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Subject: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Response to Request for Additional Information from the Materials and Chemical Engineering Branch Regarding the ANO-2 Power Uprate License Application

Gentlemen:

In a letter dated December 19, 2000, (2CAN120001), Entergy Operations, Inc. submitted a license application for Arkansas Nuclear One, Unit 2 (ANO-2) to increase the authorized power level from 2815 megawatts thermal to 3026 megawatts thermal. On June 7, 2001, NRC personnel from the Materials and Chemical Engineering Branch requested written responses to four questions regarding the December 19, 2000, application. The attachment to this letter contains the responses to the NRC Staff questions.

This letter contains no regulatory commitments.

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

Very truly yours,

Dale E. James
Acting Director, Nuclear Safety Assurance

DEJ/dwb
Attachment

A001

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NRC Materials and Chemical Engineering Branch Questions and ANO Responses Regarding the ANO-2 Power Uprate License Application

NRC Question 1 - Reactor Vessel Structural Integrity

Part 50 to Title 10, *Code of Federal Regulations*, requires that NRC-licensed utilities perform the following structural integrity analyses for the pressurized water reactor (PWR)-designed reactor vessels:

- Pressurized Thermal Shock (PTS) Analyses as required by 10 CFR 50.61,
- Pressure/Temperature (P/T) Limit and Low Temperature Overpressurization (LTOP) Analyses required by 10 CFR Part 50, Appendix G, and
- Upper Shelf Energy Analyses (USE) required by 10 CFR Part 50, Appendix G.

In Section 8.4 of the ANO-2 Power Uprate Licensing Report (PULR), you indicate:

- that a reactor pressure vessel (RPV) surveillance capsule was removed during ANO-2 Refueling Outage (RO) 2R14, and that a revised fast neutron fluence will be calculated for this capsule,
- that the revised fluence calculation will be used as the basis for revising the P/T Limit, LTOP and PTS Analyses for ANO-2,
- that, as a result of a change of the limiting ANO-2 RPV beltline material, the current curves in the Technical Specifications (TSs) are applicable through approximately 17 effective full power years (EFPYs), and not 21 EFPYs as is currently specified in TS Figures 3.4-2A, 3.4-2B, and 3.4-2C, and
- that the current TS curves are conservatively estimated to be applicable through the beginning of Cycle 16 (the next operating cycle), and that at the beginning of Cycle 15 the fuel burnup for ANO-2 was approximately 15.7 EFPYs.

It needs to be emphasized that a revised USE analysis will also be needed for a 7.5% increase in rated power. It also needs to be emphasized that this surveillance capsule was not irradiated under the power-uprated conditions; the revised fluence calculations based on this capsule, therefore, may not conservatively bound the neutron fluences used for P/T, LTOP, PTS, and USE analyses in the current ANO-2 licensing basis. The licensee is therefore requested to either:

a. provide technical analyses to demonstrate the P/T, LTOP, PTS, and USE analyses in the current ANO-2 licensing basis will remain valid (are bounded) for the neutron fluences that are estimated to result from the 7.5% increase in rated power, or

b. if the fluences used for the current P/T, LTOP, PTS, and USE analyses will not be bounded by those that will result from the 7.5% increase in rated power, provide revised P/T, LTOP, PTS, and USE analyses that are based on the neutron fluences that are estimated to result from the 7.5% increase in rated power. [NOTE: If ANO-2 reactor will reach 17 EFPYs prior to the end of Cycle 16, the current approved PT curves (i.e., TS Figures 3.4-2A, 3.4-2B, and 3.4-2C) in the ANO-2 TSs will not be valid for a portion of the next operating cycle, and revised PT limit curves should therefore be submitted six months prior to the anticipated time when 17 EFPYs will be exceeded to allow the staff ample time to approve the curves.]

ANO Response

The validity of the current pressure/temperature (P/T), low temperature overpressurization protection (LTOP), pressurized thermal shock (PTS) and upper shelf energy (USE) analyses were demonstrated in response to Generic Letter 92-01 Revision 1, Supplement 1, "Reactor Vessel Structural Integrity." This response was provided in our letter dated June 18, 1997 (2CAN069709). These analyses addressed the change in the limiting material for the ANO-2 reactor vessel. The fluence values used in these analyses were the ones used in the technical specification limits. They do not account for the 7.5% increase in reactor power. Our letter dated July 24, 2001 (2CAN070102), in part, addresses the conservatism in the fluence values out to 17 effective full power years (EFPY). As discussed in the July 24, 2001, submittal, ANO-2 will reach 17 EFPY approximately 21 effective full power days (EFPD) into Cycle 16 (the first power uprate cycle) assuming a conservative increase in flux.

New P/T and LTOP limits for ANO-2 will incorporate the surveillance capsule results and include the 7.5% power uprate fluence that is scheduled for Cycle 16 forward. The revised P/T and LTOP limits will be submitted to the NRC in sufficient time to allow six months for NRC review and approval. Included in that submittal will be the results of the PTS and USE analyses. Cycle 16 is currently scheduled to begin about May 18, 2002.

NRC Question 2 - Effect on Steam Generator Tube Integrity

The licensee installed replacement steam generators in the fall of 2000. In License Amendment 223, dated October 4, 2000, NRC approved the changes to ANO-2 TSs in regard to steam generator surveillance requirements and sleeving repair criteria as a part of steam generator replacement. However, there is no discussion of the impact of the power uprate on the steam generator tube integrity in the December 19, 2000, submittal. The staff has determined that the following issues need to be addressed for the replacement steam generators under power uprate conditions:

a. Discuss the potential impact of changes in flow rate on tube wear degradation from anti-vibration bars.

b. Discuss the potential impact of the power uprate on other modes of tube degradation (other than wear) in the replacement steam generator tubing.

c. Discuss the potential impact of the power uprate on the 40-percent plugging limit in the ANO-2 TSs.

ANO Response to Subpart "a"

The replacement steam generators were originally designed and analyzed for power uprate conditions, including consideration of tube wear degradation from the anti-vibration bars. Accordingly, the increased flow rate following power uprate is not expected to result in tube wear degradation at the anti-vibration bars. A discussion of the replacement steam generators design relative to tube vibration follows:

The primary source of potential tube degradation due to vibration is the hydrodynamic excitation of the tubes by the secondary fluid. Westinghouse has emphasized this area of replacement steam generators design in both analyses and tests, including evaluation of steam generator operating experience.

For consideration of anti-vibration bar wear, fluid-elastic tube vibration is of primary concern because it is a self-excited mechanism. Relatively large tube amplitudes can feed back proportionally large tube driving forces if an instability threshold is exceeded. Testing performed by the Westinghouse Electric Company and field experience from previous designs have been utilized to develop analysis techniques to assure significant margin to instability is maintained. Tube support spacing in the anti-vibration bars in the U-bend region provides tube response frequencies such that the instability threshold is not exceeded for power uprate secondary fluid flow conditions. This approach provides large margins against initiation of fluid elastic vibration for tubes effectively supported by the tube support system.

Additionally, the replacement steam generators include a number of features that minimize the potential for tube wear at the anti-vibration bars. Provisions to minimize the potential for wear include the selected design and configuration of the anti-vibration bar assemblies, including selection of anti-vibration bar material, and control of anti-vibration bar material thickness and tube ovality to assure tight tolerances. The five sets of anti-vibration bars in the U-bend provide redundancy so that all the tubes remain fluidelastically stable even if it is assumed that some of the support points are inactive.

As outlined, analyses and tests demonstrate that unacceptable tube degradation resulting from tube vibration is not expected for the replacement steam generators when operated at power uprate flows. Operating experience with steam generators having the same size tubes and similar flow conditions supports this conclusion.

ANO Response to Subpart "b"

The replacement steam generators were originally designed and analyzed for power uprate conditions, including potential tube degradation. The replacement steam generator tubing material is thermally treated Alloy 690, which was chosen as the optimum material for the replacement steam generators. Testing and field experience has shown it to be significantly improved in corrosion resistance compared to Alloy 600.

In addition to specification of improved tubing, power uprate was considered in the overall thermal hydraulics of the replacement steam generators. In so doing, the size of the tube bundle was increased from approximately 86,000 ft^2 in the original steam generators to approximately 109,000 ft^2 in the replacement steam generators in order to improve heat transfer, lower the T_{hot} required to support power uprate, and thereby enhance the thermal hydraulic conditions experienced by the replacement steam generator tubing. The amount of increased heat transfer area in the replacement steam generators was then evaluated for design limitations in operating conditions. Specifically, the higher heat transfer would result in decreased margin to tube dryout, mostly at the higher elevations of the tubes when at power uprate conditions.

The design of the replacement steam generators (e.g., spacing between tubes) was set to keep uprated thermal hydraulic conditions below the top of the allowable range for dryout, as specified by the Westinghouse Electric Company, based upon keeping the replacement steam generators thermal hydraulic modeling results within the current Westinghouse operating experience base.

In addition, many enhancements were made to the replacement steam generator design to provide margin against degradation at uprated conditions. These include improved tube-to-tubesheet joint design (closely controlled hydraulic expansion), anti-vibration bar design (stainless steel material, anti-vibration bars in adjacent columns are inserted to different depths to discourage the formation of flow stagnation regions with resulting deposition of sludge, and orientation of supports to minimize contact length and potential for crevice corrosion) and tube support plate design (stainless steel material, broached design to minimize stagnation regions, and shortened contact length).

ANO Response to Subpart "c"

The replacement steam generators were originally designed and analyzed for power uprate conditions, including the tube plugging limit analysis. Accordingly, the technical specification tube plugging limit is not affected. Additional information regarding the 40-percent plugging limit is contained in WCAP-15406, "Regulatory Guide 1.121 Analysis for Arkansas Nuclear One Unit 2 Replacement Steam Generators." This document was submitted to the NRC in a letter dated July 19, 2000 (2CAN070007). The analysis determined that the limiting condition for establishing the plugging limit is maintaining the required margin to tube burst for normal operating pressure differential. The analysis is performed assuming the bounding case of reduced secondary pressure to account for future tube plugging. For the case of the unplugged condition, power uprate steam pressure will be increased, normal operating pressure differential is therefore reduced, and structural margins are increased.

NRC Question 3 - ANO-2 PULR Section 2.3.1, "Fuel Pool System"

The fuel pool system, described in Section 2.3.1, has a dual function of removing heat from the spent fuel pool and removing impurities from its water. The licensee has demonstrated that the heat removal function will not be significantly affected by the power uprate, but the cleaning function was not addressed in the submittal. Please describe how the purification of the spent fuel pool water will be affected by the power uprate. Your response should address the potential effect of power uprate on the amount of impurities in the pool's water and on the performance of the ion exchange resin.

ANO Response

The purification portion of the fuel pool system maintains the clarity and purity of the water in the fuel pool, refueling cavity and refueling water tank. The purification loop consists of the fuel pool purification pump, ion exchanger, filters, strainers, and an installed connection for a floating skimmer. The fuel pool pump circulates the fuel pool water through a filter, which removes particulates larger than 5 micron size, and through an ion exchanger to remove ionic material. The purification loop is normally run on an intermittent basis when required by the fuel pool water conditions. During operational mode 1, the system is run approximately one-half time for fuel pool purification. The remaining time is used to recirculate the refueling water tank, which requires minimal purification. Power uprate will not appreciably increase fission product release from the fuel. The chemical and radionuclide composition of the spent fuel pool cleanup system is adequate for maintaining spent fuel pool water purity and clarity for uprate conditions.

NRC Question 4 - PULR Section 7.3.10, LOCA [Loss of Coolant Accident] Dose Analysis

The LOCA dose analysis, described in Section 7.3.10, contains updated particulate iodine spray removal coefficients. Please describe how these revised coefficients were determined. Provide the methods and the input parameters used in the calculations.

ANO Response

The updated particulate iodine spray removal coefficients are more conservative than the previous values. The methodology used is from the Standard Review Plan, Section 6.5.2, Revision 2. Containment spray is based on both pre- and post-recirculation conditions. A 1st order removal model is used.

$$\lambda = \frac{3hF}{2V} \times \frac{E}{D}$$

where,

- h = fall height of spray drops = 102.7 ft;
- V = net containment free volume = 1.778E+06 ft^3;
- F = spray flow = 1875 gpm prior to recirculation and 2000 gpm after recirculation;
- E = dimensionless collection efficiency
- D = average spray drop diameter

Ratio of E/D = 10 m^{-1} initially, changing to 1 m^{-1} when iodine in containment is reduced by a factor of 50

Therefore,

$$\lambda = \frac{3(102.7\ \text{ft})(1875\ \text{gpm})(60\ \text{min/hr})(0.13368\ \text{ft}^3/\text{gal})(10\ \text{m}^{-1})(1\text{m})}{2(1.778\text{E}{+}06\ \text{ft}^3)(3.28\ \text{ft})/\text{m}}$$

$$= 3.97\ \text{hr}^{-1} \text{ prior to recirculation}$$

and

$$\lambda = \frac{3(102.7\ \text{ft})(2000\ \text{gpm})(60\ \text{min/hr})(0.13368\ \text{ft}^3/\text{gal})(10\ \text{m}^{-1})(1\text{m})}{2(1.778\text{E}{+}06\ \text{ft}^3)(3.28\ \text{ft})/\text{m}}$$

$$= 4.24\ \text{hr}^{-1} \text{ after recirculation.}$$

Fall height is based on spray header elevation above the refueling floor. Pre-recirculation pump flow is based on low flow from one spray pump at a maximum containment pressure of 59 psig. Post-recirculation spray flow is based on flow from one spray pump for post RAS (Recirculation Actuation Signal) conditions. When particulate iodine in containment is reduced by a factor of 50, the assumed λ is reduced by a factor of 10 to 0.424 hr^{-1}.