Constellation Energy
Nine Mile Point Nuclear Station

P.O. Box 63
Lycoming, NY 13093

August 22, 2007

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

ATTENTION: Document Control Desk

SUBJECT: Nine Mile Point Nuclear Station
Unit No. 1; Docket No. 50-220

Submittal of Additional Engineering Evaluations for Two Reactor Pressure Vessel Weld Flaws in Accordance with Amended License Renewal Application Commitment

REFERENCES:

(a) Letter from R. B. Abbott (NMPC) to Document Control Desk (NRC), dated September 14, 1999, Submittal of 1999 Inservice Inspection Summary Report and Flaw Indication Evaluations

(b) Letter from P. S. Tam (NRC) to J. H. Mueller (NMPC), dated May 5, 2000, Nine Mile Point Nuclear Station, Unit No. 1 – Evaluation of Flaw Indications in Reactor Pressure Vessel Welds (TAC No. MA6510)

(c) Letter from J. A. Spina (NMPNS) to Document Control Desk (NRC), dated December 5, 2005, License Renewal Application (LRA) – Responses to NRC Requests for Additional Information Regarding LRA Parts 1, 2, 3 and 4 (TAC Nos. MC3272 and MC3273)

(d) NUREG-1900, Safety Evaluation Report Related to the License Renewal of Nine Mile Point Nuclear Station, Units 1 and 2, Volume 2, September 2006

By letter dated September 14, 1999 (Reference a), Niagara Mohawk Power Corporation (the previous licensee) submitted to the NRC for review and approval a structural evaluation of subsurface flaw indications found in two Nine Mile Point Unit 1 (NMP1) reactor pressure vessel (RPV) welds (RV-WD-140 and RV-WD-099) during refueling outage 15. The evaluations considered fatigue crack growth and irradiation embrittlement for up to 28 effective full power years (EFPY) of operation (i.e., the end of the original license term). The NRC staff concurred that continued operation with these flaws was acceptable until the end of the 28 EFPY in a safety evaluation dated May 5, 2000 (Reference b).

As discussed in the amended NMP1 License Renewal Application (LRA), Section 4.7.4, the analyses performed for these RPV weld flaws were considered to be time-limited aging analyses since the

A107
NRR

acceptability criteria were applicable only through the original 40-year license term. In a letter to the NRC dated December 5, 2005 (Reference c), Nine Mile Point Nuclear Station, LLC (NMPNS) made the following commitment regarding the RPV weld flaw evaluations:

> "The RPV weld flaw evaluations will be revised to consider additional fatigue crack growth and the effects of additional irradiation embrittlement (for beltline materials) associated with operation for an additional 20 years (i.e., out to at least 46 EFPY) and submitted for NRC review and approval no later than 2 years prior to the period of extended operation. If the revised calculation shows the identified flaws cannot meet the applicable acceptance criteria, the indications will be reexamined in accordance with ASME Section XI requirements."

The above commitment was affirmed in the NRC's safety evaluation report related to license renewal of NMP1, as documented in Section 4.7.4 of NUREG-1900, Volume 2 (Reference d).

In accordance with the commitment stated above, this letter is submitting additional engineering evaluations that have been performed for the subject RPV weld flaws to project the evaluations to the end of the period of extended operation, by considering additional fatigue crack growth and the effects of additional irradiation embrittlement (for beltline materials) associated with operation for an additional 20 years (see Attachment 1). The evaluations utilized inputs from scoping pressure-temperature (P-T) curves that were based on projected fluence levels corresponding to 46 EFPY, using the current NMPNS Regulatory Guide 1.190 methods approved by the NRC. In addition, the evaluations used K_{Ic} (instead of K_{Ia}) for allowable fracture toughness consistent with the current NRC-approved NMP1 P-T curve application of Code Case N-640 and IWB-3600 of the 2006 Edition of the ASME Code, Section XI. The additional engineering evaluations described in Attachment (1) are conservative and provide reasonable assurance that the flaws will remain acceptable and that structural integrity of the RPV will be maintained during the period of extended operation.

This letter contains no new regulatory commitments. Should you have any questions regarding the information in this submittal, please contact T. F. Syrell, Licensing Director, at (315) 349-5219.

Very truly yours,

Gary Jay Laughlin
Manager Engineering Services

GJL/DEV

Attachment: (1) Nine Mile Point Unit 1 – Additional Engineering Evaluations for Reactor Pressure Vessel Welds RV-WD-140 and RV-WD-099 for the License Renewal Period (Calculation S0VESSELM030, Revision 01, Disposition 01B)

cc: S. J. Collins, NRC
M. J. David, NRC
Resident Inspector, NRC

ATTACHMENT (1)

NINE MILE POINT UNIT 1

ADDITIONAL ENGINEERING EVALUATIONS FOR

REACTOR PRESSURE VESSEL WELDS RV-WD-140 AND RV-WD-099

FOR THE LICENSE RENEWAL PERIOD

(Calculation S0VESSELM030, Revision 01, Disposition 01B)

Engineering Services	DISPOSITION COVER SHEET	Page 1 (Next) 2 Total 22 Last 22

Project: NINE MILE POINT NUCLEAR STATION Unit (1,2 or 0=Both): 1 Discipline: Mechanical

Title Reconciliation of Previous RPV Flaw Evaluations for the License Renewal Period		Calculation No. S0VESSELM030	Rev: 01	Disp 01B
		Originator [signature] R. Corieri	Date 7/9/07	
(Sub)System(s) RXVE	Index No. S0	Reviewer [signature] G. Inch	Date 7/9/07	
DER, Evaluation or Change No. NCTS # 504582-19		Approver [signature] P. Bartolini	Date 7/9/2007	

Safety Class: (SR*/NSR/QXX): SR NMP Acceptance/Date N/A /

* If SR, attach or reference the associated Design Verification Report. (The attached calculation was performed by SIA under Safety Related PO # 05-55640-002 and therefore was design verified by SIA under their SR QA Program).

Superseded Document(s): N/A Output provided? N (Y/N) If yes, group(s):

Description of Change

SEE PAGE 2

Resolution

SEE PAGE 2

Cross Reference Change(s):

1. ATI-05-034-001
2. MPM-405778
3. NER-1M-063

General Reference(s): NCTS # 504582-19

Confirmation Required (Yes/No): N See Page(s):	Final Issue Status APP	Turnover Req'd (Yes/N/A): N/A

10 CFR50.59 Evaluation Number(s): Copy of Applicability Determination or 50.59 Screen Attached? Yes ☒ No* ☐ N/A ☐ *If "No", location of AD/Screen?	Component ID(s)(As shown in MEL): RPV-NR02
Key Words: License Renewal, ASME, Reactor Vessel	

Ref.

Table of Contents

Description of Change

Background:

In 1999, unacceptable indications in the RPV shell per ASME XI IWB-3500 were identified by Ultrasonic exams (UT) in axial weld RVWD-140 and shell-to-flange circumferential weld RVWD-099. The detected flaws are subsurface planar flaws located parallel to the centerline of the weld (i.e., the indications in RVWD-140 were axially-oriented and the indications in RVWD-099 were circumferentially-oriented). The flaw evaluations considered fatigue crack growth and irradiation embrittlement (only applicable for the beltline weld, RVWD-140) to 28 Effective Full Power Years (EFPY). The original flaw evaluations for these flaws were performed in revision 1 of this calculation S0VESSELM030 using a flaw handbook developed by General Electric Nuclear Energy (GENE). The original flaw evaluations were submitted to the NRC for review and approval under NMPC letter dated September 14, 1999. The NRC reviewed the original evaluations and concurred that continued operation with these flaws is acceptable through 28 EFPY, the end of the current license term, as stated in the NRC SE dated May 5, 2000.

The original flaw evaluations determined that leak test and bolt-up conditions were the most limiting conditions for fracture analysis of the flaws. The leak test (i.e., ASME XI Leakage Test) was identified as the limiting loading condition in the axial weld RVWD-140 and reactor vessel bolt-up was limiting for the shell-to-flange circ weld RVWD-099. In 2003, the NRC issued Technical Specification Amendment No. 183 which revised the NMP-1 reactor coolant system pressure-temperature limit curves and tables in Tech Spec Section 3.2.2/4.2.2, "Minimum Reactor Vessel Temperature of Pressurization". The revised P-T curves were developed using Code Case N-640 "Alternative Reference Fracture Toughness for P-T Curves". Use of code case N-640 ultimately decreased the leak test temperatures, which decreases the fracture toughness. As such, the existing flaw evaluations were dispositioned in SOVESSELMO30-01A (SIA calculation NMP-05Q-303 Revision 0) to reconcile the leak test conditions associated with the updated P-T limit curves. The calculation disposition concluded that the previously detected flaws remained acceptable when compared to the updated (lower) allowable flaw sizes at 28 EFPY. The minimum temperature for bolt-up (100 °F) remained unchanged by the Tech Spec amendment; however, the calculation disposition conservatively evaluated the flaws assuming a lower bolt-up temperature of 70 °F. The revised flaw evaluations were not submitted to the NRC for review and approval.

In 2005/2006 during the License Renewal application period, NMP1 committed to submit revised flaw evaluations for the subject flaws in the RPV shell welds to the NRC for staff review and approval at least two years prior to entering the period of extended operation. The revised flaw evaluations were to

Project: Nine Mile Point Nuclear Station Unit: 1 Disposition: 01B

Originator/Date	Reviewer/Date	Calculation No.	Revision
R. Corieri/6-18-07	G. Inch/6-18-07	S0VESSELM030	01

Ref.

consider additional fatigue crack growth and the effects of additional irradiation embrittlement (for beltline materials) associated with operation for an additional 20 years (i.e., out to at least 46 EFPY). This commitment is documented in NUREG-1900, Volume 2, Section 4.7.4.2. and in the Unit 1 UFSAR Appendix C, Section C.2.5.1. In December 2005, the attached revision 1 of SIA calculation NMP-05Q-303 revised the allowable flaw sizes for fatigue and irradiation embrittlement for 46 EFPY. Since the limiting loading condition for flaws in axial weld RVWD-140 is the leak test condition, the P-T curve for leakage testing had to first be revised for projected fluence levels corresponding to 46 EFPY. The Reference 3 calculation documents "scoping" P-T limit curves for 46 EFPY. The scoping 46 EFPY P-T limit curves were developed using the same methodology as the existing P-T curves approved by the NRC in Tech Spec amendment 183. The scoping P-T curves were based on draft best estimate neutron fluence calculations available in 2005 when the attached calculation was originated. The draft neutron fluence calculations were performed in accordance with Regulatory Guide 1.190. Subsequently the neutron fluence calculations were finalized in MPM-405778, "Neutron Transport Analysis for NMP-1". The 46 EFPY fluence exposures at weld RVWD-140 used in the attached SIA calculation was compared to the final fluence calculated in MPM-405778. This comparison determined that the fluence used in the attached calculation is conservatively bounded by the final fluence calculation. Since both the scoping P-T curve calculations and the attached SIA calculation used the higher draft fluence values, the calculated allowable flaw sizes at weld RVWD-140 are deemed to be conservative. The allowable flaw sizes for shell-to-flange weld RVWD-099 were also recalculated assuming 20 additional years of fatigue crack growth. The revised allowable flaw sizes were conservatively determined for a bolt-up temperature of 70°F, although the current minimum Tech Spec bolt-up temperature is 100°F.

Resolution & Conclusions

The attached calculations provide "scoping" allowable flaw sizes for welds RVWD-140 and RVWD-099 out to 46 EFPY in accordance with NMP1's License Renewal commitment. The calculation concludes that existing flaws in the two welds are acceptable as compared to the 46 EFPY acceptance criteria. The calculations while considered for information only are conservative and are only intended to provide reasonable assurance that the flaws will remain acceptable and the structural integrity of the RPV will be maintained during the period of extended operation. Final allowable flaw sizes will be re-calculated when P-T curves for the license renewal period are developed. The impact of the future P-T curve development on the attached calculation will be re-visited at some future time under the NMP design change control process. The NMP1 fluence methods are based on approved Regulatory Guide 1.190 methods which require maintenance of fluence projections based on routine updates using actual core operating conditions and changes to ART as needed. In addition NMP1 is part of the BWRVIP ISP Program which requires review of the ART when ISP capsules are removed. Therefore the acceptability of the flaws is reviewed whenever the ART and/or P-T curves require adjustment.

The NRC commitment as documented in NUREG-1900 and the UFSAR also states that the flaws will be reexamined in accordance with ASME Section XI as necessary. Because the revised flaw evaluations contained herein demonstrate that the flaws are acceptable for additional 20-years, the current ASME XI inspection frequency of once/interval for examination category B-A pressure retaining welds is adequate.

STRUCTURAL INTEGRITY Associates	CALCULATION PACKAGE	FILE No.: NMP-05Q-303 PROJECT No.: NMP-09Q

PROJECT NAME: Nine Mile Point **FatiguePro**

CLIENT: Constellation Energy Group (Nine Mile Point Unit 1)

CONTRACT NO.: 05-55640-002

CALCULATION TITLE: RPV Flaw Evaluation

PROBLEM STATEMENT OR OBJECTIVE OF THE CALCULATION:

This calculation provides a reconciliation of the previous flaw evaluation performed for the NMP-1 RPV. The allowable flaw sizes computed by GE for 28 EFPY for the indications in question are first reproduced. This step ensures consistency in methodology application. Then, revised allowable flaw sizes are computed for 46 EFPY (projected end-of life value for 60 years of operation) using the appropriate revised pressure test temperature for comparison to the previously as-found indications.

Document Revision	Affected Pages	Revision Description	Project Mgr. Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
0	1 - 8 On Computer Files	Original Issue	G. L. Stevens 11/5/02	G. L. Stevens GLS 11/5/02 K. K. Fujikawa KKF 11/5/02
1	1 - 13 In computer files	Revised to evaluate license renewal operation for 60 years. Revisions are marked by "revision bars" in the right hand margin.	G. L. Stevens Gary L. Stevens 12/27/2005	G. L. Stevens GLS 12/27/05 Gary L. Stevens K. K. Fujikawa KKF 12/27/05 Karen K Fujikawa

Table of Contents

List of Tables

List of Figures

1.0 INTRODUCTION

During past RPV weld examinations for Nine Mile Point Unit 1 (NMP-1), flaws were detected in the reactor pressure vessel (RPV) that required IWB-3600 evaluation [1]. The flaws were dispositioned via a RPV Flaw Handbook prepared for NMP-1 by GE [2]. The flaw handbook determined the boltup and pressure test conditions to be limiting, so allowable flaw sizes were determined based on the pressure-temperature (P-T) curve values for pressure test conditions for 20.3 and 28 EFPY. Revision 0 of this calculation was performed to reconcile the prior GE flaw evaluation due to the revision of the P-T curves to incorporate Code Case N-640 (i.e., application of K_{Ic}). The P-T curves were recently revised for license renewal operation [3]. This caused a change in the P-T curves, thereby changing the required pressure test temperature and, therefore, the resulting allowable fracture toughness. As a result, reconciliation of the prior RPV flaw evaluation was considered necessary.

In this calculation, the previous flaw evaluation for the RPV is reconciled. The allowable flaw sizes originally computed by GE for 28 EFPY for the indications in question are first reproduced. This step ensures consistency in methodology application. Then, revised allowable flaw sizes are computed for 46 EFPY (projected end-of life value for 60 years of operation) [3] using the appropriate revised pressure test temperature for comparison to the previously as-found indications.

This calculation details all inputs, methodology, and analysis results associated with the RPV flaw reconciliation analysis calculation.

2.0 INPUTS

Reference [1] provides the flaws to be evaluated, as shown in Table 1.

Table 1. Flaws To Be Evaluated

RPV Weld ID	Flaw Id	Flaw Orientation	Flaw Handbook Figure No.	Flaw Depth, 2a	1/2 Flaw Depth, a	Flaw Length, L	a/L	GE Allowable	Wall Thick, t	a/t
RVWD-099	109/139	Circ	D-3	0.396	0.198	6.75	0.0293	1.20	7.2	0.0275
RVWD-099	1-112	Circ	D-3	0.594	0.297	1.25	0.2376	1.55	7.2	0.0413
RVWD-099	1-113	Circ	D-3	0.594	0.297	3.25	0.0914	1.26	7.2	0.0413
RVWD-099	1-114	Circ	D-3	0.594	0.297	3.5	0.0849	1.24	7.2	0.0413
RVWD-099	1-115	Circ	D-3	0.552	0.276	3.5	0.0789	1.23	7.2	0.0383
RVWD-099	1-116	Circ	D-3	0.552	0.276	2.5	0.1104	1.31	7.2	0.0383
RVWD-099	1-122/149	Circ	D-3	0.453	0.2265	7.75	0.0292	1.20	7.2	0.0315
RVWD-140	55	Axial	D-12	0.396	0.198	13.75	0.0144	0.90	7.2	0.0275
RVWD-140	9-015+016	Axial	D-12	0.424	0.212	3.0	0.0707	1.00	7.2	0.0294

The remaining inputs were obtained from Reference [2], as follows:

For GE Figure D-3 Flaws:

Base Metal Thickness = 7.125" [2, Table A-1]
Clad Thickness = 0.2188" [2, Table A-1]
RT_{NDT} = 40°F [2, Table A-2, All Vertical Welds in Upper Shell Course]
Adjusted Reference Temperature, ART = 40°F (Flange region not affected by fluence)
Condition Evaluated = Boltup [2, Table A-4c]
Condition Temperature = 100°F [2, Table A-4c]
Yield Stress = 50 ksi [2, Table A-4c]
Flaw Orientation = Circumferential (see Table 1 above)
Stresses: [2, Table A-5, Non-Beltline (near flange) Boltup]

Pressure Stress = 0.0 ksi
σ_m = 0.0 ksi
σ_b = 26.0 ksi
Weld Residual Stress = 0 ksi
Clad Residual Stress = 35.0 ksi
Fatigue Crack Growth Cycles = 18 cycles/EFPY [2, p. 10] = 18 * 9.7 = 175 cycles

For GE Figure D-12 Flaws:

Base Metal Thickness = 7.125" [2, Table A-1]
Clad Thickness = 0.2188" [2, Table A-1]
RT_{NDT} = 40°F [2, Table A-2, Weld @ 225°]
ART = 122°F @ 1/4t [2, Table A-3b, Weld @ 225°]
(The above ART value is reproduced in accordance with Reg. Guide 1.99, Rev. 2 [4] in Table 2 below.)
Condition Evaluated = Pressure Test [2, Table A-4c]
Condition Temperature = 260°F [2, Table A-4c]
Yield Stress = 46.01 ksi [2, Table A-4c]
Flaw Orientation = Axial (see Table 1 above)
Stresses: [2, Table A-5, Vertical Welds Beltline]

Pressure Stress = 18.51 ksi
σ_m = 0.3 ksi
σ_b = 0.5 ksi
Weld Residual Stress = 8 ksi (bending)
Clad Residual Stress = 17.11 ksi
Fatigue Crack Growth Cycles = 18 cycles/EFPY [2, p. 10] = 18 * 9.7 = 175 cycles

Flaw eccentricity ratio, e/t:

Flaw 55: (7.98"/2 - 2" - 0.396"/2) / 7.98" = 0.22 [1, pg. A6]
Flaw 9-015+016 = (8.00"/2 - 2.20" - 0.424"/2) / 8.00" = 0.20 [1, pg. B6]

The new pressure test temperature from Figure 6 of Reference [3] is 194°F at the limiting 1/4t location for a leak test pressure of 1,050 psig (per Constellation input). Note that any potential future increases in the leak test pressure are bounded by this evaluation since a higher leak test pressure will yield a higher temperature (and the lower temperature used in this evaluation is bounding because of the associated lower fracture toughness).

Table 2. Reproduction of Original ART Calculations for 28 EFPY

NMP-1 RPV ART$_{NDT}$ Calculation for 28 EFPY

(NOTE: This calculation duplicates the previous calculation from Reference [2] for 28 EFPY, and is used for the Benchmark Analysis only.)

Location	Initial RT_{NDT} (°F)	Chemistry		Chemistry Factor (°F)	Adjustments For 1/4t				
					ΔRT_{NDT}	Margin Terms			ART_{NDT}
		Cu (wt %)	Ni (wt %)		(°F)	σ_Δ (°F)	σ_I (°F)	EFPY	(°F)
Weld @ 225° = Weld Where Flaws Are Located (use limiting Plate G-307-4 chemistry)	40	0.27	0.63	173.85	47.6	17.0	0.0	28.0	121.6
Flange Horizontal Weld	40				0.0	0.0	0.0	28.0	40.0

Note: Consistent with Reference [2], the following calculations include the cladding thickness. [illegible]

Fluence Information:

Location	Wall Thickness, t (inches) Full	1/4t	EFPY	Fluence at ID (n/cm²)	Attenuation, 1/4t $e^{-0.24t}$	Fluence @ 1/4t (n/cm²)	Fluence Factor, FF $f^{(0.28-0.10\log f)}$
Weld @ 225°	7.344	2.000	28.0	7.16E+17	0.619	4.43E+17	0.27
Flange Horizontal Weld	7.344	2.000	28.0	1.00E+00	0.619	6.19E-01	0.00

3.0 BENCHMARK ANALYSIS

As a first step, the allowable flaw sizes originally developed in Reference [2] were reproduced to substantiate the methodology used. This was accomplished using the SI Program APPENDA [5], which is an in-house, verified computer program for performing flaw tolerance analysis of reactor vessel shells. APPENDA uses the same methodology outlined in the Reference [2] report. The inputs described above were input to APPENDA for each of the flaws.

The values of the flaw eccentricity ratio, e/t, that were used to develop Figures D-3 and D-12 of Reference [2] were not documented in Reference [2]. Therefore, a range of e/t values was evaluated with the APPENDA program until the previous results were identically matched. Values of e/t of -0.17 and -0.38 were determined for Figures D-3 and D-12, respectively.

The results are shown in Figure 1 (corresponding to Figure D-3 of Reference [2]) and Figure 2 (corresponding to Figure D-12 of Reference [2]). The flaws identified in Table 1 are also included in Figures 1 and 2.

The APPENDA input files for these two cases are D3C.IN and D12A.IN, respectively, and are included in the computer files associated with this calculation. The results are documented in output summary files D3C.SUM and D12A.SUM, which were incorporated into Excel spreadsheets "Allowable Flaw Sizes (D3).xls" and "Allowable Flaw Sizes (D12).xls". All of these files are also included in the computer files associated with this calculation.

Figure 1. Benchmark Results for Vessel Flange Horizontal Weld (Figure D-3 of [2])

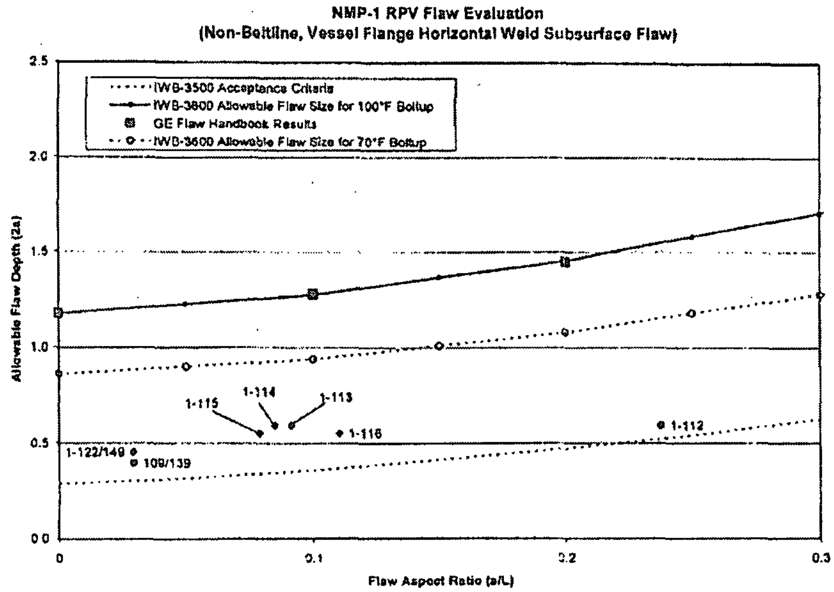
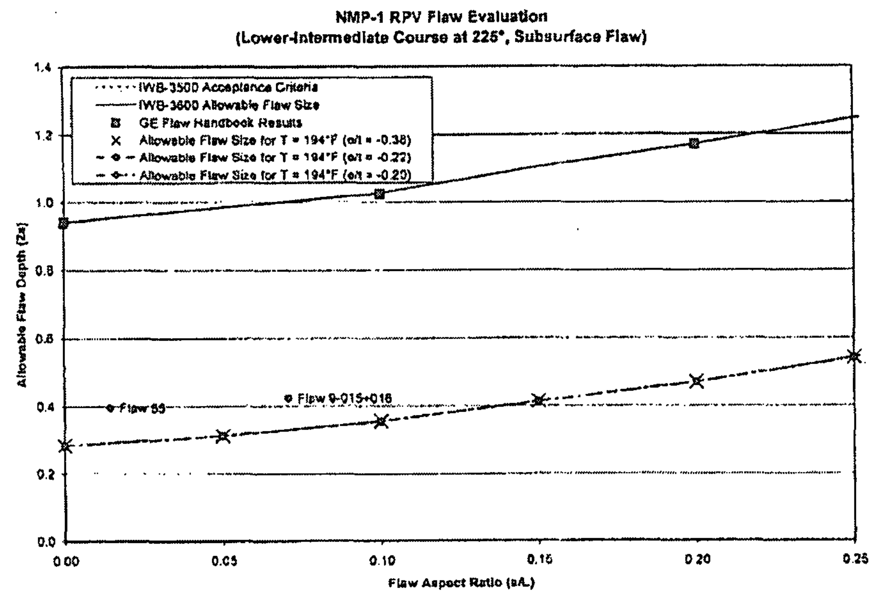


Figure 2. Benchmark Results for Lower-Intermediate Course Weld (Figure D-12 of [2])



4.0 REVISED ANALYSIS

Revised allowable flaw sizes were determined for a boltup temperature of 70°F (for information only), and the revised pressure test temperature of 194°F. The following revised inputs apply:

For GE Figure D-3 Flaws:

Condition Temperature = 70°F

Fatigue Crack Growth Cycles = 18 cycles/EFPY x (46 – 20.3*) EFPY = 463 cycles

(* EFPY level at the time of the Reference [2] analysis.)

All other inputs remain the same.

The revised allowable flaw sizes are shown in Figure 1 as "IWB-3600 Allowable Flaw Sizes for 70°F Boltup". The APPENDA input file for this case is D3D.IN, and is included in the computer files associated with this calculation. The results are documented in output summary files D3D.SUM, which was incorporated into Excel spreadsheet "Allowable Flaw Sizes (D3).xls". All of these files are also included in the computer files associated with this calculation.

For GE Figure D-12 Flaws:

Condition Temperature = 194°F

Fatigue Crack Growth Cycles = 18 cycles/EFPY x (46 – 20.3*) EFPY = 463 cycles

(* EFPY level at the time of the Reference [2] analysis.)

Stresses: All remain the same except the yield and clad residual stresses:

Yield Stress = 47.66 ksi per calculation below:

Yield Stress:			
T =	194	°F	(new pressure test temp.)
YS at 100°F =	50.00	in/in-°F	(Table A-4c of Reference [2])
YS at 260°F =	46.01	in/in-°F	(Table A-4c of Reference [2])
YS at T =	47.66	°F	(interpolated)

Clad Residual Stress = 23.00 ksi, per calculation below:

Clad Residual Stress:			
T =	194	°F	(new pressure test temp.)
σ_c at 70°F =	35.0	ksi	(pg. A-4 of Reference [2])
E_{SS} @ 70°F =	28,300	ksi	(Reference [6])
E_{SS} @ 200°F =	27,600	ksi	(Reference [6])
E_{SS} @ T =	27,632	ksi	(interpolated)
$\Delta\alpha$ for ΔT = 1080°F =	2.70E-06	in/in-°F	(pg. A-4 of Reference [2])
$\Delta\alpha$ for ΔT = -177°F =	2.44E-06	in/in-°F	(pg. A-5 of Reference [2])
ΔT = 70 - T =	-124	°F	
$\Delta\alpha$ for ΔT =	2.45E-06	in/in-°F	(interpolated)
σ_c at T =	23.00	ksi	

NOTE: The cladding stress has no effect on the subsurface flaws evaluated in this calculation, but it is included for completeness.

ART = 167.9°F @ 1/4t [3, Table 3, Plate G-307-4]
(NOTE: The above ART value is reproduced in accordance with Reg. Guide 1.99, Rev. 2 [4] in Table 3.)

All other inputs remain the same.

Table 3. Reproduction of Revised ART Calculations for 46 EFPY

NMP-1 RPV ART_{NDT} Calculation for 46 EFPY

(NOTE: This calculation duplicates the calculation from Reference [3] for 46 EFPY, and is used for the Revised Analysis.)

Location	Initial RT_{NDT} (°F)	Chemistry Cu (wt %)	Chemistry Ni (wt %)	Chemistry Factor (°F)	Adjustments For 1/4t: ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_I (°F)	EFPY	ART_{NDT} (°F)
Weld @ 225° = Weld Where Flaws Are Located (use limiting Plate G-307-4 chemistry)	40	0.27	0.53	173.85	93.9	17.0	0.0	46.0	167.9
Flange Horizontal Weld	40				0.0	0.0	0.0	46.0	40.0

Note: Consistent with Reference [3], the following calculations do NOT include the cladding thickness.

Fluence Information:

Location	Wall Thickness, t (inches) Full	Wall Thickness, t (inches) 1/4t	EFPY	Fluence at ID (n/cm²)	Attenuation, 1/4t $e^{-0.24t}$	Fluence @ 1/4t (n/cm²)	Fluence Factor, FF $f^{(0.28-0.10\log f)}$
Weld @ 225°	7.125	1.761	46.0	2.71E+18	0.652	1.77E+18	0.54
Flange Horizontal Weld	7.125	1.781	46.0	1.00E+00	0.652	6.52E-01	0.00

The revised allowable flaw sizes are shown in Figure 2 as "Allowable Flaw Sizes for T = 194°F (e/t = -0.38)". Two other cases were run for the actual flaw eccentricity ratios, e/t = -0.22 and -0.20, which are also shown in Figure 2 as "Allowable Flaw Sizes for T = 194°F (e/t = -0.22)" and "Allowable Flaw Sizes for T = 194°F (e/t = -0.20)", respectively. The APPENDA input file for this case is D12C.IN, and is included in the computer files associated with this calculation. The results are documented in output summary files D12C.SUM, which was incorporated into Excel spreadsheet "Allowable Flaw Sizes (D12).xls". All of these files are also included in the computer files associated with this calculation.

Based on the results shown in Figures 1 and 2, the following conclusions can be made with respect to the revised RPV flaw evaluation:

- ✓ The allowable subsurface flaw sizes for the Non-Beltline, Vessel Flange Horizontal Weld Region at 46 EFPY are reduced for a boltup temperature of 70°F. This is a result of the lower allowable stress intensity factor, K_{Ia}, at 70°F versus 100°F. For the limiting flaw eccentricity ratio of -0.17, which is the basis for the original flaw diagram in Reference [2], the as-found indications are acceptable compared to these lower allowable flaw sizes.
- ✓ The allowable subsurface flaw sizes for the Lower-Intermediate Course at 225° Region at 46 EFPY are reduced for the revised pressure test temperature of 194°F. This is a result of the lower allowable stress intensity factor, K_{Ia}, at 194°F versus the temperature of 260°F used in the Benchmark Analysis, and also because the fluence is higher for 46 EFPY compared to the fluence for 28 EFPY used in the Benchmark Analysis. For the limiting flaw eccentricity ratio

of -0.38, which is the basis for the original flaw diagram in Reference [2], the as-found indications are unacceptable compared to these lower allowable flaw sizes.

- ✓ For the Lower-Intermediate Course at 225° Region at 46 EFPY, and using the actual flaw eccentricity ratios of -0.22 (Flaw 55) and -0.20 (Flaw 9-015+016), the as-found indications are also unacceptable compared to the lower allowable flaw sizes for the revised pressure test temperature of 194°F.

In order to show acceptability of the flaws in Figure 2, additional analysis using the following items (some of which are identified in Section B-7 of Reference [2]) will be performed:

- Use K_{Ic} for the allowable fracture toughness. A Code change to K_{Ic} has just passed the ASME Board for implementation in IWB-3600 of ASME Code Section XI. This change should be published in the 2006 Addenda of the Code.
- A revised ART value specific to the weld location will be used. Per Constellation input, the peak fluence for the upper plate from Reference [3], as used in Table 3 and this revised analysis, is 2.33 times higher than the peak fluence for the Weld @ 225°.

Evaluation considering the above two items is performed in the next section.

5.0 REVISED ANALYSIS #2

For the D-12 flaws, revised allowable flaw sizes were determined for the revised pressure test temperature of 194°F using K_{Ic} and a revised ART value specific to the weld location being evaluated. The following revised inputs apply:

For GE Figure D-12 Flaws:

All inputs are the same as identified in Section 4.0, except:

ART = 137.3°F @ 1/4t (see Table 4)
(NOTE: The above ART value is reproduced in accordance with Reg. Guide 1.99, Rev. 2 [4] in Table 3.)

Use K_{Ic} instead K_{Ia} for the allowable fracture toughness.
*NOTE: A project-specific revised version of the APPENDA program, called APPENDA2, was used for the K_{Ic} change. The only technical change made for the software was that the data statement defining K_{Ia}, was replaced with the data statement for K_{Ic}. Thus, any program outputs still identifies that K_{Ia} is being used, but in reality the values used are K_{Ic}. Verification of this can be found by viewing the output in the *.OUT file.*

Table 4. Revised ART Calculations for 46 EFPY Using Reduced Fluence

NMP-1 RPV ART_{NDT} Calculation for 46 EFPY Using Lower Fluence

(NOTE: This calculation uses a reduced fluence for the Weld @ 225°, using a factor of 2.33 for 46 EFPY, and is used for Revised Analysis #2.)

Location	Initial RT_{NDT} (°F)	Chemistry Cu (wt %)	Chemistry Ni (wt %)	Chemistry Factor (°F)	Adjustments For 1/4t: ΔRT_{NDT} (°F)	Margin Terms σ_Δ (°F)	Margin Terms σ_I (°F)	EFPY	ART_{NDT} (°F)
Weld @ 225° = Weld Where Flaws Are Located (use limiting Plate G-307-4 chemistry)	40	0.27	0.53	173.85	63.3	17.0	0.0	46.0	137.3
Flange Horizontal Weld	40				0.0	0.0	0.0	46.0	40.0

Note: Consistent with Reference [3], the following calculations do NOT include the cladding thickness.

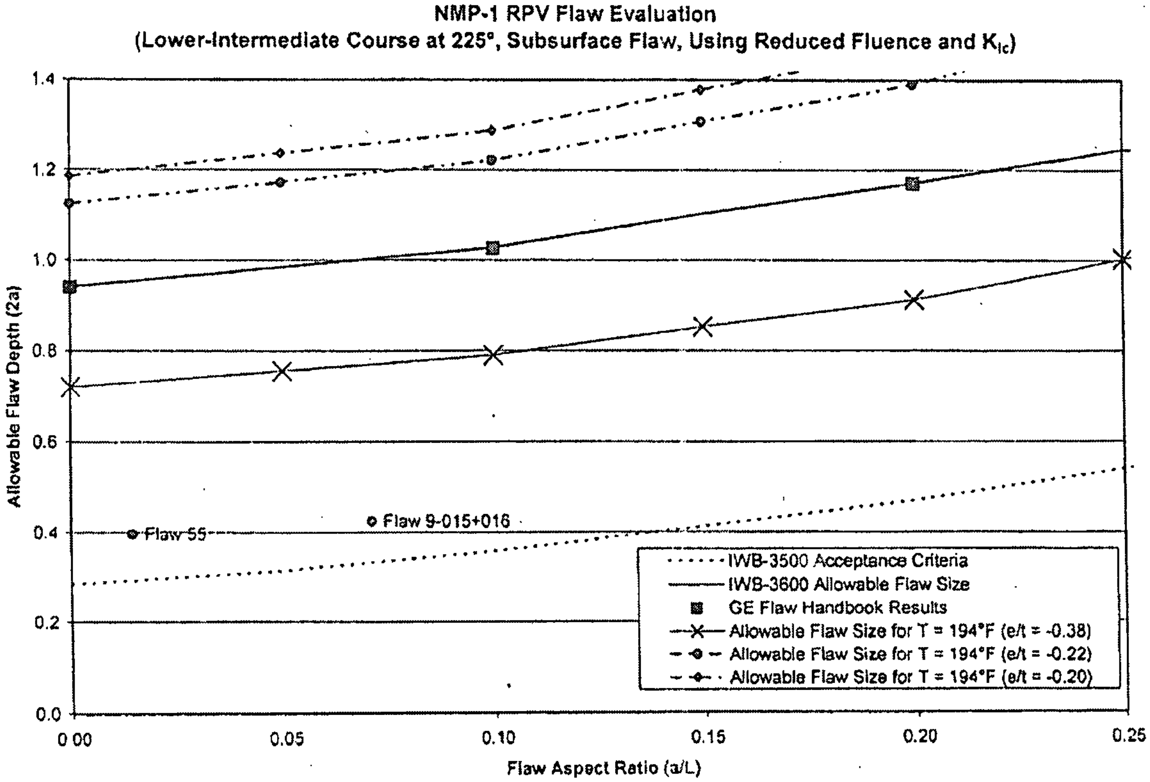
Fluence Information:

Location	Wall Thickness, t (inches) Full	Wall Thickness, t (inches) 1/4t	EFPY	Fluence at ID (n/cm²)	Attenuation, 1/4t $e^{-0.24x}$	Fluence @ 1/4t (n/cm²)	Fluence Factor, FF $f^{(0.28-0.10\log f)}$
Weld @ 225°	7.125	1.781	46.0	1.16E+18	0.652	7.58E+17	0.38
Flange Horizontal Weld	7.125	1.781	46.0	1.00E+00	0.652	6.52E-01	0.00

Note: The weld at 225° is actually at the RPV 45° azimuth which is the lowest fluence azimuth in the quadrant. The fluence at the 225° azimuth is 2.33 times less that the peak fluence. Therefore, the peak fluence is estimated above based on $2.71\times10^{18}/2.33 = 1.16\times10^{18}$.

The revised allowable flaw sizes are shown in Figure 3 as "Allowable Flaw Sizes for T = 194°F (e/t = -0.38)", "Allowable Flaw Sizes for T = 194°F (e/t = -0.22)", and "Allowable Flaw Sizes for T = 194°F (e/t = -0.20)". The APPENDA2 input file for this case is D12D.IN, and is included in the computer files associated with this calculation. The results are documented in output files D12D.SUM and D12D.OUT. D12D.SUM was incorporated into Excel spreadsheet "Allowable Flaw Sizes (D12).xls". All of these files are also included in the computer files associated with this calculation.

Figure 3. Results of Revised Analysis #2 for Lower-Intermediate Course Weld



	Revision	0	1		
	Preparer/Date	GLS 11/5/02	GLS 12/27/05		
	Checker/Date	KKF 11/5/02	KKF 12/27/05		
	File No. NMP-05Q-303			Page 11 of 13	

6.0 CONCLUSIONS

Based on the results shown in Figures 1, 2, and 3, the following conclusions can be made with respect to the RPV flaw evaluation:

- ✓ Based on the results of Figures 1 and 2, the previous allowable flaw sizes were identically reproduced using the APPENDA program. Therefore, the methodology of evaluation for the current analysis is considered validated.
- ✓ Based on the results of Figure 1, the allowable subsurface flaw sizes for the Non-Beltline, Vessel Flange Horizontal Weld Region at 46 EFPY are reduced for a boltup temperature of 70°F. This is a result of the lower allowable stress intensity factor, K_{Ia}, at 70°F versus 100°F. For the limiting flaw eccentricity ratio of -0.17, which is the basis for the original flaw diagram in Reference [2], the as-found indications are acceptable compared to these lower allowable flaw sizes.
- ✓ Based on the results of Figure 2, the allowable subsurface flaw sizes for the Lower-Intermediate Course at 225° Region at 46 EFPY are reduced for the revised pressure test temperature of 194°F. This is a result of the lower allowable stress intensity factor, K_{Ia}, at 194°F versus the temperature of 260°F used in the Benchmark Analysis, and also because the fluence is higher for 46 EFPY compared to the fluence for 28 EFPY used in the Benchmark Analysis. For the limiting flaw eccentricity ratio of -0.38, which is the basis for the original flaw diagram in Reference [2], the as-found indications are unacceptable compared to these lower allowable flaw sizes when K_{Ia} is used.
- ✓ Based on the results of Figure 2, for the Lower-Intermediate Course at 225° Region at 46 EFPY, and using the actual flaw eccentricity ratios of -0.22 (Flaw 55) and -0.20 (Flaw 9-015+016), the as-found indications are also unacceptable compared to the lower allowable flaw sizes for the revised pressure test temperature of 194°F when K_{Ia} is used.
- ✓ Based on the results of Figure 3, for the Lower-Intermediate Course at 225° Region at 46 EFPY, and using the actual flaw eccentricity ratios of -0.22 (Flaw 55) and -0.20 (Flaw 9-015+016) as well as the weld-specific fluence and K_{Ic}, the as-found indications are acceptable compared to the allowable flaw sizes for the revised pressure test temperature of 194°F.

It is therefore concluded that the previously detected RPV flaws are dispositioned for the revised pressure test temperature of 194°F and are therefore acceptable for 46 EFPY (60 years of operation).

7.0 REFERENCES

1. Niagara Mohawk Nuclear Engineering Calculation No. S0VESSELM030, Revision 1, "RPV Weld Flaw Evaluation Using GE Nuclear Energy NMP 1 RPV Flaw Evaluation Handbook (GENE-B13-01805-124, Rev. 0)," SI File No. NMP-05Q-205.

2. Niagara Mohawk Power Corporation Nuclear Engineering Report No. NER-1M-063, Revision 0, "GE Nuclear Energy RPV Flaw Evaluation Handbook for NMP1, GENE-B13-01805-124," SI File No. NMP-05Q-203.

3. ATI Consulting Report No. ATI-05-034-001, "Calculation of P-T Operating Limit Curves for License Renewal for Nine Mile Point Units 1 and 2," October 2005, SI File No. NMP-09Q-291.

4. USNRC Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, (Task ME 305-4), May 1988.

5. APPENDA, Computer Program for Performing Flaw Tolerance Analysis of Reactor Vessel Shells, Version 1.1, SIR-94-044, Revision 2, 4/24/95, Structural Integrity Associates.

6. ASME Boiler and Pressure Vessel Code, Section III, Appendix I, 1989 Edition.

6855 S. Havana Street
Suite 350
Centennial, CO 80112-3868
Phone: 303-792-0077
Fax: 303-792-2158
www.structint.com
gstevens@structint.com

July 9, 2007
GLS-07-022

Mr. Roy Corieri
Constellation Generation Group
Nine Mile Point Nuclear Station
Engineering Services Bldg. 1
348 Lake Road
Oswego, NY 13126

Subject: Flaw Proximity Assessment for Nine Mile Point RPV Flaw Evaluation

References:
1. Structural Integrity Associates Calculation No. NMP-05Q-303, Revision 1, "RPV Flaw Evaluation," 12/27/2005.
2. Niagara Mohawk Power Corporation Nuclear Engineering Report No. NER-1M-063, Revision 0, "GE Nuclear Energy RPV Flaw Evaluation Handbook for NMP1, GENE-B13-01805-124," SI File No. NMP-05Q-203.
3. Niagara Mohawk Nuclear Engineering Calculation No. S0VESSELM030, Revision 1, "RPV Weld Flaw Evaluation Using GE Nuclear Energy NMP 1 RPV Flaw Evaluation Handbook (GENE-B13-01805-124, Rev. 0)," SI File No. NMP-05Q-205.
4. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for In-service Inspection of Nuclear Power Plant Components," 1989 Edition.

Dear Roy:

Per your request, this letter is to clarify and provide supporting documentation of a flaw proximity assessment related to the reactor pressure vessel (RPV) flaw evaluation documented in the Reference [1] calculation.

BACKGROUND

The Reference [1] calculation was completed in 2005 as a part of Constellation's license renewal efforts for the Nine Mile Point Nuclear Power Station, Unit 1 (NMP-1). That calculation provides a reconciliation of the previous flaw evaluation performed for the NMP-1 RPV. An RPV flaw evaluation handbook was originally developed by GE in the Reference [2] document. Subsequent to that, during RPV exams for NMP-1 in 2000, flaws were detected, and evaluation of those flaws was performed by Constellation for 28 effective full power years (EFPY) in the Reference [3] document. The Reference

[1] calculation provided a revised flaw evaluation for 46 EFPY (projected end-of life value for 60 years of operation).

Per Reference [3], the original flaw evaluation handbook work was done in accordance with the 1983 Edition, Summer 1984 Addenda of Section XI of the ASME Code. The Reference [1] evaluation was performed in accordance with the 1989 Edition of Section XI of the ASME Code, and it was shown through a benchmark evaluation in the Reference [1] calculation that the previous work was identically reproduced. Therefore, the 1989 Edition of Section XI of the ASME Code is used in this assessment.

EVALUATION

SI did not explicitly perform a flaw proximity check in the Reference [1] calculation at the end of the evaluation period (i.e., at 46 EFPY). It was implicitly assumed that such a flaw proximity check was unnecessary, since all flaws evaluated were subsurface (i.e., not exposed to the reactor environment), and therefore the fatigue crack growth was negligible due to use of the ASME air fatigue crack growth curve. In this letter, it is further demonstrated that all relevant ASME Code rules were satisfied based on a conservative assessment of the fatigue crack growth considering operation through 46 EFPY.

Note that the calculation that follows represents a bounding crack growth calculation for all possible allowable subsurface flaw sizes for the RVWD-099 flaw diagram. This is because flaw diagrams must evaluate bounding crack growth ahead of time, since it is not known beforehand the size of a flaw that may be detected during examinations.

For flaw RVWD-099, the crack growth calculated in Reference [1] may be obtained from supporting file "D3D.SUM", which is identified in Section 4.0 of Reference [1], and is available in the supporting files associated with Reference [1]. The crack growth is 1.30×10^{-3} inch for all subsurface flaws. For the limiting case, the temperature, T, is 70°F, as noted from input file "D3D.IN" associated with Reference [1], where a constant through-wall temperature gradient was provided for the limiting stress distribution. Therefore, the crack growth is identical for all subsurface flaws since the temperature is uniform through the wall thickness.

The following provides the supporting calculation for this value (refer to Section XI of the ASME Code, Appendix A [4] for the equations used):

For T = 70°F, and a material RT_{NDT} of 40°F (per p. 4 of Reference [1]), the critical fracture toughness, K_{Ia}[1], is:

$$K_{Ia\text{-critical}} = 26.78 + 1.223\, e^{[0.0145*(T - RTndt + 160)]} = 26.78 + 1.223\, e^{[0.0145*(70 - 40 + 160)]} = 46.0 \text{ ksi}\sqrt{\text{inch}}$$

The allowable K_{Ia} is:

[1] Refer to Appendix G, G-2110 of Reference [4] for the K_{Ia} equation, which includes correction of the exponential coefficient from "1.233" to "1.223" per Figure 4-1 of WRC-175. This correction was made in later editions of Section XI.

$K_{Ia\text{-}allowable} = K_{Ia\text{-}critical}$ / (Safety Factor) = 46.0 / √10 = 14.55 ksi√inch

Per A-4300 of Appendix A, assuming the load fluctuates between the above value and zero, the stress intensity factor range, ΔK, is:

$\Delta K = K_{max} - K_{min}$ = 14.55 - 0 = 14.55 ksi√inch.

Per A-4300 of Appendix A, for a subsurface flaw, the air crack growth relationship applies:

$$da/dN = C_0 \, \Delta K^n$$

The following coefficients were used[2]:

n = 3.07
$C_0 = 1.99\text{x}10^{-10}$ S
S = 25.72 (2.88 - R)$^{-3.07}$ = 3.703449 (assuming worst-case R = 1)
$C_0 = 1.99\text{x}10^{-10}$ (3.703449) = $7.37\text{x}10^{-10}$

$$da/dN = 7.37\text{x}10^{-10} \, (14.55)^{3.07} = 2.74\text{x}10^{-6} \text{ in/cycle}$$

Using dN = 463 cycles from p. 7 of Reference [1]:

da = da/dN * (No. of applied cycles) = $2.74\text{x}10^{-6}$ in/cycle (463 cycles) = $1.30\text{x}10^{-3}$ inch

As stated previously, the above calculation is NOT for the actual flaw; rather, it is a bounding calculation made for the flaw handbook that bounds all possible allowable flaw sizes for the given temperature. Therefore, it provides a conservative and bounding value of crack growth compared to that for the actual flaw size.

From Table 1 of Reference [1], the smallest flaw depth of any flaws for RPV weld RVWD-099 is 0.396". Thus, the crack growth value calculated above represents $1.30\text{x}10^{-3}$/0.396 = 0.003 = 0.3% of the crack depth, which is insignificant. With respect to length, the SI flaw evaluation computer program performs calculations assuming a constant flaw aspect ratio, a/ℓ. Therefore, the percent change in flaw length is identical to the flaw depth, as demonstrated below.

For the same flaw, Table 1 of Reference [1] reveals an aspect ratio of 0.0144 and a flaw length, ℓ, of 13.75". The change in length, $\Delta\ell$ is therefore:

$$a/\ell = \text{constant} = (0.396/2) / 13.75 = 0.0144 = [(0.396 + 1.30\text{x}10^{-3})/2] / (13.75 + \Delta\ell)$$
$$\text{or } \Delta\ell = 0.0451 \text{ inch}$$

[2] The coefficients shown were obtained from the 1992 Addenda to Section XI and are used by SI's flaw evaluation computer program, as they are more recent and provide more conservative estimates of fatigue crack growth than the values specified in the 1989 Edition.

The change in length value calculated above represents 0.0451/13.75 = 0.003 = 0.3% of the crack length, which is insignificant.

Therefore, the change in both the depth and length is insignificant, so the flaw proximity does not differ significantly over the life of the flaw.

Similar calculations to the above apply for the flaw diagram associated with flaw RVWD-140, with the exception that the limiting stress case for flaw RVWD-140 has a through-wall temperature variation. Therefore, depending on the flaw location within the wall thickness (based on e/t), the value of temperature, T, in the above calculation will be different. Similar results were achieved (a maximum fatigue crack growth value of 1.28×10^{-3} inch was obtained in supporting file "D12C.SUM" for the other flaws evaluated in Reference [1]).

CONCLUSION

Based on the evaluation above, the change in flaw size due to fatigue crack growth for the flaws evaluated in the Reference [1] evaluation is negligible, so the initial flaw proximity check performed on the flaws remains valid at the end of the evaluation period (46 EFPY).

Please do not hesitate to contact me if you have any questions.

Prepared By: Gary L. Stevens
Gary L. Stevens, P. E.
Senior Associate

Verified By: Karen K. Fujikawa
Karen K. Fujikawa, P.E.
Senior Associate

Approved By: Gary L. Stevens
Gary L. Stevens, P. E.
Senior Associate

cc: NMP-05Q-406