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400 kV underground links for bulk power transmission

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This report presents the main developments which were conducted in France to get a significant reduction on the cost of EHV underground links.

400 kV underground solutions, optimized for bulk power transmission, which are now available, are the result of changes in the technology of cables and accessories, and also modifications to their installation, taking into account environmental issues, and operation conditions.

Large cross-sections copper conductors (up to 2500 mm^2) are designed in order to reduce the skin effect losses: the performances of various possible constructions have been assessed through direct measurements of the a.c. resistance.

XLPE insulation is designed for maximum inner and outer electrical stresses of 16 kV/mm and 7 kV/mm, respectively, and working temperatures of 90 °C in steady-state operation and 100 °C in emergency conditions.

Two lead free technologies were developed for the metallic screen.

An aluminium foil longitudinally welded and bonded to the polyethylene oversheath ensures the radial water-tightness of the cable.

A first technology combines a layer of aluminium or copper wires placed under the aluminium foil about 500 µm thick ; the second one uses a thicker non corrugated foil, sized as a function of the short-circuit current to be evacuated.

The performances of these solutions were checked, mainly through mechanical and corrosion tests.

For accessories, technologies based on prefabrication are generalized and composite terminations were tested.

Attention was paid to installation conditions, to allow for cables working at their maximum permissible temperature without risk of thermal runaway, to reduce environmental impact during construction work and to secure third parties and the public in case of breakdown.

Some link design rules were reconsidered; for instance, using ZnO non linear resistors with a rated voltage of 15 kV, to protect equipments against overvoltages during transients, enables, in specially bonded links, elementary section lengths longer than 1 kilometer.

Many tests were performed, both on cable components and on complete systems (dielectric withstand tests, short-circuit test, spike test..). As a final step of the development, a long duration test was carried out on 200 m loops of cables,, installed partly in a special backfill and partly in ducts, and including 2 outdoor terminations, 2 back-to-back metal-clad terminations and at least 2 joints. A voltage corresponding to 1.7 times the nominal voltage was applied during at least 6000 h and 250 thermal cycles (8h heating – 16 h cooling) up to 100 °C were carried out.