NEW CONCEPT IN CABLES AND ACCESSORIES FOR LOW VOLTAGE UNDERGROUND DISTRIBUTION IN SPAIN

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ABSTRACT

The circuits currently used in Low Voltage distribution networks in Spain are composed of four single-core cables of the same cross-section, with aluminium conductor, XLPE insulation and PVC sheath. This study was carried out with the aim of obtaining a cable and accessories which meet the following requirements: maintenance of the single-core design, improvement of the resistance of the cable and accessories to external agents, reduction of the environmental impact, maintenance of the cost, simplification of the assembly, reduction of stocks, safety for live work and highly reliable connections.

KEYWORDS

XZ1 oversheath, LV cable, HFFR

INTRODUCTION

Due to the difficulty in detecting earth faults in the event of damage to the insulation and sheath layers of Low Voltage (LV) networks and the consequent corrosion of the aluminium conductor, a joint study was carried out back in 1995 by the Utilities and some cable manufacturers to determine the optimal design in accordance with a series of variables assessed according to their importance (possibility of detecting defects, cost, ease of installation, etc.) (see Jicable 95 Article B.1.5).

The conclusion then reached was that the cable with Ceander type concentric conductor was the one that offered the greatest advantages and the replacement of single-core cables by the Ceander was therefore considered. After several test installations using the new cable, it was finally rejected due to its higher cost and the greater complexity in the preparation of accessories, the single-core cable being maintained despite its lower level of safety.

The advisability of modifying the design of the LV distribution cable was again raised in 2001, the following requirements being defined:

-Maintain the single-core design to aid the laying and the preparation of accessories.

-Improve the resistance of the cable and accessories to external agents (tearing, abrasion, entry of water, etc.) without compromising the reliability of the cable installation.

-Reduce the environmental impact, eliminating stabilizers with lead and plasticizers.

-Eliminate the emission of halogens in the event of fire and maintain a similar fire-resistance.

-Maintain the cost of the new cable and accessories substantially the same as the previous one.

Suitable accessories for this cable were subsequently designed with the following requirements:

-Simplification of assembly.
-Reduction of stocks.
-Safety of live work.
-Same level of environmental impact as the cable.
-Highly reliable connections.

To obtain these objectives work was basically carried out on developing a new cable, whose characteristics were defined in the standard UNE 211603 5N1, which will replace the previous low voltage RV cable. The main new developments can be found in the new oversheath compound, HFFR (Halogen Free Fire Retardant) material and in the design of new suitable accessories. This new cable will be identified as XZ1.

RESULTS

New HFFR sheath compound

To meet the new requirements the PVC oversheath has been replaced by a HFFR compound. The characteristics of this compound have been defined in the standard UNE 211603 5N1 type DMO1. This new compound, has been developed by is characterized by having a blend of polyolefins fire-proofed with a metallic hydroxide. The blend of polyolefins selected grants the sheath compound greater abrasion resistance properties, better tear resistance and resistance to the entry of water. These improvements allow the cable to be protected against possible damage caused during the laying and installation operations. They moreover reduce the environmental impact on allowing elimination of the use of stabilizers with lead and plasticizers. The fireproofing system chosen maintains the fire resistance and eliminates the emission of halogens in the event of fire. It should be stressed that the new sheath compound also prevents the flame from spreading downwards. Table 1 shows a comparison of the values that the PVC compound and the new HFFR DMO1 compound have to fulfil.

Properties	Units	PVC DMV 18	Polyolefin DMO1
Tensile strength	MPa	>12.5	>12.5
Elongation at rupture	%	>150	>300
Tear resistance	N/mm	(9)	>9(18)
Abrasion resistance			
Applied mass	Kg	(8)	12(18)
Displacement no.	-	(8)	8(8)
Absorption of water	mg/cm^2	10(at 70 ºC)	5(at 85 ºC)
Flame-retardance	-	Yes	Yes
Density of smoke	>60%	Not fulfilled	Fulfilled
Corrosiveness of combustion gases		Not fulfilled	Fulfilled

Table 1. Comparison of basic characteristics between PVC and DMO1 oversheaths.

Eleven parameters were established to appraise compliance with the requirements. Each parameter was assigned a "weight" in accordance with its importance as established by the cable users. The parameters basically refer to mechanical properties, environmental impact, safety and economic impact. Table 2 defines the parameters and their corresponding "weight".

Nº	Parameters	Weigh t
1	Tensile strength and elongation at rupture	3
2	Tear resistance	9
3	Migration of water (possibility of water penetration between insulation and sheath)	7
4	Abrasion resistance	9
5	Flame retardance (EN 60332-1-2)	5
6	Density of smoke (EN 61034-2)	7
7	Corrosiveness of combustion gases (EN 50267-2-3)	7
8	Environmental impact	5
9	Economic impact	6

Table 2. "weight" means importance of each parameter according to the users (from 1 low to 9 high)

Four levels of acceptance are defined for each of the above parameters. The levels can be poor (1), regular (2), acceptable (3) and good (4). Table 3 shows how, according to the "weight" of the parameter and its level of acceptance, the DMO1 sheath grants the XZ1 cable better performance than the former cable with PVC.

Parameter No.	PVC	DMO1
1	3x2	3x4
2	9x2	9x4
3	7x1	7x3
4	9x2	9x3
5	5x2	5x2
6	7x1	7x3
7	7x1	7x3
8	5x1	5x3
9	6x3	6x3
Total	96	181

Table 3. Estimation of the performance of PVC and DMO1 sheaths

The design of the new XZ1 cable is practically identical to the previous RV cable with PVC oversheath, but with less thickness of sheath with the aim of maintaining the same final cost. Image 1 shows the XZ1 cable (Aluminium conductor, XLPE insulation and HFFR sheath).

Image 1. Design XZ1 cable

New accessories

From among the accessories liable to be used in the new XZ1 cable, those of the pre-insulated connection type were chosen, as they present the best performance relationship. In particular, they present very good behaviour in parameters such as reliability, safety and ease of installation. Table 4 presents a quantification of the performance of the different accessories. The accessories are:

A- Heat shrink connections
B- Cold shrink connections
C- Resinous connections
D- Gel connections
E- Pre-insulated connections

Table 4 assesses the different accessories, quantifying their performance as very good VG (X9), good G (X3) and regular R (X1).

	MARKET QUALITY REQUIREMENTS	K	A	B	C	D	E
1	Simplified installation	1	R	G	R	G	VG
2	Technical performance	2	G	G	VG	R	G
3	Manual labour quality independence	5	R	G	R	G	VG
4	Security in hot line works	3	R	G	G	G	VG
5	Reliability	4	G	VG	G	G	VG
6	Economy	4	VG	G	R	G	G
	Index value		3.7	4.7	2.8	3.1	7.9

Table 4. Performance accessories

The highest index value was for the type E accessory, pre-insulated connections, which is the type of accessory selected for the laying of the new XZ1 cable. Images 2 and 3 show the cable and its corresponding type E accessories.

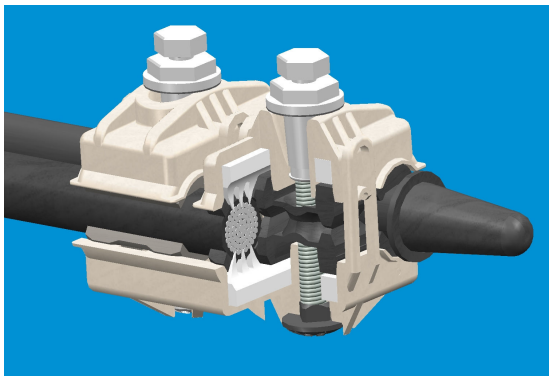

Image 2. Type E connector for XZ1 cable.

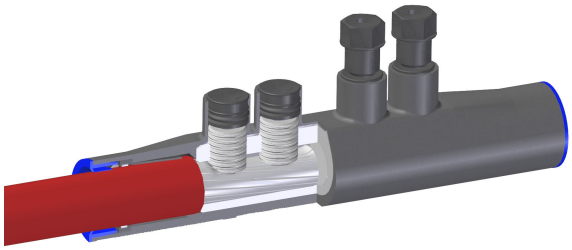

Image 3. Joint connector for XZ1 cable.

CONCLUSIONS

Use of the new HFFR DMO1 sheath in low voltage distribution network cables grants the new XZ1 cable better mechanical performance, greater resistance to external aggressions and a reduction in the environmental impact on being a halogen-free compound. At the same time it maintains the single-core design, a similar flame retardance and a similar cost. This new cable is already a concrete reality, as the Spanish utilities plan to begin installation of this cable during 2007 in low voltage distribution lines.
The new XZ1 cable was completed with the design of type E accessories (pre-insulated connections) which allow the assembly to be simplified, stocks to be reduced and live work to be carried out safely. At the same time an environmental impact level the same as that of the cable is maintained and highly reliable connections are obtained.

Acknowledgments

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Glossary

PVC: Poly Vinyl Chloride
LV: Low Voltage
HFFR: Halogen Free Fire Retardant
XZ1: New low voltage halogen free underground distribution cable.
RV: Low voltage with PVC oversheath underground distribution cable.
XLPE: Crosslinked polyethylene