

August 12, 2016

MEMORANDUM TO: Kevin Hsueh, Chief
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

FROM: Joseph A. Golla, Project Manager */RA/*
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

SUBJECT: GENERAL ELECTRIC-HITACHI NUCLEAR ENERGY – TRACG
APPLICATION FOR EMERGENCY CORE COOLING
SYSTEMS/LOSS-OF-COOLANT-ACCIDENT ANALYSES FOR
BWR/2-6 – NEDE-33005P – NUCLEAR PERFORMANCE AND
CODE REVIEW BRANCH AUDIT PLAN (TAC NO. ME5405)

By letter dated January 27, 2011, General Electric (GE)-Hitachi Nuclear Energy (GEH) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR) NEDE-33005P, Revision 0, "TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant-Accident Analyses for BWR/2-6."

The U.S. Nuclear Regulatory Commission (NRC) staff technical review has required several rounds of correspondence with GEH. In its review, the NRC staff transmitted a request for additional information (RAI) by letter dated October 19, 2012. By letter dated October 7, 2014, GEH provided its response. The NRC staff transmitted a second round RAI by letter dated September 15, 2015, to which GEH responded by letter dated February 19, 2016. The NRC staff transmitted a third round RAI to GEH by letter dated March 24, 2016, to which GEH has not yet responded.

The NRC staff has determined that an audit, following Office of Nuclear Reactor Regulation Office Instruction LIC-111, "Regulatory Audits," will be beneficial in: (1) ensuring that the draft round 3 RAI is clear and that GEH is preparing a complete response, (2) identifying specific information required, if any, to supplement the existing RAI responses, and (3) reviewing a plant-specific demonstration calculation. A non-proprietary version of the NRC staff Regulatory Audit Plan is enclosed.

Project No. 710

Enclosure:
Audit Plan

CONTACT: Benjamin T. Parks, NRR/DSS
(301) 415-0979

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REGULATORY AUDIT PLAN
NRC STAFF REVIEW OF NEDE-33005P
**TRACG APPLICATION FOR EMERGENCY CORE COOLING SYSTEM/
LOSS-OF-COOLANT-ACCIDENT ANALYSES FOR BWR/2-6**
TAC NO. ME5405

1.0 BACKGROUND

By letter dated January 27, 2011, General Electric (GE)-Hitachi Nuclear Energy (GEH) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR) NEDE-33005P, Revision 0, "TRACG Application for Emergency Core Cooling Systems/ Loss-of-Coolant-Accident Analyses for BWR/2-6."^{1,2}

The NRC staff technical review requires ongoing correspondence with GEH. In its review, the NRC staff transmitted a request for additional information (RAI) by letter dated October 19, 2012.³ By letter dated October 7, 2014, GEH provided its response.⁴ The NRC staff transmitted a second round RAI by letter dated September 15, 2015, to which GEH responded by letter dated February 19, 2016.^{5,6} The NRC staff transmitted a third round RAI to GEH by letter dated March 24, 2016, to which GEH has not yet responded.⁷

2.0 REGULATORY AUDIT BASES

The TRACG loss-of-coolant-accident (LOCA) evaluation model (TRACG-LOCA) was developed in accordance with the regulatory requirements established in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," Section 46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors" (10 CFR 50.46). In developing TRACG-LOCA, GEH considered guidance contained in two NRC Regulatory Guides (RGs). These include: (1) RG 1.157, "Best-Estimate Calculations of Emergency Core Cooling System Performance," and (2) RG 1.203, "Transient and Accident Analysis Methods."^{8,9}

The NRC staff is reviewing NEDE-33005P to determine whether TRACG-LOCA is an acceptable evaluation model as set forth in 10 CFR 50.46. In its review, the NRC staff relies on the regulatory guidance described above, as well as applicable chapters contained in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR [light-water reactor] Edition." These chapters include Chapter 6.3, "Emergency Core Cooling System," Chapter 15.0.2, "Review of Transient and Accident Analysis

Enclosure

Methods,” and Chapter 15.6.5, “Loss-of-Coolant-Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary.”^{10,11,12}

3.0 REGULATORY AUDIT SCOPE/OBJECTIVES

The NRC staff regulatory audit scope will focus on specific open items associated with NEDE-33005. The goal of the audit is to obtain clarification on the open items, and to identify what additional information, if any, should be submitted to complete the review.

3.1. MISCELLANEOUS OPEN ITEMS

3.1.1. Draft Responses to RAIs 99 and 100

GEH continues to draft responses to RAIs 99 and 100, regarding the overall combination of uncertainty and the use of the Cathcart-Pawel correlation to obtain a result for maximum local cladding oxidation. The NRC staff will audit the draft responses to these RAIs.

3.1.2. Revision to RAI 33 Response

The letter transmitting the round 2 RAI response dated February 19, 2016, indicated that a revision is planned for the response to RAI 33, which addresses the model and uncertainty for cladding strain and perforation. The NRC staff will audit the data and related material supporting this planned RAI response.

This segment of the audit will focus on ensuring that the planned revision provides sufficient information to establish that it provides adequate justification for any changes to the modeling approach or uncertainty treatment, so that follow-on RAIs are minimized.

3.1.3. Burnup Limitation

The response to RAI 97, which pertains to fuel rod swelling, rupture, and relocation, appears to be constrained by data that do not exceed current licensed burnup limitations on fuel. This may be the case with additional models or inputs, such as the fuel rod thermal-mechanical performance data that are obtained from the PRIME code. The NRC staff will review potential limitations to the TRACG-LOCA methodology that result from treatment of burnup-dependent phenomena.

3.1.4. Licensing Approaches for Expanded Operating Domains

Generally, an NRC staff approval of NEDE-33005P would be accompanied by an amendment to GESTAR-II, which would permit the application of TRACG-LOCA on a plant-specific basis without a need to request a licensing action from the NRC. The NRC staff anticipates, however, that TRACG-LOCA analyses may be used to support licensing requests, such as those associated with expanded operating domains like Maximum Extended Load Line Limit Analysis Plus (MELLLA+) and extended power uprate. The NRC staff will audit the expected content of portions of such applications that would be supported by TRACG-LOCA analyses, relative to applicable conditions and limitations that apply to requests for operating domain expansions.

3.2. DECAY HEAT

Regulatory Position 3.2, "Sources of Heat During a Loss-of-Coolant Accident," of RG 1.157 provides guidance regarding acceptable decay heat models.

The decay heat model included in TRACG04 is enhanced over what was previously provided in TRACG02. Whereas the TRACG02 code included the May-Witt decay heat model, TRACG04 adds both the 1979 and 1994 American Nuclear Society (ANS) decay heat models. The safety evaluation approving Supplement 3 to NEDE-32906P notes that the 1994 standard is used in anticipated operational occurrence, anticipated transient without scram, and American Society of Mechanical Engineers overpressure analysis; however, NEDE-33006P indicates that the 1979 ANS decay heat model is used for emergency core cooling system evaluation. The NRC staff notes that this approach is in line with the guidance contained in RG 1.157.

The vendor notes, in Table 2.5-1, on Page 2-8 of NEDE-33005P, that, "Calculations are made in accordance with the 1979 ANS Standard. Sensitivities to variations in voids, enrichment and operating history are shown in Appendix B of [NEDE-30996P-A]." The TRACG04 decay heat model is also described in Section 9.3 of NEDE-32176P, Revision 4.

In addition, the Licensing Topical Report (LTR) states, [

Further explanation is provided on Page 5-31 of NEDE-33005P, which states, in part, that "the decay heat curve becomes a function of the fuel design, depletion environment and power history. In theory, each point in the reactor has a unique decay heat curve. Fortunately, the variations in decay heat due to the above effects are small and a generic curve can be defined to cover all locations with little loss in accuracy."

From the remarks in NEDE-33005P, it is not possible to determine whether different decay heat curves are calculated for each bundle group, as the text in Chapter 2 of the LTR suggests, or whether a generic curve is used for the entire core, as suggested in Chapter 5. In addition, the LTR is not clear as to whether the effects of fuel exposure, depletion power density, irradiation time, fuel enrichment, and void fraction, are explicitly modeled on a bundle-by-bundle basis, or whether the modeling is simplified to a point that permits the use of more generic modeling approaches.

In addition to the above, GEH references NEDE-30996P-A, Appendix B, for discussion regarding the sensitivities to significant operating conditions. The NRC copy of NEDE-30996P-A does not include an Appendix B; however, NEDE-23785-1-PA does.

In addition to these documentation issues, the uncertainty treatment for decay heat also warrants discussion. A succinct and specific discussion of the uncertainty treatment does not appear in the LTR; rather, Section 5.1.3.31 states that the decay heat curve, with $\pm 1\sigma$ curves, is shown for a bundle average exposure of 11 GWd/MTU (per response to RAI 54). The decay heat entry in Table 5.1-2 refers the reader back to the text in Section 5.1.3.31. The LTR does not specifically define the approach used to address decay heat uncertainty.

The uncertainty treatment for decay heat within a realistic model warrants discussion, because the decay heat uncertainties are somewhat different from other phenomenological uncertainties. This is because the process itself occurs, stochastically, in time. Thus, the appropriateness of applying a single uncertainty multiplier for the entire time-dependent curve is questionable, and the use of a multiplier that skews the curve below the nominal value for the entire transient requires additional justification as either a realistic or conservative approach.

The NRC staff would like to accomplish the following at the audit:

- A complete copy of NEDE-30996P-A should be made available for NRC staff review.
- The TRACG-LOCA decay heat approach should be discussed, covering the following topics:
 - Basis in legacy evaluation models
 - Evolution from legacy evaluation models to present approach
 - Any linkage to other evaluation models, such as lattice physics methods
 - The uncertainty approach, for treating both operating state and phenomenological uncertainties
 - The distinction between modeling approaches that have previously been approved and those that are novel for TRACG-LOCA
 - The distinction between simplified or conservative modeling approaches, versus realistic modeling approaches, should be clarified.
- The application of the uncertainty approach should be reviewed in some of the demonstration calculations

3.3. LICENSING APPLICATION REVIEW

The NRC staff understands that GEH is preparing a TRACG-LOCA analysis to support a licensing application. The NRC staff will audit the design record file associated with this analysis.

4.0 TEAM ASSIGNMENTS

The audit team will consist of Benjamin T. Parks in the Nuclear Performance and Code Review Branch, Division of Safety Systems, Office of Nuclear Reactor Regulation.

5.0 LOGISTICS AND SCHEDULE

The audit will take place at GEH facilities in Washington, DC, from Wednesday, April 27, 2016, to Friday, April 29, 2016.

- Wednesday April 27, 1:00PM to 5:00PM (Miscellaneous Open Items)
- Thursday, April 28, 9:00AM to 5:00PM (Decay Heat)
- Friday, April 29, 9:00AM to 5:00PM (Licensing Application)

6.0 REFERENCES

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1. Harrison, James F., GE-Hitachi Nuclear Energy Americas (GEH), letter to U.S. Nuclear Regulatory Commission, "NEDE-33005P and NEDO-33005, 'Licensing Topical Report TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant-Accident Analyses for BWR/2-6,'" MFN 11-001, Project No. 710, January 27, 2011, Agencywide Documents Access and Management System (ADAMS) Accession No. ML110280323.
 2. GEH, "TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant Accident Analyses for BWR/2-6," NEDE-33005P, Enclosure 1 to MFN 11-001, Project No. 710, January 27, 2011, ADAMS Accession No. ML110280326 (proprietary). See also non-proprietary NEDO-33005, Enclosure 2 to MFN 11-001, ADAMS Accession No. ML110280325.
 3. Philpott, Stephen S., U.S. Nuclear Regulatory Commission, letter to Jerald G. Head, GEH, "Request for Additional Information Re: GE-Hitachi Nuclear Energy Americas Topical Report NEDE-33005P, Revision 0, 'TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant-Accident Analyses for BWR/2-6' (TAC No. ME5405)," Project No. 710, October 19, 2012, ADAMS Accession No. ML12242A571. See also proprietary Enclosure 2, ML12242A572.
 4. Harrison, James F., GEH, letter to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information Re: GE-Hitachi Nuclear Energy Americas Topical Report (TR) NEDE-33005P, Revision 0, 'TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant-Accident Analyses for BWR/2-6,' (TAC No. ME5405)," MFN 14-064, Project No. 710, October 7, 2014, ADAMS Accession No. ML14281A018. See also proprietary Enclosure 1, ML14281A016, and non-proprietary Enclosure 2, ML14281A015.
 5. Golla, Joseph A., U.S. Nuclear Regulatory Commission, letter to Jerald G. Head, GEH, "Request for Additional Information Regarding Review of Licensing Topical Reports NEDE-33005P and NEDO-33005, 'Licensing Topical Report TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant Accident Analyses for BWR/2-6' (TAC No. ME5405)," Project No. 710, September 15, 2015, ADAMS Accession No. ML15204A582. See also proprietary ML15204A571.
 6. Harrison, James F., GEH, letter to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information Regarding Review of Licensing Topical Reports

NEDE-33005P and NEDO-33005, 'Licensing Topical Report TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant Accident Analyses for BWR/2-6' (TAC No. ME5405)," MFN 16-008, Project No. 710, February 19, 2016, ADAMS Accession No. ML16050A139. See also proprietary Enclosure 1, ML16050A141 and non-proprietary Enclosure 2, ML16050A142.

7. Golla, Joseph A., U.S. Nuclear Regulatory Commission, letter to Jerald G. Head, GEH, "Request for Additional Information Regarding Review of Licensing Topical Report NEDE-33005P and NEDO-33005, 'TRACG Application for Emergency Core Cooling Systems/Loss-of-Coolant Accident Analyses for BWR/2-6' (TAC No. ME5405)," Project No. 710, March 24, 2016, ADAMS Accession No. ML16062A061.
8. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.157, "Best-Estimate Calculations of Emergency Core Cooling System Performance," May 1989, ADAMS Accession No. ML003739584.
9. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.203, "Transient and Accident Analysis Methods," December 2005, ADAMS Accession No. ML053500170.
10. U.S. Nuclear Regulatory Commission, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 6.3, "Emergency Core Cooling System," Revision 3, March 2007, ADAMS Accession No. ML070550068.
11. U.S. Nuclear Regulatory Commission, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 15.0.2, "Review of Transient and Accident Analysis Methods," Revision 0, March 2007, ADAMS Accession No. ML070820123.
12. U.S. Nuclear Regulatory Commission, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 15.6.5, "Loss-of-Coolant-Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary," Revision 3, March 2007, ADAMS Accession No. ML070550016.