

# Cable Aging Management

## ISSUE STATEMENT

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Concerns exist that nuclear plant safety and reliability are being adversely impacted by premature electrical cable aging-related failures resulting from exposure to localized adverse environments and service conditions. As a result, plant owners and regulators are requiring the implementation of electrical cable aging management programs and processes. Improvements to cable aging management processes, condition monitoring techniques, acceptance criteria, and aging models are necessary to support resolution of cable aging concerns. Without such improvements, cable aging management programs may have limited effectiveness.

## DRIVERS

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**Safety:** A nuclear plant's safety-related electrical cable infrastructure must be inherently reliable and maintained as such. Cable failures have challenged safety-related system readiness.

**Equipment Reliability:** Medium voltage off-site feed cable and safety-related motor feed cable failures have caused outages of 2 to 3 weeks in duration. Medium voltage cable replacement is costly and generally difficult.

**Regulatory:** The U.S. Nuclear Regulatory Commission (NRC) is requiring that cable condition monitoring be put in place. Non-U.S. regulators are following the NRC lead regarding aging cable systems. While some differences in cable materials and installation practices exist from country to country, deterioration of low and medium voltage cables is a concern to the world nuclear community.

**Limitations of Inspection Technology:** The design of nuclear plant cables limits the types of tests that may be used. While standardized, the tests provide limited information on long-term function of the cable and cannot estimate remaining life. Condition monitoring acceptance criteria is preliminary in nature and needs further improvement to assure failures are avoided and good cables are not replaced.

**Limitations of Applicable Standards:** IEEE, ICEA, and AEIC have established cable testing and manufacturing standards, but these standards provide little information on aging management programs.

## RESULTS IMPLEMENTATION

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This research effort will result in knowledge and methodologies to effectively implement cable aging management programs. Specifically, the following will be provided:

- Aging management program implementation guidance for instrumentation and control cables. Medium and low voltage cable aging management program guidance has previously been provided.
- Recommended testing methodologies applicable to specific cable types and vintages
- Advanced testing and predictive capabilities
- Additional understanding of electrical cable failure modes allowing improved testing methodology and acceptance criteria to be developed
- Useful research results/products aiding in the implementation of aging management programs. This includes test applicability matrices, qualification of separable connectors, and ongoing EPRI technical support.

## PROJECT PLAN

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### Ease of Cable Aging Management Activities

Building on the two aging management program implementation guides already published for medium voltage and low voltage cable, a third guide will be issued for instrumentation and control cable. Implementation support will be provided under a 2011 to 2012 project to resolve issues that arise. In addition, a matrix linking failure mechanisms to the applicable test by insulation type will be developed in 2011 to support cable condition monitoring and troubleshooting needs.

Medium voltage separable connectors will be qualified for safety-related use during 2011 and 2012 to allow cables to be easily disconnected from their loads for testing.

### Advanced Test Practices and Aging Models

Through a pilot project started in 2010, EPRI will produce age-accelerated medium voltage cable specimens. These specimens will permit accelerated testing and forensics, accelerated development of aging models, and development of improved condition monitoring techniques.

For cable types from plants in service in the 1970s, forensic evaluation of failed cables will continue for two years. Results will provide insights into correspondence of condition monitoring to cable breakdown strength.

In 2011 and 2012, medium voltage test results will be gathered and assessed to develop improved acceptance criteria. Failure data will also be formally gathered and assessed.

To support the development of advanced testing practices/technologies, EPRI's Nuclear Sector will coordinate activities and research with the Power Delivery and Utilization Sector.

### Submerged Medium Voltage Cable Qualification

EPRI is initiating a submergence qualification project based on IEEE Std 323-1974 qualification methodology to provide a basis for allowing medium voltage cables to be submerged. The qualification activities will be applied to modern cable types and those known to never have failed in submerged conditions. Manufacturer and insulation specific qualifications will be performed; generic insulation type qualification is not possible. Because certain cable types, such as most black EPRs and butyl rubber, have experienced water related degradation at about 30 years, submergence qualification will not be attempted.

### Susceptibility of Low Voltage Cable to Wet Aging

Little information is available on longevity of low-voltage cable under wet and submerged conditions. In 2011, research will be performed that gathers existing information on submergence of low voltage cable degradation and its effects on longevity.

## RISKS

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It may not be possible to develop accelerated aging techniques for EPR insulations or an enhanced cable test methodology.

