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Hanford Waste Vitrification Plant Project Alternatives Feasibility Study

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Prepared for the U.S. Department of Energy
Assistant Secretary forDefense Programs

Westinghouse
Hanford Company Richland, Washington

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Hanford Waste Vitrification Plant Project Alternatives Feasibility Study

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EXECUTIVE SUMMARY

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HANFORD WASTE VITRIFICATION PLANT FOREIGN ALTERNATIVES FEASIBILITY STUDY

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) has conducted defense nuclear materials production activities at its Hanford Site in the State of Washington for more than 40 yr. These activities have resulted in the accumulation of large quantities (millions of gallons) of radioactive high-level waste (HLW), most of which are currently being stored as slurries in underground tanks. It is a major mission of the DOE to achieve permanent disposal of these wastes using safe, environmentally acceptable, and cost-effective methods that meet applicable regulations. This report deals with selection of the applicable technology for converting the Hanford HLW slurries to an acceptable waste form for disposal in a geologic repository.

In June 1983, the President submitted the Defense Waste Management Plan (DWMP) (DOE 1983) to the U.S. Congress. This Plan established the fundamental goal to end present interim storage practices for defense wastes and to provide for permanent disposal. To achieve this goal, the DWMP establishes, as an objective, that the HLW be converted into a borosilicate glass waste form for shipment to a geologic repository. The Hanford Waste Vitrification Plant (HWVP) Project has been established by the DOE to accomplish this objective.

The construction of HWVP is included as the preferred HLW disposal alternative for Hanford in the final environmental impact statement (EIS) on the *Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes* (DOE 1987). The decision process culminated with the issuance of the record of decision by DOE in April 1988 (DOE 1988), which stipulates that the "preferred alternative" discussed in the EIS be implemented.

Vitrification also has been chosen for HLW at the West Valley Demonstration Project (WVDP) in the state of New York, where commercial reprocessing of spent nuclear fuel was carried out in the 1960's and 1970's, and at the Defense Waste Processing Facility (DWPF) in Aiken, South Carolina, where DOE has conducted nuclear materials production activities since the late 1940's. Both of these sites have selected a liquid-fed ceramic melter (LFCM) technology for vitrification of their HLW.

The WVDP vitrification project is expected to go into hot operation in 1991, and the Savannah River Site should do so in 1992. Current plans are for the HWVP to go into hot operation possibly as early as 1996. Because the timing of the vitrification program at Hanford is much later, it is anticipated that a significant cost and schedule savings should result from application of lessons learned at the other two plants.

During the past several decades, DOE has sponsored research and development activities in nuclear waste vitrification. As will be discussed later in this report, the DOE development programs have produced a mature LFCM

technology that is now being applied on a large scale for the vitrification of nuclear wastes in the United States, as well as in other countries. At the same time, development efforts that have produced an alternative mature vitrification technology have occurred outside this country, most notably in France. This alternative technology employs a different design approach, and it has been successfully applied to the large-scale production of vitrified nuclear waste products in France. The French technology also is being adopted by the United Kingdom.

Because of the existence of alternative technology and its apparently successful adoption elsewhere (i.e., in France and in the United Kingdom), the HWVP has determined that a reassessment of its earlier decision to use LFCM technology is warranted. This report presents results of a study to use alternative technology in the HWVP. Cost, schedule, and safety issues, as well as maturity of the technology and application to the specific wastes encountered at Hanford, were all considered in making this assessment.

2.0 HANFORD WASTE VITRIFICATION PLANT PROJECT BACKGROUND AND STATUS

2.1 DEVELOPMENT OF VITRIFICATION TECHNOLOGIES

Borosilicate glass has been chosen by most countries as the final waste form for disposal HLWs that arise from the reprocessing of irradiated nuclear fuel. Since the 1950's, extensive research and development efforts in the United States and elsewhere have established the viability of two principal vitrification technologies for producing glass waste forms on an industrial scale. These technologies are based on the liquid (or slurry)-fed ceramic melter (LFCM) and the rotary calciner/metal melter (AVH) processes. A history of the development of vitrification technology has been provided by McElroy et al. (1982), and the status of LFCMs in 1989 for vitrification of nuclear wastes has been discussed in Chapman and McElroy (1989). Also, the status of the technology at various nuclear sites recently has been reported [(Maillet 1988); (Weise 1988); (Tsuboya 1988); (Elsden 1988); (Barnes 1988); and (Weisman 1988)].

The current HWVP design is based on the LFCM process. The LFCM also has been chosen for vitrification of HLW by the WVDP and the DWPF in the United States, and by nuclear projects in Belgium [the PAMELA facility, operated jointly with the Federal Republic of Germany (FRG)] and in Japan. The Soviets use the LFCM process in their plants, and there are indications that the People's Republic of China plans to use the LFCM process as well.

In France, the rotary calciner/metal melter process has been developed for commercial application to wastes from the reprocessing of spent nuclear fuel from light water reactors (LWR). The French have constructed plants at Marcoule (AVM) and, more recently, at La Hague (AVH). The British have purchased the AVH technology from the French, and they have subsequently modified it for use in their Windscale Vitrification Plant (WVP).

The basic steps for each process are shown conceptually in Figure 2-1. The waste is prepared for treatment. Solids from the exhaust gas cleanup system and certain additives are mixed with the waste prior to vitrification. The molten glass is produced and poured into metal canisters, which are later sealed. Waste gases are collected and treated to remove particles and other contaminants. As described later in this report, an important difference in these processes is that the waste stream entering the melter is dry solids with AVH, while the waste stream is a liquid or slurry with LFCM.

2.1.1 History of Liquid-Fed Ceramic Melter Selection in the United States

Since 1966, research at Pacific Northwest Laboratory (PNL)* in Richland, Washington, has investigated a variety of approaches to the solidification

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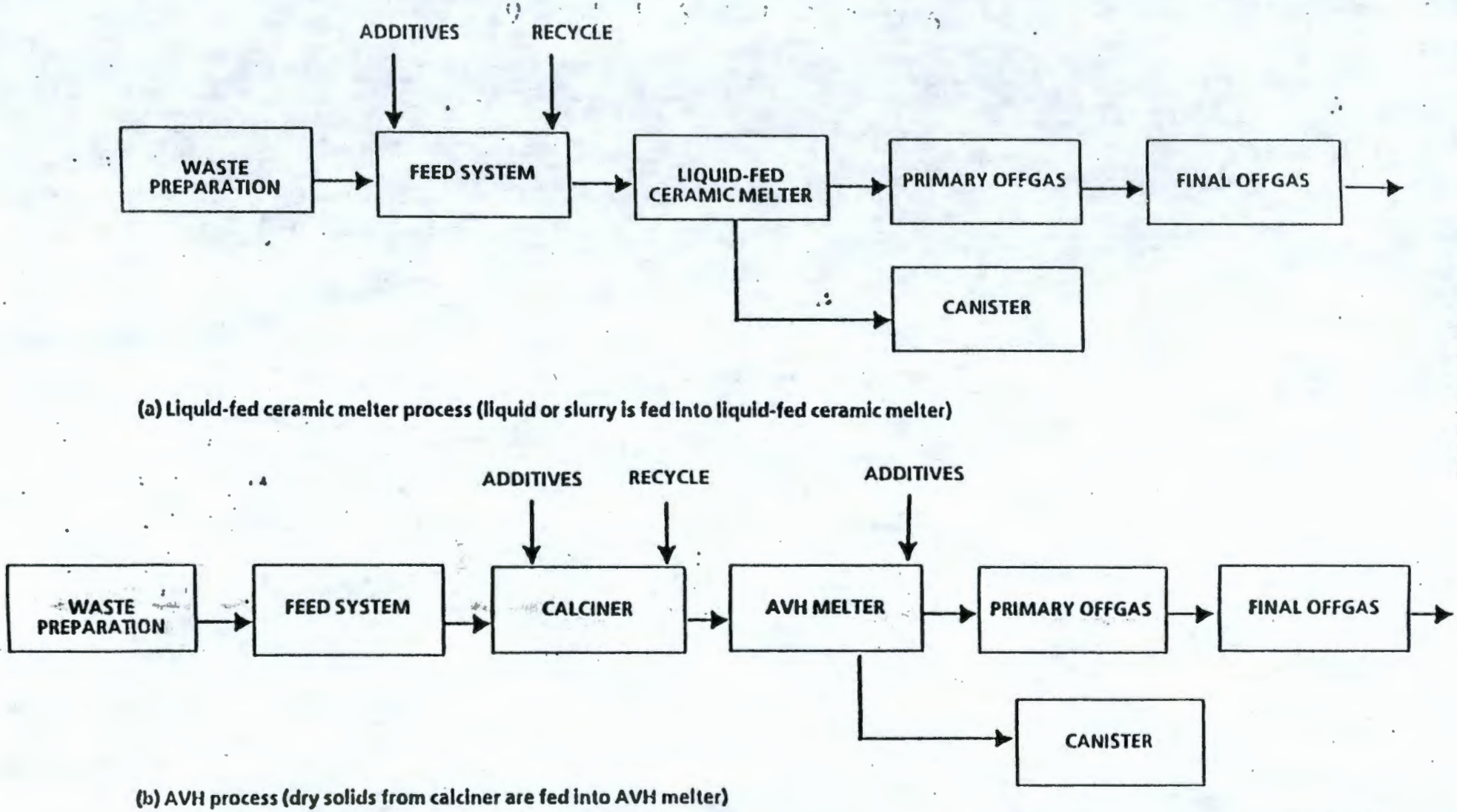

Figure 2-1. Simplified Block Diagram of Liquid-Fed Ceramic Melter and AVH Vitrification Processes.

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Figure 2-1. Simplified Block Diagram of Liquid-Fed Ceramic Melter and AVH Vitrification Process.

of radioactive waste. Processes that have been considered include pot calcination, spray calcination, fluidized bed calcination, continuous metal melter vitrification, in-can vitrification, and joule-heated continuous vitrification. Most of these systems were tested in a variety of scales with mixed results. Each had advantages as well as disadvantages. Based on a variety of comparative features, none was singularly outstanding. However, the ceramic melter represented the "industry norm." Literally thousands of melters are in use around the world. Industrial knowledge of operability, reliability, sophisticated product control, and awareness of a host of subtle technological parameters logically forced the researchers to closely examine the adaptability of the ceramic melter to the radioactive waste solidification programs.

Based on reviews of the commercial glass industry, an engineering-scale joule-heated ceramic melter was built and successfully tested with both calcine feed and liquid slurry feed. In the ensuing years, numerous test programs focused on the ceramic melter. Adaptations compatible with radioactive service were devised, performance was characterized, and numerous features were refined such that the melter readily met the requirements of the U.S. waste programs. Not the least of these was a high confidence that the quality of the glass produced was highly replicable, predictable, and could meet stringent performance and durability tests.

An aggressive approach to HLW management was initiated by DOE at the Savannah River Plant (SRP) in Aiken, South Carolina, in the late 1970's, culminating in the selection of the LFCM process in 1980 because of its demonstrated ability to provide the needed production rate and glass quality. The French technology (rotary calciner/in-can melter) was considered but not chosen, in part because it appeared that it would require six parallel melters to provide the needed production rate and, also, each melter would have an expected life of substantially less than 1 yr. In addition, technical data concerning the French process were meager and difficult to obtain in spite of cooperative exchange programs between France and the U.S. DOE. Glass quality was considered to be of major importance to the U.S. developers, and many technical details (e.g., melter residence time, vitrification temperature, devitrification phenomena, and a host of others) were simply unknown. Comparisons of the two technologies for use by DWPF were not formally documented. However, a substantial number of U.S. leaders in vitrification technology did examine the merits of the French process and could not identify any clear advantages either in cost or technology. Before and during the 1980's, the United States did develop substantial documentation on the selection of the DWPF waste form, culminating with the DWPF Environmental Assessment (DOE 1982), which presented the LFCM technology as the reference method of choice for producing borosilicate waste glass.

In 1983, the LFCM technology was selected for the WVDP after extensive consideration of the French process. The comparisons made for WVDP are documented in *Comparison of the Rotary Calciner - Metallic Melter and the Slurry-Fed Ceramic Melter Technologies for Vitrifying West Valley High-Level Wastes* (Chapman 1983). The comparisons are quite comprehensive with respect to technical/administrative and economic issues. The final decision for WVDP was made by a DOE panel that included specialists from various sites including those from France. The panel did not publish a record of their conclusions. However, it appeared that the longer residence time and higher temperatures

in the LFCM (i.e., greater probability for producing a higher quality glass product) were important factors in the decision.

With the Savannah River waste management program well underway and the West Valley program developing rapidly, the Hanford Site HLW program based its approach on their previous analyses and the direction of the *Defense Waste Management Plan* (DOE 1983), which supports the cost beneficial use of available DOE technology. In this context, previous studies conducted for the HWVP melter (1984) considered only DOE melters (DWPF, WVDP, and PNL).

In parallel with efforts by the United States, the FRG also was evaluating vitrification technology, including the French AVH process. After some time and deliberate consideration, they, too, selected the LFCM technology for development at the Karlsruhe Nuclear Research Center (KfK) and installation in their PAMELA plant in Belgium. Their basis included concerns similar to those identified in the United States -- glass quality, process temperature, devitrification effects, etc.

Japan began evaluating vitrification technologies somewhat later. They built an extensive research and development facility at Tokai and have actively investigated both the French and ceramic melter technologies. Over time, the Japanese determined that the LFCM process best meets their requirements and production goals, and they currently are engaged in an aggressive effort to develop the ceramic melter for their vitrification program.

2.1.2 Hanford Waste Vitrification Plant Melter

The LFCM operates on the same basic principle as a large number of commercial electric melters in the glass industry. Molten glass is contained within a cavity made of highly corrosion-resistant, glass-contact refractory. Behind the glass contact refractory are additional layers of lower-density backup and insulating refractories, which provide secondary glass containment and added thermal insulation. The glass is uniformly joule-heated by passing an alternating current between electrodes in contact with the molten glass.

The primary component of the HWVP LFCM process is the joule-heated glass melter (Figure 2-2). The nominal capacity of the melter is 100 kg/h (~220 lb/h); this compares with the West Valley and Savannah River melter capacities of 50 kg/h and 100 kg/h, respectively. This is a high-temperature, ceramic-lined melter with direct resistance (joule) heating of the molten glass pool accomplished by passing an alternating electrical current through the glass. The direct electrical heating of the glass eliminates energy transfer through a metal wall and, therefore, can readily be scaled-up for high throughput. In addition, the ceramic lining and air-cooled metallic electrodes allow bulk glass temperatures of up to 1300 °C (~2400 °F) during short periods of routine operation, should this be needed.

During operation, a slurry of waste containing glass-forming additives is fed directly into the molten glass pool in the melter. Heat from the glass pool (and lid heaters in the DWPF melter design) dries, calcines, and converts the liquid waste to molten waste glass. The glass product is drawn off the melter and discharged to a canister via an overflow system.

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Potential Advanced Features

HWVP Melter & Turntable

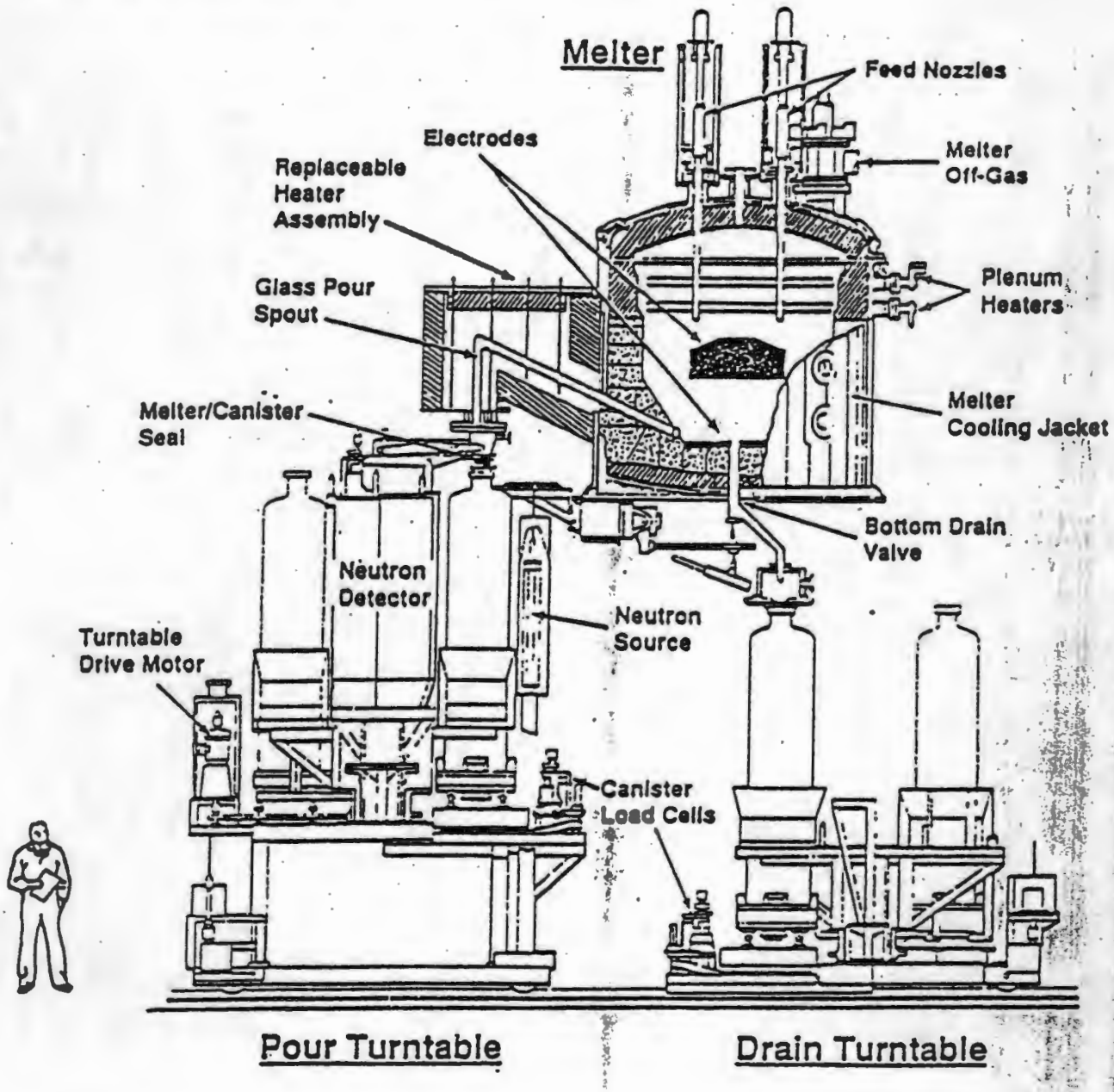


Figure 2-2. HWVP Melter and Turntable

The concentrated waste slurry, which is fed directly into the melting chamber, forms a pool that normally is separated from the molten glass by a crust of dried and calcined waste solids that together is known as the "cold cap." Moisture and some solids continuously evolve from the cold cap, but the majority of the remaining material is relatively nondispersible compared to loose calcine. The cold cap typically covers about 80 percent of the molten glass surface, and heat is transferred from the molten glass through the floating crust to the aqueous feed. Decomposition gases and waters of hydration, produced during calcination of the crust, percolate up through the crust and aqueous feed. Periodically, the aqueous feed comes in to direct contact with the molten glass through cracks or vent holes in the crust. The resulting increase in heat transfer creates temporary steam surges in the offgas flow, typically three to four times the nominal rate for a few seconds; however, the offgas system is adequately sized to accommodate the anticipated surges.

As the calcined waste crust is further heated, it begins to flux with the glass formers and goes into solution with the glass. Natural convective mixing in the glass provides a comparatively homogeneous product.

The molten glass exits the melting cavity through the throat of the discharge section of the melting cavity. Differential pressure or an air lift causes the molten glass to flow into a separate overflow chamber where it is channeled in a heated trough and poured into a receiving canister. The glass is poured from the melter by establishing a few inches of water pressure difference in the canister and pour spout relative to the melter vapor space. The pressure difference causes glass to overflow the riser and flow into the canister.

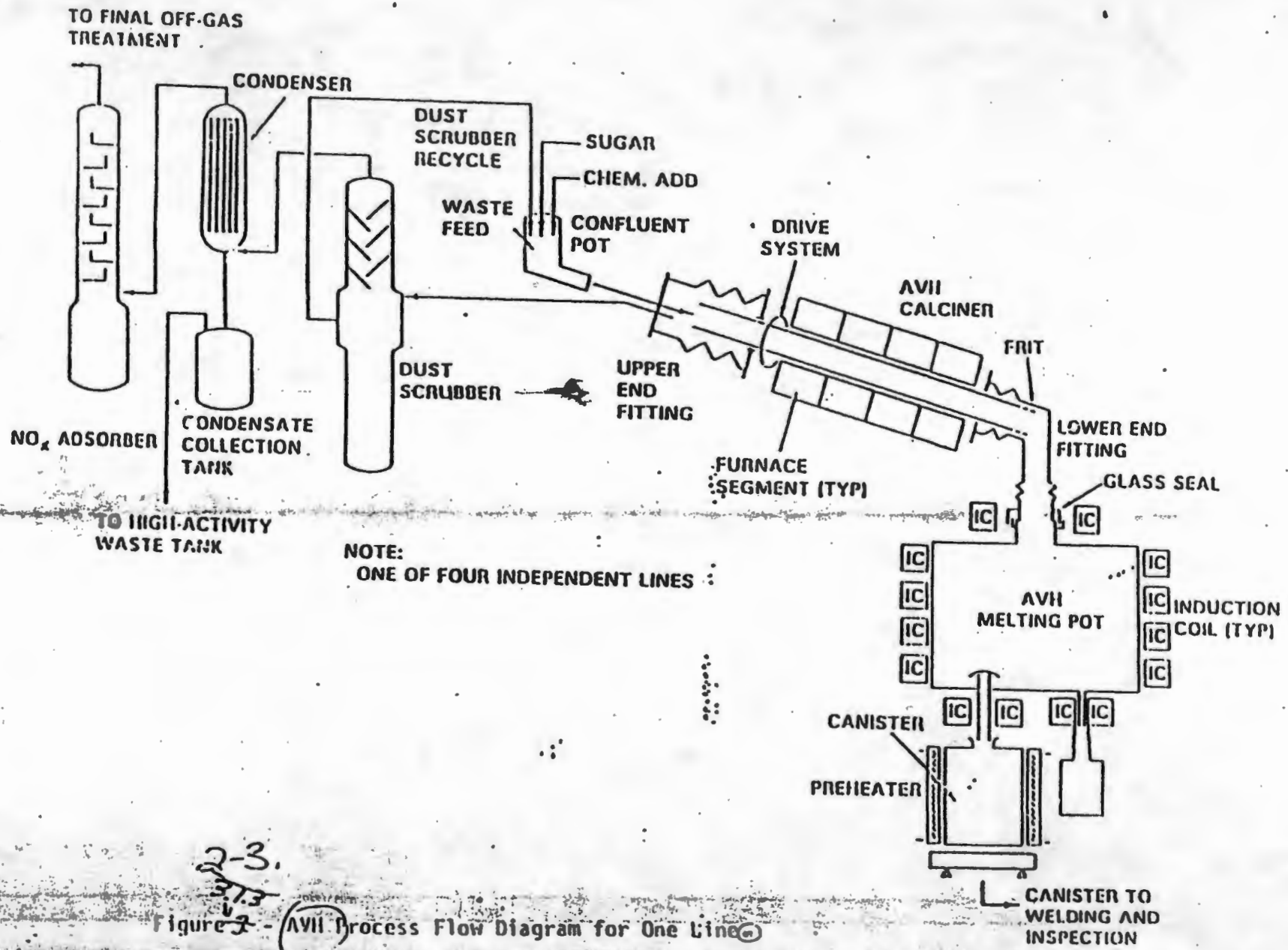
During canister changeout, melter slurry feeding is continued. Because the vacuum is not operating, the glass that is formed collects in the melting cavity. Once the canister changeout is completed, the vacuum is restarted and pouring continued.

The LFCM system is designed so that essentially all mechanical maintenance, including equipment installation and removal, can be performed from a remote location outside the hot cell employing primarily a crane and an impact wrench. Direct viewing through shielded windows will be utilized in association with indirect viewing by cameras to conduct all equipment maintenance. The cell will be equipped with an overhead crane that can be fitted with attachments, such as motorized hooks or impact wrenches, to aid maintenance.

2.1.3 Rotary Calciner/Metal Melter

The French have developed the rotary calciner/metal melter, known as the AVH process (Figure 2-3) for use at their La Hague facility. In 1957, they began research and development on vitrification of HLWs using the AVM process at Marcoule. Subsequently, many technical changes were made in the AVM process, and the modified process (AVH) was installed at La Hague.

The rotary calciner operation and the induction-heated furnace are based on the well-known UF_6 to UO_2 conversion technology and standard furnace



2-3.

Figure ~~2~~ - AVII Process Flow Diagram for One Line

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Figure 2-3. AVH Process Flow Diagram for One Line.

design. The nominal glass production rate of the AVH process is 30 kg/h (~66.1 lb/h), and this appears to be close to the maximum capacity due to inherent difficulties associated with scale-up of the rotary calciner and induction melter. The AVM process, still in operation at Marcoule, has a nominal glass production rate of 15 kg/h (~33.1 lb/h).

In the AVH process, fission product solutions are transferred into one of two waste blending and feeding tanks. One tank is used for feeding the rotary calciner while the other tank is sampled and chemically adjusted to be compatible with a glass frit used to form the glass product. The two tanks are stirred mechanically and temperature controlled by cooling coils.

Feeding of waste solutions is carried out by means of a double airlift followed by a constant-volume feeder, which enables the transfer and proportioning of the waste solutions from the feeding tank to the calciner. The primary airlift feeds the secondary airlift via a breakpot, with the excess liquid returning via the overflow to the tank. The natural submergence secondary airlift feeds the invariable volume vessel of the constant volume feeder via a breakpot, the excess liquid returning into the airlift leg. The flow rates on the primary and secondary airlifts are high enough that the solids contained in the solution remain suspended.

From the constant volume feeder, the waste solution flows to the confluent pot; this apparatus provides a hydraulic seal to separate the ventilation of tanks, breakpots, and the constant volume feeder from that of the calciner. The hydraulic seal is provided with a compressed air inlet that can resuspend any possible deposits in the waste stream. Moreover, the confluent pot receives the recycling solution from the dust scrubber. The recycling of this dust, drawn out of the calciner with the offgas, is thus carried out directly in the supply circuit, which avoids any problems related to the reconcentration and deposition of insolubles. The waste then flows by gravity into the confluent pot where a mechanical proportioning pump supplies a special calcining additive at a predetermined rate. Sugar water and ferrupore are used as additives. The additive is needed to control the volatility of ruthenium, to prevent caking of calciner wall, and to reduce the calcine particle size. The shape of the confluent pot has been specially designed to avoid any deposit and clogging that may result from the use of this additive.

The waste is calcined in a rotating tube that is heated by a four-zoned electric-resistance furnace. Each zone is precisely controlled to +/- 2 °C (+/- ~36 °F). This tube is connected to two fixed end fittings that permit mating with upstream and downstream equipment. A vacuum seal is provided by a double graphite seal ring with an annulus area held at a slight over-pressure by compressed air. The reduced particle size increases the dissolution of the calcined waste into the glass matrix during subsequent induction melting. The calcine particle size is reduced by introducing a sugar additive and using a loose rod to bang and break up lumps in the calciner.

The rotary calciner product and a separate glass frit stream are fed continuously into a metallic, induction-heated melting pot. The solid mixture is heated to a temperature of 1100 to 1125 °C (~1100 to ~2057 °F) in this

melting pot, and converted to a glass. The metallic wall of the melting pot is induction heated, and the heat is transferred by conduction to the glass. The melter is divided into eight heating zones. Thermocouples are placed in each zone to aid in determining the glass level in the pot, and the power to the corresponding induction zones is adjusted according to the increasing glass level. Because the calcine has been heated to a high temperature, there is no offgassing during this step, and the calcine readily dissolves in the glass.

For remote maintenance, the vitrification cell is equipped with shielded windows located opposite the maintenance stations. Direct viewing is used in association with cameras (indirect viewing) to conduct all equipment maintenance. The cell is equipped with an overhead crane that can be fitted with various attachments, such as motorized hooks and specialized tools, to aid maintenance. In addition, PAR-type manipulators capable of XYZ (three-dimensional) movements, which can operate in a semiautomatic mode, will be used for localized manually-controlled maintenance.

The AVM and AVH technologies are similar. Therefore, the experience the French have gained using the AVM process is relevant to the AVH process. Both the AVM and AVH processes use a rotating calciner of similar design. The principal differences between these two processes are the maintenance methods and the type of metal melter used. A circular-shaped metal melter is used for the AVM process, while an elliptical melter has been developed for the AVH process.

2.2 HANFORD WASTE VITRIFICATION PLANT PRELIMINARY DESIGN DESCRIPTION

The United States has been engaged in defense nuclear activities at Hanford for more than 40 yr. Radioactive liquid (and slurry) wastes from these activities currently are stored in underground double-shell tanks at Hanford. The HWVP will immobilize the high-level and transuranic (TRU) portions of these wastes in borosilicate glass cast and sealed in stainless steel canisters. The filled canisters will be stored at Hanford until they can be disposed of in a federal geologic repository.

2.2.1 Facility Overview

The current design concept for the primary facility features is depicted in Figure 2-4. The main process building (Vitrification Building) contains process cells with cranes and ancillary equipment needed to remotely process the high-level nuclear wastes. The cells house the melter feed preparation, vitrification, canister welding, and canister decontamination operations. A process offgas cell also is included as well as two equipment maintenance cells. Remote cells in the Vitrification Building are located under an open "canyon" area. A large canyon crane is provided for installation and removal of equipment from the cells.

Interim storage of filled canisters will be provided in separate buildings. The canisters are made of 304L stainless steel and will be

Hanford Waste Vitrification Plant (HWVP)

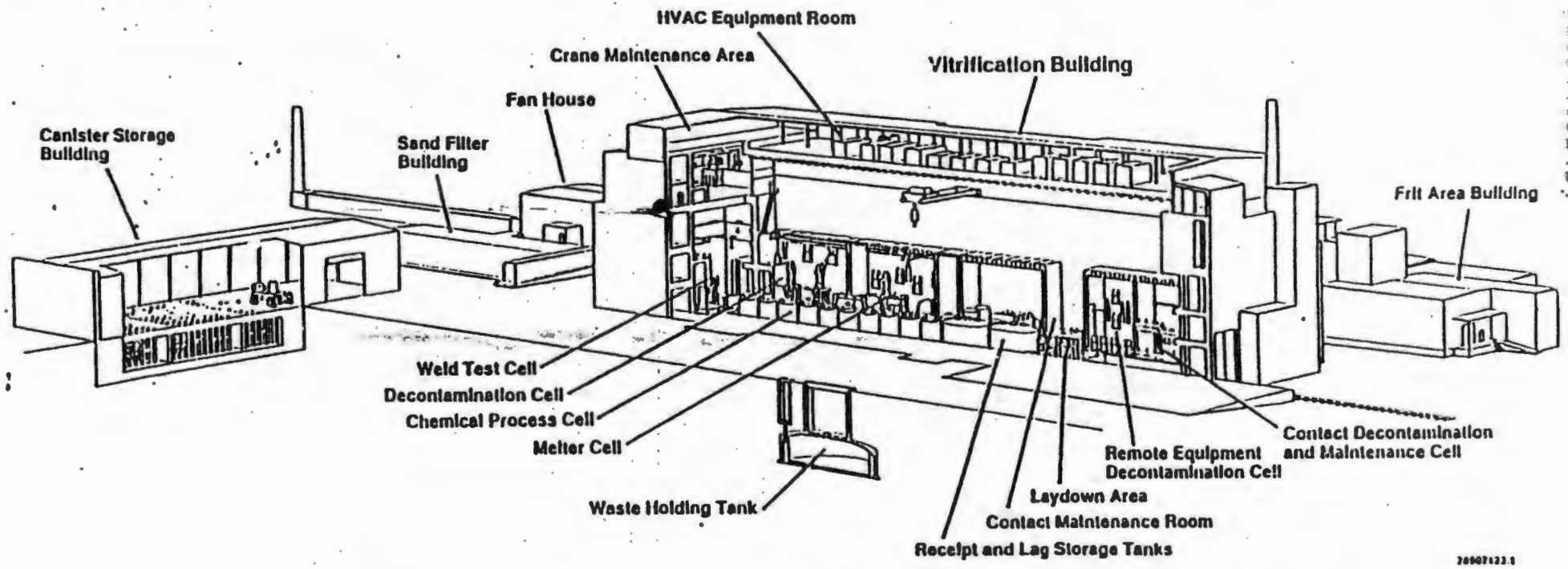

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Figure 2-4. Hanford Waste Vitrification Plant.

approximately 61 cm (~2 ft) in diameter and about 3 m (~10 ft) long. Support facilities also are included as part of the HWVP design for safe and efficient operation of the plant. These include maintenance facilities, a process steam boiler, and a bulk chemical storage area. Exhaust ventilation facilities will include filtration and an exhaust stack. An electrical substation, sanitary and storm sewers, roads, and railroads also will be provided.

Radioactive liquid waste transfers between HWVP and other Hanford Site facilities will be via underground encased transfer lines. Before transfer to HWVP, the wastes will be pretreated to separate low-level from high-level and TRU fractions. This will minimize the amount of feed to the HWVP as well as the number of canisters requiring final disposal. Waste pretreatment will be conducted at other Hanford Site facilities.

Key structures, components, and systems required for confinement of radioactivity are designed to withstand severe environmental loads and accidents, including earthquake, severe winds, wind-generated missiles, and volcanic ash fall. These "Safety Class" items include the Vitrification Building structure, cell ventilation and exhaust filtration system, and backup power system.

2.2.2 Feed Handling Systems

Feed is received via encased underground transfer lines constructed as part of the HWVP Project. The feed is placed in the receipt and lag storage tanks (RLST), which provide about 280,000 L (~75,000 gal) of feed lag storage. The feed then is concentrated by evaporation, and chemicals are added to improve redox and slurry rheology. Glass frit and recycle process waste then is added and the mixture further concentrated. After sampling and analysis to verify that the feed mixture meets requirements, the finished feed batch is transferred to the melter feed tank. Feed preparation is carried out in two tanks with 37,854 L (~10,000 gal) working volume each. Each tank is equipped with heating and cooling coils, mechanical agitator, overhead condenser, and sample and transfer pumps. A condensate accumulation tank also is provided, with an 37,854 L (~10,000 gal) working volume.

The melter feed tank also has an approximate 37,854 L (~10,000 gal) working volume and provides a continuous source of feed to the melter through two feed transfer systems operated in parallel. Centrifugal pumps and mechanical agitators are provided to handle the melter feed with 400 to 600 g/L (~0.9 to 1.3 lb) total solids (calcine basis). The melter feed solids consist of about 75 wt% glass frit and 25 wt% waste oxides.

The vitrification system equipment, located in the melter cell, consists of a refractory-lined melter box with stainless steel cooling water jacket, heating electrodes, water-cooled feed nozzles, closed circuit television, instrumentation, offgas vents, and a stainless steel turntable and canister-to-melter spout bellows seal system. In operation, the feed continuously is metered into the melter (Figure 2-5) producing waste glass at 100 kg/h (~220 lb/h).

HWVP Melter Feed System

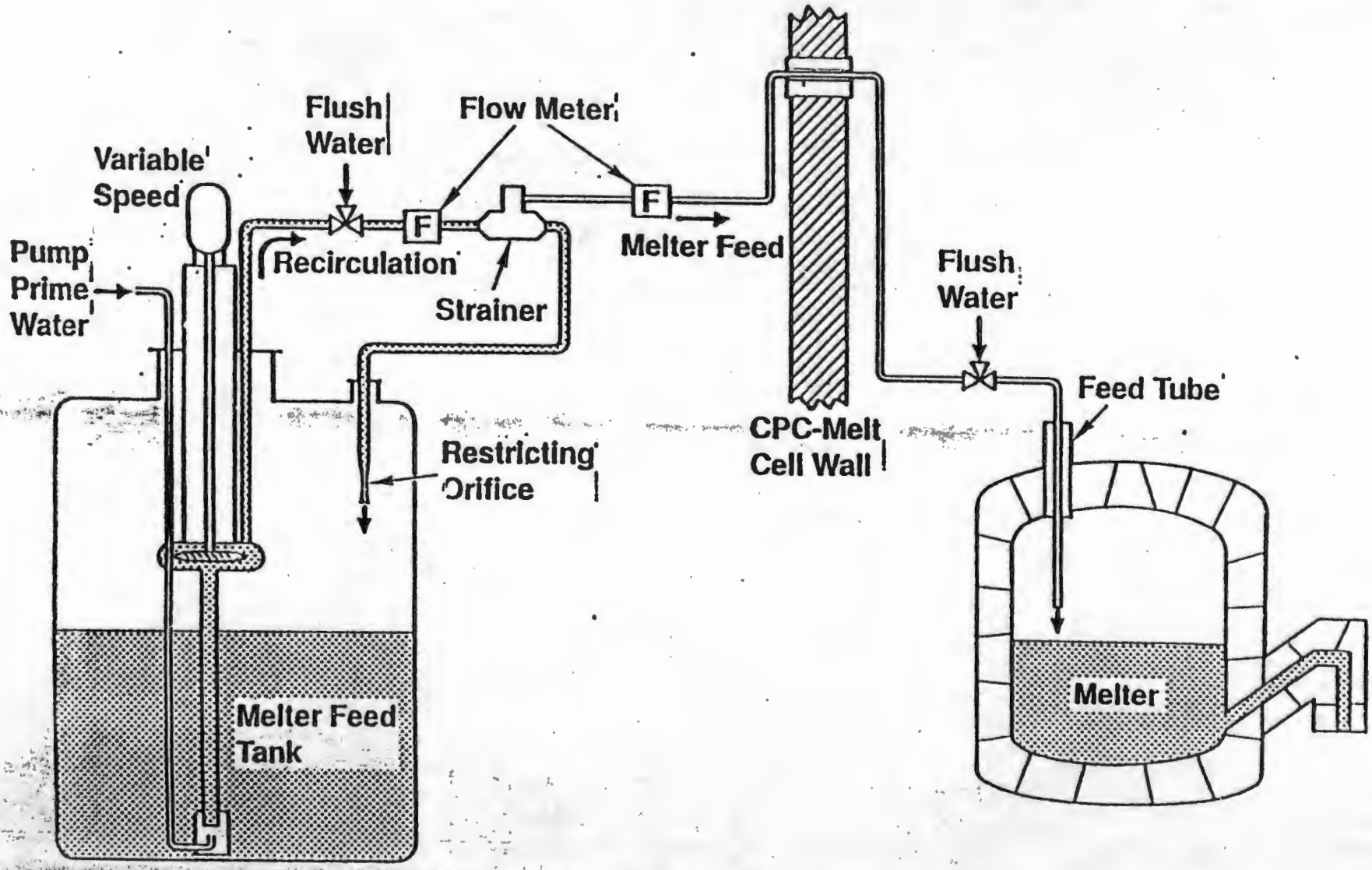

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Figure 2-5. HWVP Melter Feed System.

The elevated temperature of the molten pool in the melter vaporizes the water in the slurry, causing the formation of a "cold cap" of oxides and other chemicals over the pool. The effluent stream, containing gaseous and particulate contaminants, is treated in the melter offgas system. At the melter operating temperatures, most of the solids in the cold cap convert to oxides, which then dissolve in the molten glass. Glass is poured from the melter by establishing a vacuum in the canister and pour spout relative to the melter vapor space. The vacuum causes glass to overflow the riser and flow into the canister. Figure 2-6 provides additional information about the canister. The filled canister is cooled in a turntable and forwarded to the Canister Welding System. A preliminary design concept for the HWVP Melter/ Turntable System (see Figure 2-2) is similar to the DWPF design.

2.2.3 Offgas Treatment

The melter offgas system removes particulates, chemically reactive gases, and radionuclides such that the HWVP melter exhaust gas meets guidelines for emissions.

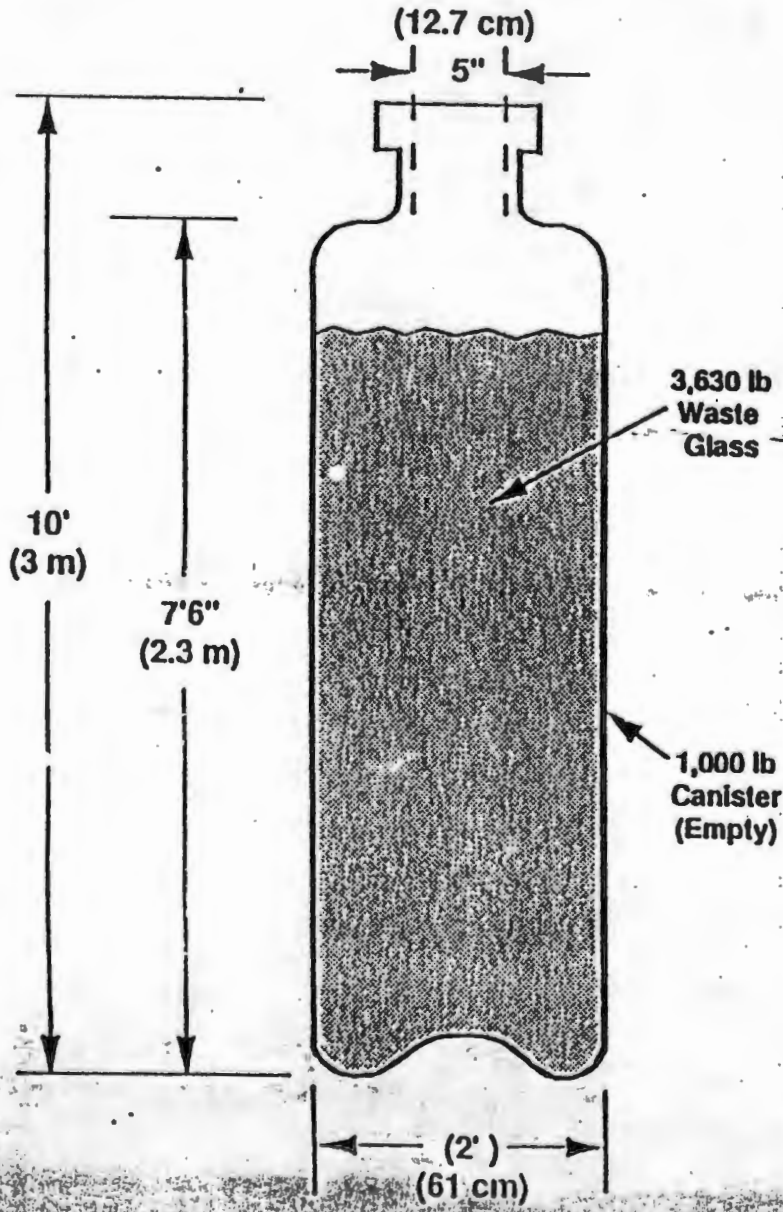
About 0.2 percent of the nonvolatile melter feed components will be entrained in the melter offgas. A larger fraction of certain components will report to the offgas system because of evaporation or chemical reaction. Offgas from the melter will flow first through a film cooler where steam and/or air is injected. The gas then is drawn into a scrubber that condenses steam and other condensables, cools the noncondensables, and removes some particulates. From the scrubber, the remaining material will pass through a high-efficiency mist eliminator, a preheater, a roughing filter, and two high-efficiency particulate air (HEPA) filters for final aerosol removal. The gas then is mixed with a stream of cell exhaust air, which is filtered again before discharge.

2.2.4 Canister Closure and Decontamination

Filled canisters will be sealed prior to decontamination and storage. The current baseline design is based on the use of a remotely operated resistance upset welding process. In this process, a cap is welded in place by application of force while current is passed between the cap and the canister for a period of seconds. A larger repair weld cap, utilizing additional pressure and current can be used to recover from any unacceptable primary weld. Because of the high cost and large space requirements for this closure system, alternative design concepts are undergoing evaluation.

After cooling, the canister is transferred from the melter cell to the decontamination cell via a tunnel. The canister is washed with water in the tunnel to reduce the potential for tracking large amounts of dispersible contamination into the decontamination cell. In the decontamination cell, the canister is blasted with an air-injected, abrasive slurry of dilute formic acid and glass frit. The canister is then water-rinsed, air dried, and moved to the smear-test station. Canisters failing the smear test are returned for additional frit blasting of those areas of the canister surface determined to be contaminated. The used decontamination slurry is recycled for use in melter feed preparation.

HWVP Canister



Canister	
Material:	Type 304L stainless steel (Schedule 20 pipe)
Surface Area:	70 ft^2 (6.5 m^2)
Heat Load:	750 - 1400 Watts
Surface Temperature:	~179° F (82° C)
Lid Temperature:	~135° F (57° C)
Glass Density:	164.8 lb/ft^3 (2.64 g/cm^3)
Glass Volume:	22 ft^3 (625 L)
Waste Loading:	25% oxide
Activity:	~4 x 10^5 Ci
Exposure Rate:	~2 x 10^4 rad/h

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Figure 2-6. HWVP Canister.

A shielded canister transporter (Figure 2-7) transfers the sealed, decontaminated canisters to a canister storage building for interim storage pending shipment to a federal geologic repository. The transporter is controlled and operated by one person located on the vehicle.

2.2.5 Control Room

The central control room is located in the Operations Control Building. It is the normal control location for most process and facility operating systems. Within the control room is the primary supervisor console and the primary consoles for the feed preparation, melter/canister, heating, ventilation, and air-conditioning (HVAC), and utilities operations.

A backup central control room is located on the second floor of the Vitrification Building. Systems are controllable from this location if the central control room becomes inoperable or inaccessible. Within this control room is the backup supervisor console and the backup consoles for the feed preparation, melter/canister, HVAC, and utilities operations.

Control room operators will control the process in semiautomatic, prompted batch mode with hold points and operator prompts separating the automatic sequence segments of the operation. Transfer, sampling, evaporation, and similar processes are initiated by the operator and automatically terminated by the batch program when the desired endpoint is reached. The operator then initiates the next step in the sequence.

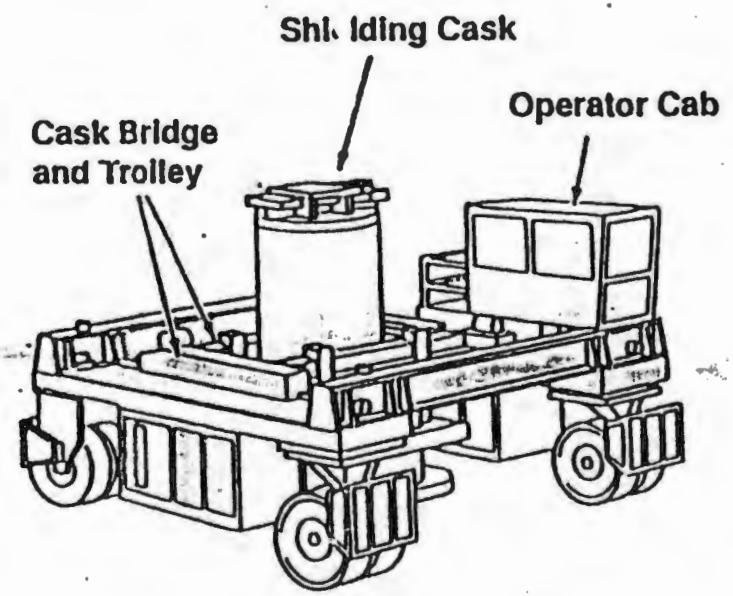
Operators can change set points, manually start and stop operations, and control the process as required to maintain safe and efficient operation. Safety interlocks and multiple levels of password access will prevent or minimize the consequences of operator error. Process displays will be designed in a hierarchical sequence so that each operator can observe and control the process operations in the desired detail. Alarms will be annunciated and displayed for the operator.

Special application local control panels are installed at various locations in the facility. They are required to assist in manual operations or control remote processes or processes that require an operator for safe completion.

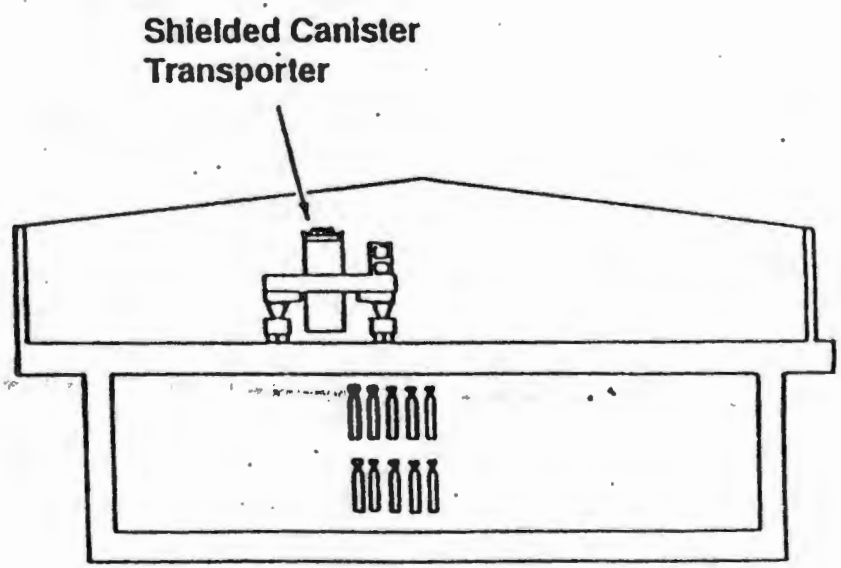
2.2.6 Remote Maintenance

Most remote maintenance is accomplished using the canyon crane and crane-mounted impact wrench. The plutonium/uranium extraction (PUREX) connector and remote flanges are used for piping, electrical, and instrumentation connections. This remote maintenance technology has been developed at Hanford and successfully utilized in reprocessing plants and in other nuclear facilities at the Hanford Site. Manipulators are used to a limited extent for operating functions and maintenance. For example, the sample and analytical cells are operated and maintained using manipulators. Manipulators also are used for decontamination and packaging of failed equipment. In-cell cranes are provided in some of the cells to perform operating functions such as handling canisters.

Canister Transportation and Storage



Shielded Canister Transporter



Canister Storage
Building

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Figure 2-7. Canister Transportation and Storage.

Crane maintenance is performed in the crane maintenance area (CMA) at the south end of the Vitrification Building. The rails of the canyon bridge crane extend directly into this area, allowing it to pass a shield door that isolates the CMA from the process canyon area. The canyon bridge crane can access cell cranes and transport them to the remote equipment maintenance cell or contact decontamination and maintenance cell (CDMC) for decontamination and repair. Components of cell cranes can be moved to the CMA by the canyon bridge crane as required for critical repairs. The CMA is equipped with decontamination solution tanks and crane wash-down facilities suitable for contact decontamination and direct maintenance. Smaller components are removed to adjoining hot repair shops, while large components are repaired in place on the crane.

Process components from the operating cells that require maintenance or disposal are moved by the canyon bridge crane to either of the maintenance cells, depending on expected feasibility of contact maintenance. The remote equipment decontamination and maintenance cell (REDC) is equipped with facilities and equipment listed below to perform all activities remotely:

- Two electromechanical manipulators and equipment stands to position components properly
- Remotely operable utility service racks to supply decontamination solutions
- Master-slave manipulator/shielded window work stations for direct cell viewing and limited lightweight repairs
- Closed-circuit television to supplement direct viewing.

The CDMC is similarly equipped to support remote decontamination and also includes a cell bridge crane that is remotely operable and by pendant from inside the cell. Utility racks supplying decontamination solutions are directly operable inside the cell. Breathing air stations and regulated tool storage also are included.

A lay-down area equipped with stands for temporary storage of failed cell components is provided in the process canyon to handle any backlog of contaminated equipment that requires maintenance.

2.2.7 Project Design Status

At present, the HWVP is near the end of the Preliminary Design phase. Construction is scheduled to start in mid1991 with hot startup planned for 1999. Construction of a similar facility, the DWPF, at the Savannah River Site in South Carolina is nearly complete. Thus, the construction and operation of the HWVP will follow that of the DWPF. Consequently, experience gained at the DWPF is being incorporated into the design of the HWVP. The design of the HWVP incorporates the special processes and equipment developed for the DWPF to a significant extent. By utilizing these designs and incorporating the DWPF experience, it has been estimated that the HWVP Project has/will realize savings of approximately $200 million.

2.3 PROJECT BASELINE COST ESTIMATE

The Project cost estimate was prepared by Fluor Daniel, Inc. (Fluor), the architect engineer (A/E) firm for the HWVP. The estimate has been reviewed by Westinghouse Hanford Company (Westinghouse Hanford) and a number of cost reduction items were implemented to reduce the capital cost of the project to the current figure of $965 million. Also, the U.S. Department of Energy-Headquarters (DOE-HQ) requested a review of the Fluor estimate to be done by their Independent Cost Estimating (ICE) Committee. The resulting estimate of by the ICE Committee was close to the estimate made by Fluor (it was approximately 5 percent higher). An extensive value engineering review also has been conducted by Kaiser Engineers Hanford Company (KEH), and a number of their findings and recommendations are currently being reviewed by Fluor for possible additional cost reduction. In addition to these cost estimates and reviews, the general construction contractor is scheduled to perform an independent "bottoms-up" cost estimate on the HWVP in March 1990.

The HWVP Preliminary Design cost estimate (draft) is a "bottoms-up" estimate based on the specifications and work scope provided by the Preliminary Design engineering and design documents. Material quantities were developed by material take-offs from Preliminary Design drawings, sketches, and transpositions developed for estimating. Material and equipment prices were obtained from current in-house pricing information and informal vendor quotations. Craft labor rates were taken directly from the Hanford Site Stabilization Agreement, Issue 12, which was in effect as of January 1989. More detailed information regarding the Preliminary Design estimate criteria and methodology are given in the sections below.

2.3.1 Hanford Waste Vitrification Plant Preliminary Design Cost Estimate Basis

The HWVP Preliminary Design cost estimate described the cost estimate basis in four major subsections as follows (these are further discussed in the Appendix):

- Estimate Criteria - describes the criteria, assumptions, and methodology used in developing the estimate.
- Basis of Material Take-off (MTO) - describes the approach, content and methods used to arrive at estimate line item quantities.
- Estimate Format and Coding - defines the estimate organization, hierarchy, and coding developed to structure the estimates in accordance with the Facility Code and Project work breakdown structure (PWBS).
- Procurement and Construction Plan - defines the contents of each of the procurement and construction packages identified in both the cost estimate and the master schedule.

2.3.2 Total Estimated Cost of Construction

Based on the preliminary designof the facility, the total estimated cost (TEC) of construction for the HWVP is $965 million. A breakdown of this total cost is given in Table 2-1.

2.4 COMPARISON OF THE HANFORD WASTE VITRIFICATION PLANT WITH DEFENSE WASTE PROCESSING FACILITY AND WEST VALLEY DEMONSTRATION PROJECT

The HWVP is to be compared with the U.S. programs at Savannah River (DWPF) and West Valley (WVDP), both of which are in more advanced stages. Using the same LFCM technology, it is anticipated that the HWVP will profit from lessons learned on the other projects, for which there should be a significant cost and schedule savings.

2.4.1 Comparison of Hanford Waste Vitrification Plant Cost Estimates with Defense Waste Processing Facility and West Valley Demonstration Project

The DWPF cost estimate and schedule history is shown in Table 2-2. The TEC (capital) for the DWPF has ranged from $970 million in 1983 to $870 million in 1987 to the TEC of $930.2M in April 1988.

The cause of recent cost escalation at the DWPF is threefold. Retrofitting activities are needed to meet new regulations that were not in effect at the time of design. There are unexpected processing problems in the front-end treatment of cesium-bearing precipitates. Extended cold runs are required to ensure that waste form qualification requirements are met.

The HWVP Project does not anticipate a similar cost growth. The HWVP is being designed to the new regulations. The cesium processing problem is unique to SRP waste. The HWVP Project has provisions for a Systems Evaluation and Test Facility (SETF), which will be housed in the 337 Building High Bay at Hanford. This cold test facility will be operational in 1994 and used for prototypic process equipment checkout, characterization, and integration. In addition, the process flowsheet will be verified and waste form qualification testing (process and product model verification) will be performed. The Distributed Control System (DCS) will be evaluated for the process equipment integration and software development/checkout. The SETF also will be used for operator training/certification and for verification of procedures.

Table 2-3 lists the WVDP cost growth reasons. The initial TEC for the WVDP was $488 million and is now at $800 million. About 63 percent of the cost increase is due to schedule extension and associated escalation and contingency. Twenty percent of the cost increase was due to underestimating the cost, and the balance is new scope.

These cost increases are unique to the WVDP; therefore, they do not affect the HWVP cost.

Table 2-1. Breakdown of Total Estimated Cost of Construction for the Hanford Waste Vitrification Plant.

WBS	Description	Escalated cost ($M)	Percent contingency	Contingency ($M)	Total cost ($M)
1.1	Project Management	45,812	10.0	4,581	50,393
1.2	Technology	--	--	--	--
1.3	Plant	--	--	--	--
1.3.1	Design	--	--	--	--
	Title I	29,928	3.3	1,000	30,928
	Title II	89,722	12.0	11,538	101,260
	Title III	40,772	15.0	6,116	46,888
1.3.2	Construction	612,158	--	118,065	729,503
1.3.3	Startup/Operations	--	--	--	--
1.4	Regulatory Compliance	4,825	10.0	483	5,308
1.5	Systems Evaluation and Test Facility	--	--	--	--
	Totals	823,217	17.2	141,783	965,000

TEC = total estimated cost
WBS = work breakdown structure

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Table 2-1. Breakdown of Total Estimated Cost of Construction for the Hanford Waste Vitrification Plant.

Table 2-2. Cost Estimate and Schedule History for Defense Waste Management Plan.

Congressional budget submission	Total estimated cost ($ millions)	Scheduled project completion	Scope additions/ deletions ($ millions)
1983	970	March 1990	Sludge only (base)
1984	910	June 1989	Sludge
1985	870	June 1989	Salt (+ $78)
1986	870	June 1989	5-yr storage (+ $31)
1987	870	June 1989	Shipping (+ $14) and incineration (+ $14.8)
1988	945	June 1990	
1989	930.2	June 1990	Delete incineration (-$14.8)
Current status (4/88)	930.2	June 1990	
Expenditures to date (4/88)	798		

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3.0 EVALUATION OF PROCESS TECHNOLOGY AND PLANT DESIGN ALTERNATIVES

3.1 PROCESSING TECHNOLOGY AND PLANT DESIGN CONSIDERATIONS

In a project as complex as the HWVP, a number of important process technology considerations must be factored into the design decision-making process. For example, the size of the U.S. canister the size of cells that house the canister closure and decontamination equipment and favors the large canyon/remote maintenance concept that has been utilized for many years in chemical processing at DOE sites. For economic and safety reasons, the large canisterized glass waste form has been selected for disposal of defense HLW in the geologic repository. Thus, the HWVP product will be very similar to that of the DWPF, with the canister handling/transporting/storage operations and requirements, the Waste Form Qualification (WFQ) and analytical procedures, and both plant features being quite comparable.

Differences in glass-producing technologies are rooted in the requirements developed for the user programs. For example, the French program can use a relatively small capacity system because of its close-coupled nuclear fuel cycle. Large inventories of waste do not accumulate nor do they have large historical backlogs that require high throughput capability to "work-off." Consequently, a systematic analysis of the requirements highlights the advantages of a given technology versus another.

While the AVH process is a proven technology for handling acidic HLW liquids, such as those produced by the French nuclear industry, its ability to handle alkaline slurries has not been demonstrated. Such handling of alkaline slurries is required of the HWVP.

3.1.1 Canister Size and Impacts

The HWVP canister size of ~3 m (9 ft 10 in.) in height and ~0.6 m (2 ft) in diameter is identical to the DWPF canister design. The basis for the canister dimensions is the recommendation of a committee formed several years ago to determine the optimum size for the canister in order to minimize burial costs in the repository and to provide maximum production throughput. Representatives from the U.S. waste producers, repositories, and PNL were members of the committee.

The committee focused on work conducted by the DOE during many years and determined that a 3 m (~10 ft) height and ~0.6 m (2 ft) pipe size for the diameter was a good choice for convenience of core drilling at the repository, canister fabrication, melter pouring, vitrification facility handling, onsite storage, and shipping. An increase in canister diameter beyond ~0.6 m (2 ft) was considered to increase canister volume, but technical studies showed that the glass tended to devitrify with projected heat loading when the canister diameter was increased; therefore, further study did not appear to be warranted. The recommended canister dimensions were found to be consistent with the internal dimensions of the shipping cask designed for fuel shipment.

With the amount of required shielding, the weight of the cask was barely under the ~36,000 kg (80,000 lb) limit for truck shipping. Calculations showed that increasing the canister size to ~0.76 m (2.5 ft) diameter would increase the weight of the shipping container above the ~36,000 kg (80,000 lb) limit. However, this evaluation was based on the shielding required for the nominal maximum case vitrified waste to be processed at the DWPF. This waste is generated about 10 yr after DWPF startup and composed of sludge cooled for about 5 yr. Evaluation of canister handling within the DWPF indicated that the canister height could not be increased significantly without impacting the building design. The combination of the original work conducted for the DOE and the committee evaluation led to the recommendation for the current canister dimensions. The DOE has standardized the canister size for all U.S. waste producers to reduce costs for shipping and repository disposal; no reduction in canister dimensions can be considered at this time.

The French nested cell and equipment design is based on a canister that is approximately ~1 m (4 ft) high and ~0.3 m (1 ft) in diameter. An increase in canister height would impact design of the cells and equipment used to position the canister under the induction melter, weld the canister lid, and decontaminate the canister surface and check for smearing. These changes to the French design would have a major impact on the nested cell concept and overall configuration of the vitrification plant. In addition, remote maintenance concepts would have to be reconsidered, and equipment used to provide remote changeout may require redesign. Redesign of some equipment would necessitate testing to verify operation prior to installation in the HWVP.

The WFQ requirements dictate that the free volume within the canister not exceed 20 percent. Gamma level detectors are incorporated into the design of the HWVP melter turntable to provide process control to fill a minimum of 85 percent of the available volume of the canister with glass. The French AVH process is designed to pour two batches of glass from the induction melter into a small canister, and no level detection is provided. Therefore, modification of the French design to handle the large U.S. canister may necessitate the use of level detectors to assure adequate filling to meet WFQ requirements because pouring of multiple melter batches to an exact height in the canister may be difficult to control.

3.1.2 Melter System Design

A single LFCM process line can provide the production rate required for each of the U.S. vitrification projects. By contrast, four complete AVH process lines would be required to provide comparable production at HWVP (i.e., 100 kg/h) and, depending on future waste classification decisions and cost/schedule considerations, U.S. inventories could require up to nearly two dozen process lines of this capacity to achieve the production mission at a single location.

During normal operation, an LFCM melter has a design life of 3 or more years. This is achieved with a refractory lining that is resistant to corrosion and erosive wear. The ceramic lining also provides the capability to operate at higher-than-normal processing temperatures for extended periods. This capability gives additional operating flexibility for corrective action

with the LFCM that cannot be achieved with the AVH process equipment. By comparison, the longest operating life achieved with an AVH-type melter to date is slightly less than 1 yr. While material improvements may be possible, the ability of an AVH melter to routinely process the Hanford waste feed streams without requiring replacement over long periods (years) is questionable.

Because the LFCM is highly reliable and has been shown to have low maintenance, this technology is compatible with requirements for equipment installation in a canyon/remote facility. This is the preferred U.S. facility design for chemical processing of high-level radioactive materials, having been proven safe and successful throughout decades of operation. Because of the number of melters required for an AVH process, the shorter design life, and the moving parts in the AVH process, the maintenance requirements are significantly greater. All of these factors lead to frequent changeout of equipment, higher unit operating costs, and a need to diverge from the "remote canyon" operating concept.

3.1.3 Process Control and Product Quality

The excellent mixing conditions inherent in the LFCM and the long mean residence time (approximately 40 plus hours) have been shown to provide a very reliable product quality. The natural relationship between uniform dispersion of constituents and durability has been known by the glass industry for many years. Research into the production of radioactive borosilicate glass has confirmed this relationship, as expected.

The long mean residence time in the LFCM process is a major factor that leads to consistently high quality. Long residence at the LFCM operating temperatures assures complete vitrification, high homogeneity, and thus a predictable product performance. Long residence also matches well with the unique neutralized alkaline waste common in the U.S. fuel cycle. Neutralized waste is filled with a host of precipitated products in the form of complex sludges. These compounds, combined with glass formers and frit, require considerable time "at temperature" to fully vitrify. The LFCM process minimizes any sludge residuals because of the high temperature and long residence. Early United States studies of processes similar to the French AVH system with short residence times revealed incomplete vitrification and a propensity towards devitrification.

The AVH process, designed for a homogeneous acidic solution feed, uses melter residence times of 4 to 8 h and approximately the same temperature range as the LFCM. For this type of waste (acidic solution), the French have demonstrated reasonable product performance. However, this information has not been disseminated in detail to interested U.S. scientists. Concerns exist regarding the methods used to evaluate the impact of the last material from the calciner that does not fully dissolve in the glass. Furthermore, very little technical data has been gathered by French researchers on calcination and vitrification of the unique neutralized (alkaline) slurries that constitute U.S. wastes. Consequently, this process could result in unacceptable product quality and would no doubt require many years of testing to provide data for U.S. wastes that would be comparable to the existing LFCM database.

3.1.4 Comparison of Overall Plant and Remote Equipment Design

Review of the general remote facility design concepts of foreign vitrification facilities shows some significant differences with the concepts currently used by HWVP. Key differences identified include: use of stacked and clustered cells, increased use of manipulators, more use of cells that can be sufficiently decontaminated to allow contact maintenance, more use of passive equipment that requires little or no maintenance, and increased location of active components requiring maintenance in contact-maintained areas in the foreign plants.

The HWVP facility design is based on the DWPF and closely follows the design principles used successfully in the reprocessing facilities at the Hanford Site and at the SRP. With this design, ceilings and floors are not common between cells (i.e., no cell stacking). The cells are arranged in two parallel rows with the floor of all cells at a near constant elevation. Material flow is generally up into and through a shielded area (canyon) above the cell complex. An exception is canister transfers that are made via transfer mechanisms in tunnels between cells. Fully remote replacement of nearly all in-cell equipment and piping is provided. Substantial flexibility is provided to revise piping configuration via jumper changes, allowing alternate operating modes and the ability to modify process flowsheet.

The French vitrification facilities are designed to minimize building square footage and maximize use of shielding walls and floors. This is accomplished by clustering and stacking the hot cells so that walls/floors can be used for both shielding and structural support. With this arrangement, material flow is both horizontal and vertical through the cell layers. The stacked cell configurations provide some improvement in structural loading efficiency and in use of shielding. Some reduction in the requirements for concrete for these purposes can therefore be expected. The typical stacked cell concept used in the French facilities replaces the open canyon used by HWVP with a number of specialized corridors for material movement. In some cases, the French plants use specialized maintenance cells dedicated to the maintenance and breakdown of failed equipment from a particular cell. A common failed equipment handling cell is used by HWVP for handling failed equipment from all cells serviced by the canyon. The French approach appears to result in a modest reduction in the overall building volume. However, the amount of concrete used in the Vitrification Building is about the same.

In the French plants, maintenance on remote equipment is performed with a variety of manipulators, special tooling, and various hoists and cranes. Where possible, standard off-the-shelf pipe and tubing connectors (modified as required) are used for the process and service connections. Where standard connectors cannot be used, special connecting devices and associated tooling are designed. The increased use of manipulators in the foreign facilities allows significantly more flexibility in equipment and cell design. This can be expected to result in simpler, less expensive equipment. However, this is achieved at the expense of adding the manipulators and their support systems (e.g., shield windows, control systems, maintenance features, and repair facilities).

A significant portion of the process equipment in the foreign plants is permanently installed and must be decontaminated prior to repair or replacement by direct contact. However, this disadvantage is partially offset by design concepts that require little maintenance on the contaminated portions. Frequently, piping is permanently installed and reduces flexibility. Significant savings in initial equipment-installed cost can be achieved by use of contact maintenance. Identification of the extent to which HWVP could use contact-maintained-equipment low/zero maintenance designs would require careful review and analysis.

3.1.4.1 Key Design Issues. Several key issues relating to equipment installation and maintenance are of primary importance in the evaluation of foreign concepts. In most cases, significant changes to the current HWVP design approach would be required to implement concepts used in foreign vitrification facilities. These issues are discussed below.

Remotely Replaceable Process Equipment

To satisfy both the as-low-as-reasonably-achievable (ALARA) requirement and plant attainment, the HWVP requires that nearly all process equipment and piping that has a projected life of less than 40 yr be replaceable by remote means. With French designs, a significant portion of the process equipment and piping is permanently installed with no provisions for remote maintenance or replacement. When the equipment fails, it must be decontaminated to an activity level that permits person entry to the cell. Thus, an important consideration in comparing foreign technology is the evaluation of alternate equipment and cell maintenance concepts. In general, equipment that is a candidate for contact maintenance must be either subject to only low levels of contamination, or it must have a low enough frequency or probability for failure that an extended time for decontamination prior to maintenance can be tolerated.

Remote Connectors

The HWVP processing systems are designed around remote piping and instrument/electrical connector technology that has been developed, standardized, and proven in practice at the Hanford Site reprocessing plants. For operation, these connectors require overhead access by both a crane and an impact wrench. Manipulators and robotics are not required for remote maintenance with this technology. Because of the extensive experience with this technology, and existence of standardized proven designs, new designs can be developed with a high degree of confidence, and development testing is not usually required. Foreign process systems do not use standardized connectors for the most part. For instance, if a connector is needed near the ceiling of a cell, a special connector and, if necessary, a manipulation device are designed, tested, and employed.

The process equipment and facility are designed around the remote maintenance technology. Use of alternate remote connectors must be considered in evaluation of alternate process technology because of the impact on equipment and cell design related to connector requirements. In general, equipment that is designed and optimized based on one remote technology will need significant redesign to be effectively used with a

different remote technology. Likewise, a facility designed around one technology is not likely to be optimized for a different technology. The result of these differences in remote technology is that acceptance of foreign equipment design frequently requires acceptance of the associated remote maintenance technology. Effective implementation also frequently requires a substantial change in facility configuration.

Process Flexibility

The current design for the HWVP CPC allows a significant amount of flexibility in the chemical processing operations. Through use of alternate jumper routings and wall-mounted rack piping connections, a large number of alternate process arrangements are possible. This process flexibility will be important if there are unexpected differences in feed composition, mission, or process chemistry compared to the design basis. The foreign facilities typically provide less flexibility. A detailed evaluation of the impact of foreign design concepts on process flexibility has not been made. This would need to be evaluated prior to any decision to use alternate design concepts.

3.1.4.2 Overall Assessment. At first glance, it appears that significant reduction in overall facility footprint could be achieved by adopting the foreign approach to facility design. However, it is not so apparent that a significant reduction in overall cost can be achieved. Important differences in feed composition, proximity to feed source and waste handling facilities, and other functional requirements complicate any comparison.

The foreign plants have a relatively high-concentration, acidic melter feed with a relatively low suspended solids content. This liquid can be pumped with simple pumps, jets, and airlifts and agitated with an air sparger. As a result, only minimal space is required above the tanks to service this equipment. In contrast, the HWVP must process neutralized feed slurries and use large mechanical pumps and agitators for slurry transfer and mixing. The severe service conditions related to handling these erosive and corrosive slurries requires that more components be remotely replaceable (including tanks and piping). If the foreign process designs were implemented, an acid digestion step could be added to the front end, or alternate equipment suitable for heavy slurry service could be used for feed preparation and handling. A feed concentration step (evaporator) must also be added to the front end of the process.

Because of its physical location, HWVP must provide significantly more facilities for feed and waste transfer, handling, and storage than the foreign facilities. About ~283,000 L (75,000 gal) of lag storage for feed slurry, and 454,000 L (~120,000 gal) of lag storage for radioactive liquid waste are required, together with four encased underground transfer lines. These scope differences must be factored into any cost comparisons with other projects.

3.1.5 Availability of Technology

The United States has been a prime developer of the LFCM technology and, as such, an active participant in foreign technology exchange programs.

These programs have been very successful. Countries like the FRG and Japan have quickly assimilated the technology and currently are engaged in their own independent development efforts. As a result of this open exchange, a wealth of information and data is now in the technical literature, with no less than three advanced national programs as active contributors. International workshops, symposiums, and temporary work assignment exchanges of technical personnel are commonplace. Consequently, LFCM design information, operating data, and technical details are readily available from multiple sources, including the other U.S. projects at Savannah River and West Valley.

In contrast to the situation for the LFCM process, the French technology has been closely held, and only limited technical details have been published. This remains true today. Although, active exchanges with the French have been pursued for years. For proprietary reasons, many technical and economic details of the AVM/AVH processes continue to be unavailable to U.S. workers.

3.2 EVALUATION OF PROCESS ALTERNATIVES FOR HANFORD WASTE VITRIFICATION PLANT

3.2.1 Technology Basis (Issues/Uncertainties)

The current plan for development of Applied Technology for the HWVP is based on adaptation of DWPF technology to the unique Hanford Site wastes for processing and vitrification. This dependence on the DWPF reduces the overall need for technology development and documentation that otherwise would be required to show that the process meets the Waste Acceptance Preliminary Specifications (WAPS). Utilization of the French rotary calciner and induction melter, in conjunction with other process equipment in the French facility, requires assessment of the impacts to various processing streams and the technology needed to support plant design, operation, and WFQ. Each of the areas where uncertainties exist regarding processability of different feeds, equipment performance, glass formulation, sampling, and means for meeting WAPS are discussed separately below.

3.2.1.1 Feed Processing. The caustic pretreated Hanford Site slurry feeds that have been concentrated and treated with formic acid to provide rheological properties needed for pump transfer will require extensive development work to determine conditions needed for processing in a rotary calciner. The processing characteristics of these feeds are vastly different from the acid solution feeds used by the French. Also, the HWVP slurries will contain additions of zeolite and diatomaceous earth from waste treatment, and the concentration of these constituents are expected to vary from batch to batch depending on the amount of waste treatment required.

The primary concern associated with the use of a rotary calciner for processing treated caustic slurry waste is the formation of mastic phases. These phases result as the waste is converted from a relatively dilute slurry to a solid. Parameters have been developed for handling the acid solutions, but more development and uncertainty exist for finding acceptable conditions for processing the caustic slurries. In addition, each of the specific HWVP waste types will require extensive development to ensure that no unexpected problems arise during production operation. The magnitude of the uncentainty

associated with the processing characteristics of the slurries in a rotary calciner leads to the conclusion that development work could take several years to prove feasibility in order to make a decision to proceed with the use of this technology. This delay in schedule would be extremely costly for the HWVP Project.

Another major concern with the AVH process is the time allowed for dissolution of the rotary calciner product in the glass. The close coupling of the rotary calciner with the induction furnace does not provide a means for isolating the calciner product and heating the glass pool for a period necessary to ensure complete dissolution of the dried calcine. Consequently, the last calciner product that enters the furnace has a very short residence time in the furnace before it is released to the canister. Although samples of glass taken for the canister tend to show that the AVH glass will pass the WAPS requirements, there is concern that these samples are not representative of the worst conditions. The current WAPS are based on the glass being processed in a LFCM that has been shown to process waste in a manner such that the glass pool is a well-stirred reactor, and there is a long residence time prior to pouring into a canister. The French process will invite questions from Technical Review Groups (TRG) regarding proof that the calcine product is uniformly dissolved in the glass. If this situation occurs, there is a high probability that a major modification to the equipment will be needed. One of the HWVP waste types (Neutralized Cladding Removal Waste) will form a calciner product of alumina and zirconia that is highly refractory and would not be expected to dissolve readily in the induction melting furnace. This result and the uncertainties associated with the other HWVP wastes could lead to severe difficulty in getting through the waste acceptance process if the LFCM is not used for vitrification.

The introduction of refractory zeolite and diatomaceous earth in variable amounts to the feed further complicates waste acceptance for a process where the residence time is of concern.

3.2.1.2 Offgas System Corrosion. The French process utilizes a dust scrubber constructed of titanium to cool the process offgas and collect the particulate for recycle to the calciner. During operation, the temperatures in this equipment are generally several hundred degrees centigrade and the flow of gas is limited to reduce the amount of particulate transport. The waste used by the French is a nitric acid solution, and it generally contains very low concentrations of chlorides. However, the wastes to be processed in the HWVP will contain substantial amounts of chlorides, as well as nitrates and nitrites. Formation of aqua regia (nitric-hydrochloric acid) in the French dust scrubber will result in corrosion of this equipment. The amount of corrosion will be significantly higher than encountered with the French wastes and, therefore, periodic frequent replacement of the equipment can be anticipated.

There is no material known that can be used for this application; therefore, the LFCM has circumvented the problem by use of offgas lines with film coolers to introduce high air flows to cool the gases and prevent condensation prior to the first stage of scrubbing. For the HWVP, the first stage of scrubbing is a submerged bed scrubber, which quenches the offgas and provides dilution to minimize corrosion.

There is no assurance that a solution can be found for modification of the offgas system that would allow the AVH process to be used for processing the HWVP wastes. The possibility exists that several years of testing and equipment modifications would be needed in order to find a solution to this problem.

3.2.1.3 **Waste Treatment.** Evaluation of the French processing scheme shows that additional slurry concentration and waste treatment would be needed to make the French facility comparable to the HWVP. With the AVH process, the condensate for the offgas system is routed to a high-activity waste tank and sent to the fuel reprocessing plant. The HWVP employs a treatment and recycle system for handling the transuranic (TRU) waste collected by the offgas system to reduce the contents of the waste stream from the plant to < 10nCi/g and remove most of the fission products for recycle to the melter feed. In order to accomplish this reduction, the waste is treated by contact with zeolite and subsequent filtration through a filter coated with diatomaceous earth. The zeolite and diatomaceous earth are combined with the spent frit in a waste recycle collection tank and sent to the slurry mix evaporator (SME) for combination with the concentrated waste slurry. The zeolite is a fine refractory powder that would be a component of the waste that is processed in the rotary calciner. The fine zeolite component would be expected to increase the amount of airborne particulate that is carried to the dust scrubber. There is no way to determine the extent of this carryover and the problems that could occur without further testing.

3.2.1.4 **Analytical Sampling and Process Control**

3.2.1.4.1 **Slurry Sampling.** The French have developed a sampling system for acid solution wastes that currently is being evaluated by the HWVP Project. This equipment is well designed for the intended purpose and can handle high-activity samples, but it has not been tested on slurries. From all indications, this equipment could be satisfactory for some HWVP analytical streams that do not contain a high solids content. Modifications to, or a combination of the French system with the existing slurry samplers, could be the most cost-effective approach for the HWVP. Uncertainties exist with the French equipment for handling slurries in the representativeness of the sample taken from the processing vessel, potential for plugging the sampler needle, design of the lines entering the sampler to accommodate the long distance from the tanks, performance of valves when slurry is present, and use of air lifts with slurries (alternate design available for HWVP). There is little doubt that extensive sampling tests would have to be conducted in addition to tests already planned for the DWPF Sampler System if the French equipment is used in the HWVP.

3.2.1.4.2 **Glass Sampling.** The need for four to five rotary calciner and induction furnace lines to provide the throughput of one LFCM introduces additional requirements for process sampling. Assuming feed concentration will be conducted using large scale equipment as planned for the HWVP, the only differences for an upgraded French facility would be in the sampling and process control required to show that the rotary calciner and induction melter are functioning properly. The blending of frit with slurry for feed

to the melter, together with the large glass pool in the LFCM and the long residence time, have been strong arguments to the regulatory agencies that minimal glass sampling is required. The number of glass samples for the LFCM process is currently being negotiated with the U.S. Nuclear Regulatory Commission (NRC) but there is a recent indication that one sample per canister may be required. This frequency of sampling is based to some extent on the feed homogeneity, residence time in the melter, continuous pouring to fill the canister, and the amount of variability that could occur from one canister to another.

The French have expressed confidence that no glass sampling is needed, based on the persuasion of their regulatory bodies not to include this requirement. In comparison to the LFCM, the above arguments do not apply for the French process because the glass frit for each batch is fed continuously to the induction melter for combination with a variable quantity of calciner product. Thus, both streams must be controlled, and variability of the glass product could occur from malfunction of the controllers or metering equipment. Some degree of variability is inherent because the amount of calciner product entering the melter will not be exactly the same for each batch. Numerous batches from the induction furnace would be required to fill the large HWVP canister. The sampling requirement for a plant constructed in this country would be dependent on negotiations with the NRC; however, if the same criteria is applied to the AVH process as has been indicated for the LFCM, as much as one sample per induction melter batch could be necessary. A several fold expansion in hot cell space used for analysis of the glass samples to conduct glass analyses, durability testing, and provide archiving could be needed. Much more record keeping also would be required.

The extent of the glass sampling needed for the AVH process introduces additional uncertainty regarding the ability to meet the 95/95 requirement* for mass balance modeling and durability. The potential for samples to be more variable in the AVH process would reduce the glass composition envelope available for processing and add restrictions that would not be imposed if the LFCM were used. In any case, there is little doubt that more analytical samples will be required and the impact of these samples on the analytical laboratory size, delays in obtaining data, product variability, certification, and record keeping would have to be considered.

3.2.1.5 Canister Welding, Decontamination, and Smearing. The equipment used by the French has been designed for handling a small canister, approximately .3 m (~1 ft) diameter by 1 m (~4 ft) in length. This equipment would require redesign to handle the large HWVP canister. Scale-up of this equipment is not expected to be a problem, but testing would be needed to verify operability. Maintenance of the French equipment is linked to the existing equipment size and placement within the nested cells. Redesign of the facility and equipment could introduce additional requirements for maintenance testing.

*The 95/95 requirement mandates that HWVP will produce glass waste for which there is 95 percent confidence that 95 percent of the product meets the WAPS.

3.2.1.6 Waste Form Qualification

3.2.1.6.1 Waste Compliance Plan and Waste Qualification Report Documentation. The HWVP Applied Technology Plan in support of the needed documentation for product acceptance, the Waste Compliance Plan (WCP) and the Waste Qualification Report (WQR), is based on utilization of DWPF information on these subjects. Some of the data referenced by the DWPF will have to be revised for the specific HWVP wastes, but a major part of the above documents will be applicable without modification. If the AVH process is used for the HWVP, the entire WCP and WQR will have to be rewritten. A new strategy for waste compliance will have to be developed for mass balance and other models discussed in these documents. If appropriate testing is not available from the French using the quality assurance (QA) level necessary for the specific application, then these tests would have to be repeated. Auditing of tests performed in the United States for information used in the WQR is not expected to be a problem from one DOE site to another. However, the use of data obtained in a foreign country presents difficult logistics and political problems with regard to auditing that would have to be worked out in any agreement with the French.

Alternatively, all information used in the WQR would have to be generated by testing in this country with an anticipated substantial cost increase to the HWVP Project.

3.2.1.6.2 Radioactive Process Testing. Current plans for radioactive process testing involve onsite shipment of actual dilute pretreated waste to shielded facilities containing bench-scale process equipment for feed concentration and vitrification in a 1/50th-scale LFCM. Testing of radioactive pretreated waste using the French rotary calciner and induction melter will be more challenging due to problems with scale-down of this equipment and difficulties in determining equipment operating parameters for processing. The overall impact of changing to the AVH technology would take considerable effort to evaluate and require further information from the French. Additional shipments of radioactive waste to the shielded facilities and use of equipment for testing that is in the neighborhood of 1/5- to-1/4 scale can be anticipated.

3.2.1.6.3 Radioactive Product Testing. Due to the questions that are expected to arise regarding residence time for dissolution of the calciner product in the glass frit, additional work would be anticipated in radioactive glass testing. Tests would focus on evaluation of the uniformity of the radioactive glass taken at different times throughout melter pouring. Formation of undissolved phases in the glass would require extensive assessment to verify there is no impact to WFQ.

3.2.2 Incremental Development Cost Increase

The applied technology required for utilization of the AVH process in the United States has been estimated based on an incremental increase over the current Applied Technology Plan submitted to the DOE. Definition of the technology development needed to support operation of an SETF and provide

specific data for the WCP and WQR is based on the assumption that tests can be performed in France to the required QA level using existing rotary calciner and induction melting equipment. Additional equipment would have to be installed in the French facilities for simulant slurry preparation and feed concentration. Development testing would be conducted using test plans similar to work performed by the PNL for Westinghouse Hanford.

Rough order of magnitude incremental costs are shown for each of the areas discussed in Table 3-1. A total incremental cost increase of $54 million is projected for development testing if a decision is made to replace the LFCM with the French rotary calciner and induction melter. A decision of this magnitude could not be made until sufficient feasibility testing had been completed to demonstrate that the French equipment was compatible with the HWVP slurry wastes and the process would meet U.S. standards for WFQ. The incremental cost of feasibility testing using concentrated slurries is about $6 million. Efforts to minimize schedule impacts would necessitate expenditure of additional funds for support of other activities during the time the work on feasibility testing is in progress. Therefore, the majority of the $54 million costs would be incurred before data are available to determine whether the process is acceptable for slurry vitrification.

Current LFCM technology has been demonstrated and considerable testing has been completed by the Savannah River Site, West Valley Nuclear Services, and Westinghouse Hanford through PNL to provide information for most of the HWVP design. There are no assurances that the AVH technology will be applicable, and the issues discussed above may not be easily resolved. Since the French have no experience with processing dilute caustic slurries, implementation would require combination of the French and U.S. technologies to provide a plant that is capable of handling the Hanford Site wastes.

3.2.3 Schedule Impacts

A conservative estimate of the delay to the HWVP Project of approximately 3 yr could be anticipated if efforts are made to incorporate the AVH technology into a plant for processing HWVP slurry wastes. Design of the slurry processing equipment developed in the United States could be made available to the French for procurement and installation at their facilities. A prototypic slurry sampler would have to be designed by the French and tested to demonstrate capability. If difficulties were encountered during this phase of the testing, then additional time delays could occur.

Consideration of the time required to obtain a prototypic slurry feed preparation system, conduct preliminary testing, and evaluate the test data to verify tank sampling capability indicates that this work cannot be accomplished in a period shorter than about 4 yr. Feasibility data to evaluate the performance of the rotary calciner and induction melter using concentrated slurries could be obtained in about 2 yr, assuming equipment is available for testing and no difficulties arise during negotiations with the French. As indicated above, the feasibility data are needed before a decision can be made to proceed with further testing. A 1-yr allowance for data evaluation and additional information accounts for the estimated 3 yr to a decision point.

Table 3-1. Incremental Development Costs for Adopting the French Process.

Activity	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	Total
Contract negotiations/travel	250	250	250	250	250	250	250	250	250	250	2,500
Feed processing											
Feasibility testing		2,000	2,000	2,000							6,000
Equipment procurement		3,000	1,000								4,000
Offgas system corrosion		1,000	1,000	1,000							3,000
Waste treatment		500	500								1,000
Analytical sampling		1,500	1,000								2,500
Canister processing		2,000	2,000	2,000							6,000
Waste form qualification											
WCP and WQR documentation		1,000	1,000	1,000	1,000	2,000	2,000	2,000	1,000	1,000	12,000
Radioactive process testing		2,000	3,000	2,000	2,000						9,000
Radioactive product testing			2,000	2,000	2,000	2,000					8,000
Total	250	13,250	13,750	10,250	5,250	4,250	2,250	2,250	1,250	1,250	54,000

WCP = Waste Compliance Plan
WQR = Waste Qualification Report

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Table 3-1. Incremental Development Costs for Adopting the French Process.

3.3 EVALUATION OF PLANT ALTERNATIVES FOR HANFORD WASTE VITRIFICATION PLANT

3.3.1 Comparison of Plant Capital Costs

The AVH systems, as implemented in Europe, appear to have lower capital costs than the canyon LFCM systems in the United States. However, the conclusion of a cost evaluation study by Slate et al. (1982) was that when they are examined on the same basis (i.e., U.S. regulations for construction and operating requirements, as well as for product quality; utilization of the canyon concept; union agreements, etc.) the capital costs are essentially equal. For example, the capital cost associated with the recently completed French facility at La Hague has been published as $565 million, at the given rate of exchange. (It should be noted that exchange rates fluctuate; in recent years, the United States-French exchange rate has varied by more than 20 percent, at the expense of the U.S. dollar!). Those figures, escalated to the midpoint of construction (with additions for U.S. regulatory and process requirements, along with a modest contingency) result in a forecasted completion cost exceeding the current estimate for the HWVP (i.e., $965 million). Seemingly lower European operating costs for the AVH vitrification plant are attributable to organizational and accounting differences and not to the specific technology used.

For this discussion, the $965 million cost estimate for the HWVP is compared with the French vitrification plant at La Hague. The cost of the La Hague plant was given to the DOE as a verbal estimate of $560 million.

To put this into perspective, the HWVP cost is for a 1999 startup and contains escalation and contingency, while the La Hague plant is for a 1988 startup. To normalize the costs, an estimation was made to build the La Hague plant at the Hanford Site with costs adjusted for currency exchange, escalation to the HWVP construction schedule, plant scope, labor rates, labor productivity factors, and plant capacity. These comparisons are summarized in Tables 3-2 and 3-3.

The HWVP preliminary design costs are used in this comparison. For the La Hague facility, the RLST, waste handling tank, SETF, feed concentration/liquid waste handling equipment, and cell volume increases to accommodate the large canister and tankage were the only scope items added. Project management and engineering labor rates also were factored by 50 percent. The base cost number in Table 3-3 includes all Zone-1 filtration, fan houses, stacks, switch gears, generators, canister storage, canister loadout, service building, support building, and manipulator. All cost elements in the base number have been factored for escalation, labor rates, and productivity.

It is evident that there is essentially no difference in the cost of the HWVP and the La Hague vitrification plant after cost normalization. La Hague is estimated to cost $1,050 million if built at the Hanford Site versus the $965 million estimated cost for the HWVP. Additional costs for a French vitrification plant built at the Hanford Site must include a requalification of the product to meet WFQ requirements (Figure 3-1) and a complete redo of the WFQ process with the NRC. The up-front advantages would

Table 3-2. Normalized Plant Cost ($M).

Element	HWVP	La Hague
Base estimate	932.5	560.0
Systems Evaluation and Test Facility	32.4	32.4
HWVP features required of AVH facility		
Receipt and lag storage tank/waste holding tank	NA	20.8
Feed concentration/liquid waste handling	NA	38.4
Cell volume increment to accommodate U.S. canister size and feed concentration tankage (est.)	NA	10.0
Adjustments*	NA	388.4
Total	965.0	1,050.0

*Cost adjustment for escalation (HWVP schedule), labor rate differences, contingency, productivity differences, and U.S. requirements (e.g., capacity) – see Table 3-3.

HWVP = Hanford Waste Vitrification Plant

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Table 3-2. Normalized Plant Cost ($M).

Table 3-3. Plant Cost Adjustment Factors.

Factor	HWVP	La Hague
Currency exchange	$1.00	6.072[a] (Francs)
Average construction labor rate	26,84/h	13.54/h[b]
Construction labor productivity (multiplier)	1	0.85[c]
Project management and engineering labor factor	1	1.5[d]
Escalation factor	1	1.35[e]
Building scale cost factor	1	1

[a]June 5, 1987, Wall Street Journal.

[b]Letter reports - Widnell and Trollope USA, Incorporated, June 1987.

[c]Report, "International Composite Cost Location Factors," R. V. Messa, CCE, 1984, AACE Transactions (used average).

[d]Based on input from European engineers/managers.

[e]Fluor Daniel, Inc. Preliminary Design estimate.

HWVP = Hanford Waste Vitrification Plant

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Table 3-3. Plant Cost Adjustment Factors.

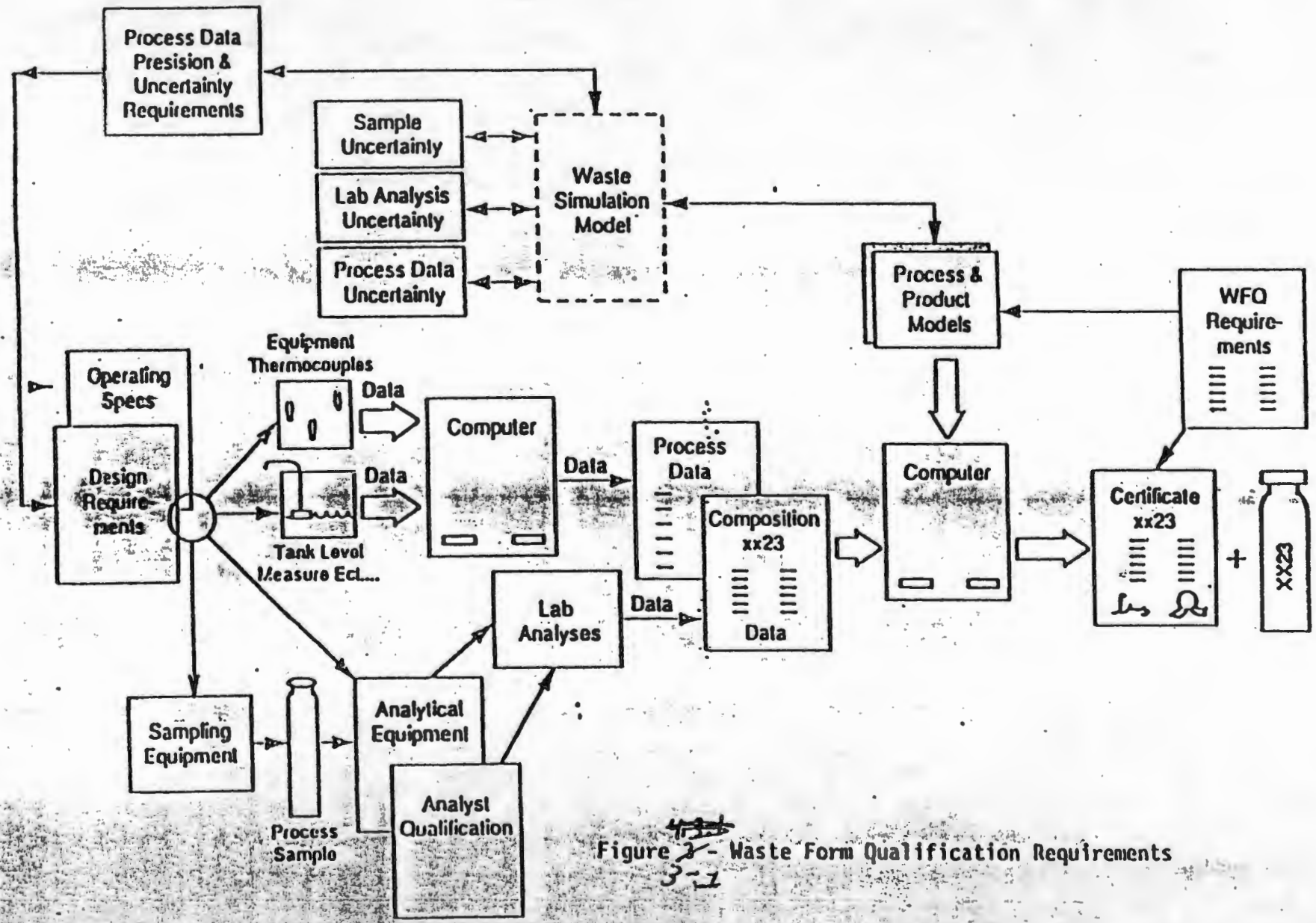

Figure ~~2~~ 3-1 - Waste Form Qualification Requirements

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Figure 3-1. Waste Form Qualification Requirements.

have to be sufficiently obvious to warrant changing from an accepted (worldwide) process to a more expensive process that must be completely qualified through extensive analysis and testing programs.

3.3.2 Reliability of Comparative Cost Estimates

The very limited cost data on the La Hague plant in France makes it very difficult to do a comprehensive cost evaluation between the two plants. The technical differences in processing and remote material handling technology between the HWVP and the La Hague plant would require a significant redesign of the French vitrification process to fulfill the HWVP process and mission.

To perform a comprehensive cost comparison, a very detailed cost estimate on the La Hague plant is required. This would require several months of preparation and evaluation.

The following key issues must also be evaluated if the French process is to be used at the Hanford Site.

- The physical construction work would be performed by U.S. (national) union craftsmen. The unit construction rates for nuclear quality work would correspond to those unit rates currently listed in the HWVP estimate. This accounts for about 75 percent of the total Project cost estimate.

- The Project would sustain a 3-3.5 yr minimum schedule slip to comply with DOE Order 4700.1's, "Project Management System," (DOE 1987) budget cycle funding schedule (this schedule slippage is discussed in Section 3.4).

- The fixed-price turn-key contracting of new Technology on projects requiring compliance with the ever-changing environmental and NRC regulatory requirements makes it virtually impossible to impose fixed-price turn-key contracting methods on a project of this nature. Several examples of this type of contract, which is subject to change, can be seen with the General Electric and Westinghouse Hanford early turn-key contracts for nuclear power plants and also the Washington Public Power Supply System contract problems.

- The French verbal quotation of $560 million is a figure that is assumed to not include contingency or escalation. The normalization of the HWVP estimate with the French plant resulted in the cost comparison shown in Table 3-2.

- The European technology utilizes a canister only 1 m (4 ft) high and 45 cm (18 in.) in diameter; the U.S. technology utilizes a canister 3 m (10 ft) high and 61 cm (24 in.) in diameter. The remote-handling technology of handling the larger and considerably heavier U.S. canisters would need to be developed for an AVH facility.

A rough cost comparison was presented above by attempting to adjust available plant cost data to a comparable basis. This comparison showed that the La Hague plant in France adjusted to the HWVP scope would cost 9 percent more. While these cost estimates provide an indication of the potential comparative costs, they are based on a number of assumptions and a relatively limited analysis. A major study would be required to:

- Develop an alternate facility concept with a reasonable level of assurance that it would meet minimum HWVP requirements,
- Develop a facility cost comparison with a level of confidence that would support a decision to either change to the alternate concept or retain the existing concept.

It is difficult to predict whether a detailed evaluation would show the potential for cost savings. In order to maximize the potential for cost savings, this evaluation would need to examine equipment and facility concepts for major processing areas to evaluate acceptability of alternate U.S. and foreign concepts and to select the most cost-effective concept for each process step or processing area. The selected concepts would then be combined and developed into an overall revised facility concept. A study level cost estimate for the alternate facility concept could then be prepared using the same or similar cost factors as used for the HWVP baseline estimate. This would produce a reliable estimate that is not significantly biased by differences in cost estimating method for the alternates being compared. To perform such a study would require 6- to- 12- plus months, depending on the availability of knowledgeable technical staff and supporting data.

In summary, the conclusion reached by this review is that the foreign vitrification plants may provide some cost savings compared to the baseline HWVP design. The savings, if any, do not appear likely to be a large percentage of the total. However, due to the large number of variables and the complexity of the design issues, a valid cost comparison would truly require a major engineering study.

3.3.3 Comparison of Regulatory Requirements

Possibly the greatest difference between HWVP and foreign plant chemical processing functions is gaseous and liquid effluent handling. Space allocations indicate that HWVP Vitrification Building volumes for effluent treatment are five times greater than La Hague. All stack emission standards for those plants are very close to that of the HWVP. Allowable stack emissions standards do not appear to be the cause of differences between plants. However, standards for liquid waste transferred to other onsite facilities do seem to be significantly different.

At the La Hague plant, vitrification cell air is first independently filtered and then mixed with the building Zone I (highest contamination potential) air. Zone I air passes through a series of redundant HEPA filters before release through the stack. Melter offgas undergoes extensive treatment processes at all plants before mixing with Zone I air. The foreign plants use HEPAs in series for the final filtration step; the HWVP uses a sand filter.

The primary difference in the gaseous effluent treatment system is that the HWVP uses a backup melter offgas system and a sand filter for final filtration. This is not a result of emissions standards but rather of design preferences and conservatism.

There is a significant difference in how the various plants handle liquid effluents created by vitrification. The La Hague plant recycles the high-level active liquid wastes back to the calciner feed tank for direct processing into the melter. Low-level wastes from the French plant are returned to the onsite reprocessing plant. The HWVP criteria require treatment of liquids leaving the facility to reduce TRU and fission product content.

The HWVP approach to, and requirements for, effluent treatment have resulted in design features that are different from the foreign facilities. In addition to a backup melter offgas system and sand filter, the HWVP has a liquid waste treatment system that includes five in-cell tanks and a ~380,000 L (100,000 gal) waste holding tank. These differences are also reflected in the Vitrification Building space allocations.

The HWVP also is required to meet a number of procedural or documentation requirements related to safety and environmental regulations. The HWVP will be permitted as a hazardous waste treatment and storage facility under the Resource Conservation and Recovery Act (RCRA) and require an air quality permit. A major change in the plant and process design would require revision and resubmission of these permit applications. A portion of the existing application could likely be used, however, substantial revision would be required and could only be prepared after the basic process and facility design concepts had been determined. An approved preliminary safety analysis report (PSAR) is also required prior to start of construction. With major design changes, the PSAR would have to be substantially revised once sufficient design detail became available.

3.4 OVERALL PLANT AND TECHNOLOGY COST/ SCHEDULE IMPLICATIONS

Figure 3-2 shows the required budget cycle for line item projects that would be followed for acquisition and implementation of alternative technology for the HWVP. The required process by which line item projects are attained will not permit easy substitution by AVH technology for the already started HWVP that has previously adopted the LFCM technology.

Current plans are for the HWVP to begin detailed design in early CY 1990. An outline for a schedule scenario is presented in Figure 3-3 and below, illustrating schedule impacts if use of alternative technology for the process and facility are to be implemented. The schedule shown indicates an approximate 3 yr delay in the start of detailed design. It may be possible to make up some of this slippage during design and construction, however, some delay in the scheduled date for hot startup would appear to be almost certain.

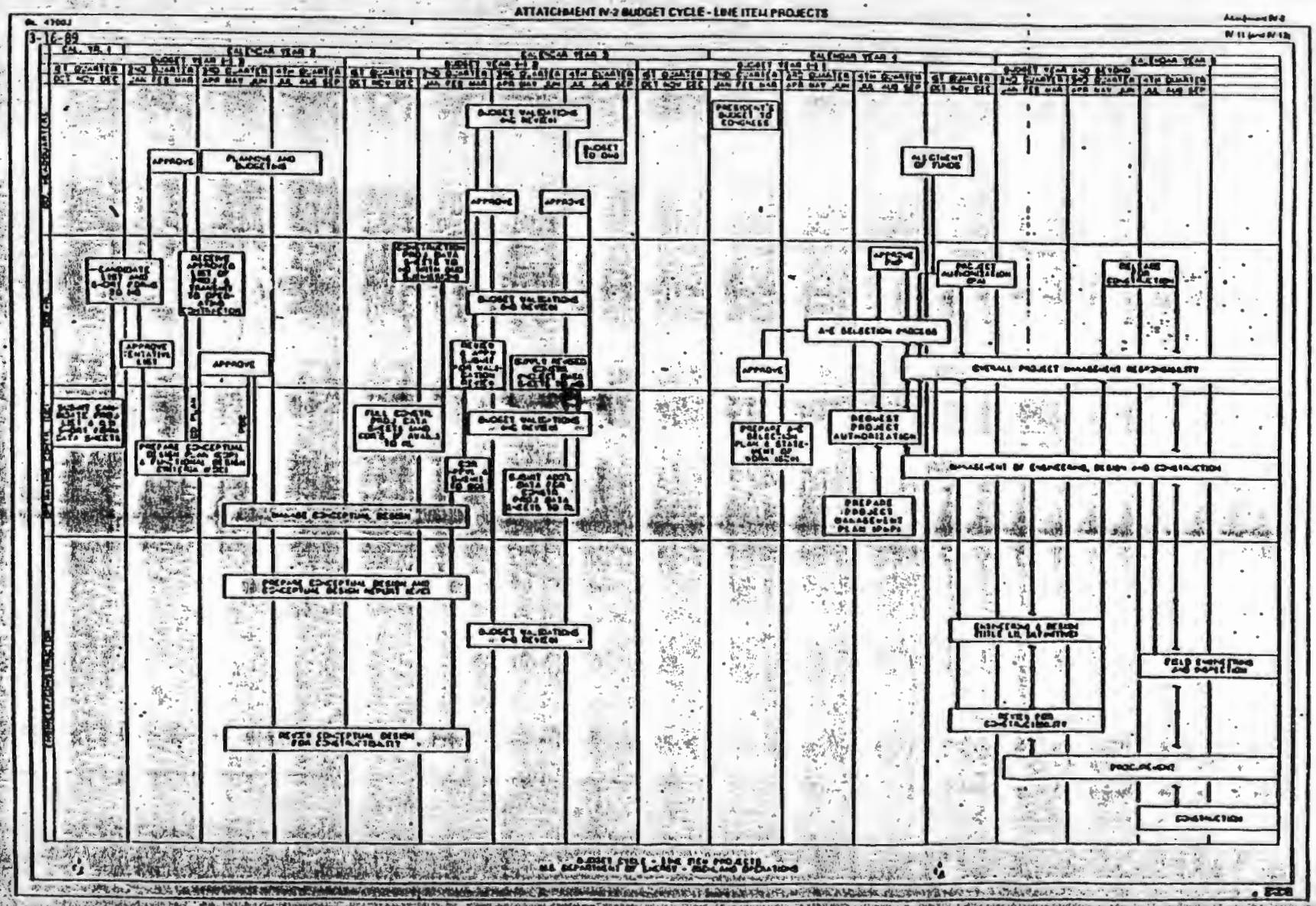

FIGURE 4.4.1 REQUIRED BUDGET CYCLE FOR LINE ITEM PROJECTS AT HANFORD.

Figure 3-2. Required Budget Cycle for Line Item Project at Hanford.

F.S. 4.4.2

Hanford Waste Vitrification Plant Alternatives Feasibility Study

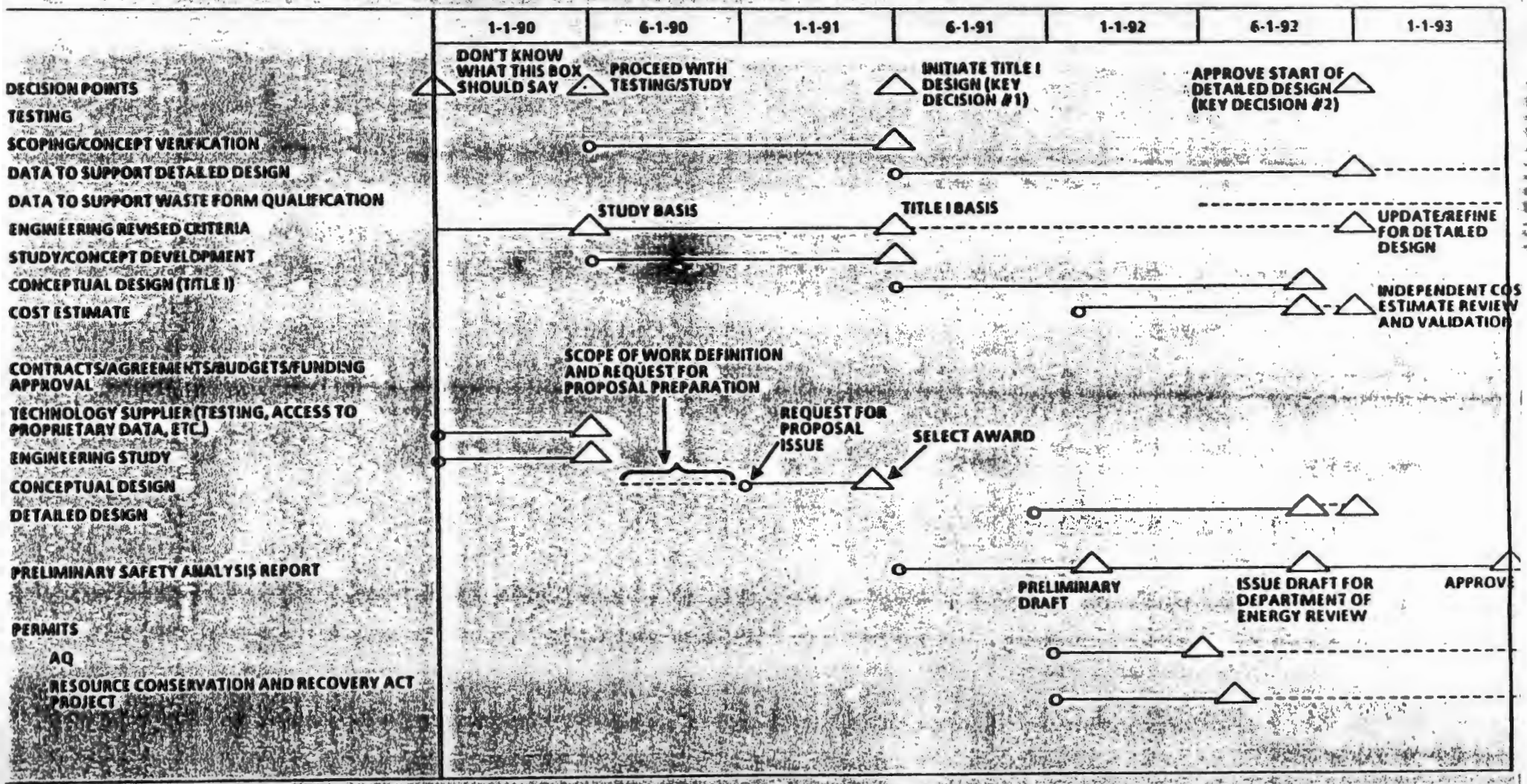

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Figure 3-3. Hanford Waste Vitrification Plant Alternative Feasibility Study.

BASIC SCHEDULE PLANS

(IF THE ALTERNATIVE AVH TECHNOLOGY IS TO BE EVALUATED AS A VIABLE CONCEPT FOR THE HWVP)

<u>January 1, 1990 - July 1, 1990</u>

- Assumes a decision is made about January 1, 1990 to aggressively pursue alternative design concepts

Primary tasks/emphasis:

- Negotiate agreement with technology supplier for exchange of proprietary technical information
- Negotiate agreement with technology supplier for performing testing, define scope and conditions
- Define scope and negotiate agreements, budget, etc. for organizations participating in engineering study
- Develop/define principal criteria to be used a basis for study

Key decision point: July 1, 1990

- Proceed with testing and concept development study
- Proceed with other supporting work

<u>July 1, 1990 - July 1, 1991</u>

Process and facility concept development and initial verification testing

Key task/emphasis:

<u>Testing</u>

- Perform initial scoping tests to verify suitability of process
- Perform tests required to finalize flowsheets

<u>Agreements/Budgets/Funding/Approvals</u>

- Develop performance data, etc., as required to support detailed design
- Define scope of work for detailed design
- Begin initial WFQ testing and establish WFQ strategy
- Define scope of work for construction management

Engineering

- Develop detailed criteria to form basis for Title I design
- Perform engineering study to develop process and facility design concepts; prepare study level cost estimate comparison

Contracts/Agreements/Budgets/Funding

- Define scope of work for Title I design, prepare and issue request for proposal
- Define scope for other project support activities (PSAR, requirements, additional testing)

July 1, 1991 - January 1, 1993

Key activities:

Testing

- Testing to provide performance data needed to support detailed design
- Definition of WFQ strategy and initial testing to support WFQ

Engineering

- Refine and update criteria to support detailed design
- Perform conceptual design (Title I)
- Prepare cost estimate, Independent Cost Estimate (ICE), and validation

Safety/Environmental

- Prepare air quality permit application
- Prepare RCRA part B permit application
- Prepare draft PSAR, submit to DOE for review

Agreements/Budgets/Funding/Approvals

- Define scope of work for detailed design
- Issue request for proposal (RFP) for detailed design
- Define scope of work for construction management

- Issue RFP for construction management
- Approval to begin detailed design (Title II), to occur on approximately January 1, 1993

Evaluation of the development costs and time required to adapt the French technology to processing and vitrification of the Hanford Site wastes indicates there will be an incremental cost increase of approximately $54 million and a schedule delay of about 3 yr to the HWVP Project. The cost increase is associated with process feasibility testing, design and testing of new equipment, resolution of issues concerning glass quality, radioactive testing, and WFQ documentation.

Comparison of plant costs that take into consideration the redesign of the French facility to handle the large U.S. canister, concentrate the waste, and provide waste treatment required for the Hanford Site shows that costs for the HWVP Project will be incrementally increased by approximately $85 million. This increase also takes into consideration costs for Project management and engineering and the installation of SETF for WFQ testing and personnel training. Delay of the HWVP Project schedule of about 3 yr would occur due to additional time required for conceptual design, cost verification, and permitting.

Combination of technology and facility cost and schedule information results in an incremental cost increase of $139 million to the HWVP Project and a high probability of a schedule delay of 3 yr. Additional escalation costs for this delay were not considered, but one can safely state that the overall cost increase will be in the neighborhood of $150 million. Based on this analysis, the current HWVP design is superior for processing the type of wastes in storage at the Hanford Site. Investments in development of technology at the SRP and at the WVDP has been utilized by the HWVP Project to reduce overall costs. Considering the magnitude of the additional cost, the Project schedule delay, and uncertainties involved with changes to the AVH technology, there does not appear to be any incentive to contemplate further interaction with the French. Any change in direction for the HWVP Project at this time will have a significant impact on the cost and lead to schedule delays.

3.5 HWVP PLANS FOR THE USE OF SELECTED FOREIGN TECHNOLOGY FEATURES AND PERTINENT EXPERIENCE

As appropriate, the HWVP plans to make use of selected foreign technology features and pertinent experience. Current plans for doing this are outlined below.

3.5.1 Ongoing Foreign Technology Evaluation by Hanford Waste Vitrification Plant

The HWVP is seriously considering use of foreign technology in several areas. The three areas currently under consideration are: power fluidics, canister closure (welder), process sampling, and glass formulation data base.

3.5.1.1 Power Fluidics. Power fluidics has been used extensively in the United Kingdom's WVP. A decision recently has been made to use this technology in a selected application in the HWVP. The application selected is for agitating and pumping of feed from the RLST. This equipment is considered to have essentially zero maintenance for the contaminated portion of the system that is housed in the RLST vessel. Therefore, this technology is of interest where advantage can be taken of the zero maintenance features in the design. The location and final design concept for the tanks is currently under evaluation. The use of power fluidics has provided enhanced design flexibility that would have otherwise increased the cost and expanded the footprint of the HWVP.

3.5.1.2 Canister Closure. The current baseline design for the HWVP canister closure is an interim closure plug (mechanical seal) installed prior to decontamination, followed by final closure plug welded in place with a resistance upset welder. This is essentially the same system used by the DWPF. Because of the high cost and large space requirements for the baseline system, the HWVP is investigating alternate canister closure techniques. Welding techniques under consideration are the gas tungsten arc weld (GTAW) that has been developed by the FRG, Japan, and at PNL, and the plasma arc (employed by the French). There appears to be a very good probability that an alternate canister closure concept will be selected for HWVP.

3.5.1.3 Process Sampling. The HWVP baseline design for obtaining liquid process samples utilizes manipulator operated sample cells for filling sample bottles. The foreign vitrification projects use automated samplers that may provide lower installed cost, reduced space requirements, and lower operating costs. Initial review of these sampling systems indicates that they are probably suitable for obtaining a large fraction of the HWVP process samples. However, the ability of these systems to obtain representative samples from the heavy slurries present in HWVP is questionable. The heavy slurry samples are the most critical for verifying compliance with waste form qualification requirements. At a minimum, a significant amount of testing would be required to verify suitability of these systems for the heavy slurry samples.

Some additional evaluation of the foreign sampling systems is continuing. However, implementation of these designs into HWVP is not considered likely because of: (1) the need for testing and possibly development work, (2) the current schedule constraints, and (3) the relatively modest cost savings expected from implementing these systems.

3.5.1.4 Glass Technology. A considerable data base on glass properties as a function of composition has been developed by the FRG, French, and UK. These data are of interest to the HWVP Project, and plans are being made to conduct further discussions in this area. Specific topics of interest are:

- Fault tree analysis
- Process and product models
- Glass product sensitivity analyses

- Glass cracking data and correlations to process conditions
- Laboratory methods for surface , precipitate, and phase examination

The French have prepared a fault tree analysis of their process that provides systematic methodology for examining various factors that can influence the product quality and plant operations. This approach may be beneficial for evaluation of the HWVP operational scheme, and it will be further examined for applicability to the WQR and readiness review.

Modeling conducted by foreign countries is somewhat different than in the United States, but further assessment of available foreign information seems warranted to provide the broadest possible base for specific models to be used for the HWVP.

Sensitivity of glasses of various compositions to leaching has been developed by all countries and at other U.S. sites. Formation of a data base for the HWVP will take into consideration a much broader range of glass compositions due to the wide gamut of the Hanford Site wastes to be processed. Use of foreign data should be highly beneficial since U.S. data generally is confined to a much smaller range of glasses.

Correlation of glass cracking with process conditions has been studied in the United States, but additional information is available from foreign countries and should be evaluated to avoid any possibility of overlooking data that could be of interest. Discussions of this subject with the foreign countries is planned.

There has been extensive evaluation of glass properties by the French, which needs to be assessed further for application to the HWVP glasses. Data are available for many properties normally not evaluated in the United States. Methods have been developed for measuring these properties on borosilicate glasses; the French data and methods may be of interest for certain glasses. Considerable effort has been expended for measuring precipitate phases in the glass, and these techniques are also of interest for comparison to standard United States evaluation methods.

3.5.2 Use of Pertinent Foreign Experience by Hanford Waste Vitrification Plant

The HWVP intends to make use of pertinent foreign experience in the handling, pretreatment, and vitrification of HLW, the decontamination and storage of glass-filled canisters, and product acceptance. As appropriate, foreign experts will be asked to serve as reviewers and consultants to the HWVP in the development of technology and the waste acceptance process.

4.0 SUMMARY AND CONCLUSIONS

If a U.S. vitrification project was to adopt the AVH technology at this time, large costs would be incurred to adapt the plant to U.S. requirements and generate the data needed to qualify the product. Processing of U.S. neutralized alkaline wastes by the AVH method would require the building of a prototypic AVH type of research and test facility in this country. Its purpose would be to study the large variety of waste types, ascertain process chemistry control parameters, embark on repository-driven waste qualification work, and verify equipment operation, remotized replacement and maintenance. Certainly, this would be no small task; the cost would be enormous, and it can be expected that the schedule impacts would be prohibitive. Estimated delays range up to 10 yr for full certification of the systems and processes.

Preliminary evaluations indicate that large savings in plant construction cost are not likely. Development of a reliable cost comparison would require a major engineering study.

In view of the specific considerations required for the management and disposal of HLW in the United States, as noted earlier, and given the state of maturity and acceptance of the LFCM technology as it existed in the early 1980's, it was then apparent to the decision-makers that this technology would best meet the needs of the U.S. Waste Management Program and should remain the DOE choice for vitrification. And, with regard to current considerations of alternative technology for the HWVP, this conclusion is still valid.

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6.0 ACRONYMS

A/E	architect engineer
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
CDMC	contact decontamination and maintenance cell
CMA	crane maintenance area
CPAF	cost-plus-award fee
CPC	chemical process cell
DCS	Distributed Control System
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOE-RL	U.S. Department of Energy-Richland Operations Office
DOE-SR	U.S. Department of Energy-Savannah River Operations Office
DWPF	Defense Waste Processing Facility
GTAW	gas tungsten arc weld
HEME	high-efficiency mist eliminator
HEPA	high-efficiency particulate air
HLW	high-level radioactive waste
HWVP	Hanford Waste Vitrification Plant
ICE	Independent Cost Estimate (Committee)
KEH	Kaiser Engineers Hanford Company
KfK	Kernforschungszentrum Karlsruhe GmbH (Karlsruhe Nuclear Research Center)
LFCM	liquid-fed ceramic melter
MTO	material take-off
NRC	U.S. Nuclear Regulatory Commission
PSAR	Preliminary Safety Analysis Report
PUREX	plutonium/uranium extraction
PWBS	project work breakdown structure
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
REDC	remote equipment decontamination cell
RFP	request for proposal
RLST	receipt and lag storage tank
SETF	Systems Evaluation and Test Facility
SME	slurry mix evaporator
SRP	Savannah River Plant
TEC	total estimated cost
TRG	Technical Review Group
TRU	transuranic
WAPS	Waste Acceptance Preliminary Specifications
WCP	Waste Compliance Plan
WFQ	waste form qualification
WQR	Waste Qualification Report
WVDP	West Valley Demonstration Project
WVP	Windscale Vitrification Plant (U.K.)

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APPENDIX

HANFORD WASTE VITRIFICATION PLANT PRELIMINARY DESIGN COST ESTIMATE BASIS

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APPENDIX

HANFORD WASTE VITRIFICATION PLANT PRELIMINARY DESIGN COST ESTIMATE BASIS

The Hanford Waste Vitrification Plant (HWVP) Preliminary Design Cost Estimate is based on considerations indicated in the four sections below.

A.1 ESTIMATE CRITERIA

This section of the Estimate Basis defines the criteria, assumptions, and methodology used in the development of the HWVP Project Cost Estimate prepared during Preliminary Design, and it is structured according to the major estimate subtotals:

- Direct costs
- Indirect costs (engineering, design and inspection, general contractor, and Project management)
- Escalation
- Contingency.

A.1.1 Direct Costs

The direct costs of the facility are defined as the following capital costs, which are estimated to be expended in the construction of the permanent plant facility.

- Direct labor
- Contractor's construction equipment
- Contractor-furnished equipment and material
- Government-furnished equipment (GFE) and material
- Sales tax
- Contractor's overhead, profit, bond, and insurance
- Business and occupation (B&O) tax
- Construction manager's general and administrative expense (G&A).

A-1.1.1 General Criteria

The following general criteria were adopted for use in the preparation of the HWVP Project Cost Estimate.

A. All direct costs are expressed in first quarter fiscal year (FY) 1990 dollars.

B. The estimate assumes all construction is by fixed price or cost plus contracting as defined by the site acquisition plan work package definitions.

C. It is assumed that a 40 h standard work week will be established at the site for all construction accounts except concrete. The concrete unit rates of installation will provide for overtime encountered during pouring.

D. Craft labor rates (journeyman) used are in accordance with the Hanford Site Stabilization Agreement (Hanford ____) (fixed-price labor rates, 200 East Area). The labor rates include all applicable union fringe benefits and state and federal legislated benefits and burdens.

E. Crew rates are developed for each Construction Standards Institute (CSI) division and subordinate element of work by mixing the applicable craft and construction equipment rates.

F. In general, all equipment, machinery, and bulk materials will be domestically purchased.

G. All engineered machinery and equipment pricing is obtained by engineering specialists from informal vendor quotes and in-house cost data. Prices include freight to job site.

H. Bulk material pricing is obtained by the estimators using vendor phone quotes and current in-house material pricing data. Prices include freight to job site.

I. Temporary facilities are estimated based on the following criteria.

- Office space is provided for construction engineering/inspection, construction management, project management, and U.S. Department of Energy (DOE) personnel based on estimated staffing requirements for the offsite architect engineer (A/E), onsite engineer-constructor, operating contractor, and DOE, respectively.

- Facilities are provided to store equipment and material GFE requiring advance procurement action.

- Fixed price contractors will supply temporary facilities to meet their own staffing, material storage, and utility requirements. Water and power will be brought to a central point onsite for contractor tie-in.

- Assume utility water and power are available from existing Hanford facilities for supply during HWVP construction.

Temporary buildings are estimated on a dollar per square foot basis, and temporary utilities and maintenance are factored from Fluor Daniel, Inc. (Fluor) experience.

J. The Washington State (Benton County) sales tax rate of 7.8 percent is applied to all material and equipment purchases and to construction equipment usage.

K. The Washington State B&O tax rate of 0.484 percent is applied to all direct costs. The B&O tax is included in the overhead, profit, bond, and insurance column of the Integrated Estimating System (IEST).

L. Fixed price of contractor's overhead cost is estimated to be 34 percent of direct labor.

Contractor's profit, bond, and insurance are estimated to be 6 percent of labor, indirects, equipment usage (construction equipment rental), and plant equipment and material (including 7.8 percent sales tax).

M. Cost plus contractor's overhead, profit, bond, and insurance are estimated to be 7.7 percent.

A-1.1.2 Construction Detail Criteria

The quantity abbreviations used throughout the estimate for all construction estimate lineitems are shown in Table A-1.

Individual standard work hour unit rates of installation are developed for each CSI Division of labor in accordance with the Preliminary Design estimate coding structure. The work hour unit installation rates are all-inclusive rates. These rates account for installation labor and general prorate direct labor, such as off-loading and storage of materials, scaffolding, and cleanup. Material take-off (MTO) allowances are included in the unit rates to allow for damage and loss.

The following assumptions and MTO allowances are used in the development of the construction work hour and material unit installation rates.

- Civil Work - Neat quantities are taken off; a slope of 1-1/2 to 1 is used on all excavation quantities, and a 15 percent swell factor is used for backfill quantities. Excavated soil is assumed suitable for backfill. No imported backfill is included.
- Concrete - Neat quantities are taken off and rounded to the nearest 10 cubic yards. Concrete material pricing is based on a batch plant at site based in accordance with Package C28 of WHC-SP-0463, *Hanford Waste Vitrification Plant Project Plant Acquisition Plan*. Concrete installation labor units include fabrication, installation and stripping of framework, installation of rebar or wire mesh, and pouring and finishing of concrete. Embedded steel weld plates

Table A-1. Quantity Descriptions.

Description	Unit abbreviations
Site clearance	CY = cubic yards
Excavation and backfill	CY
Area cover	SY = square yards
Roads (surface)	SY
Railroad track	LF = linear feet
Fencing	LF
Duct bank	CY
Concrete	CY
Structural steel	Tons
Building steel	Tons
Machinery and equipment	EA = each
Pipe	LF
Valves	EA
Conduit and wire	LF
Instruments	EA
Paint	SF = square feet
Insulation	LF
Miscellaneous individual items	EA
Miscellaneous allowances	Lot
Miscellaneous composites	Lot

for trunnion guides and cell liners are estimated in the account for metal. Embedded pipe is estimated in the account for mechanical piping.

- Steel quantities are taken off and rounded to the nearest ton. An MTO allowance of 5 to 10 percent is allowed, depending on the type of steel take-off:

Light	Qty + 10 percent
Medium	Qty + 7 percent
Heavy	Qty + 5 percent
Siding/decking	Qty + 10 percent

Steel material pricing is developed from current in-house information and informal vendor contact.

- Architectural - Various MTO allowances of 1 to 10 percent were used depending upon the type of material. Unit rates of installation are developed for the various architectural construction tasks from Fluor in-house information. Material pricing is developed from current in-house information and informal vendor contact.

- Machinery and equipment unit rates of installation are developed from Fluor data and/or crew size and duration estimates. The installation work hours include the setting and testing of

equipment. Preservation and maintenance of GFE during construction is included as an allowance under the general requirements section of the estimate.

- Piping installation unit rates are developed from Fluor data and expressed as work hours and material dollars per LF for pipe and pipe insulation, and per EA for valves. The rates assume site shop fabrication and field erection. This includes welding, erection, and bolt-up for pipe and valves. Also included are allowances for fittings, flanges, miscellaneous shoes and guides, scaffolding, 10 percent nondestruction examination, hydro-test and miscellaneous welding operations plus a 10 percent MTO allowance. Piping and material pricing is developed from current in-house information and from informal vendor contact.

- Typical jumpers for piping, electrical, and instrumentation are developed as standards for estimating purposes. The typical jumper diameter is obtained from piping and instrument diagrams (P&ID) and the average length derived from a cell layout drawing. The jumper count is obtained from P&IDs by line specification.

- The estimate for embedded pipe and conduit is developed similar to the jumper estimate, with the embed count taken from cell wall penetration drawings and checked against the P&IDs. An allowance of 50 percent on the material cost is added for quality assurance (QA)-designated [(NQA-1) (ANSI/ASME 1986)] activities.

- Electrical installation unit rates are developed from Fluor in-house data. The next result of the unit work hour installation rates approximates mid-range NECA. The bulk material costs incorporated into the material installation rates are derived from in-house pricing information and from informal vendor contract. The rates for conduit material and labor include assembly and installation costs. The rates include wire, assembly, installation, and checkout costs. An MTO allowance of 5 to 10 percent is included in the rates. Electrical equipment is priced from informal vendor quotes and from Fluor in-house information. Installation rates for electrical equipment are developed from Fluor data and/or crew size and from duration estimates.

- Instrumentation unit installation rates are developed for major equipment, instruments, valves, and bulk material. Major equipment pricing is obtained from informal vendor quotes. The Distributed Control System and Health Protection equipment is installed by the construction contractor, and checkout and testing of the equipment is provided by the vendor, which is included in the procurement cost. Control and pressure safety valve pricing was obtained from informal vendor contact and from in-house information. Labor and material rates provide for installation of block and bleed valves for each control valve. Instrument rates include calibration, process connections, installation, and loop-check. Instrument racks are priced to include rack piping.

Startup spares are not included in the capital cost estimate.

A.1.2 Indirect Costs

Indirect costs are comprised of the elements listed below:

- The A/E services to provide detail design engineering during construction, and shop and field inspection of material and equipment
- General contractor services, including bid package preparation, interface with contractors during construction and storage and maintenance oversight of material and equipment furnished to contractors as a result of advance procurement action
- Technology services, which are basic support with Defense Waste Processing Facility (DWPF)
- Regulatory/compliance, which is preparation and issuance of the Preliminary Safety Analysis Report (PSAR) and PSAR documents
- Systems Evaluation and Test Facility, which is the capital-funded portion of this facility
- Project management services to provide overall Project coordination and administration and technology plan interface coordination.

A.1.3 ESCALATION

An independent escalation study provides annual escalation rates for the HWVP Project from first quarter FY 1990 to completion of construction in first quarter FY 2000. The annual escalation rates were converted into compounded monthly escalation factors by the IEST program.

Escalation is then calculated for each procurement package, construction package, and indirect activity in accordance with the master schedule. Based on the schedule mid-points of the packages and indirect activities, the appropriate monthly escalation factors are applied to the package and indirect activity estimates (first quarter FY 1990 dollars) to arrive at escalated costs.

A.1.4 CONTINGENCY

Contingency is assessed for each design system by the estimators and engineers, based on the completeness of design information available for MTO, the adequacy of equipment specifications for in-house pricing and informal vendor quotation, and the degree of design/engineering uncertainty applicable to each system. Engineering uncertainties are included as contingency, based on rough order-of-magnitude estimates. The estimator's contingency assessment is based on review of the CSI construction accounts within each system for completeness and adequacy of design/engineering information available for estimating.

A.2 BASIS OF MATERIAL TAKE-OFF

The HWVP Project Cost Estimate is prepared from drawings, sketches, specifications, and other documents reflecting the June 5, 1989, Project design "freeze" for the estimate.

The following source material was used in the development of the estimate.

- Equipment List - Prepared by engineering--lists all major engineered equipment by systems, building location, type of equipment, and tag number. The engineering location, type of equipment, procurement source of the equipment (GFE or contractor furnished), the detailed work breakdown structure (WBS)/CSI cost code assigned for entry into IEST, the impact level, vendor-quoted cost (including freight and impact level, excluding sales tax), installation labor work hours, and the crew code of the crafts involved with the setting of the equipment. The equipment list is the control document for the mechanical equipment portion of the estimate.

- Plot Plan - Prepared by engineering--shows the relative location of the HWVP facility buildings. The plot plan was used to develop quantities of site excavation and backfill, to determine distances to estimate piping and electrical systems routed between the buildings, and to determine quantities for miscellaneous temporary and permanent civil construction activities.

- Architectural Drawings - Prepared by engineering--are the basis for all building concrete, steel, and architectural quantities.

- Process and Instrumentation Diagrams - Prepared by engineering--are the basis for piping material and sizes, valve quantities and sizes, and process instrument quantities and types. The specifications were used in conjunction with the P&IDs for piping and valve material and rating requirements and instrument type.

- Instrument index is used for quantity take-off.

- General Arrangement Drawings - Prepared by engineering--marked to show the routing of the piping and heating, ventilation, and air-conditioning (HVAC) ductwork (on separate markups) for estimating MTO. The GAs also were used as a reference in determining the quantities of electrical conduit, wire, and cable.

- The HVAC Flow and Control Diagrams - Prepared by engineering--are the basis for the type and quantity of HVAC instruments.

- Electrical One Lines - Prepared by engineering--show the power requirements and are the basis for cable sizing.

- Motor list - Prepared for electrical load requirements.

A.3 ESTIMATE FORMAT AND CODING

The Preliminary Design cost estimate is organized and coded in accordance with the Project work breakdown structure (PWBS) and the facility code structure by systems designation. Within the facilities, systems, and work package elements, CSI division codes have been assigned, which are broken down further by detail codes that define each estimate line item of work.

A.4 PROCUREMENT AND CONSTRUCTION PLAN

The Project will maximize the use of fixed-price and cost-plus-award fee (CPAF) contractors for plant construction. Management of the construction effort has been assigned to the general construction contractor (GCC). The GCC will determine and recommend to the DOE/Westinghouse Hanford Company for approval, the use of fixed-price and CPAF packages.

Fixed-price contractors will be obtained through a competitive bidding process whereby contract award is made to the lowest responsive bidder. This method of construction is viable due to the configuration of the site and the ability to separate construction activities in a logical, cost-effective manner. This method results in minimizing interfaces between contractors, thus avoiding costly delays arising from coordination problems.

The GCC has the capability to perform onsite construction with its own forces, thus providing a great deal of flexibility in protecting the schedule and budget. This method of performing construction affords the ability to effectively manage and coordinate the work by exercising direct control over the work force. This arrangement will enable the GCC to complete the work in a safe, cost-effective manner with minimal impact on others.

Twenty-five construction packages have been identified as being required for the Project. The A/E has scheduled its design activities for the sequential release of these design packages to support the Project schedule.

Major procurement actions have been identified for 36 packages that represent all equipment and material to be procured by the GCC. The GCC will provide this GFE to various subcontractors.

A.5 REFERENCES

ANSI/ASME, 1986, Quality Assurance Program Requirements for Nuclear Facilities, ANSI/ASME NQA-1-86, American National Standards Institute, New York, New York.

Hanford Site Stabilization Agreement

Morson, R. B., 1989, *Hanford Waste Vitrification Plant Project Plant Acquisition Plan*, WHC-SP-0463, Westinghouse Hanford Company, Richland, Washington.

A.6 ACRONYMS

A/E	architect engineer
B&O	business and occupation
CPAF	cost-plus-award fee
CSI	Construction Standards Institute
DOE	U.S. Department of Energy
DWPF	Defense Waste Processing Facility
FY	fiscal year
G&A	general and administration
GCC	general construction contractor
GFE	government-furnished equipment
HVAC	heating, ventilation, and air-conditioning
HWVP	Hanford Waste Vitrification Plant
IEST	Integrated Estimating System
MTO	material take-off
P&ID	piping and instrument diagrams
PSAR	Preliminary Safety Analysis Report
QA	quality assurance
SETF	Systems Evaluation and Test Facility
WBS	work breakdown structure