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2CAN051801

May 24, 2018

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: License Renewal Pressurizer Surge Line and Safety Injection Nozzle Inspection
Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6

REFERENCE: NRC Letter to Entergy, *NRC Safety Evaluation Report Related to the License Renewal of Arkansas Nuclear One, Unit 2,* dated April 7, 2005 (2CNA040504) (ML050980213) published as *NUREG-1828*, dated June 2005 (ML051730233)

Dear Sir or Madam:

Per the above reference, Entergy Operations, Inc. (Entergy) is committed to address the effects of environmentally assisted fatigue (EAF) for several of the fatigue-sensitive locations, including the pressurizer surge line and safety injection nozzle, during the period of extended operation (PEO) using one or more of the following approaches:

1. Further refinement of the fatigue analysis to lower the cumulative usage factor to below 1.0, or
2. Repair of the affected locations, or
3. Replacement of the affected locations, or
4. Manage the effects of fatigue by an inspection program that has been reviewed and approved by the NRC (for example, periodic non-destructive examination of the affected locations at inspection intervals to be determined by a method accepted by the NRC). The inspections are expected to be able to detect cracking due to thermal fatigue prior to loss of function. Replacement or repair will then be implemented such that the intended function will be maintained for the period of extended operation, or
5. Monitor ASME Code activities to use the environmental fatigue methodology approved by the Code committee and NRC.

Entergy committed to provide the NRC with inspection details prior to entering the PEO, if option 4 (i.e., inspection) was selected to manage environmentally assisted fatigue during the PEO. The scope, qualification, method, and frequency of inspections are to be provided to the NRC for review and approval prior to entering the PEO.

Entergy intends to manage the aging effects of EAF on the pressurizer surge line and safety injection nozzle through flaw tolerance evaluation and inspections. Accordingly, Attachment 1 provides the description of the flaw tolerance evaluation and proposed inspections for NRC Staff review and approval.

This letter contains new regulatory commitments, which are identified in Attachment 2. Should you have any questions concerning this submittal, please contact me.

Sincerely,

**ORIGINAL SIGNED BY STEPHENIE L. PYLE**

SLP/nbm

Attachments:

1. Description of the Proposed Method to Manage Aging due to Environmentally Assisted Fatigue for the Pressurizer Surge Line and Safety Injection Nozzle
2. List of Regulatory Commitments

cc: Mr. Kriss Kennedy
Regional Administrator
U. S. Nuclear Regulatory Commission, Region IV
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NRC Senior Resident Inspector
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U. S. Nuclear Regulatory Commission
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Rockville, MD 20852

**Attachment 1 to**

**2CAN051801**

**Description of the Proposed Method to Manage Aging due to Environmentally Assisted Fatigue for the Pressurizer Surge Line and Safety Injection Nozzle**

## 1.0 BACKGROUND

Entergy Operations, Inc. (Entergy) license renewal application for Arkansas Nuclear One, Unit 2 (ANO-2), (Reference 5.1) identified the effects of environmentally assisted fatigue (EAF) as a time-limited aging analyses that will be managed for the period of extended operation (PEO) using one or more of the following approaches:

1. Further refinement of the fatigue analysis to lower the cumulative usage factor (CUF) to below 1.0, or
2. Repair of the affected locations, or
3. Replacement of the affected locations, or
4. Manage the effects of fatigue by an inspection program that has been reviewed and approved by the NRC (for example, periodic non-destructive examination of the affected locations at inspection intervals to be determined by a method accepted by the NRC). The inspections are expected to be able to detect cracking due to thermal fatigue prior to loss of function. Replacement or repair will then be implemented such that the intended function will be maintained for the period of extended operation, or
5. Monitor American Society of Mechanical Engineers (ASME) Code activities to use the environmental fatigue methodology approved by the Code committee and NRC.

For ANO-2, the critical location of concern for fatigue cumulative usage factor (CUF) is at the elbow below where the surge line is connected to the pressurizer (Reference 5.3). For the safety injection nozzle, the highest CUF is at the thinnest section of the safety injection nozzle safe-end (Reference 5.4). The calculated CUF values for these locations were determined to exceed the ASME Code allowable usage factor of 1.0 when EAF is considered during the PEO.

In Reference 5.1 and as reflected in the Reference 5.2 of the NRC Safety Evaluation Report (SER) as Commitment 39, Entergy committed to provide the NRC with inspection program details prior to entering the PEO, if option 4 (i.e., inspection) was selected to manage EAF during the PEO. The scope, qualification, method, and frequency of inspections are to be submitted to the NRC for review and approval prior to entering the PEO.

Entergy intends to manage the aging effects of EAF on the pressurizer surge line and safety injection nozzle by a combination of inspections and flaw tolerance evaluation. Accordingly, Sections 2, 3, and 4 provide the flaw tolerance evaluation description, inspection attributes, and implementation plan for NRC Staff review and approval.

## 2.0 FLAW TOLERANCE EVALUATION DESCRIPTION

The proposed ANO-2 pressurizer surge line and safety injection nozzle inspections are based on the flaw tolerance approach documented in the ASME Boiler and Pressure Vessel Code, Section XI – Rules for In-service Inspection (ISI) of Nuclear Power Plant Components, Non-Mandatory Appendix L, *Operating Plant Fatigue Assessment*.

2.1 ASME Section XI Appendix L Analysis of the ANO-2 Surge Line

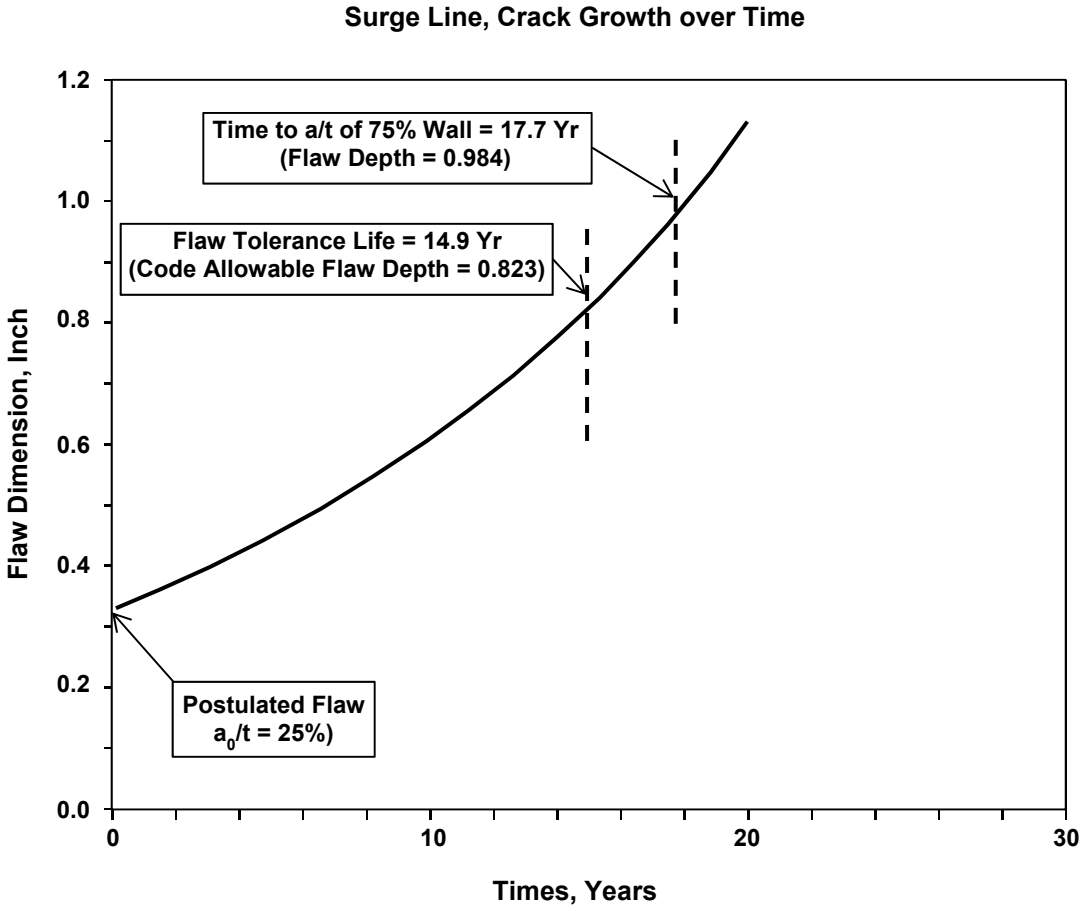
A fatigue flaw tolerance evaluation was performed specifically for ANO-2 to assess the operability of the surge line by using ASME Section XI, Appendix L, methodology and to determine the successive inspection interval for the surge line with a postulated surface-connected flaw. From a survey of the stresses and load cycles in the surge line, the bounding location was identified and evaluated in detail.

The bounding location of concern is the hot leg surge line elbow below the pressurizer, which is a Cast Austenitic Stainless Steel (CASS) SA-351 Grade CF8M material. For CASS materials with high Molybdenum content (2.0 to 3.0 wt%, including SA-351 Grade CF8M), static-cast steels with > 14% ferrite and centrifugal-cast steels with > 20% ferrite are potentially susceptible to thermal aging embrittlement (Reference 5.6). Based on a comparison of geometry, material properties, and applicable loads, the evaluation of the bounding location is also applicable to the other pipe and weld locations on the surge line.

The results of the crack growth analysis for the surge line elbow are presented in Figure 1. The technical analysis of the postulated flaw tolerance evaluation is provided in Reference 5.3.

**Figure 1**

**Arkansas Nuclear One – Unit 2**
**Results of Appendix L Damage Tolerance Calculations for Pressurizer Surge Line Welds**



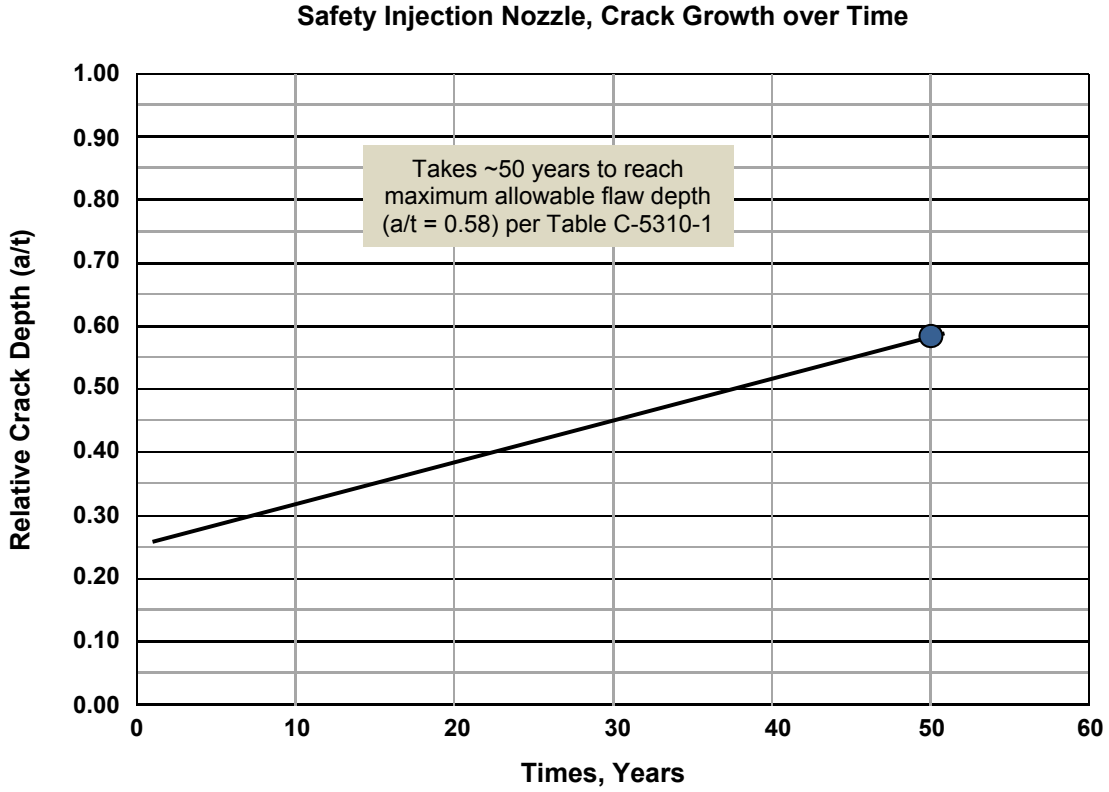
2.2 ASME Section XI Appendix L Analysis of Safety Injection Nozzle

A fatigue flaw tolerance evaluation was performed specifically for ANO-2, to assess the operability of the safety injection nozzle by using ASME Section XI, Appendix L, methodology and to determine the successive inspection interval for the safety injection nozzle with a postulated surface-connected flaw. From this analysis, the bounding location was identified and evaluated in detail. The bounding location of concern is the thinnest section of the safety injection nozzle safe-end which is a CASS SA-351 Grade CF8M material.

The results of the crack growth analysis for the safety injection nozzle are presented in Figure 2. The technical analysis of the postulated flaw tolerance evaluation is provided in Reference 5.4.

**Figure 2**

**Arkansas Nuclear One – Unit 2**
**Results of Appendix L Damage Tolerance Calculations for the Safety Injection Nozzle**



## 3.0 INSPECTION ATTRIBUTES

The attributes of the ANO-2 pressurizer surge line and safety injection nozzle inspections are discussed below:

1. Scope of the Inspections

   The pressurizer surge line piping elbow welds listed in Table 1, *ANO-2 Pressurizer Surge Line Welds and Safety Injection Nozzle Safe-Ends – Inspection Summary*, will be examined in accordance with ASME Section XI, IWB and the current ANO-2 Risk-Informed ISI Program for Class I welds (Reference 5.5). The aging effect managed with these inspections is cracking due to EAF. During the PEO, examinations of the surge line piping elbow welds, as listed in Table 1, will be in accordance with IWB-2410 and in accordance with the ANO-2 ISI Program under Augmented Programs. Pressurizer surge line elbow welds 16-011 and 16-012 were previously volumetrically examined using manual ultrasonic (UT) during 2R23 (Spring 2014) per the Risk-Informed ISI Program (N-716-1). No flaws were identified exceeding the applicable IWB-3500 acceptance standard.

   The safety injection nozzle safe-end locations listed in Table 1 will be examined in accordance with ASME Section XI, IWB-2410. The aging effect managed with these inspections is cracking due to EAF. During the PEO, examinations of the safety injection nozzle safe-end locations will be performed in accordance with IWB-2410 and the schedule of inspections, as noted in Table 1. Safety injection nozzle-to-safe-end welds 21-001, 22-001, 23-001 and 24-001 were previously volumetrically examined using encoded phased array UT during 2R23 (Spring 2014) per the Risk-Informed ISI Program (N-716-1). No flaws were identified exceeding the applicable IWB-3500 acceptance standard.

   Examination results are evaluated by qualified individuals in accordance with ASME Code Section XI acceptance criteria along with stresses and mode of failure for the appropriate material type. Components with indications that meet these acceptance criteria are considered acceptable for continued service.

2. Preventive Actions

   There are no specific preventative actions under these inspections to prevent the effects of aging.

3. Parameter(s) Monitored or Inspected

   Future ISI examinations for the pressurizer surge line elbow welds and safety injection nozzle safe-ends are planned to be a volumetric, encoded phased array UT examination at the frequency proposed in Table 1.

4. Detection of Aging Effects

   The management of degradation of the surge line elbow welds is accomplished by volumetric examination in accordance with the requirements of the ANO-2 ISI Program. The frequency and scope of examinations are demonstrated to be sufficient to ensure that aging effects are detected before the integrity of the surge line would be compromised.

The management of degradation of the safety injection nozzle safe-ends is accomplished by volumetric examination in accordance with the requirements of the ANO-2 ISI Program. The frequency and scope of examinations are demonstrated to be sufficient to ensure that aging effects are detected before the integrity of the safety injection nozzle safe-ends would be compromised.

5. Monitoring and Trending

The frequency and scope of the examinations are sufficient to ensure that the environmentally assisted fatigue aging effect is detected before the intended function of the pressurizer surge line elbow welds or safety injection nozzle safe-ends is compromised. Volumetric examinations will be performed in accordance with the inspection intervals based on the results of the postulated flaw evaluation performed in accordance to the ASME Code Section XI, Appendix L, methodology.

Flaws identified in the pressurizer surge line elbow welds or safety injection nozzle safe-ends will be evaluated by engineering to assess the effect of EAF and to determine impacts on the EAF analysis. Records of the examination procedures, results of activities, examination datasheets, and corrective actions taken or recommended will be maintained in accordance with the requirements of ANO-2 ISI Program and ASME Section XI.

6. Acceptance Criteria

Acceptance standards for the ISI examinations are identified in Subsection IWB for Class 1 components. Table IWB-2500-1 identifies references to acceptance standards listed in IWB-3500. Flaws found in the surge line elbow welds or safety injection nozzle safe-ends that are revealed by the volumetric examination require additional evaluation per the requirements of ASME Section XI.

Flaws that exceed the acceptance criteria will be entered into the Entergy Corrective Action Program. Acceptance for continued service of surge line elbow welds or safety injection nozzle safe-ends with flaws that do not meet the acceptance standards of ASME Section XI, IWB-3500, will be corrected either by repair, replacement or analytical evaluation.

Repairs or replacements will be performed in accordance with ASME Section XI, Subsection IWA-4000, as described in administrative procedure CEP-RR-001, *ASME Section XI Repair/Replacement Program*.

7. Corrective Actions

Condition Reports are generated in accordance with the Entergy Corrective Action Program for flaws that exceed the acceptance criteria. Items with examination results that do not meet the acceptance criteria are subject to acceptance by analytical evaluation per subsection IWB-3600 and/or acceptance by repair or replacement in accordance with Subsection IWA-4000.

8. Confirmation Process

When degradation is identified in the pressurizer surge line elbow welds or safety injection nozzle safe-ends, an engineering evaluation is performed to determine if the welds or safe-ends are acceptable for continued service or if repair or replacement is

required. The engineering evaluation includes probable cause, the extent of degradation, the nature and frequency of additional examinations, and, whether repair or replacement is required.

Repair and replacement are performed in accordance with the requirements of ASME Section XI, Subsection IWA-4000, and as implemented by ANO-2 administrative procedure CEP-RR-001, *ASME Section XI Repair/Replacement Program*.

9. Administrative Controls

The ANO-2 ISI Program will document the EAF inspection requirements for the ANO-2 pressurizer surge line elbow welds and safety injection nozzle safe-ends under the ASME Section XI ISI Program. Site Quality Assurance procedures, review and approval processes, and administrative controls are implemented in accordance with the requirements of Appendix B of 10 CFR Part 50 and will continue to be adequate for the PEO.

Procedures utilized include:

(1) EN-LI-102, *Corrective Action Process*

(2) CEP-RR-001, *ASME Section XI Repair/Replacement Program*

(3) SEP-ISI-ANO2-105, *ASME Section XI, Division 1, ANO 2 ISI Program*

10. Operating Experience

A sample of the surge line welds have been examined ultrasonically during the first three ISI intervals in accordance with the requirements of ASME Section XI, Subsection IWB. The safety injection nozzle-to-safe-end welds were also examined in accordance with the ANO-2 Section XI program. To date, no reportable flaws have been found in the subject pressurizer surge line elbow welds or the safety injection nozzle safe-ends. The most recent inspections were performed in the Spring of 2014. The programmatic operating experience activities described in relevant station procedures ensure the adequate evaluation of operating experience on an ongoing basis to address age-related degradation and aging management for the pressurizer surge line and safety injection nozzle.

The proposed inspections to examine the pressurizer surge line elbow welds and safety injection nozzle safe-ends listed in Table 1, for ISI intervals listed in the schedule of inspections in accordance with IWB-2410, provides reasonable assurance that potential environmental effects of fatigue will be managed such that the pressurizer surge line and safety injection nozzles will continue to perform their intended function for the extended PEO.

Corrective actions, confirmation process and administrative controls for license renewal are in accordance with the site-controlled Quality Assurance Program pursuant to 10 CFR Part 50, Appendix B, which governs all structures, systems, and components subject to an aging management review.

**TABLE 1**

**ANO-2 Pressurizer Surge Line Elbow Welds and Safety Injection Nozzle Safe-Ends – Inspection Summary**

| Unit | No. | Weld or Component | Last Examination Performed & Results (Volumetric or Surface) | Allowable Operating Period per ASME App. L Analysis | Proposed Inspections During PEO Type/ Frequency |
|---|---|---|---|---|---|
| ANO-2<br><br>4th ISI INTERVAL (2010 to 2020) | 1 | Surge Line Elbow 504-16<br>Pipe-to-Elbow Weld 16-011 | UT in 2014 (2R23) Satisfactory | Greater than 10 Years<br>(Ref. 5.3) | Volumetric Once per interval not to exceed 10 years<br>Next inspection in 2024 (2R30) |
| | 2 | Surge Line Elbow 504-16<br>Elbow-to-Pipe Weld 16-012 | UT in 2014 (2R23) Satisfactory | Greater than 10 Years<br>(Ref. 5.3) | Volumetric Once per interval not to exceed 10 years<br>Next inspection in 2024 (2R30) |
| | 3 | Safety Injection Nozzle Safe-End 503-01<br>Safe-End-to-Nozzle Weld 21-001 | UT in 2014 (2R23) Satisfactory | Greater than 10 Years<br>(Ref. 5.4) | Volumetric Once per interval not to exceed 10 years<br>Next inspection in 2024 (2R30) |
| | 4 | Safety Injection Nozzle Safe-End 503-04<br>Safe-End-to-Nozzle Weld 22-001 | UT in 2014 (2R23) Satisfactory | Greater than 10 Years<br>(Ref. 5.4) | Volumetric Once per interval not to exceed 10 years<br>Next inspection in 2024 (2R30) |
| | 5 | Safety Injection Nozzle Safe-End 503-06<br>Safe-End-to-Nozzle Weld 23-001 | UT in 2014 (2R23) Satisfactory | Greater than 10 Years<br>(Ref. 5.4) | Volumetric Once per interval not to exceed 10 years<br>Next inspection in 2024 (2R30) |
| | 6 | Safety Injection Nozzle Safe-End 503-08<br>Safe-End-to-Nozzle Weld 24-001 | UT in 2014 (2R23) Satisfactory | Greater than 10 Years<br>(Ref. 5.4) | Volumetric Once per interval not to exceed 10 years<br>Next inspection in 2024 (2R30) |

## 4.0 IMPLEMENTATION PLAN

Upon NRC approval (within 60 days) of the ANO-2 pressurizer surge line and safety injection nozzle EAF management approach, the appropriate inspection procedure(s) will be updated accordingly.

## 5.0 REFERENCES

5.1 *ANO-2 License Renewal Application*, dated October 14, 2003 (2CAN100302) (ML032890492) (ML032890506)

5.2 *NRC Safety Evaluation Report Related to the License Renewal of Arkansas Nuclear One, Unit 2,* dated April 7, 2005 (2CNA040504) (ML050980213) published as *NUREG-1828*, dated June 2005 (ML051730233)

5.3 LPI, Inc. Calculation LA161688-C-002, Rev. 0, *ANO-2 Pressurizer Surge Line 60-Year Fatigue Assessme*nt, dated May 2018

5.4 LPI, Inc., Calculation LA161688-C-004 Rev. 0, *ANO-2 Safety Injection Nozzles 60-Year Fatigue Assessment*, dated May 2018.

5.5 NRC letter, *ANO-2 – Request for Alternative ANO2-ISI-006 Re: Implementation of a Risk-Informed ISI Program Based on ASME Code Case N-716*, dated January 5, 2011 (TAC No, ME3128) (2CNA011101) (ML103500532)

5.6 Structural Integrity Report 1600402.401.R0, *Flaw Tolerance Evaluation of ANO-2 CASS Components Task 2 Report Screening of Components for Thermal Aging Embrittlement*, dated October 26, 2017

**Attachment 2 to**

**2CAN051801**

**List of Regulatory Commitments**

## LIST OF REGULATORY COMMITMENTS

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

| COMMITMENT | TYPE (check one) | | SCHEDULED COMPLETION DATE |
|---|---|---|---|
| | ONE-TIME ACTION | CONTINUING COMPLIANCE | |
| Perform volumetric inspections of the pressurizer surge line elbow locations once per interval not to exceed 10 years. | | ✓ | Beginning in 2024 (2R30) |
| Perform volumetric inspections of the safety injection nozzle safe-end locations once per interval not to exceed 10 years. | | ✓ | Beginning in 2024 (2R30) |
| Update the appropriate inspection procedure(s). | | ✓ | Within 60 days of NRC approval of the environmentally assisted fatigue management approach |