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HANFORD WASTE VITRIFICATION PLANT REMOTE HANDLING APPLICATION

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INTRODUCTION

The Hanford Waste Vitrification Plant (HWVP) Project, to be constructed on the Hanford reservation in southeastern Washington State during the 1990's, will immobilize the liquid, high-level defense waste stored there. The wastes will be retrieved from double-shell tanks and pretreated at an existing facility onsite. Pretreatment will significantly reduce the volume of wastes to be solidified in HWVP by separating the feed streams into high- and low-activity streams.

The high-volume, low-activity fraction of the waste will be sent to the Hanford Grout Treatment Facility for immobilization in a cementitious form in near-surface disposal vaults. The high-activity, low-volume fraction of the waste stream will be sent to HWVP for solidification in a vitrified (borosilicate glass) waste form. The vitrified waste will ultimately be sent to the U.S. geological repository for permanent disposal. These operations comprise the initial steps at Hanford to provide for the permanent disposal of approximately 50,000,000 gal (190,000 m^3) of high-level waste containing approximately 70,000,000 Ci of waste fission products and 70,000 Ci of transuranic (TRU) elements, including 400 kg of plutonium.

An essential design requirement of HWVP is to achieve a facility which meets the radiation protection requirements of "As Low As Reasonably Achievable" (ALARA). With the emphasis on radiation protection of the plant operating staff, it is imperative that the process operations involving radioactive materials use remote handling technology to the maximum degree economically feasible.

DISCUSSION

Because of the highly radioactive nature of the high-level defense waste to be processed in HWVP, the waste handling operations will be performed remotely, ensuring safe operating conditions for the operations staff. A large, physical plant, shown in Figure 1, will be required for this work. Following processing, the canistered, vitrified waste will be stored onsite in the Canister Storage Building until it is shipped offsite to the geological repository for permanent disposal.

The design of the HWVP is very similar to the design of the Defense Waste Processing Facility (DWPF) at the Savannah River Site (SRS) in South Carolina. Because construction of DWPF is scheduled for completion by the end of 1989, it affords sufficient leadtime over HWVP for the "lessons learned" in its operation to be effectively incorporated into the design of HWVP. Experience gained from the DWPF project has been factored into the on-going HWVP preliminary design work. The HWVP, scheduled for initial operation at the end of 1999, will continue to use DWPF "lessons learned" as its design matures.

Use of ALARA as a design approach is integral to the HWVP design philosophy. The on-going evaluations of the design to ensure compliance with the ALARA objectives will reduce the radiation exposure to workers at the facility and potential radiation exposure to the public. The incorporation of ALARA requirements in the design objectives has permitted a design evolution which maximizes attainment of the ALARA goals.

The design of the HWVP Vitrification Building uses a "canyon" concept with most remote operations in the chemical processing cell (CPC) performed with cranes, master-slave manipulators (MSM), and remotely operated, closed-circuit television (CCTV) cameras. Radioactive sludge enters the Vitrification Building CPC, is prepared and mixed with the glass formers, and is pumped to the melter cell. A liquid-fed, joule-heated, ceramic melter boils off the excess liquid and liquifies the radioactive sludge, producing a molten glass form which is transferred into a stainless steel canister. The canister is sealed with a temporary seal and transferred to the canister decontamination cell (CDC) where it is cleaned using a high-pressure, water-glass frit mixture. The canister is then checked for residual contamination in a smear test station and transferred to the weld and test cell (WTC), where the final canister closure weld is performed. The canister is then ready to be transferred out of the Vitrification Building to the Canister Storage Building. Because all of these operations involve highly radioactive components, they are performed remotely.

The canyon crane and in-cell cranes will be employed in the melter cell, the CDC, and the contact maintenance decontamination cell (CDMC). Only in-cell cranes will be used in the WTC. In addition, each of these cells will also have MSMs to assist in performing in-cell work. The MSMs will also be available in the remote equipment decontamination cell.

The Justification for New Start for HWVP specified that the Project should "take full advantage of the plant systems being designed for the DWPF." The physical arrangement and many of the specific systems and components of the DWPF plant provided the basis for conceptual design of HWVP. A number of systems and components designed for DWPF will be replicated for use in HWVP, including the melter, the canister decontamination chambers, and the shielded canister transporter.

Thus, many of the design features of the two plants are very similar. The HWVP has increased the building size somewhat to reflect "lessons learned" at DWPF, but has used the basic layout and concept employed for DWPF, and will produce canisters of vitrified waste which are the same size as those at DWPF. While the anticipated plant throughputs are equivalent for the two plants, HWVP canisters are potentially more radioactive than those produced at DWPF because of the difference in waste loading. Changes in HWVP design will accommodate the differences in input feed stream and respond to other design requirements reflecting a later point in the evolution of regulatory requirements.

A number of significant "lessons learned" from the design, construction, and startup of DWPF have been incorporated into the design of HWVP. For example, physical limitations on space were rather severe at several locations in DWPF. Additional space has been added in HWVP to facilitate installation and removal of MSMs, provide additional shop space for manipulator repair and maintenance activities, provide additional analytical laboratory facilities in HWVP to permit sample analyses for waste form qualification, and reconfigure the arrangement of processes in the CPC to meet the specific needs of HWVP. A planned series of technical information and experience exchanges between DWPF and HWVP has been on-going since 1985, and HWVP has assigned permanent personnel at DWPF to facilitate the flow of "lessons learned" into the design of HWVP.

In addition, there has been an on-going effort to use remote handling and other technology as appropriate from around the world. Remote operation design, development, testing, and operational experience on comparable projects in West Germany, France, the United Kingdom, and Japan are being evaluated for applicability to the HWVP Project. Although DWPF experience is used extensively, the designs, innovations, and experience of other vitrification facilities continue to be assessed for effectiveness, economic advantage, and potential ALARA improvement to the HWVP design.

Once radioactive operations begin, personnel access to the canyon will no longer be permitted or possible. Activities in all the canyon areas, except the CDMC and railroad well, will be performed remotely. The majority of remote operations in the CPC use the canyon crane and CCTV cameras. An impact wrench, suspended from the CPC crane, is used to tighten and loosen the connectors which connect the tanks and vessels to the other process tanks and to required services. The canyon crane will remove and replace canyon cover blocks and all major components in the canyon. The CPC crane will be maintained in the crane maintenance cell, a contact maintenance area at the extreme end of the canyon. The maintenance cell will permit decontamination of the crane to levels sufficient to permit contact maintenance work on it.

The heart of the vitrification facility is the melter. The liquid-fed, joule-heated, ceramic melter will produce borosilicate glass at a rate of 220 lb/h. The melter lifetime is expected to be three years or more, after which it will be replaced. Given the 40-year facility design lifetime of HWVP, it can be seen that melter replacement will be periodically required during the lifetime of HWVP (and DWPF). All services, feeds, and other functions necessary to operate the melter are provided through the jumpers. The entire melter, including the jumpers, is removable (as are all the major components in remote cells) and will be replaced remotely using the CPC crane. An in-cell crane in the melter cell will be used for process operations during production, including normal movements of clean and filled canisters, and canister transfer operations.

After the canister is filled, a temporary closure is remotely placed in the hot neck of the canister to provide a water-tight shrink-fit canister seal. The canisters are remotely cleaned of surface contamination in the CDC using a high-pressure stream of water and glass frit. The glass water/frit mixture is recycled into the feed preparation system so no waste stream is generated by the cleaning. The canister is then transferred to the smear test station to check for smearable contamination using a remotely applied swab. The swab is pneumatically transferred out of the smear test station to a counting station in the operating gallery. Upon verification of no smearable contamination, the canister is transferred to the WTC for the final canister closure.

The WTC in DWPF employs a large hydraulic press to reposition the temporary inner canister closure, and a large DC upset welder is used to produce the final canister closure. The highly reliable welder developed for DWPF has been demonstrated in development testing to produce extremely high-quality closure welds. The final qualification of this remote welding process will be performed during cold run testing of DWPF. While testing indicates the process is highly reliable, alternate closure welding techniques developed in this country and abroad continue to be evaluated for potential application in HWVP. The specific U.S. Nuclear Regulatory Commission (NRC) regulatory requirements for canister closure prior to placement in the geological repository are still evolving.

Although the canisters will be highly radioactive, they are expected to have no surface contamination when they reach the WTC. Therefore, the WTC has been designed as a contact maintenance area. Two cranes are provided in the WTC to ensure the ability to move a canister from the open areas of the cell to a shielded storage location in the event of equipment malfunction. Once the canister is safely stowed, personnel may enter the cell to perform repairs.

Two features are instrumental in achieving the remotability necessary in the canyon areas. Special connectors are used to connect the equipment to the appropriate wall locations. In HWVP, plutonium-uranium reduction extraction (PUREX) connectors will be used to provide the connections. The DWPF uses Hanford connectors, which were developed during the early days of the Manhattan Project construction at Hanford. The use of PUREX connectors in HWVP will ease the construction tolerances somewhat and provide a "more forgiving" design in which precise fit and alignment of the components is not as critical as in DWPF.

The other essential feature for remotability is the use of remotely controlled CCTV cameras to provide visual feedback to the operators. The CCTV cameras are placed strategically throughout the facility in the remote operating areas. The placement of the cameras in the facility was performed carefully to ensure adequate vision when performing remote operations in the cells. Remote CCTVs are also mounted on the CPC crane to permit operators to see the operations as they perform them.

Canister movement from cell to cell throughout the process is accomplished with a series of transfer tunnels and mechanical transfer carriages such as the mechanism shown in Figure 2. The details vary somewhat from location to location, but all are remotely retrievable in case of drive motor malfunction. Thus, it would be possible to retrieve a canister and store it in a shielded location to permit hands-on repair of the transfer carriages.

The shielded canister transporter is used to move the canister from the Vitrification Building to the Canister Storage Building. There is provision for picking up the shielding plug over the exit tunnel or the storage location, and moving the shielded canister cask over the opening for the plug, while maintaining the integrity of the personnel shielding. The shielded canister cask on the transporter provides personnel shielding for both the transporter operator and other operating personnel in the vicinity during transportation of the canister from the Vitrification Building to the Canister Storage Building. The canistered waste will be temporarily stored onsite in the Canister Storage Building until it is shipped to a Federal geological repository.

One of the areas of greatest difference between the two facilities is the extent and layout of the analytical area. The HWVP has provided facilities which are much more extensive than were provided in DWPF, and provides for analytical evaluations of both the process samples and the waste form qualification samples. In DWPF, provision was made for process sampling to monitor the removal of the sodium tetraphenyl borate and mercury from the sludge feed stream. Further, the DWPF waste form qualification samples, while taken in the canyon, will be analyzed in hot caves at another facility several miles distant, at Savannah River Laboratory. The DWPF analytical laboratories were fitted into limited available space in the Vitrification Building late in the facility design.

The analytical facilities in both HWVP and DWPF will make extensive use of MSMs in the hot cells, and gloveboxes for samples with low radiation levels. A series of transfer mechanisms is used to transmit samples between cells as required. The design of the analytical area for HWVP has relied strongly on the "lessons learned" from DWPF to set space requirements both for analytical operations and necessary maintenance.

Design dose rate values for various areas within HWVP were set to meet ALARA goals during normal and abnormal operations. In addition to design features to ensure ALARA, procedural constraints will further enhance ALARA operations.

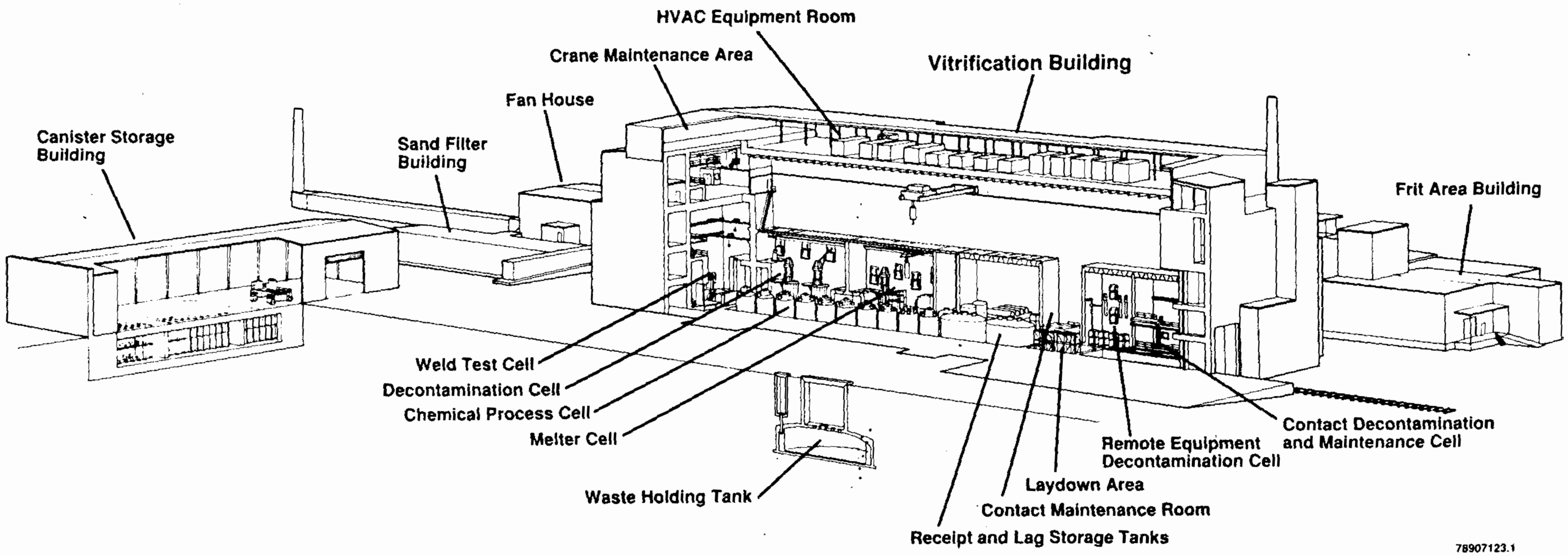
A major consideration in reducing operational exposure to radiation during HWVP operation will be conducting maintenance operations and abnormal operations as efficiently as possible. It is expected that the Systems Evaluation and Test Facility (SETF) will be a significant factor in providing both operating experience and dry-run of projected maintenance operations so that occupational exposures can be minimized. The SETF will permit many of the fit-up and systems integration testing functions for HWVP which have been performed for DWPF in the mock-up and TNX facilities. The DWPF experience has demonstrated that early fit-up and compatibility testing can save substantial time by resolving potential construction problems before they get to the field. The SETF, currently in the design requirements stage, will be constructed as part of the HWVP Project.

RESULTS/CONCLUSIONS

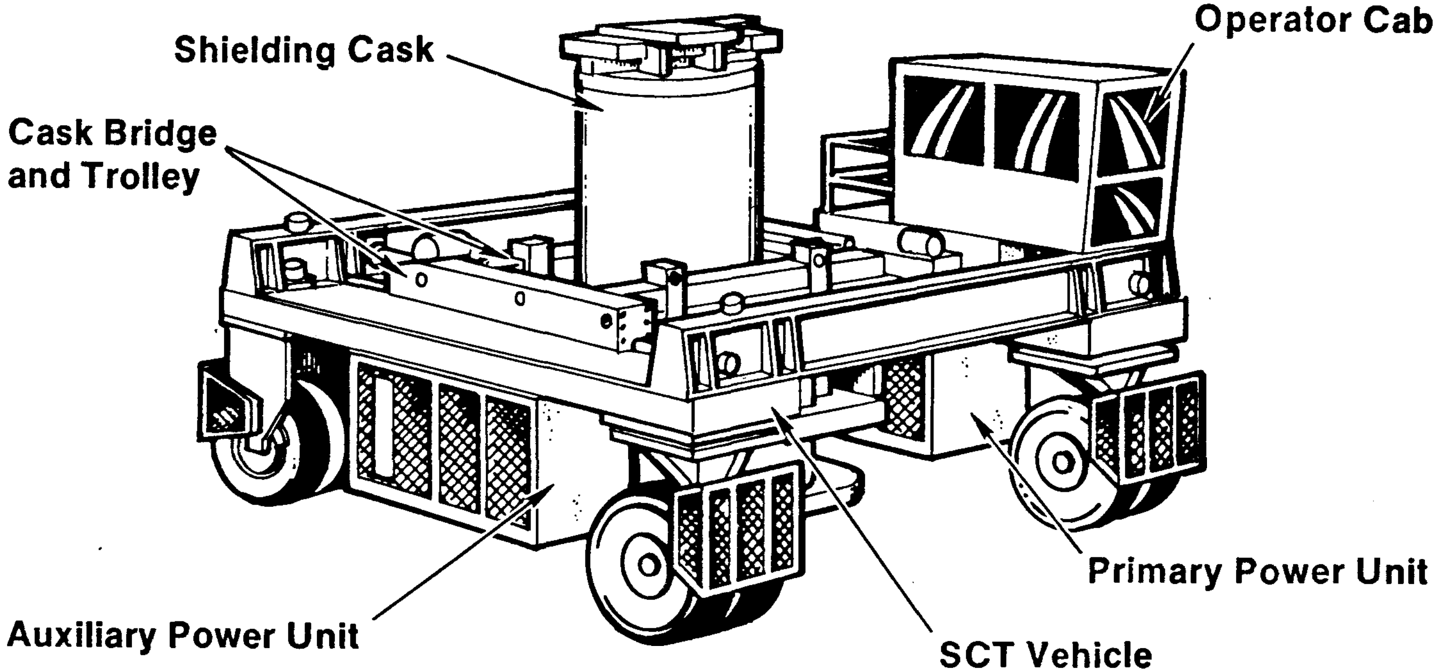
The similarities in operational philosophy and design approach between HWVP and DWPF will help ensure that HWVP meets the operational objectives at a minimum total lifetime cost. The extensive operational experience at SRS with remote facility operations has been thoroughly integrated into the DWPF design, with direct design inputs and reviews from personnel with hands-on operational experience. This experience is now being incorporated into the HWVP design.

Implementation of remote handling techniques in HWVP also relies heavily on the extensive operating experience at Hanford and other facilities worldwide. This application of remote handling illustrates how it is feasible to perform complex chemical and mechanical processes in areas where it is not possible for direct human operator access. The ability to remotely operate and maintain the facility adds flexibility to the design and will permit future process modifications, if required, while ensuring operations which are consistent with ALARA operational goals.

Hanford Waste Vitrification Plant (HWVP)



Shielded Canister Transporter



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