AUDIT SUMMARY
AP1000 Equivalent Insulation Topical Report
Jet Impingement Testing, Submergence Testing, Design Changes

Purpose

The audit was conducted to examine documents supporting the topical report and identify information that might affect the completeness or validity of the submittal.

Background

In a pre-submittal meeting on January 16, 2014, Westinghouse Electric Company (Westinghouse) presented plans for submitting a topical report (Project No. 0808) qualifying insulation material as a suitable equivalent for metal reflective insulation. The non-proprietary technical presentation slides and the meeting notice can be found in the Agencywide Documents Access and Management System (ADAMS), respectively, under ADAMS Accession Numbers ML14027A159 and ML13346A318.

In a subsequent pre-submittal meeting on May 22, 2014, with a follow-up closed portion on May 28, 2014, Westinghouse clarified plans and outlined a second topical report (Project No. 0811) detailing revised portions of APP-GW-GLR-079, "AP1000 Verification of Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident (LOCA)," as part of an effort to fully define a containment debris strategy. This meeting also went over the status and provided updates on the observations made from the February 26, 2014, non-metallic insulation testing audit. The non-proprietary Westinghouse presentation slides, meeting notice, meeting summary, and the February 26, 2014, non-metallic insulation testing audit summary, respectively, can be found in ADAMS under Accession Numbers ML14140A157, ML14126A122, ML14174B160, and ML14104B653 (see table below).

At the Hi Flow Test Facility, operated by National Testing Service (NTS) in Huntsville, Alabama, U.S. Nuclear Regulatory Commission's (NRC) staff observed jet impingement tests of the power and instrumentation cables on June 9, 2014, and the non-metallic reflective insulation on July 17, 2014. Staff observations from these tests can be found in ADAMS under Accession Number ML14289A243.

In a public meeting on September 16, 2014, Westinghouse presented a revised plan to submit a single topical report in January 2015 that will include all jet impingement and submergence testing (ADAMS Accession Number ML14287A369). On December 1-3, 2014, the staff continued the pre-submittal audit by examining the test reports and other supporting documents at the Westinghouse Twinbrook office in Rockville, Maryland. This was the final activity conducted under the pre-submittal Audit Plan (ADAMS Accession Number ML14175A913). In addition to examining the documents, the staff held discussions with Westinghouse subject matter experts on break selection, jet pressure, zone of influence, cable shielding design, and chemical effects. The staff and Westinghouse had follow-up phone calls on December 8 and December 15, 2014, to clarify information related to break size evaluation methodology, LOCA jet shape, and chemical effects. During the December 15, 2014 phone call, Westinghouse informed staff that they would revise the submittal of the topical report to March 2015.

Presentation Materials and Audit Summaries in ADAMS	
Meetings	
January 16, 2014	ML14027A159 (non-proprietary slides)
May 22, 2014	ML14140A157 (non-proprietary slides)
May 28, 2014	Proprietary
September 16, 2014	ML14287A369
Previous Audit Summaries	
February 26, 2014 audit	ML14104B653 (Summary dated March 26, 2014)
June and July 2014 testing audits	ML14289A243 (Summary dated November 18, 2014)

Regulatory Bases

- Title 10 *Code of Federal Regulations* (10 CFR), Part 52, Appendix D, Section VIII
- 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Power Reactors"
- General design criteria (GDC) from Appendix A to 10 CFR Part 50
  - GDC 4, "Environmental and dynamic effects design bases"
  - GDC 35, "Emergency core cooling"
  - GDC 36, "Inspection of emergency core cooling system"
- Standard Review Plan Section 6.3, "Emergency Core Cooling System"
- Regulatory Guide 1.82, Revision 4, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident"

Audit Date and Location

The audit was conducted December 1−3, 2014, at Westinghouse Electric Company, 12300 Twinbrook Parkway, Rockville, Maryland, 20852. The audit continued with phone calls between the staff and Westinghouse on December 8 and December 15, 2014.

Audit Team

Clinton Ashley, Reactor Systems Engineer, Office of New Reactors (NRO) (Audit Team Lead)
Timothy Drzewiecki, General Engineer, NRO
Yueh-Li (Renee) Li, Senior Mechanical Engineer, NRO
Gregory Makar, Materials Engineer, NRO
Andrew Yeshnik, Materials Engineer, NRO
Bruce Bavol, Project Manager, NRO

Westinghouse and Licensee Participants (in-person on December 1−2, 2014)

Chris Cancino
Tom Kindred
Shayantan Sinha
Kelli Roberts (Southern Nuclear Operating Company)

Additional Westinghouse Participants (by telephone December 8 and/or 15, 2014)

Steve DiTommaso (December 15, 2014)
Kevin McNamee (December 8 and 15, 2014)
Catherine Perego (December 15, 2014)
Andy Pfister (December 8, 2014)

Documents Examined

- TR-CCOE-14-02, "AP1000 Insulation Submergence Testing," Revision 0, November 2014.
- WCAP-17616-P, Volumes I & II, "Jet Impingement Testing of AP1000 Reactor Vessel Insulation System Neutron Shielding Blocks," Revision 0, November 2014.
- WCAP-17617-P, Volumes I & II, "Jet Impingement Testing of AP1000 In-Containment Cables," Revision 0, November 2014.
- APP-SSAR-GSC-154, "AP1000 AFCAP Best Estimate Large break LOCA (BELOCA) ASTRUM Analysis: Pre-Statistical Analysis – Steady State Balance and Confirmatory Study," Revision 0, Not dated.
- APP-PXS-M3C-080, "AP1000 Non-Coating Debris Contributions Towards GSI-191 Debris Limits," Revision 0, October 8, 2014.
- APP-GW-T1R-001, "AP1000 Cable Deconstruction Test Report," Revision 0, July 3, 2014.

Audit Activities

The audit consisted of five main activities:

1. Westinghouse orientation, building safety, and safety culture
2. NRC's staff entrance briefing
3. A period in which the staff examined the documents and held discussions with Westinghouse participants as needed for technical understanding
4. Exit briefing for NRC to present observations in person and Westinghouse to seek clarification
5. Follow-up phone calls for additional discussion about staff observations

Topics of Discussion between Staff and Westinghouse during the Audit

1. LOCA pipe break evaluation, selection, and pressure determination for jet impingement testing: Westinghouse described their interpretation of the Nuclear Energy Institute (NEI) 04-07 (Reference 1 and 2) alternate evaluation methodology and how they used it to determine limiting break size, and how the American National Standards Institute 58.2 jet model was used to determine pressure for the jet impingement testing.

2. Determination of zone of influence: Westinghouse explained how they were using the jet impingement testing to determine the zone of influence based on destruction pressure.

3. Design changes to neutron absorber modules: Based on jet impingement tests, the Upper Neutron Absorber modules previously designed to be [ ] were changed to [ ]. This change includes the addition of a means for [ ]. Westinghouse described the preliminary design approach.

4. Design changes to protect cable insulation: Westinghouse presented a three-dimensional computer animation to describe the barriers planned for protecting cables within the zone of influence of a limiting pipe break. Protective measures include [
]

Summary of the Audit Exit Briefing

1. LOCA pipe break evaluation, selection, and jet impingement test pressure determination

   a) Observations during exit on December 2, 2014

      - The staff observed that Westinghouse appeared to be taking a new approach (alternate methodology) toward break selection. Westinghouse indicated that the alternative break size of a guillotine break of a 14-inch schedule 160 line will be used for main loop piping in their containment debris evaluation. Westinghouse identified the approach as consistent with industry guidance and this guidance had been reviewed and approved by the NRC (i.e., NEI 04-07, Section 6). Westinghouse also explained how the zone of influence will be determined from the jet testing result and the alternative break size. Westinghouse and the NRC audit staff were not aware of any new or operating reactor that had adopted this alternative approach toward break selection. NRC staff informed Westinghouse that they would consult with additional (internal) technical staff that had more experience in applying the guidance and approvals associated with NEI 04-07. The outcome of the internal discussions was communicated to Westinghouse during a conference call on Monday, December 8, 2014, and is discussed below.

      - The staff also indicated that Westinghouse's evaluation methodology as presented is based on a free jet expansion model. The staff reiterated the concern of the jet modeling for the geometric configuration of enclosed and limited space of the reactor cavity annulus. As such, during the audit, the staff did not find resolution to the previous observation related to jet behavior in an enclosed area (reactor cavity).

      - During the jet impingement tests conducted at the NTS Hi Flow Test facility, staff noted that they would expect to see an explanation for the basis of the test shot in the final report. In particular, staff sought justification as to why the test shot is an accurate or conservative representation of the conditions encountered during a LOCA. Staff observed, during their initial view of WCAP-17616, that this observation was incorporated into the final report.

   b) Additional observations during follow-up calls December 8 and 15, 2014

      - As part of the audit process, on Monday, December 8, the staff called Westinghouse to further discuss Westinghouse's approach to break selection and staff understanding of approved guidance. During the call, Westinghouse believed they were conforming to the staff guidance. However, the staff observed that the approach Westinghouse was taking related to the alternative methodology may not be consistent with staff guidance. The main reason for the staff observation that Westinghouse may not be consistent with approved guidance was that Westinghouse's approach was limited to a Region I analysis and did not consider the Region II analysis. At the end of the call, Westinghouse agreed to review their approach and asked for another follow-up call with the staff. The follow-up call was held on Monday, December 15, 2014, and is discussed below.

- As part of the audit process, on December 15, 2014, the staff called Westinghouse to further discuss Westinghouse's alternative approach. During the call, Westinghouse explained that their revised approach would be to conduct both a Region I and Region II analysis. As such, Westinghouse clarified that their approach would conform to Section 6 of the guidance report, which describes the alternate evaluation methodology for demonstrating acceptable containment sump performance, and the associated safety evaluation.

2. Determination of Zone of Influence

Observations during exit on December 2, 2014

- Westinghouse indicated that a spherical zone of influence will be used, consistent with guidance contained in NEI 04-07. The staff reiterated the concern of the effects on the zone of influence due to enclosed, limited reactor cavity annulus space as discussed under Item 1(a) of this audit summary.

3. Design Changes to Neutron Absorber Modules

Observations during exit on December 2, 2014

- Staff noted that using the [ ] would require some means for ensuring [ ].

4. Pressurizer Cable Protection

Observations during exit on December 2, 2014

- Staff pointed out the need to have technical bases for crediting the barriers Westinghouse plans to use in the design [ ]. For example, Westinghouse should provide a basis that demonstrates how these design features serve as robust barriers that are able to withstand the break jet forces associated with a postulated high energy line pipe break and thereby prevent the generation of cable insulation debris.

- Staff pointed out the need for configuration control to ensure barriers are maintained according to the design.

5. Submergence Testing and other Chemical Effects

Observations during exit on December 2, 2014

- Staff acknowledged that most of the previous observations have been addressed in some way (e.g., identification of chemical precipitates, detection of fibers).
- Staff anticipates the topical report will include discussion of the impact of the test results and aging on the overall AP1000 chemical precipitate analysis. Staff understands that the amount of detail may depend on whether the neutron absorber blocks are [ ]. For example, treatment of the radiation effect on [ ] may be less rigorous.

a) Additional observations during follow-up call December 15, 2014

- In APP-PXS-M3C-080, [ ] is discussed as a material that "does not deteriorate under submersion." However, the WCAP-16530 chemical effects model includes [ ] as a material input for calculating the release of silicon, aluminum, and calcium. This was based on testing of other products of the same material type (E-glass). It's not clear to the staff if the submerged [ ] has been analyzed for chemical effects specifically for the AP1000.

- Also in APP-PXS-M3C-080, [ ] is recognized as having the potential to contribute to chemical debris, and encapsulation in stainless steel is specified for the submerged portion. The staff did not find any information about how the presence and integrity of this encapsulation will be ensured.

6. References

1. NEI 04-07, Revision 0, "PWR Sump Performance Evaluation Methodology," Nuclear Energy Institute, Washington, DC., dated December 2004 (ADAMS Accession No. ML050550138).

2. Safety Evaluation for NEI Guidance Report 04-07, "PWR Sump Performance Evaluation Methodology," U.S. Nuclear Regulatory Commission, Washington, DC., dated December 2004 (ADAMS Accession No. ML050550156).