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Subject: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Additional Information Regarding Reactor Pressure Vessel Integrity

Gentlemen:

By letter dated August 13, 1998 (2CNA089803), the NRC requested additional information regarding the response to Generic Letter 92-01, Revision 1, Supplement 1, "Reactor Vessel Structural Integrity," for Arkansas Nuclear One, Unit 2 (ANO-2). The Staff requested further information within 75 days in order to complete their assessment of the ANO-2 response. Attached please find the requested information.

Should you have any further questions, please contact me.

Very truly yours,

Jimmy D. Vandergrift

Jimmy D. Vandergrift
Director, Nuclear Safety

JDV/nbm
Attachment

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Generic Letter 92-01, Revision 1, Supplement 1 Additional Information

1. **With regard to upper/intermediate shell circumferential weld 8-203, weld wire heat number 10137, the revised chemistries from the Combustion Engineering Owners Group (CEOG) report dated July 1997 were provided. However, the submittal stated that this weld was not included in the evaluation because its fluence is lower than any of the other components. In order to obtain the correct docketed values for weld 8-203, please provide, (a) fluence at expiration of license (EOL), (b) ΔRT_{NDT} at EOL, (c) margin term, and (d) RT_{PTS} at EOL.**

   (a) Fluence at EOL:

   The fluence to weld 8-203 was determined using the same methodology that was used to determine the fluence to the other welds and plates. The one difference between the calculation of the fluence to this weld and the other welds and plates is the starting point. The inside surface fluence at the end of 1.69 EFPY was reported to be 1.78 E+18 n/cm^2 for all welds and plates except 8-203. This weld's inside surface fluence is listed as 0.513 E+18 n/cm^2. Based on the above information, the inside surface fluence at EOL (32 EFPY) was determined to be 7.17 E +18 n/cm^2.

   (b) ΔRT_{NDT} at EOL:

   The shift in the reference temperature is determined, in accordance with Regulatory Guide 1.99, Revision 2, by the following equation:

   $$\Delta RT_{NDT} = (CF)f^{(0.28-0.10\log f)}$$

   The term, $f^{(0.28-0.10\log f)}$, is the fluence factor and is determined by calculation or from a figure in Regulatory Guide 1.99, Revision 2, and the "f" is in terms of E+19. This term accounts for the fluence at some distance from the inner surface of the vessel. In this case, the inner surface of the vessel is the fluence of concern.

   The chemistry factor is "CF", which is a function of the copper and nickel content of the material in question.

   Based on the information provided in (a), the value for "f" in the above equation is 0.717, and the fluence factor was determined to be 0.907.

   The revised copper and nickel content for this weld is 0.216% and 0.043%, respectively. Using Table 1 of Regulatory Guide 1.99, Revision 2, a chemistry factor of 98.3 can be obtained. Multiplying the fluence factor and the chemistry factor together, the shift in the reference temperature is calculated to be 89.2°F.

(c) Margin Term:

The margin term was calculated in accordance with Regulatory Guide 1.99, Revision 2.

$$\text{Margin} = 2\,(\sigma_i^2 + \sigma_\Delta^2)^{1/2}$$

The σ_I term is equal to 0°F since the initial RT_{NDT} was determined by testing of the material. The σ_Δ term is equal to 28°F since the material in question is a weld. Based on the above, the margin term was determined to be 56°F.

(d) RT_{PTS} at EOL:

According to 10CFR50.61 the following equation is used to determine the RT_{PTS}:

$$RT_{PTS} = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin}$$

Based on the results above, ΔRT_{NDT} = 89.2°F and the margin term is 56°F. The measured Initial RT_{NDT} = -60°F, therefore,

$$RT_{PTS} = -60°F + 89.2°F + 56°F = 85.2°F$$

2. **The submittal states that Reference 18 (Report 96-R-2030-02, Revision 0, "Revised Reactor Vessel Fluence Determination") provides the details of the fluence evaluation described on pages 15 and 16. Please provide this reference or your most recent fluence determination if this report has been superseded.**

A copy of Revision 1 to ANO Engineering Report 96-R-2030-02 is attached. It should be noted that Revision 1 is the current revision of this report. The reason for the revision was to change the duration of ANO-2 Cycle 12 from the estimated value to the exact value and the estimated excore ratio for ANO-2 Cycle 13.

It should be noted that this report will be benchmarked to the results of future surveillance capsule evaluations. Entergy Operations is currently evaluating a revision to the surveillance capsule withdrawal schedule listed in the ANO-2 Technical Specifications. The revision under consideration would be to withdraw the next capsule during the steam generator replacement outage (2R14) which is scheduled for the fall of 2000.

3. **Excore ratios were used in the evaluation of the fluence. These ratios are meant to evaluate the amount of leakage from the core from cycle to cycle. The staff is not aware of the use of excore ratios in reactor vessel fluence calculations by other licensees. If not included in the response to question 2, please provide**

references for this methodology and a more detailed explanation of how the excore readings were used.

ANO Engineering Report 96-R-2030-02, Revision 1 provides the details of how the excore ratio is determined and how it was used in the fluence determination. It should be noted that the ratios calculated are ANO-2 specific. A copy of this report is attached in response to question 2.

4. **The submittal references the following statement from a safety evaluation for Calvert Cliffs dated January 2, 1996:**

> **"The methodology employed the CASK cross section set. CASK is based in an early ENDF/B version, which is known to have an iron scattering cross section error, which is corrected in ENDF/B-VI. However, we know from experience that this error appears only during neutron transmission through significant amounts of iron, as for example the thermal shield or the vessel. Neither of the Calvert Cliffs units is equipped with a thermal shield; thus, the staff does not expect the results to have been affected by the use of the CASK cross section."**

The ANO-2 vessel does not have a thermal shield, but the licensee did not use CASK for the fluence evaluation. CASK uses ENDF/B-II or ENDF/B-III and the ANO-2 evaluation uses the ENDF/B-IV library. The submittal states that, based on the above reference, the surface fluence would not change if the fluence analysis were performed using the ENDF/B-VI library. Since the ENDF/B-II, ENDF/B-III, ENDF/B-IV and ENDF/B-VI cross sections are not the same and may not change in a progressive manner, explain the relevance of the Calvert Cliffs safety evaluation citation to ANO-2.

While the libraries are different, it appears that only the iron scattering cross-section is a significant concern. This concern was noted in Draft Regulatory Guide DG-1053, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," (dated June 1996). Specifically, it noted:

> "[T]hat in many applications the ENDF/B-IV and the first three MODs [modifications] of the ENDF/B-V iron cross-sections result in as much as ~20% underprediction of the vessel inner-wall fluence and ~35% underprediction of the cavity fluence. Updated ENDF/B-V iron cross-section data have been demonstrated to provide a more accurate determination of the flux attenuation through iron and are strongly recommended. These new iron data are included in ENDF/B, version VI."

The cited safety evaluation noted the same concern with the iron cross section in the CASK library. The safety evaluation went on to note that the concern appears only during neutron transmission through significant amounts of iron, as for example the thermal shield or the vessel. The fluence that was recalculated for ANO-2 was the inside surface fluence.

Since the Calvert Cliffs units do not have a thermal shield and had the same issue related to the iron cross-section, Entergy Operations concluded that the Staff's statement in the safety evaluation was relevant to ANO-2. It should be noted that ANO-2 does not have a thermal shield and the fluence that was calculated was for the inside surface of the reactor pressure vessel. If the Staff concluded that they did not expect the results to be affected by the use of the older CASK cross-sections, Entergy Operations concluded that the use of the newer ENDF/B-IV cross-sections would also not affect the results.

Work is currently being performed to revise the ASTM Standard E900, "Standard Guide for Predicting Neutron Irradiation Damage to Reactor Vessel Material'. The NRC has representatives on the E900 committee. One of the issues faced by the committee was the impact on the revised correlation of which cross-sectional libraries are used. The committee has concluded that the inside surface fluence calculated using either ENDF/B-IV or B-VI is equivalent.

5. **Adjustments were made to the calculated fluence to account for issues such as differences in cross sectional libraries (ENDF/B-IV vs. ENDF/B-VI), and power shift. Provide additional justification for the adjustment of 10% to the 1.69 EFPY calculated fluence for the extrapolation to 21 EFPY (i.e., explain why 10% is sufficient to address all of the stated issues).**

As explained in response to question 4 above, Entergy Operations does not believe that the inside surface fluence value will change due to the use of the different cross-sectional libraries. The adjustment of 10% to the 1.69 EFPY calculated fluence was based on engineering judgement. No additional analyses were performed.