10 CFR 54

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January 12, 2024

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: **Palo Verde Nuclear Generating Station Units 1, 2, and 3**
Docket Nos. STN 50-528, 50-529, and 50-530
Renewed Operating License Nos. NPF-41, NPF-51, and NPF-74
Response to Request for Additional Information to Proposed Method to Manage Environmentally Assisted Fatigue for the Pressurizer Surge Line

By letter number 102-08633, dated July 26, 2023 [Agencywide Documents Access and Management System (ADAMS) Accession Number ML23207A248], Arizona Public Service Company (APS) submitted a proposed method to manage environmentally assisted fatigue (EAF) for the pressurizer surge line during the period of extended operation, as committed during license renewal, for Nuclear Regulatory Commission (NRC) approval for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3.

The NRC staff requested additional information to complete their review with regard to the proposed submittal. A clarifying phone call was held between the NRC staff and APS on November 30, 2023, to discuss the additional information needed. The APS response to the request for additional information is provided in the enclosure to this letter. The responses are due within 45 days from November 30, 2023 (ADAMS Accession Number ML23334A161).

No new commitments are being made to the NRC by this letter. Should you need further information regarding this letter, please contact Matthew S. Cox, Licensing Department Leader, at (623) 393-5753.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Executed on January 12, 2024
(Date)

Sincerely,

Horton, Todd (Z10098)

Digitally signed by Horton, Todd (Z10098)
Date: 2024.01.12 16:11:32 -07'00'

TAH/MSC/cr

Enclosure: Response to Request for Additional Information to Proposed Method to Manage Environmentally Assisted Fatigue for the Pressurizer Surge Line

cc:	J. D. Monninger	NRC Region IV Regional Administrator
	W. T. Orders	NRC NRR Project Manager for PVNGS
	L. N. Merker	NRC Senior Resident Inspector for PVNGS
	B. D. Goretzki	Arizona Department of Health Services – Bureau of Radiation Control

Enclosure

Response to Request for Additional Information to Proposed Method to Manage Environmentally Assisted Fatigue for the Pressurizer Surge Line

Introduction

By letter dated July 26, 2023 (Agencywide Documents Access and Management System Accession No. ML23207A248), Arizona Public Service Company submitted a proposed method to manage environmentally assisted fatigue (EAF) for the pressurizer surge line during the period of extended operation, as committed during license renewal, for U.S Nuclear Regulatory Commission (NRC) approval for Palo Verde Nuclear Generating Station, (PVNGS) Units 1, 2, and 3. The NRC request for additional information (RAI) is stated first followed by the APS response.

Regulatory Requirements

The licensee manages the aging effects of EAF on the pressurizer surge line using periodic inspections performed at a frequency determined by a flaw tolerance evaluation in accordance with American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME BPV Code) Section XI, Non-mandatory Appendix L, "Operating Plant Fatigue Assessment."

Pursuant to Title 10 of the Code of Federal Regulations (10 CFR) 54.21, "Contents of application – technical information," each application for license renewal must contain an integrated plant assessment (IPA) and an evaluation of time limited aging analyses. The plant-specific IPA shall identify and list those structures and components subject to an aging management review and demonstrate that the effects of aging will be adequately managed so that their intended functions will be maintained consistent with the current licensing basis for the period of extended operation as required by 10 CFR 54.21(a)(3).

Specifically, the regulations in 10 CFR 54.21(c)(1)(iii) states, "The effects of aging on the intended function(s) will be adequately managed for the period of extended operation."

NRC RAIs and APS Responses

NRC EMIB-RAI-1

Paris' Law is a fatigue crack growth equation that gives the rate of growth of a fatigue crack. da/dN is the fatigue crack growth for a load cycle. However, the licensee's calculation (See Table 2 of Document ID: N001-0607-00483) used fraction cycle to evaluate the crack growth (e.g., transient 1 with 1.398 cycles/year, transient 2 with 1.39 cycles/year, transient 3 with 0.531 cycle/year, transient 4 with 3.06 cycles/year, transients 6 and 7 with 2.695 cycles/year, transients 9 and 10 with 0.042 cycle/year). The NRC staff notes that the fractional cycle does not represent whole cycles or relevant crack growth. In addition, transients 9 and 10 with 10 years inspection period have 0.42 cycle/10years. The NRC staff is requesting the licensee to clarify the method with fractional (non-integer) cycles in the crack growth evaluation.

APS Response to EMIB-RAI-1

The use of fractional cycles provides a means of normalizing the event cycles on an hourly basis since the events have different numbers of cycles on an annual basis. However, on a calculational basis, the fatigue crack growth (FCG) was performed on a yearly basis for each event. The fractional cycles were based on projected cycles for a 1-year block. Although it appears that the Paris Law is based on integer cycles, non-integer cycles can be applied and used in situations involving multiple transients with different total numbers of annual cycles.

The listing of these partial-cycles is described in Sections 2.1 and 5.4 and shown in Table 2 of document 2000645.304 (Reference 4).

It is noted that Table 2 of the 2000645.304 document is the same as Tables 2 and 3 of document 2000645.302 (Reference 5), and lists the annual cycles for each corresponding transient identified by the NRC in RAI RAI-1.

Paris Law is of the form:

$$da/dN = C^{*}\Delta K^{n} \qquad (1)$$

$$da = (dN)^{*}C^{*}\Delta K^{n} \qquad (2)$$

In the above Eq. (2) for determining the crack growth, dN need not necessarily be an integer. A cycle can be divided into several parts and the crack growth performed accordingly. In this case, the ΔK is updated for each cycle, per number of divisions of the cycle.

The use of fractional cycles results in the same final crack growth or produces conservative results based on the ΔK values as demonstrated by the example below. In this example three cycle scenarios are considered.

Example Problem

Crack Model	Full-Circumferential Crack in Cylinder on the Inside Surface Inside Radius = 25 inch (in) Wall Thickness = 2.5 in Initial Crack Depth = 0.1 in
Cycle Scenarios	20 Full Cycles 40 One-Half Cycles 200 One-Tenth Cycles
FCGR Equation	Paris Law $C = 1x10^{-6}$ (in/cycle) $n = 3$

Table RAI-1-1: Results of Example Problem

	Final Crack Depth for Various Cycle Scenarios (in)		
Cyclic Stress (ksi)	**200 One-Tenth Cycles** **(200 * 0.1 partial cycles = 20 cycles)**	**40 Half Cycles** **(40 * 0.5 partial cycles = 20 cycles)**	**20 Full Cycles** **(20 * 1.0 full cycles = 20 cycles)**
10	0.1055	0.1055	0.1055
20	0.1621	0.1614	0.1606
25	0.3101	0.3012	0.2914

It can be seen from the results in Table RAI-1-1 that at lower stresses (low ΔK values), the crack growth is the same for all cycle scenarios. At higher stresses (high ΔK values), the fractional cycles produce higher crack growth (conservative). Thus, the use of fractional cycles is reasonable.

The calculational steps involved with the partial cycles are demonstrated in Table RAI-1-2 for the first three full cycles and six half partial cycles. With the full cycles, the calculation of Δa is updated three times while it is updated six times for the half cycles. After three full cycles and six half partial cycles, the crack growth for the six partial cycles is slightly higher than the full cycles due to the more frequent update of the ΔK and the subsequent Δa.

Based on the calculational approach illustrated in Table RAI-1-2, fractional cycles such as 0.042 cycles per year (0.42 cycles in 10 years) associated with Transients 9 & 10 can be conservatively accommodated. It should be noted that because of the small fractional cycle associated with this event (less than one), its contribution to the overall crack growth is very minimal within the 10 year period.

The use of fractional cycles in crack evaluation is not without precedent. It has been used in several Appendix L evaluations performed by Structural Integrity Associates, Inc. (SIA) which have been reviewed and accepted by the NRC. An example of such a submittal is provided as SIA Report 1301103.401 (Reference 1), which documents in Table 7-1, the use of partial cycles. The NRC review of this flaw tolerance evaluation is provided in Reference [2] and documents the acceptance of the evaluation. The use of fractional cycles in fatigue crack growth evaluation has also been employed in the NRC/Electric Power Research Institute (EPRI) Extremely Low Probability of Rupture (xLPR) program described in Reference [3].

Table RAI-1-2: Calculational Steps of Crack Growth with Full and Half Partial Cycles

[Cyclic Stress = 25 ksi and Initial Crack Size (a) = 0.1 inches]

Cycle Fraction = 1					Cycle Fraction = 0.5					
ΔK	$\frac{da}{dN}$	**Cumulative Cycles**	**Δa =** $1\left(\frac{da}{dN}\right)$	**New a (inch)**	**ΔK**	$\frac{da}{dN}$	**Cumulative Cycles**	**Δa =** $0.5\left(\frac{da}{dN}\right)$	**New a (inch)**	**Total Cycles**
-	-	-	-	-	16.0322	4.121E-03	0.5	2.061E-03	0.1021	-
16.0322	4.121E-03	1.0	4.121E-03	0.1041	16.2044	4.255E-03	1.0	2.128E-03	0.1042	**1.0**
-	-	-	-	-	16.3806	4.395E-03	1.5	2.198E-03	0.1064	-
16.3751	4.391E-03	2.0	4.391E-03	0.1085	16.5610	4.542E-03	2.0	2.271E-03	0.1087	**2.0**
-	-	-	-	-	16.7458	4.696E-03	2.5	2.348E-03	0.1110	-
16.7341	4.686E-03	3.0	4.686E-03	0.1132	16.9351	4.857E-03	3.0	2.429E-03	0.1134	**3.0**

NRC EMIB-RAI-2

The licensee states that the temperature for crack growth is taken as the average temperature of each transient in the page 13 of the licensee's Document (N001-0607-00485): " Fatigue Crack Growth Calculation for the Palo Verde Surge Line Appendix L Evaluation." The NRC staff is requesting the licensee to provide the technical basis for using average temperature for crack growth.

APS Response to EMIB-RAI-2

As discussed in SIA Calculation 2000645.304, Section 2.1 (Reference 4), and SIA Report 2000645.402 (Reference 9), the crack growth evaluation was performed using ASME Section XI Code Case (CC) N-809-1 (Section 2.1).

This crack growth law includes a parameter S_T that accounts for temperature effects. The technical basis of CC N-809-1 is provided PVP2015-45884 (Reference 6). Both CC N-809-1 and the technical basis do not provide guidance on what metal temperature should be used (minimum, maximum, or average) to properly evaluate transients that have temperature variance. Based on a review of PVP2019-93563 (Reference 7), the parameter S_T was developed based on isothermal test data which may not be applicable for non-isothermal (varying thermal transients) fatigue crack growth behavior, such as evaluated for the Palo Verde surge line.

In the absence of any guidance on what metal temperature to use and the fact that the parameter S_T was developed based on isothermal conditions, in SIA Report 2000645.402 (Reference 9), the flaw tolerance evaluation was performed using a conservative 360-degree circumferential crack configuration with an average temperature of the transient to represent the metal temperature when the Ks are at the maximum values. Based on the three most severe transients with highest value of growth rate (da/dN, inch/year), Table RAI-2-1 shows negligible difference between the average temperature of the transient event, T_{ave}, and the average crack face temperature, $T_{ave,\ crack\ face}$, concurrent with the maximum K value.

The value of S_T for the three most severe transients was also calculated using T_{ave} and $T_{ave,\ crack\ face}$ and the result showed less than a 3% difference when comparing the two results.

Therefore, recognizing that a conservative 360-degree circumferential crack was used in the evaluation, the use of the average temperature of the transient event as a representative metal temperature for the CC N-809-1 crack growth analysis for the ASME B&PV, Section XI, Appendix L, flaw tolerance evaluation for Palo Verde surge line is reasonable.

Table RAI-2-1: Comparison of S_T Between Transient Average Temperature and Average Crack Face Temperature for the Three Most Severe Transients

Transient Event	da/dN	Transient Average Temp., T_{ave}, °F	Average Crack Face Temperature @ Maximum K-value $T_{ave,\ crack\ face}$ °F	$S_T(T_{ave})$	$S_T(T_{ave,\ crack\ face})$	S_T (% diff)
Tran 11	7.43E-05	290.0	291.8	0.00290	0.00285	-1.8%
Tran 12	5.03E-05	315.0	316.6	0.00034	0.00035	2.9%
Tran 17	2.34E-05	603.0	602.3	0.01541	0.01533	-0.5%

Table RAI-2-1 identifies the most severe transient events (i.e., Tran 11, Tran 12, and Tran 17) that have the greatest fluid temperature rate of change, which generates larger thermal gradient stress magnitudes, as compared to other “slower” transients, and they have significant numbers of cycles (≥ 2000). From SIA Report 2000645.402, Table 2-1 (Reference 9), the following temperature fluid changes are summarized for these three transients as follows:

Tran 11 (Insurge/Outsurge, ΔT = 300°F):
  - fluid temperature decrease from 440°F to 140°F in 180 seconds
  - fluid temperature increase from 140°F to 440°F in 180 seconds

Tran 12 (Insurge/Outsurge, ΔT = 250°F):
  - fluid temperature decrease from 440°F to 190°F in 150 seconds
  - fluid temperature increase from 190°F to 440°F in 150 seconds

Tran 17 (Insurge/Outsurge, ΔT = 100°F):
  - fluid temperature decrease from 653°F to 553°F in 200 seconds
  - fluid temperature increase from 553°F to 653°F in 200 seconds

These three transients, which exhibit the greatest rate of fluid temperature change, have resulting greater thermal gradient stresses. These result in these three transients exhibiting the greatest fatigue crack growth rate per cycle (da/dN), as compared to the other transient events.

As a measure of the conservatism involved with use of the 360-degree flaw, rather than the shorter Equivalent Single Crack (ESC) allowed by ASME Code, Section XI, Appendix L, a sensitivity analysis was performed by comparing the allowable crack growth duration for an ESC using the maximum transient temperature to the 360-degree flaw using the average transient temperature, subjected to the same loading.

In this example, for the ESC methodology in ASME Section XI, Appendix L (L-3210) (Reference 8), the postulated initial flaw for austenitic piping is semi-elliptical on the inside surface. The initial flaw depth of the postulated flaw is determined from the applicable in-service inspection (ISI) acceptance standard in Table IWB-3410-1, using a flaw aspect ratio of 0.167 (1-to-6 ratio) per ASME Section XI, Appendix L-3212.

The flaw depth ratio (a/t) is determined for the component thickness of 1.312 inch, and the prescribed aspect ratio of 0.167, using linear interpolation in Table IWB-3514-1 for austenitic piping, resulting in an a/t ratio of 14.37%, which is then used to calculate the actual initial flaw depth (a = 0.1885 inch).

The next step is to calculate the initial flaw aspect ratio for the flaw growth evaluation. The aspect ratio for the semi-elliptical surface flaw is determined from Table L-3210-2 of Appendix L. This table uses the component thickness, and a calculated parameter, the membrane-to-gradient cyclic stress ratio. The membrane-to-gradient cyclic stress ratio is defined in Table L-3210-2 as follows:

Extracted from Table L-3210-2:

$$\frac{\Delta\sigma_m}{\Delta\sigma_g} = \sum_i \frac{\Omega_i}{\Omega_{total}} \times \left(\frac{\Delta\sigma_m}{\Delta\sigma_g}\right)_i \qquad (1)$$

where,

$\Delta\sigma_m$ = cyclic membrane stress

$\Delta\sigma_g$ = cyclic linear and nonlinear gradient stress

$\Omega_i = \left(\Delta\sigma_m + \Delta\sigma_g\right)_i^n \times N_i$

$\Omega_{total} = \sum_i \Omega_i$

N_i = number of cycles for i^{th} load pair or transient loading condition

n = fatigue crack growth rate exponent, (slope of the log (da/dN) versus log (ΔK) curve) = 2.25 from CC-N-809-1 Equation

The cyclic linear and nonlinear gradient stress due to thermal loads for each transient are obtained from the stress analysis. The stress results are extracted at the inside node of the stress path, and the calculated total stress value is obtained for all time points in the transient history. The total stress is assumed to be composed of a membrane and a gradient (total minus membrane) stress term.

A maximum and minimum value of both membrane and gradient stresses are obtained, and from these four values a membrane stress range value $\Delta\sigma_m$ (maximum – minimum) is determined, along with a gradient range value $\Delta\sigma_g$ (maximum – minimum). These are combined to obtain a $\Delta\sigma_m/\Delta\sigma_g$ value for each load pair. These values are then used in Equation 1 to obtain a location specific $\Delta\sigma_m/\Delta\sigma_g$ value, considering all load pairs.

Using this calculated value of $\Delta\sigma_m/\Delta\sigma_g$, Table L-3210-2 is entered and a value for the aspect ratio a/l of the postulated initial flaw is obtained for the corresponding component thickness. The calculated aspect ratio is applied to the initial flaw depth determined previously (to calculate an initial flaw length), and then both (initial depth and length) are used in the crack growth calculation.

The calculated $\Delta\sigma_m/\Delta\sigma_g$ for this example is equal to 0.612 which is used to interpolate the value of depth-to-length ratio (a/l) and the resulting a/l from Table L-3210-2 is equal to 0.1294.

The initial crack size calculated using the methodology of ASME Code Section XI, Nonmandatory Appendix L is as follows:

Initial crack depth, a = 0.1885 inch (a/t = 0.1437)

Initial total crack length, $l = 1.4567$ inch

For the fatigue crack growth of the ESC, the maximum fluid temperatures of the individual transients are used for each transient shown in Table RAI-2-2.

Table RAI-2-2: Transient Events Maximum Temperature

Transient	ANSYS ID	Maximum Transient Temperature	Minimum Transient Temperature
Plant Heatup	Tran1	540	70
Plant Cooldown	Tran2	540	70
Loss of Flow, Loss of Load	Tran3	621	551
Reactor Trip – Revised Transient	Tran4	621	572
Plant Unloading, 10% Step Down	Tran6	653(1)	593
Plant Unloading, 10% Step Up	Tran7	653(1)	593
Leak Test, 2250 psia, Down	Tran9	400	160
Leak Test, 2250 psia, Up	Tran10	400	160
I/O Heatup, ΔT = 300°F	Tran11	440	140
I/O Heatup, ΔT = 250°F	Tran12	440	190
I/O Heatup, ΔT = 150°F	Tran13	440	290
I/O Heatup, ΔT = 100°F	Tran14	653(1)	553
I/O Cooldown, ΔT = 250°F	Tran15	440	190
I/O Cooldown, ΔT = 150°F	Tran16	440	290
I/O Cooldown, ΔT = 100°F	Tran17	653(1)	553
5% Loading – New Transient	Tran18	653(1)	572
5% Unloading – New Transient	Tran19	651(1)	572

Note 1: The Code Case N-809-1 temperature factor equation for fatigue crack growth is limited to a temperature range of 300°F to 650°F. Some transient events have maximum fluid temperatures that are slightly above 650°F, such as 653°F and 651°F. For these cases, 650°F is used to calculate for the parameter defining effect of temperature, S_T. This assumption has a negligible non-adverse impact on the fatigue crack growth.

The calculation showed 30 years of crack growth before the ESC crack reached the allowable flaw size. A comparison of the two approaches (the 360-degree flaw using the average transient temperature versus the ESC flaw using the maximum transient temperature) is summarized in Table RAI-2-3.

Table RAI-2-3: Fatigue Crack Growth Result

Crack Configuration	Temperature used in the Fatigue Crack Growth	Number of Years before the Initial Crack Reaches the Allowable Flaw Size
Equivalent Single Crack (ESC)	Maximum Fluid Temperature of the transient	30 years
360-Degree Flaw	Average Fluid Temperature of the transient	13 years

The ESC allowable crack growth duration with the maximum temperature was longer, by a factor greater than two (2), than the allowable duration for a 360-degree flaw with the average temperature, thus demonstrating the conservatism of using the 360-degree flaw model assumption with the average temperature.

The 360-degree flaw model with the average temperature was used as it simplifies the significantly complex determination of the ESC aspect ratio, which requires determination of transient-specific parameters, including the membrane-to-gradient cyclic stress ratio ($\Delta\sigma_m/\Delta\sigma_g$).

<u>NRC EMIB-RAI-3</u>

The licensee used the following table to determine the maximum and minimum Stress Intensity Factors (K_{max} and K_{min}):

K_{max}	K_{min}
$K_{\text{deadweight}}$	$K_{\text{deadweight}}$
K_{residual}	K_{residual}
$K_{\text{pressure max}}$	$K_{\text{pressure min}}$
$K_{\text{crack face pressure max}}$	$K_{\text{crack face pressure min}}$
$K_{\text{thermal transient}}$	$K_{\text{thermal transient}}$
$K_{\text{startification max}}$	$K_{\text{stratification min}}$

The NRC staff notes that the K_{max} (or K_{min}) for the thermal transient pressure and temperature may not occur at the same time, e.g., during cooldown the inside surface stress increases and pressure stress decreases. Therefore, the licensee’s combination of all the K_{max} (or K_{min}) values for different cases may not be adequate. Please clarify.

<u>APS Response to EMIB-RAI-3</u>

The K-values due to pressure and thermal transient were calculated separately. Time history stress analysis was performed for thermal transients only and the Structural Integrity Associates, Inc. (SIA) proprietary software SI-TIFFANY was used to calculate the K versus time history and $K_{\text{max, thermal transient}}$ and $K_{\text{min, thermal transient}}$. Another set of static stress analysis was performed for a unit pressure (1000 psi) loading. The K value under unit pressure loading was also calculated by SI-TIFFANY. K values for unit pressure are scaled to actual minimum and maximum transient pressures to generate $K_{\text{max, pressure}}$ and $K_{\text{min, pressure.}}$

For the crack growth analysis, the $K_{\text{max, thermal transient}}$ and $K_{\text{max, pressure}}$ (and similarly $K_{\text{min, thermal transient}}$ and $K_{\text{min, pressure}}$) values calculated and extracted from the transient runs are added together to represent the transient loading block of the event. This approach is conservative and recognizes that peak K values of pressure and thermal transient loading are calculated separately, and then combining them later, which excludes any reduction in K values at a specific time point due to out-of-phasing.

As an example of the methods conservatism, a K vs time history plot of Tran4 (Reactor Trip) for a flaw with a = 0.1885 inch as an initial crack, is prepared. Figure RAI-3-1 shows the K value due to the thermal transient separately, the pressure transient separately, and the K value due to the combined pressure and thermal transient run with concurrent thermal and pressure loading.

Figure RAI-3-1: Reactor Trip (Tran4) Pressure and Thermal Transient K vs Time History

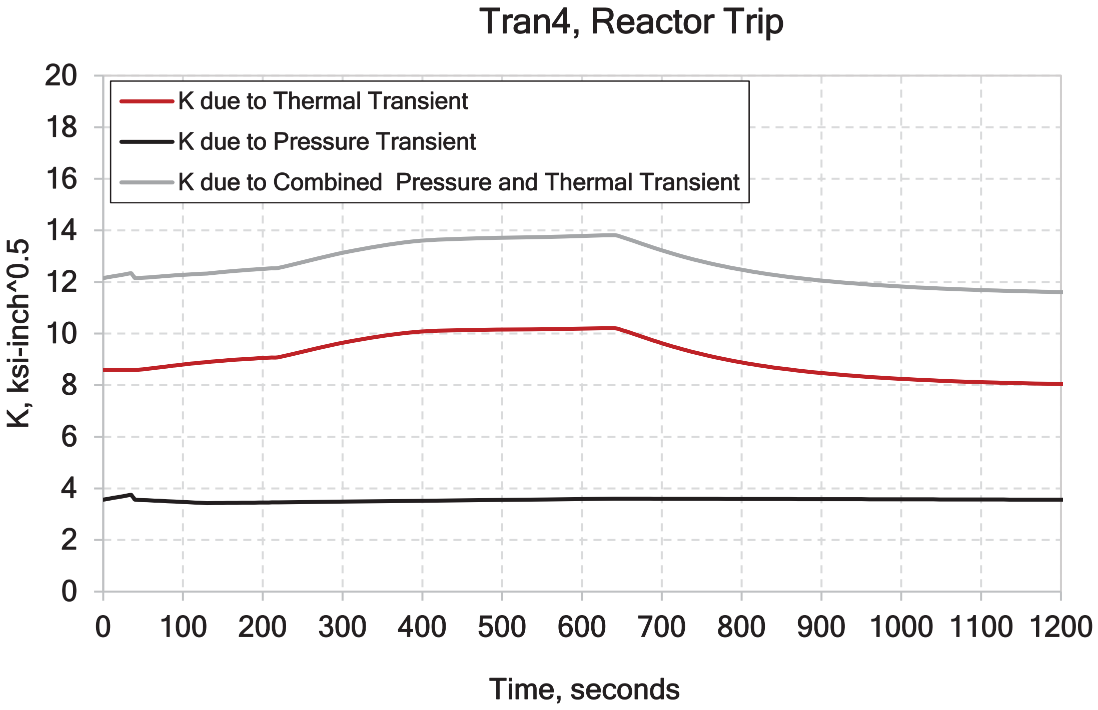

Table RAI-3-1 summarizes the K_{max} (and K_{min}) due to separate pressure and thermal transient runs versus the K_{max} (and K_{min}) due to the combined pressure and thermal transient loading. It can be seen that K_{max} (and K_{min}) due to the thermal transient alone, did not happen at the same time when K_{max} (and K_{min}) due to the pressure transient only occurred.

Table RAI-3-1: K_{max} and K_{min} due to Pressure and Thermal Transient of Reactor Trip (Tran4)

Event	Time @ K_{max}, seconds	K_{max}, ksi-inch$^{1/2}$ (Maximum value in transient)	Time @ K_{min}, seconds	K_{min}, ksi-inch$^{1/2}$ Minimum value in transient)	ΔK ksi-inch$^{1/2}$
Thermal Transient (Tran4)	640	10.211	1200	8.048	--
Pressure Transient	640	3.604	1200	3.565	--
Pressure Transient	35	3.752	130	3.432	--
Thermal Transient separately added with Pressure Transient separately	NA(1)	13.963	NA(1)	11.480	2.483
Combination of Pressure and Thermal Transient Loading Run	640	13.815	1200	11.613	2.202

Note 1: Time cannot be determined since the peak pressure and thermal transient K values are added and they occur at different times.

In SIA Calculation 2000645.304, Section 5.4 (Reference 4), and SIA Report No. 2000645.402 (Reference 9), K_{max} (and K_{min}) values due to the thermal transient only irrespective of time, and K_{max} (and K_{min}) values due to the pressure only irrespective of time, are calculated separately, and are then added as a conservative approach. As a result, the resulting K_{max} (thermal transient separately and pressure separately) is greater than the K_{max} due to the combined pressure and thermal transient run.

On the other hand, the resulting K_{min} (thermal transient separately and pressure separately) is less than the K_{min} due to the combined pressure and thermal transient run, which is conservative for K_{min}.

It is therefore concluded that the $\Delta K = K_{max} - K_{min}$ will then be greater with the combined largest K_{max} and smallest K_{min}.

Examples of maximum stress intensity at the bounding welds in the surge piping as a function of crack depth are provided in the SIA Calculation 2000645.304, figures 28 thru 33 (Reference 4). Additionally, the crack growth life duration for axial and circumferential flaws, based on depth and length, are presented in Figures 34 and 35 (Reference 4).

This approach for determining the maximum and minimum stress intensity factors (K_{max} and K_{min}) in crack growth evaluations has been used in previous Appendix L evaluations performed by SIA which have been reviewed and accepted by the NRC. An example of such a submittal is provided as SIA Report 1301103.401 (Reference 1), which documents in Section 7.2, the use of maximum and minimum stress intensity factors. The NRC review of this flaw tolerance evaluation is provided in Reference [2] and documents the acceptance of the evaluation.

NRC NPHP-RAI-1

Section 3.0 of the licensee’s submittal addresses the “operating experience” program element of the Pressurizer Surge Line Inspection Program. In comparison, NUREG-1800, Revision 2, “Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants,” dated December 2010, Appendix A, “Branch Technical Positions,” section A.1.2.3.10, “Operating Experience,” indicates that future industry operating experience should be reviewed to confirm the effectiveness of its aging management programs.

Clarify whether the licensee will continue to review industry operating experience related to EAF in pressurizer surge lines to confirm the effectiveness of the licensee’s program during the period of extended operation. If not, provide justification for why such review of relevant industry operation experience is not necessary.

APS Response to NPHP-RAI-1

PVNGS continues to follow NRC and industry guidance to perform annual Operating Experience (OE) reviews. To ensure the reviews are performed, PVNGS has an annual Repetitive Maintenance (RM) task for the Aging Management Coordinator to generate Action Items for each AMP Owner to perform the review of identified industry and PVNGS OE for potential impact to their Programs. The ‘Metal Fatigue of the Reactor Coolant Pressure Boundary’ is an existing Aging Management Program, under which the pressurizer surge lines fall, and associated OE would be included in the annual review.

References

1. Attachment 5 of FPL Letter L-2015-272, SIA non-Proprietary Report No. 1301103.401, Rev. 0, “Flaw Tolerance Evaluation of St. Lucie Surge Line Welds Using ASME Code Section XI, Appendix L,” dated May 2015, ADAMS Accession No. ML15314A161.

2. Letter from P. Buckberg (USNRC) to M. Nazar (NextEra Energy) “St. Lucie Plant, Unit Nos. 1 and 2 – Review of License Renewal Commitment for Pressurizer Surge Line Welds Inspection Program (CAC NOS. MF7026 AND MF7027),” dated October 13, 2016, includes Staff Evaluation By The Office Of Nuclear Reactor Regulation License Renewal Commitment No. 20 Submittal Of Pressurizer Surge Line Welds Inspection Program St. Lucie Plant. UNIT NOS. 1 AND 2 DOCKET NOS. 50-335 AND 50-389 CAC NOS. MF7026 AND MF7027, ADAMS Accession No. ML16235A138.

3. xLPR Version 2.2, User’s Manual, Probabilistic Fracture Mechanics Code, jointly developed by the U.S. Nuclear Regulatory Commission (NRC)'s Office of Nuclear Regulatory Research and EPRI.

4. SIA Fatigue Crack Growth Calculation for the Palo Verde (Units 1, 2, and 3) Surge Line Appendix L Evaluation, Report 2000645.304 (SDOC N001-0601-00485), Revision 1.

5. SIA Palo Verde Pressurizer Surge Line Finite Element Analysis for Appendix L Evaluation, Report 2000645.302 (SDOC N001-0601-00483), Revision 0.

6. Cipolla, R. C., and Bamford, W. H., “Technical Basis for Code Case N-809 on Reference Fatigue Crack Growth Curves for Austenitic Stainless Steels in Pressurized Water Reactor Environments”, PVP2015-45884, Proceedings of the ASME 2015 Pressure Vessels and Piping Conference, July 19-23, 2015, Boston, Massachusetts, USA.

7. Mann, J. et al., “A Critical Review of Recent Fatigue Crack Growth Data in Relation to ASME Code Case N-809”, PVP2019-93563, Proceedings of the ASME 2019 Pressure Vessels and Piping Conference, July 14-19, 2019, San Antonio, Texas, USA.

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