SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELAXATION REQUEST FROM ORDER EA-03-009 REGARDING THE

BARE METAL VISUAL EXAMINATION OF THE REACTOR PRESSURE VESSEL HEAD

FACILITY OPERATING LICENSE NO. NPF-6

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE, UNIT 2

DOCKET NO. 50-368

1.0 INTRODUCTION

Order EA-03-009, issued on February 11, 2003, requires specific examinations of the reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles of all pressurized water reactor plants. Section IV, Paragraph F, of the Order states that the Director, Office of Nuclear Reactor Regulation may, in writing, relax or rescind any of the conditions set forth in Section IV, Paragraph C of the Order upon demonstration by the licensee of good cause. Section IV, Paragraph F, of the Order states that a request for relaxation regarding inspection of specific nozzles shall 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. In addition, Section IV, Paragraph F, of the Order states that requests for relaxation of the Order associated with specific penetration nozzles will be evaluated by the Nuclear Regulatory Commission (NRC) staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3).

For Arkansas Nuclear One Unit 2 (ANO-2) and similar plants determined to have a high susceptibility to primary water stress corrosion cracking (PWSCC), in accordance with Section IV, Paragraphs A and B, of the Order, the following inspections are required to be performed every refueling outage in accordance with Section IV, Paragraph C.(1) of the Order:

(a) Bare metal visual [BMV] 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.

Footnote 3 of the Order provides specific criteria for examination of repaired VHP nozzles.

By letter dated May 8, 2003, as supplemented by letters dated June 26, August 2 (2 letters), August 27, and October 2, 2003, and public meetings held at NRC headquarters in Rockville, Maryland on June 17 and August 14, 2003, Entergy Operations Inc. (Entergy, the licensee) requested relaxation to implement an alternative to the requirements of Section IV, Paragraph C.(1)(a) of the Order for the 100% BMV examination. (Electronic copies of the June 17 and August 14, 2003, meeting summaries may be found in the Agencywide Documents Access and Management System, Accession Numbers ML032050242 and ML032410436, respectively.)

2.0 RELAXATION REQUEST FROM RPV HEAD BMV EXAMINATION, ORDER EA-03-009

2.1 Order Requirements for which Relaxation is Requested

Section IV.C.(1) of Order EA-03-009 requires, in part, that the following inspections be performed every refueling outage for high susceptibility plants similar to ANO-2:

(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.

The licensee has requested relaxation from Section IV.C.(1)(a) of the Order to perform a BMV examination of 100% of the RPV head surface (including 360° around each RPV head penetration nozzle). Specifically, the licensee is unable to comply with the 100% visual examination requirement due to inaccessibility of most of the RPV head. The inaccessible areas are due to the design of the insulation package and cooling shroud.

Relaxation was requested for the upcoming ANO-2 refueling outage in the Fall of 2003.

2.2 Licensee's Proposed Alternative Method

The licensee proposes an alternative to the Order-required BMV examination of 100% of the RPV head surface (including 360° around each RPV head penetration nozzle) that includes limited visual inspection, enhanced ultrasonic testing (UT) examination and low frequency eddy current testing (LF ECT).

Limited Visual Examination:

The licensee stated that, as part of its limited visual examination, the accessible areas of the RPV head will receive a BMV examination, looking for indications of boron residue or wastage of the RPV head that may be present. The licensee described the accessible areas to include the lower portion of the dome (i.e., the area on dome below the shroud), the flange area, and the annulus region around each of the incore instrumentation (ICI) nozzles. The licensee stated that any boron residue that is identified will be thoroughly investigated to determine the extent of its contact with the reactor vessel head, as well as its source. The licensee indicated that its limited visual inspection will also include visual inspection from above the shroud assembly, and inside each of the ICI nozzle doors. The licensee stated that this examination will have the possibility of detecting leakage that has descended onto the RPV head from external sources, as well as having the capability of looking for boron residue that may have resulted from penetration leakage and migrated to a place where it is visible at the top of the insulation.

Enhanced UT:

The licensee stated that it will use an enhanced UT examination method that can interrogate a distance of approximately 0.060 inch into the J-groove weld. The licensee stated that its enhanced UT examination technique can locate cracks in the J-groove weld that have propagated to the root of the weld. The licensee referred to the intersection of the nozzle material, weld, and Alloy 182 weld butter material as the “triple point.” The licensee contends that a PWSCC crack initiating on the surface of the J-groove weld would have to pass through the triple point area in order to provide a leak path into the annulus between the nozzle and the head and that it has performed demonstrations that show that it can locate and identify flaws that propagate to the triple point. The licensee stated that it has demonstrated the capabilities of its triple point examination technique on two mock-ups containing cold isostatic process (CIP) induced tip flaws representative of service-related PWSCC in size and location, and provided documentation describing the demonstration activities and results.

LF ECT

Entergy stated that it will perform a LF ECT examination of the annulus region of the control element drive mechanism (CEDM) and reactor head vent line penetrations. The licensee stated that its LF ECT technique can detect degradation in the upper annulus region of the RPV head around the 81 CEDM nozzles and the single vent line penetration. The licensee stated that the purpose of this examination will be to map the upper annulus region in order to detect and characterize significant degradation of the vessel head low alloy steel and that its demonstrations show that LF ECT can detect degradation in the upper annulus region.

2.3 Licensee’s Basis for Relaxation

Hardship

The licensee stated that it has reviewed the configuration of the ANO-2 RPV head assembly and concluded that due to its unique design, it would involve significant hardship to disassemble and reassemble the cooling shroud and insulation package to perform a BMV inspection. The licensee stated that the risk of damaging vital CEDM components during removal and installation of the cooling shroud and potential damage to the insulation package prevent BMV inspections from being a reasonable option. The licensee further stated that disassembly and reassembly of the cooling shroud and the insulation package would result in personnel exposure of approximately 23 man-rem.

The licensee stated that the insulation on the ANO-2 RPV head is comprised of metal reflective panels and pliable insulation collars covered with fiberglass cloth. The licensee stated that the RPV head insulation in the nozzle area is designed to conform to the curvature of the head, and is located underneath the CEDM cooling shroud orifice plate, which is also designed to conform to the curvature of the RPV head in a stair-step design. The licensee further stated that a plenum is provided at the outside of the cooling shroud orifice plate, which forces cooled air from the CEDM cooling system, across the RPV head insulation, and through holes in the orifice plate where the CEDM assemblies penetrate the cooling shroud. The licensee stated that removable insulation is provided only in the head flange and stud region, which does not interface with the RPV head area at the intersection with the CEDM or ICI nozzles to allow access for BMV inspections. Figure 1 was provided by the licensee at a public meeting held at NRC headquarters on June 17, 2003, and illustrates an overall view of the ANO-2 RPV head and shroud. Figure 2 was provided in the licensee's May 8, 2003, submittal letter, and shows a detailed view of the stair step design of the cooling shroud and the insulation design.

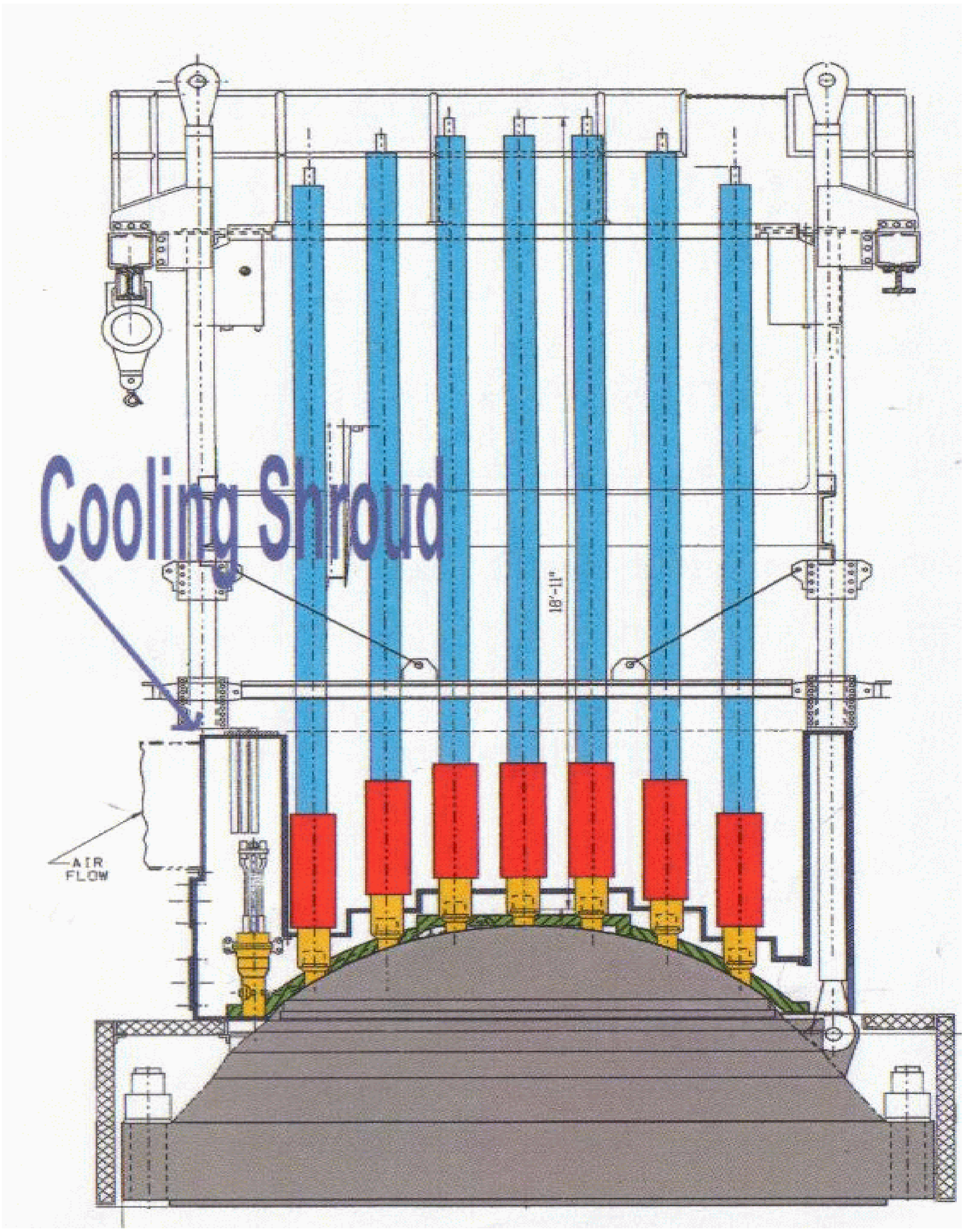

Figure 1

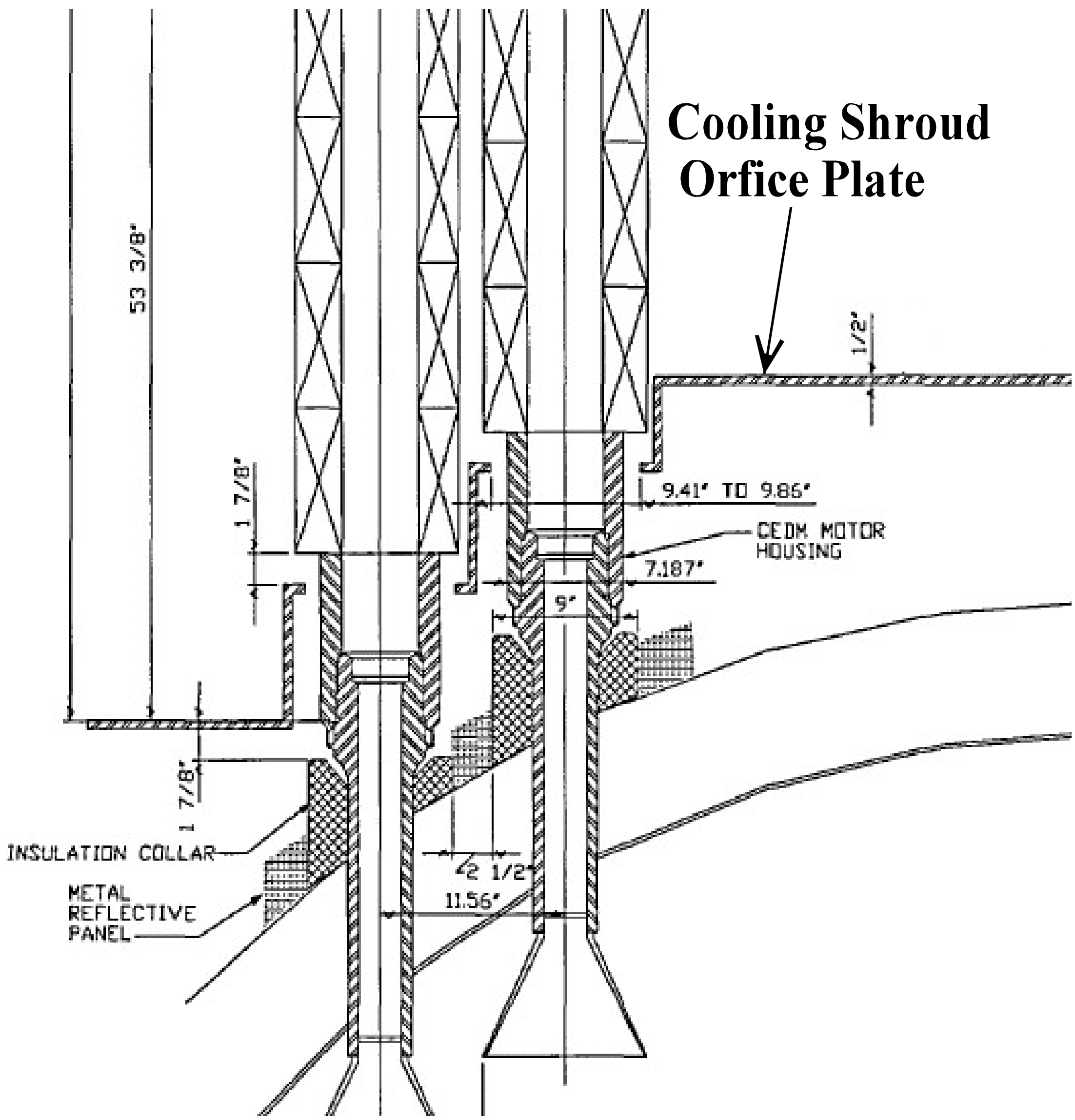

Figure 2

The licensee stated that at ANO-2, the cooling shroud fits closely over the insulation panels and only limited access can be provided to reach the insulation panels and insulation collars. The licensee stated that the ANO-2 cooling shroud and insulation package were not designed and constructed to be able to perform BMV inspections of the head and were not designed to be removed from the top of the head. The licensee stated that ANO-2 head insulation collars were installed while the remainder of the CEDM assemblies were being welded in place. The licensee further stated that because of the close spacing of the nozzles, the original construction was completed by installing each insulation collar immediately after its motor housing was welded in place, and before the adjacent CEDM motor housings were installed. The motor housings and insulation collars were installed sequentially in this manner working from the inner nozzle locations toward the periphery.

Some licensees are able to lift their RPV head insulation enough to perform a BMV examination using enhanced optical equipment. Entergy stated that in its case, this is not possible because the insulation collars around the nozzles were custom fit to follow the contour of the head surface and the nozzle surface below the omega seal welds. The licensee stated that the insulation collars were installed first, then the reflective metal insulation panels were lowered into place to fit around the collars. The licensee stated that if a means could be developed to lift the metal reflective insulation enough to insert a boroscope or fiber-optic inspection tool between the metal reflective insulation and the head surface, the collars would still prevent access to perform the visual inspection of the head surface around the nozzles. The licensee further stated that the insulation collars cannot be lifted off of the head due to the rigid 24-gauge stainless steel inner cylinder with radial spokes on top and bottom, and the close fit of the collar below the taper transition of the nozzle.

The licensee contends that removal of the cooling shroud creates substantial risks since this evolution has not been previously attempted and lifting the steel cooling shroud has a high risk of damaging the CEDM housings. Entergy stated that it is not aware of a facility that has removed the cooling shroud to perform a BMV inspection. The licensee is concerned that weight and close tolerances of the cooling shroud and lift rig, once released from the head, have the potential to shift and damage the CEDM housings while lifting.

According to the licensee, prior to lifting the cooling shroud, 81 coil stacks and 162 reactor system plant thermocouples (RSPTs) would have to be removed from the CEDM drive housings and, in addition, the 17 interconnected insulation panels would have to be removed by unbuckling the interconnections and lifting each panel over the top of the CEDM motor housings. These panels are designed to fit into place with specific configurations around CEDM nozzles. Based on experience with similar panels, Entergy believes that, if removed, the insulation panels would likely have to be replaced with new panels to restore the required fit between the panels. The head lift rig, coil stacks, and RSPTs that have to be removed require special storage racks to be designed and constructed. (Adequate planning is necessary to address the as-low-as-is-reasonably-achievable considerations, to provide storage racks for the RSPTs and coil stacks, and to address floor loading considerations and to provide available space for placing the cooling shroud and lift rig.) The dose for the removal/reinstallation of the cooling shroud (including the RSPTs and coil stack removal) and insulation components is estimated to be 23 man-rem. This estimate only includes the actual projected work and does not include contingencies that may arise, as previously mentioned.

The licensee stated that because access is available through doors in the shroud adjacent to the ICI nozzles, it will perform a BMV examination of the annulus region of all 8 ICI nozzles.

The licensee stated that the benefit derived from performing a BMV inspection, as required by the Order, is not commensurate with the potential risk and the excessive difficulty in removal and replacement of insulation components. The licensee also stated that supplemental inspections will produce an acceptable level of safety.

<u>Augmented Inspections</u>

The licensee stated that it will employ an augmented inspection strategy that includes two examinations over and above the typical examinations used to comply with the Order. According to the licensee, the non-destructive examination (NDE) strategy involves two augmented inspections that include interrogating partially into the weld metal at the triple point using UT to assure that no flaws have propagated to that point in the weld, resulting in leakage, and inspecting for wastage of the RPV head using LF ETC. According to the licensee, the combination of techniques, along with the leakage assessment UT technique (required by the Order), provides defense-in-depth for detecting both leakage and RPV head corrosion.

UT Triple Point Examination

The licensee's augmented examination using the UT examination method is explained by the licensee as follows:

> "The Westinghouse open housing UT probe has been previously demonstrated to be able to see flaws at least 0.060 of an inch into the J-groove weld. This capability was provided in an NDE demonstration report submitted to the NRC in Reference 6 [Entergy letter dated June 17, 2002, "Submittal of Demonstration Report for Volumetric Examination of Vessel Head Penetration Nozzles"]. Based on this testing, PWSCC flaws at the J-groove weld to tube interface of 0.060 of an inch into the J-groove weld will be detected. During the previous refueling outage the open housing probe was able to scan each of the penetrations and was able to confirm the integrity of the J-groove weld next to the nozzle. The UT examination of ANO-2 CEDM and ICI nozzles was performed during refueling outage 2R15 using the Westinghouse open housing UT probe. Having the capability to examine a minimum of 0.060 of an inch into the weld also provides the ability to look at the triple point where the penetration nozzle, J-groove weld and nozzle to head annulus join. The Time of Flight Diffraction (TOFD) technique will be used to examine each CEDM and ICI penetration tube, including 0.060 of an inch of the adjacent J-groove attachment weld, looking for planar-type defects within this examination volume. This 2002 Materials Reliability Program (MRP) Inspection Technology Demonstrations has demonstrated the TOFD to be capable of detecting flaws in the entire proposed examination volume, including the "triple point" region of the attachment weld. The TOFD ultrasonic inspection approach utilizes two pairs of 0.250" diameter, 55° refracted-longitudinal wave transducers facing each other. These transducers are separated from each other at a distance of 24mm PCS (probe center spacing). One transducer sends sound into the inspection volume, and the other transducer receives the reflected and diffracted signals, as they interact with the material. This technique is accurately calibrated on a calibration standard of known dimensions, which allows for accurate depth and length dimensioning and positioning of any reflectors that are recorded within the examination volume. One TOFD transducer pair detects in the axial direction of the penetration tube, and one TOFD transducer pair detects in the circumferential direction of the penetration tube. The triple point examination provides additional assurance and confidence that there are no flaws that provide a leak path to the annulus and surface of the head. Therefore, Entergy commits to assess the triple point of the nozzle examinations to further ensure pressure boundary integrity."

According to the licensee, it performed a volumetric examination of 100% of the CEDM and ICI nozzles during its last refueling outage in the Spring of 2002, and no PWSCC indications were found. The licensee feels that it is unlikely that a crack has initiated and propagated through the pressure boundary in one cycle. The licensee stated that its proposed inspection method will be able to determine if there is a through-wall or through-weld crack by interrogating the full thickness of the nozzle and at least 0.060 of an inch into the weld. The licensee stated that if there is a leak path through the weld, it would be detected with the UT inspection technique at the triple point of the nozzle, weld, and weld butter interface, and from a leakage assessment of the interference fit zone (as required by Section IV.C.(1)(b)(i) of the Order).

The licensee provided demonstration reports from its vendor pertaining to the testing of the vendor's UT examination capabilities. The licensee stated that two of the blind mock-ups that have been used for demonstrations using the Westinghouse open housing UT probe are suitable to show its effectiveness to locate flaws that have propagated to the triple point. The mock-ups were fabricated by the Electric Power Research Institute (EPRI) for the MRP Demonstration Program. The first blind mock-up is designated the Entergy/MRP mock-up. The second mock-up is designated the MRP Phase II Demonstration mock-up "K". The Entergy/MRP mock-up consisted of twelve total mock-up flaws, three of which had the tip of the flaws within the declared detection capability of the triple point examination. The licensee stated that all three of these flaws were detected in a blind test. The licensee stated that the K mock-up contained one flaw that extended to the triple point and that flaw was successfully detected in a blind test.

Low Frequency Eddy Current

The licensee stated that it will use LF ECT for wastage detection in the RPV head behind the nozzle. The licensee explains the LF ECT process as follows:

> "A rotating eddy current pancake coil is used to detect the presence, or absence, of carbon steel loss. For the small volumes of interest, the response is essentially linear with volume loss. Assuming an axial flaw length greater than the coil's field size, the circumferential cross section can be used for response comparison. Since a leak path through the RPV head thickness is considerably larger than the coil field, this approach provides reasonable assurance in detecting a loss of metal. To demonstrate this method, a series of mockups with various axial and circumferential grooves and various wall loss geometries were fabricated. In addition, the reactor vessel head at the Westinghouse Waltz Mill Service Center was inspected to determine the ability to detect the upper counter bore (0.015" on the radius). The results from the mockup tests demonstrate that a machined flaw 0.25" x 0.125" deep (0.03 sq in) and the upper counter bore 1.5" (assumed maximum coil field extent) x 0.015" deep (0.022 sq in) were detectable. Based on this testing it was determined that the equivalent depth for this detection limit is 0.060". During actual inspections on site, the leak path configuration that Westinghouse typically encounters begins as a very wide area at the top of the weld, which can neck down to as low as 0.375" wide region (riverbed area) and then slowly widens as it approaches the OD [outside diameter] of the reactor vessel head. The laboratory work that was performed during the demonstration is bounding in terms of detectable lengths and volumes of flaws. A real leak path in a RPV head would be much longer (reaching from the top of the J-weld to the OD of the reactor vessel head) than any of the notches provided in the mock-ups that were tested. The mockups used by WesDyne are considered to be very conservative from the standpoint of detection capability. The notches provide good information about the response comparison of different volumes of metal."

Summary of Planned Examinations

The licensee stated that the ANO-2 reactor head inspection approach that is being applied in lieu of a BMV inspection for the Fall 2003 refueling outage is a comprehensive methodology. The licensee stated that its inspection regimen is designed to provide defense-in-depth for detection of any PWSCC flaw that could develop in the J-groove weld or penetration nozzle. The licensee also stated that its comprehensive approach combines the use of several diverse and complementary inspection techniques and that these techniques provide a complete examination and inspection of the RPV head, which provides an acceptable level of quality and safety. According to the licensee, Figure 3, along with the information contained in the bullets following Figure 3, demonstrate how each examination and inspection technique covers the entire length of the penetration to ensure that PWSCC indications are found in the nozzle or J-groove weld, penetration leakage is detected, and that RPV head integrity is maintained. Figure 3 and the following bullets from the licensee's August 27, 2003, letter provide an overview of the CEDM configuration, insulation, superstructure interference, proposed inspection methodology, and intended purpose of the inspection as proposed by the licensee.

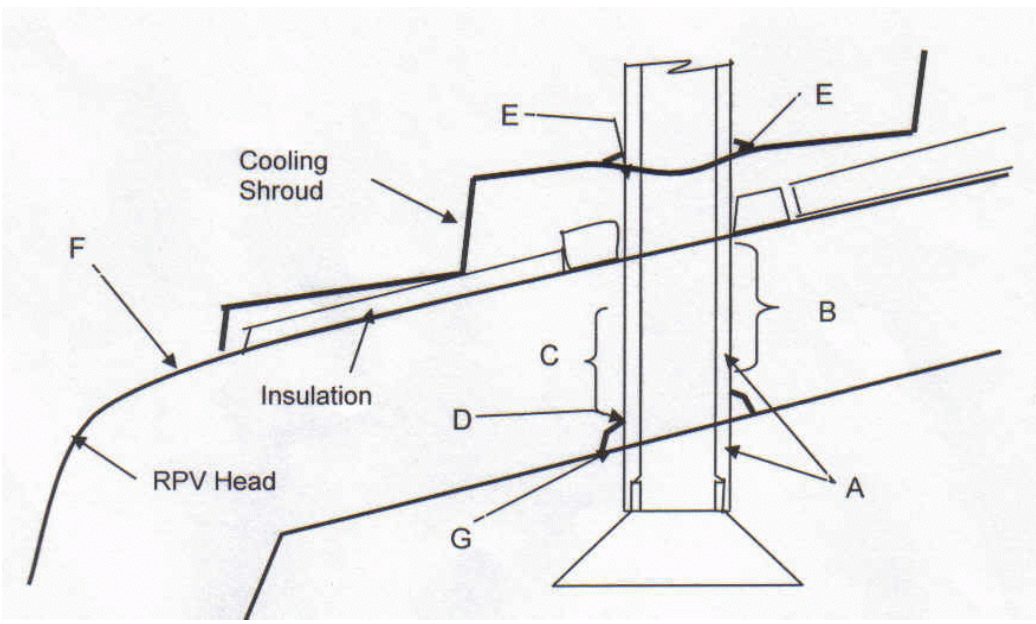

Figure 3

- A = **Volumetric Examination** of CEDM/ICI penetration tubes utilizing MRP-demonstrated UT techniques. This ensures that the critical length of the nozzle is free of defects and potential leakage paths.
- B = **Low Frequency Eddy Current Examination** of the portion of the CEDM and vent line penetrations that are above the J-groove weld. This examination will interrogate the area between the penetration tube and the reactor head, looking for degradation of the carbon steel head material.
- C = **Penetration Annulus Leakage Assessment** using Westinghouse-demonstrated zero degree UT technique. This ensures that the leak path from a leaking nozzle or weld will be detected and qualitatively determined to have a loss of interference fit through the annulus, which can also be detected by LF ETC. This examination can detect leakage through the J-groove weld or through the buttering, if it were to occur.

- D = **Triple-Point Examination** utilizing Entergy/Westinghouse-developed and EPRI/MRP-demonstrated UT technique. This process provides the unique capability to further investigate 0.060" into the J-groove weld and determine the integrity of the penetration weld and to support the conclusion that boric acid deposits will not be present on the RPV head.
- E = **Supplemental Visual Inspection** performed from above the cooling shroud plate, which has the capability of detecting boric acid that has either descended onto the head from Figure 1 above, or has migrated upward from the head and may be visible at the top of the reactor head insulation.
- F = **Bare Metal Visual Inspection** of the accessible portions of the RPV head, including the flange area, part of the lower dome, and around the annulus of the ICI nozzles. This examination is performed to detect corrosion that may have occurred in the accessible areas, to detect leakage around the ICI nozzles, and to look for evidence of boric acid residue that may have run down the head from a leaking penetration.

Conditional Examination

- G = **Surface Examination** of J-Groove Weld utilizing liquid penetrant or eddy current. This is a contingency examination that would be utilized to further investigate a positive indication of a potential PWSCC flaw found with any of the primary examination techniques.

In Entergy's August 2, 2003, letter, the licensee provided an NDE decision-making flowchart that is shown below in Figure 4. The flowchart shows the inspection decision-making process, which takes into account required inspections and augmented inspections.

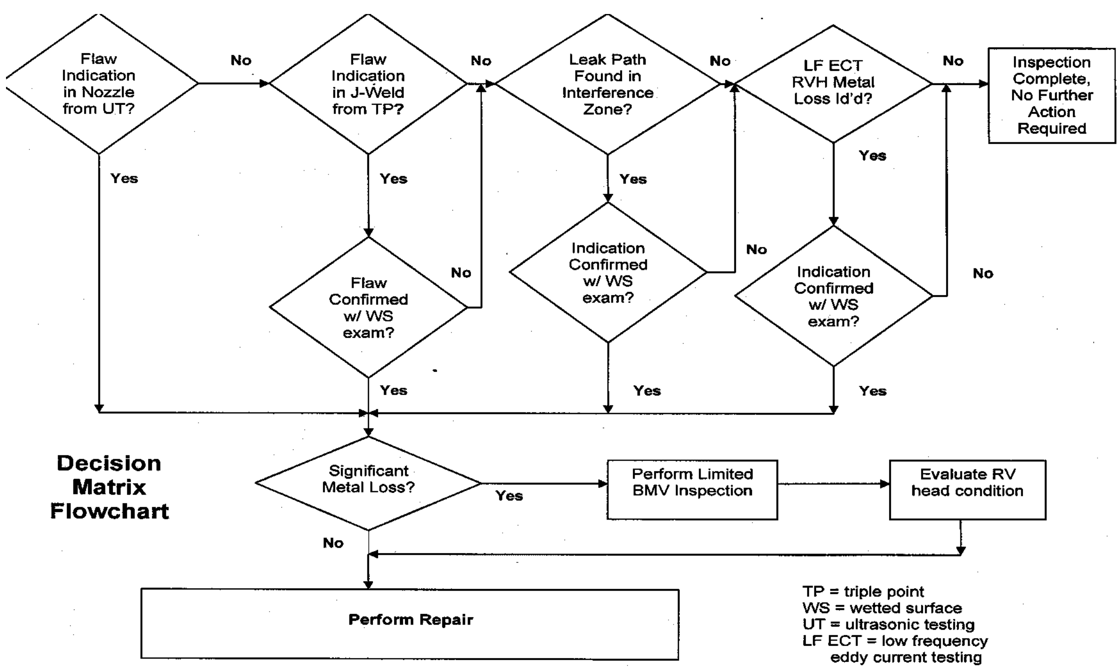

Figure 4

After conversations with the staff regarding the licensee's limited BMV examination of the RPV head, the licensee proposed that its alternative be subject to the following condition by letter dated October 2, 2003:

> "Should there be any evidence of corrosive product coming from any of the inaccessible areas on the reactor pressure vessel (RPV) head, the relaxation is rescinded until such time that the licensee can provide adequate information to the staff that ensures that the RPV head is not degraded in the inaccessible areas."

3.0 EVALUATION

The NRC staff's review of this request was based on Paragraph F of Section IV of the Order, which states:

> "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...."

To establish the acceptability of the licensee's request, the NRC staff has used Criterion 2 of Paragraph F of Section IV of the Order:

> "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."

Within the context of the licensee's proposed alternative examination of the RPV penetration nozzles, the licensee has demonstrated the hardship that would result from implementing the full extent of the BMV examinations required by the Order. The hardship identified by the licensee includes the large additional radiation exposure (23 man-rem) that would be required to remove the RPV cooling shroud to facilitate the required examinations, and possible damage to the CEDM nozzles.

Given the relatively short time span of seven months between the issuance of Order EA-03-009 and the start of ANO-2's Fall outage, the staff finds that there has not been sufficient time to carefully plan for the evolutions and contingencies to perform a 100% BMV examination. Therefore, the removal of the cooling shroud to perform the required 100% BMV of the RPV head in accordance with Order EA-03-009 would involve a hardship. ANO-2 is unique from other plants because, in order to obtain access to the bare RPV head, major disassembly is required. Removal of 162 RSPT's; 81 CEDM coil stacks; and the disconnecting, rigging and storing of the cooling superstructure, and the removal of 17 insulation panels and 81 CEDM insulation collars, would be required. Since the ANO-2 cooling system design is unique in that the CEDM cooling/insulation system was not designed to allow access to CEDM nozzles, and based on the discussion above and the information provided by the licensee, the staff concludes that both hardship and unusual difficulty exists in order to perform the BMV required by the Order. The remainder of this safety evaluation focuses on the issue of whether there is a compensating increase in the level of quality and safety such that the BMV should be implemented in accordance with the Order despite this hardship and unusual difficulty.

The functions of the BMV examination are to identify boron deposits indicative of head penetration nozzle leakage and to confirm the integrity of the RPV head and, hence, the absence of degradation on the vessel head surface. The proposed augmented examinations address BMV functions of leakage detection (through the enhanced UT triple point examination) and vessel head degradation detection (through the LF ECT).

The licensee indicated in its submittal that it had demonstrated the capability of the triple point UT examination to detect circumferential/axial PWSCC-type flaws that extend 100% through the J-groove weld to the triple point where the weld, buttering, and nozzle base material meet. The licensee stated that this process can interrogate 0.060 inch into the weld from the weld/nozzle interface, but the licensee also stated that this process can only distinguish flaws that are located up to 0.060 inch into the weld that propagate to the triple point, and flaws that do not propagate to the triple point cannot be distinguished from what the licensee and its vendor calls "weld anomalies."

In its August 2, 2003, supplemental letter, responding to the staff's request for additional information (RAI), the licensee submitted WesDyne Report WDI-TJ-012-03, Revision 0, "Triple Point Inspection using TOFD Ultrasonic Methods (Non Proprietary)." The report detailed the demonstration of the technique to ultrasonically interrogate the J-groove weld area approximately 0.060 inch beyond the OD of the nozzle. The demonstration involved exercises to detect CIP flaws that extend from Electric Discharge Machine (EDM) notches implanted in mockups fabricated by EPRI for the MRP. A CIP flaw is manufactured by implanting an EDM notch in the mockup, then subjecting the notched area to 30,000 -60,000 $lbs/inch^2$. Published data indicates that CIP flaws extending from the compressed notch tip resemble field PWSCC flaws in morphology and amplitude when detected by ultrasonic examination. The Entergy mockup simulated a nozzle OD J-groove weld with circumferential/axial CIP notches extending 25%, 50%, and 100% of the J-groove weld depth, to the area where the triple point anomaly would exist in a typical field CEDM nozzle arrangement. EPRI/MRP mockup "K" simulated a nozzle with circumferential/axial and axial/radial CIP notches.

The demonstration of the ability of the equipment and personnel to detect the flaws were conducted by EPRI through a series of blind tests. The 100% through-weld circumferential/axial and the weld axial/radial flaws were successfully detected during the blind demonstrations. The staff noted, in its review of the results in Table 2, "WesDyne detection results" (Enclosure 2 of the non-proprietary August 2, 2003, supplemental letter), that two false calls were made by the technicians on the K mockup. In its August 27, 2003, supplemental letter, the licensee indicated that the blind demonstration results show that the false calls were overcalls in which non-crack welding defects were called cracks. For this demonstration, the staff's position is that the small sample size would not disqualify the NDE technician(s) performing the testing. However, as the qualification process matures and more test samples become available for formal training, the staff would expect that overcalls be normally considered against the candidate with respect to qualification. Secondly, the overcall for this demonstration is supported by the decision matrix (discussed later) which would require confirmatory wetted surface testing to validate whether the overcall was in fact a crack. If the wetted surface examination shows no evidence of surface breaking indications, the overcall will be classified appropriately as a weld defect rather than a crack. This indicates to the staff that the inspection procedures are acceptable. Finally, the staff reviewed the TOFD data submitted by the licensee in Figures 4 through 8 of WDI-TJ-012-03-P, Revision 0 (Enclosure 2 of the licensee's proprietary August 2, 2003, supplemental letter), showing the response of the implanted CIP flaws discussed. The figures clearly show the flaws beyond the weld fusion zone of the mockups.

The staff finds the demonstrations performed by Westinghouse through the EPRI/MRP to be acceptable for the licensee's proposed use of the triple point examination technique with the open housing scanner as a complementary inspection. The staff notes that the demonstrations the licensee used to justify this technique were not specifically designed to demonstrate the ability of the technique to detect cracks that propagate to the triple point. The staff notes that the technique has limited abilities to interpret indications in the weld that do not propagate to the triple point. The staff concludes that the licensee's demonstrations provide reasonable assurance that the triple point examination will detect flaws that have propagated to the triple point and are a potential cause of leakage.

The staff has reviewed the licensee's submittal and basis for LF ETC. Since the size and orientation of the mockup flaws is classified as proprietary, the staff will discuss its findings at a general level. In order to determine the capability of the LF ECT technique to determine wastage, mockups were fabricated with a series of grooves and flat bottomed holes at specific widths and depths. These specimens were attached to CEDM nozzles that extend from the Jamesport head. The LF ECT probe was used to detect these probes from the inside diameter of the nozzles to determine what voids may be detected. The detection of the shallowest void, with respect to width and depth, will equate to the minimum volume of material missing due to wastage of the RPV head in the annulus region because they are both voids in the annulus region between the nozzle and the RPV wall. The data submitted by the licensee shows the detectable limit of the LF ECT as it equates to wall loss over a wide area rather than a small area, such as would be found during BMV inspections.

Based on the staff's review of the data submitted, the staff concludes that the licensee sufficiently demonstrated the capability of the LF ECT examination to detect significant wastage (>0.022 inch^2, corrected or 0.250 inch wide by 0.125 inch deep) at the CEDM nozzle/RPV head intersection when no interference fit is present. The data provided by the licensee indicates that this is not a direct, equivalent replacement for a BMV, because the leakage that would result from a 0.125 inch deep gap at the annulus detectable by LF ECT is much greater than the leakage that would be detected by performing the BMV when an interference fit exists. Industry experience is that the BMV can detect boric acid leakage on the order of 10^{-6} gpm when an interference fit is present through detecting minute quantities of residual boron deposit. Although the LF ECT is not as sensitive as a BMV examination, the licensee has demonstrated that the LF ECT will provide reasonable assurance that wastage will be detected.

The staff reviewed the decision matrix (Figure 4) to determine if the application of the techniques proposed took into consideration the strengths and weaknesses of the alternatives proposed. The matrix requires that a LF ECT examination be performed after the evaluation of the leak path UT examination. This is an appropriate application of the technique, considering that published data indicates the leak path UT examination is not effective where no interference fit exists between the CEDM nozzle and vessel head penetration. Therefore, a gap must exist for the LF ECT to be an effective technique which, based on the discussion above, must exceed 0.125 inch.

The staff finds that the decision matrix provides a technically sound flowpath to determine if significant wastage exists.

Based on discussion with the staff regarding the licensee's limited BMV examination of the RPV head, the licensee proposed that its alternative be subject to the following condition in a letter dated October 2, 2003:

> "Should there be any evidence of corrosive product coming from any of the inaccessible areas on the reactor pressure vessel (RPV) head, the relaxation is rescinded until such time that the licensee can provide adequate information to the staff that ensures that the RPV head is not degraded in the inaccessible areas."

Section IV.C(1) of the Order requires both a BMV and nonvisual NDE because a BMV provides a complementary and redundant means of promptly identifying leakage in the event indications of leakage and cracking are not captured by nonvisual NDE. While neither the UT triple point assessment or the LF ECT are equivalent to the BMV, the combined use of these two NDE techniques in lieu of a BMV, as conditioned above, is sufficient to provide reasonable assurance of structural integrity of the RPV head and compliance with Section IV.C.(1)(a) of the Order would result in hardship without a compensating increase in the level of quality and safety.

4.0 CONCLUSION

The staff concludes, given that the licensee's proposed alternative examination of the RPV head to include a limited visual examination, enhanced UT examination, and LF ECT examination, as appropriately conditioned, provides reasonable assurance of the structural integrity of the RPV head, inspection of the RPV head surface in accordance with Section IV.C.(1)(a) of Order EA-03-009 would result in hardship without a compensating increase in the level of quality and safety. The licensee has thus demonstrated good cause for the requested relaxation. Therefore, pursuant to Section IV, Paragraph F, of Order EA-03-009, the staff authorizes the proposed relaxation and alternative inspection for the RPV head surface at ANO-2 for one standard operating cycle, subject to the following condition that was agreed upon by the licensee by letter dated October 2, 2003:

> "Should there be any evidence of corrosive product coming from any of the inaccessible areas on the reactor pressure vessel (RPV) head, the relaxation is rescinded until such time that the licensee can provide adequate information to the staff that ensures that the RPV head is not degraded in the inaccessible areas."

Principal Contributor: R. Davis

Date: