Entergy

Entergy Operations, Inc.
1448 S R 333
Russellville, AR 72802
Tel 501 858 5000

1CAN100203

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Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555-0001

SUBJECT: Arkansas Nuclear One - Unit 1
Docket No. 50-313
Supplemental Response to NRC Bulletin 2002-02 for Arkansas Nuclear One, Unit 1

REFERENCES:

1. Entergy letter dated September 9, 2002, *Entergy 30-Day Response to NRC Bulletin 2002-02, for Arkansas Nuclear One, Unit 1* (1CAN090202)
2. Entergy letter dated September 4, 2001, *30-day Response to NRC Bulletin 2001-01 for ANO-1, Circumferential Cracking of VHP Nozzles* (1CAN090102)
3. Entergy letter dated April 1, 2002, *15-Day Response to NRC Bulletin 2002-01, Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity* (0CAN040201)

Dear Sir or Madam:

On August 9, 2002, the NRC issued NRC Bulletin 2002-02, *Reactor Pressure Vessel Head And Vessel Head Penetration Nozzle Inspection Programs* requiring licensees to provide a 30-day response to the requested information. The Arkansas Nuclear One, Unit 1 (ANO-1) response was provided to the NRC on September 9, 2002 (Reference 1), that stated that Entergy would conduct volumetric examinations on the accessible reactor vessel head penetration (VHP) nozzles using a blade probe in addition to the bare metal visual inspections.

Entergy recognized that NRC Bulletin 2002-02 provided an example inspection including a combination of bare metal visual inspections, volumetric examinations of the nozzles and examination of the J-groove weld. As previously provided in our response to NRC Bulletins 2001-01 and 2002-01 (References 2 and 3), Entergy believes that bare metal visual examinations are adequate to identify primary water stress corrosion cracking flaws before they become a safety concern. However, in our response to NRC Bulletin 2002-02, Entergy committed to perform an additional volumetric examination of the reactor vessel head penetration nozzles except for the center nozzle (nozzle 1) which contains the post-accident reactor vessel water level (RADCAL) instrument. On October 18, 2002, Entergy

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was provided a request for additional information (RAI) from the NRC, which was further discussed with the Staff on October 22, 2002. The RAI requested Entergy provide additional information regarding the basis for not conducting examinations of the VHP J-groove welds and the basis for not performing inspection of Nozzle 1 containing the RADCAL instrument. The attachment provides the Entergy response to the NRC RAI on NRC Bulletin 2002-02 for ANO-1. Nozzle 1 containing the RADCAL instrument has been volumetrically examined during this outage and no further commitments are being made.

This letter is submitted pursuant to 10CFR50.54(f) and contains information responding to NRC Bulletin 2002-02 for ANO-1.

I declare under penalty of perjury that the foregoing is true and correct. Executed on October 31, 2002.

Sincerely,

Sherrie R. Cotton

Sherrie R. Cotton
Director, Nuclear Safety Assurance

SRC/sab

Attachment: Supplemental ANO-1 Response to NRC Bulletin 2002-02, *Reactor Pressure Vessel Head And Vessel Head Penetration Nozzle Inspection Programs*

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

U. S. Nuclear Regulatory Commission
Mr. William Reckley
Washington DC 20555-0001

Attachment

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Supplemental ANO-1 Response to NRC Bulletin 2002-02, *Reactor Pressure Vessel Head And Vessel Head Penetration Nozzle Inspection Programs*

Supplemental ANO-1 Response to NRC Bulletin 2002-02, *Reactor Pressure Vessel Head And Vessel Head Penetration Nozzle Inspection Programs*

Requested Information

1. In Entergy's 30-day response to NRC Bulletin 2002-02 for Arkansas Nuclear One, Unit 1, on page 3 of 5, the scope of the reactor pressure vessel (RPV) head inspections for refueling outage IR17 is described. The inspection scope is limited to bare metal visual examination of the RPV head and volumetric examination of 68 of 69 the RPV head penetrations. As a result of recent inspection findings at North Anna, Unit 2, the NRC has concerns about the combination of non-destructive examinations and the inspection scope of the RPV head during refueling outage 1R17. The concern is that through-weld cracks in the J-groove welds may provide the conditions that could lead to circumferential cracking in the nozzle base material at or above the J-groove weld with no visual indications of leakage deposits on the RPV head.

   The licensee for North Anna, Unit 2, has identified circumferential cracks in nozzles examined with ultrasonic testing and indications were identified on the J-groove weld for a high percentage of the penetrations. According to the licensee for North Anna, Unit 2, there were no visual indications of boric acid deposits on the surface of the RPV head at all of these nozzles. This finding, if verified, indicates that cracks in the J-groove welds may provide the conditions that could lead to circumferential cracking in the nozzle base material at or above the J-groove weld with no visual indications of leakage deposits on the surface of the RPV head.

   Considering the discussion above, please supplement your Bulletin 2002-02 response with a discussion of whether the findings at North Anna, Unit 2, alters your decision to not directly examine the J-groove welds of all of the 69 nozzles.

Response:

Difference Between B&W Designed Reactor Vessel Heads and Heads Similar to North Anna

During a control rod drive mechanism (CRDM) nozzle inspection at Ringhals Unit 2 in 1992, an indication was detected in the nozzle-to-vessel (J-groove) weld at one penetration. The indication was not indicative of primary water stress corrosion cracking (PWSCC); rather the indication was attributed to a weld defect that occurred during fabrication of the CRDM nozzle to the reactor vessel (RV) weld. Studies performed on the Ringhals head indicated that the concern was a lack of fusion not associated with PWSCC. This concern with the lack of weld metal fusion is similar to that being experienced at North Anna-2. The experience to date with flaws related to B&W heads including that of Arkansas Nuclear One, Unit 1 (ANO-1) have not shown that a lack of fusion exists in any of the J-groove welds or in the interface between the butter and the RV base metal. The flaws experienced at B&W facilities are within the weld material itself or within the nozzle and are a result of PWSCC.

Consequences of A Flaw in a J-Groove Weld on a B&W Head

The safety concern for Alloy 600 PWSCC associated with vessel head penetrations (VHPs) has historically been considered to be the potential impact on generating circumferential cracking in the nozzle wall above the J-groove weld, which would have the potential to release a VHP and result in a loss of coolant accident. Other concerns such as wastage have become a potential safety concern as a result of the event at Davis Besse.

PWSCC cracking of the J-groove weld results in fracturing of the Alloy 600 metal that can be either axial or circumferential in orientation. PWSCC flaws are associated with fracturing of grain boundaries when under elevated temperatures in the presence of reactor coolant water chemistry. Flaws associated with PWSCC do not involve a lack of fusion between the weld and the penetration nozzle itself. For a J-groove weld flaw to become a safety concern for the gross loss of the reactor coolant pressure boundary, a complete severing of the weld from the nozzle would have to occur. Experience with J-groove weld flaws in contact with the nozzle primarily results in axial flaws that do not represent a concern with the bonding of the weld material to the nozzle. Even though circumferential flaws within the weld itself occur they also do not present a safety concern since there is adequate fusion to the nozzle from the weld remnant to ensure that the penetration is not released. Therefore, there is no safety concern with PWSCC flaws within the J-groove weld.

In addition, Entergy performed a review of licensee event reports (LERs) of the reactor vessel head penetrations, up to the recent fall outages, that have been experienced by B&W facilities. In review of these LERs, including discussion with certain licensees, VHP flaws that have been throughweld have also had an outer diameter (OD) nozzle flaw associated with the leak except for Three Mile Island, Unit 1 (TMI). In the case of TMI, they did not appear to detect any OD flaw in the CRDM nozzle associated with several of their pressure boundary leaks. However, in the other B&W inspections, it is concluded that PWSCC weld cracking was also evidenced by nozzle flaws. Therefore, a J-groove weld flaw would have a relatively high probability of being detected as a result of ultrasonic examination of the nozzles.

Reliability of a Throughweld Leak to be Identified During VHP Outage Inspections

Qualified Bare Metal Visual (BMV) Inspection - The 1R17 BMV inspections were performed by personnel from multiple site disciplines including those who performed the inspections during 1R16. The inspection team included personnel qualified to the requirements of ASME Section XI for performing VT-2 examinations. Personnel on the team are knowledgeable in the detection and discrimination of leakage evidenced by the accumulation of boron deposits. The knowledge gained from the flaws identified at ANO-1, Oconee and other sites has enhanced the ability of our inspection team for boric acid deposit characterization. The inspection techniques are consistent with those that have been proven successful in the detection of boron accumulation indicative of leakage.

The results of the 1R17 BMV indicated that there was only one throughwall/ throughweld leak, which was associated with nozzle 56. Other BMV nozzles were

dispositioned based on either not having any telltale boric acid deposits present or where there was no distinguishable change from previous baseline inspections. In all cases only nozzle 56 showed any boric acid flow from the nozzle annulus.

Annulus Gap Determination - Even though the conditions reported for CRDM nozzle 56 provide evidence that throughwall leakage can be detected by top head visual inspections, Entergy, with the assistance of Structural Integrity Inc, has performed analysis of the as-built dimensional fits for the CRDM nozzles in the ANO-1 head. The analysis consisted of a finite element model to include the upper hemispherical head, the upper closure flange and the CRDM housing nozzles. The finite element model for the gap analysis was used to support leak determinations and fracture mechanics evaluations. For the gap analysis, the worst (or largest) interference values were modeled to minimize the gap opening and thus the leak rate. As a result, it was shown that all nozzle interferences have sufficient gap to provide a leakage path.

Therefore, any throughwall or throughweld leak has a high certainty that leakage into the CRDM annulus will manifest itself on the reactor vessel head in the form of boric acid deposits around the nozzle annulus.

Volumetric Examinations to be Performed on ANO-1 for the 1R17 Outage- The Westinghouse supplemental examination of the ANO-1 VHPs used an axial shooting time of flight diffraction (TOFD) 24pcs (probe center spacing) transducer for their ultrasonic examination methods. Even though the primary examination used the blade probe, Entergy also used the Westinghouse open housing ultrasonic probe if control rod drives were planned for removal or where only partial data was able to be obtained from the blade probe. In addition, due to equipment problems experienced while performing ultrasonic examination during the current 1R17 outage, Entergy contracted with Framatome Technologies to assist in completing the ultrasonic examinations. The ultrasonic probes and transducers utilized by Framatome are similar to those being employed by Westinghouse and have been used at other B&W facilities. Both the Westinghouse and Framatome transducers have been demonstrated by EPRI to detect axial and circumferential flaws within the nozzle.

Since the primary safety concern associated with VHPs is the release of a nozzle, the volumetric examination will assure that there are no flaws in the nozzle that are being left in service.

Leak Path Determination above the J-Groove Weld – The transducers on the Westinghouse and Framatome blade probes, as well as the Westinghouse open housing probe, have the ability to see signals corresponding to the backwall of the nozzle to investigate the integrity of the nozzle-to-shell shrinkfit area. The data shows that the shrink fit used in construction of most RV heads is sufficiently tight to transmit measurable portions of the sound energy through the contacting interface while the majority of the energy is reflected. The difference in the energy level reflected off the backwall between areas where the fit is tight, and areas where contact is lost due to corrosion, is utilized to investigate the integrity of the nozzle shrinkfit. This can identify an area where leakage may have occurred. Even though this process has not been demonstrated through EPRI testing, it does provide additional information of VHP annulus continuity.

The ultrasonic examinations of the ANO-1 nozzles do not show a leak path present on any nozzles except for nozzle 56, which has been determined to be leaking. Nozzle 39 ultrasonic data did not show a clear interference fit contact above the weld. However, there was no indication of any flaws from the ultrasonic data or evidence of leakage from the bare metal visual inspection for nozzle 39. This information further confirms that leakage has not occurred in the nozzle annulus for other ANO-1 VHPs besides nozzle 56.

1R17 Findings for Flaws in ANO-1 Nozzles and Welds

Nozzle 56 – The qualified bare metal visual inspection identified this nozzle to be leaking during the previous cycle operation. Volumetric examination of the nozzle revealed six flaws in the OD portion nozzle wall. These flaws were axial in extent and did not indicate any circumferential orientation. This nozzle also contained the flaw that was repaired during the previous 1R16 outage (spring 2001). The 1R16 repair excavated the flaw below the 82/182 buttering and the remaining flaw was embedded with 052 weld material. Four of the indications from the ultrasonic examinations were in the area of the repair, which is believed to contain the leak path. Dye penetrant examinations were also performed that revealed cracking around the weld repair in the neighboring 082/182 weld material. There was no indication of any wastage at the annulus of the nozzle.

Other Nozzles Identified for Repair during 1R17 – Seven additional nozzles were determined to require repair during 1R17. Six of the repairs were based on indications from volumetric examinations of the nozzles and one was identified based on a rounded "porosity" indication in a J-groove weld discovered with the dye penetrant (PT) examination. The volumetric examinations of the six nozzles all showed varying lengths and depths of axial cracking below or into the J-groove weld in the OD of the nozzles. None of the indications extended above the J-groove weld into the annulus. In addition, none of the indications were identified to be circumferential. The VHP flaws identified on ANO-1 are consistent with flaws associated with early PWSCC cracking. On nozzle 54 a confirmatory PT examination was performed on the nozzle OD and the portion of the J-groove weld in the area of the ultrasonic examinations. Even though several flaws were identified in the nozzle, there were no indications of flaws in the J-groove weld.

Based on the above, it is concluded that ultrasonic examinations of the nozzle will sufficiently reveal nozzle and nozzle-to-weld interface conditions that would indicate a susceptible leak path to the annulus.

Evaluation of Other NDE Techniques for Performing Effective Weld Metal Examinations

Resources to support the RV head inspection for ANO-1 have been dedicated to the bare metal visual inspection and the use of ultrasonic techniques to characterize any flaws identified. The only J-groove weld inspections planned involved performing a PT examination where the volumetric examinations did not provide sufficient information for repairs. This PT process is very dose intensive. In light of recent J-groove weld inspection concerns and in preparation for the 1R17 outage, Entergy considered

various options for performing examination of the weld region from a broader scope. However, a complete examination of the J-groove welds created a significant challenge to resources, technology and maintaining doses as low as reasonably achievable.

Conclusions

The following points provide the basis for the adequacy of the current bare metal visual and volumetric examinations performed at ANO-1 to not require additional inspection of the J-groove welds:

- The J-groove weld buttering interface condition at North Anna provides a different failure mechanism than any experienced on B&W heads.
- Qualified bare metal visual inspections of the ANO-1 head provide assurance that leakage onto the RV head will be detected. The ANO-1 reactor vessel head is accessible such that video and boroscope inspections can be performed.
- Analysis has been performed of the nozzle to RV head interference fit to ensure that a gap exists and that leakage into the nozzle annulus will be manifested on the reactor pressure vessel head.
- Volumetric examination of the VHP nozzles have been demonstrated to detect PWSCC flaws in the nozzle wall. All PWSCC flaws will be repaired prior to heatup.
- The flaws identified during 1R17 in the ANO-1 VHPs are typical of early PWSCC degradation and are axially oriented. No flaws were identified to be circumferential.
- A "leak path" evaluation of the ultrasonic data has further confirmed that there is no indication of a leak through the VHP nozzle annulus (except for nozzle 56, which was confirmed to be leaking by bare metal visual inspection).
- Even though J-groove weld flaws may propagate faster than flaws in the nozzle, the VHP flaws experienced within the industry still preserve sufficient bonding to the nozzle and do not pose a safety concern.
- Sufficient margins exist to ensure safety while at the same time providing the opportunity for timely discovery and performance of effective repairs.

Entergy concludes that leakage through a weld is not a safety concern. However, any PWSCC flaw identified is an RCS boundary integrity concern and requires correction upon discovery. Therefore, Entergy believes that performing additional examinations of the J-groove weld would not provide significantly different information to that already being provided by the BMV and volumetric examinations to justify the additional personnel doses.

Requested Information

2. In Entergy's 30-day response to NRC Bulletin 2002-02 for Arkansas Nuclear One, Unit 1, on page 3 of 6, it is stated that volumetric examination of nozzle 1 may be performed if the visual inspection of the nozzle is inconclusive. In the bulletin response, it is explained that the basis for excluding nozzle 1 from the scope of the volumetric examination is that a RADCAL instrument would have to be removed, but a technical/safety basis is not provided.

   The staff acknowledges discussions held during the meeting on October 16, 2002, and follow-up discussions on October 17 and 18, 2002. Information you provided during those discussions does not provide sufficient technical justification to exclude nozzle 1 from volumetric examination.

   What is the technical/safety basis for excluding nozzle 1 from the scope of the volumetric examination? Specifically, what is the technical justification that nozzle 1 does not have a circumferential crack which may lead to nozzle ejection?

Response:

Based on further discussions with members of NRC management, Entergy removed the RADCAL instrument from Nozzle 1 and perform a volumetric examination of the nozzle. The volumetric examination of the nozzle was performed using an open housing probe. There were no identified flaws in nozzle 1. Therefore, all ANO-1 VHP nozzles were volumetrically examined.