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### Space charge measurements and ageing evaluation in stressed cables

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**Abstract:** The results of space charge measurements carried out on cables and on films cut from the cables are discussed in this paper. The purpose is to investigate the diagnostic features of this innovative and increasingly common technique. Measurements were made on an unaged 400 kV XLPE cable, then on the same kind of cable subjected to long-term prequalification tests for 400 kV and 500 kV levels. Measurements were also performed on films cut from these cables, searching for a support to the results obtained on cables. Variation of quantities associated to space charges did not display the same behavior and extent in cable and films, unaged and long-term stressed, once films were thermally treated. This result suggests caution in carrying out diagnostic evaluation based on the observation of bulk quantities (as space charges) that are sensitive to contaminants which may enter or leave cable with a rate that is function of time, environment and working stress.

**Keywords:** HV cables, diagnosis, ageing evaluation, space charges.

#### 1. Introduction

Space charge measurements is becoming a more and more common technique not only for the observation of accumulated charge and electrical field in insulation, but also to investigate ageing processes (ageing is meant, here, as irreversible worsening of properties associated with capability of insulation to withstand service stresses). It has been shown, indeed, that space charge can promote ageing, through internal field and local electromechanical strain and stress magnification [1-4], but it can also constitute an indicator of insulation degradation [5-7]. The latter aspect is being considered with increasing attention, since space charges can be measured on any size of cable (regarding thickness) and, even (using e.g.

**Résumé** Les résultats de mesures de charges d'espace sur câbles et sur films prélevés des mêmes câbles sont présentées dans cet article. L'objectif est d'évaluer les possibilités de diagnostic de cette technique innovante de plus en plus répandue. Les mesures ont été effectuées sur échantillons de câble PRC 400 kV non vieilli et sur échantillons du même câble soumis aux essais de préqualification pour les niveaux 400 kV et 500 kV. Les mesures ont aussi été effectuées sur des films obtenus des câbles en question, à la recherche de confirmations des résultats obtenus sur câbles. Les variations des quantités associées aux charges d'espace ne présentent pas le même comportement et extension sur câble et sur film, vierges et soumis aux essais électriques, une fois que les films ont été traités thermiquement. Ces résultats suggèrent prudence lors de l'évaluation diagnostique basée sur l'observations des quantités de volume (comme les charges d'espace) qui sont sensibles aux contaminants qui peuvent entrer dans le câble ou le quitter à une vitesse qui dépend du temps, de l'environnement et du stress appliqué.

**Mots clés:** câbles haute tension, diagnostique, évaluation de vieillissement, charges d'espace.

thermal step method [8]), on fairly long cable lengths.

In order to use space charge observation as a tool to evaluate insulation bulk degradation, suitable quantities, i.e. ageing markers, must be extracted from space charge measurements. Recent papers propose as ageing markers charge density, threshold for space charge accumulation and apparent, trap-controlled mobility. The threshold characteristic is obtained plotting the mean (absolute) space charge density, derived from the charge density profiles measured at different poling fields, as a function of poling field: the space charge accumulation threshold coincides with the bent of this characteristics, which separates low field regions at which charge is not accumulated (or it is accumulated below the sensitivity limit of the space