Rejuvenation of EPR-insulated Medium Voltage underground cables

Richard **VARJIAN** (1), David **BUSBY** (1), Glen **BERTINI** (1)

1 Novinium, Inc, Auburn, Washington, USA, richard.varjian@novinium.com , david.busby@novinium.com , glen.bertini@novinium.com

The technical case for rejuvenation of underground medium voltage polyethylene cables (PE) has been established for some time.(1,2) The dielectric strength of PE is degraded over time due to strong oxidants formed from water in a medium voltage AC electric field. The oxidants attack the polymer backbone leaving behind structures known as water trees. The reduction in dielectric strength associated with water trees and their role in space charge injection makes them precursors to electrical trees and faults. Current generation rejuvenation fluids react with and remove water leaving behind a short liquid polymer that restores the dielectric strength of PE insulation.

The technical case for rejuvenation of underground medium voltage cables with ethylene-propylene rubber (EPR) insulation has not been accepted universally for several reasons:

- EPR-insulated cables generally have enjoyed a higher in-service reliability compared to vintage PE cables
- Water trees are fewer in number and/or more difficult to detect than those in PE cables
- The paucity of water trees in EPR insulation makes their role in electrical failures more controversial
- EPR is a complex, composite material whose composition varies by manufacturer.

These factors make it difficult to relate laboratory results to field experience and to apply laboratory results commonly to all EPR cables.

The authors' firm has applied its rejuvenation treatment to a sufficient number of EPR-insulated medium voltage cables in North America to provide field performance data for EPR rejuvenation. Field data is available for over 3 million meters of underground medium voltage electrical cables of all types. The vast majority has been PE cables originally installed in the 1970's and '80's. Approximately 7.5% or 225,000 meters of the total has been insulated with EPR. The post-rejuvenation cumulative failure rate for the two types of insulation is nearly equal, 0.4%.

The chemical structures of PE and EP base polymers are very similar. The backbone is a saturated hydrocarbon. The water induced oxidation mechanism and polymer-protective-additives such as anti-oxidants apply to both polymeric materials. Additionally, silanes similar to those used in current generation rejuvenation fluids, added in minor amounts to EPR compositions, have been shown to be beneficial to electrical property retention.(3) In general, failures and lifetime limitations are related to loss of protective additives through oxidation or transport out of the material. Some proprietary rejuvenation fluid formulations contain water reactive alkoxy-silanes, anti-oxidants and other additives which replenish the depleted cache in the aged insulation.

The paper describes the rejuvenation process as applied to EPR cables, discusses the available field data in more depth and more fully outlines the nexus between generic EPR compositions and rejuvenation additives. Precautions for applying rejuvenation to EPR-insulated cables are discussed as well.

References

1) C Katz, *et al.*, "Influence of Water on Dielectric Strength and Rejuvenation of In-Service Aged URD Cables," *Proceedings of Jicable 84*, pp172-174 (1984).
2) MT Shaw and SH Shaw, "Water Treeing in Solid Dielectrics," *IEEE Transactions on Electrical Insulation*, vEI-19, pp419-452 (1984).
3) B Ohm, *et al.*, "Compounding EPDM for Heat Resistance," Rubber World, August Issue, pp33-37 (2002).