SAVANNAH RIVER SITE HIGH-LEVEL WASTE SAFETY ISSUES: THE NEED FOR FINAL DISPOSAL OF THE WASTES

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ABSTRACT

Using new criteria developed by the High-Level Waste Tank Safety Task Force, the Savannah River Site (SRS) identified six safety issues in the SRS tank farms. None of the safety issues were priority 1, the most significant issues handled by the Task Force. This paper discusses the safety issues and the programs for resolving each of them.

A key element of solving the SRS safety issues is the program for final disposal of SRS wastes, in which the wastes will be incorporated into borosilicate glass and saltstone (grout). This program is required to resolve three of the issues.

INTRODUCTION

At the Savannah River Site (SRS), near Aiken, South Carolina, approximately 35 million gallons of high-level radioactive waste are stored in 51 underground, carbon steel waste tanks. These tanks and associated facilities are distributed between the F and H areas, two nuclear processing areas at SRS, and are called the F- and H-area high-level waste tank farms.

At the request of the Department of Energy (DOE), SRS Waste Management conducted a review of the management of the tank farms for safety issues. The selection of issues and the assignment of priority to these issues was guided by criteria developed by the DOE High-Level Waste Tank Safety Task Force. These criteria are described in an earlier paper in this session.

According to these criteria a safety issue is defined as an event or condition that can lead to either:

1. an uncontrolled release of high-level waste radionuclides, or exposure to radiation that is (a) not within the approved safety envelope (i.e. an unreviewed safety question) or (b) not properly analyzed or mitigated, or
2. a loss of primary or secondary containment for high-level waste.

SUMMARY

The safety issues identified at SRS are as follow:

Priority 1

None

Priority 2

1. Storage of high-level waste in tanks that have leaked
2. Ability of waste tanks to withstand a design basis earthquake
3. Storage of high-level waste in tanks with no secondary containment

Priority 3

4. Insufficient spare tank volume for resolving other safety issues
5. Possible inadequacies in transfer line leak detection
6. Potential for formation of explosive deposits

The resolution of issues 1, 3, and 4 requires removing the wastes from the affected tanks and processing it through final disposal. An extensive program is underway at SRS that will remove the waste from all the tanks and process it into borosilicate glass and saltstone (grout) for final disposal. Continued support for this program is essential to solving these SRS safety issues.

A description follows of each safety issue and the program to resolve it.

ISSUE 1: STORAGE OF HIGH-LEVEL WASTE IN TANKS THAT HAVE LEAKED

Nine tanks at SRS have leaked some quantity of waste from primary containment -- type I tanks 1, 9, 10, 11, and 12; and type II tanks 13, 14, 15, and 16. Both of these designs of tank have carbon steel secondary pans designed to contain waste that leaks from the primary tanks. The secondary pans are 5 feet high, compared to a maximum fill limit of 23.0 feet for type I tanks and 25.5 feet for type II tanks.

The leakage from the primary tanks was through hairline cracks caused by nitrate stress corrosion cracking of the carbon steel primary tank. Controls are in place to prevent further stress corrosion cracking, including the addition of chemical inhibitors to all waste tanks and stress relief of the type III tanks, the latest design of tank. These controls have successfully eliminated leaks in SRS high-level waste tanks.

To reduce the environmental risk, sufficient liquid has been removed from the nine tanks to prevent further leakage. Also, the annular space between the primary tank and secondary pan (where the leaked waste resides) has a ventilation system designed to maintain the leaked waste in a dry state. This renders the waste immobile and inhibits corrosion of the secondary pan.

Plans are to remove the waste from the tanks and from the tank secondary pans and then retire all nine tanks from service. This is a longstanding issue at SRS, and the program to dispose of these wastes has been underway for more than ten years. One tank, tank 16, has been completely cleaned, although some residue still remains in the secondary pan. Partial waste removal has been accomplished from a number of other tanks. The program is now temporarily halted because of limited tank space to receive the waste. To continue the program, two facilities under construction must be completed and started up (See Final Waste Disposal section).

ISSUE 2: ABILITY OF WASTE TANKS TO WITHSTAND A DESIGN BASIS EARTHQUAKE

A study has recently been conducted by WSRC Seismic Engineering of the response of the type III tanks at SRS to a design basis earthquake (DBE). The study showed that the type III tanks will withstand a DBE. The type III tanks are the latest design of tanks at SRS, with full secondary containment and other improved design features, and are the only tanks planned for long-term continued use.

The response of all four tank designs in use at SRS -- types I, II, III, and IV -- has been assessed previously, although the studies did not use current methodology. Two studies were conducted by John A. Blume and Associates, one in 1975 and one in 1978. These studies showed that all four tank designs would withstand a DBE without losing integrity of the waste tank, although several areas of possible overstress were identified.

The Seismic Engineering study examined the type III tanks using up-to-date methodologies and computer codes. The study found higher safety margins than reported in the Blume study, mainly because the more sophisticated computer codes used in the later study allowed more realistic modeling of the stresses with less reliance on conservative assumptions.

There are no plans to conduct additional studies on the type I, II, and IV tanks. Plans are to retire these tanks from service as soon as possible. Because the Blume study showed that the designs of these tanks are adequate, and the Blume methodology was shown to be conservative in the type III tank study, further study of the type I, II, and IV tanks is not considered necessary.

ISSUE 3: STORAGE OF HIGH-LEVEL WASTE IN TANKS WITH NO SECONDARY CONTAINMENT

SRS has eight type IV tanks, which are single-shell tanks with inadequate secondary containment. The high-level waste has been removed from these tanks, but some residue remains. Plans are to remove these eight tanks from service. However, three of the tanks must continue to be used for a number of years, primarily as surge tanks for low-level wastes generated from the high-level waste removal program.

In addition to the type IV tanks, SRS also have five type I and four type II tanks in which some amount of waste has leaked from primary containment (See Issure 1, Storage of High-Level Waste in Tanks that Have Leaked). In these tanks, the leaked waste is being stored in the secondary pan, so the leaked waste has no secondary containment. The nine tanks will be retired from service after the waste has been removed.

ISSUE 4: INSUFFICIENT SPARE TANK VOLUME TO RESOLVE OTHER SAFETY ISSUES

Resolving issues 1 and 3 will require removing large quantities of waste from the type IV tanks and the nine type I and II tanks that have cracked. There is insufficient space in SRS tanks with acceptable secondary containment (type III tanks) to accept this waste.

This issue will be resolved by the waste disposal program, which will process all SRS wastes into glass and saltstone. First, waste will be removed from selected type III tanks to create sufficient space to carry out the waste processing program. Then waste will be removed from the tanks of concern and processed into its final form for disposal.

ISSUE 5: POSSIBLE INADEQUACIES IN TRANSFER LINE LEAK DETECTION

In 1989, contamination was found in a localized area near an H-area concentrate transfer system line, a line that carries hot, supersaturated waste from an evaporator to a waste tank. A possible explanation for the contamination is that waste leaked from primary containment and subsequently corroded a portion of the secondary containment of the line without activating a leak detection alarm. This scenario raises the concern that current leak detection methods might be inadequate, especially for supersaturated wastes that might solidify before reaching leak detection equipment. It is also possible that the secondary containment may have failed before the leak occurred in the primary.

As a result of this incident, an ongoing program was initiated to periodically test all transfer line primary lines and secondary lines. Also, the specific line near which contamination was found will be photographically inspected to determine the cause of the leak. In addition, possible upgrades are being considered in leak detection systems.

ISSUE 6: POTENTIAL FOR THE FORMATION OF EXPLOSIVE DEPOSITS

A comprehensive study has been performed to identify all shock-sensitive or explosive deposits that could form in SRS wastes. Studies are continuing to determine what compounds will persist in the waste tank environment.

In general, SRS waste chemistry does not provide conditions required for the formation of explosive deposits, but the potential for forming such deposits needs to be conclusively ruled out.

The work was prompted by a number of concerns, including several incidents with waste processed through the H-area evaporator during a five-month period in early 1970. In these incidents, popping noises were observed when personnel stepped on dried waste deposits, when equipment bumped into surfaces contaminated with dried waste, and when a sampling tool was intentionally scraped against dried waste. Although the incidents caused no equipment damage or injuries, they were a concern because they indicated the presence of a shock- sensitive compound, which was unexpected. Based on samples of the waste and a knowledge of waste chemistry, the compound was tentatively identified as silver nitride.

To prevent the formation of silver nitride, SRS prohibited the use of silver compounds in processes sending waste to the tank farms. This prohibition was successful, as evidenced by the fact that no more popping-noise incidents have occurred since 1970. Also, the waste processed through the evaporator during this five-month period was retrieved from the receipt tank, diluted with other wastes, and dispersed among three other tanks.

Since 1970, a number of studies have been conducted concerning other compounds that could participate in the formation of shock-sensitive deposits, including ammonium nitrate, oxalates, and mercury compounds. The study currently in progress is the most comprehensive to date, encompassing all previous studies and extending the scope to include all compounds that could be formed from the known species in SRS wastes. The study considers waste storage, waste removal, and processing of the waste through final disposal into borosilicate glass and saltstone.

To date, the study has identified five classes of compounds that are of concern -- flammable gases (hydrogen, benzene, and ammonia); metal nitrides; ammonia compounds and derivatives; metal NO_x compounds; and organic compounds.

The first three classes of compounds are known to be present, and controls are already in place to prevent the accumulation of hazardous quantities or concentrations. Therefore, these classes of compounds are not considered safety issues, as follows:

- Flammable gases: These have been long recognized as a hazard in radioactive waste tanks, and an extensive program of ventilation systems, monitoring, and backup controls is in place to prevent accumulation of these gases.
- Metal nitrides: As previously mentioned, silver compounds are now prohibited from processes that release waste into the high-level waste tanks. The concentrations of all metal nitrides in SRS wastes are low. Furthermore, metal nitrides are explosive only when dried. With the exception of small quantities of deposits, such as in waste tank secondary pans, SRS wastes are maintained in a wet or damp condition.
- Ammonia compounds and derivatives: Concentrations of ammonia are procedurally limited at the waste generators. Furthermore, at the high pH in SRS wastes, ammonia is volatile and is removed by the waste tank ventilation systems and especially during evaporation of the waste. Finally, as with metal nitrides, ammonia compounds are explosive only when dried.

The last two classes of compounds identified by the study are classes for which further work is needed. These two classes are a concern only after the startup of the Defense Waste Processing Facility (DWPF), so they are not current safety issues.

- Metal NO_x Compounds: Metal NO_x compounds could be formed when the DWPF recycle stream, a new stream entering the tank farm after DWPF startup, mixes with other tank farm wastes. In laboratory studies, shock sensitive deposits were detected in specimens immersed in solutions simulating the DWPF off-gas condensate stream. Based on analytical results, the solid deposits are believed to be a mercury NO_x compound. An extensive experimental program is underway to identify the compound, to establish the conditions under which the deposits are formed, and to determine what controls, if any, are necessary to prevent the formation of the deposits in the waste tanks.
- Organic Compounds: The DWPF recycle will also contain new organics not previously existing in the tank farms. These organics are the by-products of the breakdown of sodium tetraphenylborate, a chemical used in In-Tank Precipitation, one of the pretreatment processes that prepares feed for the DWPF. Studies are underway on these compounds.

FINAL WASTE DISPOSAL

As previously mentioned, a key element in the program to solve the SRS safety issues is the program that will remove the wastes from the SRS tanks and incorporate the wastes into glass, a wasteform suitable for permanent geologic isolation in a Federal Repository, and saltstone, a lower-cost wasteform. The program is illustrated schematically in Fig. 1.

SRS wastes exist in two physical forms: 1) insoluble sludges, and 2) soluble salts. These physical forms have been segregated into separate tanks, so that some tanks contain predominantly sludge and others predominantly salt. A different set of processes is planned for each form.

For sludge, the waste will be removed from the tanks using hydraulic slurrying techniques and sent to type III tanks dedicated to sludge processing. On some sludges (those highest in aluminum) the sludge will be treated to remove aluminum because aluminum interferes with glass production. All sludges, including those from which the aluminum has been removed, will be washed with water to remove soluble salts. This is necessary to limit the volume of glass produced, because the salts have limited solubility in glass. The salts that are removed will be sent to the salt tanks for further processing and eventual disposal in saltstone.

For salt, the waste will also be removed from the tanks using hydraulic slurrying techniques. Then it will be sent to four tanks dedicated to In-Tank Precipitation. The purpose of In-Tank Precipitation is to separate the principal radionuclides in the salt (Cs-137 and Sr-90) from the predominantly non-radioactive salts in SRS wastes. In-Tank Precipitation significantly reduces the cost and increases the rate of the overall waste disposal process. This is because the decontaminated salt waste, which is the largest volume component, can be sent to saltstone, a low-cost, high-volume wasteform. Therefore, the amount of waste sent to glass (and eventual geologic isolation) is greatly reduced.

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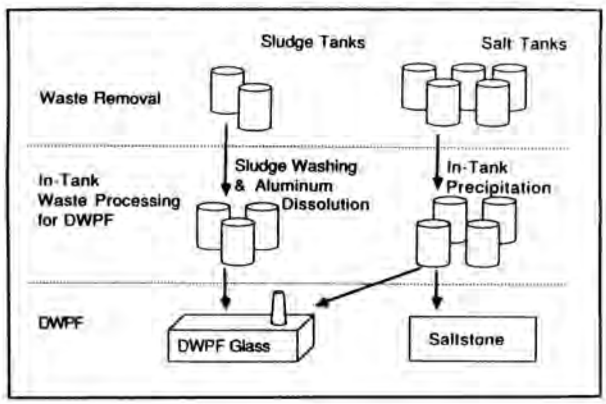

Fig. 1. Program for disposal of SRS wastes.