Entergy

Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72801
Tel 501-858-4888

Craig Anderson
Vice President
Operations ANO

0CAN040201

April 1, 2002

Nuclear Regulatory Commission
Document Control Desk
Mail Station OP1-17
Washington, DC 20555

Subject: Arkansas Nuclear One - Units 1 and 2
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6
15 Day Response to NRC Bulletin 2002-01, Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity

REFERENCES:

1. Entergy letter dated September 4, 2001, "30-day Response to NRC Bulletin 2001-01 for ANO-1, Circumferential Cracking of VHP Nozzles" (1CAN090102)
2. Entergy letter dated September 4, 2001, "30-day Response to NRC Bulletin 2001-01 for ANO-2, Circumferential Cracking of VHP Nozzles" (2CAN090102)
3. Entergy letter dated November 15, 2001, "Supplemental Response To NRC Bulletin 2001-01 Regarding ANO-2 Vessel Head Penetration Inspection Scope" (2CAN110102)
4. Entergy letter dated August 23, 2001, "VHS Presentation of ANO-1 CRDM Nozzle Inspections" (1CAN080103)

Dear Sir or Madam:

By letter dated March 18, 2002, the NRC issued Bulletin 2002-01, "Reactor Pressure Vessel Head Degradation And Reactor Coolant Pressure Boundary Integrity", requiring licensees to provide a 15-day response. Attachment 1 provides Entergy Operations, Inc. (Entergy) response for Arkansas Nuclear One (ANO), Units 1 and 2.

This letter is submitted pursuant to 10 CFR 50.54(f) and contains information responding to NRC Bulletin 2002-01 for ANO-1 and ANO-2. Commitments made in this letter are identified in Attachment 2.

A095

I declare under penalty of perjury that the foregoing is true and correct. Executed on April 1, 2002.

Sincerely,

CGA/sab

Attachments
1. 15 Day Response to NRCB 2002-01, Reactor Pressure Vessel Head Degradation And Reactor Coolant Pressure Boundary Integrity
2. List of Regulatory Commitments

cc: Mr. Ellis W. Merschoff
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

Mr. William Reckley
NRR Project Manager Region IV/ANO-1
U. S. Nuclear Regulatory Commission
NRR Mail Stop O-7 D1
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Mr. Thomas W. Alexion
NRR Project Manager Region IV/ANO-2
U. S. Nuclear Regulatory Commission
NRR Mail Stop 04-D-03
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Attachment 1

0CAN040201

# 15 Day Response to NRC Bulletin 2002-01, Reactor Pressure Vessel Head Degradation And Reactor Coolant Pressure Boundary Integrity

## 15 Day Response to NRC Bulletin 2002-01, Reactor Pressure Vessel Head Degradation And Reactor Coolant Pressure Boundary Integrity

**1. Within 15 days of the date of this bulletin, all PWR addressees are required to provide the following:**

**A. a summary of the reactor pressure vessel head inspection and maintenance programs that have been implemented at your plant,**

ANO-1:

At the beginning of each refueling outage, the reactor pressure vessel head is inspected using a remote video camera. The inspections cover 100% of the reactor pressure vessel head and nozzles to identify any boric acid deposits. These inspections are then compared with the previous baseline inspections. Past inspections were performed under the site maintenance instruction process. Based on previous inspection process and industry findings, Entergy has drafted a new ANO procedure (Procedure 2311.009, "ANO Unit 1 and Unit 2 Alloy 600 Inspection"), which has been developed to facilitate these inspections in accordance with Generic Letter 88-05[1] guidelines. In the event boric acid is identified, its source will determined and appropriate actions will be taken in accordance with the Entergy Appendix B Criterion XVI corrective action process.

ANO-1 began its enhanced video inspection program for the reactor vessel during 1R14(Spring 1998). The reactor pressure vessel head was cleaned during 1R14 to improve visual inspection capability (See Entergy response to NRC Bulletin 2001-01 in Reference 1). No degradation to the head or discoloration of boron crystals typical of corrosion/erosion was observed. The head was inspected for any indication of material wastage and to establish a baseline condition using remote video equipment. No discernable material wastage was identified during this inspection. This inspection was repeated during refueling outages 1R15 (Fall 1999) and 1R16 (Spring 2001).

During 1R15, a small "kernel" of boron was observed at the annulus of Control Rod Drive Mechanism (CRDM) nozzle #56. A careful comparison of the 1R14 and 1R15 videos was performed of the areas around the nozzle of CRDM #56. It was concluded that the boron kernel found in that outage appeared to be boron residue that had fallen into the annulus of CRDM nozzle #56 from above the nozzle. If the boron in the annulus resulted from a leak, it was expected that the boron crystals would have been continuous around the circumference of the annulus. In addition, bare metal was observed between the boron residue in the annulus. Therefore, it was concluded that the boron had likely dripped down from the insulation above.

During the 1R16 inspection, a flow path was discovered at the nozzle #56 location. Following repair of the through-wall crack in this nozzle, the outer surface of the

[1] Generic Letter 88-05, "Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants," March 17, 1988

reactor pressure vessel head adjacent to nozzle #56 was cleaned, removing the boric acid residue and the base metal was inspected for material wastage. There was no visual detection of material degradation or related surface corrosion caused by boric acid. The complete reactor pressure vessel head assembly was again cleaned in 1R16 and a new baseline inspection performed using remote video equipment. 100% of the reactor pressure vessel head and nozzles were inspected utilizing two video inspection systems, a video robot developed for the 1R16 inspection and a boroscope. Recognizing that each system possesses unique advantages, both were utilized. Even though 100% of the head was inspected, not all of the nozzle to head annulus could be viewed by the video robot. However, the downhill side of the center nozzles were inspected. To supplement the robot inspection, the boroscope was utilized to view the uphill side of the aforementioned center nozzles (Either the robotic camera or the boroscope is considered acceptable for detecting boric acid deposits on the head). Utilizing both inspection systems, approximately 90% of the nozzle to head annulus was inspected for each of the center nozzles. 100% of the downhill side of the head was inspected for every nozzle. All inspections were recorded on videotape. The only boric acid remaining after cleaning operations was a dry film (staining) at various locations on the surface of the reactor head. The film (staining) shows up on the video inspections as a dry translucent whitewash and should in no way represent a means of boric acid corrosion. No degradation to the reactor pressure vessel head was identified. A copy of a VHS formatted presentation that shows the robotic inspection capability and the as-found boric acid deposits on ANO-1 nozzle #56 was provided to the NRC in Entergy letter dated August 23, 2001 (Reference 4). Copies of the nozzle #56 post-repair inspection video were also provided to ANO's NRC resident inspectors.

ANO-2:

As discussed in response to Question B, the insulation on the ANO-2 reactor head cannot be readily removed. System Engineering personnel examine areas of the head that can be observed (around nozzles and insulation openings) for white/red rust colors which would be indicative of boric acid corrosion. Particular attention is given for possible boric acid build-up in any location on the reactor pressure vessel head. The perimeter of the reactor pressure vessel head is inspected for signs of boric acid coming from under the insulation. The insulation is inspected to determine if it is deformed or relocated for any reason to confirm there is no significant boric acid crystal build-up under the insulation. Additionally, inspections for boric acid that is being pushed up through openings in the insulation are performed. Inservice inspection personnel also routinely perform inspections of the accessible portions of the reactor pressure vessel head including the head-to-head flange weld. These inspections are consistent with the guidance of Generic Letter 88-05. To date, there has not been any evidence that would indicate leakage from any nozzle on the reactor pressure vessel head at ANO-2. In addition, there has been no identified leakage from the Control Element Drive Mechanism (CEDM) pressure housings above the head. Only a light dusting of boron crystals is visible on the insulation and shroud above the head. This dusting is due to venting the CEDMs.

**B. an evaluation of the ability of your inspection and maintenance programs to identify degradation of the reactor pressure vessel head including, thinning, pitting, or other forms of degradation such as the degradation of the reactor pressure vessel head observed at Davis-Besse,**

ANO-1:

The ability to identify external degradation of the reactor pressure vessel head is adequate based on historical inspections and reactor head cleaning efforts. The ANO-1 reactor vessel closure head is accessible such that high quality video and boroscope inspections can be performed (for the B&W head, the insulation is up off the head, and the video equipment can be easily maneuvered under the insulation). As previously stated, both remote video robot and boroscope inspection techniques are utilized. There are a few areas of the annulus around the center nine (9) nozzles that the video robot cannot access due to interference with the insulation structure. Even though 100% of the reactor pressure vessel head is inspected, not all of the nozzle to reactor pressure vessel head annulus is viewed by the video robot. However, the downhill side of the center nozzles can be inspected. In order to supplement the robot inspection, the boroscope is utilized to view the uphill side of the aforementioned center nozzles. Procedure 2311.009 will require that a team review the results of each nozzle inspection.

Entergy is confident that the inspection techniques utilized are adequate to identify any Reactor Coolant System leakage and provide data to accurately assess potential material wastage of the head.

ANO-2:

The ability to identify Reactor Coolant System leakage through any of the reactor pressure vessel head penetrations is acceptable based on boric acid inspections to date. It is not possible to perform a 100% bare metal visual examination of the ANO-2 reactor pressure vessel head without completely removing the reactor pressure vessel head closure assembly. Insulation is in contact with the reactor pressure vessel head and covers a majority of the reactor pressure vessel head surface. The insulation around the CEDM and instrument nozzles does not allow inspection of nozzle to reactor pressure vessel head interface. All welds on the nozzle and CEDM components except for the J-weld on the inside diameter of the head are above the insulation. If any leaks were to occur on any of these welded joints, boron crystals could readily be seen from above. Inspections are performed every cycle in accordance with Generic Letter 88-05. There has been no indication of boric acid build-up or leakage from any nozzle. Since there has been no identified leakage, Entergy has no reason to believe that reactor pressure vessel head degradation has not occurred at ANO-2. The following discussion provides the bases for that conclusion.

Per NUREG/CR-6245[2], leakage over a significant amount of time (six to nine years) and significant amounts of boric acid (~12 cubic feet of crystals) would be required to

[2] "Assessment of Pressurized Water Reactor Control Rod Drive Mechanism Nozzle Cracking," October 1994, Pages iii, xii, and 28

corrode the reactor pressure vessel head to a point where it challenges the structural integrity of the reactor pressure vessel head. Per CE Owners Group Reports CEN-607[3], CEN-614[4], and NUREG/CR-6245, it is highly unlikely that the evidence of this leakage would go undetected over a six to nine year period (i.e., approximately four to six GL 88-05 inspections). Twelve cubic feet of boric acid crystals is equivalent to 1000 pounds of boric acid. If corrosion were approximately proportional to leakage, then several tenths of a gpm over several years would be required to threaten the structural integrity of the reactor pressure vessel head.

Recently, through the EPRI Material Reliability Program (MRP), personnel at Davis-Besse who are participating in the root cause evaluation briefed the PWR fleet on the likely root cause surrounding the Davis Besse head wastage condition. During this briefing, it was revealed that significant amounts of boric acid crystals had been evident on the reactor head in the area of the wastage for several years prior to the discovery of the wastage. It was also noted that evidence of this leakage was visible down near the flange of the RPV head. The conditions at Davis-Besse, as described above, are consistent with the conditions that would be expected to be present to cause such wastage as described in NUREG/CR-6245 (i.e., large amounts of boric acid crystals over a period six to nine years and evidence of continuous leakage). This conclusion is consistent with the initial Probable Cause Summary Report from Davis Besse.

Additionally, Combustion Engineering (CE) Owners Group document CE NPSD-690-P[5] has previously evaluated inspecting the small bore Inconel 600 nozzles that could leak due to leakage from Primary Water Stress Corrosion Cracking (PWSCC) without removing the insulation. The document reports that if 10 pounds of boron crystals were to build-up due to PWSCC leakage, the boron would either extrude from the annulus region between the insulation and nozzle or from the insulation seams. Although this report was written for the small bore penetrations, it is considered valid for Entergy's CE reactor pressure vessel heads which includes ANO-2.

Based on the GL 88-05 inspections along with other routine inspections of the ANO-2 reactor pressure vessel head per question "A" above, Entergy has not identified any boric acid leakage that would indicate the conditions for reactor head wastage at ANO-2. Entergy will conduct a volumetric inspection of 100% of the RPV nozzles during the upcoming outage scheduled to begin in April 2002 (See Reference 3).

---

[3] "Safety Evaluation of the Potential for and Consequences of Reactor Vessel Head Penetration Alloy 600 ID-Initiated Nozzle Cracking" (May 1993) Page 3-21 and 3-22

[4] "Safety Evaluation of the Potential for and Consequences of Reactor Vessel Head Penetration Alloy 600 OD-Initiated Nozzle Cracking" (December 1993), Page 2-14 and 2-15

[5] CE NPSD-690-P, Evaluation of Pressurizer Penetrations and Evaluation of Corrosion after Unidentified Leakage Develops, January 1992.

**C. a description of any conditions identified (chemical deposits, head degradation) through the inspection and maintenance programs described in 1.A that could have led to degradation and the corrective actions taken to address such conditions,**

ANO-1:

As discussed in response to 1.A, during 1R16 a flow path was discovered at the bottom of nozzle #56. Following repair of the nozzle, the outer surface of the reactor pressure vessel head at nozzle #56 was cleaned, removing the boric acid residue, and the base metal inspected for material wastage. There was no visual detection of boric acid material degradation or related surface corrosion. The complete reactor pressure vessel head assembly was again cleaned and a new baseline inspection performed using the video robot and boroscope where 100% of the reactor pressure vessel head and nozzles were inspected. The inspections were recorded on videotape. No observable degradation to the reactor pressure vessel head was found. A copy of a VHS formatted presentation that shows the robotic inspection capability was provided to the NRC in Entergy letter dated August 23, 2001 (Ref. 4). Copies of the post-repair inspection video were also provided to the ANO resident NRC inspectors. No attempt was made to quantify the amount of leakage from nozzle #56 but it is estimated that the boron accumulation on top of the head was less than a few ounces. Due to this small amount of accumulation, there is no reason to believe that there has been corrosion to the head either within the annulus or at the top of the annulus.

ANO-2:

As discussed in response to 1.A, the GL 88-05 inspections of ANO-2 have not identified any boric acid deposits that would indicate the presence of a nozzle leak or boric acid leakage from above the head. The only boric acid noted from the inspections is a fine dust of boric acid powder over portions of reactor pressure vessel head insulation and CEDM components. The powder is very thinly and homogeneously distributed across many surfaces of the reactor pressure vessel head insulation above the reactor head. The powder is from venting of the CEDMs. Venting CEDMs produces very little boric acid residue and is estimated to be on the order of ounces. The dust from venting operations is easily discernable from the crystals formed from nozzle leakage. The very small amount of boric acid and distribution of the boric acid precludes concentrations that could harm the reactor pressure vessel head.

Entergy has no indication that any significant volumes of the boric acid have migrated to the reactor pressure vessel head because of the small volumes of boric acid found to date. In addition, based on all known boric acid degradation mechanisms, boric acid requires continuous wetting at the boric acid/carbon steel interface to produce wastage. This condition would not exist based on simple venting of the CEDMs without additional sources of moisture. The dust does not interfere with GL 88-05 inspections. ANO-2 has not identified any evidence of boric acid that would indicate leakage on the head.

**D. your schedule, plans, and basis for future inspections of the reactor pressure vessel head and penetration nozzles. This should include the inspection method(s), scope, frequency, qualification requirements, and acceptance criteria, and**

ANO-1:

Entergy will perform a qualified visual examination in accordance with procedure 2311.009, "ANO Unit 1 and Unit 2 Alloy 600 Inspection" during 1R17 (the next refueling outage scheduled for the fall of 2002). The scope and inspection methods will be similar to those conducted at previous outages. The surface of the head will be inspected for degradation. If throughwall or throughweld cracks are found and a concentration of boron is found protruding through the annulus region of the penetration, an evaluation will be performed to determine if there is a potential for wastage of the adjacent vessel material.

The visual examination will reconfirm the as-left 1R16 condition of the reactor head and determine if there is any measurable corrosion to the reactor head. The scope of future inspections will be based on the findings of the forthcoming 1R17 outage and the root cause findings at other facilities.

ANO-2:

For ANO-2, Entergy will continue performing GL 88-05 inspections in accordance with Procedure 2311.009. Additionally, volumetric examination of 100% of the reactor pressure vessel head penetrations will be performed during the next scheduled refueling outage 2R15 (April 2002). If throughwall or throughweld cracks are found and a concentration of boron is found protruding through the annulus region of the penetration, an evaluation will be performed to determine if there is a potential for wastage of the adjacent vessel material.

Based on the findings at Davis Besse, Entergy will consider any new criteria for wastage determination in our future boric acid inspections.

**E. your conclusion regarding whether there is reasonable assurance that regulatory requirements are currently being met (see the Applicable Regulatory Requirements, above). This discussion should also explain your basis for concluding that the inspections discussed in response to Item 1.D will provide reasonable assurance that these regulatory requirements will continue to be met. Include the following specific information in this discussion:**

**(1) If your evaluation does not support the conclusion that there is reasonable assurance that regulatory requirements are being met, discuss your plans for plant shutdown and inspection.**

**(2) If your evaluation supports the conclusion that there is reasonable assurance that regulatory requirements are being met, provide your basis for concluding that all regulatory requirements discussed in the Applicable Regulatory Requirements section will continue to be met until the inspections are performed.**

ANO-1 and ANO-2:

As discussed in Entergy's responses to Bulletin 2001-01 (Ref. 1 and 2), regulatory requirements are being met based on the current inspections being conducted at ANO. Based on current industry knowledge, significant material wastage (including sub-surface cavities) requires a through-wall leak or leakage from above the head onto the reactor vessel under a wetted condition. Additionally, significant boric acid concentrations must exist on the head over an extended period of time to accomplish significant degradation. Based on known information to date, there would have to exist a nozzle leak or a sustained wetted surface in the presence of boric acid to cause significant wastage to the carbon steel.

For ANO-1, only a few ounces of boron was found due to the primary water stress corrosion crack found on nozzle #56; hence, no measurable corrosion is considered probable in the annulus region between the nozzle and vessel. No other CRDM nozzles have been found with PWSCC leaks. Therefore, no significant corrosion/erosion in the annulus region is believed to have occurred. Additionally, all boron from past flange leakage from above the head has been removed by cleaning, and no corrosion to the vessel surface has been found. No measurable corrosion/wastage was identified in 1R16 from these inspections.

The inspections conducted to date were adequate to identify any discernable degradation of the reactor pressure vessel head. The identification of the through-wall crack at nozzle #56 attests to the adequacy of our programs. The crack was identified before any significant boric acid buildup or discernable material wastage occurred. The repair of nozzle #56 restored the reactor vessel head to within regulatory requirements and subsequent inspections will verify that this compliance is maintained or identify leakage before it results in significant material wastage. In addition, Entergy will continue to follow the root cause findings at the Davis Besse facility and make appropriate changes to our inspection program.

For ANO-2, no condition has been identified on the reactor head that would indicate that boric acid is present and that corrosion could occur. Although the ANO-2 head cannot be fully inspected visually, the examinations that are conducted are sufficient to identify any significant leakage that could ultimately result in material wastage. Additionally, the 100% volumetric inspection to be conducted during the upcoming refueling outage in April 2002 will further ensure that compliance with regulatory requirements is maintained. If throughwall or throughweld indications are found further evaluations will be performed to ensure that no significant degradation has occurred to the reactor head.

Attachment 2

0CAN040201

# 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) | | SCHEDULED COMPLETION DATE (If Required) |
|---|---|---|---|
| | ONE-TIME ACTION | CONTINUING COMPLIANCE | |
| Entergy will perform a qualified visual examination in accordance with procedure 2311.009 during 1R17 (the next refueling outage scheduled for the fall of 2002). The surface of the head will be inspected for degradation If throughwall or throughweld cracks are found and a concentration of boron is found protruding through the annulus region of the penetration, an evaluation will be performed to determine if there is a potential for wastage of the adjacent vessel material. | X | | 1R17<br>Fall 2002 |
| Based on the findings at Davis Besse, Entergy will consider any new criteria for wastage determination in our inspections. | | X | To Be Determined |
| For ANO-2, Entergy will perform an inspection in accordance with procedure 2311.009. If throughwall or throughweld cracks are found and a concentration of boron is found protruding through the annulus region of the penetration, an evaluation will be performed to determine if there is a potential for wastage of the adjacent vessel material. | X | | 2R15<br>April 2002 |