Entergy

Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802
Tel 479-858-4888

Jeffery S. Forbes
Vice President
Operations ANO

2CAN040602

April 27, 2006

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6
Request for Relaxation to NRC Order EA 03-09 Regarding Bare Metal Visual Inspection on the ANO-2 Reactor Vessel Head

REFERENCES:

1 NRC letter dated February 20, 2004, *Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors* (0CNA020404)

2 Entergy letter dated May 8, 2003, *Request for Relaxation from Section IV.C(1)(a) of the Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads* (2CAN050301)

3 NRC letter dated October 9, 2003, *Arkansas Nuclear One, Unit 2 (ANO-2) - Relaxation Request from NRC Order EA-03-009 Regarding the Bare Metal Visual Examination* (2CNA100306)

4 Entergy letter dated March 30, 2006, *Advance Notice of Forthcoming Request for Relaxation to NRC Order EA 03-09 Regarding the Bare Metal Visual Inspection on the ANO-2 Reactor Vessel Head* (2CAN030603)

Dear Sir or Madam:

On February 11, 2003, the Nuclear Regulatory Commission (NRC) issued the Order addressing interim inspection requirements for reactor pressure vessel (RPV) heads at pressurized water reactors and subsequently revised on February 20, 2004 (Reference 1). On May 8, 2003, Entergy Operations, Inc. (Entergy) requested relaxation from the requirements of Section IV.C(1) of the Order (Reference 2) regarding performance of a bare metal visual (BMV) inspection the RPV head surface for Arkansas Nuclear One, Unit 2

A101

I declare under penalty of perjury that the foregoing is true and correct.

Executed on April 27, 2006.

Sincerely,

for J Forbes

JSF/sab

Attachments:

1. Request for Relaxation from NRC Order 03-009 Regarding Bare Metal Visual Inspection of the ANO-2 Reactor Vessel Head
2. Complementary and Diverse Inspection Approaches
3. List of Regulatory Commitments

cc: Dr. Bruce S. Mallett
Regional Administrator
U. S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

NRC Senior Resident Inspector
Arkansas Nuclear One
P. O. Box 310
London, AR 72847

U. S. Nuclear Regulatory Commission
Attn: Mr. Drew Holland MS O-7D1
Washington, DC 20555-0001

Mr. Bernard R. Bevill
Director Division of Radiation
Control and Emergency Management
Arkansas Department of Health
4815 West Markham Street
Little Rock, AR 72205

Attachment 1 to

2CAN040602

Request for Relaxation to NRC Order EA 03-09 Regarding Bare Metal Visual Inspection of the ANO-2 Reactor Vessel Head

Request for Relaxation to NRC Order EA 03-09 Regarding the Bare Metal Visual Inspection of the ANO-2 Reactor Vessel Head

1.0 BACKGROUND

On February 20, 2004, the Nuclear Regulatory Commission (NRC) issued the revised Order [Order] addressing interim inspection requirements for reactor pressure vessel (RPV) heads at pressurized water reactors (Reference 1). This Order superseded the initial Order issued by the NRC on February 11, 2003. The NRC stated that the actions in the Order are interim measures, necessary to ensure that licensees implement and maintain appropriate measures to inspect and, as necessary, repair RPV heads and associated penetration nozzles. On May 8, 2003, Entergy Operations, Inc. (Entergy) requested relaxation from Section IV.C(1)(a) of the Order (Reference 2) to perform a bare metal visual (BMV) inspection of 100 percent of the RPV head surface for Arkansas Nuclear One, Unit 2 (ANO-2). In response to requests for additional information (RAI), Entergy submitted examination and inspection approaches for the ANO-2 fall 2003 refueling outage to provide both diverse and complementary means for compliance with the intent of the Order (Reference 3). On October 9, 2003 the NRC granted relaxation from the BMV requirements of the Order for the fall 2003 (2R16) refueling outage (Reference 4).

The following provides justification for a similar relaxation of the Order requirements for an alternative to a BMV for the upcoming fall 2006 ANO-2 outage.

2.0 ANO-2 REACTOR PRESSURE VESSEL HEAD DESIGN

The ANO-2 RPV head was fabricated by Combustion Engineering and has 81 Control Element Drive Mechanism (CEDM) penetrations, eight incore instrument (ICI) penetrations and one head vent penetration. The CEDM nozzles consist of a 4.05 inch outside diameter (OD) tube with a guide cone threaded into the inside of the bottom of the tube. In addition, a CEDM motor housing adaptor, attached at the top of the tube, tapers out to a larger diameter to mate with the 7 3/16 inch OD CEDM motor housing using an omega seal weld. The cone connections and the motor housing adaptors both closely follow the contour of the head. The ICI nozzles have an internal diameter (ID) of 4.75 inches and do not have guide cones attached. The vent line is a three-quarter inch ID NPS Schedule 80 pipe made from ASME SB-167 Alloy 600 material. The ANO- 2 reactor vessel was built to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section III, Nuclear Vessels, 1968 edition with addenda through Summer 1970. See Figure 1.

3.0 APPLICABLE REQUIREMENTS

The Order establishes the RPV head inspection requirements based on established susceptibility categories per Section IV.B of the Order. Entergy is classified in the high primary water stress corrosion cracking (PWSCC) susceptibility category based on exceeding 12 effective degradation years (EDY) of operating time.

Section IV.C(1) requires plants with RPV heads having a high susceptibility classification to perform a bare metal visual (BMV) examination of 100 percent of the RPV head surface each refueling outage per paragraph IV.C.(5)(a). Section IV.F of the Order states that the NRC may relax any of the conditions of the Order upon demonstration by the licensee that the proposed alternative(s) provide an acceptable level of quality and safety, or 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. Entergy believes the dose received to perform a BMV inspection of the RPV head due to the obstruction presented by the existing RPV head cooling shroud and the proposed augmented examinations as discussed herein meet these requirements. Accordingly, and as provided for by Section IV.F, Entergy requests relaxation from Section IV.C (5)(a) of the Order.

4.0 INSPECTIONS AND EXAMINATIONS PERFORMED ON THE ANO-2 RPV HEAD

During the course of the last three ANO-2 refueling outages, Entergy has performed non-destructive examinations (NDE) on the ANO-2 RPV head and has established that PWSCC degradation has not been experienced, to date. The last two outage examinations were performed to the full requirements of the Order or have met relaxations approved by the NRC as acceptable examination alternative. The following is a discussion of the inspections and findings conducted, to date:

2R15 (Spring 2002) Refueling Outage

Entergy performed a 100% ultrasonic test (UT) examination of the ANO-2 RPV head penetrations during the spring 2002 refueling outage. Even though this inspection was performed prior to the Order, the examinations were performed based on the considerations of NRC Bulletin 2002-01. The scope consisted of an examination of all of the RPV head penetrations 360° around each nozzle as follows:

- The NDE from under the head for the CEDMs was performed by Westinghouse using their procedures with the oversight of Entergy Engineering and Quality Control specialists. The inspection plan for the 81 CEDMs included the use of the EPRI demonstrated UT probe from above the J-groove weld to the inspectible extent of the nozzle below the weld.
- The eight ICI nozzles were similarly inspected using a comparable UT probe but modified for the larger ICI nozzle diameter.
- The single vent nozzle was inspected by a smaller UT probe that utilized axial and circumferential shooting ultrasonic shear-waves.

All 90 head penetrations were confirmed to have good pressure boundary integrity with no indications of PWSCC flaws that could cause head wastage. The outage results were reported in Reference 5.

2R16 (Fall 2003) Refueling Outage

In accordance with the Order and associated Relaxations, Entergy performed the following inspections and examinations;

- A Westinghouse open housing UT probe was used to perform examinations from 2" above the J-groove weld to the blind zone of the 81 CEDM and the 8 ICI nozzles.
- Manual eddy current (ECT) exams were conducted on the applicable exterior surface of the blind zone on 75 of the 81 CEDM nozzles near the threaded region of the nozzle.

- A "triple point" examination using the open housing UT probe was conducted from the ID of the CEDM and ICI nozzles. This exam extended into the J-groove weld next to nozzle to a 0.060" depth.
- A low frequency eddy current (LFECT) examination was conducted from the ID of the CEDM and ICI nozzles to detect wastage of the carbon steel vessel head material in close proximity to the nozzle.
- A leak path assessment of the nozzle annulus interference fit above the J-groove weld was accomplished.
- Manual PT exams were conducted on the 8 ICI nozzles.
- Manual ECT or wetted surface of the single vent line was performed.
- Visual inspections of the CEDM, ICI and vent line nozzles were conducted from above the cooling shroud. Boroscopic inspections between certain nozzles were also performed to confirm cleanliness of the shroud.
- A visual inspection of the 8 ICI nozzles and accessible CEDM was conducted at the annulus using visual and boroscopics techniques.

Neither the non-destructive examinations nor the visual inspections revealed any signs of PWSCC occurring on the ANO-2 RPV head during these inspections. The results of this inspection were reported in Reference 6.

2R17 (Spring 2005) Refueling Outage

In accordance with the Order and associated relaxations, Entergy performed the following inspections and examinations;

- A full BMV inspection was performed 360° around each penetration of the 81 CEDM nozzles, 8 ICI nozzles, and the vent line for potentially leaking penetrations or for RPV head wastage. This met the requirements of the BMV inspections required by section IV.C(5)(a) of the Order.
- A Westinghouse open housing UT probe was used to perform examinations from 2" above the J-groove weld to the blind zone of the 81 CEDM and 8 the ICI nozzles.
- Manual ECT exams were conducted on the exterior surface of the CEDM nozzles in the blind zone on 76 of 81 nozzles.
- A leak path assessment of the nozzle annulus interference fit above the J-groove weld was conducted.
- An automated ECT/UT on the face of the ICI nozzles was performed.
- Manual ECT of wetted surface of the single vent line was conducted.
- A general inspection from above the RPV head and on the RPV head flange was conducted for potential wastage.

Neither the non-destructive examinations nor the BMV inspections conducted during 2R17 revealed any signs of PWSCC or wastage occurring on the ANO-2 RPV head. The results of this inspection were reported in Reference 7.

In summary, the ANO-2 RPV head penetrations have not experienced PWSCC and there have been no signs of wastage to the RPV head.

5.0 NEED FOR PROPOSED ORDER RELAXATION

ANO-2 Cooling Shroud, CEDM Housing and RPV Head Insulation Description –

The configuration of the ANO-2 RPV head assembly is a unique design and involves significant hardship to disassemble and reassemble the cooling shroud and insulation package to perform a BMV inspection. A description of the configuration of the ANO-2 head, insulation and cooling shroud was provided to the NRC in Reference 2. Even though the insulation collars around the base of the CEDM nozzles had to be replaced in the spring 2005 refueling outage (2R17) to perform the BMV inspection, the general configuration remains the same as previously discussed in Reference 2. A pictorial representation of the cooling shroud and insulation package is shown on Figure 1.

Limitations to Conducting RPV Head BMV Inspection –

<u>ANO-2 Cooling Shroud and Insulation Design</u> - The insulation package rests directly in contact with the carbon steel surface of the RPV head, and consists of flexible insulation collars around each nozzle, with metal reflective insulation panels lowered onto the insulation collars. The metal reflective insulation panels rest directly on the surface of the head and entrap the flexible insulation collars such that they cannot be removed without first removing the metal reflective insulation panels. The cooling shroud forms a metal canopy over the insulation with only a few inches between the insulation and the shroud; therefore, the cooling shroud must be removed to be able to remove the insulation panels. The cooling shroud is sandwiched between the insulation and the coil stacks for the CEDMs, therefore, all 81 of the coil stacks and the 162 Reed Switch Position Transmitters (RSPTs) must be removed to be able to remove the cooling shroud. 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 removal of the cooling shroud creates a potential risk for equipment damage.

<u>Cooling Shroud Disassembly</u> - The head lift rig is made up of three legs that are pinned to the reactor head lifting lugs at the bottom of the legs, and are structurally connected near the top by the work platform and the stud handling hoist monorail system. The legs are also structurally connected to each other by a lead shielding support structure just above the cooling shroud. The cooling shroud is attached to the legs at the top of the shroud by trunnions. The top of the legs provide a pin connection to which the lifting tripod attaches. The tripod provides a single point of attachment at the top center of the tripod that the polar crane connects to when lifting the head. The height of the lift rig from its connection to the RPV head to the eye at the top of the tripod is approximately 33 feet. A pendulum type lift of this structure with the polar crane could experience unanticipated damage to the CEDM motor housings due to the lift rig tilting, swinging, or rotating.

As previously discussed, prior to lifting the cooling shroud, the coil stacks and RSPTs must be removed from the CEDM drive housings. After the shroud has been removed, the 17 interconnected insulation panels must be removed by unbuckling the interconnections and lifting each panel over the top of the CEDM motor housings. The flexible insulation collars then must be removed. These collars and panels are designed to fit into place with specific configurations around CEDM nozzles. Due to the close spacing of the CEDM nozzles, many of the insulation collars require special tooling to reach the collars for removal and replacement. The head lift rig, coil stacks and RSPTs that have to be removed require special storage racks.

Deferral of New Cooling Shroud Design - During 2R17, Entergy complied with Section IV.C(5)(a) of the NRC Order for conducting a BMV inspection. However, to accommodate future BMV inspections with substantially reduced occupational radiological exposure, Entergy contracted with Westinghouse to design a new cooling shroud and insulation package which was to be installed during the 2R17 outage. Access doors in the shroud enclosure would permit removable insulation cassettes with smaller doors for remote vehicle inspection. ICI nozzle shielding would be installed to contribute to personnel radiation dose reduction.

The new cooling shroud and insulation package were based on available design documentation for the existing ANO-2 head and lifting rig. However, during the attempt to install the new cooling shroud during 2R17, it was discovered that critical dimensions in the as-built configuration of the original shroud were different than the design documentation. After several attempts to make field changes to the new cooling and insulation package, it was realized that the new shroud could not be installed. The old cooling shroud and insulation package had to be reinstalled after the BMV inspection was completed. Since the insulation collars were damaged during removal, new collars were installed around the CEDM and ICI penetrations.

Further plans to install a new shroud and insulation package are being deferred until additional critical measurements can be taken for ensuring proper fit up.

Dose Impact - From the evolutions performed during the 2R17 outage, the dose for the removal and reinstallation of the cooling shroud (including the RSPTs and coil stack removal) and insulation components was approximately 17 person-rem. The dose associated with performing the required BMV inspection during 2R17 was approximately 5 Rem. Entergy expects to receive about 1 Rem for the inspections performed through the cooling shroud doors. Therefore, Entergy estimates that relaxation from the full RPV head BMV inspection requirements of the Order will save approximately 21 Rem during 2R18.

6.0 PROPOSED ALTERNATIVE TO NRC ORDER FOR THE 2R18 REFUELING OUTAGE

Visual Inspections

In lieu of performing a full BMV inspection around each of the RPV head penetrations, Entergy will perform RPV head visual inspections to the extent practical without lifting and removing the cooling shroud. Even though the majority of the RPV head is not accessible for visual inspection, there are doors that are located in the cooling shroud (8 ICI nozzle and 6 alignment key doors) which provide limited viewing of the ICI nozzles and peripheral CEDM nozzles. Therefore, to help assure a comparable level of quality, Entergy will perform a BMV inspection of the ICI nozzles and a visual inspection of the accessible CEDM nozzles through the cooling shroud access doors during the fall 2006 outage. This inspection will look for boric acid deposits that would be indicative of a penetration leak or that could potentially cause wastage of the RPV head. Entergy will perform visual inspections of the RPV head flange to identify potential boric acid deposits as well as performing inspections from the pressure-retaining components above the RPV head (in accordance with Section IV.D of the Order). Based on the inspections that will be conducted, Entergy is making the following commitment:

Should there be evidence of corrosive product coming from an inaccessible area on the RPV head, Entergy will notify the NRC of our findings and provide adequate information to the NRC staff that ensures that the RPV head is not degraded in the inaccessible area(s).

Volumetric Examinations

Entergy will perform volumetric examination of 100% of the RPV head CEDM and ICI penetrations during the 2R18 refueling outage in accordance with section IV.C(5)(b)(i) of the Order and other approved Order relaxations. The volumetric examinations will use UT probes similar to that used in the last three refueling outages. This examination will be performed using EPRI demonstrated UT examination techniques and probes for examination of the nozzle tube wall and J-groove weld interface. Entergy is seeking a separate NRC Relaxation for examination of the CEDM nozzles for the 2R18 refueling outage (Reference 9). Entergy will comply with the requirements of that Relaxation in lieu of the above examinations, as appropriate.

Per Section IV.C (5)(b)(i) of the Order, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel (leak path). The basis for this inspection is the difference between the ultrasonic reflections from an interference fit versus a free surface. A leak path in a RPV head would be indicative of a long loss of backwall reflection (reaching from the top of the J-groove weld to the OD of the reactor vessel head).

Surface Examination of Vent Line

A manual ECT of the wetted surface of the single vent line penetration will be performed per Section IV.C.(5)(b)(ii) of the Order.

Augmented Examinations

During the 2R16 refueling outage, Entergy conducted augmented examinations involving the following elements:

1. Inspect for wastage in the carbon steel of the reactor pressure vessel (RPV) head using low frequency eddy current testing,

2. Interrogate partially into the weld metal at the triple point (weld/butter/nozzle intersection) using UT to assure that no flaws have propagated at that point in the weld resulting in leakage.

These augmented examinations are over and above the typical examinations used to comply with the Order. Entergy will again perform these augmented inspections during the 2R18 refueling outage.

Wastage Detection Using the 2R16 Low Frequency Eddy Current Coils – As previously demonstrated and used during 2R16 an eddy current coil will be 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".

2R16 Triple Point Inspection –The Westinghouse open housing UT probe has been previously demonstrated to be able to see flaws to a depth of 0.060" into the J-groove weld. This capability was documented in an NDE demonstration report submitted to the NRC in support of the initial BMV relaxation. Based on this testing, PWSCC flaws at the J-groove weld to tube interface to a depth of 0.060" into the J-groove weld (triple point) will be detected. This examination will to provide additional assurance that flaws at this location will be detected.

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. The 2002 Materials Reliability Program (MRP) Inspection Technology Demonstrations has proven 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.

These augmented NDE technologies have been demonstrated and previously used on the RPV head inspections during the 2R16 RPV head examinations. The following Wesdyne demonstration reports which substantiated the techniques were provided in Reference 8:

1. WesDyne Report WDI-TJ-001-02, Rev. 01, *Detection of Reactor Head Base Metal Loss from Inside the CRDM (Non-Proprietary)*
2. WesDyne Report WDI-TJ-012-03, Rev. 0, *Triple Point Inspection using TOFD Ultrasonic Methods* (including excerpts from "MRP Inspection Demonstration Program" Updated December 11, 2002*) *(Non-Proprietary)*

Conditional Inspection – If during the examinations discussed above, a potential, but indeterminate indication of a PWSCC flaw is found with any of the primary examination techniques, a surface examination of the J-Groove Weld utilizing liquid penetrant or eddy current will be conducted for the subject penetration.

7.0 BASIS FOR RELAXATION ACCEPTIBILITY

Previous Volumetric Examination – Entergy has performed volumetric examination of each of the ANO-2 CEDM and ICI nozzles during the last three refueling outages and no PWSCC indications have been detected. The scope consisted of nondestructive examination (NDE) of the entire the RPV head penetrations 360° around the nozzle. The inspection plan for the 81 CEDMs included the use of the EPRI demonstrated UT probe from above the J-groove weld to the inspectible extent of the nozzle below the weld. The eight ICI nozzles were similarly inspected using a comparable UT probe but modified for the larger ICI nozzle diameter. The single vent nozzle was inspected by a smaller UT probe that utilized axial and circumferential shooting ultrasonic shear-waves. All 90 head penetrations were confirmed to have good pressure boundary integrity with no indications of PWSCC cracking and reactor coolant system leaks that could cause head wastage. The outage results have been reported in Reference 5, 6, and 7.

Visual Inspections – A complete BMV inspection of the ANO-2 RPV head was conducted during the 2R17 refueling outage in the spring of 2005. There were no signs of degradation. Entergy does not believe that there is an active degradation mechanism that could cause wastage of the ANO-2 head or a loss of reactor coolant pressure boundary integrity that would not be detected with the proposed examination techniques discussed above. If an active leak is detected by the proposed NDE methods, then Entergy will perform a bare metal visual examination to the extent necessary to assure that there is no wastage or boric acid corrosion. Entergy will also perform visual inspections of the RPV head flange and the pressure-retaining components above the RPV head.

During the upcoming outages, Entergy will continue to perform NDE in compliance with Section IV.C (5) (b) of the Order as modified by the approved ANO-2 Order Relaxations. As part of this examination, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel. The primary leakage assessment determination to comply with Section IV.C(5)(b)(i) of the Order uses the UT probe to verify an interference fit and to identify if an apparent flow path within the annulus exists. However, due to interferences of threaded alignment cones at the bottom of the CEDM nozzles, relaxation has been requested to perform an alternate inspection of this area (Reference 9).

The ANO-2 inspection strategy will again include the LFECT and the Triple Point examination techniques to augment the standard approaches typically used to examine RPV head penetrations for identifying flaws in the nozzle or J-groove weld. These along with the leakage assessment technique of the UT provide both a diverse and complementary means for detecting leakage and RPV head corrosion as described below.. The LFECT examination will provide a determination of a change in carbon steel depth that also provides a means of leakage detection. The LFECT assesses leakage beyond the interference fit extending to the outside diameter of the vessel.

The Triple Point examination also provides a leakage detection capability. The UT scan using the Westinghouse open housing probe has the capability to detect flaws at the interface of the J-groove weld and the OD of the nozzle wall. In order to initiate a leak, a flaw originating in the J-groove weld or the OD of the nozzle is expected to propagate through the triple point. Therefore, such flaws would be detected at the triple point of the weld, which provides an additional confidence for leakage detection.

Since the cooling shroud and insulation design of the ANO-2 RPV head does not readily allow inspection of the head surface at the CEDM nozzles, Entergy is crediting other means to assess the integrity of the head surface in this region. The primary means that will be used for wastage detection will be the LFECT technique. This technique is capable of determining wastage at or below the top of the nozzle to head annulus including the non-interference fit region. The process has been shown to have a sensitivity that will detect and measure small amounts of carbon steel wastage. In addition, the UT scan can also determine a loss of contact of the nozzle to the base metal of the head. If a leak path is detected, the UT scan can be extended to the top of the annulus to further confirm the presence or absence of interference fit at or near the top of the annulus.

The ability to see below the OD surface of the RPV head with LFECT technology for wastage provides a capability for examination that cannot be determined by the bare metal visual inspection. Therefore, Entergy considers this technique to be superior in this regard to a bare metal visual inspection for identifying wastage in areas that cannot be measured otherwise. The examinations proposed by Entergy address both leakage detection and RPV head integrity.

The proposed alternatives are the same as those proposed and approved by the NRC during the 2R16 RPV head BMV relaxation.

8.0 COMPLIANCE WITH THE ORDER RELAXATION REQUIREMENTS

Entergy believes that the basis for the Order Relaxation is justified given the following:

<u>Hardship or Unusual Difficulty</u> - The ANO-2 cooling shroud and insulation package were not designed to be removed and reinstalled from the top of the head to permit BMV inspections. Additional removal and reinstallation of the cooling shroud and insulation could potentially damage CEDM housings and the insulation without an effective means of repair. Therefore, compliance with the Order would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

<u>Acceptable Level of Safety and Quality</u> - The performance of a volumetric examination of the integrity of the RPV head nozzles along with a leakage path assessment provides the primary means to determine the integrity of the reactor coolant pressure boundary. Entergy will perform this inspection in the upcoming 2R18 refueling outage as required by section IV.C(5)(b) of the Order and with other granted Order Relaxations. Entergy will augment these inspections with the use of the LFECT and triple point examinations. Visual inspection of the ICI nozzles, accessible CEDMs, head flange and other boric acid inspections will still assure that sufficient inspections are performed to detect potential RPV head degradation mechanisms.

The alternate means for ensuring compliance with the intent of the Order are the same as those proposed and conducted during the 2R16 outage. Additional discussion for providing complementary and diverse inspection approaches are provided in Attachment 2.

Therefore, the proposed action for examination of the ANO-2 reactor vessel head will provide an acceptable level of quality and safety to ensure the integrity of the ANO-2 RPV head.

9.0 ENTERGY'S COMPREHENSIVE MANAGEMENT OF ALLOY 600

Even though the ANO-2 RPV head has not experienced PWSCC degradation, to date, Entergy recognizes the need to monitor and maintain the long term integrity of the head and other reactor coolant pressure boundary components. Entergy is procuring a new RPV head, manufactured using Alloy 690 materials which will be onsite for the spring 2008 refueling outage. However, Entergy is unable to install the new head without either cutting containment building opening or modifying the equipment hatch to get the head into the containment building. Entergy is evaluating the appropriate timing for conducting the RPV head replacement. The redesigned cooling shroud can either be installed on the existing head or the replacement head.

Entergy continues to address Alloy 600 material concerns at ANO. Coordination of these repairs and replacements are part of the overall planning strategy for maintenance the reactor coolant pressure boundary integrity of both ANO units. Several examples are noted below:

- Due to heater penetration failures, Entergy is replacing the ANO-2 pressurizer in the upcoming fall 2006 (2R18) refueling outage with a similar design using improved Alloy 690 materials.
- Entergy replaced the ANO-2 steam generators with a similar design using improved Ally 690 materials in the Fall 2000 refueling outage.
- The ANO-1 reactor vessel head and the two once through steam generators, which are a B&W design, were replaced in the fall 2005 refueling outage (1R19) with new components using Alloy 690 nozzle and weld materials.
- Entergy will be performing various Alloy 600 nozzle repairs and mitigation for both units during future refueling outages.

10.0 REFERENCES:

1 NRC letter dated February 20, 2004, Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (0CNA020404)

2 Entergy letter dated May 8, 2003, *Request for Relaxation from Section IV.C(1)(a) of the Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads* (2CAN050301)

3 Entergy letter dated August 27, 2003, *Supplemental Response to the Bare Metal Visual Relaxation Request for ANO-2 Regarding NRC Order EA-03-009* (2CAN080306)

4 NRC letter dated October 9, 2003, *Arkansas Nuclear One, Unit 2 (ANO-2) - Relaxation Request from NRC Order EA-03-009 Regarding the Bare Metal Visual Examination* (2CNA100306)

5 Entergy letter dated June 3, 2002, *30 Day Post Outage Response to NRC Bulletins 2001-01 and 2002-01 for ANO-2 and Follow-up Response to Bulletin 2002-01 for ANO-1 and ANO-2* (0CAN060203)

6 Entergy letter dated December 8, 2003, *60-Day Report for ANO-2 Reactor Pressure Vessel Head Inspection for Refueling Outage 2R16* (2CAN120302)

7 Entergy letter dated June 7, 2005, *60-Day Report for ANO-2 Reactor Pressure Vessel Head and Pressurizer Inspection for Refueling Outage 2R17* (2CAN060503)

8 Entergy letter dated August 2, 2003, *Response to Request for Additional Information on Relaxation from Performing a Bare Metal Visual Inspection on the ANO-2 Reactor Vessel Head* (2CAN080302)

9 Entergy letter dated September 9, 2005, ANO-2 Relaxation Request #5 to NRC First Revised Order EA-03-009 for the Control Element Drive Mechanism Nozzles (CNRO-2005-00048)

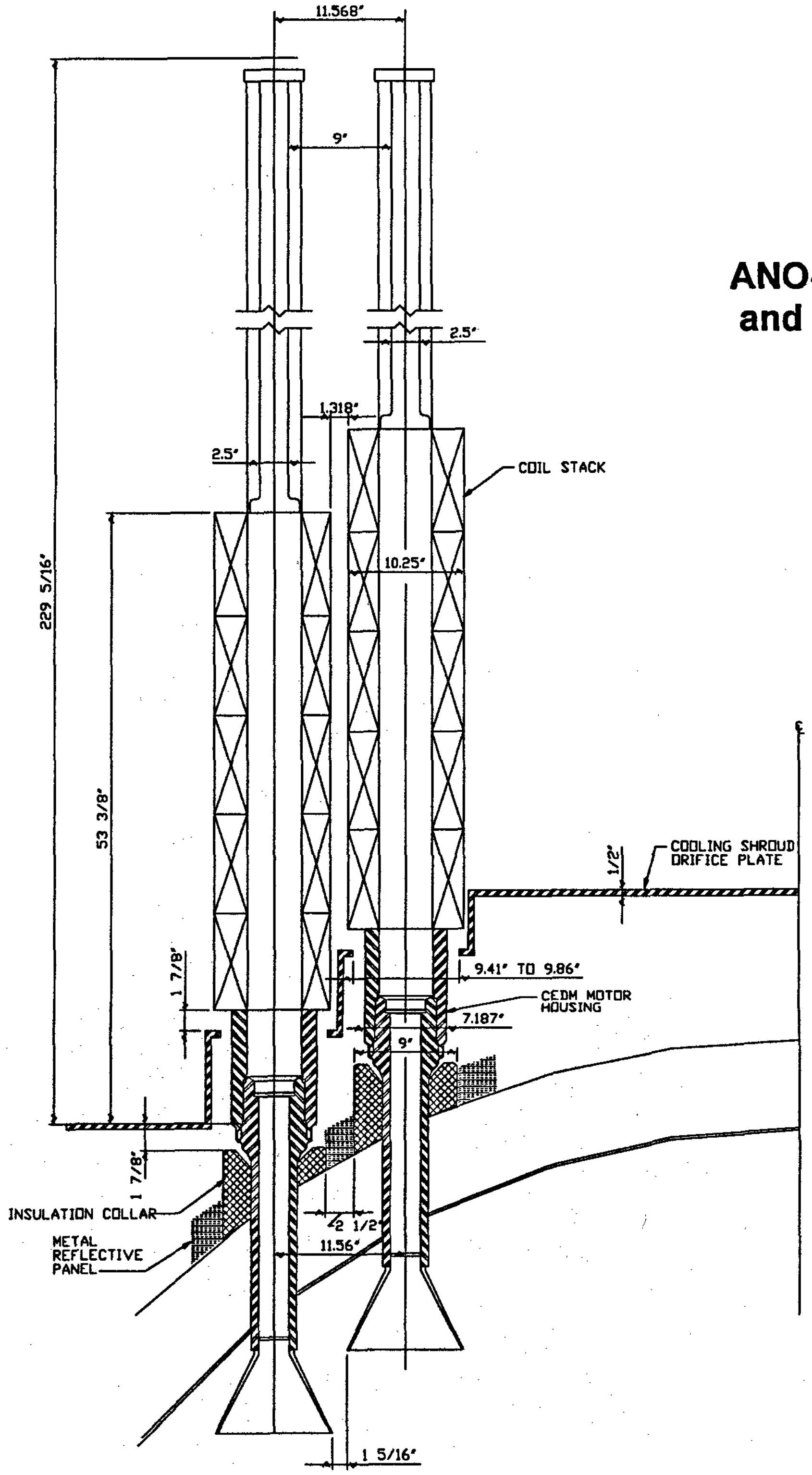


Figure 1
ANO-2 Cooling Shroud and Insulation Design

Attachment 2 to

2CAN040602

Complementary and Diverse Inspection Approaches

Complementary and Diverse Inspection Approaches

The following information is consistent with that provided to the NRC in Entergy letter dated August 27, 2003 (Reference 3 of Attachment 1).

Synergy of Inspection Methods

It is recognized by Entergy that a BMV examination of the top of the reactor head could conceivably detect a leakage path that would represent less than the minimum detectable leak size that is postulated for the LFECT technique. Because of this, LFECT is not considered to be a stand-alone detection method for possible leakage, but is to be used together with the other visual and NDE methods to determine the integrity of a given penetration. Another important factor is that Entergy obtained direct verification of the integrity of the carbon steel surface of the RPV head during the 2R17 refueling outage in 2005. The head showed no degradation and no indications of head penetration leakage or carbon steel wastage.

The ICI nozzles will receive a BMV inspection and the accessible CEDMs will receive a visual inspection, looking for indications of boric acid residue or wastage that may be present. The accessible areas will include the lower portion of the dome and the flange. Any residue that is identified will be thoroughly investigated to determine the extent of its contact with the reactor head, as well as any information as to its source. A visual inspection will also be performed from above the shroud assembly which will have the possibility of detecting leakage that has descended onto the RPV cooling shroud from external sources.

Each penetration will be comprehensively NDE inspected. For each CEDM and ICI penetration tube, a full volumetric TOFD UT examination will be utilized for the purpose of detecting PWSCC indications through the inspectible volume of the penetration tube, including both the ID and OD surfaces. This UT technique also includes the triple-point inspection capability previously discussed. As part of a separate Order relaxation, the inherent volumetric "blind zones" of some nozzles, not supported by crack growth analysis, will be examined by hand-held eddy current or liquid penetrant inspection techniques. The RPV head vent line will involve a wetted surface examination of the J-groove weld and the inner diameter (ID) of the penetration tube for a minimum distance of 2" above the weld. These examinations are expected to detect the initiation of any PWSCC flaws in the Alloy 600 material associated with this penetration.

Also included in the NDE inspection of the CEDM and ICI nozzles is an examination of the "leak path" interference fit region between the penetration tube and the annulus of the reactor head by the zero degree, straight beam UT technique. To address the possibility that no interference fit exists, and to provide a complementary and diverse method of detecting carbon steel degradation in this region, the LFECT will also be used to examine this region. The LFECT examination will supplement the wetted surfaces examination by interrogating the bore of the annulus around this penetration looking for areas of degradation that could be indicative of primary water leakage.

The individual limitations of the techniques are diminished by the diverse and comprehensive detection processes being applied. The decision matrix provides a roadmap for performance of a confirmatory surface examination or BMV in the event of significant metal loss being identified by LFECT. All examination techniques have limitations in detecting flaws. The lower limits of detection for the proposed techniques have not been established, but have been shown to provide sufficient sensitivity to detect flaws that can become safety concerns. The table below provides a summary of each technique limitation and how these limitations are mitigated by the complementary examinations proposed by Energy. As depicted, each technique is supplemented by other inspection and examination processes to ensure that challenges to penetration integrity are identified.

Exam Type	Limitation	*Supplemental examinations or dispositions*
Nozzle UT/ECT examination with Westinghouse inspection probe	Conservatively 10% through wall may not be detectable for certain type of flaws.	If an OD flaw is missed and leakage occurs or propagates into the weld, the triple point exam would detect flaws in the J-groove weld, which have the potential to leak. Additionally, one or more of the following would detect leakage: • The zero degree UT leakage assessment, • the LFECT exam, • the Supplemental visual, • or the BMV of accessible areas of the head.
Triple Point UT examination	Indication can only be found 0.060 deep into the weld and cracks propagating through the butter and leaking may not be found.	Flaws propagating through the weld and leaking have to go through either the triple point or butter to leak. Flaws going through the J-groove weld will be found through the triple point exam. Evidence of flaws propagating through the butter and leaking will be detected with one or more of the following: the zero degree UT leakage assessment exam, the LFECT exam, the Supplemental visual, or the BMV of accessible areas of the head.
Zero degree UT Leakage Assessment Exam	The Zero degree transducer cannot assess leakage for those nozzles with limited or no interference fit.	UT of the nozzle and triple point would assure no leakage through the nozzle or J-groove weld. Additionally, the LFECT exam, the Supplemental visual, and the BMV of accessible areas of the head assure no significant leakage and degradation to the head.
LFECT exam	LFECT is limited by a detection area of 0.022 square inches of metal loss; therefore leakage would not be confirmed until slight degradation has occurred in the annulus region of the bore.	This alternate inspection method is necessary will discern leakage for those nozzles in which an interference fit may not be present or where the flaw propagates through the butter beyond the triple point or through the nozzle above the J-groove weld. The LFECT will detect any significant

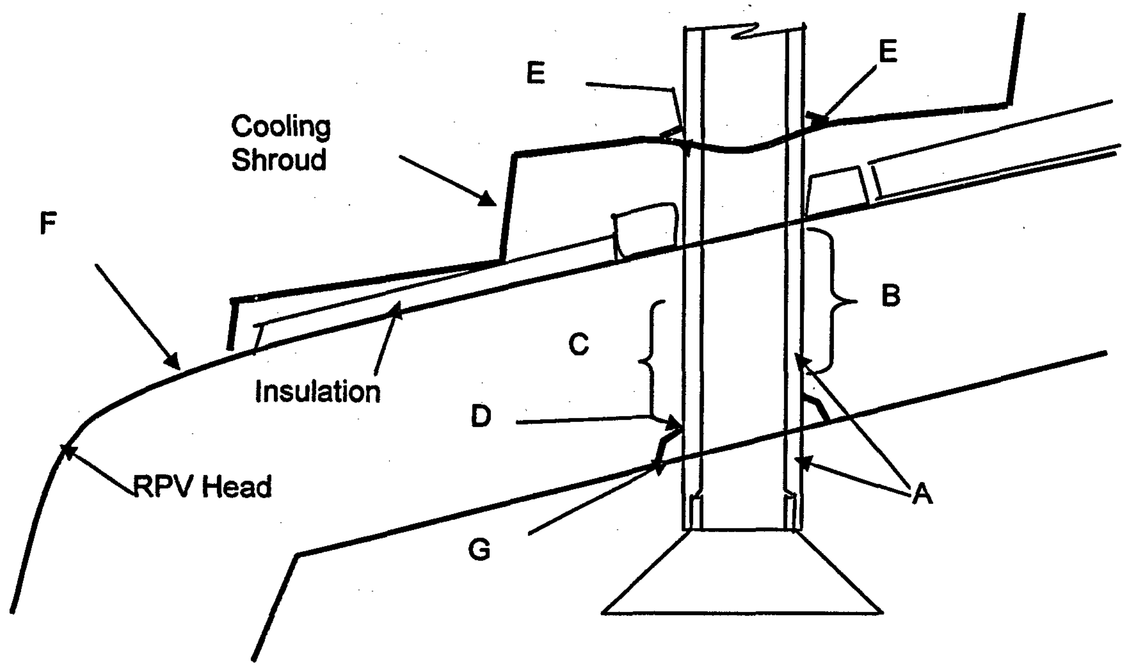
Exam Type	Limitation	*Supplemental examinations or dispositions*
		leakage and minimal head degradation. Additionally, any cracks in the nozzle and triple point will be found with UT, and the visual inspection of the accessible areas of the head will provide other means of detecting potential leakage.

The overall approach for ensuring that an acceptable level of quality and safety is being met is provided by the comprehensive examinations of the ANO-2 RPV head in the forthcoming fall 2006 refueling outage. The basis for this conclusion is provided in the subsequent portion of this response by showing compliance to the Order and not having a significant reduction in the level of quality and safety from the proposed inspection regime.

Comprehensive Approach to ANO-2 Reactor Head Inspection - The unique shroud configuration at ANO-2 creates a hardship in performing the BMV examination to meet the requirements of NRC Order EA-03-009. Because of this hardship, Entergy has developed examination approaches, as well as improvements to some of the traditional inspection techniques in order to provide an overall RPV head inspection approach that provides an acceptable level of quality and safety. The ANO-2 reactor head inspection approach that is being applied in lieu of a BMV inspection is a comprehensive methodology. This inspection regimen is designed to provide defense in depth for detection capability of any PWSCC flaw that could develop in the J-groove weld or penetration nozzle. This comprehensive approach combines the use of several diverse and complementary inspection techniques. These techniques culminate to provide a complete examination and inspection of the RPV head which provides an appropriate level of quality and safety. This complementary inspection approach is best illustrated by the following sketch (Figure 2) which demonstrates 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 the RPV head integrity is maintained.

Figure 2

Complementary Inspection Approach



Primary Examinations

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 LFECT. 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 cooling shroud from above,.

F = **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 will be utilized to further investigate a potential, but indeterminate, indication of a PWSCC flaw found with any of the primary examination techniques.

Attachment 3 to

2CAN040602

LIST OF REGULATORY COMMITMENTS

LIST OF REGULATORY COMMITMENTS

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check one)		SCHED COMP DATE
	ONE-TIME ACTION	CONT. COMP	
Entergy will perform two augmented non-destructive examination (NDE). This will include interrogating partially into the weld metal at the triple point using UT probe and inspecting for wastage of the RPV head using the LF ETC technique.	X		During the fall 2006 refueling outage
Entergy will perform a visual inspection of the ICI nozzles and accessible CEDM nozzles through the cooling shroud access doors	X		During the fall 2006 outage
If a throughwall flaw is detected, Entergy will perform a bare metal visual examination to the extent necessary to assure the structural integrity of the RPV head.	X		During the fall 2006 refueling outage
A conditional examination of the surface J-Groove weld utilizing liquid penetrant or eddy current will be utilized to further investigate a potential, but indeterminate indication of a PWSCC flaw found with any of the primary examination techniques.	X		During the fall 2006 refueling outage
Should there be evidence of corrosive product coming from an inaccessible area on the RPV head, Entergy will notify the NRC of our findings and provide adequate information to the NRC staff that ensures that the RPV head is not degraded in the inaccessible area(s).	X		During the fall 2006 refueling outage