample conditioned at room temperature for at least 4 h 3
4	Cable bending	Sealing performance (criterion 1) Pressure loss (criterion 2) Visual examination (criterion 3)	Method: Test temperatures: Bending angle: Force application: Number of cycles: Duration: Test pressure: Pre-conditioning procedure: Sample size:	IEC 61300-2-37 –15 °C ± 2 °C and +45 °C ± 2 °C +30° and –30° (maximum force shall not exceed 500 N) 400 mm from end of seal[a] 5 cycles per cable 5 min at extreme positions Internal overpressure 40 kPa ± 2 kPa sealed at test temperature Sample conditioned at the specified test temperature and test pressure for at least 4 h 3 per test temperature
5	Cable torsion	Sealing performance (criterion 1) Pressure loss (criterion 2) Visual examination (criterion 3)	Method: Test temperatures: Torque angle: Force application: Number of cycles: Duration: Test pressure: Pre-conditioning procedure: Sample size:	IEC 61300-2-5 –15 °C ± 2 °C and +45 °C ± 2 °C +90° and –90° (maximum torque shall not exceed 50 Nm) 400 mm from end of seal[a] 5 cycles per cable 5 min at extreme positions Internal overpressure 40 kPa ± 2 kPa sealed at test temperature Sample conditioned at the specified test temperature and test pressure for at least 4 h 3 per test temperature

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No.	Test	Requirement	Details	
6	Impact	Sealing performance (criterion 1) Pressure loss (criterion 2) Visual examination (criterion 3)	Method: Test temperatures: Impact tool: Drop height: Impact locations: Number of impacts: Test pressure: Pre-conditioning procedure: Sample size:	IEC 61300-2-12, method B –15 °C ± 2 °C and +45 °C ± 2 °C Steel ball of 1 kg 2 m Centre of closure at 0°, 90°, 180° and 270° around longitudinal axis of closure 1 per location Internal overpressure 40 kPa ± 2 kPa sealed at test temperature Sample conditioned at the specified test temperature and test pressure for at least 4 h 3 per test temperature
7	Crush resistance	Sealing performance (criterion 1) Pressure loss (criterion 2) Visual examination (criterion 3)	Method: Test temperatures: Load: Application area: Locations: Duration: Test pressure: Pre-conditioning procedure: Sample size:	IEC 61300-2-10 –15 °C ± 2 °C and +45 °C ± 2 °C 1 000 N 25 cm^2 (circular shape) Centre of closure at 0° and 90° around longitudinal axis of closure 10 min per location Internal overpressure 40 kPa ± 2 kPa sealed off at test temperature Sample conditioned at the specified test temperature and test pressure for at least 4 h 3 per test temperature
8	Assembly and disassembly of closures	Sealing performance (criterion 1) within 10 min after closing the closure. Visual examination (criterion 3)	Method: Test temperature: Conditioning between each re-entry: Number of re-entries: Sample size:	IEC 61300-2-33 +23 °C ± 5 °C Ageing of at least 1 temperature cycle as specified in test 9 5 3
9	Change of temperature	Sealing performance (criterion 1) Visual examination (criterion 3)	Method: Extreme temperatures: Dwell time: Rate of change Number of cycles: Test pressure: Sample size:	IEC 61300-2-22 –30 °C ± 2 °C and +60 °C ± 2 °C 4 h 1 °C/min 12 Internal overpressure 40 kPa ± 2 kPa regulated 3

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