Follow up of space charge distributions in HVDC cable during a Pre-Qualification test using the Pulse ElectroAcoustic technique and the Thermal Step Method

Ludovic **BOYER**; SuperGrid Institute, (Villeurbanne, France), ludovic.boyer@supergrid-institute.com
Pierre **MIREBEAU**; Nexans, (Calais, France), pierre.mirebeau@nexans.com
Konstantin **VERSHNIN;** General Electric, (Stafford, United Kingdom), konstantin.vershinin@ge.com
Antonios **TZIMAS;** General Electric, (Stafford, United Kingdom), currently at Advance Energy
Jérôme **CASTELLON,** Petru **NOTINGHER**; Université de Montpellier/CNRS, (Montpellier, France), jerome.castellon@umontpellier.fr, petru.notingher@umontpellier.fr

ABSTRACT

In order to better understand the evolution of space charge and electric field distortions during the application of electro-thermal stresses to a HVDC cable system, the present paper presents the follow up of periodic space charge characterizations on a HVDC cable during part of a Pre-Qualification test using both the Pulse ElectroAcoustic technique and the Thermal Step Method. The focus is on the evolution of space charge distributions during the first two load cycles and high load sequences according to the Cigré TB496 recommendation.

KEYWORDS

HVDC cables, Space charge, Monitoring, PEA, TSM

INTRODUCTION

Extruded HVDC cables present several advantages over DC mass impregnated cables. For instance, they have higher operating temperatures.

The qualification process of an extruded HVDC cable is usually done according to the Cigré TB496 recommendation [1], with accelerated electrical ageing tests phases representative of 40 years of operational life.

The HVDC cable insulation must then be designed to minimize the effects of electric stresses during different loading regimes for such qualification tests and, more importantly, when operated.

It thus appears to be important to study the evolution of the electrical state of HVDC extruded cables when submitted to accelerated ageing programs.

GE Grid solutions has built a HVDC cable ageing facility to evaluate the space charge dynamic of 200 kV rated cables subjected to a Pre-Qualification test. The tested cable presented in the current paper on which space charge measurements using both the Pulse ElectroAcoustic technique and the Thermal Step Method were performed has been provided by Nexans.

The focus of this paper is on the evolution of space charge distributions during the first two load cycles and high load sequences.

SETUP AND TEST PROTOCOL

Test object

The test object is a 200 kVdc cable system. It is composed of a 42 m long voltage loop and a 12 m long thermal image loop. The cable dielectric is made of pure XLPE and has a thickness of 18 mm. Two pre-molded joints with outer semiconducting screen breaks are also mounted on the voltage loop. They electrically isolate the different probes used for space charge measurements to mitigate the mutual electrical disturbances during the characterizations.

A picture of the cable installation used for the experiment is shown in Figure 12 at the end of the paper.

The outer sheath temperature of both the voltage and thermal image loops is controlled by water pipes in order to maintain the thermal gradient in the cable dielectric below 20 K.

Test protocol

The ageing was done at General Electric Grid Solution's Cable Ageing Facility. It follows the Cigré TB496 Pre-Qualification stressing protocol [1]. The duration of the test was 360 days at a stress voltage of 290 kV, representing 1.45 times the cable nominal voltage. The test was divided into several sequences between which the voltage polarity was reversed and the thermal sequences changed. The different stressing sequences are shown in Table 1.

Table 1: Test sequences applied to the studied sample.

LC1	LC2	HL1	HL2	ZL	LC3	LC4
40 days	40 days	40 days	40 days	120 days	40 days	40 days
+	-	+	-	-	+	-
290 kV						

The different thermal sequences are:

- Load Cycles (LC): The cable conductor temperature is cycled over 24 hours, with a first warm up phase from 33°C to 52°C during 4 hours before being kept in isothermal condition. Then the conductor is warmed up again from 52°C to 70°C during the following 4 hours in order to apply the thermal gradient condition. The cable is naturally cooled down to 33°C during the remaining 16 hours. As an illustration, the voltage loop temperature profile during a load cycle is given in Figure 1.
- High Loads (HL): The cable conductor temperature is held continuously at 70 °C.
- Zero Load (ZL): The cable conductor temperature