

**TECHNICAL DESCRIPTION OF  
FULLY DIELECTRIC LOOSE TUBE  
OPTICAL FIBER DUCT CABLE**

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Optical fiber duct cable shall be type «Fully dielectric, single mode, loose tube optical FIBER cable», according to following requirements:

- |    |                             |   |
|----|-----------------------------|---|
| 1. | No. of fibers               | 48  |
| 2. | Fiber type                  | 36 fibers type of ITU-T G-652.B / 12 fibers type of ITU-T G-655.B |
| 3. | Non metallic.               |   |
| 4. | Protection against rodents. |   |

Detailed Technical description is the following:

## 1. OPTICAL FIBER CABLE TECHNICAL SPECIFICATIONS

### 1.1 General

In this document are specified the technical parameters of the single mode optical FIBER cables.

Such cables will have the following specifications:

- from 4 up to 288 FIBER capacity
- loose tube fully dielectric design
- SZ stranded
- Polyethylene or LSZH ( Low Smoke Zero Halogen ) double sheath
- FIBER glass armoring protection against rodents
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### 1.2 Cable characteristics

The cable included in this Technical Specification must comply with the EN 60794 and other applicable reference Standards specifications.

#### **1.2.1 Manufacturing specification for cables having 12, 24, 36, 48, 60, 72, 96, 100, 120 and 144 optical fiber capacity**

Cable type:	loose tube cable
Loose tube capacity:	12 F.O. each tube
Filler elements:	Please refer to tables 1 and 2
Optical Fibers:	Single Mode Reduced (SMR) optical FIBERs
Central strength element:	Fiberglass Dielectric eventually coated
Secondary protection:	Thermoplastic made loose tube
Loose tube filling compound:	highly compatible synthetic thixotropic compound The optical core + fillers eventually needed will be assembled in a single layer
Internal wrapping:	Synthetic tape wrapping The cable core, SZ stranded around the central element, will achieve longitudinal water tightness by adopting yarns or powders water blocking elements (dry-core) (*)
Inner sheath:	Black low or medium density polyethylene or, for indoor cables, green LSZH; average thickness $\geq 0.9$ mm.
Dielectric armoring:	Double layer of Fiberglass yarns winded with opposite directions
Outer sheath :	Black medium density Polyethylene or, for indoor cables, green LSZH; average thickness $\geq 1,5$ mm.
Outer sheath marking:	The outer sheath will be marked at regular intervals of 1 meter with the following legend: Supplier Name / "PPC" / Optical Cable – Cable identification code ( refer to tab.1 e tab.2) / Year of manufacturing / Span length identification number / Sequential length mark.

(\*) Synthetic fillers are allowed

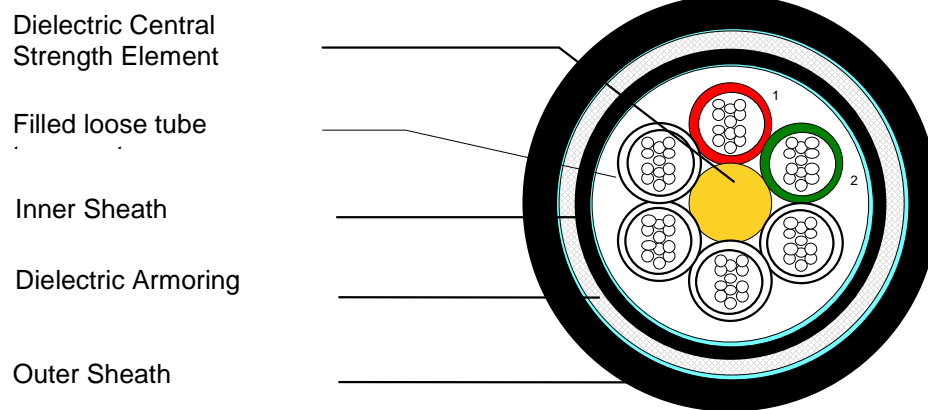
Table 1: Identification codes: Single mode loose tube dielectric optical fiber cable, PE

IDENTIFICATION CODES	
CABLE 4 F.O.	<b>TOL4D 4 2(2SMR) / VE</b>
CABLE 8 F.O.	<b>TOL4D 8 4(2SMR) / VE</b>
CABLE 12 F.O.	<b>TOL6D 12 1(12SMR) / EVE</b>
CABLE 24 F.O.	<b>TOL6D 24 2(12SMR) / EVE</b>
CABLE 36 F.O.	<b>TOL6D 36 3(12SMR) / EVE</b>
CABLE 48 F.O.	<b>TOL6D 48 4(12SMR) / EVE</b>
CABLE 60 F.O.	<b>TOL6D 60 5(12SMR) / EVE</b>
CABLE 72 F.O.	<b>TOL6D 72 6(12SMR) / EVE</b>
CABLE 96 F.O.	<b>TOL8D 96 8(12SMR) / EVE</b>
CABLE 100 F.O.	<b>TOL10D 100 8(12SMR)+1(4SMR)/EVE</b>
CABLE 120 F.O.	<b>TOL10D 120 10(12SMR) / EVE</b>
CABLE 144 F.O.	<b>TOL12D 144 12(12SMR) / EVE</b>
CABLE 168 F.O.	<b>TOL18D 168 14(12SMR) / EVE</b>
CABLE 192 F.O.	<b>TOL18D 192 16(12SMR) / EVE</b>
CABLE 216 F.O.	<b>TOL18D 216 18(12SMR) / EVE</b>
CABLE 264 F.O.	<b>TOL22D 264 22(12SMR) / EVE</b>
CABLE 288 F.O.	<b>TOL24D 288 24(12SMR) / EVE</b>

Table 2: Identification codes: Single mode loose tube dielectric optical FIBER cable, LSZH

IDENTIFICATION CODES	
CABLE 4 F.O.	<b>TOL4D 4 2(2SMR) / VM</b>
CABLE 8 F.O.	<b>TOL4D 8 4(2SMR) / VM</b>
CABLE 12 F.O.	<b>TOL6D 12 1(12SMR) / MVM</b>
CABLE 24 F.O.	<b>TOL6D 24 2(12SMR) / MVM</b>
CABLE 36 F.O.	<b>TOL6D 36 3(12SMR) / MVM</b>
CABLE 48 F.O.	<b>TOL6D 48 4(12SMR) / MVM</b>
CABLE 60 F.O.	<b>TOL6D 60 5(12SMR) / MVM</b>
CABLE 72 F.O.	<b>TOL6D 72 6(12SMR) / MVM</b>
CABLE 96 F.O.	<b>TOL8D 96 8(12SMR) / MVM</b>
CABLE 100 F.O.	<b>TOL10D 100 8(12SMR)+1(4SMR)/MVM</b>
CABLE 120 F.O.	<b>TOL10D 120 10(12SMR) / MVM</b>
CABLE 144 F.O.	<b>TOL12D 144 12(12SMR) / MVM</b>
CABLE 168 F.O.	<b>TOL18D 168 14(12SMR) / MVM</b>
CABLE 192 F.O.	<b>TOL18D 192 16(12SMR) / MVM</b>
CABLE 216 F.O.	<b>TOL18D 216 18(12SMR) / MVM</b>
CABLE 264 F.O.	<b>TOL22D 264 22(12SMR) / MVM</b>
CABLE 288 F.O.	<b>TOL24D 288 24(12SMR) / MVM</b>

Fig. 1: 12/24/36/48/60/72 FO Cable Structure Having 12 FO each Loose Tube



The geometrical and mechanical cable characteristics are given in the following table:

Table 3: Geometrical and mechanical cable characteristics

Cable capacity n° FIBER	4/8	12/24/36/ 48/60/72	96	100/120	144	168/192/ 216	264	288
External nominal diameter [mm]	11,5	15,5	16,5	18	20	21	22	22,5
Minimum bending radius [mm]	230	310	330	350	380	400	440	450
Glass yarns minimum total strength (minimum requirement )	≥ 150000	≥ 300000	≥ 300000	≥ 300000	≥ 300000	≥ 300000	≥ 300000	≥ 300000
Cable nominal weight EVE [kg/km]	110	170	200	240	260	285	335	350
Cable nominal weight MVM [kg/km]	120	215	250	300	320	355	415	430
Cable maximum pulling strength EVE [daN]	120	270	270	270	270	270	350	350
Cable maximum pulling strength MVM [daN]	120	270	270	270	270	270	350	350

N° FIBER	N° TUB.	ELEMENT n°														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	2	TR	r	TV	r											
8	4	TR	TV	TN	TN											
12	1	TR	r	r	r	r	r									
24	2	TR	r	r	TV	r	r									
36	3	TR	r	TV	r	TN	r									
48	4	TR	TV	r	TN	TN	r									
60	5	TR	TV	TN	TN	TN	r									
72	6	TR	TV	TN	TN	TN	TN									
96	8	TR	TV	TN	TN	TN	TN	TN	TN							
100	10	TR	TV	TN	TN	TN	TN	TN	TN	TN	r					
120	10	TR	TV	TN	TN	TN	TN	TN	TN	TN	TN					
144	12	TR	TV	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN			
168	1° st. 6	TR	TV	TN	TN	TN	TN									
	2° st. 8	TR	TV	r	TN	TN	r	TN	TN	r	TN	TN	r			
192	1° st. 6	TR	TV	TN	TN	TN	TN									
	2° st. 10	TR	TV	TN	TN	TN	r	TN	TN	TN	TN	TN	r			
216	1° st. 8	TR	TV	TN	TN	TN	TN	TN	TN							
	2° st. 12	TR	TV	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN			
264	1° st. 8	TR	TV	TN	TN	TN	TN	TN	TN							
	2° st. 14	TR	TV	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	
288	1° st. 9	TR	TV	TN	TN	TN	TN	TN	TN	TN						
	2° st. 15	TR	TV	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN

Legend: **TR** = red tube

**TN** = natural / white tube

**TV** = green tube

**r** = filler

### 1.2.2 Colour scheme

The loose tubes constituting the optical fiber secondary coating will be coloured according to a pilot – directional criteria. The colour code is showed in the following:

- tube n°1 BLUE
- tube n°2 ORANGE
- tube n°3 GREEN
- tube n°4 BROWN

remaining tubes (not consisting of fibers) shall be white or o natural coloured

**The loose tubes colour tonality must comply to the current CEI-UNEL 00712 specification.**

The FIBERs contained inside each tube have to be coloured in a clearly distinguishable way with the colours given in the following table:

Table 4: optical FIBER colour code

FIBER N.	Optical FIBER colour
1	Red
2	Yellow
3	Green
4	Blue
5	Violet
6	Brown
7	Black
8	Orange
9	Pink
10	Grey
11	Light Green
12	Natural

The colour identification must comply with the CEI-UNEL 00712, last edition spec..

### 1.2.3 Temperature range

- Transportation and storing: (min) -40 °C (max) +70 °C
- Installation: (min) -5 °C (max) +40 °C
- Operation: (min) -30 °C (max) +60 °C

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### 1.2.4 Reel length

Reels length must be provided according to the following table:

Table 5: Cable reel length

	From 4 up to 288 F.O.
Nominal reel length:	1050±40 m 2000±50 m 4000±100 m

Upon P.P.C. request reels having a specific length must be provided. In such a case, for each single reel, the admitted tolerance is +2%. Cable reel length shorter than 200 mt are accepted with a tolerance of + 40 mt.

The reels for cable supply must comply with UNEL standard.

The two cables head must be sealed with heat-shrinkable caps.

### 1.3. Single mode optical FIBER characteristics

#### 1.3.1 Introduction

The SMR (Single Mode Reduced) optical FIBER characteristics must comply with IEC 60793-1, IEC 60793-2 and with the others reference applicable standard.

#### 1.3.2 Composition

The FIBERs must be made with an high grade doped silica core surrounded by a silica cladding. The FIBER refractive index must be step profiled.

Uniform glass characteristics must be guaranteed for all FIBERs.

In order to guarantee uniform high quality of eventual fusion splices, the glass quality and melting temperature must be constant in all FIBERs.

Splices are not allowed in the single span length of the provided FIBER.

#### 1.3.3 Geometrical Characteristics

- |  |                |
|--|----------------|
| – Mode field diameter at 1310 nm (Peterman II <sup>9</sup> ) | 9.2 ± 0.4 μm   |
| – Cladding diameter  | 125.0 ± 1.0 μm |
| – Cladding non circularity                                   | ≤ 2 %          |
| – Mode field / cladding concentricity error                  | ≤ 1 μm         |

### 1.3.4. Primary Coating

The FIBER primary protection is made by a double layer of UV cured acrylate based coating.

- Coating diameter:  $245 \pm 10 \mu\text{m}$
- Coating non circularity:  $\leq 6\%$
- Mode field diameter / coating concentricity error:  $\leq 10 \mu\text{m}$

### 1.3.5 Wired Optical FIBER characteristics

In this section are given the technical characteristics of the wired FIBERs. The average values are intended computed on all FIBERs of a cable reel.

The FIBERs transmission parameters must be the following:

- **Atténuation Coefficient**

Atténuation Coefficient:	average value [dB/km]	Maximum value[dB/km]
1310 nm	$\leq 0.37$	0.40
1550 nm	$\leq 0.21$	0.27
1285–1330 nm	$\leq 0.41$	0.46
1525–1575 nm	$\leq 0.23$	0.28
1575–1620 nm	$\leq 0.24$	0.29
Peak at 1380 nm	–	1.0
Peak at 1625 nm	–	0.32 (for information only)

- **Bending induced loss**

The additional loss induced by a loop made with 100 FIBER turns having 30 mm radius must be:  $\leq 0.2 \text{ dB}$ .

- **Attenuation uniformity**

The FIBER attenuation must be uniformly distributed along the FIBER according to the following criteria: said  $D_0$  the straight line obtained by approximating the back scattered curve, in a logarithmic scale, with the minimum square method, excluding the Fresnel peak caused by the input and output surface reflections of the FIBER, all the diagram points must be contained between the two straight lines  $D^+$  and  $D^-$  obtained by translating in the vertical direction by  $\pm 0.055 \text{ dB}$  the straight lines  $D_0$ .

Diffusion centres are not allowed. Eventual concentrated attenuation points must be  $\leq 0.03 \text{ dB}$ .

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- **Other optical parameters**

- Cut –off wavelength:

minimum	1150 nm
maximum	1330 nm
- Chromatic dispersion coefficient ( Absolute value ):

in the range 1285-1330 nm:	average	$\leq 3.0$ ps/(nm·km)
	maximum	3.5 ps/(nm·km)
at 1550 nm:	average	$\leq 17$ ps/(nm·km)
	maximum	18 ps/(nm·km)
- Zero dispersion wavelength: 1300 - 1324 nm
- Zero dispersion wavelength slope  $\leq 0.092$  ps/(nm<sup>2</sup>·km)
- Polarisation mode dispersion  $\leq 0.5$  ps/√km

#### 1.4. Optical FIBER characteristics

##### 1.4.1 FIBER colouring

The single optical FIBER constituting the ribbon must be coloured by applying a layer of UV cured acrylate over the primary coating.

The coloring with a pigment dispersed in the FIBER coating is also allowed.

The colors must be clearly distinguishable for the entire cable life and must comply with the scheme given in the paragraph 1.1.1.

The coloured FIBER must have an external diameter of  $250 \pm 15$  μm.

##### 1.4.2 Acrylate strippability

The acrylate must be strippable with thermal / mechanical methods. The FIBER must be free from residual acrylate after the first attempt.

## 2. TESTS AND MEASUREMENTS

In this paragraph are given the tests and measurements to be executed during the cable testing.

In the column “REFERENCE VALUE” are given the acceptance test conditions.

In the column “REFERENCE SPECIFICATION” Is mentioned the technical specification or the paragraph of this specification describing the test.

In the column “ TYPE “ is identified the test type:

- Test type (T): to be executed for the product qualification, or on samples during manufacturing if requested by P.P.C.
- Acceptance test (A): to be executed on each supplied lot, besides to the tests executed during the product qualification phase.

### 2.1. Single mode optical FIBER tests and measurements

#### 2.1.1 Geometrical characteristics

TEST	REFERENCE VALUE	REFERENCE SPECIFICATION	TYPE
Mode field diameter test	$9,2 \pm 0,4 \mu\text{m}$	IEC 60793	T
Cladding diameter test	$125,0 \pm 1,0 \mu\text{m}$	IEC 60793	T
Cladding non circularity test	$\leq 2,0 \%$	IEC 60793	T
Core / cladding concentricity error	$\leq 1 \mu\text{m}$	IEC 60793	T
Coating diameter test	$245 \pm 10 \mu\text{m}$	IEC 60793	T

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### 2.1.2 Wired optical FIBER characteristics, optical and transmission

TEST	REFERENCE VALUE	REFERENCE SPECIFICATION	TYPE
Atténuation test	Par. 0	IEC 60793	A
Longitudinal uniformity test	$\pm 0,055$ dB	IEC 60793	A
Bending attenuation test	$\leq 0,20$ dB	IEC 60793	T
Cut –off wavelength test	1150÷1330 nm	IEC 60793	A
Chromatic dispersion coefficient test	Par. 0	IEC 60793	T
Zero dispersion wavelength test	1300 ÷ 1324 nm	IEC 60793	T
Polarisation mode dispersion coefficient test	$\leq 0,5$ ps/√km	ITU-T G.655	T

### 2.1.3 Environmental and mechanical characteristics

TEST	REFERENCE VALUE	REFERENCE SPECIFICATION	TYPE
Pulling test ("Proof Test")	1 %	IEC 60793	T
Breaking load test ( Weibull diagram)	$\geq 3,5$ GPa at 63% of breaking probability	IEC 60793	T
Sensitivity to corrosion dynamic factor «n» identification	$\geq 20$	IEC 60793	T
Sensitivity to corrosion static factor identification ( ns )	$\geq 23$	IEC 60793	T
Primary coating stippability load	1 – 3,5 N	IEC 60793	T
Mechanical characteristics tests with various environmental conditions	Breaking load degradation $\leq 50\%$	IEC 60793	T
Mechanical characteristics tests in saltern, acid and basic solution	Degradation nd factor $\leq 50\%$	IEC 60793	T
Thermal cycles	$\Delta$ attenuation $\leq 0.05$ dB a 1550 nm	IEC 60793	T
FIBER bending test	$R \geq 3,5$ m	Please refer to annex	T

## 2.2. Optical Fiber cable materials tests and measurements

TEST	REFERENCE VALUE	REFERENCE SPECIFICATION	TYPE
<b>FIBERglass central element</b>			
Breaking tensile test	$\geq 1400 \text{ MPa}$	Please refer to annex	T
Breaking extension	$\geq 2 \%$	Please refer to annex	T
Elasticity modulus measurement	$\geq 40000 \text{ MPa}$	Please refer to annex	T
<b>Loose Tube</b>			
Breaking tensile test (original)	$\geq 40 \text{ MPa}$		T
Breaking extension	$\geq 100 \%$		T
<b>Jelly filling the loose tube and contacting the FIBERs</b>			
Drop point measurement	$\geq 150 \text{ }^{\circ}\text{C}$	CEI 20-34/5-1	T
Cold penetration	$\geq 15050 \cdot 10^{-1} \text{ mm}$ a $-30^{\circ}\text{C}$	ASTM D217	T
<b>Glass yarns</b>			
Glass yarn total count	Please refer to		T
Breaking tensile test	$\geq 0,02 \text{ N/dTex}$		T
Breaking extension	$\geq 1,5\%$		T
<b>Polyethylene sheath</b>			
Density measurement	$\leq 0,940 \text{ g/cm}^3$	CEI 20-34/1-3	T
Thrmofluidity index measurement	$\leq 1 \text{ g/10min}$	CEI 20-34/4-1	T
Black smoke content	$2 \div 3 \%$	CEI 20-34/4-1	T
Pressure at high temperature	24 ore a $+85 \pm 3 \text{ }^{\circ}\text{C}$ residual thick $\geq 50 \%$	CEI 20-34/3-1	T
Low temperature test. Cold flexibility	$T = -35 \pm 2 \text{ }^{\circ}\text{C}$ no breaks	CEI 20-34/1-4	T
Low temperature test. Impact test	$T = -15 \pm 2 \text{ }^{\circ}\text{C}$ no breaks	CEI 20-34/1-4	T
PE sheath mechanical characteristics with and without hot air furnace ageing	ageing: 240 hours at $100 \pm 2 \text{ }^{\circ}\text{C}$ ; Acceptance: breaking load $\geq 12 \text{ MPa}$ ; breaking extension $\geq 350 \%$ ; same values after ageing;	CEI 20-34	T
Resistance to the environmental degradation(E.S.C.R.)	$\geq 48 \text{ hours}$	IEC 811 proc. B	T
<b>Sheaths LSZH</b>			
LSZH sheath mechanical characteristics with and without hot air furnace ageing	ageing: 168 hours at $100 \pm 2 \text{ }^{\circ}\text{C}$ ; Acceptance: breaking load $\geq 9 \text{ MPa}$ ; breaking extension $\geq 125 \%$ ; $\pm 30 \%$ after ageing;	CEI 20-34	T
Alogen gas produced during combustion measurement	$\leq 0,3 \%$ HCl	CEI 20-37/2	T
Smokes density measurement during combustion	$\geq 70 \%$	CEI 20-37/4 e 5 ASTM E 662	T
Tossicity index measurement of the Gas produced during combustion	$\leq 2$	CEI 20-37/7	T
Ossigen index measurement	$\geq 30 \%$ $\text{O}_2$	CEI 20-22/4	T
Gas acidity index measurement ( corrosivity ) by means of PH and conductivity measurement	PH $\geq 4.3$ conductivity $\leq 10 \text{ } \mu\text{S/mm}$	CEI 20-37/3	T
Low temperature test. Cold bending	$T = -25 \pm 2 \text{ }^{\circ}\text{C}$ craks absence	CEI 20-34	T
Low temperature test. Impact resistance	$T = -25 \pm 2 \text{ }^{\circ}\text{C}$ craks absence	CEI 20-34	T

Pressure at high temperature test	6 ore a $+80 \pm 2$ °C Residual thickens $\geq 50$ %	CEI 20-34	T
Water absorption	24 hours at $+100 \pm 2$ °C $\leq 15$ mg/cm <sup>2</sup>	CEI 20-34/1-3	T
Oils resistance	4 ours at $+70 \pm 2$ °C in oil ASTM 2; Max mechanical characteristic variation $\pm 30$ %	CEI 20-34/1-2	T

## 2.3 Tests and measurements on the finished cable

TEST	REFERENCE VALUE	REFERENCE SPECIFICATI ON	TYPE
<b>Geometric and structural characteristics</b>			
Manufacturing control (Visual inspection )	Par. 0		A
Sheaths thickness measurement (both cable head)	Inner sheath: $\geq 0,9$ mm aver. Outer sheath: $\geq 1,2$ mm aver. x 4/8FO $\geq 1,5$ mm aver. x 12÷288FO		A
<b>Mechanical tests</b>			
Tensile test	Maximum load: refer to tab. 3 $L > 50$ m; <u>Acceptance:</u> $\Delta I$ FIBER $\leq 0,33\%$ ; (with the phase variation method); absence of residual attenuation increment (A FIBER for each loose tube will be tested).	EN 60794 - E1	T
Percussion test	R=10 mm; E= 5 Nm (0,5 kgm) N°impacts = 1 in 3 different points; <u>Acceptance:</u> neither FIBER breaking nor attenuation residual increment must be measured;	EN 60794 – E4	T
Squashing test	M=1500 N/10cm <u>Acceptance:</u> neither FIBER breaking nor attenuation residual increment must be measured;	EN 60794 – E3	T
Torsion test	N°rotation=1 L=1m Mass=10 kg N°cycle=3 <u>Acceptance:</u> cable and FIBERs don't have to remain damaged.	EN 60794 – E7	T

Mandrel winding test	Procedure 1; D=20 x d cable N° turns per propeller =5 N° cycle=3 Low temperature test: T= - 15°C <u>Acceptance:</u> attenuation residual increment don't have be measured.	EN 60794 – E11	T
Repeated bending test	Mass=10 kg D=20 x d cable N° cycle=35 <u>Acceptance:</u> FIBERs don't have to remain damaged.	EN 60794 – E6	T
Eight winding test	L=300m in eight coils 4 m x 1,5 m	See annex	T
Straightening test	Φ=50 cm	See annex	T
Kink test	Φ=20 x d cable	EN 60794 – E10	T
Outer marking lasting test	Comply	See annex	T
<b>Tightness tests</b>			
Water propagation resistance	Comply	EN 60794 – F5	T
Long duration water immersion	Comply	See annex	T
<b>Environ mental tests</b>			
Thermal Cycle	T <sub>A</sub> =-30 °C T <sub>B</sub> =60 °C t <sub>1</sub> =24 h <u>Acceptance:</u> at -30 °C and 60 °C attenuation increments higher than 0,05 dB/Km at 1550 nm don't have to be measured. After the thermal cycle have been completed, residual attenuation increments don't have to be measured.	EN 60794 – F1	T
<b>Flamme propagation tests</b>			
Flame propagation test on the cable (for cables having LSZH sheath)	Comply	CEI 20–35/1	T
Fire propagation along a cable bundle (for cables having LSZH sheath )	Comply	CEI 20-22 /III	T

## 2.4 Quality levels

The lots supplied have to be tested in compliance to UNI ISO 2859 first part.

An LQA at least equal to the minimum must be guaranteed.

For the special test level S3, the sampling plan must be doubled.

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## 2.5 Tests and measurements on single mode optical FIBERs

### 2.5.1 FIBER bending measurement

#### Laser Barrier method

##### Overview

The measure is executed in normal environmental conditions, on a FIBER section free from coating, in order to evaluate the bending radius of the fiberglass structure.

##### Procedure

The FIBER sample is fixed, for instance with the aid of a vacuum pump, over a proper support, where the section free from coating protrudes for a length "D" (about 10 mm); the FIBER is free to rotate around its axis, manually or by means of a motor; during a complete rotation (360 degrees) the FIBER will be observed from one side, by means of a laser barrier, and the maximum shift  $\delta t$  will be measured with respect to a fixed surface, parallel to the FIBER axis. The FIBER bending,  $\delta f$ , is defined as:

$$\delta f = \delta t / 2$$

The bending radius, R, is related to the bending by:

$$R = (D^2 + \delta f^2) / 2\delta f$$

##### Instruments

- Laser barrier for distance measurement.
- Reference: a metal bar with flat parallel faces with tolerance less than a tenth of micron.
- Rotating support for FIBER with a "v" gap, equipped with FIBER clamp (i.e. magnetic or vacuum).
- Motor for rotation of the sample or of the support.

##### Reporting

The measures will be accompanied by the following data:

- Date of measurement.
- Sample identification.
- FIBER bending radius.

The following information shall also be reported:

- Equipment description.
- Calibration data.

## **2.6    Tests and measurements on optical Fibers materials**

### **2.6.1    Characteristics of central Fiberglass element: breaking load, ultimate elongation and modulus of elasticity**

#### **Scope**

The test objective is to determine the values of the breaking load, ultimate elongation and modulus of elasticity of the central element, made in plastic reinforced by Fiberglass.

#### **Test equipment**

Dynamometer with extensometer, with load cell.

#### **Test sample**

The sample shall have a minimum length of 300 mm.

The sample can be taken directly from an original section of the central element, or taken from a finished cable removing the plastic coating.

#### **Test procedure**

The sample must be inserted in the dynamometer clamp, so that the distance between the clamping heads is at least 200 mm.

After the application of a suitable pre-load, the extensometer is positioned and the recorder inserted.

The sample is then pulled with a clamp speed of about 5-10 mm/minute until the breaking.

The test is repeated over at least 4 more samples. If an abnormal breaking is detected, the test shall be repeated on another sample.

#### **Results**

The values of the breaking load, ultimate elongation and modulus of elasticity are noted from the load-elongation curves obtained in 5 valid tests.

### **2.6.2    Tube compatibility with the filling compound**

A section of filled tube is exposed to a pre-conditioning treatment at 70 °C for 7 days.

After the pre-conditioning treatment the tube shall be extracted from the cable, properly cleaned from filling residuals (avoiding the use of chemical substances, solvents or procedures that may scratch the external surface) and is wrapped for three complete cycles, alongside each other, over a mandrel having a diameter 30 times greater than the tube diameter.

The samples shall be examined by sight check, while they are still on the mandrel, and no crack shall be noted.

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## **2.7 Tests and measurements on finished cable**

### **2.7.1 Eight winding test**

The FIBER attenuation of the section sample shall be measured, for instance by means of a back-scattering instrument, then the same sample shall be uncoiled for the prescribed length, placing the cable in shape of 8, inside a rectangle of 4 m x 1,5 m.

The FIBER attenuation shall then be measured again, with the same method, and any attenuation increases shall be put in evidence.

The uncoiled cable part shall then be coiled again on the reel and the FIBER attenuation shall be measured again.

The measured attenuation values shall not be greater than the ones reported in the present Specification.

### **2.7.2 Loop straightening test**

A sample of proper length shall be taken from the section head. The sample shall be bent (i.e. by hand) in order to obtain a circle (loop) of the prescribed diameter. The loop endings shall then be gradually pulled, avoiding the head rotation, until the loop is straightened, having consequently forced a torsion of 360° to the cable under test.

The integrity of the outer sheath and of the dielectric armour shall then be verified.

### **2.7.3 Stamping durability control**

The durability of stampings over the outer sheath shall be verified by wiping them 10 times with absorbent cotton or a piece of wet fabric. By sight check no visible alterations shall be noted at the end of the test.

### **2.7.4 Long immersion in water**

The FIBER attenuation of the section sample, of a length suitable to obtain the required accuracy (500m or more) shall be measured, for instance by means of a back-diffusion instrument.

The sample shall then be dip in a tank at room temperature, leaving outside both ends. The FIBER attenuation shall be periodically measured, i.e. once a month, until the end of the test (at least 6 months). No noticeable attenuation variation must be measured at 1550 nm.