THE DEFENSE WASTE PROCESSING FACILITY

A STATUS REPORT

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ABSTRACT

The Defense Waste Processing Facility (DWPF) will be the nation's first production scale facility for immobilizing high-level waste for disposal. It will also be the largest facility of its kind in the world. The technology, design, and construction efforts are on schedule for "hot" operation in fiscal year 1990. This paper provides a status report on the DWPF technology, design, and construction, and describes some of the challenges that have arisen during design and construction.

INTRODUCTION

The DWPF, which is under construction at the Department of Energy's Savannah River Plant, will process Savannah River defense high-level radioactive waste so that it can be disposed of safely. The Savannah River Plant (SRP), located near Aiken, SC, has been producing nuclear materials for defense purposes since the early 1950's. These operations have produced about 33 million gallons of high-level radioactive waste, which is stored in large underground tanks. The DWPF is the result of a research and development effort that began in the early 1970's as part of the Department's overall program to achieve safe disposal of defense high-level waste. After a consensus had been reached on the process and waste form, including appropriate enviromental reviews, construction of the DWPF began in November 1983. The facility will be completed and "hot" operation will begin in 1990. The total estimated capital cost of the DWPF is $945 million.

DESCRIPTION OF PROCESS AND FACILITIES

Processing the high-level waste for disposal will begin in the large underground tanks where the waste is stored as alkaline liquids, crystalline salt, and sludge. The crystalline salts will be redissolved in the tanks and the radioactive components separated by an in-tank precipitation process.

In this process sodium tetraphenylborate is added to the dissolved salts to precipitate cesium, and sodium titanate is added to remove the trace amounts of strontium and plutonium in the solution. The precipitate containing over 99.9% of the radioactivity in the salt is then removed by filtration. The resulting decontaminated salt solution, which represents about 90% of the high-level waste volume, will be piped to a disposal area on the Savannah River site where it will be mixed with cement and fly ash to form a grout, called saltstone, which will be placed in near-surface concrete vaults for disposal.

The high-level waste sludges, which contain about 70% of the radioactivity, and the precipitate from the salt decontamination process will be piped as slurries to the vitrification or glassmaking facilities of the DWPF. This high activity fraction of the waste will go through several treatment steps prior to being fed to the glass melter. The sludge is first treated with formic acid to reduce mercury, which is then boiled off and recovered for reuse onsite. The cesium/potassium tetraphenylborate precipitate is treated in an acid hydrolysis process to decompose the tetraphenylborate ion to form benzene and cesium/potassium borate. The cesium precipitate with about 90% of the organic removed is combined with the treated sludge, solid glass-making material called "frit" is added, and the resulting slurry is fed to the glass melter.

The glass melter is the heart of the DWPF immobilization process. The waste and glass making materials are fed to the melter as a slurry containing about 45% solids, the excess water boils off at the melt surface, and the waste solids actually dissolve in and become part of the glass. The glass is poured into stainless steel canisters 0.6 m (2 ft) in diameter and 3 m (10 ft) long where it solidifies. The melter is cylindrical consisting of a water-cooled, stainless steel jacket lined with refractory materials. The glass is heated by joule heating using four electrodes spaced within the melter to control the power distribution. The vapor space temperature is controlled using resistance heaters in the melter lid. The melter operates at about 1,150°C, has a surface area of approximately 2.6 m^2 (28 ft^2), and produces about 100 kg of glass per hour.

After the glass is poured into the canisters, a temporary, water-tight plug is inserted into the canister neck. The canister is allowed to cool, and then the outside surface is decontaminated using a "frit blasting" technique. A mixture of high pressure water, air, and glass frit is sprayed on the outside surface of the canister to remove any residual radioactivity. The glass frit used to clean the canisters is then recycled to the melter feed stream.

After decontamination the canister is welded shut by an upset resistance welding technique. In this process a slightly oversized plug is pressed into the canister opening. At the same time a large current is passed through the canister and plug. The resistance of the canister plug interface causes the heat, which welds the plug in place. This provides a high quality, reliable weld by a process easily operated remotely.

The glass canisters will then be placed in temporary storage at Savannah River until a Federal repository is available for disposal. The glass waste storage building under construction as part of the DWPF project is a below-grade, air-cooled vault with capacity for about 2,400 canisters or about 5 year's production. It is expected that additional storage will be needed prior to the availability of a Federal repository.

The feed preparation, glassmaking, canister decontamination, and welding processes will be carried out in the main process building, which is a reinforced concrete, seismic, and tornado-resistant structure similar in design to the Savannah River fuel processing canyons. The building is 110 m (360 ft) long, 36 m (117 ft) wide, and 29 m (94 ft) high requiring 69,000 yd^3 of concrete and 11,000 tons of reinforcing steel. Included in the DWPF project are design and construction of the main process building and internal process equipment; a sand filter, fan house, and stack for process building ventilation; the glass waste storage building; various service and support facilities; as well as the process facilities and equipment to manufacture the decontaminated salt grout or saltstone for disposal.

REGULATORY INTERACTIONS

Construction of the DWPF required 45 separate permits to be obtained from the Environmental Protection Agency (EPA) and the State of South Carolina. Most of these are routine permits for drinking water, sanitary and chemical waste treatment systems, and air emissions. The most significant of these permits are for the treatment and disposal of the decontaminated salt as saltstone. The decontaminated salt solution meets the Resource Conservation and Recovery Act (RCRA) definition of "hazardous waste" because of its high pH and chromium content. However, the resulting saltstone was determined to be nonhazardous, thus not requiring a RCRA-type disposal system. Since the waste generation and treatment system was determined to be totally enclosed, a full RCRA, Part B permit was not required. Instead, a wastewater treatment facility permit under the Clean Water Act was issued for the saltstone groutmaking facilities, and an industrial waste landfill permit was issued for saltstone disposal in concrete vaults.

The glass waste canisters produced by the DWPF will be disposed of in a Federal repository, which will be licensed by the Nuclear Regulatory Commission (NRC). In order to provide reasonable assurance that the DWPF waste form and canister will be acceptable for disposal in a licensed repository, a Waste Acceptance Committee was formed in 1985 to develop waste acceptance specifications and to define the waste form testing, quality assurance, and documentation requirements necessary to support a licensing action. Over the past year there has been significant progress in the waste acceptance process. Specifically, the DOE Office of Civilian Radioactive Waste Management has issued the Waste Acceptance Preliminary Specifications for the DWPF. The Savannah River Operations Office is preparing the DWPF Waste Compliance Plan, which describes how the waste acceptance specifications will be met. There have also been several technology exchanges to ensure that the NRC is informed of the DWPF technology and plans for waste acceptance and that NRC concerns are considered in the planning. This is a continuing process that will proceed through the remainder of the DWPF construction and into DWPF operations to support DOE's license application and subsequently the issuance of a repository operating license by the NRC.

TECHNOLOGY STATUS

The DWPF waste immobilization process and equipment are well defined. The most recent efforts have been focused on completing the demonstrations of each unit operation on a large scale and on the testing and run-in of actual pieces of equipment prior to installation in the DWPF process building. Highlights of the process and equipment development and demonstration status are as follows:

- The salt decontamination (in-tank precipitation) process has been demonstrated full-scale using about 1.9 million liters (500,000 gallons) of actual high-level waste salt solution. An expected decontamination factor of about 5×10^4 was achieved.
- The canister decontamination system using the "frit blasting" process has been demonstrated with full-scale prototypical equipment. The first production canister decontamination chamber has been received at Savannah River and will be tested prior to installation in the DWPF.
- The Scale Melter, an approximately 40% scale prototypical melter, has been operating at Savannah River for the last year to demonstrate essentially all aspects of DWPF operation except remote replacement of the melter and/or melter components. The most significant of these demonstrations has been operation with flowsheet quantities of organics and vacuum-pouring of the glass. These demonstrations have also pointed out the need for some minor redesign in the riser and pour spout and the melter feed system.
- The demonstration of the acid hydrolysis process using one-fifth scale equipment was begun in February 1987 and has progressed as expected. This is the last unit operation to be demonstrated at or near full scale prior to the start of the DWPF system tests in 1989.

DESIGN AND PROCUREMENT STATUS

Design of the DWPF facilities is approximately 95% complete. To date, 7,600 drawings have been completed out of 7,750 required; all of the 443 material specifications have been prepared; and significant engineering tasks such as the design models and Qualify Assurance assessments have been completed. The remaining design effort is focused on incorporating vendor information on drawings, defining power and control requirements, and preparing "as-built" drawings.

The procurement effort on the DWPF project is about 80% complete. To date, 423 purchase orders have been placed totaling $240 million. Delivery has been completed on 167 of these orders.

CONSTRUCTION STATUS

Construction of the DWPF facilities is about 50% complete with a labor force of about 1,500 workers at the site. The vitrification building is about 70% complete. Concrete has been placed for about two-thirds of the building to just below the roof level. The lower corridors have been painted, and electrical conduit and cable tray, piping, HVAC duct, and work platforms are being installed. Equipment is being placed and hooked up. In the canyon cells stainless steel liners, baseplates, trunnion guide piers, crane rails, and topping slabs have been installed. Currently, nozzle boxes and electrical connectors are being installed in the cells. Mechanical completion of the vitrification facilities is expected in June 1989 with "hot" startup in 1990.

Site preparation for the saltstone processing and disposal facilities has been completed, and construction of the processing facility began in December 1986.

KEY PROJECT CHALLENGES

Remote Maintenance

When the DWPF was being planned, it was recognized that the equipment designed for remote maintenance would require special fabrication procedures to meet project specifications. For example, the centerline of nozzles on a tank must be located to within ±1.5 mm (0.060 in.) after welding and heat treatment. In addition, the nozzle's surface tilt can not exceed 0.4 mm (0.015 in.) over the full nozzle diameter. Since several pieces of equipment are installed vertically on each other, tolerances on each piece are tight to assure the entire assembly is within the required tolerance. To explain these tight tolerance requirements to the sales representatives of prospective vendors, a video tape was produced that shows the remote maintenance techniques required and explains the need for close tolerance control. Vendors selected for equipment fabrication were required to send key shop managers and craftsmen to SRP to witness remote equipment being mocked-up prior to intallation in the existing remotely maintained separations facilities. Eleven companies participated in the remote equipment orientation program. Even through the vendors for complex equipment have had difficulties meeting project requirements, the up-front planning has been the difference between success and failure.

Material Delivery

Early in the DWPF construction, it became evident that key construction material required special management attention to assure that it was delivered on time and within specifications. As noted earlier, engineered equipment was given special management attention from the start. However, construction materials were purchased by bulk order without special attention to delivery schedules. Vendors were meeting quantity requirements (i.e., number or tonnage), but specific individual items such as anchor bolts or embedded metal plates for specific concrete pours were not being shipped as needed. Teams composed of design, procurement, and construction personnel worked together to develop detailed delivery requirements, vendor ship dates, and material inspections to assure that material was available as needed. Because one of the problems identified was the availability of corrosion evaluated stainless steel, the contractor established a priority and special handling procedure for performing the necessary corrosion tests. The project's material management group is continuing to expedite items that are on or near the project critical path.

Construction Planning

In order to allow construction to begin early on the vitrification building foundation, it was necessary to freeze the building dimensions before all of the process design details were complete. When the process design was completed, the quality of embedded piping located in the walls and floor slabs had increased from 15,250 m (50,000 ft) to 30,500 m (100,000 ft). In addition, the quantity of corridor piping increased from 15,200 to 24,400 m (50,000 to 80,000 ft).

Since the size of the building had already been set, the increased quantity of pipe had to be squeezed into existing space. It became apparent that either the schedule for piping installation had to be lengthened considerably, or a revised method of installation had to be developed. The construction and design contractors reviewed design models and developed a construction approach that would allow pipe to be installed on steel frames as modules outside the vitrification building and set in place with a crane. The embedded pipe was successfully installed on schedule using 28 pipe modules. About 50% of the corridor piping is located on the third level of the building.

To install this piping in a modular fashion required a change in the method of supporting concrete forms for the roof. Instead of supporting the forms with shoring located in the corridor below, steel plates will be used as forms, and they will be supported by a steel truss system located above the forms. This design approach will keep the corridors free of shoring and allow pipe modules to be placed in the corridors by crane prior to pouring the roof slab. Ten of 84 modules have been placed on the third level using this approach. In addition to allowing pipe installation to be carried out in parallel with building construction, this piping installation method has allowed several hundred welds to be performed in the shop rather than in the tight corridors.

CONCLUSION

The DWPF project is proceeding satisfactorily. The required technology is well defined with demonstration of the last unit operation, acid hydrolysis, underway. Regulatory interactions are on track. Forty-four of 45 permits required for DWPF construction have been obtained. Interactions are underway with the Federal repository projects and the NRC staff to assure that the DWPF glass product will meet repository licensing requirements. Design is essentially complete and construction is about 50% complete with "hot" operation scheduled for 1990. Key issues such as remote maintenance, material delivery, and construction planning have been identified and are being managed. DWPF experience will provide valuable information for future DOE waste vitrification facilities.

REFERENCES

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