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### 400 kV cables for bulk power transmission systems

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#### Abstract

400 kV underground solutions, using synthetic cables, were optimised for bulk power transmission, over distances up to about twenty kilometres.

Long duration tests were carried out, as the final step of a several years long Research-Development program decided within the framework of a protocol signed with the French government to get underground 400 kV solutions available if the need arises.

The report presents the main features of this program and the solutions which have been selected on the basis of technical, economic and environmental criteria.

**Keywords** : underground link, tests.

#### 1 . Underground solutions.

From the economic analysis of possible underground solutions, which could be installed within the route of future double circuit 400 kV bulk power transmission lines, the conclusion was drawn that 4 feeders are generally necessary, each one being designed for a transmission capacity of about 1000 MVA in continuous operation.

To decrease the investment costs of underground solutions, new technologies have been developed.

Large cross-section copper conductors (up to 2500 mm<sup>2</sup>) are designed in order to reduce the skin effect losses.

The XLPE insulation, with operating temperatures of 90 °C in steady-state conditions and 100 °C in overload, is sized for inner and outer electrical stresses of about 13 and 7 kV/mm respectively.

Lead-free metallic screens were tested, the radial water-tightness being obtained with an aluminium foil longitudinally welded and bonded to the polyethylene outer sheath.

#### Résumé

Des solutions souterraines 400 kV, utilisant des câbles à isolation synthétique, ont été optimisées pour le transport de fortes puissances, sur des distances pouvant atteindre la vingtaine de kilomètres.

Des essais de longue durée ont été réalisés, étape ultime d'un programme de Recherche-Développement de plusieurs années décidé dans le cadre d'un protocole avec l'Etat Français pour disposer le cas échéant de solutions souterraines 400 kV.

Cet article présente les différents aspects de ce programme et les solutions qui ont été sélectionnées sur la base de critères techniques, économiques et environnementaux.

**Mots clés** : liaison souterraine, essais.

For accessories, technologies based on prefabrication are generalised.

Taking into account environmental impact, appreciated throughout the space requirement of the jobsite, the backfill volume, the progression speed, the average length of the approach trench, two preferential laying conditions were selected : laying in controlled backfills or in ducts.

#### 2 - Optimised conductors.

When optimising a conductor, several concerns have to be considered such as the ease of construction of the core itself (compacting, surface aspect, stranding type, possible insulations) but also of connections in accessories, or the thermomechanical behaviour (namely characterised by Young's modulus) that should be taken into account when defining the installation of the connecting equipments

But, of course, the fundamental parameter within the optimisation of conductors stays the a.c. resistance, linked to the amount of losses due to skin and proximity effects, strongly depending on the layout of the cores (cross-section of the strands, number of sectors for the segmentation, insulation between