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A.5.2. Câble à isolation gazeuse (CIG) triphasé 420 kV isolé à l'azote

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A.5.2. 420 kV three-phase compressed nitrogen insulated cable

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Résumé

Les considérations en matière d'environnement, dans l'aménagement des réseaux de transport d'électricité, rendent de plus en plus intéressantes les perspectives offertes par la mise en place de liaisons souterraines. Pour les très hauts niveaux de tension et les longueurs de plusieurs dizaines de kilomètres, le câble à isolation gazeuse (CIG) apparaît comme une solution mieux adaptée que le câble isolé classique. Proche de la technologie des postes sous enveloppes métalliques, mais entièrement voué à une fonction de transport d'énergie, le CIG que nous présentons est doté de solutions novatrices permettant à la fois une réduction du coût et un accroissement de la fiabilité. Un prédimensionnement complet de ce CIG a été réalisé grâce à l'emploi de moyens de modélisation numérique très performants. Une maquette à l'échelle réelle mais de longueur réduite vient d'être réalisée et se trouve actuellement en essais.

Abstract

Considerations linked with the environment whenever power transmission networks are being installed, mean that the prospects offered by underground transmission lines look increasingly attractive. For very high voltage levels, and distances of several tens of kilometres, compressed gas insulated cables (CGIC) appear to be more suitable than conventional insulated cables. The CGIC we are about to present, whilst closer to the technology used in metal-clad substations yet completely dedicated to the task of power transmission, is endowed with innovative solutions allowing both cost reduction and increased reliability. A complete pre-dimensioning study of this CGIC has been performed using high-performance numerical modelisation methods. A full-scale model, but of reduced length, has just been built and is currently undergoing tests.

Introduction

The development, renovation and installation of electrical transmission networks can no-longer be performed without paying close and constant attention to the environment: whether ensuring its conservation through the respect of natural sites and comfort of inhabitants, or to overcome the obstacles surrounding increasingly urbanized and sprawling consumer zones (big metropolises). These considerations seem to favour a gradual move towards underground transmission networks.

The preferential field of application of gas-insulated cables is that of power transmission for voltages in excess of 245 kV where it is particularly suited to transmission levels in the region of 2 000 MVA or even 3 000MVA, and for distances of up to 100 km.

In this field, cables using solid insulation are no longer suitable. In effect, their strong linear capacitance limits the transmission range to sections of critical length (15 to 20 km for 400 kV), between which reactive power compensation stations have to be implanted. Furthermore, due to its relatively small section, the permissible transmitted power of a 400 kV conventional cable remains limited. Finally, the very high cost per kilometre - about 15 to 20 times that of an equivalent overhead line according to information provided by users - has hindered the development of underground power cable transmission in the High Voltage field.

We are presenting a new CGIC using new techniques of design, production and laying, suitable for long-distance power transmission.

1 - Technical choices

Since the end of the 1960s many SF6-insulated metal-clad substations have been erected all over the world, particularly in the heart of big cities (the RATP substations in the centre of Paris, for example). The compactness of metal-clad equipment has of course considerably improved over the last 25 years, allowing the impact which these substations have on the environment to be significantly reduced. Most of these substations were of the single-phase type (one conductor per enclosure) until, at the beginning of the 1980s, three-phase equipment began to appear (three conductors in a common metal enclosure), further reducing the space taken up by these substations.

Gas-insulated cables are a direct off-shoot from metal-clad substation technology. Two types of design can be envisaged: a single-phase structure or a three-phase structure.

1.1. Comparison of single- and three-phase techniques

Single-phase structures have already been tested by major switchgear manufacturers the world over: we have the example of an industrially manufactured SF6-insulated CGIC in Chinon (built for EdF, FRANCE), or Claireville (for Ontario Hydro, CANADA). It should, however, be noted that there are already three-phase busbars in Japan for voltages up to 550 kV.

With a three-phase structure, the risk of perforation if an internal arc occurs in the CGIC is practically non-existent. In effect, a single-phase fault between one of the phases and the earthed enclosure systematically degenerates into a three-phase fault after a few tens ofmilliseconds, leaving just a very small current of a few hundred amperes between the enclosure and the conductor. The thickness of the outside enclosure can therefore be reduced to that required to withstand pressure.

For the same transmitted power, the power dissipated in the case of a three-phase structure is lower. For the single-phase cable, a return current equivalent to the rated current is found in each enclosure, whereas for three-phase cables there is no return current.

With buried cables, it is necessary to dig a trench approximately 2 metres wide to accommodate three-phase CGICs, and of course much wider for single-phase CGICs, due to the distances between the 3 phases required to correctly evacuate heat.

Consequently, the cost price of three-phase CGICs is a lot lower than for single-phase CGICs transmitting the same power. A single-phase CGIC requires three times as many monitoring elements, enclosures and welding as a three-phase CGIC.