HITACHI

GE Hitachi Nuclear Energy

Proprietary Notice

This letter transmits proprietary information in accordance with 10CFR2.390. Upon the removal of Enclosure 1, the balance of the letter may be considered non-proprietary.

James F. Harrison

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MFN 09-647
October 20, 2009

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

Subject: Response to NRC RAIs - NEDC-33173P, Supplement 3

By Reference 1, the NRC requested additional information to support its review of the Supplement 3 to NEDC-33173P, "Supplement for GNF2 Fuel." Enclosed are the responses to each RAI, except for RAI 8. The schedule to issue the response to RAI 8 is November 20, 2009.

Enclosure 1 contains proprietary information of the type that GEH maintains in confidence and withholds from public disclosure. The affidavit contained in Enclosure 3 is applicable to the information provided in Enclosure 1 and identifies that the information contained in Enclosure 1 has been handled and classified as proprietary to GEH. GEH hereby requests that the information in Enclosure 1 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390 and 9.17. Enclosure 2 is a non-proprietary version of Enclosure 1.

If you have any questions, please contact Mike Lalor at (408) 925-2443 or me.

Sincerely,

James F. Harrison

James F. Harrison
Vice President, Fuel Licensing
Regulatory Affairs
GE Hitachi Nuclear Energy

D065
NRR

Project No. 710

Reference:

1. NRC Letter, S. Philpott (NRC) to J. Head (GEH), "Request for Additional Information RE: GE-Hitachi Nuclear Energy Americas, LLC (GEH) Topical Report (TR) NEDC-33173P, Supplement 3, "Applicability of GE Methods to Expanded Operating Domains – Supplement for GNF2 Fuel,"' MFN 09-648, dated October 13, 2009.

Enclosure

1. Response to NRC RAIs - NEDC-33173P, Supplement 3 - Proprietary
2. Response to NRC RAIs - NEDC-33173P, Supplement 3 - Non-proprietary Version
3. Affidavit

cc: AA Lingenfelter, GNF/Wilmington
BR Moore, GNF/Wilmington
PT Tran, GEH/Vallecitos
eDRF 0000-0011-1132
JG Head, GEH/Wilmington
SS Philpott, NRC
MA Lalor, GEH/San Jose

ENCLOSURE 1

MFN 09-647

Response to NRC RAIs - NEDC-33173P, Supplement 3

GEH Proprietary Information

PROPRIETARY INFORMATION NOTICE

This enclosure contains proprietary information of General Electric Hitachi Nuclear Energy Americas LLC (GEH) and is furnished in confidence solely for the purpose(s) stated in the transmittal letter. No other use, direct or indirect, of the document or the information it contains is authorized. Furnishing this enclosure does not convey any license, express or implied, to use any patented invention or, except as specified above, any proprietary information of GEH disclosed herein or any right to publish or make copies of the enclosure without prior written permission of GEH.

The header of each page in this enclosure carries the notation "GEH Proprietary Information." GEH proprietary information is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]]. In each case, the superscript notation{3} refers to Paragraph (3) of the enclosed affidavit, which provides the basis for the proprietary determination. Specific information that is not so marked is not GEH proprietary.

ENCLOSURE 2

MFN 09-647

Response to NRC RAIs - NEDC-33173P, Supplement 3

Non-Proprietary Version

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1 to MFN 09-647, from which the proprietary information has been removed. Portions of the enclosure that have been removed are indicated by an open and closed bracket as shown here [[ ]]

ENCLOSURE 3

MFN 09-647

Affidavit

GE-Hitachi Nuclear Energy Americas LLC
AFFIDAVIT

I, James F. Harrison state as follows:

(1) I am Vice President, Fuel Licensing, Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC ("GEH"), have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosure 1 of MFN 09-644, James F. Harrison (GEH) to Document Control Desk (USNRC), *Response to NRC RAIs - NEDC-33173P, Supplement 3*, dated October 20, 2009. The proprietary information in Enclosure 1, *Response to NRC RAIs - NEDC-33173P, Supplement 3,* is identified by a single dotted underline within double square brackets. [[This sentence is an example.{3}]] In all cases, the superscript notation {3} refers to Paragraph (3) of the enclosed affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;
b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;
c. Information which reveals aspects of past, present, or future General Electric customer-funded development plans and programs, resulting in potential products to General Electric;
d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. above.

(5) To address 10 CFR 2.390 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within GEH is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed results and conclusions regarding GE Methods supporting evaluations of the safety-significant changes necessary to demonstrate the regulatory acceptability for the expanded power/flow operating domains including Extended Power Uprates, Constant Pressure Power Uprates, and the MELLLA+ domain for a GE BWR, utilizing analytical models and methods, including computer codes, which GE has developed, obtained NRC approval of, and applied to perform evaluations of transient and accident events in the GE Boiling Water Reactor ("BWR"). The development and approval of these system, component, and thermal hydraulic models and computer codes was achieved at a significant cost to GE.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 20th day of October 2009.

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

ENCLOSURE 2

MFN 09-647

Response to NRC RAIs - NEDC-33173P, Supplement 3

Non-Proprietary Version

IMPORTANT NOTICE

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NRC RAI 1

Please confirm that Plant A from NEDC-33173P, Supplement 3 "Applicability of GE Methods to Expanded Operating Domains – Supplement for GNF2 Fuel," dated July, 2009 (hereafter Supplement 3) is equivalent to Plant C from NEDC-33173P, "Applicability of GE Methods to Expanded Operating Domains," (hereafter the interim methods licensing topical report (IMLTR)) Appendix B.

GEH Response

Plant A noted in Supplement 3 is equivalent to Plant C (denoted in Figure 2-4 and Table 2-10 in NEDC-33173P)

Non-proprietary Version

NRC RAI 2

Please provide information similar to that depicted in Figures 2-1, 2-2, 2-4, and 2-5 of Supplement 3 that addresses the relative performance of TGBLA06 and MCNP for GNF2 under controlled conditions.

Also, please demonstrate consistent performance in terms of the nuclear data extrapolation to higher void fractions between GNF2 and GE14. Please provide a comparison of the extrapolated infinite lattice multiplication factor (k_{inf}) to MCNP calculations at high void conditions. For example, please use the polynomial TGBLA06 fit for k_{inf} at 90 percent void fraction to compare to MCNP calculations (or an alternative higher order transport method) for GNF2 and GE14 fuel. Compare the trends in uncertainty with the extrapolation to higher void conditions.

GEH Response

Figures 2-1 through 2-6 provide comparisons of TGBLA06 and MCNP reactivity values for GE14 and GNF2 bundles. Figures 2-1 and 2-2 present uncontrolled lattice reactivity at beginning of life, where the TGBLA06 results have been extrapolated to 90% void fraction. Figure 2-1 shows the GNF2 lattices explicitly compared to the average $\pm\sigma$ for GE14. Figure 2-2 shows the GE14 lattices explicitly compared to the average $\pm\sigma$ for GNF2. Results are shown for seven GE14 lattices, four C Lattices numbered C1 through C4, and three D lattices numbered D1 through D3. Figures 2-3 and 2-4 show the same data at a lattice exposure of 65 GWD/MT. Reactivity comparisons for the beginning of life controlled state are presented in Figures 2- and 2-6. Controlled comparisons have not been generated for 90% void fraction.

All of the figures show good consistency between the GE14 lattice comparisons and the GNF2 lattice comparisons, considering the fact that the lattices chosen for the two products contain a varying degree of enrichments and Gadolinium loadings. Both GNF2 and GE14 results show a more negative TGBLA06/MCNP difference for the vanished zone lattices. The controlled comparisons show a slight difference in reactivity results at 70% voids. The remainder of the data is very consistent.

Non-proprietary Version

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Figure 2-1 – Beginning of Life TGBLA06/MCNP Reactivity Comparisons-GNF2 Data

Non-proprietary Version

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Figure 2-2 – Beginning of Life TGBLA06/MCNP Reactivity Comparisons-GE14 Data

Non-proprietary Version

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Figure 2-3 - 65GWD/MT Exposure TGBLA06/MCNP Reactivity Comparisons-GNF2 Data

Non-proprietary Version

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Figure 2-4 - 65GWD/MT Exposure TGBLA06/MCNP Reactivity Comparisons-GE14 Data

Non-proprietary Version

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Figure 2-5 - Beginning of Life Controlled TGBLA06/MCNP Reactivity Comparison – GNF2 Data

Non-proprietary Version

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Figure 2-6 - Beginning of Life Controlled TGBLA06/MCNP Reactivity Comparison – GE14 Data

NRC RAI-3

Please revise Supplement 3 to provide more clarity regarding the PRIME peak pellet exposure limit. As PRIME has not been approved by the Nuclear Regulatory Commission (NRC) staff, please delete the peak pellet exposure limit for consistency with the status of the NRC staff's ongoing review.

GEH Response

The purpose of the paragraph is to discuss the current licensed peak pellet exposure limit for GNF2 and that the limit will be evaluated using PRIME once it is approved by the NRC. Further, the PRIME evaluation would be consistent with Limitation 12 of the NRC's Safety Evaluation approving NEDC-33173P.

Therefore, the discussion of the peak pellet exposure limit for GE14 is extraneous and has been deleted as shown in the attached. The update will be incorporated into the "-A' version of the supplement.

- [[ ]]: The GNF2 reactivity biases relative to Monte Carlo results are consistent with previous 10x10 designs, showing no change needed in stability impact for [[ ]].

- **Bundle pressure drop**: The bundle pressure drop model is based on GNF2 full-scale pressure drop measurements. In addition to the total bundle pressure drop, the axial pressure profile is accurately modeled (see Figure 2-9) by the ISCOR model, which is embedded in the stability evaluations.

2.6.3 Adequacy of Existing Treatment and Alternate Approach

The design limits and methods associated with evaluation of Stability as specified in Table 1-2 can be used for the GNF2 design under EPU conditions. All models related to stability have the same uncertainties for the GNF2 design as the GE14 design, and are acceptable for GNF2-related stability analysis.

2.7 LICENSED EXPOSURE

~~Although GE14 fuel is licensed to a peak pellet exposure limit of [[ ]], the~~The GNF2 fuel design is licensed to a peak pellet exposure limit of [[ ]] (Reference 4), based on the existing GSTRM methodology basis. GEH anticipates updating the peak pellet exposure limit for GNF2 fuel ~~to [[ ]]~~ when the new PRIME methodology is applied (Reference 17) (See Appendix A).

This licensed peak pellet exposure limit is specified and applied in the process computer to assure that fuel is not operated beyond its analyzed basis. In this application, the best estimate value of the local exposure condition is monitored against the specified exposure limit.

2.7.1 Fuel Parameters That Affect Pellet Exposure

The fuel parameters that affect pellet exposure are unchanged for GNF2.

2.7.2 Treatment of Fuel Parameter Uncertainties

The overall pin power uncertainties are unchanged for GNF2 (Section 2.2.1.2).

NRC RAI 4

The GNF2 peak linear heat generation rate (LHGR) is higher than that for GE14. Therefore, the NRC staff expects that cores designed with GNF2 fuel may include higher powered bundles. This will have the affect of potentially increasing the degree of expected bypass void formation for these assemblies early in life.

Low Flow Conditions

Please evaluate the expected degree of bypass void formation under dual recirculation pump trip (2RPT) conditions for GNF2 assuming that the GNF2 was operating at or near the peak LHGR prior to the 2RPT. Compare these results to those obtained for GE14. Evaluate any adverse impact the GNF2 bypass void formation may have on: local power range monitor detector response, stability calculations, and power shape. Please provide justification that the stability setpoint setdown limitation provides a sufficiently large conservatism in terms of long term stability solution performance to bound GNF2 relative to GE14 noting that at higher LHGR, the bypass void formation is expected to be higher.

Radial Power Shape

The NRC staff notes that GNF2 includes part length rods (PLRs) at the lattice edge. Therefore, the effect of bypass void formation at high in-channel void fractions may not have the same impact for GNF2 as GE14 – or possibly the same impact but to a different extent. Please compare the degree of power shape flattening expected for bypass void conditions for these two fuel types at high in-channel void fraction. Please compare the redistributed power shape to the location of pins that are typically limiting in terms of boiling transition.

GEH Response

Low Flow Conditions

In compliance with Limitation 17 of the Interim Methods SER for operation under EPU and MELLLA+ conditions, GNF2 fuel will be designed in such a way as to preclude operation with bypass voids greater than 5%. Parameters related to bypass void formation, such as bundle power, are therefore constrained and will be limited to ensure that the 5% limit is met at all LPRM levels during steady state conditions within the licensed operating domain [Ref. 4-1]. Therefore, with respect to potential bypass void formation, local peaking or bundle power may be different, but the envelope of initial conditions that would exist prior to an AOO or a stability event (e.g., two recirculation pump trip) will be the consistent between GNF2 and GE14. The highest calculated bypass voiding at any LPRM level will continue to be provided with the plant specific SRLR.

Even if the bypass void fraction is initially 5% at lower flow conditions and the in channel and bypass voids can increase further under 2RPT conditions, the two recirculation pump trip (2RPT) is an AOO that results in very small MCPR changes (i.e., power margin is retained at the reduced flow rates), offering ample margin to OLMCPR limits throughout the transient with either GNF2 or GE14 fuel.

The loss of recirculation pumps also results in a Limiting Condition of Operation (LCO) for the plant [Ref. 4-2, 4-3] in a region of the power-flow map where stability protection and limits are considered. The stability setdown will be designed to ensure compliance with Limitation 18, which requires consideration of LPRM and APRM calibration errors (including a provision for bypass voids). Note that the setdown is not necessary for MELLLA+ plants employing DSS-CD.

In summary, given the relevant limitations, GNF2 is not expected to result in adverse impacts relative to bypass void formation. The remainder of our response to the staff's request for additional information considers the calculated impact of a 5% bypass void fraction.

<u>Radial Power shape</u>
Bypass voiding, while uncommon, will affect neutron moderation and alter the pin power distribution in the bundle. Tables 4-1 and 4-2 evaluate the change in pin power caused by a 5% bypass void fraction in a GE14 and GNF2 lattice. The lattice parameters follow:

- Both the GE14 and the GNF2 lattices are D lattices with average enrichments of 4.51 and 4.30%. Both lattices come from the region with 14 vanished rods near the top of the fuel bundle. The GE14 lattice contains 17 gadolinium rods and the GNF2 lattice contains 16 gadolinium rods. A D lattice was chosen because the wide gap corner rod will experience a larger perturbation from a change in bypass water density.

- An in-channel void fraction of 90% is used, which is at the upper end of a range of in-channel conditions (upper elevations) in a high power bundle. For the purpose of the analysis, both the bypass and water rod are assumed to be at 5% void fraction. The actual in channel void fraction corresponding to a 5% bypass and water rod void fraction depends on the flow split between the bypass, water rod, and active channel. This flow split depends on actual operating conditions and GNF2 application. The 90% void fraction is used because it yields the highest change in rod power due to a given change in bypass/ water rod void fraction.

Figures 4-1 and 4-2 show the percent change in rod peaking due to 5% bypass and water rod void fraction for the GE14 and GNF2 lattice as a function of position in the lattice. The wide gap location is denoted by the words "control blade" in the figure and is only there to locate the position of the control blade part on the interchannel gap. All calculations are performed in the uncontrolled configuration. The gadolinium rod locations are shaded grey and the top six peaking locations in the upper right half of the lattice are identified by bold, italic font. (The peaking in the lower left half is symmetric with the upper right half.)

- The percentage change in pin power is mainly a function of pin position and is quite similar for both lattice designs.

- All of the high peaked fuel rods in both designs are located next to the bypass channel and therefore suffer a decrease in power due to bypass voiding, lowering the overall lattice peak pin power. Placing the maximum enrichment rods near the bypass enhances lattice reactivity and lowers fuel cycle cost. This behavior exists in practically all modern bundle designs.

- Larger percentage changes [[ ]] are observed for gadolinium rods. This is because the gadolinium rods start out at very low initial peaking, so the percentage change is increased, but the absolute power never approaches the level of the non-gadolinium rods.

- The maximum increase in rod power (excluding Gadolinium rods) is [[ ]]for the GE14 lattice. This increase is located at the third row in from the edge of the bundle and occurs at a low power rod having a low probability of becoming a peak rod any time in the life of the bundle.

In summary, the impact of 5% bypass voiding on lattice pin power peaking is minimal, and generally results in a decrease in lattice pin power peaking. The minimal effect is also independent of product design, being slightly less for the GNF2 case than the GE14 case. The impact on bundle R-factor is also minimal, because the bypass voiding occurs at most over the top 20% of the bundle axial height. A further discussion of the effect of bypass voiding on the bundle R-factor can be found in Reference 4-4.

References:

4-1 GEH letter, , J. Harrison (GEH) to NRC, "Implementation of Methods Limitations - NEDC-33173P (TAC No. MD0277)," MFN 08-693, September 18, 2008.
4-2 NUREG-1434, Standard Technical Specifications General Electric Plants, BWR/6, Vol. 1, Rev. 2, June 2001.
4-3 NUREG-1433, Standard Technical Specifications General Electric Plants, BWR/4, Vol. 1, Rev. 2, June 2001.
4-4 GEH Letter G. Stramback (GEH) to NRC, Responses to DSS-CD LTR RAIs (See RAI 18), MFN 05-133, November 11, 2005.

Control Blade

Conntrol Blade

[[									
									]]

LPRM

Figure 4-1 - Per Cent Difference Between 5% Bypass Void Pin Power and No Bypass Void Pin Power – GNF2 Design

Control Blade

Control Blade

[[									
									]]

LPRM

Figure 4-2 - Ratio of 5% Bypass Void Pin Power to No Bypass Void Pin Power - GE14 Design

NRC RAI 5

The NRC staff has questions regarding Figures 2-2 and 2-5 of Supplement 3:

a. Please provide the void history or void histories used to perform the TGBLA06 depletion calculations.

b. The NRC staff is aware that the version of TGBLA06 used to generate these nuclear data is corrected for the edge rod Dancoff factor calculation, but does this version also include the updates to the low-lying plutonium resonance correction?

GEH Response

The depletion history used to generated the isotopics for the 65 GWD/MT TGBLA06/MCNP reactivity comparisons carried out at 40% void fraction. The version of TGBLA06 used to generate the nuclear data includes the Dancoff correction as well as the updates to the low-lying resonance correction.

NRC RAI 6

Please clarify Figures 2-1, 2-2, 2-4, and 2-5 of Supplement 3. Specifically, clarify what is meant by relative water density. Please address that points appear for GE14 and GNF2 at the same "relative water density," however, given different geometries and arrangements of PLRs, it is not expected that identical void fractions would yield identical relative water densities, depending on how this quantity is defined.

For example, if relative water density is defined according to equation (1), the relative water density appears to be lattice geometry dependent for a given void fraction.

$$U = \left(\frac{A_f}{A_f + A_{byp} + A_{wr}} \right) \frac{\rho_f}{\rho_o} + \left(\frac{A_{byp} + A_{wr}}{A_f + A_{byp} + A_{wr}} \right) \frac{\rho_{byp}}{\rho_o}$$

Where:	U	is the relative water density,
	P	is the static density,
	A	is the flow area,
	0	denotes reference,
	f	denotes in-channel,
	byp	denotes external bypass, and
	wr	denotes water rod

At a given void fraction, the relative water density appears to vary between lattices as a function of the in-channel flow area. Please clarify why several lattices appear on these figures at the same relative water densities.

In the –A version of the TR, please revise these figures by adjusting the label of the independent axis or shifting the points to a relative water density that is consistent with the definition provided in equation (1).

GEH Response

Figures 2-1, 2-2, 2-4, and 2-5 have been modified to reflect the correct average density variation of the vanished rod lattices. The revised figures appear below and will be incorporated in the –A version.

Figure 2-1 TGBLA06 Fission Density Benchmark for GNF2, at BOC

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Figure 2-2 TGBLA06 Fission Density Benchmark for GNF2, at 65 GWD/MT

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Figure 2-4 TGBLA06 Reactivity Benchmark for GNF2, at BOC (GE14 1σ uncertainty band, dashed line)

[[

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Figure 2-5 TGBLA06 Reactivity Benchmark for GNF2, at high exposure (GE14 1σ uncertainty band, dashed line)

[[

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NRC RAI 7
Table 2-1 of Supplement 3 appears to be in error, particularly the second entry in the bottom row. Please correct this table in the –A version of the LTR.

GEH Response
Table 2-1 contains a typographical error. The revised table is attached and will be incorporated in the –A version of the supplement.

Table 2-1 GNF2 Axial Regions

Name	Description	Axial Zone Length
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		]]

Table 2-2 TIP Comparisons for BWR/4 With GNF2 Reload

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NRC RAI 8

Void history exposure reactivity coefficient biases and uncertainties predicted for GE14 may not be applicable to GNF2. The NRC staff notes that the GNF2 heavy metal loading is higher than for GE14 and, as such, at equivalent void conditions the GNF2 spectrum is expected to be harder than the GE14 spectrum on this basis.

Please provide a limited demonstration that is similar to Table SRXB-A-68-1 of Vermont Yankee Nuclear Power Station RAI SRXB-A-68 (Ref. 1) for the GNF2 lattices presented in Supplement 3. It is not necessary to provide an equally comprehensive table, but please consider the higher exposure range and please focus on lattices expected to experience higher void fractions located near the top of the core (e.g., above the part length fuel rods).

Alternatively, the NRC staff is aware of a higher order transport based lattice method under development by Global Nuclear Fuel – Americas (GNF), LANCER 2. It would be acceptable to address this RAI with a table similar to Table SRXB-68-1 that compares the TGBLA06 and LANCER 2 void reactivity coefficient biases and uncertainties for GNF2.

Alternatively, the NRC staff is aware that a void history exposure reactivity coefficient biases and uncertainties were incorporated in TRACG04. This model requires a database generated using MCNP and TGBLA06 for GE14 and GNF2 lattices. Please provide a comparison of these void reactivity coefficient data between the two fuel designs to justify the continued applicability of the bias and uncertainty used in ODYN.

Alternatively, using a GNF2 MELLLA+ core design, provide sensitivity studies using TRACG04 (with and without the void history exposure reactivity coefficient biases and uncertainties model) to generate a table similar to Table SRXB-A-68-4 (Reference 1) to demonstrate that the sensitivities for GNF2 are essentially the same or conservative relative to GE14.

References

1. Letter from Entergy to USNRC, BVY 05-088, "Vermont Yankee Nuclear Power Station, Technical Specification Proposed Change No. 263 - Supplement No. 35, Extended Power Uprate - Response to Request for Additional Information," dated September 28, 2005. (ADAMS Accession No. ML052770039)

GEH Response

The response to NRC RAI 8 will be provided at a later date.

NRC RAI 9

Please compare Figures 2-1, 2-2, 2-3, and 2-4 of Supplement 3 to Figures 3-1, 3-2, 3-3, and 3-4 of GNF TR NEDC-33270P, Revision 2, "GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II)" (ADAMS Package Accession No. ML091830644). These figures appear inconsistent. Please explain.

GEH Response

The calculations documented in NEDC-33270P, Rev. 2, were performed with a version of TGBLA06, which did not contain the corrections for Dancoff factor or the updates to the low-lying plutonium resonance correction. The results shown in Figures 2-1, 2-2, 2-3, and 2-4 of Supplement 3 to NEDC-33173P were regenerated using the most up to date version of TGBLA06.

NRC RAI 10

Please clarify the version of COBRA used to do the sub-channel analysis. Is this version of COBRA consistent with the COBRAG model description that was submitted to the NRC staff in LTR NEDE-32199P, Revision 1, "COBRAG Subchannel Code – Model Description Report" (ADAMS Package Accession No. ML071910320)?

GEH Response

The version of COBRA used in the GNF2 sub-channel analysis to support the void correlation is consistent with LTR NEDE-32199P.

NRC RAI -11

Certain features of the GNF2 fuel assembly make the bundle more stable than GE14 bundles in terms of core, regional, and channel instability modes. These include a population of shorter PLRs to increase single phase pressure drop to two phase pressure drop ratio, and a thicker fuel pellet that increases the fuel thermal time constant. Therefore, it is expected that the exclusion and back-up stability protection (BSP) regions analyzed for GNF2 fueled cores must be analyzed at increased power to flow ratios relative to the analysis conditions for GE14 fuel.

Please provide an analysis at equivalent core and channel decay ratio (0.8) for GE14 and GNF2. The results of this analysis should provide an assessment of the relative degree of in-channel and bypass void for GNF2 at the exclusion or BSP region boundary relative to GE14. Comment on the significance of the difference in these void fractions. In estimating the bypass void fraction, please use the ISCOR code (conservative) at power/flow conditions identified using ODYSY.

Please also consider that the NRC staff has approved the use of the modified shape function (MSF) relative to the generic shape function. Therefore, the limiting conditions analyzed for GE14 fuel in response to RAI 3.2(a)(iii) from the NRC staff's review of the IMLTR are not necessarily the most limiting conditions along the exclusion boundary for GNF2 fuel. In this comparison please consider the MSF an intermediate point between the natural circulation and high flow control lines to demonstrate the limiting condition has been identified.

Please compare the calculated thermal-hydraulic conditions predicted for the stability threshold for GNF2 fuel (i.e., decay ratio ~ 0.8) to the predicted thermal-hydraulic conditions present for the ODYSY high decay ratio benchmarks.

Provide justification that the sensitivity of the ODYSY code to any additional uncertainty introduced by the higher void conditions has been adequately addressed by the IMLTR safety evaluation (SE) conditions and limitations.

GEH Response

There are two applications of the Backup Stability Protection (BSP) – one for Option III and one for Detect and Suppress Solution – Confirmation Density (DSS-CD).

Only the BSP for Option III is considered here. The BSP for Option III covers for operating domain up to the Extended Power Uprate/Maximum Extended Load Line Limit Analysis (EPU/MELLLA) operating domain. The BSP for DSS-CD (which is for Maximum Extended Load Line Limit Analysis Plus (MELLLA+) implementation) has an Automated BSP with a flow-clamp scram feature, which ensures an automatic reactor scram with a two-recirculation pump trip event. Hence as a backup stability solution, there is less concern due to bypass voiding for BSP for DSS-CD. The DSS-CD LTR (Reference 11-1) outlines the requirements to cover for a new fuel product line like GNF2.

BSP for Option III

The calculation of the BSP region boundary is based on a conservative ODYSY (One-Dimensional Dynamic Code for Stability) acceptance criteria map that may be influenced by the core wide axial power distribution calculation. However, the ODYSY methodology requires the use of a conservative Haling power shape, and this is a limiting flat axial power shape compared to actual power shapes throughout the cycle. Therefore, uncertainties in the actual axial power distribution do not affect the calculation of the BSP region. Also, any uncertainties in either local or radial power distribution have no influence on the core-wide decay ratio (Reference 11-2).

Two new ODYSY cases were generated based on the Amendment 22 (A22) GNF2 and GE14 PANACEA wrap-ups. One case was along the MELLLA boundary (or the High Flow Control Line, HFCL) and the other case was along the Natural Circulation Line (NCL). The power/flow search along the NCL and the power/flow search along the HFCL yielded the 0.80 core decay ratio power/flow state points for both GNF2 and GE14 as requested in this RAI. These two comparisons bound the Modified Shape Function (MSF) or Generic Shape Function (GSF) state points in terms of bypass voiding conditions. Hence no additional MSF or GSF state points are presented here. Figure 11-1 illustrates the Controlled Entry Region boundary corresponding to the 0.80 core decay ratio for both GNF2 and GE14 using the GSF. The GNF2 Controlled Entry Region boundary tends to be smaller compared to that of GE14 as was pointed out by the staff. A smaller Controlled Entry Region boundary is conservative for the bypass voiding application since this penetrates deeper into the less stable region of the power/flow map (top left corner), where bypass voiding is more severe.

Please note that the BSP analysis is used a backup solution for Option III and that the BSP Scram Region boundary cannot be smaller than the Base BSP Scram Region (Reference 11-5), with the boundaries generated by applying either the GSF or MSF to Points A and B:

Point A: Intersection of the MELLLA upper boundary and 40% rated core flow,

Point B: Intersection of the NCL and 100% Original Licensed thermal Power (OLTP) load line.

The Base BSP Scram Region with the GSF option is also illustrated in Figure 11-1. Hence, the size of the Controlled Entry Region is also limited by the Base BSP Scram Region.

The conservative ISCOR bypass heating model at these power/flow conditions was used in the ODYSY evaluation. ISCOR computes bounding values of the bypass void fraction because the [[

]]

The GNF2 and GE14 bypass voiding results are summarized in Tables 11-1a and 1b, respectively. Since the calculated HFCL point is at a lower power/flow point than the corresponding Base BSP Scram Region end point, the results at the Base BSP Scram Region are also included and used in the GNF2/GE14 comparison for HFCL. For the NCL, the calculated Controlled Entry Region boundaries are lower than the Base BSP Scram Region and will be used in the GNF2/GE14 comparison.

In general, the GNF2 bypass flow elevation head is smaller than that of GE14 and hence the bypass flow tends to be lower for GNF2 at the same power/flow conditions. This resulted in a higher bypass exit void fraction (EVF) for GNF2 relative to GE14.

Along the NCL, the GNF2 average bypass EVF is only slightly higher [[

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at the Base BSP Scram Region boundary. The hot channel bypass EVF also shows a similar difference. Please note that the hot channel was applied with a 1.28 radial peaking factor. The hot channel bypass void model in ISCOR provides bounding values of the hot channel bypass voids, but the values are not realistic. Furthermore, the ISCOR hot channel methodology does not account for bypass cross flow that will tend to increase flow in high power zones thus reducing the bypass voids to nearly the core average level (Reference 11-3).

Despite the difference between GNF2 and GE14, these EVFs are in line with the numbers reported to the NRC as shown in Table 11-2 for MELLLA conditions. Hence the GNF2 numbers are within the ODYSY application methodology.

The hot channel (HC) in-channel void fractions at the top of the active fuel are also in line with the numbers provided earlier in the Interim Methods Licensing Topical Report (IMLTR) as shown in Table 11-3. [[

]] Hence the GNF2 numbers are within the ODYSY application methodology.

The thermal-hydraulic conditions calculated for GNF2 and GE14 BSP Controlled Entry Region boundaries are in line with the decay ratios and power/flow conditions observed in Table 11-4. The calculated decay ratios are covered by the Vermont Yankee tests. In addition, the highest core average power/flow ratios for GNF2 (57.3 MW/Mlbm/hr) and GE14 (54.6 MW/Mlbm/hr) are covered by the VY benchmark data (57.8 MW/Mlbm/hr). Hence the GNF2 numbers are within the ODYSY application methodology.

The sensitivity of the ODYSY code to any additional uncertainty introduced by the higher void conditions is adequately addressed by the SE conditions and limitations for NEDC-33173P.

As stated in the Nuclear Regulatory Commission (NRC) Safety Evaluation for NEDC-33173P (SE) (Reference 11-4, Section 6.2), the current Option III penalty in calibration errors (of less than 5 percent) for Oscillation Power Range Monitor (OPRM) cells associated with bypass voiding, is very conservative for the OPRM system since the original basis did not account for the attenuation of the OPRM cell average signal. If an OPRM channel is miscalibrated by a given factor of X percent due to bypass voids, the same bias error magnitude applies to the peak amplitude and to the average. When the peak over average is computed, the bias error (miscalibration) factor cancels out, and the percent oscillation amplitude is maintained regardless of the value (X percent) of the bias error. GEH has not credited the bias error of the average signal in the 5% calibration error penalty. This 5% penalty is adequate to cover for the expected increase in the bypass voiding due to the GNF2.

As noted in the NRC IMLTR SE (Reference 11-4, Section 6.3), the exclusion region calculations are based the following facts:

1. Exclusion regions calculation procedures are well-defined by the approved stability Long Term Solution methodology, and they use mostly prescribed power shapes. Therefore, power distribution uncertainties have a small effect on the size of the exclusion regions.

2. The ±0.2 uncertainty imposed by the DR < 0.8 criterion captures the possible effect of power distribution uncertainties and cross-section methodology errors (including the effect on void reactivity coefficient).

3. The ±0.2 uncertainty level is justified by the ODYSY and TRACG validation database. For these validation analyses, the neutronic methodology included the errors.

The implementation of BSP for Option III is a manual solution. It does not rely on the Average Power Range Monitor (APRM) flow-biased flux scram line as the means of reactor Safety Limit Minimum Critical Power Ratio (SLMCPR) protection. If a plant enters the BSP Scram Region, a manual scram is required. As long as the BSP Controlled Entry Region boundary is generated correctly, the impact due to the bypass voiding on the BSP Controlled Entry Region is minimal. The measured APRM power may be off by 1% to 2% rated power due to the bypass voiding. This is a small uncertainty that is within the typical reactor power uncertainty.

References:

11-1 NEDC-33075P-A, Rev. 6, "General Electric Boiling Water Reactor Detect and Suppress Solution – Confirmation Density," January 2008.
11-2 NEDC-33173P, "Applicability of GE Methods to Expanded Operating Domains," February 2006.
11-3 MFN 06-209, "Remaining Responses to Methods RAIs - Interim Methods LTR," June 30, 2006.
11-4 Final Safety Evaluation for GE Hitachi Nuclear Energy America, LLC Licensing Topical Report NEDC-33173P, "Applicability of GE Methods to Expanded Operating Domains" (TAC No. MD0277), July 2009.

11-5 OG 02-0119-260, "Backup Stability Protection (BSP) for Inoperable Option III Solution," July 17, 2002

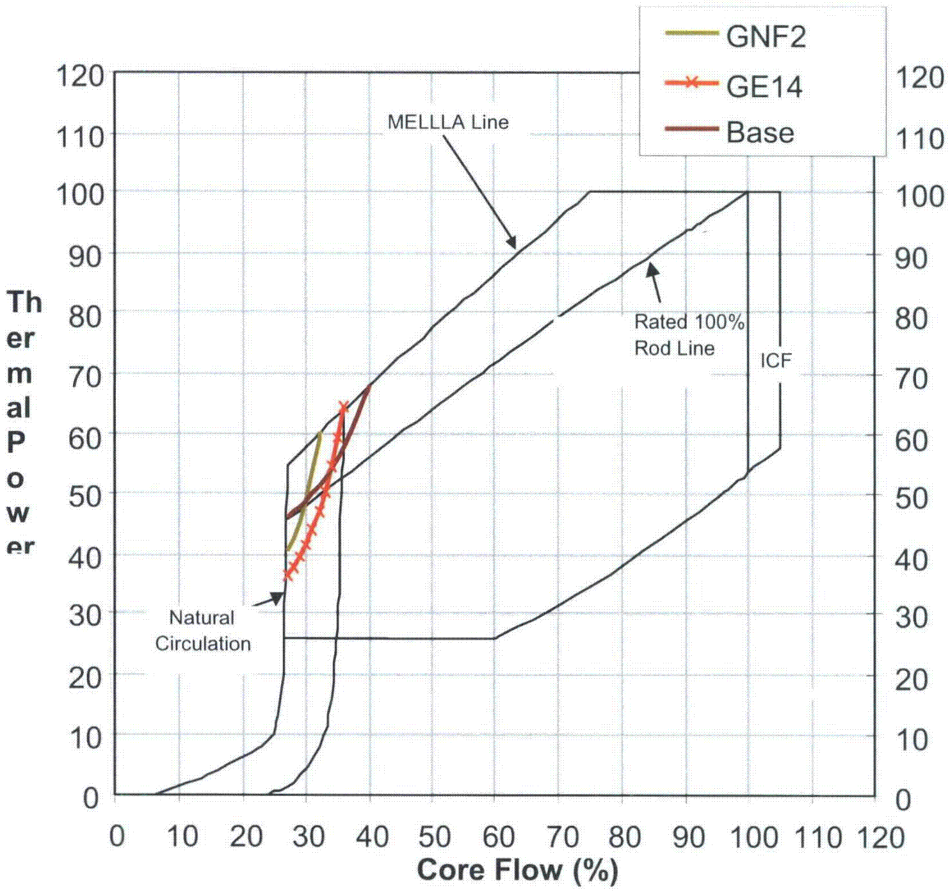

Figure 11-1. Illustration of the BSP Controlled Entry Regions and Base Scram Region

Table 11-1a. GNF2 Results*

[[										**P/F Ratio MW/ Mlbm/hr**
										]]

Table 11-1b. GE14 Results*

[[										
										]]

*EVF = Exit Void Fraction, CDR = Core Decay Ratio, HC= Hot Channel, rated power = 3323 MW, rated core flow = 108.5 Mlbm/hr.
** Hot channel applied with the standard 1.28 radial peaking factor
*** Void fraction (VF) at the top of active fuel

Table 11-2. ISCOR Bypass Voids (from Reference 11-3, Table 3.2(a)-2)

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Table 11-3. ISCOR In-Channel Voids for Selected Events and Conditions
(from Reference 11-3, Table 4.1d-4.)

Event/Condition	**ISCOR Core Average In-Channel Voids (Top of Active Fuel)**	**ISCOR Hot Channel In-Channel Voids (Top of Active Fuel)**
NMP-2 Instability Event	73%	81%
Perry Instability Event	75%	86%
VY EPU/MELLLA	76%	85%
Hope Creek EPU/MELLLA	76%	86%

Table 11-4. Summary of ODYSY Results for Vermont Yankee High Decay Ratio Tests (from Reference 11-3, Table 4.1d-1 with power/flow ratio column newly added)

Test	**Power/Flow**	**Power/Flow Ratio***	**Test Data**		**ODYSY Results**	
Point	**(% rated)**	**MW/Mlbm/hr**	**Decay Ratio**	**Frequency**	**Decay Ratio**	**Frequency**
6P	57.2/38.5	49.3	0.74	0.44	0.67	0.39
7N	51.2/32.6	52.1	1.00	0.43	0.99	0.38
8P	50.9/32.6	51.8	0.96	0.43	0.97	0.37
9P	48.1/32.4	49.3	0.81	0.42	0.86	0.36
10P	49.8/33.0	50.1	0.90	0.42	0.97	0.37
11P	67.1/38.5	57.8	0.85	0.47	0.85	0.42
12P	63.1/38.5	54.4	0.78	0.47	0.75	0.42

*Based on rated power = 1593 MW and rated core flow of 48 Mlbm/hr

NRC RAI 12

GNF2 LHGR limits are higher at low exposure than GE14 limits. However, the critical power performance as predicted by GEXL14 and GEXL17 indicates similarity between the two designs. To establish conservatism in the emergency core cooling system – loss of coolant accident (ECCS-LOCA) evaluation, it is customary to place the limiting bundle at the peak LHGR with the maximum stored energy in a bundle operating below the operating limit minimum critical power ratio (OLMCPR). This will yield the maximum value peak cladding temperature for the first peak that accounts for the maximum allowable operating space based on thermal limits considerations. Given that the GNF2 LHGR limit is much higher than that of the GE14 design, while the OLMCPR is expected to be similar, how are the ECCS-LOCA analyses initialized for GNF2 loaded cores at extended power uprate (EPU) or maximum extended load line limit analysis plus (MELLLA+) conditions? Please compare the conservatism associated with the ECCS-LOCA basis MCPR iteration for GNF2 fuel to the conservatism for GE14 fuel.

GEH Response

There is no difference in the methodology or initialization for ECCS-LOCA analysis for GNF2 loaded cores at EPU or MELLLA+ conditions as compared to a GE14 loaded core at EPU or MELLLA+ conditions. The difference in the peak LHGR of GNF2 vs. GE14 fuel will not lead to any difference in the ECCS-LOCA methodology or initialization process.

The fact that the LHGR limit for GNF2 fuel is larger than GE14 fuel does not change the ECCS-LOCA analysis modeling, which is set to represent a simplified, yet conservative core condition. The SAFER model considers [[

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Given the assumed EPU or MELLLA+ operating conditions, the above methodology determines and sets the power distribution in a conservative way. The fact that the GNF2 fuel will be able to reach a higher LHGR limit than GE14 fuel, [[

]] The EPU and MELLLA+ conditions in the initialization will be factored into the bounding power distribution for the GNF2 fuel, just as they would be factored into the power distribution for GE14 fuel under such assumptions. This will yield the maximum first peak PCT that accounts for the maximum allowable operating space based on thermal limits considerations for GNF2 fuel in like manner as the methodology has been previously applied to other fuel such as GE14.

NRC RAI 13

The NRC staff has questions regarding the continued applicability of other relevant thermal-hydraulic models to GNF2 fuel.

In-core Liquid Entrainment

Please describe how liquid entrainment in the core is modeled for GNF2. Modern liquid entrainment correlations such as the one described in NEDE-32176P, Revision 3 appear to have geometry dependence. Please address the GNF2-specific geometry in the response.

Counter-Current Flow Limitation (CCFL)

- Please provide the definition for the characteristic length, also referred to as the effective diameter, used in the calculation of the CCFL.
- Please describe how the axially varying geometry of the GNF2 bundle is treated in SAFER and CORECOOL.
- Please compare the GNF2 geometry to the experiments that were used to develop the CCFL correlation.
- Please describe how the spacers are taken into account when using the CCFL correlation.

Spray Heat Transfer

Please justify the applicability of the CORECOOL core spray heat transfer model to GNF2. Please consider the differences in the qualification data and the GNF2 fuel design.

GEH Response

Response to In-core Liquid Entrainment

The current GEH ECCS/LOCA analysis methodology for BWR/2 to 6 is SAFER, which is not a two-fluid model code like TRACG (NEDE-32176P, Rev. 4). SAFER uses a validated drift-flux model to determine the vapor and liquid volumetric fluxes in terms of the void concentration parameter, C_o, and the void-weighted vapor drift velocity, V_{gj}. These drift-flux parameters, i.e., C_o and V_{gj}, are obtained from proprietary GEH (Findlay – Dix) correlation and do not require any entrainment model. So the entrainment model of TRACG or a similar code is not relevant for SAFER LOCA analysis of core loaded with GNF2 fuel. The same is true for other GEH codes namely ODYN and ODYSY.

Within the current GEH ECCS/LOCA analysis methodology, CORECOOL code is sometimes used in conjunction with SAFER to determine a more accurate peak cladding temperature (PCT) for plants where core spray heat transfer is important and the PCT is very high. CORECOOL uses a three-field model comprising of a liquid film on the fuel rods and channel wall, liquid droplets in the vapor core and a (superheated or saturated) steam or vapor core. The decay heat is removed by radiation and convective heat transfer which is enhanced by the presence of liquid droplets formed from the break up of spray water at the upper tie plate and sputtering front of falling liquid films. The upward vapor flow rates are small at low decay heat of interest and no entrainment from the liquid film is predicted. Therefore, GNF2-specific geometry is not relevant even for CORECOOL for in-core liquid entrainment.

Non-proprietary Version

TRACG may be used as a best-estimate code in support of upper bound PCT calculation for GNF2 fuel. TRACG can simulate the axially varying geometry of GNF2 fuel assembly and uses mechanistic validated in-core liquid entrainment models and correlations.

Response to Counter-Current Flow Limitation

In the current GEH methodology, the characteristic length or the effective diameter, D, for CCFL is eliminated by multiplying the original Wallis CCFL or "flooding" equation (Reference 13-1) by $D^{0.25}$. Thus, the modified non-dimensional superficial liquid and vapor velocities, j_l^* and j_v^*, in the current GEH methodology do not contain any characteristic length or effective diameter. The constant at the right hand side of the modified CCFL equation, K (defined by $C_{Wallis}D^{0.25}$), is directly obtained from the GNF2-specific experiments. Therefore, the definition of characteristic length or effective diameter for CCFL in the current GEH methodology is irrelevant.

For the GE8 and later fuel, the upper tie plate flow area was opened to reduce pressure drop across the tie plate. As a result, the location where CCFL occurs moved [[

]] This treatment of CCFL at the UTP is conservative since liquid downflow into the bundle is reduced because of higher steam upflow at the UTP compared to that at a spacer below where the CCFL actually occurs.

Confirmatory CCFL testing for GNF2 spacers (for both Long Part Length Rods and Short Part Length Rods) have been performed . The GNF2 spacer CCFL constants are then compared to the experimentally determined StepII (GE10) and StepIII (GE11) spacer CCFL constants and the smallest of all these spacer CCFL constants is [[ ]] and this conservative value is used in SAFER for GNF2 CCFL at UTP.

Since GNF2 spacer CCFL constants are obtained from the confirmatory tests mentioned above, the axially varying geometry of GNF2 is not relevant in SAFER or CORECOOL for CCFL application.

TRACG, when used in support of the upper bound PCT calculation, simulates the axially varying geometry of the GNF2 bundle and CCFL is calculated at spacer and UTP locations as determined by the thermal hydraulic parameters.

Response to Spray Heat Transfer

CORECOOL has mechanistic models for core spray heat transfer (CSHT) as described in Chapter 5 of Reference 13-2. It consists of two basic models: a hydraulic model and a heat transfer model. The hydraulic model simulates steam, liquid droplets and liquid film flow on the fuel rods and channel wall independently and in a mechanistic manner. The heat transfer model is based on the one-dimensional heat conduction in the fuel rods and surface heat transfer including both convective and radiative heat transfers. The convective heat transfer is based on the well-known Dittus Boelter correlation with an enhancement due to liquid droplets in the vapor core. The Dittus Boelter correlation is valid over a wide range of parameters, which cover the GNF2 bundle conditions. The radiative heat transfer utilizes a mechanistic model based on view factors calculated from the actual bundle geometry.

GNF2 fuel assembly consists of eight (8) long part length rods (LPLRs) and six (6) short part length rods (SPLRs). Since the CORECOOL code structure allows a maximum of [[
]] some simplification is needed to model the GNF2 fuel bundle in CORECOOL. Specifically, [[

]] Both of these modeling treatments act to conservatively increase the PCT and cladding oxidation.

CORECOOL has been qualified with various CSHT experiments as described in Chapter 7 of Reference 13-2. All of these experiments utilized fully-rodded heated bundle simulating a BWR fuel assembly. Although GNF2 fuel assembly consists of two types of part length rods, CORECOOL can simulate such fuel assembly using mechanistic modeling of both hydraulics and heat transfer. However, because of the conservative modeling as discussed above, the CORECOOL prediction of GNF2 core spray heat transfer is expected to be conservative.

CORECOOL is primarily applied to BWR/2 plants where core spray heat transfer plays an important role in evaluating ECCS performance. For other BWRs (BWR/3 to 6), the PCT is lower and CORECOOL is usually not applied.

References

13-1 G. B. Wallis, "One-dimensional Two-phase Flow," pp. 336 – 338, McGraw-Hill Book Co. Inc., New York, 1969.

13-2 NEDO-30996-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-Jet Pump Plants, Volume I, SAFER – Long Term Inventory Model for BWR Loss-of-Coolant Analysis," Class I, March 1988.

NRC RAI-14

Section 4.2 is not sufficiently detailed. In reference to the table in Section 4.2, please address the following sections:

a) The "BWR product line" includes BWR/2. Please clarify.

b) Please footnote or otherwise clarify the "fuel product line" applicability statement to make it consistent with the Mixed Core Limitations in the NRC staff's SE to the IMLTR.

c) Please clarify the "licensing methodology" section. This section refers to GEH nuclear and safety analysis methods. Is it more appropriate to list GNF or a combination of GEH and GNF?

d) In "Operating Domain," please correct the typographical error "ELLA" to read "ELLLA."

e) The "Stability Solution" section states "GE Stability Solutions." Is it more appropriate to identify the solutions as BWR Owners' Group (BWROG) (for Options EIA, I-D, II, and III) and GEH (for Detect and Suppress Solution – Confirmation Density (DSS-CD)) stability solutions?

GEH Response

Response to Part a

The NRC approved NEDC-33173P with a BWR product line that includes BWR/2 plants. The Methods LTR is applicable to expanded operating domains including EPU and MELLLA+. GEH LTR's NEDC-32424P-A, NEDC-32523P-A, and NEDC-33004P-A address EPU applications and are applicable to BWR/2 plants. However, MELLLA+ applications are addressed by NEDC-33006, which is not applicable to BWR/2 plants. To clarify, a footnote was added to the applicability table in Section 4.2 as shown in the attached. The update will be incorporated into the "-A' version of the supplement.

Response to Part b

The phrase, "non-GE," was deleted from the applicability table in Section 4.2 as shown in the attached. The update will be incorporated into the "-A' version of the supplement.

Response to Part c

Throughout the Methods LTR, as well as Supplement 3, reference is made to GEH methods. These methods include analytical methods developed by GEH and GNF. The use of the term GEH methods is to describe the methods available to GEH and GNF and is not used to define ownership.

Response to Part d
The abbreviation for ELLLA was corrected in the applicability table in Section 4.2 as shown in the attached. The update will be incorporated into the "-A' version of the supplement.

Response to Part e
The use of the phrase, "GE Stability Solutions," was used in the Methods LTR, and was continued as part of Supplement 3 as well, since it is unaffected by the addition of the GNF2 fuel design. The use of GE Stability Solutions is used to describe stability solutions that utilize GEH analytical methods and is not used to define ownership.

4.0 LICENSING APPLICATION

4.1 OVERVIEW

The purpose of this supplement is to extend the application of Reference 1 to GNF2 fuel.

4.2 APPLICABILITY

The Applicability of GE Methods to Expanded Operating Domains LTR basis is applicable to current GEH BWR product lines licensed with GEH nuclear and safety analysis methods. The Methods LTR is applicable to plants that include current GNF fuels including GNF2. The application of these codes complies with the limitations, restrictions and conditions specified in the approving NRC SER for each code.

The parameters establishing the Applicability of GEH Methods to Expanded Operating Domains applicability envelope are:

Parameter	Generic Value
BWR Product Line	BWR/2-6*
Fuel Product Line	GE and ~~non-GE~~ fuel designs using square arrays of fuel rods, including 7x7, 8x8, 9x9, and 10x10 designs and GNF2
Licensing Methodology	GEH Nuclear and Safety Analysis Methods
Operating Domain	CPPU, EPU, with MELLLA+ including currently licensed operating domains (e.g., ELLA, MELLLA) and operational flexibility features
Maximum Rated Power Level	120% OLTP
Stability Solution	GE Stability Solutions

* MELLLA Plus is not applicable to BWR/2 plants consistent with NEDC-33006P-A (Reference 2).

4.3 PLANT SPECIFIC APPLICATION PROCESS

Each plant seeking to apply the Methods LTR must provide information supporting the application that demonstrates that the plant parameters are within the applicability definition in Section 4.2.

NRC RAI 15

Please evaluate any additional uncertainty in the power distribution that may be introduced due to the effect of bypass void formation on traversing in-core probe (TIP) instruments. Please consider conditions of bypass voiding expected for GNF2 operating at or near the LHGR limits. Please address thermal and gamma TIP instruments separately. The evaluation should consider the influence of radial power distribution, J-factor, and instrument sensitivity. The power distribution uncertainties should consider integrated TIP (radial) redings near high powered GNF2 assemblies as well as axial power distribution, which may affect the LHGR uncertainty.

GEH Response

There is nothing in the GNF2 design that alters the LPRM, Gamma TIP or Neutron TIP response to changes in the bypass void fraction. The GNF2 channel and LPRM/TIP location is identical to GE14. In the upper part of the bundle, the only difference between the two designs is the location of the part length rods. The similarity of LPRM/TIP change for the two designs is supported by the analysis presented in the response to RAI–4. The change in the corner rod power provides an upper bound for the change in both thermal and gamma TIP response due to the presence of bypass voids. These changes are summarized in the Table 15-1.

The changes are basically the same for GE14 and GNF2. The narrow-narrow corner change is slightly less than the wide-wide corner change. In C lattice plants the narrow and wide inter channel gaps are the same, so the average change would apply. A value of 1.36% is a reasonable value for an upper bound for the amount of either neutron or gamma TIP response change due to 5% bypass void fraction. This bypass void effect can be compared to a 1.2% local TIP uncertainty (Reference 15-1).

Reference

15-1 NEDC–32601P–A, Methodology and Uncertainties for Safety Limit MCPR Evaluation, August 1999.

Table 15-1 Change in Corner Rod Power Due to 5% Bypass Void Fraction

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NRC RAI 16

Limitation 6 requires that the plant specific R-factor be calculated consistent with the axial void conditions expected for the hot channel operating state. The NRC staff notes that the LHGR rod power limit for GNF2 exceeds the LHGR limit for GE14 at low exposure. Therefore, the NRC staff postulates that the bundle powers or lattice rod peaking for GNF2 bundles operated near thermal limits may exceed those experienced for GE14 bundles. Therefore, either (1) rod-to-rod power peaking, or (2) gross bundle powèr (hence void fraction) for GNF2 bundles operating in an EPU core may exceed those experienced for limiting GE14 bundles.

Please provide a demonstration calculation of the GNF2 R-factor for an EPU or MELLLA+ transition core application (one reload quantity of GNF2 fuel and the balance GE14 fuel) that illustrates how Limitation 6 is met. Specifically address the higher allowable LHGR for GNF2 fuel.

GEH Response

Reference 1 describes the R-factor parameter and the methodology for computing it for BWR fuel bundles with partial length fuel rods. This same methodology is used in computing the R-factor for use with GEXL17 in critical power predictions for GNF2. As part of verifying GEXL17 for GNF2, the void conditions expected during operation were considered in relation to the calculation of the bundle R-factor. Several GNF2 equilibrium core designs were evaluated to determine the bundle void fractions for limiting bundles. These core designs were developed at a range of power densities, including EPU conditions, and the bundle average void fractions observed. Both the void history and instantaneous void fraction were considered. The R-factor [[ ]]

These designs were prepared to represent typical GNF2 application [[ ]]. The instantaneous void fractions for the limiting bundles throughout the cycle were observed [[ ]] and the most limiting bundles were very well represented by a bundle average instantaneous void fraction of [[ ]] which was selected for use in generating R-factors for GNF2. The observed bundle instantaneous void fractions as a function of MCPR for the four (4) cores considered are provided in the Figures 16-1.

Also, a representative core comprised of one batch of GNF2 with the remainder of the core consisting of GE14 is evaluated as requested in the RAI. This core is a high power density core representative of a reactor that has installed EPU. The [[ ]] relationship is provided in the graph below and the average instantaneous void fraction for the limiting bundles throughout the cycle is [[ ]]. GNF's overall approach in confirming compliance with Limitation 6 is to perform this evaluation on a plant specific basis for plants referencing the IMLTR and confirm that the reference void fraction value [[ ]] for R-factor determination remains applicable based on the cycle average instantaneous void fraction for the limiting fuel.

In summary, a bundle average void fraction of [[ ]] is very representative of limiting GNF2 bundles over a range of conditions that includes EPU and is adequate for use in calculating rod power distributions for the bundle R-factor.

Non-proprietary Version

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Figure 16-1a

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Non-proprietary Version

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Figure 16-1b

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Non-proprietary Version

[[

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Figure 16-1c

NRC RAI 17

BSP has been approved by the NRC staff for implementation at Option III plants. However, NEDC-33173P, Revision 1 does not explicitly discuss BSP for Option III. Please provide a discussion similar to those in NEDC-33173P, Revision 1 addressing BSP for Option III. It is expected that the nature of this discussion will be generic, but please give specific consideration to GNF2.

GEH Response

The NRC-approved ODYSY methodology (Reference 17-1) is used in the Backup Stability Protection (BSP) regions calculation for every reload. The BSP regions consist of two regions, I-Scram and II-Controlled Entry. The Base BSP Scram Region and Base BSP Controlled Entry Region are defined by statepoints on the High Flow Control Line (HCFL) and on the Natural Circulation Line (NCL). The bounding plant-specific BSP region state points must enclose the corresponding Base BSP region state points on the High Flow Control Line (HFCL) and on the Natural Circulation Line (NCL). If a calculated BSP region state point is located inside the corresponding base BSP region state point, then it must be replaced by the corresponding base BSP region state point. If a calculated BSP region state point is located outside the corresponding base BSP region state point, this point is acceptable for use. That is, the selected points will result in the largest, or most conservative, region sizes. The proposed BSP Scram and Controlled Entry region boundaries are constructed by connecting the corresponding bounding state points on the HFCL and the NCL using a shape function like the Generic Shape Function (GSF) or the Modified Shape Function (MSF).

The calculation of the BSP region boundary is based on a conservative ODYSY acceptance criteria map that may be influenced by the core wide axial power distribution calculation. [[

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The results of the BSP for Option III analysis are documented in the supplemental reload licensing report. Usually, two sets of BSP regions may be generated for different rated and reduced feedwater temperature ranges. Because the BSP regions are plant- and cycle-specific it is required to calculate or validate them for each core design. Therefore, a core design including GNF2 fuel is still required to satisfy the ODYSY acceptance criteria map in the determination of the cycle-specific BSP regions.

References:

17-1 NEDE-33213P-A, Revision 0, Licensing Topical Report, "ODYSY Application for Stability Licensing Calculations, including Option I-D and II Long Term Solutions," April 2009.

NRC RAI 18

Section 3.6 of the IMLTR refers to the generic applicability envelope for MCPR margin. Section 3.6 of Supplement 3 only discusses the pressure drop and critical power correlation. The NRC staff notes that the generic applicability envelope is only applicable to GE14 and earlier fuel designs.

To assist the NRC staff in its review, please describe the calculations (and specify the methods used) that must be performed to support DSS-CD for (1) GNF2 loaded cores implementing DSS-CD, and (2) plants that utilize DSS-CD that are introducing GNF2 fuel.

Please update Supplement 3 with a discussion regarding the analyses that must be performed to support DSS-CD and address the relevant uncertainties. This discussion should be similar to the discussions provided in the IMLTR for the other stability solutions. It is expected that this discussion will be generic in nature. Please include additional discussion that specifically addresses GNF2 uncertainties.

GEH Response

Section 3.6 of the Methods LTR (Reference 18-1) discusses the use of DSS-CD and that the uncertainties in power distribution calculations and void reactivity are accounted for in the stability analysis. Section 3.6 of NEDC-33173P, Supplement 3 (Reference 18-2) concludes that the stability analysis established for DSS-CD is applicable to GNF2 fuel.

The stability Section 3.6 references Section 2.2.1.2 as a basis for pressure drop correlation. Section 2.2.1.2 describes the pressure drops and the comparison between calculated and measured pressure drops for GNF2. The provided comparison is related to ISCOR calculated pressure drops. The reference to ISCOR is for the leakage flow calculation. This is dominated by the various models for the frictional pressures drop in the leakage paths from the lower plenum and channel to the bypass, and these models are identical between TRACG and ISCOR for normal flow in the leakage paths. The leakage flow models are documented in the TRACG Model Description report (Reference 18-3).

For the active bundle the TRACG pressure drop is evaluated by direct comparisons to pressure drop data from the ATLAS and Stern Lab test bundles. Bundle pressure drop comparisons are documented in the TRACG Qualification report (Reference 18-4) for GE14 fuel. TRACG hydraulic model to calculate pressure drops is not changed for different fuel types, whereas the loss coefficients input in the TRACG channel model typically change for different fuel types. Figure 18-1 represents the comparisons between Stern GNF2 test assembly pressure drops (measured) and TRACG predicted pressure drops (calculated). [[

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The DSS-CD LTR, NEDC-33075P-A (Reference 18-5), specifies the process to extend the applicability of DSS-CD to new fuel such as the GNF2 fuel design. NEDC-330075P-A, Table 6-5 identifies various fuel transitions and the required TRACG cases required for the different transitions. One of the included transitions, Scenario 1b, addresses transitioning from an approved fuel design (e. g., GE14) to an unapproved GEH fuel (e. g., GNF2). Approved/unapproved GE fuel designs are in reference to fuel designs approval for DSS-CD applications.

In such a case, the DSS-CD LTR requires [[

]] This process would apply to both cases where a GNF2 loaded core is implementing DSS-CD and where a DSS-CD core is introducing GNF2 fuel.

The NRC subsequently approved DSS-CD LTR in letter dated November 27, 2006 (Reference 18-5). The NRC reviewed the protocol as documented in SE Section 3.3. Further, Limitations 3 and 5 of the NRC's SE states:

3. For situations where the plant applicability checklist is not satisfied (e.g., introduction of a new fuel type), Tables 6.3 and 6.4 of NEDC-33075P, Revision 5, describe a technically acceptable procedure to extend the future applicability of DSS-CD.

5. Table 6.5 of NEDC-33075P, Revision 5, describes the fuel transition scenarios, which are subject to a plant-specific review for each application.

Section 2.6 of Supplement 3 (Reference 18-2) addresses the treatment of uncertainties relative to fuel parameters that affect stability. That discussion is applicable to DSS-CD as well. The update to address this clarification will be incorporated into the "-A' version of the supplement.

<u>References</u>

18-1 NEDC-33173P, "Applicability of GE Methods to Expanded Operating Domains", February 2006.

18-2 NEDC-33173P, Supplement 3, "Applicability of GE Methods to Expanded Operating Domains – Supplement for GNF2 Fuel", July 2009.

18-3 NEDE-32176P, "TRACG Model Description," Rev. 4, January 2008.

18-4 NEDE-32177P, "TRACG Qualification," Rev. 3, August 2007.

18-5 NEDC-33075P-A, "General Electric Boiling Water Reactor Detect and Suppress Solution – Confirmation Density", Rev. 6, January 2008.

Non-proprietary Version

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Figure 18-1: TRACG calculated pressure drops versus measured Stern GNF2 test assembly pressure drops (circle symbols) for GNF2 fuel at different power and mass flux values.