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Performance development requirements for elastomers of electric power network insulators

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Abstract

The aim of this work was to present some results of the characterization of polymers insulators during their degradation, which are used in transmission threads of 69 kV. The intention was to develop performance requirements for these products.

A comparative study was done among products collected in the experimental field and the new products artificially aged in laboratory, according to the methodologies applied to polymers. Elastomeric silicon and ethylene–propylene diene rubber (EPDM) blankets were also prepared in the same way as the insulating and investigated. Based on the obtained results, it was suggested some performance requirements that may be utilized during the acquisition of these products by the dealership. In this paper, the results that induced the adoption of the performance requirements studied will be presented, in addition to the standards already utilized for product qualification.

Keywords: Polymer degradation; Natural ageing; Accelerated ageing; Polymeric insulators; Performance requirements

1. Introduction

Since their emersion, polymeric products are projected to have a long useful life for application, mainly in specific fields. It is well known the undesirable degradation effect that occurs in elastomeric components in an insulator, as the short-circuit that may cause fault or stop in the transmission net. In this way, knowing the functional and the performance characteristics of the final product is always helpful to optimize their application.

Besides the products certification by the suppliers, there must be some studies that may define the performance of the insulators, based on their degradation characterization in natural and simulated environments tests. So, beyond the functional requirements already requested, this work intends to add a contribution to the standard used, giving the opportunity to the end-users to choose the right material for a particular use, based on the tests of mass or surface properties variations proposed here.

2. Experimental

2.1. Materials

Ethylene–propylene diene rubber (EPDM) insulators of 69 kV, removed from the ground and from the storeroom.

Elastomeric blankets of silicon and EPDM, prepared in the same way as the insulators.

2.2. Characterization

The tests of several types of accelerated ageing are as follows:

Thermal Ageing Test: at 135 °C for insulators; at 100 °C and 120 °C for blankets.
Ageing Test in: water at 30 °C and in salt mist (SM).

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Ageing Photo Test in QUV.
Ageing Test by voltage and more water (disruptive voltage) phenomenon associated with the lack of insulation—NBR 6936.
Natural Ageing Test in several fields.

The measurements or follow-up tests of ageing are as follows:

Surface electric properties, evaluated through volumetric and surface resistivity; surface properties, such as roughness and shore hardness A; traction mechanic properties; Thermal properties, studied by dynamic DSC, isothermal DSC, TGA, and DMTA; physical and chemical properties, investigated by FTIR–ATR; density; leakage current measurement on the insulators; radio-interference tests (Cepel).

2.3. *Equipment used*

Cells (Fanem); Salt Mist Chamber (Bass Equipamentos Ltda, model USC-MP-02/Moderniz 2001); tank with water; QUV Weather Chamber (Comexim); fluorescent light according to ASTM G154, system for the application of unicamp high voltage, peak voltmeter, 64M-type, with digital indicator (Haefely); digital oscilloscope (Tektronix, TDS 520C, 500 MHz, 1 GS/s); multimeter (Fluke 87); 64M-type peak voltmeter with digital indicator (Haefely); high resistance meter (HP 4329A); resistivity cell with tolerance of ±5% (HP 16008A); roughness checker (Taylor–Hobson Surtronic 3); universal test machine for insulators (MTS 810); universal test machine for blankets (Kratos K2000MP) and Tesa micrometer (Isomaster, BRA-74/009-039); Tesa sliding gauge (BRA-74/009-018); infrared spectrophotometer with Fourier transform, with connected InspecIR microscope. Scanning electron microscope, SEM (Jeol, JSM, 5800 LV), with microanalysis module (Noram); Shore A hardness meter; analytical balance (Mettler) and Pycnometer; thermogravimeter analysis equipment, TGA (TA Instruments); differential exploration calorimetry, DSC (910 TA Instruments); dynamic mechanic thermal analysis, DMTA (Rheometric).

3. Results

The roughness results (Table 1), hardness Shore A (Table 2), traction tests (Table 3), are presented next.

The same ageing tests and the same type of follow-up regarding the roughness were performed on the EPDM and silicon blankets. A tendency for a minor difference between minimum and maximum roughness was observed, for the side that was identified with more roughness for the insulators, compared to the EPDM blankets; on the other hand, for the side identified with less roughness, it tended to increase the value in comparison with the others, which were manufactured under similar conditions as the insulator sleeves. Samples 1–7 present higher values, that is, the ageing in field and the ageing in water were more aggressive than the others, regarding the surface roughness property.

Table 2 displays the results of the variations in Shore A hardness, explaining the actions for the EPDM and silicon blankets and insulators.

In Table 4 displays the results obtained in the traction tests, with a speed of 53 mm/min, on new silicon samples ($t = 0$), and the different artificial ageing

The results of the variations on resistance to traction up to 20% and with a maximum ratio of lengthening up to 40% may be considered as acceptable, i.e., the products of the samples after the ageing, which maintain the variation ratio within this range, may be accepted as applicable on the field, keeping the function and a good performance. The same is applicable for the EPDM blankets, i.e., all variations in the

Table 1
Values found in the roughness measurements (μM) for EPDM insulators on both sides, identified with more and less roughness

EPDM insulators	Side with more roughness minimum roughness (μm)	Side with more roughness maximum roughness (μm)	Side with less roughness minimum roughness (μm)	Side with less roughness maximum roughness (μm)
1 (Field)	0.9	1.3	2.6	4.9
2 (QUV)	0.5	0.8	0.5	0.7
3 (120 °C)	0.4	0.9	0.4	0.8
4 (New)	0.4	0.9	0.4	0.8
5 (Sm)	0.5	0.9	0.3	0.7
7 (Water)	0.7	0.9	0.7	1.7

Table 2
Results of Shore A hardness for EPDM and silicon blankets

Blankets	EPDM ($T = 0$)	EPDM salt mist	EPDM QUV	EPDM after 100 °C
Hardness (Shore A)	73.6 ± 0.6	77.0 ± 0.2	77.4 ± 0.6	77.6 ± 0.6
Variation (%)	–	+4	+4	+5
	Silicon ($T = 0$)	Silicon and salt mist	Silicon and QUV	Silicon after 100 °C
Hardness (Shore A)	78.4 ± 0.6	80.6 ± 0.6	82.0 ± 0.7	84.2 ± 1.3
Variation (%)	–	+3	+5	+8