HANFORD WASTE VITRIFICATION PLANT PROCESS DESCRIPTION, PROCESS ADVANCEMENTS, AND HANFORD SITE INTERFACES

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ABSTRACT

Westinghouse Hanford Company, a prime operating contractor to the U.S. Department of Energy in Richland, Washington, has the lead responsibility for development, design, construction, and operation of the Hanford Waste Vitrification Plant. The Hanford Waste Vitrification Plant will be built for the U.S. Department of Energy to vitrify existing and future liquid highlevel and transuranic wastes produced by defense activities at the Hanford Site. Start of construction is scheduled for mid1991. Hot startup currently is scheduled for December 1999, and acceleration of the hot startup schedule is under consideration.

Requirements related to interfaces with existing Hanford Site facilities and other sitespecific requirements are discussed in this paper. Design of the feed transfer and lag storage, radioactive liquid waste treatment and recycle, and process offgas treatment systems is significantly affected by sitespecific requirements. Recent developments in design of these systems are described.

OBJECTIVE/MISSION

Defenserelated nuclear activities have been carried out at the Hanford Site for more than 40 years. Liquid and slurried waste generated from these activities is currently stored in underground tanks. The Hanford Waste Vitrification Plant (HWVP) vitrification process is designed to receive highlevel and transuranic (TRU) waste slurries, concentrate these wastes, and incorporate most of the radioactive components into a vitreous borosilicate waste form suitable for disposal in a deep, geologic repository.

PROCESS AND FACILITY DESIGN

The main process building (Vitrification Building) containsprocess cells with cranes and ancillary equipment needed to remotely process highactivity nuclear wastes. The cells house the melter feed preparation, vitrification, canister closure, canister decontamination, offgas treatment, process waste treatment, and equipment decontamination and maintenance operations.

Most of the remote cells in the Vitrification Building are located under a "canyon" area. A large canyon crane is provided for removing cover blocks that separate the cells from the canyon and for installation and removal of equipment from the cells. Crane/impact wrench remote maintenance technology is used for remote removal and installation of most equipment and piping. Manipulators are used for sample, analytical, and maintenance cellsand to perform limited operating functions in other cells.

Interim storage of filled canisters is provided in separate buildings. Maintenance facilities and process support systems are provided, including a process steam boiler, cooling tower, and bulk chemical handling and storage facilities.

Process Description

The HWVP vitrification process is designed to produce 100 kg/h (220 lb/h) of glass containing about 75 wt% glassforming additives and 25 wt% waste. More than 99 percent of the radioactive components in the plant feed will be incorporated in the glass.

The overall HWVP process flow is summarized in Fig. 1.

Feed slurry is transferred to the HWVP via underground, encased transfer lines. Lag storage for 12 days of plant operation is provided at the HWVP in two feed receipt and lag storage tanks (RLST).

The feed is concentrated by evaporation and mixed with glass frit, chemical additives, and internally recycled waste to yield a concentrated melter feed slurry.

Melter feed slurry is continuously fed into a ceramiclined, jouleheated melter. Water and volatile components are driven off, and the remaining components form a glass pool. Molten glass is poured into 0.6 m (2 ft) diameter by 3.0 m (10 ft) long stainless steel canisters where it cools and solidifies.

After cooling, a closure plug is placed in the canister throat. The canister is then decontaminated with a water spray, followed by an airdriven frit slurry blast and another water wash. A smear test is performed to ensure adequate decontamination. A cap is then welded into place.

Canisters that have been sealed and smeartested are moved to a storage building by a shielded canister transporter. The transporter is a wheeled vehicle with an integral shielding cask and canister handling mechanisms. The storage building is of a modular design to facilitate expansion should additional space become necessary.

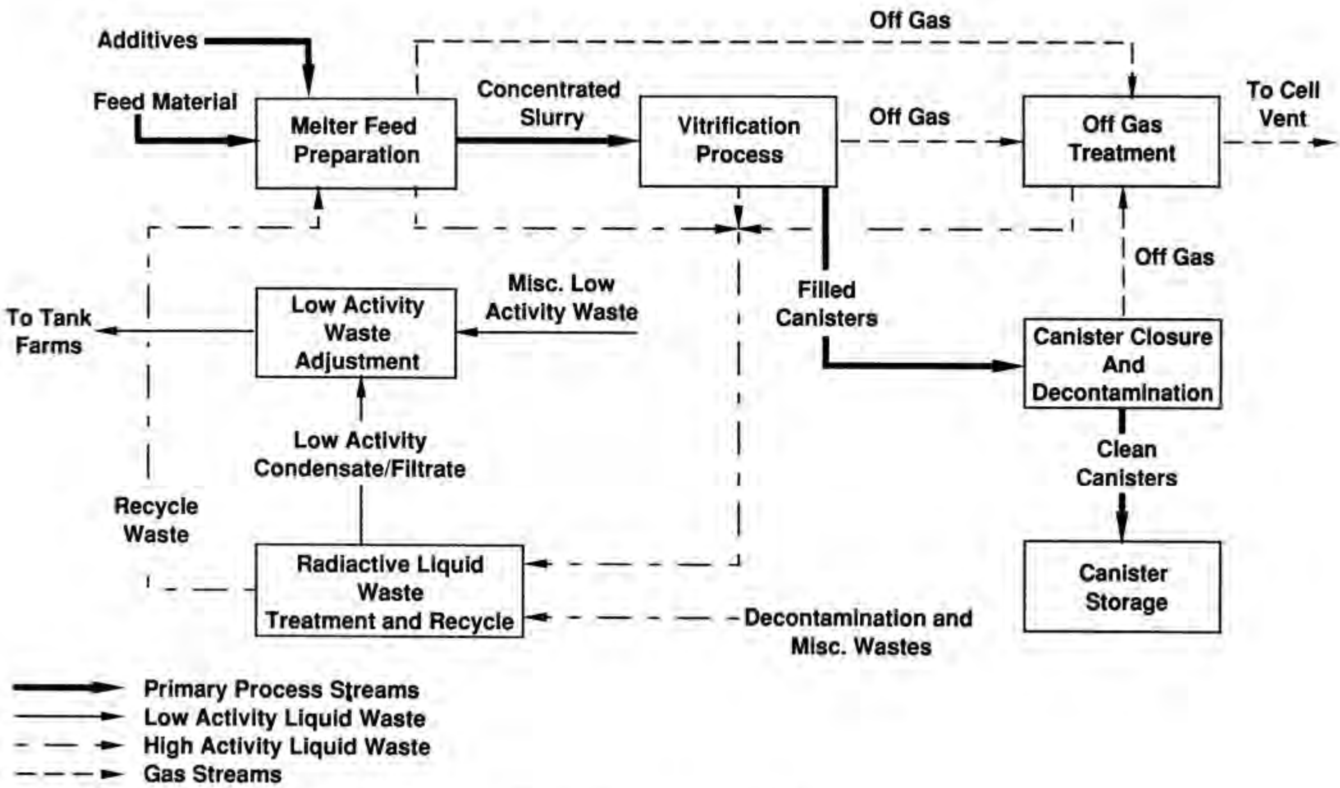

Fig. 1. Overall Process Flow.

Melter offgas (MOG) is treated with a scrubber and multiple stages of filtration. Vent gas from other process vessels is treated in a second scrubber/filtration train that also provides backup treatment to MOG.

Equipment is provided to collect and treat all radioactive liquid wastes. Highactivity liquid waste is concentrated and recycled for incorporation into the glass. Lowactivity waste is returned to the Hanford Site tank farms for disposal.

Shielded process sampling, and analytical cells, and an analytical laboratory are located in the Vitrification Building. Analysis of process streams is provided to ensure product quality and as required for plant operation.

INTERFACE WITH SITE WASTE MANAGEMENT ACTIVITIES

Liquid highlevel and TRU wastes generated at the Hanford Site are stored in underground carbon steel tanks. Acidic wastes are neutralized before storage to prevent corrosion of the tanks. Before processing by the HWVP, the waste will be pretreated to reduce inerts. Pretreatment reduces the number of canisters requiringFig. 1. Overall Process Flow. Disposal, and it reduces the concentration of some chemical components (such as sulfate) that are detrimental to the vitrification process. The pretreated waste will be placed in underground storage tanks until it can be processed by the HWVP. Inerts removed during pretreatment will be segregated in a lowlevel waste stream to be disposed of at the Hanford Grout Facility.

Liquid process waste generated by the HWVP will be returned to the Hanford Site tank farms for treatment and disposal. Treatment by the HWVP will ensure that this stream is nonTRU to allow disposal by the Hanford Grout Facility.

Solid lowlevel waste generated by the HWVP will be packaged and transported to the existing Hanford Site burial grounds for disposal. Contact handled solid TRU waste will be transferred to the Hanford Waste Receiving and Processing facility to be packaged for shipment to the Waste Isolation Pilot Plant. Decontamination facilities for failed equipment have been included in the HWVP design to minimize the quantity of remote handled TRU and highlevel solid waste generated by the HWVP. Plans for handling failed equipment in these categories have not been finalized.

HANFORD-SPECIFIC REQUIREMENTS

There are important differences between requirements for the HWVP process systems and those of other U.S. and foreign vitrification projects. Examples include feed composition; feed variability; local regulations, codes, and standards; and requirements related to the interface with existing facilities. A summary of several key Hanfordspecific requirements follows.

Feed Composition

Four feed stream composites have been identified for HWVP processing. The best characterized feed is pretreated neutralized current acid waste (NCAW). A second feed stream composite consists of pretreated complexant concentrate (CC). Plutonium Finishing Plant (PFP) wastes and pretreated neutralized cladding removal waste (NCRW) are the third and fourth identified feeds for vitrification.

A variety of other older wastes currently stored in singleshell tanks could potentially be processed by the HWVP. Because of the range of known and potential feeds, some of which are not well characterized at the present time, significant flexibility in the HWVP process and facility design is required.

Feed Transfer and Lag Storage

Feed for the HWVP will be transferred from existing facilities through nearly 3 km (2 mi) of underground piping. The HWVP requires feed lag storage sufficient to operate for 10 to 12 days between feed transfers in order to accommodate constraints of the existing facilities.

Some feeds will be relatively dilute [about 25 g/L (0.21 lb/gal) total solids on a calcine basis]. Thus, a relatively high evaporation capacity must be provided to concentrate this waste before injection into the melter. A relatively large quantity of contaminated process condensate generated during feed concentration must be treated and then disposed.

Liquid Radwaste Disposal

Radioactive liquid waste generated by the HWVP will betransferred to other existing facilities for further treatment and disposal. Because of limitations of these facilities and a waste disposal cost that increases with radionuclide content of the liquid waste, treatment is required to reduce the amount of TRU and fission products in the liquid waste stream. Corrosion inhibitors also must be added to allow handling liquid waste in existing facilities, which are constructed primarily of carbon steel.

Regulatory Requirements

Key regulations affecting the process systems include the Washington State and Federal Air Quality Regulations and the Resource Conservation and Recovery Act (RCRA) regulations. Compliance with the U.S. Department of Energy (DOE) orders, including DOE Order 6430.1A, "General Design Criteria" (DOE 1989), also is required. The HWVP will be permitted as a hazardous waste treatment and storage facility under the RCRA regulations. These regulations impose design, operation, and procedural requirements.

DESIGN FEATURES

The following sections describe design features of key systems that are significantly affected by Hanfordspecific requirements.

Feed Transfer and Lag Storage

Feed is transferred from the tank farms through underground transfer lines to the RLSTs. The RLSTs are located in the Vitrification Building.

Agitators in the tanks prevent settling of solids and mix the contents for sampling and transfer. Pulse jet tubes, as discussed in "Application of Power Fluidics in British Nuclear Reprocessing Plants" (Shaw 1989), are under consideration for agitation of the RLSTs. These operate by drawing liquid into tubes located inside the tank and periodically ejecting the liquid back to the tank through a nozzle. Each tank uses a number of tubes operated in a timed sequence. This agitation technology requires no moving parts or items that need maintenance inside the contaminated cells.

Each RLST contains pumps to transfer the RLST slurry to the melter feed preparation system and to the sample cell. Capability is also provided to pump the RLST contents back to the tank farms if required. Fluidic pumps (Shaw 1989) are being considered for use in the RLSTs. These pumps have no moving parts or components that require maintenance inside the cell.

Feed transfers from the Hanford Site tank farms will be via pipeinpipe encased transfer lines. Two pipelines connect the RLST to the interfacing feed diversion box. The transfer lines use earth covering to satisfy design shielding requirements. Bends or extension loops are provided to allow thermal expansion without overstressing the piping. This precaution is required because some of the feeds will be relatively hot [up to 88°C (190°F)] during transfer due to radiolytic heat generation. All lines are sloped and gravitydrained to a low point.

The RLSTs and transfer lines are designed to comply with all DOE Order 6430.1A, "General Design Criteria" (DOE 1989), requirements for highlevel liquid

RCRA requirements. Therefore, there is little design impact from the RCRA regulations.

Radioactive Liquid Waste Treatment and Recycle

The radioactive liquid waste treatment and recycle system receives liquid process waste from feed preparation, offgas treatment, canister decontamination, process sampling, equipment decontamination, and miscellaneous sources and processes these wastes for recycle to the feed preparation system or transfer to the tank farm.

The system is designed to allow most radioactive components in the liquid waste to be recycled to the melter. Two operating modes are available: evaporation and filtration/ion exchange. The preferred mode is selected based on need to purge soluble chemicals in the waste. Evaporation results in a cleaner waste stream, simpler operations, and less additives to the process, but it is ineffective in purging undesirable chemicals that may accumulate in the waste. Filtration is effective in purging soluble chemicals but results in increased radioactivity in the waste transferred from the plant.

Primary equipment in the radioactive liquid waste treatment and recycle system is shown in Fig. 2. Decontamination wastes from maintenance operations and condensates from feed preparation are combined in the decontamination waste treatment tank (DWTT) and concentrated by evaporation. The concentrated bottoms may be transferred to the recycle waste collection tank (RWCT) or to a filter feed tank (FFT). The FFT route is selected when purging of soluble chemicals is required. Condensate from MOG treatment can be transferred directly to the FFT or blended with other wastes in the DWTT.

After transfer of wastes to the FFT, the pH is adjusted by addition of sodium hydroxide, and powdered zeolite is added. The zeolite is added primarily to remove soluble radioactive cesium isotopes from solution. A body feed is added, and the FFT contents are then passed through a filter for removal of zeolite, suspended waste solids, and body feed. Before initiation of filtration, the filter is prepared by application of a precoat. Solids collect on the filter as a cake that is periodically backflushed to the RWCT.

The RWCT acts as an accumulation tank for all recycled waste. Bottoms from the DWTT, backflushed cake from the waste filter, and decontamination waste from canister decontamination are combined in the RWCT. These wastes are blended to ensure a homogeneous slurry, sampled, and periodically recycled to melter feed preparation.

The waste adjustment tank receives relatively clean condensate from the DWTT overhead condenser, filtrate from the filter, and miscellaneous lowactivity wastes from other sources. This waste is sampled, chemically adjusted by addition of sodium hydroxide and sodium nitrite to meet tank farm corrosion control requirements, and transferred to a large 450,000 L (120,000 gal) waste holding tank (WHT). The WHT allows the plant to operate for approximately 14 days between periodic transfers of liquid waste to the tank farms.

When operating in the filtration/ionexchange mode, theFig. 2. Radioactive Liquid Waste Treatment and Recycle.HWVP radioactive liquid waste treatment and recycle system recycles more than 95 percent of the radioactive components in the process waste to the melter feed. In the evaporation mode, more than 99 percent will be recycled. With a typical NCAW feed, the HWVP will process about 5 million L (1.3 million gal) of feed per year, containing about 50 million curies of total activity. This will result in production of about 7 million L (1.8 million gal) of process waste containing about 2 million curies of activity. The radioactive liquid waste treatment and recycle system reduces activity in this waste to less than 0.1 million curies. This process significantly reduces plant liquid waste disposal costs and contributes to overall Hanford Site waste minimization efforts.

Process Offgas Treatment

A flow diagram for the process offgas systems is shown in Fig. 3. Offgas from the melter contains a number of materials that must be removed before discharge to the atmosphere (i.e., gases, vapors, and aerosols). Offgas is drawn from the melter plenum through the film cooler where air and/or steam are added to cool the gas and solidify any molten glass or salts from the melter. The gas then enters the MOG submerged bed scrubber (SBS). The SBS is a packed bed submerged in the scrubbing liquid. Gas flows upward through the bed where the gas is cooled and scrubbed. The MOG SBS removes most large diameter particles (>95 percent) and a portion of the smaller particles, water vapor, and acid gasses. Condensate and makeup water accumulate in the SBS to form the scrubbing medium. Accumulated liquid overflows into a chamber around the SBS to maintain a constant liquid level. The offgas is cooled in the SBS by contact with the scrubbing medium, which in turn is cooled with submerged coils.From the MOG SBS, the offgas is directed into one of two parallel trains for efficient removal of remaining particles. Each train includes a highefficiency mist eliminator (HEME) followed by highefficiency dry filtration. The HEME uses a fibrous filter media that is operated wet and at low velocity [about 3 m/min (10 ft/min)]. Removal efficiencies in the HEME are expected to exceed 99 percent for both mists and submicron particles. After filtration, the offgas flows to the MOG exhaust blowers, which discharge into the cell exhaust tunnel.

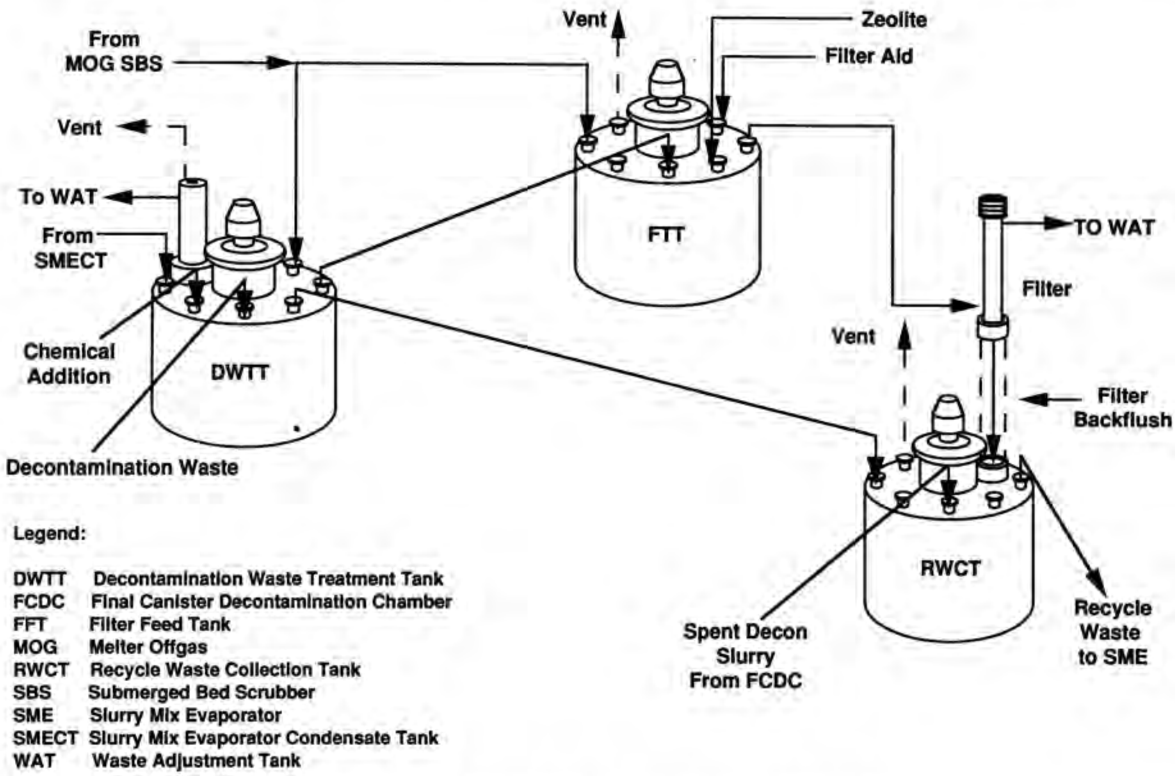

Fig. 2. Radioactive Liquid Waste Treatment and Recycle.

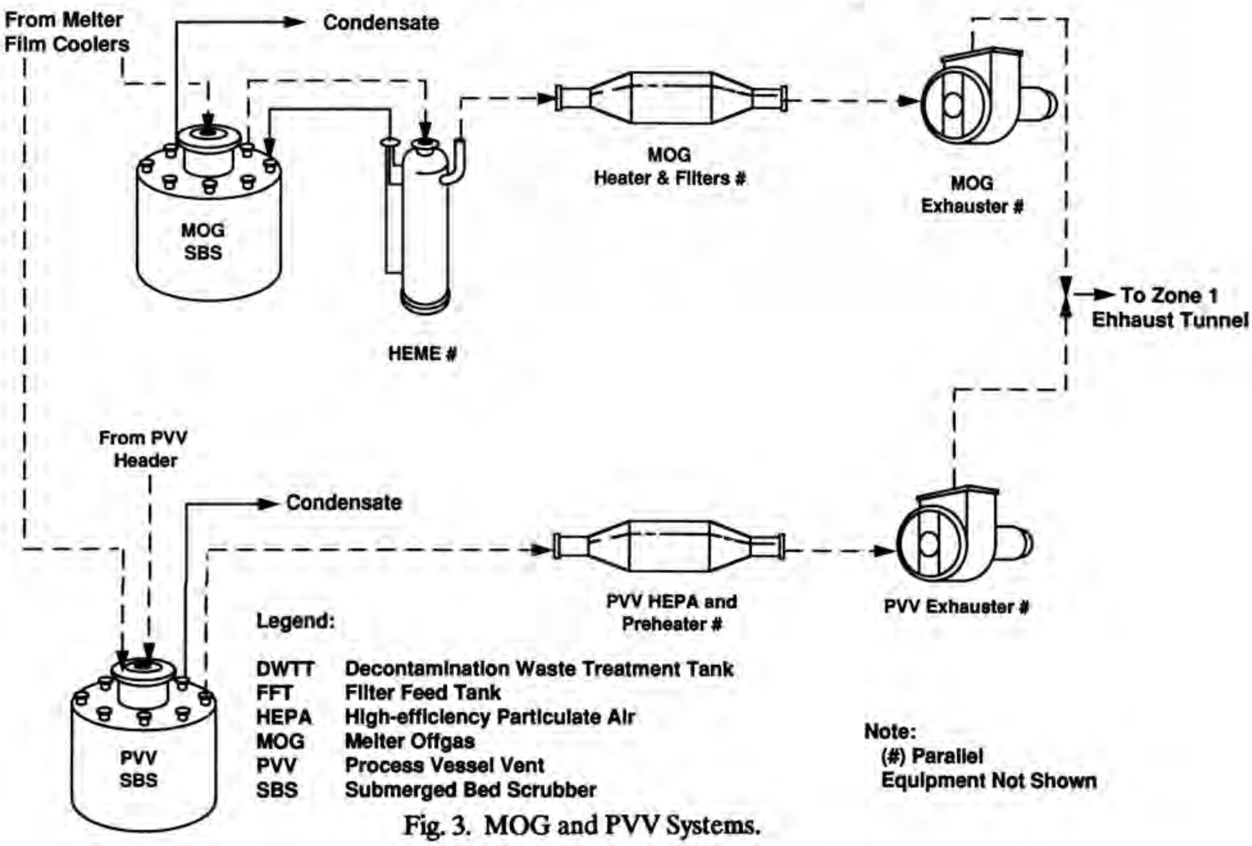

Fig. 3. MOG and PVV Systems.

In addition to the MOG system, a process vessel vent (PVV) system is provided to collect and treat offgas from process vessels in the Vitrification Building. Vent gas is collected in a header that discharges to an SBS similar to the MOG SBS. The PVV SBS removes most of the entrained liquid and solid particles and a portion of the water vapor and acid gases (principally NOx). The PVV system also acts as a backup to provide treatment of MOG when the MOG system is out of service. When in use for backup MOG treatment, the MOG flows to the SBS where it is scrubbed with the normal treated gas stream. From the PVV SBS, the gas stream passes through dry, highefficiency filters and an exhaust blower before discharge to the cell air exhaust tunnel.

The combined exhaust stream from the Vitrification Building remote cells and from the MOG and PVV systems is filtered in a deep bed sand filter before discharge through exhaust blowers to the stack. The Vitrification Building structure, sand filter, and exhaust blowers are the primary elements of the "Safety Class" confinement system, as defined in DOE Order 6430.1A (DOE 1989), that prevents release of radioactivity to the environment. These items are designed to remain functional duringFigure 3. MOG and PVV Systems.and after design basis events such as earthquake, extreme wind, ashfall, and power failure.

PROJECT STATUS

The Preliminary Design of the HWVP Project is near completion, baseline process and facility design concepts have been established, and the Preliminary Design bottomsup cost estimate is being finalized. Plans are for the HWVP to start hot operation in late 1999. However, a 1 or 2year acceleration of this schedule is under consideration. The planned schedule for initiation of major activities is as follows.

Detailed Design	January 1990
Construction	Mid 1991
Cold Testing	Mid 1998
Hot Startup	December 1999

The HWVP is designed to operate for up to 40 years. It will provide immobilization of Hanford Site liquid high level and TRU waste for the foreseeable future.

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