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MFN 12-033
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U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: Response to NRC Letter Re: Nuclear Fuel Thermal Conductivity Degradation Evaluation for Light Water Reactors using GE-Hitachi Nuclear Energy Codes and Methods (TAC No. ME6598)

By Reference 1, the U.S. Nuclear Regulatory Commission (NRC) expressed concerns regarding the use of historical fuel thermal conductivity models in the safety analyses of operating reactor plants. As reflected in the NRC evaluation attached to Reference 1, this subject has been acknowledged and evaluated by GE-Hitachi Nuclear Energy Americas LLC (GEH) and Global Nuclear Fuel–Americas, LLC (GNF), beginning in late 2006.

Throughout this letter and Enclosure 1, the term GEH may be used to collectively mean one or both GEH and GNF.

In the time period spanning 2006 through the present, GEH had a number of activities taking place in parallel that relate to this subject. One of the key licensing activities during this period was the submittal of the GNF Licensing Topical Report, *The PRIME Model for Analysis of Fuel Rod Thermal–Mechanical Performance*, January 2007, which was subsequently approved by the NRC in January 2010. PRIME thermal-mechanical modeling is designed and approved to fully address the subject phenomena of the reduction of fuel thermal conductivity with exposure. Enclosure 1 discusses how the PRIME licensing activity fits together with other activities occurring during the 2006-to-present time period and how each relates to the safety analysis results as well as closure of the subject issue.

While the NRC audit of the PRIME downstream methods implementation per NEDC-33173P Supplement 4 Safety Evaluation (SE) is currently planned for the week of July 16, 2012, the audit is not explicitly identified in the SE as a limitation or condition to implementation. GEH's reading of the NEDC-33173P Supplement 4 SE is that PRIME implementation in the downstream methods may occur via 10 CFR 50.59.

The specific PRIME transition plans include:

- GEH will distribute 10 CFR 50.46 notifications based on the Supplement 4 process in the July-August 2012 time frame. PRIME will be implemented directly in ECCS-LOCA calculations as specific plant needs require ECCS-LOCA re-analysis.
- The NRC will perform the PRIME downstream methods implementation audit per the NEDC-33173P Supplement 4 SE the week of July 16, 2012.
- GEH intends to implement PRIME into the reload process in fuel cycle designs that begin in the Fall of 2012.
- The full implementation of PRIME into the Extended Power Uprate (EPU) and Maximum Extended Load Line Limit Analysis Plus (MELLLA+) projects has begun.

If you have any questions, please contact me or Andy Lingenfelter at 910-819-5954.

Sincerely,

James F. Harrison
Vice President, Fuels Licensing
Regulatory Affairs
GE-Hitachi Nuclear Energy Americas LLC

Project No. 710

Reference:

1. Letter from Timothy J. McGinty (NRC) to Jerald G. Head (GEH), Subject: Nuclear Fuel Thermal Conductivity Degradation Evaluation for Light Water Reactors using GE-Hitachi Nuclear Energy Codes and Methods (TAC No. ME6598), March 23, 2012.

Enclosure:

1. Response to NRC Letter Re: Nuclear Fuel Thermal Conductivity Degradation – Non-Proprietary Information – Class I (Public)

cc: SS Philpott, US NRC
JG Head, GEH/Wilmington
PL Campbell, GEH/ Washington
eDRF Section 0000-0147-3697

ENCLOSURE 1

MFN 12-033

Response to NRC Letter Re: Nuclear Fuel Thermal Conductivity Degradation

Non-Proprietary Information– Class I (Public)

Discussion

The background and history included Sections 5.3 through 5.5 in the NRC staff evaluation (Reference 1 of this enclosure's cover letter) are a fair reflection of the interactions of GEH and GNF with the NRC staff from 2006 to date. These activities connect together to support different plants and products in different ways.

During this time period there were five interacting activities occurring:

1. The issue of Thermal Conductivity Degradation (TCD) in the ESBWR was being raised during the certification review,
2. The issue of TCD in the operating fleet was being evaluated via the Part 21 process, (References 1 and 2)
3. The PRIME fuel thermal-mechanical (T-M) methodology was being reviewed and approved, (References 3 - 5)
4. The consideration of TCD as a GEH methods issue was taking place during the review of NEDC-33173P, "Applicability of GE Methods to Expanded Operating Domains," and (Reference 6 and 7)
5. GNF was introducing the GNF2 fuel product line. (Reference 8)

The consideration of TCD in the ESBWR certification process was resolved via GEH responses to NRC Requests for Additional Information (RAI), Licensing Topical Reports (LTRs) and DCD changes during that review & NRC Safety Evaluations (SE).

The operating BWR fleet, using GSTRM (Reference 9) based GE14 or earlier GNF fuel products and not having NEDC-33173P, *Applicability of GE Methods to Expanded Operating Domains*, in their licensing basis, is supported by References 1 and 2. Reference 1 provided a general evaluation of the relevant safety analysis subjects as well as the fuel T-M design adequacy. The NRC staff was satisfied with these evaluations with the exception of the rod internal pressure evaluation. Subsequently, Reference 2 supplemented this evaluation and agreement was reached with the NRC staff on the GE14 rod internal pressure compliance.

The PRIME methodology in Reference 3 includes an exposure-dependent thermal conductivity model that fully addresses the issue of TCD. The completed review and approval of PRIME provides GNF and GEH the methodology by which to disposition the TCD issue. The responses to RAI 39 and its associated supplements provide an estimate of the impact of implementation of PRIME methodology on downstream safety analyses. (Reference 5)

The review of NEDC-33173P (Reference 7) resulted in a critical pressure penalty to be included in the methodology of the fuel T-M design when using the GSTRM methodology. This penalty was applied to the GE14 design resulting in a modified GE14 Thermal Mechanical Operating Limit (TMOL) (Reference 10). This modified GE14 TMOL is used for new Extended Power Uprate (EPU) and Maximum Extended Load Line Limit Analysis Plus (MELLLA+) applications and for operating plants that have NEDC-33173P (Reference 7) as part of their licensing basis.

The GESTAR II compliance report for the initial GNF2 design submitted in March 2007 was based on the GSTRM methodology (Reference 8). In 2008, following submittal of Supplement 1 of the GSTRM Part 21 (Reference 1), the GNF and NRC staffs together concluded that, while the GE14 fuel product could be supported with GSTRM, it was going to be unproductive for all involved to pursue a similar approach for GNF2. At that point, an interim limited lifetime for GNF2 (References 11 and 12) was agreed upon and all efforts were put forth to the completion of PRIME licensing. Having completed PRIME licensing in January 2010 (Reference 4), the GNF2 compliance report was updated to include the PRIME based TMOL and the full GNF2 lifetime in March 2010 (Reference 13).

PRIME Implementation Plans

GEH has been working to effect the PRIME implementation since PRIME was approved in January 2010 (Reference 4). The downstream methods plan submitted in July 2009 (Reference 14) was approved by the NRC in September 2011 (Reference 15) and incorporated into GESTAR II by the NRC approval of Amendment 33 in August 2010 (Reference 16). As noted in the SE of the downstream methods plan, it is the NRC's intention to conduct an audit of the GEH and GNF activities implementing the stated plan. The NRC audit of the PRIME downstream methods implementation per the NEDC-33173P Supplement 4 SE is currently planned for the week of July 16, 2012. However, Section 3.1 of the SE also states:

> The NRC staff finds that updating the fuel thermal models in the suite of downstream codes for consistency with PRIME constitutes a change in a method of evaluation to another method that has been approved by the NRC staff for the intended application. Therefore, per 10 CFR 50.59(c)(2)(viii), the method changes may be performed without NRC review and approval since the PRIME model has been approved by the NRC staff separately.

Hence, the Supplement 4 SE does not specify that an audit is a requirement for implementation. GEH has stated at various times and in various communications the intent not to switch from GSTRM to PRIME until the NRC audit was complete (Reference 17).

As GEH desires to complete PRIME implementation as soon as practical, EPU and MELLLA+ projects have switched to a PRIME basis, generally beginning with the Grand Gulf MELLLA+ submittal. This is consistent with Limitation & Condition 12 of NEDC-33173P (Reference 7), which requires PRIME to be utilized following its approval. Please note that the engineering and analysis studies for these types of submittals begin years prior to the submittal date and project timelines vary considerably; therefore, each project is unique in its application of PRIME. In other words, there may be License Amendment Requests (LAR) submitted following the Grand Gulf MELLLA+ LAR that do not include full PRIME implementation.

GNF will implement the PRIME T-M basis for the GE14 fuel product line in the reload work-scope for new fuel cycle designs initiated following the completion of the downstream codes implementation activities as described in NEDO-33173 Supplement 4 (Reference 17). For the GNF2 fuel product line, the PRIME based Thermal-Mechanical (T-M) design has already been implemented. Fuel products preceding GE14 (e.g., GE11 and 12), which are currently

operating, will continue to use the GSTRM basis. This approach is consistent with GESTAR II Revision 18 (Reference 18).

Specific PRIME transition plans:

- GEH will distribute 10 CFR 50.46 notifications based on the Supplement 4 process in the July-August 2012 time frame. PRIME will be implemented directly in ECCS-LOCA calculations as specific plant needs require ECCS-LOCA re-analysis.
- The NRC will perform the PRIME downstream methods implementation audit per the NEDC-33173P Supplement 4 SE the week of July 16, 2012.
- GEH intends to implement PRIME into the reload process in fuel cycle designs that begin in the Fall of 2012.
- The full implementation of PRIME into the EPU and MELLLA+ projects has begun.

NRC Letter Action Items

1. *"It is incumbent upon GEH to inform all licensees using GEH evaluation models of any analytical changes resulting from the information contained in the attached assessment report that could affect the licensees' compliance with the regulations of 10 CFR 50.46."*

Response

GEH understands their obligation to report changes to the licensees in accordance with 10 CFR 50.46.

PRIME RAI 39 (Reference 5) evaluated the effects on ECCS-LOCA of switching the fuel conductivity and gap conductance parameters from GSTRM to PRIME. These evaluations, performed using various prototypical jet-pump design BWRs, focused on the limiting peak clad temperature (PCT) calculations that typically correspond to the first knee exposure of the Thermal Mechanical Operating Limit (TMOL) curve. The effect of further fuel TCD due to higher burnup is more than offset by the decreasing TMOL. Therefore, the temperature at higher exposures will always be less limiting than the 'knee exposure' PCT for 10 CFR 50.46 compliance, with or without TCD effects. For the external-pump designs (BWR/2s), the effects of TCD on LOCA are negligible since the decay heat and core spray heat transfer are the dominant factors determining the PCT. This TCD issue is also delineated in IN-2011-21 and does not pose a new (i.e. previously unanalyzed) question, and it does not affect the BWR LOCA calculations because in a BWR the high exposures have inherently lower TMOL.

The effect of PRIME implementation is being addressed via the 10 CFR 50.46 reporting process, as explained in the approved Supplement 4 to NEDC-33173P (Reference 17). The timing of these 10 CFR 50.46 change notifications is tied to the Supplement 4 process, but may be submitted earlier than full implementation into the reload process at GEH's discretion. GEH expects to distribute the 10 CFR 50.46 notices in the July-August 2012 timeframe.

GEH is implementing, and will continue to implement, PRIME directly into the ECCS-LOCA analysis for plants that need to be reanalyzed. There is no 10 CFR 50.46 change notification associated with the direct implementation of the PRIME fuel properties as the PRIME fuel properties become part of the analysis of record.

2. *"In addition to informing licensees about possible impacts on 10 CFR 50.46 compliance, the NRC staff requests that GEH evaluate the magnitude of the effect of fuel thermal conductivity degradation on the relevant parameters of interest outlined in the enclosure (e.g., fuel centerline temperature, peak cladding temperature, rod internal pressure), and determine whether the specified acceptable fuel design limits for any licensing basis analysis using GEH models and codes are exceeded if the thermal conductivity degradation as a function of burnup is included in the analysis. "*

Response

GNF and GEH have generically performed the requested evaluations, as provided in the January 2007 Part 21 (Reference 1) and the sensitivity studies provided in the PRIME RAI 39 response (Reference 5). The NRC staff concurred with the evaluation in Reference 1 and with PRIME RAI 39. Further, the studies conducted during the PRIME implementation activities have confirmed that the sensitivities are small. As such, there is considered to be little to no detrimental impact to margins for specified acceptable fuel design limits. As noted above, full PRIME implementation has begun on EPU and MELLLA+ projects and GEH intends to implement PRIME in reload designs that begin in the Fall of 2012.

The current fuel product line T-M design basis has been discussed above. To summarize, there are three currently accepted fuel product line design bases:

1. GE14 (Plants Not Referencing NEDC-33173P) - GSTRM T-M design basis per MFN 07-040 Part 21 and its Supplement 1 (References1 and 2).
2. GE14 (Plants Referencing NEDC-33173P) - GSTRM T-M design basis per NRC Safety Evaluation for NEDC-33173P (References 6 and 7) with a specific rod internal pressure penalty included in the lifetime calculation.
3. GNF2 - PRIME T-M design basis. (Reference 13)

The GE14 T-M design basis will be updated to PRIME when the full implementation of PRIME is initiated in the Fall of 2012, consistent with Reference 18. The few fuel products older than GE14 that remain in operation will continue with the GSTRM basis until they are discharged. This approach is consistent with GESTAR II Revision 18 (Reference 18).

3. *"The NRC staff anticipates that GEH will enter this issue into its corrective action program."*

Response

CAR 58169 has been entered in the GEH system. Because the PRIME implementation project is in an advanced stage, the detail included in the subject CAR is minimal, reflecting the near term completion of PRIME implementation activities.

4. *"GEH's cooperation in providing information detailing the fuel thermal conductivity model(s) that GEH is currently using in the safety analyses of operating reactors and a list of the operating reactors that are currently using GEH thermal-hydraulic and fuel performance models and codes will assist the NRC staff in resolving this issue."*

Response

As noted in the response to Item 2 above, GEH has demonstrated an acceptable fuel T-M design basis for the two major fuel products currently in operation (GE14 and GNF2):

1. GE14 (Plants Not Referencing NEDC-33173P) - GSTRM T-M design basis per MFN 07-040 Part 21 and its Supplement 1 (References 1 and 2).
2. GE14 (Plants Referencing NEDC-33173P) - GSTRM T-M design basis per NRC Safety Evaluation for NEDC-33173P (References 6 and 7) with a specific rod internal pressure penalty included in the lifetime calculation.
3. GNF2 - PRIME T-M design basis. (Reference 13)

With respect to the change from GSTRM to PRIME fuel properties in the downstream methods, the sensitivity studies provided in PRIME RAI 39 (Reference 5) demonstrated the expected magnitude of changes in transients, stability, and ECCS-LOCA. Via the PRIME SE and the plan submitted in Supplement 4, the NRC found these sensitivity studies sufficient to accept the use of GSTRM in the interim while the PRIME basis was being implemented (Reference 15). GEH has been preparing for full PRIME implementation since the Supplement 4 plan was submitted. At this date, GEH is ready to make the change from GSTRM to PRIME fuel properties in the downstream methods. As discussed in PRIME Implementation above, GEH plans to begin full PRIME implementation in the Fall of 2012.

5. *"The NRC staff requests a telephone conference after receipt of this letter to discuss GEH's plan forward."*

Response

Completed on April 12, 2012.

6. *"The NRC staff anticipates receiving your written response to the stated concerns within 30 days of receipt of this letter. Based on the information received from GEH, the NRC staff will be able to better plan any future actions on this issue."*

Response

This letter completes this action.

References

1. Letter, J.S. Post (GE) to Document Control Desk (USNRC), Subject: Part 21 Notification: Adequacy of GE Thermal-Mechanical Methodology, GESTRM, MFN 07-040, January 21, 2007.
2. Letter, D.E Porter (GEH) to Document Control Desk (USNRC), Subject: Part 21 Notification: Adequacy of GE Thermal-Mechanical Methodology, GESTR-M – Supplement 1, MFN 07-040 Supplement 1, January 4, 2008.
3. Letter, A.A. Lingenfelter (GNF) to Document Control Desk (USNRC), Subject: GNF Licensing Topical Report, "The PRIME Model for Analysis of Fuel Rod Thermal – Mechanical Performance," NEDC-33256P, NEDC-33257P, and NEDC-33258P, January 2007, FLN-2007-001, January 19, 2007.
4. Letter, T.B. Blount (USNRC) to A.A. Lingenfelter (GNF), Subject: Final Safety Evaluation for Global Nuclear Fuel – Americas Topical Reports NEDC-33256P, NEDC - 33257P, and NEDC-33258P, "The PRIME Model for Analysis of Fuel Rod Thermal-Mechanical Performance" (TAC No. MD4114), MFN 10-090, January 22, 2010.
5. Letter, A.A. Lingenfelter (GNF) to Document Control Desk (USNRC), Subject: Accepted Versions of Global Nuclear Fuel – Americas Topical Reports NEDC-33256P, "The PRIME Model for Analysis of Fuel Rod Thermal – Mechanical Performance Part 1 – Technical Bases," NEDC-33257P, "The PRIME Model for Analysis of Fuel Rod Thermal – Mechanical Performance Part 2 – Qualification," and NEDC -33528P, "The PRIME Model for Analysis of Fuel Rod Thermal –Mechanical Performance Part 3 – Application Methodology" (TAC # MD4114), MFN 10-046, September 15, 2010.
6. Letter, L.M. Quintana (GE) to Document Control Desk (USNRC), Subject: Compilation of Responses to Methods RAIs - Interim Methods LTR, MFN 06-211, July 18, 2006.
7. Letter , T.B. Blount (USNRC) to J.G. Head (GEH), Subject: Final Safety Evaluation for GE Hitachi Nuclear Energy Americas, LLC Licensing Topical Report NEDC-33173P, "Applicability of GE Methods To Expanded Operating Domains" (TAC No. MD0277), MFN 09-808, July 21, 2009.
8. Letter, A.A. Lingenfelter (GNF) to Document Control Desk (USNRC), Subject: GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II), NEDC-33270P, March 2007, and GEXL17 Correlation for GNF2 Fuel, NEDC-33292P, March 2007, FLN-2007-011, March 14, 2007.
9. Letter, C.O. Thomas (USNRC) to J.S. Charnley (GE), Subject: Acceptance for Referencing of Licensing Topical Report NEDE-24011-P Amendment 7 to Revision 6, "General Electric Standard Application for Reactor Fuel", MFN-036-85, March 1, 1985.

10. Letter, A.A. Lingenfelter (GNF) to Document Control Desk (USNRC), Subject: GE14 Compliance with Amendment 22 of NEDE-24011-P-A (GESTAR II), NEDC-32868P, Revision 3, April 2009, MFN 09-235, April 9, 2009.
11. Letter, D.E. Porter (GEH) to Document Control Desk (USNRC), Subject: Part 21 Notification: Adequacy of GE Thermal-Mechanical Methodology, GESTR-M – Supplement 2, MFN 07-040 Supplement 2, August 28, 2008.
12. Letter, A.A. Lingenfelter (GNF) to Document Control Desk (USNRC), Subject: GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II), NEDC-33270P, Revision 1, August 2008, FLN-2008-008 August 29, 2008.
13. Letter, A.A. Lingenfelter (GNF) to Document Control Desk (USNRC), Subject: Amendment 33 to NEDE–24011–P, General Electric Standard Application for Reactor Fuel (GESTAR II) and GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II), NEDC-33270P, Revision 3, March 2010, MFN 10-045, March 5, 2010.
14. Letter, J.F. Harrison (GEH) to Document Control Desk (USNRC), Subject: Implementation of PRIME Models and Data in Downstream Methods, NEDO-33173, Supplement 4, July 2009, MFN 09-466, July 10, 2009.
15. Letter, R.A. Nelson (USNRC) to J.G. Head (GEH), Subject: Final Safety Evaluation for GE Hitachi Nuclear Energy Americas Topical Report NEDO-33173, Supplement 4, “Implementation of PRIME Models and Data in Downstream Methods” (TAC No. ME1704), MFN 11-231, September 9, 2011.
16. Letter, T.B. Blount (USNRC) to Andrew A. Lingenfelter (GNF), Subject: Final Safety Evaluation For Amendment 33 to Global Nuclear Fuel Topical Report NEDE-24011-P, “General Electric Standard Application for Reactor Fuel (GESTAR II)” (TAC NO. ME3525), MFN 10-283, August 30, 2010.
17. Letter, J.F. Harrison (GEH) to Document Control Desk (USNRC), Subject: Implementation of PRIME Models and Data in Downstream Methods, NEDO-33173, Supplement 4-A, September 2011, MFN 11-219, September 23, 2011.
18. Letter, A.A. Lingenfelter (GNF) to Document Control Desk (USNRC), Subject: Accepted Proprietary and Non-Proprietary Versions of Revision 18 to NEDE-24011–P, General Electric Standard Application for Reactor Fuel (GESTAR II), Main and United States Supplement, MFN 11-134, April 20, 2011.