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Michael A. Krupa
Director
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CNRO-2003-00038

September 15, 2003

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

SUBJECT: Entergy Operations, Inc.
Relaxation Request to NRC Order EA-03-009 for the Control Element Drive Mechanism Nozzles

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

REFERENCES:

1. Entergy Operations, Inc. letter CNRO-2003-00020 to the NRC, "Relaxation Requests to NRC Order EA-03-009," dated June 11, 2003

2. Entergy Operations, Inc. letter CNRO-2003-00033 to the NRC, "Relaxation Request to NRC Order EA-03-009," dated August 27, 2003

Dear Sir or Madam:

In referenced letter #1, Entergy Operations, Inc. (Entergy) requested relaxation from Section IV.C(1)(b) of NRC Order EA 03-009 for Arkansas Nuclear One, Unit 2 (ANO-2) and Waterford Steam Electric Station, Unit 3 (Waterford 3). Specifically, the bottom ends of the ANO-2 and Waterford 3 control element drive mechanism (CEDM) nozzles contain threads that cannot be effectively examined in accordance with Section IV.C(1)(b). The requests proposed an alternative based on stress and fracture mechanics analyses.

In a meeting held on August 14, 2003, representatives of the NRC staff and Entergy discussed these requests. As a result of this meeting, Entergy made the decision to withdraw those requests and submit new ones to address NRC comments. In referenced letter #2, Entergy officially withdrew the ANO-2 relaxation request and submitted ANO-2 Relaxation Request #1, which superceded the original request.

By this letter, Entergy officially withdraws the Waterford 3 relaxation request submitted in referenced letter #1 and submits, as Enclosure 1, Waterford 3 Relaxation Request #1, which supercedes the original request.

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Enclosure 2 contains a copy of the fracture mechanics analysis report, Engineering Report M-EP-2003-004, Rev. 0, which supports this request. In a recent telephone call, Entergy informed the NRC staff that the methodology used for both the ANO-2 and Waterford 3 requests are basically the same. The staff requested that any differences between the two engineering reports be identified; therefore, these differences are high-lighted in Enclosure 2.

Engineering Report M-EP-2003-004 is supported by information pertaining to material properties and analytical methods used in performing the welding residual stress analyses information provided by Dominion Engineering, Inc. (Dominion) via letters L-4162-00-1 and L-4162-00-2. Dominion letter L-4162-00-1 was previously submitted to the NRC staff via referenced letter #2. Enclosure 3 contains Dominion letter L-4162-00-2.

Information contained in Enclosure 3 is owned by Dominion and is considered to be proprietary and confidential in accordance with 10 CFR 2.790(a)(4) and 10 CFR 9.17(a)(4). As such, Dominion requests this information be withheld from public disclosure. The affidavit supporting this request is provided in Enclosure 4. Dominion has informed Entergy that the vast majority of Enclosure 3 is considered proprietary; therefore, Dominion considers it impractical to provide a non-proprietary version.

This letter contains commitments as identified in Enclosure 5.

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

Sincerely,

M. A Krupa

MAK/GHD/bal

Enclosures:
1. Waterford Steam Electric Station, Unit 3 Relaxation Request #1 to NRC Order EA-03-009
2. Engineering Report M-EP-2003-004, Rev. 0
3. Proprietary Information – Dominion Engineering, Inc. Letter L-4162-00-2, "Material Properties and Modeling Methods Used in Waterford Unit 3 Welding Residual Stress Analysis"
4. Affidavit for Withholding Information from Public Disclosure
5. Licensee-Identified Commitments

cc: Mr. W. A. Eaton (ECH)
Mr. G. A. Williams (ECH)
Mr. J. E. Venable (W3)

Mr. M. C. Hay, NRC Senior Resident Inspector (W3)
Mr. N. Kalyanam, NRR Project Manager (W3)
Mr. T. P. Gwynn, NRC Region IV Regional Administrator

ENCLOSURE 4

CNRO-2003-00038

AFFIDAVIT
FOR WITHHOLDING INFORMATION
FROM PUBLIC DISCLOSURE

AFFIDAVIT PURSUANT TO 10CFR2.790

I, David J. Gross, being duly sworn, affirm, and state as follows:

(1) This Affidavit supports an application to the Commission for withholding from public disclosure Dominion Engineering, Inc., (DEI) Letter L-4162-00-2, Revision 0, " Material Properties and Modeling Methods Used in Waterford Unit 3 Welding Residual Stress Analyses," dated September 11, 2003. As stated in this letter, because the non-proprietary version of this letter would remove information to the point of not transmitting any useful information, only a proprietary version will be transmitted.

(2) I am a Principal Officer of Dominion Engineering, Inc. (DEI), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of DEI. I have personal knowledge of the criteria and procedures utilized by DEI in designating information as a trade secret, privileged, or as confidential or financial information.

(3) I am making the Affidavit in conformance with the provisions of 10CFR §2.790 of the Commission's regulations and in conjunction with the application by Entergy Nuclear Operations for withholding accompanying this Affidavit.

(4) Public disclosure of the information sought to be withheld is likely to cause substantial harm to DEI's competitive position and foreclose or reduce the availability of substantial profit-making opportunities.

(5) The specific information in Letter L-4162-00-2, Revision 0, sought to be withheld in accordance with 10CFR §2.790 is as follows:

 (i) The specific material property input data used by DEI in performing welding residual stress analyses.

(6) Pursuant to the provisions of 10CFR §2.790(b)(4) of the Commission's regulations, the following is furnished in consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

 (i) DEI has held the subject information in confidence. DEI has controlled the subject information and not disclosed it at any public forum. Any disclosure to third parties has been made pursuant to regulatory provisions or proprietary agreements that provide for maintenance of the information in confidence.

 (ii) The information is of a sort customarily held in confidence by DEI. As described in paragraph (v) below, the information is held in confidence by DEI because disclosure would substantially affect DEI's competitive business position. This information principally is related to the methodology, assumptions, and detailed results of welding residual stress analysis finite element models.

(iii) The information sought to be withheld is being submitted to the NRC in confidence by Entergy Nuclear Operations in conjunction with an application by Entergy Nuclear Operations for withholding.

(iv) To the best of my and DEI's knowledge, no public disclosure of this information has been made, and it is not available in public sources.

(v) Public disclosure of the information sought to be withheld is likely to cause substantial harm to DEI's competitive position because:

(A) The subject information has substantial commercial value to DEI as significant portions of DEI's future business of providing engineering consulting to nuclear utilities in this area is substantially based upon the information sought to be withheld.

(B) The expertise represented by the subject information is a substantial part of DEI's current position as a competitor in the market of assisting nuclear utilities in the management of stress corrosion cracking material degradation. Development of this expertise by DEI required the recruitment, training, and employment of skilled engineers working in the nuclear power industry for over 10 years. The information was developed at considerable expense, including attendance at dozens of industry conferences and meetings, over more than a 10 year period of actively working in the technical engineering fields addressed by the report.

(C) Similar products and services are provided by DEI's major competitors. Acquiring of the information sought to be withheld would allow the competitors to take some share of the market for providing engineering consulting services in this area.

(D) A large effort over a sustained time period would be required by DEI's competitors and others to properly acquire or duplicate the information sought to be withheld by developing the basic methodologies, selecting and justifying the many detailed assumptions, integrating the many technical issues and concerns into a defensible technical presentation, and presenting the results in an easily comprehended manner. In some cases the subject information could only be acquired through a licensing or business agreement.

(E) There is expected to remain a marketplace for services in the areas related to the subject information and currently provided by DEI for many years into the future.

I have read the foregoing and the matters stated therein are true and correct to the best of my knowledge, information and belief. I make this Affidavit under penalty of perjury under the laws of the United States of America and under the laws of the Commonwealth of Virginia.

Executed at 11730 Plaza America Drive, Suite 310, Reston, Virginia being the premises and place of business of DEI.

September 11, 2003

David J. Gross
Principal Officer

Sworn to and subscribed before me this 11th day of September, 2003.
Witness my hand and official seal.
Anne Doane Notary Public

State of Virginia
County of Fairfax
Anne Doane Notary Public
My Comm. Exp. Aug 31, 2005

ENCLOSURE 1

CNRO-2003-00038

WATERFORD STEAM ELECTRIC STATION, UNIT 3
RELAXATION REQUEST #1

ENTERGY OPERATIONS, INC.
WATERFORD STEAM ELECTRIC STATION, UNIT 3

RELAXATION REQUEST #1 TO NRC ORDER EA-03-009

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ENTERGY OPERATIONS, INC.
WATERFORD STEAM ELECTRIC STATION, UNIT 3

RELAXATION REQUEST #1 TO NRC ORDER EA-03-009

Hardship or Unusual Difficulty without a Compensating Increase in the Level of Quality or Safety

I. ASME COMPONENTS AFFECTED

Waterford Steam Electric Station, Unit 3 (Waterford 3) has one hundred-two (102) ASME Class 1 reactor pressure vessel (RPV) head penetration nozzles comprised of ninety-one (91) Control Element Drive Mechanism (CEDM) nozzles, ten (10) Incore Instrument (ICI) nozzles, and one (1) vent line nozzle. See Figure 1 for penetration locations. This request pertains to the CEDM nozzles only.

II. NRC ORDER EA-03-009 APPLICABLE EXAMINATION REQUIREMENTS

The NRC issued Order EA-03-009 (the Order) that modified the current licenses at nuclear facilities utilizing pressurized water reactors (PWRs), which includes Waterford 3. The NRC Order establishes inspection requirements for RPV head penetration nozzles In accordance with Section IV.A of NRC Order EA-03-009, the Waterford 3 susceptibility category is "high" based on a calculated value of 16.9 effective degradation years (EDY) at the beginning of the upcoming fall refueling outage.

Section IV.C of the Order states in part:

"All Licensees shall perform inspections of the RPV head using the following techniques and frequencies:

(1) For those plants in the High category, RPV head and head penetration nozzle inspections shall be performed using the following techniques every refueling outage.

(a) Bare metal visual examination of 100% of the RPV head surface (including 360° around each RPV head penetration nozzle), AND

(b) Either:

(i) Ultrasonic testing of each RPV head penetration nozzle (i.e., nozzle base material) from two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred into the interference fit zone, OR

(ii) Eddy current testing or dye penetrant testing of the wetted surface of each J-groove weld and RPV head penetration nozzle base material to at least two (2) inches above the J-groove weld."

III. REASON FOR REQUEST

Section IV.F of the Order states:

"Licensees proposing to deviate from the requirements of this Order shall seek relaxation of this Order pursuant to the procedure specified below. The Director, Office of Nuclear Reactor Regulation, may, in writing, relax or rescind any of the above conditions upon demonstration by the Licensee of good cause. A request for relaxation regarding inspection of specific nozzles shall also address the following criteria:

(1) The proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or

(2) Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

"Requests for relaxation associated with specific penetration nozzles will be evaluated by the NRC staff using its procedure for evaluating proposed alternatives to the ASME Code in accordance with 10 CFR 50.55a(a)(3)."

Pursuant to Section IV.F(2) of the Order, Entergy Operations, Inc. (Entergy) requests relaxation from the requirements of Section IV.C(1)(b). Entergy plans to inspect RPV head CEDM penetration nozzles at Waterford 3 using the ultrasonic testing (UT) method in accordance with Section IV.C(1)(b)(i) of the Order to the maximum extent possible. However, a UT inspection of the inside diameter (ID) of the CEDM nozzles at Waterford 3 can only be performed from 2 inches above the J-groove weld down to a point approximately 1.544 inches above the bottom of the nozzle. This 1.544-inch "blind zone" is due to limitations resulting from CEDM nozzle configuration (1.344 inches) and inspection probe design (0.200 inch). These limitations and their associated hardships are discussed below.

A. Nozzle Configuration Limitation

1. Description

Guide cones are attached to the bottoms of the Waterford 3 CEDM nozzles via threaded connections. Specifically, the guide cone screws into the end of the CEDM nozzle with a welded set screw and two tack welds at the cone-nozzle interface to secure the guide cone to the nozzle. The length of the threaded connection region is 1.25 inches. Additionally, a 45° chamfer exists immediately above the threaded connection region. The length of the chamfer region is 0.094 inch. (See Figure 2 for typical nozzle details.)

Due to the threaded connection and chamfer region at the bottom of each CEDM nozzle, a meaningful UT examination in that area cannot be performed. Specifically, the chamfer region geometry causes sporadic signals; and once the guide cone is reached, sound cannot pass into the CEDM nozzle base material because of the gap that exists between the guide cone and the nozzle at the threaded connection. Therefore, UT of the bottom 1.344 inches (1.25 + 0.094) of the CEDM nozzles is not possible.

2. Hardship

Resolving the UT limitations due to nozzle configuration would require eliminating the existing CEDM nozzle-to-guide cone threaded connection and chamfer region and redesigning and physically modifying the nozzle ends to provide for an acceptable UT examination. Entergy believes to take such an approach would impose hardships and unusual difficulties without a compensating increase in the level of quality and safety for the following reasons:

a) High Personnel Dose

As mentioned above, a guide cone is attached to the bottom of each CEDM nozzle via a threaded connection. Entergy has estimated that removing and reinstalling the 91 guide cones would result in personnel exposure of approximately 1.25 man-REM per nozzle for a total exposure of 113.75 man-REM.

b) Removing, Redesigning, and Reinstalling Guide Cones

The guide cones would be removed by cutting them off at the top of the nozzle threaded region, which would result in a shorter nozzle below the weld. As a result, the blind zone would be relocated closer to the weld reducing the length of nozzle below the weld that could be inspected via UT in future inspections.

The replacement guide cone is of a welded socket design that fits over the end of the nozzle and is welded to the nozzle tube. To reinstall the cones would require a modification to the nozzle ends as well as fabrication of new cones. Having to remove the cones and replace them with new components results in additional modifications to the RPV head that go beyond the requirements and scope of the Order. In addition, installing the new guide cone would cause high residual stresses in the heat affected zone of the weld, which would increase the probability of primary water stress corrosion cracking (PWSCC).

c) Impact on Outage Schedule

Entergy estimates that to remove and reinstall each guide cone would require approximately eight (8) hours per nozzle adding as much as 30 days to the outage schedule.

B. Inspection Probe Design Limitation

1. Description

The inspection probe to be used to inspect Waterford 3 CEDM nozzles consists of seven (7) individual transducers as shown in Figure 3. Various probe configurations will be utilized to perform the UT inspections [e.g., UT time-of-flight diffraction (TOFD) and standard 0° scans.]

The inspection probe is designed so that the ultrasonic transducers are slightly recessed into the probe holder. This recess must be filled with water to provide coupling between the transducer and the nozzle wall. Because of this design, the complete diameter of the transducer must fully contact the inspection surface before ultrasonic information can be collected. Because UT probes 1 and 2 have a diameter of 0.250 inch, these transducers should, in theory, be able to collect meaningful UT data down to a point approximately 0.125 inch (1/2 diameter) above the chamfer. However, based on prior UT inspection experience and a review of UT data from previous inspections, the circumferential-shooting TOFD transducer pair only collects meaningful data down to a point 0.200 inch above the chamfer. Below this point, UT data cannot be collected.

2. Hardship

Entergy knows of no UT equipment currently available that resolves the blind zone limitation; therefore, new UT equipment would have to be developed and appropriately qualified. The time and resources required to develop this equipment is unknown.

Entergy also evaluated the feasibility of inspecting the blind zone of each CEDM nozzle using either the liquid penetrant testing (PT) method or the ECT method as specified in Section IV.C(1)(b)(ii) of the Order. Entergy found these techniques to be impractical, as discussed below.

C. Impracticality of Performing Alternative Surface Examinations

To perform a PT inspection, the guide cones would have to be removed from and reinstalled on the CEDM nozzles before and after performing the PT examinations. Performing these operations would result in a significant increase in personnel radiation exposure. Entergy estimates that the radiation exposure associated with removing the guide cone, performing the PT inspection, and reinstalling the guide cone to be approximately 2.5 man-REM per nozzle for a total exposure of 227.5 man-REM. In addition, this option would also involve those hardships described in Sections III.A.2.a) and b), above.

As with the UT inspection, the bottom 1.344 inches (threaded connection and chamfer region) cannot be inspected using ECT.

In conclusion, CEDM nozzles can be volumetrically inspected in accordance with Section IV.C(1)(b)(i) of the Order from 2 inches above the weld to the top of the blind zone (approximately 1.544 inches above the bottom of the nozzle). Below this point, Entergy believes that the hardships associated with inspection activities required by the Order as discussed above are not commensurate with the level of increased safety or reduction in probability of leakage that would be obtained by complying with the Order.

IV. PROPOSED ALTERNATIVE AND BASIS FOR USE

Paragraph IV.C(1)(b)(i) of the Order requires that the UT inspection of each RPV head penetration nozzle encompass "from two (2) inches above the J-groove weld to the bottom of the nozzle." Due to the reasons stated above, Entergy requests relaxation from this requirement for Waterford 3 CEDM nozzles and proposes a three-step alternative, which involves the use of UT examination and analysis, as described below.

A. Proposed Alternative

1. UT Examination

The ID of each CEDM nozzle (i.e., nozzle base material) shall be ultrasonically examined from two (2) inches above the weld to 1.544 inches above the bottom of the nozzle. In addition, an assessment to determine if leakage has occurred into the interference fit zone will be performed, as currently specified in Section IV.C(1)(b)(i) of the Order.

2. Analysis

For the blind zone portions of the CEDM nozzle not examined by UT as required by the Order, analysis has been performed to determine if sufficient free-span exists between the blind zone and the weld to facilitate one (1) operating cycle of crack growth without the crack reaching the weld.

The analysis is summarized in Section IV.B.2 below and is fully documented in Engineering Report M-EP-2003-004, Rev. 0 (Enclosure 2).

3. Analysis Verification, Reanalysis, and Augmented Inspections

As discussed in Section IV.B.2, the analysis is based on a detailed review of applicable Waterford 3 design drawings and actual UT data from a sister plant. Therefore, Entergy will take the following actions:

a) Entergy will inspect by UT each CEDM nozzle to determine its actual as-built configuration and determine whether or not the configuration is bounded by the analysis.

b) For conditions determined not bounded by the current analysis, Entergy will perform supplemental analysis.

   (i) If the analysis demonstrates that a crack in the blind zone will not propagate to the weld within one (1) operating cycle, no further actions will be taken.

   (ii) If the analysis indicates that a crack in the blind zone is likely to propagate into the weld within one operating cycle, the blind zone or a portion thereof as defined by analysis will be subjected to augmented inspection. The augmented inspection will utilize either ECT or PT, or a combination of both techniques.

c) Entergy will include the following information in the 60-day report submitted to the NRC in accordance with Section IV.E of the Order:

   (i) Results of the UT inspections

   (ii) Results of any required reanalysis

   (iii) Results of any required augmented inspections

B. Basis for Use

The UT examination is the volumetric technique recognized in Section IV.C(1)(b)(i) of the Order. The Entergy proposed alternative includes the use of UT to the maximum extent practical based on the limits of current technology. However, because the technology cannot provide an inspection to the extent required by the Order (i.e., to the bottom of the nozzle), Entergy proposes supplemental analysis and augmented inspection. This approach provides a level of safety and quality commensurate with the intent of the Order. Each portion of the proposed alternative is discussed below.

1. UT Examination

UT inspection of CEDM nozzles will be performed using a combination of TOFD and standard 0° pulse-echo techniques. The TOFD approach utilizes two pairs of 0.250-inch diameter, 55° refracted-longitudinal wave transducers aimed at each other. One of the transducers sends sound into the inspection volume while the other receives the reflected and diffracted signals as they interact with the material. There will be one TOFD pair looking in the axial direction of the penetration nozzle tube and one TOFD pair looking in the circumferential direction of the tube. The TOFD technique is primarily used to detect and characterize planar-type defects within the full volume of the tube.

The standard 0° pulse-echo ultrasonic approach utilizes one 0.250-inch diameter straight beam transducer. The 0° technique is used to:

- Plot the penetration nozzle outside diameter (OD) location and weld location,
- Locate and size any laminar-type defects that may be encountered, and
- Monitor the back-wall signal response to detect leakage that may occur in the interference regions of the RPV head penetration.

The UT inspection procedures and techniques to be utilized at Waterford 3 have been satisfactorily demonstrated under the EPRI Materials Reliability Program (MRP) Inspection Demonstration Program.

2. Analysis

The extent of the proposed alternative is established by an engineering evaluation that includes a finite element stress analysis and fracture mechanics evaluations. The intent of the engineering evaluation is to determine whether sufficient crack propagation length exists between the tip of a postulated crack and the weld to facilitate one cycle of crack growth without the crack reaching the weld. See Figure 4.

Four (4) CEDM nozzle locations have been selected for analysis in the engineering evaluation. The selected locations (RPV head angles) are 0°, 7.8°, 29.1°, and 49.7° with the 0° head angle at the vertical centerline of the RPV head, the 49.7° head angle location being the outermost nozzles, and the other two being intermediate locations between the center and outermost locations. The results of the stress analysis at each location are bounding for nozzles higher on the head (e.g., analysis for 29.1° bounds the intermediate nozzles between 7.8° and 29.1°). The selected nozzle head angle locations provide an adequate representation of residual stress profiles and a proper basis for analysis to bound all CEDM nozzles. The stress analyses and fracture mechanics evaluations performed to address these conditions are summarized below.

Stress Analysis

A "finite element" based stress analysis is performed on the Waterford 3 CEDM nozzles in this evaluation. For conservatism, the yield strength used in the analysis for each nozzle head angle location is the highest yield strength of all the nozzles at that head angle. Since no volumetric inspections of the RPV head penetrations have been performed at Waterford 3, the nozzle dimensions were determined by a detailed review of applicable Waterford 3 design drawings and actual UT data from a sister plant. Like Waterford 3, the sister plant is of similar CE design rated at 3410 MWt.

Based on this review, the following is concluded:

- CEDM Nozzles at 0° and 7.8° Head Angle Locations: The dimension from the top of the blind zone to the top of the weld is longer than that indicated by design. As a result, the root of the weld is higher. The leg lengths of the welds on the downhill and uphill sides of the nozzles match design. This information indicates a larger weld throat dimension, and as a result, a larger radial dimension at the ID surface of the RPV head. The FEA model has been adjusted for this larger weld size.

- CEDM Nozzles at 29.1° and 49.7° Head Angle Locations: The dimension from the top of the blind zone to the top of the weld is longer than that indicated by design. As a result, the root of the weld is higher. This information indicated a larger weld throat dimension, and as a result, a larger radial dimension at the ID surface of the RPV head. In addition, the leg lengths of the welds on the downhill sides of the nozzles are longer than indicated by design. The FEA model has been adjusted to account for the larger weld size.

- CEDM Nozzles at 42.4° Head Angle Locations: Although a stress analysis and fracture mechanics analysis is not performed on nozzles at the 42.4° head angle location, the as-built configuration of these nozzles was also evaluated to provide additional assurance that the FEA adequately models the as-built condition of all nozzles bounded by the 49.7° head angle location. Based on this review, all observations noted above for the weld at the 49.7° nozzle were also observed at the 42.4° head angle location. Therefore, this review provided additional assurance about the accuracy of the FEA model.

The FEA for the analyzed nozzles determines the stress distribution from the bottom of the nozzle to just above the top of the weld at the downhill, uphill, and mid-plane azimuthal locations. The downhill and mid-plane locations are selected for analysis because they represent the shortest distances that a crack has to propagate to reach the nozzle weld region. The uphill location is selected for completeness of the analysis. The results of the FEA are presented in Figures 4 through 17 and Tables 1 through 10 of the engineering report. The stress distributions produced by this analysis are used to perform the fracture mechanics evaluations.

Fracture Mechanics Evaluation

Safety analyses performed by the MRP have demonstrated that axial cracks in the nozzle tube material do not pose a challenge to the structural integrity of the nozzle. However, axial cracks may lead to pressure boundary leaks above the weld that could produce OD circumferential cracks and structural integrity concerns. Therefore, proper analysis of potential axial cracks in the blind zone of the CEDM nozzle is essential.

The analyses performed in the engineering evaluation are designed to determine the behavior of postulated cracks that could exist in the blind zone. Hence, the crack growth region is from the top of the blind zone to the bottom of the weld. The design review of the RPV head construction, the detailed residual stress analysis, selection of representative nozzle locations, utilization of representative fracture mechanics models, and the application of a suitable crack growth law provide a sound basis for the engineering evaluation.

Postulated cracks for the analysis include axial ID and OD part through-wall and through-wall cracks. Axial cracks are selected for evaluation in this analysis because of their potential to propagate to the weld region. Axial ID and OD part through-wall crack sizes equal twice the smallest crack sizes successfully detected by UT under the EPRI MRP Inspection Demonstration Program. Part through-wall cracks are centered at the top of the blind zone in the analysis. Through-wall cracks are postulated to exist from the top of the blind zone down to a point where the hoop stress is ≤ 10 ksi. The ID and OD part through-wall and through-wall cracks are located along the circumference of each nozzle at the 0° (downhill), 90° (mid-plane), and 180° (uphill) azimuthal locations, 0° (downhill) the furthest point from the center of the RPV head.

Thirty (30) different cases have been analyzed using crack growth rates from EPRI Report MRP-55, *Material Reliability Program – Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Material.* In summary, the evaluation results from all cases demonstrate that postulated flaws in the blind zone region will not compromise the weld in one cycle of operation. The analysis further demonstrates that a larger margin exists (i.e. longer than one fuel cycle) at all evaluated locations. Because stresses at the postulated crack locations produce a stress intensity factor that is less than the threshold value, OD part through-wall and through wall cracks are not even susceptible to crack growth by PWSCC. With respect to ID part through-wall cracks, none of these cracks came close to reaching the bottom of the weld or penetrating through the nozzle wall to the weld interface in one cycle of operation. Results of the fracture mechanics evaluations are documented in Table 13 of Engineering Report M-EP-2003-004, Rev. 0.

Additional Analyses

The fracture mechanics evaluations described above assess the potential for postulated cracks to propagate from the top of the blind zone to the weld in less than one cycle of plant operation. The potential for postulated cracks to propagate from the bottom of the blind zone to the weld was also evaluated. In general, the stress analysis indicates that the magnitude of the hoop stress distribution from the top of the blind zone to the bottom of the nozzle along both the ID and OD surfaces decreases steadily and becomes compressive. The extent or height of the compression zone for each nozzle group and azimuthal location is presented in Table 12 of the engineering report and is summarized below.

Nozzle Group	Azimuthal Location	Compression Zone Height	Maximum Hoop Stress Where No Compression Zone Exists
0°	All	0.89 inch	N/A
7.8°	Downhill	0.97 inch	N/A
	Uphill	1.26 inch	N/A
	Mid-plane	1.059 inch	N/A
29.1°	Downhill	1.148 inch	N/A
	Uphill	0 inch	< 10 ksi
	Mid-plane	0 inch	< 10 ksi
49.7°	Downhill	0 inch	< 10 ksi
	Uphill	0 inch	< 10 ksi
	Mid-plane	0 inch	19.02 ksi

The height of the compression zone is measured from the bottom of the nozzle. Within the compression zone regions, no PWSCC-assisted crack growth is possible. For those nozzle groups with a tensile stress below 10 ksi, the possibility for PWSCC crack initiation is extremely low.

However, the FEA also indicates that a hoop stress of 19.02 ksi exists along the bottom of the 49.7° CEDM nozzle at the mid-plane location. Because of this higher stress value, this nozzle location was selected for additional analysis by fracture mechanics. Based on this analysis, postulated cracks at the bottom of the 49.7° nozzle (mid-plane) do not propagate into the weld in less than one cycle of plant operation was evaluated. Furthermore, the analysis results indicate that the postulated cracks in the region do not reach the weld in nearly forty (40) years of operation. For additional details, see the Additional Analysis subsection of Section 5.0 in Engineering Report M-EP-2003-004, Rev. 0 (Enclosure 2).

Analysis Conclusions

Fracture mechanics evaluations were performed at the downhill, uphill, and mid-plane locations of the 0°, 7.8°, 29.1°, and 49.7° CEDM nozzles to assess the potential for postulated cracks to grow from the blind zone to the nozzle weld in less than one cycle of plant operation. Additional analyses were performed to assess the potential for postulated cracks to grow from along the bottom of the 49.7° CEDM nozzle at the mid-plane location to the weld in one cycle of operation. The evaluations indicate that cracks in the blind zone of the CEDM nozzle will not grow into the welds of any of the 91 CEDM nozzles at Waterford 3 within one cycle of operation. See Table 1 which identifies the nozzle locations bounded by these evaluations. For details regarding the engineering evaluation and its conclusions, see Engineering Report M-EP-2003-004, Rev. 0 (Enclosure 2).

This analysis incorporates a crack-growth formula different from that described in Footnote 1 of the Order, as provided in EPRI Report MRP-55. Entergy is aware that the NRC staff has not yet completed a final assessment regarding the acceptability of the EPRI report. If the NRC staff finds that the crack-growth formula in MRP-55 is unacceptable, Entergy shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula. If Entergy's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of Operating Cycle 13 (following the upcoming refueling outage), Entergy will, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, Entergy shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either Operating Cycle 13 or the subsequent operating cycle, Entergy shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for Operating Cycle 13 and future cycles for RPV head penetrations will be based on an NRC-acceptable crack growth rate formula.

3. Analysis Verification, Reanalysis, and Augmented Inspections

As addressed in Section IV.A.2, the stress analysis employed in the engineering evaluation utilized nozzle configuration information gleaned from design drawings and UT inspection data from a sister plant. Using UT inspection results from the upcoming fall 2003 refueling outage, Entergy will evaluate the actual as-built nozzle configurations to that assumed in the analysis. By determining each nozzle's configuration, Entergy validates the results of the analysis. In the unlikely event a nozzle configuration is not bounded by the analysis, allowing Entergy to re-analyze the nozzle using actual configuration data and the methodology described in Engineering Report M-EP-2003-004 (Enclosure 2) will result in minimal impact on outage schedule and keep radiation exposure as low as reasonably achievable.

As discussed in Section IV.A.3, above, Entergy will perform augmented inspections using either ECT or PT, or a combination of both techniques on the nozzle's blind zone or a portion of the blind zone as determined by analysis to prevent a crack from reaching the weld in less than one operating cycle. Entergy intends to use ECT as the primary surface examination technique to the extent practical. However, in cases where ECT is not effective (e.g., transducer lift-off due to surface undulations causing loss of coupling), Entergy will use PT.

Entergy believes the use of either ECT or PT, or a combination of the two techniques to augment UT is acceptable for ensuring that the required areas not justified by analysis are inspected. The Order recognizes and allows the use of either technique as acceptable for evaluating the condition of nozzle surfaces. On this basis, Entergy concludes using this examination approach provides an equivalent level of quality and safety to the options allowed by the Order.

V. CONCLUSION

Section IV.F of the Order states:

"Licensees proposing to deviate from the requirements of this Order shall seek relaxation of this Order pursuant to the procedure specified below. The Director, Office of Nuclear Reactor Regulation, may, in writing, relax or rescind any of the above conditions upon demonstration by the Licensee of good cause. A request for relaxation regarding inspection of specific nozzles shall also address the following criteria:

(1) The proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or

(2) Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety."

Section IV.C(1)(b) of the Order establishes a minimum set of RPV head penetration nozzle inspection requirements to identify the presence of cracks in penetration nozzles that could lead to leakage of reactor coolant and wastage of RPV head material.

Entergy believes that compliance with the UT inspection provisions of Section IV.C(1)(b)(i) of the Order as described in Section II above would result in hardships and unusual difficulties, as discussed in Section III above, without a compensating increase in the level of quality and safety.

Entergy believes the proposed alternative, described in Section IV, provides an acceptable level of quality and safety by utilizing inspections and analysis to determine the condition of the Waterford 3 CEDM nozzles. The technical basis for the analysis of the proposed alternative is documented in Engineering Report M-EP-2003-004 Rev. 0, which is contained in Enclosure 2 of this letter. Entergy believes that by employing analytical and inspection techniques, the three-step proposed alternative provides an adequate process for inspecting, evaluating, and determining the condition of the Waterford 3 RPV head penetration CEDM nozzles with regard to the presence of PWSCC. Entergy concludes that the proposed alternative adequately meets the intent of the Order. Therefore, we request that the NRC staff authorize the proposed alternative pursuant to Section IV.F of the Order.

TABLE 1

Summary of CEDM Nozzle Locations Bounded by Analysis

Analyzed CEDM Nozzle Location	CEDM Nozzle Locations Bounded By Analysis	
	Head Angle Location	Nozzle Number
0°	0°	1
7.8°	7.8°	2, 3
29.1°	11.0°	4, 5, 6, 7
	15.6°	8, 9, 10, 11
	17.5°	12,13, 14, 15, 16, 17, 18, 19
	22.4°	20, 21, 22, 23
	23.9°	24, 25, 26, 27
	25.2°	28, 29, 30, 31, 32, 33, 34, 35
	29.1°	36, 37, 38, 39, 40, 41, 42, 43
49.7°	32.7°	44, 45, 46, 47
	33.8°	48, 49, 50, 51, 52, 53, 54, 55
	34.9°	56, 57, 58, 59
	37.1°	60, 61, 62, 63, 64, 65, 66, 67
	42.4°	68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79
	43.4°	80, 81, 82, 83, 84, 85, 86, 87
	49.7°	88, 89, 90, 91

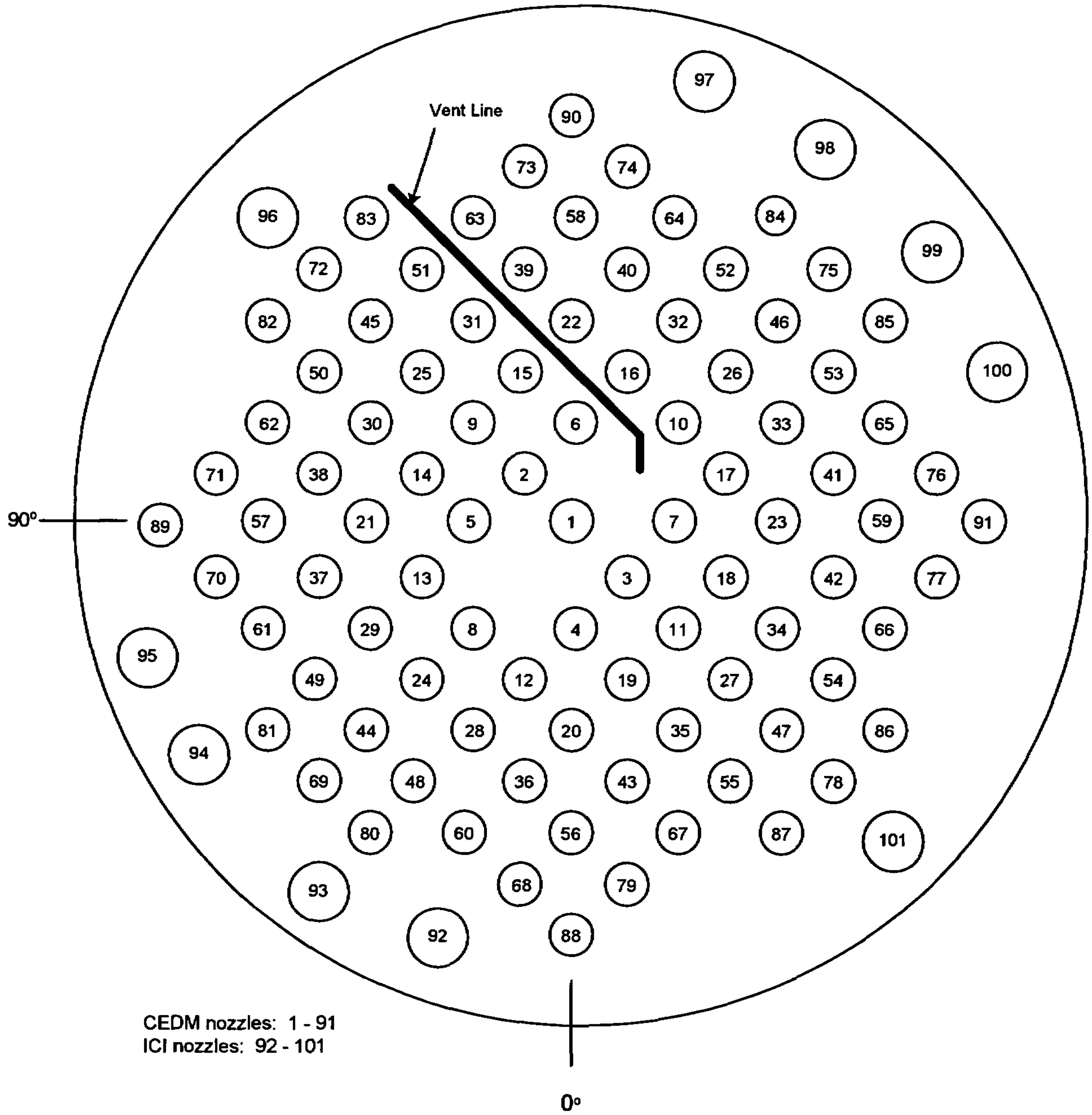


FIGURE 1
Penetration Locations in the Waterford 3 RPV Head

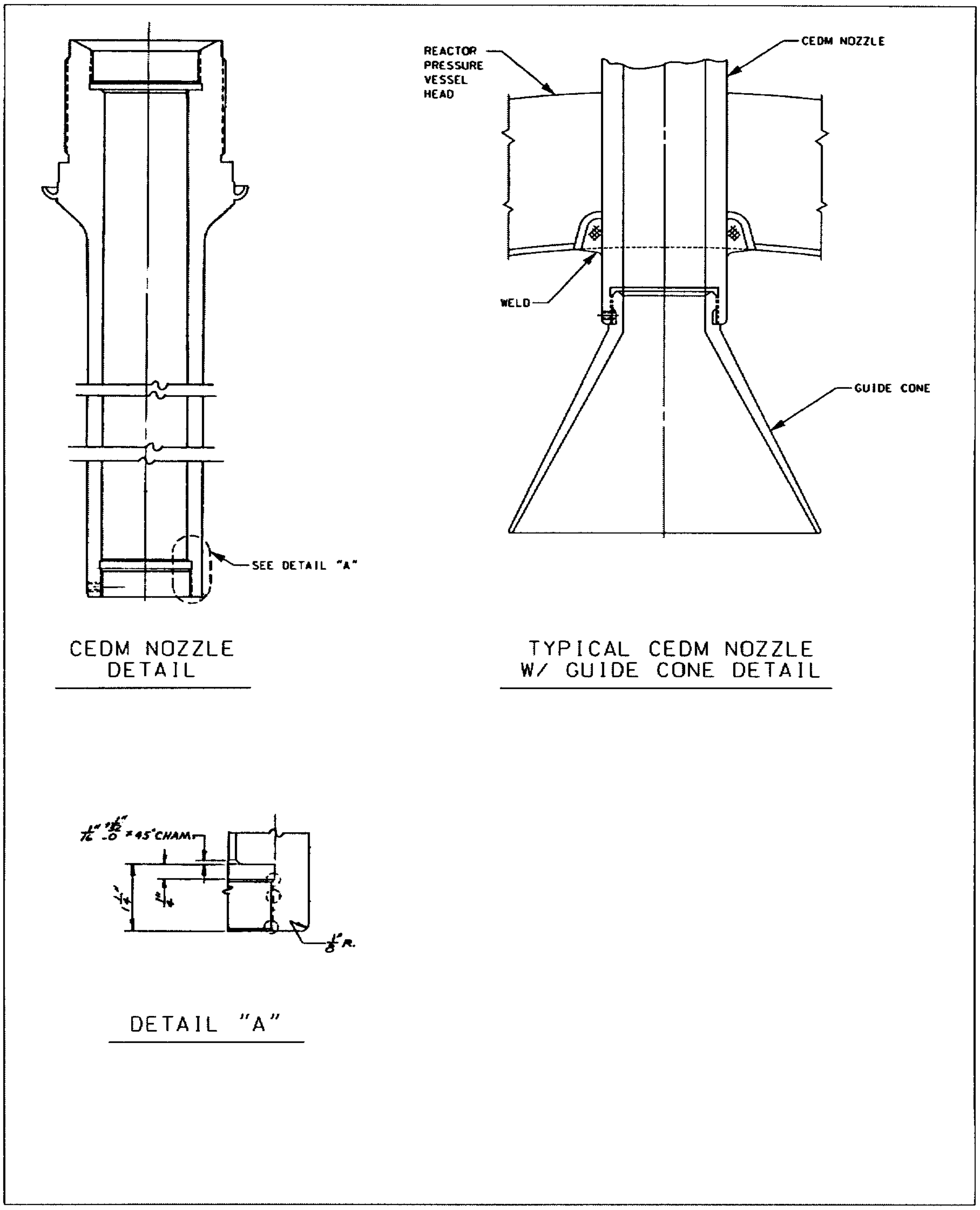
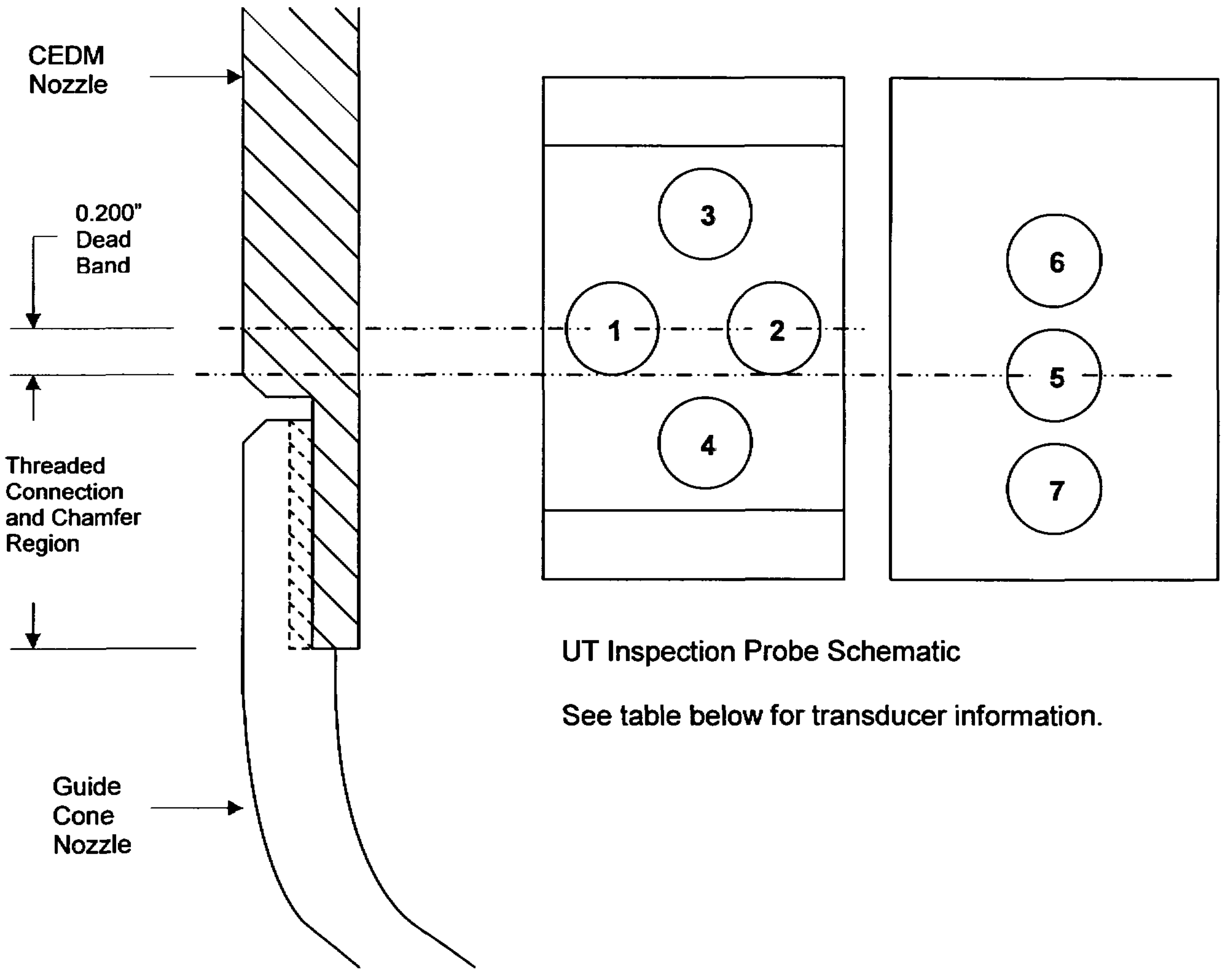


FIGURE 2
TYPICAL CEDM NOZZLE DETAILS



Position	Mode	Diameter	Description
1	Transmit	0.25 inch	Circumferential Scan Using TOFD
2	Receive	0.25 inch	Circumferential Scan Using TOFD
3	Transmit	0.25 inch	Axial Scan Using TOFD
4	Receive	0.25 inch	Axial Scan Using TOFD
5	Transmit Receive	0.25 inch	Standard Zero Degree Scan
6	Transmit Receive	0.25 inch	Standard Zero Degree Scan
7	N/A	0.25 inch	Eddy Current

FIGURE 3
TYPICAL UT INSPECTION PROBE DETAIL

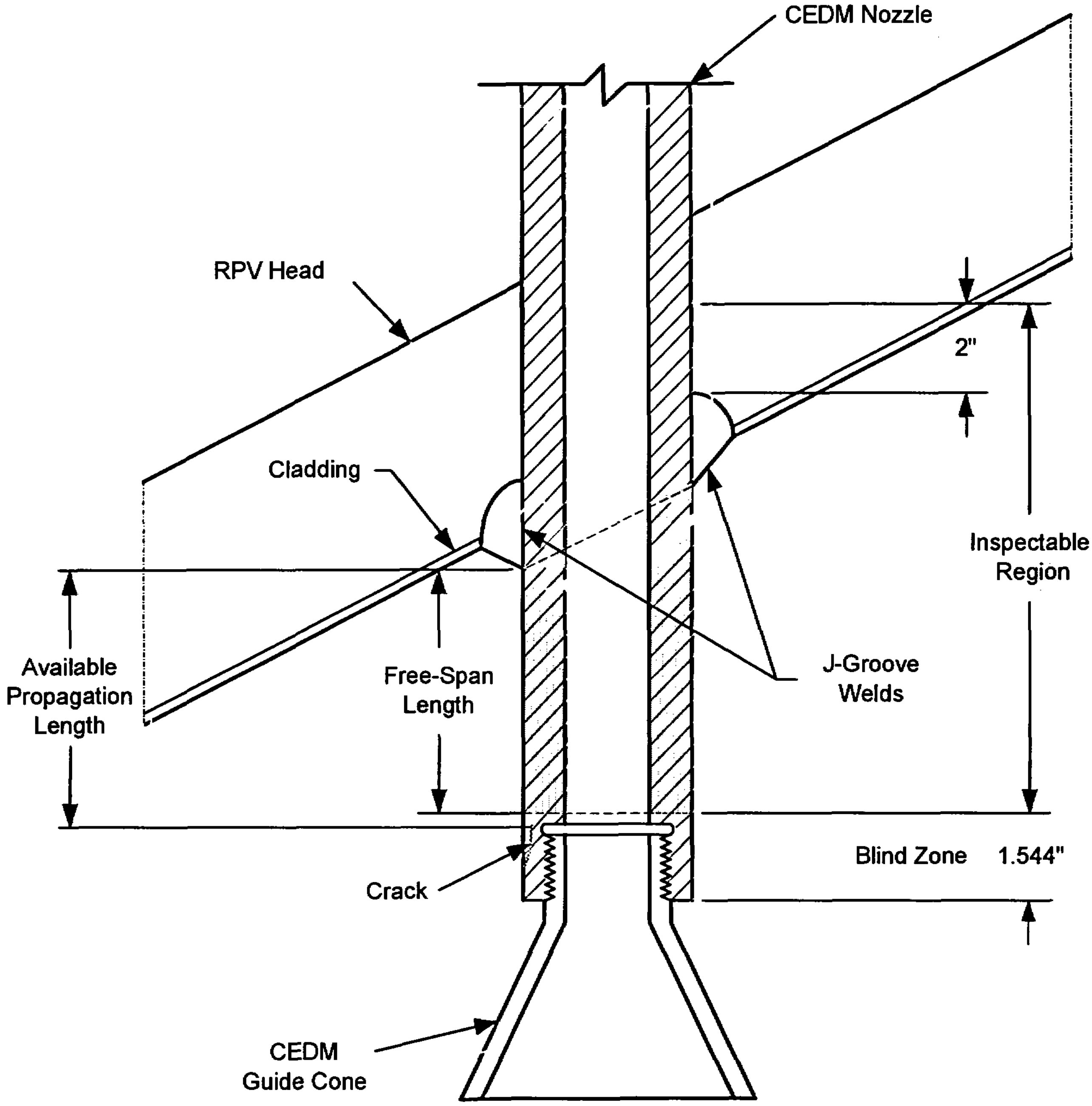


FIGURE 4
DETAIL OF CEDM NOZZLE CRACK GROWTH ANALYSIS