Audit Summary
Review of Levy Nuclear Plant, Units 1 and 2
Design Change Related to the Containment
Condensate Return Pathway

July 2015

A. Background

By letter dated May 5, 2015, Duke Energy Florida (DEF) submitted a request for exemption from the AP1000 rule and a description of associated design change departure from the AP1000 Design Control Document (DCD) Revision 19 as part of its application for a combined license (COL) for Levy Nuclear Plant Units 1 and 2 (Reference 1). The request supersedes similar previous requests (References 2 and 3). The applicant determined that this design change required it to notify the Nuclear Regulatory Commission (NRC) for review of the proposed change in accordance with Interim Staff Guidance DC/COL-ISG-011, “Finalizing Licensing-basis Information.” The Levy Nuclear Plant COL application incorporates the AP1000 DCD by reference. The exemption request was a revision of an exemption request dated February 7, 2014.

The design change modifies the interior of the containment vessel in support of the condensate return portion of the passive core cooling system. The submittal includes a report developed for the AP1000 by Westinghouse Electric Company, LLC (WEC) that provides a description of the change and the basis for the change. The report, “Changes to Passive Core Cooling System Condensate Return” (APP-GW-GLR-161), includes a regulatory evaluation of the updated condensate return design that addresses compliance with the applicable regulatory requirements, and references a set of detailed calculations supporting the departure.

This is the third audit examining other documents related to the containment condensate return system departure and design change; one was conducted in 2013 (Reference 4) and another was conducted in 2014 (Reference 5). This revision of the submittal involved no change to the design changes mentioned above, but revised the analysis methodology as compared with the February 7, 2014, submittal.

B. Bases

This regulatory audit is based on the following:

- Title 10 of the *Code of Federal Regulations* (10 CFR), Part 52, Appendix D, Section VIII
- General design criteria (GDC) from Appendix A to 10 CFR Part 50
  - GDC 2, “Design bases for protection against natural phenomena”
  - GDC 4, “Environmental and dynamic effects design bases”
  - GDC 34, “Residual heat removal”
  - GDC 35, “Emergency core cooling”
  - GDC 36, “Inspection of emergency core cooling system”
- 10 CFR 50.46 and Appendix K to 10 CFR Part 50, as they relate to analysis of passive residual heat removal heat exchanger performance

- Standard Review Plan Section 6.2.2 “Containment Heat Removal Systems”
- DC/COL-ISG-011, “Finalizing Licensing-basis Information”
- Standard Review Plan Section 6.3, “Emergency Core Cooling System”

The primary purposes of the audit was to evaluate changes made to the detailed calculations, analyses, and bases underlying the aforementioned departure and design change and confirm the staff’s understanding of the departure and design change.

The audit plan is available in the Agencywide Documents Access and Management System (ADAMS) under Accession Number ML15139A246.

C. Audit Location and Dates

Location: Westinghouse Electric Company, LLC
11333 Woodglen Drive Suite 203
Rockville, MD 20852

Dates: May 19 through July 2, 2015.

D. Audit Team Members

The following NRC staff members participated in substantive discussions during the audit:

Boyce Travis, NRC Audit Team Lead (Containment)
Timothy Drzewiecki (Reactor Systems)
Chris Van Wert (Reactor Systems)
John McKirgan (Reactor Systems)
James O’Driscoll (Containment)
Donald Habib, NRC Project Manager

E. Applicant and Industry Staff Participants

Duke Energy Florida	Westinghouse Electric Company
Bob Kitchen	Jen Meneely
Jim Thornton	Andy Pfeister
John Thrasher	Mike Patterson
Erik Wagner	Jason Eisenhauer
	Alan Macdonald
	Rick Ofstun

F. Documents Audited

The audit focused on the availability and performance of the long-term, passive removal of decay heat from the reactor coolant system using the passive residual heat removal heat exchanger (PRHR HX) and the associated containment response conditions. The audit team reviewed the following documents supporting APP-GW-GLR-161, Revision 2:

- TR-SEE-III-12-01, “AP1000 Condensate Return Test Report”
- APP-PXS-M3C-071, “Containment Response Analysis for the Long Term PRHR Operation,” Revision 2
- APP-PXS-M3C-072, “Condensate Return to IRWST for Long Term PRHR Operation,” Revision 2
- APP-SSAR-GSC-536, “AP1000 Safe Shutdown Temperature Evaluation,” Revision 3
- APP-SSAR-GSC-009, “AP1000 Plant Safe Shutdown Duration Evaluation,” Revision 0

In addition, all of the documents available previously for the 2014 audit (Reference 5) were also available to the staff.

G. Description of Audit Activities and Summary of Observations

NRC staff visited the Westinghouse office to review documents on May 19, May 22, June 4, June 11 and June 17, 2015. Staff reviewed prior revisions of these documents at a prior audit (Reference 5). As a brief summary:

- “AP1000 Condensate Return Test Report” describes the testing done to determine condensate losses along the containment shell.

- “Containment Response Analysis for the Long Term PRHR Operation” calculation details the WGOTHIC containment analysis for the non-loss of coolant accident (LOCA) transient involving the actuation of the PRHR and resulting condensation behavior.

- “Condensate Return to in-containment refueling water storage tank (IRWST) for Long Term PRHR Operation” calculation quantifies the various loss mechanisms and aggregates them with the Westinghouse-GOTHIC analysis code (WGOTHIC) containment response to calculate a wall loss rate for input into WGOTHIC.

- “AP1000 Safe Shutdown Temperature Evaluation” presents the results of the transient and SGTR computer analysis code (LOFTRAN) analyses presented in Chapter 19E of the application along with various sensitivity analyses.

Staff review primarily focused on changes made to the “Containment Response Analysis for the Long Term PRHR Operation” and “AP1000 Safe Shutdown Temperature Evaluation” calculations.

The “Containment Response Analysis for the Long Term PRHR Operation” now directly incorporates a condensate loss along the containment shell in WGOTHIC using a loss term determined from “Condensate Return to IRWST for Long Term PRHR Operation” plus a small margin. This is implemented as a constant based on the highest possible wall flow rate for conservatism. The new analysis changes the height of several junctions between modeling divisions to prevent condensate build up in modeled volume from inhibiting air flow between the volumes. In the prior revision, the condensate buildup resulted in lower air flow and therefore lower heat transfer in the passive containment coding system (AP1000) chimney and the steam generator room drains. This is not conservative, but corrects a non-physical behavior. The heat structures representing the reactor vessel and the PRHR HX are also updated with data from LOFTRAN more appropriate to the specific transient (rather than the bounding values used before). Additional changes were made to the thermal conductor used to simulate the environment (outside the containment shield building), as NRC staff examined the treatment of reactor vessel steaming in detail during the audit. Steaming that results from condensate coming into contact with the reactor vessel increases mixing below the operating deck (resulting in additional condensation on structures in this area) but also increases the return rate by allowing some "lost" condensate to again condense on the containment shell and return to the IRWST. Staff asked WEC to clarify the treatment of the reactor vessel in WGOTHIC during an audit call on May 22, 2015. Engineering staff from WEC explained that the thermal conductor representing the bottom head of the reactor vessel used a temperature boundary condition imported from LOFTRAN and a boiling correlation on the other. Once water entered the cavity, the thermal conductor fully participated in heat transfer. The holdup volume below the reactor vessel in the cavity was accounted for by adding it to the reactor coolant drain tank room, which overflows into the cavity. The applicant performed a sensitivity study in an appendix to the "Containment Response Analysis for the Long Term PRHR Operation" calculation to examine the effect of an increase in vessel area (the WGOTHIC model does not account for area on the cylindrical portion of the vessel) and no vessel area (this serves to bound the non-physicality of the entirety of the thermal conductor participating in heat transfer rather than tracking level along the vessel as the cavity fills with water). As might be expected, doubling the vessel area results in a progressively higher IRWST water level as the transient develops, while no vessel steaming results in a slightly lower water level later in the transient. Staff requested the spreadsheet corresponding to the case with no vessel thermal conductor in order to perform confirmatory analysis, which is discussed in the safety evaluation related to this departure request.

NRC staff also examined the WGOTHIC clime nodalization in detail. The nodalization is very similar to that used for the peak pressure analysis. The phenomena of interest for the condensate return analysis, however, are somewhat different than those for a LOCA. Staff inquired whether the nodalization was sufficient with respect to stratification in the containment as well as the fidelity of the temperature profile along the containment shell. WEC provided an analysis explaining that while additional refinement of the clime nodes along the shell would result in locally lower temperatures near the apex of the dome, the smaller area of the new nodes would also have more refined condensation rates. These rates, determined via testing, are much lower at the top of the shell, and therefore the impact from lower temperatures near the top of the shell would be lessened. In addition, the analysis specifies the relative amount of condensation on each clime and it's fraction of total shell area, as well as the calculated losses in each clime. A discussion of the effect on stratification of the containment is also provided; the effect of stratification in the containment for this transient cannot be precisely quantified, but because of the location of the release of the steam (the IRWST vents, just above the operating deck) combined with the coolest region of containment being near the top of the shell, it is reasonably well supported that containment above the operating deck is well mixed, as is the case for the lumped parameter model employed in WGOTHIC.

NRC staff examined APP-SSAR-GSC-536, "AP1000 Safe Shutdown Temperature Evaluation," to verify (1) that the pool boiling correlation used in LOFTRAN is consistent with what is described and approved by NRC staff in WCAP-14234, and (2) verify that the 72-hour design basis accident (DBA) analysis for the loss of alternating current (ac) power event is performed in a manner consistent with a Chapter 15 analysis as described in Section 15.0 of the AP1000 DCD, Revision 19. While investigating the use of the pool boiling correlation, NRC staff viewed LTR-TA-13-137, "Revised LOFTRAN HGOTW(TW) Array" and CN-TA-07-66, "Revision 3 of the AP1000 Reference Input for Non-LOCA Analyses" and was able to verify the implementation of the pool boiling correlation in the LOFTRAN input deck. While investigating the modeling for the 72-hour DBA analysis of the loss of ac power event, NRC staff identified that the initial power utilized in the analysis accounted for a one percent uncertainty. Section 15.0.3.2 of the DCD states that a one percent uncertainty is supported by the main feedwater flow measurement, but that a bounding value of 2 percent is used in the analysis.

During the course of the audit, WEC made APP-SSAR-GSC-009, "AP1000 Plant Safe Shutdown Duration Evaluation," Revision 0, available for staff audit. This calculation supports the assertion by the applicant in the revised final safety analysis report (FSAR) that the PRHR is capable of operating in closed loop mode for greater than 14 days. Staff examined the calculation to (1) investigate the inputs to the LOFTRAN calculation and (2) verify the result of PRHR operation for a 14-day duration. The assumptions in the calculation are generally consistent with the "better estimate" values used by the applicant to carry out the 420 °F in 36 hours analysis in Chapter 19 of the updated FSAR, which in turn come from the APP-SSAR-GSC-536, "AP1000 Safe Shutdown Temperature Evaluation" calculation. These values include nominal initial reactor power, temperature and pressure, containment conditions based on the best estimate, bounded loss rate calculation in WGOTHIC, and a standard decay heat curve with no added uncertainty. Changes to the calculation primarily have to do with those made to facilitate carrying out a LOFTRAN case for greater than 21 days, but other notable changes were made (such as incorporating a calculated core makeup tank room temperature from WGOTHIC rather than treating the value as constant, and allowing IRWST water below the heat exchanger to participate in heat transfer rather than conservatively excluding it). NRC staff interacted with engineering representatives from the applicant during the course of the audit on an audit call on June 19, 2015 regarding the condensate return ratio input into LOFTRAN from WGOTHIC for this analysis. Staff expressed reservations on the nature of and the values used for the return ratio in the long term (4+ days) of the transient. The applicant explained that the return ratio increases to values higher than the first 72 hours during the course of the transient due to the decreasing containment pressure, which allows condensate that was previously held up to be released for return to the IRWST. This explanation is in alignment with behavior seen by the staff in confirmatory analyses. The applicant also explained the curve input into LOFTRAN is an average of the values output from WGOTHIC for IRWST steaming and condensate return. Due to the nature of the WGOTHIC model for condensate losses and the choice of plot frequency, the data for the return ratio was fairly volatile. This volatility raised concerns with the staff, but due to the nature of the calculation—it does not fulfill a regulatory requirement and exists only to support a statement made in the FSAR—the staff accepts that the calculation is indicative of PRHR operation for a period longer than 14 days to support the claim made in the FSAR.

Staff also reviewed the calculations to ensure that changes made as a result of responses to staff requests for additional information (RAIs) submitted previously were included as part of the analyses.

H. Exit Briefing

The applicant and NRC staff agreed that an exit briefing was not necessary and did not conduct an exit briefing.

I. Requests for Additional Information Resulting from Audit

No RAIs were issued as a result of this audit. The applicant clarified that RAI responses related to the condensate return review already on the docket remained applicable to the current submittal, with the exception of RAIs 06.03-06 and 06.03-09. The applicant submitted revised responses in a letter dated June 11, 2015 (ADAMS Accession No. ML15166A020).

J. Open Items and Proposed Closure Paths

No open items were identified as a result of the audit.

K. Deviations from the Audit Plan

Additional documents (referenced in the documents under audit) were added, including:

- LTR-CRA-15-94, “NRC Question Regarding Clime Noding for Condensate Return Analysis”
- “Appendix I to APP-PXS-M3C-072” (spreadsheet)
- LTR-TA-13-137, “Revised LOFTRAN HGOTW(TW) Array”
- CN-TA-07-66, “Revision 3 of the AP1000 Reference Input for Non-LOCA Analyses”

L. References

1. Levy Nuclear Plant, Units 1 and 2, “Response to NRC RAI Letter 124 - SRP Section 6.3, and Supplement 6 to Submittal of Exemption Request and Design Change Description for Departure from AP1000 DCD Revision 19 to Address Containment Condensate Return Cooling Design,” dated May 5, 2015 (ADAMS Accession Number ML15131A021)

2. Levy Nuclear Plant, Units 1 and 2, “Submittal of Exemption Request and Design Change Description for Departure from AP1000 DCD Revision 19 to Address Containment Condensate Return Cooling Design,” dated April 18, 2013 (ADAMS Accession Number ML13109A533)

3. Levy Nuclear Plant, Units 1 and 2, “Supplement 3 to Submittal of Exemption Request and Design Change Description for Departure from AP1000 DCD Revision 19 to Address Containment Condensate Return Cooling Design,” dated February 7, 2014 (ADAMS Accession Number ML14042A034)

4. “Staff Regulatory Audit Summary for Review of Levy Nuclear Plant, Units 1 and 2, Design Change Related to the Containment Condensate Return Pathway,” dated September 16, 2014 (ADAMS Accession Number ML14219A169)

5. “Audit Summary for Review of Levy Nuclear Plant, Units 1 and 2, Design Change Related to the Containment Condensate Return Pathway,” dated September 2014 (ADAMS Accession Number ML14219A200)

6. NRO-REG-108, “Regulatory Audits,” dated April 2, 2009 (ADAMS Accession Number ML081910260)

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