UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
245 PEACHTREE CENTER AVENUE NE, SUITE 1200
ATLANTA, GEORGIA 30303-1257

January 24, 2018

Mr. Joseph W. Shea
Vice President, Nuclear Regulatory
Affairs and Support Services
Tennessee Valley Authority
1101 Market Street, LP 4A
Chattanooga, TN 37402

SUBJECT: SEQUOYAH NUCLEAR PLANT - NRC DESIGN BASES ASSURANCE INSPECTION (PROGRAMS) REPORT NUMBER 05000327/2017008 AND 05000328/2017008

Dear Mr. Shea:

On December 11, 2017, the U.S. Nuclear Regulatory Commission (NRC) completed onsite inspection activities at your Sequoyah Nuclear Plant Units 1 and 2. On December 11, 2017, the NRC inspectors discussed the results of this inspection with Mr. Rasmussen and other members of your staff. Additional inspection results were discussed with Mr. Rasmussen and other members of your staff on January 19, 2018. The results of this inspection are documented in the enclosed report.

NRC inspectors documented two findings of very low safety significance (Green) in this report. These findings involved violations of NRC requirements. The NRC is treating these violations as non-cited violations (NCVs) consistent with Section 2.3.2.a of the Enforcement Policy.

If you contest the violations or significance of these NCVs, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001; with copies to the Regional Administrator, Region II; the Director, Office of Enforcement; and the NRC resident inspector at the Sequoyah Nuclear Plant.

This letter, its enclosure, and your response (if any) will be made available for public inspection and copying at http://www.nrc.gov/reading-rm/adams.html and at the NRC Public Document Room in accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding."

Sincerely,

/RA/

Shakur A. Walker, Chief
Engineering Branch 1
Division of Reactor Safety

Docket No.: 50-327; 50-328
License No.: DPR-77; DPR-79

Enclosure:
Inspection Report 05000327/2017008
and 05000328/2017008 w/Attachment:
Supplemental Information

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SUBJECT: SEQUOYAH NUCLEAR PLANT - NRC DESIGN BASES ASSURANCE INSPECTION (PROGRAMS) REPORT NUMBER 05000327/2017008 AND 05000328/2017008

Distribution:
T. Fanelli, RII
M. Greenleaf, RII
C. Franklin, RII
S. Walker, RII
A. Masters, RII
S. Ninh, RII

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U. S. NUCLEAR REGULATORY COMMISSION

REGION II

Docket No.: 50-327; 50-328

License No.: DPR-77, DPR-79

Report No.: 05000327/2017008, 05000328/2017008

Licensee: Tennessee Valley Authority (TVA)

Facility: Sequoyah Nuclear Plant, Units 1 and 2

Location: Sequoyah Access Road
Soddy-Daisy, TN 37379

Dates: November 13 – December 11, 2017

Inspectors: T. Fanelli, Senior Reactor Inspector (Lead)
M. Greenleaf, Reactor Inspector
C. Franklin, Reactor Inspector

Approved by: Shakur A. Walker, Chief
Engineering Branch 1
Division of Reactor Safety

Enclosure

SUMMARY

05000327/2017008, 05000328/2017008; 11/13/2017 – 12/11/2017; TVA, Sequoyah Nuclear Plant, Units 1 and 2; Design Bases Assurance Inspection (Programs)

The onsite inspection activities described in this report were performed between November 13 and December 11, 2017, by three Nuclear Regulatory Commission (NRC) inspectors from Region II. Two Green non-cited violations (NCVs) findings were identified. The significance of inspection findings are indicated by their color (i.e., greater than Green, or Green, White, Yellow, or Red) and determined using Inspection Manual Chapter (IMC) 0609, "Significance Determination Process," (SDP) dated April 29, 2015. Cross-cutting aspects are determined using IMC 0310, "Aspects Within the Cross-Cutting Areas," dated December 4, 2014. All violations of NRC requirements were dispositioned in accordance with the NRC's Enforcement Policy dated November 1, 2016. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 6.

Cornerstone: Mitigating Systems

- Green The team identified a Green NCV of Title 10 Code of Federal Regulations 50.49(e)(5) "Aging" when the licensee failed to replace, refurbish, or demonstrate additional life for components that exceeded their qualified life. The licensee failed to justify changes to the accelerated aging calculations used for power operated relief valve harsh environmental qualification. The licensee entered this issue into their corrective action program as CRs 1365730 and 1366082, and performed operability determinations, which determined the systems were operable but non-conforming with 10 CFR 50.49.

  The performance deficiency was determined to be more than minor because it was associated with the Design Control attribute of the Mitigating Systems Cornerstone and adversely affected the cornerstone objective of ensuring the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the failure to ensure that Target Rock power-operated relief valves were qualified for the duration that they were required to operate reduced the reliability of reactor coolant system in the harsh environments of design basis accidents. In accordance with IMC 0609.04, "Initial Characterization of Findings," and Exhibit 2 of IMC 0609, Appendix A, "The SDP for Findings At-Power," the team determined that the finding was of very low significance (Green) because it was a design deficiency that affected the design or qualification of a mitigating system, however, the mitigating system maintained its operability. The team determined there was no cross-cutting aspect associated with this finding since it was not indicative of current licensee performance.

- Green The team identified a Green NCV of Title 10 Code of Federal Regulations 50.49(f) "Electrical Equipment Qualification" when the licensee failed to perform an adequate similarity analysis for the environmental qualification of their Reliance 75 horsepower reactor lower compartment cooling fan motors. The licensee entered this issue into their corrective action program as CR1366056 and performed an operability determination, which determined the reactor lower compartment cooling fan motors were operable but non-conforming in accordance with 10 CFR 50.49.

The performance deficiency was determined to be more than minor because it was associated with the Design Control attribute of the Mitigating Systems Cornerstone and adversely affected the cornerstone objective of ensuring the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, failing to ensure the qualification of the reactor lower compartment cooling fan motors adversely affected their reliability and capability in the harsh environment of a design basis accident, which in turn adversely affected the reliability and capability of other environmentally qualified components that rely on the containment cooling system. In accordance with IMC 0609.04, "Initial Characterization of Findings," and Exhibit 2 of IMC 0609, Appendix A, "The SDP for Findings At-Power," the team determined that the finding was of very low significance (Green) because it was a design deficiency that potentially affected the design or qualification of a mitigating system; however, the mitigating system maintained its operability. The team determined there was no cross-cutting aspect associated with this finding since it was not indicative of current licensee performance.

REPORT DETAILS

1. REACTOR SAFETY

Cornerstones: Mitigating Systems, Barrier Integrity

1R21 Design Bases Assurance Inspection (Programs) (71111.21N)

a. Inspection Scope

The inspectors performed an inspection conducted as outlined in NRC Inspection Procedure (IP) 71111.21N, Attachment 1, "Environmental Qualification (EQ) under 10 CFR 50.49 Programs, Processes, and Procedures." The inspectors assessed Sequoyah's implementation of the site EQ program as required by 10 CFR 50.49, "Environmental qualification of electric equipment important to safety for nuclear power plants." The inspectors evaluated whether Sequoyah's staff properly maintained the EQ of electrical equipment important to safety throughout plant life, established and maintained required EQ documentation records, and implemented an effective corrective action program to identify and correct EQ related deficiencies.

The inspection included review of EQ program procedures, component EQ files, test records, equipment maintenance and operating history, maintenance and operating procedures, vendor documents, design documents, and calculations. The inspectors interviewed program owners, engineers, and warehouse staff. The inspectors performed in-plant walkdowns (where accessible) to verify equipment was installed as described in Sequoyah's EQ component documentation files; and that the components were installed in their tested configuration. Additionally, the inspectors performed in-plant walkdowns to determine whether equipment surrounding the EQ component could fail in a manner that could prevent the safety function of the components, and to verify that components located in areas susceptible to a high-energy line break were properly evaluated for operation in a harsh environment. The inspectors reviewed and inspected the storage of replacement parts and associated procurement records to verify EQ parts approved for installation in the plant were properly identified and controlled, and that storage and environmental conditions did not adversely affect the components' qualified lives. Documents reviewed are listed in the Attachment.

The inspection procedure requires the inspectors to select six to ten components to assess the adequacy of the EQ program. The inspectors selected eight components for this inspection, five of which were located inside containment. Component samples selected for this inspection are listed below:

- FT-063-0020, Weed Instrument, Safety Injection System Pump B Flow Transmitter
- PSV-068-0334, Reactor Coolant System Pressurizer Power Operated Relief Valve
- MTRB-030-0074-A, Reactor Lower Compartment Cooling Fan Motor
- 2-MTRA-074-0020-B, RHR motor 2B
- MVOP-063-0072-A, Sump Swap-Over Valve
- MVOP-70-087, Thermal Barrier Return Containment Isolation Valve
- PS-030-0046B, Containment High Pressure Alarm Switch
- FSV-32-80, Containment Air Control Isolation Solenoid Valve

b. Findings

.1 Unjustified Qualified Life for Target Rock Power-Operated Relief Valves (PORVs)

Introduction: The team identified a Green non-cited violation (NCV) of Title 10 Code of Federal Regulations (CFR) 50.49(e)(5) "Aging" when the licensee failed to replace. refurbish, or demonstrate additional life for components that exceeded their qualified life. The licensee failed to justify changes to the accelerated aging calculations used for PORV harsh environmental qualification (EQ).

Description: The licensee incorrectly determined a longer, less limiting, qualified life that increased the probability of common cause failures during design basis accidents (DBAs). When these changes were made to the accelerated aging (Arrhenius) calculations, the licensee did not prove that the original, more limiting, qualified life was unrealistic, nor did they prove the capability of the Target Rock PORVs would not be adversely affected.

The changes to the aging calculation SQNAPS2-205 were made to the inputs for the accelerated aging rate (time and temperature) and the activation energy. The inspectors noted that the PORVs were often subjected to more severe service temperatures than were identified by Target Rock prior to these licensee changes to the original qualification. The change to the accelerated aging rate was from 46 days (1104 hours at 280°F) to 10,000 hours at 260°C (500°F). The licensee is committed to NUREG-0588 for Catgory 1 EQ requirements. When making this change, the licensee did not perform a material phase changes analysis as required by NUREG-0588. The new rate was taken from a thermal life expectancy curve used for National Electrical Manufacturers Association (NEMA), Class ratings for mean-time-to-failure (MTTF), as opposed to the required test sequences for EQ. This was not adequate to qualify the PORVs for the 60 years established by the licensee. The MTTF is the point of thermal failure. The end of qualified life required the simulation of a lifetime of thermal stress, radiation stress, and mechanical stressors prior to and during a design basis accident simulation. In addition, when the licensee changed the acceleration rate that was used in the actual qualification to anything other than what was actually performed by Target Rock testing; the change invalidated the Target Rock qualification. The licensee inappropriately changed the most limiting component identified by Target Rock as showing the most limiting activation energy. The coil epoxy potting activation energy, 0.98 eV, was disregarded in favor of the magnet wire's activation energy, 1.59 eV. The epoxy potting performed a safety function in the PORV coil assembly, thus its activation energy was required to be considered for qualified life calculations. The licensee agreed that these changes were non-conformances to 10 CFR 50.49. When the licensee recalculated the qualified life of the PORV using the justified aging acceleration rate and activation energy, the qualified life of the PORVs was significantly less than 60 years. The licensee preliminarily indicated to the inspectors that the qualified life would be less than their current age of approximately 30 years. Some of the PORVs, which have been in service since at July 19, 1980 for Unit 1 and November 5, 1981 for Unit 2,were now demonstrated to be installed beyond their qualified life.

The inspectors reviewed the licensing basis and determined the design control requirements for aging in NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment Including Staff Responses to Public Comments," dated 11/1/1981, Section 4(5) required, that "known material phase changes and reactions should be defined to ensure that no known changes occur within

the extrapolation limits," ("staff position: claims that conservative extrapolation limits have been implemented must be supported") and Section 4(6) required, "the aging acceleration rate used during qualification testing and the basis upon which the rate was established should be described and justified," ("staff position: testing of the equipment should be conducted using the most limiting (lowest) activation energy of the components"). Additionally, Regulatory Guide (RG)1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," revision 1, Regulatory Position C.5.c, "Section 6.3.3, 'Aging,' of IEEE Std. 323-1974," (the IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations), required, in part, that "the aging acceleration rate and the basis upon which it was established be described, documented, and justified."

Analysis: The failure to justify the aging acceleration rate and basis upon which it was established in accordance with NUREG-0588 and RG 1.89 was a performance deficiency. The performance deficiency was determined to be more than minor because it was associated with the Design Control attribute of the Mitigating Systems Cornerstone and adversely affected the cornerstone objective of ensuring the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the failure to ensure that Target Rock PORVs were qualified for the duration they were required to operate reduced the reliability of reactor coolant system in the harsh environments of DBAs. In accordance with IMC 0609.04, "Initial Characterization of Findings," and Exhibit 2 of IMC 0609, Appendix A, "The SDP for Findings At-Power," the team determined that the finding was of very low significance (Green) because it was a design deficiency that potentially affected the design or qualification of a mitigating system, however, the mitigating system maintained its operability. The team determined there was no cross-cutting aspect associated with this finding since it was not indicative of current licensee performance.

Enforcement: Title 10 CFR 50.49(e)(5) stated, in part, that equipment qualified by test must be must be replaced or refurbished at the end of its designated life unless ongoing qualification demonstrates that the item has additional life. Contrary to the above since August 5 1998, the licensee did not replace or refurbish equipment qualified by test at the end of its designated life nor demonstrate through ongoing qualification that the valves had additional life. Specifically, the licensee inappropriately changed the aging acceleration rate and activation energy used to determine the required end of life replacement or refurbishment schedule, and failed to perform ongoing qualification to demonstrate that the PORVs had additional life. For immediate corrective actions, the licensee entered this issue into their corrective action program as CRs 1365730 and 1366082 and performed operability determinations, which determined the systems were operable but non-conforming with 10 CFR 50.49. Because this issue is of very low significance and has been entered into the licensee's corrective action program, this violation is being treated as an NCV, consistent with Section 2.3.2.a of the NRC Enforcement Policy. (NCV 05000327/2017008-01, 05000328/2017008-01, "Unjustified Qualified Life for Target Rock Power-Operated Relief Valves")

.2 Inadequate Qualification for Reactor Lower Compartment Cooler Motors

Introduction: The team identified a Green NCV of 10 CFR 50.49(f) when the licensee failed to perform an adequate similarity analysis for the environmental qualification of their Reliance 75 horsepower (hp) reactor lower compartment cooling (RLCC) fan motors.

Description: The similarity analysis provided by the licensee in EQ Binder MOT-004, Tab C-2 was based on a qualification documented in test report NUC-22. The documented test was for a 3 hp, continuous duty, NEMA Class H-type-RH insulated totally enclosed fan cooled (TEFC) motor. The Unit 1 RLCC fan motors are Reliance 75 hp continuous duty, Class H-type-RH insulated totally enclosed air over (TEAO) motors. The licensee stated that the similarity of the motors is established by the certificate of conformance for the motors that certified the motors to IEEE Std. 323-1974 and included NUC-22 as a qualification file. The licensee furthermore based similarity on the presence of the Class H-type-RH insulation being present in both motors.

The licensee is committed to NUREG-0588 for Catgory 1 EQ requirements. Ancillary standard IEEE Std. 334-1974, "IEEE Standard for Type Tests of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations," was used by the licensee to meet the NUREG-0588 Category 1 requirements. Section 6.3.2, specified, in part, that "if a full-size machine is not tested, type test reports shall identify all materials and features not specifically representative of the full-size motors, justifying the interpretation placed on each parameter. Typical parameters as listed in Table 1." Table 1 identified parameters for normal, design basis event, and post-event endurance (DBA conditions). The parameters included, in part, radiation, voltage, pressure, temperature and temperature rise. The testing in NUC-22 subjected the 3 hp test motor to thermal aging, irradiation, and mechanical vibration, but it did not subject the test motor to DBA conditions required by Category 1 requirements and the ancillary standard. The DBAs for the 75 hp motor were identified in the Updated Final Safety Analysis Report (UFSAR) as a main steam line break and a feedwater line break. Without subjecting the 3 hp test motor to the required DBA conditions, qualification could not be established. Without justifying the interpretation placed on a complete set of material and feature parameters as required by the ancillary standard, similarity could not be established between the 3 hp test motor and the installed 75 hp motor.

The Category 1 requirements in NUREG-0588, Section 2, specified, in part, that the test sequence should conform fully to the guidelines established in Section 6.3.2 of IEEE Std. 323-1974. The test procedures should ensure that the same piece of equipment is used throughout the test sequence, and that the test simulates as closely as practicable the postulated accident environment. The requirements in IEEE Std. 323-1974, Section 6.3.2, "Test Sequence," required, in part, that the type-tested equipment shall be aged to its end-of-qualified life condition including radiation; subjected to such mechanical vibration as will be seen in service; and then operated while exposed to its most limiting simulated design basis event. In addition, NUREG-0588 resolution to Section 5(2), specified, "the staff position does not exclude the use of data from tests conducted on similar equipment as long as independent verification of similarity or equivalence can be established. It is incumbent on the applicant to have the necessary documentation to justify the adequacy of using data from similar or equivalent equipment."

Analysis: The licensee's failure to qualify the RLCC fan motors to Category 1 requirements in accordance with NUREG-0588 and IEEE 323-1974 was a performance deficiency. The performance deficiency was determined to be more than minor because it was associated with the Design Control attribute of the Mitigating Systems Cornerstone and adversely affected the cornerstone objective of ensuring the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, failing to ensure the qualification of the RLCC fan motors adversely affected their reliability and capability in the harsh

environment of a DBA, which in turn adversely affected the reliability and capability of other EQ components that rely on the containment cooling system. In accordance with IMC 0609.04, "Initial Characterization of Findings," and Exhibit 2 of IMC 0609, Appendix A, "The SDP for Findings At-Power," the team determined that the finding was of very low significance (Green) because it was a design deficiency that potentially affected the design or qualification of a mitigating system, however, the mitigating system maintained its operability. The team determined there was no cross-cutting aspect associated with this finding since it was not representative of current licensee performance.

Enforcement: Title 10 CFR 50.49(f) stated, that electrical equipment important to safety 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.

Contrary to the above, since July 1, 1986, the licensee failed to ensure that electrical equipment important to safety was qualified by one of the methods described in 50.49(f). Specifically, the licensee failed to qualify the RLCC fan motors by testing a similar fan motor with a supporting analysis to show that the RLCC fan motors would be acceptable. For immediate corrective actions, the licensee entered this issue into their corrective action program as CR1366056 and performed an operability determination, which determined the RLCC fan motors were operable but non-conforming to 10 CFR 50.49. Because the failure to verify this condition is of very low significance and has been entered into the corrective action program, this violation is being treated as an NCV, consistent with Section 2.3.2.a of the NRC Enforcement Policy. (NCV 05000327/2017008-02 "Inadequate Qualification for Unit One Reactor Lower Compartment Cooler Motors.")

.3 (Opened) Unresolved Item (URI), Potential Inadequate Use of Thermal Aging and the Arrhenius Methodology

Introduction: The inspectors identified a URI for the licensee's use of the Arrhenius methodology without consideration for the limits of extrapolation and confidence bounds for statistical uncertainties.

Description: The licensee did not consider the limits of extrapolation specified for Category 1 qualification in NUREG 0588 Section 4 and IEEE 323-1974 Section 6.5, "Determination of Qualification." NUREG-0588, Section 4(5) required, in part, that "known material phase changes and reactions should be defined to insure that no known changes occur within the extrapolation limits," ("staff position: claims that conservative extrapolation limits have been implemented must be supported"). Standard IEEE 323-1974, Section 6.5, specified, in part, that "the qualified life shall be based upon the known limits of extrapolation of the time dependent environmental effects if an accelerated aging test was used to determine the mathematical model." Ancillary quality standards to IEEE 323-1974 and nuclear industry EPRI reports specified that

extrapolating beyond the extrapolation limits could invalidate the results of the Arrhenius methodology.

The ancillary standards used for qualification of the various examples specified the limits of extrapolation to be no greater than 30 °C from the test data used to determine activation energies. In addition, the licensee did not consider adequate confidence bounds to account for the statistical uncertainties present when using the Arrhenius methodology. The inspectors noted that the uncertainties grow exponentially when exceeding the extrapolation limits.

- The Limitorque MOV motor life line appeared to have been extrapolated from test data at 240° C to 50° C, which is 190° C from the test data.
- The silicone rubber cable, life line appeared to have been extrapolated from test data at 210° C to 51.67° C, which is 188.3° C from the test data.
- The ASCO Valves, life line appeared to have been extrapolated from test data at 266° C to 40° C, which is 226° C from the test data.
- The Target Rock Valves, life line appeared to have been extrapolated upward from the test data.
- The Westinghouse RHR Motor rewind, life line appeared to have been extrapolated from test data at 180° C to 58.6° C, which is 121° C from the test data. 275° C is 216° C from test data

The ancillary quality standards used in the qualification of these examples included IEEE 98-1972, “IEEE Standard for the Preparation of Test Procedures for the Thermal Evaluation of Solid Electrical Insulating Materials;” IEEE 101-1972, “IEEE Guide for the Statistical Analysis of Thermal Life Test Data;” IEEE 117-1974, “IEEE Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery,” and other quality standards.

IEEE 98-1972, Section 10, “Temperature Exposures,” specified, in part, that “the lowest test temperature shall be chosen so that the extrapolation necessary to establish the temperature index will not be more than 25° C.”

IEEE 101-1972, Section 1.3, “Extrapolation,” specified, in part, that “extrapolation of the [qualified life] line below the range of test temperatures may cause erroneous predictions if the chemical reactions controlling the insulation aging are different at lower temperatures or if other conditions affecting the aging or the mode of failure are different. Therefore, the methods outlined in this guide are applicable only if all of the assumptions behind the use of the Arrhenius equation are met [identified in references].”

IEEE 117-1974, Section 3.3.1, “Thermal Aging,” specified, in part, “for any system being evaluated, tests are made for at least three different temperatures. The lowest test temperature should be no more than 25° C above the system temperature rating. The highest temperature test should be at least 40° C above lowest temperature test, and temperature points should be selected to give approximately equal temperature intervals. The average life at the highest temperature shall be no less than 100 hours.”

The inspectors are concerned that the licensee did not meet the aforementioned Category 1 requirements in their licensing basis. The licensee has captured these concerns in their corrective action program as CR 1366022. The inspectors need further information from the licensee and NRC technical staff to evaluate the concerns. This URI

is opened to determine if a performance deficiency exists. (URI 05000327/2017008-03, 05000328/2017008-03, "Potential Inadequate use of thermal aging and the Arrhenius methodology")

.4 (Opened) Unresolved Item, Potential Inadequate Determination of Failure Modes for Qualified Life for Foxboro/Weed Instrument

Introduction: The inspectors identified a URI to review the adequacy of the licensee's justification for failure modes and the degradation leading to them in the determination of the qualified life for the Foxboro/Weed Instrument transmitters documented in the licensee's EQ Binder IPT-002.

Description: The inspectors reviewed EQ Binder IPT-002 for Foxboro/Weed Instrument flow transmitter qualification. In reviewing qualification test report QOAACIO, Rev. A, the inspectors identified two concerns with the qualification.

a. The inspectors noted that the qualification test report identified that polysulfone had the most limiting activation energy, 0.72 eV, for the Weed instrument assembly. However, the 0.72 eV was not being used by the licensee to determine the qualified life in the Arrhenius calculations in accordance with NUREG-0588 Section 4(6) and RG 1.89, Rev. 1, C.5.c. When inspectors questioned the licensee's use of a less limiting activation energy (0.78 eV for resistors), the licensee determined that the 0.72 eV was based on the degradation and failure modes associated with the tensile strength material property for polysulfone. The licensee consulted the component manufacturer, and determined that creep was the correct material property to be evaluated for end of life. The activation energy for polysulfone creep was identified as 3.81 eV. The inspectors have challenged the licensee's determination that creep is the only material property that can produce a failure of the sealing function for polysulfone. The inspectors noted that the requirements in IEEE Std. 323-1974, Section 5 require, in part, that assurance be provided that any extrapolation or inference be justified by allowances for known potential failure modes (i.e. loss of sealing function) and the mechanisms leading to them (i.e. the degradation in various material properties).

   If the degradation associated with creep is not the only degradation mechanism that could lead to a loss of sealing function over time, inspectors question if the degradation of other material properties would have more limiting activation energies than the licensee's current activation energy for the Foxboro/Weed Instrument transmitter (0.78 eV).

b. The 0.78 eV activation energy used by the licensee for qualified life was derived from an academic white paper that documented experiments performed in the early space program. The white paper specified that its experimental methods were not validated. The vendor that qualified the transmitter subsequently used this experimental information to determine the qualified life of the transmitters. This activation energy appeared not to be valid in the range of service temperatures that the transmitters are expected to age in prior to a DBA. The inspectors identified that these experimental tests did not follow any identifiable quality standard. The tests were conducted as early as 1963, the white paper was published in 1968, and the inspectors could not identify any subsequent verification of these experimental methods. Although no failure modes and effects analysis was evident, the table of

components in the qualification appeared to identify other components that could have much more limiting activation energies that were identified by qualification, as low as 0.5 eV.

The licensee has captured these concerns in their corrective action program as CR1366039, CR 1363427. The inspectors need further information from the licensee and NRC technical staff to evaluate the concerns. This URI is opened to determine if a performance deficiency exists. (URI 05000327/2017008-04, 05000328/2017008-04, "Potential Inadequate Determination of Failure Modes for Qualified Life for Foxboro/Weed Instrument")

.5 (Opened) Unresolved Item, Potential Inadequate Justification for Eliminating Preventative Maintenance for ASCO Valves

Introduction: The inspectors identified a URI to review the adequacy of the licensee's justification for eliminating the replacement of components that have a shorter life than the qualified life of the ASCO NP-1 valves assemblies.

Description: The inspectors reviewed records in environmental qualification data package (EQDP), SQNEQ-SOL-005, Revision 47. After the valve manufacturer (ASCO) stopped providing rebuild kits, the licensee eliminated the replacement schedule for subcomponents that had a shorter life than the valve assembly. The licensee changed the inputs to the accelerated aging calculation and recalculated the life of these subcomponents from the approximate eight-year replacement schedule to approximately 32.5 years.

The licensee changed the activation energies from 0.94eV and 0.96eV for ethylene-propylene-diene-monomer (EPDM) and Viton-A, respectively, to 1.1eV for both. Both, EPDM and Viton-A are rubber elastomers used within the ASCO valve assemblies. The licensee's written justification in the EQDP referenced a review of several studies for each elastomers, which identified less limiting activation energies than the activation energies ASCO selected in their qualification test reports. Each of these studies used different material degradation mechanisms and end of life failure mechanisms to derive different activation energies. The conclusion in the EQDP, for the change justification analysis, stated in part, that "these studies show that Sequoyah's original values were, in many cases, very overly conservative." The inspectors identified that the qualification of record, report AQR-67368, selected the qualification testing criteria based on the maintenance requirements (replacement schedule) specified in Appendix C of the report. The activation energies determined applicable in the ASCO test reports, (EPDM 0.94 eV and for Viton 0.96 eV) were determined by material testing and do not appear to inspectors to be "very overly conservative" (unrealistically low) or lacking in technical merit. In addition, the licensee did not consider the effect the various formulations for EPDM and Viton-A elastomers. The different formulations could non-conservatively affect the activation energies reviewed in their justification.

The licensee subsequently replaced the accelerated aging rate used in ASCO qualification test report AQR-67368 with the more thermally severe acceleration rate used in AQS-21678/TR, "ASCO Qualification Test Report," dated 7/1/1979. AQS-21678/TR does not appear to meet Category 1 requirements, yet its' accelerated aging rate was used to replace the Category 1 qualification-aging rate in AQR-67368. The AQS-21678/TR report, specified, in part, that coils and elastomeric components shall be replaced every 4 years as noted in the Valve Design Specification Sheets. The thermal

aging in AQR-67368 simulated a minimum of 2,000 cycles (~4.5 cycles/hr.), which was more limiting than the once every 6 hours (96 cycles) specified in AQS-21678/TR. The inspector noted that the test program specified in AQS-21678/TR used IEEE 382-1972, which did not meet Category 1 qualification requirements. The test program in AQR-67368 used IEEE 382-1980, which did meet Category 1 requirements. The forward to IEEE 382-1980, stated, in part, that the testing in the report "satisfies the latest issued requirements and standards," which were the NUREG-0588 Category 1 requirements issued for comment December 1979 and published in July 1981.

The licensee also used a lower self-heating temperature than which was specified in ASCO letter "ASCO Solenoid Valve Coil Heat Rise Data," dated 5/8/1986. The licensee determined that the ASCO heat-rise data in the above document was too conservative and used heat-rise data from the first testing done by the Franklin Research Center (FRC). Later, FRC completed NUREG/CR-5141 RV, "Aging and Qualification Research on Solenoid Operated Valves," dated 4/1/1988, which was referenced in the EQDP. The NUREG specified that: Aging in forced air ovens significantly limited heat rise from self-heating. The NUREG further specified that the qualified lives of the subcomponents were significantly reduced after accounting for the differences between forced air vs less turbulent air flow and the actual temperature measurements made by ASCO vs approximate temperature measurements made by other testing. Additional difference between ASCO heat rise testing and other testing including FRC's was that ASCO drilled holes in the valves to measure the actual subcomponent temperature while others only measured externally near the subcomponents to avoid damaging the valves. This produced lower temperature readings than ASCOs. The inspectors noted that even applying the 1.1 eV currently used, the life of the elastomers appeared to be approximately 4 to 8 years, not the 32.5 years identified in the EQDP

The ASCO qualification testing used nitrogen during the qualification testing. The NUREG/CR 5141 RV specified, that oxygen exposure from plant compressed air systems produced more degradation than did the nitrogen used in the ASCO qualification testing. The licensee determined that radiation margin from the qualification tests could be used to mitigate the differences between these two gases. The inspectors determined that both ASCO qualification reports, AQS-21678/TR and AQR-67368, used nitrogen instead of air, which limited the aging degradation. The inspectors question whether radiation margin can be applied to account for the difference between oxidizing gases and inert gases. In addition, the ASCO report AQR-67368, specified, that Viton elastomers significantly degraded above 18E6 test dose not 200E6 test dose used for the margin.

The inspectors are concerned that the licensee failed to meet the Category 1 requirements as specified in NUREG-0588 and IEEE 323-1974. Category 1 specified proof of conservative extrapolations, and use of the most limiting activation energy. Additionally, that users of IEEE 382-1972 must meet Category 1 requirements. Furthermore, the inspectors noted that the licensee was made aware of similar deficiencies and NRC staff positions in Technical Evaluation Report (TER)-C5257-532, "Implementation Guidance for New and Corrective Equipment Environmental Qualification," dated 4/22/1983.

The licensee has captured these concerns in their corrective action program as CR 1366024. The inspectors need to evaluate: (1) the licensee's justification for changing the activation energy; (2) the licensee's assessment of how AQS-21678/TR met Category 1 requirements; (3) the adequacy of the licensee's heat rise data; and (4) the

licensee's evaluation of elastomer degradation from oxygen vs nitrogen gas, and their use of apparent radiation dose margin to account for these differences. This URI is opened to determine if a performance deficiency exists. (URI 05000327/2017008-05, 05000328/2017008-05, "Potential Inadequate Justification for Eliminating Preventative Maintenance for ASCO Valves")

.6 (Opened) Unresolved Item, Potential Unjustified Qualified Life for ASCO Solenoid Operated Valves (SOVs)

Introduction: The inspectors identified a URI to review the adequacy of the licensee's justification for changing the activation energy and calculating a new qualified life for ASCO NP-1 valves assemblies.

Description: The manufacturer, ASCO, conservatively established a 1.0 eV activation energy for the valve coil assemblies. The activation energy appeared to be determined by test and realistic coil failure modes. The conservative methodology used by ASCO, that used the most limiting activation energy, met the requirements in 10 CFR Part 50. By memorandum dated 8/19/2004, the nuclear utility user group for environmental qualification (NUGEQ), to which the licensee was a member, provided information supporting the use of revised activation energy values from 1.0 eV to a less limiting 1.37 eV. The memorandum (memo) specified that NUGEQ was tasked to revise the activation energy values for ASCO NP series SOVs to a less limiting one. The inspectors determined that the data and conclusions reported by NUGEQ did not appear to be justified by design control measures in accordance with 10 CFR Part 50 Appendix B Criterion III and 50.49. Adequate design control measures were specified in the Category 1 specifications established in NUREG-0588 Section 4, "Aging" and IEEE 323-1974 Section 6.3.3, "Aging," as supplemented by RG 1.89 revision 1, Regulatory Position 5 "Aging."

The NUGEQ memo specified that they obtained their data through the research of information acquired from various sources. The use of the 1.37 eV value was for significantly increasing the qualified life of the ASCO coils. The inspectors are concerned that this did not meet the requirement to prove conservative extrapolations and use of the most limiting activation energies. Based on the inspectors' review, NUGEQ did not demonstrate that the more limiting activation energies were unrealistic and could be discounted. The memo specified that the information NUGEQ used to derive 1.37 eV was based on emailed recollections of past DuPont testing. The DuPont email appeared to be supported by some identifiable test data, but was not quality related, was not commercial grade dedicated, and performed without any identifiable design control measures. In addition, the memo disregarded other coil components with more limiting activation energies by discounting the failure modes associated with them and the coil. The manufacturer ASCO found these discounted failure modes relevant to the coil safety functions. The inspectors are concerned that the licensee disregarded realistic, more limiting, failure modes without proper justification.

The design control requirements in NUREG-0588 Section 4(5) specified, in part, that "known material phase changes and reactions should be defined to insure that no known changes occur within the extrapolation limits," (staff position: claims that conservative extrapolation limits have been implemented must be supported), and Section 4(6) required, "the aging acceleration rate used during qualification testing and the basis upon which the rate was established should be described and justified," (staff position: testing of the equipment should be conducted using the most limiting (lowest)

activation energy of the components). Additionally, RG 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants," Revision 1, Regulatory Position 5.c, "Section 6.3.3, 'Aging,' of IEEE Std. 323-1974," specified, in part, that "the aging acceleration rate and the basis upon which it was established be described, documented, and justified."

The licensee has captured these concerns in their corrective action program as CR 1366020. The inspectors need to review the licensee's analysis and justification for discounting realistic failure modes, changing the activation energy, and calculating a new qualified life for ASCO NP-1 valves assemblies. This URI is opened to determine if the performance deficiency for not providing adequate justification for changing the activation energy, is more than minor. (URI 05000327/2017008-06, 05000328/2017008-06, "Potential Unjustified Qualified Life for ASCO Solenoid Operated Valves")

4. OTHER ACTIVITIES

4OA6 Meetings, Including Exit

On December 11, 2017, the inspectors presented the inspection results to Mr. Rasmussen and other members of the licensee's staff. On January 19, 2018, a re-exit meeting was conducted via teleconference to present the final inspection results to Mr. Rasmussen and other members of the licensee's staff. The inspectors confirmed that proprietary information was controlled to protect from public disclosure.

ATTACHMENT: SUPPLEMENTAL INFORMATION

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee personnel:
T. Williams, Vice President Sequoyah
M. Rasmussen, Plant Manager Sequoyah
M. Henderson, Manager Site Engineering Programs
M. McBrearty, Manager Licensing
E. Bradley, Corporate EQ
R. Abdul, SQN EQ Engineer
C. Abidi, WBN EQ Engineer
S. Bowman, Licensing Engineer
J. Policikoski, Licensing CFAM
R. Wise, Nuclear User Group Environmental Qualification (NUGEQ)

NRC personnel:
D. Hartage, Sequoyah Senior Resident Inspector
W. Deschaine, Sequoyah Resident Inspector

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened & Closed		
05000327, 328/2017008-01	NCV	Unjustified Qualified Life for Target Rock Power-Operated Relief Valves (Section 1R21.b.1)
05000327/2017008-02	NCV	Inadequate Qualification for Unit 1 Reactor Lower Compartment Cooler Motors (Section 1R21.b.2)
Opened		
05000327, 328/2017008-03	URI	Potential Inadequate Use of Thermal Aging and the Arrhenius Methodology (Section 1R21.b.3)
05000327, 328/2017008-04	URI	Potential Inadequate Determination of Failure Modes for Qualified Life for Foxboro/Weed Instrument (Section 1R21.b.4)
05000327, 328/2017008-05	URI	Potential Inadequate Justification for Eliminating Preventative Maintenance for ASCO Valves (Section 1R21.b.5)
05000327, 328/2017008-06	URI	Potential Unjustified Qualified Life for ASCO Solenoid Operated Valves (Section 1R21.b.6)

LIST OF DOCUMENTS REVIEWED

Corrective Action Documents Written as a Result of the Inspection
CR 1357231, Drawing Discrepancy
CR 1359088, Reference 2.16 of SQN-SQS2-0165 is a typo in Binder SOL-002
CR 1359106, Typo in historical EQ test report document from Wyle Labs
CR 1359770, Special storage item incorrectly stored in Level B storage
CR 1363427, Update EQ Binder SQNEQ-IPT-002
CR 1363688, Revise Binder SQNEQ-MOT-001 to capture information
CR 1365730, Target Rock EQ Binder for Qualified Life
CR 1366020, Use of NUGEQ memo for Qualified Life of ASCO valves
CR 1366022, Uncertainties and Limits of extrapolation in EQ Life calculations
CR 1366024, Target Rock and ASCO valve maintenance requirements for EQ
CR 1366039, URI associated with the weed instrument
CR 1366048, Documentation of acceptability of the RHR motor rewind
CR 1366056, Similarity analysis for motors in MOT-004 EQ Binder
CR 1366082, SQNEQ-SOL-002 does not contain justification
CR 1366085, EQ Program established initial criticality as start of qualified life
CR 1366200, U1 lower compartment cooler motor EQ qualification
CR 1366952, EQ component failure modes and degradation

Procedures
0-MI-EVV-000-157.0, Maintenance and Inspection of Target Rock Valves, Rev. 20
2-SI-ICC-030-046.B, Calibration of Containment Vacuum Relief Containment HI Pressure Alarm Switches 2-PS-30-46B, -47B, & -48B, Rev.0
NPG-SPP-04.2, Material Receipt and Inspection, Rev.5
NPG-SPP-04.3, Material Storage and Handling, Rev.5
NPG-SPP-04.4, Material Issue, Control, and Return, Rev.4
NPG-SPP-09.26.14, Motor Operated Valve Program, Rev.3
NPG-SPP-22.300, Corrective Action Program, Rev.9
NPG-SPP-22.600, Issue Resolution, Rev.2
PSS-JI-3.55, Disassembly, Cleaning, Inspection, and Reassembly of RHR Motor for Sequoyah Nuclear Plant, Rev.0
PSS-JI-RA.GEN.03.58, Refurbishment of SQN Spare RHR Pump Motor, Rev.0

Calculations
SQN-30-D053, LCC Fan Motor Horsepower and Minimum Flow, Rev. 1
SQNAPS2-205, Material Aging Analysis for 10CFR50.49 Components Located Inside Primary Containment Pressurizer Compartment, Rev. 1
SQS20165, Thermal Aging of Target Rock Solenoid Valves, Rev. 10

Self-Assessment Reports
SQN-ENG-FSA-17-003, Focused Self-Assessment Report, dated 9/15/2017
SQN-ENG-SSA-16-001, Snapshot Self-Assessment Report, dated 3/23/2016

Corrective Action Documents
CR 376399 CR 586896 CR 689306

Work Orders

05-771575-000	09-770645-000	111127195	113577059	113562631
114882925	115453413	115815610	116284991	115564272
116987951	116988734			

Miscellaneous Documents

A Standardized Procedure for Evaluating the Relative Thermal Life and Temperature Rating of Thin-Wall Airframe Wire Insulation, David Elliot, IEEE Transactions on Electrical Insulation, Vol. EI-7, No. 1, Mar. 1972

Accelerated Air-Aging Studies with Nitrile Rubber Stocks, L. Trimle and A. Cosgarea, Jr., Rubber Age, Mar 1964

AQS-21678/TR, ASCO Qualification Test Report, Rev. B

AQS-21678/TR, ASCO CATALOG NP-1 VALVES Qualified Life Based on Activation Energy, Component Replacement and Surveillance Program, Supplement 3

Supplement to AQS-21678/TR, REV. A, Qualification of ASCO Catalog NP-1 Valves with Viton-A Elastomers, dated 6/18/1980

Bulletin ML-19, Technical Information: Pyre-M.L. Wire Enamel, Rev. 7

DCN-D22501, Increase the Capability of 2-FCV-63-72 & 73 to Operate Under Differential pressure, Rev. A

DCN-M-09428, Replace Static O-Ring Pressure Switches, Rev. A

EQV 23259, Allow Installation of T Drain for 1-FCV-63-73, 2-FCV-63-72, & 2-FCV-63-73, Rev. A

EWR-14-PEF-074-036, Review and Comment/Approve Vendor-Submitted Documentation for Rewound RHR Motor Spare Stator, Apr 4, 2014

EWR-14-PEG-074-035, Review and Comment/Approve Vendor-Submitted Documentation for Rewound RHR Motor Spare Stator, Apr 4, 2014

How to Interpret Motor Temperature Tests, R. Nailen, Electrical Apparatus, Feb. 1980

IPS-325, Design Qualification Material Test Report for Materials Used in Conax Nuclear Products for Service in Nuclear Power Generating Stations, Rev. E

MCR-72-169, Long-Life Assurance Study for Manned Spacecraft Long-Life Hardware, Dec. 1972

PO 603002-2, Stator Rewind Purchase Order, Nov 22, 2013

Review of Licensee's Resolution of Outstanding Issues From NRC Equipment Environmental Qualification Safety Evaluation Reports (F-11 and B-60), Tennessee Valley Authority Sequoyah Nuclear Plant Unit 2, Mar 31, 1983

SQN-DC-V-13.9.9, Component Cooling Water System, Rev.27

SQN-DC-V-27.3, Safety Injection System, Rev.24

SQN-DC-V-27.6, Residual Heat Removal System, Rev.20

SQNEQ-IPS-002, Static O-Ring Pressure Switches, Rev. 32

SQNEQ-IPT-002, N-E10 Series Pressure and Differential Pressure Transmitters, Rev. 70

SQNEQ-MOT-001, Westinghouse Motors, Rev. 47

SQNEQ-MOT-004, Reactor Building Lower Compartment Cooler Fan Motors, Rev. 19

SQNEQ-MOV-001, Limitorque Actuators Inside Containment, Rev. 43

SQNEQ-MOV-003, Limitorque Actuators Outside Containment with Class RH Motors, Rev. 42

SQNEQ-SOL-002, Solenoid Valves, Rev. 63

SQNEQ-SOL-005, ASCO Solenoid Valves (AC CONSTRUCTION) 206-380-SERIES & NP8300 SERIES , Rev. 47

Target Rock Test Report 3996 A, Qualification Test Report for The Environmental Qualification of the Target Rock Corporation Solenoid Operated Globe Valves in Accordance with Standard Case IV Conditions (Modified) IEEE 382-1980, Rev. A

Testing for Thermal Endurance: A Case History Based on Polysulfone Thermoplastic, T. Bugel, SPE Journal Vol. 24, Mar 1968
The Reliability of Semiconductor Devices in the Bell System, D. Peck and C. Zierdt Jr., Proceedings of the IEEE Vol. 62, No. 2, Feb. 1974.
WCAP-8754, Environmental Qualification of Class 1E Motors for Nuclear Out-of-Containment Use, Rev.1