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Research and development of DC XLPE cable and associated factory joint

TERASHIMA K., ASANO M., Electric Power Development Co. Ltd., Tokyo, Japan
WATANABE K, YOSHIDA M., KON H., Fujikura Ltd., Chiba, Japan

Résumé

D'abord, le profil de la charge d'espace a été mesuré en utilisant des câbles modèles isolés avec le XLPE à remplissage inorganique amélioré (SXL-A). Les résultats ont montré que le SXL-A pouvait suffisamment supprimer la charge d'espace sous tension C.C.
Ensuite, des câbles SXL-A C.C. 500 kV grandeur nature avec isolant de 23 mm d'épaisseur et joints d'atelier associés ont été fabriqués et un essai de performance électrique initiale effectué. Cette performance s'est avérée suffisante pour les exigences du câble XLPE C.C. 500 kV.

Abstract

As a first step, the space charge profiles were measured using model cables insulated with an improved inorganic filler-added XLPE (SXL-A). Results showed that SXL-A could sufficiently suppress space charge under DC voltage.
Accordingly, full-size 500 kV DC SXL-A cables with an insulation thickness of 23 mm and associated factory joints were manufactured and initial electrical performance test were carried out. It was confirmed that they had sufficient initial electrical performance to satisfy the requirements for 500 kV DC XLPE cable.

1. INTRODUCTION

XLPE cables have not yet been used for DC transmission. This is because they have problems which are specific to DC insulation characteristics such as space charge.[1]

Based on reports that the addition of a conductive inorganic filler to the XLPE insulation provides an effective means of suppressing such space charges,[2,3] We are developing a new type of DC cable insulated by an XLPE compound containing such a filler. It has already been confirmed that ± 250 kV DC XLPE cable and their factory joints, have fully satisfactory initial characteristics, and long-term verification tests have been successfully completed.[4]

The insulation design method adopted for ±250 kV DC XLPE cables uses as the design stress an average electric field strength in the cable insulation, in the same way as for conventional AC XLPE cables.[4] On the other hand, internal electric field distribution is distorted by the space charge accumulated under DC voltage, and a new design method is therefore proposed whereby the insulation thickness of the cable is designed in due consideration of space charge influence.[5]

In this paper, we have therefore evaluated the electric field strength occurring under DC voltage by measuring the space charges, and have used the results to make a reasonable estimation of the electrical electrical strength in a full-sized 500 kV DC XLPE cable as a means of determining the insulation thickness required.

The prototype full-size cable based on this design have been manufactured and subjected to electrical tests. Work on the development of factory joints (essential in long-distance submarine cables) and on the manufacture and electrical evaluation of the prototype cables and factory joints is also reported.

2. CABLE DEVELOPMENT

(1) XLPE Insulation with Inorganic Filler

Having confirmed that the addition of a conductive inorganic filler to the XLPE insulation is an effective means of suppressing the built-up of space charges, we have worked on developing a new type of cable insulated with such a material, designated XL-A.

Although the mechanism by which DC properties are improved is still not completely understood, it may well be the case that the sources of space charges are acetophenone and ionic trace impurities, in which case their removal should suppress charge formation.

It is possible, on the other hand, that an inorganic filler could act as an adsorbent, trapping the impurities in microvoids of molecular size in the