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Dr. James Olthoff
Office of the Director
100 Bureau Drive
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Via email: james.olthoff@nist.gov

Dear Jim:

On December 2, 2021, in your role performing the non-exclusive functions and duties of the NIST Director, you asked four of us to do the following:

> "Within 90 days (March 2, 2022), provide your individual assessments of:
> 1. The conditions that allowed the February 3rd incident [at the NCNR reactor on the NIST Gaithersburg campus] to occur (TWG [Technical Working Group] + ERCAS [Event Response and Corrective Action Subcommittee] reports & presentations);
> 2. NCNR's emergency response to the incident (ERCAS report and presentation);
> 3. NIST's organizational response to the incident; and,
> 4. the efficacy and completeness of the proposed corrective actions. (TWG + ERCAS reports & presentations)."

This letter provides my response to this request. It is organized in four sections, each responding to one of the topics, followed by a general summary. My response is informed by a review of NCNR documents, by information given by NCNR and NIST staff in a series of four web meetings, and by the information received during a site visit on February 1, 2022, which included interviews with the crew that refueled the reactor on January 4, 2021 and the one that restarted it on February 3, 2021.

1. The conditions that allowed the February 3rd incident to occur.

The TWG analysis of the direct cause of failure being an unlatched fuel element is comprehensive and, in my opinion, leaves no doubt of the primary physical cause. The NCNR analyses of the root causes are also, I believe, comprehensive and accurate. They are as follows, verbatim:

Management Systems
- Insufficient change management system
- Inadequate oversight of refueling operations
- Culture of complacency in reactor operations group

Qualifications & Training
Inadequacy of training and qualification program

Procedures
Inadequacies in latch checking procedures
Procedural compliance not enforced

Instruments, Equipment, & Tools
Deficiencies in the fidelity of latch determination equipment and tools

At the heart of each of these four elements, in my opinion, is the turnover of the reactor crews due to retirements or other separations from the NCNR. The core of reactor operators has been hollowed out over time both by the retirements of highly experienced operators and the slow rate of their replacement and training of the replacements. The data provided to us show that, over the past ten years, the average years of operator experience has dropped from nearly 25 to just a bit above seven. Managing such a change in experience level would require a substantial shift in operational culture from one based on experiential knowledge to one that stresses detailed written procedures and a strict adherence to them. This culture shift, in my view, did not happen. The overall situation was not helped by a high turnover of the chief of reactor operations position in recent years, nor by the impact of COVID-19 on reactor operations, training, and certification.

Turning to the procedures and tools, the key step of latching the fuel unit into place is a manual procedure. It takes place 'blind' and requires compressing a spring, rotating the unit into place, and releasing the unit so that it latches in place. The operator does this while standing on the top of the reactor using a long tool to contact the unit. There are no fiducial marks to indicate the amount of rotation needed, and latching is confirmed by checking there is rotation (which was done incorrectly during fueling) and by a height check (unlatched units will be 'too high'). But the difference between latched and unlatched is small (less than ¼ inch) and hard to be certain about. (Upon starting the reactor, an unlatched unit can be displaced by the flow of cooling water and therefore overheat and melt, which was the case in the February incident.) During the site visit, I manipulated a mockup of the locking device and process and indeed it is difficult to be sure the element is locked. While the operators train on a simulated fuel loading rig, they report that it is unrealistic compared to the actual process. When success relies on the 'feel' of 'locking in' an element, this is a challenge for an inexperienced operator. Finally, there was discussion about the engineering group producing, at some point in the past, a new tool for refueling that was slightly longer than the old tool, but this difference was not communicated to the operations team in a comprehensive way. Its use would obviously make any height check irrelevant.

2. NCNR emergency response

The time line of the NCNR response shows a coherent response to the situation, with fission product release detection in the confinement building at 0909, followed by alert declaration at 0916, evacuation of control room at 0921, and notification of NRC and NIST management at 0929. There were no significant radiation increases at the site boundaries.

There are two points that require further discussion. First, while the alerts and evacuations proceeded appropriately and there were no injuries or significant radiation exposures, interviews with the February 4, 2021 team suggested that there had been no training or drill on what to do in the case of melting fuel elements. There also was not a check list for control room evacuation. Secondly, there seems to be a demarcation between NCNR emergency management and that of NIST itself. NCNR terminated its emergency situation at 1935 on February 3, 2021 based, as I understand, on the end of the radiation-related issues. But the building was not reclaimed at that time and indeed re-entry to the building at 0800 the next day was unsuccessful due to the presence of carbon dioxide. I think there should have been a continuous and coordinated management of emergency status until the building was returned to normal operations.

The lack of an evacuation check list opened several opportunities for bad outcomes. One of the operators pointed out a concern that a hot plate for coffee may have been left on, creating a fire hazard. More significantly, the source of carbon dioxide for blanketing the reactor had been left on, so that the building accumulated carbon dioxide in its lower levels. Reentry attempted by personnel without appropriate breathing gear the next day may have posed the most significant health and safety challenge of the whole event.

3. NIST organizational response

The NIST response overall to this situation has been good. There is a deep understanding of what needs to be done and, importantly, what communication needs to be carried out. The fact that this incident has not generated a significant number of news stories or community interest speaks to the effectiveness of engagement and communication. Communication with the NRC has been open and, as far as I can see, frank and candid. Internally, quick formation of an incident response team has given a robust framework for appropriate follow-up actions. All of the follow-up engagement that I am aware of has been collaborative and highly professional.

Nonetheless, it is striking that the analysis and remediation steps carried out have been essentially all done by NIST in-house experts. I think there is a tremendous opportunity to learn from other organizations that routinely handle or produce hazardous materials or engage in potentially hazardous processes. Examples include many elements of the chemical processing industry as well as procedures at commercial and military (Navy) nuclear power plants. What are the lessons to be learned from those operations? In particular, what elements of training and supervision can be carried over to improve NCNR reactor operations?

4. [T]he efficacy and completeness of the proposed corrective actions. (TWG + ERCAS reports & presentations)"

The proposed corrective actions fall broadly into two categories, namely the physical and process improvements needed for the fueling activity to be completed without error, and the training and staffing adjustments that need to be made to increase the quality and safety of operations overall.

In regard to the fueling activity itself, I believe that the proposed corrective actions, including installation of fiducial markings and a final visual check, will prevent future latching failures. The unknown is, of course, what other hardware or process failures could occur that could lead to even larger problems. Addressing that is the goal of a large number of corrective actions proposed by the NCNR.

We were presented with a list of seven corrective actions. They are:

1. **Change management:** Review current change management steps, manage more effectively in an environment of high attrition, assess efficacy of refueling tools, prioritize the aging reactor management program, and consider establishing a committee to track corrective actions.

   Note that a key step in managing with a high degree of staff attrition is forming and staffing a fifth shift. This fifth shift would allow time for operator training and interfacing with the engineering staff while providing some buffer for attrition. In addition, current shifts need to be fully staffed. The creation of a fifth shift and accelerated hiring for existing positions is the single most important corrective action to be taken to avoid problems in the future.

2. **Oversight:** Develop a program for robust qualification of supervisors for refueling operations.

   This is obviously a key need.

3. **Culture of Complacency:** Develop a plan for continuous improvement of reactor operations. Hold leadership accountable with enhanced communication and engagement.

   Culture change in any organization is difficult, and it will be difficult to do so in the reactor operations group. The level of experience varies widely among the operators and getting the more senior ones to adhere to written procedures and check lists for activities they have been doing by rote for years will be hard. I strongly recommend NCNR contract with experienced consultants to develop a workable approach to this change.

4. **Qualification and Training:** Rewrite and redesign training.

5 and 6. **Procedures and Procedure Compliance:** Update and modify procedures.

Actions 4, 5, and 6 taken together should mold a team of reactor operators who are highly competent and placed in a position to succeed.

7. **Latch Check:** This is discussed above.

In summary, in my view, the incident on February 3, 2021 was caused by an unlatched fuel element that moved out of position during startup, lost cooling water flow, and melted. The unlatched element occurred due to a lack of training and experience by the reactor operator who loaded that element, and that in turn reflected a lack of in-depth training programs and a lack of adherence to established procedure. In other words, he was tasked with doing a job for which he was unprepared.

The work by NCNR and NIST following the incident has been of high quality, with the exception of the attempted building reentry on the subsequent day, during which unprepared personnel encountered high levels of carbon dioxide.

While the work on corrective actions will move NCNR to a more highly functioning and safe state, implementation of all of the actions will require considerable attention by NCNR management and hiring of a substantial number of new operators. The allocation of time and resources to manage this by NIST leadership will be important. Finally, I strongly encourage NCNR to look beyond the NIST boundaries for models of training and procedure adherence in related fields or industries with similar risk profiles, and I encourage them to consult with strong change management advisors to ensure successful transitions.

Sincerely,

Eric W. Kaler
President