INDEPENDENT POWER TRANSMISSION OPERATOR S.A.

TRANSMISSION NEW PROJECTS DEPARTMENT

TRANSMISSION LINES TOWER DESIGN
AND SPECIFICATIONS SECTION

TECHNICAL SPECIFICATION OPGW
OPTICAL FIBRES CLOSURE SYSTEM

Revision March 2015

ATHENS - GREECE

1. INTRODUCTION

In this document are defined technical, constructive and functional characteristics of the OPGW optical fibre cables closure system.
This product must be installed on tower power lines, pylons, walls and others supports.
The closure system must be configured in a way that allows, from the same side, the input and output of the OPGW primary cables and the output of drop cables.
The principal characteristic of the closure system must be the possibility to separately manage the circuits using particular splicing modules, avoiding the risk to interfere with the operating circuit during the handling and network configurations operations.
As reference in fig.1 is shown the OPGW optical fibre cables closure system.

FIG. 1

2. CONSTRUCTIVE AND FUNCTIONAL CHARACTERISTICS

The closure system must be designed as a modular system, with a basic configuration that can be equipped, in factory or in the field, with different modules and/or accessories that can be used in the following configurations:

- In-line splice
- Drop splice
- Terminal splice.

The Closure system, in basic configuration, is made of a metallic watertight box. This box must have a base with entrances that can seal input/output cables, a cover and a system able to seal tightly and to re-open the base and the cover.
The base of the closure system must include at least 6 circular entrances, closed by tops, that can be opened during installation and that can accept OPGW cords and/or optical cables with different dimensions and structures.
The tight closing between base and cover must be guaranteed by the use of a crushproof material trimming.
This trimming must be removable to avoid contamination from external agents during installation and handling operations.

The base of the Closure system must be provided by a valve that verifies pneumatic tight.
Inside the closure system must be predisposed a rack that allows to assemble in a modular and flexible way the splice module necessary in the different configurations.
The Opening of closure system cover must allow an immediate access to the optical wiring, to the card with splices and to everything should be reached during normal handling operations.
The fibres inside the closure system have to be managed individually without interfering with the operating circuits and the access to the splices in the modules must happen without necessity to handle or remove wirings.
Every module must contain the fibres splice of the single circuit. It must be structured so that the single fibre should be protected and routed to guarantee the minimum bend radius even during the handling operations.
The module has to be able to accept the most common splice protection system.
Right accessories must be expected to allow the separation of the single tube fibres to guarantee the correct routing of the fibres, the respect of the minimum bend radius and an easy installation.
The central element of the cable must be mechanically fixed inside closure system and it should be able to support stresses generated from the same cable.
The steel wires of the OPGW covering cable have to be terminated outside closure system entrances.
The minimum number of optical fibres splices must be at least 48 (48+48) for each cable.
The closure systems shall be installable at temperatures between –5°C and +45°C.

3. MATERIALS CHARACTERISTICS

The Closure system must be composed by a metallic container made of a base and a cover.
The container must be resistant to corrosion and must have a low level of humidity storage.
The used plastic materials shall withstand storage temperatures of working conditions.
The trimming between base and cover must be made of a crushproof plastic material.
Generally the closure system must be made of a material that allows:

- To maintain in time the mechanical, physical and chemical characteristics of the used materials.
- To guarantee mechanical resistance of the closure systems and his internal parts to the atmospheric stresses.
- To guarantee stability of input/output fixing points of the OPGW cord and dielectric optical cables.
- To guarantee mechanical resistance to the external stresses such as acts of vandalism etc.

The supplier must declare the productive process and every kind of material used to realise the product described in this technical specification.

4. POTENZIALITY AND CONFIGURATION TYPE

4.1. BASED CONFIGURATION

The based configuration is composed by:

- A base equipped with at least six inputs that can be used to input/output of the single cables.
- A closing cover.
- A closing system between base and cover.
- A trimming between base and cover made of crushproof material.
- An internal rack to support of the splice module and wirings.

4.2. IN-LINE CLOSURE SYSTEM

This configuration must allow the splice of optical fibres between two OPGW cables.
The closure system is equipped with:

- N°1 basic closure system.
- N°2 OPGW entrance cable kit.
- N°4 closing covers for the unused holes.
- N°1 fixing cables kit.
- N°12 optical fibres splices cards.
- N°1 kit of materials and accessories necessary to the wiring.

4.3. ADD/DROP CLOSURE SYSTEM

This configuration must allow to drop some fibres from a cable trunk, by one or more, generally dielectric, cables.
The closure system is equipped with:

- N°1 basic closure system
- N°2 OPGW entrance cable kit
- N°1 dielectric entrance cable kit
- N°3 closing covers for the unused holes;
- N°1 fixing cables kit
- N°12 optical fibres splices cards
- N°1 kit of materials and accessories necessary to the wiring.

4.4. TERMINAL CLOSURE SYSTEM

This configuration must allow, on a terminal tower, the splice of the fibres contained in the OPGW cable with the fibres in the laying underground dielectric optical cable that is connected to the terminal equipment.
The closure system is equipped with:

- N°1 basic closure system
- N°1 OPGW entrance cable kit
- N°1 dielectric entrance cable kit
- N°4 closing covers for the unused hole

- N°1 fixing cables kit
- N°12 optical fibres splices cards
- N°1 kit of materials and accessories necessary to the wiring.

5. MARKING OF CLOSURE SYSTEM

Marking must allow the identification of every component production lot of the closure system. The following indications must be reported inside the closure system and outside the cover.

- Company supplying logo
- Manufacture year
- Lot number or similar identification system of the production set

Is allowed the use of not removable plastic label or label printed with permanent ink.

6. ACCESSORIES

The closure system must have the materials and accessories necessary to a correct installation.

6.1. OPGW CABLE ENTRANCE KIT

The Kit must be used in case of in-line, drop and terminal splices, to make every preparation of an OPGW cable end. The kit must allow locking and sealing the cable on the base of the closure system.
The Kit must be equipped with:

- Materials and accessories necessary to lock and seal the cable
- Device necessary to lock the central element of the cable
- Materials necessary to prepare the cable end and to separate the fibres, wiring materials.

6.2. DIELECTRIC CABLE ENTRANCE KIT

The Kit must be used in case of drop and terminal splices, to make every preparation of a dielectric cable end. The kit must allow locking and sealing the cable on the base of the closure system.
The Kit must be equipped with:

- Materials and accessories necessary to lock and seal the cable
- Device necessary to lock the central element of the cable
- Materials necessary to prepare the cable end and to separate the fibres, wiring materials.

6.3. SPLICE MODULE

The splice module must be realised to allow protection of:
- The splices between optical fibres

- The wealth cables.

The module must have a dimension that allows the management of the single circuit (two fibres per module) in the respect of a minimum radius and an easy installation.
As reference in fig. 2 is shown the splice module.

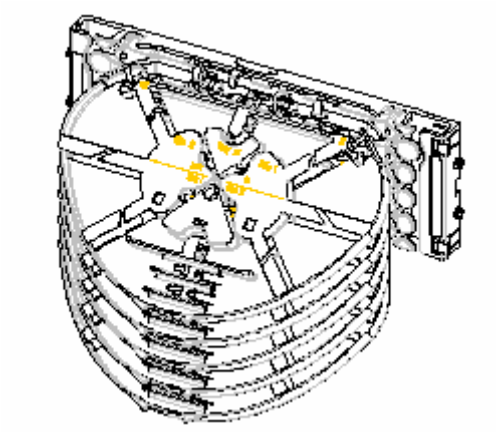


FIG. 2

6.4. SUPPORTING BRACKET

The closure system must be equipped with an adequate supporting bracket system that allows the fixing in the places where the installation is expected.
The closure systems installed on the pylons must be fixed avoiding holes or soldering (etc.) and any modifications to the pylons.

7. PRODUCT DESCRIPTION

The closure systems must be a combination of a fibre organizer and a cable closure, designed to provide environmental and mechanical protection for joints for fibre optic cables in above-ground situations.

- The closures must be dome ended and easy to open and close, without need for special tools.
- An internal mounting bracket for the organizer must be provided to allow modular and flexible mounting of all organizer modules.
- The closures must allow easy fibre access during installation, maintenance, and addition of organizer modules.
- All fibre cable elements must be routed in such a way that no transmission degradation is seen when accessing these cable elements. The minimum bend radius of the fibres after installation is 30 mm throughout the whole closure systems.
- The closures must be used in two external network functions with different sets of factory or field installable fibre management modules:

1. An in-line joint is used when lengths of cable need to be joined. The organiser tray can accommodate sufficient fibre on each side of the splice to allow for 10 resplices.
2. A Spur Joint (SJ) is used when fibres of a fibre ring are spliced to the fibres of a spur cable in order to extend the fibre ring. The organiser tray can accommodate sufficient fibre on each side of the splice to allow for 10resplices.

- It must be possible to terminate different cable types and constructions in a diameter range of 9 to 22 mm.
- Provision must be made for the central or peripheral strength members of the cables to be mechanically attached to the inner hardware of the closure. Closure mounting systems must be available.

8. REQUIREMENTS

8.1. GENERAL REQUIREMENTS

The products shall be capable of meeting the functional requirements as specified on the following pages when installed in accordance with the applicable installation instructions and tested according to the methods of test described in this document.

- Dimensions of the parts shall comply with the applicable specification control drawings as provided by the manufacturer.
- The components of the kits shall be free of defects that would adversely affect product performance.
- The effect of fungus and UV on polymeric materials shall not adversely affect product performance.
  The effect of fungus shall be determined according to ISO 846 and the effect of UV exposure shall be determined according to ASTM G154, measuring a suitable property (e.g. tensile strength / impact strength) both before and after exposure.
- Metal parts on the outside of the closure shall be resistant to the corrosive influences they may encounter in normal use.
- The products' components shall withstand storage temperatures of -30°C to +60°C and storage humidity levels up to 93%RH.
- The splice closures shall be installable at temperatures between -5°C and +45°C.
- The splice closures shall allow the accommodation of the fibres with a minimum bend radius of 30 mm.
- Each kit shall have a label with the following information:
  Supplier's name
  Product designation
  Manufacture year
  Batch number.
- All device materials that will come into contact with personnel shall be non-toxic and shall not be a potential environmental hazard.

8.2. FUNCTIONAL TIGHTNESS REQUIREMENTS

CRITERIA	METHOD AND CONDITIONS		INTERNA-TIONAL NORM	PAGE No.	REQUIREMENT
PERFORMANCE CRITERIA REFERENCE					
PRESSURE LOSS DURING TEST	Internal pressure: Test temperature: Elapsed time:	(40 □2) kPa (23 □3)℃ <12 hrs	IEC 61073-1 Par. 3.7.17	13	Difference in pressure before and after the test □□2 kPa at the same atmospheric conditions
TIGHTNESS	Internal pressure: Test temperature: Test time:	(40 □2) kPa (23 □3)℃ 15 minutes	IEC 60068-2-17 Test Qc	17	No continuous emission of bubbles
VISUAL APPEARANCE	Examination of product with naked eye		IEC 61073-1 Par. 3.3	20	No defects which would adversely affect product performance

TEST	METHOD AND CONDITIONS		INTERNA-TIONAL NORM	PAGE No.	REQUIREMENT
MECHANICAL TESTS (TIGHTNESS)					
AXIAL TENSION	Load/cable: Test pressure: Test time:	D/45 x 1000 N (1000 N max.) (40 □2) kPa sealed 1 hr each	IEC 61073-1 Par. 3.6.8.2	10	• Tightness • Pressure loss during test • Displacement □□3 mm
IMPACT	Test pressure: Test temperature: Impact tool: Weight: Drop height: Location: Number of impacts:	(40 □2) kPa sealed (23 + 3)℃ steel ball 1 kg 2 m middle of closure 1	IEC 61073 Par. 3.6.13	12	• Tightness • Pressure loss during test • Appearance
RE-ENTRIES	Number: Aging between each re-entry: Temperature range: Dwell time: Transition time: Test pressure:	10 minimum 1 cycle -30℃/+60℃ 4 hrs 2 hrs (40 □2) kPa regulated	IEC 61073-1 Par 3.6.7	14	• Tightness • Appearance

Note 1: D is the cable outer diameter in mm.
Note 2: Flexure test is not carried out since cables are clamped in an external bracket. Cables will therefore never be flexed at cable ports..

FUNCTIONAL TIGHTNESS REQUIREMENTS (CONTINUED)

TEST	METHOD AND CONDITIONS		INTERNA-TIONAL NORM	PAGE No.	REQUIREMENT
MECHANICAL TESTS (TIGHTNESS)					
SHOCK	Severity: Duration: Wave form: Number of shocks: Axes: Test pressure:	15 g (150 m/s²) 11 milliseconds half sine 3 up & 3 down 3 mutually perpendicular (40 ±2) kPa sealed	IEC 60068-2-27 TEST EA	14	• Tightness • Appearance • Pressure loss during test
SHOT GUN DAMAGE	Distance: Calibre: Lead pellets:	20 m 12/70 Nr.5 (3 mm)	IEC 60794-1-2 Method E13	15	• Tightness • No damage to organizer system
TORSION	Test pressure at RT: Test temperature: Torque: Torque application: No. of cycles:	(40 ±2) kPa sealed (-15 ±2)°C and (+45 ±2)°C Max. 50 Nm or max.90° rotation 400 mm from end of cable seal fixation. 5 per cable.	IEC 61073-1 Par. 3.6.8.3	18	• Tightness • Pressure loss during test • Appearance
VIBRATION (Tightness)	Test pressure: Frequency: Cycle: Amplitude: Cable clamping: Duration:	(40 ±2) kPa regulated (10 ±1) Hz Sinusoidal 3 mm 500 mm from end of cable seal sleeve 10 days	IEC 60068-2-6 Test Fc	20	• Tightness • Appearance
ENVIRONMENTAL TESTS (TIGHTNESS)					
TEMPERATURE CYCLING	Lowest temperature: Highest temperature: Dwell time: Transition time: Internal pressure: Number of cycles:	(-30 ±2)°C* (+60 ±2)°C* 4 hrs 2 hrs (40 ±2) kPa regulated 20	IEC 60068-2-14 Test Nb	16	• Tightness • Appearance

** If this temperature falls outside the range specified for any of the cables being used, the test temperature must be modified accordingly..*

8.3. FUNCTIONAL OPTICAL REQUIREMENTS

CRITERIA	METHOD AND CONDITIONS		INTERNA-TIONAL NORM	PAGE No.	PERFORMANCE CRITERIA TO BE CHECKED
PERFORMANCE CRITERIA REFERENCES (OPTICAL)					
CHANGE IN INSERTION LOSS	Source wavelength	1310 1550 and 1625 nm	IEC 61300-3-3 Method 1	11	δIL < 0.2 dB per incoming fibre during the test δIL< 0.1 dB per incoming fibre after the test
TRANSIENT LOSS	Source wavelength: Detector bandwidth	1550 nm, Unpolarized (0-1500) Hz	IEC 61300-3-28	19	δIL< 0.5 dB during the test measured in active circuit δIL< 0.1 dB after the test in active circuit
VISUAL APPEARANCE	Examination of product with naked eye		IEC 61073-1 Par. 3.3.	20	No defects which would adversely affect product performance

TEST	METHOD AND CONDITIONS		INTERNA-TIONAL NORM	PAGE No.	PERFORMANCE CRITERIA TO BE CHECKED
MECHANICAL TESTS (OPTICA)L					
SHOCK	Severity: Duration: Wave form: Number of shocks: Axes:	15 g (150 m/s²) 11 milliseconds half sine 3 up & 3 down 3 mutually perpendicular	IEC 61300-2-9	15	• Appearance • Transient loss
VIBRATION	Test temperature: Sweep range: - crossover frequency: - severity below 9 Hz: - severity above 9 Hz: Axes: Duration:	(+23 3)°C (5-500) Hz at 1 octave/minute 9 Hz 3.5 mm 10 m/s² 1 g) 3 mutually perpendicular 10 cycles/axis	IEC 61300-2-1	20	• Appearance • Transient loss
ENVIRONMENTAL TESTS (OPTICAL)					
TEMPERATURE CYCLING	Lowest temperature: Highest temperature: Dwell time: Transition time: Number of cycles:	(-30 2)°C* (+60 2)°C* 4 hrs 2 hrs 20	IEC 61300-2-22	17	• Appearance • Change in insertion loss

** If this temperature falls outside the range specified for any of the cables being used, the test temperature must be modified accordingly.*

IMPORTANT:

- Quoted indicated optical loss values use the optical signal at the start of the test as a reference point.
- An "incoming fiber" is defined as a part of an optical circuit containing the fibre entering the product, spliced to a fibre leaving the product. One optical circuit can contain many "incoming fibers". Light will sequentially flow through all the "incoming fibres".
- Fibre types to be used for all test samples are ITU-T G.652.B and G.655.B.

9. TEST PROCEDURES

9.1. INSTALLED PRODUCT TEST PROCEDURES

9.1.1.General

- The construction and configuration of test samples shall be as described in the test plan.
- For internal qualification or requalification the number of samples being tested shall be based on an approved statistical methodology.
- For each tightness test, 3 freshly installed samples shall be used.
- For the optical tests a minimum of one circuit shall be constructed in a sample. The circuit shall contain a minimum of 10 fusion splices.
- All installations shall be performed according to standard installation instructions and at room temperature, unless otherwise stated.
- All test samples shall be installed with cables. If it is required to use cables with performance capabilities below the requirements of any particular test, test parameters will need to be appropriately modified.
- Tightness test samples shall be installed over unspliced optical cable. The cable ends shall be capped. Test samples shall include both maximum and minimum cable diameters as specified in the applicable installation instructions. It is not necessary to use all cable ports.
- For test pressure access, a valve shall be installed in the dome or cable caps.
- Unless specified otherwise, internal pressurization is achieved with an air supply with a tolerance of 2 kPa of the specified value.
- Testing is at room temperature * unless otherwise specified. When tests are specified at temperatures other than ambient, the samples shall be preconditioned for a period of 4 hours at those temperatures.
- Pressure measurements before and after the test shall be carried out with the same pressure measurement equipment and at the same atmospheric conditions (temperature and pressure). When a difference is observed in atmospheric conditions the pressure value shall be adjusted according to the following formula: p.V/T=cte.

9.1.2.Axial Tension

Following test shall simulate cable/closure manipulation. It specifically addresses seal performance.

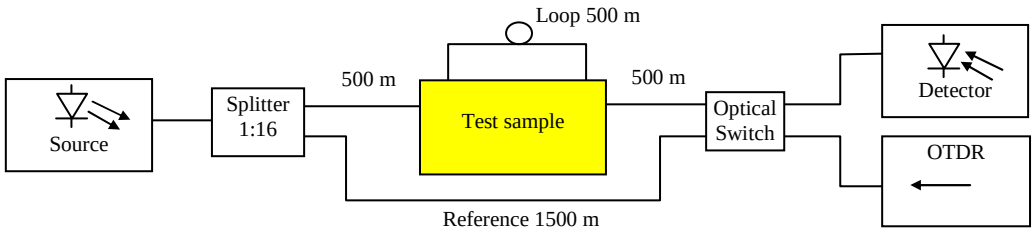
* Standard laboratory conditions of (+23 ± 3)ºC.

- Testing shall be performed in accordance with IEC 61073-1 par. 3.6.8.2.
- Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure shall be measured and recorded.
- The base assembly shall be clamped, and a force shall be applied to each of the extending cables individually for a period of one hour.
- The force per cable shall be calculated according to the equation:
  D (cable outer diameter in mm)/45mm x 1000 N, with a maximum of 1000 N.
- After completion of the test, internal pressure shall be checked and specimens shall be subjected to the tightness test described hereto.
- Cable displacement <= 3 mm.

9.1.3.Change in Insertion Loss

This is the criterion test to be used for optical measurements during and after the test. The value quoted assumes the use of a stable qualified splice/protector, well installed.

- Testing shall be performed in accordance with IEC61300-3-3 Method 1.
- This is defined as a measured attenuation which is exhibited by stable transmission measurements taken before, during and after a test.
- It shall be measured using an optical source and a detector operating at 1310 nm, 1550 nm and 1625nm.
- The test set-up is shown below:



Source: 1310 nm □□20 nm 1550 nm □□20 nm and 1625 nm □□20 nm
Switch: Repeatability better than 0.04 dB.

- The in and outgoing fibres of each circuit are spliced onto the connection fibres of the equipment. Splices shall be made using good-quality fusion splices.
- During the test the optical signal in each fibre of the fibre circuit shall be monitored with the light source and detector at both wavelengths.
- A change of more than 0.2 dB per incoming fibre (during the test) from the initial value constitutes a failure.
- A change of more than 0.1 dB per incoming fibre (after the test) from the initial value constitutes a failure.

Note: The above mentioned loss criteria are per incoming fibre. Since one circuit can contain several incoming fibres it is possible that the total circuit generates higher losses.
In this case the loss contribution per incoming fibre needs to be checked. This can be done using an OTDR or by reducing the number of incoming fibres per circuit.

9.1.4.Impact

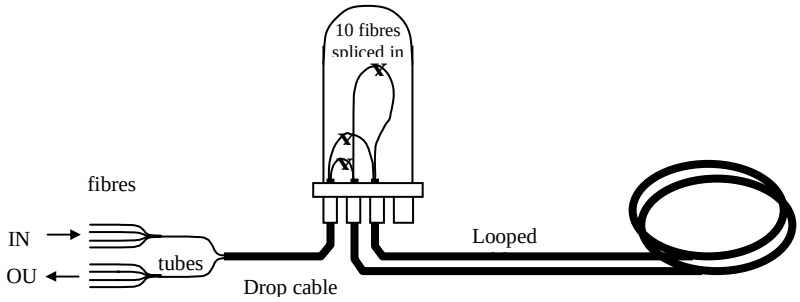
This test is included to cover the effect of falling objects (by accident), e.g. tools, etc. on the metal closure.

- Testing shall be performed in accordance with IEC 61073-1 Paragraph 3.6.13.
- Testing shall be at room temperature.
- Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure will be measured and recorded (see page 13).
- A sample shall be placed on a smooth, flat, horizontal surface with its longitudinal axis parallel to it.
- A steel ball weighing 1 kg shall be suspended at a height of 2 meters above the centre of the test specimen then allowed to fall under the influence of gravity.
- After visual inspection with the naked eye (visual appearance), pressure is checked and samples shall be subjected to the tightness test described hereto.

9.1.5.Installation of the Closure (Optical)

Description of optical test sample.

- An optical sample is prepared as follows:



- The extremities of a 50 meter looped cable (loose tube construction, 12 fibres/tube, minimum 48 fibres) are brought into a closure.
  In the closure the fibres from one cable end are spliced to the fibres at the other cable end in such a way that light will sequentially flow through 10 randomly selected fibres. All spliced fibres will be stored inside the organizer trays. Splices shall be made using good-quality fusion splices. The fibres of a drop cable are spliced to the above mentioned circuit to make external connections to a light source and an optical power meter.
- The remaining dark fibres are routed towards the organizer trays and stored inside the trays.

9.1.6.Pressure Loss during Test

This is the criterion test to be used for the tightness of a product during the test. The value quoted assumes the difference between 2 pressure measurements within 12 hours.

- Testing shall be performed in accordance with IEC 61073-1 Paragraph 3.7.17.
- This is defined as a measured pressure loss taken before and after a test with the same pressure measurement equipment and at equal atmospheric conditions (temperature and pressure).
- The pressure test equipment shall have a resolution of 0.1 kPa.
- The maximum time between the 2 measurements shall be 12 hrs (to minimize the changes in atmospheric conditions).
- A pressure loss of more than 2 kPa will constitute a failure.

9.1.7.Re-entry

This is the criterion test to be used to check the tightness performance of closure which will be re-entered several times during its lifetime.

- Testing shall be performed in accordance with IEC 61073-1 paragraph 3.6.7.
- Samples shall be pressurized internally at 40 kPa regulated.
- Samples shall be supported in racks during testing in such a way that they are thermally isolated.
- There shall be free circulation of air both between specimens and between the specimens and the chamber surfaces.
- They shall be subjected to at least 1 cycle defined as follows:

Time	**Temperature or Range**
4 hrs	+20°C
1 hr	+20°C to +60°C
4 hrs	+60°C
2 hrs	+60°C to -30°C
4 hrs	-30°C
1 hr	-30°C to +20°C
4 hrs	+20°C

- The closures are opened, resealed and pressurized again at 40 kPa regulated and the whole sequence is repeated.
- In total 10 re-entries will be carried out on each test sample.
- After testing, samples shall be examined with the naked eye for signs of defects and subjected to the tightness test described hereto.

9.1.8.Shock (Tightness)

Following test must be done to check the effect of sudden, sharp movements during transport or closure handling.

- Testing shall be according to IEC 60068-2-27, Test Ea.
- Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure will be measured and recorded as indicated hereto.
- Samples shall be strapped onto a vibration bank and subjected to 3 shocks in each direction (up and down) for 3 mutually perpendicular axes.
- Shocks shall have a half-sine waveform and an acceleration of 150 m/s^2 and a duration of 11 ms.
- After the test, samples shall be examined with the naked eye (visual appearance), and then be subjected to the pressure loss test (as indicated hereto) and the tightness test (described hereto).

9.1.9.Shock (Optical)

Following test must be done to check the effect of sudden, sharp movements on fibre and splice storage.

- Testing shall be according to IEC 61300-2-9.
- The optical test samples shall be built as described hereto.
- The optical circuit shall be connected to optical transient test equipment as described hereto.
- The cables extending from the test specimens shall be clamped so that they remain parallel to each other during testing.
- Sample shall be strapped onto a vibration bank and subjected to 3 shocks in each direction (up and down) for 3 mutually perpendicular axes.
- Shocks shall have a half-sine waveform and an acceleration of 150 m/s^2 and a durationof 11 ms.
- During and after the test, the optical signal will be monitored in the active circuit for transient optical losses as described hereto.
- After completion of the test, specimens shall be examined with the unaided eye for damage that would impair product functionality (visual appearance).

9.1.10.Shot Gun Damage

Following test must be done to specifically addresse an aerial closure's resistance when shot at.

- Testing shall be performed in accordance with IEC 60794-1-2 Method E13.
- Samples shall not be pressurized.
- 3 mm lead pellets (calibre: 12/70, Size Nr. 5) will be fired at the closure from a distance of 20 meters.
- After completion of the test, the closure shall be subjected to the tightness test described hereto.
- The closure shall be opened and checked for internal damage (visual appearance). No ammunition shall be found inside the closure.

9.1.11.Temperature Cycling (Tightness)

This is an accelerated ageing test that must be done to highlight possible material incompatibility.
It is also a lifetime simulation of seal integrity. The temperature range selected covers both indoor and outdoor closure applications but may be modified to accommodate cable specifications as necessary.

- Testing shall be according to IEC 60068-2-14, Test Nb.
- For mechanical evaluation (using tightness as the criterion test) installed closure systems shall be pressurized internally at 40 kPa regulated.
- Samples shall be supported in racks during testing in such a way that they are thermally isolated.
- There shall be free circulation of air both between specimens and between the specimens and the chamber surfaces.
- They shall be subjected to 20 cycles defined as follows :

Time	**Temperature or Range**
2 hrs	-30°C to +60°C
4 hr	+60°C
2 hrs	+60°C to –30°C
4 hrs	-30°C

- After testing, specimens will be subjected to the tightness test described hereto and samples shall be examined with the naked eye (visual appearance).

9.1.12.Temperature Cycling (Optical)

This is a lifetime simulation of optical performance to be done. The temperature range selected covers both indoor and outdoor closure applications but may need to be modified (to less severe extremes) to accommodate cable specifications as necessary.

- The optical test samples shall be built as described hereto.
- The circuit of the test sample will be connected to optical test equipment as described hereto.
- Temperature cycling test shall be according to IEC 61300-2-22.
- Samples for optical evaluation are sealed but not pressurized.
- Samples shall be supported in racks during testing in such a way that they are thermally isolated, and there shall be free circulation of air both between specimens and between the specimens and the chamber surfaces.
- They shall be subjected to 20 cycles defined as follows:

Time	**Temperature or Range**
2 hrs	-30°C to +60°C
4 hr	+60°C
2 hrs	+60°C to –30°C
4 hrs	-30°C

- The change in optical signal during and after the test is checked for each circuit as described hereto.
- After the test, samples shall be examined with the naked eye (visual appearance).

9.1.13.Tightness

This is the criterion test to be done to check the integrity of the seals both after installation and after mechanical or environmental testing.

- Testing shall be performed in accordance with IEC 60068-2-17 Test Qc.
- The tightness of installed closures shall be checked by pressurizing to 40 kPa for a period of 15 minutes while immersed in water at room temperature.
- A sample shall be considered tight if there is no continuous stream of air bubbles escaping from it.

9.1.14.Torsion

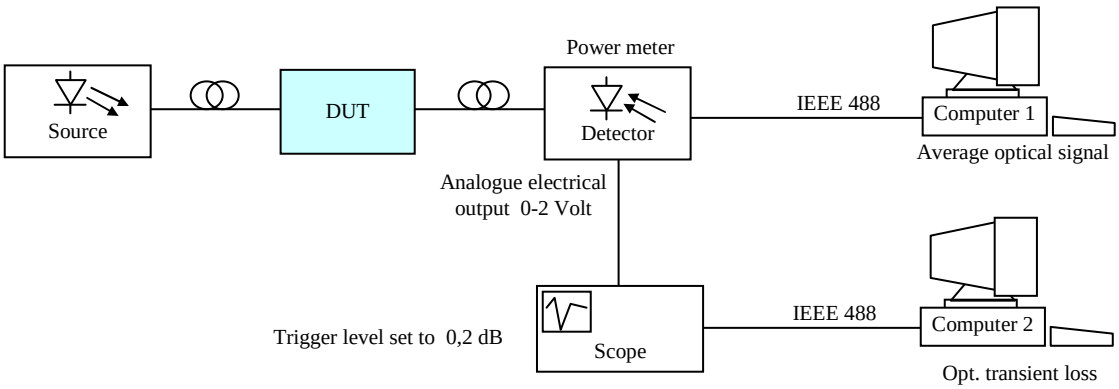
This test must be done to simulate cable/closure manipulation and focuses on the performance of seal integrity.

- Testing shall be performed in accordance with IEC 61073-1 Paragraph 3.6.8.3.
- Testing shall be done at -15°C and +45°C.
- Samples shall be pressurized internally at 40 kPa at room temperature and sealed prior to testing. The internal pressure will be measured and recorded.
- Samples shall be conditioned at -15°C or +45°C.
- Each extending cable shall in turn be clamped rigidly at a distance of 400 mm, measured from the cable seal sleeve.
- The closure system shall be axially rotated through 90° and retained in that position for aperiod of 5 minutes. The torque applied shall not exceed 50 Nm.
- It shall then be returned to its original position and the procedure repeated in the opposite direction.
- After 5 cycles, specimens shall be examined with the naked eye (visual appearance), internal pressure is checked (as described hereto) and then subjected to the tightness test described hereto.

9.1.15.Transient Loss

This is the criterion test to be done to check the influence on the optical signal transmission of active circuits during and after typical handling operations.

- Testing shall be in accordance with IEC 61300-3-28.
- It shall be measured using an optical source and a fast detector operating at 1550 nm (most sensitive for bending losses).
- The optical detector shall have a minimum bandwidth of 0 - 1500 Hz.
- The test set-up is shown below:



- The optical test samples shall be built as described hereto.
- Splices shall be made using good-quality fusion splices.
- 2 pigtails shall be spliced to the fibres of the optical link to make external connections to a light source and an optical power meter.
- During the test the optical signal in the fibre circuit shall be monitored for transient losses. A peak loss of more than 0.5 dB from the initial value constitutes a failure.
- After the test the average optical signal in the fibre circuit shall be measured. A change of more than 0.1 dB from the initial value constitutes a failure.

9.1.16. Vibration (Tightness)

This test must be done to simulate cable movement in the ports and tests the performance of the seals. The conditions relate to vibration caused by passing traffic.

- Testing shall be in accordance with IEC 60068-2-6, Test Fc.
- Samples shall be pressurized internally at 40 kPa regulated.
- The dome shall be mounted horizontally on a vibration bank, the cables shall be clampedat a distance of 500 mm from the cable seal sleeves.
- The closure shall be subjected to a vibration test with the following parameters:

Parameter	**Value**
Frequency	(10 ± 1) Hz
Cycle	Sinusoidal
Amplitude	3 mm
Duration	10 days

- After testing, specimens shall be examined with the naked eye and then subjected to thetightness test described hereto.

9.1.17. Vibration (Optical)

This vibration test must to be done to highlight possible problems caused by resonance effects. The effect on fibre and splice storage is checked. The conditions relate to vibration caused by passing traffic.

- Testing shall be in accordance with IEC 61300-2-1.
- The optical test sample shall be built as described hereto.
- The optical circuit will be connected to optical transient test equipment as described hereto.
- The closure shall be mounted on a vibration bank and shall be subjected to a sweeprange of 5-500 Hz at 1 octave/minute with the following parameters:

Parameter	**Value**
Crossover frequency	9 Hz
Amplitude below 9 Hz	3.5 mm
Acceleration above 9 Hz	10 m/s^2 (~ 1 g)

- The test shall be repeated for each of 3 mutually perpendicular axes, for a total of 10 cycles/axis.
- During and after the test the optical signal will be monitored for transient optical losses as described hereto. After completion of the test specimens shall be examined with the unaided eye for damage that would impair product functionality (as described hereto).

9.1.18. Visual Appearance

This is to be included to ensure that no obvious defects are present that would affect product performance.

- Testing shall be performed in accordance with IEC 61073-1 Paragraph 3.3.
- The closure system and components shall be inspected for flaws, defects, pinholes, cracks or inclusions visible to the naked eye.