AUDIT SUMMARY

AP1000 Alternative Insulation Topical Report – Pre-submittal Phase
Jet-Impingement and Submergence Testing for Qualifying Alternatives
to Metal Reflective Insulation

Purpose

In a pre-submittal meeting on January 16, 2014, Westinghouse presented plans for submitting a topical report qualifying insulation materials as a suitable equivalent for metal reflective insulation. The topical report will include results from submergence testing and jet impingement testing to demonstrate that debris would not be generated under AP1000 design basis loss of coolant accident (LOCA) conditions. The purpose of the audit was to identify issues that might affect the completeness or validity of the test results that will be submitted as part of the topical report.

Background

AP1000 Design Control Document (DCD), Tier 2, Section 6.3.2.2.7.1, "General Screen Design Criteria," states that Metal Reflective Insulation (MRI) is used on the reactor vessel because it is subject to jet impingement during a LOCA. The DCD also states that a suitable equivalent insulation to metal reflective may be used, which is defined as insulation encapsulated in stainless steel that is seam welded so that LOCA jet impingement loads do not damage the insulation and generate debris. Additionally, in order to qualify as a suitable equivalent insulation, testing must be performed that subjects the insulation to conditions that bound the AP1000 conditions and demonstrates that debris would not be generated.

Westinghouse plans to introduce "non-metallic insulation" at several locations around the reactor vessel either to replace metal reflective insulation or as a new installation. The installation of the "non-metallic insulation" may be better described according to its primary function as a shielding material. The design change is based upon worker dose assessments that occurred after the AP1000 design certification review.

Installation of the proposed "equivalent insulation" introduces three new materials that were not considered during the AP1000 design certification review and that have the potential to generate debris and impact generic safety issue (GSI)-191 evaluations. The three materials are micro-porous insulation, a known problematic insulation material with respect to screen and fuel clogging; boron-silicone, a neutron absorber material, whose behavior under accident conditions has not been evaluated by the staff; and lead, a gamma shielding material. Westinghouse intends to demonstrate, by testing, that a LOCA would not cause these materials, as installed (i.e., encapsulated in stainless steel), to produce debris through jet impingement or submergence.

Regulatory Bases

- Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46, "Acceptance criteria for emergency core cooling systems for light water power reactors"

Enclosure 2

- 10 CFR Part 50, Appendix A, General Design Criterion 35, “Emergency core cooling”
- 10 CFR Part 50, Appendix A, General Design Criterion 38, “Containment heat removal”
- AP1000 Design Control Document, Section 6.3.2.2.7.1, “General Screen Design Criteria”
- Regulatory Guide 1.82, Revision 3, “Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident”

Audit Date and Location

The audit was conducted on February 26, 2014, at Westinghouse Electric Company, 12300 Twinbrook Parkway, Rockville, Maryland 20852.

Audit Team

Gregory Makar, Materials Engineer, Office of New Reactors (NRO) (Audit Team Lead)
Clinton Ashley, Reactor Systems Engineer, NRO
Bruce Bavol, Project Manager, NRO
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Westinghouse Electric Company Participants

Kevin McNamee (Jet Impingement Testing)
Jonathan Schermaier (Submergence Testing and Insulation Design)
Shayantan Sinha (Licensing)

Summary of Audit Exit Meeting

I. Observations Applicable to the Entire Program

a. Potential loss of the seam weld required for protection against jet impingement. Because the seam welding is applied only to the stainless steel foil wrappers ([ ] wall thickness), the staff questioned the protection provided by the seam weld. The question is based on the possibility of the wrapper losing integrity before a postulated event as a result of manufacturing defects, damage during handling, damage while in-service (e.g., effects on wrapper integrity due the difference between manufacture and actual service conditions, such as temperature and/or pressure), or aging of the encapsulated material. The test program appeared to answer this question by including submergence test samples with a foil pouch having simulated damage (submergence test only). For jet impingement testing, it appeared that the foil pouches would be intact.

b. Aging effects. The staff questioned whether the test programs have fully addressed how material subjected to aging would perform relative to the virgin material being used in the testing. Depending on the aging mechanisms, aged material may be more susceptible to jet-impingement loads or corrosion effects when submerged than the virgin material being used in the test program.

c. Design basis for GSI-191 and long-term cooling. The staff observed that integration with the existing GSI-191 debris generation and long-term cooling design basis is not clear in the areas of break selection, jet pressure calculations, and analysis of chemical effects. In addition, justification that the tested configuration bounds the as-designed configuration and locations is not clear.

d. Repeatability and uncertainty. It was not apparent that the test programs will be able to address repeatability and uncertainty based on the number of tests and samples.

e. Requirements for the new materials. The staff identified the required air flow as an example of a requirement for the new material that could, in principle, conflict with license requirements (e.g., plant technical specifications). The temperature limit of the shielding material is [ ], and the parameters for the design of the shielding material included ventilation flow rates. The staff questioned how requirements like these (i.e., minimum ventilation flow rate) would be addressed. Another example is that the staff was unable to identify the required maintenance and inservice inspection requirements. According to the "Master Equipment Qualification Environmental Summary," the material vendor is responsible for providing these requirements.

f. Potential impact on other parameters important to safety. The shielding introduces new materials into containment, such as lead and aluminum oxide (a constituent of micro-porous insulation). The use of these materials in containment could be restricted based on safety analyses unrelated to physical and chemical debris generation. The staff questioned how development of the topical report will ensure the use of these materials is evaluated with respect to all relevant safety analyses.

II. Observations Specific to Jet Impingement Testing

a. Test acceptance criteria. The acceptance criteria for the jet impingement testing were unclear to the staff. The test plan definition of damage includes, but is not limited to, dents, punctures, tears, weld failures and sheet metal separation. A flowchart in the test plan describes a procedure to follow if damage is observed, but the procedure focuses on visually detecting exposure of the underlying non-metallic material. The staff questioned the level of allowable damage that still constitutes an acceptable test.

b. Calculation of test pressure. It was not clear to the staff that the method for determining the jet impingement pressure load at a certain distance, and the equivalent spherical zone of influence for potential break locations, are exactly the same as in the original design basis. The staff questioned whether the methods and calculations described in the test plan conform to the approved design basis for the resolution of GSI-191 for AP1000.

c. Shield block manufacturing tolerances. The staff found no specifications for the maximum allowable gap between protective plate metal used for the spot welded shield boxes, or how the test specimens were configured to bound the allowable gap.

III. Observations Specific to Submergence Testing

a. Test acceptance criteria. The staff observed that there were no acceptance criteria in the test plan related to chemical concentrations or fiber amounts measured in the test.

b. Integration with the design basis for chemical effects. The staff observed that it was not clear how the submergence testing will be integrated with the chemical analysis performed for the design certification.

c. Procedural details. The staff observed that additional detail will be needed for some procedures in order to perform a review (e.g., autoclave cleaning, filtration of liquid samples, and precipitate detection).

IV. Potential Effects on Related AP1000 Topics

a. Functionality of buoyant doors. The staff questioned whether the alternative insulation in the buoyant doors could be susceptible to degradation that could affect the functionality of the doors. The staff acknowledged that this is beyond the scope of the qualification test program (no debris generation), but that the staff would need to inquire with the branch responsible for severe accidents and probabilistic risk assessment.

b. This test program and topical report do not address the functionality of the neutron shielding for its design life with respect to personnel protection and environmental qualification of equipment. AP1000 licensees need to address this issue but it is outside the scope of this topical report development.