HFFR MATERIALS WITH IMPROVED MECHANICAL CHARACTERISTICS FOR MV CABLES SHEATING

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INTRODUCTION

As PVC inherently presents flame-resistant properties due to the existence of chlorine in its molecule when used as a cable sheath it grants the same sufficient fire-resistance for most applications. However, in many cases PVC is being replaced in Medium Voltage cable sheathing by polyolefin compounds in order to obtain a greater protection against external agents and to avoid the harmful environmental effects that can be produced by the plasticizers and heavy metals usually present in PVC compounds. In view of this, the fire-resistance presented by cables with PVC sheaths has been lost and consequently the installations in closed places involving Medium Voltage cables are becoming potentially more dangerous.
A level of fire resistance similar to that of PVC can be obtained by adequately formulating the polyolefin compounds without reduction on their cable protection characteristics and with a reasonable increase in cost. This would be the most advisable option for most installations of Medium Voltage cables.
A greater fire resistance implies a loss of the material's characteristics and an increase in its cost which advise against its use unless, due to the characteristics of the installation, fire resistance is a priority.

MV CABLES SHEATHING MATERIALS

PVC has traditionally been used as the preferred material for sheathing of Medium Voltage distribution cables (type ST2 of IEC 60 502) while polyolefin materials, especially MDPE and HDPE, fulfilling the characteristics specified for type ST7 of IEC 60 502, have preferentially been used in High Voltage cables in which a greater protection against external aggressions and moisture is considered necessary.
The improvement in the insulating materials and in the production processes of the MV cables has moved the main cause of failures to the external mechanical damages. Is for this reason that the use of polyolefin sheaths in Medium Voltage cables is becoming increasingly generalized due to their better mechanical characteristics, especially as regards resistance to abrasion and tearing and also a better resistance to moisture, while the cost of materials remains at a level that does not affect significantly the final cost of the cable (figure 1).
Environmental and safety aspects also affect this decision as the composition of these materials, unlike PVC, is zero halogen and they do not require additives like plasticisers that can migrate to the soil or stabilizers based on heavy metals.

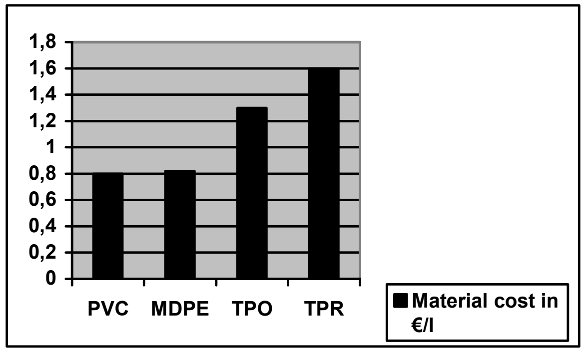

Fig. 1

THE EFFECT OF FIRE IN MEDIUM VOLTAGE CABLES

In contrast to the advantages set forth above, polyolefins have the disadvantage of being highly combustible, not offering, unlike PVC, any kind of protection against the spreading of fire. This is not of great importance in cables directly buried with their terminations installed outdoors but can be a serious danger in installations in tunnels or galleries and even in cables directly buried but whose terminations, and consequently also the adjacent sections of cable, are situated in enclosed places such as Indoor Power Substations. This kind of installations represents a very important volume and are classified as "key fire-sensitive cable installations" by the FIPEC Consortium [1].
The fires which affect cables are especially problematic due to their difficult detection and access as these cables are usually installed in enclosed areas. The type of installation and the high temperature which is generated around the cables, due to the heat from the current that they conduct in addition to that generated by the initial source of fire, favour a rapid spreading of the fire. In horizontal routes, the speed of spreading of the fire is 5 cm/min at 200 ºC, increasing to over 110 cm/min for temperatures in the region of 350 ºC while in vertical routes the spreading of the fire is almost instantaneous (>130 cm/min at 250ºC) [2].
Apart from smoke, the main danger of a fire is that it presents an explosive growth at the beginning of its development [3]. The Medium Voltage cables with non-fire-retardant polyolefin sheath do not comply with any level of fire resistance and consequently, in the event that a source of fire ignites the material, there may be a violent spreading of the fire both along the cable itself and through the drops of melted and ignited material that fall from the area affected by the initial fire.

HFFR SHEATHING MATERIALS FOR MV CABLES

Figure 2 shows the results of the Heath Release Rate measured in the Cone Calorimeter for different materials.

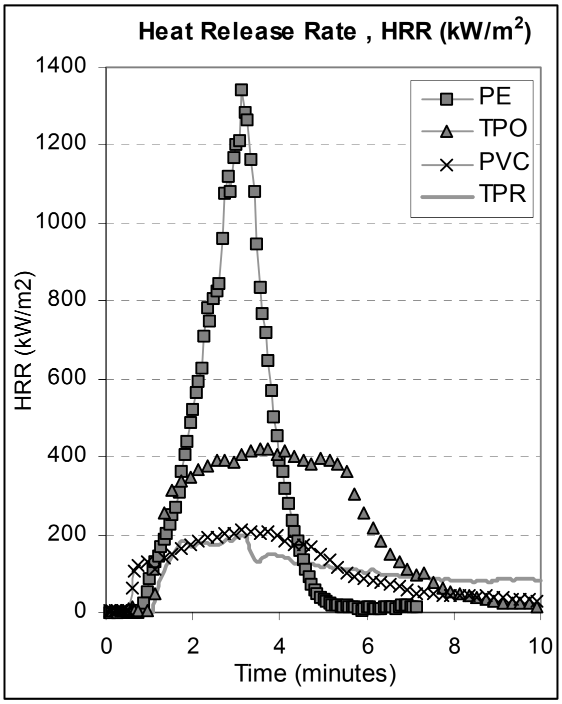

Fig. 2

It is observed that for a typical PE sheathing material the maximum peak of heat emitted exceeds by several times that of the rest of the materials, including PVC, despite the fact that the latter is not specifically fire resistant, which gives an idea of the high speed of inflammation presented by PE. The same figure also presents the results of the Heath Release Rate for two fire-retardant polyolefin compounds. TPO is a compound designed as a sheath for MV cables that should pass the fire resistance test of IEC 60332-1-2 while TPR is a compound with a higher level of fire resistance to pass the fire resistance test of IEC-60332-3-22. The reason why PVC without any kind of fire resistance treatment presents a behaviour in the face of the emission of heat similar to the TPO type polyolefin compound is the inhibition of the combustion process produced by the chlorine emitted in the decomposition of the material, therefore acting as a fire-retardant agent.

TPO is a polyolefin based compound with mechanical and moisture barrier properties as good as those of the PE sheathing grades but with an improved fire-resistance behaviour. During a fire, the burning material does not drop from the cable and the lower heath release rate compared with a non-compounded PE produces a lower speed of fire spread and even the fire extinction in the area free from an external fire source.

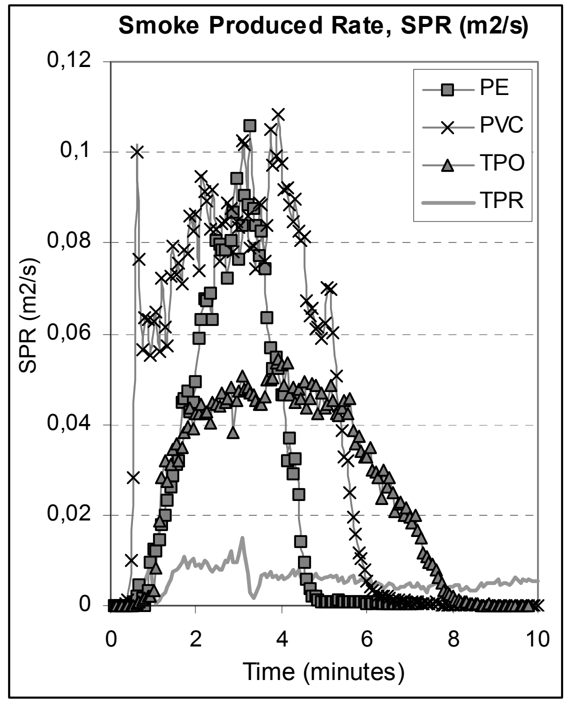

Fig. 3

As for the smoke production rate during the fire, it can be seen in Figure 3 that PVC presents a value higher than the zero halogen materials. Non-fire-resistant PE presents a maximum which coincides with the maximum emission of heat although in total the quantity of smoke emitted (area contained by the curve) is in the same order as the TPO compound. The TPR compound, due to its higher level of fire-resistance, presents the lowest value of smoke emission. PVC not only present the highest value on quantity of smoke emission but also the smoke emitted is dark, corrosive and highly toxic in contrast to the clear, non corrosive and low toxicity smoke emitted by the halogen free materials.

An increase in the fire resistance properties of polyolefins with zero halogen materials usually causes a considerable reduction in the mechanical characteristics of the compound and makes the extrusion process more difficult. For this reason, it is important to adjust the level of fire resistance to the minimum required by the application for which the cable is intended. It is possible, following this criterion, to obtain compounds to pass the fire resistance test of IEC 60332-1-2, keeping mechanical characteristics which exceed those defined for the ST-7 type materials of IEC 60502 and with a resistance to abrasion much higher than that of PVC. Table 1 presents the main characteristics of the TPO compound developed by Grupo General Cable Sistemas for this application.

A greater level of fire-resistance of the material is necessary if a level of fire resistance of the cable is demanded in accordance with IEC 60332-3-22, but then the loss of characteristics of the compound is so important that the mechanical protection offered by the sheath is greatly reduced, only complying with the characteristics corresponding to the ST-8 type of IEC-60502. Table 1 presents the main characteristics of the TPR compound developed for this application.

Table 1

Physical properties of LSF-OH sheathing materials				
Properties	**Units**	**Materials**		**Test Method**
		TPO	**TPR**	
Tensile strength	N/mm²	>12.5	>10	EN 60811-1-1
Elongation at break	%	>300	>125	EN 60811-1-1
Tear resistance	N/mm	>20	>8	ISO 34.1
Abrasion resistance on cable		Pass	Not pass	HD-605. 2.4.22
Oxygen index		>27	>32	ISO 4589
Acid gas test -Conductivity -Ph -Halogen cont.	$\mu s.cm^{-1}$ %	 <10 >4.3 <0.5	 <10 >4.3 <0.5	EN 50267-2-3 EN 50267-2-3 EN 50267-2-1

The use of polyolefins for MV cables sheathing presents considerable advantages in comparison with PVC, both from the point of view of mechanical protection (greater resistance to abrasion and to tearing) and of protection against moisture (less water permeability) and of environmental and safety factors (absence of plasticisers, halogens and stabilizers containing heavy metals).
However, polyolefins favour the spreading of fire due to their high ease of inflammation. Only in those cases in which it is highly unlikely that the cables will be affected by fire is it advisable to use non-fire-retardant polyolefins. In all other cases it is preferable to use fire-retardant compounds, although it is important to adjust the level of flame-retardancy to the minimum necessary in accordance with the type of installation for which the cable is intended, thus optimising the cost and the mechanical characteristics of the compound.

CONCLUSIONS

REFERENCES

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