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A.1.2. Extension des câbles à isolation polyéthylène réticulé au niveau 500 kV sur la base des progrès techniques atteints

PESCHKE E., SCHROTH R., OLSHAUSEN R., SIEMENS AG., Berlin, Allemagne

A.1.2. Extension of XLPE cables to 500 kV based on progress in technology

PESCHKE E., SCHROTH R., OLSHAUSEN R., SIEMENS AG., Berlin, Germany

Résumé

L'évaluation des résultats d'essais récemment obtenus sur des câbles HT isolés au PR a permis de réaliser, au niveau de 500 kV, la même épaisseur d'isolant qu'avec 400 kV il y a quelques ans. Cela a été rendu possible grâce aux progrès achevés dans le domaine des matières premières et des techniques de fabrication ayant mené à des caractéristiques électriques plus homogènes. Cela est vrai surtout pour la tenue au claquage pendant des essais aux ondes de choc et à tension alternative. On a constaté que la limite inférieure de la rigidité diélectrique (choc) était nettement plus élevée, et l'évaluation des essais récents de longue durée sous tension alternative justifie la conclusion que, à condition d'absence d'eau, le vieillissement est pratiquement nul. Des câbles 500 kV ayant une épaisseur d'isolant de 30 mm, ce qui correspond à un gradient maximum de 15,5 kV/mm, ont été soumis à premières essais de type, et ils satisfont à toutes les exigences publiées ou spécifiées dans quelques normes nationales.

Abstract

The evaluation of latest test results on XLPE high voltage cables leads to the same insulation thickness for 500 kV as it did a few years ago for 400 kV. The reason is given by progresses in material and production technologies resulting in more even electrical properties of the present cables as compared to the former ones. This holds true above all for the breakdown behaviour under impulse and under ac test conditions. There has been noticed a marked increase of the lower breakdown strength limit (impulse), and the evaluation of recent long term tests at ac voltage and load cycles justifies the conclusion that there seems to be no electrical ageing, provided that water is excluded. 500 kV cables with an insulation thickness of 30 mm corresponding to a maximum operating gradient of 15.5 kV/mm have been successfully subjected to first type tests, and they fulfill any safety requirements as published in the literature or specified by some national standards.

Introduction

In spite of worldwide intensive research and development activities, up to now the only service experience with XLPE-insulated power cables for the rated voltage 500 kV is based on a few short links without joints [1]. Larger systems with joints have not yet been installed to commercial networks. There are three main reasons for this fact:

- the necessarily high operating gradients of EHV cables leading to corresponding electrical stresses not only within the cable insulation but also at the interface with the accessories
- the long-term properties of thick-walled XLPE dielectrics under high stress conditions which are not yet cleared up beyond all doubt and
- the lack of appropriate accessories, especially of joints which should easily be assembled and free of maintenance.

The only extended power cable system above 275 kV with solid polymeric dielectrics is operated in France [2]. The insulation of these cables, however, consists of non-crosslinked low density polyethylene (LDPE) which is accepted only by a few utilities due to its limited operating temperature. Therefore most of the manufacturers concentrate on the development of XLPE power cables for 400 to 500 kV.

Due to the lack of international standards each manufacturer can dimension new EHV XLPE cables according to his own philosophy. Only EdF specified the tolerable electric stresses within the insulation of polymeric cables which can be treated as rough criteria concerning the wall thickness of the present French 400 kV LDPE cables [3]. Comparable limits are part of the more general new French Standard C 33-253 (draft) for polymer-insulated cables including XLPE above 150 kV up to 500 kV [4]. In Japan the most important cable manufacturers and big utilities have agreed on common design methods which are applied to all XLPE HV and EHV cables [5].

Some years ago, the authors of the present paper developed a modified design procedure and calculated the wall thickness of prototype XLPE cables for 400 kV based on former test results to be 31 mm [6]. In the meantime many km of HV and EHV XLPE cables have been manufactured and successfully tested, additional research work was carried out increasing the know-how and experience so that today the step to the next voltage level can be performed, i.e. 500 kV.

Calculation of insulation thickness

Procedures and definitions

The thickness of the just-mentioned 400 kV XLPE cables [6] had been calculated by the application of four independent design methods roughly described by the following keywords:

- the mean ac field strength to be withstood for the duration of one hour (method A),
- the average lightning impulse field strength to be resisted (method B),
- the maximum impulse withstand field strength at the conductor (method C),
- the maximally admissible ac field strengths at the inner and outer semiconductive layers and a limited breakdown