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Anthony J. Vitale
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PNP 2014-066

June 26, 2014

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

SUBJECT: Supplemental Response to NRC Request for Additional Information - Palisades Nuclear Plant 10 CFR 50 Appendix G Equivalent Margin Analysis – MF 2962

Palisades Nuclear Plant
Docket No. 50-255
License No. DPR-20

REFERENCES:

1. Palisades Nuclear Plant, *Application for Renewed Operating License*, dated March 22, 2005 (ADAMS Accession No. ML050940446).
2. Entergy Nuclear Operations, Inc. letter PNP 2013-028, *Palisades Nuclear Plant 10 CFR 50 Appendix G Equivalent Margins Analysis,* dated October 21, 2013 (ADAMS Accession No. ML13295A448).
3. NRC email to Entergy Nuclear Operations, Inc., *Request for Additional Information - Palisades Nuclear Plant 10 CFR 50 Appendix G Equivalent Margin Analysis - MF 2962,* dated May 13, 2014 (ADAMS Accession No. ML14133A684).
4. Entergy Nuclear Operations, Inc. letter PNP 2014-054, *Response to NRC Request for Additional Information - Palisades Nuclear Plant 10 CFR 50 Appendix G Equivalent Margin Analysis – MF 2962,* dated June 12, 2014 (ADAMS Accession No. ML14163A622).

Dear Sir or Madam:

In the Palisades Nuclear Plant (PNP) license renewal application (Reference 1), Nuclear Management Company (NMC), the former license holder for PNP, committed to submit an equivalent margins analysis (EMA) for Nuclear Regulatory Commission

(NRC) approval at least three years before any reactor vessel beltline material Charpy upper-shelf energy (USE) decreases to less than 50 ft-lb, in accordance with 10 CFR 50 Appendix G, Section IV, "Fracture Toughness Requirements."

Entergy Nuclear Operations, Inc. submitted the required EMA in Reference 2.

In Reference 3, ENO received a request for additional information (RAI) concerning the EMA submittal. The ENO response to RAI questions 1, 3, 4, 5, and 6 was provided in in Reference 4.

This letter supplements Reference 4 by providing the response to RAI question 2 in Reference 3. The response to RAI question 2 is provided in the attachment.

This letter contains no new commitments and no revised commitments.

This submittal contains no proprietary information.

I declare under penalty of perjury that the foregoing is true and correct; executed on June 26, 2014.

Sincerely,

ajv/jse

Attachment: Supplemental Response to NRC Request for Additional Information - Palisades Nuclear Plant 10 CFR 50 Appendix G Equivalent Margin Analysis - MF 2962

cc: Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC

ATTACHMENT

SUPPLEMENTAL RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION – PALISADES NUCLEAR PLANT 10 CFR 50 APPENDIX G EQUIVALENT MARGIN ANALYSIS - MF 2962

A request for additional information (RAI) was received from the Nuclear Regulatory Commission (NRC) by electronic mail on May 13, 2014 concerning the Palisades Nuclear Plant (PNP) equivalent margins analysis submittal.

Entergy Nuclear Operations, Inc. (ENO) responded to questions 1, 3, 4, 5, and 6 of the RAI on June 12, 2014.

The ENO response to RAI question 2 is provided below.

NRC Request (May 13, 2014)

2. *Section 5.1 states, "Only circumferential base metal flaws are considered in this analysis, because only the "weak" orientation USE is projected to drop below 50 ft-lbs as described below." Please demonstrate that assuming a circumferential flaw in the base metal with the weak Charpy V-Notch (CVN) value in the EMA is more limiting than assuming an axial flaw in the base metal with the strong CVN value. Please note that the significantly greater applied J integral associated with the axial flaw may challenge the fundamental assumption in the EMA submittal.*

ENO Response to RAI-2

As documented in WCAP-17651-NP, Revision 0, the PNP reactor vessel plates have sulfur content greater than the 0.018 wt-% value provided in Regulatory Guide 1.161 (Reference 1). Therefore, lower bound high-sulfur fracture toughness data from the V-50 plate included in NUREG/CR-5265 (Reference 7) was located, as documented in the WCAP, to provide justification for use of the J-R model included in Regulatory Guide 1.161.

However, since only transverse (T-L) direction, weak data, was available in this NUREG and since only the T-L upper-shelf energy (USE) dropped below 50 ft-lbs, only circumferential flaws were considered in the original WCAP submittal since there was no longitudinal (L-T) direction, strong data, for which to compare with the axial J-applied values for PNP. The ENO interpretation of Regulatory Guide 1.161 was that this was allowable and axial flaws did not need to be considered since the longitudinal final USE values of the PNP plate materials were over the 50 ft-lb limit of 10 CFR 50, Appendix G at end-of-license-extension (EOLE). However, per discussion during conference call between ENO and the NRC on June 6, 2014, axial flaws should still have been postulated, with longitudinal direction USE considered in the equivalent margins analysis.

Since the V-50 plate does not have L-T strong data reported in NUREG/CR-5265, the T-L data needs to be converted to L-T via an appropriate ratio to approximate the strong direction for direct comparison with axial flaws. The standard ratio is 65% per Regulatory Guide 1.161. Data was located in NUREG/CR-6426 (Reference 6), which had fracture toughness data for both orientations for five of the eight plate codes tested in this report. New Table 5-7 documents the material properties, initial USE values and available fracture toughness data for these materials. The average L-T/T-L fracture toughness conversion was 68% with consideration of all data, and 64% when the Z1/Z2 plate codes were excluded, as they appear to be an outlier compared to the other data points. Either calculated percent conversion supports the generic 65% conversion, which was then selected for use to ratio up the V-50 plate data to L-T orientation for comparison with axial flaw J-Applied values at PNP.

New Table 5-8 details the axial flaw safety factors for all transients, Levels A, B, C and D, with consideration of the Regulatory Guide 1.161 J-R model and limiting EOLE USE equal to 73 ft-lbs per WCAP-17651-NP. New Table 5-9 details the axial flaw safety factors for all transients, Levels A, B, C and D, with consideration of the V-50 plate data adjusted to the L-T orientation. New Figures 5-14 and 5-15 detail the applied J-Integral versus crack extension for axial flaws at 1/4t for Level A and B transients and applied J-Integral versus crack extension for axial flaws at 1/10t for Levels C and D transients, respectively. New Figure 5-16 details the axial flaw J-Integral versus crack extension at 1/4t for Level A and B transients for base metal with Regulatory Guide 1.161 model J-R curves and V-50 plate data included. New Figure 5-17 details the axial flaw J-Integral versus crack extension at 1/4t, pressure = 2.75 ksi, and a 100°F/hr cooldown transient for base metal with Regulatory Guide 1.161 model J-R curves and V-50 plate data included. Lastly, new Figure 5-18 details the axial flaw J-Integral versus crack extension at 1/10t for Levels C and D transients, for base metal with Regulatory Guide 1.161 model J-R curves and V-50 plate data included.

It should be noted, as discussed in detail in WCAP-17651-NP, that the V-50 plate data has a lower weight percent Ni value (0.23 wt-%), due to being A 302 B steel, and not SA 302 B, Modified, that contribute to the V-50 plate having lower fracture toughness than the PNP-specific plate materials. The PNP plates are SA 302 B, Modified, which means that they have at least 0.4% Ni. Nickel was added to increase toughness. Conservatively, the lowest J-R curve test data reported in NUREG/CR-5265, which is from a 6T size specimen, is used for comparison to the J-Applied values. The 6T data is considerably lower than test data for the 1T J-R data, which is the standard size specimen typically used. Therefore, the V-50 plate 6T J-R data is a conservative lower bound, viewed as the worst possible case, and selected due to being the only available fracture toughness data with high-sulfur content.

The minimum safety factor with consideration of the Regulatory Guide 1.161 J-R model, L-T orientation USE values and the PNP-specific axial flaw J-Applied values is 1.7 while the minimum safety factor with relative to the V-50 plate data and the PNP-specific axial flaw J-applied values is 1.4 at 0.1-inch crack extension. All these cases have their structural factors above the minimum requirement of 1.15 per Regulatory Guide 1.161 and are deemed acceptable. The flaw extension figures demonstrate that the NRC Regulatory Guide 100°F/hr cooldown transient with the accumulation pressure levels governs the Level A and B transients, which is the limiting case. All cases, where the Regulatory Guide 1.161 J-R material correlation is considered with axial flaw J-Applied pressure loadings, are acceptable with the applied J-integral values at 0.1-inch crack extensions below the material J-resistance ($J_{0.1}$) as required by the ASME Code Appendix K. In some instances with consideration of the V-50 plate data adjusted to the L-T orientation, the J-Material curves, adjusted to transient temperature, are either slightly below or just over the J-applied values, specifically for the Regulatory Guide 1.161 100°F/hour cooldown transient. However, as discussed above, the V-50 data is a lower bound high-sulfur data set, that is not fully representative of the PNP actual plate materials, and this result can be considered acceptable with consideration of the associated Regulatory Guide 1.161 model, and the structural factor (SF) calculations shown in Tables 5-8 and 5-9. Finally, as discussed above, the Regulatory Guide 1.161 100°F/hour cooldown transient is more limiting than the PNP-specific transients, as shown in the comparison of J-Applied curves in Figures 5-16 and 5-17. Note that the Regulatory Guide 1.161 100°F/hour cooldown transient with pressure of 2.75 ksi is more conservative than PNP cooldown transient with pressure of 2.13 ksi.

Table 5-7: NUREG/CR-6426 L-T (Strong) vs. T-L (Weak) Charpy USE and Fracture Toughness Data

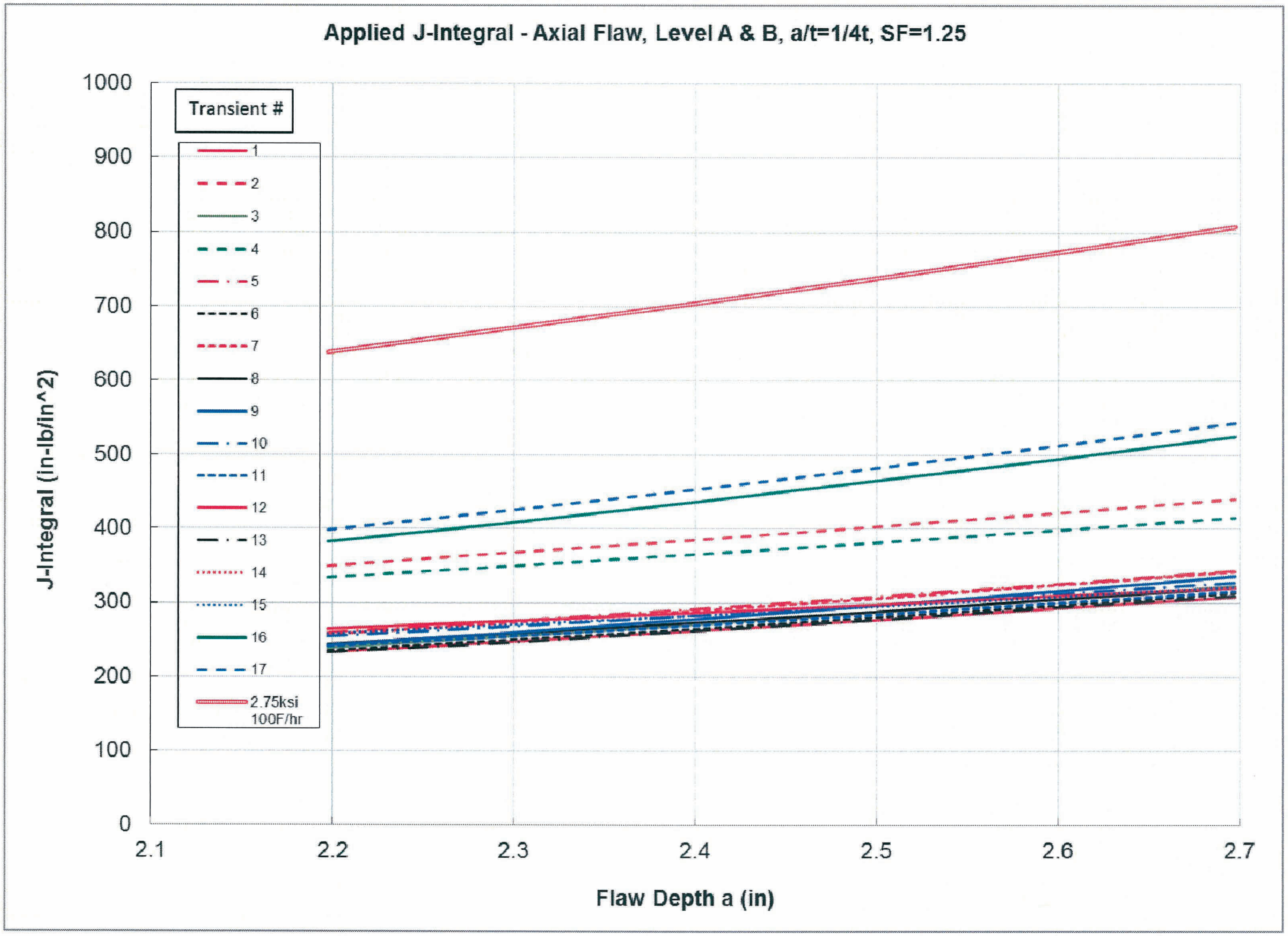
T= 180F	Plate Code	Chemistry			Initial USE (ft-lbs)		USE Ratio	$J_{0.1}$ (in/lb/in^2)		$J_{0.1}$ Ratio
		Cu	Ni	S	Longitudinal	Transverse		Longitudinal	Transverse	
Modified A302B	Z1, Z2	0.17	0.47	0.011	160	126	78.8%	3810	3300	86.6%
	Z5	0.16	0.60	0.016	153	95	62.1%	2640	1630	61.7%
	Z6A	0.18	0.49	0.013	129	113	87.6%	3570	2325	65.1%
	Z6B	0.21	0.51	0.023	117	64	54.7%	2360	1470	62.3%
	Z7	0.16	0.53	0.014	126	96	76.2%	4500	3000	66.7%
						Average (All)	71.9%		Average (All)	68.5%
						Average (Exclude Z1, Z2)	70.1%		Average (Exclude Z1, Z2)	64.0%

Table 5-8: Available Margins on Pressure Load for All Transients, Levels A, B, C and D, Axial Flaws

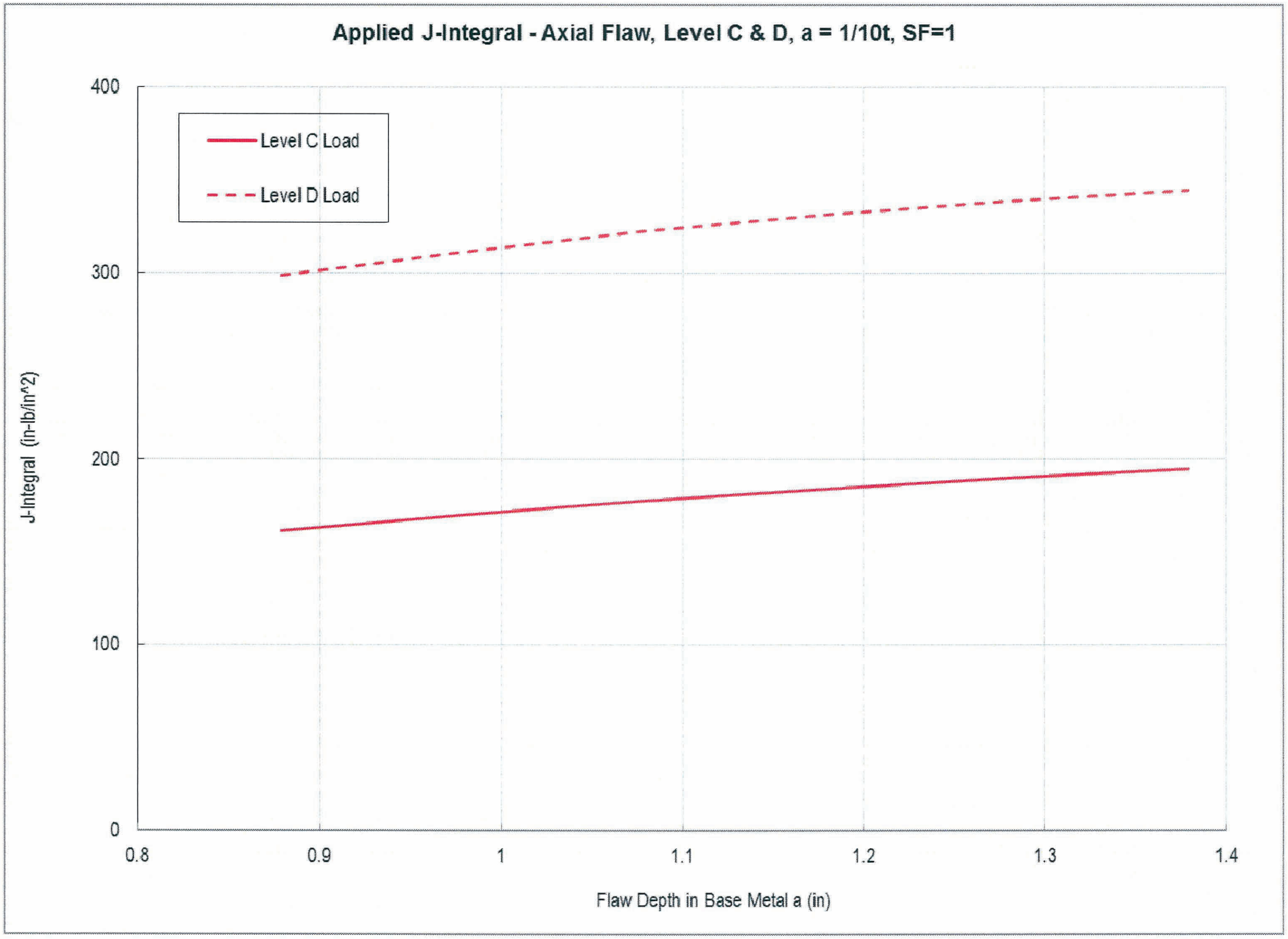
Level A and B	Base Metal – R. G. 1.161			Level C	Base Metal – R. G. 1.161			Level D	Base Metal – R. G. 1.161		
	Axial Flaw		$J_{0.1}$ material (in-lb/in^2)		Axial Flaw		$J_{0.1}$ material (in-lb/in^2)		Axial Flaw		$J_{0.1}$ material (in-lb/in^2)
Time (sec)	SF	J-applied x SF (in-lb/in^2)		Time (sec)	SF	J-applied x SF (in-lb/in^2)		Time (sec)	SF	J-applied x SF (in-lb/in^2)	
0	1.8	985	986	0	3.4	987	986	0	2.9	682	682
2800	1.7	1096	1096	1,197	5.0	1212	1213	798	4.1	831	830
3600	1.7	1138	1139	4,122	5.2	2218	2218	2,748	3.4	1490	1491
5400	1.7	1249	1249								
7200	1.8	1376	1376								
9000	1.9	1518	1518								
10800	18.5	1676	1676								
Minimum SF	**1.7**			Minimum SF	**3.4**			Minimum SF	**2.9**		

Table 5-9: Available Margins on Pressure Load for All Transients, Levels A, B, C and D, with Consideration of V-50 Plate Data and Axial Flaws

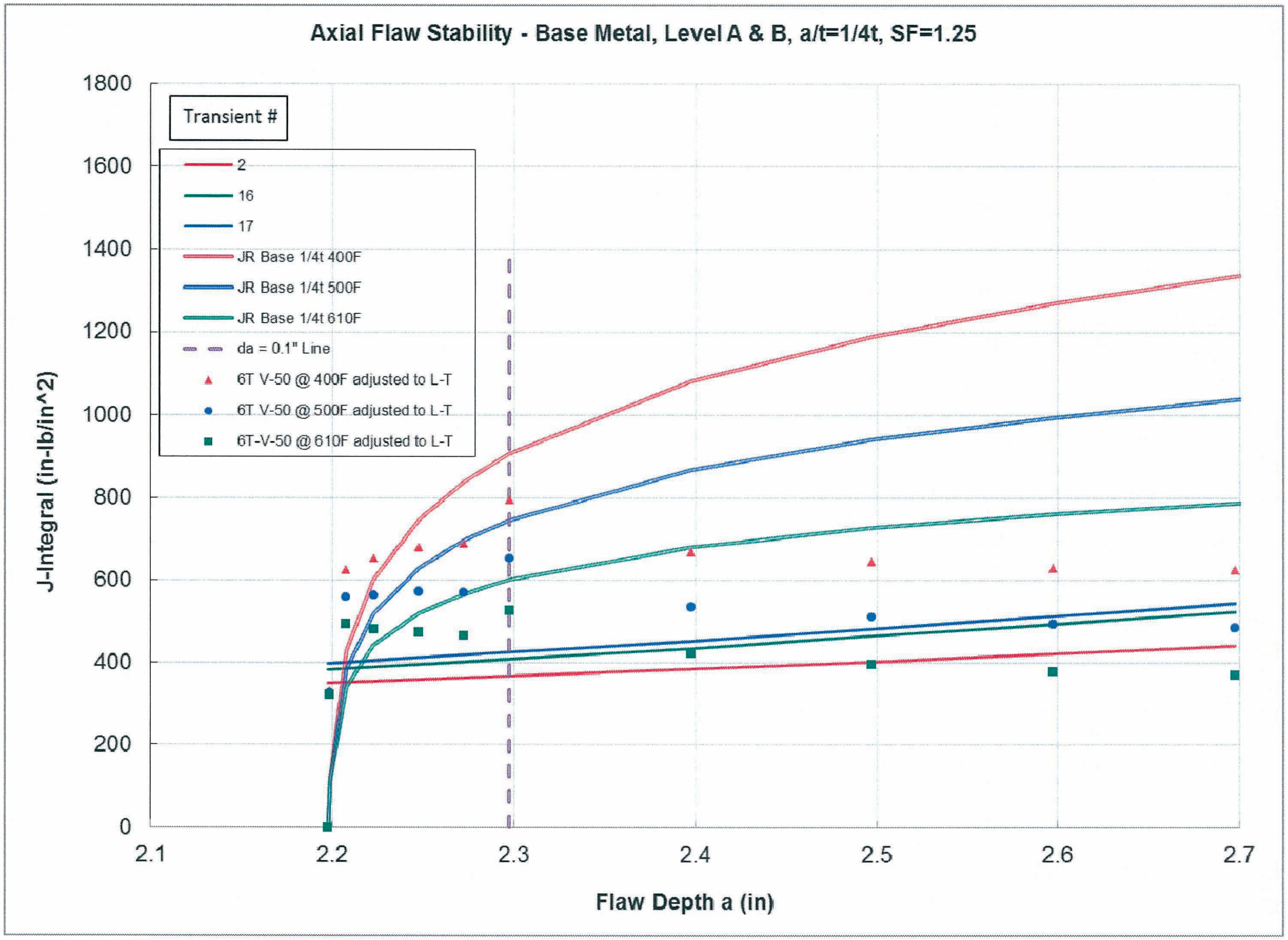
Level A and B	V-50 Plate			Level C	V-50 Plate			Level D	V-50 Plate		
	Axial Flaw		$J_{0.1}$ material		Axial Flaw		$J_{0.1}$ material		Axial Flaw		$J_{0.1}$ material
Time (sec)	**SF**	**J-applied x SF ($in\text{-}lb/in^2$)**	**($in\text{-}lb/in^2$)**	**Time (sec)**	**SF**	**J-applied x SF ($in\text{-}lb/in^2$)**	**($in\text{-}lb/in^2$)**	**Time (sec)**	**SF**	**J-applied x SF ($in\text{-}lb/in^2$)**	**($in\text{-}lb/in^2$)**
0	1.5	611	611	0	2.8	611	611	0	2.8	611	611
2800	1.4	679	679	1,197	4.0	751	751	798	3.9	743	743
3600	1.4	706	706	4,122	4.0	1,374	1,374	2,748	3.1	1335	1,335
5400	1.4	774	774								
7200	1.5	853	853								
9000	1.5	941	941								
10800	15.0	1039	1039								
Minimum SF	**1.4**			Minimum SF	**2.8**			Minimum SF	**2.8**		



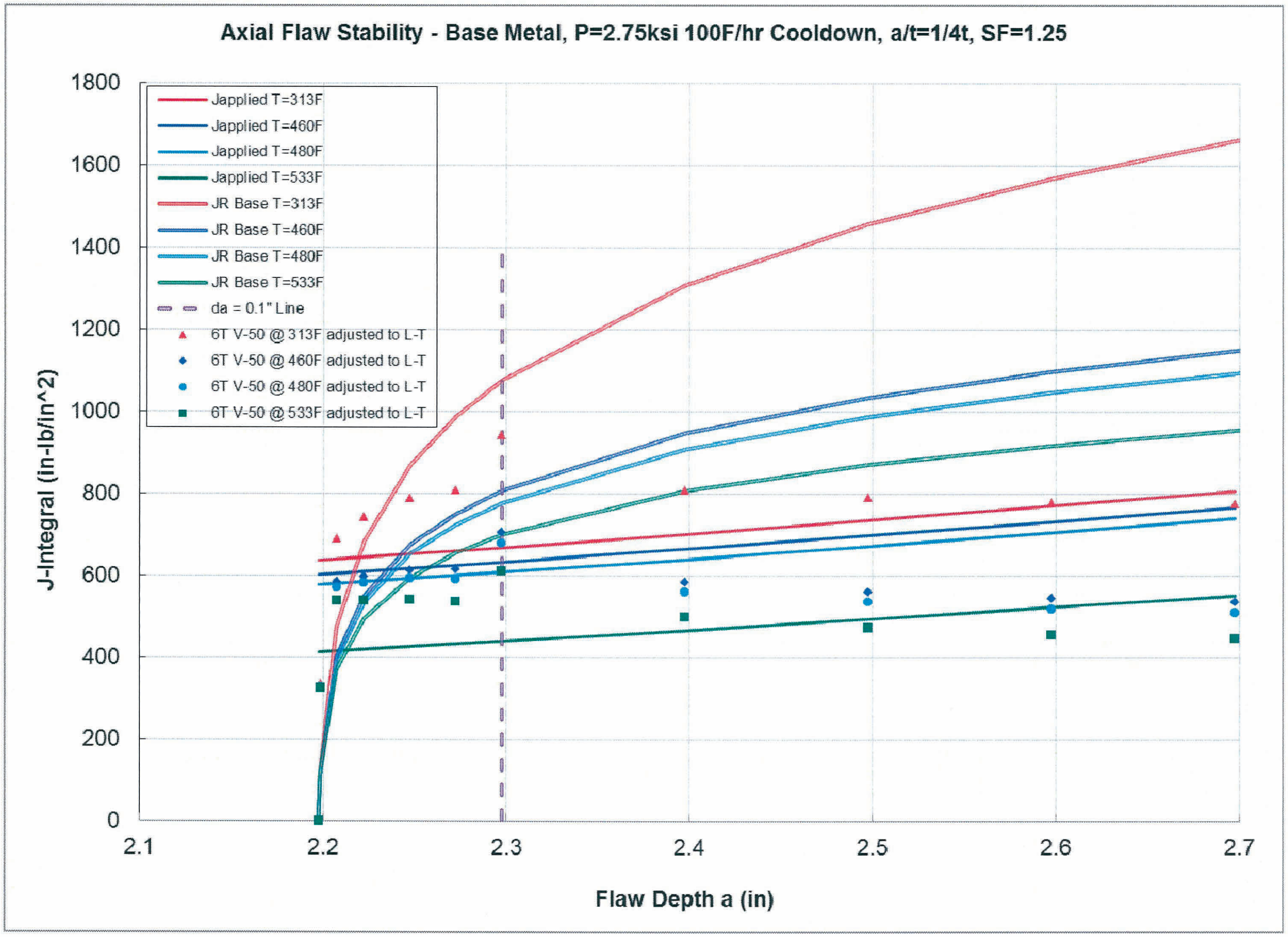
WCAP-17651-NP New Figure 5-14: Applied J-Integral versus Crack Extension for Axial Flaw – 1/4t, Level A and B



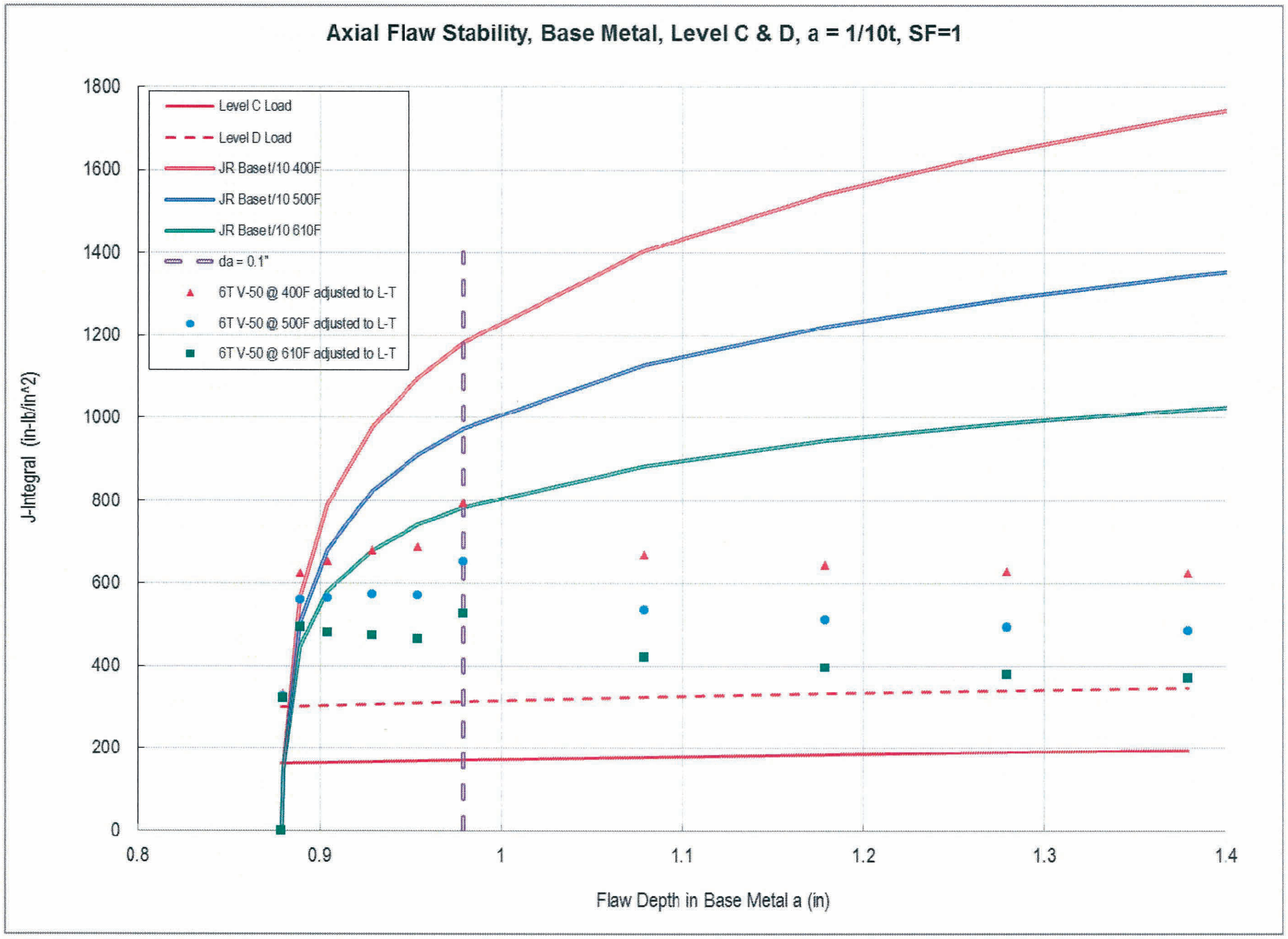
WCAP-17651-NP New Figure 5-15: Applied J-Integral versus Crack Extension for Axial Flaw – 1/10t, Levels C and D



WCAP-17651-NP New Figure 5-16: Axial Flaw J-Integral versus Crack Extension – t/4, Level A and B, Base Metal, with V-50 Plate Data Included



WCAP-17651-NP New Figure 5-17: Axial Flaw J-Integral versus Crack Extension – t/4, P=2.75 ksi, 100°F/hr Cooldown, Base Metal, with V-50 Plate Data Included



WCAP-17651-NP New Figure 5-18: Axial Flaw J-Integral versus Crack Extension – t/10, Levels C and D Loads, Base Metal, with V-50 Plate Data Included

References

1. Regulatory Guide 1.161, "Evaluation of Reactor Pressure Vessels with Charpy Upper-Shelf Energy Less than 50 Ft-Lb," U. S. Nuclear Regulatory Commission, June 1995.

2. Westinghouse Report WCAP-17651-NP, Revision 0, "Palisades Nuclear Power Plant Reactor Vessel Equivalent Margins Analysis," February 2013 (ADAMS Accession No. ML13295A451).

3. Code of Federal Regulations, 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements," U.S. Nuclear Regulatory Commission, Washington, D.C., Federal Register, Volume 60, No. 243, dated December 19, 1995.

4. ASME Boiler and Pressure Vessel (B&PV) Code, Section XI, Division 1, Appendix K, "Assessment of Reactor Vessels with Low Upper Shelf Charpy Impact Energy Levels," 2007 Edition up to and including 2008 Addenda.

5. ASME B&PV Code, Section XI, Division 1, Appendix G, "Fracture Toughness Criteria for Protection Against Failure," 1998 Edition up to and including 2000 Addenda.

6. NUREG/CR-6426, Volumes 1 and 2, "Ductile Fracture Toughness of Modified A 302 Grade B Plate Materials, Data Analysis," U.S. Nuclear Regulatory Commission, January and February 1997.

7. NUREG/CR-5265, "Size Effects on J-R Curves for A 302-B Plate," U.S. Nuclear Regulatory Commission, January 1989.