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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

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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**

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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)

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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)

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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

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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

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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

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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)

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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)

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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).

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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)

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