June 15, 2011

MEMORANDUM TO: Anthony P. Mendiola, Chief
Nuclear Performance and Code Review Branch
Division of Safety Systems
Office of Nuclear Reactor Regulation

FROM: Paul M. Clifford, Senior Technical Advisor **/RA/**
Division of Safety Systems
Office of Nuclear Reactor Regulation

SUBJECT: AUDIT PLAN FOR PWROG AND BWROG ECCS PERFORMANCE MARGIN ASSESSMENT

By letter dated May 4, 2011, the Nuclear Energy Institute (NEI) transmitted the Pressurized Water Reactor Owner's Group (PWROG) emergency core cooling system (ECCS) margin assessment report (ADAMS ML11139A309).The Boiling Water Reactor Owner's Group (BWROG) report was provided through NEI in a letter dated June 14, 2011(ADAMS ML11166A156). The purpose of this memorandum is to document an audit plan to support staff audits of the underlying Westinghouse, AREVA, and GEH engineering calculations.

In response to recent research findings which demonstrate that the current performance requirements for emergency core cooling systems (ECCSs), specified in Title 10 of the Code of Federal Regulations (10 CFR) Section 50.46(b), may not always be sufficient to ensure an acceptable level of fuel rod cladding post quench ductility (PQD) following a postulated loss of coolant accident (LOCA), the NRC has drafted a generic letter (GL). The information requested in the proposed GL would provide the NRC a basis for confirming an earlier, preliminary assessment and provide the NRC a basis for confirming continued safe operations pending completion of the regulatory framework.

As an alternative to the GL, the industry has undertaken a project to voluntarily deliver the information being sought in the GL. The PWROG and BWROG reports summarize the ECCS performance margin assessment performed to compare current margins of safety relative to the research data. As part of this audit, the staff will determine whether the industry sponsored alternative has provided the necessary information being sought by the GL.

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Audit Plan for PWROG and BWROG ECCS Performance Margin Assessment

Scope and Purpose

By letter dated May 4, 2011, the Nuclear Energy Institute (NEI) transmitted the Pressurized Water Reactor Owner's Group (PWROG) emergency core cooling system (ECCS) margin assessment report (ADAMS ML11139A309).The Boiling Water Reactor Owner's Group (BWROG) report was provided through NEI in a letter dated June 14, 2011 (ADAMS ML11166A156). The purpose of this audit is to review the underlying Westinghouse, AREVA, and GEH engineering calculations.

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Audit Agenda

Due to the proprietary nature of LOCA models, a separate audit will be required at the local offices for each fuel vendor. Each audit is expected to last two business days. In general, the staff will audit the underlying engineering calculations which document the "adjustments" and "credits" applied to previously calculated peak local oxidation, any new ECCS performance analyses, cladding hydrogen uptake models, and the logic for binning plants.

Specific focus topics are listed below:

1. To support its safety assessment, the staff intends to identify and document calculated results and adjustments for each individual plant within each bin.

2. Recognizing that the implementation of the proposed changes to 10 CFR 50.46 would take several years, the draft GL requests a commitment to assess and report any future changes in fuel design, fuel management, or calculated ECCS performance which affect the continued applicability of the information provided in response to the GL. This commitment would help the staff to ensure continued safe operation in the interim. The PWROG and BWROG reports present a snapshot of current safety margin. The staff is seeking a commitment as part of this voluntary industry initiative to fulfill this aspect of the GL. Consider how the existing annual reporting requirement in 10 CFR 50.46(a)(3) could be augmented to re-affirm plant safety in this interim period. For example, a

licensee within a plant grouping which does not credit cycle-dependent information and for which no new LOCA analysis was performed or error identified could simply state

ENCLOSURE

3. within their annual letter report that their ECCS margin assessment remains applicable. For licensees within a plant grouping which credits cycle-dependent information (e.g., rod power history), confirming continued applicability may be more difficult.

4. Section 5.1 of PWROG Report OG-11-143 defines an Appendix K to best-estimate credit of 60% reduction in oxidation. In Section 7.3, an explicit best-estimate credit of 72% reduction was applied to the calculated results of the limiting plant. Demonstrate that the 72% credit is applicable (or conservatively low) for the 6 units in LBLOCA Group 3 and that a different LBLOCA scenario (i.e., break size, initial conditions) would not yield a larger adjusted oxidation (i.e., less safety margin).

5. Section 5.2 of PWROG Report OG-11-143 defines a CQD to ASTRUM credit. The report states, "…the benefits of changing from CQD to ASTRUM best-estimate methodology was quantified for each instance." Yet, when applied to the limiting plant in LBLOCA Group 2 and Group 6, the same 50% reduction was credited. Demonstrate that the 50% credit is applicable (or conservatively low) for the 9 units in LBLOCA Group 2 and Group 6 and that a different LBLOCA scenario (i.e., break size, initial conditions) would not yield a larger adjusted oxidation (i.e., less safety margin).

6. Section 5.5 of PWROG Report OG-11-143 defines an "improved statistics" credit. Be prepared to discuss the validity of this approach and applicability of the estimated 23% reduction in oxidation without explicit calculations.

7. Describe the derivation of Figure 5 of PWROG Report OG-11-143. Is it based on explicit hot rod local oxidation calculations as a function of hot rod power level? Provide plots of fuel rod power histories for groupings where this credit is taken.

8. Describe the rod power history and burnup in the explicit calculation used in LBLOCA Group 5 (Table 5 of PWROG Report OG-11-143) and how it relates to thermal-mechanical rod power operating limits.

9. Describe how a cladding hydrogen content of 267 ppm was derived for CE plants at 50 GWd/MTU (Table 7 of PWROG Report OG-11-143) as compared with 432 ppm for W plants (Table 5 of PWROG Report OG-11-143). Also, describe the basis for the 194 ppm hydrogen level of Optimized ZIRLO.

10. Section 8 of PWROG Report OG-11-143 provides no discussion of SBLOCA Grouping for AREVA methods or cladding alloy.

11. When reload rod power history or explicit calculations at higher burnup (and lower rod power) are credited, then the amount of margin relative to the research data (Figure 1 of PWROG Report OG-11-143) should be addressed at several BU steps.

    a. For example, Table 8 jumps from a calculated 8.38% BJ-ECR to a calculated 4.9% BJ-ECR at 50 GWd/MTU without demonstrating that margin exists along the way. Same true for Table 9 which starts at a calculated 13.42 % BJ-ECR with no discussion or comparison with degradation in allowable ECR for ZIRLO as a function of burnup.

b. Describe the rod power history and burnup in the explicit calculation used in SBLOCA Groups 8 and 9 (Tables 8 and 9 of PWROG Report OG-11-143) and how it relates to thermal-mechanical rod power operating limits.

c. Discuss the applicability of the explicit oxidation calculation at 50 GWd/MTU to the 59 plants in SBLOCA Group 1 and 5 plants in Group 2.

12. With respect to Table 7 in BWROG Report TP-11-010 (Group 2), address the following items:
    a. Describe the selection of the burnup evaluation point of 56 GWd/MTU. With an estimated cladding hydrogen content of 90 ppm and an allowable time-at-temperature of 15.3 %CP-ECR, this burnup evaluation point does not appear to be as limiting as the evaluation points selected in Tables 8 through 12.

    b. With minimal margin to the onset of breakaway oxidation, discuss the attributes of the DEG break which make it most limiting for the duration where predicted cladding temperature above 800 °C.

13. With respect to Table 8 in BWROG Report TP-11-010 (Group 3), address the following items:
    a. Figure 4 indicates that calculated local oxidation is 9% ECR for the Group 3 plants; whereas, Table 8 lists < 7% ECR. Explain this difference.

    b. Was an explicit local oxidation calculation performed at a rod average exposure of 72 GWd/MTU? If so, identify the rod power assumed in this calculation.

    c. With licensed burnup limited to 62 GWd/MTU rod average, why was a burnup evaluation point of 72 GWd/MTU rod average selected?

    d. Demonstrate that at intermediate BU, margin exists to the Figure 3 allowable oxidation limits.

    e. Provide plots of PCT and local oxidation versus time for both Westinghouse and GEH fueled plants.

    f. Discuss the cladding strain values used in the LOCA analyses.

14. The GL would have requested information from all holders of an operating license or construction permit for a nuclear power reactor. It does not appear that the OG reports capture an ECCS assessment for nuclear reactors which are expected to start-up prior to the implementation of new ECCS requirements within 10 CFR 50.46. For example, Bellefonte Units 2 and 3 and Watts Bar Unit 2. Discuss the impact of the research data on projected ECCS performance at these sites.

15. Section 6.1 of PWR Report OG-11-143 discusses decay heat modeling for SBLOCA. It appears that is some cases, deviations from the Appendix K 1971 Heat Decay were made in order to gain margin. The ANS-1979 Decay Heat plus 2-sigma is mentioned as a possible deviation. Provide plots of the decay heat curves, with uncertainties, used in

the OG assessments.

16. The fuel rod cladding burst model and predicted cladding balloon strains has a significant impact on calculated peak cladding temperature and local oxidation in the burst region of the fuel rod.

    a. Discuss the burst model(s) and predicted cladding strains within each bin.
    b. Discuss predicted cladding temperature and local oxidation within the burst node and in the node directly above and below the burst node.
    c. Table 9 of PWR Report OG-11-143 indicates that some breaks with PCT > 1750 ºF do not predict cladding burst. Describe the circumstances for those cases and whether sufficient burnup sensitivities have been performed to discover more limiting cases.
    d. Provide a few representative plots of rod internal pressure versus burnup and discuss the impact of increasing rod internal pressure on predicted rod burst.

17. Section 5.3 of PWR Report OG-11-143 addresses credit for use of the C-P model. Describe whether accounting for pre-transient cladding metal corrosion implies a lower weight gain and thus lower ECR during steam oxidation. There is a general belief that corrosion is non-protective.

18. In several instances, credit is taken for projected rod power histories (i.e., power burn-down). Discuss the impact of a misplaced fuel bundle (i.e., 3rd cycle fuel bundle misloaded adjacent to several high power fresh assemblies) on predicted ECCS performance.

19. The NRC is considering a risk-informed, staged implementation strategy for the proposed revision to 10 CFR 50.46(b). Describe how the information provided in the ECCS margin assessment and plant binning could be used to inform this risk-informed staged implementation. Propose a grouping of plants (or bins) into three implementation tracks based upon margin to the research data. Also consider balancing the level of effort required to complete the LOCA model updates and individual plant ECCS demonstration between the three implementation tracks.

Location and Time

Westinghouse – TBD

AREVA – TBD

GEH - TBD

Audit Team

(Paul Clifford, NRR, audit team leader)

(Harold Scott, RES, reviewer)

(Len Ward, NRR, reviewer)

(Ralph Landry, NRO, reviewer)

Required Documentation

All engineering calculations supporting the information contained in the summary reports.

Special Requests

The NRC requests that Westinghouse, AREVA, and GEH provide:

- A working space for two business days at local facility
- The audit documents on a CD or several CDs in a text searchable format
- A telephone for contacting NRC staff at HQ
- A teleconference line for the entrance and exit meetings
- A copy of the audit documents at the local office for a period of 45 days following the exit meeting in the event that the staff requires additional review prior to issuance of the audit results summary report, audit summary, or RAIs.
- Access to fuel vendor staff familiar with the ECCS performance calculations.

Audit Products

Within 45 days of the exit meeting (last of 3 audits) the NRC staff will generate a proprietary audit results summary report and a non-proprietary audit summary. The report will describe the outcome of the NRC review of documentation and summarize that information required for the NRC to reach its safety conclusions.

The audit summary will provide a list of the audited documents and non-proprietary conveyance of the NRC staff's technical evaluation

As part of this audit report, the staff will determine whether the industry sponsored alternative has provided the necessary information being sought by the GL and make recommendations for any further actions, if necessary.