August 10, 2017

Dr. Robert Dimeo, Director
NIST Center for Neutron Research
National Institute of Standards and Technology
U.S. Department of Commerce
100 Bureau Drive, Mail Stop 8561
Gaithersburg, MD 20899-8561

SUBJECT: NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY – REQUEST FOR ADDITIONAL INFORMATION, RE: PRELIMINARY SAFETY ANALYSIS REPORT FOR THE NATIONAL BUREAU OF STANDARDS TEST REACTOR (CAC NO. MF7235)

Dear Dr. Dimeo:

By letter dated December 30, 2014, the National Institute of Standards and Technology (NIST) submitted for the National Bureau of Standards Test Reactor (NBSR), a preliminary safety analysis report (PSAR). The PSAR review is to capture work completed by NIST to date to prepare for the NBSR's high-enriched uranium to low-enriched uranium fuel conversion. During its initial technical review, the U.S. Nuclear Regulatory Commission staff identified additional information and clarification that were needed to complete its review and, as a result of that review, a request for additional information (RAI) letter dated April 25, 2015, was sent to you for your response.

You responded to the RAI on July 21, 2016. During our further review of the PSAR and your response to the previous RAIs, additional questions have arisen for which we require further additional information and clarification. We request that you provide responses to the enclosed RAI within 60 days from the date of this letter.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.30(b), "Oath or affirmation," you must execute your response in a signed original document under oath or affirmation. Your response must be submitted in accordance with 10 CFR 50.4, "Written communications." Information included in your response that is considered sensitive, or proprietary, that you seek to have withheld from the public, must be marked in accordance with 10 CFR 2.390, "Public inspections, exemptions, requests for withholding." Any information related to security should be submitted in accordance with 10 CFR 73.21, "Protection of Safeguards Information: Performance Requirements." Following receipt of the additional information, we will continue our evaluation of your PSAR.

If you have any questions about this review, or if you need additional time to respond to this request, please contact me at (301) 415-1404, or by electronic mail at Xiaosong.Yin@nrc,gov.

Sincerely,

/RA/

Xiaosong Yin, Project Manager
Research and Test Reactors Licensing Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-184

Enclosure:
As stated

cc: See next page

SUBJECT: NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY – REQUEST FOR ADDITIONAL INFORMATION, RE: PRELIMINARY SAFETY ANALYSIS REPORT FOR THE NATIONAL BUREAU OF STANDARDS TEST REACTOR (CAC NO. MF7235) DATED: AUGUST 10, 2017

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ADAMS Accession No.: ML17187B012; *concurrence via e-mail NRR-058

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OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ADDITIONAL INFORMATION

REGARDING PRELIMINARY SAFETY ANALYSIS REPORT

FOR THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY TEST REACTOR

LICENSE NO. TR-5; DOCKET NO. 50-184

By letter dated December 30, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15028A135), the National Institute of Standards and Technology (the licensee) submitted for the National Bureau of Standards Test Reactor (NBSR), a preliminary safety analysis report (PSAR) for the conversion of the NBSR from high-enriched uranium (HEU) to low-enriched uranium (LEU) fuel. During its initial technical review, the U.S. Nuclear Regulatory Commission (NRC) staff identified additional information and clarification that were needed to complete its review and, as a result of that review, a request for additional information (RAI) letter (ADAMS Accession No. ML16103A140) dated April 25, 2015, was sent to you for your response. You responded to the RAI on July 21, 2016 (ADAMS Accession No. ML16211A064).

During our further review of your PSAR and your response to the previous RAIs, the NRC staff identified additional questions for which we require information and clarification within 30 days from the date of this letter.

1 Core Loading: The regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. Provide the following, or justify why additional information is not necessary:

a. PSAR Section 4.5 describes results of analyses without providing details of the HEU and LEU fuel loadings; describe how the core loading will transition from HEU to LEU and further, describe the limiting core configuration that envelops the transition and LEU cores.

b. The Monte Carlo N-Particle Transport (MCNP) model appears to represent the fuel plates as flat; since they are curvilinear identify the “cup” orientation and whether the true geometry can affect power peaking factors and hot channel factors.

c. Some of the parameters in the PSAR Table 4.4 do not match with values in Table 4.10; update as necessary.

2 Core Reactivity: The regulations in 10 CFR 50.9, require that all submissions shall be complete and accurate in all material respects. Your response to No. 6 of the previous RAIs needs additional detail. For example, estimated critical positions (ECPs) are given, but, do not appear to be discussed in either the PSAR or the RAI response. The reactor described in the Bess paper uses TRIGA fuel (Fuel Life Improvement Program fuel and 30/20 fuel with erbium). This fuel has low burnup and a very significant calculated bias of 1,000 percent millirho is claimed. The eigenvalue spread appears to be too large to be a

defendable bias and the paper focuses on library evaluations are not ECPs. This paper does not appear to be applicable to NBSR calculations. Explain the acceptability of using this paper in the determination of ECPs, or provide NBSR ECP calculations and use them to establish the suitability of the models presented, or demonstrate why additional information is not necessary.

3 Burnup: The regulations in 10 CFR 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. Provide the following, or justify why additional information is not necessary:

The MCNP model described in PSAR Section 4.5 uses 60 materials to describe the burnup distribution in 1,020 plates. The number of materials used seem rather small comparing to the number of plates in fuel elements, provide a justification for the small number of unique fuel materials.

4 Thermal and Hydraulic (T&H) Objectives: The regulations in 10 CFR 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. Provide the following, or justify why additional information is not necessary:

As stated in the PSAR Section 4.6.1 the licensee design objective is that “the heat transfer to the primary coolant shall not exceed critical heat flux ratio (CHFR)”. This implies a departure from nucleate boiling ratio design limit of 1.0. The guidance in NUREG-1537 for engineered cooling systems is that the DNBR shall be greater than 2. Clarify what the DNBR is being used as the limiting design value for your T&H and safety analysis. The PSAR Tables 4.20 and 4.21 indicate a range of CHFR values as a function of probability levels, but it is unclear which of the probability levels are utilized when concluding that design analysis is acceptable and whether this is consistent with previous NRC guidance or approvals.

5 Power Distribution: The regulations in 10 CFR 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. Provide the following, or justify why additional information is not necessary:

It is not clear whether the peaking factors in PSAR Tables 4.23 and 4.24 are the limiting values from the limiting core configuration defined in the neutronics analysis. Provide the limiting values.

6 Maximum Reactivity Insertion Event: The regulations in 10 CFR 50.9, require that all submissions shall be complete and accurate in all material respects. Provide the following, or justify why additional information is not necessary:

a. Referring to PSAR Section 13.4.3.1, the scram setting is on high flux level but not on power as stated in the text (TS 3.2.2). Update as needed.

b. The minimum critical heat flux ratio of 1.78 stated PSAR 13.4.3.2 in the text does not match the value in Table 13.7; the value of 1.83 stated in PSAR Section 13.4.3.2 does not match the value in Table 13.8. Correct these apparent inconsistencies as needed.

c. Referring to PSAR Section 13.4.3.1, provide updated text that describes how the limiting single failure is determined and what effect it has on the consequences.

7 Loss of Coolant Accident (LOCA): The regulations in 10 CFR 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. The NRC staff understands in concept the contribution of the inner reserve tank (IRT), emergency cooling tank (ECT), sump return, and hold-up pan to the cooling of the fuel. However, the PSAR does not explain in any of the cases the sequence of events, listing the time when the IRT becomes empty, the ECT begins to operate, or when the sump return flow begins. Some of the cases describe the water level in the hold-up pan reaching the top lip in 10.9 seconds, but do not show and describe the consequences on the fuel, cladding, and coolant temperatures. Similarly, some cases indicate partial draining of the vessel but provide no dose estimates from direct shine. The volumes and performance attributes of some components are unclear. In addition, it is understood that the HEATING7.3 code is used to analyzed plate temperatures following loss of coolant, and subsequent cooling by flow of water through the distribution pan onto the fuel plates, but it is unclear how that code is interfaced to the TRACE analysis (e.g., initial and boundary conditions). Provide the following, or justify why additional information is not necessary:

a. For each case revise the sequence of events (SOE) to include the time when IRT flow is the only coolant supplied to the fuel, the time for ECT actuation, the time for recirculation flow from the pump to initiate and the point of discharge for recirculation flow. This should consider the manual actuation of the ECT and the time required for operators to diagnose the accident, decide whether to initiate bottom fill or top fill, and the time to accomplish this activity. In addition, consider the manual actuation of recirculation flow in the same manner.

b. For LOCA case 2, indicate when the vessel level reaches the top-of-fuel and what the level of the IRT is at that time (i.e., showing graphically, the IRT water level and discharge rate vs. time). Indicate at what time the IRT is fully drained.

c. For each LOCA case indicate what the limiting single failure is and ensure that the consequences of this failure are reflected in the provided results for that case.

d. For all LOCA cases, provide the water level in the fuel and the maximum cladding temperature as a function of time using a time scale that fully covers the participation of all elements of the core cooling system used in the SOE.

e. The supplied RELAP5 model input shows that the volume of the IRT is ~738 gallons and the volume of the upper plenum is ~ 1,053 gallons. Supply the total volume of the ECT, and the sump recirculation flow rate versus time for all LOCA cases.

f. Chapter 5 of the PSAR anticipates no changes due to the HEU-LEU conversion and so it contains no technical information. However, to support our review of the LOCA analysis it became necessary to review Figure 5.2 in the 2004 SAR. This graphic shows the discharge from the sump pump going to the D_2O storage tank, not directly to the ECT. Confirm the flow path used for recirculation flow and whether all powered components are on the emergency power bus.

g. PSAR 13.6.5 explains that HEATING7.3 is used to calculate the fuel temperatures in the "quiescent" water after the water has drained form the fuel. Explain in more detail where this quiescent water is located. Explain if the "quiescent" water is assumed to accumulate, exit the bottom of the fuel, or is it allowed to heat up and evaporate. Explain how the flow from the distribution pan into the fuel channels is modeled including how the water flow is distributed over the fuel assemblies, and if there is any allowance for liquid film flow over the plates. Provide assumptions, and the boundary conditions used, including film flow rate, film thickness versus distance from top of fuel plate, specific representation of water film behavior on the fuel plates, etc. used in the analysis.

h. Provide the fuel meat, and cladding temperature as a function of time based on the HEATING7.3 calculations, for at least one of the large LOCA and one of the small LOCA scenarios.

i. For cases where the fuel is partially or fully uncovered for any period of time, provide dose calculation to occupational workers and members of the public and indicate over what time interval these exposures apply. Relate these times to activities that are expected to be performed by operators who may be responding to events and compensating for them with operator actions such as opening values 32-35.

8 MHA: The regulations in 10 CFR 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. Provide the following, or justify why additional information is not necessary:

a. PSAR Section 13.8 states that I_2 is removed by the filters, however, there is no discussion of what fraction of iodine released is organic and how that affects the dose results. Regulatory Guide (RG) 1.183 is sometimes used by Research and Test Reactors licensees to provide guidance on the fraction of the iodide released that could be organic. In general, the organic fraction is considered to be unaffected by the carbon filter and will not be removed.

b. The model refers to the assumption of low wind speed, and high stable atmospheric conditions. However, it does not specifically identify the wind speed and the atmospheric stability class. Identify the wind speed and atmospheric stability class.

c. The model uses the HOTSPOT code with an elevated release. However, the stack height is not 2.5 times the height of the adjacent solid structure or higher, as needed for the consideration of an elevated release under the guidance in RG 1.145. Revise the analysis to use ground release consistent with the cited guidance.

d. The HOTSPOT code is suitable for a short-term release. Using this code for a longer period of time, as in this case where 30-day doses are considered, may lead to inaccurate estimates of dose, because the weather condition cannot be assumed to remain constant over such a period of time. Justify the use of HOTSPOT for such releases or revise the analysis.

e. In the occupational dose calculations, the model refers to a specified leak rate (considered to be the helium leak rate containing noble gases, tritium gas, and iodine) into each room; however, the PSAR is not clear on what fraction of the released gases into the helium space (with a volume of 0.7 cubic meter) would enter each room the over the specified period. Clarify what fraction of the released gases would enter each room.

f. After resolving the issues raised in the previous RAIs 9.a through 9.e, provide a complete description of inventory distribution inside the building, as well as the released values to the environment along the assumptions on the various leakage components, weather conditions parameters, so that the results can be confirmed. (For the public dose calculations, a copy of the Hotspot outputs along with their associated user mix data, will provide the requested information.)

9 External Events: The regulations in 10 CFR 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. Provide the following, or justify why additional information is not necessary:

The discussion in PSAR Section 13.12 does not address the topic of how the change in fuel affects, or doesn't affect, external events. In PSAR Table 1.1 the LEU fuel plate is significantly more massive than the HEU fuel by a factor of more than 2. It can be expected that an external event, such as an earthquake, that has lateral displacement and acceleration will result in greater stress on LEU fuel. Consider this issue and revise this PSAR section.

10 Fuel Storage: The regulations in 10 CFR 50.34(b)(2) require that an application include a description and analysis of the structures, systems, and components of the facility. The information required shall be sufficient to permit understanding of the system designs and their relationship to safety evaluations. Provide the following, or justify why additional information is not necessary:

PSAR Section 9.2 does not address the subject of fuel storage. In the 2004 SAR Section 9.2.2 it is stated that the fuel storage rack design prevents the fuel attaining a k_{eff} of 0.9. However, the SAR does not appear to reference or supply any analysis supporting this statement. In addition, the application does not address the relative reactivity of HEU and LEU fuel and so it is unclear as to how the fuel change affect fuel storage issues and how, or whether, the fuel design change will alter any issues or analyses previously submitted. Provide an analysis demonstrating that the fuel storage racks are capable of satisfying the reactivity requirements of LEU fuel.

11 Startup Plan: The regulations in 10 CFR 50.9, require that all submissions shall be complete and accurate in all material respects. Provide the following, or justify why additional information is not necessary:

Provide the startup plan, the issues to be examined, the success criteria required, and the approvals required before power ascension.