UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

April 12, 2018

Mr. Victor McCree
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: SAFETY EVALUATION FOR WCAP-17938-P, REVISION 2, "AP1000 IN-CONTAINMENT CABLES AND NON-METALLIC INSULATION DEBRIS INTEGRATED ASSESSMENT"

Dear Mr. McCree:

During the 652nd meeting of the Advisory Committee on Reactor Safeguards, April 5-7, 2018, we completed our review of topical report WCAP-17938-P, Revision 2, "AP1000 In-Containment Cables and Non-Metallic Insulation Debris Integrated Assessment," and the associated NRC staff's safety evaluation. Our Subcommittee on AP1000 also reviewed this matter on February 7, 2018. During these reviews, we benefitted from discussions with representatives of the staff and Westinghouse Electric Company. We also benefitted from the referenced documents.

CONCLUSIONS AND RECOMMENDATION

1. The methodology described in the topical report to establish the loss-of-coolant accident break size for debris assessment is appropriate.
2. The requirement that non-metallic insulation be encapsulated in containers which are located beyond a specified distance from the origin of a loss-of-coolant accident jet is sufficient to avoid producing fibrous debris from this source.
3. Testing showed that unprotected cables could be damaged and produce fibrous debris when located within a distance from a loss-of-coolant accident jet which is determined by the break diameter.
4. The recommended distance of four break diameters from a loss-of-coolant accident jet, at which unprotected cables would not be damaged, has been shown by testing to be sufficiently conservative to bound plant conditions with high likelihood.
5. The added provisions that require separate qualification of cabling not covered by the testing performed are appropriate, and the staff's safety evaluation should be issued.

BACKGROUND

The AP1000 Design Control Document (DCD) provisions which address Generic Safety Issue 191, "Assessment of Debris Accumulation on PWR Sump Performance" (GSI-191), and Generic Letter 2004-2, "Potential Impact of Debris Blockage on Emergency Recirculation during Design-Basis Accidents at PWRs" (GL 2004-02), include the requirement that fibrous debris not be generated during a loss-of-coolant accident (LOCA) due to jet impingement or chemical precipitation. The topical report, with supplemental revisions through #4, describes three specific matters not previously addressed in the DCD. These are:

1. Determination of the zone of influence (ZOI) for a LOCA water jet within which unprotected cable could produce fibrous debris.
2. Demonstration that non-metallic insulation (NMI), which will be added in certain locations in the reactor cavity, will not be a source of debris, including due to chemical precipitation.
3. Use of NEI 04-07, "PWR Sump Performance Evaluation Methodology," including its staff safety evaluation, to define the design basis debris generation break size.

DISCUSSION

Determination of the Zone of Influence for Electrical Cabling

Westinghouse performed a ZOI test program at the National Technical Systems facility for electrical cables to be installed at Plant Vogtle Units 3 & 4. Supplemental Revision 4 was added to the topical report on March 5, 2018, following our Subcommittee meeting, to make clear that the test program results are applicable only to the particular cables tested and analyzed. This limitation is necessary since there are no codes, standards, or other requirements which have been referenced, relative to cable resistance to jet impingement. Limiting future cable installation by licensees to characteristics "bounded by testing and analysis", as required by supplemental Revision 4, may not be practical over time; and further testing may, therefore, be necessary in order to qualify cables required to be used in the future. Also, the staff noted that a licensee referencing the topical report will need to assess the adequacy and suitability of protection provided for all cables within the ZOI.

The staff's evaluation of the cable testing concludes that no fibrous debris would be produced from unprotected cables located outside a ZOI determined by four break diameters (4D), as proposed by Westinghouse. We reviewed the bases for this conclusion and whether the 4D ZOI would be sufficiently conservative to bound plant conditions, including conditions within the jet at the point of impingement and variations in the cable support provided. Considering the rapid decrease in jet impingement forces at 4D and beyond, we agree that the 4D ZOI is sufficiently conservative.

Suitable Equivalency of Non-Metallic Insulation

The AP1000 DCD provides for use of metal reflective insulation which is not a potential source of fibrous debris as a result of LOCA jet impingement. It also provides for the use of a suitable equivalent form of insulation, if needed. The topical report describes testing and analysis performed to demonstrate the suitable equivalency of specific NMI.

In addition to the electrical cable testing described above, Westinghouse performed jet impingement testing at the same facility for NMI containers, as well as submergence testing for

the NMI material included in neutron shield blocks surrounding the reactor pressure vessel. The NMI is completely encapsulated in stainless steel containers that are filled with neutron-absorbing material. The containers have a single, small, screened vent to prevent buildup of internal pressure due to off-gassing caused by radiation over time.

Based on the testing performed, NRC staff found that the NMI in the containers performs as an equivalent for metal reflective insulation, from the perspective of no fibrous debris generation. This finding included consideration of potential jet confinement due to surrounding structures, as within the reactor cavity.

Based on the use of complete encapsulation of the NMI, the NRC staff did not evaluate the Westinghouse submergence testing, relative to chemical precipitate formation. We concur.

Debris Generation Break Size

The topical report applies the methodology of NEI 04-07 to define the limiting break size, depending on piping diameter. In general, a double-ended, guillotine break diameter is assumed. For main loop piping greater than a 14-inch diameter, credit can be taken for safety-related structures which would limit the separation of a double-ended guillotine break and therefore the size of the break assumed in determining the extent of the ZOI. Following an extensive analysis, the staff determined that Westinghouse has adequately established its conclusions concerning the design basis debris generation break sizes.

SUMMARY

The safety evaluation is thorough and explains the staff's review and conclusions concerning Revision 2 of the Westinghouse topical report. We conclude that the empirical tests, which are the bases for the electrical cable 4D ZOI, have been shown to bound plant conditions, as required, for the specific cables tested.

The testing performed by Westinghouse in support of the topical report findings and recommendations represents an important advance in the empirical data available to support GSI-191 and GL 2004-02, relative to fibrous debris resulting from a LOCA jet, and the staff's SE provides a very good analysis of the results. The staff's safety evaluation should be issued.

Sincerely,

/RA/

Michael L. Corradini
Chairman

REFERENCES

1. Westinghouse Electric Company LLC, WCAP-17938-P, “AP1000 In-Containment Cables and Non Metallic Insulation Debris Integrated Assessment,” Revision 2, June 7, 2017 (ML17163A296).
2. Westinghouse Electric Company LLC, “Submittal of APP-GW-GLY-152 Revision 0, ‘Supplemental Revision #4 to Topical Report WCAP-17938 Revision 2,’ (Non-Proprietary,” March 5, 2018 (ML18065A037).
3. U.S. Nuclear Regulatory Commission, “Generic Issue Management Control System for the Second Half of Fiscal Year 2017,” November 29, 2017 (ML17290A409).
4. U.S. Nuclear Regulatory Commission, Generic Letter 2004-02, “Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,” September 13, 2004 (ML042360586).
5. Westinghouse Electric Company LLC, “AP1000 Design Control Document,” Revision 19, June 2011 (ML11171A500).
6. Nuclear Energy Institute, NEI 04-07, “Pressurizer Water Reactor Sump Performance Evaluation Methodology,” Revision 0, December 2004 (ML050550138).
7. U.S. Nuclear Regulatory Commission, “Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004 02, Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), ‘Pressurized Water Reactor Sump Performance Evaluation Methodology’,” December 6, 2004 (ML043280007).
8. Advisory Committee on Reactor Safeguards, “Long-Term Core Cooling for the Westinghouse AP1000 Pressurized Water Reactor,” December 20, 2010 (ML103570138).

REFERENCES

1. Westinghouse Electric Company LLC, WCAP-17938-P, "AP1000 In-Containment Cables and Non Metallic Insulation Debris Integrated Assessment," Revision 2, June 7, 2017 (ML17163A296).
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6. Nuclear Energy Institute, NEI 04-07, "Pressurizer Water Reactor Sump Performance Evaluation Methodology," Revision 0, December 2004 (ML050550138).
7. U.S. Nuclear Regulatory Commission, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004 02, Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), 'Pressurized Water Reactor Sump Performance Evaluation Methodology'," December 6, 2004 (ML043280007).
8. Advisory Committee on Reactor Safeguards, "Long-Term Core Cooling for the Westinghouse AP1000 Pressurized Water Reactor," December 20, 2010 (ML103570138).

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