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SUPERNATANT TREATMENT SYSTEM DESIGN THROUGH TESTING

TOPICAL REPORT

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ABSTRACT

The main purpose of the Supernatant Treatment System (STS) is to remove more than 99.9 percent of the radioactive cesium (Cs-137) from the high-level waste stored in tank 8D-2. Cesium removal is accomplished in the STS by processing the supernatant (liquid) portion of the high-level waste through three or four ion exchange columns filled with zeolite. After treatment in the STS, the decontaminated supernatant is processed as low-level waste and finally encapsulated in cement for eventual disposal. The Cs-137 removed from the waste and absorbed onto zeolite ion exchange material is temporarily stored in tank 8D-1 until it can be encapsulated in glass and disposed of as high-level waste. This report discusses construction and testing of the STS.

Design of the STS was started in 1982 in parallel with the selection of the ion exchange material. The construction of this system was accomplished in five phases in parallel with completion of design to allow for faster completion of the project. The existing high-level waste storage tanks - 8D-1, 8D-2, and 8D-3 - required major renovations to permit transfer of the high-level waste from tank 8D-2 to tank 8D-1, to house the components that comprise the STS in tank 8D-1, and to store decontaminated waste in tank 8D-3. Testing in the STS started before construction was complete and was accomplished by first testing components individually. Then the system was retested using simulated supernatant. Integrated testing of the whole Integrated Radwaste Treatment System (IRTS), which includes the STS, Liquid Waste Treatment System (LWTS), Cement Solidification System (CSS), and the Drum Cell, was also performed using simulated supernatant. Finally, slightly radioactive condensate water from tank 8D-1 was processed. After successfully completing this testing, the STS started operations with radioactive supernatant on May 23, 1988.

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1.0 SUMMARY

West Valley Nuclear Services Company, Inc. (WVNS), a subsidiary of Westinghouse Electric Corporation, was awarded a contract by the Department of Energy (DOE) in 1982 to solidify the high-level waste (HLW) stored at the Western New York Nuclear Service Center into a form suitable for transportation and eventual disposal in a federal repository. This HLW remains from PUREX fuel reprocessing operations carried out from 1966 to 1972 by Nuclear Fuel Services at the West Valley reprocessing facility. The HLW, consisting of a precipitated sludge and an alkaline supernatant, is presently contained in HLW storage tank 8D-2.

WVNS decided to pre-process the supernatant and established the Supernatant Treatment System (STS) to perform this pre-processing and to reduce the total volume of the glass produced during vitrification of the HLW. In the STS, the supernatant from tank 8D-2 is decontaminated by removal of Cs-137, the major radioactive ion in solution. The decontaminated supernatant is next concentrated by evaporation in the Liquid Waste Treatment System (LWTS) and is finally encapsulated in cement and stored as low-level waste (LLW) in the Drum Cell pending a decision on ultimate disposal. The Cs-137, which remains absorbed on the zeolite ion exchange media, is temporarily stored in tank 8D-1. The zeolite will eventually be combined with the HLW sludge remaining in tank 8D-2 and sent to a slurry-fed ceramic melter, where it will be solidified into borosilicate glass.

The nonradioactive constituents of the supernatant stored in tank 8D-2 included approximately 300,000 kg of Na^{+} and 30,000 kg of SO_4^{-2} (among many other species of less significance to glass making). The chemical composition of the supernatant is shown in table 1. Based on the final glass product concentration limitations, the reference West Valley glass (see table 2) can handle the addition of no more than 40,000 kg of Na^{+} and 600 kg of SO_4^{-2} without a possible decrease in leach resistance in the glass product and melting difficulties from the formation of a molten salt phase. The STS removes the excess nonradioactive salts from the supernatant prior to vitrification of the remaining wastes. The only viable alternative to this salt removal method was dilution of the waste with appropriate glass formers which would increase the amount of glass by approximately 6-fold. The savings to the project in disposal costs for vitrified waste alone was more than $150 million.

A search for the best decontamination method for the STS process to remove cesium from the supernatant started in 1982. The amount of cesium removed from the supernatant is measured by the decontamination factor (DF);

$$DF = \frac{\text{inlet Cs-137 concentration}}{\text{outlet Cs-137 concentration}}$$

The 2 200 000 litres (580,000 gallons) of supernatant in tank 8D-2 had been calculated to contain 8 million curies of radioactive Cs-137 in 1982, which would be 7 million curies (2,000 μCi/mL)in 1988 due to dilution and decay of the radioactive cesium. The resulting cesium concentration in the supernatant had to be decontaminated from 2,000 μCi/mL to less than 1.5 μCi/mL before it could be transferred to the LWTS (required by WVNS Technical Requirement IRTS-5). The design criteria requires a cesium DF = 1000 for the STS; an operating limit of DF = 1500 was set to assure that this design limit is always met.

Table 1. Tank 8D-2 Supernatant Chemical Composition **(Rykken, 1982)**

COMPOUND	WEIGHT PERCENT[a] WET BASIS	WEIGHT PERCENT DRY BASIS	TOTAL KG IN[b] SUPERNATANT
$NaNO_3$	21.10	53.39	602,659
$NaNO_2$	10.90	27.58	311,326
$NaSO_4$	2.67	6.76	76,261
$NaHCO_3$	1.49	3.77	42,557
KNO_3	1.27	3.21	36,274
Na_2CO_3	0.884	2.24	25,249
NaOH	0.614	1.55	17,537
K_2CrO_4	0.179	0.45	5,113
NaC1	0.164	0.42	4,684
Na_3PO_4	0.133	0.34	3,799
Na_2MoO_4	0.0242	0.06	691
Na_3BO_3	0.0209	0.05	597
$CsNO_3$	0.0187	0.05	534
NaF	0.0176	0.05	503
$Sn(NO_3)_4$	0.00859	0.02	245
$Na_2U_2O_7$	0.00808	0.02	231
$Si(NO_3)_4$	0.00806	0.02	230
$RbNO_3$	0.00416	0.01	119
Na_2TeO_4[c]	0.00287	0.007	82
AlF_3	0.00271	0.007	77
$Fe(NO_3)_3$	0.00152	0.004	43
Na_2SeO_4	0.00054	0.001	15
$Li(NO_3)$	0.00048	0.001	14
H_2CO_3	0.00032	0.0008	9
$Cu(NO_3)_3$	0.00022	0.0006	6
$Sr(NO_3)_2$	0.00013	0.0003	4
$Mg(NO_3)_2$	0.00008	0.0002	2
TOTAL	39.52	100.00	1,128,861
H_2O (by difference)	60.48		1,727,341

(a) To resolve cation/anion imbalance, additional sodium was added and NO_3/NO_2 subtracted in proportion to analytical percent relative standard deviation (percent RSD).

(b) Assumes 2.856×10^6 kg in tank 8D-2.

(c) From Fission yield calculations.

Table 2. Composition of HLW Glass WV-205

COMPOUND	WEIGHT PERCENT
SiO_2	44.88
Fe_2O_3	12.16
Na_2O	10.93
B_2O_3	9.95
ThO_2	3.58
K_2O	3.57
LiO_2	3.03
Al_2O_3	2.83
P_2O_5	2.51
MnO_2	1.31
MgO	1.30
TiO_2	0.98
UO_2	0.56
REO[a]	0.28
TRUO[b]	0.04
Other	2.09
	100.00

(a) REO = Rare Earth Oxides
(b) TRUO = Transuranic Oxides

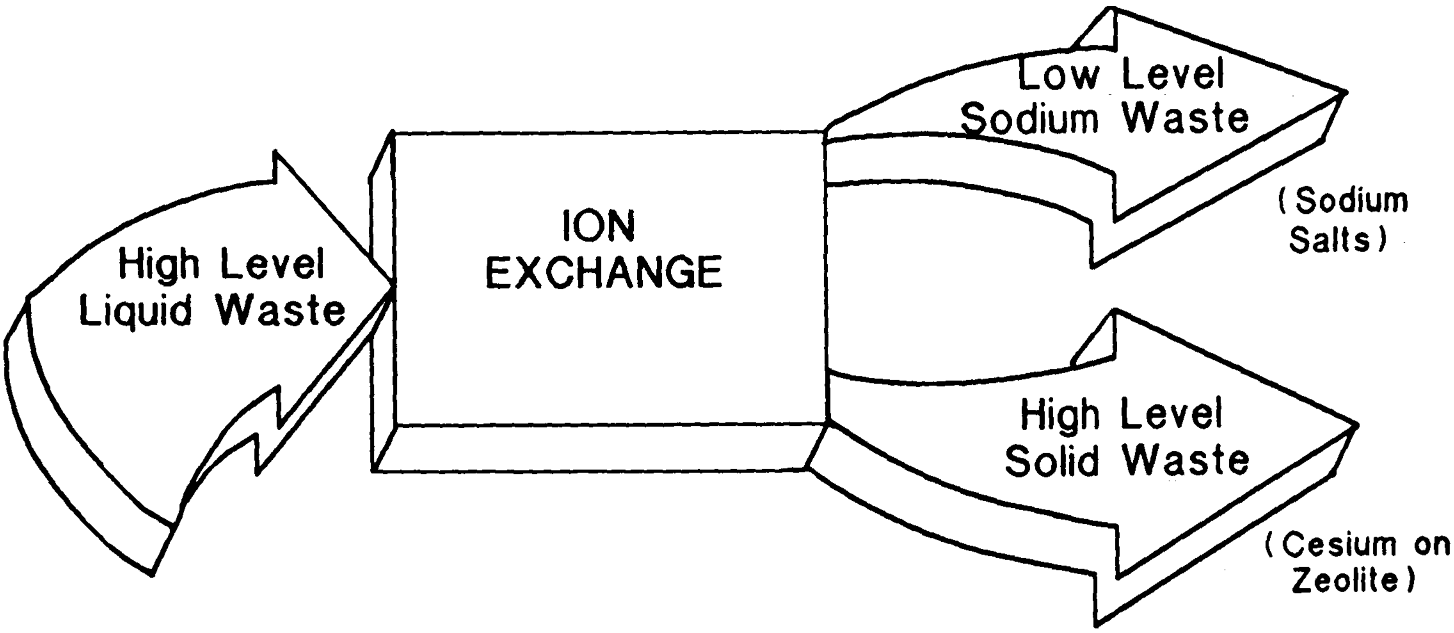
The methods considered for reducing the Cs-137 concentration from 2,000 μCi/mL to 1.5 μCi/mL were: (1) electrodialysis; (2) hyperfiltration; (3) precipitation with ferrocyanide, Sodium Tetra Phenyl Boron (NATPB), or Phosphotungstic Acid (PTA); (4) organic ion exchange using Union Carbide CS-100; (5) chelation using DeVoe/Holbein compositions; and(6) inorganic ion exchange with Duratek Corporation Durasil, natural zeolites, or Union Carbide Linde IE-95 or IE-96 medias. After extensive evaluation of experimental data with process constraints taken into account, the synthetic, inorganic ion exchange media IE-96 (Linde Ionsiv IE-96) was chosen for cesium recovery **(Carl 1987)**. IE-96 was chosen because of high sorption rate, high cesium decontamination factor, ion exchange capacity, low calcium content and compatibility with the glass formers for making borosilicate glass in the slurry-fed ceramic melter.

The STS was designed between 1984 and 1987. Engineering for the STS proceeded in parallel with the selection of the cesium removal method. The DOE, New York State Energy Research Development Authority (NYSERDA), and WVNS made the decision to place all the large process components of an essentially conventional ion exchange process totally within a contaminated underground tank (8D-1). This decision was made as part of the project charter to use existing facilities. The ion exchange components consequently were installed in tank 8D-1 and had to be designed to reliably process waste remotely for at least eighteen months. Reliable remote operation was therefore a large factor in the final decision to use the most proven method to process the waste at WVDP.

Construction was phased to allow the construction of the STS to start in parallel with completion of portions of the design. Excavation and construction of the civil works (i.e., buildings) were performed in the early phases of construction (Phases I, II, IIA, III). Openings were made into the tank 8D-1, and the STS ion exchange columns and risers (to contain the pumps) were installed in Phase IV. Also, interconnecting piping and wiring were installed in Phase IV. Finally, a system was installed for remotely transferring process samples of radioactive solution to the Analytical Laboratory in Phase V.

Nonradioactive testing of the STS involved individual component testing, individual subsystem testing, system hydraulic testing, and finally tests that integrated all four systems (STS, LWTS, CSS, and the Drum Cell) which make up the Integrated Radwaste Treatment System (IRTS). System overviews are shown in figures 1 and 2, and the STS test results are shown in tables 3 and 4. The successful completion of these tests demonstrated that STS was ready for radioactive operation. After an Operational Readiness Review Board was held, DOE-Idaho approval was given on May 20th, 1988 for beginning radioactive operation of the IRTS.

The first STS campaign was completed May 28, 1988. During this campaign, 98 420 L (26,000 gallons) of supernatant was processed with an average decontamination factor (DF) of 23,421 (compared to a goal of 1,500). The interface with LWTS worked extremely smoothly with 91 550 L (24,185 gallons) of decontaminated supernatant transferred for further processing by LWTS/CSS.



* Removes greater than 99.9% of the radioactivity contained in the supernatant onto zeolite

*Reduces the amount of high-level waste glass by separation of cesium and sodium salts

FIGURE 1
STS Ion Exchange Overview

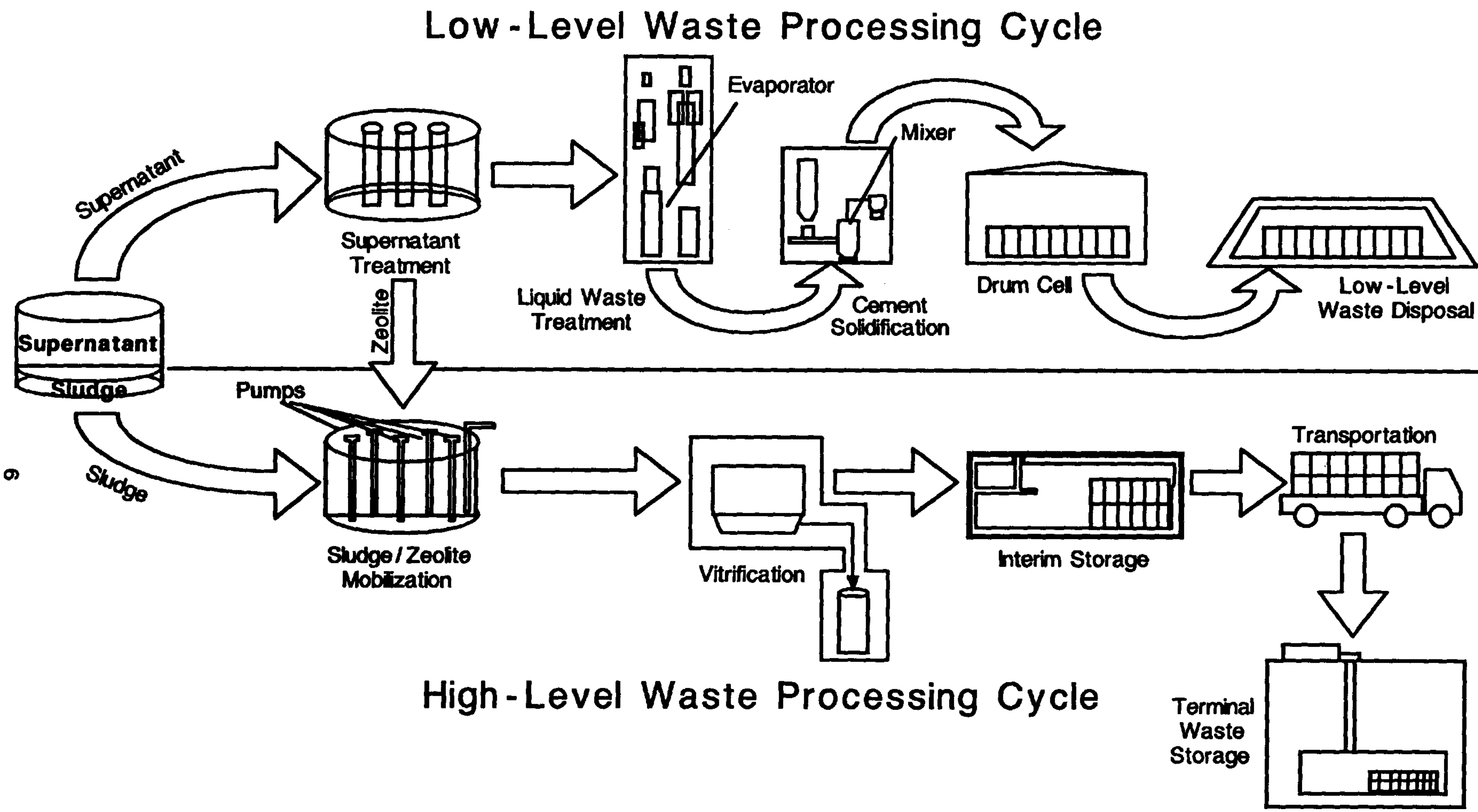


Figure 2

IRTS Process Overview

Table 3. STS Component Test Results Summary

TEST PROCEDURE	TEST RESULT
Software (SIP 87-13)	Interlocks operated as specified.
Utility and Instrument Air (SIP 87-14)	Required quality air delivered to components and utility stations at required pressure.
Electrical System (SIP 87-15)	Electrical power and control signals supplied to MCCs, switches, and breakers which provided proper electrical signals to power supplies, lighting, pump motors, and components. Measured voltage and/or amperage as required.
Sampling and Pneumatic Sample Transfer (SIP 87-16)	All sample points sampled and samples pneumatically transferred to lab.
Valves (SIP 87-62 and Others)	Automatic valves and equipment actuated from main control panel. Lights, switches, and solenoid and air operated valves functioned as required. Manual valves functioned properly.
Pumps (ALL SIPS)	All pumps except 50-G-001 checked and functioned properly. SIP 87-38 checked 50-G-001 prior to hot operations.
Instrumentation (All SIPS)	All instruments functionally checked and calibrated as required.
Water Break Tank 50-D-005 (SIP 87-17)	Tank calibrated, alarms checked, and pumps 50-G-015 and 50-G-016 operated and functionally checked.
Decontaminated Supernatant Filter 50-F-002 (SIP 87-17)	Hydraulic performance of filter was acceptable - 4-5 psi pressure drop. Loading filter could not be done as specified. Modifications made to system for batching sand.
Fresh Water Tank 50-F-003 (SIP 87-20)	Tank calibrated. Pump 50-G-005 provided required flow rate.
Zeolite and Sand Batching and Fines Removal (SIP 87-1)	Batch tank 50-D-002 calibrated. Batching system modified; and successfully retested under SIP 87-21 (Rev. 1).
Filtration and Dilution (SIP 87-22)	Performed as required.
Utilities and Drains (SIP 87-23)	Floor drains drained properly and instrumentation checked out OK. Utility supply pressure acceptable: Steam 95 psig Demin. Water 60 psig Inst. Air (CTS) 55 psig Utility Air (Comp) 122 psig Utility Water 99 psig Fire Water 47 psig

Table 3. STS Component Test Results Summary (continued)

TEST PROCEDURE	TEST RESULT
Remote Operation in Valve Aisle (SIP 87-24)	80 jumpers removed remotely; all 114 inspected and reinstalled. Ten jumpers both removed and reinstalled remotely. Pumps in valve aisle can be removed remotely except 50-G-015 which can be functionally replaced by 50-G-016 or 50-G-003.
Columns A, B, C, and D 50-C-001, 50-C-002, 50-C-003 and 50-C-004 (SIP 87-27)	Columns loaded with 12 drums of zeolite each. Hydraulic flow test thorough system were functionally acceptable (less than 10 psi across 4 columns). Demonstrated zeolite removal from column A using dip tube (alternate method) as well as bottom dump valve.
Supernatant Feed Tank 50-D-001 (SIP 87-29)	Tank calibrated. Pump 50-G-002 performed as required during initial testing, but failed two weeks later and has been replaced and retested in 87-71.
Sluice/Lift Water Tank 50-D-004 (SIP 87-30)	Tank calibrated and instrumentation checked. Pump 50-G-003 performed as required, but was replaced and retested in 87-71.
Chiller and Cooler 50-V-001 and 50-E-001 (SIP 87-30)	Simulated supernatant (190 $\pm 20^{o}$F) cooled to 43 $\pm 6^{o}$F as required.
Hydraulic Checkout	Pressure drops across the STS were acceptable at design flow rate. 1) Flow through empty system - 6 psi or less 2) Flow through loaded system - less than 10 psi.
Permanent Ventilation System (PVS) (SIP 87-43)	System functioned as required with some modification. Automatic switchover of trains occurred as expected; instruments calibrated.
Radiation Monitors (SIP 87-34)	Rate meters passed tests. Monitors calibrated.

Table 4. Integrated System Checkout Test Results

TEST	REQUIRED RESULTS	ACTUAL RESULTS
1) Column A Breakthrough	Process 71 Column Volumes (CV)of simulated supernatant before breakthrough	90 CV of simulated supernatant processed before 95 percent breakthrough
2) Prefilter	10 psi after blowback	10 psi - 3 times
3) Supernatant Chiller/Cooler	No increase in brine flow to maintain supernatant temperature at 6 $\pm$1°C	Range 3-7°C with no increase in brine flow
4) Dilution System	15 $\pm$1 weight percent Total Dissolved Solids (TDS)	Range 13.5 to 15 weight percent TDS percent Note: Supernatant feed pump introduced seal water at 0.25 gpm to reduce supernatant conc. by an additional 0.5 weight percent.
5) Decontaminated Supernatant Filter Pressure Drop	5 psi $\pm$0.2 psi	5 psi $\pm$0.2 psi
6) Transfer to LWTS	Decontaminated supernatanttransfer pump 50-G-007 performed satisfactorily	Transfer accomplished
7) Valve Aisle Operable	Satisfactory operation with Master-Slave Manipulators	Accomplished
8) SGN Sampling & Transfer System	Satisfactory sampling and transfer	Accomplished
9) Column Unloading	Column A unloaded	Accomplished

2.0 BACKGROUND

2.1 Overview of Present Operation of STS

A simplified STS flow diagram is shown in figure 3.

Supernatant is transferred from underground high-level waste storage tank 8D-2 to the STS by a submersible vertical turbine pump (50-G-001) suspended in the tank. A submerged pump is used to pump the supernatant due to high vapor pressure of the fluid. The pump has floating suction to minimize the potential for sludge pickup, and it is supported from the vault roof.

Optional filtration (50-F-001) is provided to prevent process contamination by removing sludge particles suspended in the supernatant. If the total solids in the unfiltered supernatant is at an unacceptable level (200 ppm or more) based on sample analysis, the supernatant flow will then be routed through the prefilter. The filter is capable of being pulsed and blown back with air to clean the accumulated particles from the porous tube filtering surface.

The Supernatant Feed Tank (50-D-001) serves as a surge tank for intermediate collecting and feeding of supernatant to the ion exchange columns. Supernatant which is ready for ion exchange processing is transferred from Supernatant Feed Tank 50-D-001 through the Supernatant Cooler 50-E-001 by a seal-less "canned" pump (50-G-002) at a rate of 2.0 to 6.0 gpm. The Supernatant Feed Tank 50-D-001 is pressurized with air to 13 to 15 psig to provide the suction head required for the Supernatant Feed Pump, 50-G-002. The supernatant is cooled to less than 13°C to improve the cesium removal efficiency, and then it is pumped downflow through the four ion exchange columns (50-C-001, 50-C-002, 50-C-003, and 50-C-004) in series. Each ion exchange column contains 60 cubic feet (3600 lbs) of zeolite. The system was originally designed to operate with four columns in series or three columns in series with one column temporarily off-line to change out the column loaded with zeolite. The batch method of operation allows four columns to be on-line at all times, because the loaded zeolite is now charged while the system is not processing supernatant.

Lab analysis is performed to determine the cesium loading in each ion exchange column. When the first column is fully loaded (saturated with cesium) and a minimum of 56 781 L (15,000 gallons) have been processed, supernatant processing is shut down. All columns are then flushed with demineralized water, and the system is placed on recirculation through the second, third, and fourth ion exchange columns for the remainder of the shutdown. The temperatures in the zeolite beds are monitored periodically to ensure that they are cooled to less than 13°C.

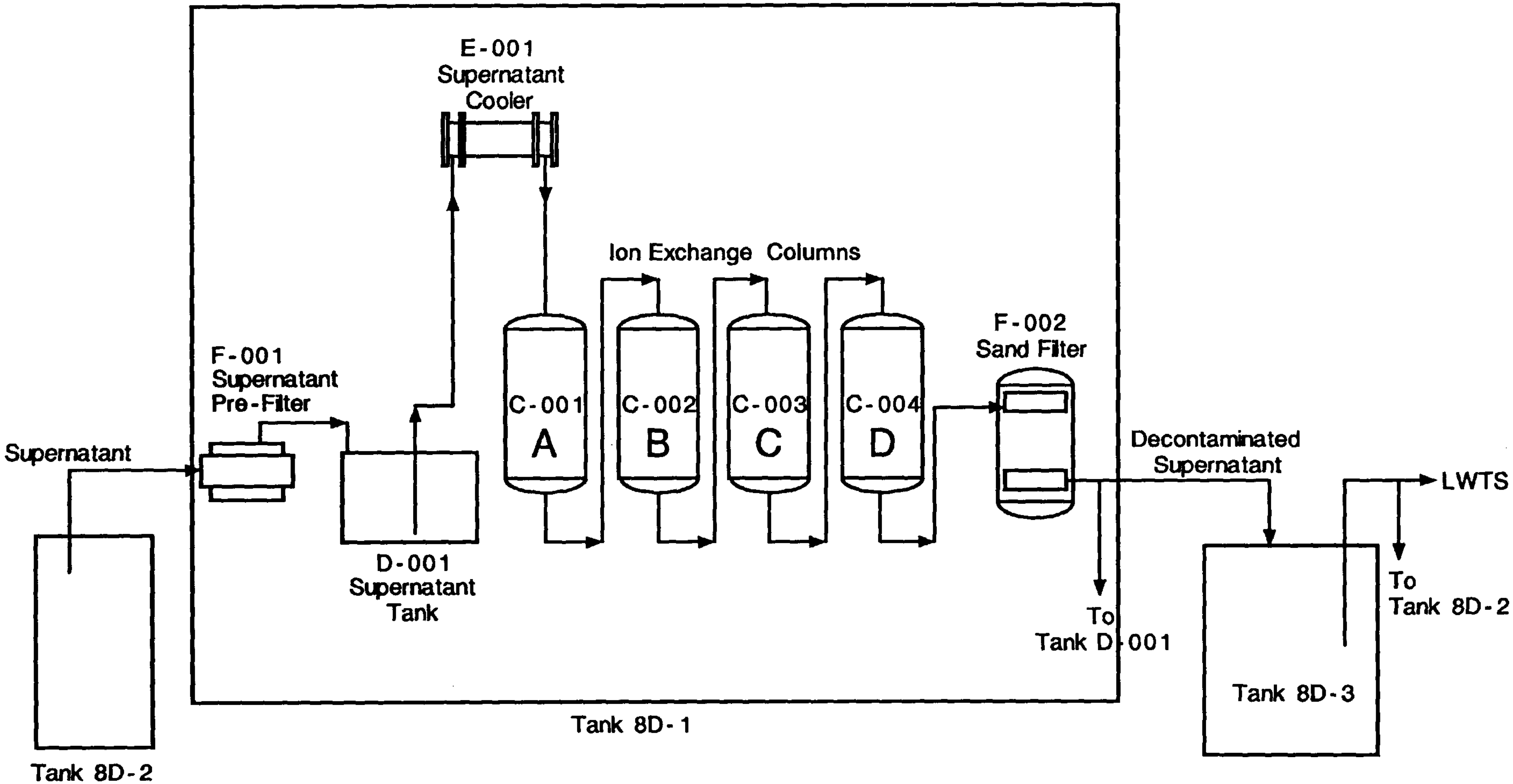


Figure 3

Simplified STS Flow Diagram

The fully loaded zeolite in the first column is replaced with fresh zeolite before the column goes back on-line. The zeolite is first rinsed of residual supernatant, and this rinse is sent to tank 8D-2. The rinsed zeolite is then sluiced to the bottom of tank 8D-1 with process water. To sluice the zeolite from the column, the bed is backwashed and expanded. Once the column bed is expanded, an outlet valve on the bottom of the column is opened to allow the loaded zeolite bed to fall to the bottom of tank 8D-1. The loaded zeolite can also be sluiced out through a dip tube to 8D-1. After a final rinse to tank 8D-1, the column is ready to be refilled with fresh zeolite. The loaded zeolite will be temporarily stored under water in tank 8D-1 at approximately 60°C for three years until the vitrification system is ready for the HLW sludge from 8D-1. The loaded zeolite stored in tank 8D-1 will then be combined with the HLW sludge in tank 8D-2 and delivered to the vitrification system.

Following ion exchange, the decontaminated supernatant is filtered to remove any suspended zeolite fines. The filtered and decontaminated supernatant is then transferred to the existing underground spare THOREX Waste Tank 8D-3. This tank has a working volume of 34 100 L (9,000 gallons) for supernatant and serves as both an intermediate storage tank and as a sampling tank.

Sample analysis is performed to verify the cesium concentration and DF of each batch of decontaminated supernatant that is produced. Decontaminated supernatant is transferred to the LWTS from tank 8D-3 in batches for volume reduction by evaporation.

In the LWTS, the decontaminated supernatant is concentrated up to 41 weight percent. This concentrated salt solution is mixed with a specially formulated cement in a high-shear cement mixing system (CSS). The batch is then discharged to a 208-litre (71-gallon) square drum as LLW. Approximately 15,000 drums of Class "C" LLW will be generated from the solidification of the decontaminated supernatant and stored in the Drum Cell.

2.2 Selection of STS Processing Method (Carl, 1986)

The selection of a process for removal of cesium from the supernatant started with the identification of all the candidate supernatant treatment processes. These processes were reviewed and laboratory tests were conducted to determine which processes were suitable for use at the WVDP using simulated supernatant. Most of the tests were conducted by Battelle PNL; some testing was also done by Westinghouse R/D and others. Tests using actual supernatant were conducted at West Valley to verify the results of the off-site tests with simulated supernatant.

The four leading processes identified in the screening tests conducted by PNL (Bray 1984b) were taken to the preliminary process design stage by EBASCO, the architect engineer for the STS design. These four processes were: (1) inorganic ion exchange with elution, (2) inorganic ion exchange without elution, (3) organic (CS-100) ion exchange, and (4) ferrocyanide precipitation.

While these leading processes were being studied by WVNS and others, other processes were being evaluated. These other processes included: (1) precipitation with Phosphotungstic Acid (PTA) precipitation or Sodium Tetra Phenyl Boron (NaTPB), (2) electrodialysis, (3) ultrafiltration, and (4) other ion exchange media.

2.3 Alternative Process Comparison and Final Selection (Carl, 1986)

The process alternatives were evaluated using the following criteria to select the most appropriate process for use in the WVDP. The criteria used were (1) process decontamination performance, (2) equipment and process complexity, (3) impact on the vitrification system, and (4) impact on the LWTS as discussed below.

2.3.1 Process Decontamination Performance

All processes were examined to insure they were capable of meeting the minimum decontamination performance for cesium removal. Many of those considered were not capable of providing a cesium DF of 1,000 and therefore were eliminated from further consideration. Those that meet the DF requirements are compared in table 5.

2.3.2 Equipment and Process Complexity

The inorganic ion exchange process was the least complex process alternative from an equipment and process standpoint. This process involved removing the cesium onto zeolite and feeding the loaded zeolite combined with the HLW sludge directly to the vitrification system. The inorganic ion exchange process would use fresh zeolite exchanger material for each loading cycle.

The organic ion exchange process, from an equipment and operational standpoint, was the most complex alternative considered for use at West Valley. The relatively low capacity of the organic ion exchange resin would dictate that the effective exchanger throughput be small (6 CV's) to maximize decontamination performance. This short operating cycle would require the use of at least three primary ion exchange columns in order to satisfy the processing time requirements. In addition, the loading, elution, and regeneration cycles associated with the organic ion exchange system would add substantial complexity to process and equipment operation.

The Sodium Tetra Phenyl Borate (NaTPB) precipitation process at first appeared uncomplicated; however, the process could not be easily applied at West Valley. The large quantity of chemicals required made the process impractical to use in a limited space. This precipitation process would require two or more batch contact operations. Additional complexity was added to the precipitation process by the post-treatment of the precipitate. This post-treatment would have involved destruction of the organic precipitate and recovery of the radiochemical concentrate. The LWTS would have become more complex because of the need to effectively treat the organic-containing liquid and gaseous effluents generated during this precipitation process.

The Phosphotungstic Acid (PTA) precipitation process also appeared simple at first. However, because of the large volume of supernatant that had to be processed (about 2 000 000 L), and the relatively small reaction vessel (tank 8D-3 working volume is 34 100 L (9,000 gallons), more than 100 batch contacts would be required to process the supernatant. In addition, the filtration requirements were not fully defined.

Table 5. Qualitative Comparison of Cesium Removal Processes for WVDP Supernatant

CANDIDATE PROCESSES[a]	Cs DF = 1000?	EQUIPMENT COMPLEXITY	RELATIVE COST	PROCESS CONSIDERATIONS	MATERIAL REQUIREMENTS
Inorganic IX Zeolite (IE-96)[b]	Yes at 25°C, pH ~ 10, 0.6 cv/Hr	Relatively Simple	Relatively Low	Significant. Amount of zeolite not easily transferred/melted. (Final design resolved all above)	80,000 kg Zeolite and 63,000 L Water (Final Design uses 47,000 kg of zeolite as received basis)
Inorganic/Elution	Yes at 25°C, pH ~ 10, 0.6 cv/Hr	Moderate	Moderate	Zeolite is not sufficiently decontaminated	91,000 kg HNO_3
Organic IX Resins (CS-100 IRC-718)	Yes at 6°C, pH ~ 13, 80 mesh	Considerable: vessels, plumbing	High	Control formate to prevent metal reduction. Autocatalytic ignition with nitric acid elution possible	2,400 kg resin 24,000 kg NaOH 90,000 kg $HN0_3$ 4.6×10^6 L water
Precipitation (NaTPB)	Yes with decanted supernatant; large quantity of chemicals required for WVDP	Considerable: acid hydrolysis, benzene incinerator	High	Organic destruction	200,000 kg NaTPB 16,000 kg CH_3OH 650,000 L water 354,000 kg of organics to LWTS/melter.
Precipitation (PTA)	Yes - pH = 0	Considerable: vessels, filters pH adjustments.	High	pH = 0, ppt separation critical. Two contacts required. Increased LLW.	350,000 kg Na0H 556,000 kg $HN0_3$ 6,280 kg PTA 2.3×10^6 ft^3 Off-Gas 690,000 L water

(a) Other processes examined, but not retained as leading candidates were: ARC-359, A-51, IRC-84, IRC-505, charcoal, electrodialysis, hyperfiltration, ferrocyanide, and biosorbents.

(b) Other inorganic media evaluated but not utilized because their performance was not as good as IE-95/96: Durasil, DeVoe/Holbein compositions, natural zeolites, synthetics zeolites, and variations to IE-95/96.

2.3.3 Impact on the High-Level Waste Vitrification System (VS)

The possible impacts from the STS processes on the VS are those that could affect glass durability, ceramic melter operation, or waste feed to the ceramic melter.

The organic ion-exchange process and NaTPB precipitation process would introduce a significant amount of organics to the VS. Depending upon the ceramic melter design, difficulties or early failure of the ceramic melter could result.

The PTA process did not seem to have any adverse impacts on the VS. The chemical species added to the vitrification feed from the precipitate should not significantly impact the chemical composition of the vitrification feed or the glass product.

2.3.4 Impact on the LWTS

The alternative supernatant decontamination processes varied widely in their impact on the LWTS. The only impact of the inorganic zeolite ion exchange process or LWTS is in the volume of decontaminated supernatant plus flush water that must be concentrated in LWTS. The organic ion exchange process would contribute the largest volume of process condensate (4.6×10^6 L) to the LWTS for further treatment. The NaTPB precipitation process would contribute substantial quantities of organic material (167 000 kg) in addition to ~700 000 L of process water to the LWTS. The treatment of this organic material might add significant complexity to the LWTS. The PTA process would increase the mass of salt required for processing in the LWTS by ~40 percent, because of additional salt added to the system from acidification and reneutralization of the supernatant.

2.3.5 Final Selection of Ion Exchange Media (Carl, 1986)

The selection of the reference supernatant treatment process for the WVDP was based on a technical ranking. WVNS ranked the processes in order based upon four general criteria which are shown below in their order of importance.

- Process performance
- Process impacts on the VS and LWTS
- Equipment and process complexity (process reliability)
- Safety and environmental considerations

Using this general ranking criteria as a guideline, the processes were ranked in the following order:

- INORGANIC ZEOLITE ION-EXCHANGE PROCESS
- PRECIPITATION PROCESS-PTA
- ORGANIC ION-EXCHANGE PROCESS
- PRECIPITATION PROCESS-NaTPB

In terms of a relative technical ranking position, the zeolite ion-exchange process was ranked first, followed closely by the PTA precipitation process. The PTA precipitation process, although complex because of the large number of batch operations required, would have a small impact on the VS. The organic ion-exchange process achieved a low ranking because of: 1) its poor decontamination performance; 2) its high equipment and process complexity; and 3) its impacts on the VS and LWTS. The NaTPB precipitation process achieved the lowest technical rating because of: 1) the relatively complex processing required for treatment of the precipitate; and 2) the significant impact of the process on both the VS and LWTS. As a result of the above technical ranking, the STS at WVNS was designed as a four-column, inorganic ion-exchange process using zeolite IE-96 media.

3.0 SYSTEM DESIGN AND CONSTRUCTION

While the ion exchange media was being selected, WVNS engineers were designing a generic system for whatever media was chosen and planning the construction of the system. It was decided to locate the STS on the WVDP Waste Tank Farm to be consistent with the overall site philosophy that existing facilities were to be used to the maximum extent practical. The existing high-level Waste Tank Farm consisted of tanks 8D-1, 8D-2, 8D-3, and 8D-4. In 1984, tank 8D-2 contained 2 195 539 L (580,000 gallons) of HLW including the supernatant to be processed in the STS; 8D-1 is a duplicate spare for 8D-2. tank 8D-4 contained 45 000 L (12,000 gallons) of THOREX waste, and 8D-3 is its spare. The four tanks are contained in three concrete vaults (8D-3 and 8D-4 are in one vault). The vaults are buried; there are 2.4 m (8 to 9 feet) of earth over the 8D-1 and 8D-2 vaults and 1.8 m (6 feet) of earth over the 8D-3 and 8D-4 vaults. Figure 4 shows the waste tank farm layout. Tanks 8D-1 and 8D-2 rest on a 12-inch layer of perlite blocks supported by a 7.62-cm (3-inch) layer of pea gravel in a carbon-steel pan. Tanks 8D-1 and 8D-2 are identical; they are 21 m (70 feet) in diameter and 8.3 m (27 feet) in height with a 2.8 by 10^6 L (750,000 gallon) capacity. The tanks are fabricated of carbon-steel plate, 1.3 cm (1/2 inch thick) on the sides and bottom and 1.11 cm (7/16 inch thick) on the roof. Each tank has an elaborate internal gridwork consisting of I-beams. The tank roof is supported by forty-five 20-cm (8-inch) diameter steel columns resting on this I-beam assembly within the tank (see figures 5A and 5B). The vault roof is supported by six 76-cm-diameter (29.9 in.) concrete columns that are each encased inside 1.2-m-diameter (3.9 ft) carbon-steel pipe. **(Schiffhauer, 1985)**

Radioactive process operations of the STS were planned to be conducted totally within the existing HLW storage tanks 8D-1, 8D-2, and 8D-3. To accomplish this, new construction was required for the transfer of the radioactive waste from tank 8D-2 to the STS, using interconnecting double-contained piping housed in a containment conduit. New construction was also required to provide support for the STS and Waste Mobilization System (WMS) process components, as well as to install risers in tanks 8D-1 and 8D-2 for inserting equipment. A pipeway and Valve Aisle were required adjacent to tank 8D-1 for process control. Although tank 8D-1 had never been used for waste storage, condensation from tank 8D-2 had contaminated the spare tank so that radiological contamination controls had to be maintained when tank penetrations were made. Fortunately, there was no contamination between the tank and the vault, and radiation levels averaged 6 to 8 mR/hr on the tank roof. This allowed conventional construction methods to be used except for tank penetrations made on tank 8D-2.

3.1 Design Requirements

The Supernatant Treatment System had to incorporate the following design features: **(Carl, 1985)**

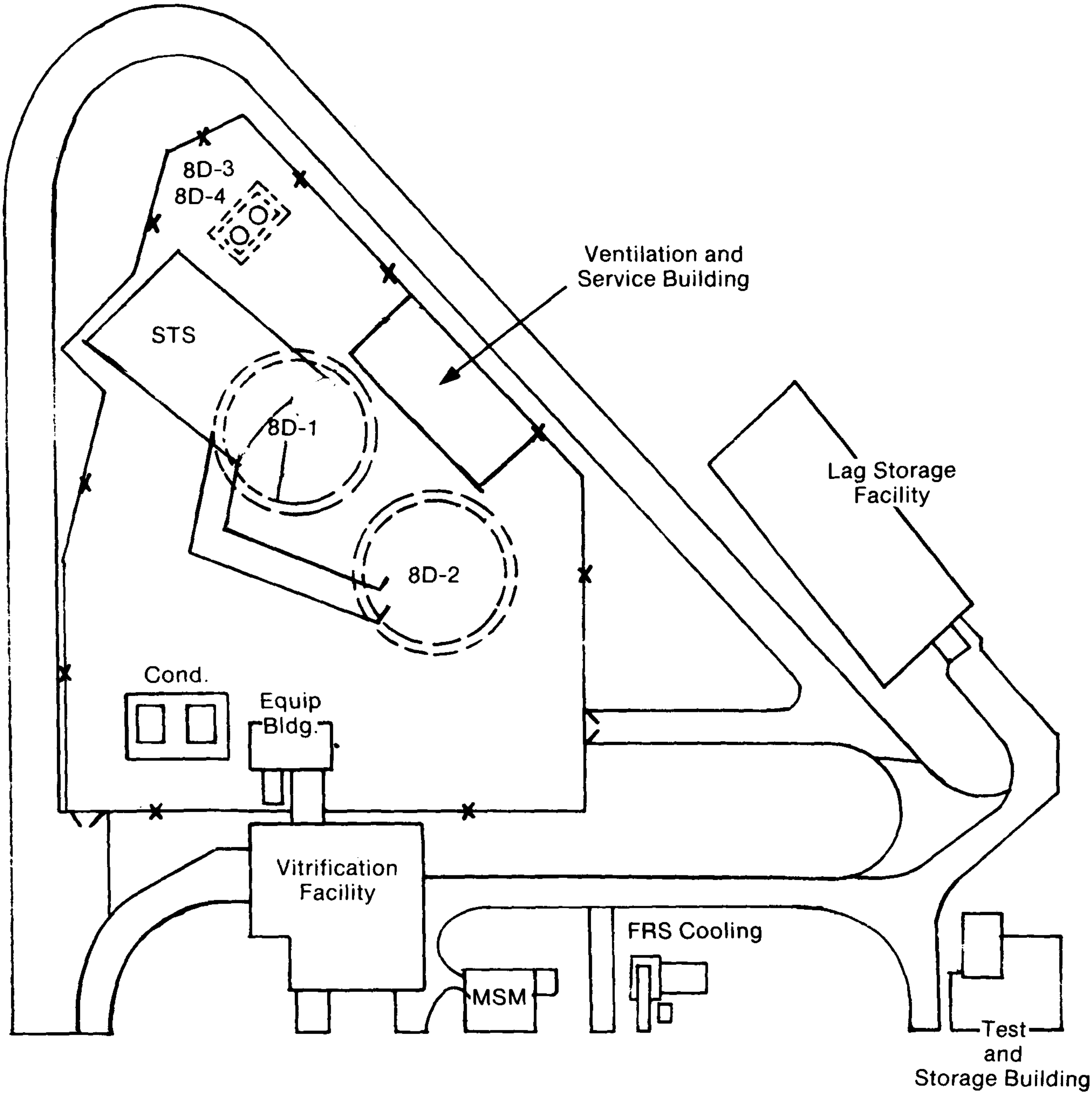


FIGURE 4
Waste Tank Farm Layout Diagram

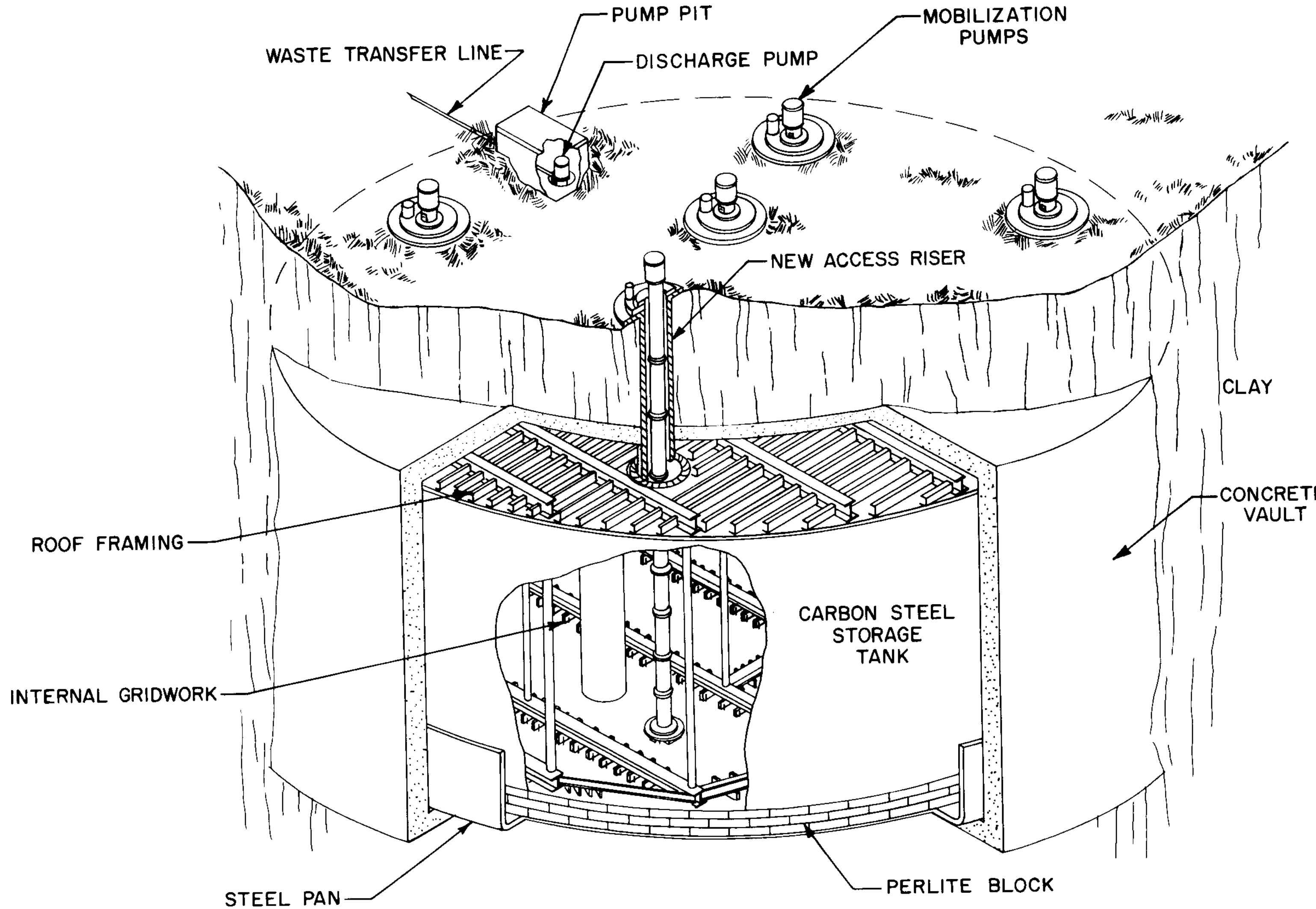
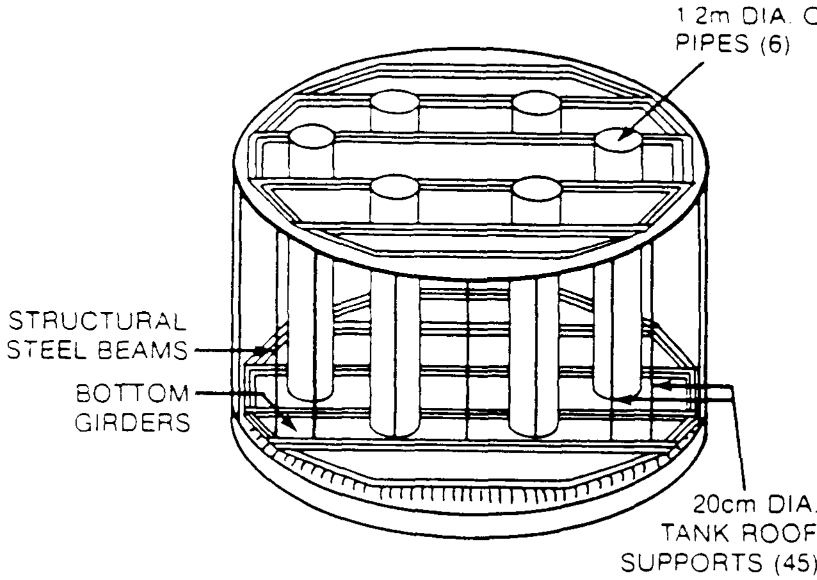
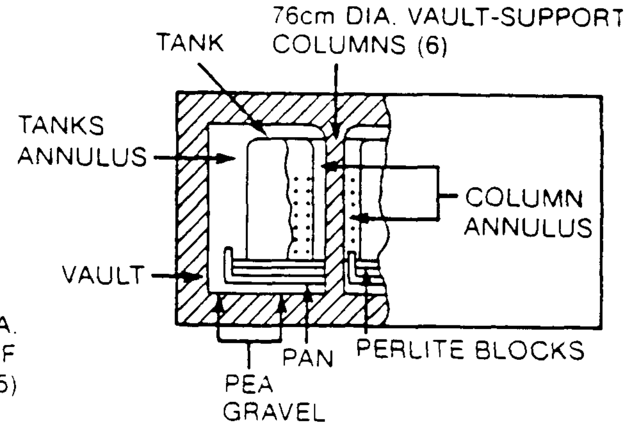


Figure 5A
Detail Diagram of 8D-1 and 8D-2



TANK INTERNAL STRUCTURE



TANK/VAULT CONFIGURATION

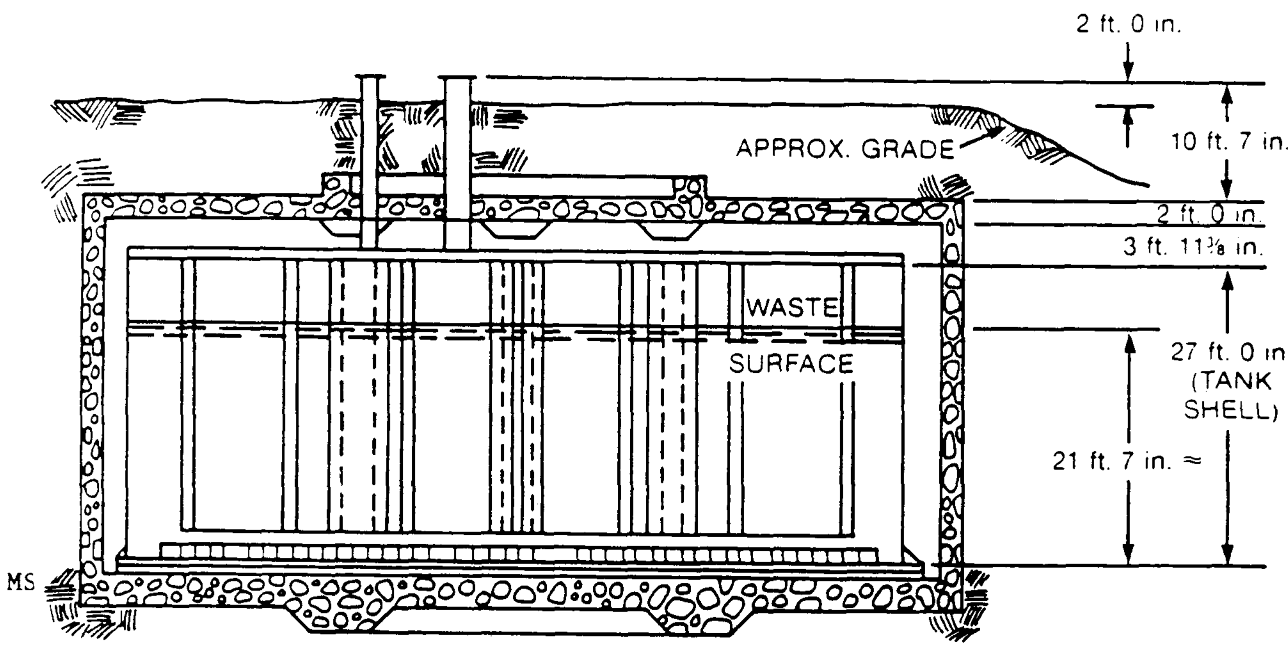


Diagram of Neutralized High-Level Waste Tank Showing Vault Elevation. Source: Janicek (1980).

FIGURE 5B
Detailed Diagrams of 8D-1 and 8D-2

- Multiple Levels of Containment
- Maximize Use of Existing Facilities
- Remote Operation
- Redundancy/Replacebility
- Simplicity
- Independent Ventilation System

Tables 6 and 7 summarize the Functional and Operational Requirements and Design Criteria for the STS.

The STS design went through the following design stages: 1) conceptual design; (2) preliminary design; and (3) final design. The conceptual design phase is controlled by the Functional and Operational Requirements and the Design Criteria for the individual systems. A Conceptual Design Report was prepared by EBASCO for several STS-proposed processes and included conceptual design system description, schedule, cost estimate, and drawings.

The preliminary design phase started after the conceptual design was complete. The STS had four different processes that were taken to the preliminary design phase. Five formal design reviews were held to compare the preliminary design against the Project objectives and requirements and to approve the design for use. During this period of time, over 181 deliverables (each deliverable item could consist of from 1 to 8 drawings, equipment specifications, or calculations) were produced by EBASCO. EBASCO had 22 engineers, at the height of the design effort, working on the design of the STS. WVNS acted as project manager for the design, and five WVNS engineers effectively directed and coordinated the EBASCO effort. Final design was completed in July 1986.

In general, the STS equipment was designed **(Carl, 1986)** for a single-use process; therefore, all efforts were made to economize as long as this could be done without loss of safety. The column flow was made low enough to give the maximum DF; contamination control was accomplished by using isolation components and remotely operated valves.

The STS Safety Analysis Report **(Brown, 1988)** was reviewed by DOE and NRC. An independent safety review of the STS requested by DOE and conducted by E.G. & G concluded that the STS was safe to operate. Dames and Moore **(Dames and Moore, 1986)** also conducted a review of the adequacy of the confinement boundaries between the STS and the environment during postulated worst-case accidents. This review concluded that there was a large margin of safety in the design of the confinement boundaries. As a result of these reviews, the NRC issued its Safety Evaluation Report (SER) indicating that the STS was safe to operate. **(SER, 1987)**

Table 6. STS Functional And Operational Requirements	
GENERAL REQUIREMENTS	• Provide to the vitrification system a slurry of cesium-loaded ion exchange media, and water containing less than 28 000 kg Sodium • Cesium DF of more than 1,000 • The cesium-loaded ion exchange media should be capable of being stored for an extended period of time in a form compatible with glass • Sampling provisions must be provided
EQUIPMENT REQUIREMENTS	• Redundant instrumentation • Decontamination capability • ALARA consideration -- no "crud" traps • Prevent contamination of noncontaminated system • A separate ventilation system • Personnel support systems -- fire protection, area radiation monitors • Interface with other systems • Design life of 10 years • Designed to be consistent with QA Program (i.e., ANSI/ASME NQA-1-1979 requirements) • Design Standards: INEL Architectural/Engineering Standards Idaho Operation Safety Design Criteria Manual DOE Design Criteria DOE ID-12044 Industry Standards: ASME, ANSI, UBC ZONE III

Table 7. Design Criteria Summary

INTERFACING SYSTEM REQUIREMENTS

LWTS	• STS shall deliver decontaminated supernatant at 50 GPM flow rate • Capable of handling supernatant diluted 2:1 with water
Zeolite Mobilization	• Cesium-loaded zeolite must be compatible with tank 8D-1, and zeolite must remain covered with water
Vitrification	• Ion exchange media must be compatible with glass
Service Utilities	• Main Plant capable of providing the following utility requirements: Backup utility and instrument air Electrical Demineralized water
Disposal Operations	• Dispose of any wastes generated during decontamination

STS PROCESS REQUIREMENTS

- Remove 90 percent of supernatant from 8D-2
- Separate 99.9 percent Cs-137 from supernatant (minimum DF = 1000)
- Render decontaminated supernatant suitable for incorporation in cement as low-level waste
- Render separated cesium to form suitable for temporary storage and delivery to vitrification system

STS STRUCTURAL REQUIREMENTS

Structural requirements for facilities intended to house STS components are as follows:

Tank 8D-1 or 8D-2 Structural Additions	UBC, Zone 3, I.F. = 1.0; Horizontal only
Pipe Culvert - Tank 8D-1 to Valve Aisle	UBC, Zone 3, I.F. = 1.0
STS Support Building Below-Grade Structure	UBC, Zone 3, I.F. = 1.0
Process Piping (8D-2 to 8D-1; 8D-1 to 8D-3, 8D-1, 8D-2, 8D-3 to LWTS	ANSI B31.3, 1984 Edition with 1986 Addendum
Equipment Supports -- for equipment suspended in tank 8D-1 or 8D-2 (including skirts)	ANSI A58.1

Table 7: Design Criteria Summary (continued)

STS OPERATIONAL REQUIREMENTS

CAPABILITY FOR BATCH OR CONTINUOUS OPERATION

OPERATED BY TRAINED OPERATORS USING WRITTEN PROCEDURES

Normal Operation	• Continual feed of supernatant to ion exchange columns • Batch transfer of decontaminated supernatant from 8D-3 to LWTS
Standby Operation	• Flush ion exchange columns with water • Dump or sluice fully loaded zeolite in lead column to 8D-1

STS SAFETY REQUIREMENTS

"MODERATE" SAFETY CLASS IN ACCORDANCE WITH ID-12044

Radiation Limits

Remote Process Operations	• No normal entry
Process Services Utilities	• Systems not normally containing radioactive material
Control Room & Continuous	• 0.5 mR/hr
Occupancy Areas	• 0.25 mR/hr or less

Fire Protection, Industrial, and OSHA Requirements

- In compliance with ID-12044
- Intercom system to connect with emergency paging system
- Telephones in control room and operating aisle

Project Requirements

- SAR, EE, OSRs provided for system
- Effluent release points monitored and sampled in accordance with ANSI N 13.1-1969 and ANSI N 42.18-1974

STS MAINTENANCE AND INSPECTION REQUIREMENTS

- Equipment in HLW tanks designed to permit remote removal and replacement
- Equipment located to minimize radiation exposure to plant personnel during maintenance
- Jumpers provided for remote replacement of probable failure components only
- Nonradioactive equipment designed and located for contact maintenance
- Two types of sumps provided to collect leaks, spills, and flushes (contaminated and clean)

3.2 STS Design Decisions

An evaluation based on the project directive to maximize the use of existing facilities concluded that the STS should be placed on the Waste Tank Farm because the Waste Tank Farm was the only existing location on the site which had the shielding and the area to house the STS without major modifications and additions or conflicts with other project requirements. The major process components of the STS (i.e., the Prefilter, the Feed Tank, the Supernatant Cooler, the four Ion Exchange Columns, and the Decontaminated Supernatant Filter) were, therefore, located in the existing underground tank 8D-1 as favored by DOE and NYSERDA. Tank 8D-1 had suitable shielding; and its volume was sufficient to serve as a backup to tank 8D-2, contain the process equipment, and provide temporary storage for the cesium-loaded zeolite. In addition, using tank 8D-1 would lower the construction costs for the STS. An additional shielded facility, the STS Support Building, was constructed to house the control room and components that would not be radioactive.

Major construction modifications were, however, required on tank 8D-1 to provide access to the tank for inserting the process components and to provide structural support for the components. The Process Component Support Structure is a semicircular structure which is itself supported off the existing vault wall and two of the 1.2-m-vault (3.94-ft) roof support columns for tank 8D-1. The process components are suspended from I-beams supported by the structural walls. A roof with removable hatch sections located over the process components is also supported by the component support structure. The 3-foot-thick concrete walls of the component support structure provide the necessary shielding. A general layout of the area with the STS component support structures shown is given in figure 6.

3.3 New Facility Design (Simpson, 1986)

In addition to the previously described modifications to the existing HLW tanks, a plan for designing and constructing new structures for the STS was developed. The new structures included the pipeway, Valve Aisle, the Support Building constructed adjacent to tank 8D-1 to provide an area for operation of the STS, and the Ventilation and Services Building.

A concrete- and steel-shielded structure was erected on top of the tank 8D-1 Vault Tank for preparing and adding fresh zeolite to the ion exchange columns. The refrigeration system for removing heat from the Supernatant Cooler, the Control Room, and a shielded Operating Aisle from which the manual valves could be remotely operated, and samples obtained using manipulators are located inside the support building. The Support Building had to be built on top of 55 piles because the backfill soil in the tank farm was not compacted after the tanks were built. The 55-foot deep piles are cast-in-place auger-type piles which were constructed as follows: (1) The ground was drilled with a hollow stem auger; (2) The plug in the hollow stem of the auger was pushed out by dropping #11 rebar through the center; (3) Concrete grout was pumped into the auger; (4) Head pressure was maintained while the auger was removed so that the concrete filled the void below the auger; and (5) A rebar cage

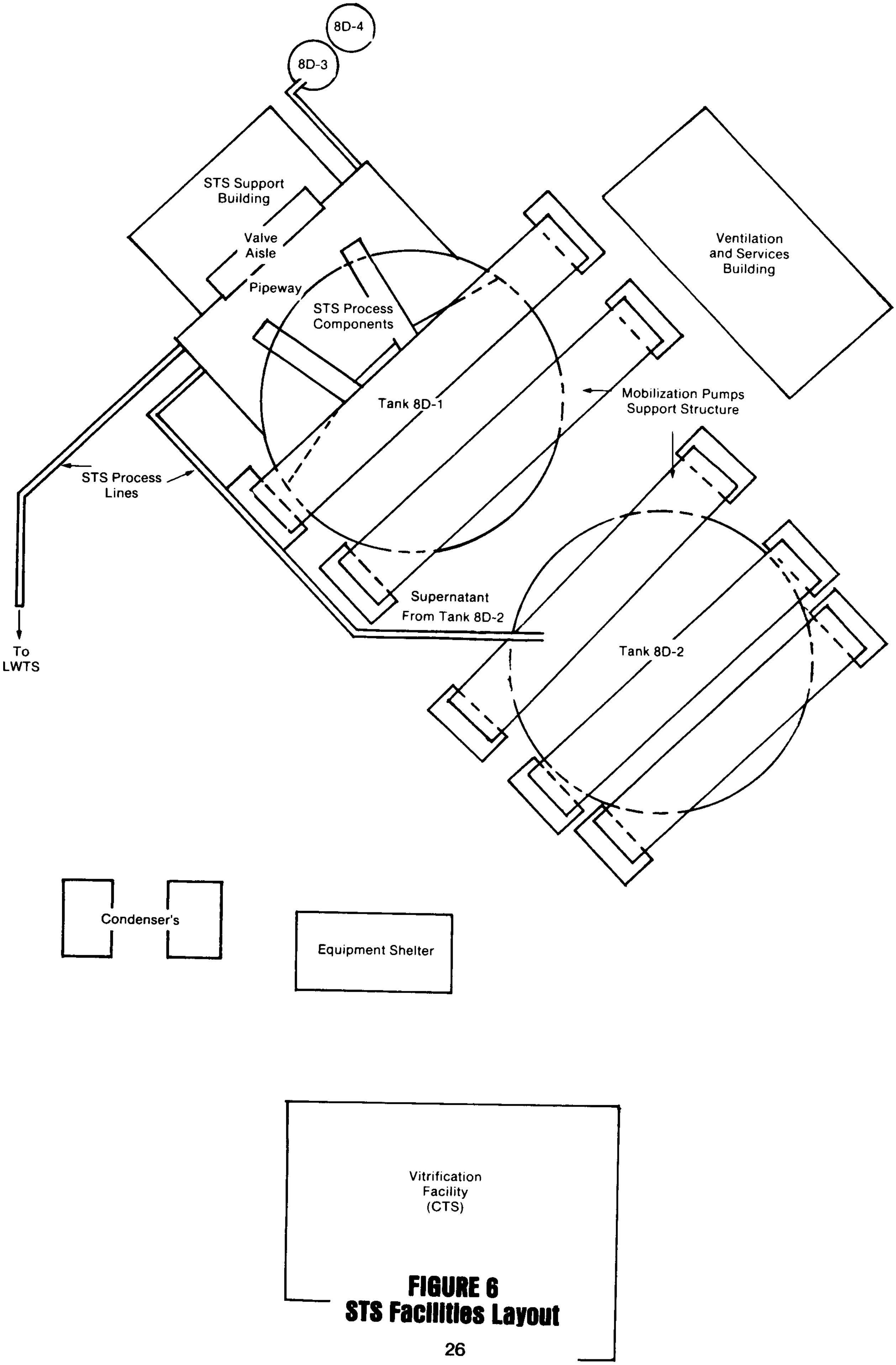


FIGURE 6
STS Facilities Layout

was then pushed into the wet concrete grout. The auger-type piles were selected for this construction since the vibration used in constructing most other types of piles could not be used in the Tank Farm area because of the possibility of causing damage to the existing tanks or the concrete vaults.

3.3.1 Pipeway

The outer support walls of the pipeway were formed by a curb with blockouts to allow for piping runs. The upper portions of the STS components (see figure 7) suspended above the tank vault roof were sealed using epoxy. The epoxy extends over the riser lips and prevents communication between the component support structure and tank 8D-1 Vault. A sump was installed on the vault roof draining through a water-filled trap to 8D-1. A separate sump was installed in the pipeway to collect any liquid for transfer back to tank 8D-2.

3.3.2 Valve Aisle

A shielded valve aisle was constructed at the northwest perimeter of tank 8D-1 in which remotely operated valves and instrumentation are located. The shield steel surrounding the valve aisle contains shielded viewing windows and manipulators to permit remote operation and replacement of components as necessary. The shield walls of the valve aisle are constructed of 12-inch-thick (30.5-cm) carbon steel; the roof is 14 inches of carbon steel. There are removable hatches above the valve aisle for access to the valve aisle for removal of large items. There are removable plugs for transfer of small items into the valve aisle.

3.3.3 STS Support Building

The STS Support Building contains auxiliary support systems and equipment required for operation of the STS. This structure houses the fresh-water tank, STS chiller, control room, HVAC equipment, and utility services. The building will be maintained as a radiologically "clean" area.

3.3.4 Waste Transfer System

Piping carrying raw supernatant between tanks 8D-2 and and the STS is double-walled stainless-steel pipe contained within a sealed stainless-steel conduit. Piping for transferring decontaminated supernatant is single-walled stainless steel; this pipe does not need to be doubled-walled because of the relatively low activity of the decontaminated supernatant. The radioactivity in the decontaminated supernatant has been decreased at least 1000 times after processing through the STS; therefore, it is no longer HLW.

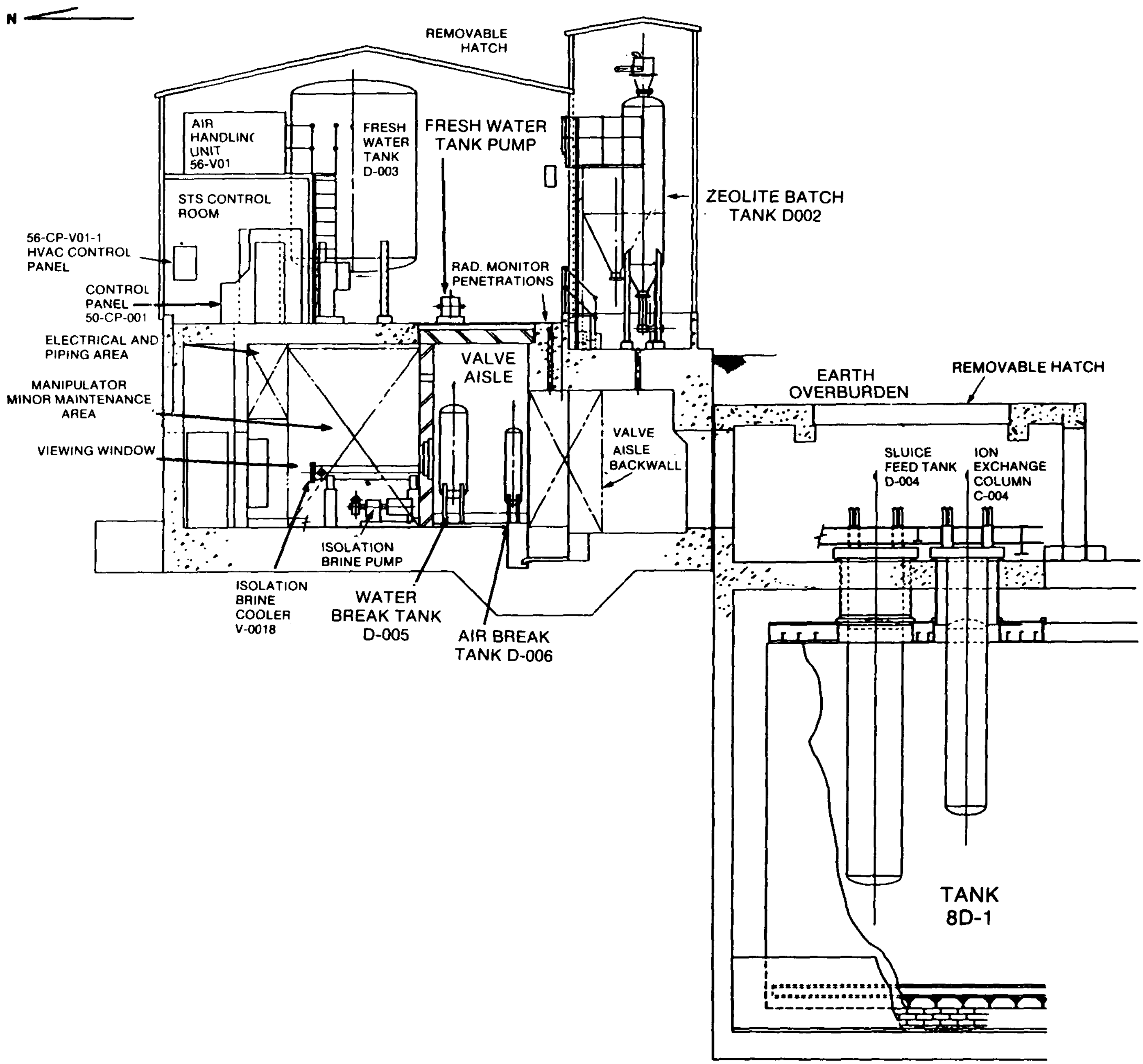


FIGURE 7
STS Support Building and 8D-1 Tank/Vault Modification

3.3.5 STS Ventilation System

In addition to the existing ventilation system on the Waste Tank Farm, it was necessary to use a temporary ventilation system to support component installation into tank 8D-1 and avoid construction delays while waiting for a permanent vent system to be designed and built. A permanent ventilation system was installed after the 8D-1 risers were installed to maintain the operating air flow requirements in the support building, valve aisle, and pipeway during radioactive operations.

3.4 Structural Specifications (Borisch, 1987)

Existing nuclear and commercial industry codes and standards were used to guide the design, construction and installation of various systems associated with the STS. The choice of construction materials, design approaches, and construction methods were well tested and have been used in many other nuclear facilities. This provided a high degree of confidence that structures/systems would behave in a predictable manner when experiencing loading levels inherent in the design codes.

The American Concrete Institute (ACI) Standard 318-77, augmented with appropriate loads and load combinations from ACI 349 in conjunction with the Uniform Building Code (UBC) Zone III, importance factor 1.0 for seismic load definition, were used in the analysis and design of the reinforced concrete portions of the 8D-1 tank top modification and vault. The American Institute of Steel Construction (AISC) Code was utilized in design of the structural steel elements.

The loads considered in the design and/or analysis were dead loads, live loads, thermal loads, seismic loads (applied as horizontal static load to both above ground structure and as part of the dynamic soil pressure loads for below ground structures), static soil pressure, equipment and piping loads, hydrostatic loads, and construction loads.

The analysis performed by Lawrence Livermore Laboratories (LLL, 1978) was used to prorate and verify the calculated dynamic soil pressure. The soil pressure established for 0.1g seismic ground acceleration was translated into an equivalent static force using a Mononobe-Okabe formula.

The loads and load combinations described were utilized in the design of the steel and concrete structure. The steel framing system was designed to carry the in-tank components and piping loads and transmit them to the shield structure's concrete walls through embedded plates. The load then is applied to the tank vault walls and interior concrete columns through the reinforced concrete walls. The roof of the shield structure is made up of cast-in-place slabs and removable panels supported by the frame and walls. Traditional statistical analysis methods were utilized in the design of both reinforced concrete and structural steel members.

The tank 8D-1 concrete vault was analyzed for the following purposes:

1. Maintenance of the vault integrity as a result of the loads from the shield structure (that is, dead loads, STS components and piping loads in conjunction with other pre-existing loads);

2. Verification of vault structure integrity subsequent to the removal of concrete cut outs for the STS components;

3. Maintenance of vault integrity under a concrete bucket drop during construction, a postulated worst case accident.

The loads delineated above were utilized in the analysis including the buoyant uplift due to hydrostatic pressure. These loads were applied to the vault in several different combinations and entered into the Stardyne Static Finite Element Analysis computer program. The computer output was then reviewed and the most critical stress elements were then used in the verification of the vault reinforcement and stresses within the concrete **(Brown, 1988)**.

As a result of the vault's floating during the original NFS construction period, the vault ceiling and bottom underwent stresses which caused cracking. This crack pattern was mapped during original vault construction. It was factored into the vault analysis and resulted in the imposition of allowable load limits during and after the cutting of holes in the vault roof for the STS components. Soil properties used in the analysis were verified by performing additional borings and sample testing.

In summary, based on the assessment under the load conditions and combinations discussed above, the tank 8D-1 vault integrity will be maintained and compiles with ACI-318.

3.5 STS Construction Phases (Simpson, 1986)

Interfacing and coordination of all construction activities was necessary to successfully complete this operation. Table 8 shows the phases of STS construction and schedule of events.

Table 8. STS Construction by Phases

Phases	Description	Start	End
Phase I	8D-1 Tank Vault modification	June 85	Nov. 85
Phase II	Pouring foundation, erecting metal support building and setting valve aisle	Jan. 86	July 86
Phase III	Installation of Temporary Ventilation System and risers,	March 86	June 86
Phase IV	STS equipment installation, piping, electrical, pump supports, Permanent Ventilation System	June 86	July 87
Remote Riser Installation	Sludge mobilization work performed on tanks 8D-1 and 8D-2 while STS was being constructed.	June 86	April 87
Phase V	Installation of Utilities and Pneumatic Sample Transfer System	Sept. 86	May 87

The major factors in maintaining the STS construction schedule were: (1) performing operations in parallel, by dividing STS construction into overlapping and separate phases; (2) timing delivery of the major components; (3) developing procedures and training for radiological controls during construction; and (4) interfacing and coordinating new system installations with existing operational systems. This action track policy permitted key phases of the work to be completed while design was being finalized on other phases. Also there were other innovations which helped to accelerate construction. For example, the valve aisle shield steel was fabricated and preassembled off-site before delivery to site for final erection. In this way, 243 tons of shield steel were erected on-site in only four days. Also, the backwall located in the valve aisle was prefabricated off-site. The backwall module contains over 200 pipe projections for attachment of the jumpers. The backwall was shipped to the site in two 16-foot sections which required only welding together once they arrived on site.

3.5.1 Design Review

The inaccessible components were designed to have low failure potential and to have alternate processing approaches available. For example, the IX columns can be bypassed using jumpers in the valve aisle. Pipes all have welded construction and are examined to standards exceeding code requirements. Most valves and instruments are located in the valve aisle on jumpers to facilitate replacement.

3.5.2 Contractor Selection and Mobilization

For each construction phase the bidding process was similar. Once the design had been reviewed and approved, that portion of the STS was ready for contractors to bid on the construction. Bid packages were sent out to all acceptable bidders; bids were received and evaluated; and construction started as soon as the bid was accepted.

WVNS served as the prime contractor for the five STS phases. There were six main subcontractors and each employed at least two subcontractors for each phase of construction of the STS. For Phase I there was, on average, a crew of 20; for Phase II, 20; for Phase III, 10; for Phase IV, 60; and for Phase V, 10. The contractors came to the site with their equipment and work force, and spent the first few weeks setting up their base of operation (trailers, power, laydown areas, tools, etc.). After setup, actual construction began.

Details of the construction performed in each of these phases follow, and the schedule of the construction activities associated with each phase is in table 8.

3.5.3 STS Phase I (figure 8)

The main-purpose STS Phase I construction contract was the removal of overburden from the top of a portion of the 8D-1 Tank Vault and the construction of the 8D-1 and STS Support Building foundation slab. The foundation slab was installed after 55 auger-cast concrete piles, which extend from the slab down to undisturbed material, were installed. The component support structure was built on top of a portion of the 8D-1 Vault. It is supported by two existing columns extending down through tank 8D-1 to undisturbed earth under the vault and by the tank vault walls themselves. In order to remove the overburden from the top of the 8D-1 Vault, the groundwater table around the 8D-1 and 8D-2 Vaults was lowered to guarantee that the 8D-1 Vault would not float.

3.5.4 STS Phase IIA (figure 9)

The STS Phase IIA construction contract consisted of constructing the concrete walls and roof slab of the lower portion of the STS Support Building, erecting the pre-engineered metal building that makes up the upper portion of the STS Support Building, installing the steel Valve Aisle that was manufactured under the Phase IIB contract, and erecting the rest of the pipeway started in Phase I. The Phase IIA contract also included constructing two zeolite mobilization pump support truss foundations.

3.5.5 STS Phase IIB (figure 10)

The Phase IIB contract consisted of fabricating and pre-assembly of the STS Valve Aisle and fabricating and assembling the transfer drawer. The steel Valve Aisle is a structure consisting of three walls and a roof section; it weighs approximately 243 tons and is made up of 4-inch-thick steel plates bolted together to make up a 12-inch-thick wall section. By pre-assembly of the Valve Aisle, a proper fit was accomplished for on-site installation during Phase IV construction when the backwall of the Valve Aisle was installed.

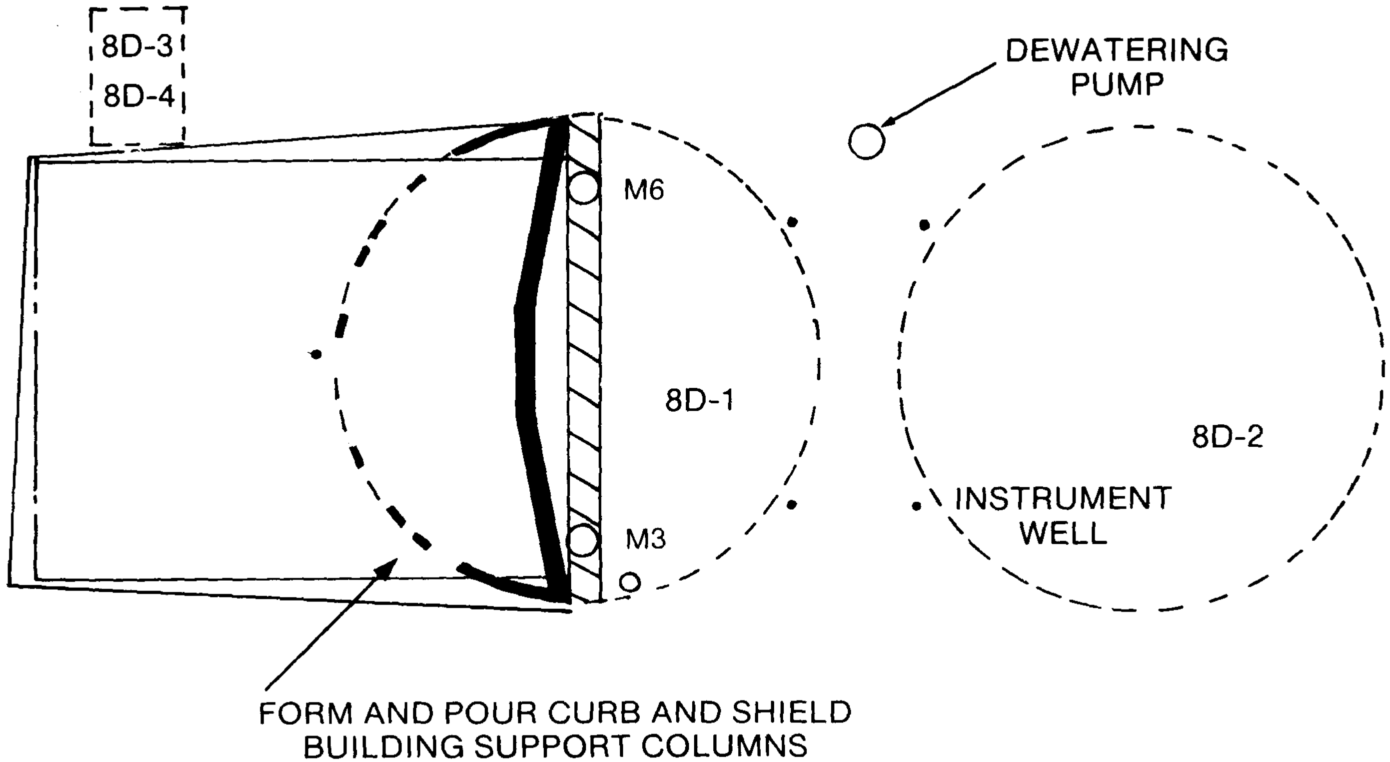


FIGURE 8
Phase I Construction Diagram

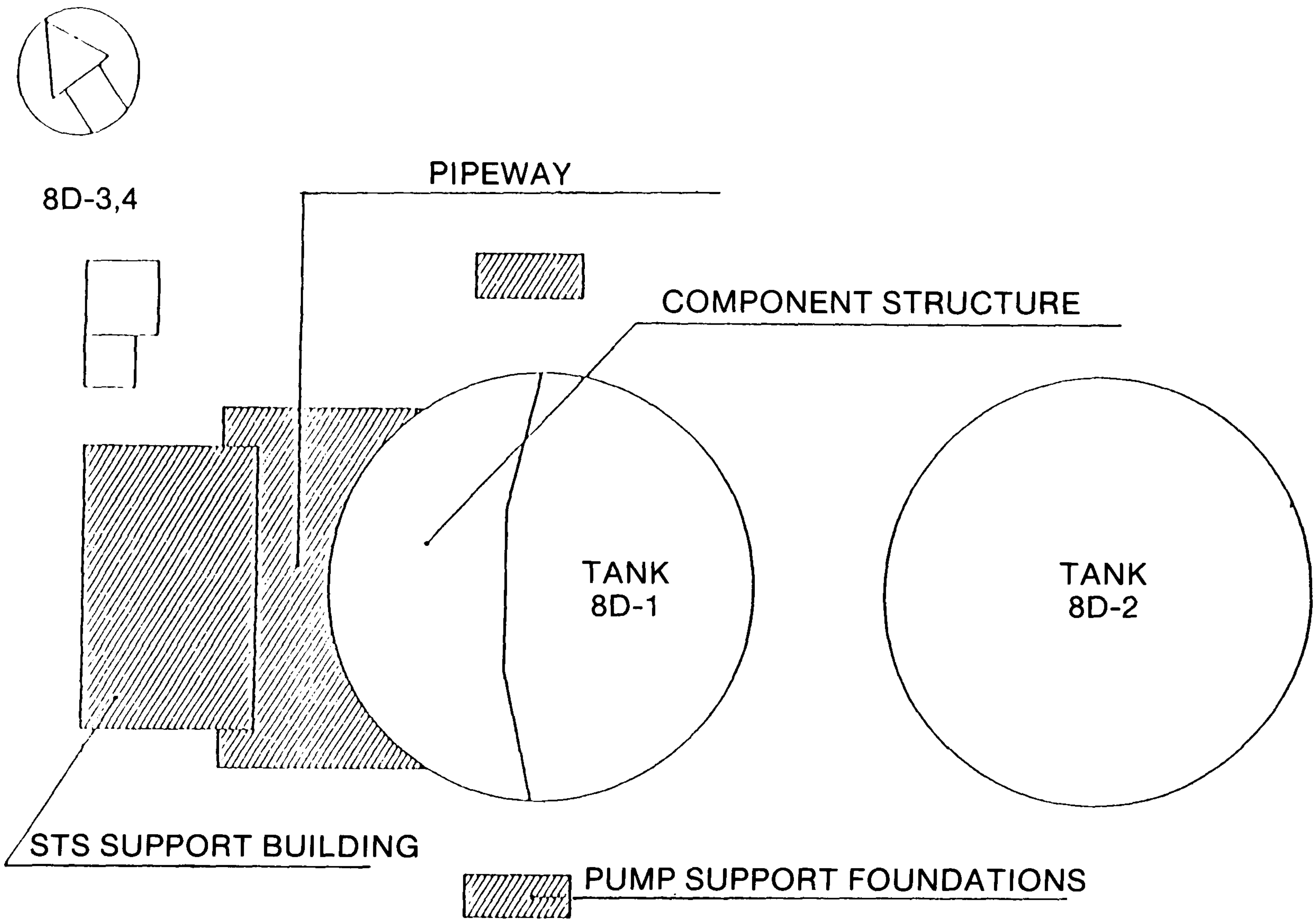


FIGURE 9
Phase IIA - Construction Diagram

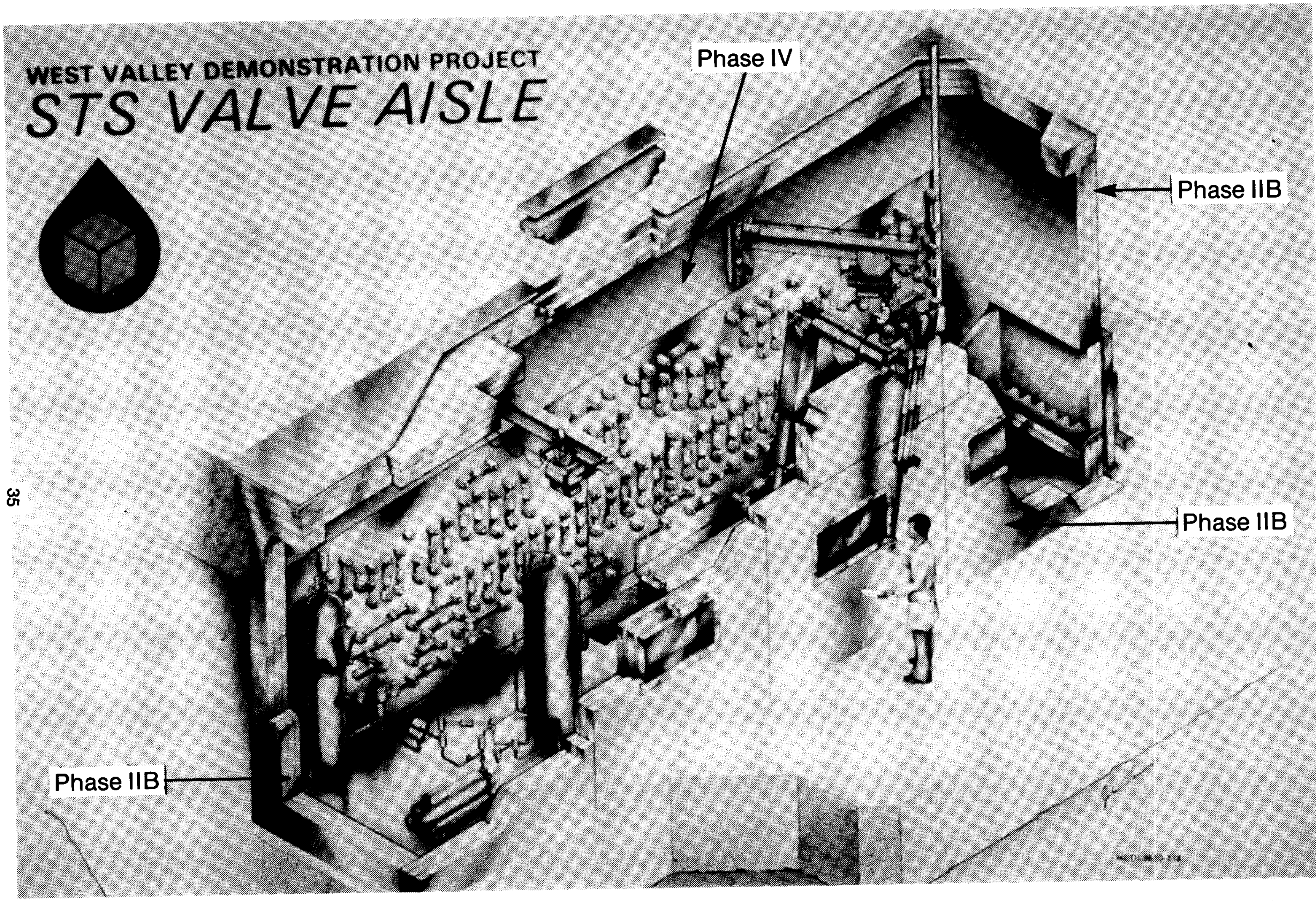


Figure 10
STS Valve Aisle

3.5.6 STS Phase III (figure 11)

The STS Phase III contract covered installation of all of the STS component risers in tank 8D-1, the construction of caissons for the risers on the 8D-1 and 8D-2 vaults, and installation of the Temporary Ventilation System (TVS) for 8D-1. See table 9 for a list of penetrations to tank 8D-1.

Preparation for the installation of the risers on tank 8D-1 required reinforcing the roof of the existing tank. The installation of the TVS system required the cutting into an existing 12-inch vent line and installing a bladder system to isolate tank 8D-1 from 8D-2 and the existing Waste Tank Farm Vent System during periods of operation.

3.5.7 STS Phase IV (figure 12)

During Phase IV the following construction was accomplished:

a. Installing the STS components into tank 8D-1 (see table 9).

b. Installing the Permanent Ventilation System.

c. Installing the Valve Aisle Backwall.

d. Installing all piping between the STS components and the Valve Aisle Backwall.

e. Installing all utility piping in the STS and Ventilation and Service Building.

f. Installing the Brine Chiller System.

g. Providing the HVAC for the STS Support Building.

h. Installing all electrical and instrumentation for the STS Support Building.

i. Fabricating and installing the supernatant transfer piping from tank 8D-2 to STS.

j. Installing pumps in 8D-3 and 8D-2.

k. Fabricating and installing the remaining zeolite pump support trusses over tanks 8D-1 and 8D-2.

3.5.8 Riser Installation (Phase IV)

This installation was not actually part of the STS construction , but it had to be completed so that the STS components could be placed in the tank. One long-shafted zeolite mobilization pump and the STS components listed in table 9 were installed in tanks 8D-1 and 8D-2 as shown in figures 13, 14, and 15.

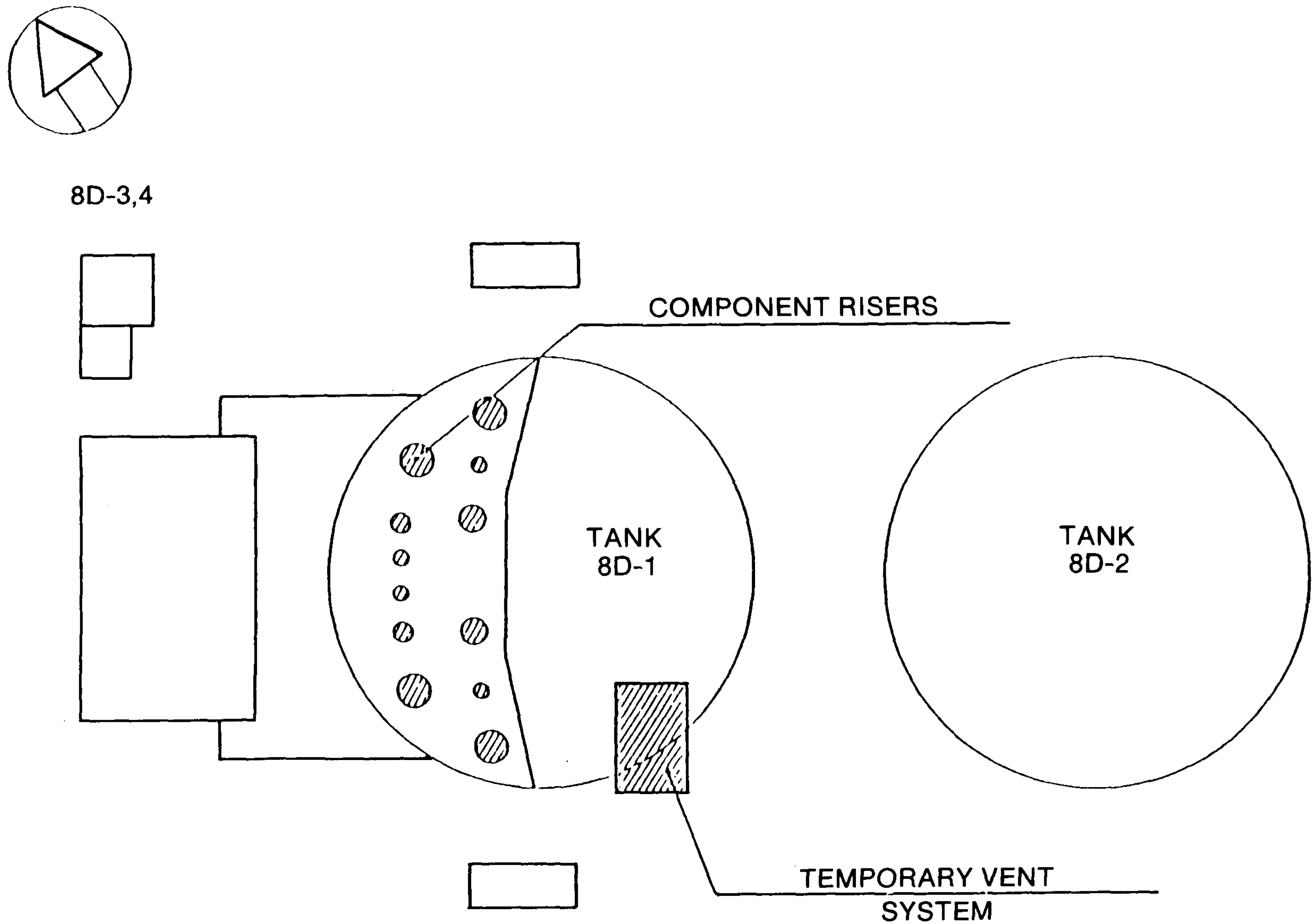


FIGURE 11
STS Phase III - Construction Diagram

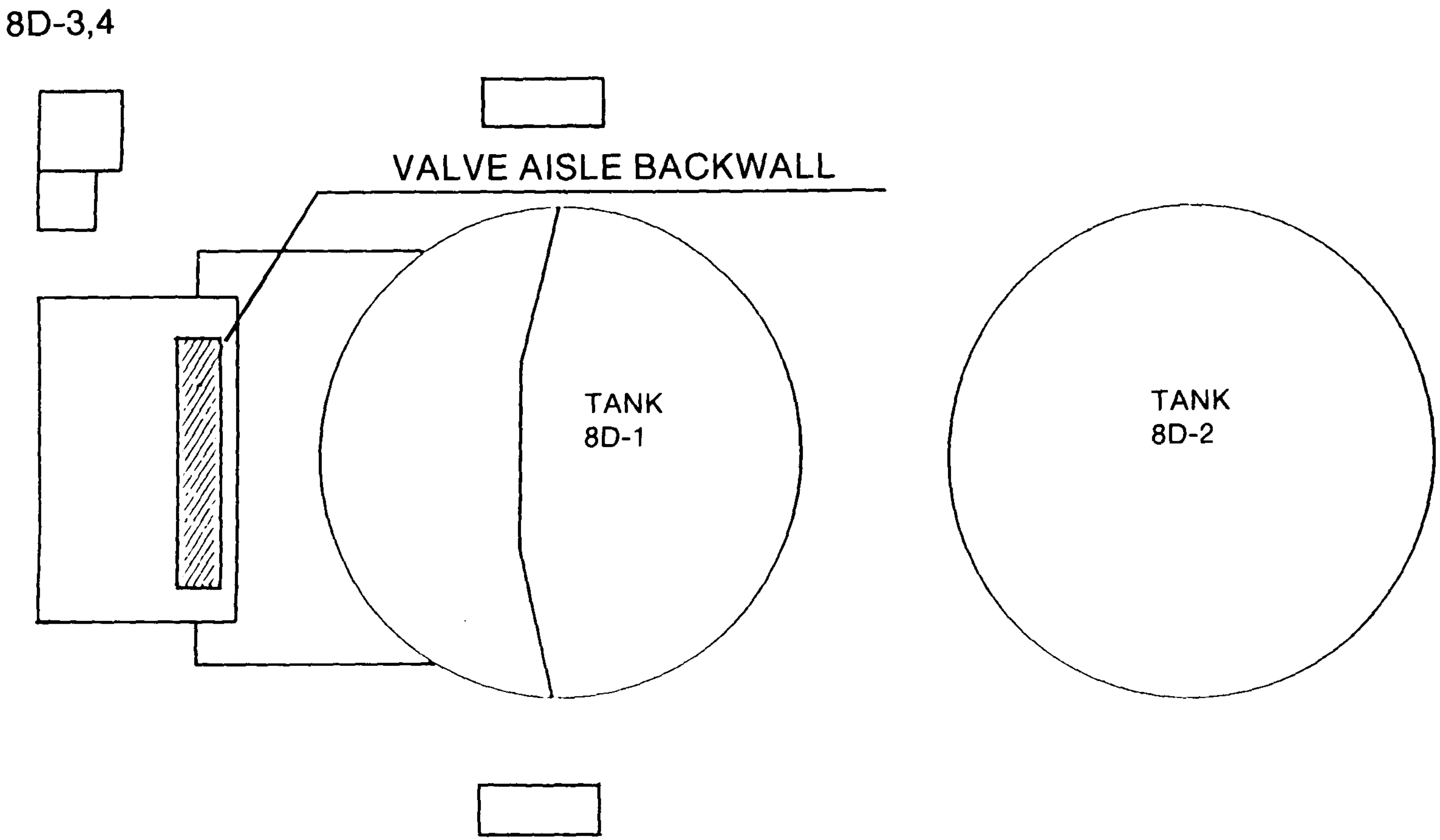


FIGURE 12
Phase IV - Backwall Installation

Table 9. Penetrations to Roof of Tank 8D-1

HOLE DESIGNATION	PURPOSE/ DESCRIPTION	APPROXIMATE OPENING SIZE	INSTALLATION METHOD
C-001	STS IX Column	4' 4"	Manual
C-002	STS IX Column	4' 4"	Manual
C-003	STS IX Column	4' 4"	Manual
C-004	STS IX Column	4' 4"	Manual
D-001	STS Supernatant Feed Tank	5' 2"	Manual
D-004	STS Sluice Feed Tank	5' 2"	Manual
E-001	STS Supernatant Cooler	3'6" x 2'0"	Manual
F-001	STS Prefilter	3' 6"	Manual
F-002	STS Postfilter	3' 0"	Manual
G-004	STS 8D-1 Pump	2'6" x 4'0"	Manual
M-2	Zeolite Pump	2' 4"	Remote
M-3	Zeolite Pump	2' 4"	Remote
M-4	Zeolite Pump	2' 4"	Manual
M-5	Zeolite Pump	2' 4"	Manual
M-6	Zeolite Pump	2' 4"	Remote
M-7	Zeolite Pump	2' 4"	Remote

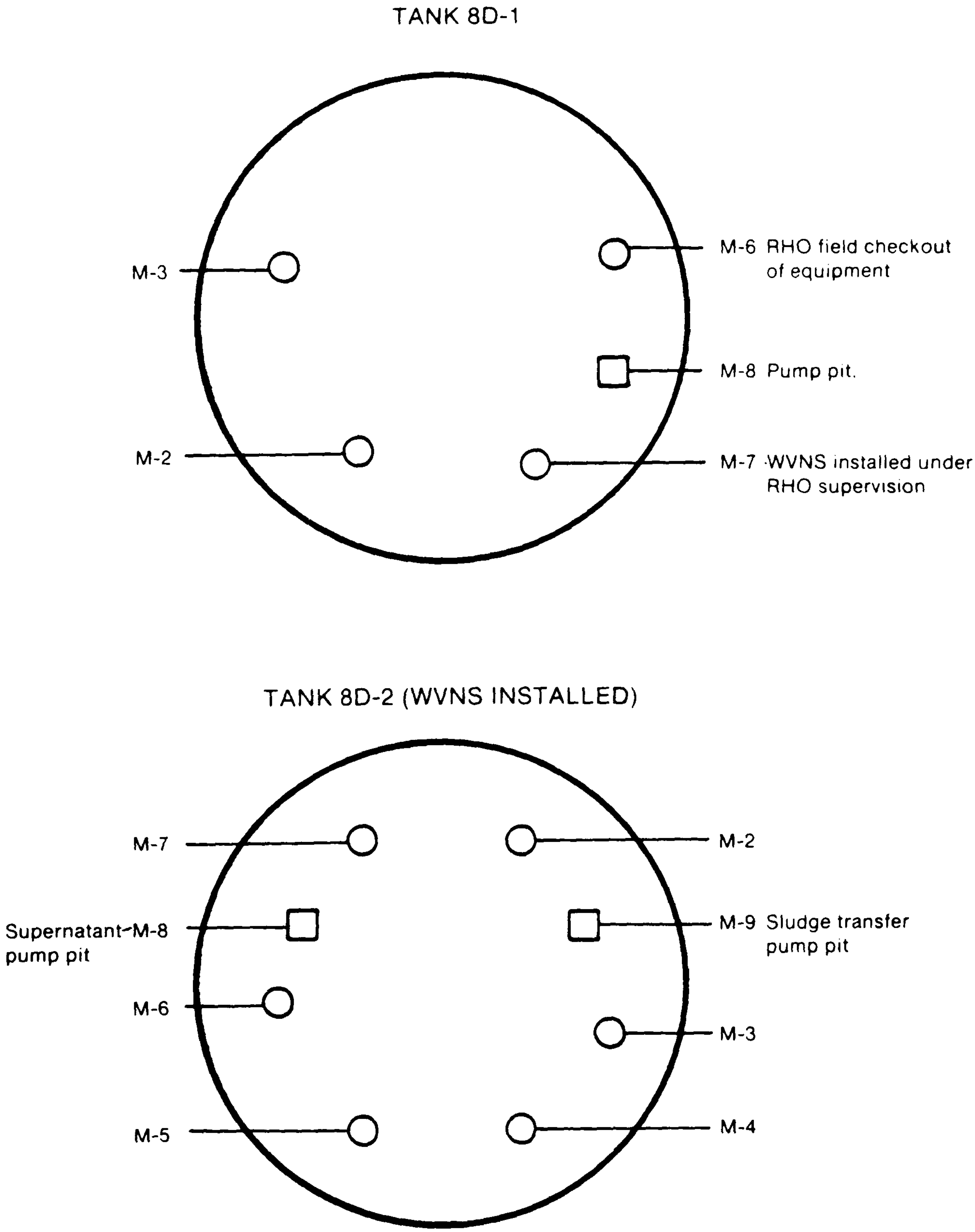


FIGURE 13
Riser Installation on Tanks 8D-1 and 8D-2

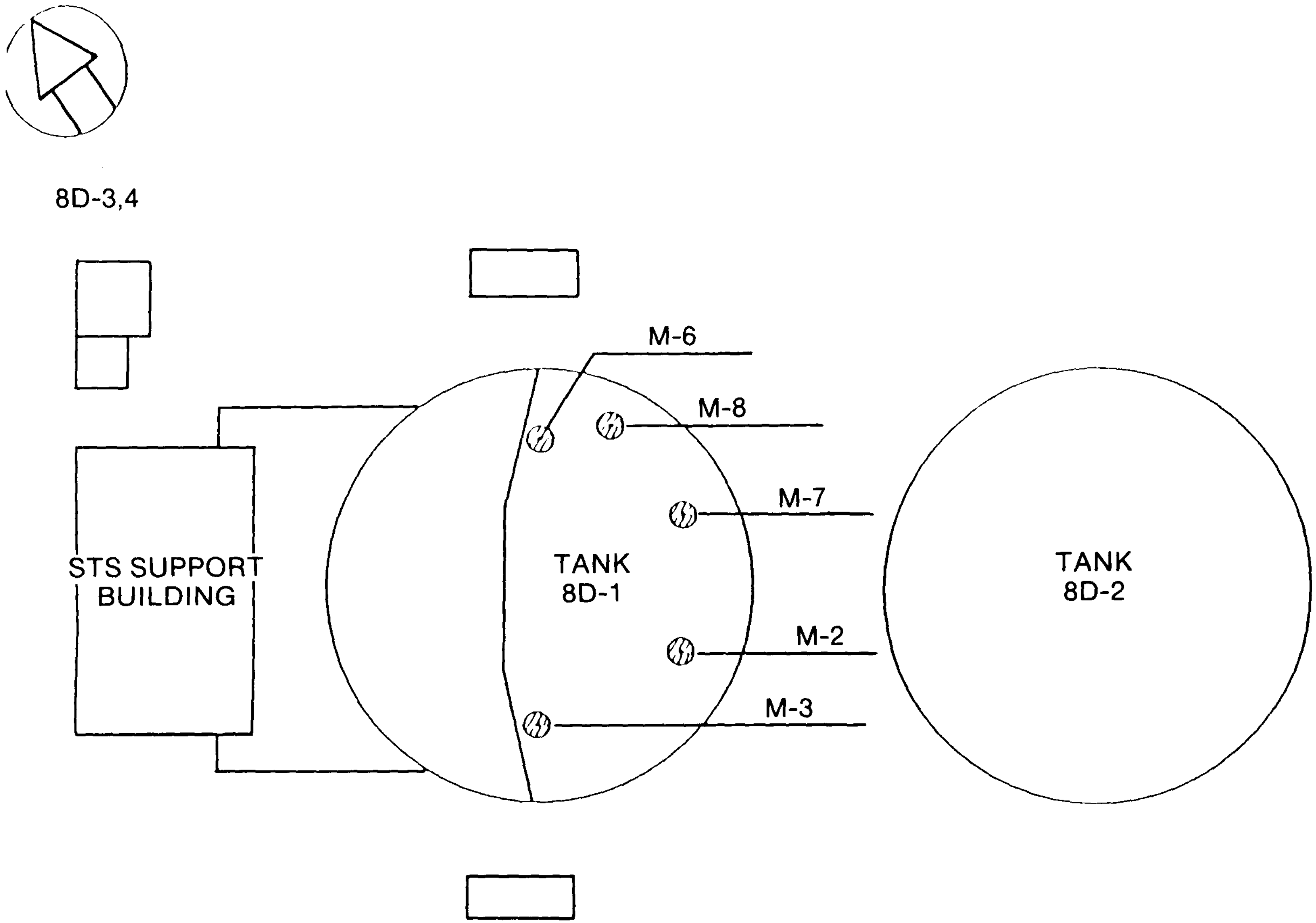


FIGURE 14
Installation of Remote Risers in Tank 8D-1

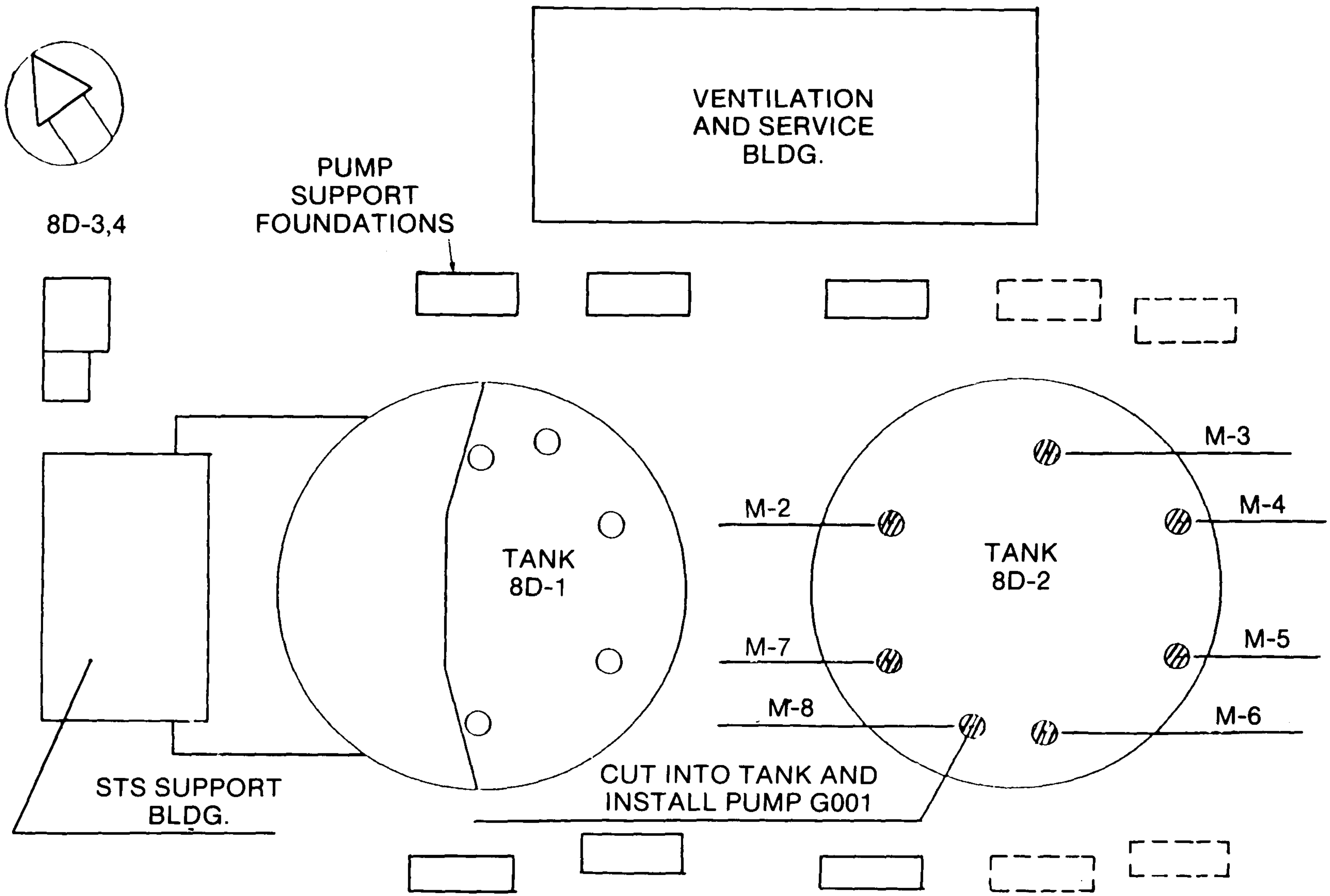


FIGURE 15
Installation of Remote Risers in Tank 8D-2

Penetrations were made in the tank roofs, risers were installed, and equipment was then inserted in the tanks. Tank 8D-2 contained HLW and therefore remote installation methods had to be designed and used for making penetrations in the tank roof.

After all penetrations were made in the tank roof, the installation of STS process components began. The components were suspended in the tank from structural steel lattice which is supported by the reinforced members supported by the concrete pipeway walls. The major components installed within tank 8D-1 include the Prefilter, Postfilter, Cooler, Feed Tank, four Zeolite Columns, Sluice Water Tank, and the various pumps.

The Supernatant Transfer Pump was installed within tank 8D-2 to transfer raw supernatant to the STS. Cutting the vault and tank roof and installing the riser and pump assemblies was done remotely. The discharge piping extending out of the tank and through the vault roof was enclosed on the vault roof by a steel-lined pump pit which provides secondary containment. The remaining sludge mobilization pumps will be remotely installed within tank 8D-2 for the eventual mobilization and transfer of the HLW sludge from the tank to the Vitrification Facility. The Decontaminated Supernatant Transfer Pump, which transfers the low-level waste salt solution from tank 8D-3 to the LWTS, was installed in tank 8D-3. As tank 8D-3 has never contained HLW, its radiological environment is similar to that of tank 8D-1 (relatively low radiation levels compared to tanks 8D-2 and 8D-4). Therefore, this installation was done manually just as the STS components were installed into tank 8D-1.

3.5.9 STS Phase V

The STS Phase V contract was for the installation of the utility lines from the plant to the STS building including the fire water lines with hydrants. Also included in the contract was the installation of the Pneumatic Transfer System for transferring radioactive samples from the STS Valve Aisle to the main plant labs.

The Pneumatic Transfer System was designed by (SGN) Societe Generale pour les Techniques Nouvelles in France for WVNS. Samples are remotely taken of the STS process and transferred pneumatically through tubes to the analytical labs for analysis. Figure 16 shows the general layout of this sampling system from the STS to the sample storage cell. The samples are taken remotely in the STS valve aisle from the seven sample jumpers (see figure 33 in Attachment C for the location of the STS sample points).

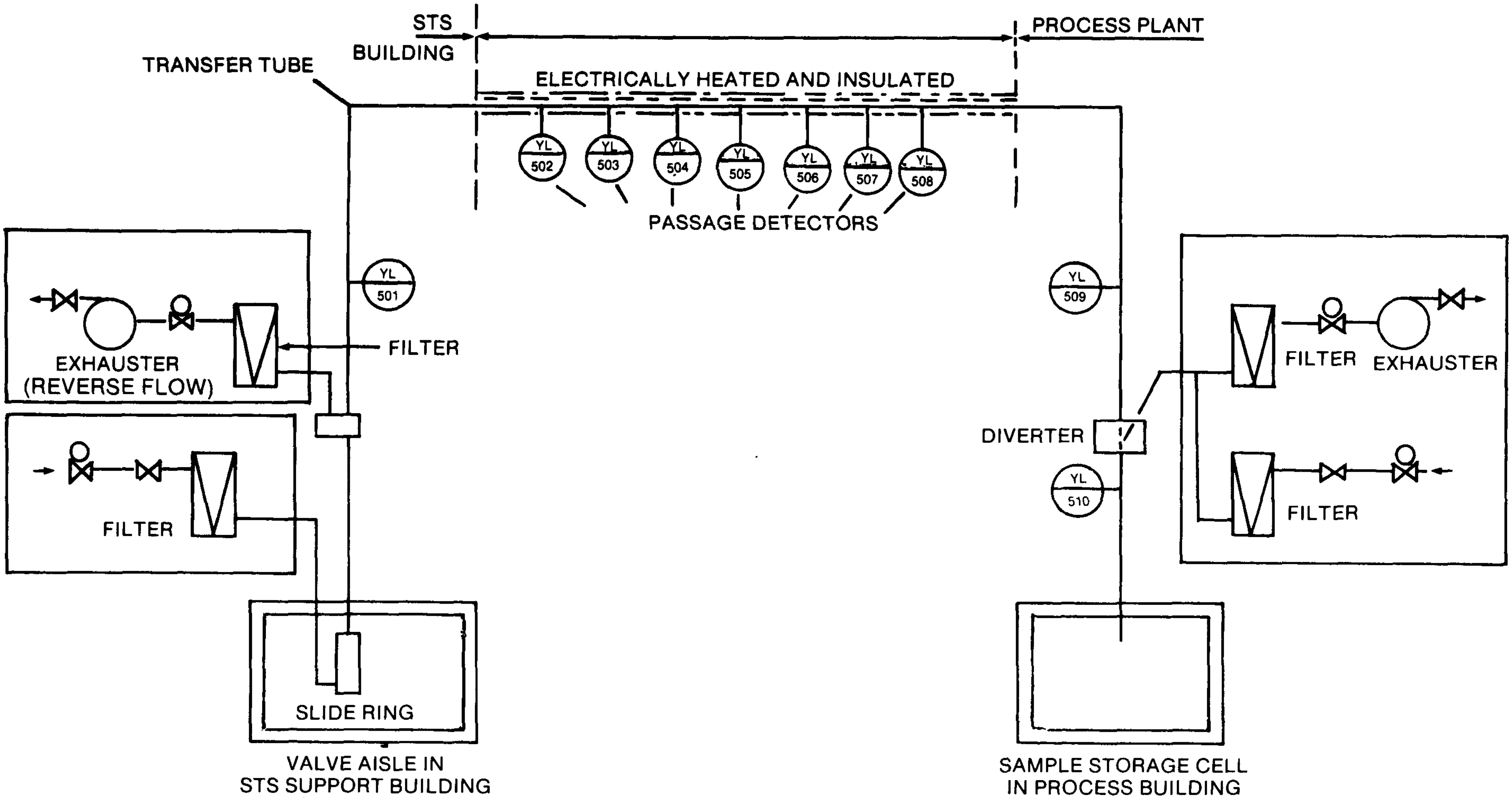


FIGURE 16
Sample Transfer System

3.6 Inspection Of Construction

3.6.1 General

The WVNS Quality Assurance (QA) department is responsible for the following:

a. Coordinating procurement requirements (e.g. hold points, inspection, documentation) for verification of quality.

b. Reviewing and approving quality-related documents including the supplier's quality assurance program as required by applicable procedures and instructions.

c. Verifying by audit, surveillance, test, or inspection that quality requirements are met for materials, components, processes, and plant and equipment modifications.

d. Verifying that the necessary quality activities are documented.

e. Auditing of project activities for compliance to operating procedures, and policies.

f. Documenting and reporting (to responsible management) nonconforming documentation, activities, and items (hardware) discovered in the course of inspections, surveillances, or audits.

g. Stopping unsatisfactory work including fabrication, delivery, or installation of nonconforming materials.

h. Ensuring that corrective actions are effectively implemented and documented in a timely manner.

3.6.2 STS Inspections

The following tests were witnessed by QA during STS construction:

1) Flushing
2) Hydrostatic testing
3) Pneumatic testing
4) Functional testing

3.7 Significant QA Findings During STS Construction

During STS construction inspections the following potential problems were identified: (1) improperly installed anchor bolts; (2) noncode radiographs of the supernatant process piping between 8D-2 and STS.

3.7.1 Anchor Bolts

A concern about the installation of anchor bolts was identified by the QA department during inspection of other construction going on at the WVDP. Some of the concerns identified were: (1) excessive angle of installation for bolts; (2) improper length of bolts; and (3) tightness of bolts.

As a result of these findings, it was decided to reinspect all STS pipe support anchors. This Ultrasonic Test (UT) and visual inspection of the anchor bolts identified some minor discrepancies that were resolved through engineering evaluation and correction of deficiencies. A summary of inspection results is shown in table 10.

Table 10. Summary of Anchor Bolt Inspection

VESSEL AND EQUIPMENT SUPPORTS	27 BOLTS
PIPE SUPPORTS IN PIPEWAY	188 BOLTS
OPERATING AISLE	88 BOLTS
VALVE AISLE	4 BOLTS
TOTAL NUMBER OF ANCHOR BOLTS IN STS	307 BOLTS
INSPECTION SUMMARY OF 215 ANCHOR BOLTS FOR 54 PLATES:	
1.9% SUSPECT ANCHORS	4 BOLTS
16.7% SUBSTANDARD WORKMANSHIP	36 BOLTS
2.3% QUESTIONABLE SIZE	5 BOLTS

3.7.2 Radiographs

During an NRC monitoring visit in January 1988, it was found that the radiographs made of shop welds in process lines were not in compliance with the piping code, ANSI B31.3. Because of this finding a re-evaluation of the STS radiographs was done.

3.7.2.1 The Re-evaluation Actions

The actions taken in response to this finding were:

- Re-reviewed radiographs on the high-level waste piping using a qualified Level III radiograph examiner, documented the conditions that did not meet the code on a nonconformance report (NR), and obtained engineering resolution.
- Re-evaluated other nondestructive examinations performed on the STS piping for adequacy and acceptability.
- Re-evaluated all other piping installations done under other subcontracts.
- Issued a Request for Corrective Action (RCA) to the subcontractor to determine the cause of the conditions found and identified actions to prevent recurrence.
- Issued an Unusual Occurrence Report (UOR) to document the condition and identified Quality Assurance Programs corrections to prevent recurrence.

3.7.2.2 Results of Re-evaluation

The noncode radiographs exhibited the following conditions: (1) the film density exceeded limits; (2) some small indications were noted; (3) several welds showed excessive weld reinforcement; and (4) one weld had a piece of wire stuck in the weld ID. The welds were read by a WVNS Level III examiner and an independent Level III examiner; both concluded that although the films were dense, they were light enough to confirm that the welds were good.

The fracture mechanics analysis performed at Westinghouse R&D concluded that for the worst-case condition that could be masked by the film density, the margin of safety is still considerable (below the fatigue threshold by a factor of 280). The integrity of the process piping and the outer, containment pipe that surrounds it was assured by the analysis.

As part of the corrective actions, WVNS subsequently performed a re-evaluation of all STS piping installation work in the STS. All other radiographs for STS piping were then re-examined for adequacy and acceptability. The review of all 2,014 radiographs made of STS piping led to engineering evaluation and acceptance of the welds in question. The PT, UT, hydro, and pneumatic tests were also re-reviewed. This review identified that some hydro and pneumatic tests on tie-in and field welds had not been performed. These welds were either subsequently hydrotested or some were examined by radiography, since the pressure test could no longer be performed.

The conclusion of this investigation, as summarized in Unusual Occurrence Report (UOR) 88-1-STS-1, was that the system is acceptable as installed and would perform at greater-than-service conditions. As a result of this UOR, WVNS and Subcontractor personnel were retrained in the use of Technical Advisory (TA) forms, since it was found that TAs had been used in this case to change the contractor's scope of work and delete certain testing requirements. Also, the use of checklists to verify that all inspections had been made before the system was accepted by WVNS was instituted. These actions helped to guarantee that there would be no more misinterpretations and missed inspections on the WVDP.

4.0 DESIGN AND OPERATING CHANGES

4.1 Batch Processing of STS

During 1987, a review of IRTS operating strategy was conducted to determine the acceptability of operating in a batch mode using fewer operating personnel. The batch operation would entail processing undiluted supernatant in the STS for one week and then shutting down to allow processing the decontaminated supernatant produced by the STS by the rest of the IRTS the next week. The STS had originally been designed to operate with diluted supernatant (2:1 dilution with water) using three ion exchange columns on a continuous basis. The suggested switch to batch operation did not cause any safety concerns and a minimum cesium DF of 1000 would still be maintained. One benefit of the batch method is that four ion exchange columns would be available for processing since the zeolite loaded with cesium would be dumped while the STS was not operating. A comparison of the two methods of operation is shown in table 11.

Table 11. Comparison of Batch vs. Continuous Processing Operation

	DESIGN CRITERIA	BATCH	CONTINUOUS
Cesium DF	≥1000	≥1000	≥1000
Zeolite Usage (PNL Data)	N/A	64,000 KG (Undiluted)	43,700 KG (Diluted)
Processing Time (Master Schedule)	12 months	26 months	12 months
Number of IRTS Operators	N/A	22	38

The following is a description of the steps for four-column, batch operation of the STS.

Startup Phase:

- Perform prerequisites before resuming supernatant processing such as: change valving and perform equipment checks.
- Charge empty column with 12 drums of fresh zeolite.
- Leak test the column before and after loading zeolite.
- Return freshly loaded column back into service.

Operational Phase:

- Decontaminate a minimum of 15,000 gallons of raw supernatant.
- Transfer decontaminated supernatant to the LWTS.

Shutdown Phase:

- Shutdown pump 50-G-001.
- Flush supernatant feed tank, supernatant cooler, ion exchange columns, and post filter with 5000 to 6000 gallons of demineralized water to 8D-3.
- Place STS in recirculation mode through the second, third, and fourth columns.
- Isolate and dump the former lead ion exchange column.

Long-Term Shutdown with Recirculation Phase:

- Monitor STS in shutdown condition.
- Record ion exchange column temperatures and pressures
- Record data on the Permanent Ventilation System, HVAC, and STS Air Compressor

4.2 PNL Study (Kurath, 1988)

Before the batch method of operation was adopted for the STS, Pacific Northwest Laboratory (PNL), WVNS, and EBASCO performed thorough reviews of the proposed batch operation of the STS. The WVNS proposed mode of operation included several significant changes in STS operation that primarily affected the operation of the ion exchange columns. One proposed change was to operate at a higher supernatant flow rate with no dilution water to achieve the same total flow through the column as per the original design. Batch operation of the ion exchange columns, as opposed to continuous operation, would require stopping all flow to the ion exchange columns for a 2-week period between each successive supernatant processing campaign.

Based on review of the existing data and the performance and analysis of several laboratory experiments, the following observations/recommendations were made by PNL.

- The total zeolite requirement for the proposed STS operational sequence (no supernatant dilution, 6°C) was estimated at about 51 000 kg (anhydrous weight) or about 64 000 kg (as received weight).
- With a supernatant dilution of 2:1 (volume water to volume of supernatant) at 6°C, the zeolite requirement could be reduced to about 35 000 kg (anhydrous weight) or about 44 000 kg (as received weight). Smaller dilutions will result in smaller but still significant reductions in the zeolite requirement.

- The system cesium DF for the proposed operational sequence will be at least 1,000 and probably greater than 10,000.
- The ion exchange columns should be operated at 6°C as proposed since higher temperatures would increase the zeolite requirement.
- Before each standby period, all four columns should be flushed with demineralized water until the sodium concentration from the last column is less than 1 g/L.
- Calculations show that allowing the partially loaded second column to sit idle for 9 to 21 days with no cooling would result in a relatively large temperature rise in the column, possibly to the boiling point. This could result in the zeolite being exposed to air. During standby, the second, third, and fourth columns should prevent an excessive temperature rise in the columns maintained at a temperature near 6°C with recycled water.
- The sodium level in the recycled water should be maintained at less than 1 g/L to minimize cesium desorption and migration. The Cs-137 concentration in the effluent from the second column should also be determined. The laboratory demineralized water recycle experiment showed that the sodium content of the recycle solution can be expected to rise during each standby period. This may require a periodic blowdown of the recycle solution to keep the sodium level below 1 g/L.
- Theoretically, 22 to 35 L/day of H_2 would be generated in the partially loaded second column during the standby period. However, grab samples taken of the process vent during actual operation failed to detect the presence of any hydrogen.
- There is a potential for a corrosion problem to occur in tank 8D-1.

Although continuous operation of the STS with diluted supernatant is the preferred mode of operation, PNL concluded that satisfactory performance could be obtained in a batch mode of operation. As a result of the concerns generated by the PNL study, WVNS investigated (1) 8D-1 corrosion and (2) hydrogen generation. The results of these investigations are discussed in the following sections.

4.3 Corrosion Test For Tank 8D-1

Tank 8D-1, which has been used to store condensate the past 20 years, is in good condition. General corrosion rates of 0.6 mil/year (measured in tank 8D-2) are insignificant when compared to the 7/16-inch thickness of the tank walls. The recent modification to 8D-1 to insert ion exchange columns by cutting holes in the roof should have no effect on the corrosion rates.

Tank 8D-1 has started to receive and store the cesium-loaded zeolite discharged from the bottom of the ion exchange columns. Figure 17 shows the layering of the zeolite in 8D-1. This zeolite builds up in piles under each of the four ion exchange columns. The zeolite is periodically redistributed in an even layer across the bottom of the tank by running the long-shafted centrifugal pumps zeolite mobilization pump installed in the tank. Approximately 60,000 kg of zeolite will ultimately be stored in tank 8D-1 until the Vitrification System is ready to accept it. At that time it will be slurried to tank 8D-2 to be combined with HLW sludge and eventually slurried to the Vitrification Facility to be incorporated into glass.

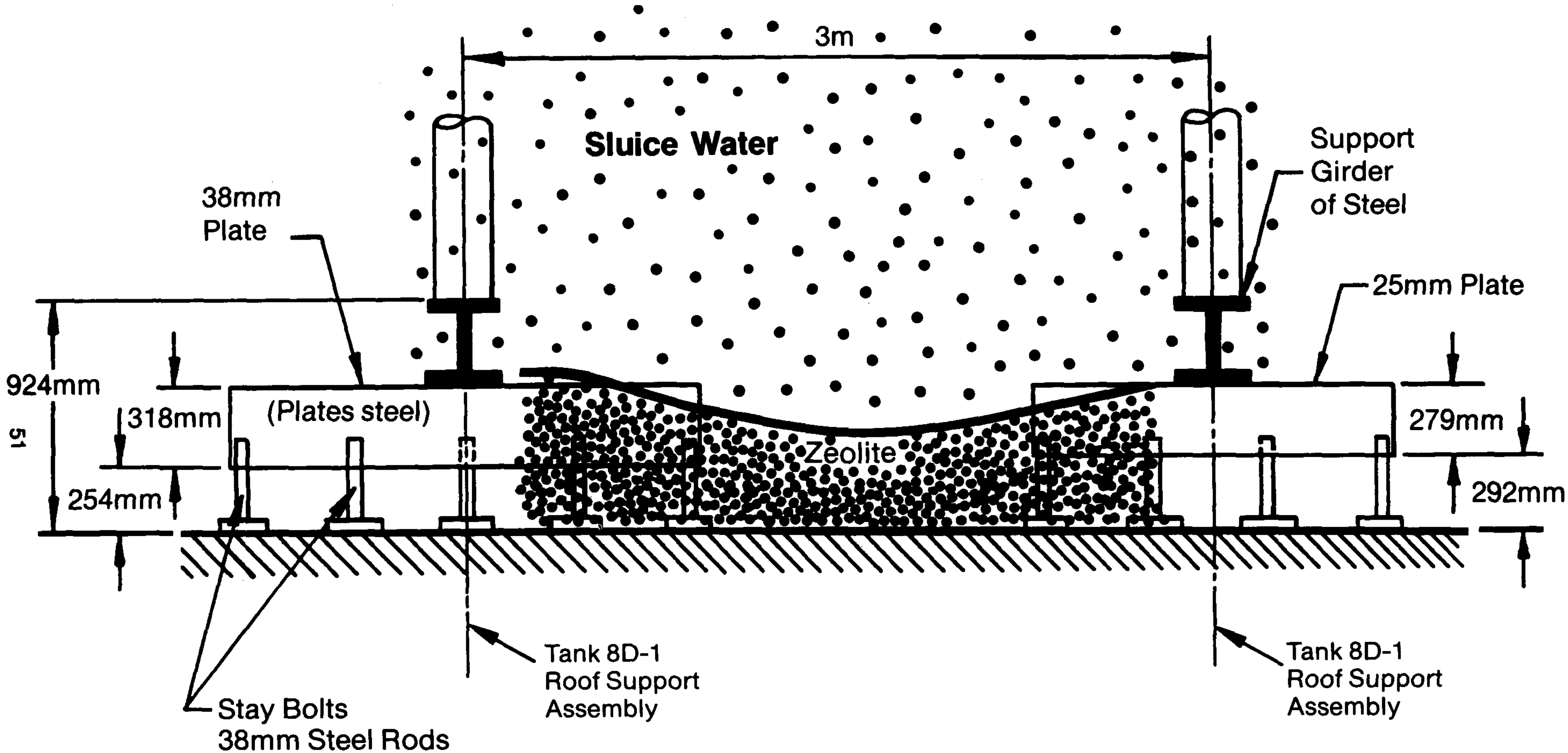


Figure 17
Tank 8D-1 Zeolite Layering Sectional View

The zeolite is presently covered with a minimum of 100,000 gallons of water. The water contains minor impurities i.e., dilute supernatant, $NaNO_3$, $NaNO_2$, and other sodium and potassium salts as well as cesium, corrosion, and radiolysis products which could affect the corrosion rate. The concentration of sodium salts is kept at less than 1000 ppm; the pH of the water is adjusted as required to maintain a pH of 11 by the addition of NaOH. The pH of a sample taken from tank 8D-1 is determined on a weekly basis. Further evaluation of the addition of $NaNO_2$ (Sodium Nitrite) to further inhibit corrosion is being performed to determine the amount of nitrite to add.

Based on available information, it was decided that there was potential for four types of corrosion: crevice, pitting, stress corrosion cracking, and general corrosion. The greatest concern is the potential for crevice corrosion and pitting.

Corrosion coupons have been placed in tank 8D-1 to monitor corrosion (see figure 18). The corrosion coupons include the following types: 1) flat-steel plates with ceramic insulating washers to form crevices for general corrosion; 2) single U-bends, double U-bends; and 3) wedge-loaded compact tension (CT) specimens. A list of coupon types and their purposes is shown in table 12.

TABLE 12. Corrosion Coupons and Purposes

Specimen	**Type of Corrosion Degradation**
Plain Flat Coupon	General Corrosion Rate Pitting
Crevice Coupon	Crevice Corrosion Pitting in Crevices General Corrosion
U-Bend	Stress Corrosion Cracking (SCC) Stress Assisted Pitting Crevice Corrosion (Double U-Bends) Crevice Assisted SCC Initiation
CT-Specimen	Overall SCC Susceptibility SCC Propagation Rate

TANK 8D-1 CORROSION COUPONS

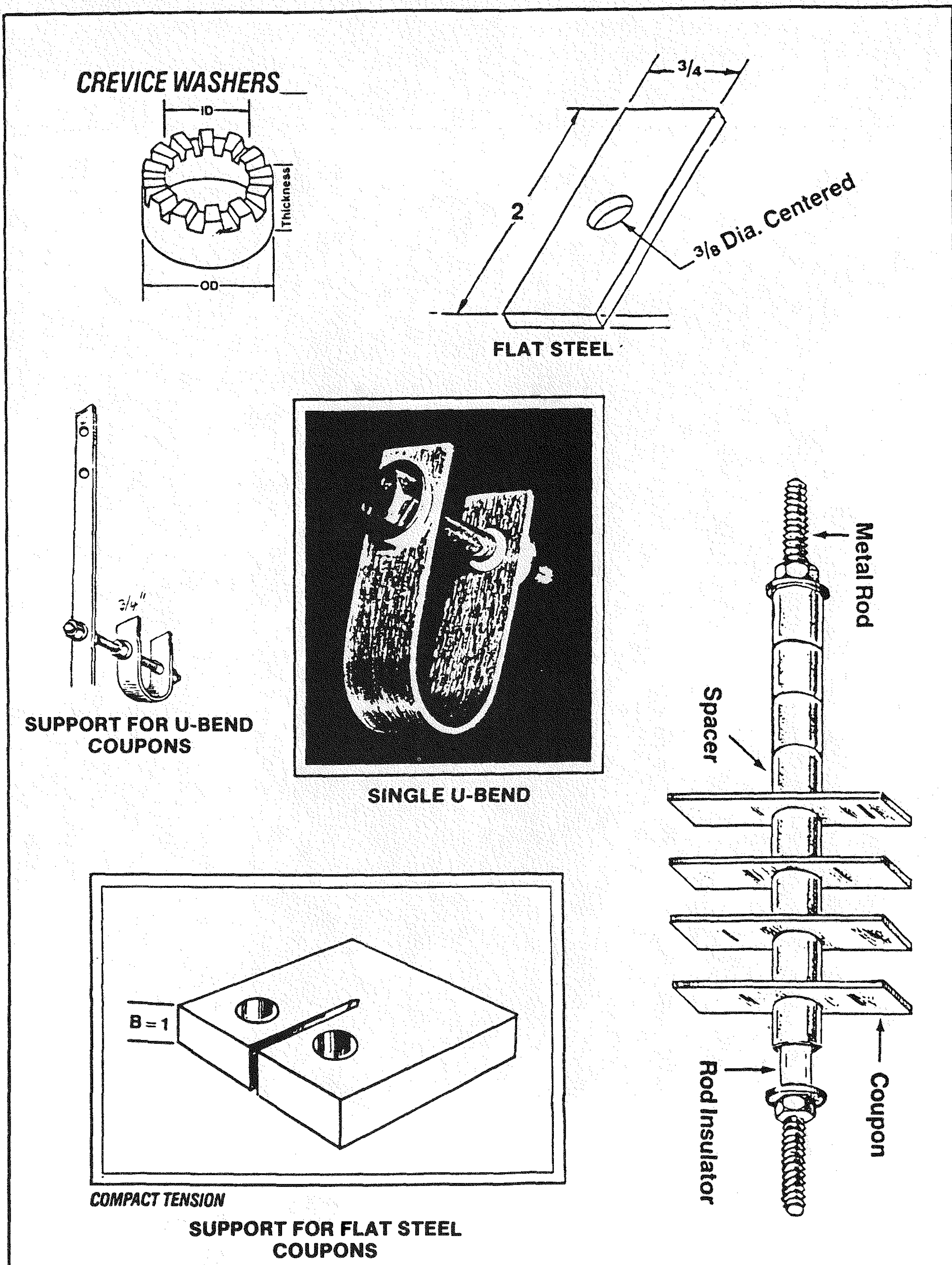


FIGURE 18
WVNS Corrosion Coupon Configuration and Monitoring

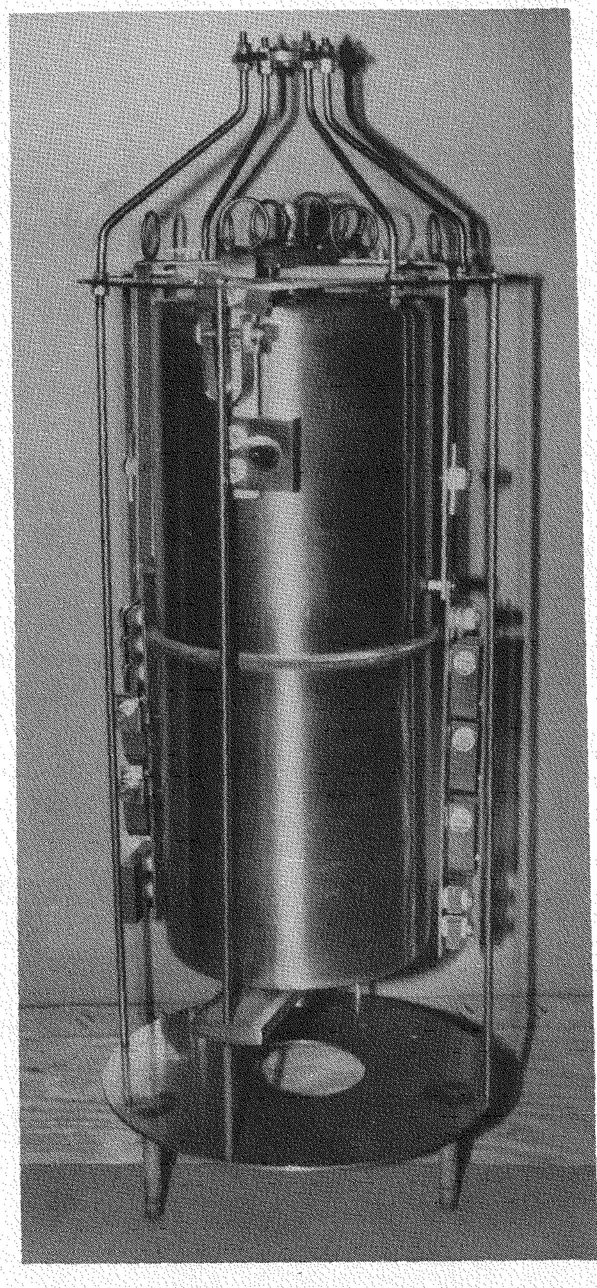


FIGURE 19
WVNS Corrosion Coupon Rack

The coupons are on two support racks. Some of the coupons are immersed in liquid (possibly covered with zeolite), and the others are floating at the liquid-vapor interface. The racks of corrosion coupons will be exposed for different intervals in the next 1 to 9 months and then the racks will be removed from the tank for inspection of the coupons. Corrosion tests performed will be in accordance with ASTM G-31, G-38, G-58, and G-1.

It was concluded that sampling of the tank contents and periodic examination of corrosion coupons, coupled with control of the tank chemistry would allow adequate monitoring and control of corrosion. A method was developed to add caustic soda solution to tank 8D-1 for pH adjustment to inhibit corrosion during hot operations. It was also concluded that the addition of nitrite to tank 8D-1 in order to minimize the potential for pitting corrosion is warranted.

4.4 Hydrogen Generation Study (Ross, 1988)

In response to the PNL study, hydrogen generation in the STS was also investigated. Hydrogen is produced during STS processing in the ion exchange columns as a result of the radiolysis of cesium loaded on the zeolite ion exchange media. In steady-state operation, the hydrogen stays in solution in the column and escapes from solution in storage tank 8D-3, where it is diluted with air. During recirculation with water, the hydrogen is diluted with air in tank 50-D-001. Hydrogen concentrations are maintained at safe levels at all times by dilution with air.

When a fully loaded column is taken off line, it is normally dumped to remove the cesium-loaded zeolite. If it cannot be dumped, it is vented to allow any gas formed to escape into the vent system to 8D-1, where in-leakage of air will dilute any hydrogen formed to well within safe limits. The proper dilution of any hydrogen formed with air was verified by sampling of the off-gas from either tank 8D-1 or tank 8D-3.

Although hydrogen gas will theoretically be produced in the STS, proper safeguards have been established which will maintain the hydrogen concentration with safe limits. Furthermore, hydrogen has never been detected in any of the gas samples collected from the Waste Tank Farm off-gas.

5.0 COLD OPERATIONS

5.1 STS Process Testing

5.1.1 Test Program Objectives

The objectives **(Denero, 1987)** of the STS test program were:

- To verify that the system installation and construction was accomplished in accordance with the design drawings, plans, and specifications prepared for the system.
- To verify that the completed and installed system complied with WVNS-DC-013, STS Design Criteria, and operated in accordance with WVNS-AA-004 "Functional and Operational Requirement (F/OR) - tank 8D-2 Supernatant Treatment System" (see tables 6 and 7).
- To provide data to engineering to establish process control parameters necessary to assure generation of an acceptable decontaminated supernatant product.
- To checkout all the fabricated and installed mechanical and electrical components including tanks, piping, and wiring for proper installation and operation as follows:

  Piping - All piping components were hydrostatically pressure tested, flushed, and visually inspected to verify proper installation and connections.

  Pumps and Motors - All pumps and motors were tested for rotational speed, correct rotation, vibration, operating temperature, amperage draw, seals, and coupling.

  Valves - All solenoid valves, automatic valves, and actuators were tested to ensure proper automatic valve operation. Visual inspections were made to verify proper installation and orientation.

  Field Instrumentation - Pressure, flow, temperature, and level switches were tested for proper response to an initiating event. Continuous level sensors, thermocouples, differential pressure sensors, and density sensors were tested and calibrated.

  Control Panel and Instruments - Programmable Logic Controller (PLC), alarms, and instrument control loops were checked for continuity and calibrated.

  Wiring including Motor Control Centers - Functionally tested the power and control circuits for continuity and expected required voltage.

  Pumps - Each pump was operated to verify flow rate and the pump performance curves.

  Vessels - Calibrated for volume; all vessels that have either level elements or level alarms were calibrated or checked for functionality.

  Freeze Protection - All components and pipes were tested for ability to be drained.

5.1.2 Tests Performed

Component Testing - The STS components including instrumentation and controls were operated manually and automatically from the STS control panel or valve aisle, as appropriate, using simulated signals and demineralized water to ensure proper operation of all components before introducing simulated supernatant. All modifications and all changes made to the program logic control software were checked during this testing.

Each component in the STS was first individually tested and then all of the components in the STS were tested together using demineralized water to ensure that operation of equipment met the design criteria requirements.

System Testing - was conducted by processing simulated supernatant in the STS for verification of zeolite loading, generation of process parameters, and gaining operating experience processing non-radioactive simulated supernatant.

Integrated Testing - the IRTS (i.e. the STS, LWTS, CSS, and Drum Cell) processed simulated supernatant to smooth out system to system transfers and coordinate operations.

Condensate Processing - The first radioactive operations in the STS were conducted with very low activity (10^{-2} μCi/mL) water from tank 8D-1. Over 70,000 gallons of water was successfully decontaminated.

5.2 STS Component Testing (Skillern, 1988)

During component testing, each component was checked for proper installation and identification, freedom of operation, hydraulics, and functional operation of the component with its associated controls, instrumentation, and interlocks.

The component test results have been summarized and put into matrix form in Attachment A. The matrix has been divided into columns containing the following information: 1) Components - a listing of the major components or support system tested which also includes their associated pumps, valves, piping, instruments, controls, and interlocks; 2) Purpose - a brief summary of test objectives; 3) Acceptance Criteria - the specific information needed to verify the component has functioned as required; 4) Test Procedure - the methods used to check the component and its associated equipment; and 5) Test Results - a statement that testing has been successfully completed and that the acceptance criteria were met, or a list of the equipment that had to be retested. Attachment A, "STS Component Testing Summary," shows that component testing confirmed that most of the components, as they were originally installed, were properly identified and functioned properly. The testing also found 4 instruments, 2 pumps, and 1 tank that did not operate or function as required; and these have subsequently been repaired, modified and/or replaced and successfully retested.

Most of the problems encountered during component testing such as pumps rotating in the wrong direction, electrical connections reversed or not made, instruments, controls and interlocks improperly wired, leaking valves and flanges, valves difficult to operate, plugged lines, instruments calibrated to wrong range, alarm set points wrong, etc., were minor. These types of problems are typically encountered during startup, and they were resolved as they were discovered.

However, two major problems did occur during the component testing. The air-operated Supernatant Feed Pump 50-G-002, located inside the Supernatant Feed Tank 50-D-001, failed after 10 hours of operation, and neither zeolite or sand could be sluiced from Batch Tank 50-D-002.

5.2.1 Pump G-002 and G-003 Replacement

Pump 50-G-002 was originally a diaphragm pump, wholly contained in the Feed Tank 50-D-001. Its failure was probably caused by the "seizing" of the sliding spool which directs air from one side of the pump to the other. Solutions considered were: 1) troubleshoot, repair and attempt to restart pump; 2) replace 50-G-002 with an eductor; 3) replacing pumps 50-G-002 and 50-G-003 with turbine pumps (pump 50-G-003 was identical to pump 50-G-002 and was also installed inside a tank); 4) installation of a bypass jumper around the feed tank and pump 50-G-002 to pump supernatant from tank 8D-2 directly to the columns; and 5) installation of a bypass jumper around the Sluice Lift Water Tank 50-D-004 and pump 50-G-003 to pump water from tank 8D-1 directly to the columns. A diagram of the original 50-G-002 and 50-G-003 pumps is shown in figure 20. Many attempts were made to restart the pump by using oil to lubricate, using higher air pressure, back pressure, and surges of air pressure to loosen the spool, and direct addition of lubricant. The pump, however, was never successfully restarted.

A temporary workaround system was therefore developed for pump 50-G-002 to keep the STS component testing on schedule. Pump G-018 (borrowed from the LWTS) was installed in the STS Operating Aisle. This changed the method of operation as tank 50-D-001 had to be pressurized to provide sufficient head to the suction of pump G-018. Pressurizing tank 50-D-001 required instrument modifications and additional safety review.

Turbine pumps installed in tanks 50-D-001 and 50-D-004 were originally selected as a permanent replacement for the existing submerged diaphragm pumps, 50-G-002 and 50-G-003. However, the schedule delay caused by the 10 to 12 weeks delivery time for the turbine pump was unacceptable. The alternate pumps selected were canned centrifugal, variable speed pumps. These pumps were more readily available (7 weeks delivery) and could be placed in the Valve Aisle where they would be accessible for replacement.

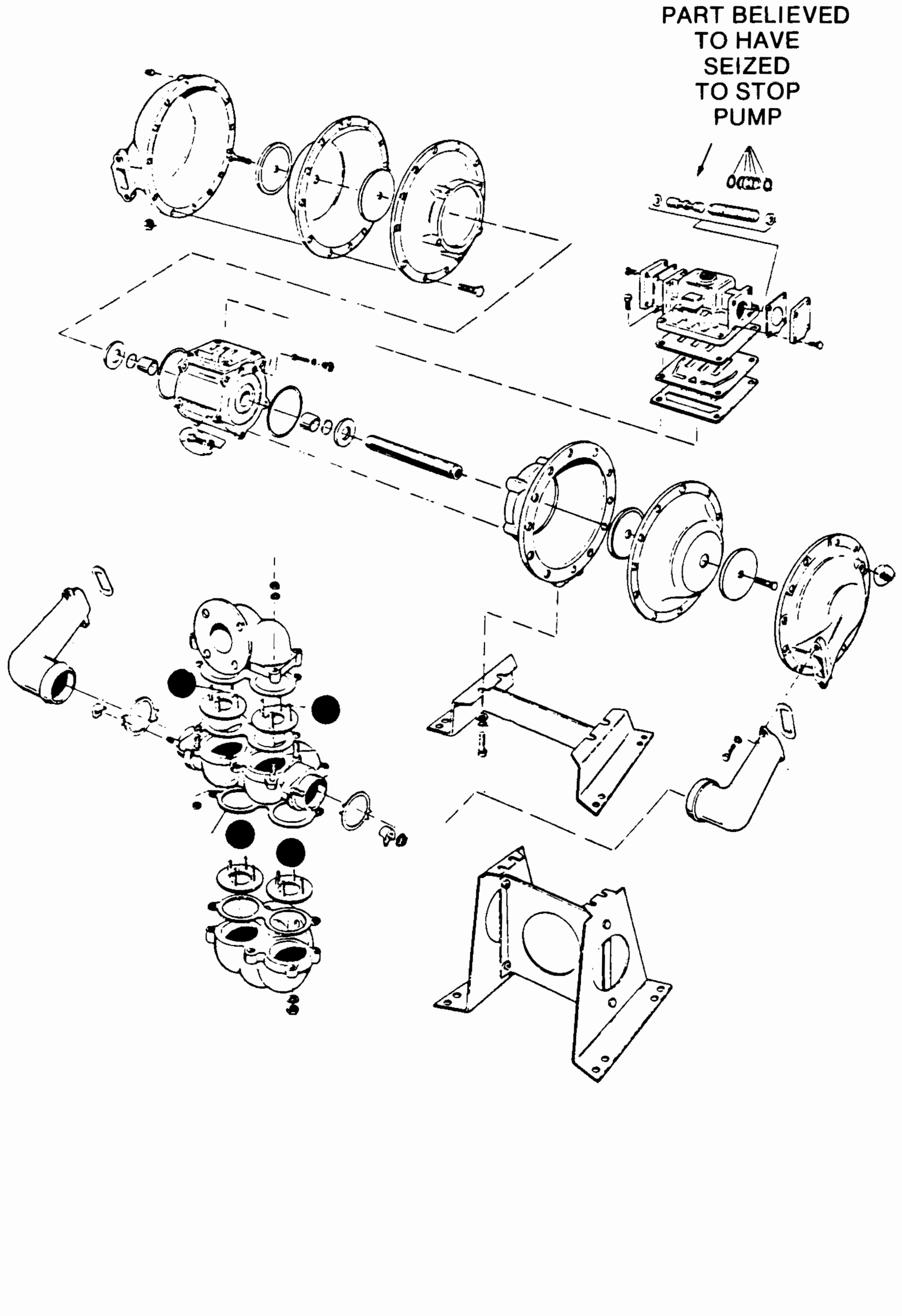


FIGURE 20
Exploded View of Original Diaphragm Pump G-002 and G-003

This replacement of 50-G-002 and 50-G-003 diaphragm pumps with canned centrifugal pumps located in the STS Valve Aisle required the following system changes:

- Pressurization of tanks 50-D-001 and 50-D-004 to approximately 15 psig to provide the necessary suction head to the pumps;
- Installing back pressure regulators on the vent lines from these tanks to 8D-1, which would act as pressure relief valves and prevent overpressurization of these two tanks; and
- Rerouting of the vent lines from the ion exchange columns directly to tank 8D-1, bypassing the Supernatant Feed Tank.

5.2.2. Pressurization of Tanks 50-D-001 and 50-D-004

Since original double-diaphragm pumps 50-G-002 and 50-G-003 were replaced with these sealess centrifugal pumps, the Supernatant Feed Tank, 50-D-001, and the Sluice Lift Water Tank, 50-D-004, were both pressurized to about 15 psig to provide the required suction head to the pumps.

Now, before the STS can be shutdown, these tanks are required by Operational Safety Requirement (OSR) to be depressurized. An independent safety analysis addressed the possibility of supernatant backing up into the STS valve aisle because of this pressurization. The major areas of concern addressed were the following:

- Level, density indicating system for 50-D-001 and 50-D-004
- Demineralized water seal flushes of pumps 50-G-002 and 50-G-003
- Instrument air lines to tank 50-D-004 and to tank 50-D-001

The multiple failures required to occur to cause backflow of supernatant are listed in table 13. The likelihood of backflow of supernatant into the operating aisle was considered remote. Operation of the STS with tanks 50-D-004 and 50-D-001 pressurized was therefore concluded to be acceptable on the basis of this analysis, as documented in the SAR **(Brown, 1988)**.

5.2.3 Loading Zeolite

To resolve the inability of the Zeolite Batch Tank, 50-D-002, and its associated equipment to sluice either zeolite to the columns or sand to the filter (see figure 21), a temporary method was developed for loading zeolite and sand to maintain the testing schedule. The design of the system was modified by elminating an eductor on the bottom of the Zeolite Batch Tank to allow gravity flow of the zeolite and water slurry. Operating procedures were then modified so that a total of twelve drums of zeolite were loaded into each column by first filling the tank 50-D-002 half full of water, then adding 6 drums of zeolite. The zeolite was washed and "fluffed" to remove the zeolite fines (i.e., the zeolite bed was suspended by increasing the water flow). The zeolite was then allowed to drain by gravity into the columns. The second six drums of zeolite were then added to the column in the same way. The sand was loaded directly into the filter fill pipe in small amounts, then flushed to the Decontaminated Supernatant Filter 50-F-002.

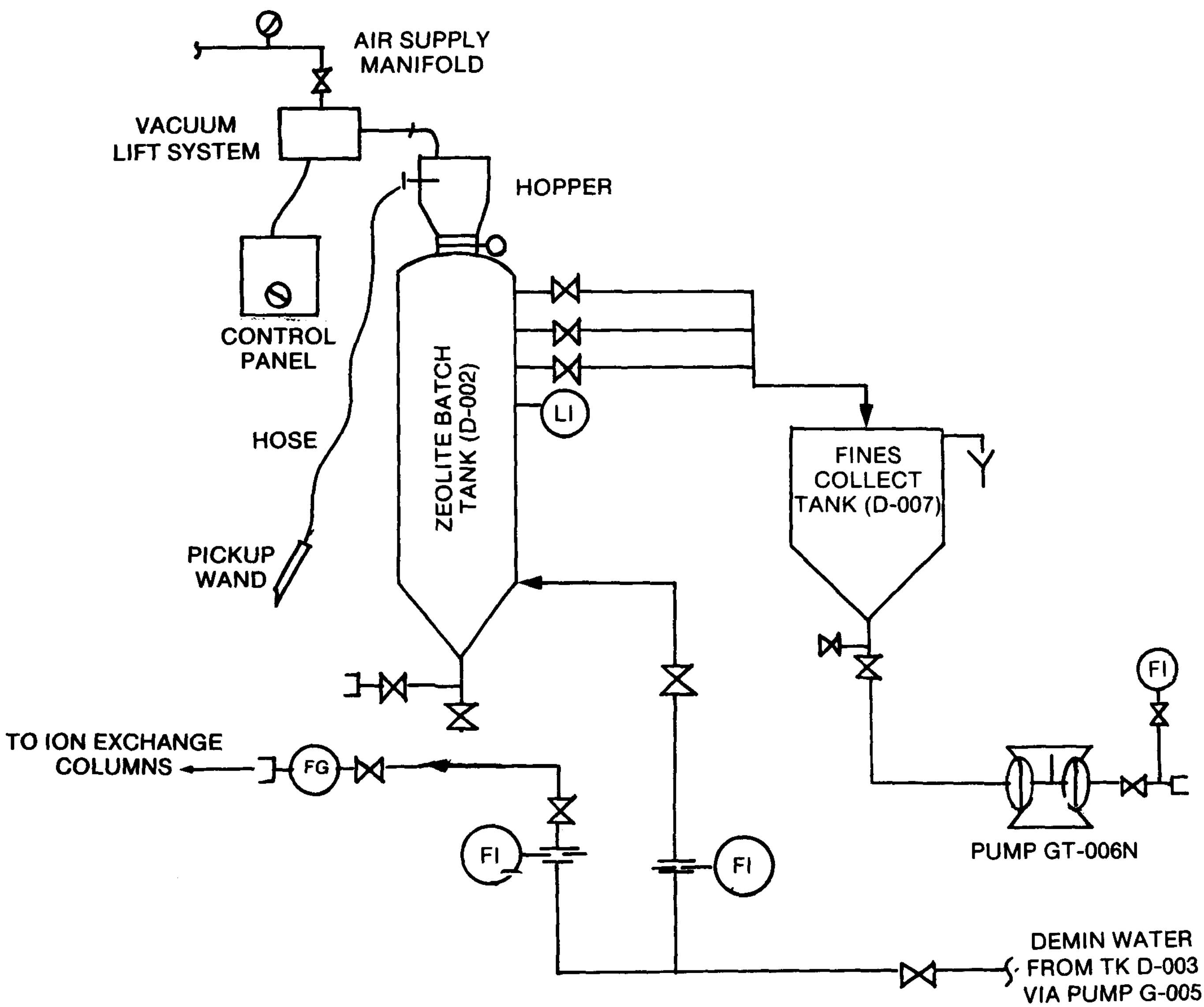


FIGURE 21
Flow Schematic STS Zeolite/Sand
Batching System

Table 13. Failures Required to Cause Backflow of Liquid HLW into the STS Operating Aisle

Accident	Line/Inst. # Involved	Description	First Failure	Second Failure	Additional Failure(s)	Associated Dose r/hr
A	FE 016 B, C	Level/density dip tubes (bubblers) in tank D-001	Failure to vent before doing maintenance	Failure to properly isolate system	Failure of one check valve	4.9
B	FI 700	Demin. water to pump G-002	Loss of demin. water pressure	Failure of first check valve	Failure of second check valve	NA
C	1-046	Air to initially pressurize tank D-001	Tank D-001 is overfilled	Loss of compressed air	Loss of backup air supply Failure of check valve SC-007	5. 8
D	FE 016 B, C	Level/density dip tubes (bubblers) in tank D-001	Loss of compressed air	Loss of backup air supply	Failure of one check valve	4.9
E	FE 016 B, C	Tubing to level/density dip tubes (bubblers) in tank D-001	Mechanical failure or personnel error causes tubing failure	Failure of one check valve	Radmonitor fails to detect increase in radiation level and automatically shutoff	4.9

5.2.4 Test Completion (Reeves, 1988)

The testing of other STS components proceeded on schedule. Replacement pumps 50-G-002 and 50-G-003 operated within acceptable ranges. The only problems encountered were difficulty in obtaining a satisfactory flow rate from pump 50-G-003 and a short-term blockage of the suction line for pump 50-G-002. To solve the first problem, a check-valve jumper on the discharge of the pump was removed and replaced with a ball-valve jumper. This provided a mechanism to adjust the back pressure on the pump by throttling the valve to prevent cavitation. A satisfactory flow rate was then achieved. The blockage of pump 50-G-002 was alleviated by backflushing the pump. When the pump was restarted, the problem had been resolved. It was suspected that the rice paper used as a purge dam for the welding gases when the associated piping was installed did not immediately dissolve. No further action was required.

Once testing of the individual STS components was complete, electrical power and instrument air failures were simulated to further test the system. This test provided proof that the auxiliary diesel generator would automatically start to provide power to the critical electrical loads upon loss of main power. This test also verified that during a failure of the STS air compressor, instrument air from the Main Plant supplied backup air to key instruments and all valves with failsafe actuators failed to the proper positions. No problems were encountered with instruments or components during this power/instrument air failure test.

The STS building ventilation system operates in conjunction with the STS Permanent Ventilation System (PVS) to ensure that the proper sweep of air from uncontaminated areas into contaminated areas (such as the Valve Aisle and Pipeway) is maintained. Testing verified independent operation of both the Control Room HVAC System and the zeolite batching/fresh water makeup area HVAC system as well as integrated operation of these systems with the PVS. All alarms, temperature controls, flow controls, and tornado dampers for the system were functionally tested and found to perform satisfactorily.

5.3 System And Checkout Of The Supernatant Treatment System (Itzo, 1988)

5.3.1 Purpose of System Test

The purposes of System Tests using Test Procedure 87-37 were to verify that:

1) A single Ion Exchange Column (Column "A") was capable of processing at least 71 column volumes of simulated supernatant before reaching 95 percent breakthrough at a column volume of 60 cubic feet (12 drums) of IE-96 zeolite.

2) The Supernatant Prefilter would operate at a maximum clean ΔP across the system of less than 10 psi at a total flow rate of 40 gpm (38 gpm slurry reject and 2 gpm filtrate flow).

3) No detrimental crystallization occurred when diluted supernatant was cooled to $6^{o}C$.

4) The dilution system was capable of automatically diluting the simulated supernatant to the set 2:1 dilution ratio in order to control the total dissolved solids concentration in the Supernatant Feed Tank to within one weight percent accuracy.

5) The Decontaminated Supernatant Filter was capable of removing 99 weight percent of zeolite fines and other particulate matter having a size greater than one micron.

6) The Decontaminated Supernatant Transfer Pump (50-G-007) was capable of batch transfer from tank 8D-3 to the LWTS of 9 842 L (2,600 gallons) in less than two hours.

7) The STS could be satisfactorily operated remotely using manipulators.

8) The remote STS sampling and pneumatic sample transfer system operated satisfactorily.

5.3.2 Test Description

Before system testing of the STS could proceed, the best method of integrated testing of the STS with the rest of the IRTS had to be determined. Under the original plan, the rest of the IRTS had to operate in conjunction with system testing of the STS, but with batch processing, the STS could operate independently. The two proposals considered for accomplishing the integrated test were:

1) Original Plan (Method 1) - Continuous mixing of fresh chemicals in the STS to make simulated supernatant. The simulated supernatant would be processed through the STS once and then transferred to LWTS.

2) Recycle Plan (Method 2) - Recirculation of simulated supernatant through STS until reaching breakthrough in Ion Exchange Column "A." More cesium would be added to the simulated supernatant each time chemicals returned to the mixing tank to replace the cesium removed by Ion Exchange Column "A." A batch of simulated supernatant would then be transferred to LWTS for the start of integrated testing when testing of the STS was complete. As is evident from table 14, method 2 would reduce the required amount of chemicals and would not produce as much waste. See figure 22 for a diagram of the flow path for the chemical containment and mixing station.

The decision was made to use the recycle plan (method 2) for the system testing of the STS. A simulated supernatant solution was prepared according to table 15 and stored in temporary tanks located outside of the STS building.

After leak testing of the temporary storage tanks and hose connections with water, the supernatant prefilter and feed dilution system were tested with simulated supernatant. See figure 23 for a simplified flow diagram of that test.

Table 14. Comparison of Two Methods for Integrated Testing of the IRTS

	METHOD 1	METHOD 2
Test Duration	280 hours	Phase 1 = 25 hrs Phase 2 = 255 hrs TOTAL 1 & 2 = 280 hrs
* Total Diluted Simulated Supernatant Waste Produced for LWTS Treatment (13% TDS)	100,800 gals	9000 to ~12000 gals
* Concentrate produced in LWTS evaporator for CSS Processing (40 to 45% TDS)	33,600 gals	3000 to ~4000 gals
* Drums of Solid Waste Produced (45 gal/drum)	733 drums	67 to 88 drums
Quantity of Chemicals Required	180,000 lbs	21,435 lbs
Chemical Cost	$53,188	$9,500

* Radioactively contaminated

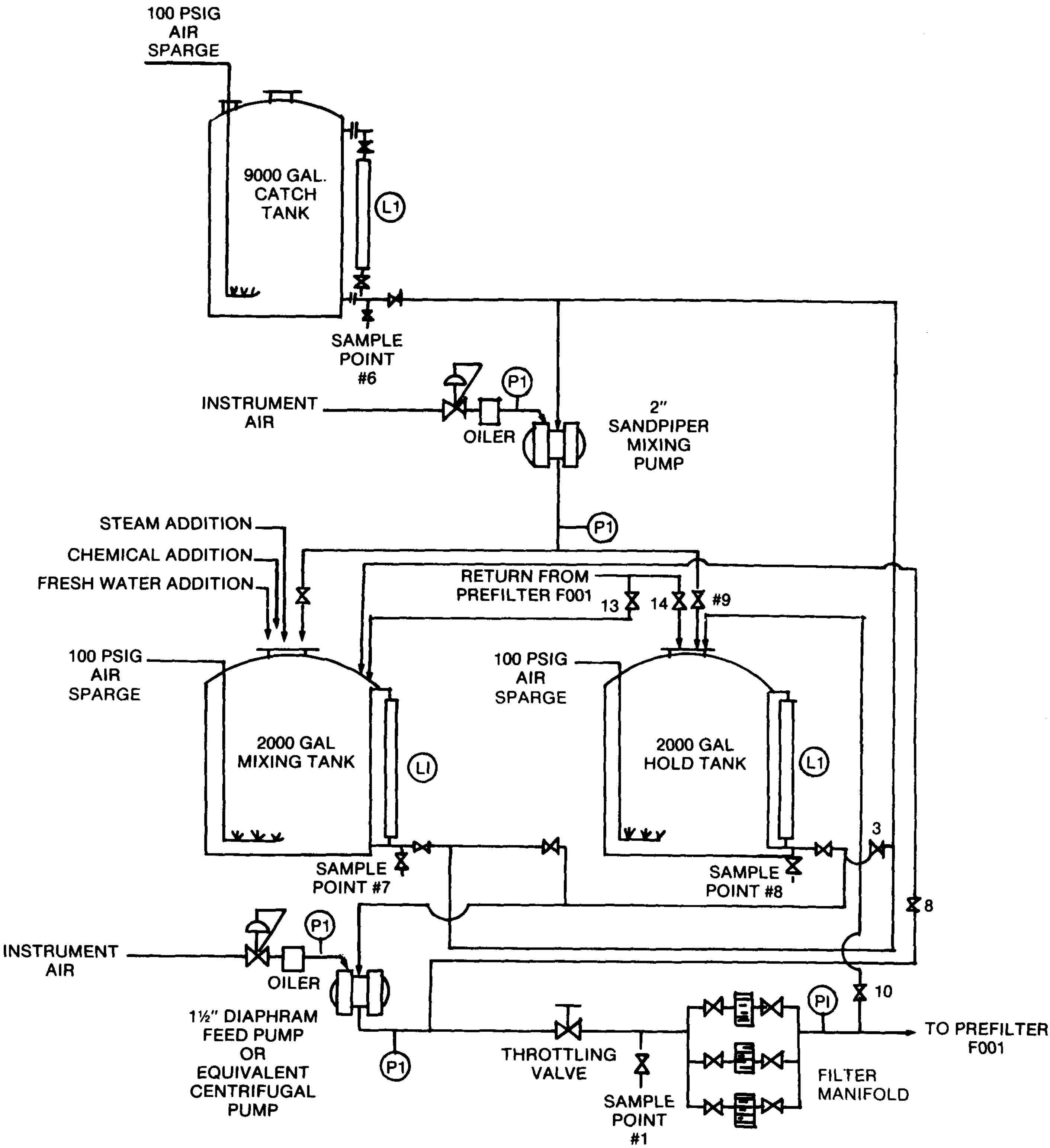


FIGURE 22
STS Chemical Equipment Setup for Testing

Table 15. Chemical Composition of Diluted Simulated Supernatant for Integrated Test

CONSTITUENT	COMPOSITIONAL RANGE (WT% - WET BASIS)
Sodium (Na)	4 - 5
Potassium (K)	0.2
Chromium (Cr)	0.02
Nitrate (NO_3)	5 - 6
Nitrite (NO_2)	2 - 3
Sulfate (SO_4)	0.5 - 1
Bicarbonate (HCO_3)	0.1
Carbonate (CO_3)	0.2
Chloride (Cl)	0.03
Hydroxyl (OH)	0.1
Phosphate (PO_4)	0.03
%Total Salts	13 - 15%
Water	85 - 87%

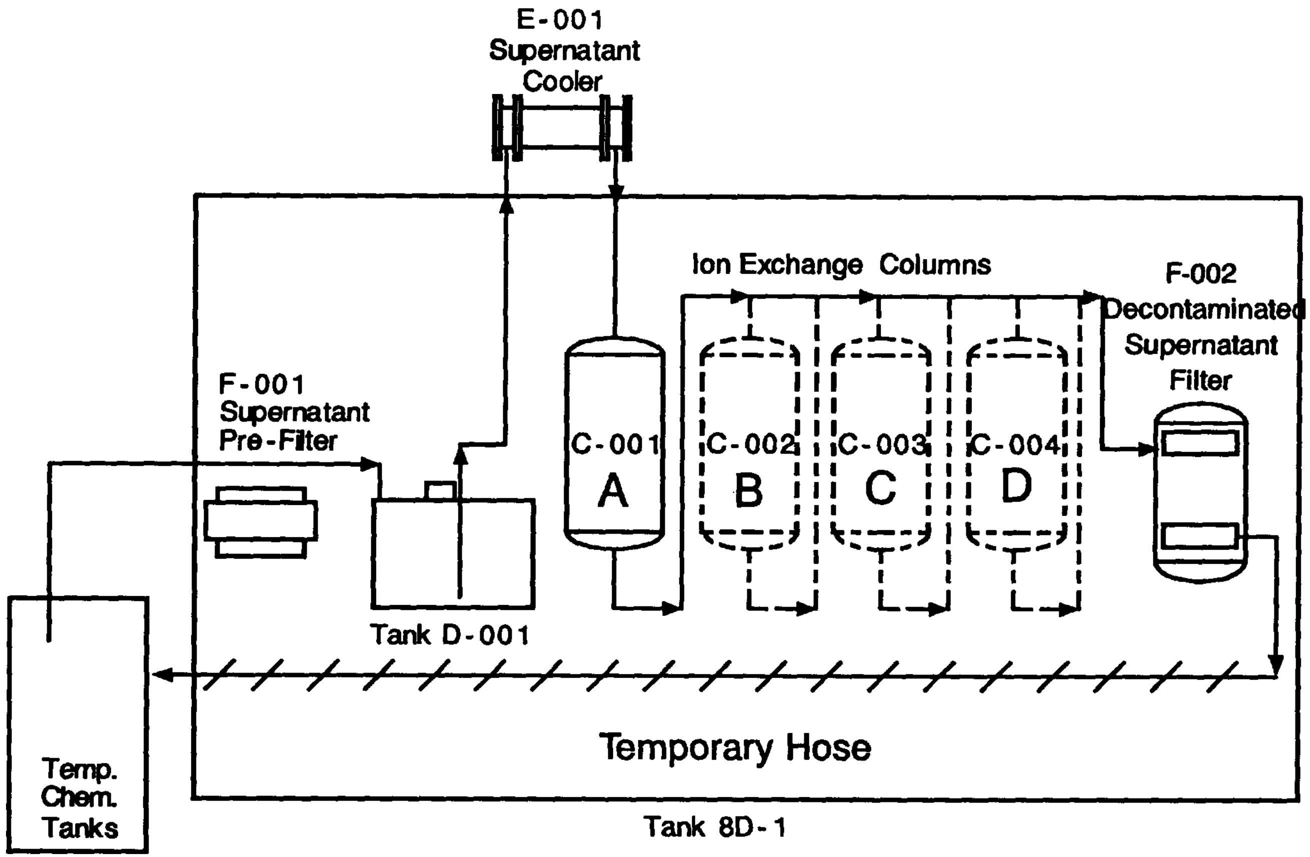


Figure 23

Equipment Configuration for the STS System Test

5.3.3 STS System Testing (Itzo, 1988)

The STS system testing under Test Procedure 87-37 preceded the integrated systems testing done under Test Procedure 87-69. The purpose of the STS system test was to test the STS system hydraulics, recheck instrumentation, verify dilution capabilities of the system, and perform a column breakthrough test using Column A. During the system test the simulated supernatant was recirculated through the STS. After the system test, this same simulated supernatant was processed one final time through the STS before being transferred to the other IRTS systems for the integrated test.

Three thousand gallons of 39 weight percent simulated supernatant were pumped from the temporary 7 570.8-L (2,000-gallon) tank through a temporary cartridge filter, the Prefilter, dilution system, and discharged into the Supernatant Feed Tank. The diluted simulated supernatant was then pumped through Column "A" and the Decontaminated Supernatant Filter and collected in a temporary 34 068.7-L (9,000-gallon) hold tank. After testing the Prefilter and the dilution system, the Prefilter was bypassed for the remainder of the test.

The Supernatant Feed Tank 50-D-001, which normally collects filtered supernatant, was used to feed the diluted simulated supernatant to the Ion Exchange Columns. The diluted simulated supernatant was then pumped from the Supernatant Feed Tank through the Supernatant Cooler (50-E-001) using a temporary pump. The temporary pump was being used in place of the 50-G-002 pump, which had failed during previous testing and was in the process of being replaced.

In the Supernatant Cooler, a shell and tube heat exchanger, the diluted simulated supernatant was first cooled to about 6°C prior to processing through the Ion Exchange Columns. The coolant used is Sodium Nitrate brine, which is in turn chilled by a Freon refrigeration unit.

During normal processing, the supernatant is processed through four Ion Exchange Columns in series; however, during this test, only Column A was loaded in order to conserve zeolite. The purpose of the test was to determine the amount of cesium which could be loaded onto the zeolite in one column.

Decontaminated supernatant exiting Ion Exchange Column A was filtered in the Decontaminated Supernatant Filter to remove zeolite fines. The Decontaminated Supernatant Filter (50-F-002) is a sand bed designed to remove 99 weight percent of particulate matter having a particle size greater than 1.0 micron.

5.3.3.1 Column "A" Breakthrough Test Results

The cesium loading profile of Column "A" charged with 12 drums (60 ft^3) of IE-96 zeolite media was determined during this test. Cesium Nitrate was added to the simulated supernatant after each cycle to replace the cesium removed in Column A. In this way, a constant cesium concentration was maintained during the test. The simulated supernatant was recirculated through column A until 95 percent cesium breakthrough was achieved. At 95 percent cesium breakthrough, the zeolite is almost completely loaded and is only removing 5 percent of the cesium in the feed.

The performance of Ion Exchange Column "A" is shown graphically on figure 24. One hundred column volumes of simulated supernatant were processed before the system test was terminated due to time constraints without reaching 95 percent breakthrough. Based on these results, a 107-column-volume capacity was predicted at the 95 percent breakthrough point. That is, 107 column volumes of undiluted supernatant would be processed through column A before 95 percent of the cesium in the feed would pass through the column and leave in the effluent.

5.3.3.2 Prefilter Functional Check

The primary purpose of the Prefilter functional test was to verify that the blowback to remove the accumulated solids, the pressure drop across the Prefilter can be restored to 10 psi or less. As shown figure 25, the pressure drop across the Prefilter after blowback did not exceed 10 psi. After 68 hours of continuous operation and three blowbacks, the clean pressure drop across the Prefilter was still less than 10 psi.

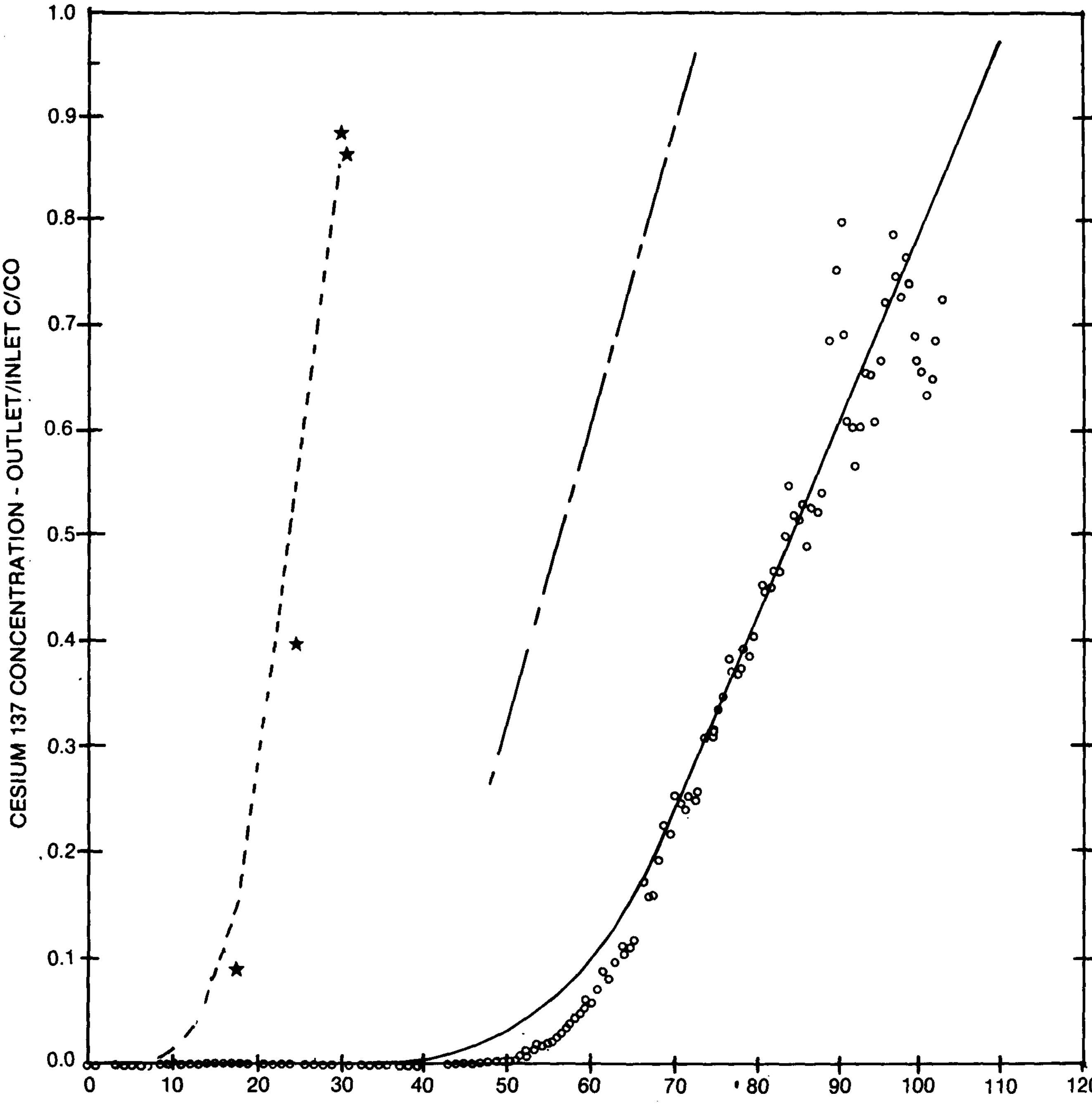
The particulates in the simulated supernatant removed by the Prefilter are believed to be dirt, grit, and undissolved chemicals.

5.3.3.3 Supernatant Chiller/Cooler Performance

Except for a brief period when the Chiller Unit was inadvertently shut down, the cooled simulated supernatant was maintained in a 3° to 7°C range (set point 6°C) with no increase in brine flow to the Brine Cooler. Based on visual observation, control valve 50-TCV-10 was fully open during system testing, indicating that some of the chilled brine was bypassing the Brine Cooler. Crystallization or precipitation of solids in the Supernatant Cooler (50-E-001) could have resulted in fouling of the heat exchanger surface, which in turn would have eventually required more brine flow to maintain the same temperature in the simulated supernatant. The fact that no additional brine flow was required indicates that no tube fouling occurred during the test. The pressure drop across Ion Exchange Column "A" or the Decontaminated Supernatant Filter did not increase during the run, again indicating that crystallization did not occur downstream.

When the chiller was inadvertently shut off, there was a brief rise in temperature above 7°C. There was also a noticeable change in cesium breakthrough from Column A during this period corresponding to this temperature increase. This temperature effect was probably amplified because the zeolite in Column A was close to breakthrough. The zeolite recovered its cesium removal efficiency soon after the temperature was decreased back to 6°C.

The chiller shutdown was caused by the actuation of a low-load sensing device which shuts down the chiller to protect it. During testing, the simulated supernatant was preheated to slightly above ambient temperature. When the STS is processing actual supernatant, the chiller will operate at design load



o ACTUAL, SIP 87-37, 0.2 CV/HR, 2:1 VOLUME DILUTION, 6°C (COLUMN 'A')

★ WVNS, LABORATORY, 0.2 CV/HR, NO DILUTION, 25°C

— — — PREDICTED, SIP 87-37, 0.2 CV/HR, 2:1 VOLUME DILUTION, 6°C

FIGURE 24
Column "A" Breakthrough Curve (System Test)

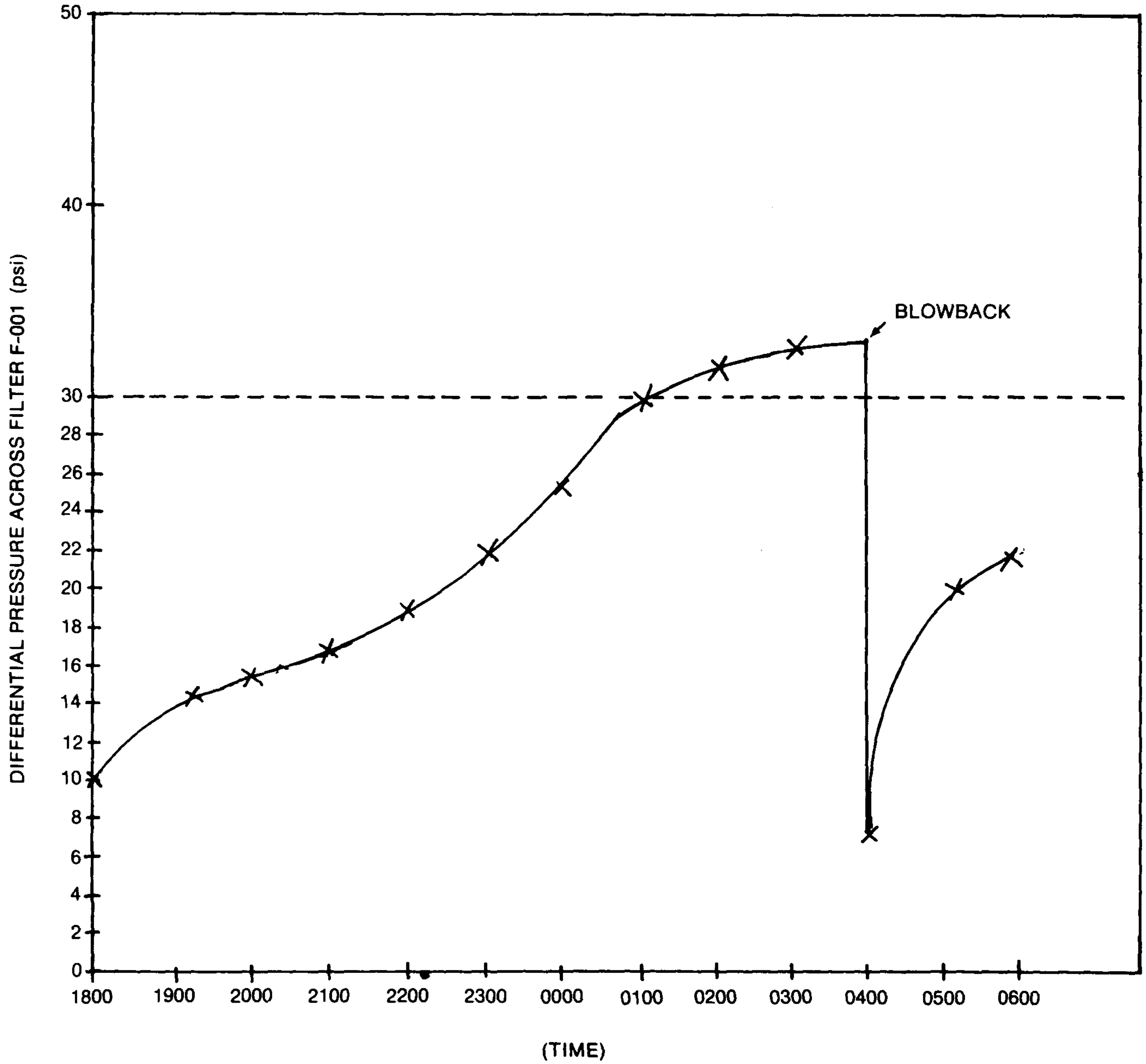


FIGURE 25
STS Prefilter Performance Test Data

because the actual supernatant temperature will be much higher, and this low-load condition should not occur. The supernatant chiller/cooler unit's performance has been previously verified under maximum anticipated heat load conditions during component testing using steam-heated water.

5.3.3.4 Dilution System Checkout

In conjunction with the functional checkout of the Prefilter, the performance of the Supernatant Feed Dilution System in automatic mode was also verified. A 2:1 volume dilution was maintained to obtain 15 $\pm$1 weight percent total dissolved solids (TDS) in the diluted simulated supernatant produced. A range of 13.5 to 15 weight percent TDS in the diluted simulated supernatant was observed during this 24-hour run. This range was not quite in the required range because the temporary "workaround" Supernatant Feed Pump upstream of the sample point introduced seal water, at 0.25 $\pm$0.05 gpm, into the process. This seal water flow decreased the TDS of the diluted supernatant by an additional 0.5 weight percent. When this additional dilution by the seal water is taken into consideration, the Dilution Control System controlled TDS within the required range. This problem will not occur during actual supernatant processing because the replacement pump for 50-G-002 is sealess. Flow meters monitoring the water and simulated supernatant streams generally also within $\pm$0.25 gpm of the corresponding STS panel flowmeters which indicated that the Dilution Control System was maintaining the proper flow ratio.

5.3.3.5 Decontaminated Supernatant Filter Test

An analysis of operating data from the Ion Exchange Column zeolite loading test revealed a differential pressure across the decontaminated supernatant filter of 5 psi, which was constant ($\pm$0.2 psi) throughout the entire 15-day test period. Suspended solids analysis performed on upstream and downstream samples showed no solids quantities above detectable limits (less than 0.01 weight percent). Thus, no measurable fines generation was observed from Ion Exchange Column A, resulting in a very low solids loading to the Decontaminated Supernatant Filter. However, further testing of this filter is not necessary, since it performed satisfactorily as a polishing filter during integrated testing.

5.3.4 IRTS Integrated Test

After the STS system testing was complete, integrated testing involving LWTS, CSS, and the Drum Cell started. The same simulated supernatant was used for this test as was used for the STS system testing. See figure 26 for the flow diagram for the integrated test.

During STS system testing, a temporary holding tank located at the chemical mix and feed station was used in place of tank 8D-3. During final integrated testing, simulated decontaminated supernatant was transferred to and stored in tank 8D-3. The Decontaminated Supernatant Transfer Pump (50-G-007), designed for making batch transfers from tank 8D-3 to LWTS, underwent mechanical and electrical checkouts prior to pumping simulated, decontaminated supernatant to LWTS tank 5D-15B during integrated testing.

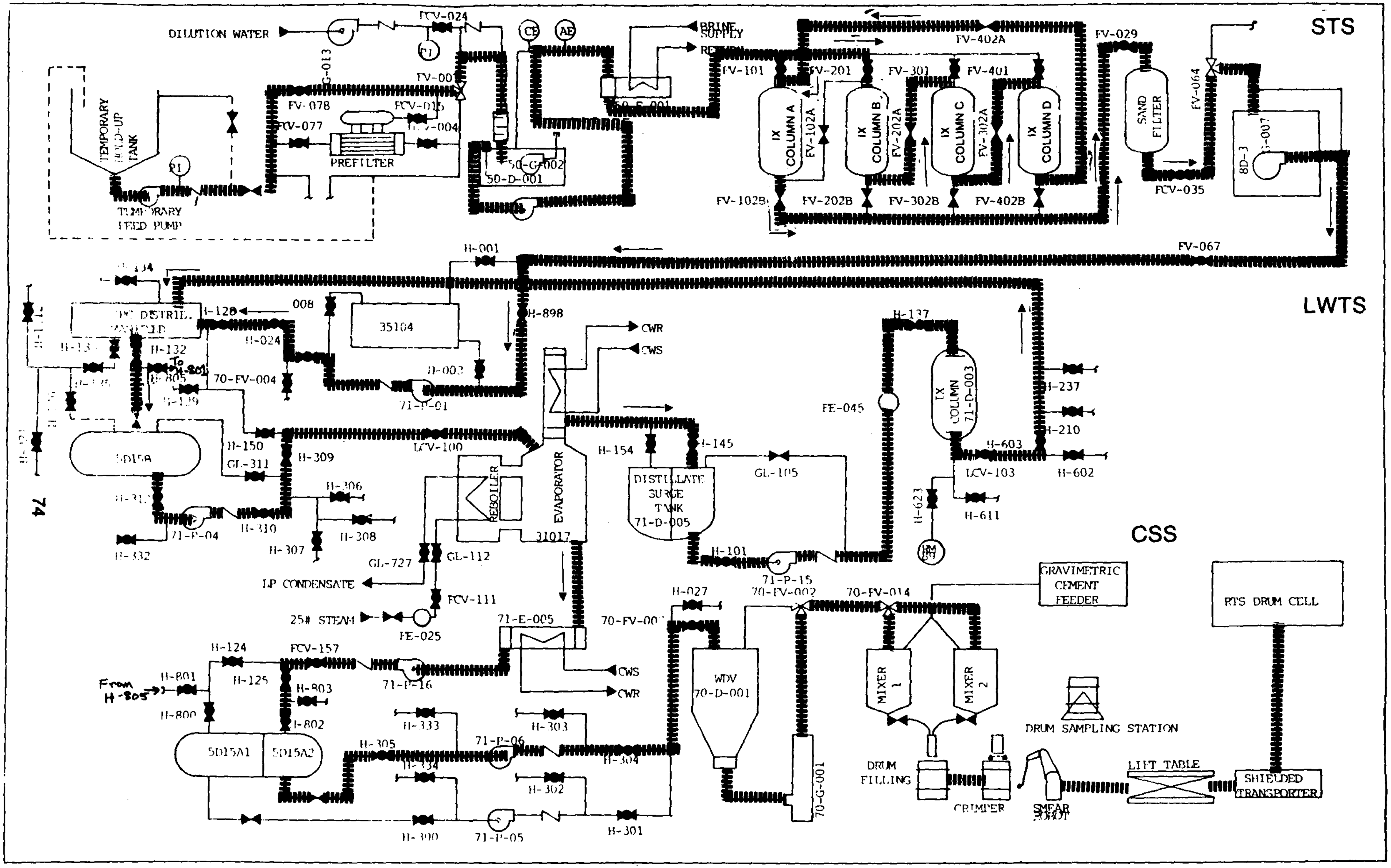


FIGURE 26
IRTS Integrated Test Flow Diagram

The simulated supernatant was successfully transferred to LWTS and was then concentrated in the LWTS evaporator and subsequently transferred to the CSS for solidification in cement. Potassium Chromate had been added to the simulated supernatant for this integrated test in order to characterize the leach performance of the solidified product produced in CSS.

5.4 Condensate Processing

After the integrated test was completed, tank 8D-1 contained about 1 060 000 L (280,000 gallons) of condensate from previous operations. Since this water was slightly contaminated (about 10^{-2} μCi/ml cesium), WVNS decided to process this water as if it were supernatant to gain system operating experience. Therefore, as the final step in integrated testing 280 000 L (74,000 gallons) of condensate from tank 8D-1 was processed through the STS. Prior to processing this slightly contaminated water, the STS Valve Aisle was sealed. During condensate processing, all valve aisle components were operated remotely as they would be during hot operations. Thus, expertise was gained operating the STS in its final configuration with mildly contaminated water. If a problem had developed during condensate processing, there was little risk associated with going back into the Valve Aisle and remedying the problem prior to the actual start of supernatant processing.

Condensate was transferred from tank 8D-1 via pump 50-G-004 into tank 50-D-004, then via pump 50-G-003 into tank 50-D-001, and through the Ion Exchange Columns and the Decontaminated Supernatant Filter into tank 8D-3. The system was operated with only one Ion Exchange Column at an average temperature 20°C and flow rate of 6 gpm. The temperature was not maintained at 6°C because the brine cooler was out of service during this run. From tank 8D-3, the treated condensate was transferred back to tank 8D-2 both directly and via tanks 35104 and 7D-2 in the LWTS.

All test objectives were successfully met during condensate processing, as shown in table 16.

5.4.1 Results Of Condensate Processing

Checkout of the Decontaminated Supernatant Transfer Pump was successfully completed, including transfer of flush water from tank 8D-3 to LWTS via tank 35104. The STS was remotely operated with master-slave manipulators according to procedures. Remote operation of the STS Sampling and Pneumatic Sample Transfer System was also performed satisfactorily. The processing of condensate from tank 8D-1 through the STS, LWTS, and back to 8D-2 was a very successful operation. The treated condensate was returned to 8D-2 during this test because there were no permits to discharge LWTS evaporator overheads. This test provided final checkout of the STS.

Table 16. Summary of 8D-1 Condensate Processing

PURPOSE	SPECIFIC OBJECTIVES	RESULTS
To process approximately 50,000 gallons of condensate solution from tank 8D-1 through the STS into either tank 8D-2 or 8D-1.	Process 50,000 gallons from 8D-1 through STS.	Actual volume processed was 73,876 gallons.
	Provide additional operator experience and familiarization of all aspects of system operation.	Operated system for 11 days.
	Provide additional equipment run-in time for greater reliability.	11 day operating period resulted in equipment malfunction on pump 50-G-002 and pneumatic sample transfer system diverter. All failures were repaired.
	Provide additional interface with integrated system (LWTS) to improve communications.	9 batches were transferred from 8D-3 to 35104. Additional batches were transferred directly to 8D-2.
	Provide experience in in remote valve operations and sampling techniques.	74 samples were taken during the 11 day run.
	Demonstrate DF of integrated system of at least 1000.	DF was greater than 1000 throughout the run.

5.4.2 Lessons Learned from Condensate Processing

The additional operating experience gained during condensate processing resulted in the identification of several minor problems that were not noted during earlier component testing. For example:

- Variations in the volume calculations and use of different specific gravity/density values resulted in calculation of different values of the actual gallons processed. This inconsistency has been corrected by implementation of a standard method for calculating volume.
- The diverter plate in the Pneumatic Sample Transfer System was malfunctioning. An investigation into the problem revealed that the motor for the diverter plate produced an insufficient amount of output torque. Engineers and technicians operated the system in manual mode until a replacement motor could be obtained. The new higher-torque motor was installed and tested in place. Currently, the pneumatic sample transfer system is fully operational.
- Minor problems with valve aisle manipulators occurred resulting in slight delays during sampling. These problems, a ripped boot and loss of "Z" motion on a manipulator, are typical problems with manipulators and were easily corrected during the run.
- There was a short-term leak through the stem of valve 50-FCV-035. The valve was cycled several times and the leak stopped. There were no further problems with the valve during the condensate processing run. An inspection of the valve following shutdown revealed a mechanical interference at certain valve positions. The interference was removed and the valve operation has been satisfactory since then.

5.5 Sample Analysis (Itzo, 1988)

During cold testing and initial hot operations, samples of the HLW supernatant in tank 8D-2 were analyzed and compared to previous sample results. Sample results are shown in table 17.

Discussion of Sample Analysis Results

Cesium

Previous estimates of the cesium concentration in the HLW supernatant were 3300 μCi/mL (1982). The average concentration of cesium based on the 1988 analyses of samples taken during initial hot operations is 2000 μCi/mL. This difference can be explained by dilution of the supernatant and the decay of the Cs-137 over the six years since the original sample was taken. The supernatant was diluted from 2 195 538 L (580,000 gallons) to about 2 649 788 L (700,000 gallons) at the start of radioactive operation by the return of the 73,000 gallons of 8D-1 condensate and by the addition of liquid wastes produced during decontamination of the existing facilities to 8D-2.

Stratification of the supernatant had been ruled out as a possible explanation by previous testing which showed that the supernatant was homogeneous. The homogeneity was confirmed by seven consistent density measurements at different tank depths and the unchanging ratio of sodium to cesium in the supernatant.

Particulate (Suspended Solids)

The STS was designed to remove 99 percent of the suspended solids, one micron or greater in the Prefilter. The Prefilter can be blown back with air to remove the solids. Because there was concern about these filter elements, which are not remotely replaceable, plugging prematurely, the decision was made during the design stage to use the Prefilter only when the concentration of suspended solids exceeds 200 ppm. Previous analysis of the supernatant showed a suspended solids concentration of 84 ppm. Samples taken just prior to and during hot operations were about 80 ppm; so the Prefilter has not yet been used to filter the supernatant.

The sample analyses shown in table 17 shows that the concentration of radionuclides in the suspended solids is approximately the same as those in tank 8D-2 sludge solids. The particle size analysis of the solids in the supernatant showed a wide particle size distribution from 0.10 to 3.0 microns, but the particles in the sludge sample taken from tank 8D-2 were all more than 3.0 microns. This indicates that the larger particles are settling out leaving the smaller particles suspended in the supernatant.

Strontium, Technetium, and Plutonium

The final concentrations of strontium, technetium, and plutonium in the supernatant affects the US NRC 10CFR61-based classification of the solidified decontaminated supernatant waste. Although no credit was taken for removal of these radiochemical species in the design, samples were taken and analyzed to determine if any removal was taking place in the STS. IE-96 zeolite has some capacity for removing strontium; it was also thought that since strontium and plutonium are highly insoluble, strontium and plutonium might be removed by filtration on the zeolite beds. However, sample analysis showed only slight removal of strontium (equivalent to a DF of 4), and no significant removal of plutonium or technetium. The resultant waste form from the IRTS process is Class C according to 10CFR61.

5.6 ORRB Review

After STS Cold Operational Testing and Condensate Processing were complete, the Operational Readiness Review Board (ORRB) was convened. The board met during the week of April 18 to review the readiness of the STS, LWTS, CSS, and Drum Cell to begin hot operations. The members of this board were 7 representatives from the West Valley Project, two Westinghouse off-site representatives, 9 DOE and NYSERDA representatives, and 3 representatives from the NRC.

Table 17. Comparison of Supernatant Suspended Solids To 8D-2 Sludge

8d-2 Suspended Solids (1988)

Gross	α	1.03 E3 μCi/g
Gross	β	1.78 E5 μCi/g
Cs-137		1.27 E3 μCi/g
Am-241		5.34 E2 μCi/g
Co-60		4.08 E1 μCi/g
Co-57		3.53 E2 μCi/g
Eu-154		7.44 E2 μCi/g
Eu-155		1.80 E2 μCi/g
Sr-90		4.89 E4 μCi/g
Na-22		2.80 E2 μCi/g
Pb-210		1.74 E2 μCi/g
Fr-223		2.22 E1 μCi/g
Total Pu		7.36 E1 μCi/g
% Fe		~32%
% Fe_2O_3		~45%

8D-2 Sludge (1982)

Fission Products

Sr-90	2.71 E+3	μCi/g
Y-90	2.71 E+3	μCi/g
Zr-93	8.05 E-2	μCi/g
Nb-93m	8.05 E-2	μCi/g
Tc-99	5.95 E-3	μCi/g
Ru-106	1.23 E+0	μCi/g
Fh-106	1.23 E+0	μCi/g
Pd-107	1.79 E-5	μCi/g
Cd-113	1.23 E+1	μCi/g
Sb-125	5.25 E+0	μCi/g
Te-125m	1.19 E+0	μCi/g
Sn-125	1.40 E-2	μCi/g
Sb-126m	9.40 E-4	μCi/g
Sb-126	9.40 E-4	μCi/g
Pm-147	3.85 E+2	μCi/g
Sm-151	7.00 E+1	μCi/g
Eu-152	1.68 E-1	μCi/g
Eu-154	7.00 E+11	μCi/g
Eu-155	1.50 E+1	μCi/g

TRU Content of 8D-2 Sludge (1982)

Pu-238	3.18 E+0	μCi/g
Pu-239	5.57 E-1	μCi/g
Pu-240	4.10 E-1	μCi/g
Pu-241	3.80 E+1	μCi/g
Pu-242	5.95 E-4	μCi/g
Am-241	4.20 E+0	μCi/g
Am-242m	7.35 E-2	μCi/g
Cm-242	7.35 E-2	μCi/g
Cm-243	1.19 E-2	μCi/g
Cm-244	3.61 E+1	μCi/g
Cm-245	5.95 E-4	μCi/g
Cm-246	7.00 E-5	μCi/g

Table 18. STS Operating Safety Margin		
	Cesium Concentration in Micro Curies/mL	Cesium Decontamination Factor
OPERATING LIMIT (SAMPLE ANALYSIS)	<1.0	1500
DESIGN BASIS	2.0	1000
OSR LIMIT (SHIELDING)	5.5	400

Table 19. Expected Cesium Decontamination Factor	
LAB (PNL) TEST	AT LEAST 1,000 >10,000 LIKELY
FULL SCALE (WVNS) TESTS:	
1) SIMULATED SUPERNATANT	1,000
2) CONDENSATE	AT LEAST 1,000

For a week, presentations were made by members of the design and operating groups to justify readiness of the IRTS to begin radioactive operation. The first 2-1/2 days the board concentrated on the STS. There were presentations on STS operations, laboratory support, environmental and safety related issues, operator training, and a system tour. Tables 18 and 19, showing the STS safety margin and expected cesium removal effiency (i.e., DF) were presented to the board. Questions asked by the board resulted in some procedure modifications, OSR modification, development of an alternate plan to dump zeolite if the column dump valve would not close, and prioritization of samples. The board recommended startup of STS following resolution of these items.

On Wednesday and Thursday, April 20 and 21st, the CSS was reviewed by the board. Presentations were given on system design, Process Control Plan, CSS Run Plan, sampling, operator training, maintenance, and integration of procedures and operations. The board concluded that the CSS was ready for hot operations after resolution of product quality and process control concerns.

The LWTS was reviewed on the afternoon of Thursday, April 21. Presentations were given on system design, instrument design, Startup and Test Plan, Run Plan, and safety training. The board concluded that the LWTS was ready to operate after a final training session for IRTS personnel, status board development, and resolution of probe plugging. It was decided that tank 5D-15B would be the control sample point for the entire IRTS process.

The Drum Cell was reviewed on Friday, April 22. The presentations included system description, emergency preparedness, operator qualification, and a System tour. The board approved the Drum Cell operation after the transport plan for abnormal situations, administrative controls, and recalculation of skyshine were resolved.

When the IRTS went into hot operations, this general operating plan was followed. The plan was to process 56 781 L (15,000 gallons) of supernatant through STS during each 2-week campaign leaving tanks 8D-3 and 5D-15B full at the end of the STS portion of the campaign. The 56 781 L (15,000 gallons) of decontaminated supernatant and 18 925 L (5,000 gallons of flush water) would be concentrated in the LWTS. About 39 700 L (10,500 gallons) which would be solidified in the CSS. The 36 000 L (9,500 gallons) of distillate from the LWTS evaporator would be transferred to the low-level waste treatment facility for further treatment before discharge. Approximately 280 drums of solidified decontaminated supernatant would be produced during each campaign and stored in the Drum Cell.

The board concluded that the IRTS was ready to begin radioactive operation, subject to open items being completed. Formal permission to proceed with operations was given on Friday, May 20 by the Manager of DOE-ID Operations. STS started testing pump 50-G-001 on Saturday, May 21; and on Monday, May 23, the STS was producing decontaminated supernatant.

6.0 RADIOACTIVE OPERATION OF THE SUPERNATANT TREATMENT SYSTEM

6.1 Final Testing (Ross, 1988)

After the Supernatant Feed Pump (50-G-001) was tested under test procedure 87-38, the last component checkout of the STS was complete. This pump had not been previously tested as part of the STS component testing because it would pump supernatant into the STS when operated. The only preoperational checkout performed on 50-G-001 was operating the pump motor uncoupled from the pump shaft, which had been performed periodically with no apparent problems. However, when the motor was connected to the pump shaft at the time of hot startup, the additional horsepower required of the motor caused the motor starter heaters in the motor control center to trip. The motor starter heaters (current limiters) for pump 50-G-001 were found to be undersized and unable to support the horsepower requirements of the pump motor when the speed of the pump was increased by the variable speed drive to provide the rated pump capacity. The undersized heaters were replaced by heaters with sufficient capacity, and pump 50-G-001 performed per design specifications. See figure 27 for the flow diagram for testing pump 50-G-001.

6.2 STS Process Control For Campaign One (Ross, 1988)

After the testing for the Supernatant Feed Pump was complete, the STS started processing supernatant. During this and following STS campaigns, STS process control was accomplished by a combination of sample analysis and radiation monitoring of the process stream. The primary method of process control is by sample analysis. The raw supernatant is sampled at the Supernatant Feed tank 50-D-001 before being fed to the Ion Exchange Columns. A sampler located at the discharge of each Ion Exchange Column provides the capability of sampling the effluent from each column. Each batch of decontaminated supernatant collected in the Decontaminated Supernatant Tank 8D-3 is sampled prior to transfer to the LWTS. Each batch of decontaminated supernatant received in tank 5D-15B in LWTS is again sampled after the transfer from tank 8D-3 is completed. Because decontaminated supernatant is constantly flowing into tank 8D-3 while the STS is processing supernatant, the sample of decontaminated supernatant taken from tank 5D-15B is more representative than that taken from tank 8D-3. The sample plan for the STS and a flow diagram identifying sample point locations (figure 33) are contained in attachment B.

The STS is required by Operational Safety Requirement (IRTS-5) to remove 99.9 percent of the cesium from the supernatant, which equates to a minimum decontamination factor (DF) of 1000 and a Cs-137 concentration of 1.5 μCi/mL Cs-137. An operational goal of a cesium DF 1500, corresponding to a cesium, concentration of less than 1.0 μCi/mL, has been set to provide a product to the customer (LWTS) which is of better qu ality than the minimum requirements dictate.

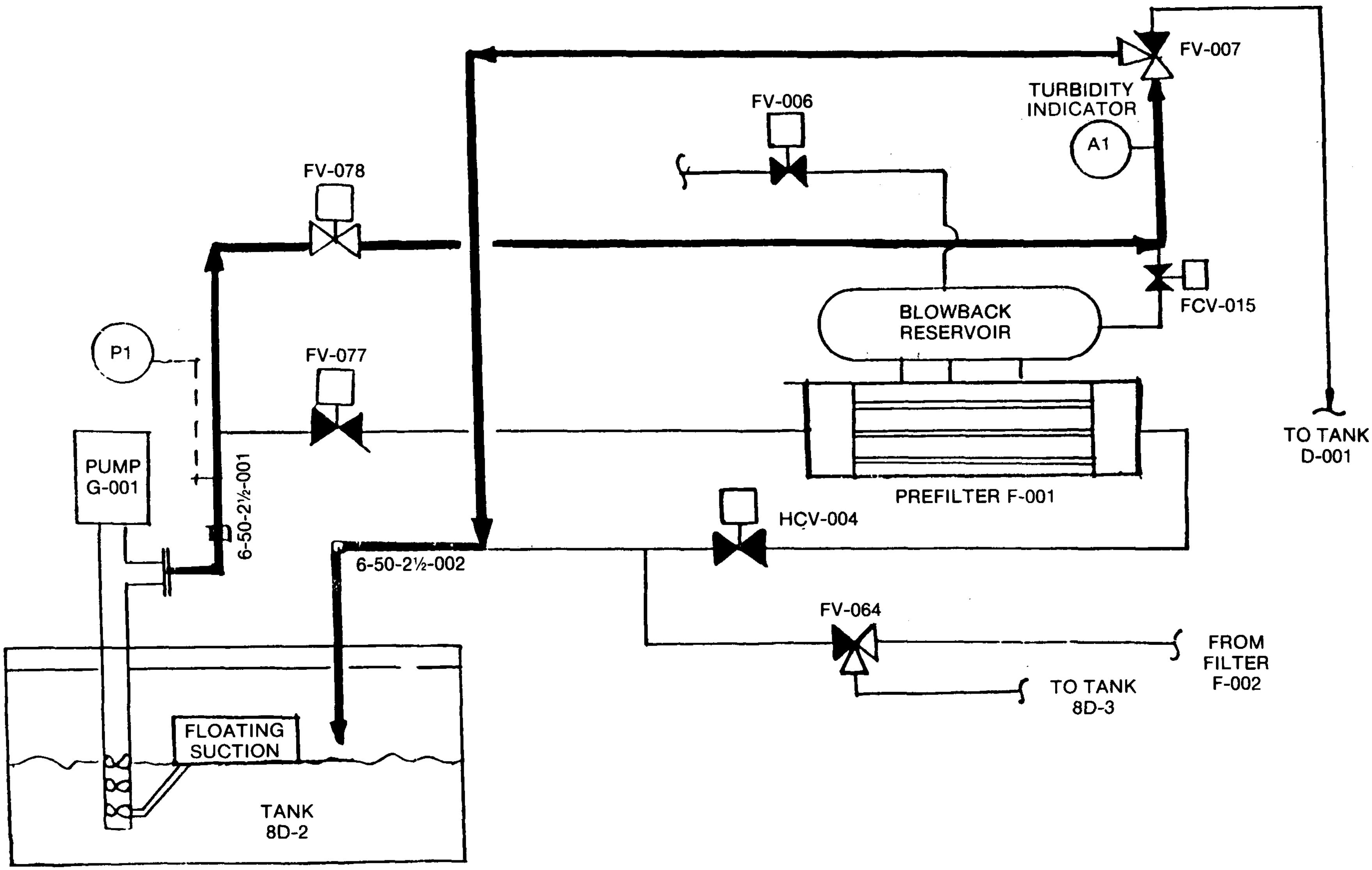


FIGURE 27
Flow Path for the Supernatant Feed Pump Test

The secondary means of process control is by continuously monitoring the radiation level of the process streams. The effluent from each Ion Exchange Column is monitored by radiation detectors. The decontaminated supernatant being transferred into or out of tank 8D-3 is also continuously monitored by radiation detectors. One drawback of the radiation detectors is that they do not read cesium concentration directly (they detect gamma radiation from the decay of Ba-137m). This results in a high "cesium" reading on the first and second column because the radiation monitors detect not only the Ba-137m in equilibrium with the cesium in solution, but they also detect the Ba-137m decaying off the cesium loaded on the zeolite in the ion exchange columns. This is not a problem in the third and fourth columns, because the columns are only partially loaded with cesium and there is sufficient time for the Ba-137m to decay to equilibrium levels prior to reaching the radiation detectors.

The radiation detectors are also affected by background radiation. As more operating data is obtained, it is believed that the background radiation can be predicted based on whichever Ion Exchange Column is the lead column. As the characteristics of the radiation detectors are determined by experience during supernatant processing, the radiation monitoring system can be more heavily relied upon for process control.

6.3 Equipment Operation (Ross, 1988)

During initial radioactive operations of the STS, the majority of the STS equipment functioned as designed, with only minor operational problems encountered.

Before beginning supernatant processing, the Supernatant Feed Pump, 50-G-001, was tested completing component checkout of the STS. Refer to figure 27 for a diagram of the test flow path for pump 50-G-001. The Supernatant Feed Pump was started on Saturday, May 21 initiating radioactive supernatant flow into the STS.

The Supernatant Feed Tank, 50-D-001, and the Supernatant Feed Pump, 50-G-002, functioned as designed. The Supernatant Cooler, 50-E-001, was unable to cool the supernatant to the desired temperature of 6°C The cooler was, however, able to provide cooling of the supernatant to $\geq$12°C at a maximum flow rate of 5.5 gpm using reduced brine temperatures. The cesium removal efficiency of the Ion Exchange Columns greatly exceeded the design basis of 99.9 percent cesium removal even at this slightly higher operating temperature.

The Ion Exchange Columns, Decontaminated Supernatant Filter, and Decontaminated Supernatant Storage Tank 8D-3 performed as expected. There was, however, a small amount of raw supernatant introduced into tank 8D-3 when a valve was left open after the transfer of processed simulated supernatant (left from the integrated testing) from tank 8D-3 back to tank 8D-2. Tank 8D-3 was subsequently flushed with approximately 15 520 L (4,100 gallons) of water back to tank 8D-2 to remove the unprocessed radioactive supernatant. A total of 1,815 gallons of decontaminated supernatant was also used to flush tank 8D-3 to 8D-2. The STS transfer procedure was subsequently changed to require that valve FV-068 be closed at the end of transfer before shutting off the transfer pump.

The majority of the valve aisle jumpers and related equipment functioned as designed. Exceptions were a minor leak at the flange holder for flow element 50-FE-015 which was repaired remotely by tightening the flange bolts, and two three-way valves that became difficult to operate. The valves involved were Valve 50-FV-007, which diverts the flow of raw supernatant to tank 50-D-001 or back to tank 8D-2, and valve 50-FV-064, which controls decontaminated supernatant flow from the outlet of the postfilter to tank 8D-3 or recycle to tank 50-D-001. The valves both had to be manually assisted with the manipulators and jib crane hook in order to actuate them. Valve handle extensions have been fabricated and installed to make manipulator operation of valves 50-FV-007 and 50-FV-064 easier.

6.4 System Performance (Ross, 1988)

During campaign one, a total Ion Exchange Column throughput of 98 421 L (26,000 gallons) was achieved, which is 113 percent of the goal of 87 064 L (23,000 gallons) for the first campaign. Note that a goal greater than 15,000 gallons was set for the first campaign because the zeolite in all of the columns was fresh.

A cesium removal efficiency of 99.933 percent, (DF of 1500), was the goal for the first campaign. The average cesium DF for the first campaign was 12 000 L based on tank 5D-15B analysis. This is equivalent to cesium removal of 99.992 percent; a DF of 8 times greater than the goal. The DF comparison when using 8D-3 and 5D-15B sample analyses is shown in figure 28. The DFs range from 10,000 to 150,000 and would have been greater if 8D-3 had not initially contained residual radioactive fluid. The official system DF for the STS is reported based upon the 5D-15B sample analysis since there is solution flowing into 8D-3 at all times.

Both tanks 8D-3 and 5D-15B always retain heels, and the concentration of cesium averages out by backmixing of new material being transferred to the tank with the old material (heel) already in the tank. The cesium DF initially appears to be low, but increases in subsequent batches as the heel remaining in tank 8D-3 is diluted with decontaminated supernatant.

Although the STS was not designed for strontium removal, a DF for Sr-90 of approximately 4 was also achieved. Sample analysis determined that no appreciable removal of other radioactive constituents such as plutonium, uranium, and technetium occurred.

Cesium loading in the lead Ion Exchange Column followed predictions by Battelle Pacific Northwest Laboratories as shown in figure 29 **(Kurath, 1988)**. Breakthrough is a comparison of the concentration of cesium in the effluent from a column to the cesium in the supernatant feed to the column. The dotted lines represent the predicted performance for the first and second columns based on PNL test data. The solid lines represent actual column performance data based on sample analyses. As shown on the curve, the lead column attained approximately 85 percent breakthrough at the end of the first supernatant campaign and the second column had attained a 5 percent breakthrough. It had been planned to load the lead column to a breakthrough of 95 percent. The STS was shutdown early based on earlier sample analyses and the PNL predicted breakthrough curve, which indicated that the load-

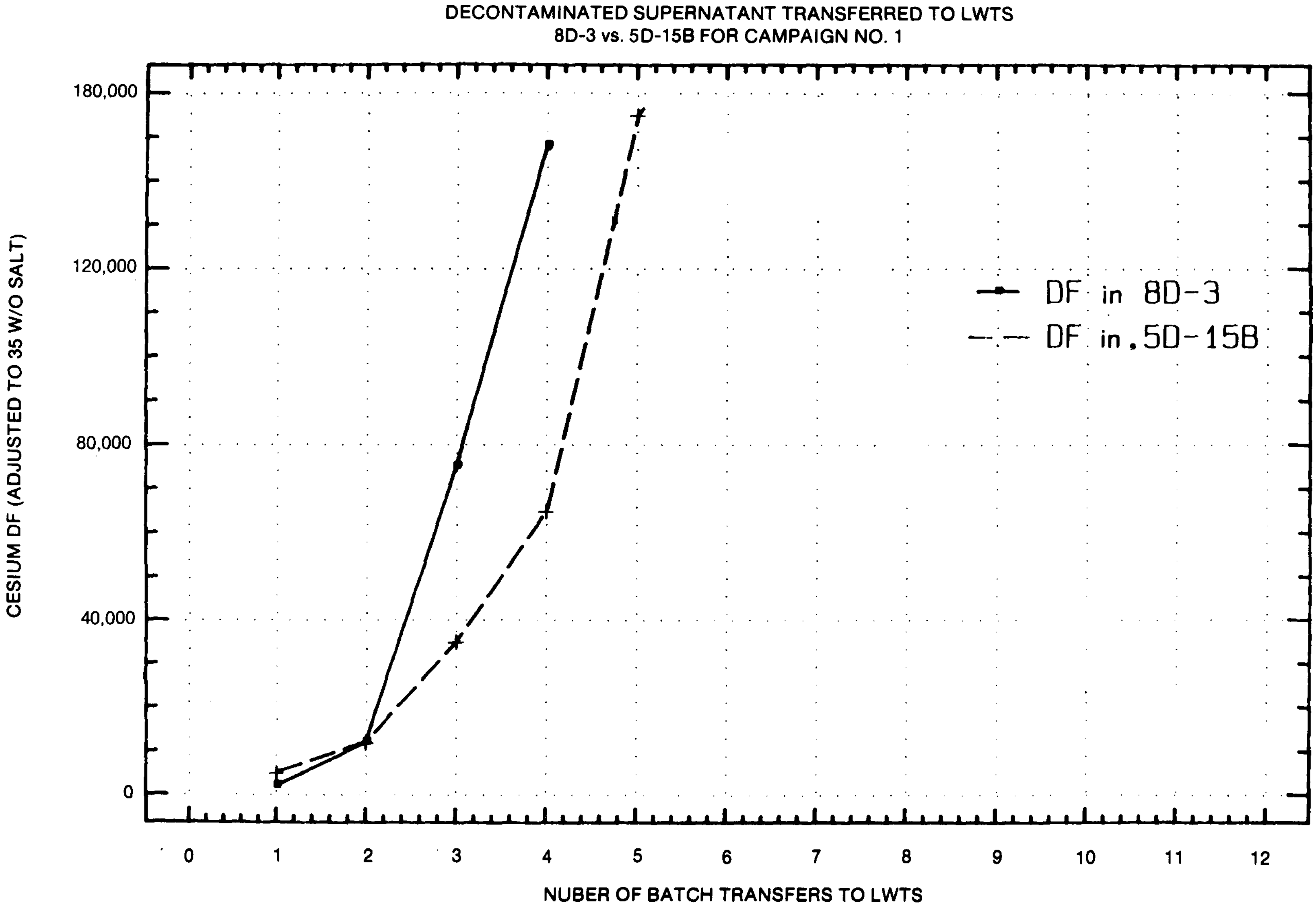


FIGURE 28
8D-3 Batch

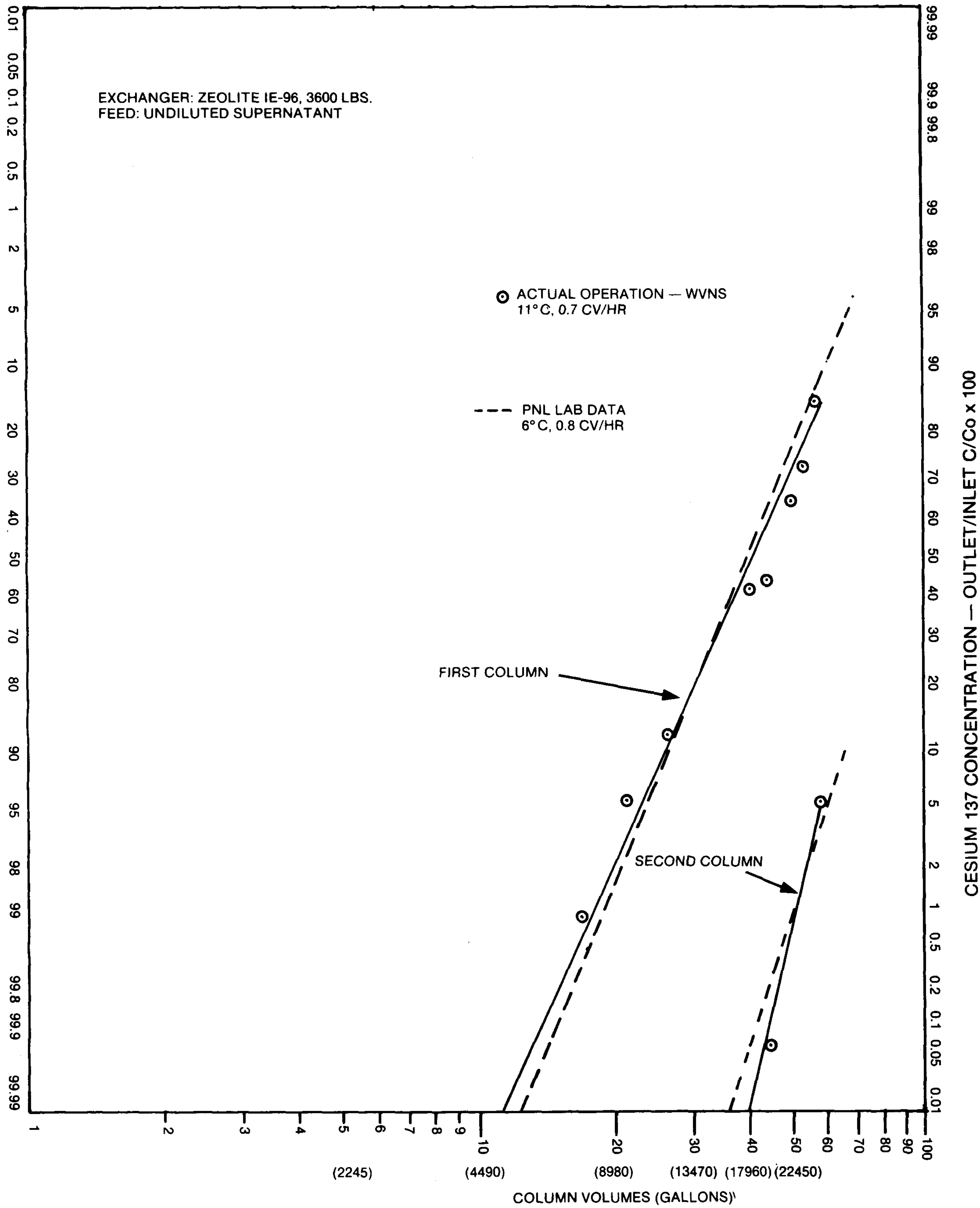


FIGURE 29
Cesium Breakthrough Curves for Campaign One

ing of cesium on the zeolite in the lead ion exchange column was still in excess of 95 percent even at 85 percent breakthrough.

6.5 Lessons Learned from Initial Radioactive Operations (Ross, 1988)

Flow readings are used in conjunction with column sample results to determine cesium breakthrough; they are also used to determine total column throughput. Problems were encountered with STS flow measurements because cumulative flow readings were not taken at the same time the sample was obtained. Therefore, it was more difficult to determine the breakthrough curves. The fact that flow totalizer 50-FQI-015 read gallons of supernatant pumped into 50-D-001 instead of gallons pumped through the columns also made the calculations more difficult.

To correct this situation and make the required information available, a new flow totalizer 50-FQI-035 was installed. This totalizer integrates the flow coming out of the columns. Operators now record the flow rate of the supernatant from 50-FQI-015 and 50-FQI-035. These corrections will enable the breakthrough curves to be calculated without interpolation.

Table 20 below is a chart showing an overview of the performance of the IRTS during Campaign 1. From 26,000 gallons of decontaminated supernatant with a Cs-137 concentration of 0.166 μCi/mL, 19,500 gallons of concentrate was produced in the LWTS. Four hundred and one drums of solidified decontaminated supernatant were subsequently produced in the CSS. Because of the cesium removal efficiency of the STS exceeded design, the total curies of cesium solidified in the decontaminated supernatant was less. As a result, the dose rate from a drum of solidified decontaminated supernatant produced in the CSS during Campaign 1 ranged from 15 to 70 mR/hr, compared with a design limit of 500 mR/hr. This lower dose rate from CSS drums is a major contributing factor in the actual dose received by personnel operating the IRTS being significally below the estimated ALARA figures as shown in figure 32.

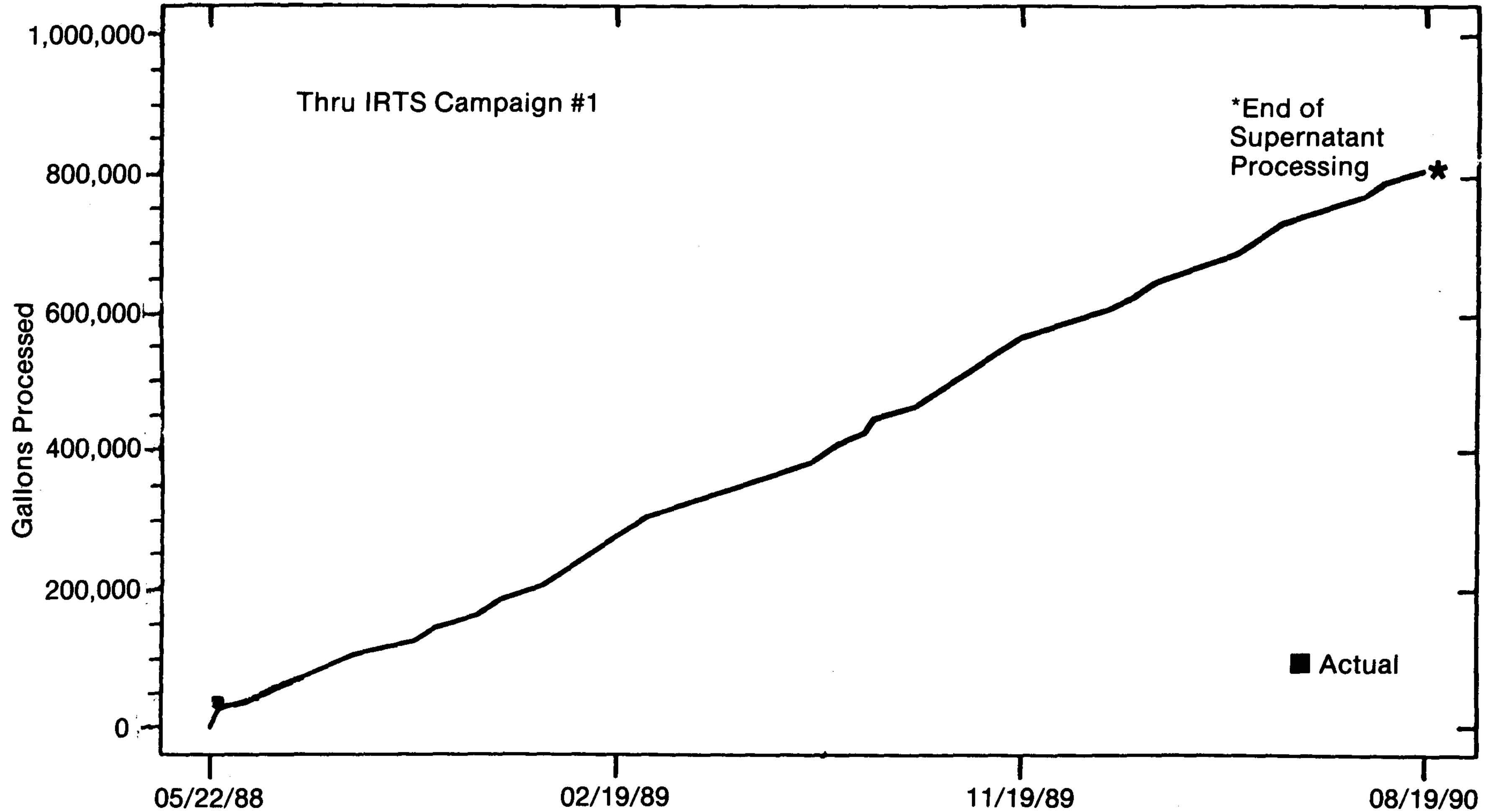
Table 20. IRTS Operation During Campaign One

5/25 to 6/17

	STS		LWTS		CSS		
Gals Trans. to LWTS	Average Cs-137 Conc. μCi/mL	Average Cs-137 DF*	Gals Conc.	Average Cs-137 Conc. After Evaporation	Number of Drums	Total Ci	Drum Dose Rate mR/hr¶
26.0K	0.166	24.0K	19.5K	0.264	401	15.19	15-70

During the first campaign, the STS safely processed a greater volume of supernatant than predicted by PNL and achieved a much greater than anticipated decontamination factor. Figures 30 to 32 show STS operating data collected during Campaign 1.

Table 21 - "STS Production Report" - gives the analysis of each batch of decontaminated supernatant produced during Campaign 1. Although the LWTS and the CSS were designed to handle cesium concentrations as high as 5.5 μCi/mL,the concentration of cesium in the decontaminated supernatant was much lower. An average of 0.17 μCi/mL for the four batches processed through STS. After concentration in the LWTS, the Cs-137 concentration was 0.26 μCi/mL.As a result, the dose rates from the drums of solidified decontaminated supernatant produced in the CSS were also much lower (< 70 mR/hr). Table 21 also gives the total quantity of decontaminated supernatant produced during the initial hot operations at 26,000 gallons. This volume exceeded the predicted throughput estimated during laboratory testing by 3,000 gallons. Figures 30, 31, and 32, show that the STS production capacity, zeolite consumption rate, and overall ALARA performance are as good or better than had been predicted.



Based on 608,000 Gallons Supernate + 200,000 Gallons Flush processed over 40 campaigns

FIGURE 30
STS Production Curve

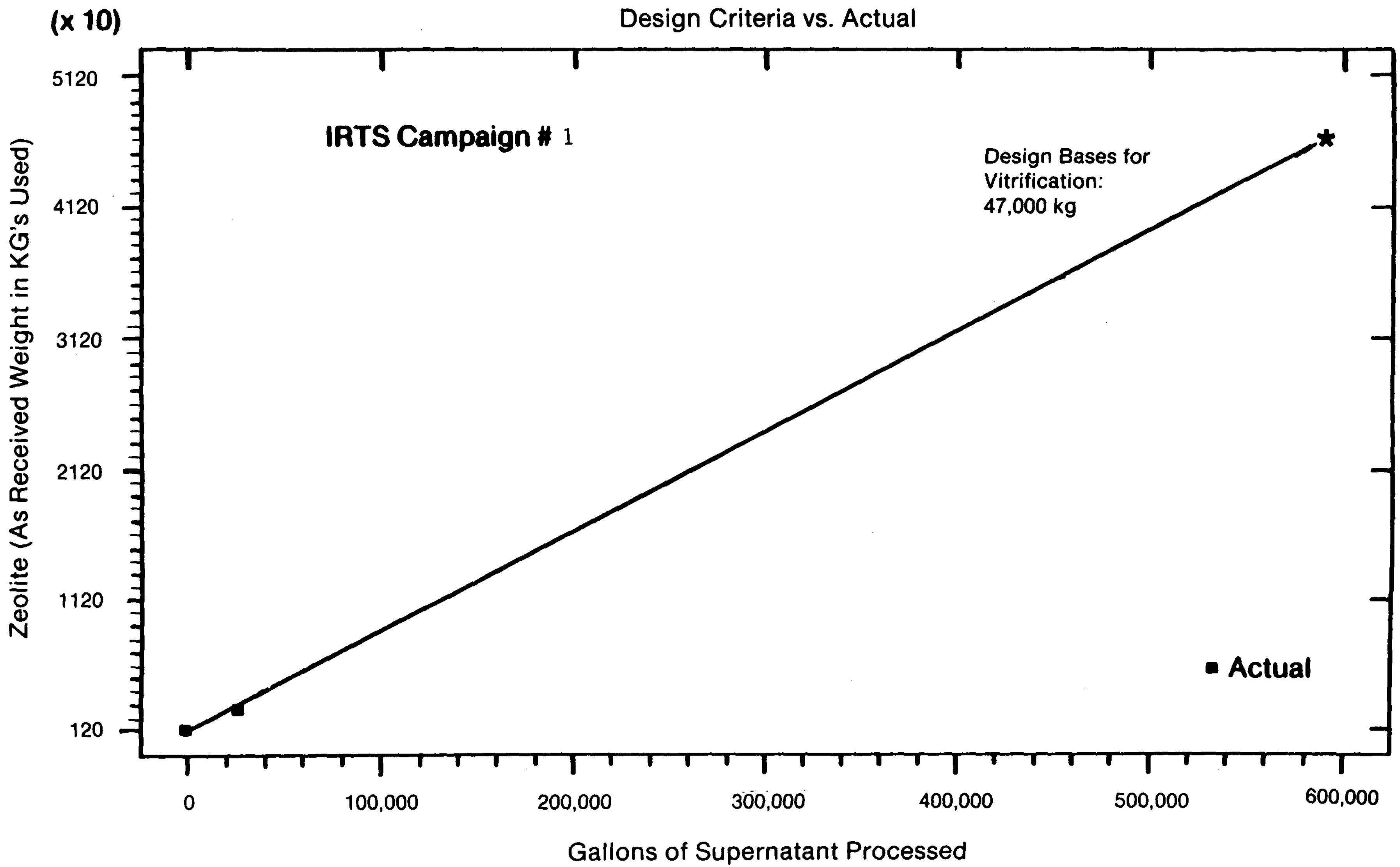


FIGURE 31
STS Zeolite Consumption

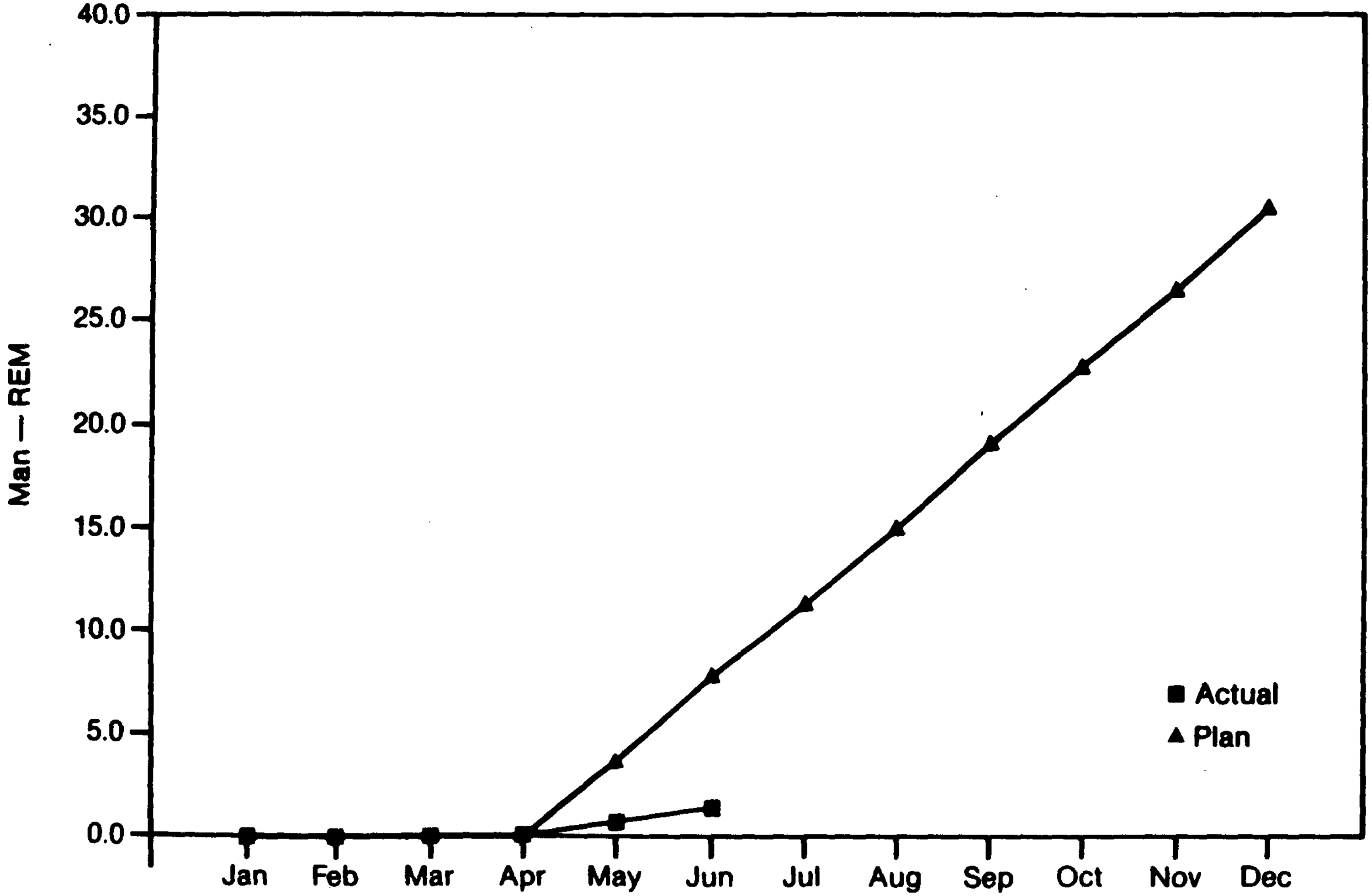


FIGURE 32
IRTS ALARA Performance

Table 21. STS Production Report

CAMPAIGN NUMBER 1

DATE	5-26-88	5-27-88	5-28-88	6-10-88
8D-3 SAMPLE NUMBER	S-006-18	S-006-19	S-006-21	S-006-22
SYSTEM FLOW RATE (GPM)	5.20	5.11	6.70	0 (shutdown)
Cs-137 CESIUM 137 ACTIVITY (μCi/mL)	6.57E-1	1.64E-1	2.79E-2	1.05E-2
TDS (WT%)	30.76	35.72	34.76	25.79
DENSITY (g/mL)	1.2274	1.2794	1.2920	1.1907
VOLUME TRANSFER TO 5D-15B	28200 L (7450 gal)	31080 L (8195 gal)	29342 L (7752 gal)	9000 L (2378 gal)
5D-15B SAMPLE NUMBER	5D-15B-1	5D-15B-2	5D-15B-4	5D-15B-4
Cs-137 CESIUM 137 ACTIVITY (μCi/mL)	4.28E-1	1.67E-1	5.92E-2	1.65E-2
TDS (WT%)	32.11	31.28	31.73	18.19
DENSITY (g/mL)	1.2522	1.2843	1.2272	1.1301
VOLUME RECEIVED IN 5D-1B	29075 L (7682 gal)	30970 L (8182 gal)	29827 L (7880 gal)	10280 L (2716 gal)
CUMULATIVE VOLUME FOR CAMPAIGN	29075 L (7682 gal)	60045 L (15,864 gal)	89872 L (23,744 gal)	100152 L (26,460 gal)

7.0 CONCLUSIONS

Initial hot operation of the STS on May 23, 1988 marked the culmination of 4 years of research, design, construction and testing. The successful startup of the STS and the fact that design goals were significantly exceeded is a tribute to the dedication of those who were involved during design, construction, testing, and operation.

WVDP personnel, in cooperation with the Department of Energy, displayed innovation in developing a solution to the challenge of disposing highly radioactive waste. Overlapping of schedules allowed the Project to move along at an accelerated pace. Installation of the STS components in the existing storage was successfully accomplished. Workarounds developed during cold testing allowed testing to continue on schedule.

A significant objective of the West Valley Demonstration Project has been accomplished in that we have demonstrated to the public that we can safely manage highly radioactive wastes.

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ATTACHMENT A

STS Component Testing Summary

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
STS Software Checkout	A checkout of the PLC and PLC software. The software checkout for control of the components; for the component shutdown, and process control interlocks and automatic sequencings of valves and pumps.	o Verify the software operation of the automatic valves using the selector switches and the graphic lights as indication of their movement. o Check the software operation of the valves and pumps using the selector switches; "Transmitter Simulation Settings and Other Simulation" and check graphic lights.	o This procedure requires the operation and/or simulation of various instruments, valves, pumps, and interlocks. o No water, steam, or air is to flow during this procedure except instrument air. No pumps are to run and all control valves connected to vessels or tanks whose operation could cause fluid to flow are to be simulated, but not operated.	The PLC software was loaded and simulated signals were inputted to the PLC. In each case the interlocks performed as specified as indicated by the control panel graphics lights. Component shutdown interlock LE-017 and LE-057 operated as specified. The interlocks were in agreement with WVNS-EQ-268, Rev. 0, "Equipment Specification Progress Narrative and Interlock Description".
Utility and Instrument Air Supply System	To demonstrate the operational and performance characteristics of air supply components.	o Compressor delivers 90 to 120 PSIG. o Particle filter element pressure differential working below the red zone. The gauge indicates green (safe) or red zone not PSIG. o Dryer cycles properly for regeneration to maintain the air quality. (No humidity alarm). o Associated valves and piping properly installed and identified. o Associated valves operate freely and do not leak. o Pressure reducing valves performing properly delivering 100, 50, and 20 PSIG air. o Lines are blown down.	Run the air compressor and its associated dryer, filters and blow down the air lines. The required quality of air is delivered to the components and utility station at the required pressure.	The air compressor was started up and provided air at 128 PSIG at the receiver tank which is acceptable. The filter DP stayed below the "red line" and the high humidity alarm did not sound. Each of the lines were blown down and checked clean on cheese cloth. The down stream pressure after each pressure reducing station were checked and 100, 50, and 20 PSIG were obtained as required. The required quality of air was delivered to the components and utility stations at the required pressure.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
STS Electrical Systems	To demonstrate the functional performance of STS electrical controls and distribution system.	o Electrical components and wires are properly installed and identified. o The MCC breakers and breaker switches are operable. o The motor controls, switches, and interlocks are operable. o Proper power supply is provided to all devices and pump motors rotate in the proper direction.	The test procedure requires that the STS MCC No. 3 and MCC No. 4 provide facilities for controlling motor starting, power distribution, and other functions, either manually or via signals from the STS Control Panel. The functions to be tested are those associated with the STS, plus various heating and ventilating devices, lighting, and air compressor power supplies.	Electrical power and control signals were supplied to MCCs, switches, breakers and when operated supplied the proper electrical signals to the power supplies, lighting systems, and pump motors and STS components, and the measured voltage and/or amperage were as required. The direction of rotation for all pumps was checked by electrically bumping the motors except as follows: 1) Pump G-001 in tank 8D-2 and G-004 in 8D-1 were coupled and were checked later on SIP 87-38; and pump G-005 Fresh Water Pump and the brine pump were also coupled and not checked. Pump G-005 was checked on SIP 87-20 and the brine pump was checked on SIP 87-30. The electric interlocks are part of "Equipment Specification Process Narrative and Interlock Description" EQ-268, Rev. 0 and have been checked. Air operated pumps 50-G-002 and 50-G-003 have been replaced by electric driven centrifugal pumps and were tested on SIP 87-71.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Sampling and Pneumatic Sample Transfer System (PSTS)	To demonstrate the functional performance of the remote sampling equipment to take a sample and prepare it for transfer to the labs. Also demonstrate the pneumatic sample transfer system will move the rabbit containing the sample vial from STS Building to the analytical sample storage cell.	o A 10 mL sample can be obtained in a sample bottle from sample points S-001 to S-007 using the manipulators. o Sample can be placed in PSTS slide ring using the manipulators. o The rabbit holding the sample bottle can be transferred from the STS valve aisle to the analytical storage cell in the Process Building within 20 to 40 seconds. o All interlock associated with the PSTS are verified. o Passage detector lights and alarms work. o Alarm if rabbit is stuck part way. o Rabbit can be transferred back to STS if rabbit becomes stuck. o Rabbit containing a vial can be transferred to the valve aisle from the operating aisle, capped and decapped using the manipulator and capping/decapping device. o Analysis of triplicate samples shows agreement in results to verify representative sample is taken.	The test procedure requires a sample be taken from each Sample Point, capped and placed in the PSTS slide ring remotely. The sample is then transferred to the PSTS diverter located on the fourth floor of the Main Plant. The sample is then transferred back to STS valve aisle. The instrumentation, controls, and alarms perform as designed.	A sample was taken from sample point S-001, capped manually not remotely and then transferred to PSTS slide ring remotely. The sample was transferred to the diverter on the fourth floor of the main plant with all instrumentation interlocks, and alarms working as designed in 40 seconds. The sample was not transferred to the sample storage cell at this time due to radiological considerations and was tested later per SIP 87-16. The other six (6) sample points S-002 - S-007 were not initially tested due to congestion in the valve aisle, but they all were checked at a later date, using SIP 87-16. The pneumatic capper/decapper was not checked out as it was not hooked up. The decision was made to go with a manual capper/decapper for reliability. The new capper/decapper has been designed, installed and was checked out on SIP 87-16. The transfer tube from the operating aisle to the valve aisle was checked at the same time. The rabbit was interrupted during transfer to actuate the alarm, and the rabbit was transferred back to the STS valve aisle to demonstrate the reversing technique.

ATTACHMENT A

STS COMPONENT TESTING SUMMARY (CONTINUED)

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Valves	Functional checkout of all STS automatic valves from the main STS control panel 50-CP-001. The manual valves are checked during the major component checkout.	o Valves properly installed and identified. o Valves operate freely. o Verify valve is in correct position. o Verify correct limit switch is tripped. o Verify solenoid valve is in correct position when deenergized. o Verify no air leaks when solenoid valve is energized. o Verify correct panel valve light indicator is lit confirming true position of valve.	Each automatic valve will be operated from a manual switch located on the main control panel and will be visually inspected to verify proper operation. Three persons involved; one in control room to activate switch and observe valve indicator respond; the second to observe the value operation, and the third person to observe the solenoid valve response. The valves are also checked with each piece of equipment they are associated with, as well as the software checked out for interlocks.	Each automatic and manual valve has been checked several times for proper installation and identification. Every valve has been checked and operates freely and has no external or internal leakage. Proper functioning was checked when the valves were checked with their associated prime component. The automatic valves were actuated from the main control panel and the panel lights, limit switches, solenoid and air operated valves all functioned as required. The interlocks and sequencing of the valve was checked with the PLC software under SIP 87-13.
Pumps	All pumps to be checked for leakage, proper installation, identification, direction of rotation, and functional performance. Specific performance requirements will be verified during preoperational system integrated testing.	o Verify proper installation, alignment, and identification. o Motor/pump turns freely. o Pump does not leak. o Electrically bump pump to confirm direction of rotation. o Check associated instrumentation, controls, and interlocks to provide proper signals and power.	Each pump and motor will be checked for proper identification, name plate data, installation and alignment. Each pump motor will then be checked for proper electrical hookup, voltage and amperage and response to electrical controls. The motor will be bumped to confirm direction of rotation. During checkout of associated major component the pump flow and discharge head will be checked.	Each pump was checked for WVNS ID Number, and manufacturer's name plate data. Each pump's installation (piping, electrical, and alignment) was found acceptable. Each pump's direction of rotation and functional performance was found to be within requirements. Pumps G-004 and G-001 were checked on SIP 87-38. Air operated pump 50-G-002 and 50-G-003 have been replaced by electrically driven centrifugal pumps which were checked at a later date on SIP 87-71. New pump 50-G-016 was also be checked on SIP 87-71. The instrumentation and controls were checked when the pump was used in major component checking. The interlocks were checked during the "STS Software Check" SIP 87-13.

ATTACHMENT A

STS COMPONENT TESTING SUMMARY (CONTINUED)

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Instrumentation	To demonstrate each instrumentation component is properly installed and identified, has the correct range, and performs in the instrumentation loop as required.	o Instrumentation properly installed and identified. o Instrumentation is calibrated or functionally checked to verify the proper ranges, accuracies, set points, readouts, and alarms, as specified in the applicable work orders. o Instrumentation loops are functional.	The primary flow and temperature elements, fixed level devices, and special process instrumentation such as pH, conductivity and turbidity will be functionally checked. The rest of the STS instrumentation will be calibrated to standards traceable to national standards. The instrumentation loop will be checked to assure the proper input signal obtains the readout and valve or pump response as specified in the applicable SIPs.	The instrumentation has been checked for proper WVNS identification, and manufacturer name plate data. The instrumentation has been functionally checked or calibrated to assure the proper range, accuracy, and function. Each instrument loop has been functionally checked to assure proper readout, function, and control. Also, each instrument or instrument loop was checked with its associated major component. The following instruments were found defective; 50-LE-057 and 50-LE-088 (level probes). These have been replaced and have been functionally checked and found acceptable.
Water Break Tank 50-D-005	To demonstrate the functional and performance requirements of the STS water break tank.	o Associated valves and piping are properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Pump 50-G-015 supplies 45 ±5 GPM of demineralized water at 45 ±5 PSIG. o Pump 50-G-016 supplies 4 to 6 GPM of demineralized water. o Instrumentation and alarms are calibrated or functionally checked. o Associated jumpers shall be removed and installed to assure proper fit.	Fill tank 50-D-005 in increment to calibrate tank reading out percent full on LI-054. Check LAH, LAL, and LSLL-054. Run pumps 50-G-015 and 50-G-016 recording pump discharge pressure and flow rate. Check pump 50-G-015 interlock to LSLL-054 interlock.	Tank 50-D-005 was calibrated by loading in increments and checking against 50-LI-054. LAH and LAL-054 Alarms were both actuated. (70 percent and 19.65 percent full respectively). LSLL-054 did not shut the pump 50-G-015 off as PLC software was not in use. The correct operation of the software was later confirmed by WO. Pump 50-G-015 discharge pressure was 52 PSIG which is acceptable based on the pump curves; the flow rate was not checked as a temporary flow meter was not installed . The flow was checked against the pump calibration curves and was in 45±5 GPM range. Pump 50-G-016 discharged 5 GPM at 15 PSIG. The associated jumpers were checked on the "Valve Aisle Operation" test.

ATTACHMENT A

STS COMPONENT TESTING SUMMARY (CONTINUED)

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Filter 50-F-002	To test the operating conditions of the STS decontaminated supernatant filter 50-F-002 to demonstrate the reliability, continuity and performance of the filter.	o Associated piping and valves properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Sluice sand to filter 50-F-002. o Check out the cold test nozzle operability. o Functional checkout of associated equipment instruments and controls.	The test will be conducted in two phases. The first phase involves hydraulic testing of the system with no sand in the filter. The second phase involves hydraulically testing of the system with 1,000 lbs. of sand in the filter. Remove sand from the filter using cold test nozzle to verify this mode of operations flushed and shutdown.	During hydraulic testing the differential pressure across the unloaded filter was 3 to 4 PSIG. The differential pressure across loaded filter 50-F-002 was 4 to 5 PSIG. The performance of 50-F-002 was confirmed on SIPs 87-37 and 87-69. The system for sluicing sand from the batch tank 50-D-002 to filter 50-F-002 did not perform as specified. The filter 50-F-002 was loaded by manually flushing small amounts of sand into the filter. It is not anticipated that the filter will require dumping and refill during operation. The sand was successfully removed from the filter through the cold test nozzle.
Fresh Water Tank 50-D-003	To verify tank 50-D-003 hydraulic capacity, and level control function, functionally check its associated pump 50-G-005, instrument and alarms, and valves and piping.	o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Associated instrumentation and alarm calibrated or functionally checked. o Pump 50-G-005 provides 135 ±10 GPM of demineralized water at 180 ±25 PSIG. o Relief valve 50-PSV-004 actuates at 265 ±20 PSIG.	During filling of tank 50-D-003 calibrate the tank, check the level instruments, alarms, and interlocks. Run pump 50-G-005 and obtain flow rates of 40 ±5 GPM and 90 ±5 GPM at the same time throughout two different flow paths.	LI-088 was replaced due to insufficient range and has been calibrated and functionally tested. The tank was calibrated against the new level instrument LI-088 during the filling operation. Level Probe LC-087 shut valve LCV-087 on high level. Pump 50-G-005 was tested at 135 ±10 GPM at 220 PSIG, and provided the required 45 GPM at 50-FE-048 and 90 GPM at 50-FE-049 at the same time at a pressure of 220 PSI. The pump output pressure of 220 PSIG was not adequate to lift relief valve 50-PSV-040. Relief valve 50-PSV-040 has been replaced with a globe valve. LSL-041 interlock to shut off pump 50-G-015 has been tested proper operation. Software signal checked okay on SIP 87-13.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Zeolite and Sand Batching, Fines Removal and Sluicing	To demonstrate the loading of zeolite to the batch tank and flushing fines to the fines collection tank. Also load sand to the batch tank. Sluice zeolite to the columns and sand to filter 50-F-002 from batch tank 50-D-002.	o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Instrumentation and alarms are calibrated or functionally checked and perform as specified. o Sluice zeolite to the columns and sand to filter 50-F-002.	Transfer 12 drums of zeolite to the batch tank, flush out the zeolite fines and sluice zeolite to column. Load 1000 lbs. of sand into batch tank and sluice to sand filter 50-F-002.	The batch tank 50-D-002 was calibrated. The batch tank was loaded with zeolite and was backwashed, collecting the zeolite fines in the fines filter and catch tank. This was discontinued as the fines filter was clogging prematurely. The original sluicing of the zeolite from the batch tank to the columns was discontinued as the flow became erratic and lines were finally plugged. The zeolite loading technique was changed as follows: The batch tank was half filled with water and six drums of zeolite put in the batch tank. The zeolite was fluffed, by backwashing, then allowed to drain by gravity to the column. During loading of the first six drums the excess water was removed from the column through the top johnson filter. The second six drums was handled in the batch tank the same way but the excess water in column was removed through the bottom johnson filter. Sand was manually fed by putting several smaller batches of sand in the fill line and then washing the sand into the sand filter. The batching system was modified and successfully retested per revised SIP 87-21.

ATTACHMENT A

STS COMPONENT TESTING SUMMARY (CONTINUED)

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Prefiltration and Dilution	Perform the functional checkout of the supernatant prefilter 50-F-001, associated piping and instrumentation/controls and the supernatant feed dilution equipment.	o Fill both sides of prefilter 50-F-001 bleeding out all air. o Each alarm and indicator shall perform as specified. o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Component shall perform as specified in the SIP.	Establish differential pressure across filter and check flow through FI-015. Using automatic sequencer back flush filter. Establish flow ratio between FIC-015 and FFIC-024.	The test was not performed as a component test and will not be part of this report. The prefilter 50-F-001 and dilution system was successfully tested on preoperational system integrated testing SIP 87-37.
Utilities and Drains	The test is to demonstrate the functional performance requirements of the STS and PVS utilities and drains.	o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Floors slope to drains and drains are not plugged. o Sump pumps operate as specified. o Sump level switches actuate alarms and pumps as specified. o Demineralized water at 50 PSIG Steam at 100 PSIG Fire water at 45/50 PSIG o Steam traps operate properly to eliminate condensate.	Fill, flush, and pressurize all utility lines. Check each utility for proper pressurizing. Check the eight floor drains for proper drainage: two drains on 92 foot level and three each on the 105 and 107 foot levels. Check sumps and sump pumps, and alarms for proper operation.	The components in the utility system checked out except for steam valve 6-SH-GL-102 which has been replaced and retested. The steam trap operated properly, but will be repositioned to prevent blowing into the sump and evaporating potentially contaminated liquid. Steam 95 PSIG Demin. Water 60 PSIG Instr. Air (CTS) 55 PSIG Utility Air (Comp) 122 PSIG Utility Water 99 PSIG Fire Water 47 PSIG The eight STS floor drains all drained properly. The drain in the PVS was also checked and drained properly. The drain from the pipe aisle to 8D-1 tank drained properly, but a water line is being added to prevent loss of seal. The PVS and operating aisle sump pumps and instrumentation both operated properly. The instrumentation LE-072 A/B for the valve aisle sump has been installed and checked out using pump 50-G-012 using SIP 87-23.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Remote Operation in the Valve Aisle	Pull, inspect, and reinstall all jumpers. Specified jumper will be pulled and reinstalled remotely.	o Remotely remove jumpers. o Check each jumper for completeness, (see drawings) strain relief, wires sealed, check for damaged insulation, control box tightness and general condition. o Check backwall gasket surfaces for burrs, nicks, and gouges that could cause leakage. o Check hand valves for free operation and handle interferences. o Stroke all auto valves. o Check male jumper gasket surface for nicks, gouges and burrs that could cause leakage. o Check clamps for completeness, smoothness of operation, lubrication and mechanical integrity.	Remove all jumpers remotely checking for balance, interference, etc. Inspect all jumpers, repair if required, and reinstall. Remove and install all pumps located in the valve aisle remotely.	Eighty (80) jumpers have been removed remotely. All one hundred fourteen (114) jumpers to be installed on the valve aisle backwall have been inspected. One hundred and eleven (111) were permanently reinstalled. The other three were installed after component and system testing was completed. A jumper data sheet has been prepared for each jumper. Ten selected jumpers were both removed and reinstalled remotely. Verified access to each and every jumper with the jib crane and manipulator. The pumps located on the valve aisle floor have been checked for remote removal and installation except 50-G-015. Pump G-015 does not have to be remotely removed because if it fails either pump G-016 or G-003 will be used in its place.
Test and Check Columns A, B, C, and D.	To demonstrate the hydraulic performance of the cesium removable columns.	o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Zeolite from one (1) column discharged through dip tube. o Pressure drop with 12 drum load is less than 10 psi at 6 GPM.	Each column and their associated lines will be filled and flushed. Two service runs will be simulated during which the flow and pressure data will be taken. One run will be with the columns empty and the other with the column loaded with 12 drums of zeolite each. Discharge the zeolite from one (1) column throughout the dip tube.	The columns were each loaded with 12 drums of zeolite. Two tests were performed: 1) flow from tank D-003 through the cooler, columns, and sand filter and 2) flow through each column (simulating each as lead column). The test results were functionally acceptable. The pressure drops, loaded or unloaded were less than 10 PSIG over all four columns. The zeolite was successfully removed from one column using a dip tube.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Supernatant Feed Tank 50-D-001	To demonstrate the functional performance of tank 50-D-001 and pump 50-G-002.	o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Tank 50-D-001 can be pumped out using pump 50-G-012. o Pump 50-G-002 transfer 26 GPM at 95 ±5 PSIG. o Fill and calibrate tank 50-D-001.	Tank 50-D-001 will be filled and calibrated. Pump 50-G-002 will be functionally tested.	Tank 50-D-001 was filled and calibrated with the 100 percent reading being 1830 gallons. Pump 50-G-002 was run and performed as required. Pump 50-G-002 failed two weeks later and has been replaced with an electrically driven centrifugal pump which required a change in the mode of operations, and instrumentation changes, which were tested on SIP 87-71. Test Exception No. 4 deleted the testing of pump 50-G-012. The new 50-G-002 pump will use the nozzle assigned for 50-G-012 and serve the same purpose. LAHH-016 Alarm was tested per SIP 87-28.
Sluice Lift Water Tank 50-D-004	The functional checkout of tank 50-D-004 and pump 50-G-003 and their associated piping, valves, instrumentation and alarms.	o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Associated instrumentation and alarms calibrated or functionally checked and function as required. o Tank 50-D-004 filled and calibrated. o Sluice pump 50-G-003 performs as specified in the SIP.	To calibrate tank 50-D-004 fill in measured increment and record level instrument and alarm points. Run pump 50-G-003 recording pump output pressure and flow and the air input to run the pump.	Tank 50-D-004 was filled and calibrated and instrumentation, control and alarm were checked. 100 percent reading equals 2,290 gallons. Air driven pump 50-G-003 performed as required, but was replaced by an electric driven centrifugal pump which requires a change in the mode of operations and instrumentation and was tested on SIP 87-71. Level probe 50-LE-057 failed and has been repaired. Tank 50-D-004 was filled and 50-LE-057 performed as specified.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Chiller and Cooler	To demonstrate the functional performance of the STS chiller and supernatant cooler.	o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak. o Can cool supernatant from 190 ±20°F to 43 ±6°F at design flow rates. o Chiller/Brine cooler can reject heat from supernatant cooler. o Supernatant pressure drop throughout cooler and associated piping is 10 psi or less.	Fill the brine loop and circulate brine. Heat the simulated supernatant to test temperatures and pump through cooler 50-E-001. Record inlet and outlet temperature, flow rate and inlet and outlet pressure of the supernatant through cooler 50-E-001.	The chiller/cooler system was loaded with brine and fresh water tank 50-D-003 was heated with steam to 190 ±20°F and pumped through the cooler. The simulated supernatant at 6 GPM was cooled to 43° ±6°F. Confirmation of the continuous functioning of the system was performed during SIP 87-37 and 87-69. Test exception No. 5 deleted the requirement to record the inlet and outlet pressure of the cooler and associated piping. The hookup was changed deleting the pressure gauges required to measure the pressure.
Hydraulic Checkout of STS	Verify proper hydraulic functioning of the STS and provide a systematic method for checking the operation of the on-line instrumentation and control hardware.	o Associated instrumentation alarms calibrated or functionally checked. o Associated valves and piping properly installed and identified. o Associated valves and pumps operate freely and do not leak.	Two service runs will be made, one with columns and sand filter empty and two with the columns loaded with 12 drums of zeolite each and the sand filter loaded with 1,000 lbs. of sand. The demin. water is pumped from the fresh water tank 50-D-003 through the fines pump 50-GT-006, the cooler 50-E-001, the column, and the sand filter 50-F-002, back to tank 50-D-003. Pressure, pressure drops, and flows will be measured and recorded.	The flow through the prefilter 50-F-001 and through each empty column, using each column as a lead column was performed and each component functioned properly except PDI-028 which did not read correctly. The differential pressure transmitter PDT-028 loop to PDI-028 was recalibrated and now functions properly. A second test was run using demin. water flowing from fresh water tank 50-D-003 through the cooler 50-E-003, all loaded columns in series, the loaded sand filter 50-F-002, and back to tank 50-D-003. The pressure drop through the columns and filter was less than 10 PSIG during all testing.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Permanent Ventilation System (PVS)	Functional checkout of filters, mechanical components, and instrumentation and control hardware and software. Subsequent system performance run and practice simulation of 8D-2 tank cutting operation using tank 8D-1.	o Obtain continuous system operation in manual mode. o Verify system blowers, dampers and valves response in manual and automatic modes. o Verify mechanical integrity of all dampers. o Verify all system alarms and indicators produce the required response. o Verify condensate from PVS unit drains back to tank 8D-1.	o Operate blowers and filters manually in the following combinations: Primary Blower/Primary Filters Secondary Blower/Secondary Filters Primary Blower/Secondary Filters Secondary Blower/Primary Filters Both Blowers/Both Filter Trains o Functional checkout of filter differential pressure alarms. o Functional checkout of airflow meters and alarms. o Checkout of air heaters and relative humidity controllers. o Check of PVS Programmable Controller and Load Program o Perform automatic switchovers (primary to secondary blower, primary to secondary filter train). o Perform tank 8D-1 hole cut simulation using M-3 Riser.	o Continuous operation witnessed in automatic and manual modes. Dampers and actuators encountered mechanical difficulties requiring maintenance and engineering rework of damper linkages and actuators, which were successfully tested. o All filters low and high differential pressure alarms verified at remote PVS Control Panel. o Power to air heaters, controlled by R.H. Controllers, switched on and measured. o Airflow and temperature/R.H. instrumentation calibrated; set points and alarms set and actuation functionally verified. o PC program loaded, and subsequently modified to reflect proper time sequencing of damper actuations with blower actuation/switchover. o System operating/flow data obtained; M-3 Riser and containment tent airflow data obtained; applicable ventilation criteria satisfied. o A simulated signal caused the unit to automatically switch the primary to the secondary side. o Prior to startup, the condensate drains were disconnected and water was poured down the drains. No backup of water was observed. o The HEPA filters have been successfully DOP tested.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Radiation Monitors	To demonstrate the operability of the STS/process monitors and STS stack monitors.	o Verify monitors are properly installed and identified. o Verify STS process monitors alarms and interlock function. o Verify stack monitor alarm and interlock function. o Calibrate the radiation detectors.	The test is in two steps: 1) Checkout the rate meter using both a signal generator and the check source. 2) Calibrate the detectors using calibrated sources. Using the signal generator, the alarms will be set and checked.	The vendor representative aided the STS startup and Radiation and Safety groups in the checkout of the radiation monitoring system using their procedures. Signal generators were attached to each system rate meter and the CPM's readouts were checked against inputs. The warning and high alarms were set and checked with continuity checks being made to assure each circuit was functioning as was required. All rate meters were checked using the check sources. All rate meters passed the checkout. Radiation and Safety, using standard source traceable to a national standard, calibrated the radiation detectors. In addition, to checking the previous process monitors and alarms, the skids were checked for taking samples from PVS stack. The transfer from one skid to the other automatically was also checked. The interlocks off the radiation monitor were checked later per SIP 87-34.

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
HVAC Equipment	To determine system characteristics and demonstrate that controls function properly.	Check all annunciators/alarms on HVAC control panel.	Balancing system.	All satisfactory.
		Test operating air handling units and condenser units.	Verification of operation and responses manual and automatic.	56-V01 - satisfactory 56-V01A - satisfactory 56-V02 - satisfactory 56-V02A - satisfactory
		Test operation of integrated HVAC System.	Check set points under SIP 87-35.	Building negative pressures were satisfactory. Tornado dampers tripped as required. Pressure drop across air filters above design value for 2 of 7 filters. OPDR issued to resolve.
		Test space heaters.		Previously checked during SIP 87-15; satisfactory operation.

ATTACHMENT A

STS COMPONENT TESTING SUMMARY (CONTINUED)

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Pump 50-G-004	To conduct detailed checkout of pump 50-G-004 prior to continuous hot operations of STS.	Verify pump and motor are properly aligned and lubricated. Verify motor recently meggered and bumped for correct rotation. Verify all associated piping and jumpers are leak tight. Determine hydraulic characteristic of pump 50-G-004 and related system piping. Compare actual operating performance data with design data.	Check pump operational characteristics and check for leaks, while pump operating under SIP 87-38.	Alignment satisfactory, pump lubricated. Motor electrical system satisfactory. Pump rotation correct. No leaks. No water hammer. No visible leakage at gland seal. No vibration observed. Bearing temperature below 180°F limit. Design / Actual 80 gpm / 40 gpm** TDH 225 / 218.5 88-92 psig / 95 psig

** Variable depending on amount of throttling on discharge valve(s).

ATTACHMENT A
STS COMPONENT TESTING SUMMARY (CONTINUED)

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS	
				Design	Actual
Replacement Pump 50-G-002 and 50-G-003	To perform an operational and functional checkout of replacement pumps 50-G-002 and 50-G-003.	Compare motor and pump operating performance against design data. Test variable speed controllers for ramping pumps. Test pressurization control/vent for tanks 50-D-001 and 50-D-004. Verify associated jumpers are leak tight.	Operate pumps under SIP 87-71.	50-G-002: 26 gpm TDH 152	Satis.* 151.8
				50-G-003: 70 gpm TDH 172	60 gpm** 154.1
				0 rpm to 3450 rpm in 2 min.	0 rpm to 3400 rpm in 2 min.
				50-D-001: 50-PIC-704 15 ±2 psig 13 psig	As recorded by 50-PI-703
				50-D-004: 50-PIC-711 15 ±2 psig	 50-PI-710 13 psig
				All satisfactory, jumper J-45 replace with a spare jumper with a block valve to provide back pressure on pump G-003.	

* No measurement device installed. This is not a critical parameter as long as it is greater than 6 gpm.

** Variable depending on amount of throttling on discharge valve(s)). These results are on the pump performance curve.

ATTACHMENT A

STS COMPONENT TESTING SUMMARY (CONTINUED)

COMPONENT	PURPOSE	ACCEPTANCE CRITERIA	TEST PROCEDURE	TEST RESULTS
Emergency Power	To verify that emergency power and/or backup instrument air are available for all critical equipment/instruments in STS as needed.	Test start-up of auxiliary diesel generator.	SIP 87-73.	Automatic startup occurred within 30 seconds as specified.
		Verify emergency lighting and PLC battery backup is operational.		Emergency lights in STS and PVS operated satisfactory. PLC battery satisfactory.
		Verify alternate power supply available from Main A if Main B is out.		Main A power supply satisfactory.
		Verify that alarms on STS and PVS control panels trip as expected upon power/instrument air lost and/or restoration.		All alarms on STS and PVS control panels tripped as expected. Satisfactory results.
		Verify actuated valves achieve fail-safe positions on loss of instrument air.		All fail-safe valves assumed failure positions within 5 to 18 minutes.
		Test technique for return to normal power supply after a power failure.		Power transfer satisfactory.
		Verify backup air supply from Main Plant provides satisfactory pressure and flow to critical instruments.		Backup air from Main Plant satisfactory. No loss in system pressure occurred.

ATTACHMENT B

STS SAMPLING PLAN

TABLE 1 - FIRST CAMPAIGN

SAMPLE LOCATION	NUMBER OF SAMPLES PER DAY	GAMMA SCAN	DENSITY	pH	TDS*	Na	CONDUCTIVITY	U & Pu	GROSS ALPHA	TSS
ANALYSIS++ PRIORITY		1	3		3	4				2
S-001	1	1	1	1	1	1	1##	1#	1	1##
S-002 to S-005	9**	9								
S-006+	1	1	1		1	1		0	1	
TOTAL	11	11	2	1	2	2	1	1	2	1)
S-007	Once Per Week	1		1		1				

CHANGES MADE IN TYPES OR QUANTITIES OF ANALYSES DENOTED BY PARENTHESES.

* BASED ON CORRELATION TO DENSITY.
** ONE SAMPLE TAKEN EACH FROM THE FIRST, SECOND, AND THIRD COLUMNS EACH SHIFT.
\+ ALSO ANALYZE FOR Np-237 and 239, Am-241, Cm-242, 243, 244, 245, AND 246, Sr-90, Tc-99.
++ IF THERE IS MORE THAN ONE SAMPLE, ANALYZE SAMPLES FROM TANK 8D-3 (S-006) FIRST, THEN NEXT ANALYZE SAMPLES FROM THE SUPERNATANT FEED TANK (S-001).
\# ANALYZE A TOTAL OF THREE SAMPLES FOR U AND Pu
\## ANALYZE ONCE PER CAMPAIGN

ATTACHMENT B (CONTINUED)

STS SAMPLING PLAN

TABLE 2 - DURING SHUTDOWN

SAMPLE LOCATION	NUMBER OF SAMPLES PER DAY	GAMMA SCAN	DENSITY	pH	TDS	Na	CONDUCTIVITY	GROSS ALPHA	TSS
ANALYSISx PRIORITY		2				1			
S-001	1	1				1			
S-002 to S-005	1*	1							
S-006									
TOTAL	2	2				1			
S-007	Once Per Week	1		1		1			

* SAMPLE TAKEN FROM SECOND PARTIALLY LOADED COLUMN (FIRST COLUMN HAS ALREADY BEEN DUMPED).

x IF THERE IS MORE THAN ONE SAMPLE, ANALYZE SAMPLES FROM THE SUPERNATANT FEED TANK (S-001) FIRST.

ATTACHMENT B (CONTINUED)

LWTS SAMPLING PLAN

SAMPLE LOCATION	SAMPLE FREQUENCY	GAMMA SCAN	DENSITY	pH	TDS++	Na	GROSS ALPHA	GROSS BETA	TOTAL+ U	TOTAL+ Pu	NEUTRAL- IZATION+++	WASTE CLASSIFICATION	RADIOACTIVE PRESOLIDIFICATION++ VERIFICATION
71-L-001	Infrequent	1	1	1					1	1			
71-L-002	Prior to transfer		1	1					1	1	1**		
71-L-003	Infrequent	1	1	1			1	1					
71-L-004	Prior to feeding evap.	1	1		1*								
71-L-005	Prior to trans. to CSS	1***			1							1	1
71-L-006	Prior to trans. to CSS	1***			1							1	1
71-L-007A	Every 8 hrs during oper.	1					1	1					
71-L-007B	Every 8 hrs during oper.	1					1	1					
TOTAL		7	4	3	3		3	3	2	2	1	2	2

* BASED ON ANALYSIS RESULTS, EXPECTED TDS (W/O) WILL BE CALCULATED.
** NEUTRALIZATION OF 3D-2 IS REQUIRED PER SOP 7-8 PRIOR TO TRANSFER TO 8D-2.
*** GAMMA SCAN FOR CS-137 NEEDED IN CONJUNCTION WITH TDS ANALYSIS.
\+ REQUIRED FOR OSR GP-7: CRITICALITY SAFETY FOR LIQUID TRANSFER.
++ REQUIRED FOR OSR IRTS-8: SAMPLING AND ANALYSIS REQUIREMENTS FOR TANK 5D-15A1 AND 5D-15A2.
+++ REQUIRED FOR OSR IRTS-1: MAINTENANCE OF CARBON STEEL WASTE TANK INTEGRITY.

ATTACHMENT B (CONTINUED)

CSS SAMPLING*

SAMPLE LOCATION	SAMPLE FREQUENCY	DRUM FILL LEVEL	ABSENCE OF FREE LIQUID	PENETRATION RESISTANCE
CSS	1 DRUM/WEEK**	1	1	1

* DETAILS OF THE CSS SAMPLE PLAN ARE CONTAINED IN WVDP-067: PROCESS CONTROL PLAN FOR DECONTAMINATED SUPERNATANT CEMENT SOLIDIFICATION. PRESOLIDIFICATION SAMPLING IS IDENTIFIED ON TABLE 5 FOR SAMPLE LOCATION 71-L-005 AND 71-L-006.

** BASED ON THE OBSERVED CONSISTENCY OF THE PROCESS.

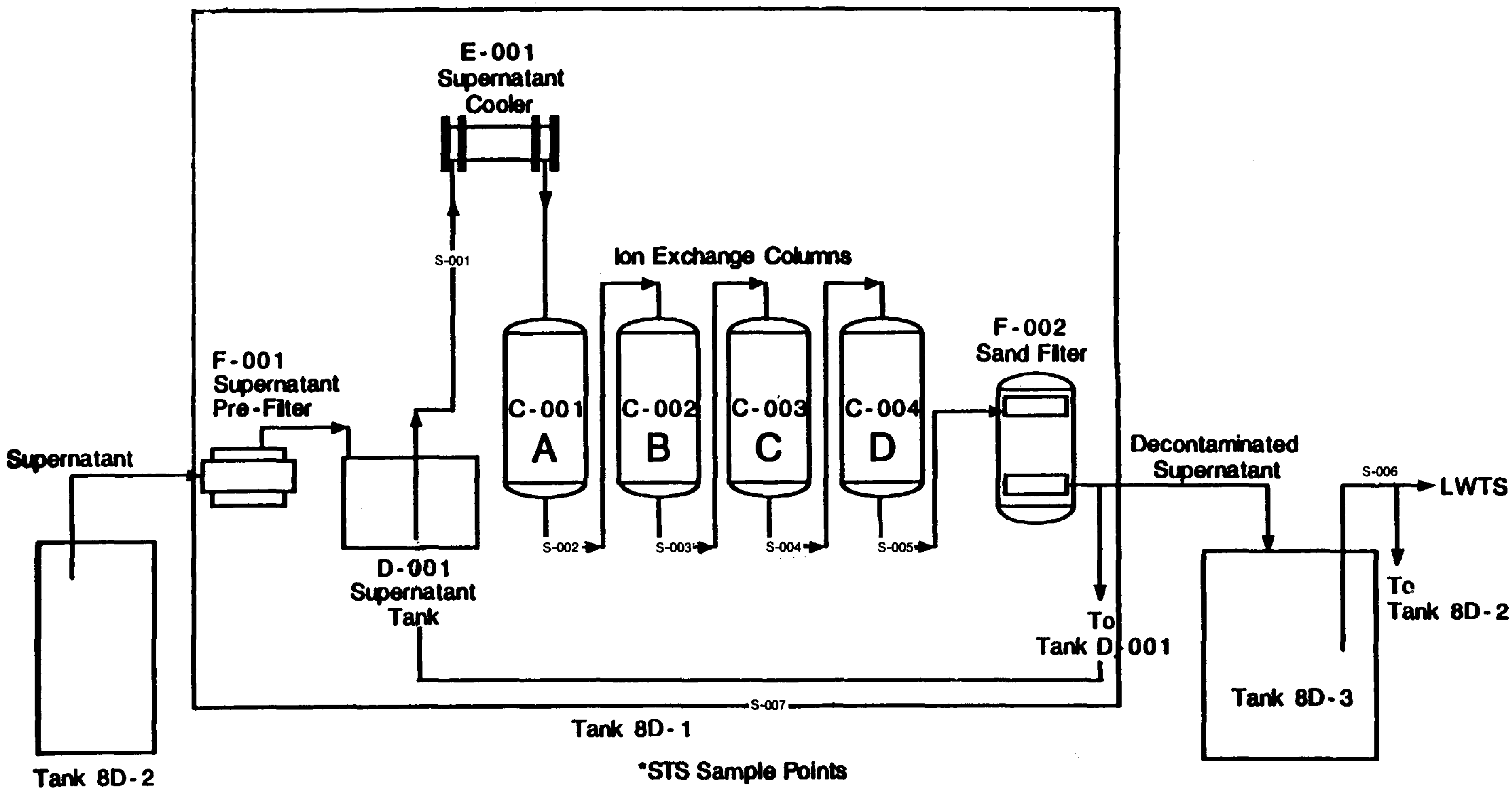

FIGURE 33
STS Sampling Points

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