



UNITED STATES
NUCLEAR REGULATORY COMMISSION
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March 1, 2018

MEMORANDUM TO: Jennifer L. Dixon-Herrity, Chief
Licensing Branch 4
Division of New Reactor Licensing
Office of New Reactors

FROM: William (Billy) Gleaves /RA/
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Office of New Reactors

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION'S AUDIT REPORT
RELATED TO LICENSE AMENDMENT REQUEST LAR-17-010
REGARDING PIPE RUPTURE HAZARD AND FLOODING ANALYSIS

The U.S. Nuclear Regulatory Commission staff conducted an audit of documents related to the Vogtle Electric Generating Plant Units 3 and 4 proposed license amendment request (LAR) 17-010. The audit was conducted at various times in the period of June 13, 2017, to January 3, 2018, at the Southern Nuclear Operating Company's/Westinghouse Electric Company's Electronic Reading Room.

The audit plan can be found in the Agencywide Documents Access and Management System (ADAMS) under accession number ML17156A426 dated June 12, 2017. A summary report of the audit is enclosed.

Docket Nos: 52-025 and 52-026

Enclosure:
As stated

cc:
Chang-Yang Li
Chandu Patel

U.S. NUCLEAR REGULATORY COMMISSION'S AUDIT REPORT RELATED TO LICENSE AMENDMENT REQUEST LAR 17-010 REGARDING PIPE RUPTURE HAZARD AND FLOODING ANALYSIS DATED MARCH 1, 2018

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**AUDIT SUMMARY REPORT
VOGTLE ELECTRIC GENERATING PLANT
LICENSING AMENDMENT REQUEST (LAR) 17-010 REGARDING
PIPE RUPTURE HAZARD AND FLOODING ANALYSIS
DOCKET NOS. 52-025 AND 52-026**

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1.0 SUMMARY

The purpose of this audit was for the staff to examine and evaluate non-docketed information:

1. To gain a better understanding of the configurations and room layouts at the Vogtle Electric Generating Plant (VEGP) AP1000 auxiliary building which may affect the flood level of each room in the building;
2. To verify and obtain clarifications on the information in LAR-17-010 and evaluate its effects on the flood analyses; and
3. To identify any information needed on the docket to support the basis of a reasonable assurance finding.

The audit was conducted from the Westinghouse Electric Company's (Westinghouse) Rockville, Maryland office and the NRC Headquarters via Westinghouse's electronic reading room (ERR) starting from June 13, 2017, to January 3, 2018. Enclosure 1 lists the documents in the ERR made available to support the review of LAR-17-010. Among these documents were the AP1000 as-designed pipe rupture hazard and flooding analyses resulting from high-energy line breaks, moderate line breaks, and through-wall cracks for all levels of the Auxiliary Building. In addition, the documents included safety-related equipment flooding target identification, compartment volume calculations, safety-related equipment dose evaluation, piping and instrumentation diagrams (P&IDs) for several systems, and pipe rupture locations.

The NRC staff conducted the audit in accordance with the NRC Office of New Reactors (NRO), Office Instruction NRO-REG-108, "Regulatory Audits." The plan for this audit, dated June 12, 2017, is available in the Agencywide Document Access and Management System (ADAMS) using Accession No. ML17156A426.

2.0 AUDIT SCOPE

The NRC staff audited the pipe rupture hazards analysis (PRHA) and internal flood analysis documents for the Auxiliary Building to support the staff's review of LAR-17-010.

The specific scope of this audit include the following topics.

- Revised flood analyses in the auxiliary building
- Revised list of safe shutdown equipment in the auxiliary building
- Revised fire protection system and fire hazard analyses
- Bounding breaks in all the rooms and all the piping systems
- Impact assessment on the wall design resulting from the revised flood heights
- Impact assessment on the human factors resulting from the revised flood analyses
- Impact assessment on the plant-specific pipe rupture hazards analysis

The staff audited the following PRHA documents:

- APP-GW-GLR-075, Revision 3, "PRHA Summary Report for Auxiliary Building,"
- APP-GW-N1-007, Revision 5, "AP1000 Design Criteria for Protection from Flooding,"
- APP-GW-POC-005, Revision 3, "AP1000 Break Locations for Pipe Rupture Hazard Analyses," APP-GW-POC-170, Revision 2, "Identification of Crack Exclusion Zones and Piping without Stress-Based Cracks within the AP1000 Auxiliary Building,"
- APP-SSAR-GSC-761, Revision 4, "AP1000 PRHA Safety-Related Equipment Flooding Target Identification,"
- APP-SSAR-GSC-737, Revision 6, "AP1000 PRHA Auxiliary Building Analysis of Internal Flooding as a result of Postulated High-Energy Line Breaks, and"
- Additional documents are listed in Enclosure 1, "List of Documents for LAR-17-010 Audit," of this report.

3.0 REGULATORY BASIS

Title 10 of the *Code of Federal Regulation* (10 CFR), Section 52.47(a)(2) requires that a standard design certification applicant provide "a description and analysis of the structures, systems, and components (SSCs) of the facility, with emphasis upon performance requirements, the bases, with technical justification therefor, upon which these requirements have been established, and the evaluations required to show that safety functions will be accomplished."

The NRC staff must have sufficient information to document its safety findings in its safety evaluation report (SER) to ensure that the licensee has adequately considered flood protection for equipment being used for safe shutdown following flooding resulting from pipe breaks and pipe cracks. Specifically, this regulatory audit is based on the following:

- General Design Criterion (GDC) 4 in Appendix A to 10 CFR Part 50, as it relates to SSCs important to safety being designed to accommodate the effects of postulated accidents, including appropriate protection against the dynamic effects and environmental effects associated with postulated pipe rupture;
- Additional detailed acceptance criteria in standard review plan (SRP) Sections 3.4.1, 3.6.1, and 3.6.2, as well as branch technical positions (BTPs) 3-3 and 3-4; and

4.0 OBSERVATIONS AND RESULTS

The staff reviewed the information provided by the licensee to gain an understanding of the VEGP PRHA in order to (1) support the staff's review of LAR-17-010 license amendment request, (2) evaluate conformance with the relevant SRPs or technical guidance, and (3) verify that the Vogtle PRHA and flood analysis are performed in accordance with the methodology and criteria described in the AP1000 Design Control Document (DCD). Several audit observations are discussed below.

Audit observations within the scope of SRP Section 3.6.2 and BTP 3-4:

Based on the information provided by the licensee in the audit, the staff did not identify any issues with the performance of the AP1000 PRHA as related to the methodology and criteria described in DCD Tier 2, Section 3.6.2. Further, the staff determined that the Southern Nuclear Operating Company's (SNC) criteria used in defining high- and moderate-energy piping are consistent with the reviewed and approved AP1000 Updated Final Safety Analysis Report (UFSAR) criteria. The staff also determined that SNC has appropriately considered breaks in high-energy piping for environmental and flooding analysis, except for piping which has been shown to meet the break exclusion criteria. For moderate-energy seismic Category I or seismic Category II piping, through-wall cracks are postulated, except for piping which has been shown to meet the crack exclusion criteria. In addition, for evaluating consequences of flooding, SNC has appropriately considered full circumferential pipe breaks in non-seismically supported moderate-energy piping (e.g., fire-protection system moderate-energy lines). The staff found that the PRHA criteria used in the above documents for determining the postulated pipe breaks/cracks locations and types for high- and moderate-energy piping are in accordance with the pertinent reviewed and approved criteria and are therefore acceptable.

Audit observations within the scope of SRP Section 3.4.1:

Based on the information provided by the licensee in the audit, the staff did not identify any issues with the performance of the AP1000 flood analysis as related to the methodology and criteria described in DCD Tier 2, Section 3.4.1. Further, the staff determined that SNC's flood analysis adequately considered all the possible sources of internal flooding in the Auxiliary Building because, in determining the limiting flooding source, SNC has considered the spectrum of breaks and cracks as discussed in SRP, Section 3.4.1, for all the compartments in the Auxiliary Building. In addition, the staff reviewed the information in the audit on the methodology, assumptions, plant layout, flood barriers, flow path, and calculated results of the flood levels. The staff found sufficient details in the audit documents. For each pipe break, the flow paths and floodable volumes of the affected rooms as well as flood levels are provided in the documents. All the important parameters such as break flows, crack flows, effective flood area for each compartment

line isolation time, and tank volumes are described in the documents. The analysis method and assumptions are consistent with the guidance in SRP, Section 3.4.1.

Audit observations within the scope of Radiation Protection:

During the audit, the staff reviewed how the PRHA flooding could affect the total integrated dose to equipment under the EQ program, as required by 10 CFR 50.49 and GDC 4. For the EQ analysis the licensee assumed that the radiologically contaminated systems failed and that the radionuclide contents dispersed in the area, and that a safety-significant component is submerged in the radioactive fluid for 2 weeks. This assumption is conservative in that it assumes essentially the worst possible radiological scenario for the equipment in those areas for a 2 week period. It is reasonable that appropriate action could be taken within two weeks of a radioactive waste release to maintain safety (such as waste cleanup, equipment replacement, and/or reactor shutdown, as appropriate). In addition, in the very unlikely scenario that during actual plant operation doses to equipment are higher than those calculated or could result in higher total integrated dose than a piece of equipment is qualified, the licensee still has to appropriately maintain the equipment, as required by 10 CFR 50.49 and GDC 4. As a result, the staff found the radiation doses calculated for equipment impacted to be acceptable.

Results

The NRC staff identified several items, as described in Enclosure 2 of this audit report, for an initial discussion. The licensee provided responses with pointers and clarifications to most of the initial items in an audit kickoff meeting, on June 13, 2017, at the Westinghouse Rockville Maryland office. Request for additional information (RAIs) were developed by the NRC staff subsequently, as the audit and review progressed. These additional RAIs and responses were documented in the following supplemental submittals and enclosures:

Supplemental 1 to LAR-17-010, dated August 21, 2017 (ADAMS Accession No. ML17233A325), which in Enclosure 5 provided SNC's responses to 5 of 7 staff RAIs and in Enclosure 6 corrected the original LAR by identifying one additional licensing basis document that was not mentioned in that LAR.

Supplemental 2 to LAR-17-010, dated October 9, 2017, (ADAMS Accession No. ML17282A014), which in Enclosure 7 provided SNC's responses to the balance of the RAIs not responded to in the August 21, 2017, letter; additional supplemental information in response to public discussions held on September 7, 2017; and a revision to Enclosure 1 from the original LAR. Enclosure 11 (ADAMS Accession No. ML17282A013) provides Table 2, "Flood Heights for Auxiliary Building RCA Rooms Affected by Flooding," which addresses the RAI regarding the flood levels for all the rooms being affected by the flooding in the auxiliary building radiologically controlled area (RCA).

Supplemental 3 to LAR-17-010, dated November 1, 2017, (ADAMS Accession No. ML17305B507), which in Enclosure 12 provided SNC's responses to a newer staff RAI, and proposed changes to licensing basis in Enclosure 13.

Supplemental 4 to LAR-17-010, dated December 1, 2017, (ADAMS Accession No. ML17335A762), which in Enclosure 15 provided SNC's responses to a third staff RAI and proposed associated revisions to licensing basis documents. Supplement 4 was updated and revised by a letter dated December 15, 2017, (called Supplement 4, Revision 1) ADAMS

Accession No. ML17349A928). This revision updated Enclosure 15 to the December 1, 2017, letter. The update to Enclosure 15 included submitting an additional statement in response to Question 1 regarding moisture incursion in the waste gas system or associated control system. The update to the UFSAR markup in Enclosure 16 added a paragraph that, in general, identified the electrical classification thereof and that the two water level sensors provide input to the Protection and Safety Monitoring subsystem.

Supplemental 5 to LAR-17-010, dated January 3, 2018, (ADAMS Accession No. ML18003B082), which in Enclosure 17 provided SNC's responses to a fourth staff RAI regarding loads on the safety-related Class 1E batteries.

5.0 CONCLUSION

As discussed in Section 4.0, "Observations and Results," above, this audit and the resolution of the subsequent RAIs support the staff evaluation that is documented in the SER.

6.0 REFERENCES

1. NRO-REG-108, "Regulatory Audits," ADAMS Accession Number ML081910260, issued April 2, 2009.
2. LAR-17-010, dated March 31, 2017 (ADAMS Accession No. ML17090A570).
3. SRP Section 3.4.1, "Internal Flood Protection for Onsite Equipment Failures" Revision 3, issued March 2007.
4. SRP Section 3.6.2, "Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping," Rev. 3, issued March 2007.
5. BTP 3-3, "Protection against Postulated Piping Failures in Fluid Systems outside Containment," Rev. 3, issued March 2007.
6. BTP 3-4, "Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment," Rev. 2, issued March 2007.

List of Documents for Licensing Amendment Request for Audit of (LAR) 17-010

| Document Number | Title |
|---|---|
| APP-GW-GLR-075, Rev.3 | AP1000 Pipe Rupture Hazards Analysis (PRHA) As-Designed Summary Report for the Auxiliary Building – All Levels |
| APP-SSAR-GSC-761, Rev. 4 | AP1000 PRHA Safety-Related Equipment Flooding Target Identification |
| APP-SSAR-GSC-737, Rev.6 | AP1000 PRHA Auxiliary Building Analysis of Internal Flooding as a Result of Postulated High-Energy Line Breaks |
| APP-SSAR-GSC-779, Rev. 2 | AP1000 PRHA Auxiliary Building Analysis of Internal Flooding as a Result of Postulated Moderate-Energy Line Breaks Affecting Levels 1 and 2 |
| APP-SSAR-GSC-740, Rev. 8 | AP1000 PRHA Auxiliary Building Analysis of Internal Flooding as a Result of Postulated Through-Wall Crack Ruptures |
| APP-SSAR-GSC-780, Rev. 2 | AP1000 PRHA Auxiliary Building Analysis of Internal Flooding as a Result of Postulated Moderate-Energy Line Breaks Affecting Level 2 Areas and Higher |
| APP-SSAR-GSC-752, Rev. 5 | AP1000 Auxiliary Building Internal Flooding Analysis Input Data |
| APP-SSAR-GSC-744, Rev. 4 | AP1000 Nuclear Island Compartment Volume Calculations Supporting Pipe Rupture Hazards Analyses |
| APP-SSAR-GSC-807, Rev. 0 | AP1000 Pipe Rupture Hazards Analysis (PRHA) Safety-Related Equipment Dose Evaluation in Auxiliary Building |
| APP-GW-N1-007, Rev. 5 | AP1000 Design Criteria for Protection from Flooding |
| APP-0000-X2-025 (UFSAR Fig. 1.2-2), Rev. 2 | Standard Plant Yard Site Plan Overall Yard Layout |
| APP-FPS-M6-001 (UFSAR Fig. 9.5.1-1 sh. 1), Rev. 8 | Piping and Instrumentation Diagram Fire Protection System |
| APP-FPS-M6-002 (UFSAR Fig. 9.5.1-1 sh. 2), Rev. 7 | Piping and Instrumentation Diagram Fire Protection System |
| APP-2030-AF-001, Rev. 4 | Turbine Building Fire Area Location Plan at EL 100'-0" |
| VS2-0000-ER-S1200, Rev. 2 | VCS Yard Electrical Underground Raceway Layout Area S12000 |
| APP-FPS-GJP-101, Rev. 1 | Fire Protection System |
| APP-GW-GJR-347, Rev. 0 | Internal Flooding Response |
| APP-GW-GJR-347, Rev. 0 | Background for AOP-347, Internal Flooding Response |
| APP-AY20-Z0-300, Rev. 0 | Auxiliary Building Stairwell S04 Louvers |
| APP-AY20-Z0-300, Rev. 0 | AP1000 Auxiliary Building S04 Louver Envelope Drawing |

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| APP-1000-AD-102, Rev. 1 | Auxiliary Building Standard Louver Details |
| APP-1050-AD-101, Rev. 5 | AP1000 Nuclear Island Door/Louver Schedule EL 135'-3" |
| APP-AY20-Z0-003, Rev. 1 | Design Specification for MSIV Compartment Lower Relief Panels |
| APP-AY20-V0-003, Rev. 0 | MSIV Compartments Lower Relief Panels A and B envelope Drawing |
| APP-GW-P0C-040, Rev. 4 | Identification of High Energy Lines, Lines to be Evaluated for Leak-Before-Break, and Break Exclusion Zones within the AP1000 Nuclear Island |
| APP-GW-P0C-005, Rev. 3 | AP1000 Break Locations for Pipe Rupture Hazard Analysis (PRHA) |
| APP-GW-P0C-170, Rev. 2 | Identification of Crack Exclusion Zones and Piping without Stress-Based Cracks within the AP1000 Auxiliary Building |
| APP-GW-P0C-175, Rev. 0 | Environmental Effects of Postulated Pipe Ruptures for Upper Levels of the Auxiliary Building |
| APP-GW-P0C-121, Rev. 3 | Environmental Effects of Postulated Pipe Ruptures for Lower Levels of the Auxiliary Building |
| APP-CVS-M6-004 (UFSAR Fig. 9.3.6-1 sh. 2), Rev. 13 | Piping and Instrumentation Diagram Chemical and Volume Control System |
| APP-DWS-M6-001 (UFSAR Fig. 9A-2 sh. 1), Rev. 5 | Piping and Instrumentation Diagram Demineralized Water Transfer and Storage System |
| APP-DWS-M6-004, Rev.5 | Piping and Instrumentation Diagram Demineralized Water Transfer and Storage System |
| APP-DWS-M6-006, Rev.6 | Piping and Instrumentation Diagram Demineralized Water Transfer and Storage System |

**Initial Items for Discussion
In the Audit of Licensing Amendment Request (LAR) 17-010**

Flood Analysis

- 1) Explain the process for how the licensee verifies the list of shutdown equipment in the auxiliary building to ensure that all the safe shutdown equipment is above the flood level or listed for submergence qualification test.
- 2) The flood analyses in LAR-17-010 do not include the floodable areas and volumes to determine the flood height. Provide detail information in the flood analyses to explain how the limiting case of 19 ft. flood height was determined for Level 1 and Level 2, including identification of pipe break room and affected rooms, floodable areas and volumes, drain flow, and flood heights of all affected rooms.
- 3) For upper levels (3, 4, and 5) provide additional details information in the flood analyses that include pipe break assumptions, break flows and water volumes, drain flow, flow path, and flood heights for all the rooms being affected.
- 4) Provide a sketch that shows the layout of these rooms, and flood propagation relationship (e.g., doors, drain and ceiling connections, flood barriers between the rooms).
- 5) Provide the flood protection assessment for the fire protection pipe breaks in the containment, turbine building and the yard area.
- 6) Provide information to explain the following inconsistency: LAR Enclosure 3, page 16 of 30, Updated Final Safety Analysis Report, Appendix 3D, Table 3D.5-4 indicates the submergence for Rooms 12264 and 12265 are 249" and 288", respectively. These are more than the limiting case of 19 ft. flood level.
- 7) Provide flood levels for the rooms listed in Table 3.3-2 (page 5 of 30 in LAR Enclosure 3), "Nuclear Island Building Room Boundaries Required to Have Flood Barrier Floors and Walls."

Fire Protection

- 1) Provide revised layout drawings showing new pumps locations.
- 2) Provide revised fire protection system P&IDs.
- 3) Provide revised fire barrier drawings in Turbine Building and Yard Area.
- 4) Provide revised cable routing drawings for fire pumps.
- 5) Provide revised Fire Hazard Analysis for Turbine Building and Yard Area.
- 6) Provide revised procedure for fire water storage tank make-up.

Human Factors

- 1) Provide information to explain the credited operator action in more detail. Specifically, is the credited operator action taken from the Main Control Room (MCR) or locally at the valve/valve operator? If it is a local action, where does the operator have to go?
- 2) The LAR submittal states that operator action is required within 7 hours of rupture initiation, not 7 hours from MCR alarm. Provide information on the available time (time period from a presentation of a cue for an action to the time of adverse consequences if the action is not taken). In other words, how long until the MCR gets the flooding alarm from the new sensors? How does this impact the time (the proposed 7 hours) that the operator actually has to take the credited action?
- 3) Did the COL holder take any steps to validate feasibility and reliability of the operator action (walkthrough, table top, simulate etc.)?
- 4) What is the consequence(s) of the operators NOT taking the action, was any risk analysis done on the failure of the Human Action?

Structure Engineering

- 1) Provide a visual characterization of the area affected by the flooding including the current wall thickness.
- 2) Provide justification how the structural walls are qualified using new flood height in the affected areas.
- 3) Provide the controlling load combination that govern the wall design
- 4) Provide configuration and mounting details of the flood relief louver installed in the wall.
- 5) Provide minimum distance between the NI structures and the new tanks in the yard to prevent external flooding and II/I interaction consideration.
- 6) What will be the storage criteria of the flood water collected from the RCA area?
Provide a design for the storage of this contaminated water.

Mechanical Engineering

To verify that the break identified in the flood analyses is the bounding break for each room in the auxiliary building, the licensee should clarify that all the piping systems (i.e., all high- and moderate-energy piping, either seismically or non-seismically supported) inside each respective auxiliary building room have been identified and the applicable pipe ruptures were considered in the licensee's flooding analysis as submitted in LAR-17-010.

Probabilistic Risk Assessment

Provide documentation of the review of the proposed modification for its potential impact on the plant-specific PRA.