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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

January 31, 1994

MEMORANDUM FOR: G. W. Cunningham, Technical Director

COPIES: Board Members

FROM: David C. Lowe

SUBJECT: Savannah River Site (SRS) - Canyon Process Vessel Integrity Trip Report (January 18-19, 1994)

1. **Purpose:** This trip report documents the Defense Nuclear Facilities Safety Board (DNFSB) technical staff (D. Lowe and J. Roarty) and outside experts (J. Nichols and J. Nestell, MPR Associates) January 18-19, 1994 review of SRS canyon process vessel integrity.

2. **Summary:**

   a. An in-service inspection program for canyon process vessels is an inherent feature for a defense in-depth strategy to minimize the potential for release of material to the environment. Westinghouse Savannah River Company (WSRC) reported that they are developing an H-Canyon equipment and piping structural integrity program (which includes an in-service inspection program) which is scheduled to be completed by August 1994. The DNFSB staff believes this program needs to be expeditiously implemented at both H-Canyon and F-Canyon in order to minimize the potential for process vessel leaks and subsequent releases to the environment.

   b. The propensity for process vessel cooling/heating coil leaks and the potential release of contamination to the environment are strikingly similar to the K-Reactor heat exchanger leak in December 1991. Similar administrative controls are relied upon to mitigate the release of radioactive material to the environment via the cooling water discharge. To provide additional assurance of avoiding a release to the environment, it is appropriate to consider additional engineered safeguards, e.g., automatic diversion of cooling water flow to a controlled volume in response to detection of radioactivity in the cooling water.

   c. There is insufficient information to draw a final conclusion as to the integrity of Tank 17.1 or any other canyon process vessel, but indications are that there is not an immediate threat to public health and safety. WSRC suspects that the majority of the unexpectedly high iron concentrations in Tank 17.1 is not from corrosion, but from process chemical additions. The principle residual concern is associated with the assumptions utilized in the Safety Analysis Report (SAR) Addendum 2 which concludes that the risk of a Tank 17.1 coil leak is acceptable.

3. **Background:** F-Canyon and H-Canyon each have 75 process vessels of various sizes and uses. These vessels are made of 304L stainless steel and many have been in use since canyon operations began in the mid-1950s (H-Canyon has 36 original process vessels, and F-Canyon has 33 original process vessels).

4. **Discussion:**

   a. Process Vessel Integrity: There have been one leaking tank wall and 143 coil failures, see Table 1. The majority of the coil leaks occurred prior to 1985. At that time the operating procedures were changed to reduce the thermal shock to the cooling/heating coils associated with switching from steam flow to cooling water flow.

      1. The most likely corrosion mechanism for the stainless steel tanks containing strong acid and internal cooling/heating coils is accelerated corrosion (intergranular attack) of weld heat affected zones. The rate of this attack depends on the temperature, acid concentration, and impurities present in the tank. Process vessels with higher temperature service history (e.g., evaporators) will suffer faster attack.

      2. Leaks are likely to occur first in the cooling/heating coils rather than in the tank walls due to the coil's higher temperature (when used for heating) and thinner wall thickness. These leaks are expected to start as small pin-hole leaks and gradually increase with time (leak before break).

      3. Leaking cooling/heating coils are more likely to result in a release to the environment than leaks in the tank walls. Leaks in the tank wall are collected in the sumps provided for each cell. The leakage is then pumped to a waste collection tank. Tank leakage can potentially escape to the environment by seepage through canyon expansion joints, and by evaporation and discharge out the stack via the sand filter. Leaks in cooling/heating coils are detected by increases in tank level from in-leakage of cooling water (higher pressure than tank) or by radiation monitors on the cooling water discharge. Approximately 44% of cooling/heating coil leaks were identified by radiation monitors in the cooling water discharge outside the canyon. After the radiation monitor alarms, there is a minimum holdup time of 2 hours prior to release to outside streams. Thus, defense against release to the environment from a cooling coil leak depends on the radiation monitor (backup provided) and appropriate action by the operator within 2 hours. The feasibility of a control system which automatically isolates the cooling water system and diverts flow to a controlled volume if a radiation monitor alarms has not been determined. Such a system would provide a layer of protection against release to the environment which is independent of operator action.

4. WSRC personnel stated that they have the capability to leak test the coils, but this is not periodically done.

5. WSRC personnel noted that a major contributor to cooling/heating coil leakage is the thermal shock associated with switching from steam flow to cooling water flow during process operations. To minimize the thermal transient in the coils, air is introduced to equilibrate temperature in the coils prior to changing from steam flow to cooling water flow. The extent of operator training and procedural limits on valve manipulation and pump start evolutions were discussed. Awareness of the potential for a water hammer transient was not demonstrated. Given the potential for this type of severe accident, it is appropriate that the safety analysis for the system consider coil leakage much greater than the magnitude associated with corrosion (pin-hole).

Equipment	1954 - 1985		1985 - 1993	
	Average Service Life (years)	Number of Failures	Average Service Life (years)	Number of Failures
Dissolver	9.3	6	20.3	1
Evaporator, Continuous	4.0	32	4.6	5
Evaporator, Batch	4.2	85	6.3	4
Heated Storage Vessels	14.0	9	21.0	1
Note: The average service life only takes into account the service history of coils that have failed; it does not take into account the service history of coils that have not failed.				

Table 1: Cooling/Heating Coil Failure History

b. Structural Integrity/In-Service Inspection Program: WSRC has concluded that because of cost and technical limitations, they will not pursue development of a remotely operated ultrasonic testing (UT) system for vessel wall thickness measurements. WSRC reported that they are developing prototype equipment and a piping structural integrity program for H-Canyon which will include in-service inspection. This program is expected to be defined for H-Canyon in August 1994 and, if appropriate, also applied to F-Canyon. Program implementation dates have not been set. The DNFSB staff believes that such a structural integrity/in-service inspection program for canyon process vessels should be expeditiously developed and implemented. The DNFSB staff anticipates that such a program, to be effective, would include the following types of positive actions in order to minimize the potential for process vessel leaks and subsequent releases to the environment.

1. Establishment of a predicted useful process vessel life based on the contents of the vessel, operating temperature, vessel wall thickness, and the number of coil replacements previously performed on the vessel. Process vessels would be inspected or replaced at the end of the predicted useful vessel life.

2. Process vessel replacement if a coil leak occurs. WSRC stated that coil replacement is no longer cost effective and that in the future the process vessel will be replaced.

3. Periodic hydrostatic leak tests of the heating/cooling coils.

4. Analysis and trending of process vessel corrosion by analyzing the tank contents for iron, chromium, and nickel. WSRC stated that a program will be established to monitor corrosion products in process solutions.

5. Monitoring of reduced chemical species to determine corrosion rates.

6. Direct corrosion monitoring utilizing probes and instantaneous corrosion measurement techniques such as electrical resistance measurements or galvanic current measurements, or alternatively, measuring weight loss of corrosion coupons.

c. Tank 17.1: Off-normal occurrence SR--WSRC-FCAN-1993-0060 reported higher than anticipated levels of iron in Tank 17.1, which contains a solution of americium (Am) and curium (Cm).

1. Tank 17.1 was used as a heated storage vessel until 1971 when a coil leak developed. The coil was replaced and the vessel was placed in the 17.1 position. In 1980, the Am and Cm solutions were consolidated in Tank 17.1, which is now used as a non-heated (temperature approximately 40°C) storage vessel.

2. The 1971 coil failure analysis report states that the minimum tank wall thickness was 0.45 inches. The original wall thickness (0.5 inch nominal) is not known. WSRC will determine the minimum wall thickness for a similar, but unused, process vessel to provide a benchmark in estimating the extent of vessel corrosion in 1971.

3. The 1993 analysis of the contents of Tank 17.1 indicate higher levels of iron than that expected from corrosion of 304L based on the amount of nickel and chromium in the solution. Therefore, WSRC concluded that the majority of the unanticipated increase in iron is not from corrosion. WSRC suspects that ferrous

sulfamate contamination may have entered Tank 17.1 when additional material was added to the tank in 1985, but there are no records of an analysis of the addition to confirm this supposition. This issue constitutes a residual uncertainty concerning tank integrity.

4. The small amounts of nickel and chromium in the 1993 sample indicate a general corrosion rate of 0.6-0.9 mils/year since 1980 which is within the range expected for the low temperature of Tank 17.1.

5. WSRC is conducting an engineering evaluation using current codes to determine the required Tank 17.1 minimum wall thickness for expected static loads and a design basis earthquake.

6. There is insufficient information to draw a final conclusion on the integrity of Tank 17.1, but indications are that there is not an immediate threat to public health and safety.

5. **Future DNFSB Staff Actions:** DNFSB staff follow-up action is required to:

a. Review resolution of the Tank 17.1 integrity issue.

b. Review the evaluation of additional engineered safeguards such as an automatic cooling water diversion system.

c. Review implementation of a structural integrity/in-service inspection program for all canyon process vessels.

d. Conduct a detailed review of safety documentation supporting the conclusion in the SAR Addendum 2 that the risk of a coil failure and subsequent release to the environment is acceptable. In particular, the basis for the release of 10 gallons and 500 Ci used in the postulated accident scenario (coil failure) will be reviewed by the staff.