

**D.2.13. Optimisation des boucles de dilatation des câbles 120 kV PR**TARNOWSKI J., IORDANESCU M.,
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Canada**D.2.13. Optimization of expansion loops of 120 kV XPLE cables**TARNOWSKI J., IORDANESCU M.,
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CanadaRésumé

Cet article porte sur une étude complète, qui fait appel à des notions théoriques et de bonnes données expérimentales, visant à optimiser l'arrangement des câbles 120 kV PR dans les chambres de jonction. L'optimisation consiste à prescrire la géométrie d'une boucle de dilatation, logeant dans une chambre de jonction de dimensions normales, de manière à minimiser les déformations unitaires de la gaine du câble. Pour répondre à cette problématique, un modèle aux éléments finis a été employé pour étudier le comportement thermomécanique des câbles en conduit. En vue d'alimenter les modèles analytiques avec des paramètres fiables et réalistes, des montages spéciaux et inédits ont été réalisés en laboratoire pour les essais de caractérisation mécanique du câble.

Abstract

This paper describes an in depth-study aimed at optimizing 120-kV XLPE cable junctions in manholes. The objective of optimization is to minimize the strain in the cable sheath by prescribing the initial geometry of the expansion loop for a normal-size manhole. A finite-element model was used to describe the thermomechanical behavior of cables in duct. In order to provide reliable and realistic parameter values to the analytical model, test installations were designed in laboratory for measuring the mechanical characteristics of this cable. The tests showed significant differences between the experimental data and that reported in the literature.

Introduction

Cables with extruded synthetic insulation are more and more commonly used on Hydro-Québec's underground high-voltage system. Contrary to standard practice in Europe and elsewhere in North America, these cables are installed in individual ducts for each phase. The major drawback of this practice is that the cables are free to move within the confinement of the ducts and at the manholes.

The heating and cooling cycles generated by the fluctuation in energy consumption cause the cables to move and expand recurrently. The size of a manhole is mainly determined by the global thermal expansion of the cable, but economic and practical reasons dictate the dimensioning of manholes as small as possible because of the congested underground space in city centres. On the other hand, a rupture in the metal sheath can occur, with consequent water infiltration in the insulation and possible water treeing, if a manhole is under-dimensioned. Fatigue stress develops from the multiple expansion and contraction cycles of the cable, representing the main cause of structural failure in cables. The seriousness of the

problem, and the risk of failure that it entails, increase as the cable is operated close to its maximum capacity.

A satisfactory service life can only be guaranteed by properly dimensioning the size of manholes and properly laying out the cables inside them. When designing underground lines, it is important to evaluate the cyclical loads so as not to exceed the fatigue strength limit of the various cable components, particularly the metal sheath. To this effect, experimental testing of a particular line presents a serious drawback in its lack of generalization of the test results for other line configurations, whereas analytical modeling provides a reliable and versatile tool, once it is validated against results from test installations.

Thermomechanical model

The thermomechanical behavior of cables in ducts was modeled and analyzed using finite elements. The finite element model considers a cable confined into the duct composed of rectilinear segments and circular elbows, between manholes. In the manholes, the cable can be either connected to an expansion loop or anchored down firmly. A thermomechanical study of cables with the ends