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U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: Duke Energy Carolinas, LLC (Duke Energy)
McGuire Nuclear Station, Units 1 and 2
Facility Operating License Numbers NPF-9 and NPF-17
Docket Numbers 50-369 and 50-370
License Renewal Surge Line and Safety Injection Nozzle Inspection

REFERENCES:

1. NRC Letter to Duke Energy, *License Renewal Safety Evaluation Report for McGuire, Units 1 and 2, and Catawba, Units 1 and 2*, dated January 6, 2003 (ML030030122)
2. NUREG-1772, *Safety Evaluation Report Related to the License Renewal of McGuire Nuclear Station, Units 1 and 2, and Catawba Nuclear Station, Units 1 and 2* (ML030850251)

Per the above references, Duke Energy Corporation (Duke) is committed to address the effects of environmentally-assisted fatigue (EAF) for several fatigue-sensitive locations, including the pressurizer surge line and safety injection nozzle, during the period of extended operations. As stated in Reference 2:

The applicant agreed not to use the flaw tolerance/inspection procedures specified in Note 1 unless such procedures have been accepted by the NRC.

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

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There are no new regulatory commitments contained in this letter. Questions regarding this submittal should be directed to Jeff Thomas at (980) 875-4499.

Sincerely,

Thomas D. Ray, P.E.
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Enclosure:

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

cc: w/Enclosure

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

1. BACKGROUND

The Duke Energy Corporation (Duke) license renewal application for McGuire, Units 1 and 2, and Catawba, Units 1 and 2 (Reference 5.1) identified the effects of environmentally-assisted fatigue (EAF) as an issue and stated in Section 4.3.1.2:

> *However, since NUREG/CR-6674 [Reference 4.3 - 5] indicated that fatigue reactor coolant environmental effects would result in an increased frequency of pipe leakage, the NRC required that utilities applying for license renewal address the effects of reactor water environment on fatigue usage in affected components.*

Duke proposed the following approach:

1. Choose 6-10 plant locations for assessment.
2. For an evaluation period, determine the EAF-adjusted Cumulative Usage Factor (CUF)at these locations, using defined transient severities and/or assumed occurrences either bounding or coinciding with realistic expectations.
3. Within the evaluation period, continually track the fatigue accumulating at the locations.
4. Compare either the recorded incidences of occurring transients with the number used in step 2, or compare the calculated EAF-adjusted CUF with that predicted in step 2.
5. Make future projections of either the EAF-adjusted CUF or the count of transient occurrences to determine the remaining time to reaching the allowables.

Note 1 to this strategy indicated that if the EAF-adjusted CUF could not be shown to remain below 1.0 then the alternatives from Draft EPRI Report, *Guidelines for Addressing Fatigue Environmental Effects in a License Renewal Application*, Electric Power Research Institute, (including Flaw Tolerance and Inspection) would be used.

For McGuire Units 1 and 2 (MNS), the critical locations of concern for fatigue cumulative usage factor (CUF_{en}) are the Hot Leg Surge Nozzle and the boron injection nozzle (References 5.3 and 5.4). The calculated CUF_{en} values for these locations were determined to exceed the ASME Code allowable usage factor of 1.0 when EAF is considered during the Period of Extended Operation (PEO).

In the Safety Evaluation Report (Reference 5.2) it states:

> *The applicant agreed not to use the flaw tolerance/inspection procedures specified in Note 1 unless such procedures have been accepted by the NRC. In addition, the applicant agreed to revise the procedure specified in LRA Section 4.3.1.2 to set Z equal to 1.0. The staff finds these commitments acceptable.*

Duke intends to manage the aging effects associated EAF on the pressurizer surge line and the safety injection nozzle with 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.

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2. FLAW TOLERANCE EVALUATION DESCRIPTION

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

The evaluations were performed in accordance with the requirements of the 2013 Edition of the ASME Code, Section XI, Appendix L. Effective August 17, 2017, the latest ASME Code edition approved by the NRC is the 2013 Edition, which includes Section XI, Appendix L. Code Case N-809, which includes the latest crack growth data, has been approved by ASME. At this time Code Case N-809 has not been officially endorsed by the NRC. However, the NRC has reviewed and approved precedent license renewal commitments pertaining to fatigue for Turkey Point (Submittal: ML12152A156 and Approval: ML13141A595) and St. Lucie (Submittal: ML15314A160 and Approval: ML16235A138) using Code Case N-809.

2.1 ASME Section XI Appendix L Analysis of the Pressurizer Surge Line

The fatigue flaw tolerance evaluation was performed specifically for MNS 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. Based on fatigue usage, the Hot Leg Surge Nozzle and Pressurizer Surge Nozzle were selected as the evaluation locations for the allowable flaw size determination. Both fixed and variable flaw aspect ratios were evaluated. The hot leg nozzle weld location was shown to be bounding, reaching the allowable flaw depth in approximately 11 years. The pressurizer nozzle takes at least 33 years to reach the allowable flaw depth. The results of the crack growth for the Pressurizer Surge Nozzle welds and Hot Leg Surge Nozzle welds are presented in Tables 1 and 2, respectively.

(References 5.5, 5.6, 5.7)

Table 1

Pressurizer Surge Nozzle Weld Crack Growth Results

Flaw Type	Aspect Ratio	Final Flaw Size					Allowable a/t	Allowable Operating Period	Successive Inspection Schedule
		a	c, inch	ℓ, inch	ℓ, deg.	a/t		years	years
Axial	Fixed	0.3212	5.8400	11.6800	-----	0.2284	0.2322	33	10
	Variable	0.4124	3.7170	7.4340	-----	0.2933	0.2951	59	10
Circumferential	N/A	0.3785	8.8023	17.6047	180.31	0.2682	0.2698	53	10

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Table 2

Hot Leg Surge Nozzle Weld Crack Growth Results

Flaw Type	Aspect Ratio	Final Flaw Size					Allowable a/t	Allowable Operating Period	Successive Inspection Schedule
		a, inch	c, inch	ℓ, inch	ℓ, deg.	a/t		years	years
Axial	Fixed	0.3196	5.8109	11.6218	-----	0.2273	0.2328	12	10
	Variable	0.4019	3.7191	7.4382	-----	0.2858	0.2950	21	10
Circumferential	N/A	0.3847	7.6940	15.3880	157.61	0.2736	0.2949	11	10

2.2 ASME Section XI Appendix L Analysis of the MNS Safety Injection Nozzle

A fatigue flaw tolerance evaluation was performed specifically for MNS, 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. Both the axial and circumferential flaws were acceptable for 60 years of operation, with the a/t ratio well below the allowable values. The results of the crack growth for the safety injection nozzle are presented in Table 3.

(References 5.8, 5.9, 5.10)

Table 3

Safety Injection Nozzle Crack Growth Results

Flaw Type	Final Flaw Size					Allowable a/t	Allowable Operating Period	Successive Inspection Schedule
	a, inch	c, inch	ℓ, inch	ℓ, deg.	a/t		years	years
Axial	0.0472	0.1975	0.3950	-----	0.1680	0.75	60	10
Circumferential	0.0427	0.2033	0.4066	34.82	0.1519	0.75	60	10

2.3 Inspection Schedule

Per the guidelines of Appendix L, Table L-3420-1, for the allowable operating periods listed in Tables 1, 2 and 3, the successive inspection schedule for pressurizer surge line welds and the safety injection nozzle is determined to be ten years for either an axial or a circumferential postulated flaw. This inspection interval will be used for all pressurizer surge line welds and the safety injection nozzle as noted in Table 4 and Table 5.

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3. INSPECTION PROGRAM ATTRIBUTES

The attributes of the MNS Pressurizer Surge Line and Safety Injection Nozzle Inspection Program are discussed below:

1. Scope of the Inspections

   The pressurizer surge line and safety injection nozzle welds listed in Table 4, *MNS Pressurizer Surge Line Welds – Inspection Summary* and Table 5, *Safety Injection Nozzles – Inspection Summary* will be examined in accordance ASME Section XI, IWB under the MNS Risk-Informed ISI Program for Class 1 welds (References 5.11 and 5.12). The aging effect managed with these inspections is cracking due to environmentally-assisted fatigue. In each 10-year ISI interval during the period of extended operation, the bounding pressurizer surge line location for each unit will be inspected (RCS Hot Leg Surge Nozzle weld) as well as Pipe to Pressurizer Nozzle welds in accordance with the MNS ISI Program. The eight Safety Injection Nozzle welds (four per unit) will also be inspected.

   Based on the flaw tolerance analyses, and per the guidelines of ASME Code, Section XI, Appendix L, Table L-3420-1, the successive inspection schedule is determined to be ten years. This inspection interval will be used for all welds in scope.

   Examination methods are determined in accordance with the requirements of the Risk Informed Inservice Inspection (RI-ISI) Programs for Class 1 piping welds. Inservice Inspection of ASME Class 1 and 2 piping welds at McGuire (Categories B-F, B-J, C-F-1 and C-F-2) is being performed in accordance with a Risk Informed Inservice Inspection (RI-ISI) Program per Section XI Code Case N-716 and associated Relief Request 13-MN-002. The Risk Informed Program does not require a surface examination to be performed for these category welds. Examination results are evaluated by qualified individuals in accordance with ASME Section XI acceptance criteria. Components with indications that do not exceed the acceptance criteria are considered acceptable for continued service.

2. Preventive Actions

   There are no specific preventive actions under this program to prevent the effects of aging.

3. Parameter(s) Monitored or Inspected

   Inservice examinations for the Pressurizer Surge Line and Safety Injection Nozzle welds will be volumetric examinations as indicated in Table 4 and Table 5.

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4. Detection of Aging Effects

The management of degradation of the surge line and safety injection nozzle welds is accomplished by volumetric examination in accordance with the requirements of the MNS 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 or safety injection nozzle 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 these welds would be compromised. 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 or safety injection nozzle welds 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 MNS 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 or safety injection nozzle welds 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 Duke Corrective Action Program. Acceptance for continued service of surge line elbow or safety injection nozzle welds 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 AD-EG-ALL-1703, *ASME Section XI Repair/Replacement Program Administration*.

7. Corrective Actions

Action Requests are generated in accordance with the Duke 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

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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 or safety injection nozzle welds, an engineering evaluation is performed to determine if they 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 MNS administrative procedure AD-EG-ALL-1703, *ASME Section XI Repair/Replacement Program Administration*.

9. Administrative Controls

The MNS ISI Program will document the EAF inspection requirements for the MNS pressurizer surge line and safety injection nozzle welds 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) AD-PI-ALL-0100, Corrective Action Program
(2) AD-EG-ALL-1702, ASME Section XI Inservice Inspection Program Administration
(3) AD-EG-ALL-1703, ASME Section XI Repair/Replacement Program Administration

10. Operating Experience

A sample of the surge line welds have been examined ultrasonically during the first four ISI intervals in accordance with the requirements of ASME Section XI, Subsection IWB with no relevant indications reported. The most recent inspections were performed on the Reactor Coolant System (NC) Hot Leg Surge Nozzle weld in 2010 and 2009 for Units 1 and 2, respectively. The Pipe to Pressurizer Nozzle welds were inspected in 2017 and 2018 for Units 1 and 2, respectively.

Since Spring 2014, the safety injection lines have had multiple piping flaws in normally isolated NC branch piping. These Code rejectable flaws were attributed to high cycle thermal fatigue due to reactor coolant system swirl penetration acting in concert with cold water inleakage. A description of these incidences is described below.

LER 370/2014-01 describes a rejectable flaw in the Unit 2 D Loop Safety Injection Nozzle. Actions were taken to repair the piping and to re-inspect other susceptible lines before the unit restarted from its refueling outage. Corrective actions included removal of a cold leg isolation valve on both units known to have legacy leakage issues. The cause was attributed to a legacy issue with leakage through the Unit 2 NC Cold Leg Injection line from a Chemical and Volume Control System (NV) isolation valve that created the high frequency thermal cycle condition which initiated the cold leg nozzle fatigue cracks.

LER 369/2014-02 describes two rejectable flaws on the Unit 1 B and C Loop safety injection lines during the Fall 2014 Outage. Actions were taken to repair the piping and to inspect other susceptible lines before the unit restarted from its refueling outage. As part of planned corrective actions, valves with the potential to cause cold water inleakage to these lines were to be monitored for leakage. A legacy issue with leakage through Unit 1 NC Cold Leg Injection from NV isolation valve created the high frequency thermal cycle condition which initiated the cold leg nozzle fatigue cracks.

LER 370/2017-01 describes that while operating at 100% power in February 2017 operators commenced a Unit 2 shutdown upon discovery of pressure boundary leakage on Unit 2 Safety Injection (NI) pipe upstream of the connection to "D" Reactor Coolant System (NC) Cold Leg. The cause of the NI pipe leak is thermal fatigue damage caused by NC cross-loop flows. The NI piping and B Loop check valves were replaced. Leakage testing and thermocouple data confirmed the RCS loop check valves as the source of leakage resulting in thermal fatigue damage in the Unit 2 D Loop Safety Injection line and was determined to be a contributing cause of this event. These causes represented previously unobserved fatigue cracking operating experience by the industry and was not addressed by the industry guidance at the time.

Modifications were performed to add a pressure bleed off line to prevent check valve leakage from migrating to the hot RCS nozzles. Industry guidance was first updated on an interim basis by MRP 2015-019 to provide new NEI 03-08 Needed and Good Practice guidance requirements that supplemented existing thermal fatigue management guidelines for normally isolated Reactor Coolant System branch lines and Residual Heat Removal (RHR) system mixing tees. MRP-146, Revision 2 was released and incorporated the interim guidance requirements. Subsequently MRP 2019-008 was issued as a result of recent industry operating experience of thermal fatigue, particularly regarding cross-flow inleakage which was previously not expected to occur during normal operation. This guidance required an update to the examination scope.

All Safety Injection Nozzle welds were inspected in 2017 and 2018 for Units 1 and 2, respectively with no recordable indications. These welds are currently being managed in accordance with MRP-146.

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 nozzles.

The MNS pressurizer surge line operating experience aligns with industry operating experience for Turkey Point Units 3 and 4 (ML12152A156), St. Lucie (ML15314A160) and Arkansas Nuclear One, Unit 2 (ML18144A970) as described in their submittals to manage the effects of aging due to EAF through a combination of inspections and flaw tolerance evaluations.

The proposed inspections to examine the hot leg surge nozzle welds and safety injection nozzle welds listed in Table 4 and Table 5, 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 throughout the period of extended operation.

4. IMPLEMENTATION PLAN

Upon approval of the proposed inspection program, related aging management program basis and implementing documents and the associated Updated Final Safety Analysis Report (UFSAR) sections will be updated accordingly.

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5. REFERENCES

5.1 Letter from M.S. Tuckman (Duke) to USNRC, Application to Renew the Operating Licenses of McGuire Nuclear Station, Units 1 & 2 and Catawba Nuclear Station, Units 1 & 2, Docket Nos. 50-369, 50-370, 50-413 and 50-414, dated June 13, 2001

5.2 NUREG-1772, Safety Evaluation Report Related to the License Renewal of McGuire Nuclear Station, Units 1 and 2, and Catawba Nuclear Station, Units 1 and 2, March 2003 (ACN: ML030850251)

5.3 MCC-1206.02-45-0019, Environmentally Assisted Fatigue Screening for McGuire (SIA File No. 1600302.301)

5.4 MCC-1206.02-45-0020, McGuire EAF Sentinel Location Optimal Dispositions (SIA File No. 1700310.301)

5.5 MCC-1206.02-45-0027, Allowable Flaw Size Determination for the Surge Line (SIA File No. 1800357.322)

5.6 MCC-1206.02-45-0028, Crack Growth Evaluation of the Pressurizer Surge Line (SIA File No. 1800357.323)

5.7 MCC-1206.02-45-0029, Flaw Tolerance Evaluation of the McGuire Pressurizer Surge Line using ASME Code Section XI, Appendix L (SIA File No. 1800357.401)

5.8 MCC-1206.02-45-0031, Allowable Flaw Size Determination for the 1.5" Boron Injection Nozzle (SIA File No. 1800357.326)

5.9 MCC-1206.02-45-0032, Crack Growth Evaluation of the 1.5-inch Cold Leg Boron Injection Line Nozzle (SIA File No. 1800357.327)

5.10 MCC-1206.02-45-0033, Flaw Tolerance Evaluation of McGuire Boron Injection Nozzles using ASME Code Section XI, Appendix L (SIA File No. 1800357.402)

5.11 MISI-1462.10-0040 GEN REQ UNIT, Fourth Interval Inservice Inspection Plan McGuire Nuclear Station Units 1 and 2

5.12 MISI-1462.10-0040AUGISI-U1&U2, McGuire Nuclear Station - Fourth Interval Augmented Inservice Inspection Plan and Schedule

5.13 Letter from R.T. Repko (Duke) to USNRC, Duke Energy Carolinas, LLC (Duke Energy), McGuire Nuclear Station, Units 1 and 2, Docket Nos. 50-369 and 50-370, Relief Request Serial # 11-MN-001, Limited Weld Examinations for Refueling Outages 1EOC20 and 2EOC19, dated September 21, 2011 (ACN: ML11279A035)

5.14 Letter from USNRC to S.D. Capps (Duke), McGuire Nuclear Station, Units 1 And 2, Proposed Relief Request 11-MN-001 (TAC NOS. ME7268, ME7269, ME7270, ME7271, ME7272, ME7273, AND ME7274), dated September 13, 2012 (ACN: ML12250A401)

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Table 4

MNS Pressurizer Surge Line Welds – Inspection Summary

Unit	No.	Weld or Component	Last Examination Performed and Results	Allowable Operating Period per ASME App. L Analysis (See Note 1)	Proposed Inspections During PEO Type/ Frequency
1	1	1NC1FW53-NW6 Pipe to Pressurizer Nozzle	2017 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	2	1NC1F3613-3092 RCS Hot Leg Surge Nozzle	2010 Satisfactory (See Note 2)	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
2	1	2NC2FW2-NW6 Pipe to Pressurizer Nozzle	2018 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	2	2NC2FW2-2 RCS Hot Leg Surge Nozzle	2009 Satisfactory (See Note 2)	Greater than 10 years	Volumetric Once per interval not to exceed 10 years

Note 1: The inspection frequency as determined by ASME Code Section XI, Appendix L analysis is more than 10 years. In accordance to the requirements of Appendix L Table L-3420-1, the surge line welds will be examined once per 10 years, at the frequency of the McGuire Nuclear Station Inservice Inspection Interval.

Note 2: This weld was the subject of McGuire Relief Request 11-MN-001 (Reference 5.13) that was approved by Reference 5.14.

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Table 5

MNS Safety Injection Nozzle Welds – Inspection Summary

Unit	No.	Weld or Component	Last Examination Performed and Results	Allowable Operating Period per ASME App. L Analysis (See Note 1)	Proposed Inspections During PEO Type/ Frequency
1	1	Cold Leg 1A Nozzle 1-1	2017 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	2	Cold Leg 1B Nozzle 2-1	2017 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	3	Cold Leg 1C Nozzle 3-1	2017 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	4	Cold Leg 1D Nozzle 4-1	2017 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
2	1	Cold Leg 2A Nozzle 1-1	2018 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	2	Cold Leg 2B Nozzle 2-1	2018 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	3	Cold Leg 2C Nozzle 3-1	2018 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years
	4	Cold Leg 2D Nozzle 4-1	2018 Satisfactory	Greater than 10 years	Volumetric Once per interval not to exceed 10 years

Note 1: The inspection frequency as determined by ASME Code Section XI, Appendix L analysis is more than 10 years. In accordance to the requirements of Appendix L Table L-3420-1, the safety injection nozzle welds will be examined once per 10 years, at the frequency of the McGuire Nuclear Station Inservice Inspection Interval.