UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 25, 2018

Mr. Scott P. Murray
Manager, Facility Licensing
Global Nuclear Fuel – Americas, L.L.C.
3901 Castle Hayne Road
P.O. Box 780
Wilmington, NC 28402

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR REVIEW OF THE MODEL NO. NPC PACKAGE

Dear Mr. Murray:

By letter dated June 19, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17170A025), Global Nuclear Fuel – Americas, LLC (GNF-A) submitted an application for revising Certificate of Compliance (CoC) No. 9294 for the Model No. NPC transport package. GNF-A proposed adding uranium concentrates and boiling water reactor/pressurized water reactor (BWR/PWR) pellet payload. To assist with our review, the U.S. Nuclear Regulatory Commission (the staff) needs the information identified in the enclosure to this letter. Discussion of this request for additional information (RAI) and a response date occurred on April 20, 2018 and April 24, 2018.

We request that you provide this information by June 1, 2018. Inform us at your earliest convenience, but no later than May 25, 2018, if you are not able to provide the information by that date. If you are unable to provide a response by May 9, 2018, please propose a new submittal date with the reasons for the delay.

Please reference Docket No. 71-9294 and EPID No. L-2017-LLA-0111 in future correspondence related to this amendment request. The staff is available to discuss these questions as well as your proposed responses. If you have any questions regarding this matter, feel free to contact me at (301) 415-6877.

Sincerely,

William C. Allen

Chris Allen, Project Manager
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9294
EPID No. L-2017-LLA-0111

Enclosure: Request for Additional Information

Request for Additional Information
Docket No. 71-9294
Model No. NPC Package

By letter dated June 19, 2017 (ADAMS Accession No. ML17170A025), GNF-A submitted an application for revising CoC No. 9294 for the Model No. NPC transport package. In this application, GNF-A requests to expand the authorized contents to include uranium concentrates and increase the weight limits of the boiling water BWR/PWR pellet payloads in the current CoC. This request for additional information (RAI) identifies information needed by the staff in connection with its review of the application. NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," was used by the staff in its review of the application.

Each individual RAI describes information needed by the NRC staff to complete its review of the application to determine whether the applicant has demonstrated compliance with the regulatory requirements.

General Information Review

1.1 Revise Table 1.1 of the Safety Analysis Report (SAR) to include the chemical compositions of the "dried calcium-containing sludges," "dried (sodium containing) sludges," and "other uranium compounds."

Table 1.1 of the SAR provides specifications for the requested contents and their chemical and physical forms. Specifically, Footnote 2 lists "dried calcium-containing sludges," "dried (sodium containing) sludges," "uranium oxide bearing ash," and "other solid uranium compounds" as proposed contents. Because these descriptions provide insufficient information regarding the specific chemical compositions or material characteristics (e.g., density), the staff is unable to determine which specific chemical compounds are being proposed for transport and perform safety evaluations accordingly. In order for the staff to evaluate the sludges, ashes, and "other solid uranium compounds" proposed for transport, the applicant needs to provide explicit descriptions for these compounds by providing their specific chemical compositions. The applicant also needs to confirm that they do not include other elements or compounds that impact criticality safety (e.g., moderators, fissile materials other than uranium, etc.) or cause significant chemical reactions (e.g., inorganic compounds).

This information is required to demonstrate compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) 10 CFR 71.33(b)(3) and 10 CFR 71.43(d).

1-2 Demonstrate that uranium tetrafluoride (UF_4) reactions will not cause significant corrosion of the inner containment canister assembly (ICCA), deterioration of the silicon gasket, or generate flammable gas.

Uranium tetrafluoride is known to react with moisture to produce hydrofluoric acid (HF), in particular when the UF_4 has a small particle size with a large surface area. The stainless steel used to construct the ICCA and the silicon rubber ICCA gasket typically are not considered to be compatible with HF solutions, as follows:

- HF can be corrosive if in contact with the Type 304L stainless steel ICCA. Laboratory testing of Type 304 stainless steels in various HF solutions at near ambient temperatures identified average corrosion rates of approximately 0.010 to 0.060 inches per year [Nickel Development Institute]. HF may also cause localized pitting and crevice corrosion, which propagates faster than the above general corrosion rates.

- The corrosion of stainless steel with hydrofluoric acid releases hydrogen gas which could potentially cause over-pressurization of the ICCA or an explosive event.

- Silicon rubber is typically not recommended by manufacturers for service in contact with HF solutions [Parker; Warco; Dow Corning] as it is generally described as unsatisfactory or subject to deterioration in this environment.

The staff requires justification that the reaction of moisture or water (due to leakage into the system) with uranium tetrafluoride will not lead to a dispersal of contents through corrosion penetration of the ICCA wall, deterioration of the seal region, ICCA over-pressurization, or an explosive event. The applicant should consider the implications of moisture in the as-loaded powder, atmospheric moisture within the ICCA, and any moisture or water that may communicate through the silicon seal.

This information is required to demonstrate compliance with 10 CFR 71.43(d) and (f).

Criticality Review

6.1 Provide criticality safety analyses for each of the proposed contents or demonstrate that the analyses presented in the current version of the SAR bound the proposed new contents, including the new contents provided by the applicant in response to RAI 1-1.

Table 6.21 of the SAR provides a list of homogeneous compounds that were evaluated for criticality safety. On the basis of the evaluation of these compounds, the applicant states that a theoretical mixture of UO_2 and water is conservatively bounding relative to mixtures of the other homogeneous compounds with water. However, the staff notes sodium uranate (Na_2UO_4), which was listed in Table 1.1 as a proposed homogeneous content, is not included in the list of homogeneous compounds in Table 6.21 and does not appear to have been evaluated for criticality safety. In addition, it is unclear to the staff whether the evaluated compounds listed in Table 6.21 include compounds that compose the "dried calcium-containing sludges," "dried (sodium containing) sludges," "uranium oxide bearing ash," and "other solid uranium compounds" listed in Footnote 2 of Table 1.1 as proposed contents. The applicant needs to either provide criticality safety analyses for all new contents as defined in the revised Table 1.1 in response to RAI 1-1 or demonstrate that the current analyses bound the proposed new contents.

This information is required to demonstrate compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

6.2 Demonstrate that it is conservative to neglect the plastic bags, bottles, and/or cans that are used inside the ICCAs in the criticality evaluation of the proposed new homogenous uranium compounds, and revise the search for the most reactive content presented in Figure 6.0, if necessary.

The applicant presented a summary of its search for the most reactive homogeneous uranium compound in Figure 6.0 of the SAR. However, it appears that the models used in the study assumed that the materials in the ICCA were mixtures of only water with the various contents. According to a letter dated June 18, 2007 (ADAMS Accession No. ML071760085), the applicant states that "shipments of powdered material will always contain three poly bottles (no void spaces)," but the plastic bottles, bags, and/or cans that are used as part of the packaging materials inside the ICCAs were not included in the models. Because plastic materials are typically comprised of mainly carbon and hydrogen and have higher neutron scattering cross sections (Σ_s) than water, they are typically more effective neutron moderators than water. Therefore, fissile systems containing plastic materials are normally more reactive than the same system that is moderated by water. Moreover, based on the results of its thermal testing of the plastic bottles (ADAMS Accession No. ML071220116), the applicant concluded that "melting of the plastic bag inside the polyethylene bottle is considered credible during the HAC fire event." This creates the potential for the plastic to mix with the fissile materials and affects criticality safety. For the above reasons, the applicant needs to either revise the models for the criticality safety analyses to include the plastic packaging materials in the ICCAs or demonstrate that it is conservative to neglect the plastic bags, bottles, and/or cans from the criticality safety analyses.

This information is required to demonstrate compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

6.3 Either provide a minimum weight limit for packaging materials with a hydrogen atom density greater than that of water or demonstrate that the package and the increased BWR/PWR pellet payloads remain subcritical in the absence of these packaging materials.

The table of allowable contents in Revision 8 of the CoC for the GNF NPC includes a maximum weight restriction of 3.7 kg on the packaging materials with a hydrogen atom density greater than that of water. However, this restriction is not present in Table 1.1 of the SAR submitted by the applicant for this amendment request. In addition, the weight limits for the BWR/PWR pellet payload listed in Table 1.1 of the SAR are higher than those listed in CoC Revision 8. It appears that both the 3.7 kg restriction on packaging materials and the 40.54 kg U pellet payload limits present in the current active CoC (Revision 8) were originally proposed by the applicant in Revision 5 of the CoC, based on the results of criticality safety analyses of the heterogeneous compounds in plastic bottles inside the ICCAs (ADAMS Accession No. ML062780337). The staff notes that the results of some of the analyses indicated that the calculated value of k_{eff} remained below the upper subcritical limit only when the plastic bottles were included in the model. It is unclear whether the 3.7 kg restriction ensures subcriticality of the package containing the higher BWR/PWR pellet payload without new criticality analyses. Therefore, the applicant needs to either provide, with supporting criticality analyses, a weight limit for packaging materials with a hydrogen atom density greater than water, or demonstrate that the package and its increased BWR/PWR pellet payload remain subcritical in the absence of these packaging materials. In addition, the applicant needs to update the SAR to include the information provided in response to this question.

This information is required to demonstrate compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

6.4 Demonstrate that the package with the proposed new contents remains subcritical when uranium-bearing contents are moderated by carbon to any degree.

On page 6-3 of the SAR, the applicant states: "Uranium-bearing contents may be moderated by water or carbon to any degree..." The staff, however, was unable to find any demonstration in the SAR that the package remains subcritical with uranium-bearing contents moderated by carbon to any degree; all criticality safety analyses for this package presented in the SAR are based on UO_2 moderated with water, as shown in Figure 6.0 of the SAR. Because carbon is a more effective moderator in terms of fuel utilization factor *f*

($f = \Sigma_a^F/(\Sigma_a^F + \Sigma_a^M)$), where Σ_a^F is the macroscopic absorption cross section of the fuel and Σ_a^M is the macroscopic absorption cross section of the moderator when ignoring the structure materials, it is well understood that graphite can be used as moderator to achieve criticality in a natural uranium-fueled reactor. The applicant needs to demonstrate that the package remains subcritical when the proposed new uranium-bearing contents are moderated by carbon to any degree.

This information is required to demonstrate compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

6.5 Revise the chemical formulas for the proposed new compounds listed in Table 6.21 using correct chemical notation for the proposed new compounds and provide information that demonstrates that the data presented in SAR Table 6.21 are accurate.

Table 6.21 provides material composition data for the proposed new chemical compounds that were evaluated in the applicant's criticality safety analyses. Since the applicant did not use standard chemical notation when providing the material composition data, the staff was unable to identify the chemical compound for case set I (4na2u2o7:uf4) and was consequently unable to determine whether or not appropriate criticality safety analyses have been performed for this compound. In addition, staff could not determine the accuracy of the data for case sets B, E, I, and L in Table 6.21 because the references provided by the applicant are not accessible to the staff. Lastly, the staff notes that for case sets G and K, the applicant indicates that the data were obtained from *Wikipedia*. Because the information presented in *Wikipedia* are typically unverified, the staff is concerned with the reliability of the data. Therefore, the applicant needs to (1) use correct chemical notation for each compound listed in Table 6.21 and clarify the nature of the compound listed for case set I to enable staff to identify it; (2) provide reliable sources (e.g., scientific papers, handbook values, calculations, etc.) that substantiate the use of the data provided for case sets B, E, G, I, K, and L; and (3) as necessary, re-perform the criticality safety analyses with more reliable data.

This information is required to demonstrate compliance with 10 CFR 71.33(b)(2), 71.55(b), 71.55(d), 71.55(e), and 71.59.

6.6 Demonstrate that the Monte Carlo calculations converge.

The applicant presents the convergence behavior of the k_{eff} calculation using the GEMER code in Figures 6.10a to 6.10d of the SAR. However, the x-axis labels of these figures appear to be incorrect because the staff expects that the ratio of the total number of batches to the number of batches skipped should always be greater than 1. Based upon the figures provided, the uncertainty of the calculated k_{eff} increases as the ratio of number of batches to number of batches skipped increases. This is inconsistent with the common understanding of the Monte Carlo method. As such, it is not clear to the staff whether these calculations have properly converged. The applicant needs to explain why the uncertainty of the calculated k_{eff} increases as the ratio of number of batches to the number of batches skipped increases and demonstrate that the calculations have converged properly.

This information is required to demonstrate compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Operating Procedures

7.1 Pertaining to loading of various contents:

a. Clarify which uranium payloads (i.e., homogeneous uranium compounds, heterogeneous PWR/BWR pellets, and heterogeneous uranium compounds) require packaging in plastic bottles and/or bags prior to loading in the ICCAs. For uranium payloads requiring packaging in plastic bottles and/or bags, the applicant should state the number of plastic bottles and/or bags required per ICCA.

b. Provide the maximum particle size for homogenous uranium compounds to enable differentiation between homogenous and heterogeneous UO_2, U_3O_8, and UO_x compounds.

In Revision 8 of the CoC for the GNF-A NPC, item 6a states that "The payload may be enclosed in plastic receptacles (e.g., bags, bottles, etc.). For payloads in plastic bottles, empty bottles may be used to minimize movement of the bottles within the ICCA." On the other hand, on page 1-8 of the applicant's SAR, it states that the payload (where payload apparently refers to homogeneous uranium compounds, heterogeneous PWR/BWR pellets, and heterogeneous uranium compounds) is enclosed in plastic receptacles (e.g., bags, bottles, etc.), and the loading procedures in Chapter 7 state that "The uranium oxides and compounds payloads are secured in plastic receptacles (e.g. bags, bottles, etc.)." In addition, GNF clarified in a June 11, 2007 meeting (ADAMS Accession No. ML071760085) that some material will not be loaded in poly bottles, poly bottles will only be used to transport powdered materials, and shipments of powdered materials will always contain three poly bottles. Based on these observations, it is unclear to the staff when and how many of the plastic receptacles are required for each payload type. Therefore, the applicant needs to clarify which payloads require packaging in plastic bottles and/or bags and provide the number of plastic bottles and/or bags that will be transported in each ICCA for a given payload.

In addition, the applicant lists homogeneous uranium oxide compounds with an "N/A" minimum particle size. However, in a CoC package clarification letter dated May 14, 2013 (ADAMS Accession No. ML13134A395), the applicant stated that "the particle size criterion for the classification of Homogeneous Uranium Oxide/Compounds is 0.059 inches (1.5 mm) and less." The staff also notes that there is overlap between the compounds classified in Tables 1.1 and 6.1 as homogeneous uranium oxide contents and heterogeneous uranium oxide contents (i.e., UO_2, U_3O_8, UO_x, $x>2$). It is unclear to the staff how, for example, homogeneous UO_2 differs from heterogeneous UO_2 when they have "N/A" and "Unrestricted" particle sizes, respectively. Such a distinction would be particularly important if homogeneous UO_2 requires loading into plastic bottles while heterogeneous UO_2 does not. Therefore, the applicant needs to identify the maximum particle size for homogeneous uranium compounds to enable differentiation of homogeneous compounds from heterogeneous compounds for proper loading and unloading of the package.

This information is requested to determine compliance with 10 CFR 71.35(c).

Editorial comments:

In addition to the information requests above, staff notes the following editorial items, which if corrected, would improve the clarity of the SAR:

1. As communicated by e-mail on August 24, 2017, the SAR submitted with your application incorrectly identifies the Model No. NPC package as a Type A(F)-85 (ADAMS Accession No. ML18071A364).
2. As discussed by phone on March 9, 2018, the SAR Table 1.1 title "Homogeneous Uranium Oxide Compounds" should read "Homogeneous Uranium Oxides/Compounds" as it appears in SAR Table 6.1 (ADAMS Accession No. ML18073A031).
3. As discussed on December 12, 2017, the word "Appendix" is not included in the titles of Appendices 6.9, 6.10 and 6.11 (ADAMS Accession No. ML18009A007).
4. SAR Sections 2.7.3 and 2.7.4 incorrectly reference the regulations in 10 CFR 71.71 instead of the correct 10 CFR 71.73 regulations.
5. Describe the package component in which the ICCA resides inside the Model No. NPC as either the "contamination shield," as done in SAR section 6.3.1.2 and SAR Figure 6.2, or as a "silo," as done throughout the remainder of the SAR.

References:

1. Corrosion Resistance of Nickel-Containing Alloys in Hydrofluoric Acid, Hydrogen Fluoride, and Fluorine, Publication No. 433, Nickel Development Institute.

2. Parker O-Ring Handbook, Parker Hannifin Corporation, 2007.

3. Warco Biltrite Chemical Resistance Guide.

4. Dow Corning Silastic® Brand Silicon Rubber: Fluid Resistance Guide, 2001.

5. J. J. Duderstadt and L. J. L. Hamilton, "Nuclear Reactor Analysis", Page 405, John Wiley & Sons, Inc., 1976.

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR REVIEW OF THE MODEL NO. NPC, DOCUMENT DATE: APRIL 25, 2018

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