UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 21, 2009

Vice President, Operations
Arkansas Nuclear One
Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 - REQUEST FOR ADDITIONAL INFORMATION REGARDING SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (TAC NOS. MC4663 AND MC4664)

Dear Sir or Madam:

By letters dated February 28 and September 15, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML080710544 and ML082700499, respectively), Entergy Operations, Inc. (Entergy, the licensee), submitted the preliminary supplemental response and final supplemental response to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors." for the Arkansas Nuclear One, Units 1 and 2 (ANO-1 and ANO-2). The licensee incorporated the comments arising from the U.S. Nuclear Regulatory Commission (NRC) staff review of the preliminary supplemental response dated February 28, 2008, and submitted the final supplemental response. The NRC staff has reviewed the licensee's submittal dated September 15, 2008,,with a focus on the review areas described in the NRC's "Content Guide for Generic Letter 2004-02 Supplemental Responses" (ADAMS Accession No. ML073110389). Based on the review, the NRC staff has determined that additional information is needed in order to conclude there is reasonable assurance that GL 2004-02 has been satisfactorily addressed. The requests for additional information (RAIs) for ANO-1 and ANO-2 are enclosed. In addition, the enclosure includes a generic set of RAIs applicable to both units regarding concerns with Westinghouse debris generation testing.

The NRC requests that the licensee respond to these RAIs within 90 days of the date of this letter. The NRC would like to receive only one response letter for all RAIs, with the exception stated below. If Entergy concludes that more than 90 days are required to respond to the RAIs, Entergy should request additional time, including a basis for why the extended time is needed.

The exception to the above response timeline is RAI No. 15 for ANO-1 and RAI No. 21 for ANO-2. The NRC staff considers in-vessel downstream effects to not be fully addressed at either of the ANO units, as well as at other pressurized-water reactors. The licensee's submittal refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." At this time, the NRC staff has not issued a final safety evaluation (SE) for WCAP-16793.

The licensee may demonstrate that in-vessel downstream effects issues are resolved for each of the units by showing that the licensee's plant conditions are bounded by the final WCAP-16793 and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve the in-vessel downstream effect RAIs by demonstrating, without reference to WCAP-16793 or the NRC staff SE, that in-vessel downstream effects have been addressed for both ANO units. The specific issues raised in these RAIs should be addressed regardless of the approach the licensee chooses to take.

The licensee should report how it has addressed the in-vessel downstream effects issue and the associated RAI referenced above within 90 days of issuance of the final NRC staff SE on WCAP-16793. The NRC staff is currently developing a Regulatory Issue Summary to inform licensees of the NRC staff's expectations and plans regarding resolution of this remaining aspect of Generic Safety Issue 191, "Assessment of Debris Accumulation on PWR Sump Performance."

If you or your staff has any questions concerning the resolution of this matter, please contact me at (301) 415-1480 or by electronic mail at kaly.kalyanam@nrc.gov.

Sincerely,

Kaly Kalyanam

N. Kaly Kalyanam, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-313 and 50-368

Enclosure:
Request for Additional Information

cc w/encl: Distribution via Listserv

REQUEST FOR ADDITIONAL INFORMATION

REGARDING SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ARKANSAS NUCLEAR ONE, UNITS 1 AND 2

DOCKET NOS. 50-313 AND 50-368

By letters dated February 28 and September 15, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML080710544 and ML082700499, respectively), Entergy Operations, Inc. (Entergy, the licensee), submitted the preliminary supplemental response and final supplemental response to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors." for the Arkansas Nuclear One, Units 1 and 2 (ANO-1 and ANO-2). The licensee incorporated the comments arising from the U.S. Nuclear Regulatory Commission (NRC) staff review of the preliminary supplemental response dated February 28, 2008, and submitted the final supplemental response.

The NRC staff has reviewed the licensee's submittal dated September 15, 2008,, with a focus on the review areas described in the NRC's "Content Guide for Generic Letter 2004-02 Supplemental Responses" (ADAMS Accession No. ML073110389) and has determined that the following additional information is required to complete the review and conclude that there is reasonable assurance that GL 2004-02 has been satisfactorily addressed. The requests for additional information (RAIs) for ANO-1 and ANO-2 are listed below, followed by a generic set of RAIs related to Westinghouse debris generation testing which is applicable to both units.

A. REQUEST FOR ADDITIONAL INFORMATION (RAI), ANO-1, SUPPLEMENTAL RESPONSE TO GL 2004-02

Debris Generation/Zone of Influence

1. Provide a more detailed summary of the basis for assuming a 5.45D (D being the pipe diameter) spherical Zone of Influence (ZOI) insulating system involving Thermal-Wrap batting and blanket covered with banded stainless steel jacket. Please address how the differences in materials and structure allow for the same high destructive pressure resistance, both for jacketing over fiberglass blanket/batting versus calcium-silicate and for the blanketing itself relative to the similar materials for which ZOI radii are provided in Table 3-2, "Revised Damage Pressures and Corresponding Volume-Equivalent Spherical ZOI Radii," of the Guidance Report/Safety Evaluation (NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation" methodology). in addition, please address uncertainties associated with the original Ontario Power Generation testing used to establish the 5.45D ZOI (e.g., scaling of the jet size to the target, determination of damage pressure in the test, and determination of

damage threshold).

2. Testing for Transco Thermal Wrap discussed in the Entergy response dated February 28, 2008, indicated that a 7D ZOI was used for that unit's analyses. Please explain the differences between these insulation systems which account for the difference in the ZOI radii. If differences between these insulation systems are not the basis for the different ZOIs, please provide alternate justification for use of the 5.45D Thermal-Wrap batting ZOI.

3. Please provide a more detailed summary of the basis for assuming a 2D spherical ZOI insulating system involving Temp Mat covered with standard Transco jacketing and fasteners (similar to the surrounding reflective metallic insulation). In particular, please address how the differences in materials and structure allow for the same high-destructive pressure resistance for the blanketing relative to the reflective metallic insulation foils for which ZOI radii are provided in Table 3-2 of the Guidance Report/Safety Evaluation. In addition, please address uncertainties associated with the scaling of the jet size to the target for the original air jet testing used to establish the 2D ZOI.

<u>Debris Characteristics</u>

4. Based upon the statement that the debris characteristics assumptions for ANO-1 are consistent with the baseline guidance, the NRC staff expected that all debris sources for which test data did not exist would be assumed to be destroyed into 100 percent small fines, as described in NEI 04-07. However, the fabric blankets installed over the reactor coolant system cold leg pipe penetrations were assumed to be destroyed into only 10 percent fibrous fines. Please provide the technical basis for this assumption. Further, please identify the destroyed form and size distribution of the remaining 90 percent of this material and provide the underlying technical basis.

<u>Latent Debris</u>

5. In the submittal dated September 15, 2008, Entergy indicated that samples had been taken for latent debris in the containment, but the submittal did not provide any details regarding the number, type, and location of samples. Please provide these details. In particular, please identify the extrapolation method used, including the statistical deviation of the results.

<u>Head Loss and Vortexing</u>

6. The testing conducted by Fauske and Associates utilized a debris addition sequence that was potentially non-prototypical and non-conservative. The addition of fibrous debris prior to particulates generally

results in lower head losses. The Fauske testing added fibrous debris first. During earlier interactions with the licensee, the NRC staff commented on the debris addition sequence. In its letter dated September 15, 2008, the licensee stated that sensitivity testing had been completed on the debris addition sequence. It is possible that the addition of fibrous debris first would not result in non-conservative results, based on the relatively low available fiber at ANO. Please provide the information regarding the sensitivity testing or other analyses showing that the addition of fibrous debris prior to other types of debris is conservative or at least neutral to the ANO test results.

7. The minimum water level included inventory from the core flood tanks. It is not clear that these sources would be available for all breaks. Please provide the minimum strainer submergence that could occur if the core flood tank volume is not included in the sump inventory. Verify that the vortexing and flashing evaluations bound this condition. Alternately, verify that recirculation is not required for all events where the accumulator volume is not fully discharged to the reactor coolant system/sump.

8. In Entergy's submittal dated September 15, 2208, Table 3.b.4-1 in the debris generation Section 3.b.4-1 appears to underestimate the amount of fibrous debris generated for the different breaks. This information was carried over into the debris amounts included in testing. It was noted that the response the licensee's submittal dated February 28, 2008, had lower debris generation amounts for the individual insulation components. The total fibrous mass listed in the table for each break appears to more closely represent the amounts of fiber reported in submittal dated February 28, 2008. The volumes of fiber reported in the table clearly represent a higher mass than is reported in the "Total Fiber" row of the table. Based on the submittal dated February 28, 2008, it is likely that testing was conducted with a conservative fiber load, but this assumption and the basis for the inclusion of the higher fibrous volumes in Table 3.b.4-1 is unclear. Please clarify the purpose of Table 3.b.4-1 and verify that the amounts of debris used in testing were scaled from debris amounts that are predicted for the various breaks considered.

9. On page 40 of its submittal dated September 15, 2008, the licensee stated that the peak head loss is extrapolated to slightly less than 8 feet at two-train full flow conditions with chemical loading. This extrapolation is based on a comparison of different reduced flow rates that were documented during the test. In particular, the response states that later batches of debris were added at 50 percent of the scaled two-train flow. Although the flow was later increased by 30 percent, it is not clear that increasing the flow through a pre-existing debris bed results in an equivalently bed compression as forming the debris bed at that increased flow rate. Furthermore, the extrapolation to higher flow rates than were considered in the test program may not be prototypical or conservative

due to additional bed compression that can occur at higher flow rates. Please provide the extrapolation methodology in more detail including assumptions made regarding how increased flow velocities affect debris bed formation and compression, and therefore, head loss.

Debris Source Term

10. Please identify/describe the specific procedures mentioned in the debris source term for control and maintenance of containment cleanliness.

Upstream Effects

11. The discussion of refueling canal drain blockage in the letter dated September 15, 2008, did not provide sufficient technical basis for the NRC staff to conclude that blockage would not occur. Please include additional discussion concerning how the following phenomena could affect the potential for drain blockage: turbulence, sheeting flow, preferentially directed drainage into the canal, and temporarily floating debris (i.e., it was not clear to the NRC staff why all floating debris will be able to pass through the drain). In addition, identify the minimum flow restriction in the drain line versus the sizes and quantities of debris that could be transported through the drain. In light of the discussion above, describe why there is high confidence of no refueling canal drain blockage without an engineered barrier to debris being installed.

Screen Modification Package

12. A stainless steel divider plate with square openings of 0.132 inches is installed between the two halves of the sump. Please provide the technical basis for concluding that blockage will not occur at this plate. Note that, if blockage could occur at this plate, then any credit for single train operation could be with only roughly half the strainer area.

Structural Analysis

13. The letter dated November 21, 2007, "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," from NRC to NEI, in Section 3.k, "Sump Structural Analysis," requests a summary of structural qualification design margins for the various components of the sump strainer structural assembly. This summary should include interaction ratios and/or design margins for structural members, welds, concrete anchorages, and connection bolts as applicable. Please provide this information.

14. The Revised Content Guide for GL 2004-02 requests a summary of the evaluations performed for dynamic effects such as pipe whip and jet impingement associated with high-energy line breaks. The submittal

which was provided merely states that, "...there are no credible jet impact hazards..." and "(t) here are no credible pipe whip effects..." Please provide a summary of these evaluations citing the reasons for the conclusion (e.g. protective barriers, the absence of high-energy sources, separation distance, administrative operational restrictions, etc.).

Downstream Effects/In-Vessel

15. The NRC staff does not consider in-vessel downstream effects to be fully addressed at ANO-1, as well as at other pressurized-water reactors (PWRs). ANO-1's submittal refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final safety evaluation (SE) for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for ANO-1 by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve this item by demonstrating without reference to WCAP-16793 or the NRC staff SE that in-vessel downstream effects have been addressed at ANO-1. Please report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff SE on WCAP-16793.

B. REQUEST FOR ADDITIONAL INFORMATION, ANO-2, SUPPLEMENTAL RESPONSE TO GL 2004-02

Debris Generation/Zone of Influence

1. Please explain what it means to position the target with its center 90° from the jet (Table 3.b.3-1 in your letter dated February 28, 2008), specifically, whether this statement refers to a seam orientation of 90°. Provide the basis for this position being the most limiting position, since previous information indicates a seam orientation of 45° is the most limiting. This previous experience appears to be consistent with the statement on page 5 of letter dated February 28, 2008, which indicates that Test #1 (with a 12D equivalent ZOI and 45° seam orientation) resulted in target material being dislodged from the pipe. Presumably no target material was dislodged in the test with a 7D equivalent ZOI. However, the only test conducted at an equivalent ZOI of 7D is one at a 90° seam orientation. Clarify the results for the tests discussed above and justify that the seam orientation for the 7D test was conservative.

2. Considering that the ANO-2 debris generation analysis diverged from the approved guidance in NEI 04-07, provide details on the testing conducted that justified the ZOI reductions for Transco Thermal Wrap. Section C of this Enclosure a list of questions that the NRC staff has developed based on concerns with Westinghouse testing conducted at Wyle Labs. It is noted that

ANO referenced WCAP-16836-NP, which was not specifically reviewed by the NRC staff. However, the NRC staff believes that the questions that were developed during the NRC staff review of the similar WCAPs apply generically to the testing credited by ANO.

3. Page 5 of your letter dated September 15, 2008, states that Transco Thermal Wrap located at a distance of 7D would be expected to become dislodged, but not sustain damage due to jet impingement, such that fibrous debris would be generated. This statement appears to be based on observations that a blanket during Test #1 was dislodged, which apparently occurred at a 12D-scaled ZOI.

   a. In light of the fact that Transco Thermal Wrap was dislodged at an equivalent ZOI of 12D, what is the basis for defining a spherical ZOI of 7D for the plant condition?

   b. Please describe to what extent the ZOI testing was prototypically scaled to model the size distribution of the debris resulting from the insulation destruction testing.

   c. Please provide a basis for concluding that the behavior observed in Test #1, where insulation was dislodged without releasing fibrous debris, is repeatable.

Debris Characteristics

4. The NRC staff SE on NEI 04-07 (ADAMS Accession No. ML050550156) recommended that calcium silicate debris be assumed as 100 percent small fines. The assumption made in the supplemental responses appears to be that 40 percent of calcium silicate debris is fines and 60 percent is large pieces. Please provide a technical basis for the assumed debris size distribution for calcium silicate. In addition, provide a comparison between the assumed calcium silicate debris size distribution and the sizes of the calcium silicate pieces used in the erosion testing program that shows that the tested size distribution is prototypical or conservative.

Latent Debris

5. Your letter dated September 15, 2008, indicated that you had taken samples for latent debris in your containment, but the submittal did not provide any details regarding the number, type, and location of samples. Please provide these details; in particular, identify the extrapolation method used, including the statistical deviation of the results.

Debris Transport

6. It is not apparent that the calcium silicate transport testing for ANO-2 was conducted in a manner that is prototypical or conservative with respect to the

plant conditions during a design basis event. Based on Reference 2, it appears that this calcium silicate transport testing will not be credited in the analyses demonstrating strainer adequacy for ANO-2. Please confirm the basis for this statement.

7. In the NRC staff's audit report for Salem Nuclear Generating Station, Units 1 and 2, dated August 12, 2008 (ADAMS Accession No. ML082170506), several technical issues were identified with respect to erosion testing that had been performed at the contractor's facilities. These technical issues included (1) non-conservatism associated with the modeling of turbulence in the test flume, (2) the use of regularly shaped debris pieces as opposed to irregular pieces that would be more prone to erosion, and (3) anomalies in the test data, wherein a significant number of long-term tests had lower cumulative eroded mass values than short-term tests. Please address whether and to what extent these issues affected the erosion testing for ANO-2 conducted at the Fauske facilities.

8. Based on the discussion in your letter dated September 15, 2009, it appeared that only one computational fluid dynamics analysis was performed for ANO-2. It is not apparent that sufficient basis is provided for considering this single simulation to be the bounding case in the supplemental response. In particular, the NRC staff noted that under steady state conditions during the recirculation phase of a loss-of-coolant accident (LOCA), the total flow rate out of the D-rings should not be dependent on the direction of the flow from the break (as stated in the supplemental response), but simply the total flow rate from the break. Please provide adequate basis to demonstrate that the debris transport conditions for the single computational fluid dynamics simulation performed for ANO-2 represent the limiting condition.

9. Your letter dated September 15, 2009, states that the single failure of a low pressure safety injection (LPSI) pump to trip at the switchover to recirculation can be addressed in 30 minutes, and the flow from an LPSI pump does not appear to be considered in the debris transport calculation. In support of these assumptions,

   a. Please provide the basis for the determination that the single failure of an LPSI pump to trip at switchover can be addressed in 30 minutes.

   b. Given that, at the increased flow rate with an LPSI pump running, one containment pool turnover could occur on the order of 30 minutes, please provide the basis for not accounting for the increased flow from the single failure of an LPSI pump to trip in the debris transport calculation.

   c. Also, please state whether conditions exist for which emergency operating procedures would either direct or allow plant operators to operate an LPSI pump in recirculation mode under design basis conditions (e.g., during hot leg recirculation). If such conditions exist, please justify the assumption in the debris transport calculation that an

LPSI pump would not be operated under design-basis post-LOCA conditions.

10. Debris transport results for Thermal Wrap insulation, while provided in your letter dated February 26, 2009, (Table 3.e.6-2), are not provided in the corresponding table in, your letter dated September 15, 2009, (Table 3.e.6-1). Based on the information in your letter dated September 15, 2009, it was not clear to the NRC staff whether, for example, this insulation was removed from the plant, whether the limiting analyzed break was changed, or whether changes to the analysis resulted in its removal from the debris source term. Please provide the basis for the observed discrepancy, identify the final transport results assumed for Thermal Wrap debris, and confirm the characteristic size distribution assumed for this debris.

Head Loss and Vortexing

11. Please provide additional information on the potential interactions between the emergency sump and the floor drains that empty into the sump. Could the floor drains provide a source of air into the sump? Can the floor drains provide a source of water to bypass the strainer allowing debris into the sump? Are the floor drains always below the minimum water level and covered by the minimum height of water postulated during recirculation? Please provide a diagram showing the relative elevations of the strainer, the strainer vent, the maximum and minimum water levels, the sump and vortex suppression structures, the floor drains, and the emergency core cooling system suction pipe(s) that exit(s) the sump.

12. Please provide the methodology used for calculation of clean strainer head loss.

13. The testing conducted by the contractor utilized a debris addition sequence that was potentially non-prototypical and non-conservative. The addition of fibrous debris prior to particulates generally results in lower head losses. The contractor's testing added fibrous debris first. During earlier interactions with the licensee, the NRC staff had commented on the debris addition sequence. It was stated that sensitivity testing had been completed on the debris addition sequence. Since ANO-2 has a low fibrous debris term (as stated in your letter dated February 26, 2009), it is possible that the addition of fibrous debris first would not result in non-conservative results. In addition, the NRC staff noted that in some tests additional particulate was added to the test after stability for the first test condition was reached in order to test multiple conditions without starting a new test (Reference 2, page 17 of 50). Given the relatively low fiber condition, it doesn't appear likely that this method of conducting multiple tests on the same basic debris bed found the worst-case thin bed debris bed head loss. Please provide the information regarding the sensitivity testing or other analyses showing that the addition of fibrous debris prior to other types of debris is conservative or at least neutral to the test results.

14. The testing head loss values listed in Section 3.f.4 of your letter dated September 15, 2009, did not seem to correspond to the head loss values listed in the chemical effects section table of results. The values for the LPSI pump failure and the non-chemical results listed in the head loss section were lower than the corresponding values in the chemical effects test results. The value for chemical effects head loss seemed to be about the same in both sections. Your letter dated September 15, 2009, stated that no viscosity correction was made to the test results. It appears that some manipulation of the data for the first two cases occurred. Please provide information that explains why the values in the two sections are not equivalent.

Debris Source Term

15. Please reference and describe the specific procedures mentioned in the debris source term for control and maintenance of containment cleanliness.

Upstream Effects

16. Your letter dated September 15, 2009, states that a larger drain cover will be placed over the refueling canal drain. Please describe the size of this cover, the size of the openings in the cover, and state whether it has a raised design or other features that would prevent debris blockage. Also, please discuss the types of debris that could be blown into the upper containment and potentially reach the refueling canal drains, including large pieces of insulation, smaller pieces of insulation, and other types of debris (e.g., miscellaneous debris). In addition, please discuss the potential for sheeting flow in the refueling canal and for temporary floatation and transport of debris over the drain due to refueling canal drain surface currents, absorption of water into the material, and subsequent sinking of the material to cover the drains. In light of the considerations above, please provide the basis for concluding that the refueling canal drain would not become blocked by post-LOCA debris.

17. Please provide justification for the sources and hold up volumes that are predicted to affect water inventory to the post-LOCA sump for the limiting cases. The minimum water level included inventory from the safety injection tanks. It is not clear that the safety injection tanks would be available for all breaks that require recirculation. In addition, it was noted that the refueling canal was credited as a hold up volume only for some breaks because other breaks will not produce debris that can plug the refueling canal drain lines. Please provide a justification for the assumption that some breaks will not produce debris that can block drainage from the refueling canal. Additionally, please provide the total volume that could be held up in the refueling canal and the information that justifies that the reported minimum water level is applicable to all cases where strainer operation is required. If necessary, please provide an updated minimum water level and update the required

calculations and the minimum submergence level for the strainer if it is necessary to revise the submergence calculation.

Screen Modification Package

18. In your letter dated September 15, 2008, you state that a stainless steel divider plate with square openings of 0.132 inches is installed between the two halves of the sump. Please provide the technical basis for concluding that blockage will not occur at this plate. Note that if blockage could occur at this plate, then any credit for single train operation could be with only roughly half the strainer area.

Structural Analysis

19. The Revised Content Guide for GL 2004-02 Supplemental Responses, Section 3k, requests a summary of structural qualification design margins for the various components of the sump strainer structural assembly. This summary should include interaction ratios and/or design margins for structural members, welds, concrete anchorages, and connection bolts as applicable. Please provide this information.

20. The Revised Content Guide for GL 2004-02 requests a summary of the evaluations performed for dynamic effects such as pipe whip and jet impingement associated with high-energy line breaks. The submittal dated September 15, 2008, merely states, "...the identified high-energy line break concerns have been evaluated and found acceptable." Please provide a summary of the evaluation which was performed to justify this conclusion.

Downstream Effects/In-Vessel

21. The NRC staff does not consider in-vessel downstream effects to be fully addressed at ANO-2 as well as at other PWRs. ANO-2's submittal refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final SE for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for ANO-1 by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve this item by demonstrating without reference to WCAP-16793 or the NRC staff SE that in-vessel downstream effects have been addressed at ANO-1. In any event, the licensee should report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff SE on WCAP-16793. The NRC staff is developing a Regulatory Issue Summary to inform the industry of the NRC staff's expectations and plans regarding resolution of this remaining aspect of GSI-191.

22. GENERIC SET OF RAIS APPLICABLE TO BOTH ANO-1 AND ANO-2 - CONCERNS WITH WESTINGHOUSE DEBRIS GENERATION TESTING

    The issues listed below are a generic set of RAIs that should be asked of licensees that credit ZOI reductions based on Westinghouse testing conducted at Wyle. The Pressurized Water Reactor Owners Group (PWROG) has committed to consider resolving some of these issues generically. The issues to be resolved by the PWROG have not been identified as of this time. The licensee should coordinate with the PWROG, as appropriate, to resolve the issues being treated generically. Note that the concerns discussed below are based on the review of WCAP-16710-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON® Insulation for Wolf Creek and Callaway Nuclear Operating Plants," and WCAP-16851-P, "Florida Power and Light (FPL) Jet Impingement Testing of Cal-Sil Insulation." However, the NRC staff believes that the issues identified below likely apply to all Westinghouse debris generation testing conducted at Wyle Labs.

23. Although the American National Standards Institute/American Nuclear Society (ANSI/ANS) standard predicts higher jet centerline stagnation pressures associated with higher levels of subcooling, it is not intuitive that this would necessarily correspond to a generally conservative debris generation result. Please justify the initial debris generation test temperature and pressure with respect to the plant-specific reactor coolant system (RCS) conditions, specifically, the plant hot and cold leg operating conditions. If ZOI reductions are also being applied to lines connecting to the pressurizer, then please also discuss the temperature and pressure conditions in these lines. Were any tests conducted at alternate temperatures and pressures to assess the variance in the destructiveness of the test jet to the initial test condition specifications? If so, please provide that assessment.

24. Please describe the jacketing/insulation systems used in the plant for which the testing was conducted and compare those systems to the jacketing/insulation systems tested and demonstrate that the tested jacketing/insulation system adequately represented the plant jacketing/insulation system. The description should include differences in the jacketing and banding systems used for piping and other components for which the test results are applied, potentially including steam generators, pressurizers, reactor coolant pumps, etc. At a minimum, the following areas should be addressed:

25. Please describe how the characteristic failure dimensions of the tested jacketing/ insulation compare with the effective diameter of the jet at the axial placement of the target? The characteristic failure dimensions are based on the primary failure mechanisms of the jacketing system (e.g., for a stainless steel jacket held in place by three latches where all three latches must fail for the jacket to fail, then all three latches must be effectively impacted by the pressure for which the ZOI is calculated). Applying test results to a ZOI based on a centerline pressure for relatively low target-length-to-diameter ratio nozzle to target spacing would be non-conservative with respect to impacting the entire target with the calculated pressure.

26. Please describe if the insulation and jacketing system used in the testing of the same general manufacture and manufacturing process as the insulation used in the plant? If not, what steps were taken to ensure that the general strength of the insulation system tested was conservative with respect to the plant insulation? For example, it is known that there were generally two very different processes used to manufacture calcium silicate whereby one type readily dissolved in water but the other type dissolves much more slowly. Such manufacturing differences could also become apparent in debris generation testing, as well.

27. The information provided should also include an evaluation of scaling the strength of the jacketing or encapsulation systems to the tests. For example, a latching system on a 30-inch pipe within a ZOI could be stressed much more than a latching system on a 10-inch pipe in a scaled ZOI test. If the latches used in the testing and the plants are the same, the latches in the testing could be significantly under-stressed. If a prototypically sized target were impacted by an undersized jet it would similarly be under-stressed. Evaluations of banding, jacketing, rivets, screws, etc., should be made. For example, scaling the strength of the jacketing was discussed in the Ontario Power Generation, Inc., report on calcium silicate debris generation testing.

28. There are relatively large uncertainties associated with calculating jet stagnation pressures and ZOIs for both the test and the plant conditions based on the models used in the WCAP reports. Please explain the steps taken to ensure that the calculations resulted in conservative estimates of these values? Please provide the inputs for these calculations and the sources of the inputs.

29. Please describe the procedure and assumptions for using the ANSI/ANS-58-2-1988 standard to calculate the test jet stagnation pressures at specific locations downrange from the test nozzle.

30. Please explain if the analysis based on initial conditions (temperature) that matched the initial test temperature? If not, please provide an evaluation of the effects of any differences in the assumptions.

31. Please explain if the water subcooling used in the analysis that of the initial tank temperature or was it the temperature of the water in the pipe next to the rupture disk? Test data indicated that the water in the piping had cooled below that of the test tank.

32. The break mass flow rate is a key input to the ANSI/ANS-58-2-1988 standard. Please describe how the associated debris generation test mass flow rate was determined? If the experimental volumetric flow was used, then please explain how the mass flow was calculated from the volumetric flow given the considerations of potential two-phase flow and temperature dependent water and vapor densities? If the mass flow was analytically determined, then please describe the analytical method used to calculate the mass flow rate.

33. Noting the extremely rapid decrease in nozzle pressure and flow rate illustrated in the test plots in the first few tenths of a second, please explain how the transient

behavior was considered in the application of the ANSI/ANS-58-2-1988 standard? Specifically, please explain if the inputs to the standard represent the initial conditions or the conditions after the first extremely rapid transient, e.g., say at one tenth of a second?

34. Given the extreme initial transient behavior of the jet, please justify the use of the steady state ANSI/ANS-58-2-1988 standard jet expansion model to determine the jet centerline stagnation pressures rather than experimentally measuring the pressures.

35. Please describe the procedure used to calculate the isobar volumes used in determining the equivalent spherical ZOI radii using the ANSI/ANS-58-2-1988 standard.

36. Please provide the assumed plant-specific RCS temperatures and pressures and break sizes used in the calculation? Note that the isobar volumes would be different for a hot leg break than for a cold leg break since the degrees of subcooling is a direct input to the ANSI/ANS-58-2-1988 standard and which affects the diameter of the jet. Note that an under calculated isobar volume would result in an under calculated ZOI radius.

37. Please explain the calculational method used to estimate the plant-specific and break-specific mass flow rate for the postulated plant LOCA, which was used as input to the standard for calculating isobar volumes?

38. Given that the degree of subcooling is an input parameter to the ANSI/ANS-58-2-1988 standard and that this parameter affects the pressure isobar volumes, please state the steps taken to ensure that the isobar volumes conservatively match the plant-specific postulated LOCA degree of subcooling for the plant debris generation break selections and if multiple break conditions were calculated to ensure a conservative specification of the ZOI radii?

39. Please provide a detailed description of the test apparatus specifically including the piping from the pressurized test tank to the exit nozzle including the rupture disk system.

40. Based on the temperature traces in the test reports, it is apparent that the fluid near the nozzle was colder than the bulk test temperature. Please describe how the fact that the fluid near the nozzle was colder than the bulk fluid was accounted for in the evaluations?

41. How was the hydraulic resistance of the test piping which affected the test flow characteristics evaluated with respect to a postulated plant-specific LOCA break flow where such piping flow resistance would not be present?

42. Please discuss the specified rupture differential pressure of the rupture disks?

43. Regarding a potential shock wave resulting from the instantaneous rupture of piping, please respond to the following questions:

44. Was any analysis or parametric testing conducted to get an idea of the sensitivity of the potential to form a shock wave at different thermal-hydraulic conditions? Were temperatures and pressures prototypical of PWR hot legs considered?

45. Was the initial lower temperature of the fluid near the test nozzle taken into consideration in the evaluation? Specifically, was the damage potential assessed as a function of the degree of subcooling in the test initial conditions?

46. What is the basis for scaling a shock wave from the reduced-scale nozzle opening area tested to the break opening area for a limiting rupture in the actual plant piping?

47. How is the effect of a shock wave scaled with distance for both the test nozzle and plant condition?

48. In cases where the application of the reduced ZOI is applied to components other than piping, please respond to this question. Please provide the basis for concluding that a jet impact on piping insulation with a 45° seam orientation is a limiting condition for the destruction of insulation installed on steam generators, pressurizers, reactor coolant pumps, and other non-piping components in the containment. For instance, considering a break near the steam generator nozzle, once insulation panels on the steam generator directly adjacent to the break are destroyed, the LOCA jet could impact additional insulation panels on the generator from an exposed end, potentially causing damage at significantly larger distances than for the insulation configuration on piping that was tested. Furthermore, it is not clear that the banding and latching mechanisms of the insulation panels on a steam generator or other RCS components provide the same measure of protection against a LOCA jet as those of the piping insulation that was tested. One WCAP reviewed asserts that a jet cannot directly impact the steam generator, but will flow parallel to it. It seems that some damage to the SG insulation could occur near the break, with the parallel flow then jetting under the surviving insulation, perhaps to a much greater extent than predicted by the testing. Similar damage could occur to other component insulation. Please provide a technical basis to demonstrate that the test results for piping insulation are prototypical or conservative of the degree of damage that would occur to insulation on steam generators and other non-piping components in the containment.

49. Some piping oriented axially with respect to the break location (including the ruptured pipe itself) could have insulation stripped off near the break. Once this insulation is stripped away, succeeding segments of insulation will have one open end exposed directly to the LOCA jet, which appears to be a more vulnerable configuration than the configuration tested by Westinghouse. As a result, damage would seemingly be capable of propagating along an axially oriented pipe significantly beyond the distances calculated by Westinghouse. Please provide a technical basis to demonstrate that the reduced ZOIs calculated for the piping configuration tested are prototypical or conservative of the degree of damage that would occur to insulation on piping lines oriented axially with respect to the break location.

50. At least one WCAP noted damage to the cloth blankets that cover the fiberglass insulation in some cases resulting in the release of fiberglass. The tears in the cloth covering were attributed to the steel jacket or the test fixture and not the steam jet. It seems that any damage that occurs to the target during the test would be likely to occur in the plant. Please explain if the potential for damage to plant insulation from similar conditions was considered? For example, the test fixture could represent a piping component or support, or other nearby structural member. The insulation jacketing is obviously representative of itself. Please explain what provides the basis that damage similar to that which occurred to the end pieces is not expected to occur in the plant? It is likely that a break in the plant will result in a much more chaotic condition than that which occurred in testing. Therefore, it would be more likely for the insulation to be damaged by either the jacketing or other objects nearby.

The licensee may demonstrate that in-vessel downstream effects issues are resolved for each of the units by showing that the licensee's plant conditions are bounded by the final WCAP-16793 and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve the in-vessel downstream effect RAIs by demonstrating, without reference to WCAP-16793 or the NRC staff SE, that in-vessel downstream effects have been addressed for both ANO units. The specific issues raised in these RAIs should be addressed regardless of the approach the licensee chooses to take.

The licensee should report how it has addressed the in-vessel downstream effects issue and the associated RAI referenced above within 90 days of issuance of the final NRC staff SE on WCAP-16793. The NRC staff is currently developing a Regulatory Issue Summary to inform licensees of the NRC staff's expectations and plans regarding resolution of this remaining aspect of Generic Safety Issue 191, "Assessment of Debris Accumulation on PWR Sump Performance."

If you or your staff has any questions concerning the resolution of this matter, please contact me at (301) 415-1480 or by electronic mail at kaly.kalyanam@nrc.gov.

Sincerely,

/RA/

N. Kaly Kalyanam, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-313 and 50-368

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Request for Additional Information

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