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Trends in new technology developments for asset management of pipe-type cable systems

PS2 – Q2: With the increased interest in retrofitting fluid-filled cable systems (pipe-type in particular) with extruded cables, what trends in technology are necessary to enhance the application, including high-stress dielectric designs, temperature performance, bonding system design and the necessary accessories?

Different asset management approaches for fluid-filled cable systems can be classified in four group of strategies:

- (1) Replacement of HPFF cables, terminations, and joints with the same technology.
  Traditional proven approach where cables and accessories – terminations and joints – are replaced with the same oil-impregnated Kraft paper insulated cables and accessories. This type of replacement was the most common until the introduction of Laminated Paper Polypropylene (LPP) insulation.
- (2) Replacement of HPFF cables and their accessories with LPP technology
  A novel approach that created a very important and large segment in FF cable technology came with the introduction of Laminated Paper Polypropylene insulation (LPP or PPP) as an alternative to Kraft paper. In some cases, LPP can reduce cable wall thickness by up to 50%; therefore, increasing the ampacity of the line by using a larger conductor. This is a very popular and cost-effective method that provides the benefit of utilizing existing pipe-type infrastructure including reservoirs and pumping stations while increasing the ampacity of the circuit. A majority of FF maintenance and replacement projects in North America today utilize LPP technology.
- (3) Partial conversion of HPFF to solid dielectric technology by utilizing transitional products
  One maintenance approach that asset managers are increasingly looking into is the replacement of an ailing FF cable section with a new extruded cable section, while the rest of the circuit would remain FF. Transition Joints from OF paper to extruded cables are required for these partial conversions, and there have been a number of projects in recent years which utilized this approach. This is especially true for SCFF cable systems, with less constraints than with pipe-type cable systems in terms of pressures, space, and ampacities.
- (4) Full conversions of HPFF circuits to solid-dielectric
  This approach is still in its infancy in North America, where the vast majority of UG transmission infrastructure is built with pipe-type cables. The main challenge with this method is to match the ampacity of the existing FF line with the new extruded cable and still fit it in the existing pipe-type infrastructure. There are a couple pilot projects that have been completed in recent years; still, more information and field experience is required for full adoption and market acceptance.

To support these different strategies, new trends are emerging in development of new materials, products and services:

- Development of improved and cost-efficient pipe-type terminations and joints
  - Replacement of porcelain insulators with composite technology
    Composite insulator technology will help with the availability of the replacement parts for the outdoor terminations, speedier installation and mitigation of vandalism; Epoxy resin insulators can replace existing porcelains for equipment-mount terminations.
  - Field graded and high strength epoxy components and barrier insulators
    Epoxy cast resins can ultimately replace oil-impregnated paper bushings, bringing down the costs, lead times and availability of the parts; epoxy parts are already used as barrier and stop insulators in HPFF joints.
- Implementation of new diagnostic and preventive maintenance tools and procedures for HPFF
  - Liquid detection systems for HPFF
    Corrosion of the pipes and loss of mass leads to fluid leaks which are currently difficult and costly to locate. Introduction of modern LDS (leak detection systems) and implementation in HPFF would drive the maintenance and environmental costs down.
  - Implementation of continuous PD monitoring for HPFF
    This will improve preventive maintenance of ageing HPFF circuits; some pilot projects are being evaluated with promising results.
- Development of new transitional products between FF and solid dielectric
  - Compact design that allows for timely repairs
  - Transition joints with cooling system for HPFF
  - Standardization of the qualification and testing of transition joints
  - Standardization of the interfaces

- Development of dielectric materials that will take higher electrical and thermal stresses
    - Enhanced XLPE formulation for cables
    - Improved materials for stress control components for terminations and joints - Epoxy, SiR, EPDM
- Development of new designs of the cable systems utilizing pipe-type infrastructure
    - Cables: different configurations (e.g. triplex with thin wall); cables with no jacket and metallic shielding, utilizing existing pipes
    - Terminations and joints: hybrid designs that combine pipe-type elements with pre-molded elastomeric parts
    - New bonding system designs
    - New installation tools and techniques

Significant industry effort is being expensed in development of number of technologies listed above.
Modern composite and epoxy casted resin materials can substitute some of the oil-filled materials and components, and prolong the life of the existing pipe-type systems.
New materials that can take higher electrical, thermal and mechanical stresses will drive the design of the cables and accessories – terminations and joints that can advance partial and full conversion of pipe-type circuits.
It is expected that this trend will continue and intensify in the near and mid-term.