August 17, 2016

James H. Riley
Sr. Technical Advisor
Nuclear Energy Institute
1201 F Street, NW, Suite 1100
Washington, DC 20004

SUBJECT: REGULATORY AUDIT PLAN FOR AUGUST 31, 2016, AND SEPTEMBER 1, 2016, AUDIT OF PWROG-15060, "PUMP SUCTION GAS ACCUMULATION OPERABILITY CRITERIA GUIDANCE" (TAC NO. MF8075)

Dear Mr. Riley:

By letters dated May 5 and 9, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML16147A079 and ML16147A123, respectively), the Nuclear Energy Institute (NEI) submitted nonproprietary and proprietary versions of topical report (TR) PWROG-15060, "Pump Suction Gas Accumulation Operability Criteria Guidance" (ADAMS Accession Nos. ML16147A080 and ML16147A124). The TR is supported by documentation that includes detailed report information.

The U.S. Nuclear Regulatory Commission (NRC) staff is currently reviewing the TR for use by licensees. As part of its review, the NRC staff will be performing a regulatory audit at the Westinghouse offices at 11333 Woodglen Drive, Rockville, Maryland 20852 on August 31, 2016, and September 1, 2016.

The audit will determine the degree that the processes used have resulted in satisfying regulatory requirements. This audit will provide information necessary to complete the NRC staff's evaluation of WCAP-15060. Enclosed for your information is a copy of the plan the NRC staff will follow on the audit.

If you any questions or require any additional information, please feel free to contact me at 301-415-7297 or Joseph.Holonich@nrc.gov.

Sincerely,

/RA/

Joseph J. Holonich, Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 689

Enclosure:
Audit Plan

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ADAMS Accession No.: ML16217A062; * concurred via e-mail **NRR-106**

OFFICE	NRR/DPR/PLPB	NRR/DPR/PLPB*	NRR/DSS/SRXB*	NRR/DPR/PLPB	NRR/DPR/PLPB
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DATE	08/8/2016	08/9/2016	08/8/2016	08/15/2016	08/17/2016

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AUDIT PLAN FOR TOPICAL REPORT PWROG-15060,

"PUMP SUCTION GAS ACCUMULATION OPERABILITY CRITERIA GUIDANCE"

(TAC NO. MF8705)

Background: By letters dated May 5 and 9, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML16147A079 and ML16147A123, respectively), the Nuclear Energy Institute (NEI) submitted nonproprietary and proprietary versions of topical report (TR) PWROG-15060, "Pump Suction Gas Accumulation Operability Criteria Guidance" (ADAMS Accession Nos. ML16147A080 and ML16147A124).

The purpose of PWROG-15060 is to provide methodologies for addressing gas movement from high point locations in system piping to pump inlets. Specifically, the report addresses applying the correclations in WCAP-17271 and WCAP-17276 in a manner which meets the limitations and conditions imposed by the safety evaluation for NEI 09-10, Rev. 1a-A (ADAMS Accession No. ML13178A152). This includes data and correlations provided in WCAP-17271,"Testing and Evaluation of Gas Transport to the Suction of ECCS Pumps," Volumes I, II, and III (ADAMS Accession Nos. ML110490341 and ML110490342, publically available and ML110490308, ML110490343, and ML110490389, not publically available) and in WCAP-17276, "Testing and Evaluation of Gas Transport to the Suction of ECCS Pumps" (ADAMS Accession No. ML110480383, publically available and Accession No. ML110480384, not publically available).

Necessary Material: Electronic Access (for viewing and printing) of all project documents

NRC Team Assignments: Eric Oesterle, Acting Chief, Reactor Systems Branch
Warren Lyon, Team Lead, Reactor Systems Branch
Jennifer Whitman, Reviewer, Reactor Systems Branch
Diana Woodyatt, Reviewer, Reactor Systems Branch

Audit Scope: The following are subjects for discussion during the audit:

1. For a planned Froude number (N_{FR}) of 2.5, the NRC staff calculates that it takes about four seconds following flow initiation for all gas to pass through the Purdue test piping. WCAP-17271-P, Volume 2, Figure 3-1130, provides flow rate as a function of time for a planned N_{FR} of 2.5. If flow rate is translated to N_{FR}, it indicates that all gas is passed through the test piping in significantly less than the time to achieve N_{FR} = 2.5. This behavior is typical of Purdue tests.

    a. Verify that this is consistent with the use of the published N_{FR} that are used to characterize the Purdue tests.

    b. Verify that this is consistent with the methodology correlations that are based on a model where N_{FR} is constant. (In the above example, N_{FR} = 2.5 but this is not achieved until all gas has passed through the test piping).

Enclosure

2. WCAP-17271-P reports intended initial void fractions (Φ) in the upper horizontal pipe and planned volumetric flow rates (Q) that appear to be used in the correlations. Please discuss if using the reported values may introduce an apparent stochastic data scatter and may bias predicted results.

3. PWROG-15060 stated that the off-take criteria will be applied well upstream of the pump suction and it is not necessary to ensure that the flow regime is in the dispersed bubbly regime as long as the flow rate is sufficient to ensure that gas bubbles will not coalesce into a stratified flow regime that could result in vortex formation at the off-take or a significant level depression at the off-take. Please substantiate this statement. Include consideration of flow characteristics at the pump suction in the discussion.

4. PWROG-15060 stated that as long as $N_{FR} \geq 1$ and the average volumetric flux ratio (β) ≤ 0.25, it can be assumed that gas (1) is moving with the liquid in either a bubbly or incipient plug flow regime and will not accumulate or stratify at a tee, and (2) the gas is transported though the off-take in the flow direction being considered. Please address this for potential configurations such as (1) with flow through a horizontal tee where there is a vertical offtake connection in which there is no flow, (2) with flow through a vertical tee where flow enters the tee from the bottom and exits through the horizontal offtake with no flow in the vertical exit pipe, and (3) where flow enters a horizontal tee through an offtake with exit flow in one horizontal connection and no flow in the other horizontal connection.

5. Flow behavior in the lower horizontal piping in the Purdue tests included the occurrence of kinematic shocks over a wide range of test conditions with a large void fraction upstream of the shock and, according to WCAP-17271, Volume 1, a low void fraction with dispersed, bubbly flow downstream of the shock. Yet Figure 14 in WCAP-17271, Volume 1, shows an almost water solid region downstream of the shock with a thin gas layer above the water; a stratified flow regime. Please discuss this apparent inconsistency.

6. The acceptable pump inlet criteria are based on existence of homogeneous bubbly flow. Discuss how this is consistent with the stratified flow regime identified in Item 5.

7. PWROG-15060 describes Equation 6-6[1] as applicable beyond the range of N_{FR} used to formulate the equation. Part of the extrapolation may be non-conservative because it would be expected to increase the β prediction required to form a kinematic shock to a value that is smaller than would result from extrapolation of the data used to formulate Equation 6-6. Please justify the described extrapolation.

8. WCAP-17271-P, Volume 1, Figure 15, illustrates a β upstream of the kinematic shock in a horizontal pipe that is immediately downstream of a downcomer (DC). Equation 6-6 predicts the minimum β ratio that will cause a kinematic shock in a horizontal pipe that is immediately downstream of a DC where the DC is of sufficient length to provide homogeneous bubbly flow at the DC outlet. The prediction is less than would be obtained from using Figure 15. Please discuss the reasons for this difference, cover how Equation 6-6 is considered with respect to the PWROG-15060 correlations, and include how the minimum β ratio is conservative or non-conservative with respect to calculation of gas transport time and downstream β.

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[1] Figure and Equation numbers where the source document is not identified are taken from PWROG-15060.

9. Please describe the derivation of Equation 6-19 in sufficient detail to verify its applicability to operability determinations and discuss the behavior illustrated in Figure 6-21.

10. Please provide a comparison of the WCAP-17271 correlation to (1) β at the bottom of the DC, (2) β at the outlet from the 90 degrees elbow at the DC exit, and (3) for Δβ for the six inch tests with an initial void fraction of 0.20 obtained from Figures 5-35 thru 5-38 of Volume III of WCAP-17271 or, if this is not considered viable due to the six inch pipe slope concern, provide the corresponding information for the eight inch test. Then discuss your conclusions with respect to the correspondence between the WCAP figures and the WCAP correlations.

11. Please provide a comparison of Equation 5-7 to transport times provided in WCAP-17271.

12. The WCAP-17271 and WCAP-17276 correlations are limited to $N_{FR} \leq 2.5$. Please discuss how potential slug flow is addressed if $N_{FR} > 2.5$.

13. Please address use of the WCAP-17271 and WCAP-17276 correlations when pipe diameter changes occur. Include a reducer immediately upstream of a pump suction connection, an orifice or venturi, and an offtake pipe diameter that is less than four inches in the discussion.

14. PWROG-15060 stated that Equation 6-1 was derived from Equation 5-6. Please provide the derivation.

15. Please walk through the development of Equations 6-10 through 6-21.

16. Discuss the potential for control of gas volume immediately downstream of a DC exit elbow when a pump takes suction from that location.

Additional subjects may be identified during the audit since the review is ongoing.

Logistics: Audit Location: 11333 Woodglen Dr., Rockville, MD 20852
Audit to start: 8:30 am, Wednesday, August 31, 2016
Audit to end: Thursday, September 1, 2016

Deliverables: The NRC regulatory audit report should be issued by October 31, 2016.