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0CAN102101

October 4, 2021

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Final Request for Additional Information Concerning Generic Letter 2004-02

Arkansas Nuclear One, Units 1 and 2
NRC Docket Nos. 50-313, 50-368, and 72-13
Renewed Facility Operating License Nos. DPR-51 and NPF-6

Entergy Operations, Inc. (Entergy) provided the final supplemental response for Arkansas Nuclear One (ANO) to Generic Letter 2004-02, dated September 13, 2004, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors (PWRs)" to the NRC by Reference 1. The NRC subsequently provided requests for additional information (RAIs) to Entergy by Reference 2 which were discussed as documented in Reference 3. NRC requested Entergy's response to the RAIs within 90 days. The RAI responses are provided in Enclosure 1.

There are no new regulatory commitments contained in this submittal.

If there are any questions or if additional information is needed, please contact Riley Keele, Manager, Regulatory Assurance, ANO, at (479)858-7826.

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

Executed on October 4, 2021.

Respectfully,

Ronald W. Gaston
Digitally signed by Ronald W. Gaston
Date: 2021.10.04 07:16:16 -05'00'

Ron Gaston

RWG/nbm

Enclosure 1: Final Response to NRC Generic Letter 2004-02 Requests for Additional Information

References:

1. Entergy letter to NRC, "Final Response to NRC Generic Letter 2004-02," (0CAN122001) (ML20353A115), dated December 10, 2020.

2. NRC letter to Entergy, "Final Request for Additional Information Concerning Generic Letter 2004-02," (0CNA072102) (ML21197A037), dated July 16, 2021.

3. NRC letter to Entergy, "Summary of September 1, 2021, Teleconference Meeting Concerning the Final Response to Generic Letter 2004-02 for Arkansas Nuclear One, Units 1 and 2," (0CNA092102) (ML21252A266), dated September 14, 2021.

cc: NRC Region IV Regional Administrator

NRC Senior Resident Inspector – Arkansas Nuclear One

NRC Project Manager – Arkansas Nuclear One

# ENCLOSURE 1

# 0CAN102101

# FINAL RESPONSE TO NRC GENERIC LETTER 2004-02 REQUESTS FOR ADDITIONAL INFORMATION

## FINAL RESPONSE TO NRC GENERIC LETTER 2004-02 REQUESTS FOR ADDITIONAL INFORMATION

The following responses are provided to the Reference 2 requests for additional information (RAIs) for Arkansas Nuclear One (ANO).

*RAI-1: In Enclosure 1 (Reference 1), on pg. 11 of 17 (PDF pg. 14), the second paragraph under test parameters appears to have one-train flow and two-train flow reversed. The velocities for one-train flow is listed as 0.008 feet per second (ft/s) (used for Test 1) and two-train as 0.004 ft/s (used for Test 2). Provide the one and two-train flow rates and state which flow rate was used for each test. State which test resulted in greater penetration.*

Response: The description of the two velocities in the submittal is a typographical error. For ANO Unit 1 (ANO-1), the strainer approach velocity is 0.004 ft/s for one-train operation, and 0.008 ft/s for two-train operation (Reference 4, Page 13). The strainer flow rate for one-train operation is 4,867 gallons per minute (gpm), and the flow rate for two-train operation is 9,734 gpm (Reference 4, Page 13).

The ANO fiber bypass Test 1 used the approach velocity of 0.004 ft/s, and Test 2 used the approach velocity of 0.008 ft/s (Reference 3, Page 5). As correctly stated on Page 4 of Enclosure 1 in the submittal (Reference 1), Test 2 resulted in higher fiber penetration than Test 1 (Reference 3, Pages 17 and 18).

*RAI-2a: Provide additional details on how the penetration models at plant scale were developed. Describe how the penetration amounts determined from the testing were scaled to the plant condition for each unit.*

Response: The model derived from Test 2 describes the fiber prompt and shedding penetration fractions as functions of cumulative fiber load on the test strainer. It is an important distinction to note that the plant strainer in-vessel analyses used the penetration fractions (not penetration debris quantities) calculated from the model. As stated in the submittal, the in-vessel analysis for reactor core inlet fiber load divided the recirculation phase into time steps. The fiber penetration model was used to determine the fiber prompt penetration and shedding fractions for each time step (Reference 1, Enclosure 1, Pages 11 and 14).

In the plant evaluation, the cumulative quantity of fiber on the plant strainer at the beginning of a time step was determined. This quantity was then scaled down to the test strainer surface area (i.e., multiplied by the ratio in surface area between the test strainer and plant strainer). The scaled fiber load was substituted into the model derived from Test 2 to calculate the fiber prompt penetration and shedding fractions for the given time step. These fractions were then applied to the plant strainer analysis to determine the fiber prompt penetration and shedding amounts for each time step, as stated in the last bullet on Page 14 and the first bullet on Page 15 of Enclosure 1 in the submittal (Reference 1).

*RAI-2b: It appears that the model depicted in Figure 3.n.1-9 (PDF pg. 16) was used for both units. Provide justification that the same model is applicable to both units even though the strainer sizes and fiber amounts are significantly different between the units.*

Response: The penetration model derived from Test 2 was applied for both units.

Figure 3.n.1-9 shows the results of an example application of the fiber penetration model: cumulative fiber penetration through the ANO-1 sump strainer as a function of time. The results shown in this figure are for demonstration purposes and were not directly used for the actual in-vessel analysis of either unit.

As stated in the submittal, Test 2 used a test strainer that is prototypical to the plant strainers of both units. Additionally, other testing conditions (e.g., fiber loads, approach velocity, water chemistry) were either representative of or bounded the plant strainer operating conditions of both units. The test was designed to characterize how fiber penetration varies as the quantity of fiber accumulated on the strainer increases. This was achieved by introducing debris into the test tank in five batches, allowing a gradual accumulation of fiber on the test strainer, and changing filter bags multiple times for each debris batch to collect long-term shedding penetration (Reference 3, Page 18). The model derived from the test data describes the fiber prompt and shedding penetration fractions as functions of cumulative fiber load on the test strainer.

As stated in the RAI-2a response, in the plant strainer in-vessel analysis, the accumulated fiber load on the plant strainer was scaled down to the test strainer surface area first before being used to calculate the fiber penetration fractions from the model. These fractions were then applied to determine the fiber penetration quantities during a time step for the plant strainer. This methodology is different from the application of simply scaling up the measured total fiber penetration quantity to the plant strainer surface area to quantify the plant strainer penetration.

*RAI-2c: Describe the relevance of the time scale on the x-axis of Figure 3.n.1-9. The NRC staff concluded that the axis implies time at a plant scale. Describe the assumptions used to develop the time scale or justify that it is not important to the calculations.*

Response: The time on the x-axis of Figure 3.n.1-9 is at plant scale. As discussed in the RAI-2b response, this figure shows results of an example application, which uses similar methodology as the actual in-vessel analysis. The prompt and shedding penetration fractions calculated from the model were used to determine the fiber penetration quantities of the plant strainer during each time step. The figure shows cumulative fiber penetration quantity over time.

Both the example application and actual in-vessel analyses assumed that the fibrous debris is uniformly distributed in the containment sump pool, consistent with the WCAP-17788 methodology (Reference 15, Section 5, Assumption 1). The in-vessel analysis was terminated when the pool fiber concentration is 0.1% of the initial fiber concentration, which is more conservative than the 1% concentration termination criteria in WCAP-17788 (Reference 16, Section 6.1.3). As shown in Figure 3.n.1-9, the cumulative fiber penetration quantity plateaus well before the termination criterion is reached.

*<u>RAI-2d</u>: Describe the application of Figures 3.n.1-10 and 11 to each unit (PDF pgs. 16 and 17). Explain how the difference in strainer area between units is accounted for in the analysis, considering that the ANO Unit 2 (ANO-2) strainer has approximately 1.8 times the area of the ANO-1 strainer.*

<u>Response</u>: It should be clarified that the prompt penetration and shedding fractions shown in Figures 3.n.1-10 and 3.n.1-11 are not inputs to the ANO in-vessel analysis of either unit. Instead, they resulted from the example application of the model to the ANO-1 strainer as shown in Figure 3.n.1-9.

As discussed in the RAI-2a response, for a given time step, the amount of fiber accumulated on the plant strainer is first scaled down to the test scale (i.e., multiplied by the ratio in surface area between the test strainer and plant strainer) before being substituted into the model to calculate the fiber penetration fractions. For example, if the same amount of fiber accumulates on the plant strainers of both units, the fiber loads scaled to the test scale will be greater for ANO-1 than ANO-2 due to much larger surface area of the ANO-2 plant strainer. As a result, when using these scaled fiber loads in the model, the calculated fiber penetration fractions for ANO-1 would be lower than those of ANO-2. In other words, the resulting fiber penetration fraction curves for ANO-2 would be different from those shown in Figures 3.n.1-10 and 3.n.1-11 for ANO-1. In summary, the penetration model derived from testing only provided fiber penetration fractions for the in-vessel analyses. Although the same model was applied to both units, the difference in plant strainer surface areas between the two units was accounted for when the model was applied.

*<u>RAI-3</u>: In Enclosure 1 (Reference 1), on pg. 15 (PDF pg. 18), the ANO-1 in-vessel fiber calculation credits one Reactor Building Spray System (RBSS) pump at minimum flow. Provide the basis for the assumption that one RBSS pump will start and continue to operate (not be shut off) during the period of interest for fiber accumulation at the core inlet. That is, confirm that the RBSS pumps start for large break scenarios and continue to run.*

<u>Response</u>: For ANO-1, the RBSS operation is initiated by a reactor building high-high pressure signal. This occurs when the reactor building pressure exceeds 44.7 psia (Reference 18, Table 3.3.5-1). This pressure is exceeded early in the event for a design basis accident (Reference 20, Attachment 1), ensuring RBSS is actuated. Once actuated, the sprays remain active for the duration of the event. After spray initiation the operator is directed to throttle the RBSS flow prior to the beginning of recirculation and maintain spray flow throughout the event (Reference 17, Page 22; Reference 14, Page 6.2-2). With the exception of indication of sump blockage, the RBSS remains active during the recirculation phase (Reference 19, Pages 75-78).

As stated in the submittal, the ANO-1 in-vessel analysis conservatively used the minimum throttled RBSS flow (Reference 16, Section 5.1.5). While the RBSS operates for the entire 30-day event, the ANO-1 in-vessel analysis reached the termination criteria (as discussed in the response to RAI 2.c) approximately eight hours after initiation of the accident (Reference 16, Attachment A). Therefore, the RBSS is active during the entire period of interest for fiber accumulation at the core inlet.

*<u>RAI-4</u>: In Enclosure 2 (Reference 1), on pg. 6 (PDF pg. 27), the ANO-2 in-vessel fiber calculation credits one Containment Spray System (CSS) pump at minimum flow. Provide the basis for the assumption that one CSS pump will start and continue to operate (not be shut off) during the period of interest for fiber accumulation at the core inlet. That is, confirm that the CSS pumps start for large break scenarios and continue to run.*

<u>Response</u>: In the ANO-2 analysis, the time when containment spray is terminated was assumed to be ten hours after the loss-of-coolant accident (LOCA). Containment spray actuation signal is automatically initiated when the containment pressure exceeds the containment pressure high-high (CPHH) setpoint of 25.7 psia (Reference 6, Pages 6.2-3 and Table 6.2-8F). Containment spray is terminated once the containment pressure and temperature drop below 22.5 psia and 140°F, respectively (Reference 13, Page 10). Note that both of these conditions must be met for termination of containment spray to occur.

Since a minimum spray operating time is conservative for the in-vessel analysis, the containment pressure and temperature curves from analysis of a small-break LOCA (SBLOCA) were used to derive the spray duration. The peak containment pressure for the SBLOCA is approximately 32 psia (Reference 7, Attachment 5) which exceeds the containment spray actuation setpoint. The earliest time the SBLOCA containment temperature drops to 140°F is approximately 300,000 seconds, or 83 hours. The earliest time the SBLOCA containment pressure drops below 22.5 psia is at 70,000 seconds, or 19 hours. For conservatism, this value was rounded down to ten hours for the spray duration in the in-vessel analysis for ANO-2 (Reference 5, Pages 10 and 11).

*<u>RAI-5</u>: The NRC staff recognizes that substantial chemical effects information was provided in the licensee's letter dated December 10, 2020, "Final Response to NRC Generic Letter 2004-02." Please also provide the WCAP-17788, "Comprehensive Analysis and Test Program for GSI-191 Closure," Test Group Number(s) that are considered representative of plant conditions for ANO-1 and ANO-2.*

<u>Response</u>: As discussed in the submittal (Reference 1, Enclosure 1, Page 15), Entergy has elected to use the Box 2 path from the NRC review guidance (Reference 8) to address in-vessel downstream effects for ANO-1, which is outfitted with a Babcock & Wilcox (B&W) nuclear steam supply system. The minimum chemical precipitation time is not required for the Box 2 path. Although the WCAP-17788 (Reference 9) autoclave Test Group 22 was performed with survey responses provided by ANO-1 (Reference 21, Page 58), comparison of the test parameters with the ANO-1 plant conditions are not necessary. Note also that the Test Group 22 autoclave tests used sodium hydroxide (NaOH) buffer as they were performed prior to ANO-1 switching to solid sodium tetraborate (NaTB) buffer in April 2021 (Reference 22).

For ANO-2, Entergy elected to use the Box 4 path from the NRC review guidance (Reference 8), and chemical precipitation was shown not to occur within 24 hours for containment sump temperatures above 135°F following the accident by using a precipitation map based on an array of representative autoclave tests from WCAP-17788, Volume 5 (Reference 9). Additionally, WCAP-17788 autoclave Test Group 18, including Test 18-01 and Test IBOB 18-02, is considered representative of the ANO-2 post-LOCA plant conditions for the in-vessel analysis. No chemical precipitation was observed during the Test Group 18 autoclave tests down to a filtration test temperature of 160°F for the 24-hour test duration (Reference 9, Vol. 5, Table 7-5).

The following table provides the critical projected ANO-2 post-LOCA conditions and debris loads at plant scale and test scale for comparison with the Test Group 18 parameters. The Westinghouse Proprietary Test Group 18 parameters are not shown.

**Critical Projected ANO-2 post-LOCA Plant Conditions**

| **Parameter** | **ANO-2 (Plant Scale)** | **ANO-2 (Test Scale, 50 L)** |
|---|---|---|
| Buffer<br>(Reference 11, Section 3.o.2.3.i) | Sodium Tetraborate | Sodium Tetraborate |
| Sump pH (Long-term)<br>(Reference 12, Section 2.0) | 7.2 – 8.0* | 7.2 – 8.0* |
| Minimum Sump Volume<br>(Reference 12, Section 6.3.3) | 1,765,085 L<br>(384,000 gal + 82,286 gal) | 50 L |
| Maximum Sump Pool Temperature<br>(Reference 10, Table 6.3-1) | 241.3°F | 241.3°F |
| Maximum Calcium Silicate<br>(Reference 10, Table 6.3-4) | 1,447,000 g | 40.99 g |
| Maximum E-Glass<br>(Reference 10, Table 6.3-4) | 900 g | 0.0255 g |
| Maximum Silica<br>(Reference 10, Table 6.3-4) | 0 g | 0 g |
| Maximum Mineral Wool<br>(Reference 10, Table 6.3-4) | 0 g | 0 g |
| Maximum Aluminum Silicate<br>(Reference 10, Table 6.3-4) | 25,400 g | 0.720 g |
| Maximum Concrete<br>(Reference 10, Table 6.3-4) | 49.3 g (4900 $ft^2$) | 0.00140 g (0.14 $ft^2$) |
| Maximum Interam™<br>(Reference 10, Table 6.3-4) | 0 g | 0 g |
| Aluminum<br>(Reference 10, Table 6.3-4) | 301.0 $ft^2$ | 0.00853 $ft^2$ |
| Galvanized Steel | Not Determined | Not Determined |

*Note: The pH values shown represent the full range of possible post-LOCA sump conditions at ANO-2 resulting from variations in the amount and concentration of the borated water potentially added to containment. The autoclave tests were run at a single target pH after buffer was added. The pH values do not change from plant-scale to test-scale.

## REFERENCES

1. Entergy letter to NRC, "Final Response to NRC Generic Letter 2004-02," (0CAN122001) (ML20353A115), dated December 10, 2020.

2. NRC letter to Entergy, "Final Request for Additional Information Concerning Generic Letter 2004-02," (0CNA072102) (ML21197A037), dated July 16, 2021.

3. Calculation CALC-ANOC-ME-20-00004 (5172ANOBP-R1-00, Revision 0), “ANO Fiber Bypass Technical Report - Alden”, Revision 0.

4. Calculation CALC-ANOC-ME-20-00003 (ENTA-049-DSPEC-001, Revision 1), “GSI-191 Large-Scale Bypass Test Specification for ANO Units 1 and 2”, Revision 0.

5. Calculation CALC-20-E-0007-02 (ENTA-049-CALC-003, Revision 2), “Arkansas Nuclear One Unit 2 In-Vessel Fiber Calculation”, Revision 0.

6. ANO-2 Safety Analysis Report, Amendment 30.

7. Calculation CALC-93-E-0021-05, “ANO-2 Containment Response to a .01 SQRFT SBLOCA with Primary Side Feed and Bleed”, Revision 0.

8. NRC Memorandum, "U.S. NRC Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of GL 2004-02 Responses”, (ML19228A011), dated September 4, 2019.

9. WCAP-17788-P, Volumes 1 - 6, "Comprehensive Analysis and Test Program for GSI-191 Closure (PA-SEE-1090)”, Revision 1, dated December 2019.

10. Calculation CALC-07-E-0012-01, “ANO-2 Chemical Effects Evaluation”, Revision 0.

11. Entergy letter to NRC, "GL 2004-02 Final Supplemental Response Arkansas Nuclear One - Units 1 and 2”, (0CAN090801) (ML082700499), dated September 15, 2008.

12. Calculation CALC-07-E-0009-01, “ANO-2 Alternate Buffer Evaluation”, Revision 0.

13. Procedure OP-2202.003, “Loss of Coolant Accident”, Revision 16.

14. ANO-1 Safety Analysis Report, Amendment 30.

15. WCAP-17788-NP, Volume 1, “Comprehensive Analysis and Test Program for GSI-191 Closure (PA-SEE-1090)”, Revision 1, December 2019.

16. Calculation CALC-20-E-0007-01 (ENTA-049-CALC-002, Revision 2), “Arkansas Nuclear One Unit 1 In-Vessel Fiber Calculation”, Revision 0 and Revision 1.

17. ULD-1-TOP-04, Revision 8, “ANO Unit 1 Containment Response to Design Basis Accidents.”

18. ANO-1 Technical Specifications, Table 3.3.5-1 (Amendment 215).

19. Procedure OP-1202.012, Revision 24, “Repetitive Tasks.”

20. Calculation CALC-88-EQ-0007-01, Revision 18, “LOCA Profile Analysis for Environmental Qualification Equipment.”

21. MCOE-TP-13-1, Revision 1, "Test Plan for Screening Plant Debris Chemical Effects Using Autoclave Exposures and Filtration under PA-SEE-1090."

22. NRC Letter, “Arkansas Nuclear One, Unit 1 - Issuance of Amendment No. 272 Re: Replacement of Reactor Building Spray Sodium Hydroxide Additive with a Passive Reactor Building Sump Buffering Agent (EPID L-2020-LLA-0036)” (1CNA032102) (ML21027A428), March 23, 2021.