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Nuclear Plant Cable Aging Management

Gary Toman

gtoman@epri.com

704-595-2073

Outline

- State of low-voltage cable aging management
- State of medium-voltage cable aging management
- Research needed to attain 80 year cable system life

State of Low-Voltage (<600 V) Cable Aging Management

- Aging of currently used insulations* and jackets*is well understood and documented (thanks to NEPO, NRC, and industry research)
- In-plant and laboratory mechanical/chemical assessment techniques are available with aging data under multiple aging regimens
- New electrical test (LIRA) allows assessment of cables from terminations. Hot spot damage can now be identified via an electrical test well before thermal/radiation damage becomes a concern

*** Cross-linked Polyethylene; Ethylene Propylene Rubber**

*** Neoprene; Hypalon; Chlorinated Polyethylene**

State of Low-Voltage Cable Aging Management

- Most of the concern relates to localized aging from localized adverse conditions (e.g., heat from adjacent pipes and valves)
- An 80 year exposure will broaden the number of cables that will require replacement from long-term thermal exposure
- Long-term wet exposure of low-voltage cable may become significant (not necessarily a large population)

Interactions that Could Affect Cable Replacement

- Replacement of the control/instrument signaling system with fiber optics could significantly reduce the number of instrument and control cables in service
- Significant plant modifications requiring new cables may occur (i.e., old cables may not be compatible with new systems)

Logistical Problems if Large Numbers of Low-Voltage Cables Have to Be Replaced

- Many plants have full trays and conduits
- Cables in control and instrument trays and conduits wrap around each other
- Removing tens of cables from trays with 100 or more cables may not be possible
- Just layering more cables on top could exceed seismic loadings limits and will significantly increase the fire load
- Alternate tray routings or replacement of “unaged” cables with the aged cables may be necessary

State of Medium-Voltage (4 to 13 kV) Cable Aging Management

- MV cables are known to slowly age by water treeing or water-related degradation in wet environments
- Ethylene propylene rubber cables (dominant type) age more slowly than crosslinked polyethylene cables
- Cables subject to long-term (decades of wetting) tend to fail whether wet in small area (feet) or entire length
- Water-treeing/water damage causes voltage stress to be concentrated in area of good remaining insulation, which eventually breaks down from overstress

MV Cable Condition Assessment

- Methods to identify damage currently depend on disconnection of cable and subjecting the cable to higher than normal operating voltage
- Methods include: tan delta; partial discharge; and high-potential testing
- Acceptance criteria is limited:
  - Tan delta – only for XLPE (EPRI is developing acceptance criteria for EPR)
  - Partial discharge – requires expert interpretation
  - Hi-pot – requires extended application to assure that weak spots are eliminated

MV Cable Condition Assessment

- Electrical tests can only be performed if cable is shielded (17 plants report some unshielded cables)
- For PD tests to be possible, shields must not be significantly corroded (long-term wetting tends to corrode copper tape shields)
- Electrical testing requires disconnection of connected loads (not necessarily a simple past-time)

Replacement Medium Voltage Cables

- Selection of replacement cable types could be different if plants know they will desire an 80 year life
- Commonly available replacement cable types are highly likely to make 60 year life mark even in wet environments, but may not make an 80 year plant life
- Consideration should be given to installation of water-impervious designs with water-proof continuous shields that keep water out of the insulation
- Replacement of MV cables inside the plant may be difficult due to limited spacing between trays and stiffness of cables (Original cables were installed before other equipment was in place)

Low-Voltage Cable Research

- Research related to logistics of possible replacements and effects could be useful.
- Effects of replacing I&C backbone with fiber optics could be studied. If a positive effect (e.g., fiber optic system replaces a large portion of aging I & C cable), further justification for fiber optic would be available.
- Research on aging effects of very long-term wetting of LV cable could be useful.
- If new low smoke, zero halogen insulations and jackets are installed, research on aging of these materials will be needed (likely in conjunction with new plants).

Medium Voltage Cable Research

- Development of a test that could assess condition of cables without use of high voltages and disconnection of loads would be useful
  - Line Resonance Analysis (LIRA) may be able to do this
  - Simulated failure conditions would have to be assessed as well as deteriorated cables removed from the field
- Continued research into the development of acceptance criteria for existing electrical tests is needed for existing and newer cable insulations
- Development of one or more aging models for wet EPR insulation would be useful in projecting remaining life (Not a simple effort)
- Developing a means for assessing non-shielded cables is desirable (Replacement cables are likely to be non-shielded as well)