DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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May 10, 1996

Mr. Mark B. Whitaker, Jr.
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0119

Dear Mr. Whitaker:

Enclosed for your information and distribution are three Defense Nuclear Facilities Safety Board staff reports. The reports have been placed in our Public Reading room.

Sincerely,

George W. Cunningham
Technical Director

Enclosures (3)

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

December 13, 1995

MEMORANDUM FOR: G.W. Cunningham, Technical Director

COPIES: Board Members

FROM: Larry Zull

SUBJECT: Trip Report - Safety Issues Associated With the Proposed Retrieval of High-Level Waste from Hanford Tank 241-C-106

1. **Purpose:** This trip report summarizes safety issues associated with Department of Energy (DOE's) proposed plan for the retrieval of high level waste from tank 241-C-106 (C-106) at the Hanford site. The safety issues were discussed with the contractor, the Westinghouse Hanford Company (WHC), during a joint meeting of representatives of the Chemical Reactions Subpanel of the Hanford Tank Advisory Panel (CRS-TAP), Tank Safety Strategy Review Team (TSSRT), DOE-Headquarters, and DOE-Richland Operations Office (DOE-RL) on November 14-16, 1995 in Richland WA. Defense Nuclear Facilities Safety Board (Board) staff member Larry Zull attended the meeting.

2. **Summary:**

   a. DOE has selected tank C-106 to test the application of "past practice sluicing" technology to retrieve high-level waste from Hanford single shell tanks (SSTs), and to resolve the high-heat waste (HHW) issue in tank C-106. However, there are many chemical process and worker safety questions that have not been addressed. Core samples have not been taken to determine the distribution of heat producing radionuclides in the sludge and hardpan layers, or to analyze and evaluate the physical and chemical compatibility of the tank C-106 waste when it is added to the existing waste in the receiver tank AY-102. Thus, it is unclear whether the proposed retrieval technology will allow safe and adequate retrieval of the HHW, or is the best technology for tank C-106 waste retrieval. DOE proposes that the other wastes in the tank (the hardpan layer and heel) be removed by commercial technologies in a future program. Thus, there is a lack of a closure criteria, and there is no decommissioning plan for tank C-106.

   b. The proposed retrieval program raises several chemical process related safety issues. The sluicing could separate the fissile plutonium material from the various absorbers and poisons in the sludge, raising potential criticality concerns.

      There are several means by which potentially dangerous gases, including NOx, ammonia, and hydrogen, can be released during the proposed operations. The release and collection of gases which may exceed the flammable limit, or be toxic to workers,

is a concern for both the process tank C-106 and the receiver tank AY-102. The amount of organic material in tank C-106 is not believed to be large, but the actual amount is uncertain. The potential for an organic reaction in tank C-106, and the receiver tank AY-102, has not been resolved. Many of these safety issues could be addressed if waste samples were taken and appropriate tests and evaluations were performed, as recommended by Board Recommendation 93-5.

c. There are also safety issues related to the waste transfer process. There is no measurement or process control of waste and sluicing fluid (slurry) density in the retrieval equipment or transfer lines to avoid the potential for plugging. As Low As Reasonably Achievable (ALARA) evaluations for the replacement or cleanout of failed or plugged equipment or lines have not been performed, or considered in the system design. Specific procedures to replace or cleanout equipment or lines have not been developed.

3. **Background:** Tank C-106, a 530,000 gallon capacity SST, is a high-heat load (greater than 40,000 Btu/hr) "watch list" tank requiring the addition of about 6,000 gallons of cooling water per month to maintain safe tank temperatures. The tank, which has been in service for 48 years, is currently listed as sound, but the probability of a tank leak increases with the tank's age. The waste in the tank consists of a 173,000 gallon layer of sludge (containing plutonium, cesium, and strontium) on top of a 24,000 gallon layer of hardpan material (from the dissolution of aluminum fuel cladding). The sludge is covered with about eleven inches of supernate to provide cooling. The radionuclides in the tank generate about 130,000 BTU/hr of heat, which exceeds the tank thermal design criteria.

The addition of cooling water to tank C-106 would need to continue until about the year 2045 to prevent overheating (a function of the strontium decay). The only viable long-term resolution of the tank C-106 HHW safety issue is to transfer the waste to a double-shell tank designed to accommodate the heat generation. DOE-RL has proposed to remove about 75% of the HHW to reduce the heat output of the remaining waste to less that 40,000 BTU/hr. This will allow for cessation of the active ventilation and cooling water additions. The HHW is to be retrieved from tank C-106 by the method of "past practice sluicing," and the waste transferred into the double-shell receiver tank 241-AY-102 (AY-102) which is designed to contain the HHW heat load. The retrieval process is expected to be a batch process. It could take one to several weeks, depending on the amount of waste dilution, to remove the waste from tank C-106.

4. **Discussion**: The purpose of the meeting was to discuss the mission and safety issues associated with the proposed retrieval plan, and provide comments on the recently issued document "Safety Assessment For Tank 241-C-106 Waste Retrieval Project W-320," (WHC-SD-WM-SAD-024, Rev 0), dated October 20, 1995. The following are major issues raised during the meeting.

   a. Application of Retrieval Technology to C-106: DOE has selected tank C-106 to test the application of "past practice sluicing" technology to retrieve high-level-waste from Hanford SSTs, and to resolve the HHW issue in tank C-106. However, no core samples have been taken to mix the waste with the sluicing fluid (raw water and corrosion inhibitors) to demonstrate that the sludge can be suspended in the sluicing fluid and pumped the one-quarter mile to the double shell receiver tank AY-102 without precipitating and causing plugging in the transfer line. There are also chemical compatibility questions in regard to heat generation and gas generation, which are discussed later. Overall, it is unclear whether the proposed retrieval technology would allow adequate retrieval of the waste, or is the best technology for tank C-106 waste retrieval.

   b. Retrieval Success Criteria: DOE-RL proposed that the removal of 75% of the HHW from tank C-106 be the success criteria, since then the tank would no longer need active ventilation or cooling water addition for tank safety. However, Amendment 4 to the Tri-Party Agreement (TPA) states that tank wastes shall be removed to the limit of technology, or 99% by volume (averaged over the tank), whichever is cleaner. Therefore, the appropriate success criteria for the retrieval project is unclear.

   c. Radionuclide Distribution: The composition and amount of the waste in tank C-106 is known (based on past tank inventory records), but the distribution of the radionuclides in the tank are not well known. The retrieval project plans to remove the sludge layer, in which most of the radionuclides are assumed to be located. However, it is suspected that some of the strontium has migrated into the hardpan layer below the sludge, and may not be removed by the sluicing process. Although temperature distribution calculations indicate that a majority of the strontium has remained in the sludge, the amount of strontium in the hardpan, and the rate of mass transport of the strontium into the hardpan, are not well known. The last waste sample, taken in 1986, did not provide this information. The 1986 sample only provided a 30% recovery, and did not penetrate far into the hardpan.

d. Waste Compatibility: Prior to the start of sluicing operations, the original supernate in tank AY-102 will be removed and replaced with corrosion-inhibited water that will be used as the fluid for sluicing the tank C-106 sludge waste. The waste slurry from tank C-106 will then be pumped into tank AY-102. After the solids have settled out of the sluicing water/sludge mixture in receiver tank AY-102, the water will be repumped to tank C-106 to be reused as the sluicing fluid. However, tank AY-102 contains about 32,000 gallons of its own compacted solids/sludge. Compatibility testing to identify possible adverse effects (energetic reactions, heat generation, gas generation and release, etc.) of adding the tank C-106 waste to the waste in tank AY-102 has not been performed.

   The CRS-TAP and the Washington Department of Ecology suggested that a new sample be taken to evaluate the waste compatibility. The sampling and evaluation of high-level waste from individual Hanford tanks was also recommended in Board Recommendation 93-5. However, it is recognized that the radial distribution of material in tank C-106 is variable, and that representative samples may be difficult to obtain given the available sampling locations.

e. Heat Generation During Waste Retrieval: Because the cooling water layer above the sludge must be removed to allow effective sluicing, a chiller is being installed on tank C-106 to keep the waste subcooled during retrieval. The tank will be chilled for several months before sluicing begins; however, the ability of the chiller to remove heat generated during the retrieval process has not been evaluated. During retrieval operations some of the sluicing fluid will be vaporized by contact with regions of high heat in the sludge. Heat will also be released by the dissolving of sludge layer soluble materials in the sluicing fluid (heat of solution). The ability of the chiller to remove this heat, and prevent excessive waste and tank temperatures, has not been evaluated.

f. Criticality Potential: There is about 96 kg of plutonium in tank C-106, and 8.7 kg in receiver tank AY-102. The proposed sluicing of the sludge could separate the fissile plutonium material from the various absorbers and poisons in the sludge, raising potential criticality concerns. A criticality assessment specifically for tank C-106 has not been performed. The amount of plutonium in tank C-106 now exceeds the site criteria for fissile material control. The sludge retrieved from tank C-106 may therefore need to be transferred into two different double shell tanks to avoid violating a mass criticality safety limit. It should also be noted that the double shell tanks at Hanford are currently operating under interim mass criticality safety limits of 0.013 g/l concentration, and 25 kg Pu equivalent until the safety basis for new limits can be determined.

g. Gas Generation: There are several means by which potentially dangerous gases, including NOx, ammonia, and hydrogen, can be released during the proposed retrieval operations. Entrained gases can be released from the sludge when it is sprayed with 120 psi sluicing fluid, or when the slurry goes through the vertical centrifugal suction pump and booster pump which transfers the slurry into tank AY-102. The rate at which entrained gases may be released is also a concern, as is the formation of a large vapor bubble in the waste which could splash waste up into the air inlet or exhaust risers in the dome.

The release and collection of gases which may exceed the flammable limit, or are toxic to workers, is a concern for both the process tank C-106 and the receiver tank AY-102. The generation and retention of gases in the receiver tank AY-102, and the effect of loss of ventilation in tank AY-102, have not been evaluated. There also does not appear to be adequate instrumentation and equipment for monitoring and measuring the concentration of gases in tank C-106, the transfer line, or tank AY-102 either during or after operations.

h. Organic Reactions: The amount of organic material in tank C-106 is not believed to be large, but the actual amount is unknown. Organic material can be in the sludge and the hardpan. If the waste remaining in tank C-106 was allowed to dry-out after the HHW retrieval program, as currently planned, the resulting high temperatures could cause an energetic organic reaction. The potential for such a reaction in tank C-106, and the receiver tank AY-102, has not been resolved. However, the organics in tank C-106 may have degraded more than in other SSTs because of the high heat conditions.

i. Waste Transfer: The sluiced sludge will be pumped about one-quarter mile from tank C-106 to the receiver tank AY-102. The density of the sludge is expected to be about 15-20% weight solids in a slurry mixture. The solids loading limit is currently 30% in the transfer line from tank C-106 to tank AY-102. Flowmeters will be installed to measure the flowrate of the slurry as it is pumped from tank C-106 to tank AY-102, but there is presently no measurement of the slurry density to determine the solids loading (and hence, avoid the potential for plugging) in the transfer or the return line. There is also no automatic process control of the flow. The amount of gas that can be tolerated in the transfer line is unknown. The potential for solids to plug the pumps or the lines during operations, or after pump shutdown, has not been fully evaluated.

j. Worker Safety: The major risks to plant workers include failure of tank C-106 integrity (a major leak), the emission of toxic or flammable gases during the proposed operations, and potential radiation exposure due to the need to replace plugged or failed equipment or lines.

ALARA evaluations for the potential replacement of failed equipment, or clearing of plugged equipment, lines, or instrumentation have not been performed, or considered in the system design. Specific procedures to clear plugged equipment or lines, or replace failed equipment, have not been developed.

k Lack of Closure Criteria: After the HHW sludge is pumped out of tank C-106, a hardpan layer and a waste heel may still remain in the tank. Removal of the sludge layer using "past practice sluicing" will not meet the TPA Milestone M-45-03 requirements to complete the SST waste retrieval demonstration. If the failed heel jet in tank C-106 could be replaced, much of the heel might be removed.

In order to complete the SST waste retrieval demonstration in tank C-106, DOE proposes that commercial technologies be used to retrieve wastes that are not removable by sluicing. The commercial technologies would be evaluated and demonstrated by the Acquire Commercial Technology for Retrieval (ACTR) project at some time in the future. Therefore, there is a lack of a closure criteria, and there is no decommissioning plan for the C-106 tank.