Worldwide experiences and challenges with EHV XLPE cable projects 330kV to 500kV

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With an experience of more than 1,300 km underground XLPE cables and more than 2,650 sealing ends (almost 1,700 joints) for operation voltages 330 - 500kV over a period of 20 years, the technical solutions and concepts for development, manufacture, assembly, testing and operation are largely confirmed. Concepts are introduced and the advantages and disadvantages are balanced compared to other directions of development.

As a special highlight of the EHV cable technology one of the longest 500kV cable systems installed in Moscow (Russia) is described with its current operating experience. After a rather short project running time of less than 17 months between order intake and commissioning the project has been completed in May 2012. A total amount of 70 km 500kV XLPE cable, 138 joints and 12 outdoor terminations have been manufactured, delivered, installed and commissioned successfully for the customer FSK-Meszentra (Russian National Grid Company). The project was planned in order to replace a 11 km long 500kV double system overhead transmission line. The cables which are laid in trefoil in ground show a conductor cross section of 2500 mm², an insulation thickness of 28 mm, copper screen wires and a laminated HDPE sheath. Radial water protection is ensured by a 0.2 mm thick laminated aluminium foil whereas the HDPE sheath delivers the mechanical protection during installation and operation. This sheath design delivers a very slim cable design with optimised screen losses and is well accepted in several countries for decades. The conductor consists of oxidized wires to reduce the skin effect losses. With the chosen laying arrangement this allows a rated continuous power transmission of 860 MVA per cable system.

The joint design of one-piece type joints made from silicone rubber has an integrated screen separation section to allow both, cross bonding and single point bonding applications. The joint corrosion protection design consists of a rigid glass fibre re-enforced plastic housing which is filled with cast resin. The design has been qualified according the IEC 62067, annex G requirements as well as the extensive mechanical loading test followed by a water immersion test acc. to NGTS 3.05.02 requirements. The outdoor termination design is based on the dry plug-in termination which is integrated into a pre-fabricated and pre-tested gas-filled bushing. This design allows a short installation time and avoids any liquid fillings. This type of termination was adapted to the extreme temperature conditions of the Moscow region by an external heating system. The AC voltage commissioning test has been carried out by applying the series resonant testing principle. In order to generate the required testing current of 120 A at a testing voltage of 320kV five testing modules were operating together. The installation quality was checked by using inductive type PD sensors temporarily installed at the cable screen.

High reliability, reduced repair times and decreasing cable and accessory prices make the EHV XLPE cable system competitive with overhead lines, especially in difficult terrain or environment, urban areas, industrial plants and with high land prices. In addition to the major projects with large system lengths in metropolises such as currently installed in Moscow and London, cable projects in the most remote regions of the world, very often connections within cavern hydropower plants between main transformer and switchgear, require a very high wealth of experience in design, grounding concepts, transportation as well as in laying and fixation concepts.

In contrast to alternative cable designs with e.g. enamelled wires, the oxidized wires allow jointing of the conductor without special treatment of the single wires, which accelerates the overall jointing, while still gaining from the same k_s-factor improvement. The laminate sheath design likewise allows for a resilient and easy handling of the screen on site for cable layings and accessory installations compared to lead or thick aluminium sheaths.