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U.S. Nuclear Regulatory Commission
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Subject: Draft Safety Evaluation for Global Nuclear Fuel Proposed Amendment 51 to Topical Report, NEDE-24011-P-A-29, General Electric Standard Application for Reactor Fuel (GESTAR II) (EPID L-2020-TOP-0012)

In Reference 1, the NRC provided a draft Safety Evaluation (SE) for the proposed GESTAR II Amendment 51 and requested that Global Nuclear Fuel - Americas LLC (GNF) identify any information that it considers proprietary and provide comments on factual errors or clarity concerns.

The NRC has marked two instances of proprietary information in the SE. GNF did not identify additional proprietary information in the draft SE. The comments summary table and SE markup in Enclosure 1 identify three minor typographical items and one clarity concern. Also included in Enclosure 1 are changes to Appendix B to address Limitation & Condition 1. Those pages with changes are shown in full markup mode. These changes will be incorporated into the accepted (-A) version of GESTAR II when the final SE is issued.

If you have any questions, please contact me or Kent Halac at 910-819-5307.

Sincerely,

Brian R. Moore
General Manager, Core & Fuel Engineering
Global Nuclear Fuel – Americas, LLC

Docket No. 99901376
Project No. 712

Reference:

1. Letter from Dennis C. Morey (NRC) to Michelle P. Catts (GEH), Subject: Draft Safety Evaluation for Global Nuclear Fuel Proposed Amendment 51 to Topical Report, NEDE-24011-P-A-29, General Electric Standard Application for Reactor Fuel (GESTAR II) (EPID L-2020-TOP-0012), October 13, 2020.

Enclosure:

1. Comment Summary Table, Draft SE Markup, and Revised Portions of Appendix B to Address Limitation & Condition 1

cc: N Otto, US NRC
MP Catts, GEH/Wilmington
KE Halac, GNF/Wilmington
PLM Specification 005N9722 R2

ENCLOSURE 1

M200139

Comment Summary Table, Draft SE Markup, and Revised Portions of Appendix B to Address Limitation & Condition 1

Non-Proprietary Information

Comment Summary Table for Draft Safety Evaluation for Global Nuclear Fuel Proposed Amendment 51 to Topical Report, NEDE-24011-P-A-29, General Electric Standard Application for Reactor Fuel (EPID L-2020-TOP-0012)

Location	Comment
Page 7 Line 35-36	Minor Typo. It seems there should be a line between the 2 bullets. *Suggested change shown in the markup.*
Page 10 Line 44-45	Minor Typo. Needs a space between 560 and assemblies. *Suggested change shown in the markup.*
Page 11 Lines 1 and 9	For clarity suggest adding "thermal mechanical design" to be consistent with the Appendix B Section 2.3 statement. At a minimum, LUAs shall be compliant to all thermal-mechanical design requirements in Section 1.1.2 prior to insertion. … satisfy all GESTAR II **thermal-mechanical design** criteria … *Suggested changes shown in the markup.*
Page 18 Line 21	Minor editorial. Delete extra word "showing". This ~~showing~~ demonstrates compliance………. *Suggested change shown in the markup.*
Page 18 Section 4.0	The Appendix B revisions required per this limitation are illustrated in the enclosed revised pages. These changes will be made in the accepted (-A) version of GESTAR II.

OFFICE OF NUCLEAR REACTOR REGULATION

DRAFT SAFETY EVALUATION FOR AMENDMENT 51 TO GLOBAL NUCLEAR FUEL

TOPICAL REPORT NEDE-24011-P-A-29, GENERAL ELECTRIC STANDARD

APPLICATION FOR REACTOR FUEL (GESTAR II)

(EPID: L-2020-TOP-0012)

1.0 INTRODUCTION

By letter dated March 17, 2020 (Ref. 1), as supplemented by letter dated July 31, 2020 (Ref. 2), Global Nuclear Fuel – Americas, LLC (GNF) submitted Amendment 51 to NEDE-24011-P-A-29, General Electric Standard Application for Nuclear Fuel (GESTAR II) for U.S. Nuclear Regulatory Commission (NRC) staff review and approval. Amendment 51 involves two modifications stemming from past NRC audits: (1) updating the lead fuel assembly provisions and (2) adding a new subsection containing a commitment to confirm the applicability of the GESTAR II design criteria for new fuel assembly design features.

The existing lead fuel assembly requirements in GESTAR II are a composite of old letters which have been a source of confusion and questions over the years. The new content proposed in Amendment 51 clarifies the definitions for lead fuel assemblies and the differences in test requirements and numbers for the different types of lead assemblies. Specifically, an overarching lead fuel assembly program is presented that defines a different lead-use program for each of three different types of lead assemblies: lead test assemblies (LTAs), lead-use assemblies (LUAs), and high-burnup lead-use assemblies (HBLUAs). The new overarching lead assembly program is encapsulated in a new appendix, Appendix B, "Lead Assembly Programs," to GESTAR II.

To improve the efficiency and effectiveness of its review, the NRC staff conducted an audit for Amendment 51. Due to the Coronavirus Disease-2019 (COVID-19) pandemic, the audit was conducted remotely using multiple webinars to facilitate discussions. The audit took place over several weeks in May - June 2020. The NRC staff's audit report (Ref. 3) documents the objectives and findings of this audit.

2.0 REGULATORY EVALUATION

GESTAR II Amendment 51, Appendix B, clarifies the requirements for lead assemblies within the GESTAR II licensing framework. Lead assemblies may impact the performance of co-resident fuel or safety-related systems, structures, and components (SCCs). In light of this, the performance of lead assemblies and their potential impacts are evaluated against the following regulations used to assess steady state, anticipated operational occurrences (AOOs), and postulated accident performance of nuclear fuel systems and design which are found in the following sections of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities."

- 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," which establishes the minimum requirements for principal design criteria for certain water-cooled nuclear power plants. In particular, General Design Criterion (GDC)-10, "Reactor Design," which requires that the reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that specified acceptable fuel design limits (SAFDLs) are not exceeded during any condition of normal operation, including the effects of AOOs; GDC-27, "Combined Reactivity Control Systems Capability," which requires the reactivity control systems to be designed to have a combined capability, in conjunction with poison addition by the emergency core cooling system, of reliably controlling reactivity changes to assure that under postulated accident conditions and with appropriate margin for stuck rods the capability to cool the core is maintained; and GDC-35, "Emergency Core Cooling," which requires, in part, a system to provide abundant emergency core cooling such that it prevents fuel and clad damage that could interfere with continued effective core cooling and limits clad metal-water reaction to negligible amounts.

- 10 CFR 50.34, "Contents of Applications; Technical Information," which provides the requirements for the Final Safety Analysis Report required for each plant and includes the requirements for licensees to perform analysis of normal operation, transients, and postulated accidents to demonstrate safety of their facilities.

- 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," which establishes criteria for emergency core cooling system performance following postulated loss-of-coolant accidents. In particular, limits are placed on peak cladding temperature, maximum cladding oxidation, and maintaining a geometry amenable to core cooling.

- 10 CFR 50.59, "Changes, Tests, and Experiments," which establishes criteria for assessing whether licensees may make changes in the facility and/or procedures as described in the final safety analysis report (as updated), and conduct tests or experiments not described in the final safety analysis report (as updated) without obtaining a license amendment under 10 CFR 50.90. 10 CFR 50.59 is pertinent to Amendment 51 because the criteria presented within this regulation are assessed when licensees intend to insert lead assemblies or apply analysis methodologies to predict lead assembly performance.

- 10 CFR 50.67, "Accident Source Term," which provides regulatory requirements and establishes criteria for assessing radiological consequences employing an alternate source term. 10 CFR 50.67(b)(1) states that a licensee who seeks to revise its current accident source term in design basis radiological consequence analyses shall apply for a license amendment under § 50.90. Furthermore, the Statements of Consideration[1] for 10 CFR 50.67 includes the following restriction concerning the use of 10 CFR 50.59 to assess changes to the radiological source term:

  After a licensee has been authorized to substitute an alternative source term in its design basis, subsequent changes to the facility that involve an alternative source term may be processed under § 50.59 or § 50.90, as appropriate.

[1] 64 FR 72001, Dec. 23, 1999

> *However, a subsequent change to the fractions of the fission product inventory of the radionuclides released from the reactor fuel, their chemical and physical form, or the timing of their release as tabulated in the regulatory guidance (with deviations proposed by the licensee and approved by the NRC) could not be implemented under § 50.59. This provision applies only to these tabulated parameters.*

10 CFR 50.67 is pertinent to Amendment 51 because the lead assembly safety demonstration must address potential impacts of the lead assemblies on the UFSAR radiological consequences. For plants which have adopted 10 CFR 50.67, any increase in the overall radiological source term introduced by the lead assemblies would necessitate a license amendment request.

Regulatory guidance for the review of fuel system materials and designs to assure adherence to Appendix A to 10 CFR Part 50, GDC-10, “Reactor Design,” GDC-27, “Combined Reactivity Control Systems Capability,” and GDC-35, “Emergency Core Cooling,” is provided in NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants” (SRP), Section 4.2, “Fuel System Design” (Ref. 4). In accordance with SRP Section 4.2, the objectives of the fuel system safety review are to provide assurance that:

- The fuel system is not damaged as a result of normal operation and AOOs (per GDC-10),
- Fuel system damage is never so severe as to prevent control rod insertion when it is required (per GDC-27),
- The number of fuel rod failures is not underestimated for postulated accidents (for dose assessment per 10 CFR 50.34), and
- Coolability is always maintained (per GDC-27, GDC-35, and 10 CFR 50.46).

GESTAR II defines fuel licensing acceptance criteria and establishes the basis for evaluating new fuel designs, developing the critical power correlation for these designs, and performing reload safety analyses. Following the GESTAR II process to demonstrate compliance with the specified fuel licensing acceptance criteria constitutes NRC acceptance of the new fuel design without specific NRC review.

As mentioned above, the purpose of Amendment 51 is to clarify the requirements for lead assemblies within the GESTAR II licensing framework. Amendment 51 supersedes a series of NRC and General Electric (GE) letters dating back to the early 1980s, which attempted to provide clarification on lead assembly programs but also generated some additional confusion. This is not the first attempt by the NRC staff to clarify requirements associated with lead assembly programs. In 2003, the NRC staff approved Westinghouse Topical Report (TR) WCAP-15604-NP, Revision 2-A, “Limited Scope High Burnup Lead Test Assemblies” (Ref. 5). The purpose of TR WCAP-15604-NP, Revision 2-A. was to provide guidance and a basis for the operation of a limited number of high-burnup fuel assemblies beyond the then-current fuel design limit. The WCAP-15604-NP limited scope high-burnup LTAs are equivalent to Amendment 51 HBLUAs in that both are approved, production fuel assembly designs being irradiated beyond current burnup limits for the purpose of collecting data and gaining operating experience to support a future licensing action.

In that TR, the staff accepted the following attributes of a high-burnup LTA program:

- Irradiation of up to 9 pressurized water reactor (PWR) LTAs and 32 boiling water reactor (BWR) LTAs is permitted.

- Irradiation to a rod-average burnup up to 75 GWd/MTU is permitted.

- The analytical models used to evaluate the performance of the LTAs beyond current burnup limits may need to be modified versions of the models reviewed and approved by the NRC. In some cases, conservatism may be added, as appropriate.

The NRC staff's prior approval of this LTA program was used to guide its review of Amendment 51 (see Section 3).

Under BWR Standard Technical Specifications (STS) Section 4.2.1, "Fuel Assemblies" (Ref. 7), "[a] limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions." Many licensees have adopted this language or other, substantially similar, language into plant-specific TS.

In a letter dated June 24, 2019, to the Nuclear Energy Institute (NEI) (Ref. 6), the NRC staff provided clarification of the regulatory path for LTAs. That letter clarified the NRC staff's interpretation of the STS provision regarding LTAs.[2] During its review, the NRC staff used relevant portions of the NEI letter to guide its review of Amendment 51 (see Section 3). Some of this relevant text is excerpted below.

- Because LTAs have not completed representative testing (i.e., collected sufficient data to fully characterize irradiated material properties and performance), the STS LTA provision restricts LTAs to a "limited number" in "nonlimiting core regions." Licensees can demonstrate compliance with the STS LTA provision that LTAs are of "limited number" and "in nonlimiting core regions" through an evaluation of the LTAs using sound engineering judgment and analytical codes and methods that reflect well-established engineering practices, and by conservatively addressing uncertainties in input parameters and models using the current state of knowledge and all available data to the extent practical. The staff expects that this evaluation will confirm that the updated final safety analysis report (UFSAR) safety analyses and core operating limits report (COLR) limits remain applicable and bounding. If a licensee cannot demonstrate compliance with these restrictions within the STS LTA provision, then prior NRC approval may be necessary to insert LTAs.

- The evaluation of LTA campaigns requires some engineering judgment because of the incomplete availability of representative data before irradiation of the LTAs, and evaluation may necessitate using modified or different codes and methods in the form of: (1) modifications to approved codes and methods, (2) use of approved codes and

[2] As discussed below, the GESTAR II LTA program, defines three types of assemblies: LTAs, LUAs, and HBLUAs. The NRC staff views the NEI LTA letter as only applying to LTAs not to LUAs or HBLUAs.

methods outside the bounds for which they were explicitly approved, or (3) use of a code or method, based on well-established engineering practices, that the NRC has not previously approved. Use of these modified or different codes and methods, solely for the evaluation of “a limited number” of LTAs, may be acceptable without additional NRC approval for confirming that the LTAs are placed in nonlimiting regions and that the core operating limits and UFSAR safety analyses, which themselves are calculated using approved codes and methods, remain applicable.

The NEI LTA letter also addresses whether exemptions from 10 CFR 50.46 are needed for LTAs. Some licensees deemed exemptions from 10 CFR 50.46 necessary because 10 CFR 50.46 indicates the requirements presented therein are applicable to fuels with zircaloy or ZIRLO cladding but lead assemblies may be comprised of zirconium-based (i.e., not strictly zircaloy or ZIRLO) or non-zirconium claddings, which may then require an exemption. Per the NEI LTA letter:

- Insertion of LTAs under the STS LTA provision requires demonstration that under normal operation, AOOs, and postulated accidents, the performance of the LTAs will not negatively impact the performance of the co-resident fuel and confirmation that the UFSAR safety analyses and COLR limits remain applicable and bounding. This includes the demonstration of emergency core cooling system performance required to ensure compliance with 10 CFR 50.46, if applicable. In other words, the LTAs’ performance must not significantly influence the plant’s behavior under loss-of-coolant accident conditions or adversely affect the performance of the emergency core cooling system. Under these conditions, the licensee remains compliant with 10 CFR 50.46 because the emergency core cooling system performance demonstration remains applicable and bounding.

Based on this, the NEI letter states that an exemption may not be required since the LTA safety assessment confirms that the emergency core cooling system performance demonstration remains applicable and bounding. While LUAs and HBLUAs, as defined below, are likely to employ Zircaloy-2 (Zry-2) cladding and hence remain within the range of applicability of 10 CFR 50.46, LTAs, as defined below in the GESTAR II program, may be comprised of developmental zirconium alloys or non-zirconium alloys. For these instances, the licensee may need to further limit the number of LTA (or lead rods) based on the characterization of its performance under LOCA conditions to satisfy the TS LTA provision.

The NEI LTA letter also provides guidance related to 10 CFR 50.59 evaluations. With respect to 10 CFR 50.59(c)(2)(viii), the letter states that lead assembly programs which satisfy the TS LTA provisions do not result in a “departure from a method of evaluation” because the presence of these lead assembly programs does not affect the performance of safety-related SSCs, and therefore, the method of evaluation used in establishing the design bases will remain the same. In such cases, the licensee may not meet 10 CFR 50.59(c)(2)(viii), and therefore, may not require a license amendment because of this criterion.

3.0 TECHNICAL EVALUATION

Enclosures 1 and 2 of Reference 1, as amended by Reference 2, provide changes to GESTAR II (Ref. 8) which implement the two objectives. Amendment 51 adds the following new General Criteria in Sections 1.1.1 and 1.2.1 of GESTAR II:

> GNF will document in the new fuel compliance report that the criteria defined in GESTAR II are appropriate for use with any new features of the fuel design. When new or modified criteria or requirements for new design features are needed, they will be submitted for review and approval by the NRC.

This update was prompted by NRC staff concerns that new design features may require new or modified criteria to ensure acceptable performance and compliance with applicable regulatory requirements. The new text requires GNF to perform and document an assessment of the new design features against existing criteria and if necessary, submit new or modified criteria for NRC review. The NRC staff finds these changes acceptable.

Amendment 51 includes several changes from GE to GNF to acknowledge a change in corporate identity. These changes are administrative in nature and acceptable.

Amendment 51 also includes a change to GESTAR II Section 3.4.1, "Introduction and Bases." As described in Reference 2, the first sentence was deleted to clarify the scope of the reload licensing process. Removal of the first sentence achieves the objective of clarifying the broader scope of the reload licensing process and is therefore acceptable.

One of the main objectives of Amendment 51 was to update and clarify the lead-use fuel assembly provision in GESTAR II. Section 1.1.1, "General Criteria," of GESTAR II states that new design features will be included in lead-use assemblies. This statement has been problematic since "new design features" was not defined. Amendment 51 proposed a change to this section to clarify the difference between new design features, which require inclusion in LUA irradiation programs, and equivalent replacement components (i.e., components that are functionally equivalent), which do not require LUAs. The NRC staff agrees that equivalent replacement components which meet all the requirements of GESTAR II do not require LUA irradiation programs. This has always been the intent of the fuel design change process embedded in GESTAR II. LUA irradiation programs are intended to confirm in-reactor performance of new design features which are outside GNF operating experience. Appendix B has been added to define LTA, LUA, and HBLUA irradiation programs and associated restrictions on quantities and placement (i.e., operating conditions). Citations to earlier GE and NRC letters within GESTAR II Sections 1.2.1, "General Criteria," 1.5, "References," 2.3.3, "Post–Irradiation Surveillance," and 2.4, "References," that describe lead-use assembly and surveillance programs have been removed.

3.1 Lead Assembly Programs

BWR STS include a common LTA provision within Section 4.2.1, "Fuel Assemblies." This provision states:

> A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

This sentence allows licensees to load LTAs on a restricted basis such that a licensee can only load "a limited number" in "nonlimiting core regions." The restriction on quantity is warranted since the irradiated material properties and performance of the lead features may not be fully characterized. Hence, the ability to predict the assemblies' in-reactor performance during normal operation, AOOs, and postulated accidents has higher uncertainty (than approved coresident fuel assemblies which are analyzed using approved methods). The restriction on core location translates into constraints on operating conditions (e.g., local power density) and is needed to provide additional margin to safety criteria due to increased uncertainty.

The TS for a majority of operating BWRs contain this provision or very similar language. Section B.1, "Introduction," of Amendment 51 refers to this LTA provision and states "a licensee may load lead assemblies according to the requirements defined in this appendix, provided GESTAR II is referenced in the Technical Specifications." During a virtual audit (Ref. 3), NRC and GNF staff discussed the need to clarify the bases for satisfying the limited number and nonlimiting location requirements within the STS LTA provision for each type of lead assembly program.[3] Specifically, based on these discussions, GNF proposed new or modified text to address the following topics:

- Connection between GESTAR II Appendix B and the STS 4.2.1 LTA provision.
- Licensee's 10 CFR 50.59, "Changes, Tests and Experiments," evaluation of lead assembly programs and when a license amendment request may be needed.
- Bases for a specified limited number of LUAs and HBLUAs in different BWR core configurations.
- Bases of limited number of LTAs.
- Treatment of concurrent lead assembly programs in different BWR core configurations.
- Bases for determining non-limiting location for each lead assembly program during normal operations and under design-basis accident (DBA) conditions

In response to a request for additional information, RAI #1 (Ref. 2), GNF proposed changes to the GESATR II lead assembly program requirements in Appendix B. The modified language and bases for NRC approval are described below for each type of lead assembly program.

[3] The audit report refers to the lead assembly program as the lead use program. This SE uses the phrase lead assembly program to avoid confusion with the lead use assembly program, which is only one of the three programs relevant to this amendment.

LTA Programs

As described in Section B.2.2, “Lead Test Assemblies,” of Amendment 51, LTAs are fuel assemblies with unapproved technologies. Hence, the purpose of an LTA program is to collect data that supports a fundamental understanding of how a new technology performs in-reactor.

Analytical Models and Methods

As described in Section B.2.2 of Amendment 51, LTAs may use approved methodologies outside application ranges for design evaluations or, in some cases, unapproved methodologies without the need for a license amendment. Amendment 51 also states that the design of LTAs will be accomplished using sound engineering judgment and analytical codes and methods that reflect well-established engineering practices to provide assurance that the LTA does not adversely affect nuclear safety. In prior guidance (Ref. 6), the NRC staff stated that, for the purposes of confirming that the UFSAR safety analyses and COLR limits remain applicable and bounding, the evaluation of LTA campaigns requires some engineering judgment because of the incomplete availability of representative data before irradiation of the LTAs. The NRC staff also stated that evaluation may necessitate using modified or different codes and methods in the form of: (1) modifications to approved codes and methods, (2) use of approved codes and methods outside the bounds for which they were explicitly approved, or (3) use of a code or method, based on well-established engineering practices, that the NRC has not previously approved. Given that these modified and/or unapproved analytical limits and methods will only be used to confirm that UFSAR safety analyses remain valid and satisfy the Section B.5 program requirements (associated with LTA restrictions on quantity and core location), the NRC staff finds this acceptable.

Adherence with Limited Number STS Provision

As described in Section B.2.2.1, “Quantities of LTAs,” of Amendment 51, the safety risk of a new technology depends on the relative certainty (or the degree of characterization) in performance. Since the new technology features of LTAs and their degree of characterization will vary, Section B.5.1, “Additional Requirements for LTAs are as follows,” requires that the number of LTAs operating in each plant to be established based on the potential effect on nuclear safety. This justification shall be provided in the information letter sent by the licensee to the NRC as part of the description of the LTA program. Additionally, the general program requirements listed in Section B.5 of Amendment 51 also need to be satisfied as part of the LTA limited number bases. The NRC staff acknowledges that the potential effect of LTAs on nuclear safety may be informed by the placement of LTAs in non-limiting locations. Therefore, the NRC staff assessed the adequacy of the limited number of LTAs with respect to the STS provision in conjunction with the definition of non-limiting location, below.

Adherence with Non-Limiting Location STS Provision

Section B.2.1, “Non-Limiting Locations,” of Amendment 51 provides guidance for adhering to the non-limiting location restriction in the STS LTA provision. As described, the restriction is not generally associated with a particular core location. Rather for a location to be non-limiting, Section B.2.1 establishes two criteria. First, that lead assemblies be designed and their associated core location chosen such that reload fuel assemblies are limiting during steady state operation as determined by the Reference Loading Pattern and associated TS thermal limits monitoring for linear heat generation rate, maximum average planer linear heat generation rate, and minimum critical power ratio. Second, that lead assemblies are designed and analyzed to assure regulatory requirements for DBAs are maintained with sufficient margin to account for uncertainties.

The definition for non-limiting location discusses maintaining reload fuel assemblies as limiting with respect to TS thermal limits monitoring. This means LTAs must have a thermal margin setback in comparison to the reload fuel assemblies. As discussed in the previous subsection, the new technology features of LTAs and their degree of characterization will vary. Therefore, the amount of thermal margin setback will need to be proportional to the degree of uncertainty in properties and performance to ensure that regulatory requirements are satisfied. Section B.5 of Amendment 51 lays out general program requirements that must be met to ensure regulatory requirements are satisfied. As defined in Section B.5 of Amendment 51, the general programs requirements that are pertinent to LTA thermal margin setback and associated uncertainties include the following:

- For normal operations and AOOs, lead assemblies shall be designed as non-limiting relative to reload assemblies for those regulatory requirements that are evaluated to have increased uncertainty because of the new design features;

- Compliance with SAFDLs shall be maintained;

- For DBAs, lead assemblies shall be designed to assure regulatory requirements are maintained with sufficient margin to account for uncertainties; and

- No more than a minimal increase in radiological consequence compared to the licensee’s UFSAR basis consistent with the requirements of 50.59.

Preserving additional thermal margin, relative to the co-resident reload batch fuel bundles, up to the magnitude necessary to account for uncertainties and satisfy the above general program requirements ensures that the presence of the LTAs will not result in fuel damage as a result of normal operation and AOOs, or underestimate fuel damage and challenge core coolable geometry and control rod insertion during postulated accidents. This is consistent with SRP Section 4.2. In addition, these general program requirements are consistent with the staff’s prior LTA guidance in that UFSAR safety analyses and COLR limits remain applicable and bounding. Compliance to the above general program requirements will be provided in the information letter sent by the licensee to the NRC as part of the description of the LTA program.

Regarding the limited number of LTAs, as the degree of characterization of the new technology features increases, a larger number of LTAs and/or lower amount of thermal margin setback may be justifiable. Thus, the LTA criteria for limited number and non-limiting location work in concert to provide reasonable assurance of no undue risk to public health and safety.

Based on the above, the staff finds the combination of limited number and non-limiting location for LTAs consistent with the relevant regulatory requirements and the STS LTA provision and are, therefore, acceptable.

LUA Programs

As described in Section B.2.3, “Lead Use Assemblies (LUAs),” of Amendment 51, a LUA is a pre-production prototype of a new fuel design, which contains new design features that are distinctly different from previous fuel designs. The purpose of LUAs is to confirm expected operation of a new fuel design rather than to gather specific technical information.

Per Section B.2.3, a new fuel design is comprised of new features that are designed with NRC-approved methods and design criteria to be compliant with GESTAR II requirements. Once compliance with new fuel licensing requirements in GESTAR II is shown, a new fuel design can be inserted in full reload applications. The following text was extracted from the Executive Summary of the GNF2 fuel bundle GESTAR II compliance report (Ref. 9) and provides an example of where the GESTAR fuel change process was used to introduce a new fuel bundle design.

> This report presents generic information relative to the GNF2 fuel design and analyses of GE Boiling Water Reactors for which GNF provides fuel. The scope of assessments is in accordance with the fuel licensing acceptance criteria as specified in NEDE-24011-PA, General Electric Standard Application for Reactor Fuel (GESTAR II) ... and is often called the Amendment 22 process. The criteria in GESTAR II establish the basis for evaluating new fuel designs, developing the critical power correlation for these designs, and determining the applicability of generic analyses. This process has been applied in the licensing of the GE14, GE12, GE13, and GE11 fuel designs....
>
> As stated in GESTAR II, "Fuel design compliance with the fuel licensing acceptance criteria constitutes USNRC acceptance and approval of the fuel design without specific USNRC review." All of the criteria defined in GESTAR II have been met for the GNF2 fuel design.

As discussed above, GE amended GESTAR II Section 1.1.1. to clarify when existing fuel designs may be modified and inserted in reload quantities, and when they constitute new fuel designs and require the use of LUAs.

Analytical Models and Methods

As described in Section B.2.3 of Amendment 51, LUAs are designed with NRC-approved methods and design criteria to be compliant with GESTAR II requirements. This is consistent with the currently approved GESTAR II fuel design change process.

Adherence with Limited Number TS Provision

As described in Section B.2.3.1, “Quantities of LUAs,” of Amendment 51, the number of LUAs operating in each plant shall be limited to 16 for plants with greater than or equal to 560 assemblies and 8 for plants with less than 560 assemblies. Amendment 51 states that these numerical limits meet the definition of a “limited number” in a licensee’s TSs because the assemblies are designed to be compliant with all NRC requirements and if failures were to occur, the number would be limited, readily detectable and handled by normal plant operating systems. Given that LUAs are pre-production prototype fuel designs, analyzed with NRC-approved codes and methods, and satisfy all GESTAR II **thermal-mechanical design** criteria, the NRC staff finds the numerical limits acceptable.

Adherence with Non-Limiting Location STS Provision

Just as with LTAs, the LUA criteria for limited number and non-limiting location work in concert to provide reasonable assurance of adequate protection of public health and safety. Given that LUAs are pre-production, prototype fuel designs, analyzed with NRC-approved codes and methods, and satisfy all GESTAR II **thermal-mechanical design** criteria, the staff accepted the specific limited number defined above. This limited quantity, combined with thermal margin setbacks to the degree necessary to account for uncertainties and satisfy the general program requirements discussed in the LTA Non-Limiting Location STS Provision subsection above, provides reasonable assurance of adequate protection of public health and safety. This is because preserving additional thermal margin, relative to the co-resident reload batch fuel bundles, up to the magnitude necessary to account for uncertainties and satisfy the general program requirements ensures that the presence of the LUAs will not result in fuel damage as a result of normal operation and AOOs, or underestimate fuel damage and challenge core coolable geometry and control rod insertion during postulated accidents. This is consistent with SRP Section 4.2, thus satisfying the relevant regulatory requirements. The non-limiting location definition for LUAs is thus consistent with the STS LTA provision and is, therefore, acceptable.

<u>HBLUA Programs</u>

As described in Section B.2.4, "High-Burnup Lead-Use Assemblies (HBLUAs)," of Amendment 51, HBLUAs are assemblies of licensed fuel designs (e.g., GE14, GNF2, GNF3) that will be irradiated beyond their current licensed burnup limit. The purpose of a HBLUA is to increase operational experience and to collect performance data that may be used to evaluate extension of current burnup limits.

Analytical Models and Methods

Per Section B.5.3, "Additional Requirements for HBLUAs are as follows," HBLUAs will be analyzed using GNF's NRC-approved analytical models and methods (e.g., PRIME). Section B.5.3 also indicates that, if GNF's licensed methodologies have limitations on exposure, they may be applied beyond their approved range to account for the increased exposure.

HBLUAs are assemblies that have been demonstrated to be compliant with all NRC requirements up to the current licensed burnup, which means the thermal and mechanical performances of these assemblies are well-understood and incorporated into GNF's licensed analytical models and methods. These analytical models and methods are greatly informed by the extensive high-burnup experience GNF has from operating fuel in various European plants, which means the increase in model and method uncertainties associated with incrementally extrapolating them beyond their approved range to include the operating conditions of the HBLUAs is minimal. For the purpose of evaluating a limited number of HBLUAs, the use of approved methods beyond their range of applicability is consistent with the staff's previous approval (Ref. 5). Therefore, based on the above, the NRC staff finds the application of GNF's licensed methodologies beyond their approved exposure range when analyzing HBLUAs acceptable.

Adherence with Limited Number TS Provision

As described in Section B.2.4.1, “Burnup Limit and Quantities of HBLUAs,” of Amendment 51, the number of HBLUAs operating in each plant shall be limited to 16 for plants with greater than or equal to 560 assemblies and 8 for plants with less than 560 assemblies. Amendment 51 states that these numerical limits meet the definition of a “limited number” in a licensee’s TSs because the assemblies are compliant with all NRC requirements up to the current licensed burnup and GNF has extensive high-burnup experience in European plants, meaning there is little risk of failure during normal operations. If failures were to occur, the number would be limited, readily detectable and handled by normal plant operating systems.
As described in Section 2 of this safety evaluation, the staff previously approved up to 32 BWR high-burnup LTAs (Ref. 5). Amendment 51 proposed a more restrictive limit on the quantity of HBLUAs. Restrictions on the limited number of HBLUAs are closely tied to the proposed burnup limit and will be dispositioned below.

Burnup Limit

Section B.2.4.1 proposes that HBLUAs be allowed to achieve a maximum fuel pellet burnup equivalent to GNF’s operating experience in some European BWRs. During a virtual audit (Ref. 3), GNF presented a summary of their European operating experience. This information was necessary to justify the limiting quantity and maximum burnup of HBLUAs proposed in Appendix B. Therefore, in RAI #2 the staff asked GNF to provide the operating experience information needed to support the staff’s safety finding. In response to RAI #2 (Ref. 2), GNF provided further insights into their European high-burnup experience, including licensed burnup limits and distribution of exposures (i.e., number of fuel bundles and their associated burnups). The NRC staff confirmed the distribution of exposures provided in the response to RAI #2 encompassed the increased burnup limit requested in Amendment 51. GNF also highlighted the extent of their PRIME qualification empirical database as additional justification of their high-burnup experience; the database includes data collected from burnups higher than the current burnup limit.

The NRC staff has found PRIME’s fuel temperature model acceptable well above the current burnup limit (Ref. 10). However, during the NRC staff’s review of PRIME, the staff only assessed the acceptability of the fission gas release model up to the current burnup limit of 62 GWd/MTU rod-average. To assess the applicability of PRIME’s fission gas release model up to the exposure limit proposed in Section B.2.4.1, NRC staff re-examined the fission gas release data provided in the PRIME qualification database (Ref. 10). The NRC staff observed that the fission gas release model consistently and conservatively overpredicted fission gas release by **[ ]** across the range of exposure data up to **[ ]** GWd/MTU rod-average. This burnup is only slightly less than that requested in Section B.2.4.1. Extrapolating the fission gas release model to the requested burnup is expected to yield an increased uncertainty. However, based on the few data points within the database that exist beyond the proposed burnup, the uncertainty is not expected to experience a radical departure from the trend observed in the rest of the database. When considering that HBLUAs will be placed in the core in limited numbers and in non-limiting locations (discussed below), the NRC staff does not expect the increased modeling uncertainty across the small extrapolation range to result in a non-conservative prediction of fission gas release. The NRC staff therefore finds the fission gas release model acceptable for use in the present application of analyzing the performance of HBLUAs up to the proposed burnup.

As described in Section 2 of this safety evaluation, the staff previously approved up to 75 GWd/MTU rod-average burnup for the limited scope high-burnup LTAs (Ref. 5). Depending on fuel rod axial enrichment and poison zoning, 75 GWd/MTU rod-average corresponds to 82 – 86 GWd/MTU peak pellet. Amendment 51 proposed a similar burnup limit for the HBLUAs.

Based upon consistency with previous staff approvals (Ref. 5), European in-reactor operating experience, and PRIME's extensive empirical database, the NRC staff finds the proposed HBLUA limitations on limited number and fuel burnup acceptable and consistent with the STS LTA provision.

Adherence with Non-Limiting Location STS Provision

Like with LTAs and LUAs, the HBLUA criteria for limited number and non-limiting location work in concert to provide reasonable assurance of adequate protection of public health and safety. Given that HBLUAs are comprised of proven, and NRC-approved fuel bundle designs and materials; analyzed with NRC-approved methods (modified as necessary to capture extended burnup effects) and acceptance criteria; and operated within existing GNF operational experience, the staff accepted the specific limited number defined above. However, unlike LTAs and LUAs, HBLUAs do not require thermal margin setbacks to ensure that they are less limiting than the co-resident, batch-loaded fuel bundles. Uranium-235 depletion during normal operation up to the existing burnup limit (boundary for start of HBLUA program) ensures that HBLUAs will operate at substantially lower bundle power because they have less uranium-235 to fission. This reduced power would be credited to account (much like thermal margin setpoints) for high-burnup uncertainties and satisfy the following program requirements.

- For normal operations and AOOs, lead assemblies shall be designed as non-limiting relative to reload assemblies for those regulatory requirements that are evaluated to have increased uncertainty because of the new design features;

- Compliance with Specified Acceptable Fuel Design Limits (SAFDLs) shall be maintained;

- For DBAs, lead assemblies shall be designed to assure regulatory requirements are maintained with sufficient margin to account for uncertainties; and

- No more than a minimal increase in radiological consequence compared to the licensee's UFSAR basis consistent with the requirements of 50.59.

Due to their nature, HBLUA fuel rods will experience a longer in-reactor residence, higher fission density, higher fission gas production, higher fission gas release (from the fuel pellet into the fuel rod plenum region), and higher fluence to assembly components. Because of these inherent extended burnup-related phenomena, HBLUAs will not be non-limiting with respect to margin to many important design and performance indicators (e.g., cladding oxide thickness, rod internal pressure). However, any increased uncertainty associated with predicting the impact of these extended burnup-related phenomena on fuel rod performance during normal operation, AOOs, and postulated DBAs, will be assessed in the demonstration showing they meet the general program requirements in Section B.5. To ensure that the HBLUAs operate in accordance with the HBLUA safety demonstration, the COLR Thermal-Mechanical Operating Limits (TMOL), which specifies the allowable peak local heat generating limit as a function of peak pellet exposure, will be modified, expanding peak pellet exposure out to the HBLUA burnup limit. Monitoring thermal limits to ensure consistency with safety analyses is consistent with the reload process approved within GESTAR II.

All of this ensures that the presence of the HBLUAs will not result in fuel damage as a result of normal operation and AOOs, or underestimate fuel damage, and challenge core coolable geometry and control rod insertion during postulated accidents. The HBLUA non-limiting definition thus satisfies the regulatory requirements, is consistent with the STS provision, and is therefore acceptable.

3.1.1 Testing and Reporting

Section B.3 of Amendment 51 describes the testing and inspection plans and reporting requirements for each of the lead assembly programs. For all programs, the licensee will send an information letter to the NRC. Generally, the information letter will describe the program, including both the duration of the program and an inspection plan with basis. In addition to the information letter, for LUAs GNF must provide the NRC with a LUA report describing the new fuel design and overall LUA plans, prior to insertion of the first LUAs of a new fuel design. Finally, HBLUA test plans and performance findings shall be included in the annual GNF Technology Update meetings. The NRC staff has reviewed these requirements and finds them acceptable.

3.1.2 Duration of Testing

Section B.4 of Amendment 51 describes the duration of testing (i.e., length of irradiation) for each of the lead assembly programs. For each program, the testing duration shall be defined in an information letter provided to the NRC. Restrictions on fuel burnup are addressed above.

3.1.3 Safety Demonstration

To provide reasonable assurance of public health and safety, the quantities and location (i.e., operating power) of lead assemblies are restricted. As described above for each lead assembly program, to demonstrate compliance with these restrictions, the licensee may employ NRC-approved analytical models and methods, including their use beyond current range of applicability, modified versions of these approved methods, or new methods based on sound engineering practices. Section B.5 of Amendment 51 provides general program requirements for all lead assembly programs. Of the general program requirements presented, the following requirements are pertinent to developing and documenting compliance with the quantity and location restrictions for lead assemblies:

1. Compliance with Specified Acceptable Fuel Design Limits (SAFDLs) shall be maintained. Lead assemblies shall be accounted for in standard reload licensing evaluations documented in the Supplemental Reload Licensing Report (SRLR) or other appropriate licensing reports.

2. GNF shall provide the licensee a technical evaluation report that addresses all fuel design and safety requirements not considered in the SRLR and needed to support insertion of the lead assemblies by either a 50.59 assessment or a Licensing Amendment Request, if the 50.59 is not successful.

   The lead assembly technical evaluation report shall demonstrate that lead assemblies have a minimal increase in radiological consequence compared to the licensee's UFSAR basis consistent with the requirements of 50.59. Changes to inputs and assumptions that could be credited to account for additional uncertainties associated with LTAs, LUAs, and HBLUAs are listed below:

   a. Reduced lead assembly fuel rod power relative to peaking factors assumed in dose calculations

   b. Time-in-life and radionuclide decay

   c. The lower gap fractions at high exposures for modern fuel types

3. For normal operations and AOOs, lead assemblies shall be designed as non-limiting relative to reload assemblies for those regulatory requirements that are evaluated to have increased uncertainty because of the new design features.

4. For DBAs, lead assemblies shall be designed to assure regulatory requirements are maintained with sufficient margin to account for uncertainties.

Originally, Section B.2.3.2 of Amendment 51 stated "licensees may take exception to the Regulatory Guide 1.183 guidance…." This assertion was based on "studies [that] have indicated that the gap fractions in Regulatory Guide 1.183 are conservatively acceptable for increased exposures and the radial peaking of high exposure bundles would be substantially less than licensing basis peaking assumptions." During a virtual audit (Ref. 3), NRC and GNF staff discussed the text and requirements related to radiological consequence assessments for lead-use programs. The NRC staff had concerns that Appendix B did not clearly stipulate that licensees must demonstrate that current UFSAR radiological consequence assessments remain applicable and bounding. In response to RAI #3 (Ref. 2), GNF proposed changes which addressed the NRC staff concerns. The new requirements are documented in Section B.2.5 of Amendment 51 and summarized in item #2 above.

As discussed in Sections B.2.5 and B.5 of Amendment 51 (Ref. 2), the lead assembly technical evaluation report shall demonstrate that all radiological consequences have no more than a minimal increase in consequences docketed within the licensee's UFSAR. Under 10 CFR 50.59(c)(2)(iii), a licensee may make proposed changes or conduct tests or experiments if the proposed change, test, or experiment would not "[r]esult in more than a minimal increase in the consequences of an accident previously evaluated in the [UFSAR]." While the above-discussed demonstration is consistent with this requirement, altering or slightly increasing said radiological consequences is not consistent with the non-limiting restriction of the STS 4.2.1 LTA provision. To satisfy the more restrictive STS 4.2.1 LTA provision, the lead assembly technical evaluation report must demonstrate that all radiological consequences docketed within the licensee's UFSAR remain applicable and bounding.

To aid in the demonstration that all radiological consequences have no more than a minimal increase in consequences docketed within the licensee's UFSAR, Sections B.2.5 and B.5 of Amendment 51 (Ref. 2) provide analytical methods which may be used in the technical evaluation. As described further below, these same analytical methods could also be used to satisfy the more restrictive STS 4.2.1 LTA provision requirement that all UFSAR radiological consequences remain applicable and bounding.

For DBAs involving significant core damage and larger radiological source terms (e.g., loss-of-coolant accident, control rod drop accident) as compared to DBAs involving limited fuel damage, one acceptable method of demonstrating that the UFSAR radiological consequences remain applicable and bounding is to show that impact of the limited quantity of lead assembly fuel rods, if they are predicted to fail, does not increase the total radiological source term assumed in the licensee's UFSAR radiological consequence assessments.

For DBAs involving limited fuel damage (e.g., fuel handling accident), one acceptable method of demonstrating that the UFSAR radiological consequences remain applicable and bounding is to show that the total radiological source term residing in the void volume of the lead assembly fuel rods is lower than that assumed in the licensee's UFSAR radiological consequence assessments. In addition, the total number of failed fuel rods must remain below that assumed in the UFSAR radiological consequence assessments.

The only means to assess the potential impact of the lead fuel assemblies on the radiological consequences is to evaluate the differences in the design, physical properties, and operation of those rods. The potential impacts of fuel rod design and operating history on the total radiological source term residing in the lead fuel rods are unknown and may negatively impact radiological consequences. For example, a new fuel rod cladding material could promote higher fuel temperature, release more fission gas, and increase the total radiological source term residing in the lead fuel rods (relative to UFSAR analyses). Alternatively, dopants added to UO_2 fuel pellets could increase fuel thermal conductivity which would promote lower fuel temperature, release less fission gas, and decrease the total radiological source term residing in the lead fuel rods (relative to UFSAR analyses). Thus, the licensee's determination of whether the lead assembly program satisfies the STS 4.2.1 LTA restrictions and whether it can be conducted without a license amendment request must always consider the potential impacts of fuel rod design and operating history.

To aid in this demonstration, Amendment 51 provides three analytical approaches, which Amendment 51 refers to as "credits," related to lead assembly fuel rod design specifications and operational characteristics that could be used when calculating the total radiological source term residing in the void volume:

1. Reduced lead assembly fuel rod power relative to peaking factors assumed in dose calculations

2. Time-in-life and radionuclide decay

3. The lower gap fractions at high exposures for modern fuel types

While Amendment 51 describes these particular items as potential “credits,” they are actually analytic approaches licensees can use during the safety demonstration. These three approaches are only “credits” if the lead fuel rods are designed and operated in a manner which results in a lower overall source term. Credit 3 relates to lead fuel assembly design specification and material properties, credits 1 and 3 relate to power operating history, and credit 2 relates to the time-in-life dependent release and decay of radionuclides. These three credits permit licensees to determine the total radiological source term residing in the void volume of the lead assembly fuel rods, which, as discussed above, is one method of demonstrating that UFSAR radiological consequences remain applicable and bounding. If these three approaches yield a lower source term, then that demonstrates that the lead assembly fuel rods are less limiting than the UFSAR radiological consequences assessments. If the lead assembly fuel rods are less limiting than the USFAR radiological consequences assessments, then the risk to the public is either not impacted or is reduced by the presence of the lead assemblies. Therefore, these credits are an acceptable means of demonstrating that the exiting UFSAR radiological consequences remain applicable and bounding.

As described earlier in this safety evaluation and in prior guidance (Ref. 6), use of modified analytical methods, solely for the evaluation of a limited number of lead assemblies, is acceptable for confirming that they are placed in non-limiting locations and that the UFSAR safety analyses, which themselves are calculated using approved codes and methods, remain applicable and bounding. Based on the STS 4.2.1 restrictions and low probability of design basis accidents, employing the above analytical methods in this manner does not constitute a departure from a method of evaluation described in the UFSAR as defined by 10 CFR 50.59 (c)(2)(viii). Use of the above analytical methods also does not constitute a subsequent change to the fission product inventory of the radionuclides released from the reactor fuel as defined by 10 CFR 50.67 because they help demonstrate that the source term residing in the void volume of the lead assembly fuel rods is lower than the total radiological source term assumed in the licensee’s UFSAR radiological consequence assessments.

A condition on the staff’s approval of Amendment 51 is necessary to ensure the more restrictive provisions of STS 4.2.1, relative to 50.59(c)(2)(iii), are satisfied. Specifically, the acceptance criterion used to judge the impact of the lead assemblies on the radiological consequences, as discussed in Section B.2.5 and B.5 of Amendment 51, must be revised:

> L&C #1: Sections B.2.5 and B.5 of Amendment 51 must be revised to replace the criterion “no more than a minimal increase in consequences” with the criterion “demonstrate that all radiological consequences docketed within the licensee’s UFSAR remain applicable and bounding”.

Satisfying the above general program requirements ensures that the presence of lead assemblies will not result in fuel damage as a result of normal operation and AOOs, or underestimate fuel damage and challenge core coolable geometry and control rod insertion during postulated accidents. This is consistent with SRP Section 4.2. Based on this, the staff finds the general program requirements, as amended by L&C #1, acceptable for demonstrating compliance with the restrictions on the combination of lead assembly quantities and location.

During a virtual audit (Ref. 3), NRC and GNF staff discussed the possibility of multiple, concurrent (or overlapping) lead assembly programs in a single reactor core. These discussions resulted in the following restriction:

> When more than one type of lead assembly is inserted in a given cycle, the maximum number of lead assemblies shall be limited to 20 for plants with greater than or equal to 560 assemblies and 12 for plants with less than 560 assemblies.

Given that the individual and combined effects of the multiple lead assembly programs will need to satisfy the general program requirements listed above pertaining to demonstrating compliance with lead assembly quantities and location restrictions, the NRC staff finds this limitation acceptable.

3.2 LTA Exemption to 10 CFR 50.46

Section B.2.2.2 of Appendix B as presented in Amendment 51 includes a provision for the exemption of LTAs from 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors." Section B.2.2.2 states that, because LTAs shall be shown to not significantly influence the plant's behavior under LOCA conditions or adversely affect the performance of the emergency core cooling system, it is not necessary for the licensee to request an exemption to 10 CFR 50.46. This ~~showing~~ demonstrates compliance with the 10 CFR 50.46 fuel performance and emergency core cooling system performance requirements. This is consistent with the guidance provided in the NEI LTA letter regarding whether an exemption from 10 CFR 50.46 is necessary as discussed in Section 2.0 of this safety evaluation.

Because compliance with the fuel performance and emergency core cooling system performance requirements of 10 CFR 50.46 will be demonstrated for reactor cores with LTAs co-resident with reload fuel, licensees will remain compliant with 10 CFR 50.46. Therefore, the NRC staff finds that an exemption to "expand" the applicability of 10 CFR 50.46 to other materials is not necessary under the GESTAR II framework for a licensee to conduct an LTA campaign under the STS LTA provision so long as the licensee makes the requisite showing under Section B.2.2.2.

4.0 LIMITATIONS AND CONDITIONS CONCLUSION

Licensees referencing GESTAR II Amendment 51 must ensure compliance with the following conditions and limitations:

1. Sections B.2.5 and B.5 of Amendment 51 must be revised to replace the criterion "no more than a minimal increase in consequences" with the criterion "demonstrate that all radiological consequences docketed within the licensee's UFSAR remain applicable and bounding".

5.0 CONCLUSION

The purpose of Amendment 51 was to modify the provisions within GESTAR II related to introducing fuel design changes. Stemming from past NRC staff audits of new fuel bundle design compliance reports, the main two GESATR II modifications included: (1) updating the lead fuel assembly provisions and (2) adding a new subsection containing a commitment to confirm the applicability of the GESTAR II design criteria for new fuel assembly design features. Amendment 51 introduces Appendix B, “Lead Assembly Programs,” which presents requirements for three distinct lead assembly programs within the GESTAR II licensing framework. Specifically, Appendix B defines the bases for satisfying the limited number restriction and non-limiting core location restriction within STS Section 4.2.1 for LTAs, LUAs, and HBLUAs. This new appendix supersedes a composite of legacy letters related to lead assemblies.

Based upon its review of GESTAR II Amendment 51, RAI responses, and the virtual regulatory audit, the NRC staff finds that Amendment 51 complies with the relevant regulatory requirements and the STS provision. The NRC staff consequently finds Amendment 51 acceptable.

6.0 <u>REFERENCES</u>

1. Global Nuclear Fuel Americas, “Proposed Amendment 51 to NEDE-24011-P-A-29, General Electric Standard Application for Reactor Fuel (GESTAR II),” March 17, 2020, ADAMS Package Accession No. ML20077J159.

2. Global Nuclear Fuel Americas, “Response to Nuclear Regulatory Commission Request for Additional Information Regarding Amendment 51 to NEDE-24011-P-A-29, General Electric Standard Application for Reactor Fuel (GESTAR II),” July 31, 2020, ADAMS Package Accession No. ML20213C646.

3. U.S. Nuclear Regulatory Commission Regulatory Audit of Global Nuclear Fuel - Americas (GNF) Topical Report, NEDE-24011-P-A-29, GESTAR II, Amendment 51 Appendix B, Lead Assembly Programs Audit Summary Report, July 21, 2020, ADAMS Accession No. ML20177A294.

4. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants” (SRP), Section 4.2, “Fuel System Design,” Revision 3, March 2007, ADAMS Accession No. ML070740002.

5. Westinghouse Topical Report, Limited Scope High-Burnup Lead Test Assemblies,” WCAP-15604-NP, Revision 2-A, September 2003, ADAMS Accession No. ML070740225.

6. NRC Letter to NEI, “Clarification of Regulatory Path for Lead Test Assemblies,” June 24, 2019, ADAMS Accession No. ML18323A169.

7. NUREG-1433, “Standard Technical Specifications, General Electric BWR/4 Plants,” Revision 4, April 2012, ADAMS Accession No. ML12104A192.

8. NEDE-24011-P-A, Revision 30, “General Electric Standard Application for Reactor Fuel (GESTAR II), April 2020, ADAMS Package Accession No. ML20104C087.

9. Global Nuclear Fuels America, “GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II),” NEDO-33270, March 2007, ADAMS Accession No. ML070780337.

10. Final Safety Evaluation by the Office of Nuclear Reactor Regulation Topical Report NEDC-33256P, NEDC33257P, and NEDC-33258P, “The Prime Model for Analysis of Fuel Rod Thermal-Mechanical Performance,” ADAMS Package Accession No. ML100210284.

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Change Pages for Draft SE Response

Appendix B

Lead Assembly Programs

extensive high-burnup experience in European plants, meaning there is little risk of failure during normal operations. If failures were to occur, the number would be limited, readily detectable and handled by normal plant operating systems. Therefore, these limits of HBLUAs meets the definition of a "limited number" in a licensee's Technical Specifications. These limits supersede the 2% limit on extended life NSF channels in Reference 1.

B.2.5 Limitations and Exceptions

The lead assembly technical evaluation report shall demonstrate **that all radiological consequences docketed within the licensee's UFSAR remain applicable and bounding** ~~that all radiological consequences have no more than a minimal increase in consequences docketed within the licensee's UFSAR~~ even with some bundles or rods exceeding current exposure limits. Changes to inputs and assumptions may be used in the technical evaluation to demonstrate that lead assemblies have no ~~more than a minimal~~ increase in consequence compared to existing UFSAR radiological consequences and these changes do not constitute a departure from an approved methodology as defined by 50.59 and the requirement of NRC approval to use under 10 CFR 50.67. Such changes to inputs and assumptions reflect the low probability of occurrence for postulated accidents and the limited quantity of lead assemblies and are based on sound engineering judgement, well-established engineering practices, and all available data to the extent practical. Examples of changes to inputs and assumptions which fit this definition and could be credited to account for additional uncertainties associated with LTAs, LUAs, and HBLUAs are listed below

- Credit for reduced lead assembly fuel rod power relative to peaking factors assumed in dose calculations. Fuel rod power history has a direct impact on both the rate and quantity of fission gas released from the pellet into the fuel rod plenum. During a postulated accident, the quantity of fission gas residing in the plenum and available for release upon cladding failure will be less in fuel rods operating at lower power. To fulfill the non-limiting location requirement, LUA and LTA fuel rods will likely operate at lower power than the leading co-resident fuel and certainly below COLR power limits (which likely coincide with peaking assumed in dose calculations). Based on the natural consequence of fissile depletion and diminishing reactivity at higher exposure and the fact that power is constrained by COLR power limits that are reduced at higher exposures, HBLUAs operate at power levels significantly below those assumed in dose calculations. By crediting the reduced power and associated plenum inventory for LUAs, LTAs and HBLUAs, it may be possible to **demonstrate that all radiological consequences docketed within the licensee's UFSAR remain applicable and bounding.**~~show no more than a minimal increase in consequence compared to the current UFSAR radiological consequences consistent with the requirements of 50.59.~~

- Credit for time-in-life and radionuclide decay. Long-lived, stable radionuclides (e.g., Kr-85 with a 10.8 year half-life) accumulate in the fuel rod plenum with maximum quantities near end-of-life. Whereas the maximum quantity for short-lived, volatile radionuclides (e.g., I-131 with a 8 day half-life) tends to occur earlier in life when the ratio of release rate (function of burnup and temperature) to production rate (i.e., fission rate) is at its highest. RG 1.183 Table

3 (Reference 2) provides acceptable radionuclide gap fractions which have been adopted by many licensees. The values in Table 3 represent a composite worst time-in-life; meaning that the long-lived radionuclides represent end-of-life and the short-lived radionuclides represent earlier-in-life. For HBLUAs, the accumulated quantity of long-lived radionuclides will increase and may exceed the RG 1.183 Table 3 gap fractions; however, the quantity of short-lived radionuclides will decrease and remain well below the RG 1.183 Table 3 gap fractions. Since the short-lived radionuclides (e.g., I-131) have a larger impact on overall radiological consequences, it may be possible to **demonstrate that all radiological consequences docketed within the licensee's UFSAR remain applicable and bounding.**~~show that HBLUAs have no more than a minimal increase in consequence compared to the current UFSAR radiological consequences consistent with the requirements of 50.59.~~

- Credit for fuel rod design and operating history. For example, the design of 10x10 fuel rods compared to 8x8 fuel rods leads to lower fuel temperatures and results in lower gap fractions. In addition, using the actual operating history for the evaluation of HBLUAs may also be used to show reduced gap fractions at higher exposures such that HBLUAs have no ~~more than a minimal~~ increase in consequence compared to the **docketed values within the licensee's UFSAR and that the docketed values remain applicable and bounding.**~~current UFSAR radiological consequences consistent with the requirements of 50.59.~~

It is acceptable to insert more than one type of lead assembly in any given cycle. The expectation is that the most likely combinations are HBLUAs with LUAs and HBLUAs with LTAs. Because of the low risk of operating the maximum number of HBLUAs, it is judged acceptable to operate an additional 4 LUAs or 4 LTAs to allow for symmetric usage of lead assemblies in core design. Like the HBLUAs, there is low risk in operating LUAs and for LTAs the technical justification for operating 4 with 16 HBLUAs shall be provided to the NRC in the information letter sent by the licensee. Therefore, when operating with more than one type of lead assembly, the maximum number shall be limited to 20 for plants with greater than or equal to 560 assemblies and 12 for plants with fewer than 560 assemblies. These limits apply to any combination of LTAs, LUAs and HBLUAs operating in a cycle and meet the "limited number" requirement in the Technical Specifications.

B.3 Test Plans and Reporting to the NRC

B.3.1 Lead Test Assemblies

The testing and inspection plans associated with an LTA program are variable and depend on the nature of the new technology. The licensee inserting an LTA shall send the NRC an information letter that describes the LTA program, the duration of the LTA program, and associated inspection plans. LTA test plans and performance findings shall be included in the annual GNF Technology Update meetings. LTAs shall be characterized prior to insertion to provide a baseline for subsequent inspections.

B.5 Program Requirements

The following provides general requirements for inserting any lead assembly, regardless of the type. Specific requirements are then defined for LUA, LTA, and HBLUA.

Common general requirements for inserting lead assemblies are as follows:

1. Compliance with Specified Acceptable Fuel Design Limits (SAFDLs) shall be maintained. Lead assemblies shall be accounted for in standard reload licensing evaluations documented in the Supplemental Reload Licensing Report (SRLR) or other appropriate licensing reports.

2. GNF shall provide the licensee a technical evaluation report that addresses all fuel design and safety requirements not considered in the SRLR and needed to support insertion of the lead assemblies by either a 50.59 assessment or a Licensing Amendment Request, if the 50.59 is not successful.

   The lead assembly technical evaluation report shall demonstrate that lead assemblies have no ~~more than a minimal~~ increase in radiological consequence compared to the **docketed values within the licensee's UFSAR and that the docketed values remain applicable and bounding.**~~licensee's UFSAR basis consistent with the requirements of 50.59.~~ Changes to inputs and assumptions that could be credited to account for additional uncertainties associated with LTAs, LUAs, and HBLUAs are listed below:

   - The reduced lead assembly fuel rod power relative to peaking factors assumed in dose calculations.
   - The time-in-life and radionuclide decay.
   - The lower gap fractions at high exposures for modern fuel types.

3. When lead assemblies are inserted into a plant, the licensee shall send the NRC an information letter describing the LUA, LTA, or HBLUA program, including an inspection plan with basis and duration of program. The information letter shall be sent to the NRC no later than 60 days after startup of the cycle in which the program will begin. Should unforeseen plant operational issues result in the need to modify the program, the licensee shall provide an updated letter informing the NRC of the changes 60 days after the change has been designed.

4. A summary of the status of all lead assembly programs (including available inspection results) shall be provided annually in a presentation at the Technology Update meeting between GNF and the NRC or in a report sent to the NRC.

5. For normal operations and AOOs, lead assemblies shall be designed as non-limiting relative to reload assemblies for those regulatory requirements that are evaluated to have increased uncertainty because of the new design features.

6. For DBAs, lead assemblies shall be designed to assure regulatory requirements are maintained with sufficient margin to account for uncertainties.

7. When more than one type of lead assembly is inserted in a given cycle, the maximum number of lead assemblies shall be limited to 20 for plants with greater than or equal to 560 assemblies and 12 for plants with fewer than 560 assemblies.