A4.1

Thermomechanical modeling of 345 kV XLPE cables in duct

TARNOWSKI J., IORDANESCU M., AWARD R., ROYER C., Hydro-Québec (IREQ), Québec, Canada

Résumé

Cet article porte sur la modélisation thermomécanique des câbles 345 kV à isolation extrudée de trois différents manufacturiers internationaux. Ces trois câbles ont subi des essais électriques et thermomécaniques de longue durée sur le site d'essai d'Hydro-Québec. Au cours de ces essais, les efforts dans les appuis et les déplacements des câbles dans les chambres de jonction engendrés par le cyclage thermique ont été mesurés. Les valeurs mesurées ont servi par la suite à la validation des modèles aux éléments finis, développés pour les câbles en essais. Bien que l'écart entre les efforts mesurés et calculés dans les appuis a été parfois important en terme de grandeurs absolues, leurs valeurs ne dépassent généralement pas 35% des efforts internes du câble.

Abstract

This paper deals with the thermomechanical modeling of 345-kV extruded cables from three different international manufacturers. The cables were subjected to electrical and thermomechanical long-term tests at Hydro-Québec's test site. The tests involved measuring the stresses in the supports and the cable displacement inside the joint manholes caused by thermal cycling. These results were then used to validate the finite-element models developed for the cables under test. Though the discrepancy between the stresses that were measured and those calculated in the supports was at times considerable in terms of absolute values, these generally did not exceed 35% of the cable's internal thrust.

Introduction

The heating and cooling cycles generated by the fluctuation in energy consumption cause the cables to move and expand recurrently. This cyclic expansion results in the mechanical loads, developed in the cable and the clamps. It is important to quantify these loads when designing underground lines to ensure that they do not exceed the limits of the resistance of the accessories and the endurance of the materials of the various cable components, especially the metallic sheath. The experimental approach, when considered alone, has major drawbacks in the form of a high cost and the difficulty in generalizing the test results. Analytical modeling is an efficient and versatile tool provided that it can be validated with a test installation. The primary aim of this study is thus to develop and validate models of the thermomechanical behaviour for 345-kV extruded cables based on the finite-element method. The models and their validation involve three cables of different international manufacturers. These cables successfully passed long-duration electrical and thermomechanical tests at IREQ's test site [1].

Modeled systems

The main specifications of the 345-kV cables, installed on three test loops at Hydro-Québec's research institute in Varennes, are listed in Table 1.

In addition to the cables under study, the three experimental installations are very similar and can therefore be represented using a single diagram (Fig. 1). Each complete test loop is about 165 m long and includes:

- two outdoor terminations;
- a manhole for the entry and exit of the overhead-underground section of the cable;
- current transformers;
- a joint manhole in which a premoulded (or pre-fabricated) joint was made;
- SF_6 terminations.

Three typical parts can be identified on the above installation, i.e. part AB between the outdoor termination and the joint in the joint manhole, part BC between this joint and the SF_6 termination, and part CD between the SF_6 termination and the other outdoor termination. Considering that the cable sections on each part are blocked at their ends, the parts in question become virtually independent from the perspective of thermomechanical behaviour. Analytical modeling is limited to part AB of the route, which consists of sections that typify the thermomechanical behaviour of cables, i.e.:

- overhead-underground section;
- section of the cable in duct;
- section of the cable in the joint manhole, formed into an expansion loop.