Dominion Nuclear Connecticut, Inc.
Millstone Power Station
Rope Ferry Road
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November 21, 2003

Dominion

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

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DOMINION NUCLEAR CONNECTICUT, INC. (DNC)
MILLSTONE POWER STATION, UNIT 2
SUPPLEMENTAL INFORMATION TO A STRUCTURAL INTEGRITY EVALUATION SUPPORTING THE REQUEST RR-89-48 FOR THE ULTRASONIC TEST COVERAGE REQUIREMENTS IN NRC ORDER EA-03-009

On February 11, 2003, the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-03-009 for interim inspection requirements for reactor pressure vessel (RPV) heads at pressurized water reactor facilities. The Order requires specific inspection of the RPV head and associated penetration nozzles. On October 3, 2003, pursuant to the procedure specified in Section IV.F of the Order, Dominion Nuclear Connecticut, Inc. (DNC) requested relaxation from requirements of the Order regarding the ultrasonic test examination (UT) coverage for the control element drive mechanism (CEDM) penetration nozzles (Request Number RR-89-48).

On October 10, 2003, DNC provided the non-proprietary and proprietary versions of a supporting structural integrity evaluation report for the DNC request RR-89-48. On November 5, 2003 and November 20, 2003, DNC provided additional information related to the structural integrity evaluation report. Two additional NRC questions were received on November 18, 2003. Attachment 1 of this letter supplements the information previously provided on November 20, 2003.

There are no regulatory commitments contained within this letter.

If you should have any questions regarding this submittal, please contact Mr. David W. Dodson at (860) 447-1791, extension 2346.

Very truly yours,

Leslie N. Hartz
Vice President – Nuclear Engineering

A101

Attachment (1)

cc: U. S. Nuclear Regulatory Commission
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The Director, Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Leslie N. Hartz who is Vice President – Nuclear Engineering of Dominion Nuclear Connecticut, Inc. She has affirmed before me that she is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of her knowledge and belief.

Acknowledged before me this 21st day of November, 2003.

My Commission Expires: May 31, 2006.

Notary Public Vicki L. Hull

(SEAL)

Attachment 1

Millstone Power Station, Unit 2

Supplemental Calculations: Head Penetration Inspection Coverage

Millstone Power Station, Unit 2
Supplemental Calculations: Head Penetration Inspection Coverage

On October 10, 2003,[1] Dominion Nuclear Connecticut, Inc. (DNC) provided the non-proprietary and proprietary versions of a supporting structural integrity evaluation report[2] for the DNC request RR-89-48. On November 5, 2003,[3] and November 20, 2003,[4] DNC provided additional information related to the structural integrity evaluation report. As a result of U.S. Nuclear Regulatory Commission (NRC) review of the inspection coverage achieved at Millstone Unit No. 2, the NRC staff asked several additional questions about the technical justification prepared by Westinghouse in their structural integrity evaluation. The goal of this technical note is to supplement the information provided in DNC letters dated November 5, and November 20, 2003.

The guidelines set for the additional calculations were the following:

- Flaws do not need to be postulated in regions where the stresses are below 20 ksi,
- Length of the postulated flaws should correspond to the length of the un-inspected regions,
- Tubes which received a supplemental die penetrant exam are acceptable,
- Postulated flaws need to conservatively reflect the types of flaws that were found in the Millstone tubes in the inspections recently completed.

A review was made of the tubes with less than the required coverage, to identify the three key dimensions needed for the evaluation. First, a tabulation was prepared of the tubes with coverage issues, showing the distance from the bottom of the as-built weld to the location where coverage was not achieved (Table 1). Second, a table was prepared of the indications found at Millstone 2, to identify the length and depth reported (Table 2). The minimum distance from Table 1 was 0.39 inches. The penetration angles for these tubes are 29, 37, and 42.5 degrees. Third, the location where the OD stresses drop below 20 ksi was identified, from the stress distributions already provided in WCAP 15813, Appendix B. That distance was found to be 0.5 inches in every case.

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(1) DNC Letter, "Millstone Power Station, Unit No. 2, Supplement to Request Number RR-89-48 for Relaxation From Nozzle Inspection Ultrasonic Test Coverage Requirements in Order EA-03-009," October 10, 2003, (Accession No. ML032930097)

(2) WCAP-15813-P, Revision 1, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Millstone Unit 2," August 2003. (Proprietary)

(3) DNC Letter, "Millstone Power Station, Unit No. 2, Response to Request for Additional Information on RR-89-48 for the Nozzle Inspection Ultrasonic Test Coverage Requirements in Order EA-03-009," dated November 5, 2003.

(4) DNC Letter, "Millstone Power Station Unit 2, Response to Request for Additional Information on RR-89-48 for the Nozzle Inspection Ultrasonic Test Coverage Requirements in Order EA-03-009," November 20, 2003.

Previous Submittal

Based on the previous discussion, the region of concern is a distance of 0.11 inches at most for the penetrations in question. In response to a previous RAI, discussions were provided to further explain the calculations carried out in WCAP 15813 Rev.1, to predict the future growth of flaws below the attachment weld region. These flaws were postulated at a distance of 0.5 inches below the attachment weld region, and used the postulated initial flaw sizes shown below. Note that, for the affected penetration angles, the postulated flaw sizes all exceed the length of concern here, 0.11 inches. Note that there were no coverage issues with the center penetration, which is the only one with a postulated flaw less than 0.11.

Postulated Through-wall flaws for WCAP 15813

Nozzle Angle (Degrees)	Initial Thru-Wall Flaw Length (in)
0	0.085
29.1	0.117
37.1	0.406
42.5	0.160

Additional Calculations

Supplemental calculations were performed on the penetrations of interest. Rather than consider a wide range of semi-elliptic surface flaws, a range of through-wall flaws was considered to conservatively bracket all the possible situations. Calculations were completed for cases in which the bottom extremity of the flaw is defined to be where the hoop stress drops below 20 ksi, and also below 10 ksi. The stresses at the upper extremity of non-coverage were used in the analysis, in all cases, to add additional conservatism.

Results

The results are shown below. As an example, the calculation for the 29.1 degree case is discussed. As shown below, the length of the postulated through-wall flaw is 0.11 inches. The crack growth was calculated with the MRP-55 Rev.1 crack growth curve, using a stress intensity factor expression from Tada, as described below. The resulting time to grow to the bottom of the weld for the worst case is 4.42 EFPY, or 4.9 years using an availability of 0.9 for the plant. This is the governing case for all the evaluations carried out. As seen in the Results of Calculations section, the worst case penetration gives results of 2.7 years under more conservative assumptions, and the other penetrations give even more time for the flaw to reach the bottom of the weld.

Methodology for K Calculation

Axial thru-wall flaw in a cylinder (Stress Analysis of Cracks Handbook, Tada, 2nd Edition, solution 34.1):

$K_I = \sigma\sqrt{\pi a}\,F(\lambda)$

Where $\lambda = a/\sqrt{Rt}$

$F(\lambda) = (1+1.25\lambda^2)^{1/2}$ for $0 < \lambda \leq 1$

$F(\lambda) = 0.6+0.9\lambda$ for $1 \leq \lambda \leq 5$

σ = average hoop stress through the nozzle wall thickness at the upper extremity

Results of Calculations

Lower Extremity at 20 ksi

Nozzle Angle (Deg)	Initial Thru-Wall Flaw Length (in)	EFPY to reach weld bottom	Calendar Years to reach weld bottom (availability = 0.9)
29.1	0.11	4.42	4.9
37.1	0.09	5.17	5.7
42.5	0.07	9.55	10.6

Lower Extremity at 10 ksi

Nozzle Angle (Deg)	Initial Thru-Wall Flaw Length (in)	EFPY to reach weld bottom	Calendar Years to reach weld bottom (availability = 0.9)
29.1	0.39	2.44	2.7
37.1	0.30	2.74	3.0
42.5	0.13	5.06	5.6

Example Calculation: Most Conservative Case

The calculations discussed above, whose results are shown in the Results of Calculations section above, were based on the stress results for either the inside or the outside surface, whichever curve dropped below the chosen stress criterion first. In most cases the appropriate stresses were those at the outside surface, which is the location of the recently found indications.

A more conservative case was also considered, where the point of limiting stress was taken as that where the inside surface stress drops below 20 ksi. The limiting (29.1 degree) case was used, and the numbers appear below.

Initial Through-Wall Flaw Size

Upper Extremity: End of the inspection zone
Lower Extremity: 20 ksi hoop stress on the inside surface

Example: For 29.1° Penetration Downhill Side:

Upper extremity: 0.39" from bottom of weld
Lower extremity: 0.79" from bottom of weld
Initial thru-wall length = 0.40"

K Expression:

Axial thru-wall flaw in a cylinder (Stress Analysis of Cracks Handbook, Tada, 2nd Edition, solution 34.1):

$K_I = \sigma\sqrt{\pi a}\,F(\lambda)$

Where $\lambda = a/\sqrt{Rt}$

$F(\lambda) = (1+1.25\lambda^2)^{1/2}$ for $0 < \lambda \leq 1$
$F(\lambda) = 0.6+0.9\lambda$ for $1 \leq \lambda \leq 5$
σ = average hoop stress through the nozzle wall thickness at the upper extremity

Acceptance Criteria: 1.5 years for the upper extremity of the flaw to reach the bottom of the weld.

Results

The calculation shows that the initial flaw length of 0.40 inches grows to the bottom of the weld in 2.42 EFPY year, or 2.7 calendar years assuming 90 percent availability.

Conclusion

Based on the above, DNC concludes that the Millstone Unit No. 2 reactor vessel head inspection program meets the NRC's requirements and that operation of Millstone Unit No. 2 during cycle 16 poses no undue risk to the public health and safety.

TABLE 1
EXTENT OF ULTRASONIC TEST (UT) EXAMINATION COVERAGE IN CEDM NOZZLES IN (2R15)
- List Sorted by Downhill Side Coverage -

Angle	Penet. No.	Minimum Distance Below the Weld Toe (Inches)			Penet. No.	Minimum Distance Below the Weld Toe (Inches)		
		On the Downhill Side	90° From Downhill	270° From Downhill		On the Downhill Side	90° From Downhill	270° From Downhill
	55 (1)	0.23	2.32	2.30	58	0.55	2.99	2.76
	59 (1)	0.25	3.10	2.67	69	0.55	3.00	2.70
	42 (2)	0.31	2.28	2.31	31	0.56	1.93	2.12
	27 (1)	0.33	1.76	1.85	10	0.59	1.49	1.47
	33 (1)	0.35	1.57	1.41	29	0.59	1.69	1.69
	56 (1)	0.35	1.97	2.05	46	0.59	2.56	2.63
	65 (1)	0.37	2.69	2.67	57 (2)	0.59	2.56	2.28
29.1	32	0.39	1.55	1.63	61	0.59	2.60	2.75
42.5	60 (2)	0.40	2.99	2.71	63	0.59	3.14	2.79
35.6	38	0.42	2.20	2.80	13	0.63	1.89	1.69
35.6	36	0.47	1.92	2.12	25	0.63	1.61	1.68
38.5	43	0.47	2.38	2.62	37 (2)	0.63	2.11	2.11
38.5	44	0.47	2.63	2.68	49	0.63	2.79	2.26
38.5	45	0.47	2.50	2.54	14	0.70	1.69	1.75
42.5	66	0.47	2.95	2.53	16	0.70	1.84	1.75
11	9	0.48	1.36	1.42	35	0.71	2.33	1.84
22.4	11	0.48	1.36	1.42	12	0.74	1.80	1.66
38.5	48	0.48	2.20	2.27	39	0.74	2.26	2.00
37.1	51	0.48	2.52	2.60	53	0.74	2.38	2.50
42.5	68 (2)	0.48	3.01	2.95	3	0.75	1.26	1.18
25.3	20	0.49	1.77	1.53	5	0.75	1.12	1.31
25.3	23	0.49	1.75	1.85	64	0.75	3.11	2.79
29.1	26 (2)	0.50	1.88	1.95	1	0.78	0.98	0.98
	19	0.51	1.65	1.57	4	0.79	1.20	1.30
	41	0.51	1.99	2.04	8	0.79	1.22	1.18
	62	0.51	2.97	2.71	47	0.79	2.79	2.61
	67	0.53	2.41	2.52	7	0.80	1.27	1.16
	6	0.55	1.77	1.49	17 (2)	0.80	1.84	1.75
	15	0.55	1.69	1.65	22 (2)	0.82	1.89	1.97
	18	0.55	1.81	1.73	40	0.82	2.43	2.24
	24	0.55	1.76	1.68	2	0.88	1.37	1.39
	28	0.55	1.96	2.14	21 (3)	n/a	n/a	n/a
	30	0.55	1.69	1.73	34 (3)	n/a	n/a	n/a
	52	0.55	2.67	2.34	50 (3)	n/a	n/a	n/a
	54	0.55	2.31	2.23				

NOTES: (1) A supplemental PT is required. (2) Repair on this nozzle in 2R15 will preclude the need for a supplemental PT. (3) Previously repaired nozzle in 2R14 with greater than 1 inches extent of coverage below pressure boundary weld.

Table 2: Indications found at Millstone Unit 2, Fall 2003

Penetration Number	Penetration Angle	UT Indication Length, inches	UT Indication Depth, inches	Aspect Ratio
13	22.4°	0.61	0.15	4.07
13	22.4°	0.75	0.06	12.50
17	23.9°	1.21	0.30	4.03
22	25.3°	0.73	0.16	4.56
22	25.3°	0.36	0.11	3.27
26	29.1°	0.55	0.39	1.41
26	29.1°	0.69	0.17	4.06
31	29.1°	0.94	0.11	8.55
37	35.6°	0.79	0.35	2.26
42	38.5°	0.75	0.35	2.14
46	38.5°	0.84	0.18	4.67
47	38.5°	0.98	0.15	6.53
57	37.1°	0.59	0.19	3.11
57	37.1°	0.43	0.36	1.19
60	42.5°	0.71	0.18	3.94
68	42.5°	0.77	0.29	2.66

NOTES: (1) A supplemental PT is required. (2) Repair on this nozzle in 2R15 will preclude the need for a supplemental PT. (3) Previously repaired nozzle in 2R14 with greater than 1 inches extent of coverage below pressure boundary weld.