B.9.4. Investigations sur des isolations PRC après un essai de vieillissement sous fort champ

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B.9.4. Investigation of XLPE insulations after high stress ageing

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Résumé

Les câbles 400 kV isolés au PRC sont utilisés à des gradients autour de 15 kV/mm. Il y a 10 ans encore, il y avait des doutes sur l'application possible de si hautes contraintes parce qu'on craignait un vieillissement électrique prématuré. Ce problème a été étudié à l'aide d'un câble HT ayant une épaisseur d'isolation permettant de réaliser des essais de claquage avant et après plusieurs années sous une contrainte de 16 kV/mm, avec cycles thermiques. Différentes conceptions de gaines et l'influence du SF_6 sur le système d'isolation ont également été pris en compte pour les essais.

Abstract

XLPE insulated 400 kV cables operate with stresses around 15 kV/mm. Ten years ago there were doubts about such high stresses due to the fear that premature electrical ageing might occur. This problem has been studied by means of a HV cable with a wall thickness permitting breakdown tests before and after operation at 16 kV/mm with thermal cycles over some years. Different sheath designs and the influence of SF_6 gas on the insulation system were tested as well.

1 Introduction

At the end of the 1980s, discussions took place whether stresses greater than 15 kV/mm at the conductor of XLPE cables should be permitted. It was an item for discussion at a HV workshop held at the first Jicable conference in 1987 [1]. Since that time, many systems for voltages 400 kV and 500 kV with stresses around 15 kV/mm were put into operation worldwide. Numerous development and qualification tests have demonstrated that a reasonable life time can be expected. One problem in testing 400 kV cables is that AC breakdown tests before and after operation are not possible due to practical limitations. So we set ourselves the task of operating a trial cable length as a model of a 400 kV cable for a period of several years, followed by breakdown tests to determine any signs of electrical ageing. The use of different protection systems should contribute to answer the question whether an aluminum laminated moisture barrier is sufficient to prevent the diffusion of water compared to a corrugated copper sheath.

The cable with a corrugated sheath offered the opportunity to study the influence of pressurized SF_6 gas on AC breakdown strength and ageing. The positive effect of SF_6 was attributed in the literature published in the 1980s to the suppression of partial discharges inside microvoids and to the trapping of electrons.

Finally, we intended to study the question whether high AC prestressing has any detrimental effect on the insulation. For some time, there has been an ongoing discussion that routine tests at stresses higher than 27 kV/mm could cause such deterioration.

2 Cable Design

A copper conductor cross-section of 400 mm^2 and an XLPE insulation wall thickness of 11 mm were selected. This gives at the long-term test voltage of 135 kV a stress of 16 kV/mm which lies in the upper range for 400 kV cables.

The core was manufactured in 1989 on a catenary CV line using a double-tandem extruder arrangement, dry nitrogen curing and water cooling. One half of the cable used a longitudinally water tight copper wire screen and an Al/MDPE laminated sheath and the other half used a copper corrugated sheath with a MDPE covering over sheath. The conductor of the latter cable was filled with SF_6 gas under a pressure of 3 bar.

3 Test Installation and System Operation

The long-term tests were performed like previous tests [2] in a solidly grounded 220 kV three-phase network under normal operating conditions. A cable loop of 220 m length was connected to one phase of a 220 kV busbar via a switch panel with circuit breaker and the necessary protective devices (Fig. 1). This busbar was fed directly from the power station. The system was designed for a BIL of 1050 kV.

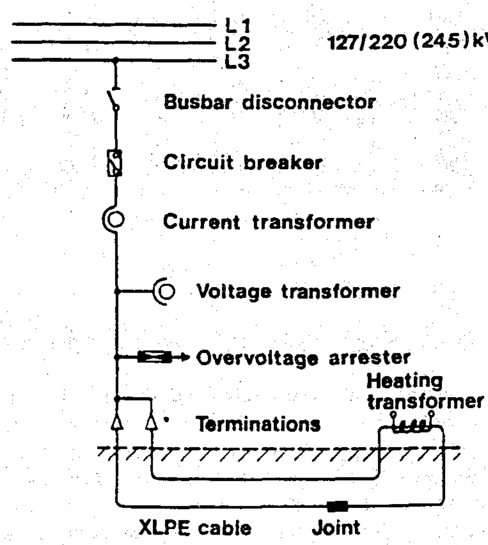

Fig. 1: Block Diagram for Cable System

The cable loop was connected via 220 kV terminations (porcelain insulators filled with SF_6, EPR stress cones). The cables with the laminated sheath and the copper sheath, each 110 m long, were connected by a SF_6-filled joint with a back-to-back stress cone arrangement. The cables were laid directly in the ground at a depth of 1 m and with a cable spacing of 7 cm.