WSRC-RP-89-782

VITRIFICATION AT THE SAVANNAH RIVER SITE (U)

by

Michael K. Carlson
Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

A paper proposed for presentation
16th Annual National Energy Division Conference
American Society for Quality Control
Fort Lauderdale, FL
September 17-20, 1989

and for publication in the Proceedings of the meeting

WASTE VITRIFICATION QA

VITRIFICATION AT SAVANNAH RIVER SITE (U)

Michael K. Carlson
Waste Management Quality Manager

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

ABSTRACT

Construction of the Defense Waste Processing Facility (DWPF) at the Savannah River Site is nearing completion, and preparations are being made to start nonradioactive cold runs. Because quality assurance requirements for the DWPF are similar to those for the Hanford Waste Vitrification Project, this presentation describes: the need for the facility, the chemical processes involved in preparation of waste for vitrification, handling and preparing the product for storage, and the unique equipment developed for remote operation and maintenance.

PURPOSE

The purpose of the Defense Waste Processing Facility (DWPF) at the Savannah River Site (SRS) is to immobilize the site's liquid high-level radioactive waste by vitrification. The vitrified waste will then be ready for transport to a geologic repository for permanent storage.

PARTICIPANTS

The Savannah River Site is operated for the Department of Energy by the Westinghouse Savannah River Company (WSRC). WSRC, directly or through subcontractors, manages all SRS activities—including design, construction, operation, research, and development. Although the April 1, 1989, change in operating contractor from E. I. du Pont de Nemours and Company to Westinghouse Savannah River Company is continuing to result in significant sitewide organizational changes, continuity among DWPF Project personnel and organizations has been maintained. Design of the DWPF continues to be subcontracted to Bechtel National, Incorporated, and the primary subcontractor for the vitrification building remains Morrison-Knudsen-Ferguson. Checkout and run-in activities, currently in progress, are being completed by approximately 500 DWPF Operations and Works Engineering employees, who will ultimately operate the facility.

The DOE Savannah River Operations Office and DWPF Project Office have governing responsibilities for the site and project, respectively. They are responsible to Defense Waste Transportation Management, which, through DOE-Defense Programs, is the link to the ultimate customer—the Office of Civilian Radioactive Waste Management (RW). RW will be the licensee for the National High-Level Waste Repository, which will be licensed by the Nuclear Regulatory Commission. Because the vitrified waste becomes part of the repository, it is also licensed by the NRC. All federal participants may join Operations and Project Offices in their overview of High-Level Waste Form production.

Technical and quality assurance approaches in this endeavor are shared with the Hanford Waste Vitrification Project (HWVP) and the West Valley Demonstration Project (WVDP).

BACKGROUND

The mission of the Savannah River Site is to safely produce nuclear materials for the Department of Energy and Department of Defense, while protecting employee and public health and the environment. Production of those nuclear materials has resulted in generation of 85 million gallons of high-level radioactive waste at the Savannah River Site over the last 35 years. The radioactive waste is chemically treated to inhibit corrosion of one-million-gallon carbon steel waste storage tanks. Depending on the origin of the waste, it is segregated as salt (primarily sodium nitrate) or sludge (metal hydroxides). The waste is cycled through a slow process of cooling, concentration by evaporation, settling or precipitating, decanting for additional evaporation, and aging to reduce the radioactivity level. As a result of this process, the current inventory of high-level radioactive waste is 34 million gallons, the majority of which is nonradioactive sodium nitrate salt.

Preparing concentrated waste for DWPF has become a major program item of the SRS Interim Waste Management Department. Concentrated waste is slurried and pumped to processing tanks. Sludge is heated, reacted with sodium hydroxide, and washed to remove aluminum, which greatly increases the viscosity of the future glass product (making it difficult to process). One 700,000-gallon batch of sludge can be produced every 22 months. Processing salt is more complex because nonradioactive components are separated to minimize the volume of waste to be vitrified and stored in the repository. The In-Tank Precipitation process (ITP) is a combination of precipitation, adsorption, and filtration, which removes 99.9% of the radioactivity (primarily cesium-137) from the stream. Addition of sodium tetraphenylborate precipitates potassium and cesium, and addition of a slurry of sodium titanate in alcohol adsorbs plutonium and strontium. About 500,000 gallons of radioactive solids will be filtered out for transfer to DWPF annually, and 7,500,000 gallons of decontaminated salt solution will be pumped to the new SRS Saltstone facility each year for final interment.

The Interim Waste Management Department tank farm where this waste is processed and stored consists of four evaporators, numerous pumping stations, and 51 carbon steel waste tanks of varying design and ages, ranging in capacity from 750,000 to 1,300,000 gallons. Twenty-five tanks are actively involved in the waste management process described above, 19 are full and awaiting waste removal, one tank has had the sludge removed and is retired, five tanks are dedicated to chemical processing of salt and sludge in preparation for the DWPF, and one tank is maintained as an emergency spare. Two of the five processing tanks currently contain the first salt and sludge batches prepared for vitrification in DWPF, and one tank contains the first batch of decontaminated waste for Saltstone.

Although isolation of waste from the environment has been successful, it has become increasingly clear that reliance on engineered structures is acceptable for interim storage only. Waste must be converted to an immobile form. The worldwide choice for method of immobilization has been vitrification in borosilicate glass. The Defense Waste Processing Facility is designed to vitrify the current inventory of radioactive waste at the Savannah River Site within 20 years after facility startup, and keep pace with waste generation thereafter.

FEED PREPARATION AND VITRIFICATION PROCESS

After the approximately million-gallon batches in the SRS Interim Waste Management Tank Farm have been chemically treated, washed, and homogenized, each batch is characterized by sampling and analysis at the Savannah River Laboratory. During full production, a sludge batch will provide DWPF feed for about 2.4 years, and a salt batch for about three months. These are referred to as macrobatches.

Eight-thousand-gallon batches of processed waste are pumped about one mile from the million-gallon tanks to the remotely operated and maintained DWPF Chemical Process Cell (CPC), where the two streams are acidified, concentrated by evaporation, and blended. Salt precipitate is routed to the Salt Processing Cell where it reacts with formic acid, copper formate, and hydroxyl ammine nitrate to decompose and form a low activity organic stream, which will be stored for later incineration, and a highly radioactive aqueous stream. Sludge goes to the Sludge Receipt and Adjustment Tank (SRAT) where the metal oxides are reduced with formic acid, and where water is evaporated. Aqueous product is added from the Salt Processing Cell for blending, continued evaporation, and mercury removal. Nonradioactive mercury is removed from the cell and purified separately. This combined salt and sludge batch is transferred to the Slurry Mix Evaporator Tank (SME) where glass frit is added to the blended waste. This slurry is then concentrated to 50% solids by evaporation to form an 8,000-gallon batch, which is sampled and analyzed to verify that it meets composition requirements to make good quality glass. No other adjustments to chemistry are made after this point. When accepted, the batch is pumped to the Melter Feed Tank (MFT) where it is again sampled and analyzed to provide input to the product analysis. Each canistered glass product will be traceable to a Melter Feed Tank batch, which will be traceable to salt and sludge macrobatches.

Final product chemistry and properties are a direct function of Melter Feed Tank batch chemistry, so it is considered the first step in production of the product. Feed is pumped to the melter and Joule-heated to 1,100°C, where water flashes off and sludge, salt, and frit form a cold cap, or crust, over the melt surface. The melter feed rate is adjusted so that the cold cap always covers about 90% of the surface, and the design rate of 228 pounds of glass per hour is achieved. As the cold cap melts, it becomes part of the homogeneous pool of borosilicate glass. The cold cap and melter vapor space are heated by plenum heaters, while the glass pool is heated by submerged electrodes passing current through the melt.

The offgas generated in the melter is cooled and condensed. The gas portion is decontaminated through a series of sprays, condensers, and filters before being monitored and exhausted to the atmosphere. The condensibles are recycled to the Interim Waste Management tank farm for evaporation.

DWPF ARRANGEMENT AND EQUIPMENT

The Defense Waste Processing Facility is a three-story, reinforced-concrete structure similar to the existing 221-F and -H Chemical Separation Facilities (canyons) at SRS. The Chemical Process Cell (including the Salt Cell) is located in the center of the building. It is designed for remote operation and maintenance. Within this cell is a line of ten 10,000-gallon tanks and other equipment. Pumps, agitators, and condensers are mounted on the tank tops. Tanks are precisely located in this "canyon" by trunnion buttons extending from the tanks to trunnion guides mounted on the "canyon" walls. This allows remotely removeable pipes (jumpers) to be installed and connect equipment to precisely located wall nozzles. All tanks, pumps, agitators, condensers, heating coils, and equipment frames can be removed by a remotely controlled 117-ton-capacity crane.

The DWPF contains both remote and hands-on decontamination and maintenance facilities where equipment can be repaired. The second and third floors contain electrical, instrument, and cold feed facilities. A mezzanine between the first and second floor, adjacent to the CPC, contains sampling and analytical facilities.

The rest of the DWPF is not like other facilities at SRS, because it provides for significant operator interaction to handle and process the canistered glass product. Four-ft-thick shielding walls are required to protect operators from glass-filled canisters with radiation levels of 5,000 R/hr. Shielding windows, master-slave manipulators, in-cell cranes, remote handling devices, and video cameras are used to perform tasks.

PRODUCT HANDLING

Clean, type 304L stainless steel canisters manufactured and inspected to meet stringent requirements and tolerances are introduced into the Melt Cell via an underground trolley and in-cell crane. The 10-ft tall, 2-ft diameter canisters have unique identification numbers that are visible through the shielding windows, or by video camera. The canister is placed in a turntable and rotated under the melter pour spout. Glass is siphoned out of the melter into canisters using suction from a pump in the CPC. Pouring at the design rate of 228 pounds per hour will result in filling a canister every 16 hours. After filling, the canister is rotated in front of a shielding window, where an operator places a temporary plug in the hot canister opening, which shrinks tightly around the plug as the canister cools. When the canister has cooled, it is moved to another station in the Melt Cell where it is leak-tested to verify that it forms a watertight seal. This is a critical prerequisite for the next step in the process—canister decontamination.

The canister is moved into the Canister Decontamination Cell where it is blasted by a high-pressure jet of glass frit-water slurry. Decontamination of the canisters to meet DOT requirements is verified by smear testing the canister in front of a shielded window using master-slave manipulators. Smear discs are transferred out to the operating corridor through a pneumatic tube. Inspectors verify that contamination levels are acceptable before the canister moves to the next station—the Weld and Test Cell.

Final closure of the canister is achieved by pressing out the temporary plug, and upset/resistance welding a new plug in its place. Weld quality is judged by visual inspection and the data trail relating force and current as a function of time (nominally 240,000 amps in 1.5 seconds with 70,000 pounds applied). A final smear test is made to verify that the canister does not have transferrable contamination.

The last step before transferring the canister to the Glass Waste Storage Building is to verify that records are complete and accurate. The Glass Waste Storage Building has the capacity to store about five-years production of glass-filled canisters. A shipping facility will be built in the future to load canisters into shipping casks for transport to the repository.

DWPF STATUS

As noted above, waste has been processed and is ready to feed the DWPF. The DWPF is approximately 95% mechanically complete (except for the Salt Cell, which was started late) with 50% checkout and run-in completed. Procedures, training, Operational Readiness Review, Process Hazards Reviews, and control system testing are the most significant items to be completed before cold runs start. Integrated Cold Runs with simulated radioactive melter feed are scheduled to start in March 1991. It is then that documentation will be provided for significant portions of the Waste Form Qualification Report, verifying implementation of the Waste

Compliance Plan and compliance with the Waste Acceptance Preliminary Specification. If no significant problems are encountered during Integrated Cold Runs, operation with radioactive material could start in early 1992.

Similarly, the starting date of Integrated Cold Runs with simulated radioactive melter feed is the required implementation date for the High-Level Defense Waste Processing Quality Assurance Program. Implementation of this program is particularly challenging now because of the competing activities of design, construction, testing, procedure writing, training, and operation; and the organizational transitions occurring to match the tasks.

ACKNOWLEDGMENT

The information contained in this article was developed during the course of work done under Contract No. DE-AC09-76SR00001 (now Contract No. DE-AC09-88SR18035) with the U.S. Department of Energy.