EQ Cable Qualified Life

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Overview

- Environmental qualification background
- Member practices for extending qualified life for life extension
- EPRI research and support efforts for life extension
- Summary

Qualification of EQ Cables- Originally Installed

- EQ methods used for original cables per IEEE 323-1974
  - Type testing (preferred)
  - Analysis (least preferred)
  - Operating Experience
  - Combined
  - On-going
- Qualifications were performed for 30-40 year operating life of the plants
- Recent qualifications of new cables have been done to 60 years (i.e. APR 1000 cables)

Qualification of EQ Cables- Changes in IEEE 323

- IEEE 323-1983 introduced methods for extending qualified life
  - First attempt to address license extension in the standard
  - Not endorsed by the US NRC
- New methods included the following examples
  - Type testing of new cables, naturally aged cables removed from harsh environment, naturally aged cables subjected to accelerated aging followed by successful passing of design basis accidents
  - Periodic surveillance/maintenance testing, replacement or refurbishment program
  - Condition based qualified life
  - Reduction of conservatism in the original qualification due to operating environment

License Extension in US 40 - 60 Years

- 10CFR50.54 requirements as implemented under NUREG 1801, Generic Aging Lessons Learned
- EQ cables are not specified in the Aging Management Plans for cables
- EQ regulation 10CFR50.49 and Regulatory Guide 1.89 dictate the requirements
- Regulatory Guide 1.89 endorses IEEE 323-1974 methods for EQ
- All US licensees used time limited aging analysis (TLAA) reviews to eliminate conservatism from lifetime calculations and in most cases obtained 60 year or greater qualified life

License Extension in US 60 - 80 Years

- NUREG/CR-7153, Volume 5, “Expanded Materials Degradation Assessment (EMDA) Volume 5: Aging of Cables”
  - Identified knowledge gaps on cable aging
    - Activation energy
    - Diffusion limited oxidation (DLO)
    - Dose Rates
    - Inverse temperature
    - Moisture
    - Understanding of actual operating environments

License Extension in US 60 - 80 Years

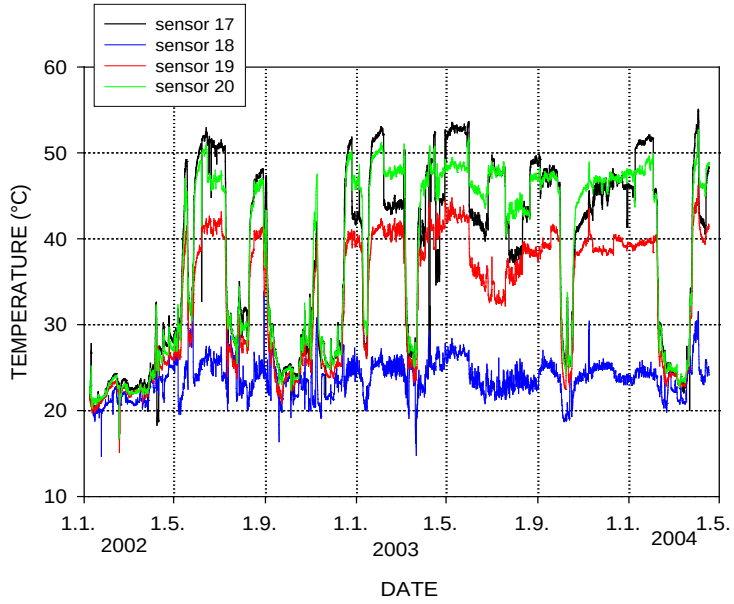
- Raises question on how these knowledge gaps effect how cables age….Do they matter?
- Research on EMDA knowledge gaps is being done and mainly funded by US Department of Energy and performed at US national laboratories
  - EPRI coordinates, provides technical input, and monitors their research plans and results
- US sites (Turkey Point, Peach Bottom, Surry) have submitted or will soon submit their license request for 80 years
  - None of them have plans to extend their cable qualified life using type testing, on-going qualification or conditional qualification
  - All continue to rely on excess conservatism of original EQ qualification testing or replacement if they do not

EQ Qualified Life Extension of Cables – International

- There has been no single path taken for EQ cable qualified life extension
  - Japan has used type testing of naturally aged cables + accelerated aging to 60 years using both sequential aging (Japan Electric Association Guide JEAG 4623-2008) and simultaneous aging (JNES-RE-2013-2049)
  - Spanish utilities may follow a similar approach as Japan
  - EDF is developing “virtual polymer tool” and plans to compare naturally aged cable to the aging curve predicted by the tool to determine condition based qualified life
  - CEZ has done extensive operating environment studies and used the results to re-calculate cable life
  - KRSKO is doing some replacements and condition monitoring
  - Vattenfall has extended many of their electrical penetration units to 60 years
- The path chosen seems to be dependent on what the regulators will accept

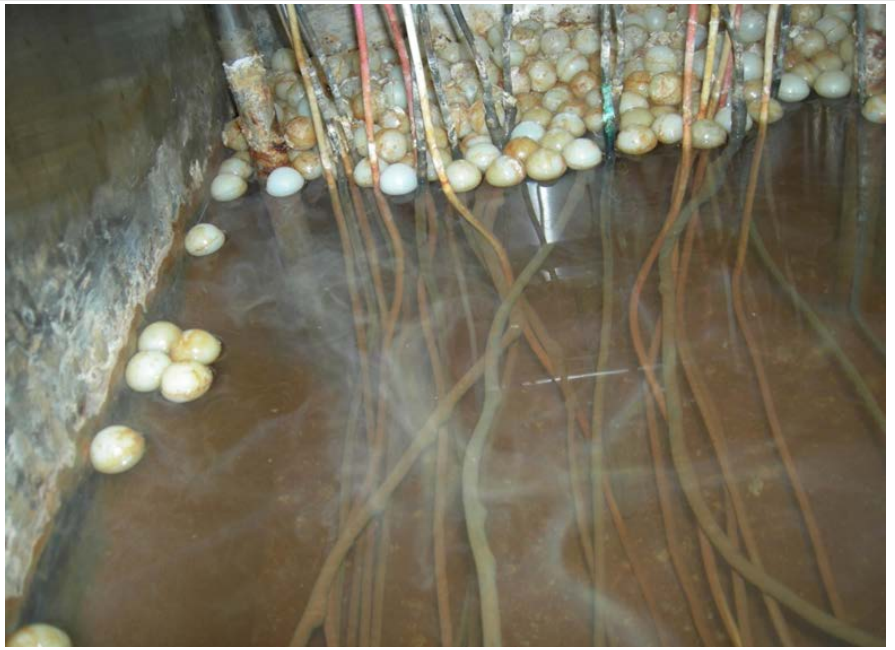
EPRI Research Efforts LTO/Plant Engineering

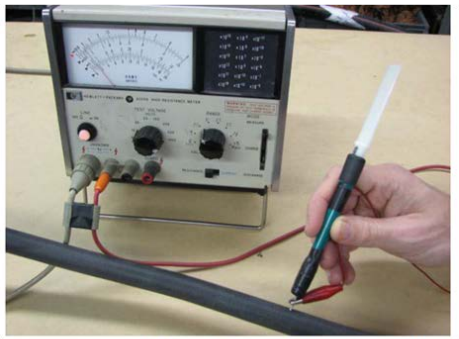
- Initial focus was on establishing cable operating environments (3002010404, 3002000816)
  - Radiation and temperature monitors installed in vicinity of large cable populations and specific adverse environments
  - Results: temperatures and radiation levels in most locations for the plants studied (US PWR, BWR, and Russian PWR (CEZ plants) were well below design values)

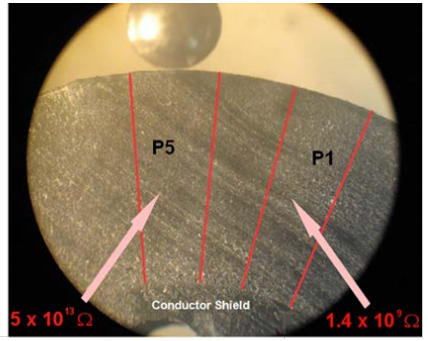


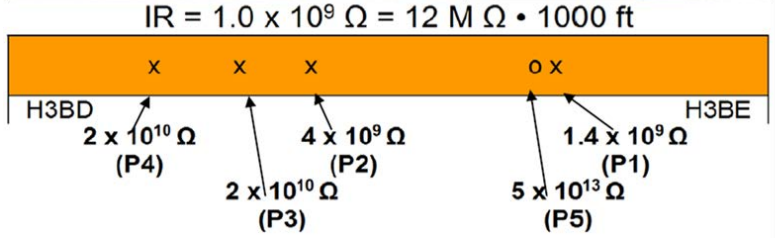
EPRI Research Efforts

- Submergence research to determine degradation modes for low and medium voltage cables
  - Low voltage cable wet stability project (3002007991)
  - Medium voltage cable failure mechanism research (3002005323, 3002002993, 3002000554, 1024894, 1022965, 1021069, 1018777, 1015070)
  - Submergence qualification studies (3002013176, 3002010618)



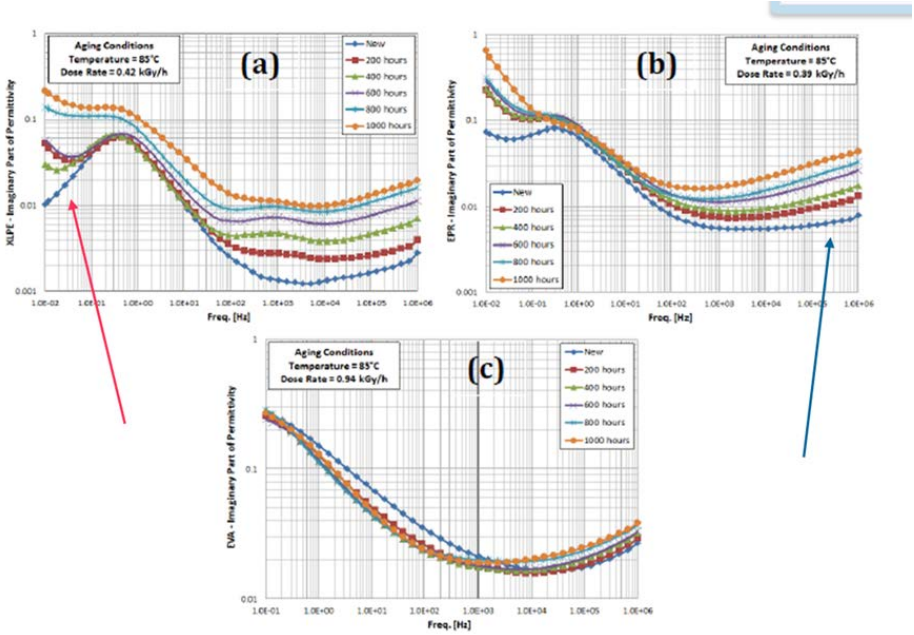






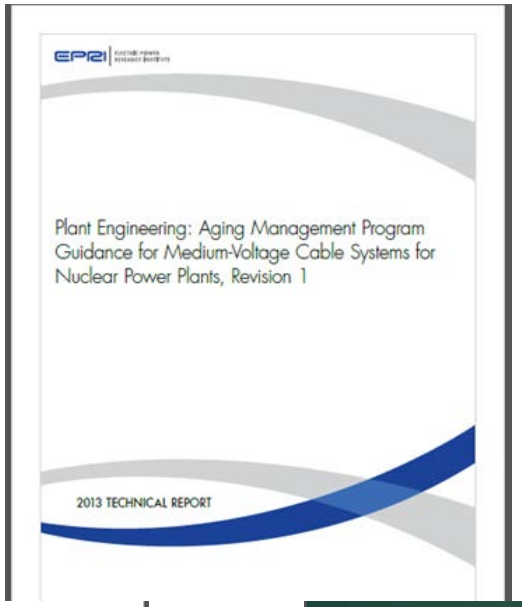
Recent Research Focus

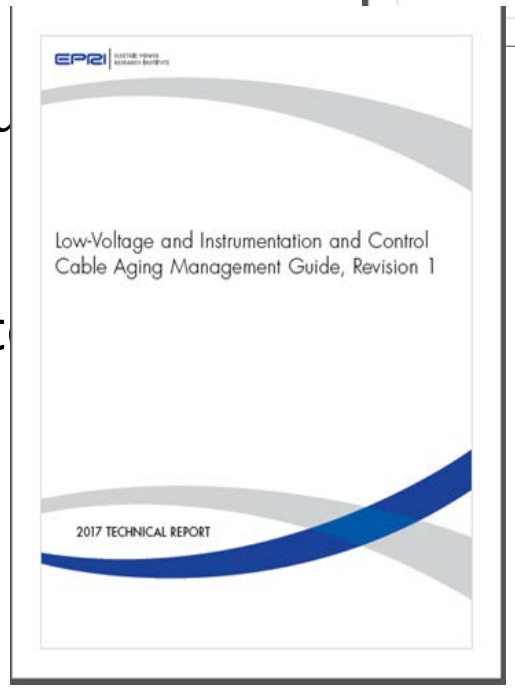
- Recent focus has shifted to improved condition monitoring
  - Low voltage dielectric spectroscopy (3002010403)
  - Spread spectrum time domain reflectometry (new project in 2018)

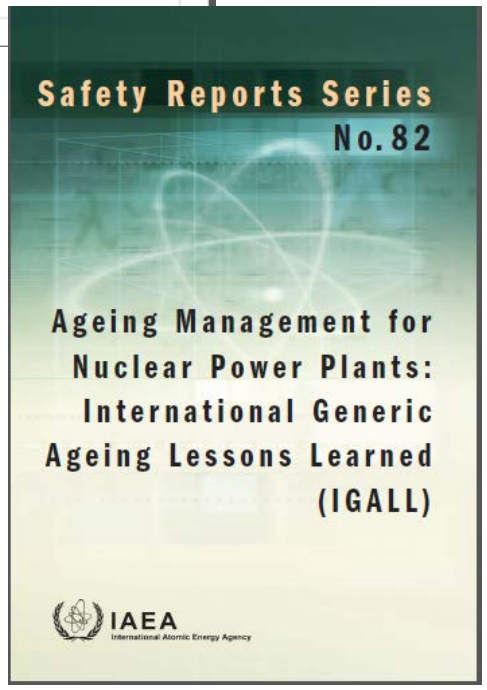


Recent Research Focus

- Supporting long term operation
  - IGALL development for cable aging management plans (Revision 3 and 4)
  - Coordination and collaboration with US NRC and DOE/National Labs EMDA research efforts
  - Support member cable aging management program implementation and license extension
  - Involvement in European Union/Material Aging Institu for virtual polymer tool development (supports condition-based qualified life method)
- EPRI cable aging management guides will updat as required by EMDA research results







Review

- IEEE 323 has several methodologies for extending cable qualified life
- No single method has been relied upon
- Method used is somewhat determined by what Regulator will accept
- EPRI research and support efforts are focused on license extension and improved condition monitoring

Questions and Discussion

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