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VITRIFICATION FACILITY INTEGRATED SYSTEM PERFORMANCE TESTING REPORT

Topical Report

By
Dan Elliott

May 1, 1997

Work Performed Under Contract No. DE-AC24-81NE44139

Prepared by
West Valley Nuclear Services Co., Inc.
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U.S. Department of Energy
Assistant Secretary for Nuclear Energy

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DISCLAIMER

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ABSTRACT

This report provides a summary of component and system performance testing associated with the Vitrification Facility (VF) following construction turnover. The VF at the West Valley Demonstration Project (WVDP) was designed to convert stored radioactive waste into a stable glass form for eventual disposal in a federal repository. Following an initial Functional and Checkout Testing of Systems (FACTS) Program and subsequent conversion of test stand equipment into the final VF, a testing program was executed to demonstrate successful performance of the components, subsystems, and systems that make up the vitrification process. Systems were started up and brought on line as construction was completed, until integrated system operation could be demonstrated to produce borosilicate glass using nonradioactive waste simulant. Integrated system testing and operation culminated with a successful Operational Readiness Review (ORR) and Department of Energy (DOE) approval to initiate vitrification of high-level waste (HLW) on June 19, 1996.

Performance and integrated operational test runs conducted during the test program provided a means for critical examination, observation, and evaluation of the vitrification system. Test data taken for each Test Instruction Procedure (TIP) was used to evaluate component performance against system design and acceptance criteria, while test observations were used to correct, modify, or improve system operation. This process was critical in establishing operating conditions for the entire vitrification process.

1.0 INTRODUCTION

1.1 Background of WVDP

The WVDP was established in 1980 by an Act of Congress as a DOE high-level radioactive waste management project. The primary objective of the WVDP is to solidify HLW into a form suitable for transportation and disposal to a federal repository. The HLW at West Valley, NY resulted from the reprocessing of approximately 640 tons of spent nuclear fuels by a previous site operator. West Valley Nuclear Services Co., Inc. (WVNS), a subsidiary of Westinghouse Electric Corporation, was selected to be the prime contractor for site operations and assumed control February 1982. In July 1983, the DOE formally selected borosilicate glass as the waste form for disposal. FACTS was conducted on the component test stand (CTS) from December 1984 to December 1989 to provide component and system verification concurrent with final VF design and construction.

The purpose of this report is to briefly describe the VF integrated system test program that was conducted subsequent to facility construction/conversion in preparation for HLW operations at the WVDP.

1.2 Vitrification Process Description

The goal of the vitrification process is to convert the HLW from its initial sludge/liquid form into a borosilicate glass waste form contained within stainless steel canisters. The canisters can then be stored temporarily in the High-level Waste Interim Storage Facility (HLWIS) in the existing Main Plant (figure 1-1) until they are ultimately shipped to a federal repository. The following section provides a summary description of the vitrification process.

The HLW is transferred from Waste Tank Farm (WTF) Tank 8D-2 into the VF concentrator feed makeup tank (CFMT) where it is combined with an in-cell recycle stream from the off-gas scrubbing submerged bed scrubber (SBS). CFMT samples are collected and the contents concentrated thereby removing excess water. Meanwhile, the samples are transferred to the Analytical Lab for determination of chemical and radiochemical composition. Based on this analysis, appropriate glass-forming chemical additives are premixed in the cold chemical system (CCS). Once ready, the chemicals are transferred into the CFMT and the CFMT is again sampled to ensure the feed composition will result in the specified target glass characteristics.

Following verification of the desired feed composition, the mixture is transferred into the melter feed hold tank (MFHT). The melter is fed continuously from the MFHT

In the melter, the water will evaporate from the feed and the remaining solids will calcine. The calcined wastes and glass formers will melt into the glass pool where they will homogenize. The glass is periodically airlifted into a canister. The canister is positioned under the melter by the canister turntable -- a four-position, four-canister device -- that allows one canister to be filled while two canisters cool. The other canister is then available for removal/replacement.

The cooled canister is removed from the turntable and moved to the weld station where a stainless steel lid is welded to the canister. From the weld station, the canister is then moved to the canister decontamination station where decontamination of the canister surface is accomplished by chemical etching. Welded and decontaminated canisters are moved from the Vitrification Process Cell to the HLWIS Facility where they are placed into racks for interim storage.

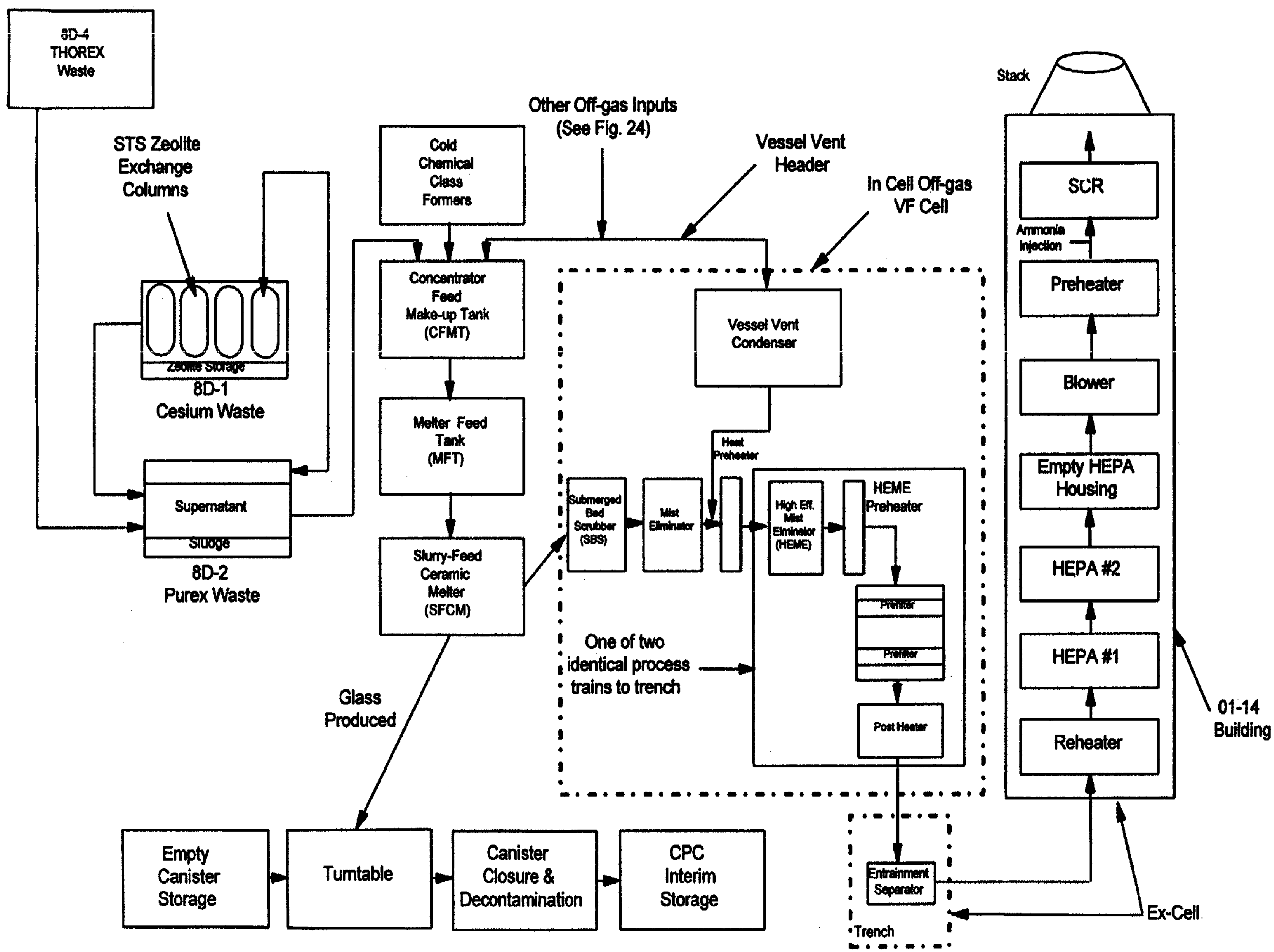

Figure 1-1. Vitrification Process

During the melting process, steam, volatile elements evaporating from the glass pool, and feed particles entrained in the process off-gas will be vented to the off-gas treatment system. The first stage of the process is the SBS where off-gases are quenched and particulate is scrubbed through a submerged bed of ceramic spheres. After the SBS, the off-gas is drawn through a preheater and then a high-efficiency mist eliminator (HEME) to remove mist and fine particulate. It is then heated and introduced through a high-efficiency particulate air (HEPA) filter to remove particulates. At this point, the off-gas is essentially free of radiological pollutants. It then passes into another building via an underground trench where oxides of nitrogen (NOx) are abated by catalytic reaction with ammonia. A final stage of HEPA filtering is also provided in this building prior to venting the off-gas to the environment through the Main Plant stack.

The primary process vessels are all maintained at relative vacuums by the vessel vent system. The vessel vent gas passes from a header through a condenser until it joins the off-gases prior to the HEME preheater. The vessel vent system also provides a means to bypass the SBS in the event the melter off-gas line becomes plugged.

The Vitrification Process Cell is maintained at a vacuum by a heating, ventilation and air conditioning (HVAC) system for contamination control. Any air leakage associated with the cell's shield walls will be into the cell, where it is exhausted through a series of HEPA filters.

A canister load-in facility is provided for introducing canisters into the processing facility. Canisters are inserted horizontally through a cylindrical shield door into the Equipment Decontamination Room (EDR). The canisters are then upended and placed on the transfer cart using a crane. The transfer cart transports them into the Vitrification Process Cell, where they are moved into the canister storage rack for eventual loading into the turntable.

1.3 Functional and Checkout Testing of Systems (FACTS) Summary

From December 1984 to December 1989, the WVDP successfully demonstrated the ability of the Vitrification Facility to produce high-quality glass on a production schedule. Approximately 150,000 kg of glass was produced and thirty-seven FACTS tests were performed using nonradioactive isotopes, in lieu of radioactive species, to produce a waste glass as close as practical to the projected HLW glass. The testing demonstrated the WVDP waste glass qualification approach as well as process system, subsystem, and component performance. The systems/subsystems tested included the: melter (glass production) and canister turntable; melter off-gas cleanup and ventilation system (excluding NOx abatement components); and slurry feed preparation system.

Following the final FACTS run, the Vitrification Facility was disassembled for examination of test components and conversion for radioactive service. Based on the successful FACTS Program, portions of the test facility (MFHT, CFMT, CCS) were reassembled and reused.

1.4 Transition to Integrated Testing and Operations

The WVDP CTS Conversion to Vitrification Facility Test Program Plan, WVNS-TPL-63-001, was developed to provide focus and emphasis to the transition from construction to operations. The plan covered the phased turnover and graded approach to testing including precommissioning (initial component alignments, calibrations, etc), commissioning (initial component/subsystem operation), and performance testing (not previously demonstrated) of the systems associated with the vitrification process.

Some of the precommissioning and commissioning type testing was accomplished by the construction subcontractors with oversight provided by WVNS. The bulk of the non-performance type testing was accomplished with Maintenance or contract maintenance and Operations personnel under the direct supervision of WVNS qualified test engineers.

Nearly all performance testing was accomplished by Vitrification Operations personnel under the direction of WVNS qualified test engineers. The performance testing incorporated extensive use of existing standard operating procedures (SOP) and developmental vitrification procedures (DVP) to allow for continual procedural refinement, procedural validation, and to provide operating experience and training opportunities for Operations personnel prior to radioactive operations.

Performance testing progressed from component and subsystem demonstration first using water, then testing with (nonradioactive) slurry and finally with fully integrated system test runs known as integrated operations (IO). The integrated operation runs culminated with approval for radioactive operation in June 1996. The main focus of this report is the integrated operation testing.

2.0 TESTING

2.1 Summary of Test Program and Integrated Operations Runs

While considerable performance testing was accomplished prior to melter operation, the bulk of the performance testing took place during the series of integrated operational runs. These test runs were structured to demonstrate system operation in a stepwise manner. Each integrated test run was developed according to specific operational task requirements, such as the ability to feed the melter, produce a canister, or abate NOx. Six integrated operational runs were prepared that advanced through progressive stages of VF operation, from initial melter feeding to operation of the entire Facility under full radiological controls (i.e., simulation of HLW operation).

These integrated test runs, or IOs, were coordinated under the Vitrification Facility Integrated Operations Run Plan, WVNS-TPL-63-004. This Run Plan provided technical guidance and logical sequencing of necessary operations and testing to be performed during each IO. The Run Plan invoked the use of standard operating procedures, providing repeated opportunities to field check the procedures prior to radioactive operations.

The purpose of the first integrated test run, IO #1, was to demonstrate the ability to prepare slurry and feed the melter using in-cell systems and components, including the CFMT, MFHT, melter (with melter viewing, pour viewing, film cooler, and canister infrared level detection systems [ILDS]), distributed control system (DCS), closed loop cooling water system, waste header, SBS, off-gas blowers, and vessel ventilation system. This IO marked the initiation of slurry feed to the melter and fully integrated melter performance testing.

The next two integrated test runs, IO #2 and IO #3, demonstrated the ability to maintain melter feed operations using a fully operational ex-cell off-gas system (including NOx abatement) and an HVAC system in addition to all components and systems used for IO #1. These test runs also provided the opportunity to develop operator proficiency and collect data regarding glass oxidation-reduction (Redox) control. It was during IO #3 that the melter was diagnosed to exhibit undesired glass migration through the melter dam (from the main melt cavity to the discharge cavity). IO #3 was concluded, the melter was shutdown and cooled down, and melter repairs were performed.

Following melter repairs, melter startup heaters were utilized to reheat the melter and re-initiate joule heating. The fourth integrated test run, IO #4, was then commenced to operate the VF systems including the melter, off-gas system, NOx abatement, and all VF support systems. IO #4 was used to perform melter retesting following repairs, complete outstanding TIPs, including testing of the turntable and transfer cart.

The purpose of IO #5 was to operate the Vitrification Facility as an integrated plant to allow Vitrification Operations to acquire prototypic operational familiarity. The Vitrification Facility was run (still using glass-former slurry from waste simulant) to complete the objectives of filling at least four canisters while moving one canister through the process cycle from insertion into the turntable, filling it with glass, having it shard-sampled, having the lid welded, and performing decontamination and all associated canister handling activities.

Following IO #5, vitrification system hot ties were accomplished to connect the previously nonradiologically contaminated Vitrification Facility to the contaminated Waste Tank Farm, sample transfer, and EDR facilities. Vitrification operations were still performed using waste simulant in lieu of high-level waste. However, due to the potential for radioactive contamination of the Vitrification Facility, the Vitrification Facility was posted as a radiologically controlled area and all radiological requirements were followed during the final integrated run, IO #6. The objective of IO #6 was to demonstrate safe operation of all the VF systems under full radiological controls. Four canisters were prototypically produced, starting with the load-in of empty canisters into the EDR and ending with the off-loading of filled, welded, and decontaminated canisters from the transfer cart into the High Level Waste Interim Storage Facility storage racks. IO #6 also provided for completion of transfer cart performance testing (involving cart movement into radiologically contaminated areas). Finally, IO #6 provided a means for various Operational Readiness Review groups to assess WVNS preparations and readiness for full radiological waste processing.

2.2 Sludge Mobilization High-level Waste Transfer System

2.2.1 Sludge Mobilization High-level Waste Transfer System Functions

The sludge mobilization high-level waste transfer system's (SMTS) primary function is to deliver Tank Farm waste to the Vitrification Facility for processing. The HLW transfer piping (double-walled) is housed in a common containment system called the trench, connecting Pits 8Q-1, 8Q-2, 8Q-4, 8Q-5, and the Vitrification Facility. The pits provide a means to remotely access valves, instruments, and mechanical jumpers for maintenance, line flushing, and future decontamination/decommissioning (figure 2-1).

2.2.2 SMTS Testing

The SMTS integrated radioactive transfers were simulated as closely as possible with actual system operation using approved operating procedures. Transfer pump operation was simulated using a test pump of the same performance and ratings as the SMTS removal pumps. Proper operation of all controls, indications, alarms, computer programming, and physical system integrity were verified during actual system operations using a test pump and water via normal and alternate flow paths.

One phase of testing was performed in preparation for transferring thorium extraction (THOREX) waste from Tank 8D-4 into Tank 8D-2. Proper operation of the equipment and the ability for actual physical accomplishment was verified against the operating procedure. The crucial parameter of THOREX transfer testing was the ability to set and automatically control THOREX flow at 1 to 2 gallons per minute.

Another phase of testing was accomplished to support transferring Zeolite from Tank 8D-1 to Tank 8D-2. Testing was accomplished in basically the same manner as THOREX transfer testing. Water was used for all testing and grinder operation.

Sludge transfers from Tank 8D-2 to the Vitrification Facility were simulated in the same manner as the other transfer testing. A flexible jumper was installed in the VF primary process cell to provide a simulated flow path to the CFMT.

At the completion of testing, all line were blown down and the system was placed in a shutdown lineup, effectively isolating it from the VF until hot ties were made in preparation for radiological operations. The waste header and condensate header lines coming to the Waste Tank Farm from the VF were not yet connected to the SMTS at this point. A temporary culvert with storage vessels was designed and installed in the Waste Tank Farm to simulate waste Tanks 8D-4 and 8D-3 receiving VF waste header discharges and condensate (from CFMT boiling evolutions), respectively, in support of VF system testing.

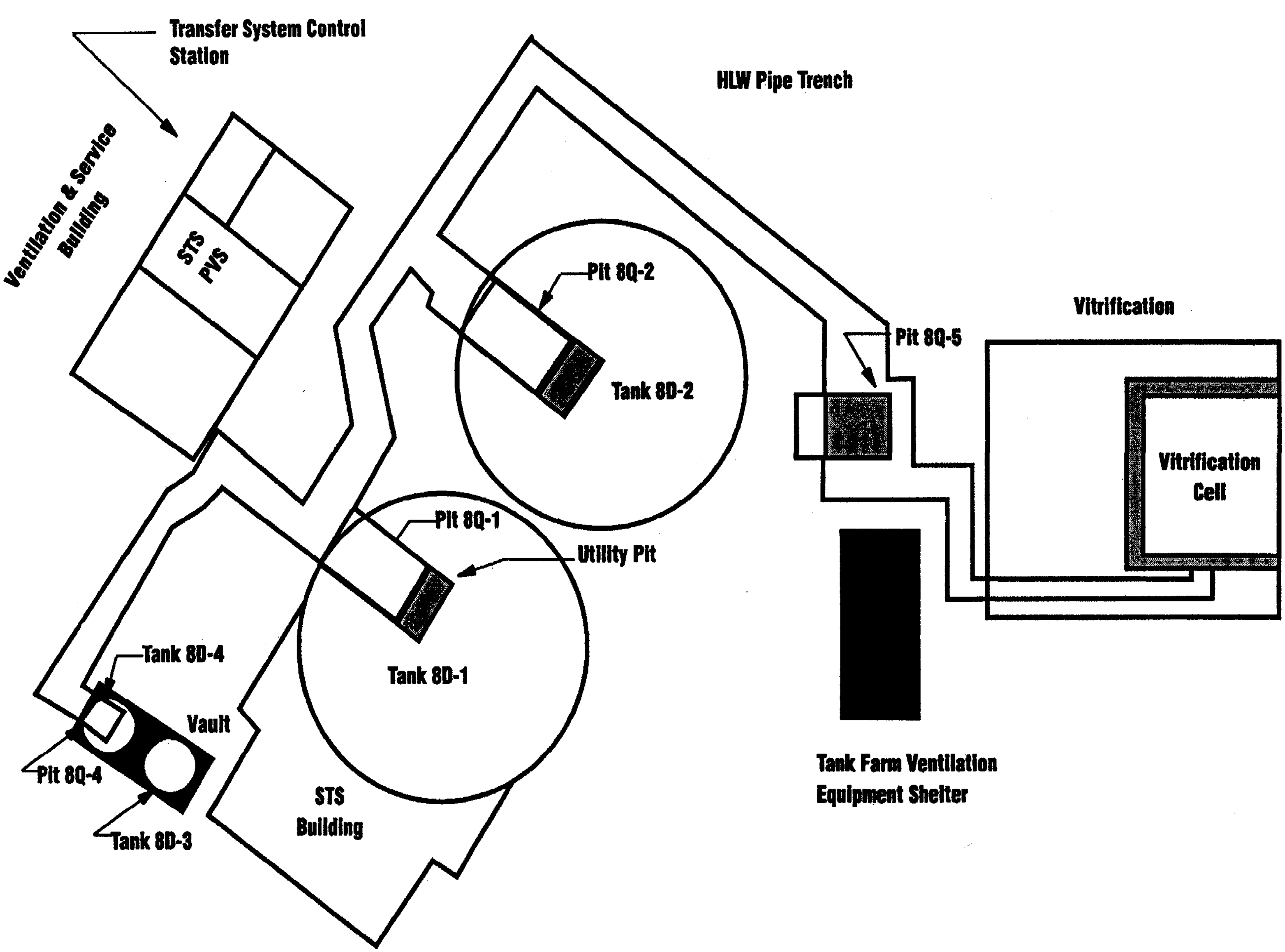

Figure 2-1. Tank Farm General Arrangement

2.3 Cold Chemical System

2.3.1 Cold Chemical System Functions

The cold chemical system, independently housed in a building located on the west side of the Vitrification Facility, includes three slurry mix tanks, three solution preparation tanks, two day tanks (nitric and caustic), one drain tank for waste collection, two material delivery subsystems (solid and liquid), and the tank ventilation subsystem (figure 2-2.)

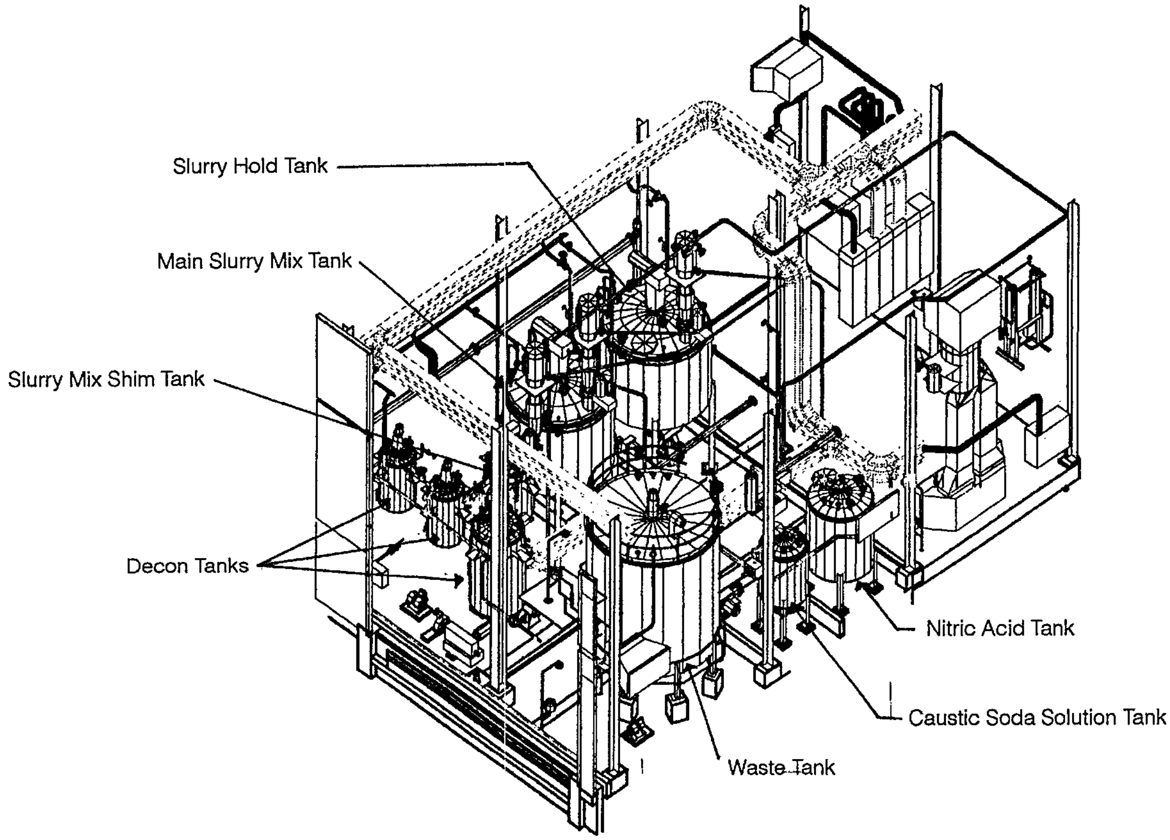

Figure 2-2. Cold Chemical System Arrangement

The cold chemical system serves the following functions:

- Batch preparation of glass formers and shim waste simulants. The slurries and solutions are prepared in the slurry mix tanks and transferred to the primary process cell, primarily into the CFMT.
- Batch preparation of decontamination solutions. These solutions are then transferred to the Vitrification Facility (i.e., for canister decontamination operations).
- Supply metered quantities of demineralized water to certain components in the Vitrification Process Cell.
- Maintain pressure and ventilation control on all cold chemical system tanks.

2.3.2 Testing

Prior to the introduction of chemicals into the cold chemical system, performance testing was done by simulating system operations using water and air. With the initial component startup testing complete on pumps, grinders, agitators, and associated control and instrumentation loops, the Cold Chemical Facility was placed into a normal valve and breaker lineup in preparation for system testing. See table 2-1 for a brief testing summary.

Table 2-1: Cold Chemical System Performance Testing Summary

Test	Test Objectives Achieved
Work Order 9303066, Cold Chemical System Process Functional Test	Demonstrated scrubber tank automatic level control feature.
	Demonstrated proper interlocking between the primary and backup scrubber pumps.
	Maintained vessel vacuums adequately, even during scrubber pump switchover on simulated loss of primary pump.
	Maintained vessel vacuums during simulated tank maintenance (removal of tank manway cover).
	Verified proper valve interlock operation to automatically stop filling the nitric acid and/or caustic soda day tanks when the associated tank high-level trip point is reached.
	Verified proper valve interlock operation preventing delivery of nitric or caustic to more than one tank at time.
	Verified proper pump interlock operation preventing simultaneous operation of the nitric and caustic metering pumps.
	Verified proper pump interlock operation to shutdown nitric and caustic metering pumps upon receiving a high-level trip from Tanks 65-D-01, 65-D-02, 65-D-03, 65-D-04, 65-D-07, 65-D-08, or 65-D-09.
	Performed batch additions from the nitric acid and caustic soda day tanks to Tank 65-D-02.
	Simulated liquid chemical addition by transferring water to Tanks 65-D-02, 65-D-03, and 65-D-04 using the eductor (steam jet) system.
	Verified proper agitator interlock operation to shutdown the agitator upon reaching the low-level trip for Tanks 65-D-01, 65-D-02, 65-D-03, 65-D-04, 65-D-07, 65-D-08, or 65-D-09.
WVNS-TIP-019, Cold Chemical Slurry Testing	Prepared a batch of slurry in the cold chemical system to verify the following operations: demineralized water batch addition, nitric acid batch addition, caustic soda batch addition, liquid chemical addition using the eductor system, solid chemical transfer using the VAC-U-MAX™ system, tank recirculation, in-line grinding, sampling, and flushing of the tank recirculation line.
WVNS-TIP-058, Cold Chemical System Performance Test	Prepared a complete waste simulant batch, glass-former batch, and sugar shim solution batch using approved operating procedure.
	Demonstrated that a minimum vacuum of -2" w.c. can be maintained on all cold chemical tanks when operating the cold chemical vessel ventilation system at fully capacity.

Test	Test Objectives Achieved
Table 2-1: Cold Chemical System Performance Testing Summary (cont.)	
WVNS-TIP-058, Cold Chemical System Performance Test	Maintained proper vessel pressure control in sending and receiving vessels when transferring decon solutions, sugar solution, and slurry from cold chemicals vessels to VF primary process vessels (ensuring cold chemical vessels are always maintained at a higher pressure than primary process vessels to preclude the potential for backflow from the VF). Transfers performed: 65-D-07 to the CFMT, 65-D-09 to the CFMT, 65-D-02 to the CFMT, and 65-D-04 to the CFMT. Demonstrated that flowrate attained through Slurry Grinders 65-T-02, 65-T-03, and 65-T-03 are greater than 70 gpm (to ensure solids remain suspended). Demonstrated that scrubber temperature does not exceed 100°F during a typical slurry batch preparation.

The vessel ventilation subsystem (venturi scrubber) was operated to verify proper operation of the pump sequencing interlocks (i.e., autostart of the standby pump upon loss of the primary pump) and to demonstrate vacuum pressure control on all cold chemical vessels. Early testing revealed pressure control imbalances between tanks caused by varying lengths of vent piping and their associated pressure drops. This problem was alleviated by installing and adjusting throttle valves in the tank vent lines to properly balance the air flows and balance tank vacuums.

Nitric Acid Day Tank (65-D-05) and Caustic Soda Day Tank (65-D-06) and their associated delivery systems were operated to perform (simulated) metered batch acid and caustic additions to a slurry mix tank and to verify proper valve alignment interlocks. Water was transferred to each of the slurry mix tanks using the liquid chemical transfer system to simulate liquid chemical transfer. This system employs a steam jet in order to transfer liquid chemicals from their storage containers into the slurry mix tanks. Initially, steam jet operation would cause unsatisfactory tank pressurization surges. Orifices, subsequently installed in the supply piping, limited the volumetric flow and mitigated the pressure transients. Main Mix Tank (65-D-03), Slurry Hold Tank (65-D-02), and Shim Mix Tank (65-D-04) testing consisted of interlock verifications, batch demineralized water additions and line flushes, grinder operation, tank recirculation, and tank-to-tank transfers. Decontamination Solution Preparation Tanks, 65-D-07, 65-D-08, and 65-D-09, were tested by performing batch water additions, flushes, and interlock verifications. Interlock checks and utility water flushes were performed on Drain Tank 65-D-01. All normal transfers from Cold Chemical Tanks 65-D-02, 65-D-03, 65-D-04, and 65-D-07, to the CFMT and MFHT were simulated using water. Appropriate flow rates for slurry transport (> 72 g.p.m.) were demonstrated for the slurry tank pumps.

The purpose of initial slurry/feed preparation testing was to simulate actual cold chemical system operations as closely as possible without the use of Resource Conservation and Recovery Act (RCRA)-identified hazardous constituents in the waste simulant or glass-former mix. In the initial performance testing (WVNS-TIP-019), the cold chemical system was operated to prepare a slurry batch in Tank 65-D-03. Operations included batch additions of demineralized water, nitric acid, and caustic soda with metering pumps.

Liquid chemicals were added using the liquid eductor and dry chemicals were added via the VAC-U-MAX™ dry chemical transfer system. As part of the dry chemical transfer sequence, a knife-gate valve, isolating the tank from its associated dry chemical hopper, opens to admit dry chemical into the tank. The knife-gate valves experienced operating difficulties, especially binding and jamming, due to chemical buildup. Design modifications were made (i.e., air purges installed to keep operating surfaces clean and larger valve actuators installed) leading to successful system operation.

Following chemical addition, vessel recirculation was accomplished with the in-line grinder operating. Significant deterioration of the teeth on the grinder blades was observed. As a result, grinder blade combinations were changed (i.e., fine blades were replaced with coarse blades) and the frequency of grinder blade inspections and preventive maintenance activities were increased.

Finally, samples were drawn and recirculation line flushes were completed. This slurry batch was not subsequently transferred to the VF since the CFMT and MFHT were not yet ready to accept chemicals.

Cold chemical system performance testing continued with WVNS-TIP-058. Transfers were made from Cold Chemical Decontamination Tanks, 65-D-07 and 65-D-09, to the VF to demonstrate proper tank vacuum control during transfers. For all transfers, CFMT pressure was always maintained more negative (-5" w.c. nominal) than the cold chemical source tank (-2" w.c. nominal) to preclude the potential for backflow from the VF. Using approved operating procedures, cold chemical systems were operated to prepare a waste simulant batch in Tank 65-D-02 and a glass-former batch in Tank 65-D-03. The waste simulant was sent to the CFMT and marked the first introduction of slurry into the primary process cell. The glass-former batch was subsequently transferred into the CFMT as part of the CFMT slurry performance testing. In both cases, transfers were monitored to demonstrate proper vessel vacuum control. Finally, a sugar solution was prepared in Shim Mix Tank, 65-D-04 and transferred to the CFMT.

During integrated operations, the ability of the cold chemical system to successfully prepare and transfer slurries and solutions was demonstrated several times. Several waste simulant and glass-former batches were prepared that resulted in acceptable melter feed slurry in the CFMT. This served as an independent verification of the successful performance of the cold chemical system that was separate from the testing described above.

2.4 In-cell Feed Preparation and Sampling

In-cell feed preparation and sampling encompasses the CFMT, the MFHT, the slurry sample station (and associated air displacement slurry [ADS] sample pumps), and support equipment for temperature control, pressure control, level indication, slurry transfer, and mixing (see figures 2-3 and 2-4).

2.4.1 Concentrator Feed Makeup Tank Functions

The CFMT receives waste, glass-forming chemicals, and in-cell process recycle stream to mix and concentrate slurry feed for delivery to the Melter Feed Hold Tank. The CFMT, made of Hastalloy C-22 for corrosion resistance, has a nominal design volume of 22,600 liters (6,000 gal.). There are two (one side, one bottom) half-pipe (3.5 inch, schedule 10) heating/cooling jackets that accept steam or cooling water for vessel temperature control. A 40 hp motor-driven agitator is provided to maintain homogeneity of the slurry. Vessel level, density, and pressure indication is provided by any of three independent bubbler assemblies on the tank. Vessel pressure is maintained at a nominal vacuum of -5" w.c. via a mechanical jumper connection to the vessel vent header. A seal pot connects the CFMT to the waste header, providing an overflow path as well as a means of overpressure protection for the CFMT. The CFMT has two steam jets (eductors) that provides a means to transfer the contents of the CFMT to the MFHT or to the Waste Tank Farm. The CFMT seal pot also has a steam jet for emptying the seal pot to the waste header.

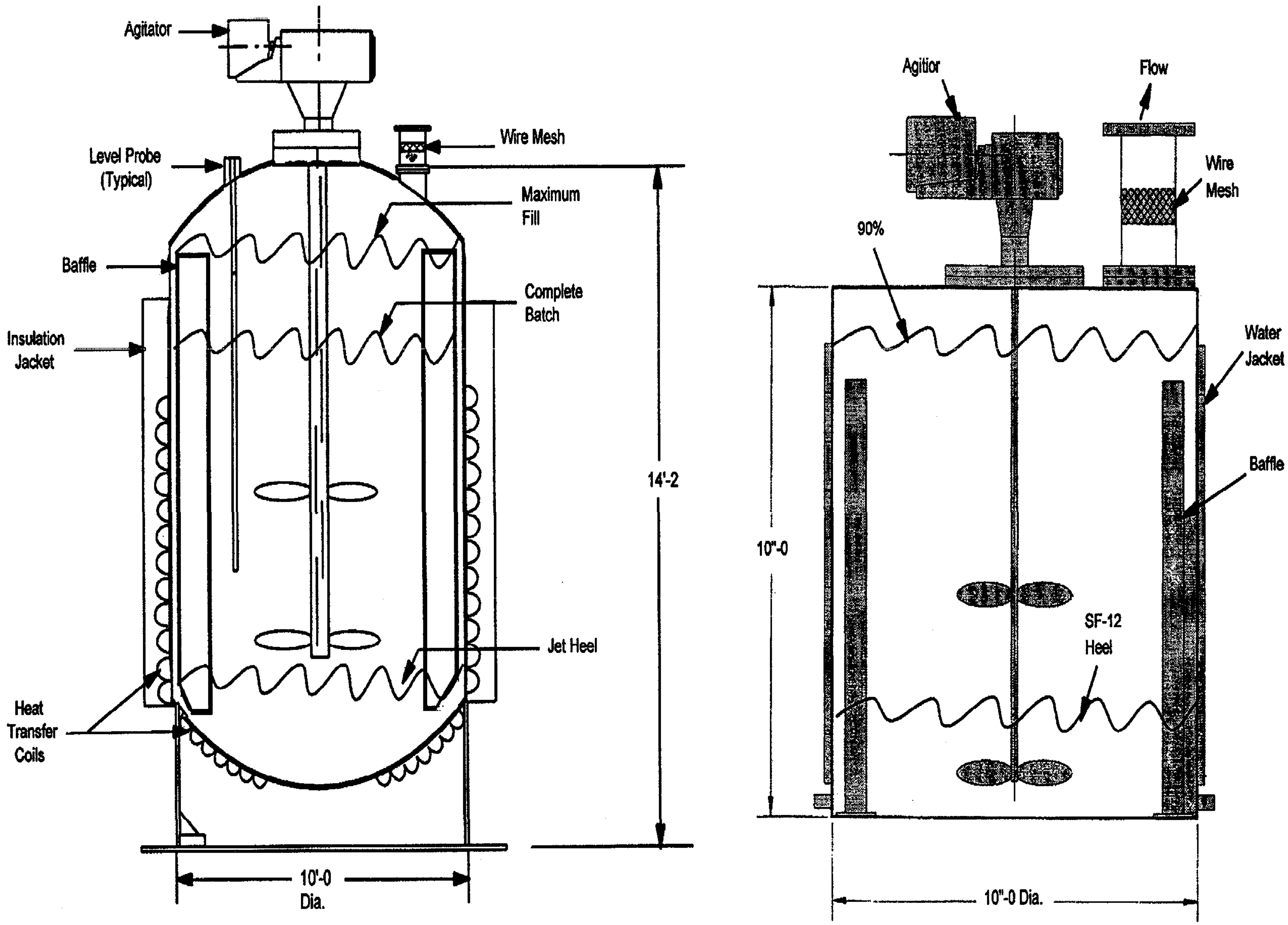

Figure 2-3. CFMT/MFHT Cutaway

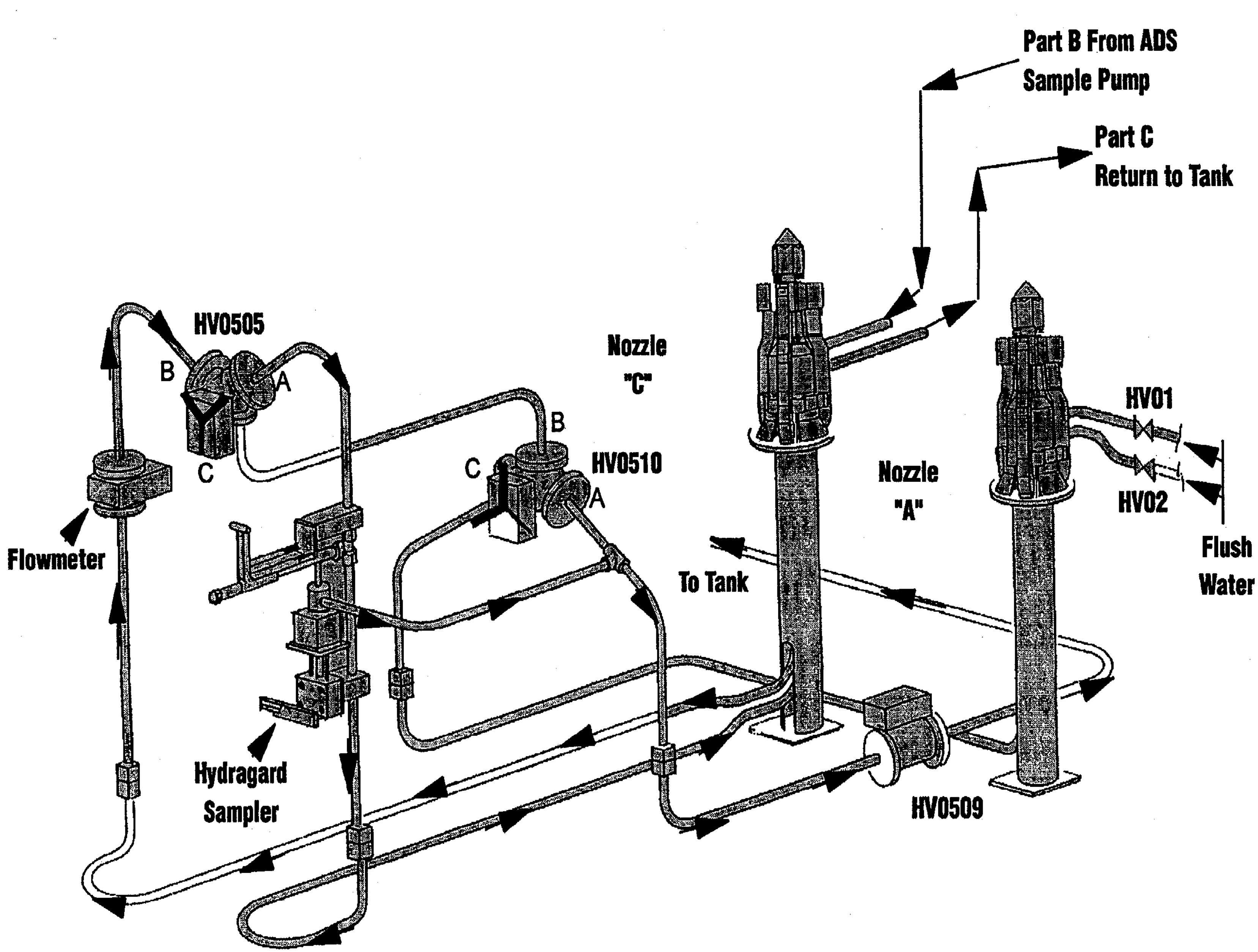

Figure 2-4. Slurry Sampler Arrangement

2.4.2 Melter Feed Hold Tank Functions

The MFHT holds and mixes slurry feed from the CFMT for delivery to the melter. The CFMT, made of 304L stainless steel, has a nominal design volume of 18,900 liters (5,000 gal.). The MFHT has an exterior cooling jacket containing internal baffles to cause water to spiral within a rectangular channel. A 15 hp motor-driven agitator is provided to maintain homogeneity of the slurry. Vessel level, density, and pressure indication is provided by any of three independent bubbler assemblies on the tank. Vessel pressure is maintained at a nominal vacuum of -5" w.c. via a mechanical jumper connection to the vessel vent header. A seal pot connects the MFHT to the waste header, providing an overflow path as well as a means of overpressure protection for the MFHT. The MFHT has two steam jets (eductors) providing a means to transfer the contents of the MFHT to the CFMT or to the waste header. The MFHT seal pot also has a steam jet for emptying the seal pot to the waste header. An ADS pump provides the means to feed slurry to the melter.

2.4.3 Slurry Sampling Functions

The slurry sample station is an integral part of feed preparation. It provides the means to sample HLW from the CFMT (for determination of the chemical additions needed for feed makeup) and for sampling melter feed from either the CFMT or the MFHT (for confirmation of feed composition following chemical additions). Slurry is circulated from the CFMT to the slurry sample station with an ADS pump. At the sample station, operators using remote manipulators draw slurry samples using in-line, closed-loop liquid samplers.

2.4.4 Testing

Performance testing of the CFMT and MFHT was accomplished in two phases. First using water as the process fluid, then using simulated waste and glass former (slurry) to meet test requirements set forth in WVNS-SD-63I, Primary Process System Description and WVNS-SD-69A, Vitrification Facility System Description. A brief summary of the performance tests are provided in table 2-2. Due to construction completion schedules, the CFMT and MFHT (and the supporting subsystems/components) were turned over for testing prior to other systems. As a result, most all of the performance testing associated with the CFMT and MFHT was completed prior to melter startup and IO #1. Also, since the ex-cell off-gas system had not yet been constructed, a temporary off-gas blower system was designed and installed to provide motivation for the in-cell off-gas and vessel vent system for maintaining vessel vacuums.

Table 2-2:In-cell Feed Preparation Test Summary

Test	Test Objectives Achieved
WVNS-TIP-025, Concentrator Feed Makeup Tank Heating/ Cooling Performance - Water	Simulated slurry concentration evolution using approved operating procedures.
	Achieved an evaporation rate of greater than 300 gal./hr.
	Maintained CFMT and vessel ventilation pressure less than cell pressure at all times.
	Cooled the contents of the CFMT from 100°C to 40°C within 8 hours.
	Demonstrated proper operating control logic.

Table 2-2:In-cell Feed Preparation Test Summary (cont.)	
Test	Test Objectives Achieved
	Demonstrated proper jacket pressurization control in that no negative pressures occurred in either CFMT jacket (due to steam collapse) between cessation of steam flow and the initiation of cooling water flow.
WVNS-TIP-026, SBS to CFMT Transfer - Performance with Water	Simulated transfer of SBS process fluid to the CFMT using approved operating procedures.
	Demonstrated proper control logic for Steam Jets J-3114 and J-3015.
	Demonstrated that the relative flowrates of Jets J-3114 and J-3105 are appropriate for maintaining the SBS bed level at overflow during the transfer.
	Demonstrated no siphon exists between the SBS and CFMT as a result of transfer.
	Maintained CFMT, vessel ventilation, and melter pressure at less than cell pressure throughout the transfer.
	Demonstrated auto-start feature of the CFMT agitator on increasing level.
	No unexpected alarms activated due to the transfer.
WVNS-TIP-037, CFMT to MFHT Transfer - Performance with Water	Simulated transfer of slurry from the CFMT to the MFHT using approved operating procedures.
	Transferred the entire contents of the CMFT (i.e., one full-batch equivalent) to the MFHT without interruption of the transfer by the MFHT high-level interlock.
	Demonstrated auto-shutdown feature of the CFMT agitator on decreasing level.
	Demonstrated proper operating control logic for Steam Jet J-0115, including auto-shutdown upon a high-level condition in the MFHT.
	No unexpected alarms activated due to the transfer.
WVNS-TIP-039, MFHT to CFMT Transfer - Performance with Water	Simulated transfer of slurry from the MFHT to the CFMT using approved operating procedures.
	Transferred the entire contents of the MFHT (i.e, one full-batch equivalent) to the CFMT without interruption of the transfer by the CFMT high-level interlock.
	Demonstrated proper operating control logic for Steam Jet J-1105, including auto-shutdown upon a high-level condition in the MFHT.
	No unexpected alarms activated due to the transfer.
WVNS-TIP-053, Jet Transfers to the Waste Header - Performance Test with Water	Simulated transfer of slurry and process fluids from the MFHT, MFHT seal pot, and CFMT seal pot to the waste header using approved operating procedures.
	Demonstrated proper operating control logic for Steam Jet J-1305 (MFHT seal pot to waste header). J-0305 (CFMT seal pot to waste header), and J-1117 (MFHT to waste header).
	Achieved a flowrate of greater than 25 gal./min. for Steam Jet J-1117.
	Maintained MFHT, CFMT, and vessel vent header pressures between -0.1" and -10" w.c. during all transfers.
	Maintained waste header pressure less than 12" w.c. during all transfers.
	No unexpected alarms activated due to the transfer.

Table 2-2:In-cell Feed Preparation Test Summary (cont.)	
Test	Test Objectives Achieved
WVNS-TIP-053, Jet Transfers to the Waste Header - Performance Test with Water	Ensured no process fluid flow to the north sump during all transfers.
WVNS-TIP-054, System 65 Transfers to CFMT/MFHT - Performance Test with Water	Simulated transfers of slurries and process fluids from Cold Chemical Tanks 65-D-02, 03, 04 and 07 to the CFMT and MFHT at design flowrates, using approved operating procedures.
	Maintained pressures less than 0" w.c. in the CFMT and MFHT for all transfers and subsequent line flushes.
	No unexpected alarms activated due to the transfer or subsequent line flushes.
WVNS-TIP-057, Miscellaneous CFMT/MFHT Performance Test with Water	Simulated transfer of slurry form the CFMT to the Waste Tank Farm, and CFMT/MFHT bubbler blowdowns and flushes using approved operating procedures.
	Overflowed the CFMT, through the seal pot, at maximum expected flowrate without approaching CFMT design pressure to demonstrate overpressure protection capability of the seal pot.
	Demonstrated a flowrate of greater than 65 gallons/min. for Steam Jet J-0117 to ensure effective slurry solid transport to the Waste Tank Farm.
	Demonstrated proper operating control logic for Steam Jet J-0117.
	Demonstrated that no siphon is established between the CFMT and the SBS as a result of overflowing the CFMT.
WVNS-TIP-059, Concentrate Slurry Performance Test	Used approved operating procedures to: deliver slurry to the CFMT from the cold chemical system, boil the CFMT to concentrate the slurry, cool the slurry, and perform CFMT bubbler assembly blowdowns and flushes.
	Maintained CFMT pressure within -0.1" to -10" w.c. throughout the transfer, boiling, and cooling evolutions.
	Demonstrated less than 0.1 ppm carryover of Cs to the condensate header during CFMT boiling.
	Demonstrated proper CFMT jacket pressurization logic to preclude negative pressures.
	Demonstrated no foam migration from the CFMT toward the vessel vent header during CFMT boiling.
	Demonstrated no condensate-induced water hammer in the CFMT jackets.
	Cooled concentrated slurry from 100°C to 40°C within 8 hours.
WVNS-TIP-063, Transfers to the CFMT Performance Test	Used approved operating procedures to: deliver glass-former chemicals from the cold chemical system to the CFMT, transfer slurry from the CFMT to the MFHT (J-0115), transfer slurry from the MFHT to the CFMT (J-1105), transfer slurry from the CFMT to the Waste Tank Farm (J-0117), and sample the contents of the MFHT and CFMT.
	Maintained CFMT, MFHT, and vessel vent header pressures between -0.1" and -10.0" w.c. during all transfers.
	Demonstrated slurry homogeneity in the CFMT and MFHT over normal operating ranges and determined a minimum MFHT operating volume with acceptable homogeneity.

Table 2-2:In-cell Feed Preparation Test Summary (cont.)	
Test	Test Objectives Achieved
WVNS-TIP-067, MFHT Performance Test	Used approved operating procedures to: pump slurry from the cold chemical system to the MFHT, transfer slurry from the CFMT to the MFHT (J-0115), and perform blowdowns and flushes of the MFHT bubbler assemblies.
	Maintained MFHT and vessel vent header pressures between 0.1" and -10.0" w.c. during all transfers.
	Demonstrated ability to maintain MFHT slurry temperature less than 40°C.
	Demonstrated that MFHT agitation does not cause foam migration to the CFMT.

Heating and cooling for the CFMT was evaluated both with water and with waste simulant (slurry). While a maximum evaporation rate of 306 gallons/hour was achieved using water as the process fluid, this testing prompted some system and operating modifications. During testing, the vessel vent system had to be operated at vacuums up to -13" w.c. in order to maintain CFMT pressure below the high-pressure interlock value - where steam flow would be automatically shutdown. Subsequent modifications included changing the steam control scheme from flow controlling to pressure controlling, reducing the steam line relief valve setpoint, and reducing the allowable operating steam pressure range identified in the SOP. While these modifications reduced the maximum attainable evaporation rate, the resulting evaporation rate was still less than the waste sample analysis time period that establishes the process requirement. In addition, testing showed that the tank level could be used to determine the end point for slurry concentration.

Minor problems were experienced with control loops and sluggish system response during vessel heating and cooling. System response was enhanced by rerouting the ex-cell return piping and by installing inserts in the in-cell return piping to increase condensate velocity.

System logic and piping checks were performed for the slurry sample station, which samples both the CFMT and the MFHT. Sample repeatability tests were done to verify sampling operations.

The rest of the performance testing with water consisted mainly of performing water transfers using steam jets. These tests demonstrated proof of flow (i.e., no obstructions), the impact of various steam jet transfers on interfacing system pressure control, interlock verifications, and proper jet control logic to prevent back-siphoning of process fluid into the operating aisles. Steam jet controls are set up to automatically initiate an air purge of the jet assembly once steam is secured. The purpose is to displace residual steam which, if allowed to condense in the assembly piping, could create sufficient vacuum in the piping to draw process fluid out of the associated vessel. Several of the transfer tests performed with water revealed undesirable pressure transients experienced in the vessel ventilation system. As a result, modifications were made to add a positioner to PV-1502 (vessel vent header pressure control valve). Subsequent retests, performed with simulated waste slurry, proved successful.

Testing of the CFMT and MFHT seal pot jets uncovered a potential jet plugging problem. The orifices in the 1.5 gallon/minute jets tended to clog easily. Both jets, J-0305 and J-1315, were replaced with larger orifice, 45 gallon/minute steam jets to preclude clogging.

During testing of the CFMT and MFHT bubbler assemblies, it was noted that blowing down the bubbler lines with instrument air led to undesirable pressure transients in other vessels including the melter. Flow-restricting orifices were designed and installed in the instrument air supply lines for the bubblers to mitigate the pressure transients. Subsequent retests showed satisfactory pressure control.

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2.5. Slurry-fed Ceramic Melter

2.5.1 Slurry-fed Ceramic Melter (SFCM) Functions

The SFCM is a water-jacketed, stainless steel box with an interior comprised of various refractory material in contact with molten glass. Three immersed metal electrodes are used to transfer electrical energy through the molten glass thereby providing the heat necessary to dry and melt the slurry feed into molten glass. There are two discharge chambers (one is an installed spare) equipped with pour troughs. These are separated from the main melter cavity by a refractory wall and air-cooled inconel plates, called dams, to prevent glass migration through the wall. Molten glass is transferred from the main cavity to the discharge cavity through a passage by means of an airlift - a controlled addition of air bubbles near the bottom of the passage. The discharge chamber temperature is maintained with resistance heaters to ensure the glass remains molten as it falls into the canister positioned below the chamber. The electrodes and electrode shrouds and penetrations are also air-cooled. A bubbler assembly provides indication of the molten glass level, glass density, and melter main cavity plenum pressure. Arrangements of thermocouples provide temperature indications for the molten glass, melter plenum, melter refractory, and melter discharge chamber. The melter is fed continually from the MFHT using an ADS pump. This air-driven pump delivers an essentially fixed volume of feed per pump cycle to the melter. The feed rate is regulated by controlling the pump cycle period (see figures 2-5 and 2-6).

The melter viewing system consists of a periscope that extends into the melter plenum and ex-cell camera/control components. The system has sensitivity that extends into the infrared range for monitoring the melter cold cap. The periscope and internal lenses are cooled by air, while the lower lens is also provided with a periodic steam purge for cleaning.

The melter is maintained at a nominal vacuum of -5" w.c. Melter off-gases are exhausted to the off-gas system. Since the gas generation rate (derived from feed conversion) fluctuates significantly and feed pump cycles result in periodic air addition to the melter, a pressure control loop is provided to control air injection for maintaining the desired melter pressure. The off-gas jumper (connecting the melter to the SBS) has a air-supplied film cooler and pneumatically driven brush cleaner at its inlet to mitigate sticky deposits that may lead to jumper/nozzle blockage.

2.5.2 Testing

In preparation for melter startup and integrated testing, substantial preliminary testing was performed on the melter and its auxiliary equipment. Functional tests of control logic and interlocks were completed on supporting equipment such as:

- The melter alternate vent valve that maintains melter vacuum should the normal pressure control scheme fail (i.e., blocked off-gas jumper).
- The cooling air system to the melter plenum viewer periscope that periodically steam purges the lower lens to clean it. The subsystem that supplies cooling air to the melter off-gas film cooler.
- The film cooler cleaner that drives a brush down into the film cooler and nozzle C of the melter to remove any accumulated calcine deposits.
- The melter airlift subsystem that supplies a controlled stream of air to the molten glass, lifting the glass to the pour trough where it falls into a canister.
- The side and bottom melter cooling water jackets and the air cooling for the melter dam and east trough.
- Melter electrode controls for controlling glass temperature.
- The bubbler system that provided melter level, density, and pressure indications.

Glass temperature in the melter is maintained by controlling the electrical current established between the three melter electrodes. Heat is generated due to the resistance (to electrical current) in the molten glass pool, referred to as joule heating. Until the glass temperature is above roughly 800°C, it will not pass sufficient electrical current to establish joule heating. The startup of the melter was then a three-step process. First, a slow, controlled heatup of the melter was accomplished using five resistance-type "startup" heaters. A slow temperature ramp was required in order to drive residual moisture from the melter refractory without damaging the refractory. Once a steady internal temperature of approximately 1,050°C was obtained, frit was added to the melter plenum. Frit is basically tiny glass beads of the same composition as the WVDP test glass. As the frit becomes molten, more frit is added until molten glass is covering the bottom and side melter electrodes. Finally, power is applied to the melter electrodes to establish current flow and joule heating. With joule heating established and the molten glass temperature controlled, the temporary startup heaters are secured, removed, and the melter is reconfigured with jumpers for normal operation.

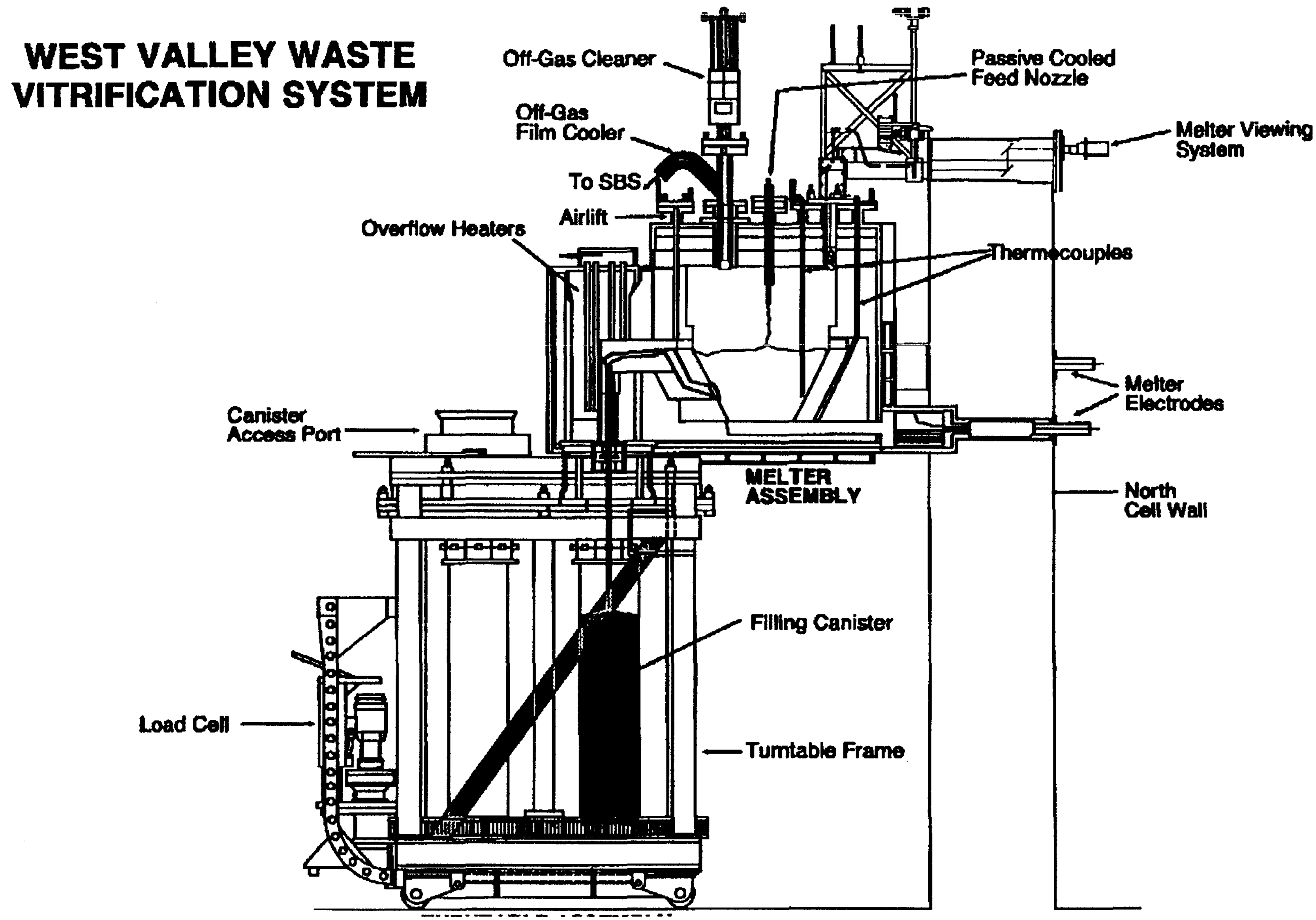
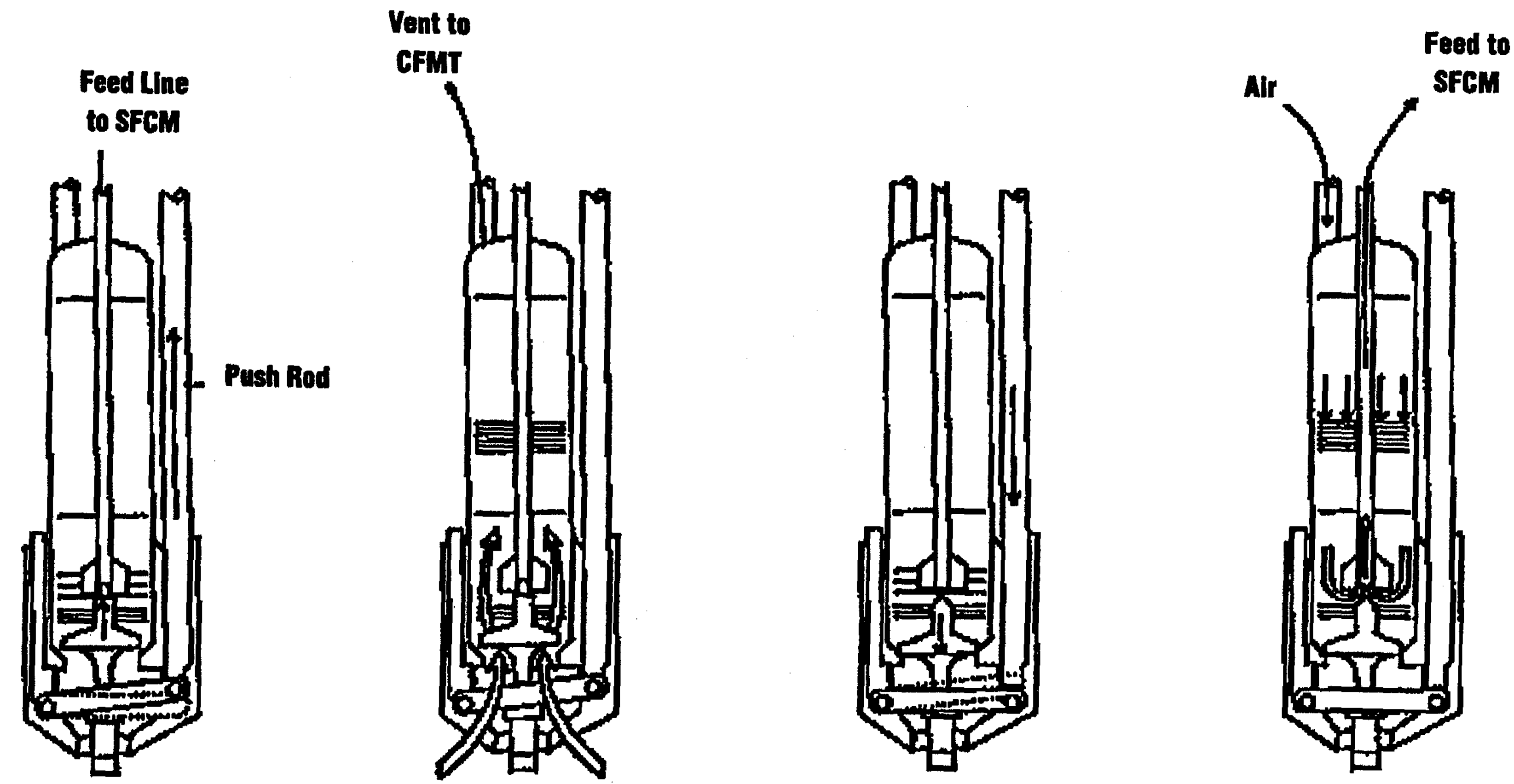


Figure-2 5. Melter/Turntable



Cycle 1

Push Rod moves poppet (Check Valve to the Up Position, thus opening the Chmaber to CFMT & closing the Feed Line to SFCM.

Cycle 2

Slurry in CFMT enters and fills the Chamber. Air is vented back into the CFMT.

Cycle 3

Push Rod moves Poppet to the Down position, thus closing Chamber to CFMT & opening Feed Line to SFCM.

Cycle 4

Air pressure, whcih is controlled by the Micro Processor, enters the Chamber and forces the slurry up the Feed Line to the SFCM.

Figure 2-6. ADS Pump Cycles

When frit addition was first initiated, in the beginning of August 1995, the melter startup heaters failed due to a buildup of frit dust on the heating elements. Frit addition was initially made using a hopper and an auger to convey the frit into the melter. The auger tended to grind the glass beads, producing undesirable amounts of frit dust. Subsequent frit additions were made without the use of the hopper/auger assembly while heaters were not installed in the melters. No further difficulties associated with frit dust were encountered. During heater replacement, degradation of the alumina nozzle liners was observed. Broken pieces of liner were observed in the glass pool. The melter was allowed to cool and the liner fragments were removed from the glass pool. A series of analyses were performed to determine the cause of the fractures and the necessary repair.

Some of the melter nozzles on the original FACTS melter had severely corroded due to sodium and sulfur vapors. Replaceable, highly corrosion resistant alumina liners were designed and built into the production melter to protect the melter nozzles and lid from corrosion. Although alumina is resistant to corrosion, it is prone to crack from thermal stress (possibly from the initial melter heatup) and/or material stress (due to jumper placement during melter reconfiguration). The decision was made to replace the alumina liners with Inconel™ 690. However, with Inconel™ it was necessary to ensure that the conditions necessary for sulfidation corrosion were not present.

Nozzle liners provide protection between the nozzle walls and the melter inserts (i.e., thermowells, plugs, film cooler, etc.). If the liners corrode, vapors can pass through to the melter lid and condense. Sulfidation of the melter lid over time could occur if the lid or nozzle temperatures were between 600°C and 900°C. Lid/nozzle temperatures in this range are feasible as the nominal operating temperature of the melter plenum ranges from 400°C to 1,150°C. A heat transfer analysis was done for the melter nozzles and liners to obtain predicted temperatures for the lid. The predicted temperatures ranged between 170°C and 420°C. To verify the analysis, thermocouple measurements were taken at several points on the melter. The temperatures observed were well below those predicted by the analysis. Nozzle repair was completed in late August 1995. Shortly after that, melter heatup was accomplished and joule heating was initiated.

Once joule heating was established, the melter was operated to fill one complete canister. This testing was referred to as the 'Frit Run', since frit was periodically added to the melter in lieu of slurry feeding. The Frit Run allowed for testing the melter under normal operating conditions while final construction and (initial) testing of the ex-cell off-gas system was being completed. Operation of the melter using frit did not produce NOx-laden melter off-gases. The frit addition method was used to fill one complete canister and perform initial performance testing of the melter airlift, melter plenum viewer, ILDS, turntable load cells, and various melter cooling systems. See table 2-3 for a brief summary of the melter performance testing.

Table 2-3. Melter and Turntable Performance Testing Summary

Test	Test Objectives Achieved
WVNS-TIP-061, Melter Frit Run Testing	Established joule heating of the melter.
	Demonstrated proper operation of the melter airlift to fill a canister between 90% and 95% full.
	Demonstrated the ability to cool the melter electrodes, east trough, and dam with air, and the melter exterior with water at normal operating temperatures.
	Demonstrated the ability to adequately monitor the glass pour stream (and detect erratic pours).
	Demonstrated the ability of the ILDS to provide level detection for the canister profile from 4% up to the 95% fill level.

Table 2-3. Melter and Turntable Performance Testing Summary (cont.)	
Test	Test Objectives Achieved
WVNS-TIP-061, Melter Frit Run Testing	Maintained discharge section temperature 1,050°C to 1,150°C during glass pours.
	Demonstrated that the weight of glass transferred to a canister, as determined by melter mass balance and/or turntable load cell readings, was within 200 kg of the canister weight measured after canister removal (using a dynamometer).
	Demonstrated the ability of the melter viewing system to: provide a general view across the melt surface, maintain the lenses clear during startup and idle periods, and allow for local adjustments to gain, focus, and black level to enhance melter plenum images.
	Remotely aligned the canister using the turntable to within ± 1/16".
	Demonstrated that the turntable can be rotated and a new canister aligned within a five minute period.
WVNS-TIP-075, Melter Performance Testing	Initiated feed and established steady-state feeding and periodic air lifts using approved operating procedures to produce at least one filled canister.
	Demonstrated initial baseline glass production rate of 27.5 kg-glass/hr.
	Demonstrated successful operation of the melter feed pump (ADS) including:
	1). Ability for the DCS trend screen feature to monitor pump operation and help to detect aberrant pulses (which are symptomatic of feed line pluggage) and
	2) Flushing the feed line to clear blockages while maintaining melter pressure between -0.5" w.c. and -10.0" w.c.
	Deliberately initiated the melter high-pressure interlock to demonstrate satisfactory operation of the automatic melter venting feature, film cooler response, and melter viewing system.
	Demonstrated effective methods for determining amounts of glass transferred from the melter to the canister.
WVNS-TIP-068, Performance Testing of the Canister Turntable	Remotely removed filled canisters and replaced them with empty canisters using approved operating procedures.
	Demonstrated that canister changeout operations can be performed while maintaining melter pressure within a range of -0.5" w.c and -10.0" w.c.
	Demonstrated satisfactory remote operation (seating and unseating) of the east and west bellows assemblies.
	Demonstrated effective seating of the canister adapter flanges in the event of a high-vacuum condition in the melter.

WVNS-TIP-075 initiated slurry feed to the melter in late September 1995. This marked the beginning of fully integrated operations (IO #1). Testing during IO #1 focused on melter operation. Melter feed was started, secured, and restarted numerous times to observe the impact on the melter plenum viewer, film cooler, and film cooler cleaner. The slurry feed line was deliberately clogged in order to test the effectiveness for detecting blockage and using flushing to clear the blockage. The melter was operated at steady-state feeding in order to produce one filled canister. A glass production rate of 27.5 kg/hour was obtained. Finally, a high-pressure condition in the melter (greater than -0.1" w.c.) was created to test the system response to the melter high-pressure interlock, where the melter is automatically vented directly to the vessel ventilation header.

Melter pressure fluctuations were experienced throughout integrated testing. Operating experience and troubleshooting provided solutions to pressure control including the following:

- Addition of a digital filter to the melter pressure control loop.
- Adjustments to the hardware controlling air injection to the melter to make the system more responsive.
- Redesigned turntable seals to limit air in-leakage from the turntable.
- Addition of a flow-restricting orifice to the pressure equalization jumper that essentially connects the main melter cavity to the turntable plenum.
- A software interlock created to prevent simultaneous automatic air blowdowns of the MFHT and CFMT bubbler assemblies.

During the course of integrated melter operations, some difficulties were encountered with cycling the film cooler cleaner up and down. Successful performance was restored following some minor design changes to the pneumatic air lines and reducing the size of the internal brush.

As melter feeding and glass production continued in support of the subsequent IOs, irregular glass pour streams were observed. At one point, the melter discharge port was completely blocked leading to glass buildup in the discharge cavity that had to be cleared using manual tools. In mid-November, a visual examination revealed evidence of glass migration through the refractory wall that separates the melter main cavity from the discharge cavity (see figure 2-7). Glass had been slowly draining to the (cooler) discharge port where it accumulated sufficiently to interfere with the normal glass pour stream. Testing activities were halted for extensive examination and subsequent repair of the melter.

The melter has two discharge chambers: the west chamber, used for production; and the east chamber, an installed spare. Examination of the west chamber revealed the following: the trough was slightly displaced outward and rotated downward roughly two degrees; seal welds joining the trough to the dam had failed and the dam had bowed outward leaving a gap between the dam and the melter chamber. Inspection of the east discharge chamber showed no trough displacement, weld failure, or dam distortion.

Analyses of all critical data confirmed that trough displacement, weld failure, and dam distortion in the west discharge chamber had been caused by a combination of factors: high temperature, thermal expansion at large temperature differentials, restraint that prevented expansion, lack of proper trough reinforcement, and the presence of residual weld stresses due to the melter heatup rate.

A repair plan was developed and implemented that both corrected and improved the design of the discharge chambers. Weld repair included increasing weld size, adding a weld to the bottom of each trough, and using a weld procedure specifically developed to reduce distortion and stress during the weld process. Reinforcement repair involved adding two gussets (outer and inner) to both discharge troughs. It also added an expansion joint made of fiberboard layers to the top of the dam to allow expansion of the dam and hence reduce stress. Refractory modification involved using a stack a six keystone-shaped bricks placed on top of a rectangular-shaped brick to provide greater structural support for the trough.

A series of computer thermal and stress analyses were done at the Westinghouse Science and Technology Center in Pittsburgh, PA to confirm the repair plan. Determinations were made to confirm that sufficient expansion space was provided and that time must be allowed for thermal stress relief during melter heatup. The original melter heatup curve was based on refractory concerns. Based on evaluations of the thermal and stress analyses, adjustments were made to the heatup curve to allow time for creep and stress relief in the melter dam to occur.

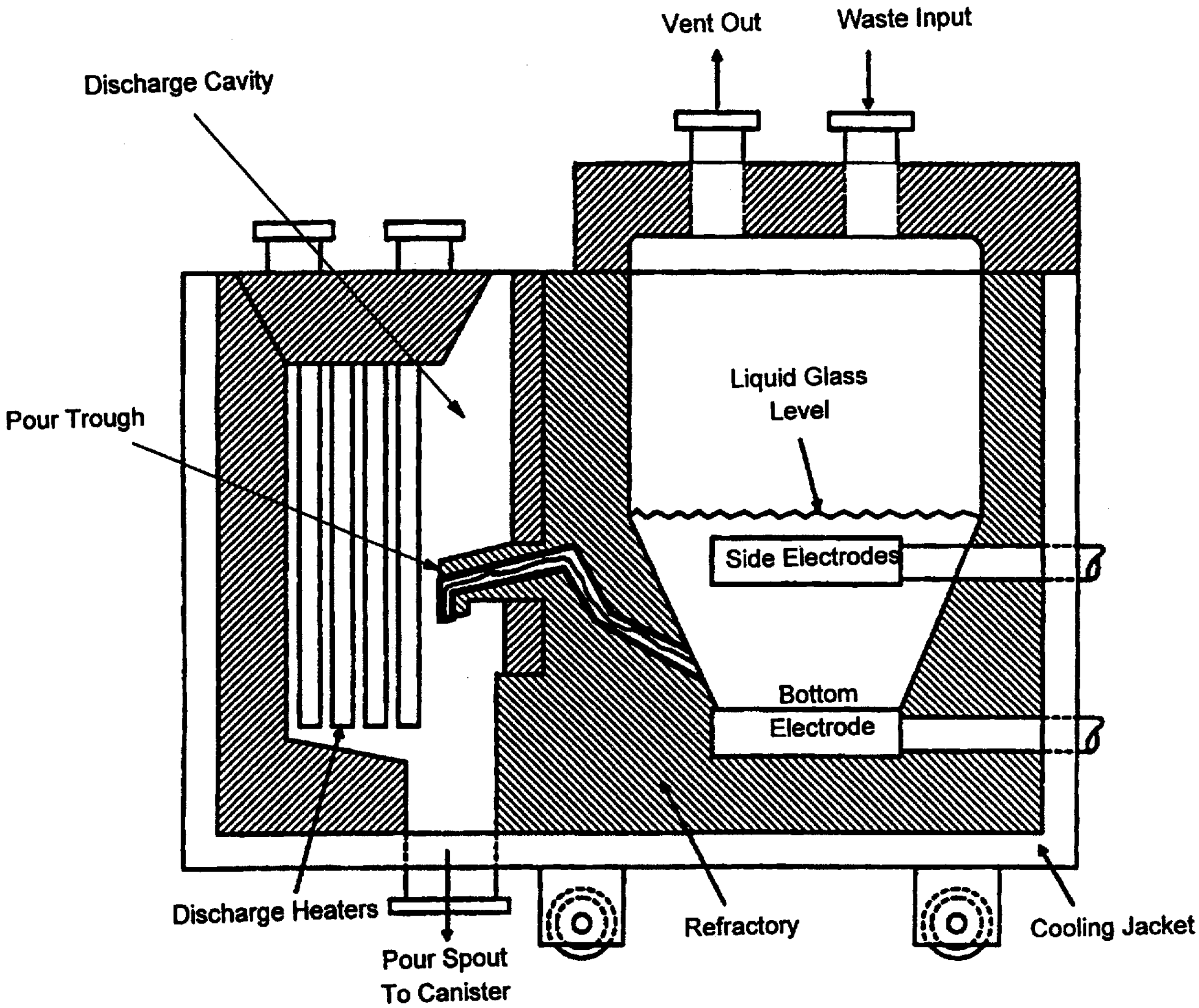


Figure 2-7. Melter Section View

Melter restart activities began in mid-February 1996. Melter startup heaters were again used to heatup the melter (and glass inventory) to the point where joule heating could be established. This demonstrated the ability to restart a melter filled with cold, solidified glass using normal startup heaters. During the restart, a pinhole-sized leak was discovered in a melter cooling jacket weld. Restart continued following an extensive weld inspection and weld repair of the leak. With the melter again operating, IO #4 was performed to retest the melter modifications and complete turntable performance testing.

2.6 Canister Turntable

2.6.1 Canister Turntable Functions

The canister turntable has several basic functions: 1) To permit inloading and outloading of production canisters. The load-in/load-out port and its associated components allow for loading canisters into and out of the turntable. The load-in port cover must be remotely removed and reinstalled each time a canister is loaded or off-loaded. 2) To provide a means to continuously monitor the amount of glass being transferred from the melter to a canister. Load cell platforms are provided to continuously monitor canister weight. Canister fill level is also continuously monitored using an ILDS. 3) To provide a mechanism by which filled canisters are moved out from under the melter pour trough and empty canisters are moved into position for filling. The canister turntable is a four-position, open support structure consisting of a stationary frame and a rotating frame. The upper, stationary portion of the turntable is sealed to the melter discharge chamber (see figures 2-5 and 2-8), while the rotary portion is driven by a 2 hp motor and drive assembly to position an empty canister under the melter pour spout for filling while allowing filled canisters to cool prior to removal. 4) To provide a limited sealed system through which glass is poured. Flange adapter seals, which seal under their own weight, provide a vacuum seal between the canisters and the turntable. These seals must be removed and reinstalled remotely into the turntable each time a filled canister is replaced with an empty one. All these turntable components - load-in/load-out port mechanisms, drive motor, load platforms, flange adapter seals, and ILDS camera - must be remotely maintained.

2.6.2 Testing

The primary operational functions of the turntable components were tested independently of one another and as an integral assembly during the commissioning test period. In addition, during commissioning testing, the remotability aspects of each of the various support features of the turntable were heavily tested. Integrated performance testing focused on the ability to maintain the turntable and melter vacuum under normal pressure and temperature conditions associated with glass-pouring operations. See table 2-3 for a brief summary of turntable performance testing.

During testing, all turntable functions were controlled from the middle East Operating Aisle of the VF. In addition, the remote crane consoles and the in-cell closed circuit television (CCTV) cameras were used to position and manipulate the crane just as they would be moved during normal operations. These tests uncovered several system shortcomings that required redesign and/or modification.

The existing CCTV network did not have adequate coverage to support several turntable functional and remotability operations. As a result of this finding, a portable remote camera was added to the compliment of CCTV cameras. This not only proved to be a solution to the turntable problem, but has proven to be valuable in performing other remote operations as well.

The seal material used in the adapter flange seal assemblies could not withstand the temperatures generated at the canister flange during filling. This led to a redesigned adapter flange assembly incorporating an alternate seal material capable of withstanding the high temperatures experienced.

During the remote removal and replacement of load platforms, it was found that the crane hook could not engage on the canister pedestal (which must be removed prior to load platform removal). The canister pedestals were subsequently redesigned, modified, and retested to demonstrate remote handling capability.

During glass-making operations, air flow from the turntable into the melter discharge chamber was great enough to cause irregularities with the glass pourstream. An orifice was installed in the pressure equalization jumper that connects the melter discharge section to the melter cavity. The reduction in air flow due to the orifice, combined with modifications to the flange adapter seal and load-in cover seal, eliminated the pourstream irregularities.

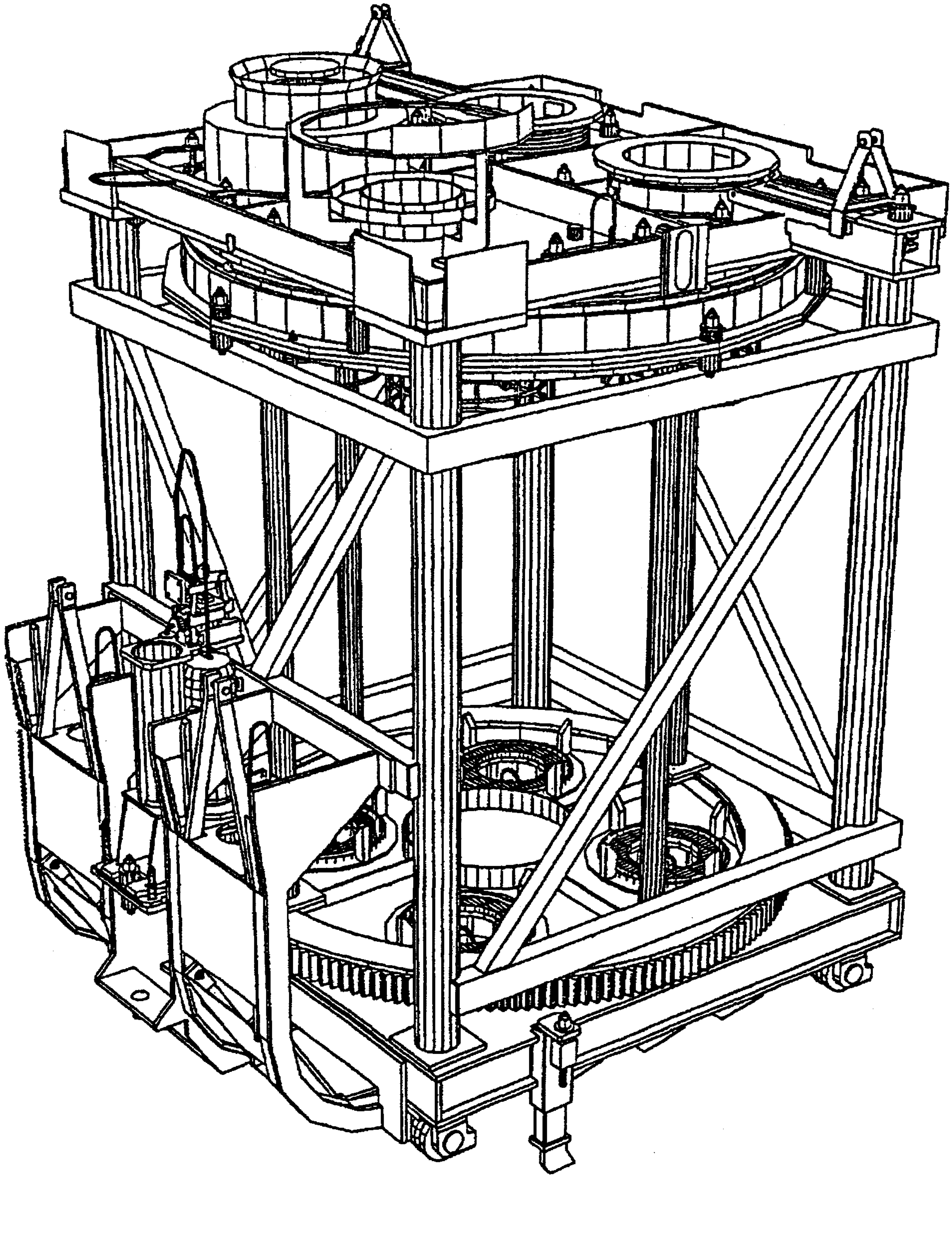


Figure 2-8. Turntable Schematic

2.7 Canister Welding Station

2.7.1 Weld Station Functions

The canister lid welding station remotely welds a stainless steel lid onto a canister flange after the filled canister is removed from the turntable. Prior to welding, glass fill height of the canister is measured and shards from the top surface of the glass are collected for archiving and/or subsequent sample analysis of glass composition. The weld station has two canister holding compartments - one for welding and one for backup canister storage. The remote weld head consists of a guide rack and support ring, carriage drive unit, torch, and cable assembly. All weld head controls are managed through a welder control console located outside the cell. Weld acceptability is determined by weld process control and remote visual inspection (see figure 2-9).

2.7.2 Testing

Prior to installation of the weld station in the Vitrification Process Cell, the canister lid welder had gone through extensive developmental and qualification testing, both at the vendor and at WVNS. Developmental testing was performed to evaluate different set points for welder operating parameters, based on resulting weld quality. Near the end of developmental testing, five canisters, which had been welded using the newly developed weld parameters, were drop-tested to demonstrate compliance with the Waste Compliance Plan. Each canister met helium leak-tests before and after drop-testing. Canister lids were also evaluated by burst- and metallographic-testing to determine compliance with the requirements.

Once installed in the Vitrification Facility, performance testing demonstrated the ability to successfully measure canister fill height, obtain shard samples, and weld a canister lid - including visual inspection and subsequent acceptance of the weld. See table 2-4 for a brief summary of performance testing. While performance testing involved welding only one canister, subsequent integrated system operations encompassed numerous canister lid welding evolutions for operator training and proficiency, demonstrating continued successful weld station performance. Also, continued canister welding evolutions refined remote lid handling and weld inspection methodology.

2.8 Canister Decontamination Station

2.8.1 Canister Decontamination Station Functions

After a lid has been welded to the canister, the canister is placed in the canister decontamination station where it is submerged in a nitric acid-cerium (+4) solution to etch off a thin layer of the canister's exterior. This layer contains sub-micron particles of fixed contaminants in the oxide layer. The station has two tanks; one to contain the canister and decontamination solution and the other to accept and neutralize the spent decontamination solution. The canister decontamination tank (CDT) has an internal heating/cooling coil, a sparge ring for solution agitation, a spray ring for removal of residual solution from the canister, and a bubbler assembly for level indication. The neutralizer tank is equipped with an eductor-type sampler, a bubbler assembly for level indication, a sparge ring, and a steam jet to transfer the neutralized decontamination solution to the SBS for recycling back into the feed preparation process. The neutralizer tank is maintained under a vacuum (nominal -5" w.c) via connection to the vessel vent header (see figure 2-10).

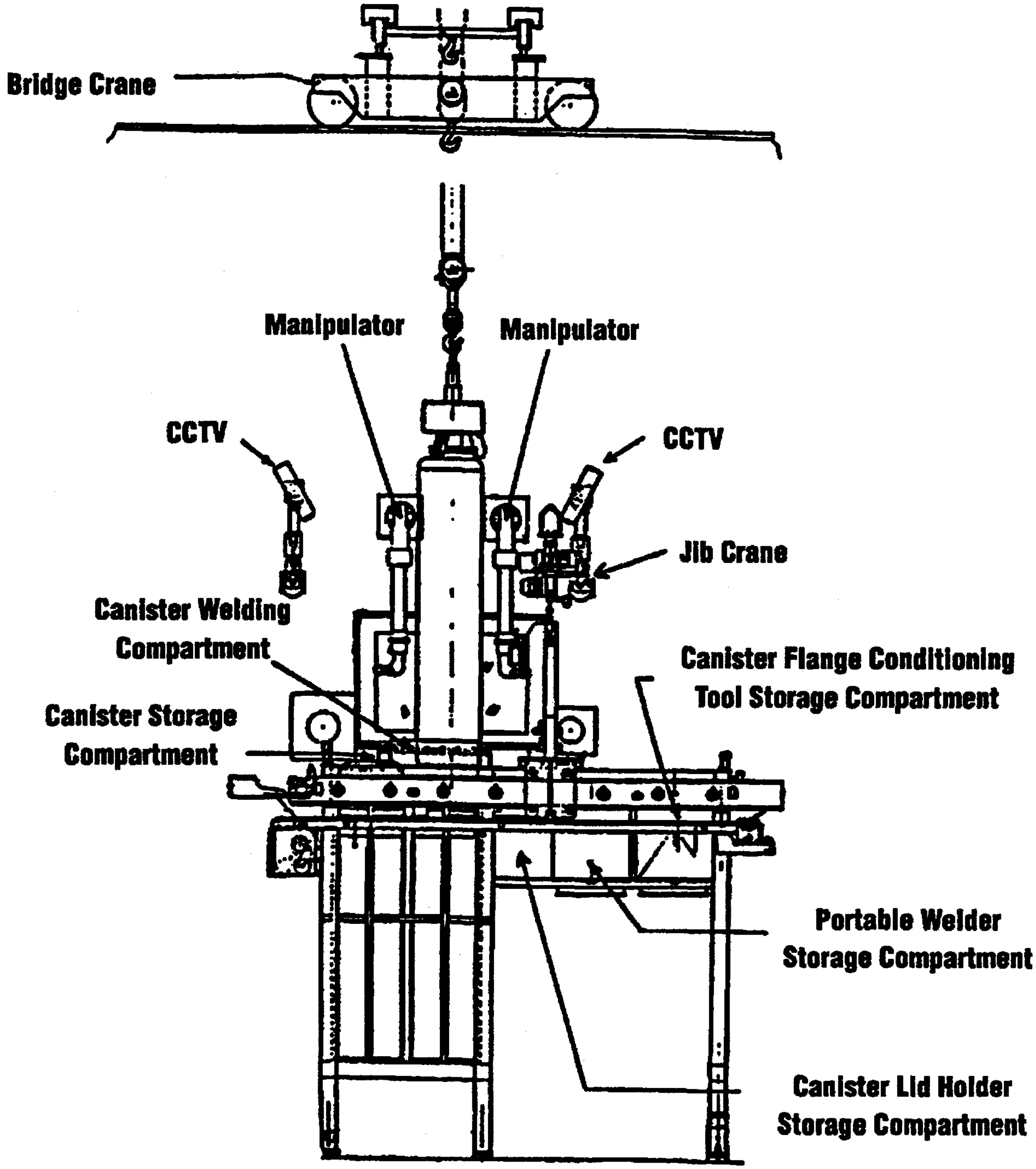


Figure 2-9. Canister Weld Station

Table 2-4: Weld Station Performance Testing Summary	
Test	Test Objectives Achieved
WVNS-TIP-077, Shard Sampler and Glass Depth Performance Test	Demonstrated satisfactory operation of the shard sampler vacuum pickup assembly to collect glass shards and deposit them in sample vials in order to fill three vials greater than 1/3 full.
	Verified that an operator can read the canister fill height scale to within 1/4".
	Used approved operating procedures and remote handling equipment to successfully transfer shard sample vials from the weld station to the sample transfer cell via the slurry sample station.
WVNS-TIP-079, Canister Welder Performance Test	Successfully completed a remote canister lid weld while the cover gas supply automatically switched to backup. No deleterious change in the characteristics of the arc or of the weld was evident as a result of the switchover. Associated audible and visual alarms functioned as required.
	Successfully completed a remote canister lid weld using approved operating procedures and appropriate weld station tools for performing the weld and subsequent visual inspection of the weld.
	Identified and resolved all potential physical interferences with weld station operations.
	Verified that visual inspection of a canister weld prep area before welding and of the completed weld can be successfully performed using the remote weld station camera with normal in-cell lighting.
	Successfully completed a remote canister lid weld with air currents expected during normal system operation (i.e., HVAC fans and in-cell coolers operating).

2.8.2 Testing

Prior to final installation of the canister decontamination station and subsequent system testing, full-scale testing was accomplished in the Vitrification Test Facility (VTF) to confirm the decontamination process. Full-size, glass-filled, oxidized canisters produced during FACTS were subjected to the decontamination process and test variations were conducted to evaluate different methods for achieving a more complete cleaning process. This testing confirmed that the proposed process could be used successfully by altering several aspects of the proposed process, including adding a nitric acid rinse prior to the final water rinse, increasing the cerium concentration used in the process, and specifying a finer surface finish for the canisters.

Following installation of the decontamination station in the Vitrification Process Cell, components were commissioned and the two tanks were volume calibrated in preparation for system performance testing. In WVNS-TIP-066, Canister Decontamination System Performance Test, all testing of the canister decontamination system was accomplished using water to simulate all decontamination chemicals. Using approved operating procedures, all aspects of canister decontamination were demonstrated. Simulated nitric acid solution was prepared in the cold chemical facility and transferred to VF Nitric Acid Hold Tank, 63-V-048. A filled, welded canister was remotely placed in the canister decontamination tank and the tank was filled with simulated decontamination solution. Decon solution was heated to the required temperature in the CDT. Difficulties were encountered with the steam heating cycle as a low coil pressure interlock would repeatedly shut down the steam supply. A low-pressure, or vacuum, condition is avoided in the steam coil to

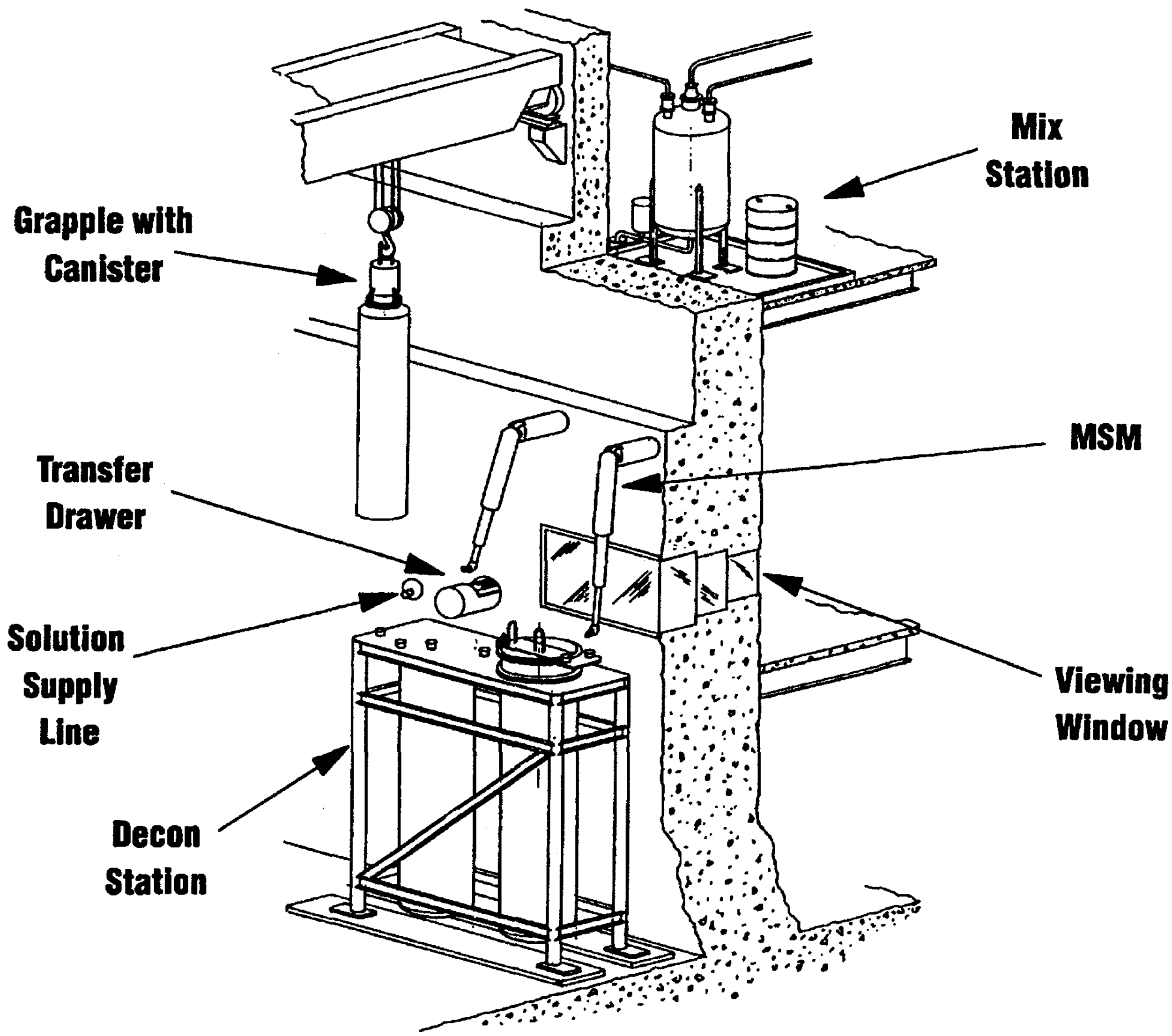


Figure 2-10. Canister Decontamination Station Arrangement

preclude any possibility that a coil leak would allow contamination into the coil (and subsequent contamination of ex-cell piping). By changing the location of the steam control valve from the inlet to the outlet of the coil, where coil pressure was sensed, sufficient back-pressure was created for the sensing unit to measure true coil pressure.

Transfers from the CDT to the neutralization tank and from the neutralization tank to the Waste Tank Farm were performed to show proper operation of Steam Jets J-4413 and J-4621, respectively. Satisfactory pressure control in the SBS and vessel vent header was demonstrated by opening the CDT lid and operating the C-sampler, an air-supplied eductor, while observing pressure changes in interfacing systems.

After performance testing was complete, numerous canister decontamination evolutions were accomplished during integrated operations. Performed for establishing operator proficiency, most of the decontamination operations were simulated with water. Chemicals (nitric acid, cerium nitrate, and hydrogen peroxide) were eventually introduced in the latter portion of integrated operations, where prototypic operation was demonstrated. Initial results showed incomplete etching of the canister surface around the bottom of the canister. The decontamination chemical recipe was subsequently modified to achieve uniform surface metal removal.

2.9 In-cell Vessel Ventilation and Off-gas Treatment System

The in-cell vessel ventilation and off-gas treatment system includes all vessels and equipment required to collect, treat, transfer, and process gases and vapors from the melter and other in-cell equipment to the off-gas treatment equipment located out of the Vitrification Process Cell (see figures 2-11 and 2-12). Redundant blowers in the ex-cell off-gas treatment system provide the motive force for off-gas flow in the cell.

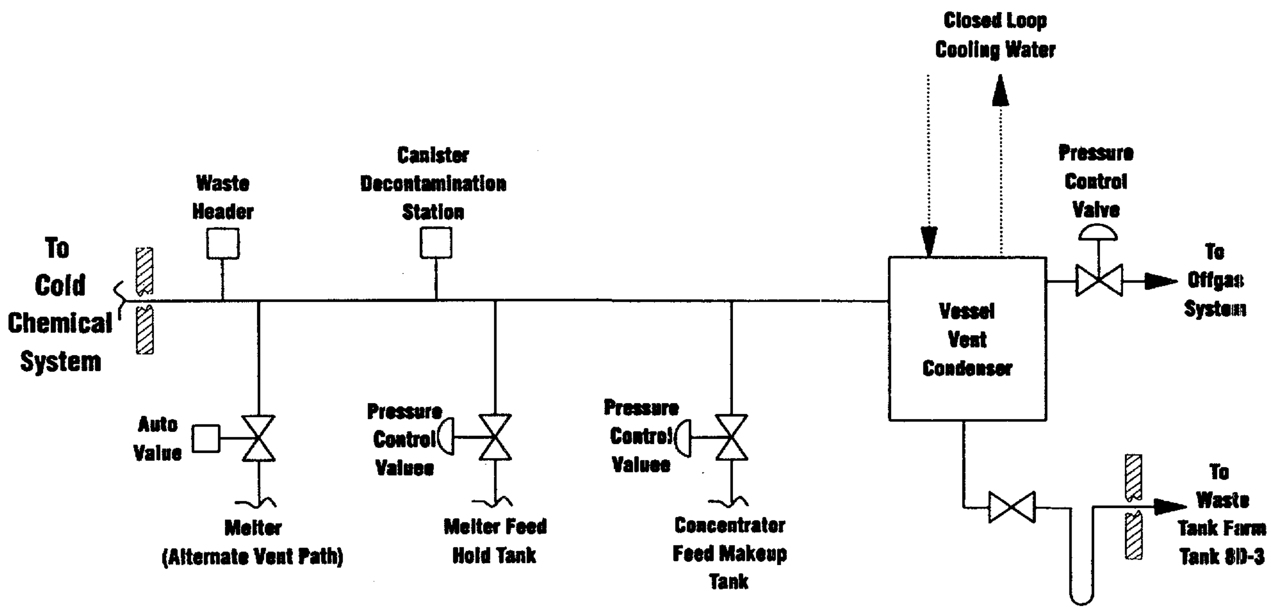


Figure 2-11. Vessel Ventilation System

2.9.1 Vessel Ventilation System functions

The vessel vent header maintains a slight vacuum on the CFMT, MFHT, waste header, and canister decontamination station by drawing gases and vapors from these process components and directing them into the off-gas system via the vessel ventilation condenser. The condenser is provided to condense steam from CFMT boiling evolutions and direct the condensate to Tank 8D-3 in the Waste Tank Farm. Gases and uncondensed vapors are directed through a jumper and pressure control valve to the in-cell off-gas treatment system. The vessel vent system is also connected to the melter plenum (through a normally closed control valve) to provide an alternate vent path should the off-gas jumper plug.

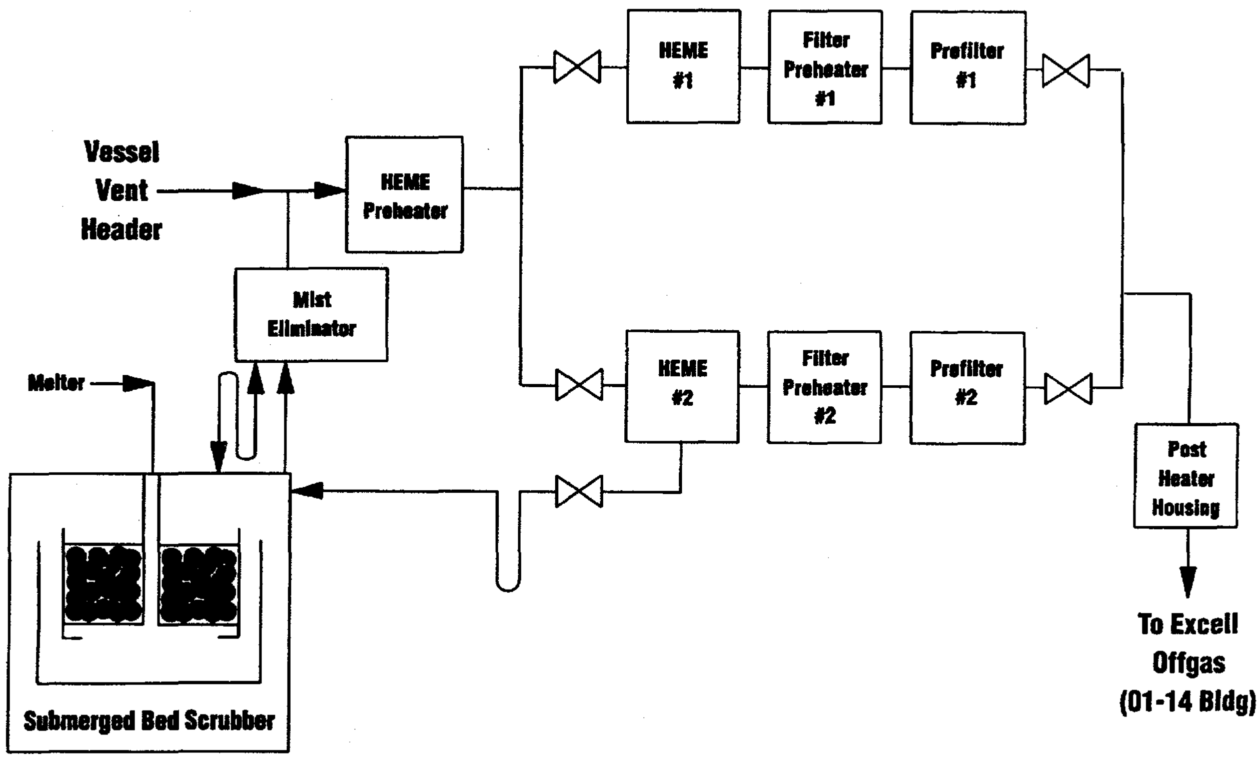


Figure 2-12. In-cell Off-gas System

2.9.2 In-cell Off-gas Treatment System Functions

Melter off-gases are first quenched and scrubbed of entrained radioactive particulate by the SBS. The SBS consists of two concentric cylindrical vessels. The inner vessel contains a scrubbing bed packed with ceramic spheres, internal cooling coils, and a bubbler assembly for level, density, and pressure indications. The outer receiving vessel has an external cooling jacket and a bubbler assembly for level, density, and pressure indications. Steam jets are provided for transferring liquid from receiver vessel to scrubber vessel, scrubber vessel to CFMT, and receiver vessel to waste header. Off-gases leave the SBS through a demister pad and preheater. This preheater is only used for maintaining off-gas temperature when switching from one operating train to the other.

The rest of the off-gas system consists of two redundant trains, each including a HEME for removal of entrained liquid droplets, a filter preheater, and a prefilter to capture dry radioactive particulate. This results in preventing significant radioactive contamination from reaching the ex-cell system where NOx abatement is accomplished. The redundant trains recombine prior to leaving the Vitrification Process Cell.

2.9.3 Testing

A temporary off-gas blower assembly was designed and installed to simulate the ex-cell, off-gas blowers. This allowed in-cell performance testing to progress in parallel with final construction and commissioning of the ex-cell, off-gas system. Performance testing involved demonstrating SBS capabilities to quench and cool melter off-gases, vessel vent header vacuum control, steam jet operation, and SBS sampling capabilities using an eductor-type remote sampling device (C-sampler). Testing was also accomplished to demonstrate the ability to perform routine remote maintenance on the system, including switching off-gas trains and in-cell filter replacement. See table 2-5 for a brief summary of performance testing. While table 2-5 lists those performance tests directly involved with the in-cell off-gas and vessel ventilation system, most of the tests associated with the interfacing in-cell systems included activities to test the performance of the off-gas and vessel ventilation system to control pressure on all affected in-cell vessels during various process evolutions. Vessel vent header and vessel (CFMT and MFHT) pressures are controlled below cell pressure by means of pressure control valves. During initial testing, vessel vacuums experienced undesirable transients leading to higher than nominal vacuums (i.e., -15" w.c. instead of -5" w.c.). Pressure control valves were unresponsive and stiff. Addition of volume boosters improved performance by doubling the volume of instrument air delivered to the valves positioners.

The in-cell flow element, FE/FE-3916, for sensing off-gas flow prior to the exiting Vitrification Process Cell, proved unreliable. After repeated troubleshooting attempts, this flow sensor was removed and all off-gas, flow-related operating logic was modified to rely on Off-gas Flow Element FE/FT-6003, located in the 01-14 Building. Subsequent testing proved the modification to be successful.

Table 2-5:In-cell Off-gas And Vessel Ventilation System Performance Testing Summary

Test	Test Objectives Achieved
WVNS-TIP-038, Vessel Vent System Vacuum Control Performance Test	Maintained acceptable vessel vent header pressure bands at varied nominal vacuum control setpoints.
	Maintained acceptable vacuum in the CFMT while boiling at varied evaporation rates, up to and including the maximum expected evaporation rate, and varied vessel vent condenser condensate outlet temperature.
WVNS-TIP-055, Submerged Bed Scrubber (SBS) Performance Test	Verified the ability of the SBS to quench melter off-gases, both with melter idle and while feeding, to less than 45°C and maintain scrubber solution below that temperature.
	Demonstrated that SBS cooling can cool condensate and decontamination solutions from 50°C to less than 40°C in less than 4 hours.
	Demonstrated operation of Steam Jet J-3124 to transfers SBS solution to the Waste Tank Farm, including proper control logic for air purging the jet piping to preclude steam collapse and subsequent vacuum formation.
WVNS-TIP-056, "C" Sampler Performance Test	Operated the remote "C" sampler, using approved operating procedures, to successfully draw liquid samples from the SBS and the canister decontamination station neutralization tank.
	Verified that "C" sampler operation does not adversely affect vessel vacuum control.
WVNS-TIP-060, Vessel Vent and Off-gas System - Corrective Maintenance and Operational Test	Used the CCTV system, crane, impact wrench, and approved operating procedures to switch redundant off-gas trains by remote manipulation of in-cell manual valves.
	Used the CCTV system, crane, impact wrench, and approved operating procedures to remotely remove and reinstall prefilter assemblies.

Table 2-5:In-cell Off-gas And Vessel Ventilation System Performance Testing Summary (cont.)

Test	Test Objectives Achieved
	Verified proper concurrent operation of the vessel vent system and SBS based upon satisfactory differential pressure readings across the in-service prefilter assemblies during integrated system operation. Verified no water condensation in the prefilter assemblies during integrated system operation.

The SBS had been redesigned since FACTS testing. However, to assure that the process SBS vessel would provide the same particulate removal efficiency as the FACTS SBS, the critical geometric parameters were retained. These included the diameter of the off-gas downcomer, the location of the off-gases delivered beneath the bed, the depth and diameter of the bed, the packing used in the bed within the scrubber vessel, and the location of the bed within the scrubber vessel. A solids suspension system, designed to mobilize and center solids in the receiver tank for subsequent removal by jetting, was incorporated into the new SBS design. Developmental testing of solids mobilization and transfer was conducted at the Westinghouse Science and Technology Center using full-scale equipment as well as sludge accumulated in the original SBS during FACTS testing. This testing demonstrated the capability for removing essentially all the solids, leaving no more than 2 gallons of solution in the SBS receiver.

2.10 Ex-cell Off-gas Treatment System

The ex-cell off-gas treatment system supplies the motive force to maintain the in-cell vitrification process equipment at a slight vacuum relative to ambient cell pressure for contamination control purposes. It also provides atmospheric protection by destroying acidic oxides of nitrogen (NOx) and removing radioactive particulate that escapes the in-cell off-gas treatment system.

2.10.1 HEPA Filtration

The off-gas stream leaves the Vitrification Facility through a heated trench and then enters the ex-cell off-gas treatment system where it passes through HEPA filters. There are two redundant trains (one is an installed backup), each containing an electric reheater prior to the dual HEPA filter elements to elevate the gas temperature above its dewpoint (see figure 2-13).

2.10.2 Motivation

Following filtration, the off-gas passes through an off-gas blower. There are three blowers installed in parallel - one operating, the others providing reliable, independent backup. The blower suction header has an air in-bleed and pressure control valve to provide pressure control as the blowers operate at a constant speed (to produce a nominal 1,300 acfm discharge airflow). See figure 2-14.

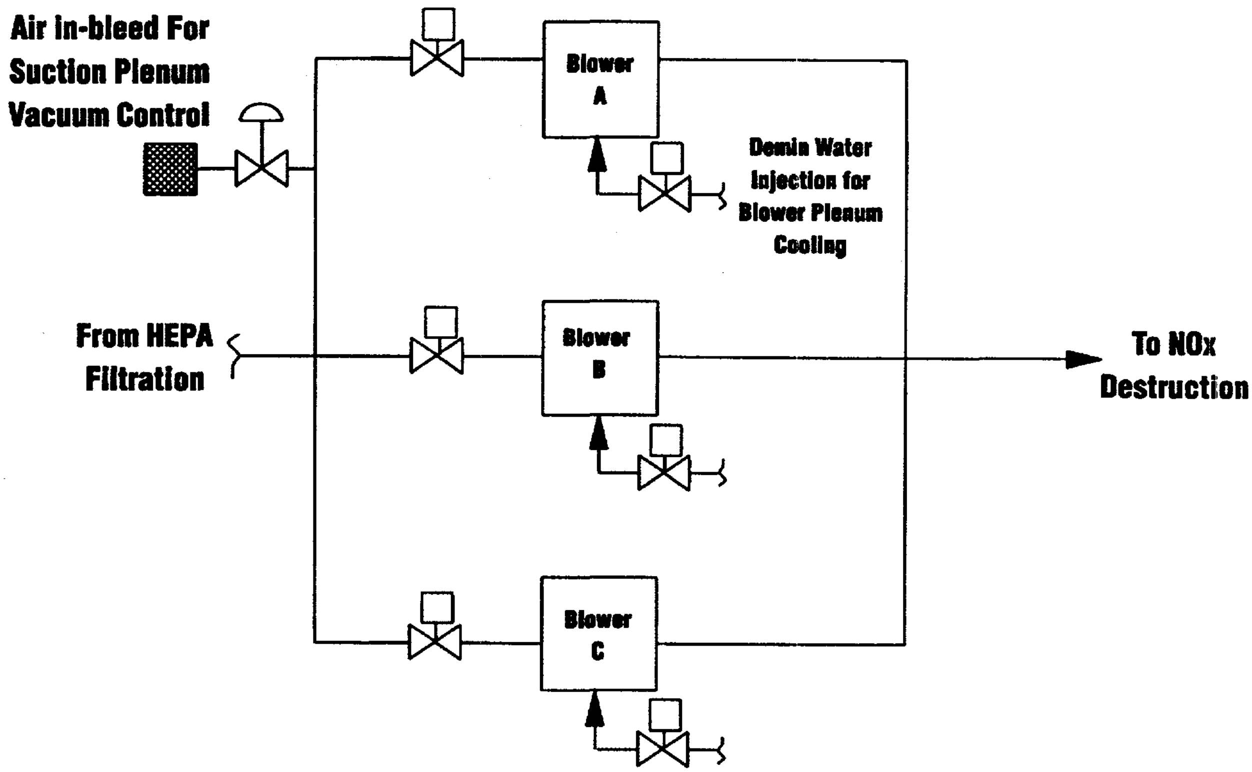


Figure 2-13. Ex-cell Off-gas HEPA Filtration

2.10.3 NOx Destruction

After the blower, the off-gas passes through the NOx abatement equipment. NOx abatement is accomplished by selective catalytic reduction of the NOx gases with ammonia to produce nitrogen, oxygen, and water vapor. The NOx destruction equipment includes redundant off-gas preheaters to increase the off-gas temperature to promote the desired reaction, an ammonia supply system to provide the reactant, and redundant catalytic converters to accelerate the reaction. Four analyzers are used to monitor NOx and ammonia levels. One infrared NOx analyzer is connected upstream of the converters while an infrared NOx analyzer and an infrared ammonia analyzer are connected downstream of the converters. One spare chemiluminescent analyzer is available to sample for NOx either upstream or downstream of the converters (see figure 2-15).

2.10.4 Testing

Performance testing in the ex-cell off-gas system addressed three major aspects of the system: HEPA filtration testing; blower functional and interlock testing; and NOx abatement performance. See table 2-6 for a brief summary of performance testing.

Each redundant train contains two filter elements in series. All four elements were tested with dioctyl phthalate (DOP) not only to prove filter efficiency, but also to field validate the DOP testing procedure. During this testing, the off-gas reheaters were not available for operation. This led to significant moisturecondensation and collection occurring in the filter housings. As a result, modifications were madetothe filter housing to allow draining of the housings, should condensation occur under normal operating conditions.

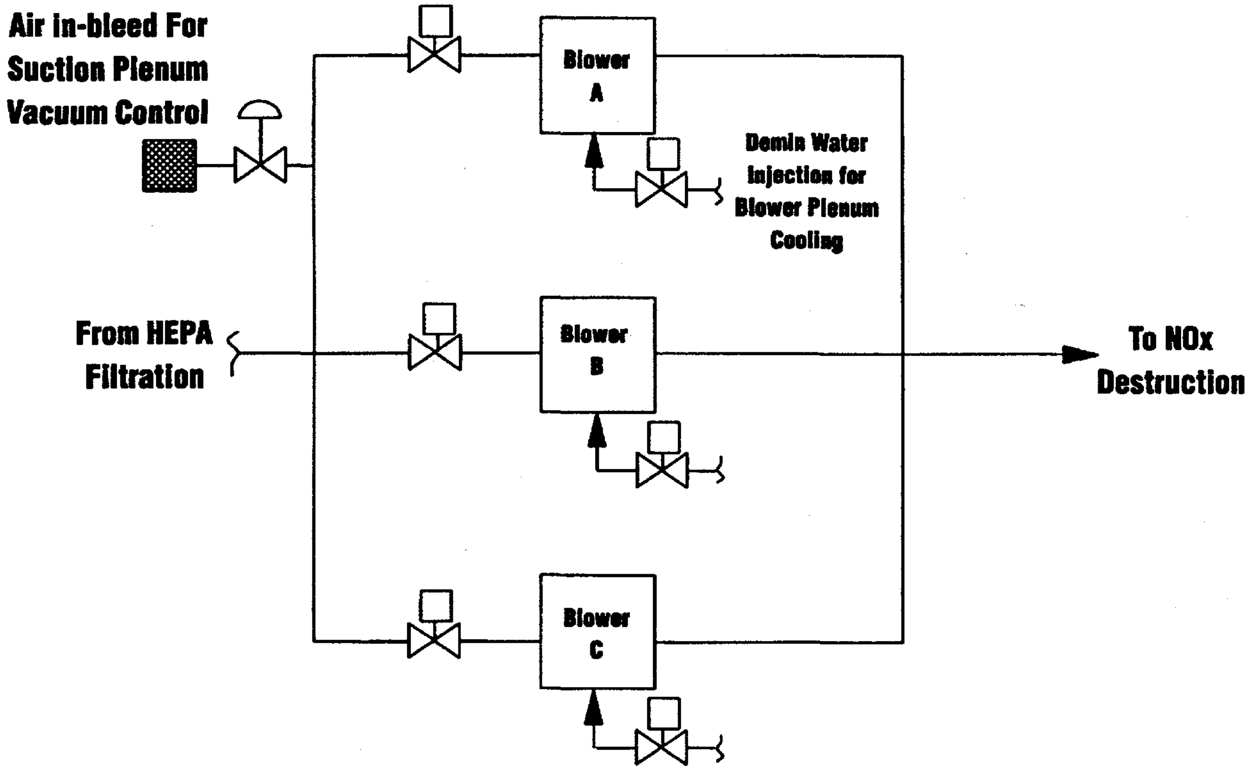


Figure 2-14. Ex-cell Off-gas Motivation

Table 2-6:Ex-cell Off-gas Treatment System Performance Testing Summary

Test	Test Objectives Achieved
WVNS-TIP-050, Ex-cell Off-gas System Blower Performance Test	Demonstrated the ability to automatically control blower suction control within 5" w.c. of the designated setpoint.
	Verified that, upon loss of normal power, a backup power source will automatically re-establish power supplies to essential instrumentation, controls, and utility services such that: 1) One of the redundant off-gas blowers automatically starts, 2) Vacuum control is re-established at the blower suction sufficient to provide control to within 5" w.c. of the designated setpoint, and 3) Off-gas flow is re-established from the Vitrification Facility to the 01-14 Building.
	Verified that upon automatic shutdown of the operating blower, due to high exit temperature interlock, one of the redundant off-gas blowers automatically starts and re-establishes blower suction vacuum to within 5" w.c. of the designated setpoint.
	Verified that upon automatic shutdown of the operating blower, due to inadequate inlet vacuum interlock, one of the redundant off-gas blowers automatically starts.
WVNS-TIP-051, Ex-cell Off-gas System HEPA Filter Performance Test	Verified the DOP aerosol collection efficiency for each HEPA filter to be no less than 99.95% by testing them in place per approved operating procedures.

Table 2-6:Ex-cell Off-gas Treatment System Performance Testing Summary (cont.)

Test	Test Objectives Achieved
WVNS-TIP-052, Ex-cell Off-gas NOx Abatement Performance Test	Demonstrated NOx emission rates of less than 2.3 kg/hr both during initiation of melter feed and during normal melter feed operations.
	Demonstrated that the temperature of the off-gas stream entering the catalytic converter can be maintained within 10°C of the preheater outlet setpoint (320°C) during initiation of feed and normal melter feed operation.
	Verified that maximum temperature reached within an operating catalytic converter during steady-state melter feeding is less than 450°C.
	Verified that ammonia slip from the converter can be controlled to less than 100 ppm during periods of maximum feed rate (associated with initiation of melter feed) and less than 50 ppm during normal melter feed operation.
	Verified that the NOx analyzers provide consistent, comparative readings based upon independent calculations.

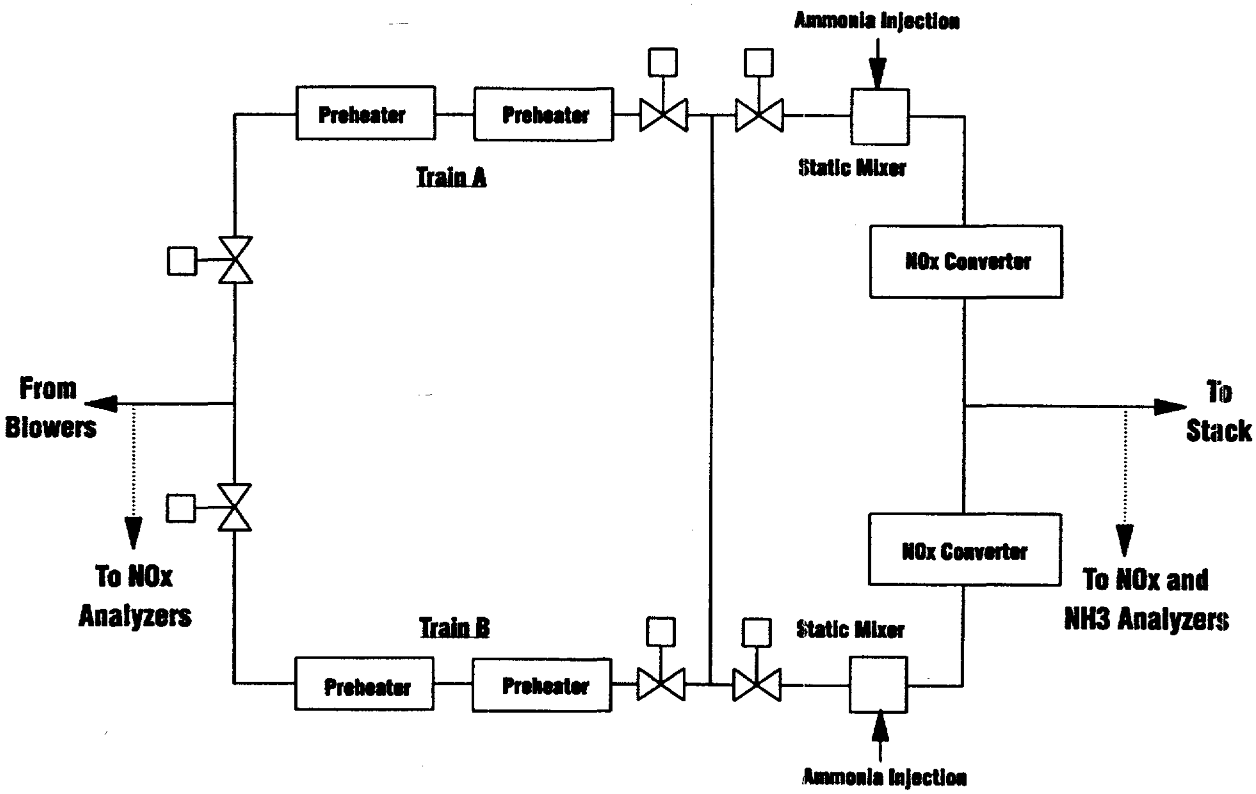


Figure 2-15. Ex-cell Off-gas NOx Destruction

Off-gas Pressure Control Valve PCV-6313, which modulates to control the amount of air in-bleed to the blower suction, did not initially appear to be as responsive as needed. This made it difficult to maintain a nominal pressure of -75" w.c., since blower plenum pressure would remain at approximately -85" w.c. even with the control valve operating in the fully open position and melter pressure control parameters at their nominal values. The screen to the outside air inlet was found to be clogged with insects. The screen was modified and blower speed was adjusted so that PCV-6313 would normally operate at the approximately 50% open position, providing greater vacuum control capability.

The selective catalytic destruction system used for NOx abatement proved itself to be functional. Testing demonstrated a steady-state (normal melter feeding) NOx release not exceeding 0.2 lb/hr. The ammonia slip - concentration of ammonia in the converter effluent - was shown to average about 6.5 ppm, much less than the 50 ppm necessary for the undesired production of ammonium nitrate.

2.11 Waste Header

2.11.1 Waste Header Functions

The waste header includes piping to collect waste liquids and slurries from various locations within the Vitrification Process Cell including the CFMT, MFHT, SBS, canister decontamination station, and any wastes that spill or drain to one of the in-cell sumps. The waste header directs liquids and slurries to Tank 8D-4 in the Waste Tank Farm. The sumps (north and south) are equipped with bubbler assemblies for level indication and steam jets for emptying the sumps. The waste header is maintained at a nominal vacuum of -3" w.c. via connection to the vessel vent header (see figure 2-16).

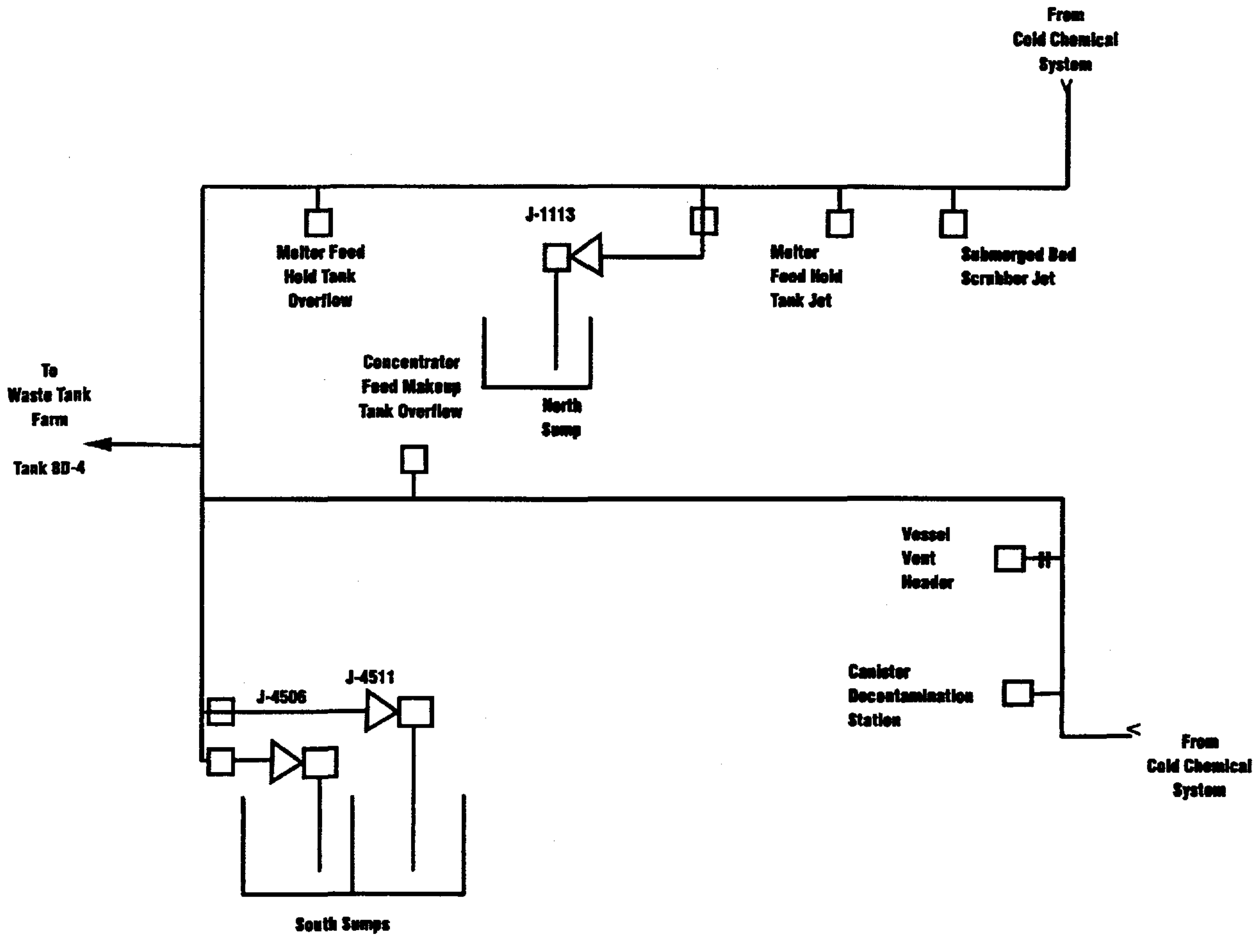


Figure 2-16. Waste header

2.11.2 Testing

The waste header system is basically a passive system and performance testing consisted of a checking the header flow capacity and sump jet operation. Testing was integrated in that vessel ventilation system operation was required to provide normal operating vacuum for the waste header.

In Waste Header Flow Capacity Test, WVNS-TIP-022, water was pumped from Cold Chemical Tank 65-D-04, via the normal header flush path, through the waste header to a temporary receiving tank in the Waste Tank Farm. Flow rates were varied from 25 g.p.m. to 75 g.p.m. while monitoring waste header pressure. No indication of header pressure increase nor evidence of fluid backup into interfacing system piping was observed. A second test was performed to observe the effects of pumping concentrated melter feed through the header. In this test, header pressurization and subsequent slurry overflow to the north sump was observed. This test, however, utilized a workaround that was not prototypical of normal waste header operation. Slurry was pumped from the CFMT with High-capacity Steam Jet J-0117 - normally used for transferring CFMT slurry to Waste Tank Farm Transfer Pit 8Q-5 - and a temporary hose/throttle valve assembly routed to a spare connection located next to the north sump jet connection on the waste header. Subsequent testing of South Sump Jet, J-4506, with concentrated slurry exhibited acceptable performance of the waste header.

WVNS-TIP-023, Waste Header Sump Jet Performance Test, demonstrated the following for North Sump Steam Jet J-1113, and South Sump Steam Jets J-4506 and J-4511:

- All jets were capable of self-priming.
- All jets exhibited proper operating control logic, including a timed air purge of the jet following the operating cycle to preclude steam collapse and subsequent vacuum-induced backflow.
- All jets provided acceptable flow rates for transferring water and unconcentrated melter feed.
- The north sump steam jet - the only sump exposed to potential overflow of concentrated feed - provided an acceptable flow rate for transferring concentrated melter feed.

2.12 Canister Movement and Remote Handling

2.12.1 Canister Handling and Movement

Several components work in conjunction to lift and transfer empty, filled, or partially filled canisters throughout the Vitrification Facility. Moving canisters within the Vitrification Process Cell and to the HLWIS is accomplished by cranes, grapples, impact wrench, and a radio-controlled transfer cart. Containing the cell and tunnel environment and permitting canister transfers between HVAC zones is accomplished using door controls to open and close shield doors. Empty canisters are transferred into the Vitrification Facility from the Load-in Facility (horizontally) through a shielded port using cranes and an upending device (see figure 2-17).

2.12.2 Remote Handling and Maintenance Functions

Cranes, the transfer cart, various tooling and fixtures, and remote manipulators are used to perform several remote handling of maintenance functions such as:

- Handling of samples
- Operation of in-cell isolation valves
- Changeout of consumables (filters, thermowells/thermocouples, melter discharge lid heaters, etc.)
- Removal and replacement of remote mechanical and electrical jumpers.

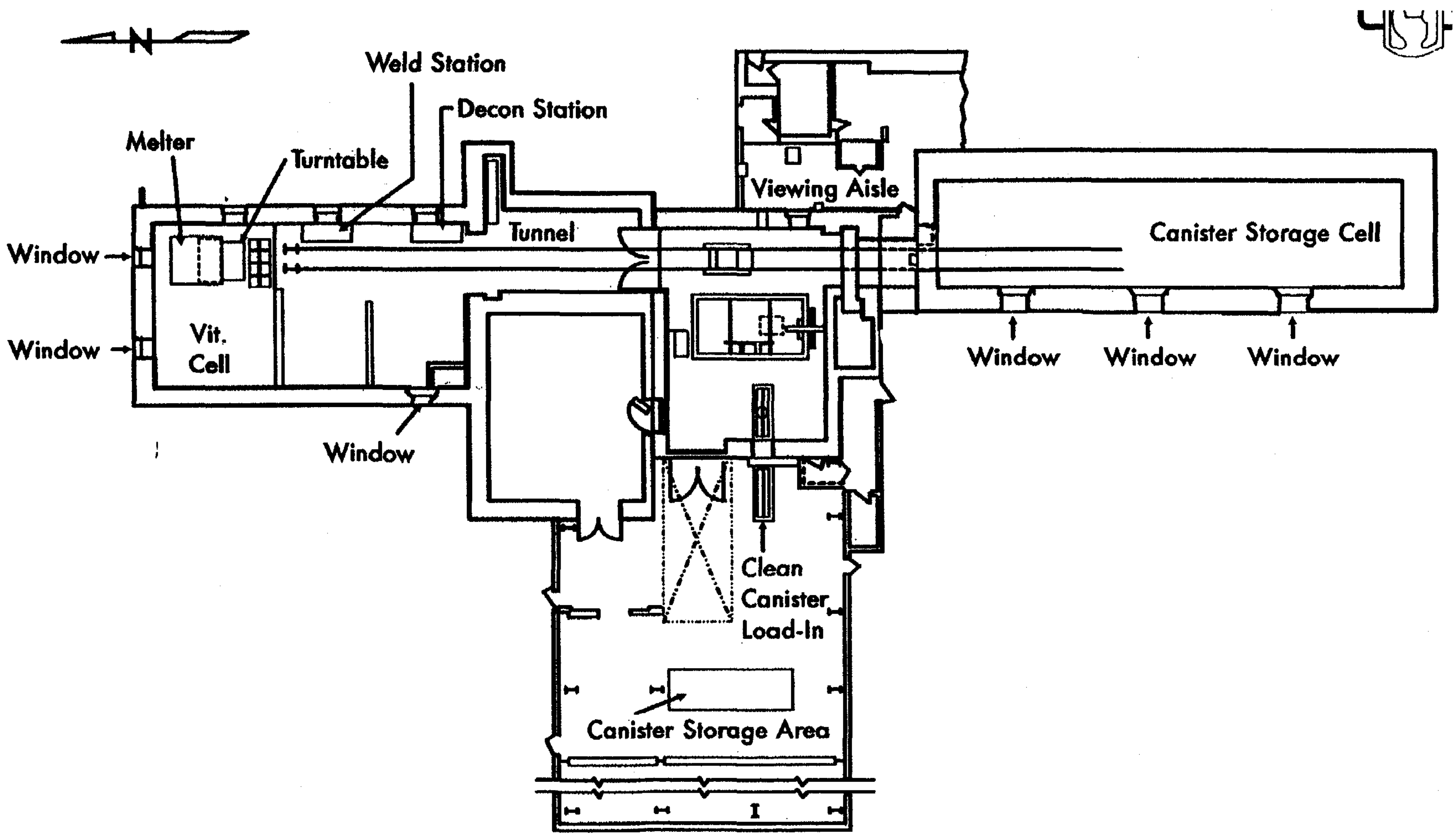


Figure 2-17. Canister Travel Path

Maintenance of most in-cell components is aided by a jumper system that uses a 3-jaw, remotely-operated connector. The remote connector is operated using an electric impact wrench suspended from a crane hook.

2.12.3 Testing

During assembly of the in-cell primary process equipment, the final installation of any remote mechanical or electrical jumper was performed "hands-off", using the crane only. Each installation was witnessed by a WVNS test engineer, in accordance with WVNS-EQL-005, Government Furnished Equipment List for WVNS-CS-139, to ensure that the jumpers exhibited satisfactory fit-up and the PUREX end connectors were ultimately accessible. These visual verifications, performed in parallel with cell construction, saved significant critical path time in the test schedule.

The in-cell cranes were tested early to verify their complete range of motion and crane hook access within the Vitrification Process Cell. Swapping of crane bridges and trolleys was demonstrated in conjunction with vendor testing and operator training.

Performance testing encompassed the functional testing of various shield doors, both manual (doors #3, #4, and #5) and remotely operated (doors #1, #2, and #8), transfer cart performance, canister loading into the EDR, and performance of expected melter maintenance (i.e., thermowell/thermocouple replacement). See table 2-7 for a brief summary of performance testing.
Initially, the Vitrification Process Cell was isolated from the EDR which is an existing, radioactively contaminated facility. The transfer cart charging location, normally established in the EDR, was temporarily established in the VF transfer tunnel, allowing initial cart testing and operation. Once the hot-tie was completed between the VF and the EDR, the charging location was moved to its final location and the cart could be operated over its full range of travel. When attempting to first operate the cart within the EDR, difficulties were experienced with radio communications between the cart and the control station. Troubleshooting led to control circuit rewiring that alleviated the problems. When the cart was first driven into the HLWIS Facility, it experienced difficulty when entering the cell. The transition rails connecting the EDR rails to the HLWIS Facility rails were subsequently removed, modified, and reinstalled. Transfer cart testing was then successfully completed.

Testing melter maintenance activities led to minor redesign of the melter discharge lid remote handling tool, the melter gasket remote handling tool, and the melter film cooler cleaner lifting bail.

Successful canister handling operations were repeatedly demonstrated during IO #5 and IO #6, where canisters were loaded, filled with glass, lid-welded, and decontaminated using remote handling equipment. IO #6 culminated with the transport of 4 filled canisters into the HLWIS Facility where they were off-loaded into storage racks.

Table 2-7: Canister Movement And Remote Handling Performance Testing Summary

Test	Test Objectives Achieved
WVNS-TIP-064, Melter Remote Maintenance Test	Demonstrated the ability to remotely changeout the melter discharge section lid.
	Demonstrated the ability to remotely maintain the melter feed jumper and off-gas jumper.
	Demonstrated the ability to remotely maintain the melter feed jumper.

Table 2-7: Canister Movement And Remote Handling Performance Testing Summary (cont.)	
Test	Test Objectives Achieved
WVNS-TIP-064, Melter Remote Maintenance Test	Demonstrated the ability to remotely maintain the melter film cooler leaner and to remotely recover a failed/stuck film cooler cleaner brush.
	Demonstrated the ability to remotely replace melter thermowells and thermocouples.
WVNS-TIP-073, Shield Door (#2) 63-M-002 Performance Test	Demonstrated that the door fully opens and closes without any discrepancies in LIFT and LOWER modes.
	Demonstrated that the door, when forced out of synchronization, has the capacity to automatically recover and function normally.
	Verified that the control system for door operation can automatically recover after power outages at various time of operation and still function normally.
	Operated the door through 20 cycles to demonstrate normal operation without discrepancies.
WVNS-TIP-082, Shield Door (#3) 63-M-003 Performance Test	Verified that the door #3 leafs align with the door frames per design drawings.
	Demonstrated that opening/closing wheels turn with minimum effort, vertical locking rods fully extend in the closed position (to lock the door), and fully contract in the open position.
Work Order 9500582, Shield Door 63-M-001 Functional Test	Demonstrated that door #8 can undergo 20 successive operations without failure.
Work Order 9500660, Shield Door 63-M-008 Functional Test	Demonstrated that door #1 can undergo 20 successive operations without failure.
Work Order 9500247, Shield Door 63-M-004 Functional Test	Verified that the door #4 leafs align with the door frames per drawings.
	Demonstrated that the opening/closing wheels turn with minimum effort, vertical locking rods fully extend in the closed position (to lock the door), and fully contract in the open position.
Work Order 9500248, Shield Door 63-M-005 Functional Test	Verified that the door #5 leafs align with the door frames per design drawings.
	Demonstrated that the opening/closing wheels turn with minimum effort, vertical locking rods fully extend in the closed position (to lock the door), and fully contract in the open position.
WVNS-TIP-084, EDR/Load-in Port Performance Test	Used approved operating procedures to stage, inspect, and load an empty canister through the load-in port from the Load-in Facility into the EDR.
	Verified proper operation of the canister tipping (upending) device in the EDR.
WVNS-TIP-085, Transfer Cart Operational Testing	Used approved operating procedures to run the transfer cart over its fully range of travel, both unloaded and loaded with ten tons of test weights.
	Demonstrated cart battery life to be roughly 21 hours.
	Verified proper operation of shield door/cart proximity interlocks.
	Demonstrated the ability to recover a stalled cart.

2.13 Electrical Distribution and Backup Power System

2.13.1 Electrical Distribution and Backup Power System Functions

Besides providing electrical power to feed the various Vitrification Facility loads, the electrical distribution system (EDS) includes an on-site standby diesel generator (SDG) and uninterruptable power supplies (UPS) to provide power to selected loads in the event that site power is lost. Four separate UPS systems supply battery-backed, regulated power to the various vitrification process control and instrumentation equipment, allowing operators to continue to monitor the process throughout a loss of site power and subsequent restoration of power. The SDG, rated at 600 kW, is designed for starting and automatically accepting either of the HVAC exhaust fans in order to maintain proper cell negative pressure. A second diesel generator - part of the existing supernatant treatment system / permanent ventilation system (STS/PVS) - is rated similarly to the VF SDG and is available to provide backup power to the melter electrodes to maintain molten glass temperatures if normal site power is lost. These diesel generators; along with two other existing diesel generators: the Utility Room diesel generator and the Utility Room expansion diesel generator; provide for a safe and orderly shutdown of the vitrification process in the event of an off-site power loss.

2.13.2 Testing

Testing focused on vitrification SDG performance and the ability to provide backup power to the HVAC system and other selected equipment. Testing also covered UPS performance, melter electrode backup power, and baseline data on electrical distribution equipment. See table 2-8 for a brief summary of performance testing.

Table 2-8: Electrical Distribution and Backup Power System Performance Testing Summary

Test	Test Objectives Achieved
WVNS-TIP-020, Standby Diesel Generator Integrated Test	Demonstrated the ability of the standby diesel generator to start under full load (600 kW) and maintain steady-state, fully loaded operation for two hours.
	Demonstrated the ability of the diesel fuel oil system to automatically deliver fuel oil to the fuel oil day tank whenever the day tank level falls below 87%.
WVNS-TIP-048, Vitrification Standby Power Test #1	Verified acceptable voltage, current, frequency, and power factor values for the standby diesel generator running with full expected load.
	Demonstrated that, upon receipt of a low-voltage signal due to loss of normal power, the standby diesel generator automatically starts and is available to accept loads within 10 seconds.
WVNS-TIP-049, Vitrification Loss-of-Power Test	Demonstrated automatic switchover capability of the 01-14 Building HVAC exhaust fans initiated by a loss of power. Verified that backup Exhaust Fan 475-101 is energized by backup power and its associated inlet damper is open following the loss of normal power.
	Demonstrated that the STS/PVS standby diesel generator starts automatically upon loss of normal power and supplies backup power to a power panel in the VF (to ultimately supply backup power to the melter electrodes).
	Demonstrated that the VF HVAC exhaust fan running prior to the site power loss will restart once its associated switchgear is energized from the standby diesel generator.

Table 2-8: Electrical Distribution and Backup Power System Performance Testing Summary (cont.)

Test	Test Objectives Achieved
WVNS-TIP-049, Vitrification Loss-of-Power Test	Demonstrated proper response of the diesel generator room inlet and exhaust dampers to loss of site power and subsequent diesel startup.
	Demonstrated proper function of outdoor air intake and exhaust dampers to provide alternate ventilation during loss of power and accompanying shutdown of the VF air supply unit.
	Verified that 01-14 stack radiation monitoring equipment functions properly without intervention through the loss of power and subsequent restoration of power by the standby diesel generator.
WVNS-TIP-074, DCS/PLC Uninterruptible Power Supply Performance Testing	Verified that steady-state voltage, current, and frequency values are within specified ranges for all four UPS units.
	Demonstrated the UPS units are capable of providing the battery power necessary to maintain 30 minutes of full-rated load following the loss of primary power source. This ensures that the Control Room continues to operate during a plant power interruption.
	Demonstrated that no interruptions of power to connected loads were experienced during testing, including manual switching between the UPS inverter (normal source) and the UPS alternate (bypass) source.
WVNS-TIP-080, Backup Power Test for Melter Electrodes	Demonstrated the ability to supply backup power to the melter electrodes (from the STS/PVS diesel generator) in less than 1 hour and prior to melter glass temperature falling below 1,000°C.
	Demonstrated the ability to maintain melter glass temperature above 1,100°C using backup power.
	Obtained data showing that melter glass temperature will decrease from 1,150°C (normal operating temperature) to 1,000°C in roughly two hours upon loss of electrode power.
WVNS-TIP-081, Utility Room Expansion Diesel Generator Load Test	Demonstrated the capability of the Utility Room expansion standby diesel generator to properly power the 01-14 HVAC fan (475-101) and NOx process blower (64-K-003B) upon loss of normal ac site power.
WVNS-TIP-086, Vitrification Electrical Distribution Capacity Testing	Demonstrate the voltage, current, and frequency values at the incoming feeders for the vitrification electrical distribution equipment are within specified ranges.
	Verified that each feeder breaker rating, trip setting, and overload heater size are within acceptable values.

Precommissioning/commissioning testing was conducted on the diesel fuel oil system control circuitry, the diesel generator autostart control circuitry, and the A1/A2 switchgear controls. These systems were verified to be operational prior to integrated testing.

The vitrification standby power diesel generator was tested to full load using a load bank. During this test the diesel fuel oil system operated automatically to maintain a constant supply of fuel to the diesel via the day tank. The phase rotation of the diesel generator output was tested prior to placing A1 and A2 switchgear loads on the diesel generator. The phase sequence was found to be incorrect, was rewired, and then retested satisfactorily. The diesel generator autostart circuitry was tested to verify that, upon a loss of power to the A1/A2 switchgear, a run request would be sent to the diesel generator.

During Vitrification Standby Power Test #1, normal supply power was interrupted and the vitrification standby diesel generator started automatically within 10 seconds. The following occurred automatically:

- Diesel Generator Room inlet and outlet dampers opened
- The vitrification process Control Room air handler restarted
- The diesel fuel oil day tank automatically refilled to maintain the fuel level above 87%
- Stairway pressurization fans started
- 67-UPS-1 switched back to its normal power supply (A1)
- Backup Closed Loop Cooling Water Pump 66-G-11 started.

Frequency, voltage, current, and the power factor were recorded during a 2 hour generator run. All parameters were determined to be within specification. Initially, problems were encountered with restarting the HVAC exhaust fan, but circuitry was corrected and satisfactorily retested at a later date.

The Utility Room expansion diesel generator was also load-tested and tested for automatic start on loss of power. The STS diesel generator was already on-line and operational and, therefore, was not tested by itself as part of the Vitrification Test Program.

A vitrification loss-of-power test was conducted during a site power outage. The outage was initiated by interrupting normal supply power to the site. All 4 diesel generators started automatically and provided power to required loads.

The ability to provide backup power to the melter electrodes was tested concurrently with the vitrification loss-of-power test. Following the automatic start of the STS/PVS diesel generator, breakers were manually aligned to provide power to the appropriate VF power panel. The breaker to melter electrode power was then closed and melter average glass temperature was maintained above 1,000°C. The following additional selected loads were also placed on the STS/PVS diesel generator:

- 63-UPS-2 normal power
- 63-UPS-3 normal power
- Cold chemical lighting
- Cold Chemical Control Panel, 65-CP-01
- MFHT agitator
- CFMT agitator
- Main Vitrification Facility Air Handling Unit, 67-V-001
- Melter discharge chamber heaters.

Four separate UPS systems were tested to ensure the ability to switch to alternate power, both manually and automatically upon loss of normal power supply, and to operate for thirty minutes on battery charge only. The four UPS systems tested include 67-UPS-1 (associated with HVAC equipment), 63-UPS-2 (associated with vitrification process Control Room equipment), 63-UPS-3 (associated with the DCS), and 63-UPS-010 (associated with ex-cell off-gas system equipment).

2.14 Vitrification Facility HVAC

2.14.1 Vitrification Facility HVAC Functions

The Vitrification Facility HVAC system provides for area temperature and humidity control and confinement of airborne radioactivity by directing air flow from areas of low potential for contamination to areas of successively higher potential for contamination. Three confinement zones are defined for this purpose. Zone I consists of those areas that are expected to contain airborne activity during normal operations - Vitrification Process Cell, transfer tunnel, and Crane Maintenance Room (CMR). Zone II consists of operating areas and other potentially contaminated areas surrounding Zone I. Zone III designates areas inside the Vitrification Building that are expected to be free of contamination (e.g., Vitrification Process Control Room). See figure 2-18.

The Vitrification Facility main HVAC system consists primarily of one supply air handling unit, three 50% capacity (HEPA) primary/in-cell filter banks, an internally partitioned secondary filter unit, and two 100% capacity redundant exhaust fans. Supply air to the Vitrification Process Control Room is supplied by separate air handling units. A chilled water system removes heat at the air handling units and from cell coolers located within the Vitrification Process Cell.

An independent HVAC system provides ventilation for the 01-14 Building that houses the ex-cell off-gas treatment equipment. The building is maintained under negative pressure by one of two redundant blowers and exhaust air is filtered before being discharged to the exhaust stack. Stack exhaust for both the 01-14 Building and the VF ventilation systems are monitored continuously for airborne radioactive particulate.

2.14.2 Testing

HVAC testing consisted of equipment functionality (fans, dampers, chillers, coolers), fan reliability testing, interlock/alarm verifications, and air balancing to establish proper pressure relationships. Tests were also run to demonstrate the ability to start fans after a power loss, adjust dampers when control logic fails, and replace/test filters. See table 2-9 for a brief summary of performance testing. Air balancing was performed in stages as cell closures occurred, with the final air balance performed after making the hot tie between the Vitrification Process Cell and the EDR.

Initially, design negative pressures could not be attained in-cell (Zone I) with the design exhaust volume due to excessive air in-leakage to the Vitrification Process Cell. Total interior reconstruction of the shield door #2 hoist house, combined with the addition of flow-restricting devices at the normal transfer air paths, reduced in-leakage sufficiently to achieve design value negative pressure with only a 20% increase in exhaust volume (vs. >50% increase prior to the corrections). Difficulty in attaining design negative pressures in the ex-cell spaces (Zone II) was corrected using all of the following actions:

- Space-by-space search and repair of leak paths
- Addition of door seals at all door sets
- Re-balance of the HVAC supply system
- Modification of tornado dampers
- Modification of ex-cell exhaust flow controls
- Installation of orifice plates to balance resistance between the in-cell and ex-cell airstreams.

Filter replacement testing also resulted in changes to the bag-in/bag-out procedure, modification to the filter retrieval mechanisms and filter retraction clips, and development of new procedures and equipment for DOP testing of the primary and secondary filter units.

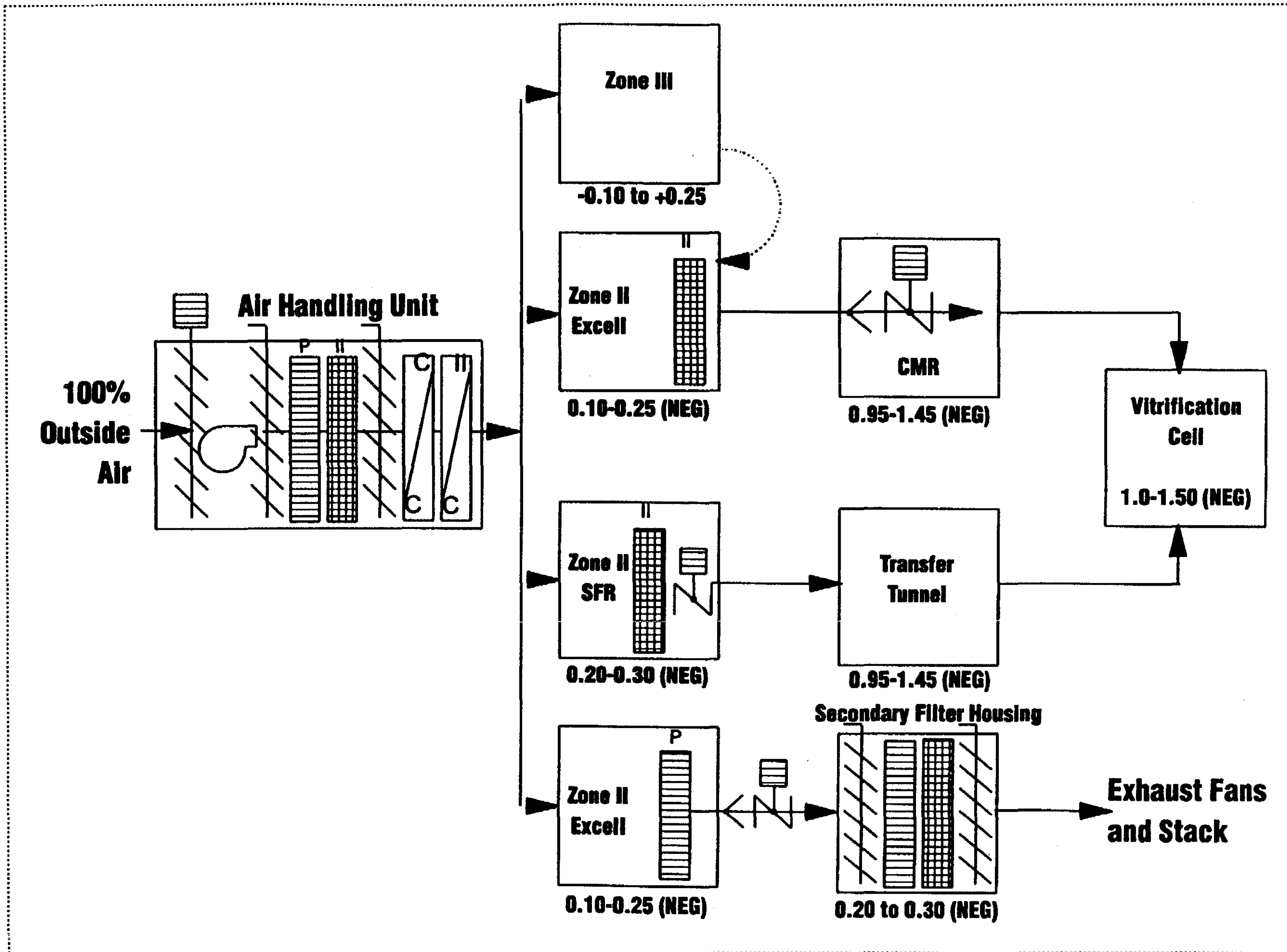


Figure 2-18. HVAC Confinement Zones

Table 2-9: HVAC Performance Testing Summary	
Test	Test Objectives Achieved
WVNS-TIP-021, Vitrification Facility HVAC Performance and Functional Verification Testing for Air Handling Units 67-V-003A and 67-V-003B	Maintained Vit. Process Control Room at indoor design conditions during normal operation and abnormal events (i.e., loss of power, loss of instrumentation).
	Maintained the Control Room at a positive pressure with respect to the adjacent areas during normal operation.
	Provided cooling/ventilation through the loss of chilled water.
WVNS-TIP-027, VF In-cell Coolers' Performance Test	Demonstrated proper function of chilled water control valves for each cooler.
	Demonstrated proper function of fan motors for each cooler.
	Demonstrated proper function of the coolers upon loss of instrument air (i.e., failure positions of chill water flow control valves).
	Demonstrated adequate Vitrification Cell cooling under upset conditions (loss of an in-cell cooler, chill water restart).
	Obtained baseline data for chill water supply/return temperatures and line flowrates.
WVNS-TIP-028, Test Instruction Procedure for the VF Chilled Water System	Demonstrated successful operation of Chiller Sequence Panel, 67-V015D, for controlling chiller operation.
	Demonstrated successful operation of Overpressure Control Valve, PDV-004.
	Demonstrated successful operation of the chiller flow switches and low-flow alarms.
WVNS-TIP-029, Vitrification Chiller Equipment Room Ventilation Performance Test	Demonstrated successful operation of Chiller Equipment Room Supply Fan (67-K-003), Discharge Damper (67-Y-038), Temperature Control Thermostat (67-TS-028), and high-temperature alarm indication.
WVNS-TIP-030, VF Diesel Generator Room Ventilation Performance Test	Confirmed proper operation of Diesel Generator Room Ventilation Dampers (67-Y-009 and 67-Y-010) under conditions of diesel on-line, diesel off-line, loss of instrument air, loss of normal power, and high room temperature.
WVNS-TIP-031, VF Primary Filters Remoteability Replacement Test	Demonstrated remote replacement of prefilter and HEPA filter elements at all three primary filter housings 67-T-001A, B, and C.
	Demonstrated replacement of HEPA filter elements in Secondary Filter Unit Modules, 67-T-002A through L.
	Demonstrated replacement of prefilter and HEPA filter elements associated with Outdoor Air Supply and Air Handling Unit, 67-V-001.

Table 2-9: HVAC Performance Testing Summary (cont.)	
Test	Test Objectives Achieved
WVNS-TIP-031, VF Primary Filters Remoteability Replacement Test	Demonstrated replacement of prefilter and HEPA filter elements associated with transfer air system at Filter Housings 67-F-005, 67-F-010, 67-F-011, and 67-F-019.
	Demonstrated the bag-in/bag-out process for dirty filters including proper operation of isolation dampers and vent ports provided for filter changeout.
	Demonstrated the ability to DOP-test the primary HEPA filter banks and secondary HEPA filter elements.
WVNS-TIP-032, VF HVAC Stack Monitoring System	Demonstrated the capability for stack exhaust monitoring and sampling under normal conditions.
	Verified capability of automatic switchover to backup vacuum pump on loss of primary pump (for both monitoring and sampling systems).
	Verified capability of automatic switchover to backup radiation monitors on loss of primary radiation monitors.
	Setpoint-tested radiation monitors using alpha and beta test sources.
	Demonstrated proper operation and alarm function for the seismic sampling system.
	Verified proper system operation continues under standby power on loss of normal power.
WVNS-TIP-033, Air Supply, Exhaust, and Stairway Ventilation System	Demonstrated automatic switchover from the primary exhaust fan to the standby exhaust fan upon loss of primary exhaust fan (due to both manual and automatic trip).
	Verified proper automatic operation of Dampers 67-Y-008 and 67-Y-044 to supply backup ventilation for the Secondary Filter Room.
	Demonstrated proper operation of Main Air Handling Unit (67-V-001), Stairwell Fans (67-K-004 and 67-K-005), and interlocks.
	Demonstrated proper operation (both manual and automatic) of numerous isolation dampers.
	Demonstrated proper function of the HVAC system to maintain proper cell ventilation upon loss of instrument air.
WVNS-TIP-043, Ventilation in Building 01-14	Demonstrated satisfactory negative pressure control of the Zone I spaces with and without supply unit operation.
	Demonstrated proper system operation in response to changing discharge temperatures, including low-temperature air supply unit shutdown and high-temperature air supply unit shutdown/stairwell pressurization.
	Demonstrated proper system operation in response to a building fire alarm.
	Demonstrated proper system performance in response to simulated filter loading.

Table 2-9: HVAC Performance Testing Summary (cont.)	
Test	Test Objectives Achieved
WVNS-TIP-043, Ventilation in Building 01-14	Verified automatic switchover to the backup exhaust fan operation in response to loss of suction, momentary loss of power, and loss of instrument air.
	Simulated various system/component pressure conditions to verify alarm settings, annunciator responses, and damper control responses.
WVNS-TIP-046, 01 Cell Heat Removal	Demonstrated ability to maintain the 01 cell airlock temperature at 40°F to 70°F while NOx abatement is in progress.
	Demonstrated ability to maintain temperature at the midpoint of the 01 cell to 118°F or less while NOx abatement is in progress.
WVNS-TIP-076, 01-14 Building Stack Radiation Monitor System Test	Verified proper operation of the automatic start of the standby vacuum pump upon low flow or loss of primary pump.
	Check failure mode alarms of the (primary and backup) alpha and beta continuous air monitor units.
	Verified detector efficiency and alarm functions of the (primary and backup) alpha and beta continuous air monitors using traceable sources.
	Performed changeover of the primary detectors to the backup detectors.

2.15 Distributed Control System

2.15.1 Distributed Control System Functions

The distributed control system (DCS) provides the ability to control and monitor process systems, mechanical and electrical equipment, alarm off-normal conditions, acquire data, perform calculations, and provide reports on equipment and alarms. The DCS utilizes programmable local controllers (PLCs) and DCS controllers as the final control devices. The PLCs and DCS controllers are interconnected by data highways and local area networks to central VF Operator Interfaces (OIs) located in the Vitrification Process Control Room (VPCR) (see figure 2-19). From the VPCR, operators can monitor and control the vitrification process including the CFMT, MFHT, melter, in-cell and ex-cell off-gas systems, and canister decontamination, as well as interfaces with the sludge mobilization and transfer system and cold chemical system.

2.15.2 Testing

Most of the vitrification system performance testing described in the preceding sections required equipment/system control through the DCS and the operator interfaces in the VPCR, known as sparcstations. Satisfactory performance of the components and systems also required satisfactory performance of the control system. Testing specifically associated with the DCS, as described in this section, involved the capability to place equipment in a safe condition without use of: the Control Room sparcstations, general Control Room DCS equipment performance under loss of Control Room HVAC, and complete alarm report verification for all System 63 (vitrification process), System 64 (ex-cell off-gas), System 47 (01-14 Building HVAC), and System 67 (vitrification HVAC) alarms. See table 2-10 for a brief summary of performance testing.

Table 2-10: Distributed Control System Performance Testing Summary	
Test	Test Objectives Achieved
WVNS-TIP-070, DCS Performance Test	Demonstrated satisfactory ergonomic features of the VPCR.
	Demonstrated that equipment controlled through each of the four DCS cabinets and three programmable local controllers (PLCs) can be placed in an idle mode without use of Control Room equipment.
	Demonstrated that the VPCR DCS equipment is capable of operating during a failure of Control Room ventilation.
WVNS-TIP-071, Instrumentation and Control DCS Alarm Performance Test	Verified that all System 47, 63, 64, and 67 alarms specified in the engineering-released functional logic diagrams are reported on OI displays.
	Demonstrated the capability of the DCS to attach an urgency category (A1, A2, A3, or E) and a time stamp to incoming alarms.

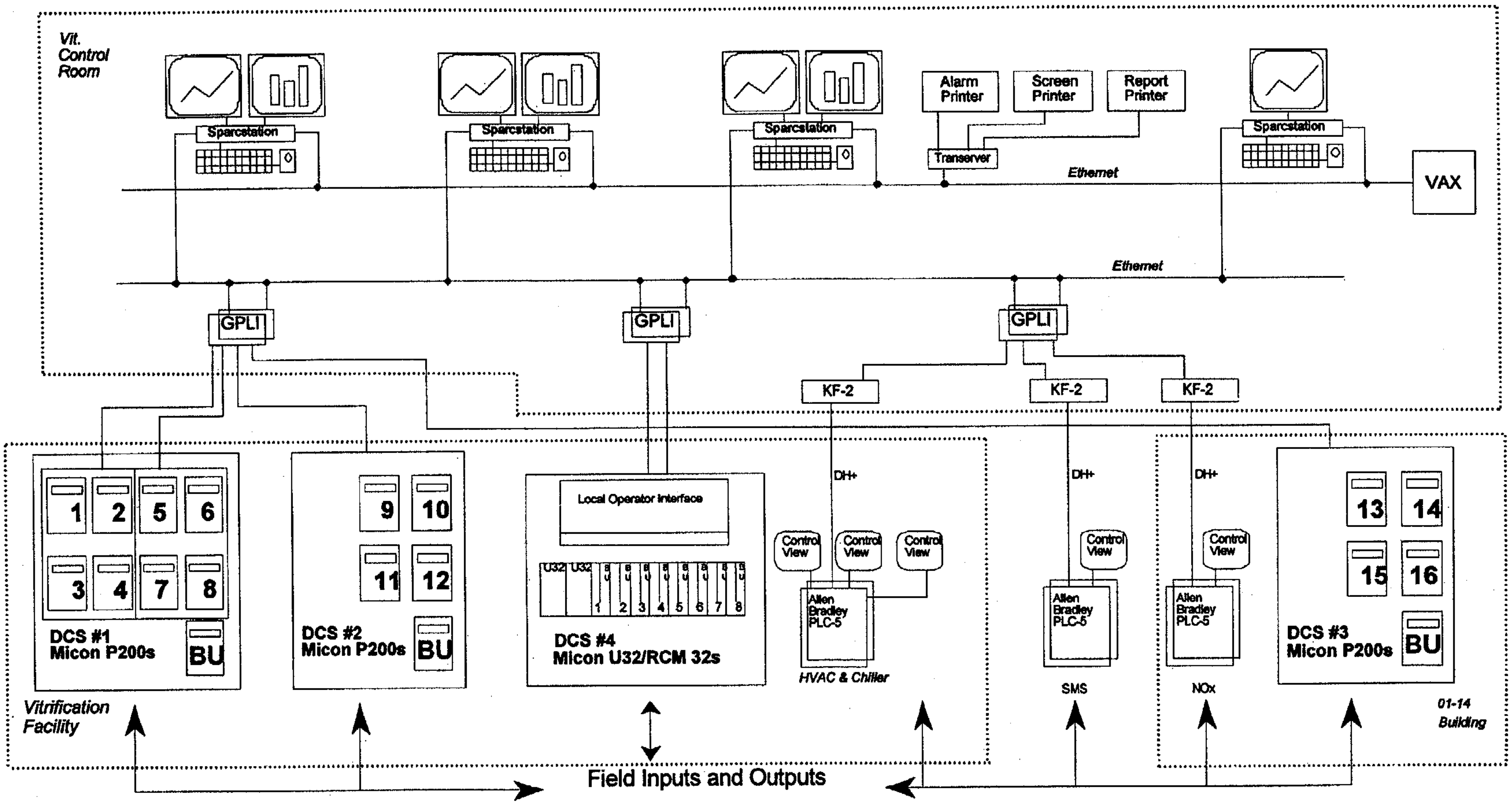


Figure 2-19. Distributed Control System Arrangement

3.0 Summary

The Vitrification Facility Test Program encompassed a phased turnover and graded approach to testing in the areas of feed preparation, chemical preparation, glass production, canister welding and decontamination, canister handling, off-gas treatment, vessel pressure control, HVAC, remote maintenance, control systems, electrical distribution, and backup power. Following system turnover and commissioning testing, performance testing provided:

- Confirmation of selected functional design requirements as identified in the system description test requirements.
- Demonstration that the various systems can operate in a safe and environmentally sound manner.
- Enhancement of the training level of the Operations personnel, providing valuable operating experience and baseline data prior to the introduction of radioactive waste.

Melter operation and testing uncovered flaws that led to uncontrolled glass migration and subsequent glass blockage in the melter discharge port. Subsequent investigation, repair, and retesting not only resulted in satisfactory melter operation but also demonstrated successful restart of the melter, containing a solid glass inventory, using the startup heaters.

Testing led to various modifications and enhancements to improve system performance. Integrated operational runs were the culmination of months of component and subsystem performance testing and provided a smooth, controlled transition to radioactive HLW processing.

4.0 References

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LIST OF ACRONYMS

ADS	Air Displacement Slurry
CCS	Cold Chemical System
CCTV	Closed Circuit Television
CDT	Canister Decontamination Station
CFMT	Concentrator Feed Makeup Tank
CMR	Crane Maintenance Room
CTS	Component Test Stand
DCS	Distributed Control System
DOE	Department of Energy
DOP	Dioctyl Phthalate
DVP	Developmental Vitrification Procedure
EDR	Equipment Decontamination Room
EDS	Electrical Distribution System
FACTS	Functional and Checkout Testing of Systems
HEME	High-efficiency Mist Eliminator
HEPA	High-efficiency Particulate Air
HLW	High-level Waste
HLWIS	High-level Waste Interim Storage
HVAC	Heating, Ventilation, and Air Conditioning
ILDS	Infrared Level Detection System
IO	Integrated Operation
MFHT	Melter Feed Hold Tank
OI	Operator Interface
ORR	Operational Readiness Review
PLC	Programmable Logic Controller
RCRA	Resource Conservation and Recovery Act
Redox	Oxidation Reduction
SBS	Submerged Bed Scrubber
SDG	Standby Diesel Generator
SFCM	Slurry-fed Ceramic Melter
SMTS	Sludge Mobilization High-level Waste Transfer System
SOP	Standard Operating Procedure
STS/PVS	Supernatant Treatment System / Permanent Ventilation System
THOREX	Thorium Extraction Process
TIP	Test Instruction Procedure
UPS	Uninterruptible Power Supply
VF	Vitrification Facility
VPCR	Vitrification Process Control Room
VTF	Vitrification Test Facility
WTF	Waste Tank Farm
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services Co., Inc.