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CNRO-2004-00039

August 13, 2004

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

SUBJECT: Response to NRC Request for Additional Information Pertaining to Waterford 3 Relaxation Request #4 to NRC Order EA-03-009 for the Control Element Drive Mechanism Nozzles (TAC No. MC2643)

Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCE: Entergy Operations, Inc. letter CNRO-2004-00020 to the NRC dated April 15, 2004

Dear Sir or Madam:

In the referenced letter, Entergy Operations, Inc. (Entergy) requested relaxation from Section IV.C(5)(b) of First Revised NRC Order EA-03-009 for Waterford Steam Electric Station, Unit 3 (Waterford 3) via Waterford 3 Relaxation Request #4. On June 6, 2004, the NRC staff transmitted to Entergy via e-mail a Request for Additional Information (RAI) pertaining to this request. On June 18, 2004, representatives of the staff and Entergy held a telephone conference to discuss the RAI questions. During that call, one of the questions was withdrawn. Entergy's responses to the remaining questions are provided in Enclosure 1 of this letter. Enclosure 2 provides requested information pertaining to the as-built configuration of the Waterford 3 CEDM nozzles based upon ultrasonic examination data collected during recent refueling outage RF12.

This letter contains no commitments.

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If you have any questions, please contact Guy Davant at (601) 368-5756.

Sincerely,

FGB/GHD/ghd

Enclosures: 1. Response to the NRC's Request for Additional Information
2. Waterford 3 CEDM Nozzle As-Built Free Span Lengths

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ENCLOSURE 1

CNRO-2004-00039

RESPONSE TO THE NRC'S REQUEST FOR ADDITIONAL INFORMATION

RESPONSE TO NRC'S REQUEST FOR ADDITIONAL INFORMATION

By letter dated April 15, 2004, Entergy Operations, Inc. (Entergy) requested relaxation to implement an alternative to certain requirements of First Revised NRC Order EA-03-009 for control element drive mechanism (CEDM) nozzles at Waterford Steam Electric Station, Unit 3 (Waterford 3). The NRC staff requests additional information for its review.

1. To perform the review, it is necessary to have the distance from the bottom of the J-groove weld to the top end of the blind zone in a nozzle. Please revise the relaxation request to reflect the distance from the bottom of the J-groove weld to the blind zone instead of the distance above the bottom of the nozzle.

   Response:

   The actual distances from the bottom of the J-groove weld to the blind zone, designated as the free span lengths, for the 91 CEDM nozzles are provided in Enclosure 2.

2. Please provide the inspection scope and coverage obtained during the previous RF12 inspection in October, 2003. As the Revised Order requires NDE 2 inches below the J-groove weld or one inch below the J-groove weld where the stress is below 20 ksi, provide a list of nozzles which UT coverage was less than 1 inch below the J-groove weld.

   Response:

   The inspection scope consisted of UT volumetric inspection of the 91 CEDM nozzles from 2 inches above the J-groove weld down to the blind zone below the weld. The actual free span lengths are provided in Enclosure 2.

3. Please discuss if the same inspection techniques will be used as in the last inspection at Waterford 3. Describe if there have been improvements made in inspection logistics and techniques to potentially improve coverage to meet the Order requirement.

   Response:

   At this time, Entergy is planning to use the same inspection techniques that were used during RF12.

4. On Page 5 of 18 of the submittal regarding alternative surface examinations, please explain why eddy current testing (ECT) cannot be performed on the outside diameter (OD) surface of the nozzles below the weld. Please also explain if a liquid penetrant testing (PT) inspection can be performed on the OD surface below the weld.

   Response:

   Entergy has the capability to perform either ECT or PT inspections on the OD surface of the CEDM nozzles below the toe of the J-groove weld. However, to do so would result in high radiation exposure to workers estimated between 27 and 45 man-R for the 91 nozzles. As documented in the relaxation request and supporting Engineering Report

M-EP-2003-004, sufficient free span length exists between the toe of the J-groove weld and the top of the blind zone to preclude a crack in the blind zone from reaching the weld within one cycle of operation. Therefore, Entergy believes that to perform either ECT or PT on the OD surface of the nozzle below the weld, thereby exposing personnel to high radiation levels in light of the analysis results, would not be appropriate.

5. This submittal referenced Entergy Engineering Report M-EP-2003-004, Rev. 0. The staff understands that there had been revisions to the report as result of Request for Additional Information (RAIs) from the staff in September and October of 2003. Please confirm that this is the correct version of the report that supports the submittal dated April 15, 2004.

   Response:

   Engineering Report M-EP-2003-004 has not been revised since being submitted to the staff in support of the initial Waterford 3 Relaxation Request #1 (see Entergy letter CNRO-2003-00038 dated September 15, 2003). As stated in our submittal dated April 15, 2004, Revision 0 of the report does support Waterford 3 Relaxation Request #4. Additional information was provided to the staff via Entergy letter CNRO-2003-00057 dated October 24, 2003, in which, Entergy responded to an NRC question pertaining to reanalysis criterion. In that letter, Entergy provided the amount of free span length, designated as "minimum propagation length", required for each nozzle group. A nozzle with less free span length than the designated minimum propagation length would require augmented inspection. As can be seen from data provided in Enclosure 2, the actual as-built free span lengths of the CEDM nozzles exceed the minimum propagation lengths. Therefore, no augmented inspections of the CEDM nozzles were required.

6. The submittal referenced stress analysis performed (Engineering Report M-EP-2003-004) for the previous inspection relaxation request in 2003. Page 6 of the submittal stated that the analysis was based on a review of applicable Waterford 3 drawings and actual data from a sister plant. Is the analysis still bounding given the field data obtained from the last inspection? Please explain if the stress analysis should be revised given the revision of the Order, actual dimensions obtained from last outage at Waterford 3, and any other change that may be applicable since the last inspection.

   Response:

   As stated in Section IV.A.2 (page 6 of 18), during RF12, Entergy inspected by UT each CEDM nozzle to determine its actual as-built configuration. These inspections confirmed that the as-built nozzle configurations are bounded by the analysis. No revision to the analysis is necessary.

7. This item was withdrawn by the NRC staff in a conference call conducted on June 18, 2004.

Below are questions regarding the fracture mechanics analysis in the Entergy Engineering Report M-EP-2003-004, Rev. 0 (Engineering Report).

8. Page 10 of 57, the through-wall crack is postulated to exist from the top of the blind zone down to a point where the hoop stress is less than 10 ksi. For the partial through-wall crack, 0.32 inch of initial crack is assumed. Discuss why the initial crack is not assumed from the top of the blind zone to the bottom of the nozzle as described in MRP-95.

   Response:

   The mathematical fracture mechanics model for a through-wall axial flaw evaluated by Entergy in Engineering Report M-EP-2003-004 is discussed initially on page 10, and then further discussed on pages 40 through 43. The bottom of the CEDM nozzle is generally in a very low tensile (0 to 10 ksi) or compressive through-thickness stress distribution. A primary water stress corrosion cracking (PWSCC) flaw will not initiate and grow in such a stress field. In evaluating the "residual plus operating" stress distributions (such as those depicted in Figures 4 through 7 of the report) for the four CEDM nozzle groups, Entergy determined that a postulated initial through-wall flaw extending from top of the blind zone down the nozzle to a point where the tensile stress would still enable growth (≥ 10 ksi) would be reasonable and conservative. This configuration of a through-wall axial flaw would be subject to tensile stresses over the entire crack area as opposed to being loaded in tension near the top and compression near the bottom of the flaw if it were oriented from the top of the blind zone to the bottom of the nozzle.

   To confirm the supposition that sizing a through-wall flaw with a length from the top of the blind zone to a region where average through-wall stress was approximately 10 ksi would be a conservative approach, Entergy performed a detailed analysis in Appendix D, Attachment 3, to Engineering Report M-EP-2003-004. This analysis compared the stress intensity factors (SIFs) and the stress intensity correction factors (SICFs), or flaw magnification factors, based on Entergy's through-wall axial flaw model to those derived from a conventional center cracked panel (CCP) with an SICF of 1.0. Comparisons of the magnification coefficients and the SIFs between these two flaw models are shown in Figures 21 through 23 of the report. The results show Entergy's flaw model to produce more conservative (higher) SIFs in the region of interest (at and below the top of the blind zone). The higher SIFs would, in turn, produce higher PWSCC flaw growth rates than those derived using SIFs from the conventional edge crack model. With the exception of the mid-plane (90° azimuth) location on the 49.7° nozzle group, all through-wall flaws postulated by Entergy exhibited no flaw growth out of the blind zone and toward the weld in one or two fuel cycles.

   For the mid-plane (90° azimuth) of the 49.7° nozzle group, the inside diameter (ID) stresses at the bottom of the nozzle were approximately 19.02 ksi and required a flaw configuration spanning from the nozzle bottom to the top of the blind zone. In order to evaluate this condition, an edge crack model was used. The methodology and results are documented on Pages 51 through 55 of the report. Figure 33 shows that the presumed edge flaw at the mid-plane azimuth would not grow to the weld for about 39 years. Thus, in one or two fuel cycles, no detectable growth of the flaw from the top of the blind zone will occur.

9. For the partial through-wall crack analyzed, it seems that the initial depth assumed was obtained from an EPRI report, as Reference 4, which has not been published. Please explain whether the initial depth assumed has been verified.

Response:

The initial depths and lengths were finalized in EPRI MRP-89 in September 2003, specifically in Section 5 of the document covering the WesDyne UT demonstration results.

Entergy used a 7% part through-wall depth for the ID axial flaw (0.04627 inch flaw in a 0.661 inch wall thickness), while MRP-89, Table 5-1 shows the minimum flaw detected of 5% through-wall; thus, Entergy has a slightly larger, more conservative initial flaw depth. Similarly for the OD axial flaw, Entergy used a 12% (0.07932 inch) part through-wall depth, which slightly bounds the 10% deep minimum flaw detected using the WesDyne "open tube" probe in Table 5-1 for OD axial part-through-wall flaws.

10. The blind zone in each nozzle includes the threaded connection. Discuss the possibility of a crack initiated from the threads. Discuss how the stress in the threads is modeled in the analysis.

Response:

The threaded connection that joins the CEDM guide funnel to the CEDM tube/nozzle at distance below the bottom of the weld was not explicitly modeled using finite elements. Figures 4 through 7 of Engineering Report M-EP-2003-004 show the "residual plus operating" hoop stress plots for the four nozzle groups evaluated. With the exception of the ID surface at the 90° azimuthal position on the 49.7° CEDM nozzle, the bottom of the nozzle where the threads would be located is in a very low tensile to compressive stress field. For the 90° azimuth (or mid-plane) location on the 49.7° nozzle, the ID hoop stress at the bottom of the nozzle is 19.02 ksi (as mentioned on Page 17 of the report). To thoroughly address this location for the presence and subsequent growth of an undetected flaw, a deterministic fracture mechanics evaluation was performed as discussed on page 51 of the report.

The addition of threads to the bottom of the finite element model, subject to the same stresses as the current model plus some thread engagement stresses, must overcome compressive through-wall stresses generally between 0 and -10 ksi. These compressive stresses result from the physical response of the nozzle reacting to the stresses and deformations generated during welding. Pressure is applied to both inside and outside surfaces of the funnel/nozzle connection, which effectively balances operating mechanical stresses. Any tensile stresses sufficient to initiate a PWSCC flaw in the threaded region and grow it in a primary water environment are not present in the Waterford 3 CEDM nozzle threaded region due to the distance removed from the weld region.

11. The report stated that the formulation provides the correction factors to correct the SIF for a flat plate solution. The SIF formulation was obtained from Reference 8 that analyzed the SIF for pipes and cylinders. Why are the correction factors needed?

Response:

The discussion of the through-wall flaw SIF formulation begins on Page 30 of Engineering Report M-EP-2003-004. The correction factors referred to are the membrane and bending components, A_e and A_b respectively, defined at the bottom of Page 30 and the top of Page 31 and originally from Reference 8. These membrane and bending factors are used to modify the SIF for a flat plate, K_p (also shown on Pages 30 and 31), and correct the flat plate configuration for thickness, curvature, and flaw length. K_p is calculated for a cracked flat plate by applying the same boundary conditions and loads that exist on the cracked cylinder or tube. This discussion and methodology is included on Page 31.

12. On Page 46, Table 13 of the Engineering Report, for the 29.1° nozzle on the uphill side, the ID crack growth is 3.456 inches in length. For the 49.7° nozzle on the uphill side, ID crack growth is 6.147 inches. However, it further stated that the growth per cycle is zero "as determined from UT data."

    1) Please explain to what UT data this is referring and why is it relevant to Waterford 3's analysis?

       Response:

       The UT data referred to on Page 44 of Engineering Report M-EP-2003-004 is the "Plant A" (or Sister Plant) UT data provided to Entergy and used in lieu of Waterford 3-specific UT data (not available at the time the Engineering Report was written). This Plant A UT data was the basis for conservatively determining the weld size, the "free span" length and the "propagation length" (defined on Page 6). It is the value of the propagation length (the distance from the crack tip to the bottom of the weld) for each nozzle group that is tabulated in Table 13 of the report.

    2) Please discuss the potential for a crack to propagate into the J-groove weld within a cycle in light of the high crack growth rate.

       Response:

       There is no high crack growth rate present, since the dimensions of 3.456 inches (for the 29.1° nozzle) and 6.147 inches (for the 49.7° nozzle) refer to the AVAILABLE length from the tip of the presumed initial crack to the bottom of the weld. The stress fields in these regions (Figures 4 through 7 of Engineering Report M-EP-2003-004) are predominantly low tensile (between 0 to 10 ksi) to compressive through-wall. These low stresses preclude a conducive condition for PWSCC flaw growth.

ENCLOSURE 2

CNR0-2004-00039

WATERFORD 3 CEDM NOZZLE AS-BUILT FREE SPAN LENGTHS

WATERFORD 3 CEDM NOZZLE AS-BUILT FREE SPAN LENGTHS

NOZZLE	HEAD ANGLE (degrees)	LOWER HILLSIDE[1]	
		AXIAL WELD HEIGHT (Inches)	FREE SPAN LENGTH (Inches)
1	0.0	0.68	1.32
2	7.8	0.72	1.36
3	7.8	1.28	1.20
4	11.0	1.12	1.24
5	11.0	1.04	1.36
6	11.0	1.16	1.40
7	11.0	1.00	1.28
8	15.6	1.28	1.20
9	15.6	1.12	1.28
10	15.6	1.04	1.24
11	15.6	0.92	1.12
12	17.5	1.40	0.96
13	17.5	1.24	1.32
14	17.5	1.28	1.36
15	17.5	0.80	1.40
16	17.5	1.08	1.16
17	17.5	1.16	1.08
18	17.5	1.16	1.28
19	17.5	0.80	1.32
20	22.4	1.56	0.92
21	22.4	1.40	1.08
22	22.4	1.24	1.20
23	22.4	1.24	1.08
24	23.9	1.08	1.16
25	23.9	1.40	1.16
26	23.9	1.48	0.96
27	23.9	1.36	0.92
28	25.2	1.24	1.04

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[1] The lower hillside dimensions are provided since they are more restrictive and bound the upper hillside dimensions.

NOZZLE	HEAD ANGLE (degrees)	LOWER HILLSIDE[1]	
		AXIAL WELD HEIGHT (Inches)	FREE SPAN LENGTH (Inches)
29	25.2	1.28	1.08
30	25.2	1.32	1.12
31	25.2	1.00	1.28
32	25.2	1.36	1.12
33	25.2	1.16	1.32
34	25.2	1.44	1.08
35	25.2	1.20	0.92
36	29.1	1.40	0.92
37	29.1	1.36	1.12
38	29.1	1.52	0.96
39	29.1	1.24	1.04
40	29.1	1.04	1.08
41	29.1	1.28	1.2
42	29.1	0.96	1.20
43	29.1	1.48	0.94
44	32.7	1.32	1.04
45	32.7	1.48	0.92
46	32.7	1.32	1.16
47	32.7	1.52	0.98
48	33.8	1.40	0.92
49	33.8	1.32	1.04
50	33.8	1.28	1.08
51	33.8	1.04	1.00
52	33.8	1.28	1.04
53	33.8	1.00	1.20
54	33.8	1.52	0.84
55	33.8	1.44	0.80
56	34.9	1.48	0.76
57	34.9	1.44	1.04
58	34.9	1.48	1.08
59	34.9	1.12	1.08
60	37.1	1.56	0.84

		LOWER HILLSIDE[1]	
NOZZLE	HEAD ANGLE (degrees)	AXIAL WELD HEIGHT (inches)	FREE SPAN LENGTH (inches)
61	37.1	1.32	0.96
62	37.1	1.40	1.08
63	37.1	1.04	1.12
64	37.1	1.49	0.68
65	37.1	1.12	0.88
66	37.1	1.44	0.80
67	37.1	1.44	0.80
68	42.4	1.68	0.80
69	42.4	1.52	0.80
70	42.4	1.72	0.88
71	42.4	1.72	0.88
72	42.4	1.56	0.84
73	42.4	1.36	1.16
74	42.4	1.44	1.20
75	42.4	1.76	0.96
76	42.4	1.16	1.04
77	42.4	1.48	0.76
78	42.4	1.84	0.60
79	42.4	2.04	0.44
80	43.4	1.68	0.80
81	43.4	1.24	1.04
82	43.4	1.52	0.84
83	43.4	1.40	0.90
84	43.4	1.32	1.08
85	43.4	1.48	1.00
86	43.4	1.72	0.64
87	43.4	2.04	0.40
88	49.7	2.00	0.68
89	49.7	2.04	0.56
90	49.7	1.88	1.04
91	49.7	2.08	0.56