ENCLOSURE 3 TO NL-11-123

LTR-PAFM-11-136NP, REV. 0 "TECHNICAL JUSTIFICATION TO SUPPORT EXTENDED VOLUMETRIC EXAMINATION INTERVAL FOR INDIAN POINT GENERATING STATION UNIT 2 REACTOR VESSEL INLET NOZZLE TO SAFE END DISSIMILAR METAL WELDS," NOVEMBER 2011

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
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Revision 0

Technical Justification to Support Extended Volumetric Examination Interval for Indian Point Generating Station Unit 2 Reactor Vessel Inlet Nozzle to Safe End Dissimilar Metal Welds

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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 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 dissimilar metal (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 dissimilar metal butt welds at the Reactor Vessel (RV) inlet nozzles every second inspection period not exceeding 7 years. A volumetric and 100% eddy current surface examination were performed for the Indian Point Unit 2 reactor vessel inlet nozzle to safe end dissimilar metal butt welds during the Spring 2006 Re-Fueling Outage (RFO) and no indications were detected.

The next required volumetric examination for the Reactor Vessel inlet nozzle DM welds will be during the Spring 2012 RFO in accordance with Code Case N-770-1. This evaluation will determine the impact of performing the volumetric examination during the Spring 2014 RFO. The time interval between the previous examination in Spring 2006 RFO and the planned examination in Spring 2014 RFO is 8 years rather than the 7 years allowed by Code Case N-770-1. Therefore, a relief request was submitted to the Nuclear Regulatory Commission (NRC) seeking relaxation from the ASME Code Case N-770-1 examination requirement to be able to defer the volumetric examination from the Spring 2012 RFO to the Spring 2014 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 undetected axial and circumferential flaw size that could be left behind in service and remain acceptable for a service life of 8 years from the Spring 2006 RFO to the Spring 2014 RFO. The maximum undetected flaw size will then be compared to the flaw size which could have been reasonably missed during the Spring 2006 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 2012 RFO to the Spring 2014 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 undetected flaw size that would be acceptable in the DM welds for the duration from the Spring 2006 RFO to the Spring 2014 RFO. This maximum allowable flaw size would be the largest flaw size that could go undetected during the Spring 2006 RFO examination of the RV inlet nozzle dissimilar metal weld and be acceptable for a service life of 8 years from the Spring 2006 RFO to the Spring 2014 RFO. The maximum allowable undetected 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 dissimilar metal 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 the Stretch Power Uprate program, which is documented in the engineering report WCAP-16156-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 dissimilar metal 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 dissimilar metal welds is provided in Section 4.0. The determination of end-of-evaluation period allowable flaw sizes is discussed in Section 5.0.

The maximum allowable undetected flaw size will be determined based on the crack growth due to PWSCC growth mechanism at the RV inlet nozzle dissimilar metal 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 2012 to the Spring 2014 RFO.

3.0 Nozzle Geometry and Loads

The dissimilar metal weld geometry for the Indian Point Unit 2 Reactor Vessel inlet nozzle is based on the nozzle detail drawings (Reference 5). 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 the Stretch Power Uprate program (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 crack growth.

Table 3-1
Indian Point Unit 2 Reactor Vessel Inlet Nozzle Geometry and Normal Operating Temperature

Dimension	Inlet Nozzle
Outside Diameter (in.)	32.5
Inside Diameter (in.)	27.5
Thickness (in.)	2.50
RV Inlet Nozzle Fluid Temperature = 536°F[1]	

Notes:

1. Actual plant operating temperature is in the range of 535-536°F.

Table 3-2
Indian Point Unit 2 Reactor Vessel Inlet Nozzle Piping Loads

Loading	Forces (kips)	Moments (in-kips)		
	Fx (Axial)	Mx (Torsion)	My (Bending)	Mz (Bending)
Deadweight	-0.344	-254.6	-96.8	-535.7
Normal Operating Thermal	13.0	-2732.6	1509.5	-5258.2
OBE (Operational Basis Earthquake)	59.3	554.5	2550.1	560.3
DBE (Design Basis Earthquake)	88.9	831.8	3825.2	840.4
Max LOCA (Loss of Coolant Accident)	833.6	1401.9	19618.9	2928.7

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 (Reference 6) based on the Indian Point Unit 2 Reactor Vessel inlet nozzle DM weld specific configuration (Reference 5). Figure 4-1 shows a sketch of the inlet nozzle DM weld configuration. The finite element analysis (FEA) in Reference 6 is based on a two-dimensional axisymmetric model of the inlet nozzle dissimilar metal 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, and the stainless steel weld attaching the safe end to the piping. The FEA also assumes a 360° inside surface weld repair with a repair depth of 50% through the dissimilar metal weld thickness, which is consistent with MRP-287 guidance (Reference 7). The following fabrication sequence was simulated in the finite element residual stress analysis based on the information provided in the reactor vessel nozzle details drawings (Reference 5):

- The inlet nozzle was welded to the safe end ring forging using an Alloy 182 weld. The outer and inner diameters of the dissimilar metal weld were machined to finished size.
- An assumed 50% inside surface weld repair 360° around the circumference was conservatively simulated in the Alloy 182 weld, which is consistent with MRP-287 (Reference 7).
- The welded configuration was then raised to a temperature of 1100°F to simulate post-weld heat treatment.
- Shop hydrostatic test was then performed at a pressure of 3110 psig and a temperature of 300°F
- The safe end was then machined for the piping side weld preparation.
- The machined safe end was welded to a long segment of stainless steel piping using a stainless steel weld.
- A plant hydrostatic test was performed at 2485 psig pressure with a temperature of 300°F.
- After the plant 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 three different cuts (centerline path on the DM weld, and two paths along the fusion lines of the DM weld) from the DM weld were obtained. The hoop welding residual stresses based on the limiting centerline cut along the DM weld are used in the analysis and shown in Figure 4-2. The axial residual stresses do not vary significantly for the three cuts along the DM weld. The axial residual stresses that would result in the most limiting PWSCC crack growth are used in the analysis and shown in Figure 4-2, which is the stress profile along the centerline path of the DM weld.

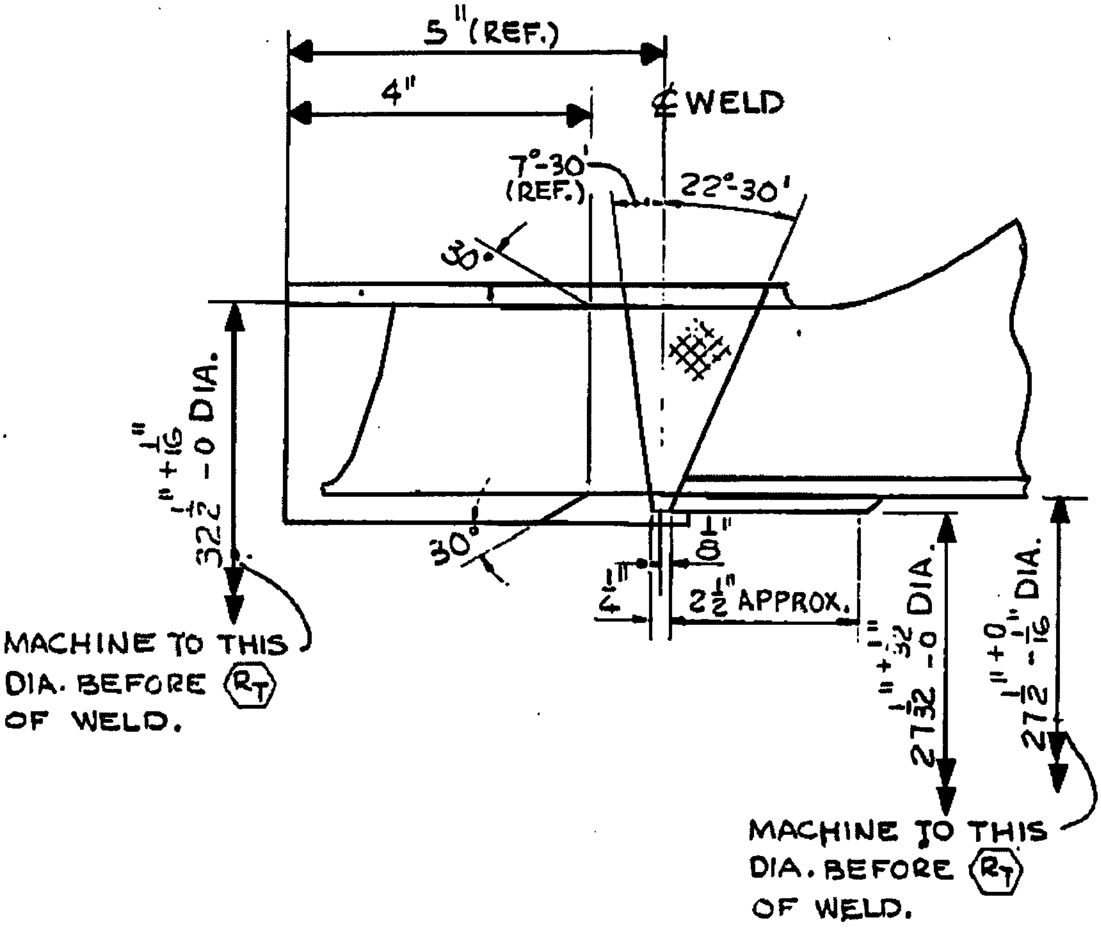

Figure 4-1: Indian Point Unit 2 Reactor Vessel Inlet Nozzle DM Weld Configuration

a,c,e

Figure 4-2: Reactor Vessel Inlet Nozzle DM Weld Through-Wall Residual Stress Profiles 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 2012 RFO to the Spring 2014 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).

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 end-of-evaluation period allowable 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 dissimilar metal 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 Indian Point Unit 2, Z factors based on Reference 8 are used in the analysis to provide a more representative approximation of the effects of the dissimilar metal welds. The use of Z factors in effect reduces the 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 end-of-evaluation period allowable 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 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 Code Section XI. For circumferential flaws, axial stress due to the pressure, deadweight, thermal expansion, seismic and LOCA loads are considered in the evaluation. As for the axial flaws, hoop stress resulting from pressure loading is used. The RV inlet nozzle piping loads (Table 3-2) at the DM weld locations for Indian Point Unit 2 are based on the Stretch Power Uprate program (Reference 3).

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 end-of-evaluation period allowable flaw size was calculated for the axial flaw 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 undetected flaw size that would be acceptable based on ASME Section XI acceptance criteria (Reference 2) for the duration from the Spring 2006 RFO to the Spring 2014 RFO. The maximum allowable undetected 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, stress corrosion crack 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 dissimilar metal welds, the crack tip stress intensity factors can be determined based on the stress intensity factor expressions from Reference 9. The through-wall stress distribution profile is represented by a 4th order polynomial:

$$\sigma\left(\frac{a}{t}\right) = \sigma_0 + \sigma_1\left(\frac{a}{t}\right) + \sigma_2\left(\frac{a}{t}\right)^2 + \sigma_3\left(\frac{a}{t}\right)^3 + \sigma_4\left(\frac{a}{t}\right)^4$$

where:

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

a 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 536°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 0.0018 for the location of interest at the inlet nozzle documented on Page A172 of the reactor vessel stress report CENC-1110 (Reference 10) and that the Stretch Power Uprate program has negligible impact on the usage factor at the inlet nozzle (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 2012 RFO to Spring 2014 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 dissimilar metal welds must not exceed 7 years. A relief request has been submitted to the NRC 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 dissimilar metal welds from the Spring 2012 RFO to the Spring 2014 RFO. Since no recordable indications were detected during the Spring 2006 RFO, technical justification can be developed to support deferring the volumetric examination from the Spring 2012 RFO to the Spring 2014 RFO by calculating the maximum undetected flaw size that could be left behind in service and remain acceptable for a service life of 8 years from the Spring 2006 RFO to the Spring 2014 RFO. This maximum undetected flaw size can then be compared to the flaw size which could have been reasonably missed during the Spring 2006 RFO inlet nozzle DM weld examination. It should be noted that an eddy current surface examination was also performed on the inside surface of the inlet nozzle DM welds in Spring 2006 RFO with no detected indications. This surface examination provides additional assurance that no inside surface connected, or surface breaking flaws were missed during the Spring 2006 RFO.

The maximum allowable undetected flaw depth is determined by subtracting the PWSCC crack growth for a plant operation duration of 8 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 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 undetected 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 hoop welding residual stresses used in the PWSCC crack growth analysis for the axial flaw is shown in Figure 4-2. The PWSCC crack growth analysis of the circumferential flaw considered two cases: normal operating piping loads with axial residual stresses (shown in Figure 4-2) and normal operating piping loads without residual stresses in order to obtain the most limiting crack growth results since a portion of the residual stress profile is compressive. The PWSCC crack growth result for the circumferential flaw was found to be more limiting for the case without residual stresses (pressure, deadweight, normal operating thermal loads) than the case with residual stresses (pressure, deadweight, normal operating thermal loads, residual stresses).

The PWSCC crack growth curves and the maximum allowable undetected 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 undetected flaw sizes for the axial and circumferential flaws are tabulated in Table 7-1.

Table 7-1
Maximum Allowable Undetected Flaw Sizes

	Axial Flaw (Aspect Ratio = 2)	Circumferential Flaw (Aspect Ratio = 10)
Maximum Allowable Undetected Flaw Size (a/t)	0.48	0.49
Flaw Depth (inches)	1.20	1.23
Flaw Length (inches)	2.40	12.3

The maximum allowable undetected flaw sizes shown in Table 7-1 are the largest undetected axial and circumferential flaw sizes that could be left behind in service and remain acceptable for a service life of 8 years from the Spring 2006 RFO to the Spring 2014 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 undetected flaw sizes are larger than the flaw sizes that could have been reasonably missed during the last Spring 2006 RFO volumetric examination of the RV inlet nozzle DM welds.

Therefore, deferring the volumetric examination for the RV inlet nozzle DM welds from the 7 years allowed by Code Case N-770-1 to 8 years is technically justified. This is because the maximum allowable undetected flaw sizes that have been shown to be acceptable for a service life of 8 years from the Spring 2006 RFO to the Spring 2014 RFO in accordance with the ASME Section XI IWB-3640 acceptance criteria are larger than the flaw sizes that might have been reasonably missed during the Spring 2006 RFO.

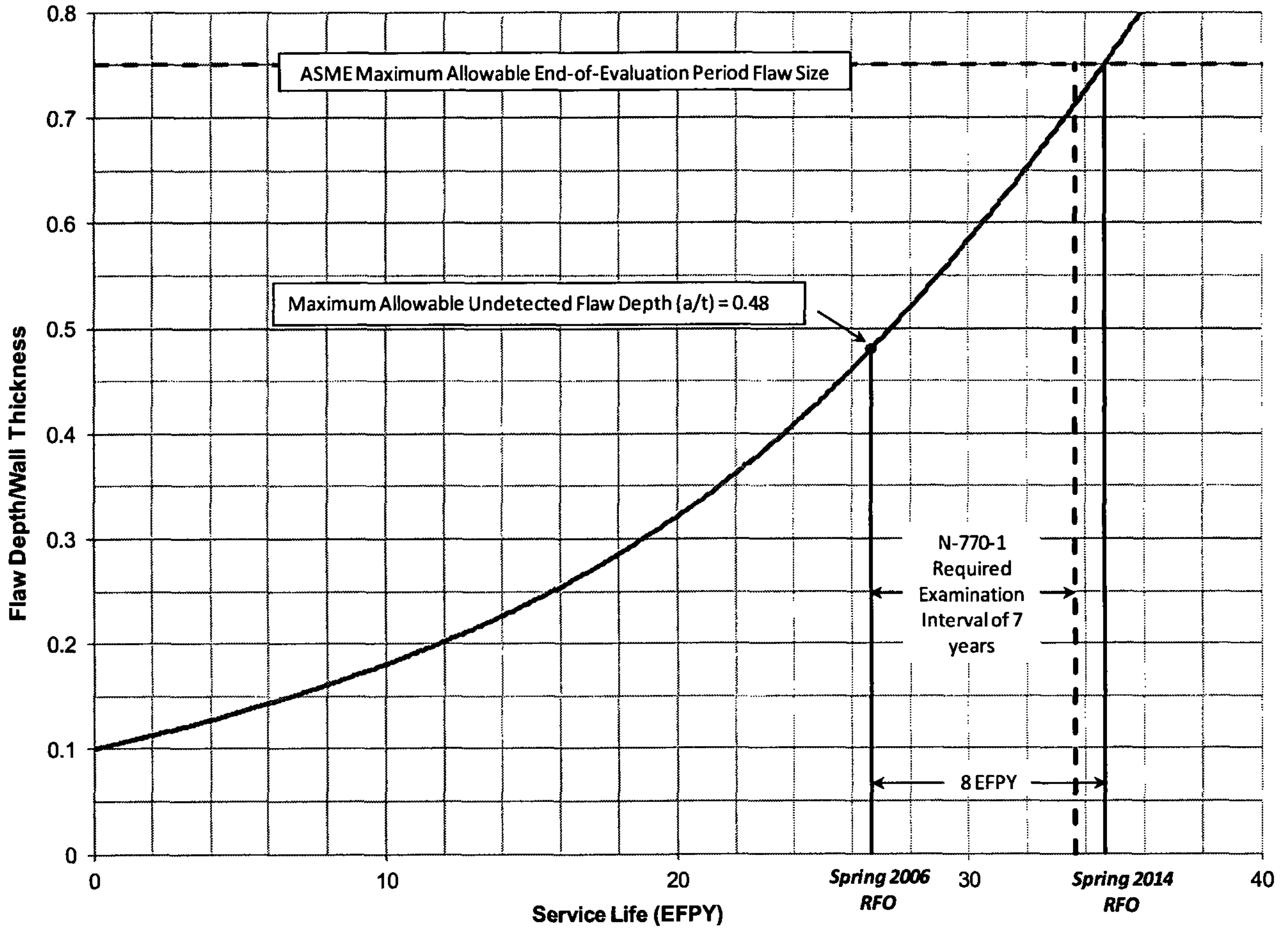

Figure 7-1: PWSCC Crack Growth Curve for Inlet Nozzle Axial Flaw (DM weld), Aspect Ratio = 2

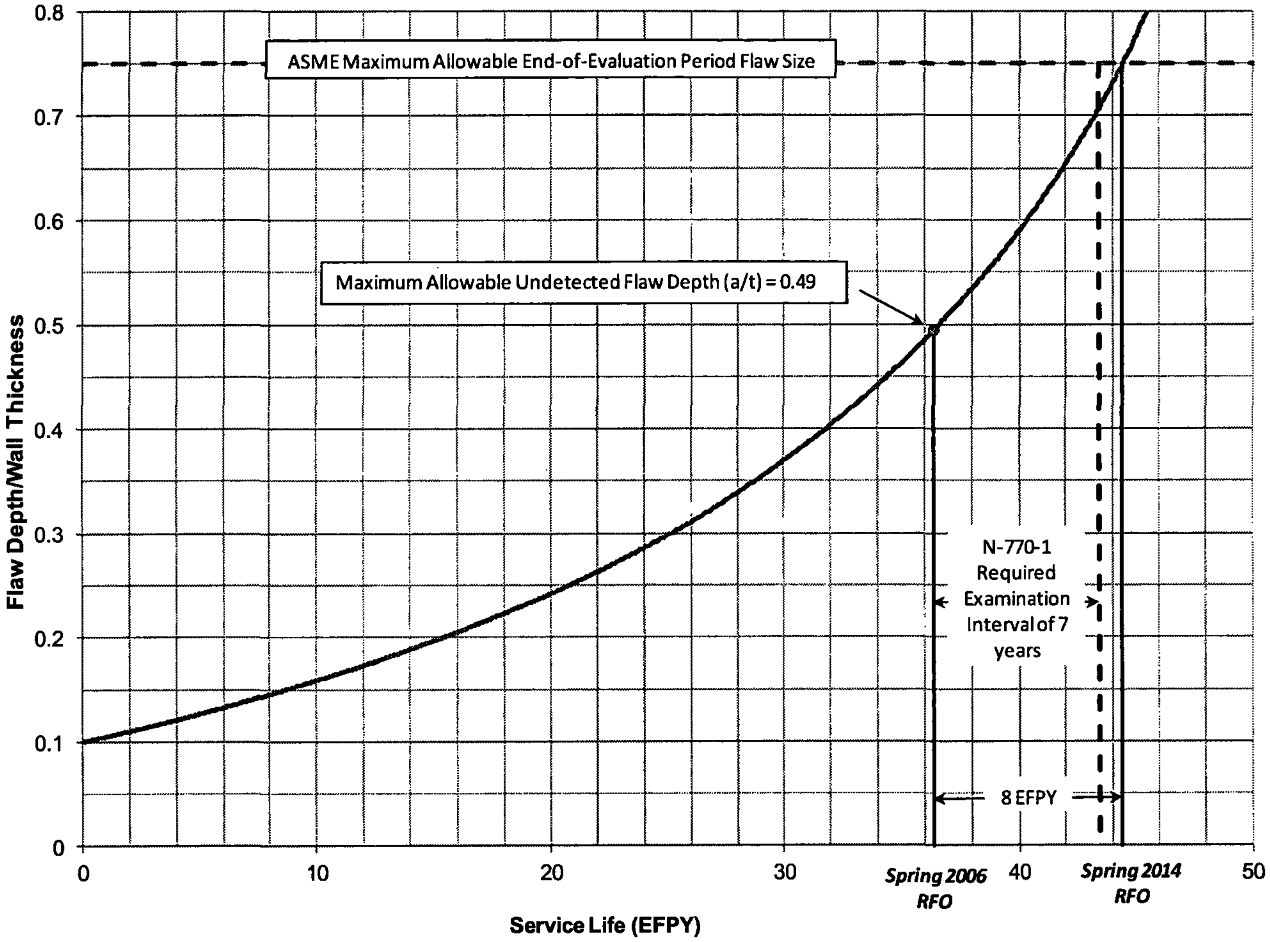

Figure 7-2: PWSCC Crack Growth Curve for Inlet Nozzle Circumferential Flaw (DM weld), Aspect Ratio = 10

8.0 Summary and Conclusions

A volumetric examination of the reactor vessel inlet nozzle to safe end dissimilar metal butt welds was performed at Indian Point Unit 2 during the Spring 2006 RFO and there were no recordable indications. The next required volumetric examination will be during the Spring 2012 RFO in accordance with Code Case N-770-1. However, the volumetric examination will be deferred to the Spring 2014 RFO for the Indian Point Unit 2 Reactor Vessel inlet nozzle DM welds. Since the time interval between the previous examination in Spring 2006 RFO and the planned examination in Spring 2014 RFO exceeds 7 years, which deviates from the Code Case N-770-1 inspection interval requirements, a relief request was 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 undetected axial and circumferential flaws that could be left behind in service and remain acceptable for a service life of 8 years from the Spring 2006 RFO to the Spring 2014 RFO. The maximum undetected flaw size can then be compared to the flaw size which could have been reasonably missed during the Spring 2006 RFO inlet nozzle DM weld examination.

Based on the PWSCC crack growth analysis results from Section 7.0, the maximum allowable undetected flaw sizes for the reactor vessel inlet nozzle DM welds are tabulated in Table 8-1. These allowable undetected axial and circumferential flaw sizes have been shown to be acceptable in accordance with the ASME Section XI IWB-3640 acceptance criteria through the Spring 2014 RFO taking into account of potential PWSCC crack growth since the last volumetric examination during the Spring 2006 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 undetected 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 2006 RFO. It should be noted that an eddy current surface examination was also performed on the inside surface of the inlet nozzle DM welds in the Spring 2006 RFO with no detected indications. This surface examination provides additional assurance that no inside surface connected, or surface breaking flaws were missed during the Spring 2006 RFO. As a result, deferring the volumetric examination for the RV inlet nozzle DM welds from 7 years allowed by Code Case N-770-1 to 8 years is technically justified. This is because the maximum allowable undetected flaw sizes that have been shown to be acceptable for a service life of 8 years from the Spring 2006 RFO to Spring 2014 RFO in accordance with the ASME Section XI IWB-3640 acceptance criteria are larger than the flaw sizes that might have been reasonably missed during the Spring 2006 RFO.

Table 8-1
Maximum Allowable Undetected Flaw Sizes

	Axial Flaw (Aspect Ratio = 2)	Circumferential Flaw (Aspect Ratio = 10)
Maximum Allowable Undetected Flaw Size (a/t)	0.48	0.49
Flaw Depth (inches)	1.20	1.23
Flaw Length (inches)	2.40	12.3

9.0 References

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