A Physical Model to predict the Impact of Defects on the Breakdown of XLPE under HVDC Thermoelectrical Stress

Julien **FERNANDEZ,** Raphaël **GUFFOND,** Siwar **MHABRECH,** Lisa **CONVERT,** Nexans Ampacity, (France), julien.fernandez@nexans.com, raphael.guffond@nexans.com

Quentin **EYSSAUTIER**, Nexans Norway AS, (Norway), quentin.eyssautier@nexans.com

☐ **Young Researcher** (Proved full-time engineering and science university researchers and Ph.D.students under 35 YO)

ABSTRACT

In the actual context of energy transition and electrification, the need for reliable power cables for electricity transport is of key interest. This work aims to study the impact of contaminants produced in Cross-Linked Polyethylene (XLPE) extruded cables on their performance for High-Voltage Direct Current (HVDC) distribution. The breakdown strength of XLPE samples with and without oxidized XLPE particles is measured on plate samples and compared. In parallel, a breakdown prediction model based on the calculation of insulation local properties evolution under a voltage ramp and temperature in an XLPE material is used to predict dielectric strength with and without defects. Experimental and numerical results are compared and discussed.

KEYWORDS

HVDC; XLPE; protrusions; oxidized contaminants; breakdown; modelling.

INTRODUCTION

More than ever nowadays, the global increase of energy demand and the electrification of our society leads to the need of efficient ways to produce and transport this energy. HVDC XLPE power cables are of high interest to answer this energy demand, however it still rises numerous questions and obstacles [1] [2]. One main challenge is to control at microscopic level the presence of defects present in the insulation system, which may reduce cable lifetime [2] [3]. Their impact has been extensively discussed in the literature, and their nature is also well identified, as represented in Figure 1. As shown in this figure, most common encountered defects can be physical (inorganic contaminants, protrusions, voids) and chemical (water, organic contaminants and molecular by-products,). Their influence on the performance of the insulation has been studied under several different conditions [4] [5] [6] [7] [8]. Though their impact under DC stress remains to be clarified. It is believed that in terms of damage inception, without taking into account the presence of chemical species, the field distribution as well as local variation can have a strong influence on the other properties of the material, such as charge injection, conductivity, or space charge accumulation [9]. The presence of these defects can have a detrimental effect on the electrical field distribution. Thus it is of high interest to define acceptance criteria for the presence of such irregularities in power cables. In a previous work, the effect of semicon protrusions on XLPE plates has been studied and modelled using a developed physical bipolar charge transport model for breakdown prediction [10]. In this study, the focus has been made on the effect of organic contaminants, more specifically oxidized XLPE particles, which can arise in power cables due to for instance early oxidation of the insulation during long extrusion run. Their experimental replication and effects on dielectric strength and the modelling of the impact on insulation properties have been analysed.

MATERIALS AND METHODS

Materials and Samples Preparation

Test samples are XLPE plates prepared by compression molding, a batch of them including oxidized particles of the same material. First, XLPE films of 0.1 mm in thickness are aged in a forced convection oven at 150°C during increasing oxidation time representative of extrusion run duration, from “low” to “high” odixation. The films are then crushed in order to obtain fine particles out of them. They are dispersed in the center between two LDPE pressed plates of 0.4 mm thickness. The whole preparation is crosslinked together to form one single XLPE plate of 0.8 mm thickness. Reference samples without particles inclusion were also made. All samples are finally degassed

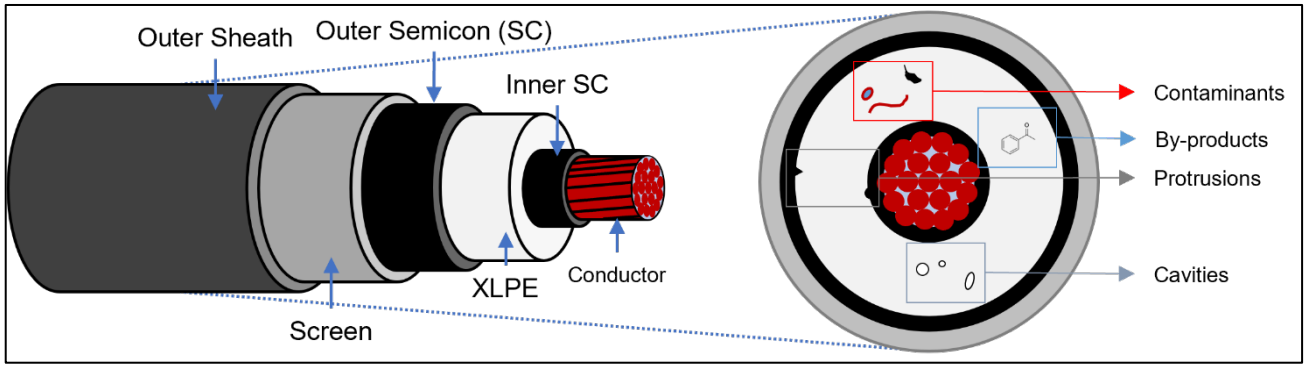

Figure 1: Scheme of a HV cable and the different insulating and conductive layers (left), and zoom-in some frequently encountered physical and chemical defects in HV cable insulation (right).