# Review of IEC/IEEE 60780-323

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# IEC/IEEE 60780-323

- This Presentation will Cover:
- Introduction
- Background
- Changes to Standard
  - Definitions
  - Design Extension Conditions
  - Aging
  - Non-seismic Vibration
  - Programmable Devices
- Other IEEE Working Groups

# Introduction

- Harmonized IEC 60780-1998 and IEEE 323-2003
- First Discussed in 2006
- Began in 2010
- IEC/IEEE 6078-323 *Nuclear facilities – Electrical equipment important to safety – Qualification* Published in 2016
- Based on IEEE 323-2003
- Make Qualification Simpler and Cost Effective for Manufacturers and Nuclear Facilities
- Expected IEC/IEEE 60780-323 Adopted as European Norm

# Background

- Moisture and Submergence
  - Generic Letter 2007-01, *Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients,* issued in 2007
  - Regulatory Guide 1.211, *Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants*, issued 2009 for IEEE 383-2003 with some exceptions
  - Information Notice (IN) 2010-26, *Submerged Electrical Cables,* issued in 2010
  - New Passive Plants 1 Year Post LOCA Submergence
- Condition Monitoring
  - NUREG/CR-7000, *Essential Elements of an Electrical Cable Condition Monitoring Program*, issued in 2010
  - Regulatory Guide 1.218, *Condition-monitoring Techniques For Electric Cables Used In Nuclear Power Plants*, issued in 2012
- NUREG/CR-7153, Vol. 5, *Expanded Material Degradation Assessment (EMDA)*, issued in 2014, which identified knowledge gaps in cable aging, testing, monitoring and recommended future areas of research

# NRC Regulatory Guide 1.211

- “Power cables that are routed underground should be capable of performing their function when subjected to anticipated environmental conditions such as moisture or flooding.”
- Clause 9.1, General, should be supplemented to include the following: “Documentation should also include manufacturer’s inspection and maintenance requirements.”
  - Note – This was added to IEEE 383-2015
- “Programs for monitoring of environmental conditions (such as temperature, radiation levels), and condition monitoring should be implemented for safety-related power, instrumentation, and control cables.”
- “For safety-related power cables that are inaccessible or installed underground, appropriate inspection, testing and monitoring programs should be implemented to detect degradation. The condition monitoring and its frequency may be adjusted based on the cable performance.”

# EMDA

- EMDA Identified Knowledge Gaps that Include:
  - Activation Energy
  - Diffusion-Limited Oxidation
  - Low Dose Rate Effects
  - Synergistic Effects of Aging
  - Inverse Temperature Effects
  - Moisture Effects
  - Actual Environments

# Life

- 87 Reactors Received Renewed Licenses to Operate to 60 years
  - 9 Under Review and 4 More Expected
- NUREG-1801 R2, *Generic Aging Lessons Learned (GALL) Report* 2010
- NUREG-2191, *Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report*, 2017, recommendations for aging management of components for SLR period (60 to 80 years)
  - Environmental Qualification, Performance and In-service Testing of Cables Identified as an Area of Significant Technical Issues for SLR
- Most New Plants Require 60 Year Life For Cables
- Some Existing Plants Looking to 80 Year Life

# Definitions

- Some Definitions Modified from IAEA Definitions.
- Condition indicator was modified from the IAEA definition.
  - Note information that was in IEEE definition is contained in the text.
- Design extension conditions was added based on IAEA Safety standards series SSR2/1:2012.
- Definition of equipment important to safety was added. This is in 2 parts to take into account how IEC standards interpret this and how IEEE standards interpret this.

# Equipment Important to Safety

- Equipment that is part of a safety group and/or whose malfunction or failure could lead to undue radiation exposure of the site personnel or members of the public. Equipment including:
  - Those structures, systems and components that prevent anticipated operational occurrences from leading to accident conditions;
  - Those features that are provided to mitigate the consequences of malfunction or failure of structures, systems and components

# Equipment Important to Safety

- A) For usage consistent with IEC 61226, equipment important to safety are as follows:
  - all I&C equipment performing Category A to Category C functions (in accordance with the IEC 61226 categorisation scheme),
  - all electrical equipment needed to ensure emergency energy supply to this equipment in case of a loss of normal power supply,
  - all electrical equipment needed to ensure ultimate energy supply in case of total loss of on-site power (if selected as design extension condition to be mitigated).

# Equipment Important to Safety

- B) For usage consistent with other IEEE documents and a Class 1E categorization; for equipment important to safety, qualification is essential to the following:
  - electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or
  - electric equipment that are otherwise essential in preventing significant release of radioactive material to the environment.

# Design Extension Conditions

- **Design Extension Conditions**
  - accident conditions that are not considered for design basis events, but that are considered in the design process of the facility in accordance with best estimate methodology, and for which releases of radioactive material are kept within acceptable limits. Design extension conditions include severe accident conditions.
- For all items of equipment required to operate under design extension conditions, demonstrable evidence shall be provided that it is able to perform its function(s) under the applicable service conditions including design extension conditions.

# Design Extension Conditions

- Some equipment needs to be qualified for conditions that are beyond design basis of the plant (e.g., extended station black out, extreme natural hazards, and severe accident). For such equipment plant specific accident profile may be used for component specific qualification requirements.
- Design bases and design extension conditions should be periodically reassessed in response to events in the region, shared international experience or other findings.

# Design Extension Conditions

- To account for these new situations, the following, shall be addressed:
  - identify changes in the plant design needed to limit the consequence of these situations on equipment,
  - justify that the existing qualification programme covers new requirements or, if it is not the case, perform the qualification programme for addressing the change in the anticipated environments.
- DEC Definition Provided and Information Provided, but No Requirement Other Than Where Already Required and Should Periodically Access New Information

# Qualified Life

- A qualified life is not required for equipment located in a mild environment and which has no significant aging mechanisms **and is operated within the limits established by applicable specifications and standards.**
  - Bold Text Has Been Added
  - No Change if No Significant Aging Mechanism
  - New Plants Starting at 60 Years For Many Components and Likely Look To 80 Year Life Or Greater
    - Same Commercial Standards That Expected 20 to 40 Years May Not Provide Life for 60 to 80 Years

# Age Conditioning

- Arrhenius methodology is an acceptable method for accelerating time-temperature ageing effects during type testing.
  - No Change From Previous Version
- Thermal ageing considering the life time under the maximum temperatures during normal operation shall be performed based on applicable laws describing the thermal degeneration process of  the components of the equipment.
  - Can use Arrhenius as noted Above

# Age Conditioning – Cautions

- The selection of the model, the definition of the aging parameters as well as the performance of the thermal aging test shall be described and justified in the test plan.
- Limits of used materials and possible acceleration effects shall be identified and taken into account when selecting test parameters for thermal ageing.
- It is not acceptable to exceed temperatures causing qualitative changes in the physical properties and chemical properties.

# Age Conditioning – Radiation

- Dose rate acceleration, within equipment limits, is an acceptable method for accelerating radiation degradation effects.
  - No Change from 2003
- The dose rate for radiation ageing should be as low as can be accommodated within reasonable cost and schedule.
  - No Change from 2003
- Information on condition monitoring and ageing assessment can be found in IEEE Std 1205-2014, IEC 62342 and IEC/IEEE 62582-1.
  - Added IEC References
- Radiation ageing shall be performed on all materials and components for which radiation causes significant ageing.
  - No Change from 2003

# Age Conditioning – Additional Information

- Semi-conductor and polymer should be considered to be sensitive to both radiation dose rate and heating.
- The use of programmable devices in reactor containment is generally avoided due to their sensitivity to radiation.
- When determining the radiation dose and dose rate for radiation ageing, or temperature for thermal ageing, oxidation and gaseous diffusion effects should be taken into account.
- For radiation ageing, it is always better to apply a total dose higher than the dose corresponding to the expected service life, so as to obtain a margin taking all these elements into account.

# Age Acceleration – Cautions

- Accurate acceleration of ageing depends on detailed knowledge of the factors which influence equipment and of the synergies which take place between influence quantities.
- It also requires correct assessment of the dominant ageing processes in any particular case.
- This means that the selection of ageing tests can be difficult and that attempts to achieve large accelerations contain significant risk of error.
- The risk of overestimation of qualified life or qualified condition due to diffusion limited oxidation effects of application of excessive temperatures or dose rates depends on the materials involved.
- Thus, the need for compensation by conservatisms in the selection of total radiation dose and calculation of qualified life and margins in qualified condition is material dependent.

# Diffusion Caution

- Limiting gaseous diffusion at high dose rates and temperature can influence the oxidation of internal parts of materials and components.
- This should be considered in establishment of qualified life and qualified condition.

# Age Sequence

- 2003
  - The sequence of age conditioning should consider sequential, simultaneous, and synergistic effects in order to achieve the worst state of degradation.
- 2016
  - Possible synergies should be considered.
  - Tests bringing into effect simultaneously the combination of ageing environmental conditions shall take measures to verify that the acceleration of the tests, compared with actual operating conditions, does not alter the effects due to the combination.
  - Sequential ageing tests, each of which brings into effect only one of the simulated ageing conditions involved, shall be performed in a conservative sequence which maximizes the ageing effect.

# Operationally Cycled

- Equipment important to safety shall be operationally cycled to simulate expected mechanical and electrical ageing of the components to be tested. Operational cycling shall be performed prior to seismic testing for equipment determined during the design process to have significant mechanical and/or electrical ageing mechanisms. The wear ageing should be performed under expected electrical load unless otherwise justified. Equipment and components whose seismic capabilities may be degraded due to wear ageing shall be identified and their replacement interval specified in the qualification documentation.

# Non-seismic Vibration

- **Non-seismic** vibration, which may produce significant degradation (e.g., fatigue, wear) during normal and abnormal use, shall be ~~simulated~~ **taken into account in the age conditioning sequence** prior to the seismic tests. Vibration to be ~~simulated~~ **considered** includes self-induced vibration, ~~and~~ vibration from piping, pumps, and motors~~. Other~~ **and other** vibration such as hydrodynamic loading~~s should be simulated~~.

- Not Much Change From 2003.

# Thermal Heating

- During age conditioning the equipment should be energised as in normal conditions of operation and periodically checked.
- If equipment is not continuously energised, it shall be justified that the thermal heating of equipment due to being energised is taken into account and that adequate design precautions have been taken to limit thermal heating.

# Moisture

- moisture (humidity level, condensation, submergence and corrosive environment) noted as aging factor to be considered
  - Environmental extremes of humidity noted in 2003
  - Condensation, chemical spray, and submergence were noted in 2003 as service conditions
  - Moisture, Humidity, Water and Chemicals noted in IEEE 1205 as aging mechanisms

# Operating Experience

- In 6.1.2 added: “When qualification for mild environment is required,” before operating experience.  This is to indicate that operating experience alone is only applicable to mild environments.

# Programmable Devices

- In 6.1.1 some editorial and added “Equipment qualification testing shall be performed with equipment functioning in a state representative of its intended use in actual operation (including any software).”
- Qualification testing of programmable equipment shall be performed with the equipment functioning using configuration (including software and diagnostic tools) representative of those in actual operation, while the system is subjected to the specified environmental conditions. All portions of the programmed equipment necessary to accomplish safety functions or whose failure could impair safety functions should be exercised during testing. A representative configuration of the computer-based system shall be subjected to type testing. Testing of the whole computer-based equipment is preferred. When testing as a whole is not practical, testing of individual modules shall include analysis of the cumulative effects of environmental and operational stress and the dynamic response of the I&C system to the most limiting environmental and operational conditions.

# Condition Monitoring

- In 6.2 changed extension of qualified life to reassessment of qualified life. This is to highlight that change in qualified life may be longer or shorter.
  - This section was re-written for clarity and broken into multiple methods.
- 6.3 on condition monitoring was expanded. "Since measurements for condition indicators may be taken at one temperature, additional data may be required to provide a correlation with time and temperature." was added.
- In 7.3.4 & 7.3.5 noted that margin should be considered as part of the qualified life objective and are to be preserved while utilizing provisions for reassessing qualified life.

# Other IEEE Working Groups

- D7W – Evaluation of Installed Cable Systems (P1186)
- D12D – Plant Life Extension
- D20W – Guide for Specifying and Selecting Cables for Nuclear Faculties (P2776)
- IEEE 344 Harmonizing With IEC 60980, *Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generating stations*
- P2425 *Standard for Electromagnetic Compatibility Testing of Electrical and Instrumentation and Control Equipment at Nuclear Power Generating Stations and Other Nuclear Facilities*

# QUESTIONS