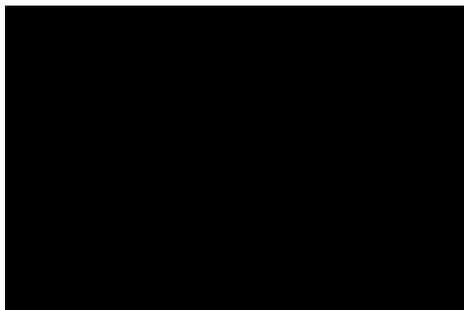


# Qualification, Dedication and Reverse Engineering

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# Presentation Objectives

- Discuss how Dedication & Reverse Engineering can impact qualification
- Identify where misunderstanding of the different processes can result in potential regulatory issues
- Review aspects of a recent example where unclear distinction between the different processes led to an Unresolved Item in an NRC EQ Inspection

# Basic Concepts

What is Equipment Qualification?

- **The generation and maintenance of evidence to assure that nuclear safety related systems and equipment will operate on demand, to meet system performance requirements**

What is Environmental Qualification (EQ)

- **The generation and maintenance of auditable evidence that ensures that safety systems and equipment will operate on demand, to meet system performance requirements *within specified environmental conditions***

# Basic Concepts

## Qualification Methods

**10 CFR 50.49(f) allows 4 methods of qualification:**

**(f) Each item of electric equipment important to safety must be qualified by one of the following methods:**

- (1) Testing an identical item** of equipment under identical conditions or under similar conditions with a supporting analysis to show that the equipment to be qualified is acceptable.
- (2) Testing a similar item** of equipment with a supporting analysis to show that the equipment to be qualified is acceptable.
- (3) Experience with identical or similar equipment** under similar conditions with a supporting analysis to show that the equipment to be qualified is acceptable.
- (4) Analysis in combination with partial type test data** that supports the analytical assumptions and conclusions.

# Basic Concepts

## Qualification Methods

Regulatory Guide 1.89, Revision 1 says the procedures described by IEEE Standard 323-1974 are acceptable for satisfying the Commission's regulations pertaining to qualification of electrical equipment with some clarifications and additional specific guidance. The clarifications do not impact qualification methods.

# Basic Concepts

## Qualification Methods

**IEEE Standard 323-1974 states the following methods are acceptable for demonstrating qualification:**

5.1 Type Testing

5.2 Operating Experience

5.3 Analysis

5.4 Combination of the above methods

# Basic Concepts

## Qualification Methods

### **IEEE Standard 323-1974 states:**

It is the primary role of qualification to assure that for each type of Class 1E equipment the design and the manufacturing processes are such that there is a high degree of confidence that future equipment of the same type will perform as required.

## Summary

Based on these documents, re-qualification is not necessary if similarity to the test item is established.

But what constitutes an adequate similarity analysis?

## Similarity Analysis

There is very little regulatory guidance on what constitutes an adequate similarity analysis.

There is industry guidance in the form of Standards and consensus documents that provide considerations for similarity analyses.

## Similarity Analysis

The 1983 and later versions of IEEE Std 323<sup>1</sup> provide criteria to be considered to extrapolate test data to similar equipment:

Material

Stress

Size

Aging Mechanisms

Shape

Function

<sup>1</sup> The current version of IEEE Std 323 endorsed by Reg Guide 1.89, Revision 1 is IEEE Std 323-1974. In a periodic review of RG 1.89 performed in December 2018, NRC Staff recommended revision of RG 1.89 to endorse the latest version of standard, IEC/IEEE 60780-323:2016.

## Similarity Analysis

IEEE Std 381-1977 (Modules), if the word device is substituted for module, provides a concise summary of the Standard's perspective on establishing similarity. Considerations include:

1. Component physical arrangement: size, mounting features, interconnections, stresses, heat generation/dissipation, and electromagnetic susceptibility
2. Aging effects
3. Environmental effects
4. Performance requirements

## Similarity Analysis

EPRI 1021067, *Nuclear Power Plant Equipment Qualification EQ Reference Manual, Revision 1*, Chapter 7 and Appendix C provide additional detail.

Insights into NRC perspectives on similarity can be gained from a paper presented at the 2014 NRC Workshop on Vendor Oversight, *Establishing Similarity to Previously Qualified Equipment*, Jacobson (ML 14153A170)

## Similarity Analysis

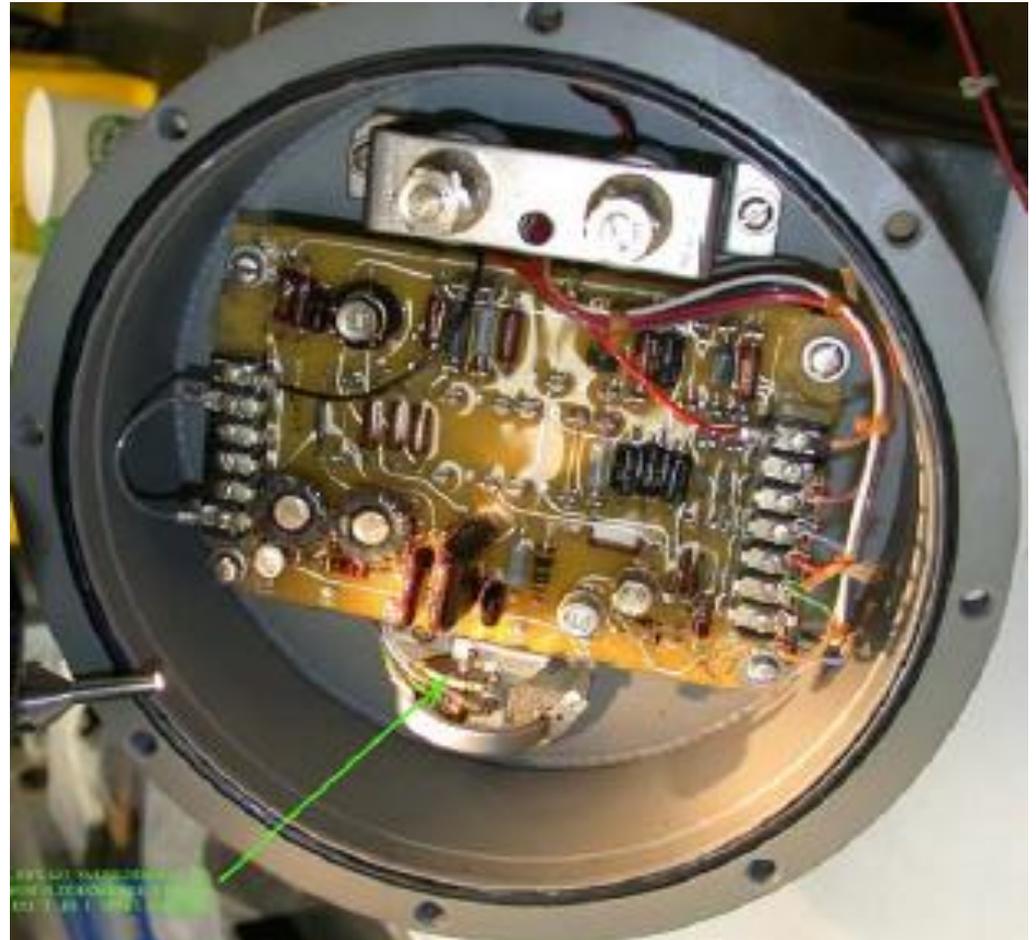
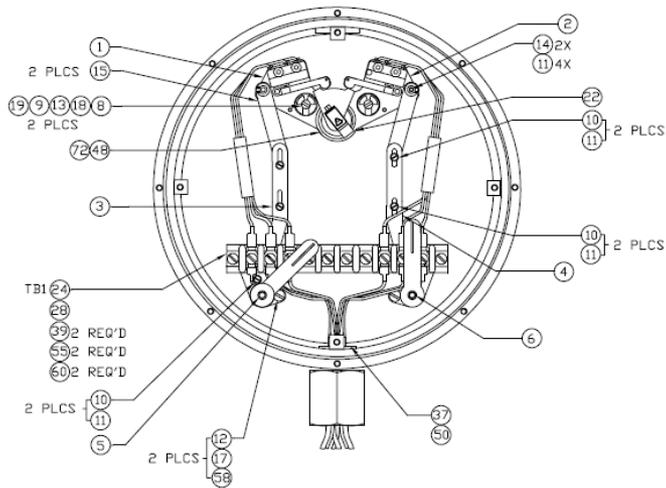
Question:

Can Commercial Grade Dedication and/or Reverse Engineering be used to establish similarity?

Let's review a recent NRC Inspection Issue that brings to light some issues and misunderstandings

# Case Study - Commercial Grade Dedication Unresolved Item

## Barton O-ring Commercial Grade Dedication



# Case Study

## Background

- The Licensee qualified Barton 764 Transmitters to Westinghouse Reports WCAP-8687 Supp. 2 - EQTR-E03A and WCAP-8587 Supp. 1 - EQDP-ESE-3A. The vendor, Westinghouse, was no longer able to supply housing and cover O-rings because the transmitter supplier (Cameron) no longer maintained a 10CFR50 Appendix B QA Program.
- The Licensee procured replacement O-rings from an alternate supplier, Curtiss-Wright.
- The O-rings supplied to the Licensee by both Curtiss-Wright (CW) and Westinghouse were manufactured and supplied by Parker.
- The O-rings supplied by Curtiss-Wright were supplied to the Licensee as basic components. Curtiss-Wright dedicated the O-rings by performing dimensional checks, durometer measurements and verifying material composition by infrared spectroscopy.
- Additionally, Curtiss-Wright compared the results of these tests to the same tests performed on an O-ring purchased by the Licensee from Westinghouse.
- Parker confirmed to Curtiss-Wright that the EPDM compound had not changed between the batches of the TVA-provided O-ring and the CW supplied O-rings.

# Case Study

## Background

- The Licensee's EQ File has two narrative sections describing the reverse engineering of the Curtiss-Wright-supplied O-rings.
- The Licensee Procurement Engineering Group Package describes the reverse engineering process and based on the reverse engineering and equivalency evaluation indicate that the substituted O-rings is a change in procurement process only.

# Case Study

## Background

During the inspection, the NRC posed this question: “Tab C/C-10 of WBNEQ-XMTR-001 provides justification of reverse engineered O-rings. Provide justification for why it is acceptable to qualify these O-rings to original test report?” (question extracted from licensee inspection database)

The licensee provided the following explanation:

Some O-rings were purchased from Westinghouse and certified to be equal to or better than the O-rings supplied with the original transmitters, and are therefore qualified to the original qualification reports.

More recently, O-rings were purchased from CW/Scientech under their Appendix B QA Program, compared to Westinghouse-supplied O-rings, and are the same compound as the Westinghouse-supplied O-rings.

# Case Study

## Background

During the inspection, the NRC posed this question: “Can spectroscopy validate the activation energy and aging mechanisms of a material?”  
(question extracted from licensee inspection database)

The licensee included the following statement: “The current replacement O-ring materials are supplied to TVA by EGS (QualTech / Curtiss-Wright), and the materials are dedicated in accordance with TVA approved Curtiss-Wright dedication test procedure# CJ5765-1 Rev. 0 (Reference PEG Package P01453092).” (response extracted from licensee inspection database)

CW was treated as an alternate supplier. There is no discussion of reverse engineering in the licensee response to the inspector question.

## Case Study

**Based on the information provided during the inspection, the NRC opened an Unresolved Item (URI)**

### **What does the URI state?**

Watts Bar Inspection Report 2017-007: (NRC Report 05000390/2017007 and 05000391/2017007 (ML17220A153))

Potential Failure to Justify Qualification of O-Rings by Commercial Grade Dedication

- 1) The inspectors could not verify that this dedication process specified the required critical characteristics to ensure compliance with 10 CFR 50.49.

### What does the URI state?

Watts Bar Inspection Report 2017-007 (NRC Report 05000390/2017007 and 05000391/2017007 (ML17220A153):

- 2) The inspectors further questioned how uncertainties could be determined and evaluated from these techniques. Since the licensee is relying on this dedication process, the components were not aged and tested in accordance with 10 CFR 50.49 requirements. The licensee contends that the verification of the material by FTIR and durometer analysis provided reasonable assurance that the original qualification test reports by Westinghouse remained applicable to the dedicated O-rings. This URI is opened to determine if a performance deficiency exists.

## Case Study

**Consider this statement from NRC Report 05000390/2017007 and 05000391/2017007 (ML17220A153):**

- In 2008, TVA began to dedicate commercial grade O-rings from Parker Hannifin through a vendor, QualTech.

## Case Study

**Consider this statement from NRC Report 05000390/2017007 and 05000391/2017007 (ML17220A153):**

When asked if this FTIR or durometer test can verify activation energy or other aging mechanisms, the licensee stated, that FTIR cannot by itself validate activation energy or thermal aging mechanisms.

# Case Study

## Discussion

- **Did the vendor actually use reverse engineering or commercial grade dedication?**
- **In this case, does it matter from a qualification perspective?**

## Case Study

- **Did the vendor establish that the replacement item was equivalent?**
- **What critical characteristics were evaluated?**
  - Durometer
  - Material Composition (By Fourier-Transform Infrared Spectroscopy (FTIR))
  - Dimensions

## Case Study

### Summary of Issue

Use of the term “Reverse Engineered” brought into question if the original qualification test was still applicable.

The inspector is asking if activation energy is a critical characteristic.

## Case Study

- **Activation Energy is a material property. If you verify the material to be the same (dimensionally & material composition) you have verified the activation energy to be the same.**
  
- **Even so, how could one re-verify activation energy as a critical characteristic?**

## Case Study

### How would you re-verify activation energy as a critical characteristic?

- One method would be to compare the activation energy of a known sample of the materials. TVA provided a single Westinghouse-supplied O-ring for comparison.
- One could determine the activation energy by Differential Scanning Calorimetry or Thermogravimetric Analysis. There is enough sample material to do this. However, these methods are not recommended for determining thermal life of materials and are essentially material composition comparisons. The FTIR is a more precise method of material composition comparison.

# How would you re-verify activation energy as a critical characteristic?

- Determine an activation energy of the material per traditional methods accepted for thermal life evaluation or thermal index determination. These methods require large number of samples and recommended aging times are between one week and one year. There is not enough sample material in one O-ring to perform this testing.
- The activation energy used in qualification of the O-rings is based on testing outside the qualification program. Usually a conservative value of several candidates is chosen. Therefore, unless there is enough sample material to determine the activation energy of the original O-ring, activation energy cannot be used as a critical characteristic, and even if enough sample material were available, it is not a practical test from a time perspective.

## Summary

- Commercial Grade Dedication is a process to accept items for use as basic components. If qualification **applies**, critical characteristics **are necessary to ensure the dedication establishes that qualification is maintained.**
- Reverse Engineering **involves application of techniques to recover design information to facilitate replacement of an item. Qualification must be addressed during the RE process.**

## Summary

- Commercial Grade Dedication currently has an endorsed process, whereas Reverse Engineering is not a term that is even defined in regulatory space
- Activation energy is not a practical critical characteristic, nor is it required to verify material similarity

## Conclusion

After nearly two years, the URI was closed, concluding no performance deficiency existed. **NRC Report 05000390/2019001 and 05000391/2019001 (ML19133A221) (05/13/2019):**

The inspectors reviewed additional information provided by the licensee, including commercial grade dedication documentation from the vendor and independent technical assessments of their commercial grade dedication process. The inspectors noted that the O-rings in question were sourced from the same manufacturer (Parker Hannifin) as those used by Westinghouse and Cameron/Barton (the original O-ring suppliers prior to the change in 2008). Based on the above information, the inspectors determined that the licensee had reasonable assurance of a like-for-like material replacement for the original Westinghouse/ Cameron supplied O-rings, and therefore, no performance deficiency existed.

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