EPRI Update on EQ Projects

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April 2026

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  - Current status
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- IAEA TECDOC on CBQ
- Update of Equipment Qualification Reference Manual, Revision 1
- Cable research and activities.

Limitorque Actuator Life Extension Project

Limitorque Actuator Life Extension Project (ALE)

- 3002020841 **Limitorque Actuator Fatigue Life Extension, Revision 1: Update to 1016701-July 2021**

Why this work was necessary?

- **Aging plant challenge:** Many nuclear plants approach/extend beyond original 40-year life and Limitorque actuators reach the 2,000-cycle qualified life.
- **Observed overloads:** Field MOVs experienced thrust/torque cycles above manufacturer ratings; utilities needed a defensible basis to continue operation.
- **Cost/availability driver:** Extending actuator life can defer costly actuator replacements and better allocate maintenance resources.
- **Regulatory/qualification gap:** NRC concerns and qualification limits required documented methods to justify extended fatigue life.

ALE Project (continued)

- Criteria for application and methodology was established
  - Leveraged industry test programs
  - Component-level fatigue models for thrust-train and torque-train components (LiFE/LTAFLA software lineage) to compute cumulative fatigue damage and remaining allowable cycles.
- For many SMB/SB sizes, fatigue life can be generally extended up to 4,000 cycles at or above 100% ratings, using ALE and required maintenance.
- Actuators needing DBE (LOCA/HELB) function for more than 40 years; 2000 cycles not included.
- Soft clutch or non-metallic environmental aging (thermal/radiation)—outside ALE scope.

Limitorque Valve Actuator Life Extension, Part 2 3002032010

- **Objective:** Supplement original Eqtest to enable extension beyond 40 years or 2000 cycles.
  - **Mild-environment mechanical cycling:** 8000 cycles (sets of 1000 cycles with inspections).
  - **Harsh-environment EQ program:** thermal aging (60 years at 60º C.), radiation (normal & DBE), **+2000 mechanical/electrical cycling**, vibration aging, seismic DBE, pressure cycling, DBE, functional tests after each step.
  - Based on original Limitorque qualification programe + inputs from **IEEE 382**

Harsh-environment EQ program

- NUGEQ members review draft EQ tech specification and EQ plan:
  - Motor insulation class Reliance H, (addition of 575 Vac motor in test specimen configuration).
  - Soft clutch included .
  - Temperature vs time/Pressure vs time profile designed to envelope previous Limitorque tests.
- Test Fixtures will be used for all baseline and functional tests (including accident simulation). Designed to operate the motor and electrical switches across a range of conditions while **collecting test data**.
  - Actuator shaft torque (via a load cell mounted to the reaction plate)
  - Current and Voltage (including Instantaneous motor current on all three phases)
  - Spring pack displacement; Switch state; Shaft rotation
  - Temperature (motor, actuator housing, etc.)
- In addition to IR other electrical parameter maybe electrical parameters derived from previous EPRI cable research (such as LFDS and PDC) will be measured to explore feasibility for their application in Condition Based Qualification approach. 3002020818

IR (Insulation Resistance); LFDS (low-frequency dielectric spectroscopy); PDC (polarization depolarization current)

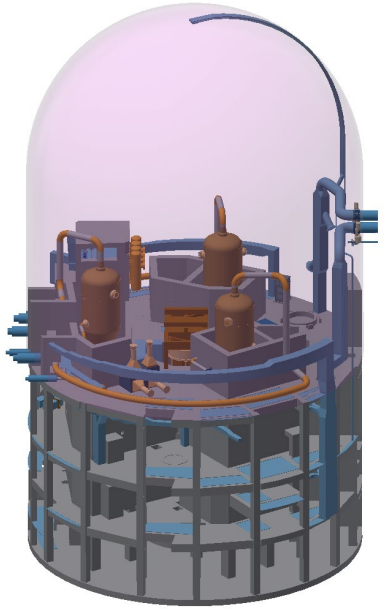
Digital Twin: Interactive Database Knowledge Visualization Platform (IDKVP)

General information

- Current software is based on Westinghouse 4-loop PWR 3002029382 with focus on In-Service Inspection program.

New development

- Collaborative effort between EPRI and Centrales Nucleares Almaraz *-Trillo (CNAT) to create a new IDKVP.
- Development of EQ module
  - **High-fidelity digital twins (thermal & radiation)** — *3D CFD-based thermal models* and *Monte Carlo (SCALE 6.3.1) radiation models* to provide temperature and accumulated dose throughout rooms, including areas lacking sensors.
  - **Targeted scope and integration** — Digital twins developed for specific rooms (and a full reactor/auxiliary building radiation model) and integrated into the IDKVP environmental qualification module for equipment-level assessment.
  - **Improved qualified-life calculation** — New functionality to compute equipment qualified life periodically using real data and predictive models (e.g., Arrhenius for temperature) to replace overly conservative sensor-based estimates.



***two Westinghouse 3-loop pressurized water reactor (PWR); CFD (Computational Fluid Dynamic)**

Current status

- EQ module already developed
- Other modules such as In Service Inspection; Flow Assisted Corrosion; Fatigue will be improved to incorporate Flex Operation consideration.
- Beta version is expected to be available late 2026-early 2027

Update of TR-104873

Methodologies and Processes to Optimize Environmental Qualification Replacement Intervals

Current status

TR-104873 was issued in 1996. The technical basis of the methodologies and analyses described in the report remains valid; however, there are several reasons to update it:

- Many **new or revised industry reports** related to EQ have been issued (such as 3002018283)
- Significant generational **turnover in the nuclear industry**, creating the need for clearer, more structured, and easier-to-apply guidance.
  - Include decision-flow charts to help users select qualified-life or replacement-interval techniques.
  - Provide a simplified classification of available techniques, including room for newer approaches.
  - Highlight technique feasibility based on equipment type, available information and optimization techniques already implemented.
  - Add short step-by-step examples with numbers to aid practical understanding.
- **Long-Term Operation (License Renewal/Subsequent License Renewal)** may introduce different plant conditions that make some techniques more favorable than others.
- Grouping of **Alternate Methods** as precursors to performing evaluations of EQ replacement intervals and qualified lives, including new alternate methods (e.g., 10CFR50.69 RISC-3 and **condition-based qualification**).Updated references to new and revised industry and regulatory resources that can provide further guidance

IAEA TECDOC on CBQ

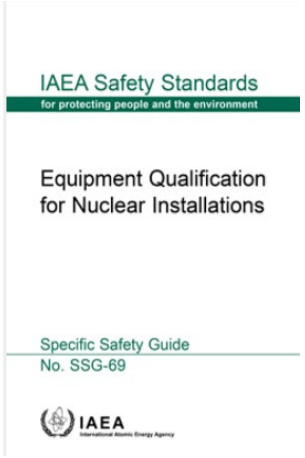
IAEA TECDOC on CBQ: why EPRI is leading & where we go

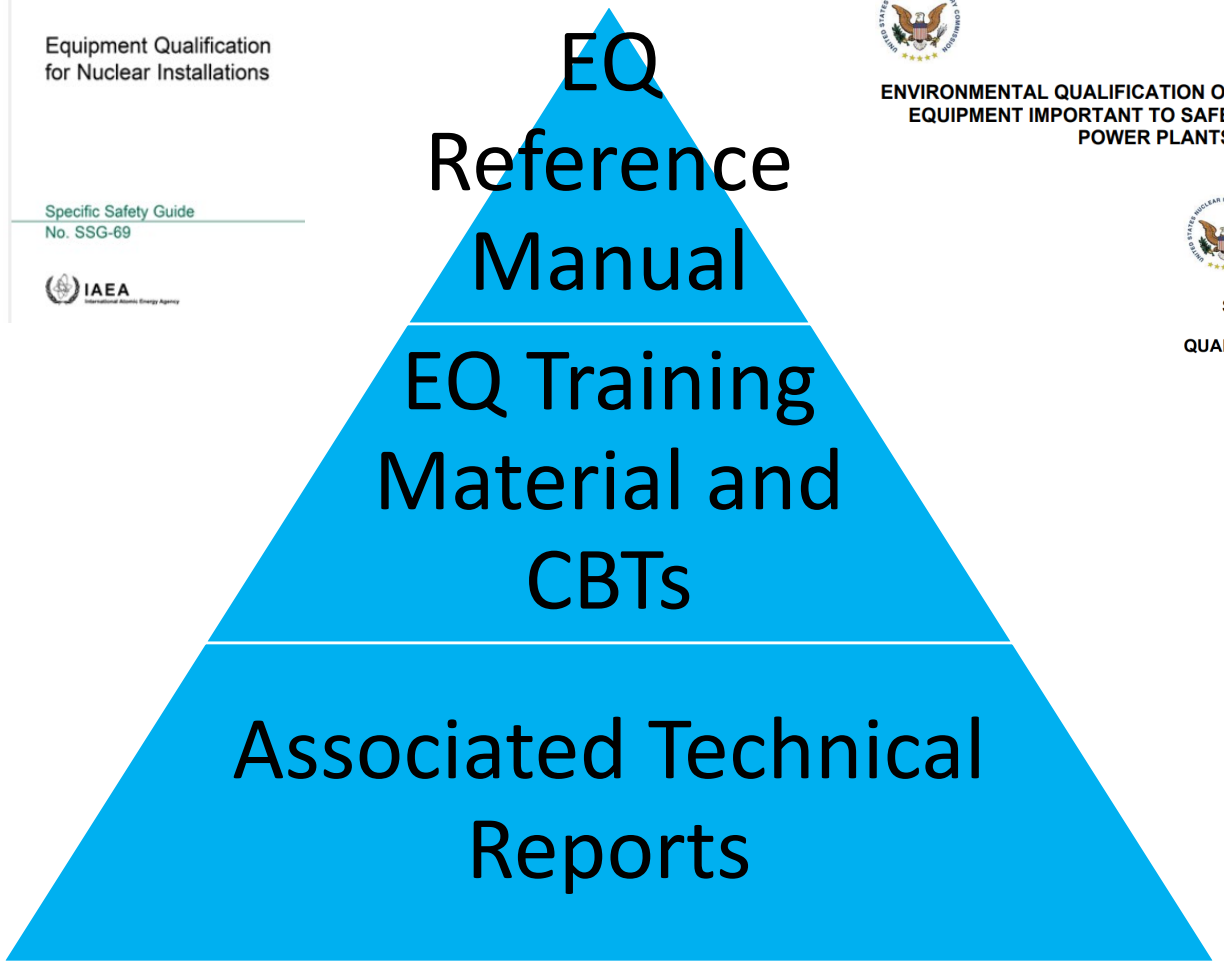
EPRI support several activities with IAEA such as **IGALL** and International Network on Life Management of Nuclear Power Plants (**LMNPP**) by organizing cooperation and knowledge sharing.

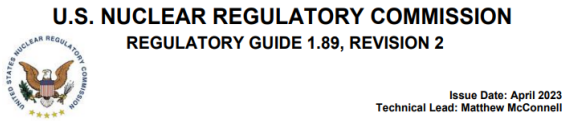
- CBQ has been highlighted through IAEA activities (e.g., CBQ WS, EQ Meeting 2024) in the context of LMNPP Working Group 5 and is feeding into a forthcoming IAEA TECDOC on CBQ.
  - **Global NPP fleet is aging**: median unit age ~37 years, with ~1/3 of ~440 operating units already in long-term operation (LTO); ~27 Member States have implemented or are implementing LTO programmes.
  - Traditional **qualified-life** approaches may not reflect **actual field conditions** or real-time degradation; Condition-Based Qualification (CBQ) addresses this.
- EPRI technical basis (cables): The TECDOC leverages EPRI's published work Condition-Based Qualification of Class 1E Cables.
- It will include state of the art in several Member States (e.g. USA, China, South Korea, Argentina).
- Status & next steps: The document structure/index is more less defined. Consolidated document is expected by the end 2026. final publication will depend on IAEA publication times.

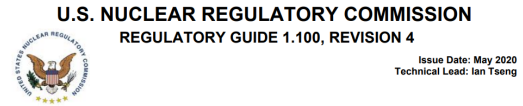
Update of 1021067 Nuclear Power Plant Equipment Qualification Reference Manual, Revision 1

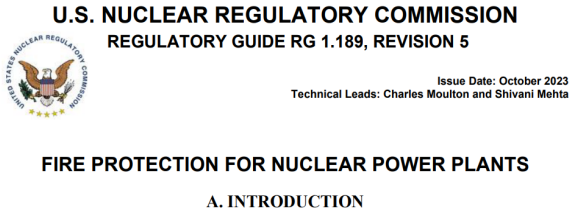
Equipment Qualification (EQ) Program Updates











Project Strategy

- Availability: Report available at no cost (or low cost, ~$600). A companion EPRI Wiki will launch after publication to enable advanced search and translation

- **Structure & navigability (no renumbering):**Retain the current chapter/appendix structure and section numbering to protect existing references across utilities, procedures, and training.

- **Project approach & timeline** (two years) incremental delivery following the work sequence
  - Identify stand-alone sections for early drafting
  - Review each section; separate “static” vs “dynamic” content; draft updates.
    - Static: foundational EQ principles, methods, definitions, non-version-specific process guidance.
    - Dynamic: standards & regulatory items (NRC Reg Guides with IEC/IEEE dual-logo endorsements; IEC/IEEE 60780-323; RG 1.89 Rev 2), international guidance (IAEA SSG-69/67; IGALL), and recent EPRI research (condition-based qualification; 10 CFR 50.69 alternate treatments; risk-informed HELB; EQ life optimization)
  - Discuss and approve the draft version with TAG
  - Create the corresponding wiki page and transfer dynamic content

Cable related topics

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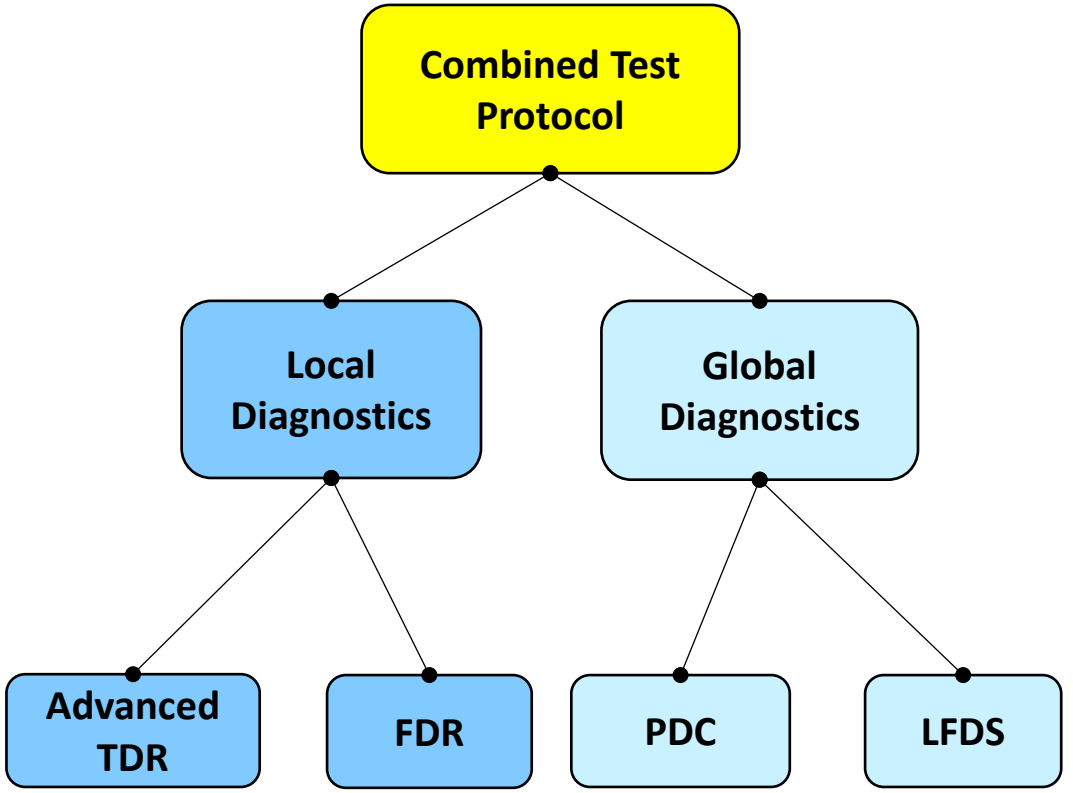
IEC IEEE 62582-??

- During 2.17 group meeting addition of new Condition Monitoring techniques was discussed. Related EPRI research
  - Long-Term Operations: Initial Findings on Use of Dielectric Spectroscopy for Condition Monitoring of Low Voltage Nuclear Power Plant Cables (2017-publicly available).
  - Dielectric Spectroscopy of Low Voltage Nuclear Power Plant PVC Insulated Cables from EDF (2022 publicly available).
- The technique has been implemented by several EPRI members (USA, Brazil, Slovenia, Czechia, etc.). EPRI members of IAEA-IGALL project will share inputs in the context of AMP210_Condition_Monitoring_of_Cables update.

- Test Protocol for Condition Monitoring of Low Voltage Cable Using Dielectrically Based Methods (2021 restricted)

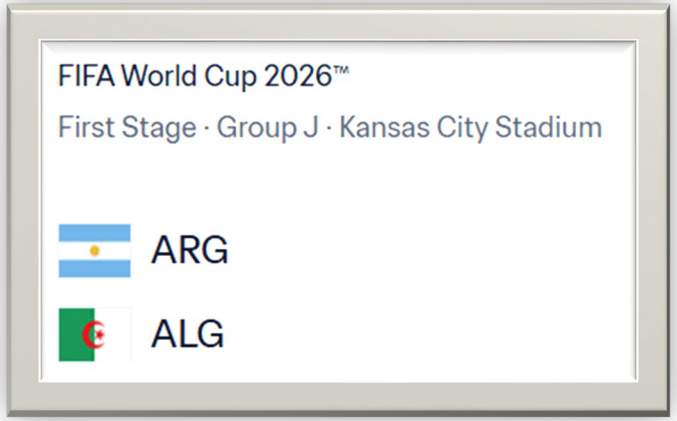
- Compare results of ***multiple techniques***
  - Low Frequency Dielectric Spectroscopy (LFDS)
  - Polarization Depolarization Current (PDC)
  - Advanced Time Domain Reflectometry (TDR)
  - Frequency Domain Reflectometry (FDR)



EPRI Cable user group with EQ content.

- **Top Focus Areas**
  - Member Roundtable
    - Common experiences with Medium Voltage Accessory install errors.
    - Perspectives on use of Dielectric Spectroscopy and Polarization/Depolarization testing.
  - New Cable Training
  - EPRI Research Updates
  - 3rd day will be devoted to roundtable of CBQ applied on Cables. EPRI research gaps barriers, industry presentation, etc.

~~**Technical tour**~~



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