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

May 15, 2018

MEMORANDUM TO: Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operator Reactor Licensing
Office of Nuclear Reactor Regulation

FROM: Victor G. Cusumano, Chief ***/RA/***
Technical Specifications Branch
Division of Safety Systems
Office of Nuclear Reactor Regulation

SUBJECT: VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2 - AUDIT REPORT OCTOBER 24, 2017, THROUGH MARCH 26, 2018, RE: SYSTEMATIC RISK-INFORMED ASSESSMENT OF DEBRIS TECHNICAL REPORT (CAC NOS. MF9685 AND MF9686; EPID L-2017-TOP-0038)

By letter dated April 21, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML 17116A096), as supplemented by letter dated July 11, 2017 (ADAMS Accession No. ML17192A245), Southern Nuclear Operating Company submitted a plant-specific technical report for Vogtle Electric Generating Plant (VEGP), Units 1 and 2, and requested U.S. Nuclear Regulatory Commission (NRC) approval of the methods and inputs described in the technical report. The plant-specific technical report describes a risk-informed methodology to evaluate debris effects with the exception of in-vessel fiber limits.

The NRC staff conducted the audit from October 24, 2017, through March 26, 2018, to support its review of the technical report and increase their level of knowledge and understanding of the topic and associated methodologies. The enclosure provides the Audit Report in accordance with LIC-111, "Regulatory Audits," for conveyance to the licensee.

Enclosure:
Audit Report

CONTACT: Stephen J. Smith, NRR/DSS
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SUBJECT: VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2 - AUDIT REPORT OCTOBER 24, 2017, THROUGH MARCH 26, 2018, RE: SYSTEMATIC RISK-INFORMED ASSESSMENT OF DEBRIS TECHNICAL REPORT (CAC NOS. MF9685 AND MF9686; EPID L-2017-TOP-0038), Dated: May 15, 2018

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ADAMS Accession No.: ML18117A209 ***via e-mail** **NRR-106**

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AUDIT REPORT

GENERIC SAFETY ISSUE 191

OCTOBER 24, 2017 THROUGH MARCH 26, 2018

SOUTHERN NUCLEAR OPERATING COMPANY

VOGTLE ELECTRIC GENERATING PLANT, UNITS 1 AND 2

DOCKET NOS. 50-424 AND 50-425

1. Scope and Purpose

By letter dated April 21, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17116A096) as supplemented by letter dated July 11, 2017 (ADAMS Accession No. ML17192A245), Southern Nuclear Operating Company submitted a plant-specific technical report for Vogtle Electric Generating Plant, Units 1 and 2, and requested U.S. Nuclear Regulatory Commission (NRC) approval of the methods and inputs described in the technical report. The plant-specific technical report describes a risk-informed methodology to evaluate debris effects with the exception of in-vessel fiber limits.

The audit was conducted in two parts. The first part of the audit was conducted at Enercon Services Inc.'s offices in Albuquerque, NM, on October 24-26, 2017. The second part of the audit was conducted at NRC headquarters on March 26, 2018. Between the two meetings, the NRC staff was able to review documentation made available by the licensee on an electronic portal. The audit process allowed the NRC staff to gain significant knowledge and understanding of the methods the licensee is using in its evaluation as well as the ability to check the calculations performed by the software being used to model the plant. The NRC staff reviewed both risk assessment and traditional engineering calculations and methods used by the licensee in its technical report. The audit plan for the first part of the audit can be found in ADAMS at Accession No. ML17277A489. The audit plan for the second part of the audit can be found at Accession No. ML18051A317.

Specific topics discussed during the audit included:

- Approaches to compute the amount of debris generated and transported to the strainer(s) given a break of a specified size, at a specified weld location, a range of orientations, and the operating state of the plant, starting from the computer-aided design model of the nuclear power plant.
- Approaches to compute the conditional failure probabilities.
- Approaches to compute the core damage frequency using break frequencies in NUREG-1829, "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process," April 2008, Volumes 1 and 2 , and the NRC initiating event database for small LOCAs.
- Approaches to validate the application of the Break Accident Debris Generation Evaluator (BADGER) and Nuclear Accident Risk Weighted Analysis (NARWHAL) computer codes as applied to VEGP.
- Methods used to ensure the computer assisted design (CAD) model and BADGER as described in the submittal accurately represents the as-built, as-operated plant.

Enclosure

- Methods used by the licensee to model the generation, transport, and effects of debris consistent with approved methodologies (e.g., NRC staff's safety evaluation for Nuclear Energy Institute (NEI) 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology").
- Modelling of plant conditions to provide a realistic or conservative estimation of the effects of debris on recirculation.
- Use of guidance reports in the computation of debris amounts and transported amounts.
- Methods used to verify and validate the risk-informed computations, including verification and validation documentation.

A list of NRC and licensee staff and contractors that were present during the audit is included below.

<u>NRC Audit Team</u>:

- Michael Marshall, project manager, NRC
- Victor Cusumano, branch chief, Technical Specifications, NRC
- Steve Smith, technical reviewer, debris generation/transport, NRC
- Candace de Messieres, technical reviewer, probabilistic risk assessment, NRC
- Paul Klein, technical reviewer, chemical effects, NRC
- Matt Yoder, technical reviewer, coatings and chemical effects, NRC
- Mehdi Reisi-Fard, acting team, lead, probabilistic risk assessment, NRC*
- Bryce Lehman, technical reviewer, structural, NRC*
- Keith Tetter, technical reviewer, probabilistic risk assessment, NRC*
- Osvaldo Pensado, NRC contractor
- Stuart Stothoff, NRC contractor

*Second portion of the audit only (March 2018)

<u>Licensee Representatives</u>

- Phillip Grissom, Southern Nuclear
- Owen Scott, Southern Nuclear
- Pamela Burns, Southern Nuclear
- Tim Sande, Enercon
- Kip Walker, Enercon
- Diane Jones, Enercon
- Blake Stair, Enercon
- Dave Tolman, Enercon+
- Austin Glover, Enercon+
- Alan Mertens, Enercon+
- Caitlin Cisneros, Enercon+
- David Jurjevich, Enercon+
- Manuel Martinez, Enercon+
- Haifeng Li, Enercon (phone)+
- Eric Crabtree, Enercon (phone – entrance meeting)+
- Cory Lane, Enercon (phone – entrance meeting)+

- Mehdi Tadjalli, Enercon (phone – entrance and exit meetings)+
- Ernie Kee (independent consultant)+

+ First portion of the audit only (October 2017)

2. Documents Audited

The NRC staff audited several documents which are listed below. In addition to the documents listed, the licensee made presentations to address issues that were identified in the audit plans.

The list of documents audited by the NRC staff follows.

- 1130VNPBYP-601-NONQA, Rev. 00, Vogtle Penetration Data Correlation Technical Report
- 1130VNPBYP-R2-00-NONQA, Rev. 00, Vogtle Nuclear Plant Fiber Penetration Testing Technical Report
- BADGER-SQAP-01, Rev. 0, BADGER Software Quality Assurance Plan
- BADGER-SRS-03, Rev. 0, BADGER Software Requirements Specification
- BADGER-SCMP-01, Rev. 0, BADGER Software Configuration Management Plan
- BADGER-SVVP-03, Rev. 1, BADGER Software Verification and Validation Plan
- BADGER-SAD-02, Rev. 0, BADGER Version 2.1 Software Architecture Document
- BADGER-SDID-02, Rev. 0, BADGER Version 2.1 Software Design and Implementation Document
- BADGER-SVVR-04, Rev. 1, BADGER Version 2.1 Software Verification and Validation Report
- BADGER-SUM-02, Rev. 0, BADGER Version 2.1 Software User's Manual
- NARWHAL-SUM-02, Rev. 1, NARWHAL Version 2.1 Software User's Manual
- NARWHAL-SQAP-01, Rev. 1, NARWHAL Software Quality Assurance Plan
- NARWHAL-SRS-01, Rev. 2, NARWHAL Software Requirements Specification
- NARWHAL-SCMP-01, Rev. 1, NARWHAL Software Configuration Management Plan
- NARWHAL-SVVP-01, Rev. 2, NARWHAL Software Verification and Validation Plan
- NARWHAL-SAD-01, Rev. 1, NARWHAL Software Architecture Document
- NARWHAL-SDID-02, Rev. 1, NARWHAL Version 2.1 Software Design and Implementation Document
- NARWHAL-SVVR-03, Rev. 1, NARWHAL Version 2.1 Software Verification and Validation Report Independent Qualification Testing
- NARWHAL-SVVR-04, Rev. 1, NARWHAL Version 2.1 Software Verification and Validation Report Developer Unit and Integration Testing
- SNCV083-CALC-003, Rev. 2, Vogtle Debris Transport Calculation for Resolution of GSI-191
- SNCV083-CALC-02, Rev. 6, Vogtle Debris Generation Calculation for Resolution of GSI-191
- SNCV083-PR-03, Rev. 3, Vogtle Unit 1 CAD Model Summary Report
- V-RIE-IEIF-GSI-191-U00-001, Rev. 1, High Likelihood Configurations for Vogtle GSI-191 Evaluations
- V-RIE-IEIF-GSI-191-U00-004, Ver. 2, GSI-191 Risk Quantification for Vogtle
- V-RIE-IEIF-GSI-191-U00-004, GSI-191 Risk Quantification for Vogtle
- V-RIE-IEIF-GSI-191-U00-002, Ver.1, September 2016, Vogtle Units 1 and 2 Base Case GSI-191 PRA Model Development and Evaluation
- V-RIE-IEIF-GSI-191-U00-003, Ver. 1, September 2016, Vogtle Units 1 and 2 Internal Event PRA LOCA Frequency Development and Basis for GSI-191 Evaluations

- X4C1204V10, Ver. 1, November 2016, Vogtle Units 1 and 2 Risk-Informed GSI-191 Conditional Failure Probability Calculation
- SNC Response to NRC Request for Additional Information (RAIs 11-14) – ADAMS Accession No. ML18009A841, January 9, 2018
- SNC Response to NRC Request for Additional Information (RAIs 16-36) – ADAMS Accession No. ML18045A094, February 12, 2018

The licensee also provided BADGER and NARWHAL result databases so that the staff could evaluate the data for consistency and perform confirmatory evaluations to ensure that the results of the software provided accurate results and the models were consistent with NRC staff guidance.

3. Audit Activities and Observations

3.1 Debris Generation and Transport

The licensee provided an overview of the debris generation and transport methodology. The calculations are performed in BADGER and NARWHAL, but also include post-processing of the BADGER data before it is input into NARWHAL.

The licensee described how the debris generation values were validated against values calculated by hand. The licensee also described that the debris masses and size distributions are calculated during post-processing of the BADGER data in Microsoft Access before data are imported to NARWHAL.

The licensee provided details on the transport methodology which is implemented in NARWHAL. The methodology uses all of the modes of transport included in NRC guidance. These are the blowdown, washdown, pool fill, and recirculation phases of transport. NARWHAL calculates the amounts of each type of debris that reach the strainer for select pump states. The software then assumes the debris is in the pool at locations associated with the scenario being considered. The debris is transported to strainers in proportion with the flow through each strainer. This method was not understood by the staff during its review of the submittal. The licensee also explained how timing of pump changes of state were modeled. The licensee stated that the metrics and methods used in the transport evaluation were based on NRC staff guidance. The licensee provided information to justify that specific break and recirculation scenarios were representative or bounding of other breaks that use the metrics from the chosen scenarios.

The transport calculations also include the mass balance calculations that predict how much debris arrives at each strainer and how much is collected in the reactor core. The licensee discussed the calculations and the penetration testing that was conducted to determine how much debris could pass through the strainer and potentially reach the core. The licensee stated that nine large scale penetration tests were conducted to determine conditions that resulted in the largest amount of penetration. Small scale testing was used to eliminate some variables. The penetration testing was designed to maximize penetration through the strainer based on plant conditions. The licensee developed a penetration correlation based on the test results.

The licensee stated that it performed several mass balance calculations by hand to verify that the NARWHAL calculations were correct. The plant conditions for the various calculations were varied to ensure that the range of plant conditions was covered.

For the cold-leg break fiber loading, the licensee stated that it used a conservative decay heat curve and added 20 percent to the boil off rate to provide margin in the calculation.

The NRC staff had noted that some partial breaks at the same location and orientation created lesser amounts of debris than smaller breaks at the same location and orientation. This behavior appears to be non-physical. The licensee stated that the response to RAI 11.b provided the response to this question. The response stated that the debris generation results were reviewed and it was discovered that 47 zones of influence (ZOIs) associated with specific breaks and orientations exhibited this behavior. This represents 0.04 percent of the ZOIs evaluated. Upon further review, it was discovered that 25 of these errors were conservative and 22 were non-conservative. The cause was determined to be that the software used to calculate the interference between the postulated jet and the target material has difficulty calculating the interference when the jet boundary is very close to the outer surface of the target insulation. To correct the issue, the licensee substituted the next larger break size debris amount for the erroneous amount. The licensee also ran a sensitivity case that showed that the variations in the debris quantities had no effect on conditional failure probabilities.

The NRC staff noted that the debris generation quantities in NARWHAL for fire barrier material were inconsistent with those in BADGER. The licensee noted that the response to RAI 11.a addressed this issue. The issues were caused by putting the fire barrier small pieces of debris, which contain both particulate and fibrous material, in the particulate category. The licensee stated that the model was corrected to differentiate between fibrous and particulate debris for this material type. The licensee also stated that other materials do not have both fibrous and particulate components. The error was stated to have no effect on conditional failure probabilities.

3.2 Risk Assessment Methodology and Results

The licensee provided a high level overview of its risk assessment methodology and results. The licensee described that it followed Regulatory Guide (RG) 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-specific Changes to the Licensing Basis,” Revision 2, and considered insights from draft RG 1.229, “Risk-Informed Approach for Addressing the Effects of Debris on Post-Accident Long-Term Core Cooling” (ADAMS Accession No. ML15335A179) and the safety evaluation associated with closure of GSI-191 at South Texas Project, Units 1 and 2 (ADAMS Accession No. ML17019A002). The licensee discussed several specific topics related to its risk analysis including the development of scenarios (i.e., an initiating event followed by a plant response, such as a combination of equipment successes, failures, and human actions, leading to a specified end state, such as event prevention, core damage, or large early release), the selection of initiating event frequencies, generation of conditional failure probability (CFP) values from NARWHAL, probabilistic risk assessment (PRA) model changes, core damage frequency (CDF) and large early release frequency (LERF) results, and sensitivity and uncertainty analysis.

After the licensee described its screening and scenario development process, the NRC staff questioned whether the high level screening criteria used to establish the set of scenarios considered in its evaluation were documented in its submittal. The licensee provided references to sections in the submittal where the results of the high level screening criteria were provided. The staff communicated that a summary of the high-level screening process, including a description of the process for evaluating both primary and secondary side breaks inside containment, may be needed on the docket to support the NRC’s ongoing review of the licensee’s submittal.

The NRC staff questioned how high-likelihood scenarios were derived and how the low-likelihood delta CDF and LERF values were calculated. The licensee presented a summary of its process and the staff communicated that a summary of this process may be needed on the docket to support the NRC's ongoing review of the licensee's submittal.

The NRC staff identified that the risk analysis did not include an assessment of internal fires or address some other external hazards. The licensee described its rationale for the scope of its PRA to support its GSI-191 analysis at VEGP. The NRC staff communicated that a summary of this rationale may be needed on the docket to support the NRC's ongoing review of the licensee's submittal.

The NRC staff requested that the licensee describe how dependencies and common cause failures were treated in the risk analysis (e.g., are there unique common cause failures that need to be considered in risk evaluations?) and how it was determined that the approach used does not impact the results. The licensee described the process implemented and supported the conclusion that relevant common cause failure processes are included in its analysis.

The NRC staff questioned how the small break LOCA (SBLOCA) frequency used in the risk analysis was derived. The licensee stated that NUREG/CR-6928, "Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants," which contains the most updated information, was used. Additionally, the licensee stated that SBLOCAs have no effect on plant risk in the analysis relevant to this review.

The NRC staff asked the licensee to explain the effects of an interpolation error in Table 1 of calculation V-RIE-IEIF-GSI-191-U00-003, Vogtle LOCA Frequency Development, Rev. 1. The staff noted that interpolated values were outside bounds for the two-inch break size median and 95^{th} percentile, and that such an interpolation error caused an incorrect error factor (EF) for medium breaks. The licensee stated that the EF is not used in the analysis, but is being corrected for use in other calculations.

The NRC staff asked the licensee to explain how each high likelihood scenario modeled in NARWAL for large break LOCAs is reflected in the VEGP PRA since it appeared that scenarios with one centrifugal charging pump (CCP) failure or one safety injection pump (SIP) failure were not included. The licensee described that these cases do not need to be explicitly modeled in the PRA because a failure of the CCP or SIP would not change the flow through the residual heat removal (RHR) pump and associated strainers (i.e., CCP and SIP pumps piggyback off the RHR pump) and therefore are reflected in the no equipment failure configuration case.

3.3 NARWHAL

The licensee described software validation and verification (V&V) that was performed to ensure that NARWHAL performed calculations as expected. Two separate V&V programs were undertaken. One was performed by the staff that developed the software and another was conducted by independent staff not involved in the development of NARWHAL. Most validation calculations were performed using Microsoft Excel. The licensee stated that to date, there were five minor errors identified in released versions of NARWHAL. The errors were considered minor because they caused insignificant errors in calculations.

The licensee described the sensitivity studies performed during the analysis. The sensitivity studies were intended to provide additional certainty that the models, assumptions, and inputs used in the analysis do not result in underestimation of risk.

The licensee stated that the NARWHAL software continues its calculations after a failure is identified. This feature allows identification of additional failure modes occurring in the same simulation for diagnostic purposes.

3.4 BADGER

The licensee stated that BADGER does not calculate the debris size distribution. BADGER calculates the volume of debris based on the ‘interference” between the target, or debris source, and the radius of the jet damage zone. Based on the volume of debris generated, an independent program in Microsoft Access calculates the masses and size distributions for each debris type based on the centroid distance. The post-processed data is then used by NARWHAL for calculations of debris distributions to the strainers, the core, and determination of failure conditions. BADGER only has to be run once unless changes in the plant (e.g., insulation amounts) cause changes in debris estimates. The same BADGER output is used as input to the various scenarios (e.g., pump stated configurations) independently addressed by NARWHAL.

3.5 Break Selection

The licensee provided details on the break selection process for secondary side breaks and their evaluation. Risk for these breaks is driven by an operator action to realign the containment spray (CS) pumps for recirculation. If the realignment is performed correctly, secondary breaks will not result in failures.

The licensee discussed welds that were excluded from the break selection process. Any weld that is normally isolated from the pressurized portion of the RCS by an isolation valve or check valve was not included in the population of welds evaluated. These welds not included in the analysis are referred to as isolable welds.

3.6 Headloss

The NARWHAL calculations for headloss extrapolation to its 30 day value used the limiting test as its basis. This results in conservative headloss extrapolation. The extrapolation used assumed a logarithm of time. The logarithmic function was fit to experimental data and then shifted upward to absolutely bound all test data. The extrapolated headloss at 30 days was conservatively assumed to occur at 7.5 hours after the accident. (Chemical headloss from aluminum precipitates was usually not included in the total headloss until around 24 hours after the accident.)

Viscosity and density corrections for headloss due to temperature and flow differences from the tested condition were calculated using test data from flow sweeps. The test flow rates were representative of the full flow rate assumed in the NARWHAL calculations.

The licensee clarified that the clean strainer headloss value is 4.4 inches, not 4.4 feet. The submittal contained a typo.

The licensee clarified the methodology used to incrementally increase headloss based on the debris loading on the strainers, headloss extrapolations in time, and other parameters that can affect the headloss such as the precipitation of chemicals.

The licensee clarified that a debris bed thickness discrepancy identified by the staff was due to an assumption of mechanical blockage of some area of the strainer. The licensee agreed that the staff calculation was correct.

The NRC staff noted that the air void fraction in the strainer would calculate negative values which is non-physical. The licensee stated that the air void fraction calculation represents the amount of air that remains within the strainer and that this option was not used by Vogtle. (NARWHAL simulations for Vogtle assumed that all entrained gases pass to the pump suction.) Enercon stated that NARWHAL would be updated to eliminate the potential for negative values for this parameter.

3.7 Net Positive Suction Head (NPSH)

The NPSH calculation is dependent on the sump level calculated by NARWHAL. The licensee stated that the sump level calculation was a linear relationship between the volume assumed to be in the sump and the level of water in the containment. The level is also corrected for holdup volumes and temperature.

3.8 Coatings

The licensee stated that the coating dry film thickness assumptions were based on the maximum allowable thicknesses from plant specifications. If specifications were not available, the thickness calculation assumed the maximum recommended thickness from the manufacturer.

BADGER has difficulty calculating interferences between the assumed jet radius and small thickness targets. Therefore, the calculation assumed a one-inch thickness for the coatings, then proportionally corrected the volumes to the assumed thicknesses.

During the first part of the audit, the NRC staff questioned whether the coating amounts used in the testing had been corrected for density when the test surrogates were identified. The staff stated that using a surrogate with a density greater than the plant coating would be non-conservative if test scaling is based on mass. The staff stated that guidance is that surrogates should model the volume of coating in the plant, not necessarily the density. The volume of the surrogate is most important because the volume of the particles in the bed are the primary driver of headloss. Vogtle determined that the coating amounts would have to be re-evaluated. The original assumption of 100 percent transport of unqualified coatings will have to be revisited. During the second part of the audit, the licensee provided a discussion of its resolution to the coating issue. The resolution had also been transmitted to the NRC as responses to RAIs 24 and 35. The issue was resolved by assuming that the unqualified coatings fail as 100 percent particulate as was assumed initially. However, the licensee credited a lower transport fraction of the debris in upper containment for scenarios that do not result in the initiation of containment spray. For scenarios where sprays are initiated, 100 percent transport is assumed, and for scenarios where sprays are not initiated, 10 percent transport is assumed. The licensee determined that the updated assumptions result in the same conditional failure probabilities calculated using the initial assumptions. The staff stated that they were concerned that the sensitivity studies could be affected by the new assumptions.

The NRC staff questioned whether having the limiting coatings debris quantity for secondary side breaks bounded by the quantities calculated for primary breaks ensured the secondary breaks were properly bounded by the amounts of debris in the test. The licensee stated that the coating amounts for secondary breaks calculated using the updated coating assumptions are bounded by the tested amounts. The licensee also said that all calculations and sensitivity studies will be rerun using the updated assumptions and submitted to the NRC.

3.9 Chemical Effects

The licensee described the methodology used to calculate the amount of chemical precipitates in the sump pool and the assumptions regarding chemical effects and headloss. The licensee stated that chemical precipitates were assumed not to result in additional headloss until a minimum bed thickness was reached on the strainer. Calcium phosphate is assumed to result in headloss as soon as the minimum bed thickness collects on the strainer. The NRC staff was concerned with the threshold bed thickness. The licensee stated that sensitivity studies were performed to ensure that the threshold bed thickness did not significantly affect the risk results.

The NRC staff noted that the headloss test with the less limiting headloss had a higher calcium phosphate headloss than the test that ultimately resulted in a limiting headloss. The licensee stated using the headloss test with the highest total headloss was conservative and also noted that NPSH failures do not contribute to risk for Vogtle. The licensee also noted that sensitivity studies were conducted to ensure that the assumptions used for the headloss model did not significantly affect the risk results. One of these sensitivity studies used the higher calcium headloss that resulted during the full load test that had the higher calcium headloss, but lower overall headloss.

Aluminum based precipitation is not predicted until the sump temperature is reduced to the point where the aluminum solubility limit is reached. If the solubility limit for aluminum is not reached before 24 hours, precipitation is assumed to occur at that time.

The licensee also discussed the assumptions associated with time steps around 24 hours because the staff was concerned that the assumptions would result in some chemical precipitate collecting on the CS strainers instead of the RHR strainers. The licensee stated that the CS pumps remain in operation for one minute following the assumed time of precipitation and that this does not result in a significant change in the amount of aluminum precipitate calculated to arrive at the RHR strainers. The licensee also stated that there is considerable conservatism in the chemical effects model that will offset the small non-conservatism that might be caused by the timing assumptions.

The NRC staff questioned why the amounts of calcium precipitates at the strainer do not increase in proportion to the amount of Nukon in the pool after a specific amount of Nukon has been transported to the pool. The licensee stated that the NARWHAL model was a reproduction of the NRC approved methodology for calculating the amount of calcium precipitate. The NRC staff stated that they would review the model and determine if additional information is required. If so, an RAI will be sent to the licensee.

3.10 Structural Evaluation

The NRC staff identified what appeared to be conflicting information in the submittal regarding the structural analysis of the strainers. The staff stated that the structural evaluation states that the crush pressure of the strainer is 10.1 ft. The headloss section states that the strainer has 24 ft. of structural margin. The NPSH section states that headloss may reach 14 ft. If the headloss exceeds the crush pressure of the strainer, it should be assumed to fail. The NRC staff asked the licensee to clarify this issue. The licensee stated that the original structural analysis assumed that the crush pressure of the strainer was 10.1 ft. and found all components to pass the stress acceptance criteria. The stress analysis was revisited in an attempt to increase the crush pressure and employed a new model to increase the stress limit of some welds. The updated model found that the overall, updated crush pressure was increased to 24 feet. based on the updated strainer size. The NRC will consider generating an RAI to request formal transmittal of the information that was discussed during the audit.

3.11 Path Forward

Due to the modeling changes required as a result of NRC staff and licensee findings during the review of the submittal, changes to the model used for the initial submittal were identified. These changes require that the model be rerun with the updated information to attain updated risk, sensitivity, and parametric results that reflect the current model conditions. The licensee agreed to submit a supplement with the updated information.

The NRC staff will consider generating an RAI regarding the structural question discussed above.

The NRC staff will consider generating an RAI regarding high and low-likelihood scenarios.

The NRC staff will consider generating an RAI regarding high level screening criteria.

The NRC staff will consider generating an RAI regarding the scoping of external hazards, including fire, in the PRA.

The NRC staff will consider generating an RAI regarding the screening of SSBI scenarios.

The NRC staff will review the information discussed during the audit and determine whether additional information is required on the docket. If so, the NRC staff will use the RAI process to request the required information.

4. Closing Briefing

The NRC staff provided the following feedback to the licensee at the end of part one of the audit on October 26, 2017. The NRC staff expressed their appreciation for Enercon hosting the audit and for the participation of the licensee and the associated parties. The staff stated that they learned a great deal about the methodology and assumptions used in the analysis. The staff also stated that they acknowledged the complexity of the NARWHAL software and the amount of work that was required to build and validate the code. The staff also acknowledged the versatility of the software and the relative ease with which it could be understood. The NRC staff and the licensee agreed to hold the audit open to allow unanswered issues to be resolved. The staff stated that they remained concerned with the treatment of coatings and the documentation of conservatism in the chemical effects evaluation. The licensee agreed to provide the NRC staff with additional documentation to facilitate their understanding of the analysis.

At the end of part two of the audit in March 2018, the NRC staff and the licensee discussed the best path forward to ensure that information necessary for the review was provided on the docket. The actions are summarized above in the path forward section. The NRC staff noted that the audit was effective, informative, and productive. Further, the objectives defined in the audit plan were accomplished. The staff stated that the information, knowledge, and understanding obtained during the audit will enhance and support the ongoing review of the licensee's submittal. The staff also noted that the audit process was beneficial in reducing the number of RAIs required for the staff to make their final determination on the licensee's submittal. The NRC staff thanked the licensee and their contractors for supporting the audit in a quality manner.