Attachment 3

Duke Energy Carolinas, LLC

McGuire Nuclear Station, Unit 1

Relief Request Serial # 15-MN-001

One copy of Westinghouse LTR-PAFM-14-114-NP, Revision 0, "Technical Justification to Support Extended Volumetric Examination Interval for McGuire Unit 1 Reactor Vessel Inlet Nozzle to Safe End Dissimilar Metal Welds." (Non-Proprietary)

LTR-PAFM-14-114-NP
Revision 0

Technical Justification to Support Extended Volumetric Examination Interval for McGuire Unit 1 Reactor Vessel Inlet Nozzle to Safe End Dissimilar Metal Welds

February 2015

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FOREWORD

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1.0 Introduction

Service induced cracking of the nickel-base alloy components and weldments have been occurring more and more frequently in recent years, resulting in the need to repair and/or replace these components. Such cracking and leakage have been observed in the reactor vessel upper and bottom head penetration nozzles as well as the dissimilar metal (DM) butt welds of the pressurizer and reactor vessel nozzles exposed to the high reactor coolant temperatures. These Pressurized Water Reactor (PWR) power plant field experiences and the potential for Primary Water Stress Corrosion Cracking (PWSCC) require reassessment of the examination frequency as well as the overall examination strategy for nickel-base alloy components and weldments. Code Case N-770-1 (Reference 1) provides the visual and volumetric inspection guidelines for the primary system piping DM butt welds to augment the current inspection requirements.

In accordance with Code Case N-770-1 guidelines, volumetric examinations are required for the unmitigated DM butt welds at the Reactor Vessel (RV) inlet nozzles every second inspection period not exceeding 7 years. A volumetric examination was previously performed for the McGuire Unit 1 reactor vessel inlet nozzle to safe end DM butt welds during the Spring 2010 Re-Fueling Outage (RFO). The next required volumetric examination for the Reactor Vessel inlet nozzle DM welds will be during the Spring 2016 RFO in accordance with Code Case N-770-1. This evaluation will determine the impact of performing the volumetric examination during the Fall 2020 RFO. The time interval between the previous examination in Spring 2010 RFO and the planned examination in Fall 2020 RFO is 10.5 years, rather than the 7 years allowed by Code Case N-770-1. Therefore, McGuire Unit 1 is seeking relaxation from the ASME Code Case N-770-1 examination requirement to be able to defer the volumetric examination from the Spring 2016 RFO to the Fall 2020 RFO. The technical justification to support this relief request is developed in this report based on a flaw tolerance analysis. The objective of the flaw tolerance analysis is to determine the largest initial axial and circumferential flaw sizes that could be left behind in service and remain acceptable for a service life of 10.5 years from the Spring 2010 RFO to the Fall 2020 RFO. This maximum allowable initial flaw size can then be compared to any indications detected during the Spring 2010 RFO inlet nozzle DM weld examination, as well as to a flaw size which could have been reasonably missed during the Spring 2010 RFO inlet nozzle DM weld examination based on the current inspection detection capability.

The following sections provide a discussion of the methodology, geometry, loading and the flaw tolerance analyses performed to develop the technical justification for deviating from the volumetric examination requirements of Code Case N-770-1.

2.0 Methodology

In order to support the technical justification for deferring the volumetric examination from the Spring 2016 RFO to the Fall 2020 RFO, it is necessary to demonstrate the structural integrity of the RV inlet nozzle DM welds subjected to the PWSCC crack growth mechanism. To demonstrate the structural integrity of the DM welds, it is essential to determine the maximum allowable initial flaw size that would be acceptable in the DM welds for the duration from the Spring 2010 RFO to the Fall 2020 RFO. This maximum allowable initial flaw size would be the largest flaw size that could be acceptable for a service life of 10.5 years until the Fall 2020 RFO. The maximum allowable initial flaw size for a given plant operation duration can be determined by subtracting the PWSCC crack growth for that plant operation duration from the maximum allowable end-of-evaluation period flaw size, which is determined in accordance with ASME Code Section XI (Reference 2).

To determine the maximum allowable end-of-evaluation period flaw sizes and the crack tip stress intensity factors used for the PWSCC analysis, it is necessary to establish the stresses, crack geometry and the material properties at the locations of interest. The applicable loadings which must be considered consist of piping reaction loads acting at the DM weld regions and the welding residual stresses which exist in the region of interest.

The latest piping loads at the reactor vessel inlet nozzle DM weld locations are based on WCAP-15639-P (Reference 3). In addition to the piping loads, the effects of welding residual stresses are also considered. For PWSCC, the crack growth model for the DM weld material is based on that given in MRP-115 for Alloy 182 weld material (Reference 4). The nozzle geometry and piping loads used in the fracture mechanics analysis are shown in Section 3.0. A discussion of the plant specific welding residual stress distributions used for the DM welds is provided in Section 4.0. The determination of the maximum allowable end-of-evaluation period flaw sizes is discussed in Section 5.0.

The maximum allowable initial flaw size will be determined based on the crack growth due to the PWSCC growth mechanism at the RV inlet nozzle DM weld. The PWSCC crack growth is calculated based on the normal operating temperature and the crack tip stress intensity factors resulting from the normal operating steady state piping loads and welding residual stresses as discussed in Section 6.0. Section 7.0 provides the crack growth curves used in developing the technical justification to deviate from the Code Case N-770-1 guidelines by deferring the volumetric inspection of the RV inlet nozzle DM welds from Spring 2016 to the Fall 2020 RFO.

3.0 Nozzle Geometry and Loads

The DM weld geometry for the McGuire Unit 1 Reactor Vessel inlet nozzle is based on the nozzle detail drawings (Reference 5). The operating temperature of the reactor vessel inlet nozzles is based on the reactor vessel equipment specification (Reference 6). The RV inlet nozzle geometry and normal operating temperature are summarized in Table 3-1.

The piping reaction loads at the RV inlet nozzle DM weld locations are based on WCAP-15639-P (Reference 3) and are summarized in Table 3-2. These loads are used in determining the maximum allowable end-of-evaluation period flaw sizes and the PWSCC growth.

Table 3-1
McGuire Unit 1 Reactor Vessel Inlet Nozzle Geometry and Normal Operating Temperature

	Dimension
Outside Diameter (in.)	32.552
Inside Diameter (in.)	27.500
Thickness* (in.)	2.526
RV Inlet Nozzle Normal Operating Temperature = 557.5°F	

*Thickness is representative of DM weld only and does not include inside and outside surface cladding.

Table 3-2

McGuire Unit 1 Reactor Vessel Inlet Nozzle Piping Loads

Loading	Forces (kips)	Moments (in-kips)		
	Fx (Axial)	Mx (Torsion)	My (Bending)	Mz (Bending)
Deadweight	1.2	-130.1	-108.0	693.1
Normal Operating Thermal	10.3	200.0	-1110.1	1747.2
OBE (Operational Basis Earthquake)	57.2	776.4	1710.7	339.0
SSE (Safe Shutdown Earthquake)	100.6	1352.3	2979.1	603.2
Pipe Break	552.9	512.9	3439.3	75.2

4.0 Dissimilar Metal Weld Residual Stress Distribution

The welding residual stresses used in the PWSCC crack growth analysis are determined from the finite element stress analysis (FEA) in Reference 7 based on the McGuire Unit 1 Reactor Vessel outlet nozzle DM weld specific configuration. The geometry and configuration of the Reactor Vessel inlet and outlet nozzle DM weld regions are very similar. The Reactor Vessel outlet nozzle DM Weld has a thickness of 2.558" while the Reactor Vessel inlet nozzle has a thickness of 2.526", and both nozzles have cladding on the inside and outside surfaces. Furthermore, the inlet and outlet nozzle safe-end lengths between the DM welds and stainless steel welds are the same. Therefore, the outlet nozzle FEA model from Reference 7 is acceptable for use in the determination of the McGuire Unit 1 inlet nozzle residual stresses. Figure 4-1 shows a sketch of the McGuire Unit 1 inlet/outlet nozzle DM weld configuration.

The FEA in Reference 7 is based on a two-dimensional axisymmetric model of the outlet nozzle DM weld region. The FEA model geometry includes a portion of the low alloy steel nozzle, the stainless steel safe end, a portion of the stainless steel piping, the DM weld attaching the nozzle to the safe end, the stainless steel weld attaching the safe end to the piping, and cladding on the inside and outside surfaces of both welds and the safe-end. The FEA also assumes a 360° inside surface weld repair with a repair depth of 50% through the DM weld thickness, which is consistent with MRP-287 guidance (Reference 8). The following fabrication sequence was simulated in the FEA and matches the information provided in the reactor vessel nozzle details drawings (Reference 5):

- The unbuttered nozzle was welded to the safe end ring forging using an Alloy 82/182 weld. The outer and inner diameters of the DM weld were machined to finished size.
- An assumed 50% inside surface weld repair 360° around the circumference was conservatively simulated in the Alloy 82/182 weld, which is consistent with MRP-287 (Reference 8).
- The welded configuration was then raised to a temperature of 1100°F to simulate post-weld heat treatment.
- The safe end was then machined for the piping side weld preparation.
- The Alloy 82/182 cladding is deposited on the inside and outside diameter of the DM weld region.
- The machined safe end was welded to a long segment of stainless steel piping using a stainless steel weld.
- A hydrostatic test was performed at 3110 psig pressure with a temperature of 310°F.
- After the hydrostatic test, normal operating temperature and pressure was uniformly applied three times to consider any shakedown effects, after which the model was set to normal operating conditions.

Based on the FEA model, residual stresses at two different cuts (centerline path on the DM weld, and an inclined path through the DM weld) in the DM weld were obtained. The hoop and axial welding residual stresses for the centerline path through the DM weld are shown in Figure 4-2 and for the inclined path through the DM weld are shown in Figure 4-3. The residual stress from the centerline and inclined paths are very similar, and the path that provides limiting PWSCC growth is used in the analysis.

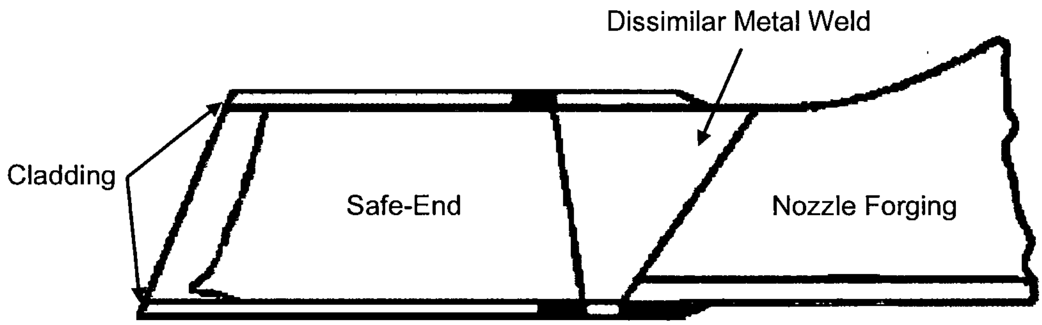

Figure 4-1 McGuire Unit 1 Reactor Vessel Inlet and Outlet Nozzle DM Weld Configuration

a,c,e

Figure 4-2: Reactor Vessel Nozzle DM Weld Through-Wall Residual Stress Profiles at Centerline Path Through DM Weld with Post-Weld Heat Treatment and 50% Inside Surface Weld Repair

a,c,e

Figure 4-3: Reactor Vessel Nozzle DM Weld Through-Wall Residual Stress Profiles at Inclined Path Through DM Weld with Post-Weld Heat Treatment and 50% Inside Surface Weld Repair

5.0 Maximum Allowable End-of-Evaluation Period Flaw Size Determination

In order to develop the technical justification to defer the volumetric examination of the RV inlet nozzle DM welds from the Spring 2016 RFO to the Fall 2020 RFO, the first step is the determination of the maximum allowable end-of-evaluation period flaw sizes. The maximum allowable end-of-evaluation period flaw size is the size to which an indication is allowed to grow to until the next inspection or evaluation period. This particular flaw size is determined based on the piping loads, geometry and the material properties of the component. The evaluation guidelines and procedures for calculating the maximum allowable end-of-evaluation period flaw sizes are described in paragraph IWB-3640 and Appendix C of the ASME Section XI code (Reference 2). Since the limit load expressions given in ASME Section XI 1998 edition with 2000 addenda (Reference 2a), which is the current ASME Section XI Code of Record for McGuire Unit 1, have been changed in later Code editions, the limit load expressions from the 2007 edition with 2008 Addenda of the ASME Section XI Code (Reference 2b) were also used in determining the maximum allowable end-of-evaluation period flaw size.

Rapid, nonductile failure is possible for ferritic materials at low temperatures, but is not applicable to the nickel-base alloy material. In nickel-base alloy material, the higher ductility leads to two possible modes of failure, plastic collapse or unstable ductile tearing. The second mechanism can occur when the applied J integral exceeds the J_{Ic} fracture toughness, and some stable tearing occurs prior to failure. If this mode of failure is dominant, then the load-carrying capacity is less than that predicted by the plastic collapse mechanism. The maximum allowable end-of-evaluation period flaw sizes of paragraph IWB-3640 for the high toughness materials are determined based on the assumption that plastic collapse would be achieved and would be the dominant mode of failure. However, due to the reduced toughness of the DM welds, it is possible that crack extension and unstable ductile tearing could occur and be the dominant mode of failure. To account for this effect, penalty factors called "Z factors" were developed in ASME Code Section XI, which are to be multiplied by the loadings at these welds. In the current analysis for McGuire Unit 1, Z factors based on Reference 9 are used in the analysis to provide a more representative approximation of the effects of the DM welds. The use of Z factors in effect reduces the maximum allowable end-of-evaluation period flaw sizes for flux welds and thus has been incorporated directly into the evaluation performed in accordance with the procedure and acceptance criteria given in IWB-3640 and Appendix C of ASME Code Section XI. It should be noted that the maximum allowable end-of-evaluation period flaw sizes are limited to only 75% of the wall thickness in accordance with the requirements of ASME Section XI paragraph IWB-3640 (Reference 2).

The maximum allowable end-of-evaluation period flaw sizes determined for both axial and circumferential flaws have incorporated the relevant material properties, pipe loadings and geometry. Loadings under normal, upset, emergency and faulted conditions are considered in conjunction with the applicable safety factors for the corresponding service conditions required in the ASME Section XI Code. For circumferential flaws, axial stress due to the pressure, deadweight, thermal expansion, seismic and pipe break loads are considered in the evaluation. As for the axial flaws, hoop stress resulting from pressure loading is used.

The maximum allowable end-of-evaluation period flaw sizes for the axial and circumferential flaws at the RV inlet nozzle DM welds are provided in Table 5-1. The maximum allowable end-of-evaluation period axial flaw size was calculated with an assumed aspect ratio (flaw length/flaw depth) of 2. The aspect ratio of 2 is reasonable because the axial flaw growth due to PWSCC is limited to the width of the DM weld configuration. For the circumferential flaw, a conservative aspect ratio of 10 is used.

Table 5-1
Maximum End-of-Evaluation Period Allowable Flaw Sizes
(Flaw Depth/Wall Thickness Ratio - a/t)

Axial Flaw (Aspect Ratio = 2)	Circumferential Flaw (Aspect Ratio = 10)
0.75	0.75

6.0 PWSCC Crack Growth Analysis

A PWSCC crack growth analysis was performed to determine the maximum allowable initial flaw size that would be acceptable based on ASME Section XI acceptance criteria (Reference 2) for the duration from the Spring 2010 RFO to the Fall 2020 RFO. The maximum allowable initial flaw size for the given plant operation duration is determined by subtracting the crack growth due to PWSCC for the specific plant operation duration from the maximum allowable end-of-evaluation period flaw size shown in Table 5-1.

Crack growth due to PWSCC is calculated for both axial and circumferential flaws using the normal operating condition steady-state stresses. For axial flaws, the stresses included pressure and residual stresses, while for circumferential flaws, the stresses considered are pressure, 100% power normal thermal expansion, deadweight and residual stresses. The input required for the crack growth analysis is basically the information necessary to calculate the crack tip stress intensity factor (K_I), which depends on the geometry of the crack, its surrounding structure and the applied stresses. The geometry and loadings for the nozzles of interest are discussed in Section 3.0 and the applicable residual stresses used are discussed in Section 4.0. Once K_I is calculated, PWSCC growth can be calculated using the applicable crack growth rate for the nickel-base alloy material (Alloy 182) from MRP-115 (Reference 4). For all inside surface flaws, the governing crack growth mechanism for the RV inlet nozzle is PWSCC.

Using the applicable stresses at the DM welds, the crack tip stress intensity factors can be determined based on the stress intensity factor expressions from API-579 (Reference 10). The through-wall stress distribution profile is represented by a 4^{th} order polynomial:

$$\sigma = \sigma_0 + \sigma_1 \left(x/t\right) + \sigma_2 \left(x/t\right)^2 + \sigma_3 \left(x/t\right)^3 + \sigma_4 \left(x/t\right)^4$$

Where:

σ_0, σ_1, σ_2, σ_3, and σ_4 are the stress profile curve fitting coefficients,

x is the distance from the wall surface where the crack initiates;

t is the wall thickness; and

σ is the stress perpendicular to the plane of the crack.

The stress intensity factor calculations for semi-elliptical inside surface axial and circumferential flaws are expressed in the general form as follows:

$$K_I = \sqrt{\frac{\pi a}{Q}} \sum_{j=0}^{4} G_j(a/c, a/t, t/R, \Phi)\sigma_j \left(\frac{a}{t}\right)^j$$

Where:

a: Crack depth

c: Half crack length along surface

t: Thickness of cylinder

R: Inside radius

Φ: Angular position of a point on the crack front

G_j: G_j is influence coefficient for j^{th} stress distribution on crack surface (i.e., G_0, G_1, G_2, G_3, G_4)

Q: The shape factor of an elliptical crack is approximated by:

$Q = 1 + 1.464(a/c)^{1.65}$ for $a/c \leq 1$ or $Q = 1 + 1.464(c/a)^{1.65}$ for $a/c > 1$

The influence coefficients at various points on the crack front can be obtained by using an interpolation method. Once the crack tip stress intensity factors are determined, PWSCC crack growth calculations can be performed using the crack growth rate below with the applicable normal operating temperature.

The PWSCC crack growth rate used in the crack growth analysis is based on the EPRI recommended crack growth curve for Alloy 182 material (Reference 4):

$$\frac{da}{dt} = \exp\left[-\frac{Q_g}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right]\alpha(K)^{\beta}$$

Where:

$\frac{da}{dt}$	=	Crack growth rate in m/sec (in/hr)
Q_g	=	Thermal activation energy for crack growth = 130 kJ/mole (31.0 kcal/mole)
R	=	Universal gas constant = 8.314×10^{-3} kJ/mole-K (1.103×10^{-3} kcal/mole-°R)
T	=	Absolute operating temperature at the location of crack, K (°R)
T_{ref}	=	Absolute reference temperature used to normalize data = 598.15 K (1076.67°R)
α	=	Crack growth amplitude
	=	1.50×10^{-12} at 325°C (2.47×10^{-7} at 617°F)
β	=	Exponent = 1.6
K	=	Crack tip stress intensity factor $MPa\sqrt{m}$ ($ksi\sqrt{in}$)

The normal operating temperature used in the crack growth analysis is 557.5°F at the RV inlet nozzle. It should be noted that the fatigue crack growth mechanism is not considered in the crack growth analysis as it is considered to be small when compared to that due to the PWSCC crack growth mechanism at the reactor vessel inlet nozzle for the duration of interest. This is demonstrated by the low fatigue usage factor of 0.00561 at the inlet nozzle location of interest in the reactor vessel analytical report CENC-1206-A1 (Reference 11). Therefore, it is not necessary to consider fatigue crack growth in the evaluation.

7.0 Technical Justification for Deferring the Volumetric Examination from Spring 2016 RFO to Fall 2020 RFO

In accordance with ASME Code Case N-770-1 (Reference 1), the volumetric examination interval for the unmitigated reactor vessel inlet nozzle to safe end DM welds must not exceed 7 years. McGuire Unit 1 is seeking relaxation from the ASME Code Case N-770-1 requirement in order to defer the volumetric examination of the reactor vessel inlet nozzle to safe end DM welds from the Spring 2016 RFO to the Fall 2020 RFO. Technical justification can be developed to support deferring the volumetric examination by calculating the maximum allowable initial flaw size that could be left behind in service and remain acceptable for a service life of 10.5 years between the Spring 2010 and Fall 2020 RFOs. This maximum allowable initial flaw size can then be compared to any indication detected during the Spring 2010 RFO inlet nozzle DM weld examination, as well as to a flaw size which could have been reasonably missed during the Spring 2010 RFO inlet nozzle DM weld examination.

The maximum allowable initial flaw depth is determined by subtracting the PWSCC crack growth for a plant operation duration of 10.5 years from the maximum allowable end-of-evaluation period flaw depth shown in Table 5-1. The end-of-evaluation period flaw depth is calculated based on the guidelines given in paragraph IWB-3640 and Appendix C of ASME Section XI Code (Reference 2). The PWSCC crack growth at the Alloy 82/182 weld is calculated based on the normal operating condition, piping loads, and the welding residual stresses at the DM weld as well as the crack growth model in MRP-115 (Reference 4). The maximum allowable initial flaw depth was calculated for an axial flaw with an assumed aspect ratio of 2. An aspect ratio of 2 is reasonable for the axial flaw due to the DM weld configuration since any PWSCC axial flaw growth is limited to the width of the weld. For the circumferential flaw, a conservative aspect ratio of 10 is used in the crack growth analysis.

The PWSCC crack growth analysis of the axial and circumferential flaws considered three cases each: normal operating piping loads with residual stresses for centerline and inclined paths (shown in Figure 4-2 and Figure 4-3) and normal operating piping loads without residual stresses in order to obtain the most limiting crack growth results since a portion of the axial and hoop residual stress profiles are compressive. It was determined that the cases which included only piping loads and no residual stresses were limiting for both axial and circumferential flaws due to the compressive regions in the residual stress profiles. The exclusion of residual stresses in the evaluation is conservative.

The PWSCC crack growth curves and the maximum allowable initial flaw sizes for an axial flaw and a circumferential flaw are shown in Figures 7-1 and 7-2 respectively. The horizontal axis displays service life in Effective Full Power Years (EFPY), and the vertical axis shows the flaw depth to wall thickness ratio (a/t). The maximum allowable end-of-evaluation period flaw sizes are also shown in these figures for the respective flaw configurations. Based on the crack growth results from Figures 7-1 and 7-2, the maximum allowable initial flaw sizes for the axial and circumferential flaws are tabulated in Table 7-1.

Table 7-1
Maximum Allowable Initial Flaw Sizes

	Axial Flaw (Aspect Ratio = 2)	Circumferential Flaw (Aspect Ratio = 10)
Maximum Allowable Initial Flaw Size (a/t)	0.47	0.38
Flaw Depth (inches)	1.19	0.96
Flaw Length (inches)	2.38	9.60

The maximum allowable initial flaw sizes shown in Table 7-1 are the largest axial and circumferential flaw sizes that could be left behind in service and remain acceptable for a service life of 10.5 years from the Spring 2010 RFO to the Fall 2020 RFO. In accordance with the detection and sizing requirements in Supplement 10 of ASME Section XI Appendix VIII (Reference 2) pertaining to the qualification of inspection procedures, the minimum required detectable flaw depth is 10% of the wall thickness. As a result, based on the current inspection detection capability, these maximum allowable initial flaw sizes are larger than the flaw sizes that could have been reasonably missed during the last Spring 2010 RFO volumetric examination of the RV inlet nozzle DM welds.

During the Spring 2010 inspection, the ultrasonic examination detected a single fabrication indication which was not in the DM weld but at the cladding to nozzle base metal interface of the Loop D RV inlet nozzle for McGuire Unit 1. The fabrication indication is adjacent to the DM weld and eddy current testing of the inside surface at the location of the interest confirmed that the indication was not surface breaking. The detected embedded indication was found to have a total depth of 0.16 inch and a length of 0.48 inch. Only 0.05 inch of the total flaw depth was located in the nozzle base metal, and the remaining depth was located in the cladding. The detected indication was shown to be acceptable based on the 1998 Edition with 2000 Addenda of the ASME Section XI Code, IWB-3500 standards and it remains acceptable based on the 2007 edition with 2008 addenda of the ASME Code as well. The maximum allowable initial flaw sizes determined in this report are far larger than the IWB-3500 allowable flaw sizes. As a result, the fabrication defect detected during the Spring 2010 RFO inspection is bounded by the allowable initial flaw sizes shown in Table 7-1, and would remain acceptable through the Fall 2020 RFO.

Therefore, deferring the volumetric examination for the RV inlet nozzle DM welds from the 7 years allowed by Code Case N-770-1 to 10.5 years is technically justified. This is because the maximum allowable initial flaw sizes that have been shown to be acceptable for a service-life of 10.5 years from the Spring 2010 RFO to the Fall 2020 RFO in accordance with the ASME Section XI IWB-3640 acceptance criteria are larger than the detected indication size and the flaw sizes that might have been reasonably missed during the Spring 2010 RFO.

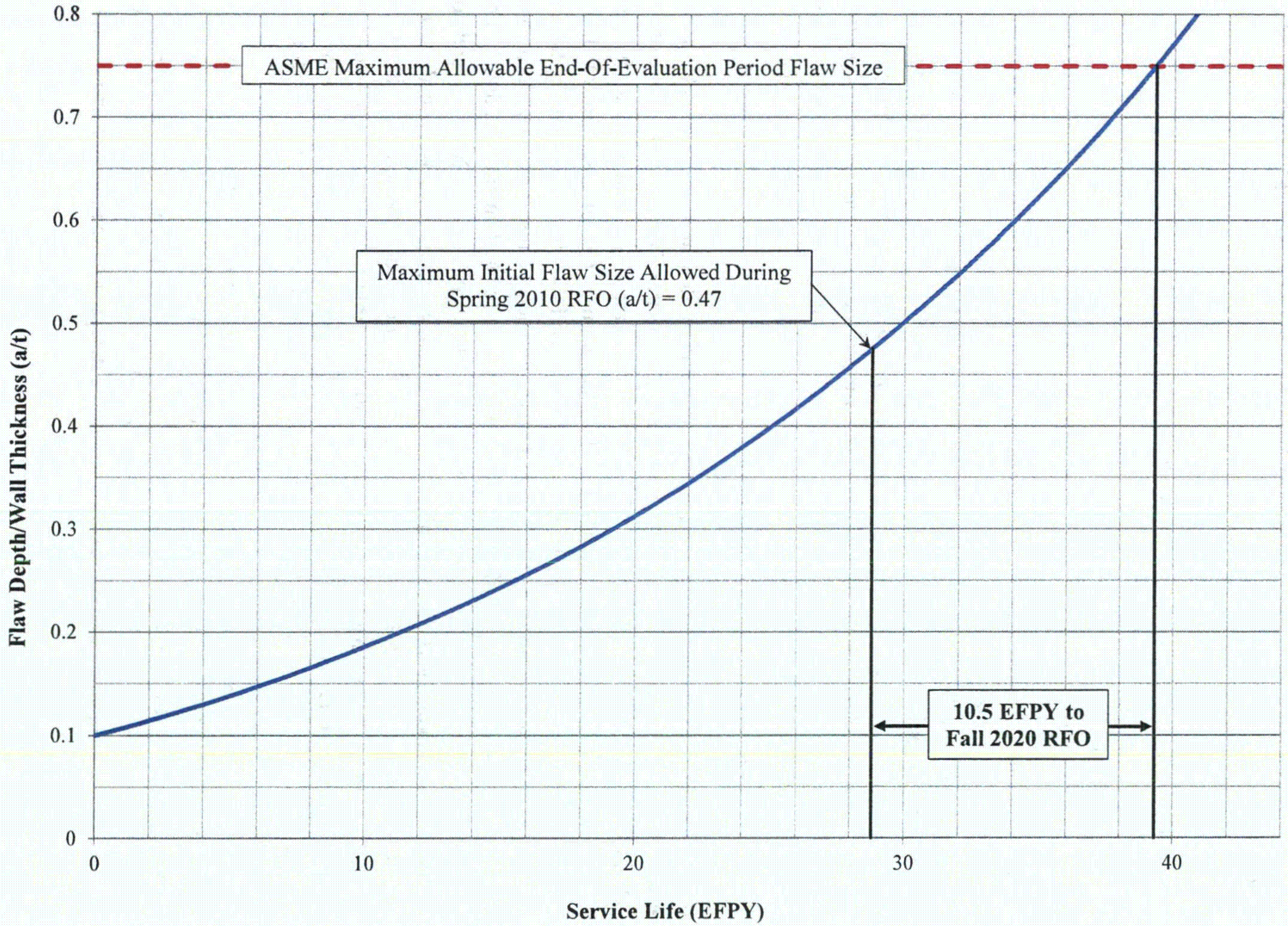

Figure 7-1: PWSCC Crack Growth Curve for Inlet Nozzle Axial Flaw (DM weld), Aspect Ratio = 2

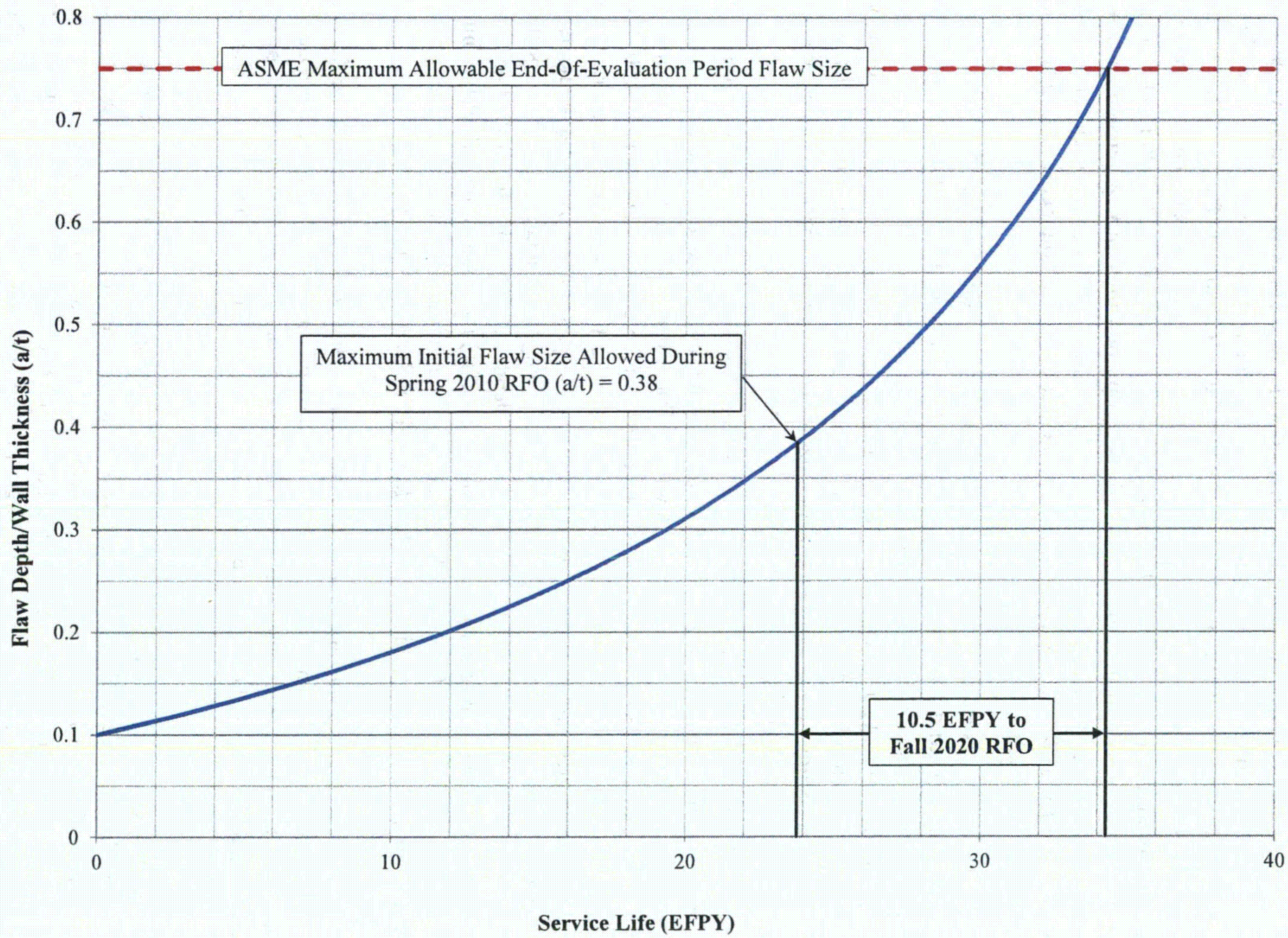

Figure 7-2: PWSCC Crack Growth Curve for Inlet Nozzle Circumferential Flaw (DM weld), Aspect Ratio = 10

8.0 Summary and Conclusions

A volumetric examination of the reactor vessel inlet nozzle to safe end DM butt welds was performed at McGuire Unit 1 during the Spring 2010 RFO. The next required volumetric examination will be during the Spring 2016 RFO in accordance with Code Case N-770-1. However, the volumetric examination will be deferred to the Fall 2020 RFO for the McGuire Unit 1 Reactor Vessel inlet nozzle DM welds. Since the time interval between the previous examination during the Spring 2010 RFO and the planned examination in Fall 2020 RFO exceeds 7 years, which deviates from the Code Case N-770-1 inspection interval requirements, a relief request will be submitted to the Nuclear Regulatory Commission (NRC) seeking relaxation from the ASME Code Case N-770-1 examination requirement to defer the volumetric examination of the inlet nozzle DM welds.

This letter report provides technical justification to support the relaxation request by performing a flaw tolerance analysis to determine the largest initial axial and circumferential flaws that could be left behind in service and remain acceptable for a service life of 10.5 years from the Spring 2010 RFO to the Fall 2020 RFO. This maximum allowable initial flaw size can then be compared to the indication detected during the Spring 2010 RFO inlet nozzle DM weld examination (see Section 7.0), as well as any flaw size which could have been reasonably missed during the Spring 2010 RFO inlet nozzle DM weld examination.

Based on the PWSCC crack growth analysis results from Section 7.0, the maximum allowable initial flaw sizes for the reactor vessel inlet nozzle DM welds are tabulated in Table 8-1. These allowable initial axial and circumferential flaw sizes have been shown to be acceptable in accordance with the ASME Section XI IWB-3640 acceptance criteria through the Fall 2020 RFO taking into account of potential PWSCC crack growth since the last volumetric examination during the Spring 2010 RFO. In accordance with the detection and sizing requirements in Supplement 10 of ASME Section XI Appendix VIII pertaining to the qualification of inspection procedures, the minimum required detectable flaw depth is 10% of the wall thickness. Therefore, based on the current inspection detection capability, these maximum allowable initial flaw sizes are larger than the flaw sizes that could have been reasonably missed during the last volumetric examination of the RV inlet nozzle DM welds in Spring 2010 RFO.

During the Spring 2010 inspection, the ultrasonic examination detected a single fabrication indication at the cladding to nozzle base metal interface of the Loop D RV inlet nozzle for McGuire Unit 1. This fabrication defect, which is not in the DM weld, is bounded by the allowable initial flaw sizes shown in Table 8-1 and would remain acceptable through the Fall 2020 RFO.

As a result, deferring the volumetric examination for the RV inlet nozzle DM welds from the 7 years allowed by Code Case N-770-1 to 10.5 years is technically justified. This is because the maximum allowable initial flaw sizes that have been shown to be acceptable for a service life of 10.5 years from the Spring 2010 RFO to the Fall 2020 RFO in accordance with the ASME Section XI IWB-3640 acceptance criteria are larger than the detected indication size and the flaw sizes that might have been reasonably missed during the Spring 2010 RFO.

Table 8-1
Maximum Allowable Initial Flaw Sizes

	Axial Flaw (Aspect Ratio = 2)	Circumferential Flaw (Aspect Ratio = 10)
Maximum Allowable Initial Flaw Size (a/t)	0.47	0.38
Flaw Depth (inches)	1.19	0.96
Flaw Length (inches)	2.38	9.60

Note: Aspect ratio = flaw length/flaw depth

9.0 References

1. ASME Code Case N-770-1, Section XI Division 1. "Alternative Examination Requirements and Acceptance Standards for Class 1 PWR Piping and Vessel Nozzle Butt Welds Fabricated with UNS N06082 or UNS W86182 Weld Filler Material With or Without Application of Listed Mitigation Activities." Approval Date December 25, 2009.
2. Rules for Inservice Inspection of Nuclear Power Plant Components, ASME Boiler & Pressure Vessel Code, Section XI.
    a. 1998 Edition through 2000 Addenda.
    b. 2007 Edition through 2008 Addenda
3. Westinghouse Report WCAP-15639-P, Rev. 0, "Flaw Evaluation Handbook for McGuire Unit 1 and Catawba Unit 2 Reactor Vessel Nozzle Safe End Weld Regions," March 2009.
4. Materials Reliability Program: Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Alloy 82, 182, and 132 Welds (MRP-115), EPRI, Palo Alto, CA: 2004. 1006696.
5. Drawings for McGuire Unit 1 RV inlet nozzle:
    a. Combustion Engineering Drawing E-235-444-7 (MCM-1201.01-0147), Rev. D8, "Pressure Vessel Final Machining for Westinghouse Electric Corp. 173" I.D. Reactor Vessel."
    b. Combustion Engineering Drawing E-235-445-1 (MCM-1201.01-0148), Rev. D3, "Nozzle Details for Westinghouse Electric Corp. 173" I.D. Reactor Vessel."
6. Equipment Specification 678849, Rev. 0, "Addendum to Equipment Specification 676413, Rev. 2, Reactor Vessel, Reactor Coolant, DAP – 105, McGuire Unit #1."
7. Dominion Engineering, Inc. Document C-8794-00-02, Rev. 0, "Welding Residual Stress Calculation for Clad RPV Outlet Nozzle – 50% Repair Case."
8. Materials Reliability Program: Primary Water Stress Corrosion Cracking (PWSCC) Flaw Evaluation Guidance (MRP-287). EPRI, Palo Alto, CA: 2010. 1021023.
9. Materials Reliability Program: Advanced FEA Evaluation of Growth of Postulated Circumferential PWSCC Flaws in Pressurizer Nozzle Dissimilar Metal Welds (MRP-216, Rev. 1): Evaluations Specific to Nine Subject Plants. EPRI, Palo Alto, CA: 2007. 1015400.
10. American Petroleum Institute, API 579-1/ASME FFS-1 (API 579 Second Edition), "Fitness-For-Service," June 2007.
11. Combustion Engineering Report CENC-1206-A1, "Addendum 1 to Analytical Report for Duke Power Company McGuire Unit No. 1 Reactor Vessel."

Attachment 4

Duke Energy Carolinas, LLC

McGuire Nuclear Station, Unit 1

Relief Request Serial # 15-MN-001

Westinghouse Application for Withholding Proprietary Information from Public Disclosure CAW-15-4089, accompanying Affidavit, Proprietary Information Notice, and Copyright Notice.

Westinghouse

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Engineering, Equipment and Major Projects
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Proj letter: DPC-15-9

CAW-15-4089

February 6, 2015

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-PAFM-14-114-P, "Technical Justification to Support Extended Volumetric Examination Interval for McGuire Unit 1 Reactor Vessel Inlet Nozzle to Safe End Dissimilar Metal Welds." (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-15-4089 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The Affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying Affidavit by Duke Energy.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference CAW-15-4089, and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

CAW-15-4089
February 6, 2015

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

I, Henry A. Sepp, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

Henry A. Sepp, Director
MCRE-Engineering Services

(1) I am Director, MCRE-Engineering Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitute Westinghouse policy and provide the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(iii) There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iv) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(v) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-PAFM-14-114 P-Attachment, "Technical Justification to Support Extended Volumetric Examination Interval for McGuire Unit 1 Reactor Vessel Inlet Nozzle to Safe End Dissimilar Metal Welds" (Proprietary), for submittal to the Commission, being transmitted by Duke Energy letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with technical justification to support extended volumetric examination interval for McGuire Unit 1 reactor vessel inlet nozzle to safe end dissimilar metal welds, and may be used only for that purpose.

(a) This information is part of that which will enable Westinghouse to:

(i) Provide technical justification to support extended volumetric examination interval for McGuire Unit 1 reactor vessel inlet nozzle to safe end dissimilar metal welds.

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of providing technical justification to support extended volumetric examination interval for reactor vessel nozzle to safe end dissimilar metal welds.

(ii) Westinghouse can sell support and defense of industry guidelines and acceptance criteria for plant-specific applications.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC associated with technical justification to support extended volumetric examination interval for McGuire Unit 1 reactor vessel inlet nozzle to safe end dissimilar metal welds, and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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