Thermo-mechanical behavior of HV and EHV large conductor XLPE cables in duct-manhole systems

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This paper describes the continued research work by EPRI (the Electric Power Research Institute) on the thermo-mechanical behavior of large conductor cables in duct-manhole systems.

Transmission Class XLPE insulated cables with large conductor sizes up to 2500 mm^2 are being installed in duct-manhole systems in North America. The duct-manhole system has well proven advantages of minimum disruption to traffic in busy urban roads. Duct-manholes are thermo-mechanically classified as semi-flexible systems. Duct systems can be designed to alleviate the magnitude of axial thrust acting on joints at manhole positions. Provision is made in the selection of the duct diameter for the sideways movement of the thermally expanded cable to permit it to form thermo-mechanical patterns and so absorb a proportion of the thermal strain. In CIGRE paper B1-111, 2006, EPRI describes two design methods to i) calculate the magnitude of the axial force and ii) constrain the joint within the manhole. These used mechanical parameters extrapolated from those measured on small conductor size cables, these being a 138kV 750 mm^2 copper tape screen and a 230kV 1250 mm^2 lead sheathed design.

Since 2006 EPRI has used advanced FEA modeling techniques to design and construct a 59m long test rig to simulate the full sized performance of cables in duct systems and to quantify the thermo-mechanical performance of large conductor EHV cables.

This paper describes the formative FEA modeling work for the design of the test rig and the commissioning of the rig with a 345kV, 2000 mm^2 copper conductor, XLPE insulated, corrugated aluminum sheathed cable. The rig is designed to i) measure the magnitude of the axial force at each end of the cable sample rig and ii) record the shape of the thermo-mechanical cable patterns, both quantitatively by measuring the transverse position of the cable at one metre intervals along the length and visually by opening four inspection hatches positioned along the rig.

A study is made of the effective magnitude of the cable thermo-mechanical parameters e.g. cable axial stiffness EA, bending stiffness EI, axial stiffness JI and coefficient of thermal expansion. *The key findings for large conductor cables in duct-manhole installations are that i) the magnitude of axial force is lower than extrapolated from smaller conductor cables and ii) thermo-mechanical patterns form, but are less pronounced in the magnitude of lateral deflection.*