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## E.2. Caractérisation et diagnostic des câbles HT et THT par la méthode de l'onde thermique

TOUREILLE A., Univ. Montpellier II, Montpellier, France
SANTANA J., BERDALA J., Câbles Pirelli, Sens, France

## E.2. Characterization and diagnostic of HV and VHV cables by the thermal step method

TOUREILLE A., Univ. Montpellier II, Montpellier, France
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**Résumé:**

**Le choix des matériaux détermine en grande partie les caractéristiques électriques et physiques du câble. L'étude de l'isolation du câble doit garantir ses caractéristiques initiales mais également la pérennité de celles-ci dans le temps et dans son environnement de fonctionnement. L'évaluation du comportement électrique passe par l'examen d'un large éventail de couples isolant - semi-conducteur pour permettre une première sélection de matériaux. Pour cela, nous utilisons une méthode d'analyse donnant un spectre de la répartition du champ électrique résiduel aux contacts et à l'intérieur de l'isolant. Nous pouvons ainsi étudier le comportement de ces échantillons face à des contraintes électriques, de température et de durée. nous avons procédé au contrôle systématique de l'état électrique d'une série d'échantillons plan en PEHD, PEBD et PRC avec divers semi-conducteurs comme électrodes grâce au banc de mesure de charges d'espace basé sur la méthode de l'onde thermique.**

**Abstract:**

**The choice of materials determines - for a large part - the electric and physics properties of cable. The study of insulating material for cable must be garant with initial properties but so with the duration in the surrounding of using. the evaluation of electric state is checked by the study of possible couples "insulating - semiconducting shields" to allow a first selection of materials. To do it, we use a method which analyses the space charge density at the contact and in the bulk. We can study the influence of various parameters such as electric gradient, temperature, duration of the stress. We have studied in the same way PEHD, PELB and XLPE with different shields as electrodes thanks to the space charge measurement bench using the thermal step technique.**

### I. Introduction:

This study has been made with the collaboration of Cables Pirelli . The Thermal Step Method allows to measure the remaining space charges in an insulating material after charging : this technique is very sensitive and follows the evolution of " electric state " of the devices ( cables or slabs ) with the time . This is a good tool to choose the better materials . Its easy using , its very good rate signal on noise , open numerous industrial applications to give evidence of important parameters leading to the set up of space charges in particular with the making process of devices .
We applied The Thermal Step Method to differents Polyethylens , various contacts , and in cables to show that and we deduce some interesting general results.

### II. Experimental procedure :

The principle of the thermal step method has been already described in many papers [1,2,3]. In the case of the cable, the stimuli can be created: by cooling (negative step from 20°C to -25°C) which keeps the reached temperature constant close to the external electrode during the measurement. . The experience is discribed in figure 1 (same principle for a slab). After the acquisition of the current inherent of the variation of dilatation and permittivity by the thermal wave, we proceed to the deconvolution of the current to obtain the distributions of the electric field and the space charges distributions.

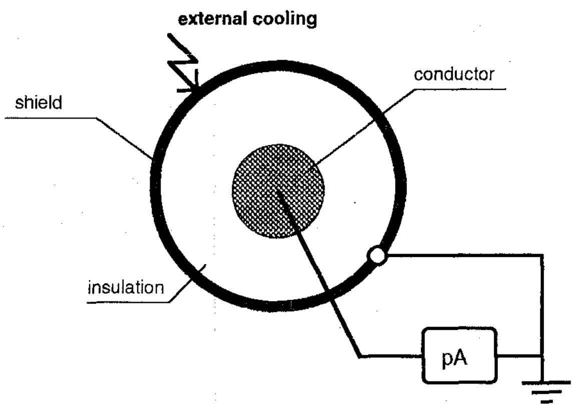


Figure 1 : Experimental scheme

The samples are charged at different temperatures ( 50°C or 70°C ) during several days ( 1 or 3 or 6 ) with various DCvoltages ( 20 or 40 KV )
The measurements are made after charging , cooling at room temperature and in short-circuit.

### III Application to the slabs ( 2 mm thick ):

**1-XLPE**

We have studied the influence of charging time .
Typical curves are shown in fig 2 ( anode on the left on all figures ) with the evolution for charging 1 , 3 ,6 days at 50°C and 70°C ( Insulating material IA , shield SB )

The charges are more important with one day at 50°C and then decrease at 70°C certainly by an increasing of conduction .

The typical profil positive negative positive has been found often : it seems relative to the process of slab making [4] .

Then we have studied the semi conducting material ( shield for the cable , insulating material IA , shield SC ) :fig 3 : we keep the same insulating material and we change the electrode : the influence is sensitive .

In the same way we have changed the insulating material and keep the same electrode fig 4 ( insulating material ID , shield SB )

The conclusions give evidence that the important structur is the couple " insulating material- semiconducting shield ": this check allows to choose the best couple .

**2-LDPE**

Similar distributions are found in LDPE with some general remarks . The magnetude of space charges are less important at 50°C but more stronger at 70°C :relative to XLPE results : this material must work to weak temperatures .

**3-HDPE**

This material presents less of space charge density than the two other PE , but is very sensitive to adjuvants and additives .: certainly this material is more cristalline . Then the profil of space charge cannot the general results obtained on the other PE