DOCKET: 70-1113

LICENSEE: Global Nuclear Fuel – Americas, LLC
Wilmington, North Carolina

SUBJECT: GLOBAL NUCLEAR FUEL - AMERICAS – CHANGES TO MATERIALS LICENSE SNM-1097 AND AMENDMENT 14
(ENTERPRISE PROJECT IDENTIFICATION L-2018-LLA-0139)

BACKGROUND

In a letter dated May 10, 2018 (GNF-A, 2018a), Global Nuclear Fuel – Americas (GNF-A) submitted a License Amendment Request (LAR) for Chapter 5, Nuclear Criticality Safety, of the license. Evaluated in this review was the GNF-A response (GNF-A, 2018b), dated August 2, 2018, to a Request for Additional Information (RAI) sent on June 29, 2018 (NRC, 2018). The most current application (GNF-A, 2016a) was considered as a part of this review.

DISCUSSION

The licensee's LAR submittal included a revision to Chapter 5 and described administrative changes, clarifications, and several proposed technical changes. The licensee provided a technical justification for each proposed change. In response to NRC staff's request for additional information, the licensee provided additional supporting information as described below. The following section summarizes each proposed change and describes the staff's review. The staff reviewed the licensee's proposed changes to Chapter 5.0 of the LA relative to the previous approved version (GNF-A, 2016a) using the guidance provided in Chapter 5, "Nuclear Criticality Safety," of NUREG-1520, Rev. 2 (NRC, 2015). The proposed changes are discussed below.

(1) Revised LA Chapter 5.1.1 "Criticality Safety Design Philosophy"

Update to ANSI/ANS-8.1 Reference

Chapter 5.1.1 of the LA currently identifies the Double Contingency Principle (DCP), as described in Section 4.2.2 of the American National Standard (ANSI) ANSI/ANS-8.1 (ANSI, 1998), "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," as the fundamental technical basis for the design and operation of processes within the GNF-A fuel manufacturing operation. The proposed change would update the reference to the DCP from the ANSI/ANS-8.1 1998 version to the 2014 (ANSI, 2014a) version. Chapter 5.4.3.1.1 of NUREG-1520 states that, in general, an applicant (or licensee) should commit to the most current version of a standard that has been endorsed by the NRC in Regulatory Guide (RG)-3.71. Revision 2 of RG-3.71 (NRC, 2010), currently endorses the 1998 version of ANSI/ANS-8.1 with one exception. However, the exception involves guidance on validating calculational methods for NCS, and does not affect the endorsement of Section 4.2.2 as it relates to the DCP.

Because the NRC does not currently endorse the 2014 version of the standard, the staff reviewed the 2014 version and did not identify any additional exceptions or clarifications needed to make it acceptable for use in licensing with respect to the proposed change. Additionally, the NRC has issued a draft update to RG-3.71, Rev. 2, as draft guide DG-3053, "Nuclear Criticality Safety Standards for Nuclear Materials Outside Reactor Cores" (NRC, 2017) which discusses the 2014 version of the standard and does not identify any additional exceptions or clarifications that would affect the proposed changes. Therefore, the staff finds this proposed change to be acceptable.

Addition of ANSI/ANS-8.1, Section 4.1.2, to NCS Design Philosophy

The proposed change adds an additional NCS philosophy from ANSI/ANS-8.1, Section 4.1.2, regarding process analysis. ANSI/ANS-8.1 (ANSI, 2014) describes this philosophy as:

> *"Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions."*

As previously stated, RG-3.71, Rev. 2 (NRC, 2010), endorses ANSI/ANS-8.1 (NRC, 1998), with one exception. Because the NRC does not currently endorse the 2014 version of the standard, the staff reviewed the 2014 version and did not identify any additional exceptions or clarifications needed to make it acceptable for use in licensing with respect to the proposed change. Additionally, the NRC has issued a draft update to RG-3.71, Rev. 2, as draft guide DG-3053, "Nuclear Criticality Safety Standards for Nuclear Materials Outside Reactor Cores" (NRC, 2017) which discusses the 2014 version of the standard and does not identify any additional exceptions or clarifications that would affect the proposed changes. Therefore, the staff finds this proposed change to be acceptable.

Revision to the Definition of DCP

As previously discussed, LA Chapter 5.1.1 currently identifies the DCP as the fundamental technical basis for the design and operation of processes within the GNF-A fuel manufacturing operation. However, there is one important distinction between how the DCP is defined in Section 4.2.2 of ANSI/ANS-8.1 (ANSI, 2014a) and the current LA (GNF-A, 2016a). The DCP as defined in ANSI/ANS-8.1 uses the term "should," whereas the current LA uses the term "shall." This is an important distinction as ANSI/ANS 8.1, Section 3.2, states that the use of the word "shall" is to denote a requirement, whereas the use of the word "should" is used to denote a recommendation.

The proposed change revises the DCP, as stated in LAR Chapter 5.1.1, to use the word "should" as opposed to "shall," bringing LA Chapter 5.1.1 into alignment with the DCP as stated in ANSI/ANS-8.1 (ANSI, both 1998 and 2014 versions). RG-3.71, Rev. 2 (NRC, 2010), endorses section 4.2.2 (describing the DCP) of ANSI/ANS-8.1. Additionally, the definition of the DCP as stated in Title 10 of the *Code of Federal Regulations* (10 CFR), Part 70, is consistent with ANSI/ANS-8.1 in that it also uses the term "should." Therefore, the staff finds the proposed change to be consistent with NRC endorsed standards and regulations, and to be acceptable.

Replacement of "IROFS" with "Parameters," Chapter 5.1.1(e)

Chapter 5.1.1 of the LA currently states that the licensee's NCS program management commits to several objectives, including establishing and maintaining NCS subcritical limits for identified items relied on for safety (IROFS). The proposed change replaces the term "IROFS" with the term "parameters."

Section 3.3 of the ANSI/ANS-8.1 (ANSI, 2014a), defines parameter as one of the total set of factors that defines a fissionable system and determines its neutronic behavior. Generally, NCS parameters include (but are not necessarily limited to) fissionable mass, neutron absorption, geometry, neutronic interaction, concentration, moderation, enrichment, reflection, volume, and heterogeneity. Section 3.3 of the ANSI/ANS-8.1 (ANSI, 2014a), defines subcritical limit as the limiting value assigned to a controlled parameter that results in a subcritical system under specified conditions. While the controlled parameter limit may allow for uncertainties in the calculations and experimental data used in its derivation, it does not necessarily account for contingencies such as double batching or failure of analytical techniques to yield accurate values. In meeting the requirements of 10 CFR 70.61(d), which requires, in part, the assurance of subcriticality under all normal and credible abnormal conditions, such contingencies must be considered and may affect the overall design or limits associated with an IROFS. While the subcritical limits established and maintained by the NCS program may be used to inform the design or limits associated with IROFS, they are situationally dependent and ultimately may differ. The staff finds the proposed change to align with the terminology used in ANSI/ANS-8.1 (ANSI, 2014), and to be acceptable.

Other Proposed Changes to LA Chapter 5.1.1

The staff reviewed all other proposed changes from LAR Chapter 5.1.1 and determined that they did not alter the technical meaning of the licensee's commitments, and are therefore acceptable.

(2) Revised LA Chapter 5.1.4.1, "Posting of Limits and Controls"

Chapter 5.1.4.1 of the LAR currently contains a significant amount of detail as to what type of information may be included on NCS postings. The proposed change would remove much of the detail, and instead refer to the licensee's internal procedures for requirements and guidance on what information should be included on NCS postings.

Chapter 5.1.3 of the LAR discusses the licensee's commitments in regard to procedures, and states that the procedures that govern the handling of enriched uranium are reviewed and approved by the NCS function. Additionally, this section states that each Area Manager is responsible for developing and maintaining procedures that incorporate limits and controls established by the NCS function. Although the proposed change removes details as to what type of information may be included on NCS postings and instead refers to the licensee's internal procedures, the licensee's commitments regarding internal procedures provide reasonable assurance that NCS postings of limits and controls will be maintained such that there is no degradation to the NCS program. Therefore, the staff finds this proposed change to be acceptable.

(3) Revised LA Chapter 5.3.1, "General Configuration Management" and LA Chapter 5.3.2.5, "Criticality Accident Alarm System (CAAS) Design and Performance Requirements"

Chapter 5.3.1 of the LA currently states that criticality safety analyses are a collection of information that provide sufficient detail, clarity, and lack of ambiguity to allow independent judgment of results in accordance with the 2005 version of ANSI/ANS-8.19, "Administrative Practices for Nuclear Criticality Safety," (ANSI, 2005).

Chapter 5.3.2.5 of the LA currently states, in reference to the licensee's criticality accident alarm system (CAAS), that individual unit detectors are located to assure compliance with the appropriate requirements of the 2003 version of ANSI/ANS-8.3, "Criticality Accident Alarm System," (ANSI, R2003).

The proposed changes would update these references from the 2005 version of ANSI/ANS-8.19 to the 2014 version (ANSI, 2014b), and from the 2003 version of ANSI/ANS-8.3 to the reaffirmed 2012 version (ANSI, R2012). Section 5.4.3.1.1 of NUREG-1520 states that, in general, an applicant (or licensee) should commit to the most current version of a standard that has been endorsed by the NRC in Regulatory Guide (RG)-3.71. RG-3.71, Rev. 2 (NRC, 2010), currently endorses the 2005 version of ANSI/ANS-8.19 and the 1997 (reaffirmed in 2003) version of ANSI/ANS-8.3 with exceptions. The exceptions taken to ANSI/ANS-8.3 do not, however, affect the proposed changes. Because the NRC does not currently endorse the newer versions of these standards, the staff reviewed the newer versions of both standards and did not identify and additional exceptions or clarifications needed to make them acceptable for use in licensing with respect to the proposed changes. Additionally, the NRC has issued a draft update to RG-3.71, Rev. 2, as draft guide DG-3053 (NRC, 2017), which discusses the newer versions of both standards and does not identify any additional exceptions or clarifications that would affect the proposed changes. Therefore, the staff finds these proposed changes to be acceptable.

(4) Revised LA Chapter 5.3.2.7, "NCS Records Retention"

Chapter 5.3.2.7 of the LA currently states, in regard to records of criticality safety analyses, that "such records are retained during the conduct of the activities and for six months following cessation of such activities to which they apply or for a minimum of three years." The proposed change removes details describing records retention requirements, and instead states that such records are retained in accordance with internal records management requirements outlined in LA Chapter 11.8.

Chapter 11.8 of the LA states that "records of criticality safety analyses are maintained in sufficient detail and form to permit independent review and audit of the method of calculation and results. Such records are retained during the conduct of the activities and for six months following the cessation of such activities to which they apply or for a minimum of three years." Although the proposed change removes details describing records retention requirements from LA Chapter 5.3.2.7, Chapter 11.8 contains the same details. Therefore, the staff finds the proposed change to be acceptable.

(5) Revised LA Chapter 5.4.1, "Control Practices" and Chapter 5.4.1.1, "Verification Program"

Changes to the Description of Control Practices and the Verification Program

Chapter 5.4.1 of the LA currently states that prior to use in any enriched uranium process, NCS controls are verified against NCS analysis criteria, and that the integrated safety analysis (ISA) program implements performance based management of process requirements and specifications that are important to NCS. The proposed change removes this text, and instead states that the Area Manager, with NCS support, implements the limits and controls documented in the Criticality Safety Analysis (CSA). Additionally, LA Chapter 5.4.1.1 currently states that the NCS function observes or monitors the performance of initial functional tests and conducts pre-operational audits to verify that the controls function as intended and the installed configuration agrees with the CSA. The proposed change revises this statement to state that the NCS function conducts pre-operational audits (e.g., field verification of design features, functional test review) to verify that the installed configuration agrees with the CSA.

In comparing the proposed language to the current language contained in LA Chapter 5.4.1.1, the licensee's commitment that the NCS function observes or monitors the performance of initial functional tests has been removed. However, the proposed change provides a parenthetical which clarifies that the pre-operational audits performed by the NCS function to verify that the installed configuration agrees with the CSA include such activities as functional test reviews. Therefore, the proposed change does not alter the licensee's commitments with respect to observing or monitoring functional tests. The use of the term "pre-operational audits" necessitates that such audits be conducted prior to operation or use in any process involving fissionable material (e.g., enriched uranium). The proposed change does not alter the licensee's commitments with respect to performing such audits, nor does it alter their commitments to conduct these audits *prior* to use in any enriched uranium process. The proposed revision to LA Chapter 5.4.1 states that the Area Manager, with NCS support, implements the limits and controls documented in the CSA. In comparing this to the current language contained in LA Chapter 5.4.1, the proposed change clarifies that the implementation of limits and controls documented in the CSA is the Area Manager's direct responsibility, not the ISA program. The proposed change does not alter the licensee's commitments with respect to the implementation of limits and controls documented in CSAs.

Because the proposed change does not alter the licensee's commitments with respect to performing pre-operational audits and the commitments to conduct such audits *prior* to use in any enriched uranium process, nor does the proposed change alter the licensee's commitments with respect to the implementation of limits and controls documented in CSAs, the staff determined the proposed change does not significantly impact the licensee's programmatic commitments for management of the NCS program, and is therefore acceptable.

<u>Other Proposed Changes to LA Chapters 5.4.1 and 5.4.1.1</u>

The staff reviewed all other proposed changes from LA Chapters 5.4.1 and 5.4.1.1, and determined that they did not alter the technical meaning of the licensee's commitments, and are therefore acceptable.

(6) Revised LA Chapter 5.4.2.1, "Passive Engineered Controls," and Chapter 5.4.2.2, "Active Engineered Controls"

Chapter 5.4.2.1 of the LA currently defines a passive engineered control as "a device that uses only fixed physical design features to maintain safe process conditions without any required human action." The proposed change alters the definition, defining a passive engineered control as "a device that uses only fixed physical design features to maintain safe process conditions. Beyond appropriate installation and management measures (e.g., periodic inspection, preventive maintenance), a passive engineered control requires no human action to perform its safety function."

Chapter 5.4.2.2 of the LA currently defines an active engineered control as "a physical device that uses active sensors, electrical components, or moving parts to maintain safe process conditions without any required human action. Assurance is maintained through specific periodic functional testing as appropriate. Active engineered controls are designed to be fail-safe (i.e., meaning failure of the control results in a safe condition)." The proposed change alters the definition, defining an active engineered control as "a physical device that uses active sensors, electrical components, or moving parts to maintain safe process conditions. Beyond appropriate installation and management measures (e.g., periodic functional testing), an active engineered control requires no human action to perform its safety function. Assurance is maintained through specific periodic calibration, functional testing, and preventive maintenance as appropriate. Active engineered controls that are designed to be fail-safe (i.e., meaning failure of the control results in a safe condition) are preferred."

The proposed changes do not significantly alter the licensee's commitments contained in LA Chapters 5.4.2.1 and 5.4.2.2, and are therefore acceptable.

(7) Revised LA Chapter 5.4.2.3, "Administrative Controls"

Revision to the Use of Administrative Controls

Chapter 5.4.2.3 of the LA currently states that the use of administrative controls is limited to situations where passive and active engineered controls are not practical, whereas the proposed change states that their use *should* be limited to such situations.

NUREG-1520 (NRC, 2015) states that passive engineered controls are generally considered preferable to active engineered controls, and that active engineered controls are generally considered preferable to administrative controls. This is because, ordinarily, passive engineered controls are the most reliable, and administrative controls are the least reliable. Although preferred, the use of administrative controls only in situations where passive and active engineered controls is not practical is not specifically required by 10 CFR Part 70. Therefore, the staff determined that the proposed change is consistent with the requirements of 10 CFR Part 70 in regard to NCS, and is acceptable.

Other Proposed Changes to LA Chapter 5.4.2.3

The staff reviewed all other proposed changes from LA Chapter 5.4.2.3 and determined that they did not alter the technical meaning of the licensee's commitments, and are therefore acceptable.

(8) Revision to LA Chapter 5.4.3, "Specific Parameter Limits"

Replacement of "Safe Geometry" with "Favorable Geometry"

Chapter 5.4.3 of the LA currently states that the safe geometry values of Table 5.1 are specifically licensed for use at GNF-A. The proposed change alters the statement to read that favorable geometry values of Table 5.1 contain dimensions for sphere, cylinder, and slab which may be used for applicable operations. A key distinction between the two statements is the replacement of the term "safe geometry" with "favorable geometry."

NUREG-1520 (NRC, 2015)) defines favorable geometry as "a characteristic of structures, systems, devices, or equipment such that fissile material maintained within specified dimensions will be subcritical under the most reactive credible conditions (defined for a given isotopic composition and physiochemical form)." This differs in that the term "safe geometry" generally refers to a characteristic of structures, systems, devices, or equipment such that fissile material maintained within specified dimensions will be subcritical under absolute optimum conditions not specific to a given isotopic composition or physiochemical form. The use of the term "favorable geometry" is highly preferred because it not only better describes the characteristic of structures, systems, devices, or equipment, but it also introduces less opportunity for confusion. The staff determined that the proposed change does not alter the licensee's commitments with respect to the use or application of the limits contained in Table 5.1, and is therefore acceptable.

Applicability of Favorable Geometry and Safe Batch Values with Respect to Reflection and Moderation

Chapter 5.4.3 of the LA currently states that application of the geometry values contained in Table 5.1 is limited to situations where the neutron reflection present does not exceed that due to full water reflection.

The proposed change clarifies that the application of the favorable geometry values contained in Table 5.1, and the safe batch values contained in Table 5.2, are both limited to situations where the neutron reflection present does not exceed that due to full water reflection and the moderating material is not more effective than water. The proposed change is conservative, provides better clarity on the applicability of favorable geometry and safe batch values, and does not alter the licensee's commitments with respect to the application of the values contained in Tables 5.1 and 5.2. The staff determined the proposed change is acceptable.

Deletion of 1 of 4 Methods of Applying Safe Batch Values

Chapter 5.4.2.3 of the LA currently states, with respect to the safe batch values contained in Table 5.2, that criticality safety may be based on U-235 mass limits in either one of four methods. The proposed change deletes the method that states where engineered controls prevent over batching, a mass of 75 percent of the minimum critical mass shall not be exceeded.

The licensee stated in their letter dated August 2, 2018 (GNF-A, 2018b) that the reason for the proposed change was that the method was no longer used. The deleted method does not necessarily represent a license commitment; it simply represents one of four acceptable methods for applying the safe batch values contained in Table 5.2. The staff determined that the proposed change does not alter the technical meaning of the licensee's commitments with respect to specific parameter limits, and is therefore acceptable.

Other Proposed Changes to LA Chapter 5.4.3

The staff reviewed all other proposed changes from LA Chapter 5.4.3 and determined that they did not alter the technical meaning of the licensee's commitments, and are therefore acceptable.

(9) Revised LA Table 5.1, "Favorable Geometry Values"

The proposed change replaces the term "safe" with "favorable" in the title of Table 5.1. The acceptability of this change is described in the discussion of the revised LA Chapter 5.4.3 above.

(10) Revised LA Chapter 5.4.4.2, "Mass"

The proposed change deletes the statement when only administrative controls are used for mass controlled systems, double batching is considered to ensure adequate safety margin.

Chapter 5.1.1 of the proposed LA states that "before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions." Although the proposed change deletes the explicit statement regarding the consideration of double batching, the commitments of the proposed LA Chapter 5.1.1 require the licensee to consider and assure subcriticality of all normal and credible abnormal conditions, including conditions involving over batching. The staff finds the proposed change to be acceptable.

(11) Revised LA Chapter 5.4.4.3, "Moderation"

Chapter 5.4.4.3 of the LA currently states that "when moderation is the primary criticality safety control parameter, the following graded approach to the design control philosophy is applied in accordance with established facility practices (in decreasing order of restriction):

- At each enriched uranium interface involving intentional and continuous introduction of moderation (e.g., insertion of superheated steam into reactor), at least three controls are required to assure that the moderation safety factor is not exceeded. At least two of these controls must be active engineered controls.

- At enriched uranium interfaces involving intentional but non-continuous introduction of moderation, at least three controls are required to assure that the moderation safety factor is not exceeded. At least one of these controls must be an active engineered control, unless a moderation safety factor greater than 3 is demonstrated.

- For situations where moderation is not intentionally introduced as part of the process, the required number of controls for each credible failure mode must be established in accordance with the DCP.

When the maximum credible accident is considered, the safety moderation limit must provide sufficient factor of safety above the process moderation limit. The "moderation safety factor" is the ratio of the safety moderation limit to the process moderation limit. The moderation safety factor will normally be three or higher, but never less than two. In some cases, as described above, increased depth of protection may be required, but the minimum protection is never less than the following: two independent controls prevent moderator from entering the system through a defined interface and must fail before a criticality accident is possible."

The proposed change replaces the above entirely with a statement that "process evaluations for moderator controlled areas (MCAs) and moderator restricted areas (MRAs) shall explicitly identify the limits, controls, and engineered barriers for designated moderator control areas. Material properties, credible moderator present in, introduced to, or accumulated in an MCA/MRA shall be considered. Credible non-uniform distribution of moderators, moderator content measurement, and fire suppression methods shall also be considered."

The licensee stated in their letter dated August 2, 2018 (GNF-A, 2018b) that after over 20 years of operating history, GNF-A operational experience/lessons-learned supports the removal of the above text as it is no longer necessary for designated MRA processes. In meeting the licensee's commitments to NCS design philosophy as described in the proposed change to LA Chapter 5.1.1, before a new operation is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions. The conditions described in the deleted text (moderator introduction that is intentional and continuous, intentional but non-continuous, or unintentional) represent examples of normal and credible abnormal conditions that must be evaluated and determined to be subcritical. Although the proposed change deletes the above text, the licensee's commitments with respect to design philosophy, as described in the proposed change to LA Section 5.1.1, provide reasonable assurance that when moderation control is used, it will be used such that adequate protection of criticality hazards is provided. The staff finds the proposed change to be acceptable.

(12) Revised LA Chapter 5.4.4.4, "Concentration (Density)"

<u>Change to Preferred Method for Controlling Concentration</u>

Chapter 5.4.4.4 of the LA states that when concentration is the only parameter controlled to prevent criticality, concentration may be controlled by two independent combinations of measurement and physical control, each physical control capable of preventing the concentration limit being exceeded. Chapter 5.4.4.4 of the LA currently states that the preferred method of attaining independence is that at least one of the two combinations is an active engineered control.

The proposed change replaces the phrase "The proposed method of attaining independence…" with "The preferred method of demonstrating double contingency…" The importance of independence in this context is with respect to satisfying the DCP; therefore, the proposed change does not alter the technical meaning, and is therefore acceptable.

The proposed change also changes the preferred method of attaining independence (i.e., demonstrating double contingency) from at least one of the two combinations being an active engineered control, to one of the two combinations being a passive engineered control or at least one of the two being an active engineered control. NUREG-1520 (NRC, 2015) states that passive engineered controls are generally considered preferable to active engineered controls, and that active engineered controls are generally considered preferable to administrative controls. This is because, ordinarily, passive engineered controls are the most reliable, and administrative controls are the least reliable. Therefore, the change to the preferred method of attaining independence (i.e., demonstrating double contingency) by the use of a passive engineered control is conservative, and therefore acceptable.

Deletion of Controls Necessary to Detect and/or Mitigate the Effects of Internal Concentration

Chapter 5.4.4.4 of the LA currently states that "each process relying on concentration control has in place controls necessary to detect and/or mitigate the effects of internal concentration within the system, otherwise, the most reactive credible concentration is assumed." The proposed change removes this commitment.

The proposed LA Chapter 5.4.5.5 states that limits derived from calculations are based on most reactive values of uncontrolled parameters or based on worst credible values of uncontrolled parameters with documented justifications. Therefore, although the proposed change removes the statement that the most reactive credible concentration is assumed, the licensee's commitments from LA Chapter 5.4.5.5 provide reasonable assurance that there is no degradation to the licensee's commitment to use the most reactive credible concentration unless specifically controlled. Therefore, the staff finds the proposed change to be acceptable.

Other Proposed Changes to LA Chapter 5.4.4.4

The staff reviewed all other proposed changes from LA Chapter 5.4.4.4 and determined that they did not alter the technical meaning of the licensee's commitments, and are therefore acceptable.

(13) Revised LA Chapter 5.4.4.5, "Neutron Absorber"

Chapter 5.4.4.4 of the LA currently allows credit to be taken for neutron absorbers, such as gadolinia, added to fuel bundles. The proposed change would also allow credit to be taken for neutron absorbers, such as gadolinia, added to in-process fuel. The licensee stated in their letter dated August 2, 2018 (GNF-A, 2018b) that the term "in-process" fuel is used to describe nuclear material in a form other than a final process (e.g., uranium powder mixture, uranium ceramic pellet, fuel rod).

Because the use of a neutron absorber added to in-process fuel is not completely aligned with traditional methods of crediting absorbers (i.e., in this application the neutron absorber is technically neither a fixed or soluble absorber), there is not a directly applicable ANSI/ANS standard available for guidance. GNF-A considered ANSI/ANS-8.14, "Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors," (ANSI, 2011a) and ANSI/ANS-8.21, "Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors," (ANSI, 2011b) in order to determine if either standard would be applicable for use in crediting neutron absorbers added to in-process fuel. The licensee determined that for a form such as a uranium powder mixture, the presence of a neutron absorber does not meet the definition of a fixed absorber in ANSI/ANS-8.21, and is closer to the definition of a soluble neutron absorber in ANSI/ANS-8.14.

The licensee, therefore, developed the requirements for crediting neutron absorbers added to in-process fuel (established in LA Chapter 5.4.4.5) based on the administrative requirements and guidance from ANSI/ANS-8.14. The licensee performed an NCS analysis to determine the minimum weight percent of gadolinia necessary to assure subcriticality (GNF-A, 2016b).

The staff performed independent calculations to evaluate the impact on system reactivity due to the presence of gadolinia added to in-process fuel. The staff considered two bounding scenarios: 1) an infinite, homogeneous moderated system and 2) an infinite, heterogeneous moderated system. These two bounding scenarios were performed to evaluate the effects of gadolinia's presence within the system during multiple credible abnormal conditions, including moderation upsets (both interstitial and interspersed), and non-uniform gadolinia distribution within the fuel. All calculations performed independently by NRC staff were performed using approved modeling and simulation code Standardized Computer Analyses for Licensing Evaluation (SCALE/ KENO-VI)-6.1 code with the Evaluated Nuclear Data File (ENDF/B-VII) continuous energy library).

Infinite, Homogeneous System: In order to simulate an infinite system, a cuboid geometry was considered with mirror boundaries on all faces. The contents of the cuboid were uranium dioxide (UO_2), enriched to 5 weight percent ^{235}U, and gadolinium oxide (Gd_2O_3) mixture with varying H_2O weight fractions to simulate interstitially-moderated conditions. Theoretical densities were used for both UO_2 and Gd_2O_3. The staff confirmed the licensee's calculational result that for an infinite system under optimally-moderated conditions, 0.3 weight percent Gd_2O_3 was sufficient to assure subcriticality in accordance with LA Chapter 5.4.5.1.

Infinite, Heterogeneous System: For this calculation, the staff considered a lattice of dodecahedrons to simulate a heterogeneous system of UO_2 / G_d2O_3 particles in water. As before, the infinite system was simulated using a cuboid geometry with mirror boundaries on all faces. Theoretical densities were used for both UO_2 and Gd_2O_3. The staff confirmed the licensee's calculational result that for an infinite, moderated heterogeneous system, 0.3 weight percent Gd_2O_3 was sufficient to assure subcriticality in accordance with LA Chapter 5.4.5.1.

The staff reviewed both ANSI/ANS-8.21 (ANSI, 2011b) and ANSI/ANS-8.14 (ANSI, 2011a) and determined that ANSI/ANS-8.14 was more applicable. The staff noted that the most significant requirements from ANSI/ANS-8.14 were to verify (using an appropriate method) the continued presence of the neutron absorber in the fuel, its distribution, and its concentration. The staff determined that, when applied with the licensee's NCS design philosophy described in the proposed LA Chapter 5.1.1, the proposed change meets the intent of the applicable portions of ANSI/ANS-8.14 (ANSI, 2011a). The proposed change commits to verifying (using an appropriate method) the continued presence of the absorber in the fuel, its distribution, and its concentration. The proposed change commits to including such factors as process conditions, hazards, and human errors for potential degradation of the absorber in the system design. The proposed change commits that the acquisition, storage, preparation and use of the absorbers should conform to the licensee's established quality control practices. The licensee's commitments in the proposed change provide reasonable assurance that when a neutron absorber control is used, it will be used such that adequate protection of criticality hazards is provided. The licensee's commitments regarding design philosophy, as described in the proposed LA Chapter 5.1.1., provide reasonable assurance that when a neutron absorber control is used, that all normal and credible abnormal conditions will be evaluated and assured to be subcritical. The staff finds the proposed change to be acceptable.

(14) Revised LA Chapter 5.4.5.1, "k_{eff} Limit"

Correction Regarding the Inclusion of Bias and Bias Uncertainty

Chapter 5.4.5.1 of the LA currently states that when validated computer analytical methods are used, it is required that the effective neutron multiplication factors (k_{eff}), including applicable bias and bias uncertainty corrections, for credible process upset conditions are less than or equal to the established Upper Subcritical Limit (USL), that is:

$$k_{eff} + 3\sigma \leq USL$$

The proposed change removes the statement regarding the inclusion of applicable bias and bias uncertainty, such that the statement reads that it is required that k_{eff} of the system (plus three times the standard deviation of the Monte Carlo code) must be less than or equal to the established USL.

Chapter 5.4.5.3 of the LA provides a definition for USL which already includes applicable bias and bias uncertainty, that is:

$$USL = 1 + \beta - \sigma_{\beta} - MMS$$

Therefore, the current language contained in LA Chapter 5.4.5.1 is technically inaccurate. The proposed change corrects this inaccuracy and provides a correct method for incorporating bias and its uncertainty. The staff determined that the proposed change is acceptable.

Other Proposed Changes to LA Chapter 5.4.5.1

The staff reviewed all other proposed changes from LA Chapter 5.4.5.1 and determined that they did not alter the technical meaning of the licensee's commitments, and are therefore acceptable.

(15) Revised LA Chapter 5.4.5.3, "Validation Techniques"

The proposed change includes several administrative changes that do not impact the technical meaning of the licensee's commitments, and are therefore acceptable. However, the proposed change also includes added language to the section that discusses the minimum margin of subcriticality (MMS) regarding the consideration of the Monte Carlo code standard deviation. The acceptability of this proposed change is described in the discussion of the revised LA Chapter 5.4.5.1 above.

(16) Revised LA Chapter 5.4.5.5, "Criticality Safety Analysis"

Changes to CSA Requirements

Chapter 5.4.4.5 of the LA currently details the information to be contained in the licensee's CSAs. The proposed change still commits to CSAs being prepared and updated for each new or significantly modified unit or process system in accordance with established configuration management control practices defined in Chapter 11, which includes the use of documented and approved procedures. Limits are derived based on most reactive values of uncontrolled parameters or based on worst credible values of uncontrolled parameters with documented justifications. The proposed change significantly alters the organization and format of the CSAs; however, it does not meaningfully impact the CSA's content or the technical meaning of the licensee's commitments. The staff finds the proposed change to be acceptable.

Other Proposed Changes to LA Chapter 5.4.5.5

The staff reviewed all other proposed changes from LA Chapter 5.4.5.5 and determined that they did not alter the technical meaning of the licensee's commitments, and are therefore acceptable.

(17) Other Proposed Changes

The staff reviewed all proposed changes from the following sections of the LA and determined that they did not negatively impact the licensee's programmatic commitments for management of the NCS program, and are therefore acceptable.

- LA Chapter 5.1.2.1, "Changes to Facility"
- LA Chapter 5.3.2.1, "Training and Qualification of NCS Staff
- LA Chapter 5.3.2.2, "Auditing, Assessing, and Upgrading the NCS Program"
- LA Chapter 5.3.2.4, "Modifications to Operating and Maintenance Procedures"
- LA Chapter 5.4.1.2, "Maintenance Program"
- LA Chapter 5.4.2, "Means of Control"
- LA Chapter 5.4.2.3, "Administrative Controls"
- LA Chapter 5.4.4.1, "Geometry"
- LA Chapter 5.4.4.8, "Reflection"
- LA Chapter 5.4.5.1, "Spacing (or Unit Interaction"
- LA Chapter 5.4.5.2, "Analytical Methods"
- LA Chapter 5.4.5.4, "Computer Software and Hardware Configuration Control"

CONCLUSIONS

The staff reviewed the proposed changes to LA Chapter 5, "Nuclear Criticality Safety," together with supporting analyses and responses to staff questions. Based on the review discussed in this report, the staff determined that the changes were conservative, technically sound, and satisfied the requirements of 10 CFR Part 70 The staff therefore recommends that this license amendment request be approved.

REFERENCES

(GNF-A, 2018a) Global Nuclear Fuels – Americas, "NRC License SNM-1097 - License Amendment Request," May 10, 2018 (ADAMS Accession No ML18166A137).

(GNF-A, 2018b) Global Nuclear Fuels – Americas, "NRC License SNM-1097 - License Amendment Request RAI Response," August 2, 2018 (ADAMS Accession No ML18214A199).

(NRC, 2018) U.S. Nuclear Regulatory Commission, "Request for Additional Information for License Amendment Request for GNF-A," June 29, 2018 (ADAMS Accession No ML18176A153).

(GNF-A, 2016a) Global Nuclear Fuels – Americas, "License Renewal Application," October 27, 2016 (ADAMS Accession No ML17006A312).

(NRC, 2015) U.S. Nuclear Commission, "Standard Review Plan for Fuel Cycle Facilities and License Applications," NUREG-1520, June 2015 (ADAMS Accession No. ML15176A258).

(ANSI, 1998) ANSI/ANS-8.1, 1998, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," American Nuclear Society, La Grange Park, IL, 1998.

(ANSI, 2014a) ANSI/ANS-8.1, 2014, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," American Nuclear Society, La Grange Park, IL, 2014.

(NRC, 2010) U.S. Nuclear Regulatory Commission Regulatory Guide RG-3.71, "Nuclear Criticality Safety Standards for Fuels and Material Facilities," Revision 2, USNRC, dated December 2010.

(NRC, 2017) U.S. Nuclear Regulatory Commission Draft Regulatory Guide RG-3.71 (DG-3053), "Nuclear Criticality Safety Standards for Nuclear Materials Outside Reactor Cores," US NRC, dated August 2017.

(ANSI, 2005) ANSI/ANS-8.19, "Administrative Practices for Nuclear Criticality Safety," American Nuclear Society, La Grange Park, IL, 2005.

(ANSI, 2003) ANSI/ANS-8.3, "Criticality Accident Alarm System," American Nuclear Society, La Grange Park, IL, 2003.

(ANSI, 2014b) ANSI/ANS-8.19, "Administrative Practices for Nuclear Criticality Safety," American Nuclear Society, La Grange Park, IL, 2014.

(ANSI, 2012) ANSI/ANS-8.3, "Criticality Accident Alarm System," American Nuclear Society, La Grange Park, IL, R2012.

(GNF-A, 2016b) CSA-900.04.100, Rev 0, "Criticality Safety Analysis Minimum Gd_2O_3 for Maintaining UO_2/H_2O Systems Subcritical," November 2016.

(ANSI, 2011a) ANSI/ANS-8.14, "Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors," American Nuclear Society, La Grange Park, IL, R2011.

(ANSI, 2011b) ANSI/ANS-8.21, "Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors," American Nuclear Society, La Grange Park, IL, R2011.

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