TYPE TEST REPORT FOR
OPGW 50E86z-48M (7448)

Client: **TERNA**
Dates: **June 8-10th 2011; June 25-29th 2011; July 1st 2011**
Drum tested: **N-22620-Y; N-22618-W (3.12) and X-02450-F (all tests)**

The following Composite Fiber Optic Ground Wire (OPGW) cable type tests have been carried out in accordance with the specifications referred:

Tests on wires before stranding		**Standard**	**Date**
1.1	Wire performance (A,B)	CEI 7-2	June 8th 2011
1.2	Mech. Prop. of wires (C)	CEI 7-2	
1.3	Wrapping test (D)	CEI 7-2	
1.4	Torsion test (E)	CEI 7-2	
1.5	Galvanizing thickness (I)	CEI 7-2	June 8-10th 2011
Tests on wires after stranding			
2.1	Wire performance (A,B)	CEI 7-2	June 8th 2011
2.2	Mech. Prop. of wires (C)	CEI 7-2	
2.3	Wrapping test (D)	CEI 7-2	
2.4	Torsion test (E)	CEI 7-2	
2.5	Galvanizing thickness (I)	CEI 7-2	June 8-10th 2011
Tests on completed cable			
3.1	Cable performance, formation…	CEI EN 50182	June 8th 2011
3.2	Mass verification	CEI EN 50182	
3.3	Ultimate tensile strength	CEI EN 50182	June 9th 2011
3.4	Q-test	UX LC 3907	June 8th 2011
3.5a	Stress-strain test	CEI EN 50182	June 9-10th 2011
3.5b	Stress-strain with new tension assembly	CEI EN 50182	July 1st 2001
3.7	Internal self-damping	CIGRE No. 62	June 25-29th 2011
3.8	Aeolian vibrations (new tension assembly)	UX LC 3907	
3.9	Mechanical cycles simulating thermal excursions (new tension assembly)	UX LC 3907	
3.10	Sheave test	IEC 60794-4-1	June 8th 2011
3.11	Wire unwrapping	UX LC 3907	June 10th 2011
3.12	Attenuation linearity	IEC 60793 C1C	June 9th 2011
3.13	Temperature cycles	IEC 794-1-F1	June 6-9th 2011

Tests on fittings		Standard	Date
4.1	Verification of dimensions	UX LM 3900	June 27-29th 2011
4.2	Galvanizing test	CEI 7-6	
4.3	Slip test for suspension clamp (SC)	UX LM 3900	
4.4	Failure load test for SC	UX LM 3900	
4.5	Clamp bolt tightening test for SC	UX LM 3900	
4.6	Slip test for tension clamp (TC)	UX LM 3900	
4.7	Failure load test for TC	UX LM 3900	
4.8	Slip test for groove clamps (GC)	UX LM 3900	
4.9	Clamp bolt tightening test for GC	UX LM 3900	
4.10	Clamp bolt tightening test for damper (D)	UX LM 808	
4.11	Attachment of weights to messenger (D)	UX LM 808	
4.12	Attachment of clamp to messenger (D)	UX LM 808	
4.13	Clamp slip test for damper	UX LM 808	
4.14	Damper characteristic test	UX LM 808	

All cable tests except 3.7 to 3.9 have been performed at Prysmian Cables y Sistemas, Ctra. C-15 Km-2, Pol. Ind. Masia d'en Notari-PRYSMIAN, 08800 Villanova y la Geltrú, Barcelona, España, by Dr. J. Martín-Regalado, from Prysmian Cables y Sistemas. Tests were witnessed by Eng. A. Piccinin and Mr. G. Gennusa from TERNA S.p.A. Results for these tests were found satisfactory as per the following attached reports. The only exception was the stress-strain test (3.5a) that could not be fully completed because of the failure (twist) of the tension deadend at 85% RTS.

In order to fix the issue, NES S.p.A. developed and manufactured along weeks 24th and 25th a new tension deadend with a large diameter wire. Tests 3.7 to 3.9 where carried out at Nuova Electtromeccanica Sud S.p.A. by Eng. C. Garescí with such new tension dead-end assembly. The three tests were witnessed by Eng. A. Piccinin and Mr. G. Gennusa from TERNA S.p.A., and by Dr. J. Martin-Regalado, from Prysmian Cables y Sistemas. The results for these tests were found satisfactory as per the attached reports in Annex A.

To complete the cable qualification, the stress-strain test was repeated at Prysmian with the new tension deadend. The test was witnessed by Eng. F. Guerra from NES, and Eng. C. Garescí from NES S.p.A. Result for the stress-strain tests was satisfactory as per the attached reports 3.5b

Type and acceptance tests on fittings where carried out at Nuova Electtromeccanica Sud S.p.A. by Eng. C. Garescí. Tests were witnessed by Eng. A. Piccinin and Mr. G. Gennusa from TERNA S.p.A., and Dr. J. Martín-Regalado, from Prysmian Cables y Sistemas. The results for these tests were found satisfactory as per the attached reports in Annex B.

Josep Martín Regalado
Prysmian Cables y Sistemas

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Visual Aspect, Wire Diameter and Section before stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the visual aspect, diameter and section of the wires.
Instruments: Vernier MITUOTOYO

TEST SETUP AND PROCEDURE:

The visual aspect of the wires is examined by bare eye. The diameter of the AG wires is obtained from the average of two measurements. The section is calculated from the average diameter

PASS/FAIL:

Diameter: 3.47±0.07 mm. The values shall be in accordance with cable specifications.

RESULT:

The wire surface of all wires is regular, free from imperfections and defects. The average diameter of the wires is 3.47 ± 0.01 mm. The following table summarizes the results:

Sample	1st [mm]	2nd [mm]	Average [mm]	Surface [mm^2]	Pass
1	3.47	3.47	3.47	9.46	OK
2	3.46	3.45	3.46	9.38	OK
3	3.46	3.47	3.47	9.43	OK
4	3.47	3.48	3.48	9.48	OK
5	3.46	3.45	3.46	9.38	OK
6	3.46	3.47	3.47	9.43	OK
7	3.47	3.47	3.47	9.46	OK
8	3.47	3.48	3.48	9.48	OK
9	3.46	3.46	3.46	9.40	OK
10	3.47	3.47	3.47	9.46	OK

CONCLUSION:

The wires before stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Mechanical properties on wires before stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Aim: To determine the tensile properties of the AG wires as raw material
Instruments: TENSILE MACHINE SHIMADZU AUTOGRAPH AGI50KN

TEST SETUP AND PROCEDURE:

All galvanized wires samples before armoring are prepared for the test. The samples are installed between the jaws of the vertical test machine. An external gauge 250mm long is attached to the test specimen. The samples are initially loaded to 290 Kg (30 daN/mm^2). The load is continuously increased at a constant rate to determine the load at 1% strain (AS wires only), **T@1%**, the tensile strength, **T_S**, and the elongation at break, **s**.

PASS/FAIL:

The pass criteria for the tensile properties of the wires are summarized in the following table:

Type	T_S [daN] **[Kg]**	T_S [daN/mm^2] **[Kg/mm^2]**	S [%]	T@1% [daN/mm^2] **[Kg/mm^2]**
AG type 170 (∅ 3.00-3.50mm)	1530 **1560**	161.8 **164.9**	4.0	122.5 **124.9**

RESULT:

The following table summarizes the results:

# sample	T_S [Kg]	T_S [Kg/mm^2]	S [%]	T@1% [Kg/mm^2]	Pass
1	1585	167.6	5.6	150.8	OK
2	1579	168.9	5.6	152.9	OK
3	1594	169.6	6.9	154.6	OK
4	1593	168.5	6.5	153.6	OK
5	1594	170.6	7.1	155.7	OK
6	1587	168.8	6.3	154.0	OK
7	1597	168.9	5.9	151.9	OK
8	1588	167.9	6.4	152.1	OK
9	1589	169.0	6.5	152.8	OK
10	1596	168.8	6.6	154.1	OK

CONCLUSION:

The wires before stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Wrapping test on wires before stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the mechanical properties of the AG wires.
Instruments: Machine for torsion test on wires

TEST SETUP AND PROCEDURE:

All AG wire samples before stranding are prepared for the test. Each specimen, 350mm long each, shall be wrapped a minimum of 8 turns on a mandrel whose diameter is 10.41mm (3 times the wire diameter).

PASS/FAIL:

The wire shall withstand without fracture not less than 8 turns.

RESULT:

The following table summarizes the results:

# sample	Number of turns	Pass
1	8	OK
2	8	OK
3	8	OK
4	8	OK
5	8	OK
6	8	OK
7	8	OK
8	8	OK
9	8	OK
10	8	OK

CONCLUSION:

The wires before stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Torsion test on wires before stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the mechanical properties of the AG wires.
Instruments: Machine for torsion test on wires

TEST SETUP AND PROCEDURE:

All AG wire samples before stranding are prepared for the test. Each specimen, 350mm long, is gripped at its ends in the vises of the torsion machine, one of which is free to move. The sample is twisted by rotating one of the vises at 60 turns/min until fracture is observed. The number of twists at fracture is recorded.

PASS/FAIL:

The wire shall withstand without fracture not less than 12 twists in a length equivalent to 100 times the nominal diameter of the wire.

RESULT:

The following table summarizes the results:

# sample	Number of torsions	Pass
1	32	OK
2	30	OK
3	34	OK
4	30	OK
5	30	OK
6	33	OK
7	31	OK
8	31	OK
9	31	OK
10	31	OK

CONCLUSION:

The wires before stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Galvanizing verification before stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the galvanizing properties of the AG wires.
Instruments: Precision balance

TEST SETUP AND PROCEDURE:
All AG wire samples before armoring are prepared for the test. This test consists on

a) Verification of the Zn mass per surface unit

The mass of the Zn layer, *P*, is determined by the difference of mass after (*m1*) and after (*m2*) immersion of the sample in the Aupperle solution. Being *r =(m1-m2)/m2* is the ratio between the mass Zn and steel, *P*, is given by the formula $P[g/m^2] = 1950 \cdot \varnothing_{final}[mm] \cdot r$, where $\varnothing_{final}[mm]$ is the wire diameter after Zn has been removed.

b) Verification of the galvanizing thickness uniformity

The samples shall be immersed in Preece solution (1.186 g/ml @ 18ºC) 3 times along 1 minute and 1 more time for ½ a minute. Solution shall be used of a maximum of 7 wire samples every 5 immersions/sample, after which it shall be renewed

c) Verification of the adherence of the Zn layer

The adherence of the Zn layer shall be controlled wrapping the wire in closed helix around a mandrel 13.9mm diameter (4 times the wire diameter) at a speed not larger that 15 turns/minute.

PASS/FAIL:

The pass criteria for each one of the sections is:
a) The mass of Zn per surface unit shall be not less than 244 g/m^2
b) The samples shall withstand a number of 3 immersions of 1 minute and 1 immersion of ½ minute long in Preece solution without the onset of a cupper deposit adhered to the surface
c) The Zn layer shall remain adhered to the steel core

RESULT:
a) Verification of the Zn mass per surface unit

The following table summarizes the results:

# sample	m1 [g]	m2 [g]	r	$\varnothing_{final}$ [mm]	Mass of the Zn layer [g/m^2]	Pass
1	22.90	21.50	0.065	3.31	420	OK
2	22.41	20.82	0.076	3.32	494	OK
3	21.90	20.65	0.061	3.32	392	OK
4	21.82	20.61	0.059	3.33	381	OK
5	22.12	20.66	0.071	3.33	459	OK
6	22.15	20.69	0.071	3.32	457	OK
7	21.75	20.42	0.065	3.30	419	OK
8	21.88	20.59	0.063	3.31	404	OK
9	21.98	20.70	0.062	3.32	400	OK
10	21.85	20.58	0.062	3.30	397	OK

b) Verification of the galvanizing thickness uniformity

The following table summarizes the results:

# sample	Deposits of Cu after immersions	Pass
1	NO	OK
2	NO	OK
3	NO	OK
4	NO	OK
5	NO	OK
6	NO	OK
7	NO	OK
8	NO	OK
9	NO	OK
10	NO	OK

c) Verification of the adherence of the Zn layer

The following table summarizes the results:

# sample	Pass
1	OK
2	OK
3	OK
4	OK
5	OK
6	OK
7	OK
8	OK
9	OK
10	OK

CONCLUSION:

The wires before stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Visual Aspect, Wire Diameter and Section after stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the visual aspect, diameter and section of the wires.
Instruments: Vernier MITUOTOYO

TEST SETUP AND PROCEDURE:

The visual aspect of the wires is examined by bare eye. The diameter of the AG wires is obtained from the average of two measurements. The section is calculated from the average diameter

PASS/FAIL:

Diameter: 3.47±0.07 mm. Values shall be in accordance with cable specifications.

RESULT:

The wire surface of all wires is regular, free from imperfections and defects. The average diameter of the wires is 3.47 ± 0.02 mm. The following table summarizes the results:

Sample	1st [mm]	2nd [mm]	Average [mm]	Surface [mm^2]	Pass
1	3.47	3.47	3.47	9.46	OK
2	3.46	3.47	3.47	9.43	OK
3	3.47	3.48	3.48	9.48	OK
4	3.45	3.46	3.46	9.38	OK
5	3.47	3.48	3.48	9.48	OK
6	3.47	3.47	3.47	9.46	OK
7	3.47	3.47	3.47	9.46	OK
8	3.46	3.47	3.47	9.43	OK
9	3.46	3.46	3.46	9.40	OK
10	3.47	3.47	3.47	9.46	OK

CONCLUSION:

The wires after stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Mechanical properties on wires after stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Aim: To determine the tensile properties of the AG wires as raw material
Instruments: TENSILE MACHINE SHIMADZU AUTOGRAPH AGI50KN

TEST SETUP AND PROCEDURE:

All galvanized wires samples after armoring are prepared for the test. The samples are installed between the jaws of the vertical test machine. An external gauge 250mm long is attached to the test specimen. The samples are initially loaded to 290 Kg (30 daN/mm^2). The load is continuously increased at a constant rate to determine the load at 1% strain (AS wires only), **T@1%**, the tensile strength, **T_S**, and the elongation at break, **s**.

PASS/FAIL:

The pass criteria for the tensile properties of the wires are summarized in the following table:

Type	T_S [daN] **[Kg]**	T_S [daN/mm^2] **[Kg/mm^2]**	S [%]	T@1% [daN/mm^2] **[Kg/mm^2]**
AG type 170 (∅ 3.00-3.50mm)	1452 **1480**	153.5 **156.5**	3.5	122.5 **124.9**

RESULT:

The following table summarizes the results:

# sample	T_S [Kg]	T_S [Kg/mm^2]	S [%]	T@1% [Kg/mm^2]	Pass
1	1593	168.5	6.7	146.5	OK
2	1600	169.1	6.1	145.2	OK
3	1603	168.5	6.8	146.9	OK
4	1586	168.7	6.3	145.2	OK
5	1594	167.5	6.7	145.6	OK
6	1592	168.4	6.4	144.9	OK
7	1594	168.6	6.8	145.4	OK
8	1600	169.1	6.7	145.0	OK
9	1600	170.2	6.2	152.4	OK
10	1589	168.0	5.8	147.5	OK

CONCLUSION:

The wires after stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Wrapping test on wires after stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the mechanical properties of the AG wires.
Instruments: Machine for torsion test on wires

TEST SETUP AND PROCEDURE:

All AG wire samples after stranding are prepared for the test. Each specimen, 350mm long each, shall be wrapped a minimum of 8 turns on a mandrel whose diameter is 10.41mm (3 times the wire diameter).

PASS/FAIL:

The wire shall withstand without fracture not less than 8 turns.

RESULT:

The following table summarizes the results:

# sample	Number of turns	Pass
1	8	OK
2	8	OK
3	8	OK
4	8	OK
5	8	OK
6	8	OK
7	8	OK
8	8	OK
9	8	OK
10	8	OK

CONCLUSION:

The wires after stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Torsion test on wires after stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the mechanical properties of the AG wires.
Instruments: Machine for torsion test on wires

TEST SETUP AND PROCEDURE:

All AG wire samples after stranding are prepared for the test. Each specimen, 350mm long, is gripped at its ends in the vises of the torsion machine, one of which is free to move. The sample is twisted by rotating one of the vises at 60 turns/min until fracture is observed. The number of twists at fracture is recorded.

PASS/FAIL:

The wire shall withstand without fracture not less than 10 twists in a length equivalent to 100 times the nominal diameter of the wire.

RESULT:

The following table summarizes the results:

# sample	Number of torsions	Pass
1	32	OK
2	31	OK
3	33	OK
4	32	OK
5	32	OK
6	33	OK
7	33	OK
8	34	OK
9	36	OK
10	33	OK

CONCLUSION:

The wires after stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Galvanizing verification after stranding**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2**
Objective: To verify the galvanizing properties of the AG wires.
Instruments: Precision balance

TEST SETUP AND PROCEDURE:

All AG wire samples after armoring are prepared for the test. This test consists on

a) Verification of the Zn mass per surface unit

The mass of the Zn layer, *P*, is determined by the difference of mass after (*m1*) and after (*m2*) immersion of the sample in the Aupperle solution. Being *r =(m1-m2)/m2* is the ratio between the mass Zn and steel, *P*, is given by the formula $P[g/m^2] = 1950 \cdot \varnothing_{final}[mm] \cdot r$, where $\varnothing_{final}[mm]$ is the wire diameter after Zn has been removed.

b) Verification of the galvanizing thickness uniformity

The samples shall be immersed in Preece solution (1.186 g/ml @ 18ºC) 3 times along 1 minute and 1 more time for ½ a minute. Solution shall be used of a maximum of 7 wire samples every 5 immersions/sample, after which it shall be renewed

c) Verification of the adherence of the Zn layer

The adherence of the Zn layer shall be controlled wrapping the wire in closed helix around a mandrel 13.9mm diameter (4 times the wire diameter) at a speed not larger that 15 turns/minute.

PASS/FAIL:

The pass criteria for each one of the sections is:

a) The mass of Zn per surface unit shall be not less than 244 g/m^2

b) The samples shall withstand a number of 3 immersions of 1 minute and 1 immersion of ½ minute long in Preece solution without the onset of a cupper deposit adhered to the surface

c) The Zn layer shall remain adhered to the steel core

RESULT:

a) Verification of the Zn mass per surface unit

The following table summarizes the results:

# sample	m1 [g]	m2 [g]	r	$\varnothing_{final}$ [mm]	Mass of the Zn layer [g/m^2]	Pass
1	21.89	20.59	0.063	3.31	408	OK
2	22.09	20.77	0.064	3.33	413	OK
3	22.12	20.61	0.073	3.29	470	OK
4	22.07	20.58	0.072	3.33	470	OK
5	22.11	20.75	0.066	3.29	420	OK
6	21.74	20.46	0.063	3.30	403	OK
7	22.19	20.48	0.083	3.30	537	OK
8	22.31	20.78	0.074	3.30	474	OK
9	21.92	20.64	0.062	3.32	401	OK
10	21.79	20.53	0.061	3.21	384	OK

b) Verification of the galvanizing thickness uniformity

The following table summarizes the results:

# sample	Deposits of Cu after immersion	Pass
1	NO	OK
2	NO	OK
3	NO	OK
4	NO	OK
5	NO	OK
6	NO	OK
7	NO	OK
8	NO	OK
9	NO	OK
10	NO	OK

c) Verification of the adherence of the Zn layer

The following table summarizes the results:

# sample	Pass
1	OK
2	OK
3	OK
4	OK
5	OK
6	OK
7	OK
8	OK
9	OK
10	OK

CONCLUSION:

The wires after stranding met the requirements according to CEI 7-2 standard.

TEST REPORT

Type of cable: **OPGW 50E86z-48M (7448)**
Test name: **Cable performance, formation, diameter, section, lay length**
Laboratory: PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard: **CEI 7-2 / UX LC3907**
Objective: To verify that the OPGW cable being tested is compliant with the specifications
Instruments: Caliper

TEST SETUP AND PROCEDURE:

A one meter OPGW sample is cut. The cable diameter and lay length are measured. The wires are removed and wire diameter is measured on all samples as well as the aluminum tube. The optical core is removed. The PBT tube and fiber colors are checked.

PASS/FAIL:

The measurements shall be compliant with cable data sheet #7448 and UX LC3907.

RESULTS:

The following table summarizes the results.

Parameter	UX LC3907	Cable data sheet	Measurement
# PBT tubes, color	1, BLUE	1, BLUE	OK
# fibers per tub	48	48	OK
Fiber color code	According to table in Par 2.1	According to table in Par. 2.1	OK
# AG wires	Not specified	10	10 – OK
∅ AG wires [mm]	Not specified; Tol= ±2%	3.47± 0.07	3.47± 0.02 – OK
Wiire section [mm^2]	Not specified	9.46	9.46 - OK
$\varnothing_{ext}$ Alum. tube [mm]	Tol. = ± 1.5%	8.10 ± 0.12	8.12 – OK
∅ cable [mm]	$\leq 15.0\ ^{+1}_{-1.5}$	15.0	15.03 – OK
Lay ratio	Not specified	Not specified	12.24 – OK
Electrical resistance [Ω/Km]	Not specified	< 0.63	0.58 – OK

CONCLUSION:

The cable is full compliant with the cable data sheet and Table UX LC3907

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Mass verification**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**CEI 7-2 / UX LC3907**
Objective:	To verify the weight and of the OPGW cable.
Instruments:	Scale PRECISA 300C-300D

TEST SETUP AND PROCEDURE:

The cable mass per unit length is measured on an OPGW 3.0 meter long sample using a calibrated scale.

PASS/FAIL:

The values shall be in accordance with cable data sheet (860 Kg/Km). Tolerance =2%

RESULT:

The cable mass per unit length is 861 Kg/Km.

CONCLUSION:

The cable met the requirements for test according to the cable data sheet.

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Ultimate Tensile Strength**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**CEI EN 50182**
Aim:	To measure the failing load of the cable.
Instruments:	TENSILE EQUIPMENT J. BOT EG&G CD400

TEST SETUP AND PROCEDURE:

The OPGW cable sample submitted to stress-strain test is installed in a hydraulically activated horizontal test machine (Fig. 3.1). The cable length under test (between dead-end assembly loading points) is 16.0 m. The dead-end assembly have reference NES 8.22.15.007-1. Cable load is uniformly increased up to the failing load and the Ultimate Tensile Strength (UTS) recorded.

PASS/FAIL:

Cable failure shall occur above the specified tensile strength (147 KN = 14984 Kgf).

RESULTS:

Fig. 3.2 shows cable load vs. time for the test. The cable failure occurs at 15795 Kgf (154.9 KN), that is 105 % of the RTS value. Fig. 3.3 shows the cable after failure.

CONCLUSION:

The cable met the requirements for the test according to the CEI standard.

Fig. 3.1.- Setup for Ultimate Tensile test

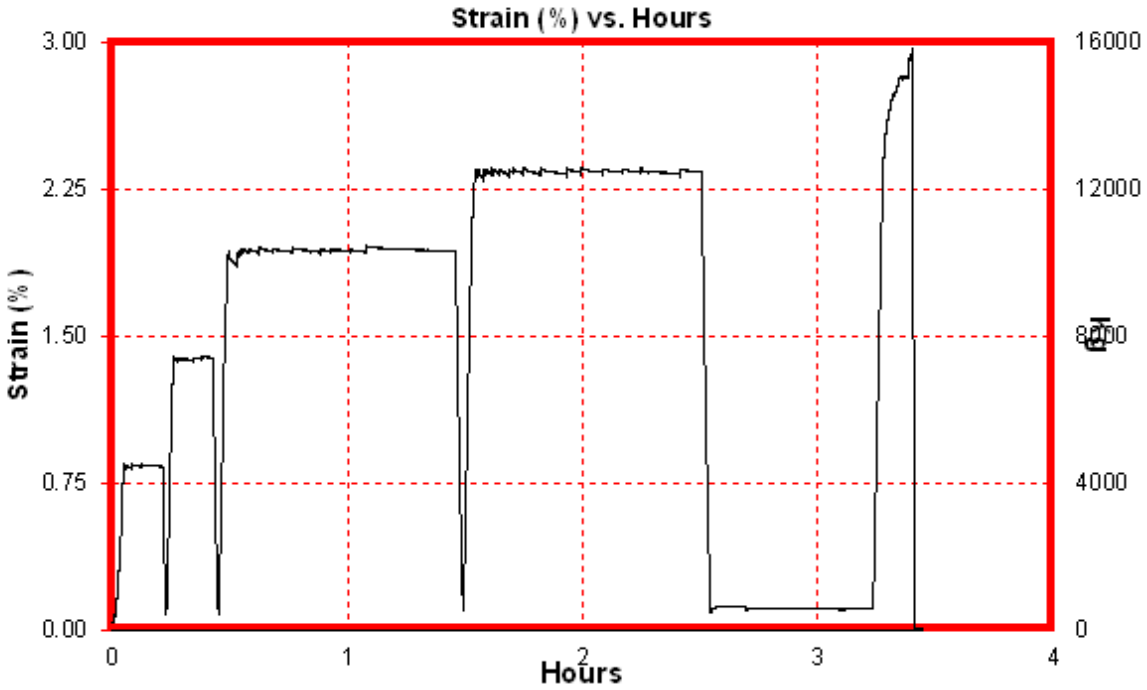


Fig. 3.2.- Cable load vs. time for Tensile test

Fig. 3.3.- Cable aspect after failure

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Q-test**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**UX LC 3907**
Aim:	To verify the optical properties of the cable up to 70% of the RTS with all fittings installed.
Instruments:	TENSILE EQUIPMENT J. BOT, EG&G CD400

TEST SETUP AND PROCEDURE:

An OPGW cable sample is installed in a hydraulically activated horizontal test machine. The cable length under test (between dead-end assembly loading points) is 22.0 m. The dead-end assemblies are fresh (unused) with reference NES 8.22.15.007-1. The suspension clamp is AGS type with reference NES 8.21.15.007. The arrangement of the suspension is such that the output angle is 20º both sides at 70%RTS. Fig. 4.1 shows the setup of the test.

All 48 fibers are spliced in series for attenuation measurements. The optical length for the test is 2064 meters (48x43m). The attenuation measurement is performed continuously during the test by source and powermeter.

Cable load is raised in intervals up to 70% RTS (10500 Kgf). The load is then released.

Fig. 4.1.- Setup for Ultimate Tensile test

PASS/FAIL:

Optical attenuation changes shall not exceed 0,1 dB/Km tested fiber @ 1550 nm up to 60% RTS. Optical attenuation changes in the range 60% to 70% RTS shall be reversible after the load is released.

RESULT:

Fig. 4.2 shows the Load cycle vs. time for the test. The attenuation change never exceeded 0.03 dB/Km (0.066 dB/2.064 Km) up to 70% RTS. The attenuation change is positive which means a slight improvement with increasing load.

CONCLUSION:

The cable met the requirements for the test according to TERNA specifications.

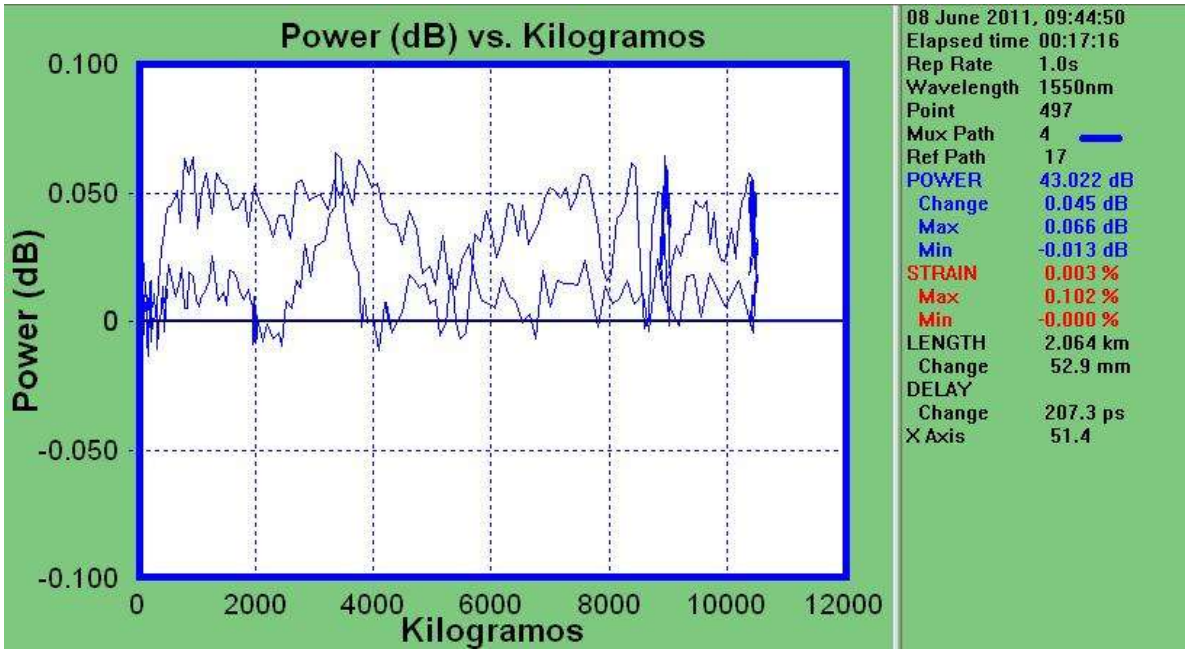


Fig. 4.2.- Attenuation change vs. Load for Q-test

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Stress strain test**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**CEI EN 50182**
Aim:	To check the modulus of elasticity of the cable.
Instruments:	TENSILE EQUIPMENT J. BOT EG&G CD400

TEST SETUP AND PROCEDURE:

An OPGW cable sample is installed in a hydraulically activated horizontal test machine. The cable length under test (between dead-end assembly loading points) is 16.0 m. The dead-end assemblies are new (unused) with reference NES 8.22.15.007-1. Ambient temperature is recorded before and after the test. Fig. 5.1 shows the setup of the test.

The following load cycles shall be performed (the rate of loading is such that the time to reach 30%RTS is 1< t [min]< 2)

- Load initially 5% RTS and set gages at zero.
- Increase the load until 30% RTS and hold during 30 min. Release to initial load.
- Increase the load until 50% RTS and hold during 60 min. Release to initial load.
- Increase the load until 70% RTS and hold during 60 min. Release to initial load.
- Increase the load until 85% RTS and hold during 60 min. Release to initial load.
- Raise cable load until 100% RTS is reached

Cable modulus shall be determined from the data relative to the range at 70% RTS

PASS/FAIL:

The modulus of the cable shall be in accordance with the cable data sheet: 137 KN/mm^2, considering a cable cross-area of 128 mm^2.

RESULT:

Fig. 5.2 shows the Strain vs. Load for the test. Temperature before and after the test was 23ºC. Fig. 5.3 shows cables strain and cable load versus time. System (cable+tension assembly) behavior is fine up to the forth cycle (85% RTS). Then load is released in order to apply the last cycle up to 100%RTS. At this interval, when cable load reaches 10000 Kgf approximately, the tension deadend twisted causing an abrupt decrease of the load, as shown in Fig. 5.4. Fig. 5.5 shows the condition of the tension deadens at this point. Load was increased again to check if 100%RTS could be reached but the system failed again because of additional twists.

At this point test was interrupted and a solution was agreed between Prysmian and NES in order to repeat the test avoiding deadends twisting. The solution was based on mounting the tension deadends completely (all loops) and attaching the cable tail to the tensile machine as shown in Fig. 5.6.

A fresh (unused) cable sample was mounted with fresh (unused) tension deadends following NES recommendations (see. Fig. 5.7). The load cycle was applied according to the CEI 7-2 standard. Ten minutes after reaching the 85% RTS interval, the tension deadend twisted suddenly causing an abrupt load reduction to 4000Kgf, approximately (see details in Figs. 5.9 and 5.10).

Pictures were taking showing the condition of the tension deadend (Fig. 5.11). For information purposes, it was decided to raise the load to the 85% RTS value but just before reaching 11000 Kgf, there was a new abrupt reduction of the cable load caused by the breakage of three wires of the tension deadend (Fig. 5.12). At this point, it was decided to finish the test.

Fig. 5.13 shows the stress-strain data corresponding to the release period from 70%RTS in Fig. 5.2 (first stress-strain test). The calculated cable modulus is 135 KN/mm^2 in good agreement with the value declared in cable data sheet (137 KN/mm^2).

CONCLUSION:

Although the cable met the requirements for the test according to the CEI standard and TERNA specifications, After internal deliberations, TERNA decided to refuse the current design of the tension deadend assembly (NES 8.22.15.007-1). It was finally agreed by Prysmian and NES to re-design the assembly and continue with the system (cable+fittings) qualification once the new tension assembly is internally approved.

Fig. 5.1.- Setup for Ultimate Tensile test

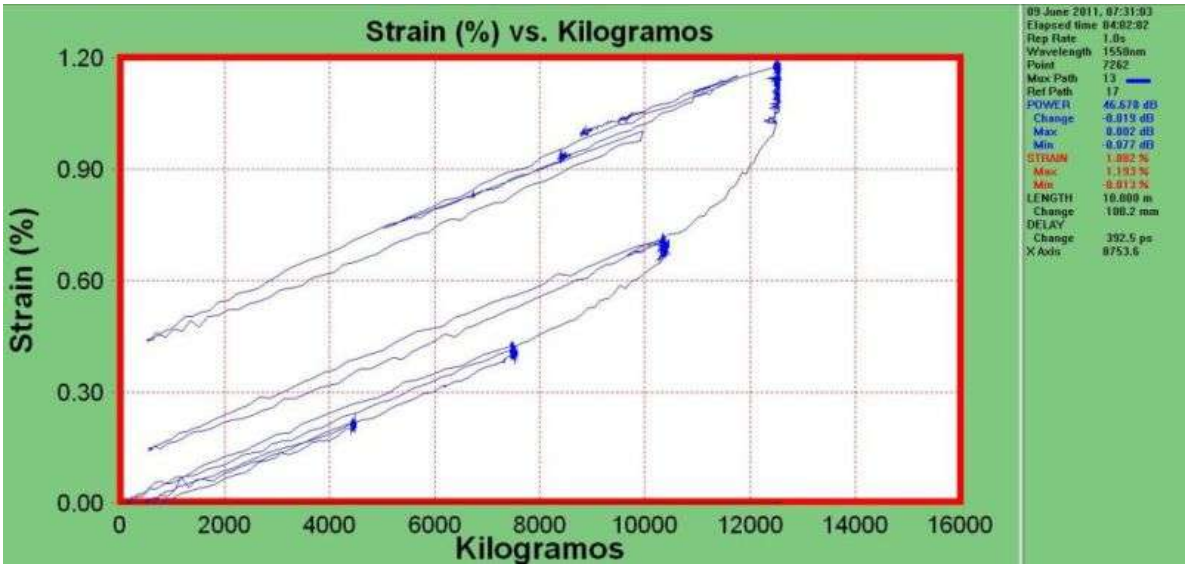


Fig. 5.2.- Cable strain (down) versus cable load during stress strain test

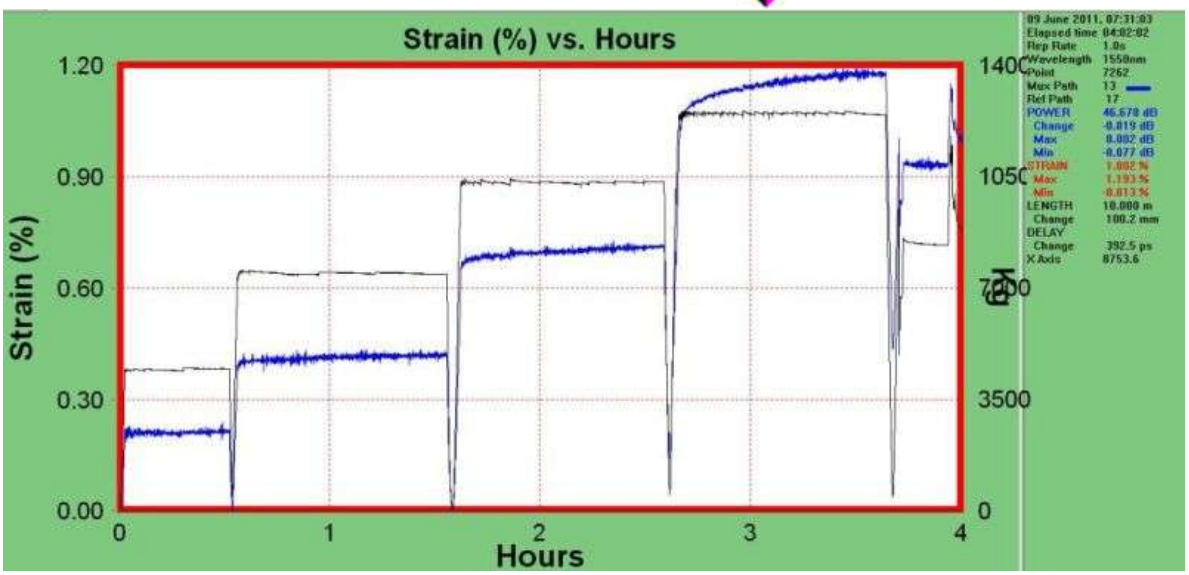


Fig. 5.3.- Cable strain and cable load versus time during stress strain test

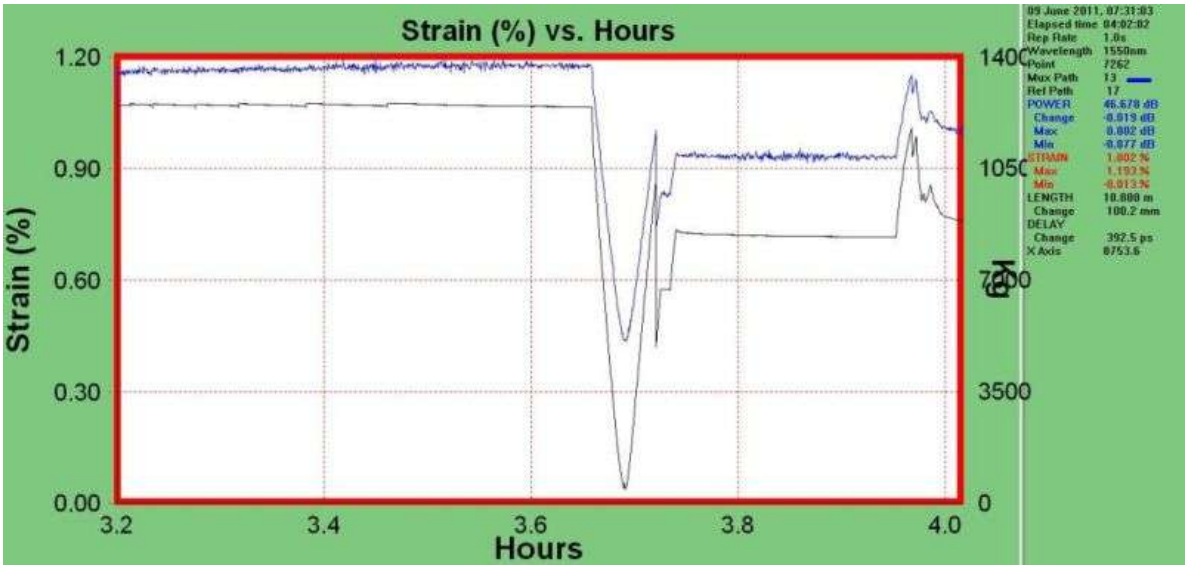


Fig. 5.4.- Cable strain and cable load versus time during stress strain test

Fig. 5.5.- Condition of tension deadends after twist at 10000Kgf approximately

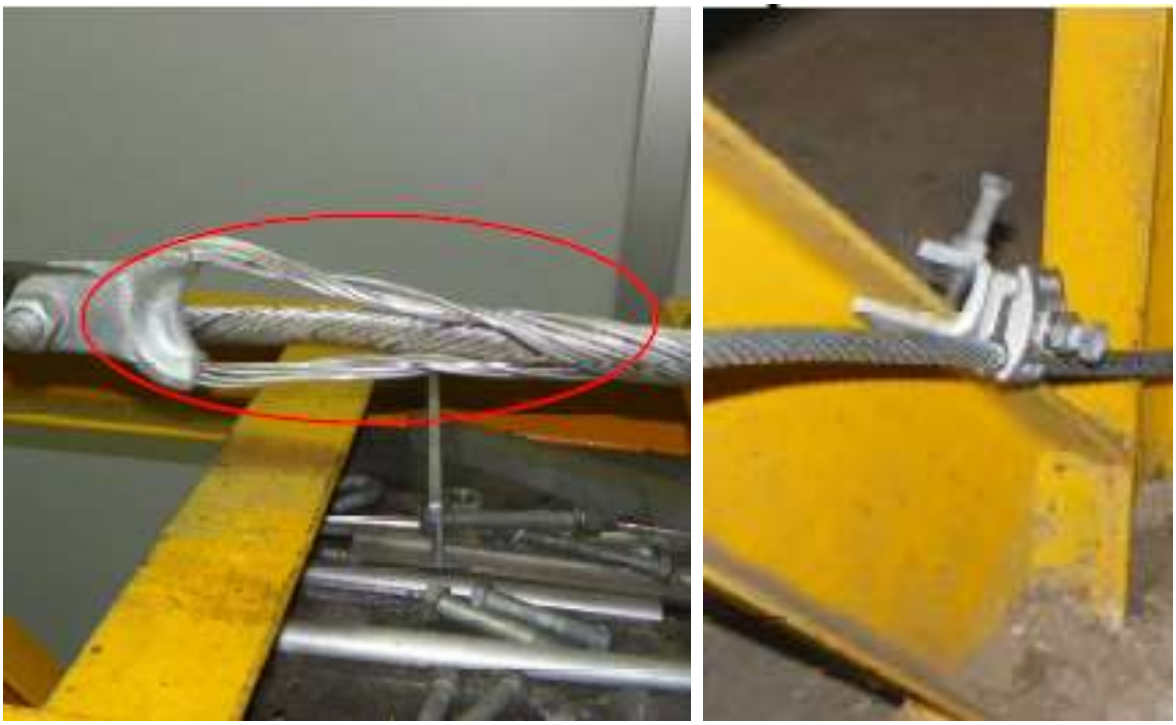


Fig. 5.6.- New Setup proposal for Stress strain test to avoid tension deadend twist

Fig. 5.7.- Setup for Stress-strain test blocking the cable

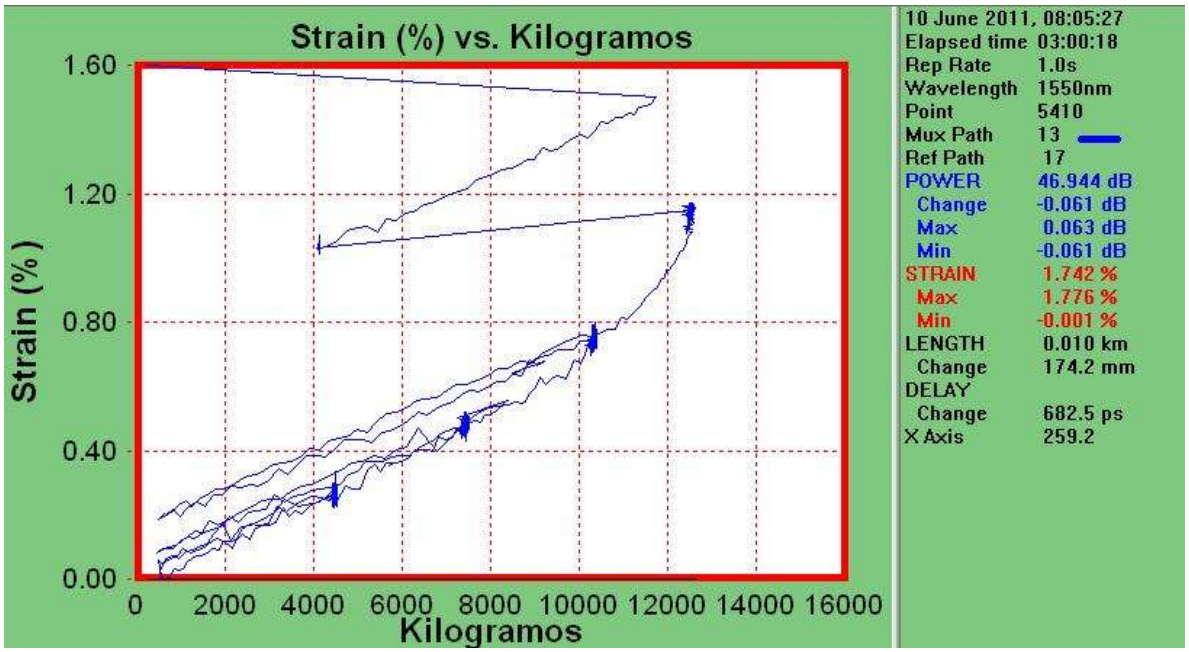


Fig. 5.8.- Cable strain (down) versus cable load during stress strain test

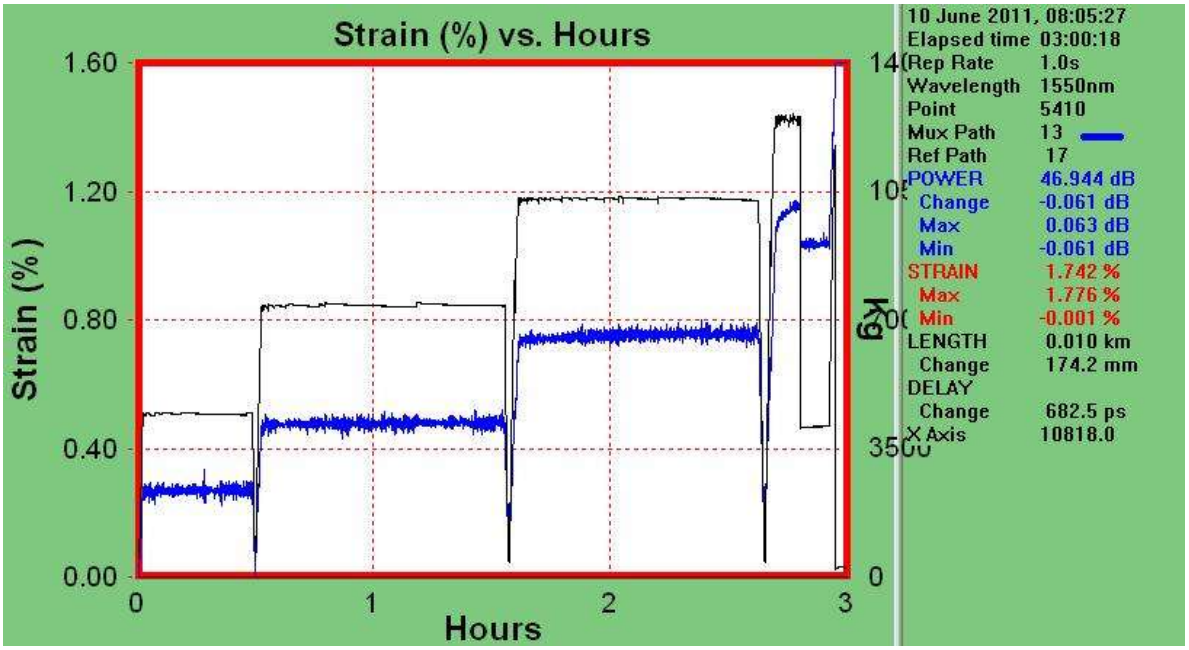


Fig. 5.9.- Cable strain and cable load versus time during stress strain test

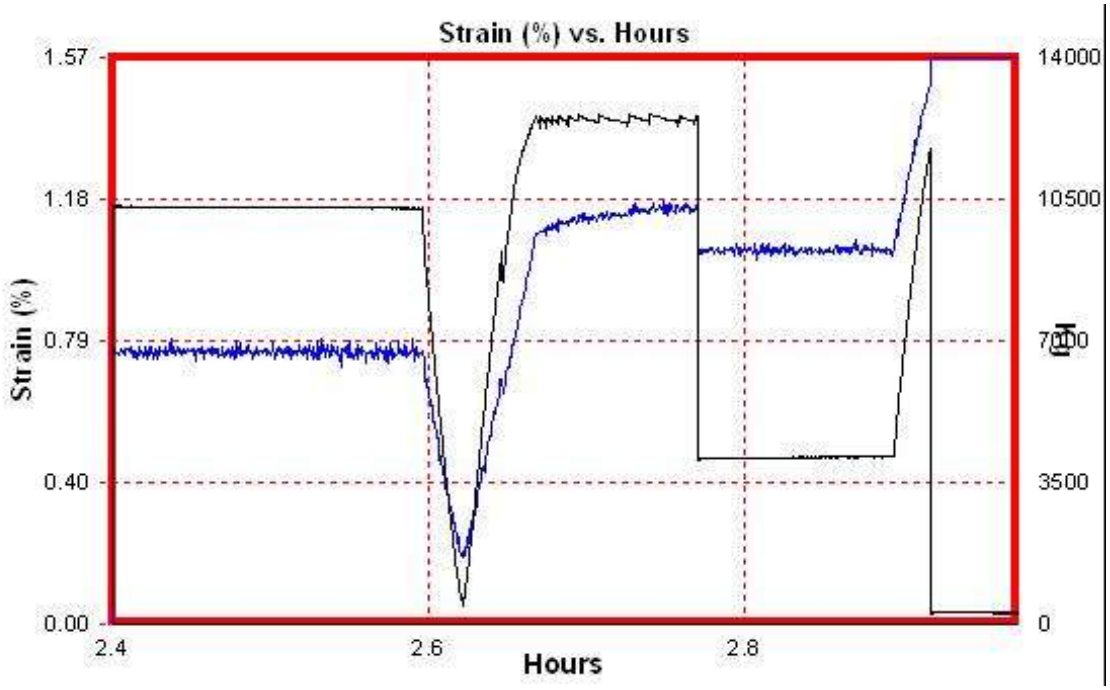


Fig. 5.10.- Cable strain and cable load versus time during stress strain test

Fig. 5.11.- Condition of tension deadends after twist at 85%RTS and load is abruptly reduced to 4000Kgf

Fig. 5.12.- Condition of tension deadends after trying to increase cable load. Three wires of the tension deadend broke before reaching 11000Kgf

MODULUS - OPGW 50E86z-48M

Stress strain data

Load	Strain
1526	0.08
2010	0.11
2518	0.14
3092	0.17
3638	0.20
4204	0.23
4775	0.26
5342	0.29
5927	0.33
6488	0.36
7039	0.39
7599	0.43

Ajuste minimos cuadrados: Strain = A * Stress + B, donde
A= 5.679E-05
B= -0.008
de donde obtenemos

	Medido1	Nominal	Unitats
Modul*Seccio:	17276	17549	KN
Seccio	128	128	mm2
Modul real	135	137.1	KN/mm2

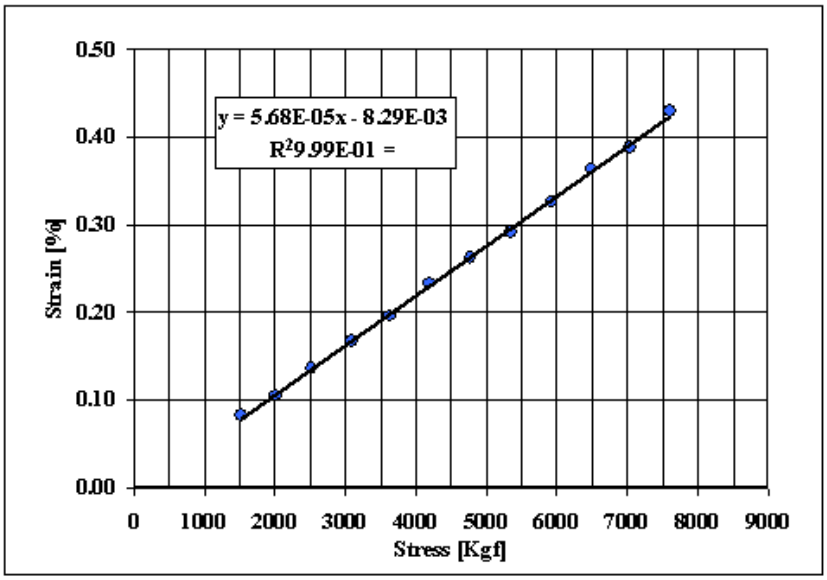


Fig. 5.13.- Calculation of elasticity modulus

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Stress strain test**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**CEI EN 50182**
Aim:	To check the modulus of elasticity of the cable.
Instruments:	TENSILE EQUIPMENT J. BOT EG&G CD400

TEST SETUP AND PROCEDURE:

An OPGW cable sample is installed in a hydraulically activated horizontal test machine. The cable length under test (between dead-end assembly loading points) is 16.0 m. The dead-end assembly with reference NES 8.22.15.007-3 corresponds to the re-designed type where tension deadend has been produced with 7AS wires 4.62mm diameter.

The following load cycles shall be performed (the rate of loading is such that the time to reach 30%RTS is 1< t [min]< 2)

- Load initially 5% RTS and set gages at zero.
- Increase the load until 30% RTS and hold during 30 min. Release to initial load.
- Increase the load until 50% RTS and hold during 60 min. Release to initial load.
- Increase the load until 70% RTS and hold during 60 min. Release to initial load.
- Increase the load until 85% RTS and hold during 60 min. Release to initial load.
- Raise cable load until 100% RTS is reached

Cable modulus shall be determined from the data relative to the range at 70% RTS

PASS/FAIL:

The modulus of the cable shall be in accordance with the cable data sheet: 137 KN/mm^2, considering a cable cross-area of 128 mm^2.

RESULT:

Fig. 6.1 shows the Strain vs. Load for the test. Fig. 6.2.shows cables strain and cable load versus time. System (cable + tension deadend) behaves properly for the duration of the test. Figs. 6.3 to 6.8 show the condition of the tension deadends at each load interval. No cable twist was observed even during the Ultimate Tensile Strength test additionally performed for information purposes (Fig. 6.9). Cable UTS was found to be 15820Kgf (105% RTS) .

Fig. 6.10 shows the stress-strain data corresponding to the 70%RTS interval. The calculated cable modulus is 137 KN/mm^2 in agreement with the value declared in cable data sheet (137 KN/mm^2).

CONCLUSION:

The cable met the requirements for the test according to EN 50182 and TERNA specifications.

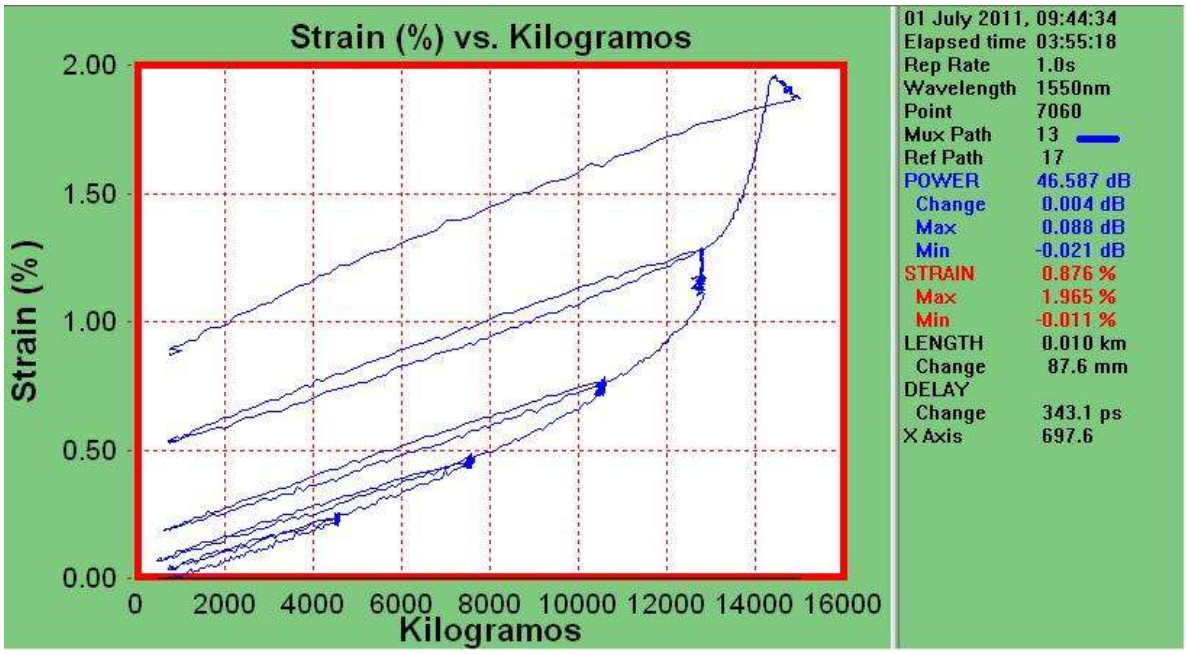


Fig. 6.1.- Cable strain (down) versus cable load during stress strain test

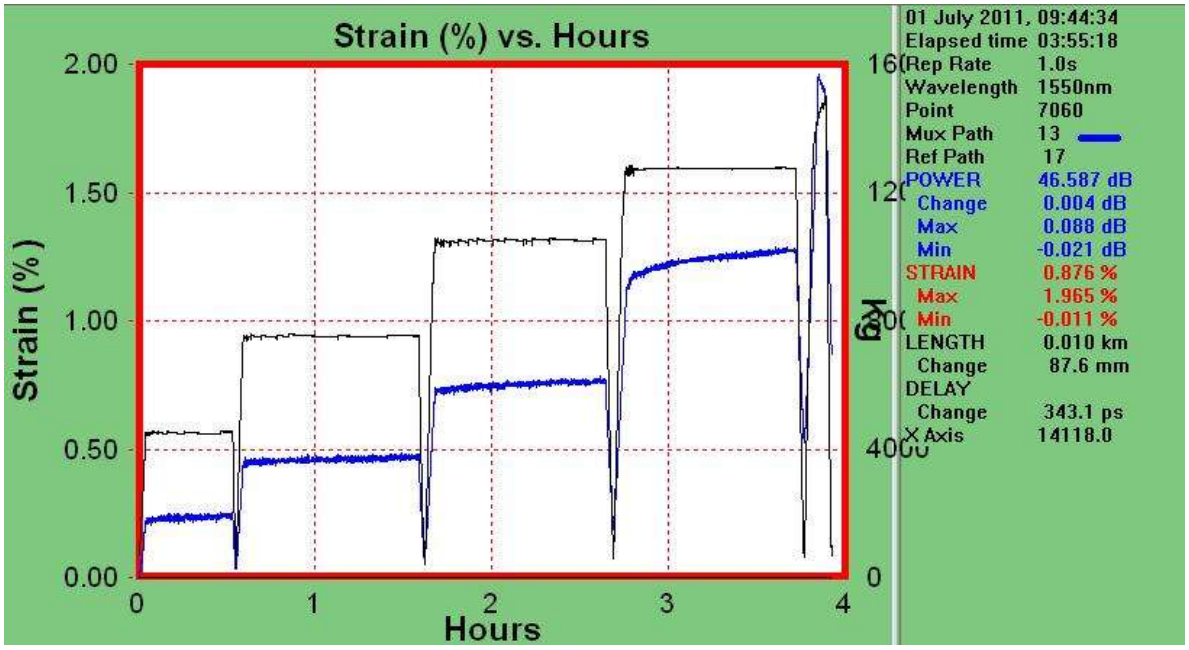


Fig. 6.2.- Cable strain and cable load versus time during stress strain test

Fig. 6.3.- Condition of tension assembly at 5%RTS

Fig. 6.4.- Condition of tension assembly at 30%RTS

Fig. 6.5.- Condition of tension assembly at 50%RTS

Fig. 6.6.- Condition of tension assembly at 70%RTS

Fig. 6.7.- Condition of tension assembly at 85%RTS

Fig. 6.8.- Condition of tension assembly at 100%RTS

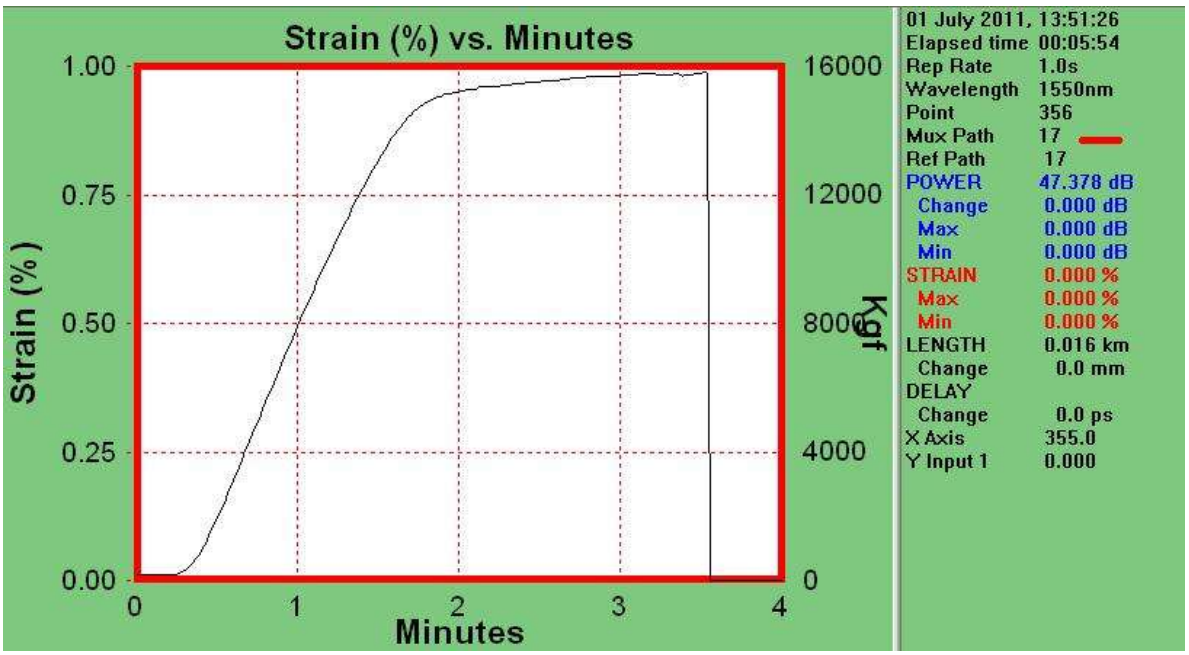
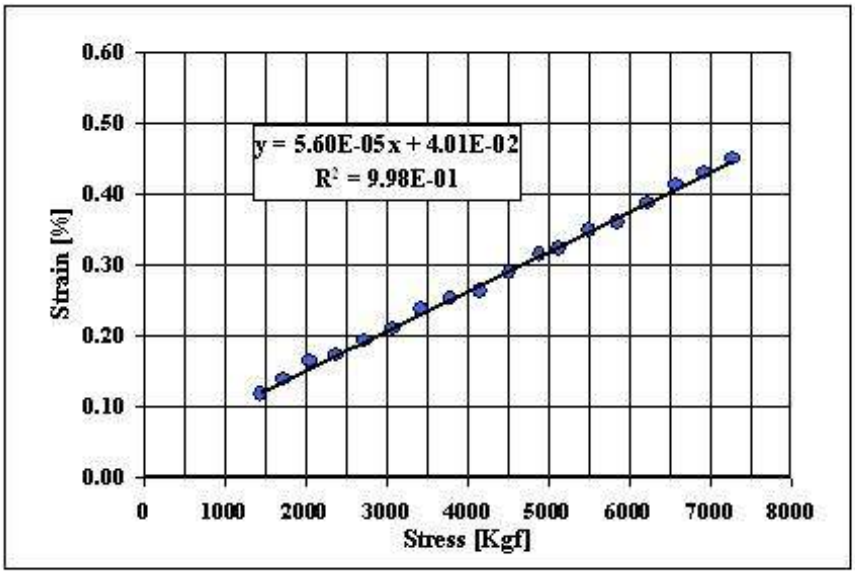


Fig. 6.9.- Cable load vs time during additional UTS test

MODULUS - OPGW 50E86z-48M

Stress strain data

Load [Kgf]	Strain [%]
1448	0.117
1736	0.139
2063	0.165
2390	0.174
2735	0.194
3086	0.211
3433	0.237
3794	0.254
4164	0.263
4523	0.289
4891	0.316
5132	0.323
5503	0.350
5863	0.361
6231	0.388
6578	0.413
6921	0.431
7274	0.451



Ajuste minimos cuadrados: Strain = A * Stress + B, donde
A= 5.598E-05
B= 0.040
de donde obtenemos

	Measured	Nominal	Unitat
Modul*Seccio:	17523	17549	KN
Seccio	128	128	mm2
Modul real	137	137.1	KN/mm2

Fig. 6.10.- Calculation of elasticity modulus

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Sheave test**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**IEC 60794-4-1 Par. 8.3**
Aim:	To verify that stringing of the OPGW with the recommended sheave size would not damage or degrade the quality of the optical fibers.
Instruments:	TENSILE EQUIPMENT J. BOT SHEAVE MACHINE, CD400

TEST SETUP AND PROCEDURE:

An OPGW sample is installed in a sheave machine. The cable length under test (between deadend assembly loading points) is 18.0 m. All fibers are spliced in series for attenuation measurements. The optical length for the test is 864 meters (48x18m). The attenuation measurement is performed continuously during the test.

The cable sample is pulled forward and backward 10 times through the 780 mm diameter sheave. Other setup parameter values are the pulling tension: 2250 Kgf (15% of the RTS); the pulled length: 3.2 meters; and the deflection angle: 30º. Fig. 7.1 shows the setup.

Micrometer readings of the cable diameter are performed at the beginning, mid-point and end of the pulled length after and after the test. After the test is complete, the cable strands are removed and the aluminum pipe diameter is measured at the marked points of the pulled length.

Fig. 7.1.- Setup for Sheave test

PASS/FAIL:

Optical attenuation changes shall not exceed 0.1 dB/Km tested fiber @1550 nm. Cable ovality, defined as Ovality=[$\varnothing_{max}$ - $\varnothing_{min}$]/[$\varnothing_{max}$ + $\varnothing_{min}$], shall not exceed 10%. No evidence of damage shall be observed on the parts of the OPGW submitted to test.

RESULT:

Fig. 7.2 shows the attenuation change (up) and the cable load (down) vs. time for the test. The average load during the test is 2250 Kgf, although small variations of ±3% of this load occur during each cycle. The attenuation change never exceeded 0.07 dB/Km (0.058 dB/0.864Km) during the test and is reversible after the load is released.

Regarding the deformation of the cable and the aluminum tube, the following tables summarize the results:

#	CABLE DIAMETER.					
	SOUTH		CENTER		NORTH	
	MIN [mm]	MAX [mm]	MIN [mm]	MAX [mm]	MIN [mm]	MAX [mm]
Before	14.63	15.05	14.68	15.08	14.67	15.07
After	14.56	15.10	14.48	15.05	14.48	15.06
Ovality [%]	1.8%		1.9%		2.0%	

#	ALUMINIUM TUBE DIAMETER.					
	SOUTH		CENTER		NORTH	
	MIN [mm]	MAX [mm]	MIN [mm]	MAX [mm]	MIN [mm]	MAX [mm]
After	8.08	8.14	8.02	8.18	8.03	8.15
Ovality [%]	0.4%		1.0%		0.7%	

The averaged cable ovality measured at 2250 Kg (before the test) is 1.3%. The maximum measured ovality of the cable, $[\varnothing_{max} - \varnothing_{min}]/[\varnothing_{max} + \varnothing_{min}]$, is 2.0% and occurs at north section. The average aluminum tube external diameter outside the tested area is 8.1mm. After completion of the test, the maximum ovality measured in the aluminum tube, $\text{Ovality}=[\varnothing_{max} - \varnothing_{min}]/[\varnothing_{max} + \varnothing_{min}]$, is 1.0% and occurs at the center section.

CONCLUSION:

The cable met the requirements for the test according to the IEC standard.

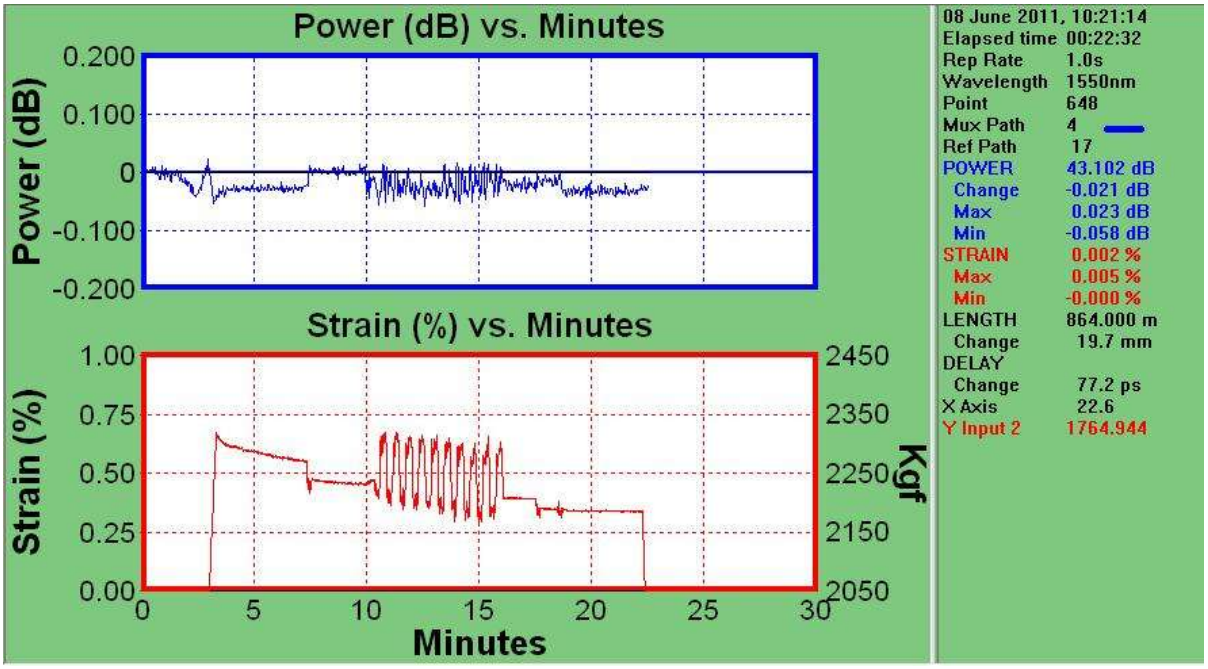


Fig. 7.2.- Attenuation change (up) and Cable load (down) vs. time during sheave test

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Wire unwrapping**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**UX LC3907**
Aim:	To verify that the wires do not unwrap when broken up to 18% RTS.
Instruments:	TENSILE EQUIPMENT J. BOT SHEAVE MACHINE, CD400

TEST SETUP AND PROCEDURE:

The cable length under test (between dead-end assembly loading points) is 16.0 m. The dead-end assembly are new (unused) with reference NES 8.22.15.007-1. Two wires are broken by hand at mid point of the cable sample. Cable load is increased to 18%RTS and the unwrapped length of the broken wires (if any) is measured. The test is repeated on two additional samples

PASS/FAIL:

The unwrapped length of the wires shall not exceed 40cm. The maximum distance from the wire end to the cable shall not exceed 15cm.

RESULT:

At 18%RTS there is no wire unwrapping in any of the three samples. Cable condition at the broken wire location before and after the 18%RTS load application is shown in Fig. 8.1. The behavior was identical for the three different samples

Fig. 8.1.- Cable aspect before (left) and after (right) 18% RTS load application on first cable sample

After 18%RTS application and for information purposes,

a) Cable load was raised up to 60% RTS for the first sample. No wire unwrapping was observed up to this load (Fig. 8.2)

b) Cable load was raised to force wire unwrapping (Fig. 8.3). Failure (see Fig. 8.4) was observed at 72%RTS or 10850Kgf .

c) Cable load was released and 4 additional wires were broken on the same sample, spaced 0.5m. Cable load was raised up to failure which was observed at 5194 Kgf (Fig. 8.5).

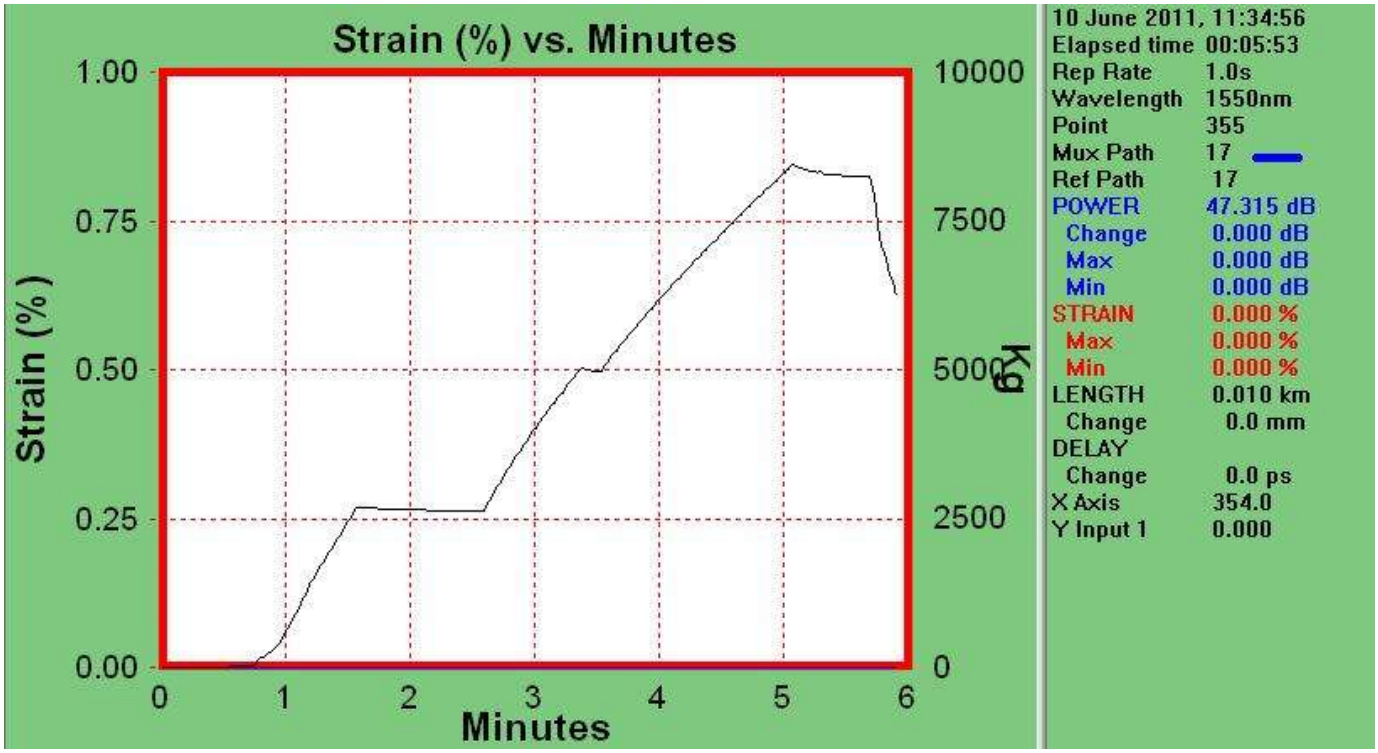


Fig. 8.2.- Cable load vs. time for first cable sample

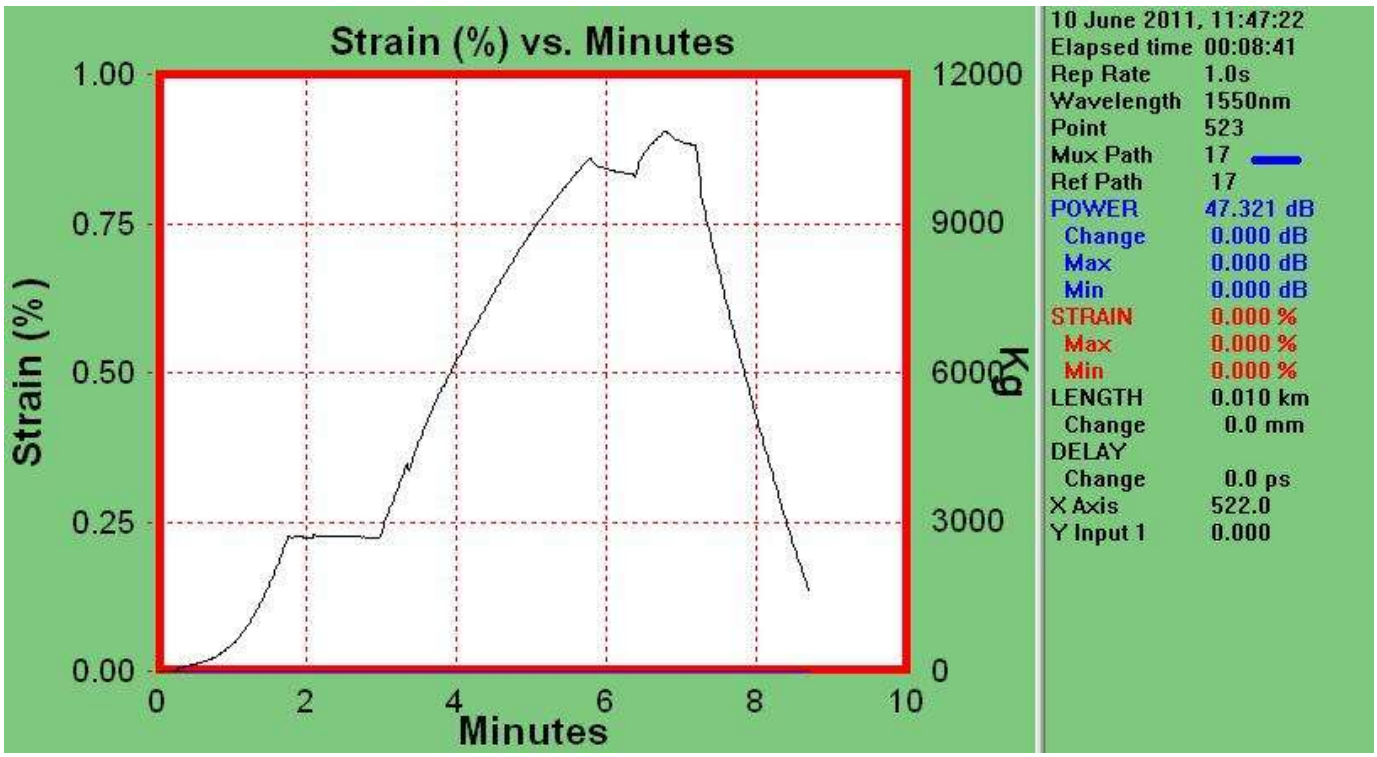


Fig. 8.3.- Cable load vs. time for second cable sample

Fig. 8.4.- Cable aspect after 18% RTS (left) and 72%RTS (right) load application on second cable sample

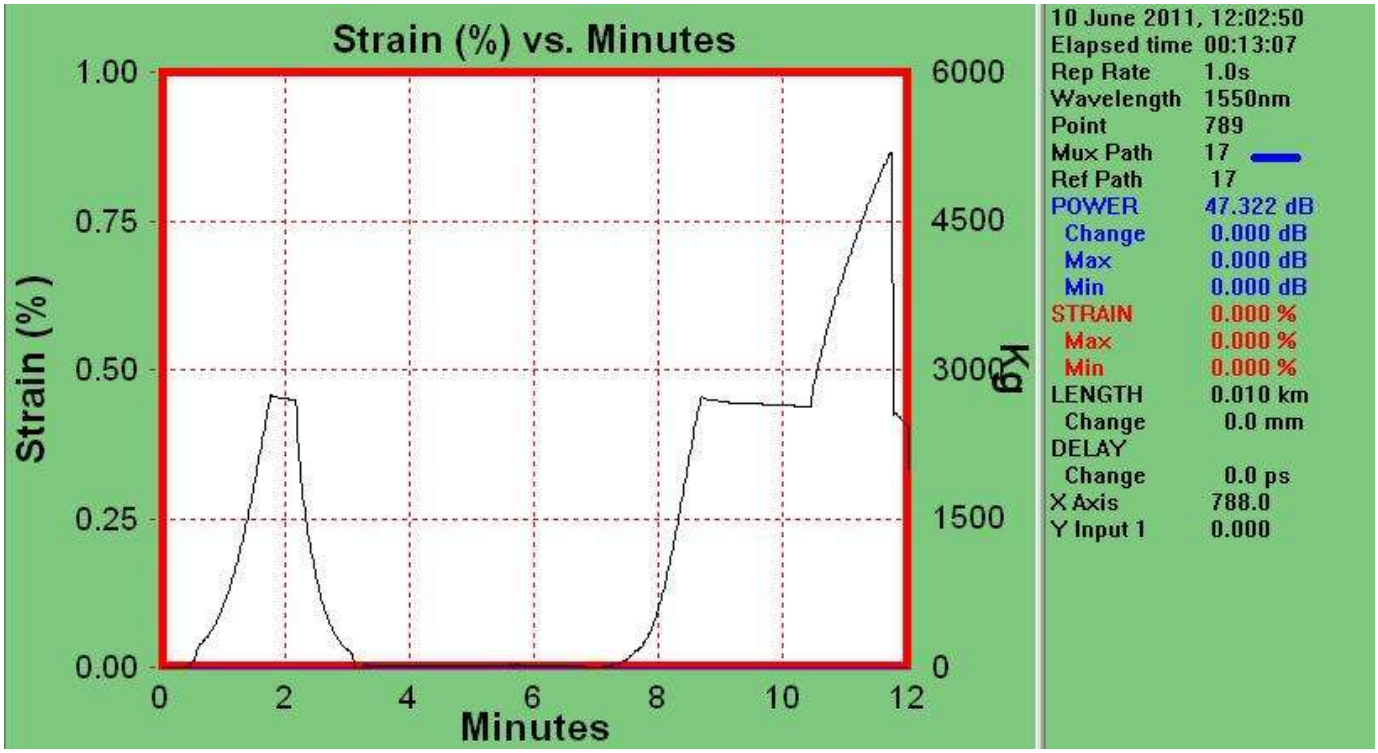


Fig. 8.5.- Cable load vs. time for third cable sample

CONCLUSION:

The cable met the requirements for the test according to the TERNA standard.

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Attenuation coefficients and linearity**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**IEC 793-1-C1C, UX LC 3907**
Objective:	To verify the attenuation coefficients of the fiber.
Instruments:	OTDR ANRITSU MW9060A

TEST SETUP AND PROCEDURE:
The two OPGW drums of the project were used for the test. The attenuation coefficients and linearity are obtained by OTDR measurements.

PASS/FAIL:
The attenuation coefficient shall be in accordance with the specifications: 0.36 dB/Km@ 1310nm and 0.22 dB/Km@ 1550nm. In addition, attenuation steps, if any, shall not exceed 0.05 dB.

RESULT:
For drum N22618W the maximum/average/minimum attenuation coefficients are:

- 0.34 / 0.33 / 0.33 dB/Km @1310nm
- 0.21 / 0.19 / 0.19 dB/Km @1550nm

For drum N22620Y the maximum/average/minimum attenuation coefficients are:

- 0.34 / 0.33 / 0.32 dB/Km @1310nm
- 0.21 / 0.20 / 0.19 dB/Km @1550nm

Annex B contains the table data and the OTDR traces for all 48 fibers at 1310 and 1550nm of both drums. It can be checked that there are no attenuation steps so that all traces are linear (all points are within two parallel lines translated at ±0.05 dB). For information, the OTDR traces of the original prototype drum (X-02450-F) are also attached

CONCLUSION:
The cable met the requirements for the test according to the IEC standard and TERNA specifications.

TEST REPORT

Type of cable:	**OPGW 50E86z-48M (7448)**
Test name:	**Temperature Cycling**
Laboratory:	PRYSMIAN CABLES Y SISTEMAS, S.A.
Test Standard:	**UX LC 3907**
Objective:	To determine the stability behavior of the optical attenuation in the OPGW cable when submitted to temperature cycles.
Instruments:	Temperature chamber INELTEC EG&G CMP500

TEST SETUP AND PROCEDURE:

A drum with an OPGW sample 1493 m long is introduced inside the $27m^3$ climatic chamber. Four optical loops with two fibers each are spliced for attenuation measurements. The total length under test is 2986m (2fo x 1493m) for each of the eight measurement channels.

The temperature and the attenuation change are recorded as a function of time with a sampling rate of 1 sample every 5 minutes.

The following cycle is applied

- The drum is pre-conditioned at 25±3ºC for 6 hours.
- The temperature is raised to 60ºC and kept constant for 4 hours.
- The temperature is decreased to -25ºC and kept constant for 4 hours.
- The 60ºC/-25ºC cycle is repeated twice
- The temperature is decreased to –40ºC and kept constant for 4 hours.
- The temperature is raised to -25ºC and kept constant for 4 hours.
- The temperature is raised to +25ºC and kept constant for 1 hour

PASS/FAIL:

Optical attenuation changes shall not exceed 0.1 dB/Km during the test

RESULT:

Figs. 9.1 and 9.2 show the Temperature trace and the Attenuation change vs. Time for the test. During the test, the attenuation change never exceeded 0.003 dB/Km (0.01 dB / 2.99 Km) for any of the fibers.

CONCLUSION:

The cable met the requirements for the test according to TERNA standard.

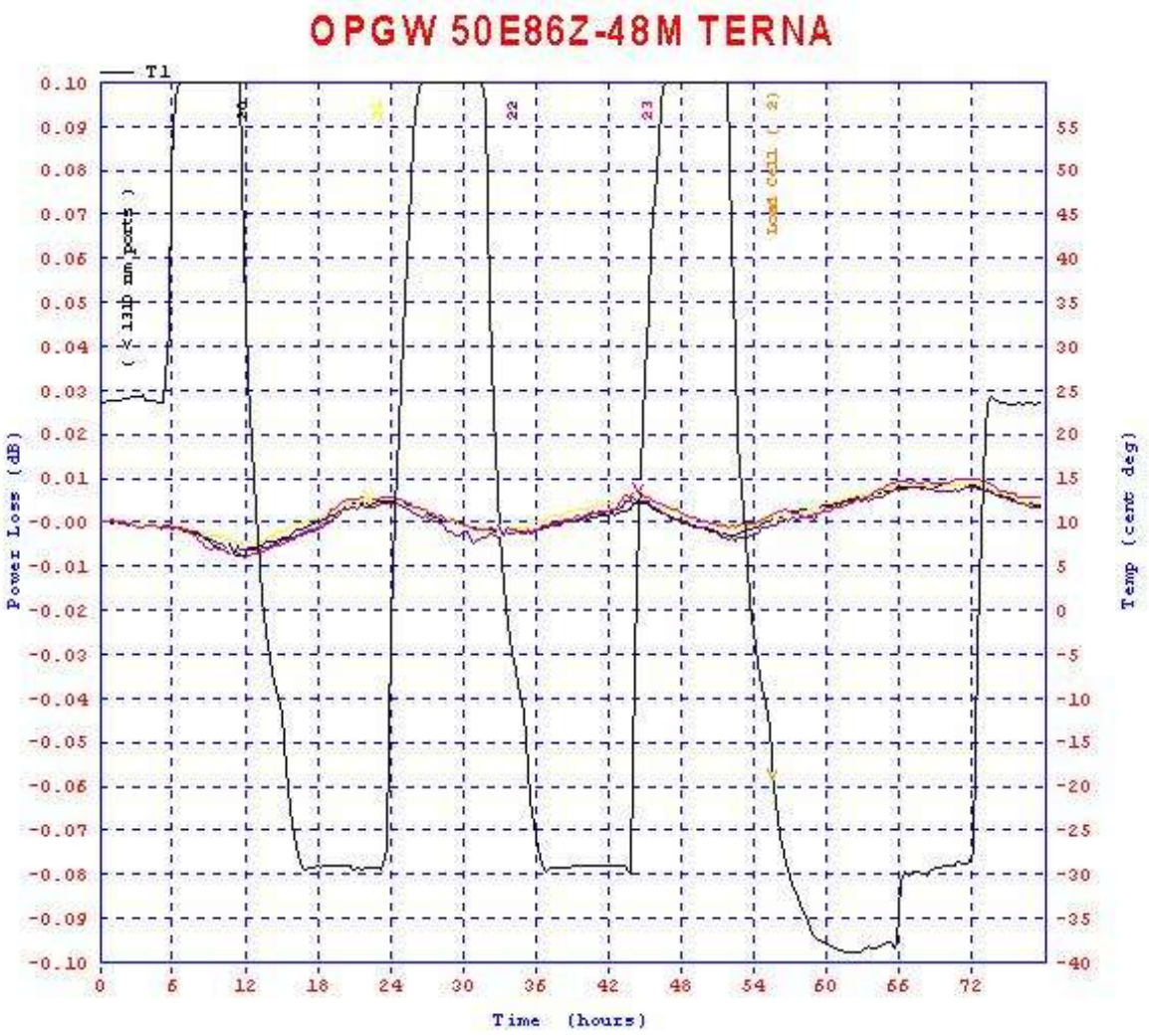


Fig. 9.1.- Temperature trance and attenuation change vs. time for measurement channels 20, 21, 22 and 23 @1310nm

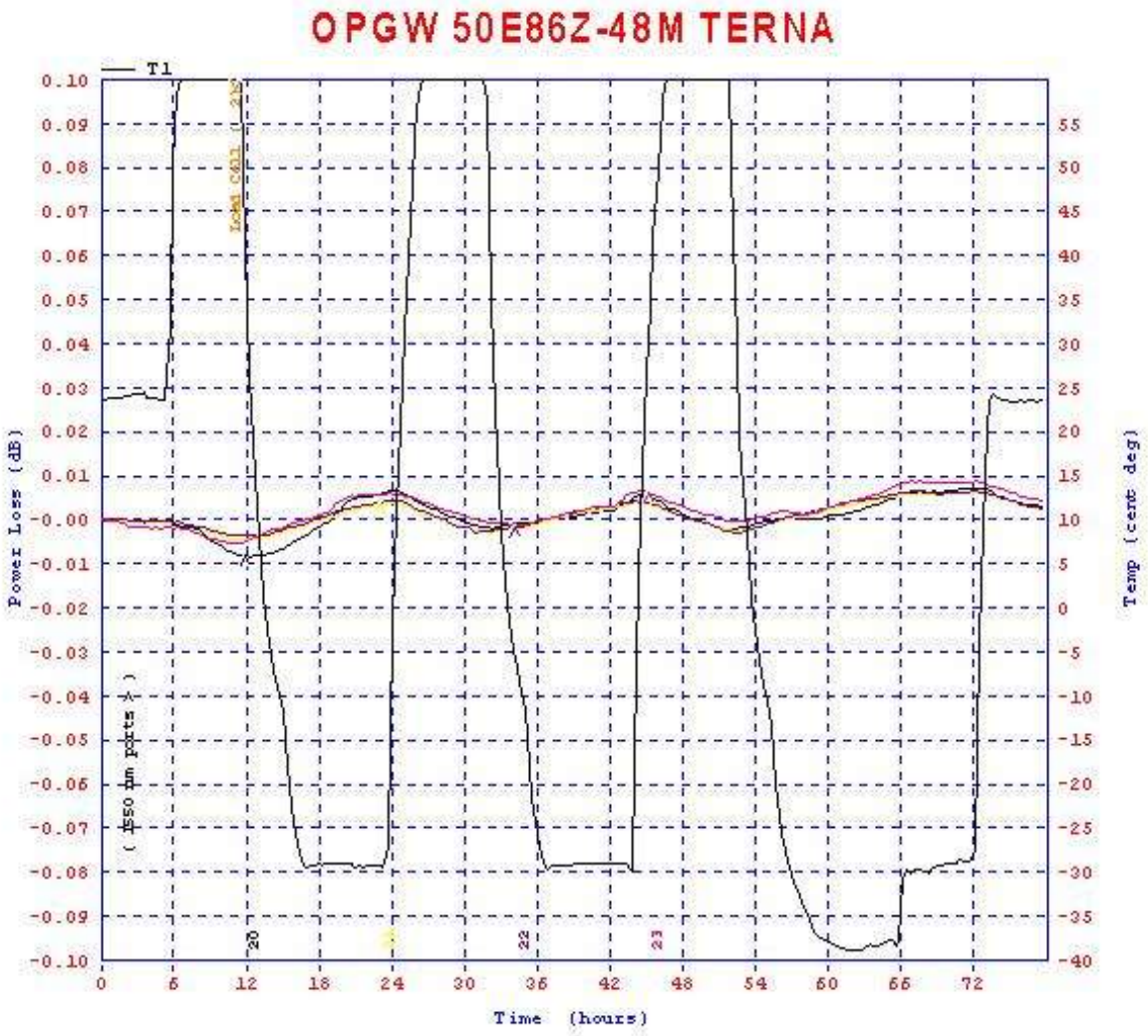


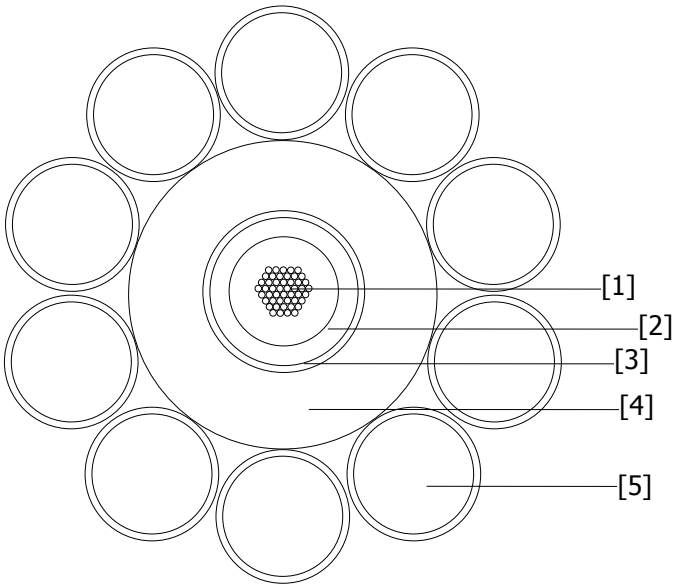
Fig. 9.2.- .- Temperature trance and attenuation change vs. time for measurement channels 20, 21, 22 and 23

Cable data sheet

OPGW 50E86z

Ref: **7448**

OPTICAL GROUND WIRE with capacity for 48 optical fibres



Introduction

Features and benefits

This cable has been custom designed to best match with customer requirements from optical, electrical, mechanical, quality and cost point of view, optimising diameter, weight, breaking load and short circuit capacity.

Optical core is made of optical fibres [1] covered by small PBT loose buffer tube [2] that leaves the fibres free from strain even at highest operating loads.
In sections where there is a high contamination or in the proximity of the sea, Prysmian recommend greasing the cable.

A hydrogen absorbent jelly [3] protects the fibres against the optical degradation caused by this element.

The aluminium tube [4] provides the cable with:
- high short circuit capacity minimizing material
- best solution to avoid cable corrosion
- a perfect sealing for the optical core
- a high crush resistance

The wires of...
- galvanised steel [5].

...provides the cable with:
- the required strength.
- a very good lightning resistance
- best solution to avoid cable corrosion.
- the remaining short circuit capacity.

PRYSMIAN CABLES & SYSTEMS

Rev.:	Date:	Issued by:
01	23-mar-10	V.Ghinaglia

OPGW 50E86z

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OPTICAL GROUND WIRE with capacity for 48 optical fibres

Fibre characteristics

See our technical document reference 4377 "SM Light™ optical fibres".

Cable structure

Optical core

Cables with 48 fibres:

- Without rings: blue, orange, green, brown, slate, white, red, black, yellow, violet, pink, aqua.
- With 1, 2 and 3 rings: blue, orange, green, brown, slate, white, red, natural, yellow, violet, pink, aqua.

Aluminium Tube

Approximate Outer Diameter: 8.1 mm

Armour

Layer 1:

- 10 galvanised steel wires of 3.47 mm.
- Right lay sense (Z).

Cable characteristics

Mechanical and physical

Approximate cable diameter:	15.0 mm
Approximate cable weight:	860 kg/km
Rated tensile strength:	147 kN
Maximum load without fibre elongation:	84 kN
Elasticity Modulus*:	137.1 kN/mm^2
Section*:	128.0 mm^2
Linear expansion thermal coefficient:	13x10^{-6} ºC^{-1}
Minimum bending radius**:	
• On pulley blocks (first and last of each reel, span ≥ 600 m or angles > 15º):	400 mm
• On pulley blocks (others):	300 mm
• On tensioner devices:	600 mm
• After clamping (slack cable):	300 mm
Operating temperature range: from -30ºC to +70ºC	

*for stress-strain calculus

**see "Installation procedures for OPGW fibre optic cable" document reference SIG-07-PE-PA-013

Electrical

Electrical resistance (20ºC): 0.63 Ω/km
Short circuit rating from 50ºC: 80 kA^{2}s
Short circuit current for 0.5 s: 12.6 kA

OPGW 50E86z

Ref: **7448**

OPTICAL GROUND WIRE with capacity for 48 optical fibres

Routine tests

100% of optical fibres will be measured by OTDR technique before leaving factory.

Installation procedure

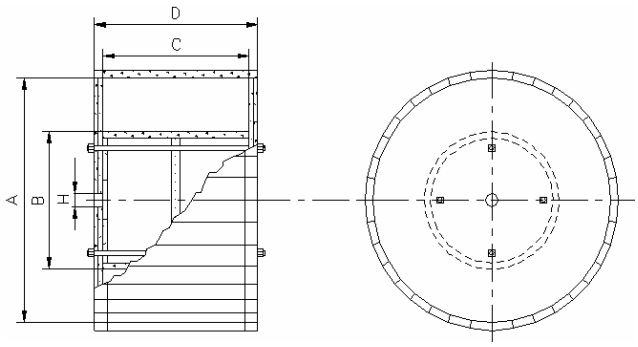
Prysmian recommends to install the cable described in this specification following the latest version of our "Installation procedures for OPGW fibre optic cable" reference SIG-07-PE-PA-013, "Instruction for the installation of the EWMJ joint box" reference FO-02 and "Instruction for the installation of the EWJ joint box" reference FO-01.

Reels

	Type W	**Type P**
Wheel (A):	1500 mm	2100 mm
Cylinder (B):	900 mm	900 mm
Inside (C):	930 mm	900 mm
Outside (D):	1050 mm	1050 mm
Axe (H):	105 mm	105 mm
Weight:		
- empty:	166 kg	360 kg
- full:	3004 kg	5004 kg
Maximum length:	3.3 km	5.4 km
Tolerance length of the produced reel: ±3%		

NOTE:
Ordered lengths should include a distribution of lengths, i.e., all reels cannot be ordered at the maximum.
The reel lengths' distribution should be as follows:

Reel lengths	
0 - 2500	More than 5%
2500 - 4000	More than 40%
4000 - 5400	Less than 55%



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