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For Signature of:

Routing:

Description:
Generic Request for Order EA-03-009

Assigned To:
K500

Contact:
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Special Instructions:

NUCLEAR ENERGY INSTITUTE

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October 15, 2003

Dr. Brian W. Sheron
Associate Director for Project Licensing and Technical Analysis
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, DC 20555-00011

SUBJECT: Generic Request for Order EA-03-009

PROJECT NUMBER: 689

Dear Dr. Sheron:

On September 26, 2003, NEI submitted a generic request for Order EA-03-009 (Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors). During a telephone conference call on October 9 the staff raised a number of questions on the submittal. Responses to the staff questions are enclosed.

Any NRC staff review of the enclosed information is exempt from the fee recovery provision contained in 10 CFR Part 170. This submittal provides information that might be helpful to NRC staff when evaluating licensee submittals provided in response to Order EA-03-009. Such reviews are exempted under §170.21, Schedule of Facility Fees. Footnote 4 to the Special Projects provision of §170.21 states, "Fees will not be assessed for requests/reports submitted to the NRC...as means of exchanging information between industry organizations and the NRC for the purpose of supporting generic regulatory improvements or efforts."

If there are any questions on these matters, please contact me (202-739-8080 or am@nei.org) or Jim Riley (202-739-8137 or jhr@nei.org).

Sincerely,

Alex Marion

Alexander Marion

Enclosure

c: Mr. Bill Bateman, NRC
Mr. Terence Chan, NRC
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Supplement to MRP-95 Addressing Action Items from 10/09/03 Teleconference with NRC

Peter C. Riccardella
Structural Integrity Associates
Oct. 10, 2003

1. **Relationship between yield strength and stress / stress intensity factor.**

   Stresses from two prior analyses of a Plant A, 38° nozzle (50 and 38 ksi yield strengths) were extracted. For 50 ksi YS, the maximum computed axial stress at the triple point was 21.0 ksi, versus 16.8 ksi for the 37 ksi YS case. Thus a ratio of 1.35 on yield strength resulted in a ratio of 1.25 for stress in the nozzle. This is consistent with the best-fit yield strength exponent in the correlation (Ref. 1) in the range of 0.6 to 0.7.

2. **Table of maximum stress at boundaries of proposed examination zone, considering stress orientation (hoop or axial), nozzle surface (ID or OD) and location (uphill, downhill or sidehill).**

   The requested table is attached (Tables 1 and 2). Tensile stresses in excess of 20 ksi are highlighted by shaded cells in the table.

3. **Revised Table 4-3, addressing smaller angle nozzles.**

   The revised version of Table 4-3 is also attached. The worst case growth time for an axial crack below the nozzle occurs at the downhill side of the Plant B 13° nozzle. In this nozzle location, the predicted time to grow an axial crack from an initial size of 1.21" (bottom of tube to edge of inspection zone) to a length of 1.96" (bottom of tube to lowermost edge of the weld) is 28,000 hours at 600° F. This compares to the previous worst case crack growth rate at 600° F reported in the original Table 4-3 of 53,000 hours.

4. **Evaluation of semi-elliptical surface flaw in tensile region below weld of worst-case nozzle.**

   A semi-elliptical, ID surface flaw was assumed to be present at the limiting, downhill location of the above-noted worst case nozzle (Plant B 13°). An expanded plot of the hoop stresses in that region is provided in the attached Figure 1. The assumed semi-elliptical surface flaw is also superimposed on that plot. The surface flaw was assumed to extend from the point at which the ID hoop stresses become positive to the edge of the inspection zone (0.75" below the weld). This results in a flaw length of 0.75" at the surface. A flaw aspect ratio of 0.5 was assumed, which yields a maximum depth of 0.375", more than half the tube wall thickness. The mid-plane ID surface stresses were assumed to be acting on the flaw, which yields a K at the flaw tip impinging on the inspection zone of 22.0 ksi√in, which is considerably less than the stress intensity factor reported in the revised Table 4.3 for a through-wall crack impinging on the inspection zone (36.6 ksi√in). Even if the stress at the edge of the inspection zone 44 ksi ID to 14 ksi OD is assumed to be acting over the entire flaw (a very conservative assumption), the resulting stress intensity factor is 36.1 ksi√in which is still smaller than the through-wall crack value. Thus it is demonstrated that the through-wall crack assumptions used in MRP-95 (from the bottom of the tube to the edge of the inspection zone) conservatively bound the crack growth rates that would be predicted for smaller surface flaws in the tensile region, for the worst case nozzle and flaw location.

References:

1. E. S. Hunt, D. J. Gross, G. A. White, R. Pathania, "Stress Predictive Algorithms for CRDM Nozzles," *Proceedings: 1997 EPRI Workshop on PWSCC of Alloy 600 in PWRs* (Daytona Beach, FL, February 25-27, 1997), EPRI, Palo Alto, CA: 1997, TR-109138-P2. pp. E18-1 through E18-16

Table 1
Stresses at Boundaries of Proposed Examination Zones above Weld
(Cells with Stresses Exceeding the 20 Ksi Target Are Shaded)

Plant	Nozzle Angle-Azimuth	Inspection Zone Dist. from Weld	Stresses at Edge of Inspection Zone Above Weld (ksi)			
			ID-Hoop	OD-Hoop	ID-Axial	OD Axial
A	38-Downhill	3.41	16.2	-10.9	9.6	-8.4
	38-Sidehill	2.08	-2.1	-7.8	11.7	-6.7
	38-Uphill	0.75	13.8	-19.7	4.0	-7.2
A	26-Downhill	2.57	11.5	-9.7	13.0	-10.2
	26-Sidehill	1.66	1.8	-1.9	12.7	-10.0
	26-Uphill	0.75	13.4	-13.1	8.7	-8.6
A	18-Downhill	2.01	11.9	-5.2	17.8	-10.5
	18-Sidehill	1.38	7.7	-1.4	15.6	-11.5
	18-Uphill	0.75	14.9	-7.0	12.7	-9.0
A	0-All	0.75	26.3	0.3	19.3	-13.7
B	43-Downhill	3.8	7.5	-1.8	4.4	9.3
	43-Sidehill	2.27	1.5	-0.4	2.4	-8.1
	43-Uphill	0.75	16.2	-14.4	4.8	-7.2
B	30-Downhill	2.85	4.7	-2.1	6.3	5.0
	30-Sidehill	1.8	2.9	-2.4	7.2	-11.9
	30-Uphill	0.75	18.6	-9.7	10.3	-11.2
B	13-Downhill	1.7	1.6	-7.0	18.2	-9.1
	13-Sidehill	1.2	10.3	-5.8	17.7	-14.7
	13-Uphill	0.75	18.8	-5.5	17.3	-15.6
B	0-All	0.75	29.2	-3.3	26.8	-21.3
C	48-Downhill	4.17	12.0	-1.4	11.3	17.2
	48-Sidehill	2.46	-2.9	6.6	-0.6	-0.6
	48-Uphill	0.75	11.5	-6.6	2.6	-7.6
D	49-Downhill	4.23	11.5	-6.4	5.7	2.0
	49-Sidehill	2.49	-2.6	0.1	6.7	-1.5
	49-Uphill	0.75	15.7	-23.5	4.7	-12.6
D	8-Downhill	1.31	14.7	-0.9	16.2	-13.4
	8-Sidehill	1.03	18.4	-1.7	17.6	-14.9
	8-Uphill	0.75	21.0	0.2	17.9	-14.7
D	55-Downhill(ICI)	4.62	20.7	1.7	3.0	4.6
	55-Sidehill(ICI)	2.69	9.5	13.1	3.7	4.2
	55-Uphill(ICI)	0.75	22.5	-1.6	-0.3	-5.1

Table 2
Stresses at Boundaries of Proposed Examination Zones below Weld (Cells with Stresses Exceeding the 20 Ksi Target Are Shaded)

Plant	Nozzle Angle-Azimuth	Inspection Zone Dist. from Weld	Stresses at Edge of Inspection Zone Below Weld (ksi) ID-Hoop	OD-Hoop	ID-Axial	OD Axial
A	38-Downhill	0.75	-14	-2.6	0.1	1.6
	38-Sidehill	2.08	0.6	0.8	14.4	-17.8
	38-Uphill	3.41	10.9	-20.1	13.4	-10.5
A	26-Downhill	0.75	9.8	1.5	9.6	-8.7
	26-Sidehill	1.66	3.2	-0.3	20.0	-21.7
	26-Uphill	2.57	7.7	-19.7	18.9	-20.3
A	18-Downhill	0.75	18.0	10.7	20.0	-18.5
	18-Sidehill	1.38	14.6	-0.3	28.0[1]	-26.9
	18-Uphill	2.01	10.9	-17.3	26.0[1]	-28.5
A	0-All	0.75	31.9	13.7	29.2	-25.9
B	43-Downhill	0.75	20.0	20.0	23.0[1]	-15.5
	43-Sidehill	2.27	13.9	-8.4	17.0	-27.8
	43-Uphill	3.8	-10.7	-6.2	3.4	-2.1
B	30-Downhill	0.75	36.2	16.1	29.8	-24.9
	30-Sidehill	1.8	9.4	-6.7	27.1	-26.5
	30-Uphill	2.85	-9.1	-11.5	6.6	-10.6
B	13-Downhill	0.75	44.4	13.8	33.5	-33.9
	13-Sidehill	1.2	25.2	0.5	38.1	-35.3
	13-Uphill	1.66	4.9	-15.2	26.3	-26.6
B	0-All	0.75	32.0	13.8	34.0	-31.2
C	48-Downhill	0.75	-11.3	13.9	16.2	-3.4
	48-Sidehill	2.46	15.5	-8.3	15.8	-22.1
	48-Uphill	4.17	2.0	-11.9	10.6	-1.3
D	49-Downhill	0.75	8.2	14.3	14.4	-1.4
	49-Sidehill	2.49	10.5	3.9	20.0	-29.4
	49-Uphill	4.23	13.8	-20.5	12.4	-3.1
D	8-Downhill	0.75	33.7	12.5	26.9	-24.4
	8-Sidehill	1.03	28.5	4.1	32.3	-30.2
	8-Uphill	1.31	22.6	-3.6	33.6	-31.4
D	55-Downhill(ICI)	0.75	12.2	-0.2	1.7	-0.6
	55-Sidehill(ICI)	2.69	A[2]	A[2]	A[2]	A[2]
	55-Uphill(ICI)	4.62	A[2]	A[2]	A[2]	A[2]

1. Axial stress exceeds 20 ksi, but not considered an exception because stress at weld is compressive (See Figure A-26 of MRP-95 for example)
2. Boundary of examination zone is beyond bottom end of nozzle.

Revised Table 4-3
Crack Growth times for Postulated Axial Cracks at Edge of Below Weld Inspection Zone to Reach Weld (Including Lower Angle Nozzles that Violate the 20 ksi Criteria)

PLANT/NOZZLE	LOCATION	K @ STARTING FLAW SIZE (KSI-√IN)	CRACK GROWTH TIME TO BOTTOM OF WELD (HRS)				
			580° F	590° F	600°F	602° F	605° F
Plant A (B&W 38°)	DOWNHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
	SIDEHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
	UPHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
(B&W 0°)	ALL	18.1	89000	69000	54000	51000	47000
Plant B (W 2-LOOP 43.5°)	DOWNHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
	SIDEHILL	38.4	101000	78000	61000	58000	54000
	UPHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
(W 2-LOOP 30°)	DOWNHILL	20.4	83000	64000	50000	47000	44000
	SIDEHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
	UPHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
(W 2-LOOP 13°)	DOWNHILL	36.6	47000	37000	28100	26700	24700
	SIDEHILL	10.8	158000	123000	95000	91000	84000
	UPHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
(W 2-LOOP 0°)	ALL	9.1	152000	125000	92000	87000	81000
Plant C (W 4-LOOP 48.8°)	DOWNHILL	9.54	92000	71000	55600	53000	49000
	SIDEHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
	UPHILL	16	Arrests	Arrests	Arrests	Arrests	Arrests
Plant D (CE 49.7°)	DOWNHILL	10	87000	67000	53000	50000	46000
	SIDEHILL	46.2	122000	94000	74000	70000	65000
	UPHILL	< 8.19	No Growth	No Growth	No Growth	No Growth	No Growth
(CE 8°)	DOWNHILL	28.8	72000	56000	43000	41000	38000
	SIDEHILL	18.8	114000	88000	68000	65000	60000
	UPHILL	11.4	241000	186000	145000	138000	128000

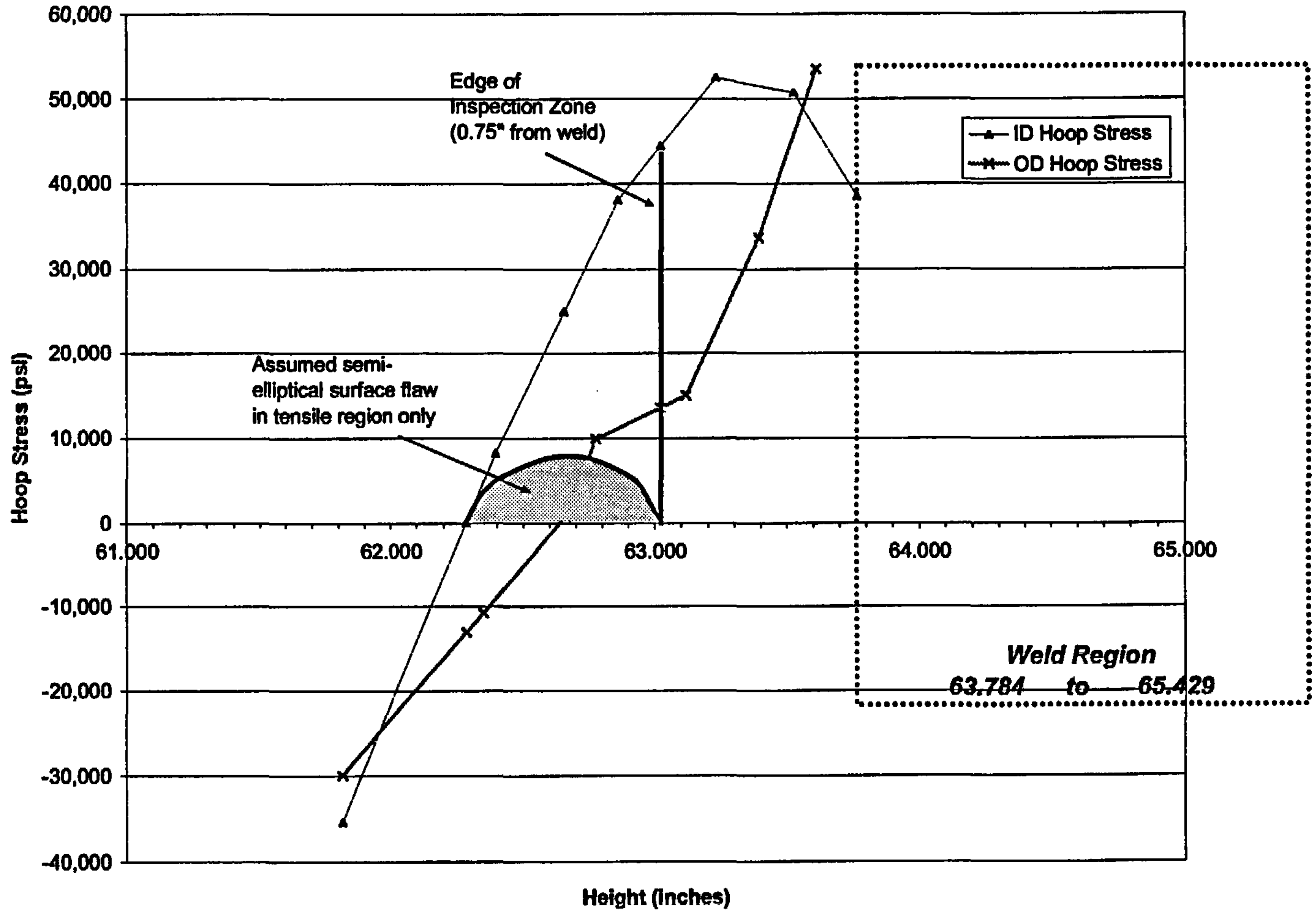

Figure 1 – Expanded Plot of Hoop Stresses in Region below 13° Nozzle in Plant B Showing Semi-Elliptical Surface Flaw Assumption