## B.9.5. Facteur de dissipation de câbles PR en vieillissement accéléré

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## B.9.5. Dissipation factor of accelerated aged XLPE power cables

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**Résumé**

Ce papier traite du facteur de pertes diélectriques (tg δ) des câbles MT à isolation PRC soumis à des tests de vieillissement accéléré en milieu humide. Il est montré que ce facteur de dissipation à 50 Hz est souvent corrélé avec la tension de claquage en courant alternatif et avec la longueur des arborescences d'eau. L'augmentation du facteur de dissipation aprés un vieillissement en milieu humide est probablement une conséquence liée à l'accumulation d'ions dans les arborescences d'eau. Donc, les mesures de tg δ pourraient être utilisées pour estimer la dégradation globale générée par les arborescences d'eau, mais ne détecteraient pas toujours le point faible du câble, par exemple une longue arborescence isolée qui, elle, détermine la tension de claquage.

**Abstract**

The paper deals with the dissipation factor (tan δ) of cross-linked polyethylene MV cables subjected to wet accelerated ageing tests. It is shown that the 50 Hz dissipation factor is often correlated with the ac breakdown strength and water tree length. The increased dissipation factor after wet ageing is probably a consequence of accumulation of ions in water trees. Thus, tan δ measurements may be used for estimation of the overall water tree degradation, but will not always detect the weak link of the cable, for example a singular long tree that determines the breakdown strength.

### 1. Introduction

The extent of water tree degradation of XLPE power cables is normally determined by ac breakdown tests and microscopy inspection. A disadvantage is the destructive nature of these techniques. Therefore they cannot be used on power cables in field service. For this reason, a number of non-destructive diagnostic techniques have been proposed [1,2]. One method that is showing promising results involves measurement of the dissipation factor (tan δ) at different frequencies [3]. To further clarify the possibility to use tan δ measurements for this purpose, this paper presents results from accelerated water treeing tests of 24 kV XLPE cables. The tan δ at 50 Hz is compared to breakdown strength, water content and water tree number and length.

### 2. Experimental technique

Three medium-voltage XLPE cables have been subjected to wet accelerated ageing. The 24 kV cables, which are triple-extruded, are described in table I. The insulation thickness is 5.5 mm. They have different insulating and semiconductive materials; both standard and water tree retardant compounds were included in the evaluation.

**Table I.** Tested XLPE power cables.

| Cable | Insulation |
|---|---|
| 1 | Homopolymer |
| 2 | Modified polymer |
| 3 | Modified polymer |

The outer sheathing was removed prior to ageing. Thus, the insulation screen is the outermost layer.

The ageing method is described in table II. Table II shows the evaluated properties.

A second set of specimens from cable I was aged without applied electric stress, otherwise with the same ageing parameters as the other specimens.

### 3. Results

Figures 1 to 5 show the time dependence of the breakdown strength, bow-tie tree density, water tree length, water content and dissipation factor. Included in three graphs are results from the cable 1 aged without electric stress. All reported properties of unaged specimens refer to values obtained after degassing at 80°C for 14 days.

Evidently the wet ageing behaviour of the three cables are very different. In order to elucidate a possible correlation between ac breakdown strength and dissipation factor, these factors are plotted against each other in figure 6.

### 4. Discussion

**AC breakdown strength**

The ageing process of all cables, but in particular cable 1, was found to be rapid when using the selected ageing parameters. The ageing of cable 1 was terminated after eight weeks due to repeated failures between three and eight weeks. The ac breakdown strength decreased from 50 to only 20 kV/mm during this time period. The ageing was much slower in cable 2 and 3: the first failure of cable 3 occurred after 19 weeks, while there were no failures of cable 2 before the ageing was terminated after 26 weeks. Ageing without electric field of cable 1 samples caused a minor but significant reduction.