Study of XLPE dielectric properties for HVDC cables during combined thermal and electrical ageing test

Aurélien **HASCOAT**, Jérôme **CASTELLON**, Serge **AGNEL;** IES, Université Montpellier 2, France,
aurelien.hascoat@ies.univ-montp2.fr, jerome.castellon@ies.univ-montp2.fr, serge.agnel@ies.univ-montp2.fr

Wilfried **FRELIN**, Philippe **EGROT;** EDF R&D, Les Renardières, Ecuelles, France,
wilfried.frelin@edf.fr, philippe.egrot@edf.fr

Soraya **AMMI**, Pierre **HONDAA;** RTE, Paris La Défense, France,
soraya.ammi@rte-france.com, pierre.hondaa@rte-france.com

Dominique **LE ROUX**, Johan **ANDERSSON**, Virginie **ERIKSSON;** BOREALIS, Stenungsund, Sweden,
dominique.leroux@borealisgroup.com, carljohan.andersson@borealisgroup.com, virginie.eriksson@borealisgroup.com

ABSTRACT

This work investigates the evolution of dielectric properties of XLPE, used as insulation in HVDC cables, submitted to electrical and thermal ageing test. The aim is to improve the knowledge about the XLPE ageing under DC conditions.

This study is carried out on Rogowski samples, made of XLPE insulation with semi conductive electrodes, aged at 70, 80 and 90°C under an electrical field of 30 and 60 kV/mm.

Dielectric loss factor, electrical resistivity and space charge accumulation have been measured in order to detect a possible evolution of the dielectric properties related to the combined thermal and electrical ageing test.

KEYWORDS

HVDC, cables, XLPE, ageing test, electrical resistivity, dielectric loss factor, space charge

INTRODUCTION

The development of High Voltage Direct Current (HVDC) cables have to be designed according to specific criteria and with materials with appropriate properties. The operational experience of extruded HVDC cables was started some 15 years ago and is steadily growing. The electrical properties of the cross-linked polyethylene (XLPE) have been widely studied under AC stress, however the behaviour of these materials under high DC stress is less known and needs thorough investigation.

To be requested by utilities and TSO, XLPE insulation operates under HVDC should be better known in terms of behaviour, lifetime and performances. A better knowledge of HVDC insulation could allow manufacturers, utilities and TSO to propose more relevant qualification process and to ensure that cable systems will remain safe and operational during their whole life duration. It is well known that, during DC conditions, the electric field distribution is highly dependent on operating conditions (thermal gradient and electric field) and can be affected by electric charges trapped in the insulation [1-2].

In order to identify ageing processes, XLPE samples have been subjected to electrical and thermal ageing test. This work investigates the evolution of the electrical state of the XLPE during this ageing test. Thus, different parameters have been monitored to identify an evolution of the dielectric properties related to possible ageing processes: electrical resistivity, dielectric loss factor and space charge accumulation. The space charge accumulation is investigated in depth in order to consider the true electric field to which the insulation is submitted.

SAMPLE PREPARATION

Rogowski samples (Fig. 1) have been made using a conventional HVDC XLPE material qualified for voltage up to 320 kV. The insulation material is first compression moulded at 120°C in order to form the Rogowski shape. Thereafter, thin semi-conductive plaques are added on both side of the insulation shape and all layers are cross-linked together at 180°C. Finally, samples are conditioned during 72 hours at 70°C.

The dimensions of the active area are 50 mm in diameter with insulation thickness of 0.5 mm or 1 mm.

Fig. 1: XLPE sample with semi-conductive electrodes.

AGEING TEST SET-UP

The ageing test of the samples was performed in an oven at 70, 80 and 90°C under normal atmospheric conditions and submitted to the following respective electric field stress: 30 and 60 kV/mm, during 14 months (442 days). For each temperature, an oven has been used to test 20 samples (10 having 0.5 mm insulation thickness and 10 having 1 mm insulation thickness – see Fig. 2). A high voltage DC power supply was connected to each oven in order to apply 30 kV to the samples. Consequently, 0.5 and 1 mm samples have been submitted respectively to 60 and 30 kV/mm.

Fig. 2: Ageing test set-up with 0.5 mm samples (up) and 1 mm samples (down).