NCNR Response to November 17, 2021 request for supplemental information

1. In Enclosure 6, “Memorandum on Recovery Items” (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21274A024), NIST stated that a contract has been awarded to clean the reactor upper and lower grid plates. In the NRC special inspection team interim report (ADAMS Accession No. ML21077A094), the inspectors observed the presence of once molten material deposited on the lower grid surfaces. Enclosure 6 does not include a discussion specifically related to an assessment to examine additional components such as, but not limited to, shim arm extensions, fuel element transfer chute, and the lower grid plate.

a. Describe how these components were examined or, if they were not examined, provide a justification that the event did not impact these components.

A visual examination of the upper and lower grid plate determined that there was no damage to either grid plate, only deposits of once molten material. The once molten material when contacting the grid plates no longer contained sufficient heat to cause any damage to the grid plates. Likewise, any once molten material that made it to components that are even further removed from the once molten material, such as the shim arm extensions and the fuel element transfer chute could not be damaged by it. It should be noted that all the once molten material remained under cover of (heavy) water during the entire incident.

b. Discuss if non-destructive examinations are planned for these components or, if none are planned, provide a justification that the event did not impact these components.

The upper and lower grid plates have been visually examined multiple times and will be examined again once debris cleanup is complete. A visual inspection will be made of all accessible core structures, including the shim arm extensions prior to startup. Flow velocity in all areas of the reactor is too low to make abrasion from fuel particles a concern.

2. The restart request included lists of planned inspections; however, the request did not describe the details of these future inspections.

a. Describe the major activities and evaluations that are part of these inspections and provide the associated acceptance criteria to demonstrate that the scope and depth of these activities are sufficient to ensure the safe operation of the facility.

b. Describe how NIST intends to use the results of the inspections to inform its assessment of the components in the surrounding area.

c. Describe how NIST will determine if there are any residual issues from the damaged fuel element.

d. Additionally, to support NRC schedule planning, provide the dates for the planned inspections.

See table below.

inspection	***Acceptability criteria/notes***	***Approximate date***
Fuel elements for reuse	*No debris present over 2 mm in any dimension (see #10 below) and no visible damage to fuel.*	*March 2022*
Visual inspection of latch status	*All elements verified latched.*	*Testing completed. Visual inspections now required following all refuelings*
Reactor metrology inspections	*Results will be used to inform possible changes in index plate positioning and pickup tool redesign.*	*Finished by February 2022*
Primary system	*No visible fuel debris in the vessel. No viable pathway for fuel debris to enter vessel that would impact reactor operation or result in an increased release of fission products that would result in a significant dose to the public.*	*March 2022*
In-vessel inspection (post grid plate cleanup)	*No observable debris*	*February 2022*

3. In Enclosure 5, "Latch Improvement Safety Analysis" (ADAMS Accession No. ML21274A023), NIST identified improvements in the latching process. However, this enclosure did not include a description of how the improvements in the latching process will be demonstrated prior to restart. Describe the plans for demonstrating the improved latching process, and training reactor operators, prior to restart.

Improvements in index plate marking will be made and demonstrated to provide unambiguous indication of latching. Latching will now be verified by a two-step process, a verification of the latch position by attaching a tool to the fuel head latch mechanism and ensuring the latch mechanism is rotated to the proper position by comparing the tool's rotational position to fiducial reference marks on the index plate. Once this is complete a visual inspection will be performed of each latch position. Once the latch verifications are complete, no additional contact with the fuel will be permitted without reperforming both checks.

An underwater observation camera system has been developed. This camera has the same mechanical interface to the fuel transfer mechanisms as a fuel element. As such it can be maneuvered immediately over each fuel element allowing an inspection of the latch bar and the extent to which it is oriented in the correct position (thus proving a full latching). This camera will be proven to have the clarity and resolution for an operator to make an unequivocal determination that each element is latched prior to reactor restart.

Procedures for both the rotational checks and visual checks are being drafted. Both processes will be demonstrated and tested, along with required operator training on each prior to the loading of fuel in preparation for restart.

4. The restart request and enclosures did not identify the actions to prevent inadvertent unlatching of a fuel element by the pickup tool during reactor startup activities. Describe the actions that NIST plans to take during reactor startup activities to prevent inadvertent unlatching of a fuel element.

See question #3 above. The tool to be used for the "latch check" will have clear markings that will match newly installed markings on the reactor index plate. The camera will be deployed after the last latch check has taken place. As discussed in attachments 4 and 5 (IE-CA-5), no further contact with the fuel head by any tool will be allowed after the camera observation is complete, so there is no possibility of inadvertent unlatching.

5. In Enclosure 7, "Corrective Actions Required Prior to Reactor Startup" (ADAMS Accession No. ML21274A025), NIST indicated that Corrective Action IE-CA-2 for the improved latching process is complete. Describe the activities that were implemented to verify the effectiveness of the improved latching process, including long-term plans to incorporate the improvements in the latching process into operator training and each future reactor startup.

See answer to Questions #3 and #4.
As discussed in Attachment 5, the two now-required methods of latch verification will provide unambiguous verification that an element is latched. AR 6.0, Refueling Operation, is being modified to incorporate these new requirements and personnel will be required to undergo training and annually demonstrate their proficiency in performing these requirements prior to being allowed to perform refueling operations. The camera system that has been developed will undergo careful testing to ensure it provides the visual clarity to unambiguously determine if fuel elements are latched.

6. Many of the proposed corrective actions reference procedure enhancements, however, procedure enhancement appears to be inconsistent with the root cause evaluations related to lack of procedure use. Describe how NIST plans to address reinforcement of procedure use during complex or infrequent evolutions.

All personnel have undergone extensive training in procedure use and adherence and this will be an ongoing required training for requalification. Adherence to procedures will be made much more straightforward because the way NIST will use procedures is being changed. Many procedures will be read step by step and line items in the procedure will be checked off deploying a "circle-X" process. In addition, the procedures are being rewritten such that the workflow will be sequential vis a vis the procedure steps, making the circle-X process possible. Prior to the incident many procedures were non-sequential, meaning that the user of the procedure would have to skip back and forth in a procedure to get a particular job done. Critical procedures will also require the use of a reader worker method. An individual will be assigned as the reader. They will read each step of the procedure to the "workers" and then observe the step is performed and then "X" the procedure. The improvement in procedure writing and adherence is itself anchored in a new set of administrative rules that standardize the formatting and content of procedures and the requirements for procedure adherence.
Reactor supervisors are also being trained and standards are being put into place for supervisor oversight to ensure that procedure use and adherence policies are being followed and the staff are being held accountable.

7. The restart request and enclosures did not describe the multiple coolant pump starts and the need to reperform latching inspections. Provide an evaluation of the impact of restarting the pump multiple times, including the potential effect on latched fuel elements.

When a fuel element is fully latched, it is held in place in the notch in the upper grid plate, with the spring acting as a compressive force of about 40 pounds on the element. When primary pumps start, hydraulic forces within the element increase this force against the upper grid plate, making the possibility of moving the latch outside the notch even less likely. Subsequently stopping the flow only serves to bring the force back to its original value given from the spring. There is no mechanism, either by flow or vibration from multiple pump cycles, that would significantly reduce the force between the latch and the upper grid plate and thus it is not credible for a fully latched element to become unlatched by flow changes, no matter how frequent. By extension this means that if a camera observation indicates that a fuel element is properly latched there is no amount of pump restarts that can result in an unlatched element.

As noted in the TWG report, only if an element were to be "partially" unlatched with the latch not in the upper grid plate notch, there is the possibility that flow forces could move this latch towards the unlatched position. On a fully unlatched element, multiple pump starts could first "float" the element, then when the pump is stopped, the fuel element nozzle is unlikely to re-enter the hole in the lower grid plate and would eventually be parked against its neighbors (as was found).

8. In Enclosure 4, "Root Cause Response" (ADAMS Accession No. ML21274A022), NIST included: "QT-CA-4: Provide consistent and structured training and immediate and continual feedback to trainees during OTJ [on the job] training to ensure comprehension of performance expectations," and "QT-SPI-3: Continuously evaluate and revise the training based on the performance of licensed SROs [senior reactor operators] on the job."

a. Describe how NIST will ensure, test, and measure the proficiency of operator training (including fuel movements and latching) consistent with the root cause "QT-CA-4" and "QT-SPI-3" responses.

Several measures are being put into place. These include: 1) training and documented qualification of supervisors on training consistency, 2) implementation of an annual qualification of all operators in moving fuel, prior to any fuel movements, with the operator demonstrating their proficiency to an SRO, 3) implementation of a continuous learning program, and 4) periodic management reviews of the effectiveness of the training and refueling qualification programs.

b. Describe how the training will be incorporated into future operator actions, including enhanced procedure use.

The above programs will be permanently included in our reactor requalification program. This will include annual training on procedure use and compliance. Training effectiveness will be periodically evaluated by Operations Management.

9. NIST discussed in the restart request that technical specification (TS) 3.9.2.1 (1) is not an effective means to ensure that the fuel element is latched between the reactor

grid plates. Therefore, it appears that a license amendment revising TS 3.9.2.1 may be necessary prior to the NRC authorizing restart. Provide an assessment of the existing TS and plans related to a license amendment request to revise the TS if it is deemed necessary to ensure safe reactor operation.

Currently TS 3.9.2.1.(1) allows for one of three methods to prove that the fuel is latched:

(1) Elevation check of the fuel element with main pump flow.

(2) Rotational check of the element head in the latching direction only.

(3) Visual inspection of the fuel element head or latching bar.

A license amendment to TS 3.9.2.1. will be submitted requiring that (2) rotational checks and (3) a visual inspection must be performed any time the fuel heads are contacted before a reactor restart to verify that all fuel elements are fully latched.

10. In Enclosure 6, NIST indicated that a fuel reuse evaluation is underway.

a. Provide details about the studies performed to support this evaluation.

Observation of all fuel channels of each undamaged element looking for the presence of particulate matter that is jammed between fuel plates will be performed. A pump system is being designed to displace water via backflow through the fuel elements to remove any possible debris. This will be followed by detailed visual inspections of each element.

b. Identify and provide a technical justification for the specific conditions under which the existing fuel elements can be reused.

No visible damage to the element and no particulate matter visible between fuel plates (or a fuel plate and a side plate) are the criteria under which a fuel element can be re-used.

c. Provide calculation notes or files associated with the analysis of foreign particle size and the effect of reactor coolant flow on the remaining elements.

See attached report "Heat transfer in a disc wedged between two fuel element plates". The maximum "allowable" particle size will, if caught in an element, have no significant effect on the flow to other elements. See also "Analysis of cooling flow through 29 fuel elements with fuel element 1175 dislodged."

d. Identify and describe the analytic methods used for these analyses.

The analytic methods are described in the above listed report~~s~~.

e. Provide information demonstrating that the methods used for these analyses are appropriately qualified.

The analytic methods (hand calculations) were performed using the conservative assumptions listed. No software programs were used.

f. Provide additional detail concerning the status and plan for these analyses, given that the paragraph concludes with the statement that "This work will be performed under the SATOC [Single Award Task Order Contract]."

By "this work" referenced here, we mean the backflushing and inspection of all fuel elements to be reused. A setup is envisioned whereby the elements are backflushed at a flow rate that exceeds the normal coolant flow. This will happen in the stored fuel pool with equipment that will be designed, built and operated by a technical consultancy contractor which operates under a Single Award Task Order Contract (SATOC) with NIST. The thermal calculations will not be performed under this contracting vehicle, but rather in-house.

11. In Enclosure 6, NIST indicated that an engineering study of future redesign of the fuel head is underway. State whether the redesign is necessary prior to the restart of the reactor. If so, provide additional detail about this engineering study, including specifically how the study will evaluate the impact of such a redesign on the thermal-hydraulic and mechanical performance of the fuel bundles.

Detailed video examination of the failed element showed clear signs that it was in an unlatched configuration and showed no signs of mechanical failure of either the fuel element head or latch. Subsequent replacement of the element back into the grid showed no signs of mechanical anomalies and the element latched and unlatched normally. We have uncovered no evidence of any Part 21 defects and have shared this conclusion with the fuel element manufacturers.
As mentioned in attachment 3, redesign of the element head is not necessary prior to reactor restart. It is very questionable if a redesign of the fuel element will provide any benefits that are not already being reaped by the introduction of the underwater camera. However, the study will determine if any small benefits arise from a redesign. Any fuel head redesign will have no effect of the hydraulic path of the coolant through a fuel assembly. The latch bar will remain and will not change shape.

12. In Enclosure 8, NIST indicated that Corrective Action MS-CA-3 provides the assessment of the efficacy of all tools. In addition, Corrective Action IE-SPI-2 requires the tool manufacturer to provide accurate dimensional inspection reports to be completed after the restart of the NIST reactor. Identify the date when the NRC will be notified of the completion of these corrective action items for potential follow-up review by the NRC staff.

Measurements of all relevant reactor components are currently underway. The results of these measurements will be used to determine what changes may be desirable for tool replacement. Tool replacement would take place in late CY 2022 or CY 2023. We will notify NRC when plans for tool replacement are firmer.