# A.7.3. Etude de l'origine des charges d'espace consécutives à la fabrication de plaques de polyéthylène

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# A.7.3. Study of the origin of space charge created during preparation of polyethylene plaques

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Résumé

L'étude montre l'existence d'une répartition de charge d'espace non négligeable dans des plaques de polyethylene juste après leur mise en oeuvre par moulage en compression. Ces plaques n'ont été soumises à aucun champ électrique avant les mesures..l'influence de la masse moléculaire et de la densité des résines de base de polyethylène sans adjuvant est étudiée en détails. Il apparait que la masse moléculaire qui détermine les propriétés de fluidité du polymère au moment de la mise en oeuvre, joue un role important dans la distribution des charges d'espace à température ambiante. Il n'a pas été trouvé d'influence de la densité.

Abstract

The study demonstrates the existence of substantial space charge in polyethylene plaques directly after pressmoulding. The plaques have thus not been subjected to an applied electric field before the measurement. The influence of molecular weight and density of polyethylene base resins without additives was studied in detail. It appears that the molecular weight, which determine the flow properties of the polymer during pressmoulding, plays an important role for the space charge distribution at room temperature. No influence of the density was found.

## Introduction

The appearance of space charges in polymeric insulation subjected to high electric field is a phenomenon of great importance for the dielectric performance of polymeric high voltage direct current (HVDC) cables. The space charge will lead to deviations in the electrical field distribution, possibly causing failures by high local stresses. Many papers have dealt with this subject [1,2,3,4,5]. It has been shown that the space charge properties depend not only on the material type, but also on type of test sample and pre-treatment method applied before measurement. Examples of material properties that may be important are density, crystalline structure and molecular weight. The cooling rate used during preparation of test samples may also play important role. This study involves determination of the space charge distribution in pressmoulded polyethylene plaques directly after preparation of the samples, that is without applying electric voltage to the samples before the measurements. It will be shown that space charge will be observed in these samples and that the thermal step method is suitable to compare the space charge properties of different materials.

## Experimental procedure

### Sample preparation

The samples have been pressmoulded from extruded tapes of polyethylene base resins. The use of tapes, and no pellets, eliminates granular interfaces which can act as traps for electrons and consequently change the space charge behaviour.
The materials are moulded at 185°C: 20 min/1 bar + 3 min/100 bars + 3 min/200 bars. The samples are then cooled (under 200 bars pressure) to room temperature (~40°C/min). The thickness of the samples is 2 mm.
Aluminium electrodes (diameter=40 mm) are then deposited under vacuum on each side of the sample

### Description of the Thermal Step Method

The thermal step method developed by A. Toureille, was used in this study for determination of the space charge distribution in the pressmoulded plaques.
The method is based on measurements of the thermodilatation current caused by the application of a so called thermal step. The sample is at room temperature. The temperature of one side of the sample is then quickly cooled to -20°C while the other side is kept at room temperature. The propagation of thermal step through the sample leads to thermal contraction of the successive material layers and will thus displace the space charges in the layers. The displacements will create a current in the external circuit joining the two electrodes.

The current is:

$$I(t) = -\alpha . C . \int_0^D E(x) . \frac{\delta T}{\delta t} . dx$$

where $\alpha = \alpha_x - \alpha_\varepsilon$ with

$\alpha_x$ linear expansion coefficient of material
$\alpha_\varepsilon$ thermal dependence of permittivity coefficient
C: Capacitance of sample
T: Temperature
D: Thickness of sample
E(x): Electric field strength in elementary thickness dx

$$\alpha = \frac{1}{l} . \frac{\delta l}{\delta T} - \frac{1}{\varepsilon} . \frac{\delta \varepsilon}{dT} = \frac{1}{C} . \frac{\delta C}{\delta T}$$

$\alpha$ is obtained by the measurement of capacitance under differents temperatures .
The space charge and electric field distributions are calculated from the current by a deconvolution algorithm developped at the Laboratoire d' Electrotechnique de Montpellier. The theory and the numeric treatment (Fourrier series or derivation) have been described in detail in previous papers [6,7,8].

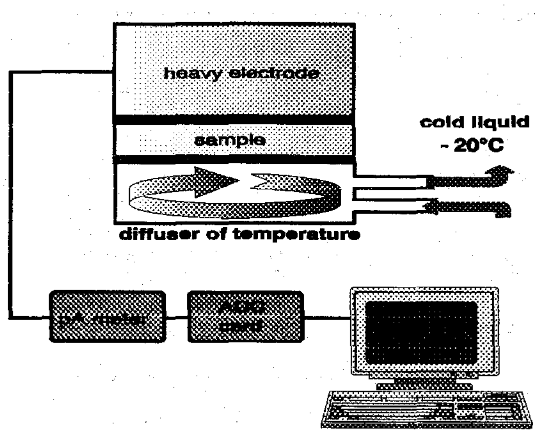


figure 1: Experimental cell