DEFENSE NUCLEAR FACILITIES SAFETY BOARD

625 Indiana Avenue, NW, Suite 700, Washington, D.C. 20004-2901
(202) 694-7000

September 23, 2002

The Honorable Jessie Hill Roberson
Assistant Secretary for Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Ms. Roberson:

The staff of the Defense Nuclear Facilities Safety Board (Board) visited Oak Ridge National Laboratory (ORNL) on July 30, 2002, to review the safety of sodium fluoride (NaF) traps stored in Building 3019A, a defense nuclear facility at ORNL. The NaF traps store uranium-233 hexafluoride (UF_6) from the Molten Salt Reactor Experiment. Pressure from radiolytic gas production continues to build in the NaF traps, representing a potential hazard to workers when the traps must be handled and a potential contamination hazard should the traps begin to fail in storage.

The Board understands that ORNL has installed and tested equipment to convert the UF_6 in the traps to a stable form, developed most of the associated procedures, and trained operators. Unfortunately, ORNL has determined that valves in the hydrogen fluoride (HF) system of the conversion equipment must be replaced because they contain parts that are susceptible to corrosion in HF. On July 19, 2002, the Department of Energy's (DOE) Oak Ridge Operations Office directed ORNL to stop work on the conversion project and develop alternative approaches for processing and disposing of the UF_6.

The Board is concerned that a major redirection of this work could interfere with the timely remediation of the hazards posed by the NaF traps. Experience at other DOE sites has shown that redirection of projects in favor of undeveloped alternatives often results in significant delays, and may even prevent the work from being accomplished.

The enclosed report summarizes issues discussed during the staff's recent review of the storage and remediation of the NaF traps.

Pursuant to 42 U.S.C. § 2286b(d), the Board requests a briefing by DOE within 60 days of receipt of this letter regarding its plans for remediating the hazards posed by the NaF traps in a safe and timely manner.

Sincerely,

John T. Conway
Chairman

c: Mr. Mark B. Whitaker, Jr.
Mr. Raymond L. Orbach

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

September 3, 2002

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: H. W. Massie

SUBJECT: Safe Storage of Sodium Fluoride Traps, Oak Ridge National Laboratory

This report documents a review conducted by the staff of the Defense Nuclear Facilities Safety Board (Board) of the storage of sodium fluoride (NaF) traps containing uranium-233 (U-233) hexafluoride (UF_6) recovered from the Molten Salt Reactor Experiment (MSRE). The traps are stored primarily in tube vaults along with other U-233 materials in Building 3019A, a defense nuclear facility at Oak Ridge National Laboratory (ORNL). As part of this review, staff member H. W. Massie visited ORNL on July 30, 2002.

Description of NaF Traps. ORNL is storing 26 NaF traps, containing a total of 23 kg of U-233 in the form of UF_6, in Building 3019A. The trap vessels are made of Monel 400, a nickel-copper alloy that is corrosion resistant to UF_6 and fluorine. All welds in the trap vessels were made using Monel filler wire, and the four vessel penetrations are made from Monel tubing. The design pressure of the vessels is 800 pounds per square inch gauge (psig) at 100°F and 250 psig at 700°F. The trap temperatures are less than 100°F under current storage conditions. The traps have two small (1/4 inch) valves. The exposed surfaces inside the valves are made of such materials as copper, phosphor bronze, and Monel. During final assembly, the traps were pressure tested to 1000 psig.

Radiolysis in NaF Traps and Pressure Monitoring. The internal pressure of the traps is increasing because of radiolysis of the NaF–UF_6 compound, which evolves fluorine gas. ORNL monitors the pressure in two traps (traps #1 and #6) stored in Cell 1 of Building 3019A. Figure 1 (attached) presents pressure data provided to the Board's staff by ORNL. The figure shows that the pressure in trap #6 is approaching 300 psig and is continuing to increase. Trap #1 contains considerably less material and has generated less pressure.

The pressure instrument is calibrated for pressures up to 250 psig. Therefore, ORNL is now estimating the pressure for trap #6 based on extrapolation of the calibration data, contrary to industry standards for calibration. Hence, uncertainty exists in the pressure measurements, and this uncertainty will increase as the pressure continues to rise above the calibrated range of the instrument. Furthermore, trap #6 is not believed to be the worst-case trap; thus higher pressures are expected to exist eventually in nine traps stored in the Building 3019A tube vaults. At this time, only one other trap is calculated to have a higher pressure than trap #6.

During the staff's July 30, 2002, visit, ORNL stated that the pressure increase is due to radiolytic production of fluorine gas via the following reaction:

$$Na_2UF_8 \rightarrow Na_2UF_7 + F \rightarrow Na_2UF_7 + \tfrac{1}{2} F_2$$

Radiolysis from alpha decay is likely the primary contributor to gas generation. ORNL previously estimated that the G-value of the radiolysis was 0.44 molecules of fluorine gas (F_2) per 100 electron volts (eV) of decay energy. More recently, ORNL stated that the G-value is now estimated to be about half of that estimate, based on pressure measurements for trap #6. ORNL is not certain about the reason for the reduction in G-value, but postulates that it may be due to an approach toward equilibrium between radiolytic gas production and back reactions of the fluorine. The staff believes that only the larger G-value of 0.44 molecules/100 eV can be justified in the absence of data from a properly calibrated pressure instrument for higher pressures (i.e., ≥250 psig). Hence, the staff believes ORNL ought to develop the processing plan and schedule based on the higher G-value.

Stabilization and Disposition of NaF Traps. Action must be taken before the pressure in the traps begins to threaten their integrity or reaches a level at which excessive hazards would be involved in moving them or opening them for processing. Although ORNL originally planned to store the traps for only about 3 years, all but two of the traps have been stored for more than 4 years, including trap #6.

Until recently, ORNL was preparing to convert the UF_6 from the NaF traps to a stable uranium oxide that would comply with DOE standard DOE-STD-3028-2000, *Criteria for Packaging and Storing Uranium-233 Bearing Materials*. ORNL initiated the conversion project in 1999, with plans to conduct the operation in Building 4501. The original schedule was to start conversion in spring 2002, but the work has been delayed for several reasons, including the need to apply lessons learned in conduct of operations and equipment shakedown testing from the Building 3019A U-233 inspection project.

ORNL has installed the conversion equipment in a hot cell; trained the operators; and conducted a comprehensive test program, which included integrated system testing, equipment shakedown testing, and checkout of many of the procedures. It was estimated that all 26 traps could be processed in 2–1/2 years. Unfortunately, ORNL found a major problem with the valves in the hydrogen fluoride (HF) system. ORNL personnel stated that they had specified Inconel 600 material for the valves to provide corrosion resistance to HF. However, ORNL found that the bellows assemblies on the valves contain stainless steel parts that would corrode in HF. On July 19, 2002, while ORNL was in the process of buying and installing replacement valves, the Department of Energy's Oak Ridge Operations Office (DOE-ORO) directed ORNL to stop work and develop alternative approaches for disposing of the material in the NaF traps.

Alternative Approaches for NaF Trap Stabilization. DOE-ORO is proposing the pursuit of alternate disposal methods as part of the DOE-Headquarters Cleanup Reform Initiative. Unlike the conversion project, for which equipment has been installed and operators trained, the alternative approaches have not yet been developed. DOE-ORO is proposing to

depressurize the traps, and process the UF_6 with depleted uranyl nitrate and nitric acid. This will result in a down blended solution that will be neutralized with sodium hydroxide for placement in the Melton Valley Storage Tanks. This approach requires the installation of substantial additional equipment. DOE-ORO is also evaluating another approach that would involve converting the UF_6 to uranyl fluoride (UO_2F_2) for storage. UO_2F_2 is more stable than UF_6 but less stable than uranium oxide. This latter approach can use much of the existing equipment.

DOE-ORO believes that an alternate approach will allow the traps to be stabilized in 3–4 years at a lower cost than the baseline conversion process, and has requested proposals from both the ORNL contractor (UT Battelle) and the Oak Ridge site environmental management contractor (Bechtel-Jacobs) for such alternatives. DOE-ORO expects to receive proposals from the two contractors and make a decision.

DOE-ORO also requested that ORNL evaluate ways of depressurizing the traps to postpone the need to empty them and process their contents. The process equipment already installed within the conversion project could be used to vent the traps. The principal concern with this approach is the need to ensure that the valves on the traps can be properly resealed so that they do not leak and contaminate the tube vaults after being returned to storage. DOE-ORO's facility representative has raised concerns that the delicate bellows seal on the valves may be damaged or otherwise not reseal properly if the valves are cycled to relieve pressure in the traps. DOE-ORO plans to leak test the valves at 100 psig after venting and to develop tools and procedures for replacing a valve stem/bellows assembly.

Staff Evaluation. The staff reviewed the safety analysis and hazards associated with the NaF traps. As long as the traps remain in the tube vaults, the hazards are minimal, but failure of traps in the tube vaults would require potentially hazardous cleanup actions. Worker hazards also exist during transfer of the NaF traps from storage to the processing location. ORNL is reanalyzing the carrier design for the NaF traps to accommodate transport of traps that contain elevated pressure.

The staff believes that redirection of the stabilization effort for the NaF traps could interfere with timely remediation of the above hazards. Experience has shown that redirection of projects in favor of undeveloped alternatives often results in delays. In the case of the NaF traps, DOE-ORO's proposal to dispose of the materials in the Melton Valley Storage Tanks is feasible only if it can be accomplished during the 4–5 year operational period of the Melton Valley Transuranic Waste Treatment Project, which involves removing and disposing of the wastes from the tanks. If the selected alternative approach cannot meet that schedule, the opportunity to dispose of the materials from the NaF traps in the Melton Valley Storage Tanks will be lost.

While it is DOE's prerogative to choose among technically acceptable alternatives for its stabilization activities, the staff believes it might be prudent to continue replacing the defective valves for the existing conversion equipment in parallel with the development of alternative approaches. Doing so would provide better assurance that DOE will be able to stabilize the materials, or at least relieve the pressure, before the NaF traps develop integrity problems. ORNL estimates it would take about a year to complete installation of the new valves and to retest the system.

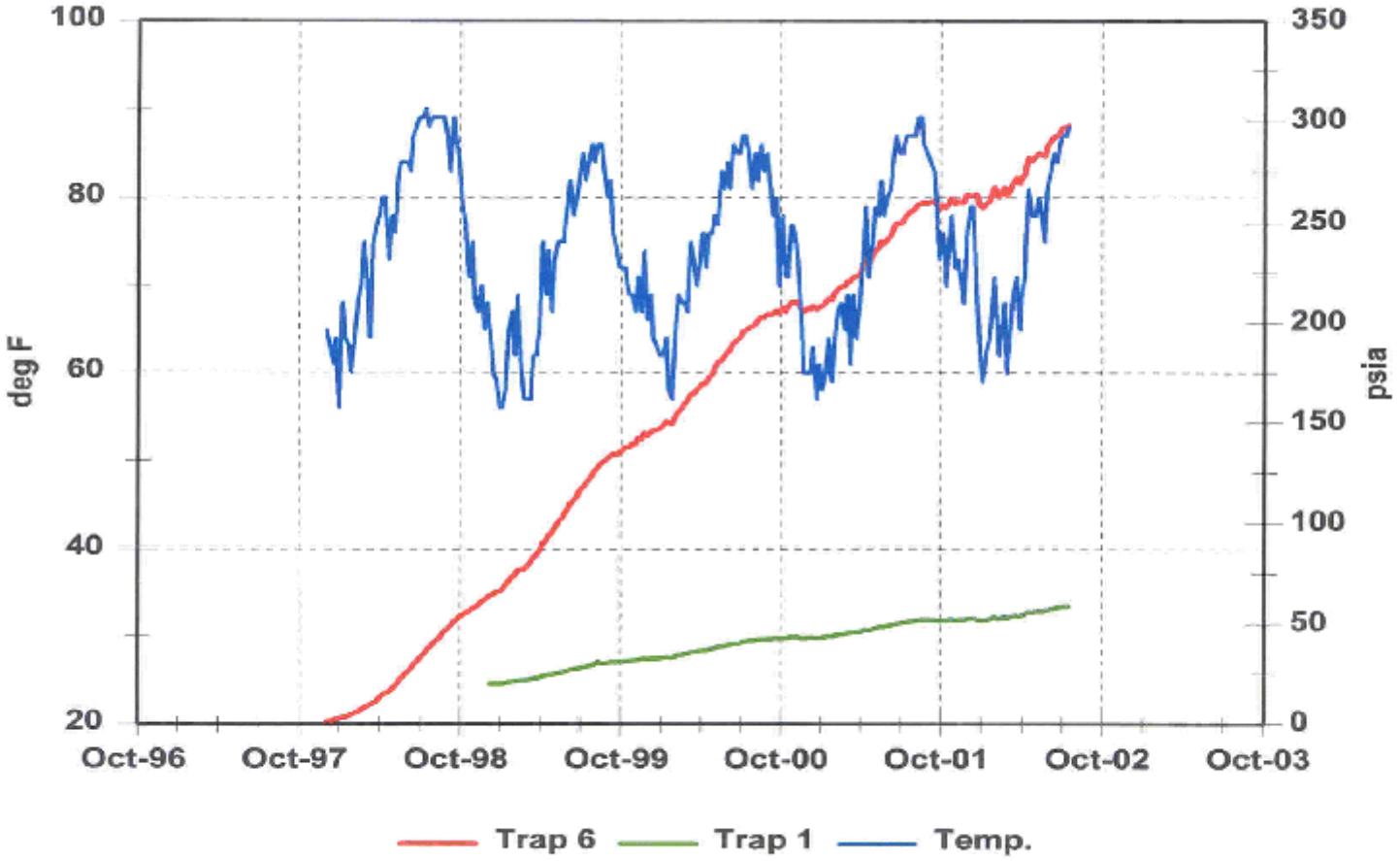

Figure 1: Pressure in the two monitored NaF/UF_6 traps, and temperature in Bldg 3019.