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WEST VALLEY DEMONSTRATION PROJECT

SAFETY ANALYSIS REPORT

WVNS SAR-004

REV. 7

SUPERNATANT TREATMENT SYSTEM

Controlled Copy No. 30

SAR:0000863.RM

West Valley Demonstration Project

Doc. Number WVNS SAR-004

Revision Number 7

Revision Date 05/06/92

SAFETY ANALYSIS REPORT FOR

SUPERNATANT TREATMENT SYSTEM

J. J. PROWSE, M. A. SCHIFFHAUER

SAFETY & ENVIRONMENTAL ASSESSMENT

REQUIREMENT FOR ENVIRONMENTAL REVIEW MET BY REFERENCED DOCUMENT: EL:90:0137

DATED: August 6, 1990

HAZARD CLASSIFICATION: Moderate (DOE Approved DW:90:0811)

APPROVALS: D C Burns 4/2/92
D. C. Burns, Vitrification In-Cell Engineering Manager, Date

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RE Lawrence 4/2/92
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WV-1160, Rev. 0

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WV-1816, Rev. 1

RECORD OF REVISION

PROCEDURE

If there are changes to the procedure, the revision number increases by one. These changes are indicated by placing a heavy vertical black line located in the right-hand margin adjacent to the sentence or paragraph which was revised.

Example:

The redline in the text indicates a change.

Rev. No.	Description of Changes	Revision On Page(s)	Dated
0	Original	All	
1			
2	Major revision to reflect a new operating approach and redesigned pumps and equipment.	All	
3	Incorporate editorial changes in review of Rev. 2	43, 79 132, 136, and Tables 9.1-1, 9.2-5, 9.2-6 and 9.2-7	
4	Reflect changes in operating protocol for supernatant sample pneumatic transfer system	62, 90, 91, 92	
	Engineering Release #1429		8/88
5	Per ECNs #2716, 2716A, 2607A	76, 137, 138 A-1, A-2, A-3, A-4, A-5,	4/89
	Addendum 1		
6	Major rewrite to incorporate the Sludge Mobilization and Wash System and Addendum 1.	All	9/91

RECORD OF REVISION (CONTINUATION SHEET)

Rev. No.	Description of Changes	Revision on Page(s)	Dated
7	Per ECN No. 4850	4-17, 4-27 6-6, 6-14, 6-15, 9-12, 9-13, 9-14, 9-15, 9-23, 9-24, 9-25, 9-26, 9-27,9-28	05/06/92

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NOTE: All figures are located at the end of the document in numerical order.

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ACRONYMS AND ABBREVIATIONS

Å	Angstrom (10^{-8} centimeter)
ACI	American Concrete Institute
AEDE	Annual Effective Dose Equivalent
AISC	American Institute of Steel Construction
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
APOC	Abnormal Pump Operating Condition
ARM	Area Radiation Monitor
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
Bq	Becquerel
c	Centi, Prefix for 10^{-2}
C	Coulomb
°C	Degrees Celsius
CAM	Continuous Air Monitor
cc	Cubic Centimeter
CEDE	Committed Effective Dose Equivalent
cfm	Cubic Feet per Minute
CFR	Code of Federal Regulations
Ci	Curie
Cs	Cesium
CSS	Cement Solidification System
Cv	Column Volume
CY	Calendar Year
DB	Dry Bulb
DBE	Design Basis Earthquake
DBEQ	Design Basis Earthquake
DBT	Design Basis Tornado
DC	Drum Cell
D&D	Decontamination and Decommission
DEC	New York State Department of Environmental Conservation
DF	Decontamination Factor
DOE	Department of Energy
DOP	Dioctyl phthalate
DOT	Department of Transportation
EDE	Effective Dose Equivalent
EPA	Environmental Protection Agency
EPZ	Emergency Protection Zone

ACRONYMS AND ABBREVIATIONS (continued)

°F	Degrees Fahrenheit
ft	Feet
G	Giga, Prefix for 10^9
g	Gravitational Acceleration Constant
g	Gram
gal	Gallon
gpm	Gallons Per Minute
h	Hour
HEPA	High Efficiency Particulate Air
HLW	High-Level Radioactive Waste
hp	Horsepower
HV	Heating and Ventilation
HVAC	Heating, Ventilation, and Air Conditioning
ID	DOE Idaho Operations Office
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
in	Inch
IRTS	Integrated Radwaste Treatment System
IWP	Industrial Work Permit
k	Kilo, Prefix for 10^3
keff	Effective Neutron Multiplication Factor
L	Liter
lbs	pounds
LLL	Lawrence Livermore Laboratory
LLW	Low-level Radioactive Waste
LLWTF	Low-level Waste Treatment Facility (02 Plant)
lpm	Liters Per Minute
LWTS	Liquid Waste Treatment System
u	Micro, Prefix for 10^{-6}
m	meter
m	Milli, Prefix for 10^{-3}
M	Mega, Prefix for 10^6
MCC	Motor Control Center
mol	Mole
MT	Metric Ton
n	Nano, Prefix for 10^{-9}
Na	Sodium
NEMA	National Electrical Manufacturers Association
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
OSR	Operational Safety Requirement
oz	Ounce

ACRONYMS AND ABBREVIATIONS (continued)

p	Pico, Prefix for 10^{-12}
P	Peta, Prefix for 10^{15}
P&ID	Piping and Instrumentation Diagram
Pa	PascalPC Partition Coefficient
pcf	Pounds per Cubic Foot
PLC	Programmable Logic Controller
PNL	Pacific Northwest Laboratory
psf	Pounds per Square Foot
psi	Pounds per Square Inch
psig	Pounds per Square Inch Gauge
PSO	Plant Systems Operations
Pu	Plutonium
PVC	Polyvinyl chloride
PVS	Permanent Ventilation System
QA	Quality Assurance
QAP	Quality Assurance Procedures
QAPP	Quality Assurance Program Plan
QMM	Quality Management Manual
[illegible]	Roentgen
rem	Roentgen Equivalent Man
rpm	Revolutions per Minute
RWP	Radiation Work Permit
s	Second
SAR	Safety Analysis Report
scfm	Standard Cubic Feet per Minute
SMS	Sludge Mobilization System
SMWS	Sludge Mobilization and Wash System
Sr	Strontium
STP	Standard Temperature and Pressure
STS	Supernatant Treatment System
Sv	Sievert
T	Tera, Prefix for 10^{12}
Ti	Titanium
TLD	Thermoluminescent Dosimeter
TR	Technical Requirement
TVS	Temporary Ventilation System
UBC	Uniform Building Code
UL	Underwriters Laboratories
V&S	Ventilation and Service Building
VF	Vitrification Facility
VOG	Vessel Off-Gas System

ACRONYMS AND ABBREVIATIONS (concluded)

W	Watt
wt%	Weight percent
WTF	Waste Tank Farm
WTFVS	Waste Tank Farm Ventilation System
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services Co., Inc.
WVPP	West Valley Policies and Procedures
y	Year

D.1.0 INTRODUCTION AND GENERAL DESCRIPTION OF THE FACILITY

D.1.1 INTRODUCTION

This Safety Analysis Report (SAR), WVNS-SAR-004, Volume III, Part D, Supernatant Treatment System (STS), was prepared to meet the requirements of the U.S. Department of Energy (DOE) Order DOE-5481.1B (U.S. DOE, 1986), Idaho Operations Office (ID) Order ID-5481.1A (U.S. DOE-ID, 1989), and West Valley Nuclear Services Co., Inc. (WVNS) Policy and Procedure WV-906, Rev. 8 (WVNS, 1990). Further introductory information relating to the WVDP Act, ancillary tasks and supporting activities that must be accomplished may be obtained from Section A.1.1 of Volume I of the Project SAR (WVNS-SAR-001).

Former PUREX reprocessing activities generated high-level radioactive waste (HLW) that is stored in Tank 8D-2. This HLW is separated into an alkaline supernatant and sludge. It is the task of the WVDP to convert the HLW into borosilicate glass for ultimate storage in a federal repository. (The preliminary SAR for the Vitrification Facility (VF), in which the HLW will be converted into borosilicate glass, is WVNS-SAR-003.) In order to accomplish this mission pretreatment of the HLW is necessary.

The pretreatment is performed by the Sludge Mobilization and Wash System (SMWS), analyzed in this SAR, and the Integrated Radwaste Treatment System (IRTS) which consists of the STS, analyzed in this SAR; the Liquid Waste Treatment System (LWTS), described and analyzed in WVNS-SAR-005, Volume IV, Part H; the Cement Solidification System (CSS), described and analyzed in WVNS-SAR-008, Volume IV, Part G; and the Drum Cell (DC), described and analyzed in WVNS-SAR-007, Volume IV, Part K.

The SMWS will remove the interstitial salts and salt crystals from the PUREX sludge by mobilizing the sludge with the sludge mobilization pumps and using dilute caustic solution to suppress actinide solubility while dissolving the salt and salt crystals. However, salt and salt crystals are deleterious to the performance of the VF's melter; in order to adequately wash the sludge, four wash cycles may be necessary. The resultant liquid, the sludge wash solution, will be processed by the IRTS. The washed sludge will be stored in Tank 8D-2 until it is used as melter feed to the VF.

The SMWS consists of the caustic solution, which will be added to Tank 8D-2, and sludge mobilization pumps. The sludge mobilization pumps are suspended from a pump support structure above Tank 8D-2.

The STS has radiologically decontaminated approximately [illegible]0% of the alkaline supernatant remaining from PUREX reprocessing activities. The term "supernatant" specifically refers to the liquid portion of the HLW remaining in Tank 8D-2 from PUREX reprocessing activities and not to sludge wash solution as defined above; however, when used to describe equipment, the term is synonymous with sludge wash solution. Radiological decontamination of supernatant, specifically cesium, was achieved through the use of ion exchange material or zeolite, Ionsiv IE-96™. The STS will continue to use Ionsiv IE-96™ for the removal of cesium from the sludge wash solution; however, zeolite treated with titanium may be used, as necessary, to additionally remove plutonium and strontium. The plutonium removal may be necessary in order to meet the U.S. Nuclear Regulatory Commission's requirements for stable low-level radioactive waste (LLW) form disposal. The LLW form produced by WVNS is described and analyzed in the CSS SAR, WVNS-SAR-008, Volume IV, Part G.

The STS consists of a floating suction pump, suspended in Tank 8D-2, a prefilter, a chiller/cooler, up to four ion exchange columns in series, and a post filter, all contained within Tank 8D-1.

D.1.2 GENERAL PLANT DESCRIPTION

The WVDP site is located in a rural setting approximately 50 km (30 mi) south of Buffalo, New York, at an average elevation of 400 m (1,300 ft) on New York State's western plateau. The plant facilities used by the WVDP occupy approximately 63 hectares (156 acres) of chain-link fenced area within a 1,350 hectares (3,300 acres) reservation that constitutes the Western New York Nuclear Service Center (WNYNSC). The communities of West Valley, Riceville, Ashford Hollow and the village of Springville are located within 8 km (5 mi) of the plant. Several roads and one railway pass through the site, but no human habitation, hunting, fishing or public access is permitted on the WNYNSC.

The STS is located and the SMWS will be located in the Waste Tank Farm (WTF) (Figure D.5.1-1). Radioactive components (i.e., prefilter, chiller/cooler, ion exchange columns, and postfilter) are located within the HLW Tank 8D-1 (Figures D.5.1-2, D.5.1-3, D.5.2-5 through D.5.2-7) and the SMWS (i.e., supernatant removal pump, sludge mobilization pumps) are located within HLW Tank 8D-2 (Figure D.4.1-2).

There are several important design considerations to ensure the safety of the system. These are described in detail in Section D.8.1.2. The most important are that the HLW tanks are maintained under negative pressure, that structural barriers have been designed such that the confinement of liquid HLW will not be compromised by any credible design basis event, and that redundancy in critical aspects of the operation is used. An example of the redundant nature of the operation is the ventilation systems. Both of the ventilation systems used by the STS contain redundant ventilation trains and are connected to emergency backup power.

Additional design considerations can be found in Section D.4.0. Operational considerations are maintained by administrative and procedural control as described in Section D.8.1.3. Also, Operational Safety Requirements (OSRs) and Technical Requirements (TRs) are presented in Volume VI, Part M.11 of the Project SAR.

D.1.3 GENERAL PROCESS DESCRIPTION

A simplified description of the overall WVDP activities is presented in Section A.1.3 of Volume I and includes those processes required for HLW handling and vitrification. The combined SMWS and STS processes presented in this volume will provide the means to wash soluble salts from the HLW sludge waste in Tank 8D-2 and treat the wash solutions such that the effluent wash water can be concentrated in the LWTS facility and made into a cemented waste form in the CSS facility.

The SMWS is equipped to add a dilute caustic solution to the HLW Tank 8D-2. Once the dilute caustic solution is added, a series of five long-shafted centrifugal pumps are used (Figure D.4.1-1) to agitate the tank contents and suspend the settled solids. These SMWS mobilization pumps will mix the solids and added solution, accelerating dissolution of salt crystals. The exact duration of mixing will be determined by sampling the liquid periodically and tracking the change in salt concentration in solution. After the salt concentration has leveled off, the mixing will stop and the solids will be allowed to settle.

After the solids have settled below the floating suction of the STS Wash Solution Removal Pump (50-G-001), wash solution transfer to the STS facility can begin. As a precaution to solids carryover to the ion exchange columns, a prefilter (50-F-001) is installed between the transfer pump discharge and the column batch feed tank (50-D-001). This prefilter is a 0.5 μm (5000 Å) sintered metal crossflow filter.

The STS process was designed to operate continuously using three ion exchange columns. During continuous operations, one column is off-line to recharge the ion exchange media while the others are on-line. However, it can be operated as a batch system and up to four columns used. The processing of wash solutions is planned to be performed in a batch or bleed and feed mode. Approximately 150,000 L (40,000 gals) will be processed weekly.

As an aid to the efficient loading of cesium onto the ion exchange zeolite, the filtered sludge wash solution can be diluted with water and cooled via a brine solution in a shell-and-tube heat exchanger to as low as 6°C (43°F). Also, depending on the need to reduce the plutonium content of the wash solution, titanium-treated zeolite may be used in place of some or all of the usual IE-96™ zeolite. The Titanium-treated zeolite will remove Plutonium from the wash solutions. The issue of criticality control is addressed in Section D.9.2.4.

To reduce the salt content of the HLW washed sludge to a level acceptable for future vitrification, a total of four wash cycles is tentatively planned. Table D.1.3-1 provides preliminary estimates of the volumes of caustic wash solutions and wash water that will be used in the sludge washing process. If indicated, additional wash cycles will be performed or the quantities of wash solution and caustic will be adjusted to meet the end goal.

D.1.4 IDENTIFICATION OF AGENTS AND CONTRACTORS

Section A.1.4 of Volume I identifies the agents and contractors responsible for implementing the WVDP. The relationships between WVNS and agents and contractors is illustrated in Figure A.1.4-1 of Volume I.

D.1.5 STRUCTURE OF THIS SAR

The concept of this modular SAR is explained in Section A.1.5 of Volume I. The structure of the SAR is patterned after NRC Regulatory Guide 3.26. See the Table of Contents, which reflects this pattern.

Since it was published as Table A.1.5-1 of Volume I in June, 1985, the format of the WVDP SAR has evolved as required by changes in Project milestones. As originally conceived, sludge mobilization, washing and transfer of all HLW (loaded zeolite, THOREX and washed sludge) was to be included in Part E, Volume III, "Sludge Mobilization System (SMS)". Because of revisions to the Project schedule, it has not been feasible to follow the original outline for the Project SAR (Table A.1.5-1). The current plan is to issue a separate module, Part E of Volume III, to cover the HLW transfer operations. A copy of the current structure of the Project SAR is provided in Table D.1.5-1 and will be added to Volume I during the scheduled routine update. Structural changes in response to revisions in Project milestones are anticipated.

D.1.6 REQUIREMENTS FOR FURTHER/NEW TECHNICAL INFORMATION

The STS will use a newly developed ion exchange material, Titanium-treated zeolite. Testing has been performed by WVNS and Pacific Northwest Laboratory (PNL) to ensure applicability and reliability of the material (Bray, 1990). This testing bracketed the proposed operating conditions, which included flow-rate, temperature, and pH.

Physical integrity of the Titanium-treated ion exchange material will be verified by the manufacturer for each batch of material through wet attrition testing. This testing is being performed as part of the quality assurance requirements of quality level C material.

REFERENCES FOR SECTION D.1.0

Bray, L. A., Frank T. Hara, and Thomas F. Kazmierczak. December 1990, "Evaluation and Selection of a Process to Remove Plutonium from West Valley High-Level Waste Sludge Wash Water," Draft C.

Table D.1.3-1

PROPOSED WASH CYCLE FLOW SUMMARY

Process Stream	Cycle 1 L (gals)	Cycle 2 L (gals)	Cycle 3 L (gals)	Cycle 4 L (gals)
20% Caustic Solution to Tank 8D-2	32,000 (8,500)	8,100 (2150)	8,100 (2150)	8,100 (2150)
Caustic Dilution Water to Tank 8D-2	270,000 (70,900)	992,000 (262,000)	992,000 (262,000)	992,000 (262,000)
Flow rate to STS from Tank 8D-2	8 - 23/min (2 - 6/min)	8 - 23/min (2 - 6/min)	8 - 23/min (2 - 6/min)	8 - 23/min (2 - 6/min)
STS Dilution Water Flow Rate	8 - 23/min (2 - 6/min)	0/min	0/min	0/min
Flow rate to Tank 8D-3	15 - 45/min (4 - 12/min)	8 - 23/min (2 - 6/min)	8 - 23/min (2 - 6/min)	8 - 23/min (2 - 6/min)
Total Volume to LWTS	2,063,000 (545,000)	1,003,000 (265,000)	1,003,000 (265,000)	1,003,000 (265,000)

TABLE D.1.5-1
CURRENT (1990) STRUCTURE OF THE WEST VALLEY DEMONSTRATION PROJECT SAFETY ANALYSIS REPORT

Volume	Title	Part	WVNS SAR Designation
I	Project Overview and General Information	A	001
II	Existing Plant and Operations	B	002
III	High-Level Waste Vitrification		
	• Vitrification Facility[1]	C	TBD[3]
	• Supernatant Treatment System[2]	D	004
	• SMS and HLW Transfer	E	TBD
IV	Waste Management, Storage and Disposal		
	• High-Level Waste Interim Storage	F	TBD
	• Cement Solidification System	G	008
	• Liquid Waste Treatment System	H	005
	• Size Reduction Facility	I	010
	• Lag Storage Facility	J	009
	• Disposal Area Operations	K	006 & 007
V	Final Decontamination, Decommissioning and Waste Shipment	L	TBD
VI	Operational Safety Requirements	M	NA

Notes:

1. SARs for the Vitrification Facility (Part C) and High-Level Waste Interim Storage (Part F) to be combined into one document.

2. Includes a revision for the Sludge Mobilization and Wash System

3. Preliminary SAR for the Vitrification Facility is SAR-003

D.2.0 SUMMARY SAFETY ANALYSIS

A summary of the safety analyses performed for the STS and SMWS is presented in this chapter. Additional details on these analyses and supporting systems analyses can be found in appropriate sections of this and other volumes.

D.2.1 SITE ANALYSIS

D.2.1.1 NATURAL PHENOMENA

See Section A.2.1.1 of Volume I.

D.2.1.2 SITE CHARACTERISTICS AFFECTING THE SAFETY ANALYSIS

The STS is located within the WVDP waste tank farm (WTF). The major processing components of the STS that are in radioactive service are located within the spare HLW Tank 8D-1. The sludge wash solution is transferred from HLW Tank 8D-2 through the valve aisle adjacent to Tank 8D-1 and on to the components in the spare HLW tank.

The STS support building, adjacent to the valve aisle at the northwest perimeter of Tank 8D-1, contains the STS control room, cold operations support, and utility services. Ventilation for contamination control is provided by the Permanent Ventilation System (PVS) and the original WTF Ventilation System (WTFVS). The WTF is at an elevation well above potential flooding.

The SMWS will be located within the WTF. The major processing components of the SMWS in radioactive service are located within HLW Tank 8D-2. The Ventilation and Service (V&S) building is located at the north perimeter of Tank 8D-2 and will contain the SMWS support equipment. Ventilation for contamination control is provided by the WTFVS and the STS PVS.

The hypothetical accidents analyzed are, therefore, associated with the HLW tanks, HLW sludge mobilization and washing, and the ventilation system functions. Airborne radioactivity resulting from one of these accidents could be released directly to the environment from the HLW tanks, from the PVS in the WTF, or through the WTFVS which exhausts through the main process plant [illegible] ccidental liquid releases of radioactive material to the environment [illegible] etermined not to be credible for the SMWS as determined by confinement barrier integrity review (Gates, 1991).

Major loads associated with site-specific, design basis natural phenomena (e.g., tornados and earthquakes) have been analyzed with appropriate margins of safety. See Table D.4.3-1 (Gates, 1986). Other site-specific loads (e.g., high winds or snow loading) were also explicitly included in the design criteria, but were typically subsumed by other, more controlling loads and their associated margins of safety. The site's topographic setting renders the likelihood of major flooding not credible, and local run-off and flooding is adequately accommodated by natural and man-made drainage systems in and around the WTF.

Weather conditions such as rain, freezing rain, and snow are circumstances that must be accommodated during the construction and installation phases of the STS and SMWS. These conditions are, of course, common at the WVDP and the various Project departments are accustomed to dealing with them. Construction activities are routinely conducted within weather enclosures. Operations that have a potential for the airborne release of radionuclides are typically conducted within containment tents which also afford protection from foul weather. Finally, when inclement weather precludes a particular activity, the Radiation Safety, Industrial Safety, and Construction Management Groups will secure that activity and wait for more appropriate conditions.

For further information concerning site characteristics refer to Section A.3.0 of Volume I.

D.2.1.3 EFFECT OF NEARBY INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES

There are no nearby industrial, transportation, or military facilities that affect the safety of the Project Operations. See Section A.2.1.3 of Volume I for further discussion.

D.2.2 RADIOLOGICAL IMPACT OF NORMAL OPERATIONS

Both on-site and off-site dose assessments were performed in order to determine the radiological impact of normal operations (Section D.8.0). The dose to on-site personnel is from work in areas of elevated external radiation levels (gamma levels) relative to background. Operations will not normally be conducted in areas subject to airborne or surface contamination. The annual collective occupational dose (Section D.8.4) was estimated to be less than 3 person-cSv (3 person-rem).

To estimate the off-site dose, the airborne pathway and indirect liquid release to the environment from the STS and SMWS were calculated. Most of the radioactive material released via the airborne pathway will be exhausted from the WTFVS through the main plant stack. Small airborne releases will also occur from the PVS in the WTF during mobilization pump installation. The AIRDOS-PC (AIRDOS-PC, 1989) dispersion code was used to estimate the atmospheric transport and diffusion of radioactive particulates. The resulting concentrations were coupled with dosimetry models to estimate the dose to off-site individuals. The dose to the maximally exposed off-site individual was calculated to be 500 nSv (50 μrem) per year (Section D.8.6.3). The liquid release would be from normal routine lagoon discharge after treatment in the LWTS and Low-Level Waste Treatment Facility (LLWTF), also referred to as the 02 Plant. The resulting concentrations of the decontaminated wash water solutions were used in conjunction with the LADTAP-II (LADTAP-II, 1980) liquid release model to calculate the effective dose equivalent. These doses are reported in Volume IV, Part H (WVNS-SAR-005).

D.2.3 RADIOLOGICAL IMPACT FROM ABNORMAL OPERATIONS

Abnormal operations are events that could occur from malfunctions of systems, operating conditions, or operator error. Abnormal events are only of consequence for those systems in the STS and SMWS that process, control, or confine radioactive material. The abnormal events considered (Section D.9.1) are of little consequence to workers and do not result in a significant release of radioactive or hazardous material to the environment. STS and SMWS abnormal events is presented in Table D.2.3-1.

D.2.4 ACCIDENTS

Five hypothetical bounding accidents associated with operation of the SMWS and STS were analyzed (Section D.9.2). These accidents scenarios analyzed were chosen based upon a screening process that involves identifying the highest consequence conditions for each of the major components of the system. Consequence is proportional to the concentration of the radioactivity or the total radioactivity contained within the component, the mode of failure, the path of release for the source term (direct to the environment or through a filtered ventilation system), and the release height. In other words, the initial conditions, within physical boundaries, for each of the major components is set to maximize the off-site dose, given an accidental failure of the component. Those components that are representative of others and impart a larger consequence are then chosen to bound the system. No weight is given to the probability of failure, mode of failure, or initial conditions. All bounding analyses are of a deterministic nature and are considered to be the worst case.

The first accident assumes the collapse of the roofs of the vault and HLW Tank 8D-2, exposing the tank contents to the wind and resulting in a high evaporation rate of radioactive material directly to the environment. The second and third accidents involve spills of sludge wash water solution. The fourth accident covers overloading and ultimate over-pressurization of an ion exchange column due to the inability to remove the loaded zeolite. The fifth accident involves a High Efficiency Particulate Air (HEPA) filter fire within the WTFVS with the release assumed to occur from the main plant exhaust stack. Confinement barrier integrity review (Section D.4.3.2) indicates that accidental release of liquid HLW directly to the environment cannot occur with less than six times the design basis earthquake. A summary of STS and SMWS accidents is presented in Table D.2.4-1.

D.2.5 NONRADIOLOGICAL IMPACTS

This SAR does not specifically address nonradiological hazards associated with the SMWS and the STS. Nonradiological accidents are not considered because of the low toxicity and volatility of chemicals used. The only hazardous material directly associated with the SMWS and the STS is dilute sodium hydroxide. The hazards associated with the handling and storage of this chemical are specifically evaluated in WVDP-096, "Safety Assessment of WVDP Hazardous Substances."

D.2.6 CONCLUSIONS

This SAR was prepared to meet the requirements of DOE-ID Order 5481.1A, "Safety Analysis and Review System for DOE-ID Managed Activities," DOE Order 5481.1B, "Safety Analysis and Review System," and WVNS Policy and Procedure WV-906, "Safety Review Program." The analysis indicates that the STS and SMWS can be operated safely as designed. The STS and SMWS have been designed to reduce hazards to acceptable levels by instrumented control of the process and by conducting operat ... remotely within sealed and shielded multiple containments. Conservative assumptions lead to an estimated worker collective dose of less than 3 person-cSv (3 person-rem) per year from normal operations, in keeping with the philosophy of as low as reasonably achievable (ALARA) and the requirements of DOE Order 5480.11, "Radiation Protection for Occupational Workers." Calculated doses to the maximally exposed off-site individual and operating personnel were determined for normal, abnormal and accident conditions. The bounding doses calculated for the maximally exposed off-site individual are 700 nSv/y (70 μrem/y) for normal operations and 8 mSv (800 mrem) for accident conditions. Abnormal operations are expected to have inimal impact to off-site individuals. The bounding doses calculated for operating personnel are 3 person-cSv/y (3 person-rem/y) for normal operations, 0.5 person-cSv (0.5 person-rem) for expected abnormal operations, and 15 cSv (15 rem) for accident conditions. Calculated doses to the maximally exposed off-site individual were determined both normal and accident conditions.

For routine operation, the doses are well within the requirements of DOE Order 5400.5, and ID Order 5400.5, "Radiation Protection of the Public and the Environment."

REFERENCES FOR SECTION D.2.0

AIRDOS-PC, 1989 United States Environmental Protection Agency, "User's Guide for AIRDOS-PC, Version 3.0," EPA/520/689-035, December 1989.

Gates, 1986 Dames and Moore, "8D-1 Zeolite Mobilization System Confinement Barrier Integrity Review," Subcontract No. 19-CWV-21511, Task 10, December 1987.

Gates, 1991 Dames and Moore, "8D-2 Sludge Mobilization Wash System Confinement Barrier Integrity Review," Subcontract No. 19-CWV-21511, Task 10, April 1991.

LADTAP-II, 1980 Oak Ridge National Laboratory, "User's Manual for LADTAP-II - A Computer Program for Calculating Radiation Exposure to Man from Routine Release of Nuclear Reactor Liquid Effluents," NUREG/CR-1276, May, 1980.

WVDP-096, "Safety Assessment of WVDP Hazardous Substances," Rev. 0, December 1990.

Table D.2.3-1

SUMMARY OF STS AND SMWS ABNORMAL OPERATIONS

Abnormal Event	On-site Collective EDE (person-cSv or person-rem)	Detection Method	Possible Cause	Corrective Action	Effects and Consequences
Leak in STS Cooler/Chiller System	Minimal	Area radiation monitor alarm	Structural failure; pressure gradient failure	Isolate, decontaminate, and repair or replace cooler/chiller	Decreased operating efficiency
Replace Faulty (Leaking) Block Connector Assembly	0.008	Visual inspection; instrumented alarms in the control room	Gasket or valve seal failure	Remote repair or replacement	Decreased operating efficiency
Sticking ("Hang-Up") of a Sludge Wash Solution Analytical Sample in the Pneumatic Transfer System	0.24	Failure to receive sample at destination	Loss of vacuum during transfer or a misalignment of the transfer system tubing	Vacuum reversal; removal of pipe section	Increased transfer time for samples from the valve aisle to the analytical aisle
Cesium Breakthrough to Tank 8D-3	Minimal	Sample and analysis	Reduced ion exchange efficiency	Return solutions through recycle lines for rework in STS	Decreased operating efficiency
Failure of Tank 8D-2 Supernatant Transfer Pump	0.5	Loss of fluid flow, high solids or abnormal pressure indications in the control room	Mechanical failure	Failure-mode dependent	Inability to efficiently transfer sludge wash solution to STS
Failure of Major STS Processing Component in Tank 8D-1	0.5	Process instrumentation and alarms	Mechanical failure of support equipment	Replace or repair support or equipment of ion exchange column	STS downtime
Mobilization Pump Failure	0.5	Contamination in pump house; No current flow; Excessive current flow	Seal failure; mechanical failure	Replace or repair mobilization pump; install spare mobilization pump	Possible delay in performing SMWS operations
Sparge Line	0.5	Inability to sparge column; increased general radiation area exposure rate; low pressure alarm or back-pressure alarm	Rupture or depressurization of the sparge line	Remote removal and replacement of sparge line	Inability to use sparge line; possible decrease in column efficiency from remaining heel; inability to use column

Table D.2.4-1

SUMMARY OF STS AND SMWS ACCIDENT ANALYSES

Accident	On-site CEDE (cSv or rem)	Off-site CEDE (cSv or rem)	Detection Method	Possible Cause	Corrective Action	Effects or Consequence
Tank 8D-2 Roof and Vault Collapse	15	0.8	Visual	Greater than 6 times the Design Basis Earthquake of 0.1 g	Erection of containment over tank, if possible; evacuation of nearby residents; transfer of HLW to spare HLW Tank 8D-1 if available	Worst case accident; on-site and off-site surface soil contamination; serious delay in WVDP activities
HLW Transfer Pipe Rupture between Tank 8D-2 and Tank 8D-1	5.6	0.3	Leak detection alarm in pipe chase	Mechanical failure	Discontinue HLW transfer; provide containment; utilize spare transfer line	STS downtime during decontamination
Spill of Sludge Wash Solution in Valve Aisle	< 0.001	<< 0.001	Area radiation monitor alarms	Mechanical failure	Discontinue HLW transfer; replace or repair failed component	STS downtime during decontamination and replacement or repair
Ion Exchange Column over-pressurization	0.004	< 0.001	Effluent monitor alarm	Inability to remove heat from decay due to reduced column flow	Remove zeolite from column through bottom dump valve, if possible	STS downtime during repair or replacement of ion exchange column
HEPA Filter Fire	N.A.	< 0.001	Fire alarm system	Outside ignition source	Use of fire suppression equipment	Replacement of HEPA filter

D.3.0 SITE CHARACTERISTICS

Site characteristics potentially affecting the WVDP as a whole are detailed in Volume 1, Section A.3. Site characteristics affecting the STS and SMWS are described below.

D.3.1 GEOGRAPHY AND DEMOGRAPHY OF WVDP ENVIRONS

See Section A.3.1 of Volume I for a general site discussion. There is no effect on STS and SMWS operations from geography and demography of WVDP environs.

D.3.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

See Section A.3.2 of Volume I for a general site discussion. There is no effect on STS and SMWS operations as a result of these site characteristics.

D.3.3 METEOROLOGY

Design characteristics associated with system component installation (i.e., adding sludge mobilization pumps to Tank 8D-2) did not consider site meteorology. The installation of pumps or any other component into HLW tanks would not be performed during any extreme meteorological event (e.g., high winds, heavy rain, or major snow storms). These conditions would be included in operation-specific procedures. Site characteristics affecting the design and operation of the SMWS have been considered (e.g., the pumps will be housed in heated weather enclosures).

See Section A.3.3 of Volume I for a general discussion of meteorology around the WVDP.

D.3.4 SURFACE HYDROLOGY

See Section A.3.4 of Volume I for a general discussion of surface hydrology around the WVDP. Surface hydrology characteristics did not affect the STS and SMWS design.

D.3.5 SUBSURFACE HYDROLOGY

See Section A.3.5 of Volume I for a general discussion of subsurface hydrology around the WVDP. Subsurface hydrology characteristics did not impact the STS and SMWS design.

D.3.6 GEOLOGY AND SEISMOLOGY

See Section A.3.6 of Volume I for a general site discussion. Soil conditions and site seismic criteria were used in both the original design of the STS and SMWS as well as structural review evaluations.

D.3.7 SITE ECOLOGY

See Section A.3.7 of Volume I for a general discussion. There is no effect on the STS and SMWS operation as a result of site ecology.

D.4.0 PRINCIPAL DESIGN CRITERIA

D.4.1 PURPOSE OF THE STS AND SMWS

The HLW remaining from PUREX process operations at West Valley are contained in Tank 8D-2 and consist of a precipitate (sludge) and an alkaline supernatant. The primary objective of the STS is to reduce the volume of HLW, which will be solidified on-site into borosilicate glass, the terminal waste form.

The volume of the terminal waste form can be reduced by a factor of approximately six if he radioactive species (primarily ^{137}Cs) contained n the supernatant and sludge wash solutions can be separated from other compounds dissolved in the supernatant.

The STS will remove the sludge wash solution from Tank 8D-2 and decontaminate it (remove the strontium, cesium, and plutonium) to a level that will permit the decontaminated sludge wash solution to be sent to the LWTS and then to the CSS for solidification in cement as a LLW. The STS uses a separation process with a cesium-specific zeolite to ion exchange cesium from other species dissolved in the sludge wash solutions and, when needed, a Ti-treated zeolite to retain the plutonium. The system is to be located on the WTF with the major process components in radioactive service housed in Tank8D-1. Details for the LWTS can be found in Volume IV, Part H (WVNS-SAR-005). Details of the CSS can be found in Volume IV, Part G (WVNS-SAR-008).

Deco amination of the supernatant and sludge wash solutions will be done in two phases. The first phase, which has been completed, decanted the supernatant with minimal disturbance of the sludge layer. This phase primarily separated cesium from the other salts in the supernatant. The second phase, sludge washing, purposely agitates the sludge to remove the salts from the sludge so they may also be decontaminated. Decontamination of the sludge wash solution will separate plutonium and strontium in addition to cesium.

Washing of the sludge consists of adding dilute caustic solution to Tank 8D-2 and mixing it with the settled PUREX sludge. Mixing will be accomplished by using a series of mobilization pumps to be installed within Tank 8D-2 (Figure D.4.1-1). These pumps are long-shafted centrifugal pumps that extend into the tank through access sleeves called risers (Figure D.4.1-2). Tank 8D-2 and its vault were modified to create additional access risers (Figure D.4.1-2) for the installation of sludge mobilization equipment. Details of the modifications, equipment used, and method of installation can be found in "Safety Analysis Report for Remote Riser Installation and Penetration of Tank 8D-2" (Brown 1986). Structural modifications to these original structures were analyzed by various engineering design organizations to verify the structural integrity of the tank and its vault (Tank Roof Analysis [Rockwell, 1984]; Vault Roof Analysis [Rockwell, 1985]; 8D-1 Tank Vault Top Slab Evaluation [Ebasco, 1986]; and Vault 8D-1/8D-2 Finite Element Analysis [Ebasco, 1990]. In addition to these analyses, an assessment and evaluation of the reserve capacity of the tank and its vault were performed (Gates, 1991) under design basis loading conditions. The SMWS consists of the mobilization pumps themselves, the pump support structure of steel trusses on concrete piers, and spread footing foundations that support the 15-m long pump column over the Tank 8D-2 vault. Variable speed controllers will be used to control and monitor the pump operation.

The mobilization pumps installed to mix the sludge and the dilute caustic solution will be run intermittently for approximately five days per wash. After the sludge and dilute caustic solution are mixed, the pumps are shut down and the solids are allowed to settle. Once the solids settle, the STS supernatant feed pump, which is a floating suction pump, is used to transfer the sludge wash solution to STS for decontamination. This process will be repeated approximately four times to adequately wash the sludge.

The radioactive species retained from the supernatant and sludge wash solution processing will be temporarily stored as loaded zeolite (ion exchange media) at the bottom of Tank 8D-1 under a water cover. It will ultimately be blended with the sludge remaining in Tank 8D-2 and the acidic THOREX wastes from Tank 8D-4 for use as melter feed.

Details pertaining to STS design presented in this and subsequent chapters of this SAR module are based on the most recent STS design criteria (Carl, 1985), Pump Support Design Criteria (Ebasco, 1985), Remote Riser Installation Design Criteria (Schiffhauer, 1986), Sludge Mobilization Waste Removal System Design Criteria (Schiffhauer, 1990), and the Tank 8D-1 and 8D-2 Waste Mobilization Pump Equipment Specifications (Schiffhauer, 1987).

D.4.1.1 STS FUNCTIONS

The major processing functions of the STS are summarized below and are described in detail in Section D.6.0. A schematic of the STS process is presented in Figure D.5.1-5.

D.4.1.1.1 SLUDGE WASH SOLUTION TRANSFER

A vertical turbine pump in Tank 8D-2 is to be used to decant the sludge wash solution from Tank 8D-2 and transfer it in a buried pipe conduit through the valve aisle to the supernatant prefilter.

D.4.1.1.2 SLUDGE WASH SOLUTION FILTERING AND COOLING

The sludge wash solution is filtered to remove suspended fines (sludge particles), and cooled from approximately 90°C (194°F) to as low as 6°C (43°F) for optimum processing conditions. The prefilter and supernatant cooler are located within Tank 8D-1. The STS chiller, which supplies the cooling fluid (salt solution) to the cooler, is located in the STS support building.

D.4.1.1.3 ION EXCHANGE

Following filtration and cooling, the sludge wash solution is passed through up to four in-series ion exchange columns containing zeolite. The majority of the cesium plutonium, and strontium dissolved in the sludge wash solution, transfers to the zeolite. The ion exchange columns are located in Tank 8D-1.

D.4.1.1.4 DECONTAMINATED SLUDGE WASH SOLUTION COLLECTION AND TRANSFER

Following ion exchange, the decontaminated sludge wash solution is filtered to remove suspended zeolite fines and collected in a holding tank (Tank 8D-3). Following sampling, it is transferred to the LWTS Tank 5D-15B (exiting) and on to the evaporator for concentration, if necessary. The decontaminated sludge wash solution is transferred to the CSS where i is incorporated into cement as low-level waste.

D.4.1.1.5 SPENT ZEOLITE DISCHARGE

The loaded ion exchange medium (zeolite) is discharged from the ion exchange columns to the bottom of Tank 8D-1. The discharged zeolite will be stored under water cover at the bottom of Tank 8D-1 for ultimate transfer to the vitrification process for use as melter feed. Following discharge, the ion exchange column is recharged with fresh zeolite, that is radiologically clean.

D.4.1.1.6 MOBILIZATION PUMPS

Long-shafted centrifugal pumps are supported from 15-m (50 ft) long segmented, tubular stainless steel columns that house the pump drive shaft. The mobilization pumps are positioned at the bottom of the tanks 8D-1 and 8D-2 approximately 30 cm from the tank floor and have two opposed nozzles. These pumps provide agitation by using the fluid in the tank to resuspend the spent zeolite in 8D-1 and the sludge in 8D-2. The pumps operate at a flow rate of

2300 lpm (600 gpm) out of each nozzle and are continuously rotated 360 ° at a rotational speed of 0.5 rpm. Each pump is operated with a 110 kW (150 hp) motor which is housed outside the tank.

Jet impingement loads from a plugged pump nozzle (e.g., the worst hypothetical jet force generated by the pump under abnormal operating conditions) were applied analytically to the pipe column support for the tank roof system. The force generated by one nozzle having all the flow discharging from it (i.e., one of the two nozzles plugged) has been calculated to be 212 kg (468 lbs) at the nozzle. The structural connections at the bottom of the tank (Figure D.4.1-3), designed to stiffen the tank roof, consists of 4-cm (1.5-in) diameter (A36) staybolts welded to the tank floor on 15-cm (6-in) diameter pads that are attached to a series of 2.5-cm (1-in) thick A283C plates. These plates support an I-beam in which 20-cm (8-in) diameter schedule 80 pipes rest. The 20-cm (8-in) pipes are attached to the tank roof. As a worst case scenario it has been assumed that the 212 kg (468 lbs) is directed perpendicular to a plate. This scenario was used to estimate the maximum stress in both the plate and staybolt. In addition, the plate with a single staybolt was used in the base analysis. The stresses in the staybolt are the governing stresses and are 68% of the allowable in the conservative calculation.

Typically the bottom structure is supported by as many as five staybolts and the nearest plate is 46 cm (18 in) away from a jet. In all cases the plates that are in close proximity to the jets have a minimum of three staybolts. It is also important to note that the pump jet can not directly impinge a plate during operation. Although there are approximately 70,000 expected operating cycles during the life of the Project, fatigue of the structure is not an issue since the actual stresses are not high enough to warrant this consideration.

The worst case geometry between a mobilization pump nozzle stream and the vertical plate fins (gridwork members under the horizontal column support beams at the bottom of the tank) showed a margin of safety against yielding of the plate or its supporting staybolts much greater than four times the abnormal jet impingement loading. Collapse or failure of a single staybolt and supporting fin would have no influence on the overall vertical load-carrying integrity of the column and its supporting beam system. All of the plate fins and staybolts under a single column would have to be sheared out by the impinging pump nozzle stream to cause a local roof column collapse. None of the nozzles can apply a load sufficient to cause a complete column collapse under the worst case scenario. Thus, this mode of potential failure has been shown to be highly improbable.

Cyclic fatigue failure of the tank roof column support system is also unlikely considering the very low stress levels induced in the structural system under normal operating conditions.

The analysis of the abnormal operating condition of the sludge mobilization pumps has been described by Gates (1991).

D.4.1.1.7 MOBILIZATION PUMP CONTROLLERS

The mobilization pumps are operated from a 110 kW (150 hp) adjustable frequency invertor drive. These controllers will allow the pumps to be operated over a range of 900 rpm to 2,000 rpm. The controllers are housed in a separate building known as the V&S Building. Using variable speed drives allows the pumps to be "soft" started at a reduced speed while maintaining a constant torque.

D.4.1.1.8 MOBILIZATION PUMP SUPPORT STRUCTURE

The pump support structure consists of steel trusses on concrete piers and spread footing foundations. The complete mobilization pump assembly is supported off the external steel truss above the 8D-1 and D-2 vaults. None of the mobilization pump loads are imparted to the top of the original tank or its concrete vault.

A Uniform Building Code (UBC) static seismic load analysis was performed for the design. A clearance gap between the pumps (pump column) and waste tank structures (tank access risers on 8D-1 and 8D-2) was not established for seismic purposes. The gap was established as a result of construction tolerances.

Although the basis for seismic loading used in the design of the mobilization pumps, support structures, and the tank access risers was a UBC static lateral loading, an independent dynamic interaction analysis was performed (Gates, 1991) to evaluate the clearance gap under a 0.1 g Design Basis Earthquake using the NRC Regulatory Guide 1.60 response spectra and NRC Regulatory Guide 1.61 damping values. The results of the analysis indicate that impact may occur between the Tank 8D-2 riser and the M-1 pump column at earthquake motions slightly greater than half the Design Basis Event. However, no failure of the pump column or surrounding tank riser will occur until earthquake motions exceed four times the Design Basis Event. The Tank 8D-2 M-1 riser is the one original riser on the tank used for the SMWS. Impact between the pump column and the pump access risers installed for the SMWS was shown not to occur until motions exceeded the Design Basis Earthquake.

D.4.1.1.9 PUMP ENCLOSURE BUILDINGS

Heated, fiberglass buildings containing the required utilities for pump operations enclose each mobilization pump. The buildings protect the pumps from the outdoor elements and also provide freeze protection for the utilities.

D.4.1.2 FEEDS TO THE SMWS AND STS

There are to be six major feeds to the SMWS and STS:

- Sludge wash solutions from Tank 8D-2. (The chemical and radiological characteristics of sludge wash solution are presented in Tables D.8.2-1 through D.8.2-2).
- Chemical additives for pH adjustment when necessary. (See Section D.6.4.)
- Fresh zeolite as a batch process feed to the ion exchange columns.
- Demineralized water for sludge wash solution dilution, zeolite rinse and sluice, and cooling.
- Air to push sludge wash solution out of the ion exchange column.
- Dilute caustic for sludge washing to Tank 8D-2.

D.4.1.3 SMWS AND STS PRODUCTS AND BY-PRODUCTS

The three products of the SMWS and STS process are decontaminated sludge wash solution, which will be transferred to the LWTS, the loaded spent zeolite discharged to the bottom of Tank 8D-1, and the washed PUREX sludge that remains at the bottom of Tank 8D-2. By-products include radiologically contaminated post-filter media and filter backflush, rinse and sluice waters (which are processed in the STS with subsequent sludge wash solution flows), cold zeolite fines as a backwash and contaminated air treated by the PVS and the WTFVS. Detailed discussions of these waste streams can be found in Section D.7.0.

D.4.2 STRUCTURAL AND MECHANICAL SAFETY CRITERIA

D.4.2.1 USE OF ORIGINAL FACILITIES

Consistent with overall WVDP philosophy, original equipment and facilities have been used to the extent practicable for the STS and SMWS. Original equipment and facilities are those that existed at the West Valley site before the WVDP. The major STS processing components in radioactive service are located within the original spare HLW Tank 8D-1. Following ion exchange within Tank 8D-1, the decontaminated sludge wash solution (cesium, strontium and plutonium removed) will be fed to original Tank 8D-3, from which batch transfers will be made to the LWTS. The ion exchange medium (zeolite) will be discharged as needed from the new ion exchange column to the bottom of Tank 8D-1, which will function as a temporary storage reservoir for this material until it is transferred to the VF via 8D-2 for use as melter feed. The zeolite mobilization pumps in tank 8D-1 are used to help redistribute the zeolite at the bottom of the tank during STS operations.

The major SMWS processing components will be located within HLW Tank 8D-2. Following sludge mobilization and washing within Tank 8D-2, the wash solutions will be fed to the STS. The washed PUREX sludge will remain in Tank 8D-2 which will function as a temporary storage reservoir for this material until it is transferred to the VF for use as melter feed.

During SMWS and STS operations, the original WTFVS will continue to provide ventilation for contamination control and air treatment support for Tanks 8D-1, 8D-2, 8D-3, and 8D-4.

D.4.2.2 NEW FACILITIES AND STRUCTURES

In addition to the original facilities described above, operation of the STS required additional new facilities which included:

- STS support building, located on the northwest perimeter of Tank 8D-1, which contains the STS control room, fresh zeolite and water tanks, STS chiller and utility services (cold operation support).

- Valve aisle, located between the support building and Tank8D-1, which is a shielded (steel) structure in which remotely operated valves and related instrumentation are located.

- Shield structure (pipeway), which is a concrete and steel structure erected on top of the Tank 8D-1 vault. It provides containment and structural support for the upper portions of the STS processing components which are suspended from it and into Tank 8D-1, and for the pipe runs between the valve aisle, these components, and the tank itself.

- Ventilation and Service Building, which houses the mobilization pump motor controllers and support electrical feeds as well as the PVS.

- The STS Building Heating, Ventilation, and Air Conditioning (HVAC) and the PVS provides ventilation and heating to the STS support building and exhaust air from the valve aisle and pipeway. The heating, air conditioning and air supply components are located inside the STS Support Building. The

PVS is located in the V&S Building near Tank 8D-1 on the WTF.

- Pump support structure, which carries the loads of the SMWS mobilization pumps and its support equipment.

Figure D.4.2-1 provides a simple schematic of the STS and SMWS that identifies major new facilities and significant modified structures.

D.4.2.3 CODES AND STANDARDS

Both the STS and SMWS Design Criteria were based on DOE Order 6430.1 General Design Criteria. The INEL Architectural Engineering (AE) Standards Manual has been used as the "Primary Guidance" for AE design and preparation of specific task design criteria. The AE standard is a supplement to 6430.1 and contains more detailed design criteria specific to DOE-ID facilities. The criteria in this manual are based on applicable DOE Orders, including DOE-ID supplements, and on the national consensus codes and standards.

Codes and standards that are being used in the design and construction of SMWS and STS facilities (new and modified) are discussed in Section D.5.2.3 and summarized in Tables D.5.2-2 and D.5.2-3, a and b.

Information on loads and their combinations that were used to assess the integrity of STS structures under design basis loadings and severe natural phenomena events and the results of these analyses are presented in Section D.9.3. Additional information on the design of STS and SMWS structures and confinement barriers can be found in Gates, 1986, 1987, and 1991.

D.4.3 SAFETY PROTECTION SYSTEMS

D.4.3.1 GENERAL

The STS and SMWS has been designed to allow for safe operation. Control of radioactivity is the primary safety concern. Specific safety protection systems are described in the following subsections.

D.4.3.2 PROTECTION BY MULTIPLE CONFINEMENT BARRIERS AND SYSTEMS

The major STS processing components that are in radioactive service are located within the HLW Tank 8D-1. STS processing components consist of the ion exchange columns, supernatant feed tank, sluice feed tank, supernatant cooler, prefilter, postfilter, and sluice water feed pump. Figure D.4.3-1 provides a schematic of these components. All components of the SMWS that are in radioactive service are in HLW Tank 8D-2. Any leakage that could result from failure of these components would be contained within the tank. The tank itself is contained within an approximately 61 cm (2 ft) thick concrete vault. The tank atmosphere is maintained under negative pressure relative to surrounding areas by the WTFVS to ensure air leakage is into, rather than out of, the tank. This exhausted air is processed and filtered by the WTFVS as described in Sections D.5.4.2 and D.7.4.

Processing components suspended within the tank are structurally supported by a steel structure erected above the tank vault with the loads transferred into the ground via the vault substructure, and pipeway structure or spread footers. The pipeway provides secondary containment for the top portions of the STS components suspended in Tank 8D-1 and for piping runs between the components of the STS and the valve aisle.

The shielded (steel) valve aisle provides shielding and containment for remotely operated valves and associated STS instrumentation. The valve aisle contains shield windows and manipulators for remote service of these valves. Control of these STS operations is directed from the control room located in the STS support building with selected local control (e.g., for zeolite batching).

Piping used to transfer the sludge wash solution from Tank 8D-2 to Tank 8D-1 is double-walled and contained within a buried steel conduit. The piping runs are laid to maintain a gradient such that any leakage from the primary pipe would be drained and collected in sumps and would be returned to the tanks.

Table D.4.3-1a identifies the specific primary confinement barriers and associated support barriers for each major structure/component in the STS. The table follows the sequence of sludge wash solution flow from Tank 8D-2 to the STS processing components suspended in Tank 8D-1. Structural and design considerations for these barriers are presented in Section D.5.2.3. Table D.4.3-1b summarizes the impact of a number of scenarios upon the integrity of the various confinement barriers related to the SMWS and identifies the backup that prevents either a vapor or a liquid barrier breach.
The existing nuclear fuel reprocessing plant constructed in the mid-1960s at West Valley was designed to the 1961 Uniform Building Code. This facility predated DOE/NRC development of seismic design criteria for non-reactor nuclear facilities. The designers conservatively selected the Uniform Building Code Seismic Zone 3 (the highest seismic zone for earthquake design) as the basis for earthquake design at West Valley.

When WVNS took on the responsibility for decommissioning the nuclear fuel reprocessing plant and removing the high-level nuclear wastes from the storage tanks, it was accepted by the WVPO that the existing facilities would not be upgraded to existing seismic design standards (Ploetz, 1989). However, where new facilities were constructed on existing facilities, or adjacent to existing facilities, all new construction was to be designed in such a manner as to not diminish the seismic capacity in the existing structures.

Furthermore, safety-related facilities involved in the storage, transfer, and processing of low-or high-level nuclear wastes were to be designed in the initial stages of Project development to the current Uniform Building Code with varying levels of importance factor which depends on the degree of the safety required based on the potential risks from seismic failure. (Table 3-1 from the STS report illustrates the types of seismic importance factors employed in the various confinement barriers constructed adjacent to and over tank 8D-1 as part of the STS process.)

As the Project evolved from a research-oriented test facility to a production-oriented low-and high-level waste decommissioning facility, seismic standards following DOE 6430.1 guidelines were developed using probabilistic site-specific studies to assess the appropriate ground motion for the design basis event. The design basis event selected for design of safety-related facilities has a return period of approximately 1,000 years for a peak ground acceleration at the 84th percentile of 0.1g (annual frequency of exceedance of 10^{-3}). Response spectra for the Design Basis Earthquake was selected from NRC Regulatory Guide 1.60 and the associated damping values from Regulatory Guide 1.61.

All major structures, process vessels and piping serving as primary barriers for the high-level nuclear waste storage, transfer, or processing have been designed or reviewed under the Design Basis Earthquake, as either part of the original design or part of the confinement barrier integrity review. Most of these analyses have involved dynamic rather than pseudo-dynamic analysis.

Analyses were performed to assess the integrity of SMWS and STS confinement barriers under various design basis conditions (manmade and natural phenomena). Table D.4.3-2 lists the general references used for the confinement barrier integrity analyses. The primary confinement barriers will survive extreme environmental loading (e.g., design basis earthquake and tornado events), without structural failure and leakage of HLW wastes into the environment because there is sufficient reserve capacity inherent in the original construction as well as in the conservative design of the construction. Any structural modifications to the original underground storage tanks were reanalyzed to verify that their structural integrity was not compromised. The loadings and combinations that were considered and the results of these analyses are summarized in Section D.9.3. Additional information on the design of STS and SMWS confinement barriers and on the barrier integrity analysis can be found in Gates, 1986, 1986b and in Gates, 1991, respectively.

D.4.3.3 PROTECTION BY EQUIPMENT AND INSTRUMENT DESIGN AND SELECTION

All equipment and instrumentation for the STS and SMWS were selected and purchased in compliance with the WVNS Quality Assurance Program described in Section A.12 of Volume I. The quality levels of the individual components for the STS are presented in Section D.4.4. Specific examples of safety protection provided by equipment and instrumentation design are as follows:

- Because the STS is a remote operation designed for minimum access, it is heavily instrumented. Most controlled parameters have at least two sensors of dissimilar operating principles or an alternative instrument detection system that can be used in the event of failure of one sensor.

- The mobilization pumps are the only major operating components of the SMWS and are contained within the Tank 8D-2. The pump system is designed to permit semi-remote removal and replacement.

- The process equipment systems of the STS are designed to be fail-safe in the event that failure of a primary control device occurs.

- Key process variables of the STS are monitored. Those variables that could affect the safety of operations have both an audible alarm and an illuminated face plate on an alarm panel. Examples of these process variables are: high differential pressure across the supernatant prefilter; low flow of wash solution to the supernatant feed tank; supernatant feed tank high high-level; temperature, both high and low, of the wash solution to the ion exchange columns; high radiation alarm on the supernatant cooler brine return line; high temperature in each ion exchange column; high radiation alarm on each column discharge; high radiation on post filter discharge and feed to LWTS for monitoring decontaminated wash solution; radiation monitors on ventilation stack discharge lines. These alarms are shown in figures D.6.1-1 through D.6.1-6. A graphic display is used on the control panel (control room) to minimize operator error.

- Key SMWS equipment variables will be monitored. Those variables (i.e, pump motor amperage, Tank 8D-2 liquid temperature, WTFVS off-gas temperature, pump seal water pressure, low flow to pump columns, pump enclosure temperature) that could affect the safety of operations will be wired to automatically shut down the mobilization pumps if a component fails.

- STS has sufficient instrumentation and controls such that it can be monitored and shutdown from the centralized control panel.

- During off-line operations review and recording of an STS column temperature and pressure readings will provide early warning of column heating from cesium remaining in the column.

D.4.3.4 NUCLEAR CRITICALITY SAFETY

Based upon documented criticality safety evaluations (Section D.9.2.4), criticality during STS operations is not credible (Prowse, 1992). The initial concentration for alpha plutonium is expected to be less than 0.03 μCi/mL of sludge wash solution. This results in a maximum of 114 g of fissile plutonium in solution in Tank 8D-2 which is a safe mass per DOE Order 5480.5. The maximum safe mass for the ion exchange columns, the most restrictive vessel, was determined to be 1.0 kg of fissile plutonium. Therefore, to provide an operational envelope, the maximum concentration of alpha plutonium analyzed for purposes of criticality safety is 0.25 μCi/mL for the first wash cycle and 0.1 μCi/mL for the remaining 3 wash cycles. These values result in a maximum of 952 g of fissile plutonium in solution in Tank 8D-2 in the first wash cycle, less than the maximum safe mass, with a Tank 8D-2 volume of 1.35 ML and less than 845 g of fissile plutonium in solution (assuming 3 ML of sludge wash solution to be processed) in Tank 8D-2 in the remaining 3 wash cycles combined. Accidents (Section D.9.2) analyzed assume an alpha plutonium concentration of 0.664 μCi/mL for conservatism. A discussion and summary of the methodology and calculations that support this conclusion are given in Section D.9.2.4.

Design criteria and operating constraints in the STS process eliminate the possibility of a criticality during the sludge washing operation, as discussed in Section D.9.2.4. Operational Safety Requirement IRTS-12 (formerly TR-IRTS-12) places limiting conditions for operation on the liquid feed from Tank 8D-2 to the ion exchange columns containing Ti-treated zeolite to verify that the actual concentration of undiluted sludge wash solution in Tank 8D-2 is less than 0.25 μCi/mL for the first wash cycle and 0.1 μCi/mL for the remaining 3 wash cycles.

D.4.3.5 RADIOLOGICAL PROTECTION

Radiological protection systems consist of those facilities and equipment that ensure the confinement of radioactivity and the control of general exposure rates. These systems have been designed to provide positive confinement of radioactivity. The major radiological protection systems inherent in the design of the STS and SMWS include the following:

- The containment and shielding provided by Tanks 8D-1, 8D-2, 8D-3 and their vaults.
- The shield structure (pipeway) erected above the 8D-1 vault.
- The shielded valve aisle.
- The WTFVS and PVS.
- Radiation and radioactivity on-line monitoring systems and analytical support systems.
- Piping and pipeline conduits.
- The positive hydrostatic pressure maintained in the soil embedment external to the tank vaults.

The major radiological protection systems of the SMWS, in addition to those which already exist as part of the STS, include the following:

- Shielding is provided by the water-filled mobilization pump support column.

- No routine occupancy of the pump enclosures is expected during normal operations.

Shielding has been installed (valve aisle, shield structure) to maintain radiation exposure ALARA. The design objective is to limit exposure rates in any full time occupancy area to 65 nC/kg-h (0.25 mR/h). Radiological areas for the STS and SMWS have been established, per WVDP-010, "Radiation Controls Manual" requirements, as follows:

Process - Equipment normally in radioactive service, accessible only after decontamination (e.g., valve aisle, pipeway, etc.). No occupancy is expected during normal operations. These are Controlled Areas posted as High or Very High Radiation Areas. No occupancy is expected during normal operations.

Support - Systems that are normally not used in radioactive service, and/or services accessible during normal operations for controlled periods (e.g., operating aisle in front of the valve aisle, zeolite and water tank area). These are High Radiation Areas or Radiation Areas. Intermittent occupancy is expected during normal operations.

Control Room and Utility Area - Remote controls and equipment never used in radioactive service, accessible at all times (routine occupancy during normal operations). These areas are Low-Level Radiation Areas.

The SMWS design objective was to limit exposure rates in any controlled occupancy area to ≤645 nC/kg-h (2.5 mR/h). During mobilization pump installation, the radiation dose rates may exceed 645 nC/kg-h (2.5 mR/h).

Directly over the Tank 8D-2 access openings the radiation dose rate may be >39 µC/kg-h (150 mR/h) while the shield plug is removed from the riser. However, radiation protection controls and procedures and ALARA principles will be maintained through the use of semi-remote installation techniques.

The process system itself shall act as the primary confinement for radioactivity (processing components, valves, piping, and tanks). Ventilated and monitored secondary confinements are designed to inhibit, contain, and eliminate possible contamination (in pipe runs, valve aisle, pipeway, and sampling ports).

In order to minimize the potential for contamination by leaks, the systems designed to routinely carry process liquid are hard-piped and welded. Valves, pumps, and other sources with a high probability of contamination are enclosed by ventilated and monitored secondary confinements.

A goal of radiological protection design is to prevent the backflow of radioactivity into normally nonradioactive systems and areas through nonradioactively contaminated chemical and instrument lines. For those chemical and instrument lines potentially exposed to process pressure, means of isolation (e.g., block and bleed valves) or check valves have been incorporated to prevent pressure transmission to normally nonradioactive systems.

An additional design feature of the STS that enhances control of radioactivity is a dynamic graphic display on the control panel (control room) to minimize operator error. This display provides operators with real-time information regarding system status.

D.4.3.6 FIRE AND EXPLOSION PROTECTION

The STS has fire detection, alarm, and suppression systems commensurate with needs as determined by the WVNS Radiation and Safety Department. Fire protection systems are installed, maintained, and tested in accordance with the requirements of DOE-ID Order ID 12044, "Operational Safety Design Criteria Manual." Information relating to fire protection systems for the STS can be found in Section D.5.4.9. A telephone is located in the control room, the operating aisle (valve aisle operation area) and in the V&S Building. An intercom system connected to the 812 System (emergency all-page) is also installed. A discussion of the potential for temperature/pressure excursions within the STS is presented in Section D.9.2.5.

D.4.3.7 RADIOACTIVE WASTE HANDLING AND STORAGE

From the perspective of secondary waste management, the STS and SMWS have been designed as a self-contained closed system. Secondary waste streams are reused whenever possible and/or returned to Tanks 8D-1 or 8D-2. Specific examples of the "closed" nature of the STS and SMWS process are provided below:

- The supernatant filter backwash is returned to Tank 8D-2.
- Ion exchange column backwash and rinse effluents are returned to Tank 8D-1 for rework by the STS.
- The decontaminated supernatant post filter sand will be dispensed to Tank 8D-1 if recharge is necessary (see Section D.7.2).
- Potentially radioactive sluice water solutions are sent to Tank 8D-1 for reuse.

- The fluid or sludge wash solution never leaves Tank 8D-2 during agitation to wash the sludge.

The STS design philosophy includes the capability for remote removal and replacement of failed equipment. Should components previously in radioactive service require replacement, they will be overpacked as required upon removal before being transferred for waste disposal.

The SMWS design includes the capability of semi-remote removal and replacement of failed pumps. Should radioactively contaminated pumps require replacement, they will be decontaminated and overpacked as required upon removal before being transferred for waste disposal.

Air exhausted from STS facilities is treated by the PVS. Details pertaining to this system can be found in Sections D.5.4 and D.7.4

Air exhausted from Tanks 8D-2 and 8D-1 is treated by the WTFVS. Details pertaining to this system can be found in Sections D.5.4 and D.7.4.

Additional details pertaining to the nature and handling of STS radioactive wastes can be found in Section D.7.0.

D.4.3.8 INDUSTRIAL AND CHEMICAL SAFETY

The administrative controls for industrial and chemical safety implemented for the STS and SMWS are presented in the WVNS Industrial Hygiene and Safety Manual (WVDP-011). Additionally, the relevant requirements for industrial and chemical safety contained in DOE-ID Order ID 12044, "Operational Safety Design Criteria Manual" have been incorporated into STS and SMWS procedures and facilities. The STS and SMWS design also incorporated relevant requirements from ID Appendix 0550, "Standard Operational Safety Requirements" into operating procedures. The effects of a potential chemical accident (the inadvertent addition of a caustic into the ion exchange system) is discussed in Section D.9.2. Cold chemical process systems are discussed in Section D.6.4.

The dilute caustic solution will be shipped in federal/NYS Department of Transportation authorized truck tank trailers, each having a capacity of approximately 19,000 L (5,000 gals.) or smaller sized tote tanks having a capacity of approximately 2,100 L (550 gals.). The container in which caustic is shipped may in turn serve as the temporary storage tank on-site in compliance with federal EPA/NYSDEC Chemical Bulk Storage Regulations (6 NYCRR). If the Caustic Truck Tank Trailer shall be emptied over an extended period of time, it shall be positioned within the Caustic Storage/Truck Unload/Transfer Station at the WTF. The Caustic Storage/Truck Unload/Transfer Station will consist of a graded base (to include a sand overlay), concrete traffic barriers, and secondary spill containment within the traffic barriers.

Recognizing that major or even minor spills could result in hazards to WVDP personnel, the public, and the environment, the WVDP has implemented an Oil, Hazardous Substances, and Hazardous Wastes Spill Prevention, Control and Countermeasures Plan (WVDP-043, November 1989). This operating plan reviews in detail release flow paths, sources, system design and the containment of possible spills or releases as well as prevention, preparedness, response, and notification procedures. Specifically, the plan conforms to the requirements of 40 CFR Part 112 and Part 151 (proposed), both dealing with facilities having a potential for hazardous substances releases.

D.4.4 SAFETY CLASSIFICATION OF STRUCTURES, COMPONENTS AND SYSTEMS

The WVDP Safety Classification System, which complies with DOE Order 6430.1A, "General Design Criteria," consists of three safety classes listed in decreasing order of importance: Safety Class A, Safety Class B, and Safety

Class C. Class N is not important to safety in comparison to Safety Classes A, B, and C. These four classes are defined as:

Safety Class A - Structures, systems, and components whose failure to function as designed could cause an off-site effective dose equivalent in excess of 25 cSv (25 rem).

Safety Class B - Structures, systems, and components whose failure to function could cause and off-site effective dose equivalent in excess of 0.5 cSv (0.5 rem).

Safety Class C - Structures, systems, and components whose failure to function could cause an on-site effective dose equivalent in excess of 3 cSv (3 rem).

Class N - Structures, systems and components not important to safety (specifically, radiological safety as defined above).

Table D.4.4-1a presents safety classifications for the structures, systems, and components associated with the STS. Table D.4.4-1b indicates the safety classifications for the structures, systems, and components associated with the SMWS. The criteria and procedures used to determine safety class designation are presented in Section A.4.4 of Volume I.

Since the dose to the maximally exposed off-site individual as the result of any credible accident considered for the STS or SMWS does not exceed 5 mSv

(500 mrem) annual effective dose equivalent (AEDE) (see Section D.9.2), none of the structures, systems or components require a Safety Class A or B.

Because the primary function of the STS is to process HLW, any item whose failure could result in workers coming into close contact with radioactive process streams requires a safety classification of C (since the potential would exist for a worker exposure in excess of 3 cSv [3 rem]). Components and facilities that function as confinement systems for HLW and ventilation systems that confine radioactivity require Safety Class C since failure of these components could result in the loss of radioactive material confinement. Additionally, instrumentation systems whose function is to monitor, measure and/or control radioactivity or radiation levels also are designed as Safety Class C since their failure could result in undetected exposures. All other items are classified N.

D.4.5 DESIGN CONSIDERATIONS FOR DECONTAMINATION AND DECOMMISSIONING

The STS and SMWS have been designed in a manner to facilitate eventual decontamination and decommissioning (D&D). Specific design details include the following:

- System components installed in original HLW tanks have been designed to permit semi-remote removal and replacement such as, ion exchange columns, pumps, and filters.
- Installed in the Tank 8D-2 access sleeve are a series of spray nozzles that can be used to flush a mobilization pump as it is removed from the tank.
- Components in accessible areas (valves and instruments) shall be either subject to contact maintenance or modular replacement following remote decontamination via flushing of vessels, equipment, and pipes.

- Pumps, valves, and associated piping connections are designed to minimize "collection pockets" for ease of decontamination, maintenance and replacement.

- All components and lines are capable of handling a wide range of decontamination fluids.

- The material of construction is 300-series stainless steel to minimize incorporation of contamination into surfaces.

- Pump volutes are fitted with a volute flush line that allows flushing out the volute, impeller, and pump suction screen.

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STS CONFINEMENT BARRIER SUMMARY

No.	Structure or Component	Function	Primary Barrier	Support Barrier
1A	Tank 8D-2	High-level waste storage -- supernatant and sludge	Carbon steel tank	Negative internal pressure via waste tank farm ventilation system
			Reinforced concrete vault and steel liner pan[1]	Positive external pressure provided by hydrostatic head kept at a constant level by pump feed*
		Soil excavation in tight clayey till	Water saturation of clay to prevent seepage (pump supplied)	
1B	Transition from Tank 8D-2 to Pump Pit	Penetration of steel tank top and vault roof	Steel pump column	
			Carbon steel riser	Negative internal pressure via waste tank farm ventilation system
			Reinforced concrete tank vault and steel liner pan[1]	Positive external pressure provided by hydrostatic head kept at a constant level by pump feed
			Soil excavation in tight clayey till	

TABLE B.4.3-1a

STS CONFINEMENT BARRIER SUMMARY

No.	Structure or Component	Function	Primary Barrier	Support Barrier
2A	Supernatant Pump and Pit	Supernatant transfer	Single wall stainless steel pipe and pump Pump pit with liner (steel changer or reinforced concrete)[1] Soil backfill and tank excavation	Negative internal pressure via waste tank farm ventilation system
2B	Transition from Pump Pit to Conduit	Penetration of pump pit wall	Double wall stainless steel pipe (dual barrier) Bulkhead	
3A	High Level Waste (HLW) Transfer Conduit	Supernatant transfer	Double wall stainless steel pipe (dual barrier) Stainless steel conduit[1] Soil excavation and backfill (5-foot minimum cover)	Negative internal pressure via new STS ventilation system
3B	Conduit Transition to Pipeway of STS Building	Penetration of pipeway wall	Double wall stainless steel pipe (dual barrier) Bulkhead	

TABLE B.4.3-1a

STS CONFINEMENT BARRIER SUMMARY

No.	Structure or Component	Function	Primary Barrier	Support Barrier
4A	Pipeway of STS Building	Passageway for all hot (radiological) flows of STS process	Double wall stainless steel pipe (dual barrier)	
			Reinforced concrete pipeway of STS building with epoxy-coated catch basin and stainless steel lined sump pit[1]	Negative internal pressure via new STS ventilation system
			Partial soil embedment	
5A	Valve Aisle of STS	Process flow control	Single wall stainless steel pipe and valves	
			Steel and reinforced concrete box	Negative internal pressure via new STS ventilation system
			Valve aisle backwall bulkhead	
			Reinforced concrete pipeway of STS building with epoxy-coated catch basin and stainless steel lined sump pit	Negative internal pressure via new STS ventilation system
			Reinforced concrete lower level of STS building[1]	Negative internal pressure via new STS ventilation system
			Partial soil embedment	

TABLE B.4.3-1a

STS CONFINEMENT BARRIER SUMMARY

No.	Structure or Component	Function	Primary Barrier	Support Barrier
5B	Valve Aisle to 8D-1 Shield Structure Through Pipeway	Penetration of expansion joint between STS building and 8D-1 shield structure	Double wall stainless steel pipe (for high pressure raw supernatant) or single wall pipe for other process flows[1]	
6A	Shield Structure Over Tank 8D-1	Confinement barrier for STS process vessels	Doulbe or single wall stainless steel pipes	
			Reinforced concrete shield structure and tnak vault with epoxy-coated floor[1]	Negative internal pressure via new STS ventilation system
			Soil backfill and tank excavation	
6B	Upper Portion of STS Process Vessel in Shield Structure Over Tank 8D-1	STS processing	Stainless steel pipes	
		Vessel shield plug with gasket plus reinforced concrete shield structure and vault roof with epoxy-coated floor[1]	Negative internal pressure via new STS ventilation system	
		Soil backfill and tank excavation		
			One-inch expansion joint with rubber water stop[1]	Negative internal pressure via new STS ventilation system

TABLE B.4.3-1a

STS CONFINEMENT BARRIER SUMMARY

No.	Structure or Component	Function	Primary Barrier	Support Barrier
6C	Transition from Shield Structure into Tank 8D-1	Penetration of reinforced concrete vault roof and steel tank top	Stainless steel pipes	Carbon steel riser sleeve with flexible rubber boot. Negative internal pressure via waste tank farm ventilation system
		Reinforced concrete tank vault and steel liner pan	Positive external pressure provided by hydrostatic head kept at a constant level by pump feed	
7	Bottom Portion of STS Process Vessel in Tank 8D-1	STS processing	Stainless steel process vessel	
			Carbon steel tank	Negative internal pressure via waste tank farm ventilation system
			Reinforced concrete tank vault and steel liner pan[1]	Positive external pressure provided by hydrostatic head kept at a constant level by pump feed
			Soil excavation in tight clayey till	Partial soil embedment
8	Tank 8D-1	Storage of cesium loaded zeolite	Same as Tank 8D-2	
9	Pipeway Transition to Conduit to Tank 8D-3	Penetration of pipeway wall. Single stainless steel pipe[1]	Bulkhead	

STS CONFINEMENT BARRIER SUMMARY

No.	Structure or Component	Function	Primary Barrier	Support Barrier
10A	Low Level Waste Transfer Conduit	Transfer of decontaminated supernatant to Tank Vaults 8D-3 and 8D-4	Single wall stainless steel pipe Stainless steel conduit Soil excavation and backfill	Negative internal pressure via waste tank farm ventilation system
10B	Conduit Transition to Tank 8D-3 through 8D-3/8D-4 Tank Vault	Penetration of Tank Vault for 8D-3 and 8D-4	Single wall stainless steel pipe Soil excavation backfill	
11	Tank 8D-3 Reinforced concrete vault with stainless steel pan	Temporary storage of decontaminated supernatant	Stainless steel tank[1] Soil excavation in tight clayey till	Negative internal pressure via waste tank farm ventilation system
12	Decontaminated Supernatant Transfer Piping from 8D-3 to Tank 35104	Transfer of decontaminated supernatant from Tank 8D-3 to Tank 35104	Single stainless steel pipe soil excavation	

TABLE 4.3-1a

STS CONFINEMENT BARRIER SUMMARY

ENDNOTES

1. Highest barrier reliability for seismic.

2. Raw supernatant flows into a double wall stainless steel pipe from the valve aisle backwall, through the pipeway (lower portion of STS building) into the shield structure on top of 8D-1 Tank Vault. As the pipe transitions from the pipeway to the shield structure it passes through a building separation joint (e.g., expansion joint).

3. Decontaminated supernatant flows in a single wall stainless steel pipe from the final process component (vessel) through 8D-1 shield structure, pipeway, valve aisle and back to pipeway before it exits the STS building. All barriers in this pathway have previously been defined.

4. Decontaminated supernatant is transferred via tank roof pump pit and piping to underground Tank 35104 (Liquid Waste Treatment System).

CONFINEMENT BARRIER SUMMARY FOR SLUDGE MOBILIZATION AND WASH SYSTEM

Structure of Function	Primary Barrier	Support Barrier	Component
Tank 8D-2	Storage of Sludge and Supernatant from PUREX process	Carbon steel tank	Negative internal pressure via WTFVS
		Reinforced concrete vault and steel liner pan*	Positive external pressure provided by hydrostatic head kept at a constant level by pump feed
		Soil excavation in tight clayey till	Water saturation of clay to prevent seepage (pump supplied)
Transition from Tank 8D-2 to top of vault roof Negative internal pressure via WTFVS	Riser penetration through steel tank top and vault roof, passageway for pump and pump column	Column steel riser sleeve	Negative internal pressure via WTFVS
		Reinforced concrete tank vault and steel liner pan	Negative internal pressure via WTFVS
	Soil excavation in tight clayey till	Positive external pressure provided by hydrostatic head kept at a constant level by pump feed	

CONFINEMENT BARRIER SUMMARY FOR SLUDGE MOBILIZATION AND WASH SYSTEM

Structure of Function	Primary Barrier	Support Barrier	Component
Transition from top of vault roof to seal ring plate	Riser enclosure of pump column penetration through soil cover over tank vault roof	Carbon steel riser	Negative internal pressure via WTFVS
		40" diameter steel casing	None
		96" diameter steel culvert	None
		Concrete/grout fill between casing and culvert	None
		Soil backfill and tank excavation in tight clayey till	None
Transition from top of seal ring plate to bottom of bearing plate on spray chamber	Riser enclosure of pump column penetration	Carbon steel riser, expansion bellows, carbon steel riser spray chamber	Negative internal pressure via WTFVS
Upper and lower bearing plates	Seal for pump rotating assembly	Carbon steel upper and lower bearing plates	Negative internal pressure via WTFVS
Upper bearing plate, split support spacers, and pump mounting plate	Cap for riser enclosure and vapor seal for penetrating pump support column	Carbon steel rotating bearing, split support spacers, and pump mounting plate	Negative internal pressure via WTFVS
Pump column and shaft seals	Fluid barrier and structural support for pump and pump drive shaft	Stainless steel pump column and upper and lower mechanical seals on drive shaft	Positive internal water pressure of 50 psig and 40 ft of water column pressure.

TABLE 4.3-1b

CONFINEMENT BARRIER SUMMARY FOR SLUDGE MOBILIZATION AND WASH SYSTEM

Structure of Function	Primary Barrier	Support Barrier	Component
Shield plug	Temporary closure for riser sleeve	Carbon steel plug with concrete and steel plate shielding	Negative internal pressure via WTFVS

* Greater barrier reliability for seismic loads

** Pump column and seals are a barrier to migration of high level radioactive liquid wastes up the rotating drive shaft to the pump upper mechanical seal.

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SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE SUPERNATANT TREATMENT SYSTEM

Component or System	Safety Class	Service Class	Quality Level
STRUCTURES	N	IV	N
- Sheet Metal Building	C	IV	C
- Operating Aisle/Controlled Area			
- High-Level Waste (HLW) Tank Vault (8D-1)	C	III	C
- Liner/Sump in Structure above Modified Vault (8D-1)	C	III	C
- HLW Tank Vault (8D-2)	C	III	C
- HLW Tank Vault (8D-3)	C	III	C
- Connecting Underground Pipe Containment (Tank 8D-1 to Tank 8D-3 and 8D-4)	C	IV	C
- Connecting Underground Pipe Containment (Tank 8D-1 to Tank 8D-2)	C	IV	C
- Shield Wall in Valve Aisle (VA)	C	III	C
- VA Maintenance Door			
- VA Shield Window	C	III	C
- VA Floor Liner/Sump	C	III	C
- Pipeway (epoxy coated)	C	III	C
	C	III	C
SUPERNATANT PROCESSING			
- High-level Waste (HLW) Storage Tanks	C	III	C
• HLW Tank 8D-1			
(Modifications to provide tank access)	C	III	C
• HLW Tank 8D-2			
(Modifications to provide tank access)	C	III	C
• HLW Tank 8D-3			
- Supernatant Processing Tanks			
• Supernatant Feed Tank	N	IV	N
• Sluice/Lift Water Tank	N	IV	N
• Fresh Water Tank	N	IV	N
• Break Tanks	N	IV	N

TABLE D.4.4-1a

(Continued)

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE SUPERNATANT TREATMENT SYSTEM

Component or System	Safety Class	Service Class	Quality Level
- Pumps			
• Supernatant Pump	N	III	N
• Supernatant Feed Pump	C	IV	N
• Sluice/Lift Water Pump	C	IV	C
• Sluice Water Recycle Pump	C	IV	N
• Fresh Water Pump	N	IV	C
• Decontaminated Supernatant Transfer Pump	N	III	C
• Cooling Fluid Transfer	N	IV	N
• Break Tank Pumps	N	IV	N
• Zeolite Distribution Pumps	C	III	C
- Heat Exchangers			
• Supernatant Cooler	N	III	C
• Chiller	N	III	C
• Air Cooled Condenser	N	III	C
- Filters			
• Supernatant Prefilter	N	III	C
• Decontaminated Supernatant Prefilter	N	III	C
- Material Handling System			
• VA Crane	N	IV	N
• Operating Aisle Crane	N	IV	N
• Mobile Cranes (as needed)	N	IV	N
• VA Manipulator			
• VA Transfer Equipment	N	III	C
• Zeolite Handling	N	IV	N
• Fresh Zeolite Fines	N	IV	N
Removal	N	IV	N
- Process Piping			
• Supernatant	C	III	C
• Decontaminated Supernatant	C	III	C
• Chemical Addition	N	IV	N
• Remainder	N	IV	N

TABLE D.4.4-1A

(Continued)

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE SUPERNATANT TREATMENT SYSTEM

Component or System	Safety Class	Service Class	Quality Level
- Valves			
• Supernatant	C	III	C
• Utility	C	III	C
• Decontaminated Supernatant	C	III	C
• Full-port Ball Valves (IX Column Discharge)	N	III	C
• Zeolite Jumpers			
• Chemical/Zeolite	N	III	C
Addition	N	IV	N
• Remainder			
- Process Valve Manifold/Racks	C	III	C
- Ion Exchange Columns	N	IV	N
MONITORING SYSTEMS, CONTROLS AND INSTRUMENTATION			
- Area Radiation Monitors	C	IV	C
- Airborne Particulate Monitors	C	IV	C
• Continuous Air Monitors			
• Effluent Monitors			
- Ventilation Monitoring System and Alarms	C	IV	C
- Supernatant Sampling System	C	IV	C
- Process Radiation Monitoring	C	III	C
- Communications Equipment	N	IV	N
- Lighting (VA)	N	IV	N

(Continued)

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE SUPERNATANT TREATMENT SYSTEM

Component or System	Safety Class	Service Class	Quality Level
- Electronic Systems and Controls			
• VA and Critical Apparatus in other Locations	C	III	C
• Controlled Area	N	IV	N
• Remainder	N	IV	N
- Pneumatic Instruments and Controls			
• VA and Critical Apparatus in other Locations	C	III	C
• Controlled Area	N	IV	N
• Remainder	N	IV	N
- Instrument Racks	N	III	C
- Instruments and Sensing Elements (operational)	C	III	C
• VA and Critical Apparatus in other Locations			
• Controlled Area	N	IV	N
• Remainder	N	IV	N
UTILITIES AND SUPPORTING SYSTEMS			
- Electrical Power Systems	C	III	C
• Valve Aisle Supply	C	IV	C
• Operating Aisle and Controlled Air Supply	C	IV	C
• Control Panel	C	IV	C
• Motor Control Center	C	IV	C
• Conduits and Trays	C	IV	C
• Utility Air (pumps/sumps)	C	III	C
• Instrument Air (operating valves)	C	IV	C
• Recycled Condensate Evaporator	N	IV	N
• Demineralized Water	N	IV	N
• Fire Detection and Protection	N	IV	N
• Safety Shower and Eyewash			

TABLE D.4.4-1a

(Concluded)

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE SUPERNATANT TREATMENT SYSTEM

Component or System	Safety Class	Service Class	Quality Level
• Lightning Protection	N	IV	N
VESSEL VENT SYSTEM	C	III	C
HEATING AND VENTILATION (HV) SYSTEM			
-Ducting and Dampers	C	III	C
-Blowers	C	III	C
-Exhaust Filtration	C	III	C

NOTE: At boundaries between items of differing Safety Classification, interfaces appropriate to the higher Safety Class must be provided.

TABLE D.4.4-1b

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE SLUDGE MOBILIZATION AND WASH SYSTEM

Component or System	Safety Class	Service Class	Quality Level
PUMPS			
- Sludge Mobilization Pumps	C	III	C
- Electrical Support Equipment	C	III	C
STRUCTURES			
- Pump Weather Enclosures	N	IV	N
- Pump Support Structure	C	III	C
- Tank Access Risers	C	III	C
- Pump Spray Chambers	C	III	C
SLUDGE WASH SOLUTION PROCESSING			
- Ti-treated Zeolite	C	III	C

D.5.0 STS AND SMWS FACILITIES DESIGN

D.5.1 SUMMARY DESCRIPTION OF THE STS AND SMWS

D.5.1.1 LOCATION AND FACILITY LAYOUT

The STS and the SMWS, are located within the WVDP WTF. Figure D.5.1-1 shows the location of STS and SMWS structures and facilities in relationship to the WVDP site.

Radioactive operations of the STS are to be conducted within the modified structures of HLW Tanks 8D-1, 8D-2, and 8D-3; in a pipeway and valve aisle adjacent to Tank 8D-1; within interconnecting pipe conduits underground; and within the Ventilation Systems. The major STS processing components that are in radioactive service are located within the modified structure of spare HLW Tank 8D-1. The PVS has been erected on the Tank Farm in the vicinity of Tank 8D-1 and housed in the V&S Building.

Sludge washing operations of the SMWS will be conducted within the modified structures of HLW Tank 8D-2 on a support truss that spans the tank vault and is within the WTF. Figure D.5.1-2 is a plan view of Mobilization Pumps in Tank 8D-2 and Figure D.5.1-3 is a cross section view of the Mobilization Pump in the 8D-2 modified structures. The major SMWS processing components that will be in radioactive service will be located within and above HLW Tank 8D-2. The electrical support equipment for the SMWS is housed within the V&S Building.

STS nonradioactive support operations are conducted in the STS Support Building, located at the northwest perimeter of Tank 8D-1. This building houses the STS control room and various cold operations and utility services required to support STS operations. Table D.5.1-1 lists the location of major STS components and Figure D.5.1-4 shows the layout of the STS facilities.

SMWS nonradioactive support operations will be conducted in the V&S Building, located at the northwest perimeter of Tank 8D-1. This building will house the SMWS control room and various motor controllers for SMWS operations.

D.5.1.2 PRINCIPAL FEATURES OF THE STS AND SMWS

The primary objective of the STS is to pretreat the HLW presently stored in Tank 8D-2. The HLW stored in Tank 8D-2 has physically separated into a liquid phase salt solution (supernatant) above a semisolid sludge. Volume reduction will be accomplished by removal of the cesium contained in the supernatant and interstitial liquid in the sludge, allowing disposal of decontaminated supernatant and sludge wash solution as LLW.

Within the STS the supernatant has been and the sludge wash solutions will be "decontaminated" into a salt solution of relatively low radioactivity that will be transferred to the LWTS for volume reduction and ultimate incorporation into a cement matrix. The cement will be disposed of as a LLW (see SAR Volume IV, "Low-Level Class B and Class C Radioactive Waste Handling, Storage, and Disposal Operations for the Radwaste Treatment System Drum Cell").

The primary objective of the SMWS is to mix the settled PUREX sludge with dilute caustic solutions. The existing STS will treat these solutions using the same equipment used to treat the supernatant except that the composition of the ion exchange material will differ.

The majority of the cesium and a fraction of the plutonium and strontium originally contained in Tank 8D-2 and dissolved in the supernatant or dissolved from the sludge during sludge washing will be loaded onto an inorganic zeolite within the STS ion exchange system and will be stored at the bottom of Tank 8D-1. The loaded ion exchange medium (zeolite) will ultimately be transferred from Tank 8D-1 to the VF for use as melter feed blended with the washed sludge remaining at the bottom of Tank 8D-2 and the THOREX waste from Tank 8D-4. Section D.6.0 presents detailed discussions of STS and SMWS Process Systems and Operations. Figure D.5.1-5 is a schematic diagram of the STS Process.

The WVNS site boundary, exclusion area, restricted area, and layout/location of site utility supplies are noted in Section B.5.1.2 of Volume II. STS utility supplies are directed from the main plant with local control exercised from the STS Support Building or from the SMWS Mobilization Pump Enclosure Buildings, as appropriate. The STS PVS exhausts effluent air from a small 10-meter stack (33 ft) located on the WTF. Section D.7.4.1 presents a detailed discussion of the PVS. The original WTFVS, which will continue to supply ventilation to Tanks 8D-1, 8D-2, 8D-3, and 8D-4 for contamination control during STS operations, exhausts through the main processing plant stack along with exhausted air from other Project activities. Section D.7.4.2 discusses the WTFVS.

D.5.2 FACILITY MODIFICATION AND CONSTRUCTION FOR THE STS AND SMWS

D.5.2.1 MODIFICATIONS TO ORIGINAL FACILITIES

Modifications have been made to the HLW tanks and their vaults in order to install STS and SMWS equipment. The major processing components (nonpump) that are in radioactive service are installed within Tank 8D-1 and the STS valve aisle. The supernatant and decontaminated supernatant transfer pumps are installed in Tanks 8D-2 and 8D-3 respectively. The sludge mobilization pumps will be installed in Tank 8D-2.

On-site development and testing using a one-sixth scale model (Schiffhauer, 1987) has shown that the sludge can be resuspended and removed from the tank bottom, as demonstrated for HLW at other DOE facilities, using multiple mixing pumps.

Rockwell (1984) conducted a static analysis for Tank 8D-2 to substantiate the adequacy of the tank roof when two of the steel roof rafters were cut for remote installation of the mobilization pump risers. This analysis demonstrated the adequacy of the modification to the tank under gravity loads.

A dynamic interaction analysis between the steel tank, interconnecting pump access risers and concrete vault was not performed. However, dynamic analysis by Lawrence Livermore Laboratories (1978) indicated horizontal relative movement at the tank roof under twice the design basis earthquake would be relatively small. Furthermore, considering the very low relative stiffness associated with the risers as compared to the entire tank and its surrounding vault, engineering judgment would conclude that little transfer of force and thus insignificant interaction effects would be induced in the tank due to riser attachment. The risers are not anchored laterally to the tank vault but are permitted to slide on a steel pipe casing, thus isolating them from forces that might have been produced by the relative motion between the steel tank roof and the vault roof under earthquake conditions. A separation gap of 25 mm is provided for construction tolerance requirements around the risers installed for use in the SMWS. This gap will also accommodate relative movements that might be induced in an earthquake. Gates (1986 and 1991a) has shown analytically that the pump access riser welded at the top of the tank could withstand four times the design basis earthquake before rupturing.

D.5.2.1.1 MODIFICATIONS TO TANK 8D-1

Detailed discussions of the methods and safety aspects of the necessary modifications to Tank 8D-1 are presented in Brown (1985a). A summary of facility modifications for the STS is presented in this section.

Modifications have been made to the spare liquid waste storage Tank 8D-1 for the operation of the STS and future zeolite removal operations. Major process components of the STS are located within Tank 8D-1, and the tank is used as a storage reservoir for the loaded zeolite (ion exchange material) produced by the STS process. Tank modifications were made for the installation of the zeolite mobilization/removal pumps that will be used to slurry the loaded zeolite and the supernatant postfilter sand (see Section D.7.2) from the tank bottom and transfer it to the Vitrification System. On-site scale model development testing have also shown that the zeolite and the postfilter sand can be resuspended and removed from the tank bottom as had been demonstrated for HLW at other DOE facilities.

The modifications to Tank 8D-1 included the following major steps and activities:

- Excavation to expose a portion of the tank vault concrete roof.
- Penetration of the vault roof.
- Removal of rafter sections from the tank roof and installation of cross channel beams.
- Installation of riser assemblies between the vault and tank roof. These risers are carbon steel and are welded to the tank roof.
- Penetration of the tank roof within the riser assemblies.
- Installation of STS components and zeolite mobilization pumps.

Tank 8D-1, like 8D-2, is a reinforced carbon steel vessel, approximately 8 m (27 ft) high by 21 m (70 ft) in diameter, with 20 cm (8 in) channels on 38 cm (15 in) centers skip welded to then and Wash System
vessel is fully contained within a 61-cm (2-ft) thick reinforced concrete vault. The modifications to Tank 8D-1 were necessary for the vessel to be used as a secondary containment for the supernatant treatment system and to permit zeolite removal for melter feed. For both purposes, holes were cut

through the vault and roof of Tank 8D-1. The holes cut for the STS (10) house the major process components that are in radioactive service. The holes cut for zeolite mobilization and removal (6) will be for the zeolite mobilization pumps. The tank penetrations required for the installation of the STS and for the two zeolite pumps located in the STS area were performed manually. The remaining penetrations for the zeolite mobilization and removal pumps were cut remotely to gain experience for riser installation in Tank 8D-2. Figure D.5.2-1 depicts the locations of STS component and zeolite mobilization pump (WVNS sluice pump) penetrations made in the STS area of the Tank 8D-1 roof. Table D.5.2-1 provides pertinent information regarding these penetrations and is keyed to Figure D.5.2-1.

The vault roof is cut above each required tank penetration. Cuts were made one at a time. Vault holes were made with a water-jet cutter (manual) or a concrete coring device (remote).

After all vault holes were cut, tank top modifications began. Risers from the tank top through the vault were installed one at a time. First, the steel tank roof was modified by installing channel beams between the rafters after the rafters were cut so that the integrity of the roof framing was not compromised. Then, rafter portions in the area of the penetrations were removed and weld preparations made at the tank top. For all penetrations except the five zeolite pump locations not in the STS area—locations M-2, M-3, M-6, M-7, & M-8—(see Figure D.5.2-1), these activities were done manually by workers within the vault on the tank roof.

The riser assemblies were lowered through the vault hole and welded manually to the top of the tank. STS penetrations were used as a two-part riser sleeve and boot arrangement with the lower portion (boot) welded to the tank roof. For the five pump penetrations outside the STS area (see Figure D.5.2-1), the one-piece riser was welded directly to the tank top. Welds were then inspected, the roof cut, a shield plug installed, and riser installation continued at the next vault hole.

Once all risers were in place and welded to the tank roof, cuts were then made into the tank roof. The welded riser assembly ensures that once the tank roof has been penetrated, there is no communication between the tank contents and the vault. The Tank Farm Temporary Ventilation System (TVS), which has been replaced by the PVS, maintained downward air flow through the open riser and into the tank through the roof cut. Only one tank roof penetration was open at a time for short periods. Safety and environmental aspects of the TVS are addressed in Brown (1985a). Design and operation of the TVS is discussed in Schiffhauer (1985).

Cutting the five penetrations outside the STS area for the zeolite mobilization/removal pumps included the same basic steps as the STS penetrations, but it was done remotely. A boom crane was used to lower a turntable mechanism down through the riser to the tank roof. The turntable was used for both welding and cutting. A closed-circuit TV system was used to monitor these activities. Demonstration of the remote techniques at Tank 8D-1 was useful in preparing for the installation of the risers on the roof of Tank 8D-2 for supernatant and sludge removal. Figure D.5.2-2 illustrates the remote riser installation technique and use of the remote turntable for cutting and welding the tank roof.

Once all penetrations were made in the tank roof, the installation of STS process components began. The components were suspended in the tank from a structural steel lattice is supported by the reinforced members that are in turn supported by the concrete pipeway walls. The major components installed within Tank 8D-1 include the supernatant pre- and postfilters, cooler, feed tank, zeolite columns (4), sluice water tank, and the various pumps (see Table D.5.2-1). During equipment installation only one tank penetration was opened at a time. The structural analysis performed for Tank 8D-1 modifications is described in Section D.5.2.3.1.

D.5.2.1.2 MODIFICATIONS TO TANKS 8D-2 AND 8D-3

The supernatant transfer pump now installed within Tank 8D-2 will transfer sludge wash solution to the STS. Cutting of the vault and tank roof and installation of the riser and pump assemblies were done remotely as previously described for the zeolite mobilization removal pumps installed in Tank 8D-1. 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 (concrete or steel) which provides a secondary containment interface with the Waste Transfer System (HLW conduit - see Section D.5.2.2). Additionally, in a similar remote manner, sludge mobilization pumps will be installed within Tank 8D-2 for the mobilization of the HLW sludge in the tank. Detailed discussions of the safety and environmental aspects of modifications to Tank 8D-2 for installation of access users and equipment are provided in Brown (1986). The modifications to Tank 8D-2 included the following major steps and activities:

- Excavation to expose a portion of the concrete tank vault roof.
- Coring of the vault roof.
- Removal of rafter sections from the tank roof and grinding of the roof top.
- Installation of riser assemblies between the vault and tank roof. These risers are carbon steel and are welded to the tank roof.
- Penetration of the tank roof.
- Installation of a shield plug or SMWS mobilization pumps.

The decontaminated supernatant or wash solution transfer pump, which transfers the LLW salt solution from Tank 8D-3 to the LWTS, was installed in Tank 8D-3. As Tank 8D-3 never contained HLW, its radiological environment was similar to that of Tank 8D-1 (relatively low compared to Tanks 8D-2 and 8D-4).

Therefore, this installation was done manually like the STS components installed in Tank 8D-1 as previously described. This pump discharges through a steel-lined pump pit constructed on the vault roof secondary containment.

D.5.2.2 NEW FACILITY CONSTRUCTION

In addition to the previously described modifications to the original HLW tanks, the following new structures were erected for the STS:

D.5.2.2.1 PIPEWAY

A concrete and steel "shield structure" pipeway) was erected on top of the Tank 8D-1 vault and structurally supported by the vault sides. Concrete pilings support the valve aisle and STS support building. The pilings are 17 m (55 ft) deep.

The outer walls of the pipeway are formed by a curb with support columns to allow for piping runs. These retaining walls and columns support the structural members that span between them and support the STS equipment. The walls and columns also support the concrete roof and structural beams. Figure D.5.2-3 shows the pipeway above the 8D-1 vault with the STS components suspended from the vault roof/pipeway floor into the tank.

The upper portions of the STS components suspended from the shield structure floor (vault roof) are sealed with water stops and epoxy. The epoxy extends over the riser lips. This prevents communication between STS fluids that may leak and the Tank 8D-1 vault. Any leakage into Tank 8D-1 from the components will be identified by routine analysis of Tank 8D-1 process water samples. Leakage into the shield structure above the Tank 8D-1 vault will result in increased concentrations of radioactive material in the STS PVS off-gas and will therefore be detected by the STS Effluent Monitoring System.

D.5.2.2.2 VALVE AISLE

A shielded Valve Aisle constructed at the northwest perimeter of Tank 8D-1 contains remotely operated valves and associated instrumentation. The Valve Aisle also contains shield windows and manipulators to permit remote operation and replacement of components. The shielded walls and roof of the Valve Aisle are constructed with 30 cm (12 in) of steel. The Valve Aisle provides secondary containment of HLW piping and valves between the Operating Aisle in the STS Support Building and Tank 8D-1. The Valve Aisle is shown in Figure D.5.2-4.

Any leakage into the Valve Aisle or the pipeway behind the Valve Aisle back wall is collected in a common sump located near the back wall of the Valve Aisle. Level indicators in the sump detect any liquid buildup and activate a pump to transfer the sump contents to Tank 8D-2. Any leakage onto the top of Tank 8D-1 will enter Tank 8D-1 via the radwaste drain.

D.5.2.2.3 STS SUPPORT BUILDING

Attached to the Valve Aisle is the STS Support Building, which contains auxiliary support systems and equipment for operation of the STS. This structure houses the fresh water and zeolite storage tanks, associated delivery systems, control room, HVAC equipment, and utility services. The building is maintained as a radiologically "cold" area. The orientation/layout of the pipeway, Valve Aisle, and STS Support Building relative to Tank 8D-1 is shown in Figures D.5.2-5 and D.5.2-6. The Support Building is shown in Figure D.5.2-7.

D.5.2.2.4 WASTE TRANSFER SYSTEM

Transfer pipelines carrying HLW and decontaminated supernatant or sludge wash solution are enclosed as described below:

- Sludge wash solution between Tanks 8D-2 and 8D-1 via a pipe conduit, the pipeway, and valve aisle.

- Decontaminated sludge wash solution to/from Tank 8D-3, from/to the STS pipeway, and to Tank 5D-15B.

Secondary containment is provided for pipelines carrying HLW. Piping carrying sludge wash solution between Tank 8D-2 and the STS is double-walled stainless steel contained within a stainless steel conduit pipe. Leak detection is also provided for these lines. Piping carrying decontaminated sludge wash solutions between the ion exchange columns and Tank 8D-3 is contained inside a stainless steel conduit pipe which provides double containment.

Seismically designed concrete or steel shield walls provide secondary containment for all piping within the Valve Aisle and Pipeway areas of STS.

After confirmation of its activity level, decontaminated sludge wash solutions will be transferred between Tanks 8D-3 and 5D-15B in the LWTS in a single wall stainless steel pipe. Portions of this piping are direct-buried and contained within a 25 cm (10 in) polyvinylchloride pipe (hazardous waste containment) with the remainder located inside of a nonseismic concrete culvert. All other utility (nonradioactive) piping within STS is single-walled.

At a future date, loaded zeolite will be transferred from Tank 8D-1 to the VF along with HLW sludge from Tank 8D-2 and HLW THOREX waste from Tank 8D-4. The design and safety analysis of this piping will be addressed separately in the SMS HLW Transfer SAR. (Table D.1.5-1).

D.5.2.2.5 STS HV AND PVS

A heating and ventilation system (HVAC) was constructed to support STS operations. The STS PVS is located in the Tank Farm near Tank 8D-1. The remaining components such as air supply units and temperature control equipment are located within the STS Support Building. This system supplies fresh air to the occupied areas of the STS Support Building. Air is exhausted to the environment from a stack located in the Tank Farm following treatment by the PVS. The STS HVAC System and the PVS are described in detail in Sections D.5.4.1 and D.7.4.

Tanks 8D-1, 8D-2, 8D-3, 8D-4, and the major STS and SMWS components suspended in Tank 8D-1 are normally vented by the original WTFVS (see Sections D.5.4.2 and D.7.4).

D.5.2.3 STRUCTURAL SPECIFICATIONS

The WVDP is being implemented through use of existing technology and standard engineering procedures to the maximum extent feasible. Thus, existing nuclear and commercial indust. codes and standards can be used to guide the design, construction, and installation of various systems associated with the Project. The choice of construction materials, design approaches, and construction methods are well tested and have been used in many other nuclear facilities. This provides a high degree of confidence that structures/systems will behave in a predictable manner. Engineering codes, construction codes, and standards applicable to the general design and operation of the STS are listed in Table D.5.2-2. Applicable design codes for each of the major STS and SMWS confinement barriers (see Section D.4.3.2 and Table D.4.3-1) are provided in Tables D.5.2-3a and D.5.2-3b.

D.5.2.3.1 STRUCTURAL ANALYSES OF THE MODIFICATIONS TO TANK 8D-1 FOR THE STS

D.5.2.3.1.1 DESIGN CRITERIA

The American Concrete Institute (ACI) Standard 318-77, appropriate loads and load combinations from ACI 349, the UBC Zone III, and 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 used in designing the structural steel elements of the structure. 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 structures 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 Laboratory (LLL 1978) was used to prorate and verify the calculated dynamic soil pressure. The soil pressure established for 0.1 g seismic ground acceleration was translated into an equivalent static force using a Mononobe-Okabe formula.

D.5.2.3.1.2 DESIGN OF CONCRETE SHIELD STRUCTURE

The loads and load combinations described in the previous paragraph 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 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 statics analysis methods were utilized in the design of both reinforced concrete and structural steel members.

D.5.2.3.1.3 CONCRETE TANK 8D-1 VAULT INTEGRITY ANALYSIS

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

- Maintenance of the vault integrity as a result of the loads from the shield structure (i.e., dead loads, STS components and piping loads in conjunction with other pre-existing loads);
- Verification of vault structure integrity subsequent to the removal of concrete cut-outs for the STS components and;
- Maintenance of vault integrity under a concrete bucket drop during construction.

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 reviewed and the most critical stress elements were then used to verify the vault reinforcement and stresses within the concrete.

As a result of the vault's floating during the original construction period, the vault ceiling and bottom underwent stresses that caused cracking (see Section D.9.3.2.2). This crack pattern was mapped by Bechtel. It was factored into the vault analysis and resulted in the imposition of allowable load limits during the construction phase (during and after cutting 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 will comply with ACI-318 during construction and operation.

D.5.2.3.1.4 STEEL TANK 8D-1 MODIFICATIONS

Since the steel roof girders were not cut and loads on the channel rafters after cutting were locally transferred to the roof girders, the steel tank as a whole was not reanalyzed dynamically or statically. The equipment suspended inside Tank 8D-1 is structurally isolated from the carbon steel tank roof. The steel liners (risers) connecting the carbon steel tank with the concrete vault contain a flexible "boot" to maintain tank and vault isolation at all times.

In summary, this structural modification approach did not cause additional stress on the original steel tank.

D.5.2.3.2 STRUCTURAL ANALYSES OF THE "MODIFICATIONS" TO TANK 8D-2 FOR THE SMWS

D.5.2.3.2.1 DESIGN OF THE SMWS STRUCTURE

The loads and load combinations described in Section D.5.2.3.1, Ebasco (1985) and Schiffhauer (1986) were utilized in the design of the steel and concrete structures. The steel truss framing system was designed to carry the pump loads and transmit them to the ground. Dynamic loads from the operation of the mobilization pumps were also analyzed. The mobilization pump operating frequencies are approximately 30 Hz (1800 rpm). Startup frequencies could be as low as 10 Hz under transient conditions. The pump support structure was specifically designed to act as a relatively stiff platform under lateral seismic loads to minimize the potential of pump column impact with risers and tank bottom obstructions (Ebasco, 1986). Furthermore, to minimize resonance with the pump operating frequencies, a 10 Hz separation was provided as the design objective of the support structure. Independent dynamic analysis of the pump support structure and its flexible foundation system (Gates, 1991a) shows that the fundamental translational modes of the truss in the horizontal and vertical directions are on the order of 2.5 to 4 Hz. Horizontal translation perpendicular to the longitudinal axis (e.g., transverse translation) has a natural frequency of 2.5 Hz. Thus, a separation between the fundamental truss frequencies and the operating frequency of the motor has been provided that exceeds the design objective of 10 Hz. Higher modal flexural frequencies of the truss in its fundamental transverse and longitudinal modes are in the range of 4 to 5 Hz, still well below the operating frequency of the pump motors. No restrictions have been imposed on the operating frequencies of the pumps to minimize resonance that might result from multiple pump operations. The riser loads are applied to the vault roof. Traditional analysis methods were utilized in the design of both reinforced concrete and structural steel members (Ebasco, 1986).

D.5.2.3.2.2 CONCRETE TANK 8D-2 VAULT INTEGRITY ANALYSIS

The Tank 8D-2 concrete vault was analyzed to verify that vault integrity would be maintained with the loads from the new access risers and subsequent to the removal of concrete cutouts for the SMWS pump components (Rockwell, 1985).

Detailed documentation of the concrete tank vault flotation during construction along with mitigative action has been documented by Barnstein (1965 and 1966) (Gates, 1991): An extensive program of soil investigation was carried out using a series of shafts under the tank vaults to identify the state of cracking in the vault slabs as well as the voids that had developed under it. These materials were removed and the entire tank area was grouted and brought into a relative level alignment, slightly twisted out of original tank orientation.

The loads used in the analysis included 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 used in verifying vault reinforcement and stresses within the concrete (Ebasco, 1986).

Soil properties used in the analysis were verified by additional borings and sample testing (Gates, 1986). Design standards used in the analyses can be found in the references used in Table D.4.3-2.

In summary, based on the assessment under the load conditions and combinations discussed above, the Tank 8D-2 vault integrity has been maintained (Ebasco, 1990, 1986a).

D.5.2.3.2.3 STEEL TANK 8D-2 MODIFICATIONS

The tank top was analyzed assuming the steel roof girders had not been cut and a maximum of two channel rafters had been cut. The steel tank as a whole was reanalyzed statically. The steel risers connecting the carbon steel tank were pulled in tension and supported on the vault, this results in the same roof loads as existed before modifications. In summary, this structural modification approach does not cause additional stress on the original steel tank roof (Rockwell, 1984).

D.5.3 STS AND SMWS SUPPORT SYSTEMS

D.5.3.1 VENTILATION

Operation of the STS is supported by two separate and independent ventilation systems: the STS PVS and the original WTFVS. These two systems are described in detail in Sections D.5.4.1 and D.5.4.2, respectively.

The PVS provides fresh air and temperature control to occupied areas in the STS Support Building and exhausts air for contamination control from the STS Valve Aisle and pipeway through the STS PVS stack. Major components of the

PVS are contained and protected from the weather in a metal building located on the Tank Farm near Tank 8D-1. The STS PVS is additionally described in Section D.7.4.

The original WTFVS will continue to exhaust air for contamination control from the HLW tanks (8D-1 through 8D-4) during normal STS operations along with the off-gas from the STS processing components suspended in Tank 8D-1. Following off-gas treatment (see Section D.7.4), the exhausted air is combined with effluents from other Project activities and monitored at the Main Processing Plant Stack before to release to the environment.

D.5.3.2 MONITORING AND LEAK DETECTION SYSTEMS

Operation of the STS is supported by various monitoring and leak detection systems for process control and to ensure that on-site and off-site exposures to radiation and radioactive materials are maintained ALARA. These systems are described in this section and in detail within other sections of this SAR, as noted.

D.5.3.2.1 ENVIRONMENTAL MONITORING SYSTEMS

Effluent releases from the operation of the STS are monitored via the existing on-site and off-site monitoring program that has been in place since the inception of the WVDP in 1981. This program is described in Section A.8.6.1 of Volume I. Minor modifications have been made to this program to meet the specific monitoring requirements associated with operation of the STS.

Details and results of the WVDP on-going monitoring program are available in a[illegible] reports. It is envisioned that the current program will be continued [illegible] il the WVDP is completed.

The PVS, located in the Tank Farm near Tank 8D-1, is locally monitored by an additional effluent sampling system similar to that used for continuous monitoring of exhausts from the original WTFVS at the Main Processing Pl ıt Stack.

The specifics regarding instrumentation and methods used to continuously monitor radioactivity in airborne effluents from the STS are described in Section D.8.6.1.

D.5.3.2.2 ON-SITE EXPOSURE CONTROL

The Health Physics and Radiation Protection Programs for the STS is the same as for other Project activities and is operated in accordance with the requirements of the WVNS Radiological Controls Manual, WVDP-010.

Workers are individually monitored for external radiation exposure via thermoluminescent dosimeters (TLDs) that are exchanged and analyzed on a routine basis. Area Radiation Monitors (ARMs) and Continuous Air Monitors (CAMs) are appropriately located within occupied areas of the STS support building and the V&S Building, which provides audible and visual alarms should external radiation levels or airborne radioactivity levels exceed preestablished set points.

The Health Physics program for the Project is described in Section A.8.5 of Volume I. Additional information on radiation detection instrumentation for worker protection during STS operations is presented in Section D.8.3.4.

D.5.3.2.3 PROCESS CONTROL

Radiation monitoring instruments (on-line monitors) are also used in the STS to monitor the radioactivity within contained systems such as pipes and vessels. During system on-line operations readouts of these devices are continuously monitored in the STS control room. Alarm indications are provided on an annunciator panel in the STS control room if preestablished limits are exceeded.

Additionally, the Pneumatic Transfer System is used to routinely extract process samples for off-line analysis from the valve aisle. These samples are remotely removed from the process and transferred to the analytical cell in the main processing facility for various radiochemical analyses. Analyses of process samples, used in combination with the radiation monitors, ensure that radioactivity is not transferred to systems/areas not intended to receive such material.

Monitoring and sampling systems and procedures for STS process control are described in detail in Section D.6.7. Radionuclide concentration limits and related process monitoring requirements are discussed in Volume VI, TR-IRTS-5.

D.5.3.2.4 LEAK DETECTION SYSTEMS

In addition to the environmental and radiation monitoring systems previously described in this section, several leak detection systems are used in the STS to identify leakage of process solutions.

A liquid level detection system exists (as NFS, Inc. original equipment) in both the Tank 8D-1 and 8D-2 pans to identify leakage from the HLW tanks. (An examination of the vault/pan/tank design makes it clear that the pans function more to facilitate leak detection than to serve as secondary containment. This latter function is served by the concrete vaults.) Leaked fluids can be returned from the pans to the tanks via pumps.

The immediate area surrounding HLW Tanks 8D-1 AND 8D-2 has a series of water monitoring and injection wells. These wells allow measurement of groundwater level and water sampling for radioactive contamination analysis. Monitoring and trending on these many wells has indicated uniform groundwater levels between wells and no radioactive contamination has been discovered.

Currently per a SOP, a monitoring well within the WTF area is monitored for groundwater level, three times daily, and radioactivity, weekly and prior to pumping out of groundwater.

The groundwater level surrounding the vaults is maintained at a minimum elevation (above the bottom of the 8.2 m [27 ft] HLW Tanks) of 7.6 m (25 ft) by way of a level indicating controller which allows water to be injected into wells. The 2,300,000 L (600,000 gals.) working capacity of each HLW Tank corresponds to a 6.7 m (22ft) height, which is lower than the minimum ground water elevation. Since at least 1982, no water injection has been necessary to maintain this minimum groundwater level. This is due to the high ground water table at the site. WVNS is forced to pump ground water out of a dewatering well and sump from underneath the vault to maintain the ground water level within a desired range (7.6 m [25 ft] to 10.3 m [34 ft]). The frequency of pumping depends on the seasonal climatology; however, the well is typically pumped between one and four times per month throughout the year.

The carbon steel pan in the 8D-2 vault has been tested, and it is apparent that a leak exists that allows water to pass between the pan and vault. The pan itself cannot, therefore, be considered as either containment or as a full range adjunct to the detection system for leaks from Tank 8D-2. However, the liquid level detection system in 8D-2 continues to be a viable detection system for potential tank leaks whose rate of outflow exceeds that of the pan or whose volume would be large enough to register on the pan level detector.

The pan contents in the 8D-1 vault are still isolated from the vault. When water is pumped from the pan, the vault level does not change. The water that does collect in the pan is analyzed for radioactivity.

If either tank were to leak, the vault and silty till soil around the vault provide the containment t prevent leakage to the accessible environment. Water can be injected around the outside of the vaults to maintain a piezometric potential greater than the level that would exist if the entire contents of either Tank 8D-1 or 8D-2 were released to their respective vaults. The head on the outside of the vault would cause the leakage to be from the outside to the inside. The water on the outside of the vaults also keeps the silty till wet and highly impermeable (very low migration rates ~ 10^{-8} cm/s) to water flow. A review of the injection well water addition records for the past year has shown that no water needed to be added to the system. This is indicative of the "tightness" of the soils in which the tanks are situated and of the fact that natural infiltration is typically sufficient to maintain the desired degree of soil saturation. A review of the Tank 8D-1 and 8D-2 pans sample records indicate water does infiltrate into the pans. No records are kept as to the volume of water pumped from the pans. The level instruments that exist in each vault have high-level alarms that are set to keep this water off the bottom of the waste tanks.

A large seismic event, in excess of the design basis event, could hypothetically rupture the tank and the vault. However, the inward piezometric gradient and the highly impermeable nature of the surrounding soils make the release of HLW to the accessible environment highly unlikely. The high clay content and over consolidated nature of the surrounding, undisturbed silty till are, in effect, a highly durable "bathtub" for the 8D-1/8D-2 vault complex. Since much of the water is effectively "locked up" in the clay fraction of the till it is highly unlikely that it could be lost during a seismic event. Furthermore, even if water in the system were to be lost or head differentials were to equilibrate, additional water could easily be added to the system. This could be accomplished via the injection system or, failing that, through the standpipes that surround both vaults and are in direct hydraulic communication with the gravel layer that underlies the vaults.

Leakage in the valve aisle/pipeway areas will be collected in a sump. Actuation of a pump will return fluids to Tank 8D-2. A level alarm in this sump identifies the leakage condition.

Additionally, a leak detection system is installed within the annular space between the double walls of the STS transfer piping. Leaked fluids will be returned by gravity to Tank 8D-2. The transfer conduit between Tank 8D-2 and STS is connected by a drain to Tank 8D-2 in the event that the double-walled pipe leaks into the conduit. A summary of leak detection and mitigation capabilities for the major structures/barriers of the STS is presented in Table D.5.3-1.

All operating procedures for transferring liquids require that the start of the transfer process be monitored to ensure that corresponding volume increases and decreases occur as expected or that the transfer can be secured immediately.

Mobilization pump seal performance will be routinely monitored to determine if any contamination is migrating into the pump column.

D.5.3.2.5 CONTAINMENT METAL CORROSION

WVNS has a program in place for monitoring and control of corrosion in carbon steel HLW Tanks 8D-1 and 8D-2.

Tank wall thicknesses of Tanks 8D-1 and 8D-2 were last measured in 1982 using ultrasonics. There was no evidence of thinning of the tank walls through general corrosion. Visual inspection of internal and external tank surfaces indicated loose surface scale and pitting. The design corrosion allowance for these HLW tanks is 6.4 mm (0.250 in).

Tank 8D-3 is a stainless steel tank used as a temporary hold tank for decontaminated sludge wash solutions and has never been used to contain HLW. Therefore it has never been inspected.

Tank 8D-4 is also a stainless steel tank since it contains an acidic THOREX waste. Inspection of corrosion coupons, which were removed in 1987, indicated minimal thinning (i.e., at least an order of magnitude less than that in Tank 8D-2 - 0.003 mm [0.12 mils] total of corrosion over a 7.5 year time span). The design corrosion allowance for the stainless steel HLW tanks is 1.8 mm (0.07 in).

Corrosion is controlled in carbon steel HLW Tank 8D-1 by the addition of corrosion inhibitors (i.e., caustic for pH control and sodium nitrate).

The carbon steel HLW tanks were stress-relieved by heat treatment after fabrication. However, it is difficult to say today what the stress condition is because of the effects of differential settlement. Nevertheless, stress corrosion cracking has never been observed in corrosion coupons removed from either Tank 8D-1 or 8D-2.

The corrosion-resistant stainless steel tank is relied upon as a passive means of controlling corrosion in Tank 8D-4. The low corrosion rates observed support this approach.

D.5.3.3 AUXILIARY POWER

Requirements for auxiliary power for the STS and SMWS are necessary for maintaining vital services, including lighting, ventilation and monitoring systems. The operational safety requirements for auxiliary power distribution to the STS are described in Volume VI Section M.11. STS electrical systems are discussed in Section D.5.4.4.

Should a power outage occur during STS operations, the STS would be shut down and would not be restarted until complete system control and normal power is restored. The SMWS would shut down during a power outage; however, the WTFVS would continue to provide tank ventilation since it is on auxiliary power.

D.5.4 DESCRIPTION OF SERVICE AND UTILITY SYSTEMS

D.5.4.1 STS BUILDING HEATING AND VENTILATION SYSTEM

The STS H&V system is designed to provide area temperature control, a minimum differential pressure, and a minimum average air velocity. The system is also designed to prevent airborne contamination in routinely occupied areas by routing ventilation air from areas of low contamination to areas of higher contamination potential. A minimum differential pressure of 15 mm (0.6 in) water column is maintained between routinely occupied areas and potentially contaminated areas. Inlet air is filtered, and if necessary, cooled or heated for personnel comfort.

Control of contamination within designated areas is accomplished by maintaining these areas under negative pressure relative to "cold" areas, using an air lock or contamination control tents that allow entry into contaminated areas (considered abnormal events—see Section D.9.1.2), and ensuring that negative pressure and ventilation flow will continually be maintained between clean and potentially contaminated areas.

The area differential pressure ranges maintained with reference to the atmosphere are (values in standard atmospheres [inches of water column]):

• Control room	0.0 to +0.002 (1.0)
• Zeolite/fresh water tank areas	0.0 to +0.0002 (0.1)

- Area external to valve aisle (Operating aisle) -0.002 (-1.0) to -0.0015 (-0.6)

- Pipeway/top of 8D-1 tank -0.007 (-3.0) to -0.006 (-2.4)

- Valve aisle -0.007 (-3.0) to -0.006 (-2.4)

During normal operations, air flows from the supply fan through a filter to the fresh water/zeolite area from which air is directed to the operating area in front of the Valve Aisle. The control room has a separate HVAC system that draws from the outside air. Operating areas are protected by fire dampers between floors.

Approximately 1.9 m^3/s (4,000 cfm) of ventilation air is directed from the operating aisle to the valve aisle and into the pipeway. Air leaving the operating aisle passes through a roughing filter, HEPA filter, and tornado damper. Air leaving the pipeway to the PVS passes through a butterfly valve.

Air is then routed directly to a train consisting of roughing and HEPA filters (two) in series. One of two trains (parallel, redundant) will always be operational. The ventilation air then flows to exhaust blowers; both are powered by electricity. One is maintained as a backup designed to start automatically if the primary blower fails. An auxiliary power supply (electric) is provided to these blowers.

Major HV components (PVS blowers) are designed for contact maintenance. Temporary containments and/or increased air flow will be used to maintain contamination control should maintenance operations be necessary involving the pipeway or the valve aisle.

During shutdown of the supply air system for either maintenance or because of failure, gravity dampers in the zeolite/fresh water area will open to allow continuous ventilation, although without mechanical temperature control of the air. The STS Building HVAC floor plans are shown in Figures D.5.4-1 and D.5.4-2.

D.5.4.1.1 MAJOR COMPONENTS AND OPERATING CHARACTERISTICS

D.5.4.1.1.1 AIR SUPPLY UNIT

The air supply system consists of an air inlet damper, coils with bypass damper, heater, prefilter, filter, blower, duct work and controls.

The system is designed to maintain inside air temperature, based on outdoor design conditions of 31°C (88°F) dry bulb and 22°C (71°F) wet bulb for summer and -17°C (2°F) dry bulb in winter:

Area Inside Air Temperatures	Summer (max)/Winter (min)
Control Room	26°C (78°F) DB/20°C (68°F) DB
Zeolite/fresh water area	36°C (97°F) DB/18°C (65°F) DB
Valve Aisle	44°C (111°F) DB/21°C (70°F) DB
Pipeway/top of tank	54°C (130°F) DB/21°C (70°F) DB

The air supply unit is sized to deliver 2.1 m^3/s (4,550 cfm) of heated and filtered air to the building.

D.5.4.1.1.2 DUCTWORK

Air is distributed from the supply to the operating areas through ductwork constructed according to standards of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE).

Ductwork is constructed from 304 or 304 L stainless steel and galvanized steel material.

D.5.4.1.1.3 INLET FILTERS AND DAMPERS

Air enters the control room and fresh water/zeolite areas through separate filter and damper assemblies during normal operations.

D.5.4.1.1.4 HEATERS

Outside air under low ambient temperature conditions is preheated by the air-handling unit coils, which provide air temperature control. Local unit heaters provide the final space temperature control. Unit heaters are provided with individual limit thermostats for automatic control. A manual switch is provided with every heater to allow for manual operations if required.

D.5.4.1.5 EXHAUST FANS

The exhaust fans (PVS blowers) provide the system draft and are rated for 100% flow capacity of the HV system with all the filters at the changeout pressure drop. Both exhaust blowers are electrically operated. The backup will automatically activate if the primary blower fails or if primary power is lost.

D.5.4.1.1.6 EXHAUST FILTERS

Ventilation air flows from the pipeway and HLW pipe conduit and is exhausted through a roughing filter and two sets of HEPA filters in series (see Figure D.7.4-1). The filters are housed within the air treatment system and are connected with a heater and mist eliminator. HEPA filters are contained by a housing constructed of stainless steel. Provisions have been made to DOP test the installed filters before the system begins operating. The differential pressure is measured across each filter holder in the HV system. The primary filter holder has local low/high pressure alarms that sound a trouble annunciator in the control room. A remote trouble alarm in the STS control room would alert operators of a problem with the PVS.

D.5.4.1.1.7 DISCHARGE DUCTWORK

Following off-gas treatment, the ventilation air has passed through the blower and discharged through the STS PVS stack (see Section D.7.4). Air is continuously sampled to assess radioactive material releases (see Section D.8.6.1).

D.5.4.1.2 SAFETY CONSIDERATIONS AND CONTROL INTERFACES BETWEEN CLEAN AND CONTAMINATED AREAS

Should it be necessary, temporary containment enclosures will be provided for entry into contaminated areas and will be maintained under negative pressure to ensure that air flows from clean to contaminated areas.

The air supply unit runs continuously, supplying temperature-controlled outdoor ventilation air through a filter to the zeolite/fresh water areas. Filters and valves are installed in the transfer ducts between the fresh water/zeolite area and the operating aisle work area. A separate air supply unit operates in a similar fashion for the control room. Thermostats control space temperature for the two supply systems.

Fire dampers (ventilation system) and fire doors (1.5 h minimum rating) will isolate the zeolite/fresh water area from the Operating Aisle in the event of a fire in the STS Support Building. The PVS dampers are designed to fail safe in the closed position in the event of loss of utility air pressure. The backup blower will automatically come on-line should primary electrical power be lost or the primary PVS blower fail.

D.5.4.1.2.1 AIR FILTRATION

For protection of personnel, filter systems are provided in the following locations in the intake:

- Low-efficiency filters in the outdoor air intake section of the air supply fan;
- Low-efficiency filters in the transfer air ducts connecting the zeolite/fresh water area with the operating aisle;
- HEPA filters located in the transfer air ducts connecting the operating aisle work area to both the valve aisle and the pipeway;
- Low-efficiency filters located in the air intake of the control room supply fan.

All filters are replaceable and each filter bank is provided with pressure differential indications for resistance measurements and to identify replacement intervals.

Air leaving contaminated areas is filtered in the PVS by two sets of HEPA filters after passing a mist eliminator, heater, and roughing filter to entrap moisture and particulates. HEPA filters are in a housing to provide contamination control during changeout. Filters will be changed with bag out/bag in procedures. The differential pressure is measured across each filter holder in the PVS system. The primary filter holder has local low-and high-pressure alarms that sound a general trouble annunciator in the STS control room.

In response to low/high differential alarms, the parallel and redundant filtering train will be automatically activated. This redundancy ensures continuous and adequate air filtration and treatment should filter failures occur.

D.5.4.2 WTFVS

The original WTFVS will continue to provide routine ventilation to Tanks 8D-1, 8D-2, 8D-3, 8D-4, new pits on these tanks, and the STS process vessels that are suspended in 8D-1 during STS operation. Section B.5.4 and Figure B.5.4-6 of Volume II (WVNS-SAR-002) provide additional information on the WTFVS.

Air is removed from the tanks at approximately 0.07 m^3/s at standard temperature and pressure (STP) (150 scfm) and is passed through a condenser and knock out drum. The air is then heated before passing through a HEPA filter coupled with a blower. The filter and the blower have a redundant, parallel system as a standby in case of failure. The exhaust lines are connected to the main plant stack. Before release, the exhausted air is monitored to ensure radioactive releases are being maintained ALARA. (See Sections D.7.4 and D.8.6.1 for descriptions of the WTFVS and Monitoring Program.)

D.5.4.3 COMPRESSED AIR

Utility air and instrument air are required by the STS to operate instruments, control valves, and pumps. This air is supplied from either the main plant system (described in Section B.5.4.3 of Volume II) or from the air compressor located on the V&S Building. The STS is designed to fail-safe during loss of air pressure. Air requirements for the STS are presented in Table D.5.4-1.

D.5.4.4 ELECTRICAL SYSTEM AND AUXILIARY POWER SUPPLY

The primary and emergency power systems for the WVDP are described in Section B.5.4 of Volume II. Electrical power for the STS is supplied from the main plant utility services (480 volt, three phase), to a motor control center (MCC). From the MCC, the power is distributed to the STS equipment and control panels through conduits embedded in STS facility floors and walls. Normal electrical power requirements for operation of the STS are 190 (255) to 200 kW (270 hp). The STS is designed so that all valves and equipment fail safe in case of electrical power failure. The SMWS will require 370 (500) to 560 kW (750 hp). The SMWS will shut down (pump stop) in a fail-safe condition in the case of electronic power failure.

Auxiliary power backup is supplied to lighting, ventilation, and monitoring systems. Back-up power is provided to the STS by automatic switching to a diesel generator with sufficient stored fuel for eight hours of continuous operations. Specific requirements for STS auxiliary power requirements are addressed in Operational Safety Requirements found in Part M of Volume VI.

Electrical power requirements for the STS are presented in Table D.5.4-1.

D.5.4.5 WATER SUPPLY

The plant water supply and the plant demineralized water systems are described in Section B.5.4.5 of Volume II. These provide water for the STS and are supplemented by the water supply from the STS fresh water tank in the STS Support Building. Water requirements for the STS are provided in Table D.5.4-1.

Mobilization pump seal water is supplied from the plant utility water supply system. Seal water pressure and flow are monitored at the pump.

D.5.4.6 STEAM SUPPLY

A steam line from the plant main steam supply is provided to the STS. Steam is used intermittently to blow down instrument probes in the Level/Density Indicating System.

D.5.4.7 SANITARY FACILITIES

Operators can use the facilities within the main process building.

D.5.4.8 SAFETY COMMUNICATIONS AND ALARMS

The STS is provided with instrumentation to monitor flow, pressure, fluid levels, temperature, and radiation levels to ensure system operations are controlled and system limitations are not exceeded. Major STS equipment is operated remotely from control panels located in the control room. In the event of abnormal conditions, the process equipment can be manually shut off. Safety related systems (e.g., ventilation system) are designed to achieve a safe condition automatically should off-normal conditions occur (i.e., dampers close, backup fan starts, etc.) or redundant systems are activated. Automatic controls for all subsystems are provided with manual override capabilities.

The STS has instrumentation and controls to allow the system to be started, operated, monitored, and shut down from the control room. The control panel is equipped with a dynamic graphic display to reduce the likelihood of operator error. The instrumentation indicates or alarms (or both) abnormal and undesirable conditions that could adversely affect system or equipment performance or inadvertently affect interfaces with other systems. During emergency conditions, external communications can be through the plant telephone system.

Examples of safety related systems that provide alarm indications in the STS control room include:

- Ventilation System differential pressures
- Radiation Monitoring Systems
- Effluent Monitoring Systems
- Leak Detection Systems
- Pneumatic Sample Transfer System
- Fire Protection System (Section D.5.4.9).

D.5.4.9 FIRE PROTECTION SYSTEM

A fire in the STS or SMWS is considered highly unlikely. The valve aisle and the pipeway are constructed of concrete and steel and the liquid supernatant is nonflammable. The only potential fire hazards are the electrical wire insulation, grease in the pump motors, the sample vials and sample transfer "rabbits," and the small amount of wipes used during sample collection, which shall be kept in fire-resistant containers. None of these is a high risk fire hazard.

The STS has fire detection equipment, alarm systems, and suppression systems commensurate with needs as determined by WVNS Radiation and Safety. This includes fire extinguishers, emergency exit lighting and a Halon™ system in the control panel. Additionally, fire suppression systems have been installed in the operating aisle and in the PVS Building. Fire prevention and fire fighting procedures for the STS are in accordance with existing WVDP procedures (see Section B.5.4.4, Volume II).

WVNS maintains a highly reliable alarm detection system through a semi-annual site fire detection and alarm system inspection. In addition, the services of a Fire Protection Engineering firm are subcontracted annually to do a thorough survey of the WVDP Fire Protection Program. This serves as an audit of the

WVNS systems and programs to ensure compliance with the "improved risk" level of protection required by DOE. The WVDP Fire Protection Plan is contained in Chapter 5 of "Industrial Hygiene and Safety Manual" (WVDP-011).

D.5.4.10 MAINTENANCE SYSTEMS

The STS has been designed for remote operation. All equipment not required to be located in radioactive process areas is located in "cold" areas to permit contact maintenance. Contact maintenance will be performed on equipment previously used in radioactive service only after efficient decontamination in accordance with existing WVNS procedures (WVDP-010, "Radiological Controls Manual"). Where this is not feasible, equipment is be remotely removed and replaced.

All equipment and piping in radioactive service is drained and flushed to reduce radiation levels before any personnel enter process areas such as the valve aisle or pipeway. Instruments are designed to permit isolation for periodic maintenance. STS equipment and components are arranged, located, and shielded to minimize radiation exposure to plant personnel should maintenance be necessary.

STS design considerations for equipment/component decontamination were additionally discussed in Section D.4.5. Potential effects of maintenance activities in the valve aisle are discussed in Section D.9.1.

D.5.4.11 COLD CHEMICAL SYSTEMS

The STS cold chemical systems are described in Section D.6.3.1 (Cold Chemical Receiving and Handling).

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TABLE D.5.1-1

LOCATION OF MAJOR STS COMPONENTS

Process Components (Radioactive Service)	Original Tanks 8D-1, 8D-2 and 8D-3.
Process Valve Aisle	Valve Aisle adjacent to Tank 8D-1.
Interconnecting Piping	Valve Aisle, above original Tank 8D-1 and in new Waste Transfer System (shielded pipe containment) communicating with the LWTS, Tanks 8D-1, 8D-2, 8D-3, and the Vitrification Facility.
Auxiliaries and Controls (Nonradioactive Service)	STS Support Building in the WTF.
STS PVS	Ventilation Building in the WTF.
Pipeway/Shield Structure	Between STS Support Building and Tank 8D-1 and above Tank 8D-1 vault.

TABLE D.5.2-1

PENETRATIONS MADE IN THE ROOF OF TANK 8D-1

Hole Designation	Purpose/ Description	Approximate Opening Size m (ft)	Installation Method
C-001	STS IX Column	1.3 (4.3)	Manual
C-002	STS IX Column	1.3 (4.3)	Manual
C-003	STS IX Column	1.3 (4.4)	Manual
C-004	STS IX Column	1.3 (4.4)	Manual
D-001	STS Supernatant Feed Tank	1.6 (5.2)	Manual
D-004	STS Sluice Feed Tank	1.6 (5.2)	Manual
E-001	STS Supernatant Cooler	1.1 x 0.6 (3.5 x 2)	Manual
F-001	STS Prefilter	1.1 (3.5)	Manual
F-002	STS Postfilter	0.9 (3)	Manual
G-004	STS 8D-1 Pump	0.8 x 1.2 (2.5 x 4)	Manual
M-2	Zeolite MOB Pump	0.7 (2.3)	Remote
M-3	Zeolite MOB Pump	0.7 (2.3)	Remote
M-4	Zeolite MOB Pump	0.7 (2.3)	Manual
M-5	Spare Pump	0.7 (2.3)	Manual
M-6	Zeolite Pump	0.7 (2.3)	Remote
M-7	Spare Pump	0.7 (2.3)	Remote
M-8	Zeolite Removal Pump	0.7 (2.3)	Remote

TABLE D.5.2-2 ENGINEERING CODES/STANDARDS FOR STS

Vessels	ASME Section VIII, Division I, 1983 Edition (Vessels were built to code but not "U" Stamped (National Board Stamp))
Piping	ANSI B31.3, 1980 Edition
Symbols for Welding and Nondestructive Testing	AWS A.2.4-79
Dimensions and Tolerances	ANSI Y 14.5, 1973 Edition
Effluent and Process Control	ANSI N 13.1, 1969 Edition ANSI N 42.18, 1974 Edition
Structural	AISC Eighth Edition
	International Conference of Building Officials (IC/O), UBC, 1982 Edition
Ventilation Handbook	ERDA 76-21, Nuclear Air Cleaning
Structural Welding	AWS D1.1, 1980 Edition
Electrical/Instrumentation	National Electrical Code, ANSI/NFPA-70
	National Fire Protection Association (NFPA) National Fire Codes
	ANSI Standards
	National Electrical Manufacturers Association (NEMA) Standards
	Institute of Electrical and Electronics Engineers (IEEE) Standards Underwriters Laboratories, Inc. (UL) Standards and "Product Directories)
	Illuminating Engineering Society (IES) Lighting Handbook
	DOE 6430.1, "General Design Criteria Manual," 12-12-83

TABLE D.5.2-2 ENGINEERING CODES/STANDARDS FOR STS (continued)

	Department of Labor, "Occupational Safety and Health Standards," Title 29, Code of Federal Regulations (CFR), Part 1910
	Electrical and Electronics Graphic Symbols and Reference Designations, ANSI/IEEE Y32E
	National Electric Safety Code, ANSI-C2
	Instrumentation Society of America, ISA-S5.1-73
	Instrumentation complies with ISA Recommended Practices
Machined Surfaces	ANSI B46.1, 1978 Edition
Shell-and-Tube Heat Exchangers	ASME Section VIII, Division 1, 1983 Edition, and TEMA, Class C, Sixth Edition, 1978, With Addenda Through 1982
Material Specification	ASME Section II
Nondestructive Examination (NDE)	ASME Section V
Qualifying Welders and Welding Procedures	ASME Section IX
Architecture	"INEL Architectural Engineering Standards," US DOE - Idaho Operations Office, Idaho Falls, Idaho, Rev. 3, June 15, 1982
Design	Operational Safety Design Criteria Manual, ID-12044, US DOE - Idaho Operations Office, Idaho Falls, Idaho

TABLE D.5.2-2 ENGINEERING CODES/STANDARDS FOR STS (continued)

Quality Assurance	ANSI-ASME NQA-1-1979
Tank 8D-1 or 8D-2	UBC, Zone 3, I.F. = 1.0; Horizontal Structural Additions only
Pipe Chase - Tank 8D-1	UBC, Zone 3, I.F. = 1.0; to Valve Aisle
Equipment Support - Equipment Suspended in Tank 8D-1 or 8D-2 (including skirts)	ANSI A 58.1
STS Building Below-Grade	UBC, Zone 3, I.F. = 1.0; Structure
Process Piping (8D-2 to 8D-1; 8D-1 to 8D-3; 8D-1, 8D-2 not including 8D-3 to 35104)	WVNS-DC-013

TABLE D.5.2-2 ENGINEERING CODES/STANDARDS FOR STS (concluded)

Equipment supports - not suspended in Tanks 8D-1 or 8D-2	UBC - no seismic load
Metal Building	NYSBC, 97 mph wind, 40 lb/ft^2 snow
Equipment (including equipment suspended in Tank 8D-1 or 8D-2 and the Valve Aisle	No seismic load

TABLE D.5.2-3a

DESIGN CODES AND STANDARDS FOR SYS CONFINEMENT SYSTEMS

Structure or Confinement	Confinement Barrier	Design Code or Standard	Seismic Factors	Foot-Note
Tank 8D-2	Carbon steel tank	API 650 (1961 version)	None	
	Reinforced concrete tank vault	1961 UBC	Z=III	(2)
		1956 ACI, Building Code Requirements for R/C, 318-56		
	Soil excavation and backfill	Bechtel construction specifications - 1963		
Riser	Carbon steel riser	1982 UBC ANSI B31.3, 1980	Z=3 IF=1.0	(3)
	40" diameter carbon steel casing	1982 UBC ANSI B31.3, 1980	Z=3 IF=1.0	
	Concrete/Grout Fill	ACI 318-77	None	
	Expansion Bellows	ANSI B31.3, 1980	None	
	Carbon steel Riser Spray Chamber	AISC 8th Edition 1980	None	
	Bearing Plate	1985 UBC AISC 8th Edition 1980	Z=3 IF=1.5	
Pump Column	Stainless Steel Pump Column	1985 UBC ASME Section VIII	Z=3 IF=1.5	
	Fluid Seals	WVNS-EQ-202, Rev. 5	None	
Shield Plug	Carbon Steel Pipe	ANSI B31.3, 1980	None	

(1) Tornado wind and missile loading was not a design requirement for the SMWS facility.

(2) Seismic zone, Z=III, of the 1961 Uniform Building Code (UBC) is slightly different from the 1982 and 1985 UBC, Z=3.

(3) Design codes and standards for the Remote and Manual Riser Penetrations of Tank 8D-2 are referenced in WVNS-DC-026, Rev. 0, June, 1986.

(4) Design codes and standards for the Pump Column are referenced in WVNS-EQ-202, Rev. 5, October, 1990.

TABLE D.5.2-3b

DESIGN CODES AND STANDARDS FOR STS STRUCTURAL SYSTEMS

System	Structural Component	Design Code and Standard	Seismic Factor(1)	Foot-Note
MOB Pump	Pump, Column & Motor	1985 UBC	Z=3 I=1.5	(2)
	- Steel	AISC 8th Edition 1980		
	- Welding	AWS Section D1.1 ASME Section VIII, V, IX		
	- Steel Pipe, Valves and Fittings	ANSI, B16.5, B16.11, B16.34, B31.3, 1980 Edition		
Pump Support Structure (Truss & Footings)	- Structural System	1985 UBC	Z=3 I=1.5	
	- Steel Truss	AISC 8th Edition 1980 ASW D.1.1, D1.84 ANSI A56.1 - 1982	I=1.07 Exp=C	(3)
	- Concrete	ACI 318-77		
	- Footings	Dames & Moore, 1986 Foundation Recomm.		

(1) Tornado wind and missile loading was not a design requirement for the SMWS facility.

(2) Design codes and standards for the Sludge Mobilization Pumps are referenced in WVNS-EQ-202, Rev. 5, October 1990.

(3) Design codes and standards for the Sludge Mobilization Pump Support Structure are referenced in WVNS-EBAR-735, 735A and 534.

TABLE D.5.3-1 STS LEAK DETECTION SYSTEMS

Structure Barrier	Nature of Leak	Detected By	Mitigation
Tanks 8D-1 and 8D-2	Tank leaks into vault	Leak detection system in vault pan	Can pump fluids from pan/vault back to tank; can pump fluids to other identical tank/vault system.
Supernatant Pump Pit, Top of Tank 8D-2	Leak from Transfer piping (single wall in pit) into pit	Major leak detected by low pressure/low flow alarms in STS control room	Gravity drain into Tank 8D-2
HLW Transfer Conduit	HLW Transfer piping (double walled within conduit) leaks into conduit	Leak detection system in annular space between pipe walls	Drain pipe in conduit; gravity drain back to Tank 8D-2
		Vapor detected by STS Off-Gas Treatment system effluent monitoring system	
Pipeway/Valve Aisle	Transfer piping or valves leak into pipeway or valve aisle	Valve Aisle Sump has high fluid level alarm	Pump actuates in response to high fluid level in sump; returns fluids to Tank 8D-2
		Vapor detected by STS Off-Gas Treatment system effluent monitoring system	
Components in Tank 8D-1	Fluids leak from components into tank	Laboratory analysis of sluice lift water	Return fluids to Tank 8D-2 for rework by STS
	DF across IX system less than adequate; supernatant transferred to Tank 8D-3	On-line radiation monitors	
LLW Transfer Conduit	LLW Transfer within leaks into conduit	Leak detection system in annular space	Pump to Tank 8D-2, if needed

TABLE D.5.4-1 STS UTILITIES REQUIREMENTS

Utility	Flow	Pressure (psig)	Service
Instrument Air	300 scfm	105	Pumps, Valve Operators
Utility Air	50 scfm	100	Utility Station
Demineralized Water	40 gpm	40	Fresh Water Tank
Recycle Water	15 gpm	40	Break Tank
Plant Water	25 gpm (ea)	50	Utility Station
Electrical Power	190 to 200 kW at 480 V, 3 phase		
Steam Supply	Intermittent	150	Blow-down Instrument Sensing Lines

D.6.0 STS AND SMWS PROCESS SYSTEMS

D.6.1 PROCESS DESCRIPTION

The SMWS and STS processes have been designed to remove sulfate salts from the HLW sludge in Tank 8D-2. In general, the process involves adding dilute caustic solution to the 8D-2 tank and mixing. The sulfate salts dissolve into the wash solution. Subsequently the wash solution will be pumped from Tank 8D-2, filtered, diluted with water as desired, and cooled in a shell-and-tube heat exchanger. The wash solution will then be directed through up to four columns of ion exchange zeolite for decontamination of cesium. As needed for plutonium removal from the wash solution, a titanium-treated zeolite can be combined with or replace all the usual zeolite to provide decontamination of both plutonium and cesium. The decontaminated wash solution will then be pumped to LWTS for concentration and subsequent cement waste form production in CSS.

The following sections describe the individual portions of the combined SMWS and STS processes.

D.6.1.1 SLUDGE WASHING

The SMWS portion of the process provides the equipment to add a dilute caustic solution to the HLW Tank 8D-2. As found in laboratory testing with actual sludge, water by itself dissolves some Pu and U as well as the sulfate salts. It has been determined experimentally that by adding a dilute caustic solution to the sludge the dissolution of Pu and U is greatly reduced (Bray, 1990).

Once the dilute caustic solution is added, a series of five long-shafted centrifugal pumps will (Figure D.4.1-1) agitate the tank contents and suspend the settled solids. The exact duration of mixing will be determined by sampling the liquid and tracking the change in salt concentration in the wash solution.

During the agitation, a significant amount of energy will be transferred to the HLW tank contents from the five mobilization pumps. A temperature rise is expected until the energy input is dissipated via evaporation of water from the liquid surface. Calculations indicate the maximum temperature expected in the tank is 95°C. Once agitation is stopped, a temperature decrease to the previous radiogenic temperature of 60°C is expected.

After the salt concentration has leveled off, the mixing will be stopped and the solids allowed to settle. Solids settling times, as determined in the laboratory, are approximately 3 - 5 m/day (10 - 15 ft/day). The actual settling of solids will be tracked using in-tank equipment: density indicators placed at different tank heights and a buoyancy probe that will give an accurate (±5 cm, ±2 in) indication of the level of the solids/liquid interface.

After the solids have settled about 30 cm (1ft) below the floating suction of the STS Wash Solution Removal Pump (50-G-001), wash solution transfer to the STS facility can begin. A floating suction is provided to minimize the potential that sludge would be picked up during operation. Pump and suction are both supported from the vault roof and located inside Tank 8D-2. Pump capacity is 150 lpm (40 gpm) at 653 kPa (80 psig) discharge pressure with 15 (5) - 30 lpm (8 gpm) minimum flow rate.

Provisions have been made to allow for remote flushing and removal in case of pump failure. (Replacement of a failed pump is discussed in Section D.9.1.5). The sludge wash solution shall be decanted and pumped at temperatures as high as 90°C (194°F) to the prefilter (50-F-001) in Tank 8D-1.

D.6.1.2 PREFILTRATION AND COOLING

Sludge wash solution contained in Tank 8D-2 may be filtered through a sintered metal filter, depending on suspended solids loading, and must be cooled before processing. Filtration is provided to prevent process contamination by sludge particulates suspended in the sludge wash solution (see Figures D.5.2.1 through D.5.2.7 for the location and arrangement of equipment). Additionally, filtration removes some insoluble strontium and plutonium present in the suspended solids contained in the sludge wash solution. The filter is designed for a flow forward rate of 23 lpm (6 gpm) and 1.0 μm particle retention with recirculation of excess flow back to Tank 8D-2. It is capable of being back-pulsed (blown back) with filtrate to clear particulate accumulation on the porous tube filtering surface. Air pressure is used to blow back the filtrate from a reservoir located downstream of the filter. The liquid removed during back pulsing will contain the solids filtered from the sludge wash solution and will be transferred back to Tank 8D-2. Precoating of the filter by use of filtrate recycle will be required to obtain a clear filtrate. Instrumentation to measure pressure drop is provided. Provisions have been made for remotely flushing the prefilter. The supernatant feed tank (50-D-001), installed in Tank 8D-1, is provided to collect filtered sludge wash solution. The tank serves as an intermediate collection and feed tank to feed sludge wash solution to the ion exchange process. (Tank capacity is 6,400 L [1,700 gals].)

The filtered sludge wash solution may be stored in the supernatant feed tank, which provides about five hours of hold-up based on 23 lpm (6 gpm) undiluted sludge wash solution feed processing rate through the ion exchange columns. A water line and static mixer have been provided for sludge wash solution dilution. Previous STS operation identified water dilution as one means to achieve efficient cesium loading on the ion exchange zeolite. Depending on the concentration of salts in the wash solutions, water dilution may be used during sludge wash processing at the discretion of the operating staff. The supernatant feed tank also is attached to a chemical addition line that can be used to add decontamination or pH adjustment chemicals. No chemical additions via this port are planned at this time.

Sludge wash solution ready for ion exchange processing will be cooled to as low as 6°C (43°F) with chilled coolant (salt solution). The isolation chiller, which supplies the chilled coolant to the cooler in Tank 8D-1, is located in the STS building. The sludge wash solution will be pumped by the canned centrifugal pump (mounted in the valve aisle) through the cooler (50-E-001) to the cesium removal (ion exchange) columns (50-C-001, 50-C-002, 50-C-003, 50-C-004). Pump capacity is 98 lpm (26 gpm) at 760 kPa (95 psig) discharge pressure with net forward flow rate of 23 lpm (6 gpm).

D.6.1.3 ION EXCHANGE

After filtration, dilution (if desired), and cooling in the shell-and-tube heat exchanger, the wash solution will be passed downward through one to four ion-exchange columns in series. Column size is 1 m (3.4 ft) in diameter x 4.4 m (14.5 ft) in height. Selection of the STS configuration will depend principally on the salt solution concentrations of cesium, plutonium, and sodium as well as the number of fully functional columns available and the zeolite consumption goals.

The STS process was designed to operate continuously using three ion exchange columns. During continuous operations one column would be off-line to recharge the ion exchange media while the others would be on-line. However, it has been routinely operated as a batch system and usually three to four columns were used.

Previously, the STS was operated with IE-96™ zeolite used to retain cesium from the HLW supernatant. With all other things constant, the lower the temperature the greater the ion exchange capacity of the ion exchange material for cesium. It was also found that dilution with water allowed increased loading of cesium onto the zeolite ion exchange material. Nominal operating ranges for key parameters include:

Temperature	6°C to 40°C
Flow Rate	2 gpm to 8 gpm
Dilution	0% to 300%

Depending on the need to reduce the plutonium content of the wash solution, titanium-treated zeolite may be used in place of some or all of the usual IE-96™ zeolite. The Ti-treated zeolite will remove Pu and Sr from the wash solutions in addition to removing Cs. The operating parameters for the titanium-treated zeolite are expected to remain the same as the base IE-96™ zeolite.

Continuous on-stream activity monitoring is provided to detect bed exhaustion and final product activity. Samples of the decontaminated wash solution will be taken to ensure that an appropriate process decontamination factor (DF) is achieved (see D.6.7). Any column from the series may be taken off line and its zeolite dumped and replaced. It is expected that the lead ion exchange column will approach breakthrough at nearly the same time that the final product activity begins to approach the operational limit.

When any zeolite bed is determined to need zeolite replacement, the wash solution at the top of the column will be flushed back to Tank 8D-2 with water. The zeolite will be sluiced with process water to the bottom of Tank 8D-1. In the event that normal zeolite sluicing is prevented by valve malfunction, a dip tube installed in the ion exchange columns allows back sluicing of zeolite to Tank 8D-1. Alternatively, the sludge wash solution may be blown back to Tank 8D-2 with air. The blowback is accomplished with 20 psig air and is complete when the decrease in column pressure indicates the liquid has been displaced. The air supply to the column being inadvertently left on would be noticed in shift readings or, eventually, in a high pressure alarm on Tank 8D-2.

Following a final rinse (also discharged to Tank 8D-2), the column will be recharged with fresh zeolite. A normal charge of zeolite is about 1[illegible] liters of zeolite, although an additional cap of zeolite of more than 400 liters may be added as needed.

D.6.1.4 FINAL FILTRATION

Decontaminated sludge wash solution exiting the last column in series will be filtered to remove zeolite fines that could recontaminate the process. This filter is a sand bed type that may require periodic changeout of the filter medium. Instrumentation and valving are provided to ensure a clear decontaminated sludge wash solution. Sand bed removal and flushing will be done remotely. The spent sand will be discharged to the bottom of Tank 8D-1.

D.6.1.5 DECONTAMINATED SLUDGE WASH SOLUTIONS COLLECTION AND TRANSFER

Filtered and decontaminated sludge wash solution will be fed to the original underground HLW Storage Tank 8D-3. This Tank serves as both intermediate storage (53,000 L [14,000 gals]) and as a sampling Tank. Continuous on-stream activity monitoring and periodic sampling ensures that decontaminated sludge wash solution transferred to the LLW CSS has been decontaminated to meet specifications (see Section D.6.7). A recycle line to Tank 8D-1 allows additional decontamination of the sludge wash solution if required. Decontaminated sludge wash solution will be transferred to the LWTS from Tank 8D-3 in batches. Batch transfer from Tank 8D-3 to underground Tank 5D-15B (LWTS feed Tank) (57,000 L [15,000 gals]) will be approximately 38,000 L/batch (10,000 gals./batch).

D.6.1.6a SPENT ZEOLITE DISCHARGE AND STORAGE

The current method of spent zeolite discharge is discussed in Section D.6.1.6.b. After a column is exhausted (confirmed by sampling the effluent from the lead column or by reaching allowable throughput dictated by criticality control), it is valved off from the process. The bed is pressurized from the top with air to purge contaminated sludge wash solution ([illegible],300 L [1400 gals]) back to Tank 8D-2, leaving a wet bed of zeolite in the column. The column is filled and rinsed with water via the rinse/sluice water pump. The column rinse effluent is also directed to Tank 8D-2.

After rinsing, the bed can be backwashed and expanded with water. Subsequently, the lift water outlet valve is shut while the bed solids outlet valve is opened to sluice the spent zeolite bed to Tank 8D-1. The column is then rinsed (rinse water to Tank 8D-1) to wash any residual zeolite from it. The bed solids outlet valve is closed and fresh zeolite is then loaded into the empty column via the zeolite batching tank (50-D-002).

An alternate method of removing zeolite from the ion exchange columns is provided in the event that the dump valve on the bottom of a column fails. Zeolite would be sluiced out through a dip tube located inside the column and then through a pipe directly to Tank 8D-1. The pipe is entirely contained within the pipeway. An isolation valve on this pipe between the ion exchange column and Tank 8D-1 would be manually opened using a reach rod in the event it were necessary to sluice out a column using this method.

Computer modeling of the zeolite pile in Tank 8D-1, performed by Battle-Pacific Northwest Laboratories, has indicated only a 1°C (2°F) probable increase in temperature under the zeolite pile. The temperature difference is small due to significant convective fluid flow through the zeolite pile produced by radiolytic decay heat of the cesium-137-laden zeolite.

This modeling and the discussion of results is documented in a Battelle-PNL letter report of March 1991, "Reactions of Hydroxide and Nitrite Ions with IE-96™ Zeolite," by L. D. Anderson.

D.6.1.6b SPARGE LINE ADDITION FOR ALTERNATIVE ZEOLITE DISCHARGE METHOD

Zeolite discharge from the ion exchange columns has been performed using the installed dump valves, as described in Section D.6.1.6a of this SAR. However, failure of the dump valve on one of the four columns has caused that column to be temporarily inoperable and has raised concerns about the reliability of the dump valves on the three remaining columns. Because failure of a dump valve was anticipated during detailed design, an alternate method of discharging zeolite from the ion exchange columns was developed for use on all four columns. The alternate method involves pressurizing the column with air and charging water back through the bottom Johnson screen, thus creating a zeolite/water slurry. The slurry is then discharged into Tank 8D-1 through a previously installed dip tube called the "J" nozzle with its inlet at the lower end of the column. Concern over failing to remove all of the zeolite and leaving a heel of zeolite in the bottom of the column below the "J" nozzle inlet has led to design of an air sparge to ensure that the zeolite remains in slurry during sluicing operations. Air is supplied to the air sparge through a stainless steel flexible hose with an external connection outside Tank 8D-1.

The following paragraphs address the design and installation of these sparge lines to the ion exchange columns and the safety issues related to their use. Use of the "J" nozzle itself was previously analyzed.

Each air line consists of a 13-mm (0.5-in.) O.D. schedule 40 stainless steel pipe that enters Tank 8D-1 through an original riser, where it changes to a stainless steel flexible braided hose leading to a flange attached to the dump valve on the bottom of the column. A fitting extends up from the flange a short distance into the column. The fitting is designed to ensure that any zeolite that has settled on the bottom is resuspended during sparging. The end of the fitting includes an orifice or screen to prevent zeolite fines from entering and migrating back up the sparge line in a quantity that would plug it.

The zeolite mobilization pump risers in which the sparge lines are installed (M4 and spare riser M5) penetrate the concrete pipeway roof and concrete tank vault roof and connect to the Tank 8D-1 steel roof. The operating station for the sparge line system is approximately 1.5 m (5 ft) above grade level in the waste tank farm controlled area. The air line operating stations for each sparge system include a filter, an isolation valve to isolate the entire system, a three-way valve to supply the stop-valve actuator, an isolation valve to isolate the sparge line only, and an isolation valve to isolate the pressure sensor and low pressure alarm (Figure D.6.1-17). From the operating station, the line extends down to the riser and enters the riser 1.8 m (6 ft) above the pipeway roof. Inside the riser, each line has two check valves and an air-operated stop valve installed in the vicinity of the tank vault roof. The air line to actuate this valve is separate from the sparge line but is attached to and runs alongside the sparge line. A single air line supplying both the sparge air and valve actuation air is used to ensure that any loss of air supply pressure during sparging will also cause the stop valve to close.

During operation, one line provides air for sparging the column. The second line provides air from the three-way valve to the stop valve actuator. This second air line does not contact sludge wash solution or Tank 8D-1 contents or air and thus does not have a potential to become radioactively contaminated. The valve actuator is mechanically coupled to the air-driven operator so that it is impossible for liquid to reach the operator air line. Indication of proper sparge system operation during sluicing is provided by two methods. The first method requires monitoring the sparge airflow rate during sluicing to ensure that air flow is maintained. The second method requires installation of a sealed detector in the STS pipeway with a radiation detector to monitor radiation increases resulting from zeolite passing through the piping between the J nozzle on the ion exchange column and Tank 8D-1.

When the sparging process has been completed, the three-way valve is depressurized by venting to the atmosphere, thus shutting the air-operated stop valve and isolating the sparge line. The sparge line is then isolated from the air supply and left pressurized to 170 kPa (10 psig) greater than the ion exchange column operating pressure to preclude any possibility of backflow into the sparge line. An installed pressure sensor provides an alarm on decreasing residual sparge line pressure approaching the ion exchange column operating pressure.

Installation of this equipment within two of the spare Tank 8D-1 risers required removal of the previously installed riser shield plugs. The initial need for the shield plugs was to reduce radiation levels in the pipeway during riser installation and STS construction. Radiation levels at the riser top are generally low (5 μC/kg-h [20 mR/h]) due to the geometry of the riser opening and the existence of the concrete vault roof and gravel backfill. Also, the cesium-loaded zeolite in the bottom of Tank 8D-1 is shielded by approximately 2.4 m (8 ft) of water. Replacement of the shield plugs with a sealed cover on the riser top to prevent entry or spread of contamination provides an equivalent level of protection to personnel.

A total of four sparge systems (one per column) have been installed using two Tank 8D-1 risers. Two airlines (one for sparging the column and one for operating the stop valve) are installed per column sparge system. Installation within Tank 8D-1 used a remotely controlled arm to reduce exposure of personnel. The highest radiation level observed has been 5 μC/kg-h (20 mR/h) at the riser top with the shield plug removed. This does not present a significant problem for equipment installation into the riser. Contamination control was provided through use of a containment tent over the riser while the equipment was being installed. A sealed cover was placed over the riser top following installation and ventilation was provided as normal through the WTFVS. During installation, ventilation was provided by the STS PVS through Tank 8D-1 to ensure minimum 0.67 m/s (125 linear ft/min) of air flow throughout the riser. During installation, air entered through a roughing filter in the containment and flowed through the riser to the tank, exhausting through two banks of HEPA filters. When installation operations were secured the riser opening and remote arm were covered with a temporary closure to reduce air infiltration. As installation of equipment through these risers did not require opening of the riser to the pipeway, no additional ventilation or modification of STS ventilation was required. Total radiation exposure to workers during installation of the sparge lines is was less than 1 person-cSv (1 person-rem

D.6.1.7 SAND FILTER DISCHARGE

The sand filter has been designed to be discharged in the same manner as the columns. (See description in Section D.6.1.6, Spent Zeolite Discharge). It is anticipated that the sand will be discharged only once before final D&D efforts. However, discharge of sand into Tank 8D-1 may be performed during STS operations if cesium-loaded zeolite fines break through the postfilter. The postfilter would then be recharged using the appropriate valve box.

D.6.1.8 FRESH ZEOLITE FILL

Fresh zeolite (shipped in 208-L [55-gal.] drums) is loaded into a water-filled batching tank. It is then backwashed to remove fines. After fines are removed, fresh zeolite is charged into the columns as a water slurry. Batching is a hands-on operation, so fresh water is used to slurry zeolite to the columns. Since contamination is present in the columns, all slurry and sluice water is discharged to Tank 8D-1 or 8D-2 and is a source of secondary waste, which is recycled within the STS.

D.6.1.9 IDENTIFICATION OF ITEMS FOR SAFETY ANALYSIS CONCERN

The radioactive nature of HLW in the STS and SMWS requires that processing be achieved with minimum radiation exposure to operating personnel and maximum protection to the environment. The major items of safety analysis concern are:

- Ensuring the confinement of radioactivity (e.g., maintaining ventilation to and negative pressure on Tanks 8D-1 and 8D-2).
- Maintaining the release of radioactivity in compliance with ALARA and below the limits specified in DOE orders (e.g., maintenance of HEPA filtration on ventilation systems; effluent monitoring program).
- Avoiding nuclear criticality accidents (e.g., implementation of OSR-IRTS-10).
- Avoiding cross contamination between radioactive and nonradioactive systems.
- Minimizing the risk of accidents through proper design, construction, and adherence to policy and procedures.
- Preventing temperature rise to damaging levels in off-line ion exchange columns.

The STS is remotely operated and maintained because of the high radiation levels of the material being processed. Occupational doses are maintained ALARA through the use of shielding and administrative and procedural controls. All continuously occupied areas have been designed to maintain dose rates below 65 nC/kg-h (0.25 mR/h). (Design and operating considerations regarding safety protection are presented in Sections D.4.3 and D.8.1.) Proper safety precautions for maintenance activities are specified in Radiation Work Permits (RWPs) and Industrial Work Permits (IWPs) as appropriate.

The major mechanism for ensuring the confinement of airborne radioactivity is the STS HV AC System. This system maintains process areas at a slight negative pressure relative to the surrounding areas to ensure that air leakage is into, rather than out of, potentially contaminated areas. Two exhaust blowers are provided for this system. Both are driven by an electric motor. Each is connected to both the normal and auxiliary power supplies.

Effluents from the site are monitored to ensure that releases are in compliance with applicable DOE guidelines. This monitoring program is described in Section D.8.6.1.

D.6.2 PROCESS CHEMISTRY AND PHYSICAL CHEMISTRY PRINCIPLES

The principal goals of the combined SMWS and STS processes are to remove soluble salts from the HLW sludge in Tank 8D-2 and decontaminate the wash solutions to a level acceptable for processing in both LWTS and CSS.

The main decontamination effect that must be achieved is the reduction in the cesium level in the wash solutions. Regulatory limits (10 CFR 61) do not require any cesium removal before creation of a cemented waste form for disposal. Operational limits have been set on the STS effluent that provide ALARA protection to the operating staff in the downstream LWTS and CSS facilities.

The process limits associated with the STS ensure that the following criteria are met:

1. Waste produced shall meet (TR-IRTS-5) the qualification of the Process Control Plan.

2. STS shall meet the Drum Cell acceptance criterion of less than or equal to 5.5 μCi/mL of ^{137}Cs in LWTS concentrates used to produce the final waste form for storage in the Drum Cell, and a final product concentration of less than or equal to 68 nCi/g in the final waste form, if the waste is to be solidified in the CSS (TR-IRTS-5).

3. Undiluted sludge wash solution shall have an alpha Pu concentration of less than 0.25 μCi/mL in the first wash cycle and 0.1 μCi/mL in the remaining 3 wash cycles (OSR-IRTS-12).

4. Less than 1 ML of undiluted sludge wash solution shall be processed through any ion exchange column containing Ti-treated zeolite between Ti-treated zeolite discharges during the first wash cycle (OSR-IRTS-12). Less than 3 ML of undiluted sludge wash solution shall be processed through any ion exchange column containing Ti-treated zeolite between Ti-treated zeolite discharges during the remaining 3 wash cycles (OSR-IRTS-12); however, if a Ti-treated zeolite column is used in the first wash cycle and continues to be used in subsequent wash cycles then 2.5 times the volume processed through the column from the first wash cycle must be included as part of the 3 ML volume limit for the remaining 3 wash cycles (OSR-IRTS-12). The first wash cycle concentration limit is 2.5 times greater than the remaining three and must therefore be weighted accordingly.

Previously, the STS was operated with IE-96™ zeolite for the retention of cesium from HLW supernatant. With all other things constant, the lower the temperature the greater the ion exchange capacity of the ion exchange material for cesium. It was also found that dilution with water allowed increased loading of cesium from HLW supernatant. Nominal operating ranges for key parameters include:

Temperature	6°C to 40°C
Flow Rate	2 gpm to 8 gpm
Dilution	0% to 300%

Sludge washing will dissolve the sodium sulfate crystals known to be present in the HLW sludge in Tank 8D-2. Laboratory testing has also shown that some fraction of the uranium and plutonium may dissolve during the sludge washing depending on the caustic concentration. Washing sludge without caustic has shown significant quantities of both uranium and plutonium in the wash solutions.

The key process for maintaining a low Pu content in the wash solution is hydroxide molarity in Tank 8D-2. An active control program (OSR-IRTS-12) based on routine sampling and measurement of the Pu concentration in the Tank 8D-2 wash solution will be used to guide caustic additions to Tank 8D-2 to suppress Pu solubility. Laboratory experiments have indicated that the rate of hydroxide consumption is approximately .94 µg-mol OH^-/L-day. This results in a reduction of pH from approximately 12.6 (0.03 µCi/mL) to 11.7 (0.25 µCi/mL) in approximately 370 days due to absorption of carbon dioxide from the ventilation air.

If sufficient plutonium is determined to be present in the sludge wash solution, then the normal ion exchange material (Ionsiv IE-96™) will be replaced partially or in full with titanium-treated IE-96™. The Batelle-Pacific Northwest Laboratory proprietary coating produces an ion exchange media that retains plutonium and strontium while keeping almost all of the cesium affinity of the parent IE-96™ zeolite. The retention of plutonium and strontium is thought to be adsorption by the titanium material deposited on the zeolite. Typical titanium levels in the zeolite are 3 - 6 wt% of the anhydrous zeolite, expressed as TiO_2.

Regulatory limits (10 CFR 61) dictate < 100 nCi/g of TRU in the cemented waste form from the CSS. The use of titanium-treated zeolite in the STS will depend on the level of plutonium in the Tank 8D-2 wash solution as well as the consumption rate of the solution in the CSS waste form. Recent sludge wash analyses show that with the high level of caustic established in Tank 8D-2, the level of plutonium is sufficiently low (< 0.03 µCi/mL) to obviate the need for titanium-treated zeolite.

D.6.2.1 ION EXCHANGE MEDIUM

After evaluating currently available ion exchange materials and using experimental data with process constraints taken into account (e.g., pH level, temperature, pressure, and flow rate), the inorganic ion exchanger IE-96™ (Linde Ionsiv IE-96™ synthetic zeolite) was chosen for cesium recovery because of its high sorbtion rate, DF values, exchange capacity, and compatibility with glass formers for borosilicate glass (Pope, 1985).

Synthetic zeolite (IE-96™) is an alkali metal sodium alumina silicate of the chabazite structure ($Na_2O \cdot AL_2\ O_3 \cdot Si\ O_2$) in the mixed ionic form of Na+, Mg^{++}, Ca^{++}. IE-96™ is a molecular sieve which is used because its small and uniform pore structure can absorb small molecules and exclude molecules larger than the pore opening (pore opening 370 x 420 pm [3.7 x 4.2 Å]).

The performance of the inorganic zeolite IE-96™ is dependent on temperature, salt concentration, flow rate, Na/Cs (sodium/cesium) feed ratio and pH levels as demonstrated below:

Process Parameters	Dependency
Temperature	Lower temperature [6°C (43°F) design] will enhance Cs recovery
Salt Concentration	Lower concentration of salt will enhance cesium recovery.
pH levels	pH level will be <13 to enhance cesium recovery.
Flow rate	Cs loadings are enhanced by lower flow rates.
Na/Cs mole ratio	Cs loading is enhanced by lower Na/Cs mole ratios in the feed.

The Ti-treated zeolite is a newly developed ion exchange material for Pu and Sr removal. Physical dependencies were determined by PNL using batch distribution tests. It was determined that Sr and Pu extraction efficiencies increase with both temperature and pH increases, while Cs removal efficiency decreases with increased temperature and pH. Further, the percent loading of titanium on the zeolite decreases the Cs extraction efficiency slightly at weight percents greater than 1.0.

A multi-tiered supplier qualification program is in place to verify the capability of a vendor to prepare the Ti-treated zeolite. Part of the qualification work includes stability and handling tests. Product availability and practicality are the net result of having determined that a vendor is capable of producing the Ti-treated zeolite per the procurement specifications.

Table D.6.2-1 shows the chemical composition specifications for the Ti-treated ion exchange medium.

D.6.3 MECHANICAL PROCESS SYSTEM

D.6.3.1 COLD CHEMICAL RECEIVING, HANDLING AND TRANSFER

Zeolites are delivered in 208-L (55-gal.) drums and handled by operators trained to handle these materials. Safety equipment that includes rubber gloves, goggles, and respiratory protection equipment, as necessary, are worn during these operations. Additionally, portable eye wash stations are available in the STS support building. Material safety data sheets are maintained in the Project files and will be filed for all chemical agents. Safety considerations for chemical handling are in accordance with the WVNS Industrial Hygiene and Safety Manual (WVDP-011). The use of chemical additives for process pH and hydroxide molarity control is discussed in Section D.6.4.

D.6.3.2 FRESH ZEOLITE LOADING

Fresh zeolites are fed to the STS process as a water slurry. Dry zeolite (from drums) is transferred to the zeolite batch tank located in the STS building, using a pneumatic system to transfer zeolite into the 0.03-m^3 (1-ft^3) capacity hopper. The hopper empties directly into the batch tank. The batch tank is only used for fresh (nonradiological) zeolite.

D.6.3.3 SLUDGE WASH SOLUTION TRANSFER AND HANDLING

Removal of sludge wash solution from Tank 8D-2 is accomplished by the vertical turbine pump 50-G-001. Sludge wash solution is pumped to the prefilter at approximately 90°C (194°F) at a design flow rate of ≤151 lpm (40 gpm) with sludge wash solution in excess of the 23 lpm (6 gpm) through the prefilter being returned to Tank 8D-2.

D.6.3.4 DECONTAMINATED SLUDGE WASH SOLUTION TRANSFER AND HANDLING

The decontaminated sludge wash solution will be stored in original underground stainless steel HLW Tank 8D-3. This tank provides intermediate storage for the LWTS. In the event that the sludge wash solution is not sufficiently decontaminated, (analyzed before transfer from Tank 8D-3 to the LWTS) it will be recycled back to Tank 8D-2. Sludge wash solution will be continuously fed into Tank 8D-3 from the postfilter. Once a sample is analyzed to verify adequate decontamination, the contents of Tank 8D-3 will be transferred in batches to Tank 5D-15B of the LWTS. While awaiting sample analysis and during transfer to Tank 5D-15B the on-line radiation monitor on the inlet of 8D-3 shall be monitored to verify that the sludge wash solution has been sufficiently decontaminated.

D.6.3.5 LOADED ZEOLITE TRANSFER AND HANDLING

The radioactive species separated by the process will be stored on zeolite covered with water for an extended period of time in Tank 8D-1 before delivery to the Vitrification System. The loaded zeolite will be at less than 60°C. The storage system consists of the 8D-1 tank, a sluice water tank, a sluice water pump, and zeolite distribution pumps. The zeolite distribution pumps (55-G-006, 55-G-007, 55-G-008, 55-G-009, 55-G-010) are 110 kW (150 hp) centrifugal pumps that are mounted in the M-6 and M-3 riser in Tank 8D-1, respectively. Approximately five of these pumps will be installed.

These pumps have been sized to operate at low pressure and high flow rate. Under normal operating conditions, structural integrity will not be compromised by damage to tank internals (Gates, 1987).

The zeolite mobilization pump is located just above the bottom of Tank 8D-1 and is supported from a 15-m (50-ft) tubular steel column that houses the pump-to-motor drive shaft. The pump motor is located on the external truss above Tank 8D-1. All pump, column, drive shaft, and motor loads are carried by the independent external truss.

The pump does not remove materials from the tank but serves to redistribute the zeolite over the bottom of the tank. The pump discharges 2,300 lpm (600 gpm) from each of the two nozzles, which spray in opposite directions while the entire pump assembly rotates about the vertical support column at 0.5 rpm. The pump has been sized to operate at low pressure and high flow rate.

Under normal operating conditions, the pump and its supporting elements (e.g., column, drive shaft, motor) will not produce added vertical loads on the original tank vault roof or internal steel tank. Nor will the jet impingement load from pump nozzle under normal operation compromise the structural integrity of the tank internal support structure (column supports) or breach the tank wall or bottom barriers (Gates, 1987).

D.6.3.6 SLUDGE MOBILIZATION PUMPS

A series of 15-m (50-ft) long mobilization pumps identical to the zeolite distribution pumps will be installed at strategic locations within Tank 8D-2 (Figure D.4.1-1) through access sleeves (risers), before sludge washing. As described earlier, the mobilization pump has been sized to operate at low pressure and high flow rate. Under normal operating conditions, structural integrity will not be compromised by damage to tank internals (Gates, 1987 and 1991). The pumps are located just above the bottom of Tank 8D-2 and are supported from a 15 m tubular column that houses the pump-to-motor drive shaft. The pump motor is located on the external support truss above Tank 8D-2. All pump, column, drive shaft, and motor loads are carried by the independent external support truss. The mobilization pumps do not remove material from the tank, but serve to resuspend the settled sludge from the bottom of the tank. These pumps will provide agitation by using the fluid in the tank to resuspend the sludge. The pump and its supporting elements will not produce added vertical loads on the original tank vault roof or internal steel tank. Nor will the jet impingement load from pump nozzles under normal operation compromise the structural integrity of the tank internal support structure or breach the tank wall or bottom barriers (Gates, 1991). The pumps have two opposed nozzles at the bottom and discharge at a flow rate of 2300 lpm (600 gpm) from each nozzle. The pumps will have a rotational speed of 0.5 rpm. Since all the electrical and mechanical rotating equipment requiring service are external to the tank, all pump maintenance (i.e., greasing bearings, oiling motors) is performed by conventional means.

D.6.4 CHEMICAL PROCESS SYSTEMS

The SMWS will add dilute caustic to Tank 8D-2. The caustic is expected to be commercial rayon grade caustic soda solution produced by the mercury cell electrolytic process. The dilute caustic is handled by conventional means (i.e., tanks, tank trucks, metered pumps, drums) by operators trained in handling this material. Safety equipment that includes plastic coveralls, rubber gloves, and goggles are required to be worn when working with these chemicals. Emergency eye wash stations will be available in the dilute caustic transfer areas.

The dilute caustic solution will be discharged from storage (storage is described in Section D.4.3.8) by pressurization of the tank trailer with conditioned plant air or electrically powered or truck tractor-engine-powered pump. In either case, the dilute caustic addition will be volumetrically batch-metered. After the dilute caustic addition is complete, the pipeline will be flushed with water. The caustic is expected to enter Tank 8D-2 through an existing spare 5-cm (2-in.) pipe in riser N12, unless an alternative riser is determined to be more advantageous. The dilute caustic will free fall from the top of the tank/riser into the tank. Alternatively, the additions may be made via a pipeline that extends down beneath the tank liquid level to minimize caustic aerosol carryover into the WTFVS.

D.6.5 PROCESS SUPPORT SYSTEM

D.6.5.1 WATER RECYCLE

The water recycle subsystem provides water for backflush, dilution, ion exchange column rinse and for equipment decontamination, should maintenance or removal of equipment in radioactive service be required. The source of water is the secondary waste water at the bottom of Tank 8D-1 or demineralized water, depending on need and availability. The system is remotely operated via valves and block connectors in the valve aisle.

D.6.5.2 PROCESS INSTRUMENTATION AND CONTROL SYSTEM

The STS control panel provides the principle method of process control for the STS/SMWS. A supporting control system used is the laboratory information management system (LIMS).

The information management and control strategy for the STS/SMWS is implemented using the STS control panel in conjunction with the associated local control panels, process actuators, instruments, and other monitoring equipment.

STS control panel and LIMS are designed to operate independently without loss of function if the other panel fails. There are no interconnections.

From the STS control panel the operator can remotely monitor all major aspects of the system. For emergencies, the process pumps can be manually shut down with the emergency stop button in the STS control panel and restarted through the normal startup sequence by the operators. The control panel provides for safe operation with an alarm system that alerts the operators of any abnormal condition. Various electrical interlocks additionally ensure safe operation during STS processing. The P&ID's show the instrumentation and control features associated with process control, process monitors, alarms, and their interrelationship. The P&ID's apply during normal and abnormal operation, and during accident conditions. The redundancy of the control approach is evident by inspection of the P&ID's. A summary of major process instrumentation for the STS/SMWS is found in Table D.6.5-1.

The operator is able to monitor process conditions through panel mounted instrumentation. This includes a panel mounted graphic display flow diagram.

Primary functions of the computer and control systems are summarized below.

STS Control Panel and Associated Local Control Panels

- Implement automatic regulation of key process evolutions
- Monitor procedures initiated by the operator to ensure that the process is placed in a safe operating condition
- Monitor operations (data collection is by manual means)
- Provide interfaces by which operators interact with the process
- Assist with orderly shutdown when requested by the operator
- Monitor the STS/SMWS plant and ensure continued safety of the plant when operations are suspended

Laboratory Information Management System (LIMS)

- Assists in operation of the analytical facility

- Maintains records of samples from receipt to disposal
- Records and transmits results of sample analyses to the VAX

D.6.5.3 SYSTEM AND COMPONENT SPARES

Due to the single use nature of the STS process and the finite operational period expected (<10 y), problems associated with major component failure due to factors such as fatigue and corrosion, are expected to be minimal. Therefore, maintenance of on-site spares for most major STS processing components in radioactive service is not deemed necessary. However, spares for selected components particularly susceptible to failure, i.e., pumps, valves, and jumpers are maintained on-site as backups. Additionally, for equipment not in radioactive service, vendor recommended spare parts are stored on-site for selected equipment.

D.6.6 CONTROL ROOM

Figure D.6.6-1 presents the STS control room panel layout. The control room location within the STS building is shown on Figure D.5.2-6. The SMWS control room will be located in the V&S Building (Figure 6.6-2), which is located in the WTF. The SMWS Control Room consists of a series of variable speed controllers for the mobilization pumps. Also included in the control room are the motor starters to the mobilization pump rotating assemblies. All pump monitored operating variables are mounted on the variable speed controller doors.

Because the STS and SMWS can be operated independently at different times, separation of the control rooms will not impose difficulties in coordinating processing of sludge wash solutions.

D.6.7 STS AND SMWS SAMPLING AND ANALYTICAL REQUIREMENTS AND PROCEDURES

Capabilities for complete radiochemical analysis of STS solutions are continuously provided to monitor and control the STS process control and to ensure the confinement of radioactivity. This is accomplished by two independent Analytical Support Systems: an "On-Line" Radiation Monitoring System and the "Off-Line" Pneumatic Sample Transfer System (lab analysis). The On-Line Radiation Monitoring System provides continuous, real-time analysis of the radioactivity within enclosed systems (piping, vessels). Gamma scintillation detectors (on-line monitors) installed within the process continuously monitor radioactivity and will signal alarms in the STS control room should significant deviations above/below preset levels occur. The detectors have been appropriately selected and/or shielded to provide the necessary range of sensitivities.

In addition to this on-line system, samples of sludge wash solution, decontaminated sludge wash solution and various process solutions will be routinely extracted via remote techniques from sampling ports in the valve aisle for complete radiochemical analysis. The sample is extracted from the process stream using established sampling procedures to ensure a representative sample has been taken. Using manipulators, STS operators will extract process samples (up to 50 mL [1.7 oz]) into a sample vial. The vials will be remotely placed into a transfer vessel (known as a "rabbit") which will be pneumatically transferred from the valve aisle to the Analytical Cell of the main processing plant via the Pneumatic Transfer System. Alternatively, vials could be manually transferred in appropriately shielded containers if necessary.

The rabbit will be remotely placed by a manipulator into the slide ring within the valve aisle. An electronic signal will be sent to the Analytical Cell indicating that a sample is ready to be transferred. A vacuum system activated by the technician at the analytical aisle will transfer the rabbit to a receiver box in the Analytical Cell. The vacuum system will be capable of pulling 100 m^3/h of air thr gh the sender box. Upon receipt, a "received" signal is sent to the operator the STS Support Building. Once received in the Analytical Cell, samples will be diluted and aliquots will be extracted for various radiochemical analysis.

Photocells, located throughout the length of the Pneumatic Transfer System piping, will track the movement of the rabbit. The major components of the Pneumatic Transfer System are constructed of 304 L stainless steel. The transfer system piping has been designed to maintain exposure at any routinely accessible surface to 65 nC/kg-h (0.25 mR/h) averaged over any one-hour period.

Operating procedures have been developed for operation of the Pneumatic Transfer System and for interfacing with the plant analytical laboratory. The consequences and mitigation of a processing sample becoming "stuck" in the transfer system piping is discussed in Section D.9.1.3.

Similarly, to monitor and control the STS integrated process and to ensure the confinement of radioactivity, complete radiochemical analyses of sludge wash solutions will be provided through two independent Analytical Support Systems: an "On-Line" Radiation Monitoring System and the "Off-Line" (laboratory analysis) Pneumatic Sample Transfer System. The STS Run Plan will specify the sampling plan to be used by operations. This provides the minimum sampling frequency to be used for each sample point during routine operations and periods of water recirculation. The limits for sample results and the appropriate actions required to control the process are contained within STS procedures.

WVNS has a well-equipped analytical laboratory to support the STS and SMWS. The facilities include: five analytical hot cells for the preparation or isotopic separation of radioactive samples; one analytical hot laboratory, equipped with six fume hoods, for the preparation or separation of radioactive samples; and three glove boxes for the handling of high-activity alpha samples.

In addition to adequate facilities, the analytical laboratory uses the following analytical equipment: ICP-MS; ICP-AES; three N-Type high purity intrinsic germanium photon detectors; planar high-purity intrinsic germanium photon detector; four ultra-low background alpha/beta counters; single chamber, low background, alpha/beta counter; four silicon charged particle detectors; liquid scintillation counter; laser fluorimeter; atomic absorption, ion chromatograph; and other common analytical equipment.

All aqueous radioactive laboratory wastes are returned to Tank 8D-2 via the hot lab prime hood or the hot cell drains. All organic radioactive laboratory waste is collected in approved satellite accumulation areas and turned over to Waste Management for proper disposal. All solid radioactive waste is double bagged in drums and turned over to Waste Management for compaction and proper disposal.

REFERENCES FOR SECTION D.6.0

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Table D.6.2-1 CHEMICAL COMPOSITION OF TITANIUM-TREATED IE-96™ ZEOLITE

COMPONENT	ANHYDROUS WEIGHT PERCENT
TiO_2 (from treating)	≥3.0 - ≤6.0
TiO_2 (from zeolite)	≤0.485
Total Chloride	≤0.020
Fe_2O_3	≤4.85
Al_2O_3	≤18.9
CaO	≤1.46
MgO	≤0.97
Na_2O	≥6.31
K_2O	≤1.46
$SiO_2 + Al_2O_3 + Na_2O + K_2O$	≥87.3
All others	≤1.94

TABLE D.6.5-1

PROCESS INSTRUMENTATION

SYSTEM: Supernatant Treatment System (STS)
SECTION: Supernatant Filtration and Cooling

INDICATOR	LOCATION	FUNCTION/FEATURES
Liquid Level	HLW tank 8D-2 Supernatant feed tank 50-D-001 Valve aisle sump Process line secondary containment	Monitor liquid level for process control. All instruments equipped with high level alarms except tank 8D-2. Tank 50-D-001 and the valve aisle sump level instruments have low level alarms. Tank 50-D-001 high level alarm is interlocked with supernatant feed pump 50-G-001 to shut off the pump and prevent overfilling D-001.
Temperature	Supernatant cooler 50-E-001 inlet and outlet Brine chiller 50-E-002 inlet and outlet	Monitor and control temperature of supernatant and brine cooling medium for proper process operation. There are high and low temperature alarms on the brine chiller effluent and on the supernatant cooler effluent.

TABLE D.6.5-1

PROCESS INSTRUMENTATION

SYSTEM: Supernatant Treatment System (STS)
SECTION: Supernatant Filtration and Cooling

INDICATOR	LOCATION	FUNCTION/FEATURES
Flow	Supernatant line tank 50-D-001 Demineralized water line to tank 50-D-001 Bubbler probe lines to tank 50-D-001	The supernatant and water flow instruments are an integral part of process control. The dilution of supernatant with water controls the salt and cesium concentration. The water flow instrument and the 50-D-001 bubbler probe flow instrument are equipped with low flow alarms.
Pressure	Inlet and effluent to Supernatant filter 50-F-001 Discharge of feed pump 50-G-002 Tank 50-D-001	These instruments serve process control functions such as monitoring differential pressure across the supernatant filter 50-F-001, pump operation and tank pressure. Alarms of high differential pressure across the filter and low pressure on pump 50-G-002 discharge are provided.

TABLE D.6.5-1 (continued)

PROCESS INSTRUMENTATION

SYSTEM: Supernatant Treatment System (STS)
SECTION: Ion Exchange

INDICATOR	LOCATION	FUNCTION/FEATURES
Liquid Level	Column vent/air pressurization line on jumper in STS valve aisle	These conductivity level instruments indicate the columns are full of liquid; no variable level reading.
Temperature	Upper, middle and lower area of the ion exchange columns	Monitor column temperatures at three levels. High temperature alarms are provided as warning signals to take steps to prevent the zeolite from becoming excessively hot due to radioactive decay heat.
Pressure	Inlet feed line to the columns on a valve aisle jumper	Monitors column pressure which can indicate fouling of the zeolite.
Radiation Detection	Column bottom outlet effluent line	Used for control of the process by monitoring and limiting the radioactivity of the column effluent liquid in the line. These instruments are equipped with a high radiation alarm and a warning alarm normally preset at a lower level.

TABLE D.6.5-1 (continued)

PROCESS INSTRUMENTATION

SYSTEM: Supernatant Treatment System (STS)
SECTION: Ion Exchange

INDICATOR	LOCATION	FUNCTION/FEATURES
Flow	Sluice/liftwater header to all columns	Monitors the flow of sluice water to the columns during regeneration of the column.

TABLE D.6.5-1 (continued)

PROCESS INSTRUMENTATION

SYSTEM: Supernatant Treatment System (STS)
SECTION: Final Filtration and Storage

INDICATOR	LOCATION	FUNCTION/FEATURE
Liquid Level	Decontaminated supernatant collection tank 8D-3	Monitor tank liquid level, also provide secondary method of determining flow rate through STS system. Instrument equipped with high and low level alarms.
Pressure	Inlet and outlet lines to the decontaminated supernatant filter 50-F-002 on jumpers in the STS valve aisle - inlet and outlet linked to read differential across filter.	Monitor inlet, outlet, and differential pressure across the filter to indicate fouling or plugging.
Flow	Outlet of the filter on a jumper in the STS valve aisle.	Monitor and control the flow rate through the ion exchange columns and decontaminated supernatant filter. This instrument is connected to a flow totalizer, which measures the total flow.

TABLE D.6.5-1 (continued)

PROCESS INSTRUMENTATION

SYSTEM: Supernatant Treatment System (STS)
SECTION: Final Filtration and Storage

INDICATOR	LOCATION	FUNCTION/FEATURE
Radiation Detection	Outlet line of filter 50-F-002 on jumper in STS valve aisle. Discharge line of decontaminated supernatant pump 50-G-007 on jumper in STS valve aisle.	Monitor radiation levels of the lines. Both instruments are equipped with a high radiation alarm and a warning alarm normally preset at a lower level. The high radiation alarms are interlocked with auto valves to redirect or stop flow in the event of alarm. The high alarm on filter 50-F-002 effluent changes the position of a three-way valve which delivers flow to tank 8D-3 to deliver flow back to tank 50-D-001. The high alarm on the discharge of pump 50-G-007 closes the discharge valve to the liquid waste treatment system (LWTS).

TABLE D.6.5-1 (concluded)

PROCESS INSTRUMENTATION

SYSTEM: Sludge Mobilization and Wash System

INDICATOR	LOCATION	FUNCTION/FEATURES
Pump Speed	Pump motor control panel in PVS building	Measures frequency to indicate pump speed during sludge mobilization.
Amperage	Pump motor control panel in PVS building	Monitors amperage to indicate relative pump operating conditions
Time	Pump motor control panel in PVS building	Indicates the time the pump has been operated.
Radiation Detection	Individual pump enclosure	Monitors the pump column for radioactive contamination. High radiation activates the external pump enclosure visual alarm and horn.
Temperature	Individual pump enclosure	Monitors pump enclosure temperature to detect abnormal conditions. High and low temperature activates the external visual alarm and horn.

D.7.0 WASTE CONFINEMENT AND MANAGEMENT

D.7.1 WASTE MANAGEMENT CRITERIA

Criteria for the management of radioactive waste generated by the WVDP are described in the WVDP Long-Term Radioactive Waste Management Plan (WVDP-019). The guiding principles followed in the preparation of this plan are:

- Minimize all waste generation,
- Provide as much flexibility as possible in designed facilities to accommodate future uncertainties (e.g., liquid and solid waste volumes, storage, process equipment),
- Segregate uncontaminated from contaminated waste as early as possible to minimize additional storage, disposal, and transportation requirements.
- Minimize occupational exposures,
- Minimize costs,
- Protect the worker, public health, and the environment, and;
- Conform to applicable DOE Orders and guidance from other regulations provided by Department of Transportation (DOT), Environmental Protection Agency (EPA), NRC, and New York State.

D.7.2 RADIOLOGICAL WASTES

From the perspective of liquid radiological waste management, the STS has been designed as a self-contained, closed system. All liquid radioactive by-product streams generated by STS processes is returned to Tanks 8D-1 or 8D-2 for rework (as sludge wash solution feed) or for reuse within the STS (see Section D.7.5). Only the decontaminated sludge wash solution collected in Tank 8D-3, which is considered an STS product, leaves the system (to the LWTS) during the operational phase of the STS.

Solid radioactive wastes generated from normal STS operations potentially include spent roughing and HEPA filters from the WTFVS and/or PVS and the possibility of failed components, which would be remotely removed from radioactive service and overpacked before disposal. These solid wastes are disposed of according to existing WVNS Procedures, which are prepared to comply with applicable DOE Orders.

The loaded spent zeolite discharged to Tank 8D-1 is considered an STS product. The only other solid radioactive waste that may be generated by the STS will be spent sand from the supernatant postfilter. This sand may also be discharged to Tank 8D-1 along with the spent zeolite and would ultimately be transferred to the vitrification process for use as melter feed.

D.7.3 NONRADIOLOGICAL WASTES

The only nonradiological wastes expected to be generated by the STS or SMWS will be nonradioactive, nonhazardous wastes from cold operations in the support buildings.

D.7.4 GASEOUS WASTES

Operation of the STS and SMWS will generate gaseous radioactive wastes treated by two separate and independent ventilation systems: the STS PVS and the original WTFVS. The basic characteristics of air treatment for these two systems is described in this section. The schematic drawing of the sludge wash process flow (Figure D.5.1-5) shows these two existing ventilation systems.

D.7.4.1 STS PVS

The STS PVS provides contamination and temperature control to the STS support building, valve aisle, pipeway, and components suspended in Tank 8D-1 and is schematically depicted in Figure D.7.4-2. Outside air is supplied to the operating areas of the STS support building from separate supply fans. Recirculation air (0.7 m^3/s at STP [1500 scfm]) is provided to the control room and approximately 2.3 m^3/s at STP (4800 scfm) is supplied to the fresh zeolite and water tank area on the second floor. Leakage of approximately 0.05 m^3/s at STP (100 scfm) is expected from the control room and 0.5 m^3/s at STP (1000 scfm) from the fresh zeolite and water area. The operating area in front of the valve aisle receives approximately 1.8 m^3/s at STP (3800 scfm) from the zeolite area. This air is then directed to the valve aisle or into the pipeway/shield structure on top of the Tank8D-1 vault. An infiltration of 0.09 m^3/s at STP (200 scfm) enters the pipeway from the tank farm piping trenches. The resulting approximately 1.9 m^3/s (4000 scfm) is then exhausted to the STS PVS air treatment system where one of two parallel (identical standby) air cleaning trains processes the exhaust air. Each train passes the exhausted air through a mist eliminator, heater, roughing filter and two sets of HEPA filters in series before release to the environment. This system is also connected to an emergency backup power generator. The exhaust air is sampled continuously and monitored by continuous air monitors. Gross alpha/beta and tritium are analyzed weekly in the WVDP Environmental Laboratory. In addition, weekly gamma isotopic analyses are performed if gross activity rises significantly. Weekly filter samples are composited quarterly and analyzed for specific radionuclides of interest.

During mobilization pump installation, exhaust air from Tank 8D-2 will be handled through the PVS. Approximately 0.3 m^3/s at STP (550 scfm) of ventilation air is pulled through Tank 8D-2 to the PVS during a typical mobilization pump installation. This air flow is required to be through a riser access opening in order to comply with the minimum capture velocity across any opening in the WTF HLW Tanks. The minimum capture velocity is 0.64 m/s (125 ft/min).

D.7.4.2 WTFVS

The original WTFVS will continue to provide routine ventilation to Tanks 8D-1, 8D-2, 8D-3, and 8D-4 during STS and normal SMWS operations. The WTFVS is an existing facility constructed in the early 1960s as part of the original reprocessing plant. This ventilation system was not seismically designed or qualified to a DBE. If this equipment does fail and/or on-site backup power is lost during a seismic event, the negative pressure on the HLW Tanks will be lost. However, a loss of a negative pressure does not necessarily result in a backflow out of the tanks. Some draw is maintained on the HLW tanks even when the WTFVS is not operational as a result of natural convection and operation of the main plant ventilation system to which the HLW Tanks exhaust.

The STS process off-gas from the components suspended in Tank 8D-1 are vented into Tank 8D-1. Details pertaining to the design and operation of the WTFVS are presented in Section B.5.4 and Figure B.5.4-6 of Volume II. Air is removed from the tanks at approximately 0.07 m^3/s (150 scfm). This is supplied by leakage from many openings in the system. The Tank 8D-1 and Tank 8D-2 off-gas passes through a condenser to remove water vapor. The Tank 8D-3 and 8D-4 off-gas is passed through a caustic scrubber and then joins the flow from Tanks 8D-1 and 8D-2. The air stream then passes through a knock-out drum and demister to remove entrained liquid. The condensate is returned to Tank 8D-2 while the noncondensibles pass through a heater, then through a single HEPA filter and blower. Both the filters and the blowers have redundant spares connected in parallel to provide continuous exhaust in the event of off-gas equipment failure. This system is also connected to an emergency backup power generator. Following off-gas treatment the exhausted air is combined in the plant stack with effluents from other Project activities. The exhaust air is sampled continuously and monitored by continuous air monitors off-line. Gross alpha/beta and tritium are analyzed weekly. In addition, weekly gamma isotopic analyses are performed if gross activity rises significantly. Weekly filter samples are composited quarterly and analyzed for specific radionuclides of interest. The filter and blower are paralleled with identical standby units. The exhaust line from the blowers connects to the main process plant stack. A basic schematic of the WTFVS Off-Gas Treatment System is shown in Figure D.7.4-3.

During sludge mixing, each mobilization pump will add approximately 90 kW (120 hp) of heat to the Tank 8D-2 contents. The total heat input rate to the tank, with five pumps running, is approximately 450 kW (600 hp). This is in addition to the 50 kW (70 hp) generated by radioactive decay of the remaining unwashed sludge. Assuming that all the heat generated by the pumps produces water vapor, approximately 1,000 L/h (4 gpm) of vapor would pass through the WTFVS. Since the condensers have a design capacity of 4,700 L/h (21 gpm), the water vapor generated from the sludge mixing operation should be condensed efficiently.

D.7.5 LIQUID WASTES

As indicated in Section D.7.2, liquid radioactive wastes resulting from STS operation are returned to Tanks 8D-1 and 8D-2 for rework or reuse within the STS. The condensate from off-gas treatment, sluice, and backwash waters from ion exchange operation is returned to Tank 8D-1 for reuse as STS process water. The prefilter backwash/return and ion exchange rinse solutions are returned to Tank 8D-2 for rework as sludge wash solution feed. Fluids collected in the valve aisle and/or pipeway sumps are transferred back to Tank 8D-2 for rework.

All other process solutions are continuously recycled through their respective closed loops (e.g., sludge wash solution feed recycles through the supernatant feed tank, refrigerant between cooler and chiller, fresh zeolite backwash).

D.7.6 LIQUID WASTE SOLIDIFICATION

The SMWS will produce a sludge wash solution that will be delivered to the STS. The chemical composition of the wash solutions will be slightly different from the chemical composition of the supernatant. Once the wash solutions are decontaminated through the STS, the solution will be transferred to the LWTS evaporator for concentration. The concentrated decontaminated wash solutions will then be incorporated into a cement waste form for ultimate disposal. Since the waste composition of the wash solutions differs from the composition of the supernatant, a new cement recipe will be developed and tested for certification as a Class C LLW. The qualification and certification of the waste form will require a new process control plan for the CSS that will control the quality of the product.

See Section C.7.6 of Volume III and Sections G.7.6 and H.7.6 of Volume IV for further details concerning integration of the SMWS into these systems.

D.7.7 SOLID WASTES

The only solid radioactive wastes potentially generated by the STS will be spent roughing and HEPA filters from the PVS, failed components that would be remotely removed from service and replaced, and materials used within the valve aisle such as wipes and sampling needles. The handling of the wastes will be in accordance with implementing procedures for the WVNS Radiological Controls Manual (WVDP-010) and WVDP Waste Management Plan (WVDP-019).

The only other solid wastes expected to be generated are nonradioactive, nonhazardous wastes, and zeolite fines from cold operations in the STS support building.

In addition to these wastes generated from normal STS operations, the only wastes potentially generated from the SMWS will be the mobilization pumps. The handling of these wastes will also be in accordance with implementing procedures for the WVNS Radiological Controls Manual (WVDP-010) and WVDP Waste Management Plan (WVDP-019)

REFERENCES FOR SECTION D.7.0

WVDP-010, 1989 West Valley Demonstration Project. 1989. "Radiological Controls Manual." Rev. 3.

WVDP-019, 1990 West Valley Demonstration Project. 1990. "Long Term Radioactive Waste Management Plan." WVDP-019, Rev. 8.

D.8.0 RADIATION PROTECTION

D.8.1 ENSURING THAT OCCUPATIONAL RADIATION EXPOSURES ARE AS LOW AS REASONABLY ACHIEVABLE

D.8.1.1 POLICY CONSIDERATIONS

See Section A.8.1.1 of Volume I.

D.8.1.2 DESIGN CONSIDERATIONS

The most important consideration in maintaining exposures ALARA is to ensure the control of radioactivity:

- The SMWS components that will be in radioactive service will be remotely operated and will be located within Tank 8D-2.
- The tank atmosphere is maintained under negative pressure relative to surrounding areas to ensure that air leakage is into, rather than out of, the tank.
- SMWS structural barriers important to the control of radioactivity have been designed such that the confinement of liquid HLW will not be compromised by any credible design basis event.
- Radioactive liquids are transported between tanks and components via remotely operated and instrumented valving and piping systems.
- Remotely operated valves are contained within a shielded valve aisle which contains shield windows and manipulators.

- The shield structure (pipeway) erected on top of the Tank 8D-1 vault provides secondary containment for the upper portions of components suspended in the tank and for piping runs between the components and the valve aisle.

- Remote control of STS operations are monitored from the control room located in the STS support building. The control room contains a graphic display providing operators with real-time information regarding system status.

- The STS is highly instrumented. Remote indicating radiological instruments are used extensively to monitor process conditions and to provide verification that systems are operating within design conditions.

- The potential backflow of radioactivity into normally nonradioactive systems and areas through cold chemical and/or instrument lines will be prevented via block and bleed valves.

Additional mitigative design measures include:

- Use of solid state electronic instrumentation and control equipment to provide high reliability.

- Use of redundancy in critical aspects of the operation.

- Ability to monitor and control the process remotely and to identify leaks remotely from the control panel within the control room.

- Equipment design to enable remote replacement of failed components if necessary.

D.8.1.3 OPERATIONAL CONSIDERATIONS

In conjunction with design considerations, administrative procedures and controls are key considerations in ensuring that the radiation exposure of operators are maintained ALARA. STS operations and control will be

exercised from the control room within the STS support building. This facility is maintained as a non-radiological area. The SMWS Operations and Control will be exercised from both the V&S Building and the Tank Farm area itself.

Administrative and procedural control is maintained in accordance with the WVNS Industrial Hygiene and Safety Manual (WVDP-011), the Radiological Controls Manual (WVDP-010) and specific STS Standard Operating Procedures (see Section D.10.4). The STS Operator Training Program is discussed in detail in Section D.10.3.

A fully instrumented control panel including graphic display is provided to operators with real-time information regarding system status, leaks, deviation from normal operating parameters, etc. Audible and visual alarms indicate when expedient operator responses are required to correct abnormal conditions.

Shielding of workers from piping and valves in radioactive service is provided by the valve aisle and shield structure (pipeway) 65 nC/kg-h (0.25 mR/h) for full time occupancy. Manipulators and shielded viewing windows are incorporated into the design of the valve aisle.

D.8.1.3.1 PROCESS

Equipment normally used is accessible after sufficient decontamination, as determined by WVDP-010 and implementing procedures. Occupancy of process areas under abnormal operations is performed in accordance with WVDP-010 and implementing procedures.

D.8.1.3.2 CONTROL ROOM AND UTILITY FACILITIES

Remote controls and areas never used in radioactive service are accessible to personnel at all times. Administrative and procedural control are maintained in accordance with the WVNS Industrial Hygiene and Safety Manual (WVDP-011, 1989), the Radiological Controls Manual (WVDP-010, 1989) and specific SMWS Standard Operating Procedures (Section 10.4). Operators are provided with a comprehensive training program, commensurate with the requirements of the DOE 5480 series, by the Training and Operations Engineering staffs. The STS Operator Training Program is discussed in detail in Section D.10.3.

Additionally, OSRs establish and maintain process parameters within the design and safety limits for SMWS operation (Section M.11.0 of Volume VI).

D.8.1.3.3 SUPPORT SERVICES

Systems and equipment that are normally used in radioactive service are accessible to personnel only for controlled periods. Administrative controls for access are based on data provided by radiation monitoring instrumentation and/or radiological survey. The operating aisle (in front of the valve aisle), chiller, and fresh zeolite and water tank area, etc. are examples of "support service" areas.

D.8.2 SOURCES OF RADIATION AND RADIOACTIVITY

D.8.2.1 CONTAINED SOURCES

The process feed stream from the SMWS to the STS is sludge wash solution from HLW Tank 8D-2. The metal concentrations in the respective wash solutions are listed in Table D.8.2-1. The estimated maximum concentrations of radionuclides are listed in Table D.8.2-2. The total volume of wash water to be processed is approximately 4,000,000 L through the STS, LWTS, and CSS. Approximately 400,000 L of wash water will remain in HLW Tank 8D-2.

When the first column reaches the "breakthrough" condition, (i.e., the zeolite is maximally loaded and the column extraction efficiency becomes reduced to an undesirable level) or the STS is shut down following completion of a batch run, the column is remotely valved out of the process. The loaded zeolite within the column is then sluiced to the bottom of Tank 8D-1 and the column is recharged with fresh zeolite, and is then available to be valved back into the process. The maximum loading of a Ti-treated zeolite column is shown in Table D.9.2-4.

The multiple confinement features and shielding aspects of the SMWS and STS design preclude personnel from coming into contact with radioactive materials during normal operations of the SMWS. Specifics of the STS design can be found in Section D.8.3.1. The sludge mobilization pumps are bottom voluted; therefore the HLW will never leave Tank 8D-2 during the washing operations. No personnel access to the valve aisle or pipeway above the tank vault should be necessary.

D.8.2.2 AIRBORNE RADIOACTIVITY SOURCES

The STS support building is vented by its own heating and STS PVS. Clean air is supplied from outside the building. The facility is maintained as a nonradiological area and therefore negligible concentrations of radioactive material are expected in areas occupied by operations personnel. Ventilation for the STS system maintains airflow from regions with low potential for airborne radioactivity to areas of potentially elevated activity. Thus, the air supplied to the STS support building exits into and through the valve aisle and pipeway and ultimately passes through several stages of roughing and HEPA filtration prior to release to the environment.

Under normal conditions, clean air within the STS control room and utility areas is exhausted into the valve aisle. Airborne radioactivity in occupied areas is expected to be low. However, continuous airborne radioactivity monitors are located within the STS support building to alert personnel quickly of ventilation system abnormal conditions by sounding audible alarms if elevated levels of airborne contamination occur. The major source of airborne activity would be from filtered, dilute, wash water vapor. The on-site effects from this source are minimal, as the release point is the main plant stack (60 m). Thus there would be negligible impact to personnel in the control room and aisleways. At a minimum, continuous airborne samplers are located in the fresh zeolite and water tank area and in the access area (operating aisle) in front of the valve aisle. Airborne radioactivity levels are expected to be less than 0.1 times the derived air concentration (DAC) for all radionuclides under normal and expected abnormal conditions within normally occupied areas of the STS and SMWS control rooms. The release of airborne radioactivity to the environment is discussed in Section D.8.6.3.

D.8.3 RADIATION PROTECTION DESIGN FEATURES

Radiation protection features basic to the design of the STS and SMWS are dedicated to maintaining ALARA radiation exposures to members of the general public and work force. Effective control of radiation exposures depends primarily on design features that provide adequate shielding from all sources of radiation, provide for remote operations and maintenance, containment of radioactivity within the process, proper ventilation, effluent control, and overall monitoring and surveillance to verify design controls. These physical design features, plus strict adherence to the operational requirements given in WVDP-010, "Radiological Controls Manual," provide effective radiation control.

D.8.3.1 STS AND SMWS DESIGN FEATURES

All HLW handling and processing for STS and SMWS occurs within shielded containment structures. Valves are remotely operated within the shielded valve aisle. A highly instrumented control room, including visual display and visual/audible alarm systems, enables STS and SMWS operators to control the process from a remote location. Equipment and components in radioactive service have been designed for remote removal and replacement should failure occur. Variable speed motor controls for the sludge mobilization pumps are located in the V&S Building, allowing pump operations to be performed from a remote location.

Occasional activities at other locations within the STS support building (fresh zeolite area, operating aisle, utility and support services) will be for short periods of time. These areas are not expected to contain radioactive materials under normal operating conditions.

Ventilation for heating and cooling is provided to the STS Support Building by a separate system referred to as the STS Heating, Ventilation and Air Conditioning System (HVAC). This fresh air is routed from the control room (radiologically cold area) to the utility and support areas of the building (no expected radioactivity areas). The building exhaust is routed through the valve aisle and pipeway. This air is then treated by the PVS before being released to the environment. Air cleaning components of the PVS include a mist eliminator, roughing filter, and two HEPA filter banks in series for particulate removal before discharge. Details of the STS HVAC can be found in Section D.5.4.1 and details of the PVS can be found in Section D.7.4.

D.8.3.2 SHIELDING

Radiation shielding analyses were performed to determine the required shielding for the STS valve aisle and pipeway between the valve aisle and Tank 8D-1

(Ebasco 1985a, Ebasco 1985b, O'Ahoofe, 1985). The areas of concern include the external regions of the walls and roofs of these structures 65 nC/kg-h (0.25 mR/h) in any full time occupancy area.

Calculations were performed using the computer code QADMOD, a point kernel gamma ray shielding code (Radiation Research Associates, 1979) provided by ORNL. The version of the code used for these calculations has been verified and approved for use as a shielding design code at WVNS (Peterson, 1984).

The calculation method used by this code involves representing a volume-distributed source of radiation as a number of point isotropic sources. The distances through all regions traversed by line-of-sight from the point sources are computed for each receiver of interest. Energy dependent exponential attenuation factors and energy dependent buildup factors are determined from the computed distances through the regions and the characteristics of the materials within each region. These factors are then applied to calculate the direct gamma ray exposure rate and the exposure rate with buildup. Build-up takes into account the exposure rate from unscattered plus scattered gamma rays.

D.8.3.2.1 PIPEWAY AREA (CONCRETE SHIELDING)

The STS pipeway model used in the analysis is depicted in Figure D.8.3-1. The "source" was assumed to be a rectangular region, 17.7 m (58 ft) x 3.3 m (10.8 ft). The source region was assumed to be 15 cm (6 in) from the roof and front wall and 30 cm (1 ft) from the side walls. The source region was homogenized taking into account the relative volume fractions of the piping material (stainless steel), source medium (assumed to be water at 1.0 g/cc) and air. This was determined to be an adequate and conservative approach since the final piping arrangement was not yet known at the time of the analysis. The source concentration (supernatant) was taken to be 230 MBq/mL (6210 μCi/mL) of cesium-137 (Ebasco, 1985a). Tables D.8.3-1 (walls) and

D.8.3-2 (roof) present the results of the QADMOD code analysis for various concrete densities. To meet the design criteria of ≤65 nC/kg-h (0.25 mR/h), a 91 cm (36 in) concrete thickness was installed for the pipeway walls and roof.

D.8.3.2.2 VALVE AISLE (STEEL/IRON SHIELDING)

The valve aisle model used in the shielding analysis is depicted in Figure D.8.3-2. The "source" was assumed to be a rectangular region, 1.5 m (5 ft) x 1.8 m (6 ft) x 1.5 m (5 ft) located 15 cm (6 in) from the side and front walls and approximately 2.7 m (9 ft) from the roof. Source strengths of 76 (20), 189 (50), and 379 L (100 gal) of supernatant were used in the calculations. The source region representation was similar to that used for the pipeway analysis. Tables D.8.3-3 (front wall), D.8.3-4 (side walls) and D.8.3-5 (roof) present the results of the QADMOD evaluation for the three source strengths. The valve aisle walls and roof are built with a 30-cm (12-in) thickness of steel to meet the design criterion of ≤65 nC/kg-h (0.25 mR/h). This analysis also assumed a source concentration of 230 MBq/mL (6210 μCi/mL) ^{137}Cs. The maximum sludge wash solution concentration is expected to be <61 MBq/mL (1640 μCi/mL), which is well within the shielding design limits.

D.8.3.3 VENTILATION

The STS PVS (described in Section D.5.4.1 and D.7.4) provides fresh air to the operating areas of the SMWS and STS support building and ventilation for contamination control to the valve aisle, pipeway, and components in Tank 8D-1. Air flowing through the STS facilities is from regions having a low probability for airborne radioactivity to areas having a potential airborne contamination. Specifically, the air flow sequence is from the control room to fresh zeolite and water area to the operating aisle (occupied areas of increasing contamination potential) and then into the valve aisle and to the pipeway (unoccupied areas which could contain airborne radioactivity from piping/valving leaks, etc.). Air is exhausted from the pipeway and treated via a mist eliminator, heater, roughing filter, and 2 HEPA filters to remove entrained radioactive material before release to the environment through a short (10 m) stack.

The STS effluent monitoring system (described in Section D.8.6.1), in conjunction with pressure drop measurements across the filters, provides operating data regarding the potential loading of these filters. If replacement of filters is necessary, waste disposal of spent filters will be in accordance with the requirements of the WVNS Radiological Control Manual (WVDP-010). Personnel doses from this operation are noted in section D.2.4. Tanks 8D-1, 8D-2, and 8D-3 will continue to be vented via the original WTFVS. (See Sections D.5.4.1 and D.7.4 for details pertinent to the Off-Gas Treatment System.)

D.8.3.4 AREA RADIATION AND AIRBORNE RADIOACTIVITY MONITORING INSTRUMENTATION

Continuous radiation monitoring capabilities are provided to warn of undesirable trends and/or abnormal conditions. An ARM and a CAM are located in the fresh zeolite dispensing area and in the manipulator operating aisle (minimum of two arms and two cams for each area). Radiation monitoring is connected to emergency backup power.

Area radiation monitors provide an audible alarm when a preset exposure rate is reached. These instruments can be operated in the useful range of 26 nC/kg-h (0.1 mR/h) to 2.6 mC/kg-h (10 R/h). Continuous airborne monitors sample air through a fixed particulate filter at flow rates greater than 0.001 m^3/s (several cfm) and will alarm when a preset count rate is reached. These instruments use open window GM detectors, which are sensitive to both beta and gamma activity.

Radiation monitoring instruments are also used in the STS to monitor the radioactivity within contained systems (pipes, tanks) and to ensure that radioactivity is not transferred to systems/areas not intended or designed to safely receive such material (utility lines, cold systems). Radiation monitoring for process control is discussed in Section D.6.7.

D.8.4 ESTIMATED ON-SITE DOSE ASSESSMENTS

Operation of the STS and SMWS will require personnel to work in areas where radiation levels are higher than background and thus incur radiation doses. The maximum annual collective occupational dose associated with SMWS would result from continuous operations and is estimated to be approximately 3 person-cSv (3 person-rem) based on the following assumptions:

- Normal operation of the SMWS in conjunction with STS would require nine to ten operators (three per shift, three shifts/day) with routine system shutdowns for ten days between wash campaigns, resulting in approximately 5 person-mSv/y (500 person-mrem/y). Areas occupied by personnel on a full-time basis were designed to maintain radiation exposure rates ≤65 nC/kg-h (0.25 mR/h).

- Pump installation will require five persons for a total of 80 hours to install all five sludge mobilization pumps. It is expected that this will result in approximately 1 person-cSv (1 person-rem).

- Buoyancy probe measurements to determine sludge settling is expected to involve two persons for 8 hours for each of the four washes. It is estimated that this will result in approximately 2 person-mSv (200 person-mrem) of exposure for all washes combined.

- No significant radiation dose to individual workers is expected from maintenance activities such as HEPA filter changeouts (<1/y) and mobilization pump maintenance. Therefore, it is estimated that all maintenance activities would result in approximately 1 person-cSv/y

(1 person-rem/y). Circumstances requiring workers to be in proximity to components in radioactive service and contributing any significant dose are considered "abnormal events" and are discussed in Section D.9.1.

- SMWS operations on HLW Tank 8D-2 will not require full-time occupancy and access to this area is limited and controlled. Therefore, this operation will contribute no significant radiation dose (approximately 5 person-mSv [500 person-mrem] for the entire SMWS operation).

Actual routine operation of the STS during sludge wash solution processing compared to the STS supernatant processing will probably result in somewhat lower occupational annual doses because the sludge wash solutions are expected to be lower in activity than the supernatant. The WTF has both physical and administrative entry controls.

D.8.5 HEALTH PHYSICS PROGRAM

The STS is operated in compliance with the requirements of the WVNS Radiological Controls Manual, WVDP-010, and DOE Order 5480.11. The WVNS Radiological Controls Manual specifies the requirements for radiation protection of occupational workers, unborn children, students, minors, and on-site members of the public as required by DOE Order 5480.11, Section 9. The health physics program for the STS is the same as for other Project activities. The health physics program for the Project is discussed in Section A.8.5 of Volume I.

D.8.6 OFF-SITE DOSE ASSESSMENT

D.8.6.1 EFFLUENT MONITORING PROGRAMS

Effluent releases from the operation of the STS and SMWS will be monitored via the existing on-site and off-site monitoring program which has been in place since the inception of the WVDP in 1981. This program is described in Section A.8.6.1 of Volume I. Minor modifications will be made to this program, if needed, to meet the specific monitoring requirements associated with operation of the STS and SMWS. Details and results of the WVDP ongoing monitoring program are available in annual reports. It is envisioned that the current program will be continued by DOE until the WVDP is completed.

The original WTFVS will continue to supply ventilation needs to Tanks 8D-1, 8D-2, 8D-3, and 8D-4 during STS and SMWS operation. This system exhausts into the main process building stack. Effluents from the WTFVS will continue to be monitored at the stack along with effluents from other Project activities as described in Section B.5.4.1.2.2 of Volume II. The WTFVS is described in Sections D.5.4.1 and D.7.4.2.

Ventilation air exhausted from the STS support building is released at the STS PVS stack located at the WTF The PVS is described in Section D.5.4.1 and D.7.4.1. Monitoring equipment for the PVS also is located at the tank farm.

A probe is used to withdraw sample gas which passes through a sampler, an alpha particulate monitor, and a beta particulate monitor simultaneously. These continuous air particulate monitors provide alarm indications in the STS building control room, should radioactive particulate levels in the exhaust air exceed preset levels. The sampler media is screened weekly for gross radioactivity and quarterly composites of the glass fiber filters are analyzed for specific isotopes, including gamma-emitting radionuclides, strontium-90, and transuranics. Flow and count-rate sensors will activate a backup vacuum pump and various alarms if equipment failures occur. This system is provided with auxiliary backup power.

D.8.6.2 ANALYSIS OF MULTIPLE CONTRIBUTION

See Section A.8.6.2 of Volume I.

D.8.6.3 ESTIMATED EXPOSURES FROM AIRBORNE RELEASES

The major effluent resulting from operation of the SMWS and STS during washing will be filtered, dilute, wash water vapor. It is assumed that 1,000,000 L of wash water vapor will leave Tank 8D-2 during the washes, that approximately 970,000 L will return to the WTF from the condenser, and that the partition coefficient (ratio of radionuclide concentration in liquid to that in the vapor) will be 1000. In addition, the following radioactive DFs are used: condenser, DF = 30; 1 bank HEPA filters, DF = 1,000 (ANSI-1980). These assumptions lead to an overall DF for radioactivity for the WTFVS, including the partition coefficient, of 3×10^7. Further, approximately 70% of the wash solution will be removed and processed by the IRTS between each wash. Based on the above assumptions, it is calculated that 185 MBq (5 mCi) of ^{137}Cs will be released from the main stack, resulting in a maximum individual off-site effective dose equivalent from all radionuclides of 700 nSv (<70 μrem) annually as determined by AIRDOS-PC (AIRDOS-PC, 1989; WVDP-065). Table D.8.6-1 lists the total airborne release of each of the major radionuclides for the SMWS.

During mobilization pump installation, exhaust air from Tank 8D-2 will be handled through the PVS. The PVS consists of two parallel air cleaning trains, one of which is an identical, dedicated spare, that process the exhaust air. Each train will pass the exhausted air through a mist eliminator (DF = 30), heater, roughing filter, and two sets of HEPA filters in series

(DF = 1000 x 100) before release to the environment. With a partition coefficient of 1000, the resultant PVS DF is 3×10^9. The PVS exhaust air is monitored before release to the environment by an effluent sampling system similar to that at the main plant stack. Approximately 0.3 m^3/s at STP (550 scfm) of ventilation air is pulled through Tank 8D-2 to the PVS during a typical mobilization pump installation. Assuming dry air is pulled through the tank and exits saturated, the resulting radioactive release, assuming pump installation will take nine months, is 148 kBq (4 μCi) of ^{137}Cs, resulting in an offsite maximum effective dose equivalent from all radionuclides of <10 nSv (<1 μrem) annually as determined by AIRDOS-PC.

The STS valve aisle equipment vents to the PVS. However, the releases of radioactive material from the STS are expected to remain low because the PVS exhausts air only from the STS support building, which contains very small quantities of airborne radioactive material, and from the valve aisle and pipeway in which the radioactive material is completely contained within enclosed valves and piping. During calendar year (CY) 1989 when supernatant was being processed, the total release was less than 7.4 mBq (0.2 μCi). Nonetheless, the exhaust air from the PVS will be monitored as described above.

After the wash solutions are decontaminated in the STS, the solutions are transferred through a 5-cm (2-in) double-walled underground stainless steel pipe to the LWTS where it is concentrated by evaporation. The off-gases from the evaporator are vented to the original Vessel Off-Gas (VOG) system located in the former reprocessing plant. The VOG system consists of a condenser, a knock-out drum, scrubber, cyclone, heater, HEPA filters, and exhausters. Exhaust air then passes through a second HEPA filter bank before discharge via the main stack. Releases from the VOG system would be at least 100 times less than the release from the PVS due to the extra bank of HEPA filters. This effluent release is monitored by the main stack monitoring system.

D.8.6.4 LIQUID RELEASES

With respect to liquid radioactive wastes, the SMWS and STS will be operated as a closed, self-contained system. There will be no direct release of liquid radioactive material to the environment from the normal operation of the SMWS (Section D.7.5). Additionally, the potential for release of liquid HLW to the environment under design basis accident conditions is considered not credible (Sections D.9.2.5 and D.9.3).

There will be liquid releases from the LWTS as a result of concentrating the decontaminated sludge wash solutions. Approximately 4,000,000 L of wash solution will be removed from Tank 8D-2 and processed through the IRTS. The LWTS will discharge approximately 2,500 000 L of evaporator overheads or condensate. The remaining concentrate will be incorporated into a cemented solid waste form in the CSS.

The radioactivity concentration in the LWTS feed is the activity of the decontaminated wash solution produced by STS. The decontaminated wash solution is volume-reduced in the LWTS by evaporation. The vapor passes through a high-efficiency condenser and the condensate passes through an ion exchange bed before release to the interceptors and Lagoon 2. From Lagoon 2 the liquid is processed by the LLWTF and ultimately discharged to the environment via Lagoon 3.

Discharged liquid from the LWTS is sampled and the concentration of radioactivity is determined before discharge. The acceptance criteria for release to the interceptors is that the concentration of radioactivity must be less than 185 mBq/mL (5 x 10^{-3} μCi/mL) (not including tritium). Operation of the SMWS will produce LWTS evaporator overheads that easily meet this criteria. Indirect liquid releases are expected from the LWTS. The estimated total radioactivity assumed to be released in liquid effluent (LWTS condensate) is discussed in Part H of Volume III.

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TABLE D.8.2-1 METAL CONCENTRATIONS IN WASH SOLUTIONS

Major Metals	First Wash µg/mL	Second Wash µg/mL	Third Wash µg/mL	Fourth Wash µg/mL
Al	4.9E+01	4.9E+01	3.2E+01	1.7E+01
Fe	2.4E-01	8.0E-02	2.0E-02	1.0E-02
Ca	3.5E+00	3.2E+00	3.3E+00	2.3E+00
Cr	6.9E+01	2.5E+01	6.8E+00	1.8E+00
Mg	9.7E-01	6.6E-01	3.9E-01	3.6E-01
Mn	9.0E-01	2.7E-01	9.0E-02	1.9E-01
Mo	2.0E+01	7.3E+00	2.1E+00	5.8E-01
Na	2.8E+04	1.0E+04	3.1E+03	1.3E+03

TABLE D.8.2-2 MAXIMUM RADIONUCLIDE CONCENTRATIONS

Nuclide	First Wash Conc. Bq/L (Ci/L)	Second Wash Conc. Bq/L (Ci/L)	Third Wash Conc. Bq/L (Ci/L)	Fourth Wash Conc. Bq/L (Ci/L)
H-3	9.29E+05 (2.51E-05)	2.43E+05 (6.56E-06)	[illegible].35E+04 (1.72E-06)	1.66E+04 (4.40E-07)
C-14	1.64E+06 (4.43E-05)	4.29E+05 (1.16E-05)	1.12E+05 (3.03E-06)	2.93E+04 (7.91E-07)
Fe-55	1.42E+03 (3.84E-08)	3.71E+02 (1.00E-08)	9.71E+01 (2.62E-09)	2.54E+01 (6.86E-10)
Co-60	1.48E+05 (3.99E-06)	3.86E+04 (1.04E-06)	1.01E+04 (2.72E-07)	2.64E+03 (7.12E-08)
Ni-63	1.02E+07 (2.76E-04)	2.67E+06 (7.22E-05)	6.98E+05 (1.[illegible]9E-05)	1.83E+05 (4.93E-06)
Sr-90+	4.18E+07 (1.13E-03)	1.09E+07 (2.95E-04)	2.85E+06 (7.71E-05)	7.46E+05 (2.02E-05)
Tc-99	1.90E+07 (5.13E-04)	4.96E+06 (1.34E-04)	1.30E+06 (3.50E-05)	3.39E+05 (9.15E-06)
Ru-106	1.04E+04 (2.81E-07)	2.71E+03 (7.34E-08)	7.10E+02 (1.92E-08)	1.85E+02 (5.01E-09)
Sb-125	2.68E+06 (7.24E-05)	7.00E+05 (1.89E-05)	1.83E+05 (4.95E-06)	4.78E+04 (1.29E-06)
Te-125m	6.01E+05 (1.62E-05)	1.57E+05 (4.25E-06)	4.11E+04 (1.11E-06)	1.07E+04 (2.90E-07)
I-129	2.51E+03 (6.80E-08)	6.57E+02 (1.78E-08)	1.72E+02 (4.64E-09)	4.49E+01 (1.21E-09)
Cs-134	3.03E+07 (8.18E-04)	7.91E+06 (2.14E-04)	2.07E+06 (5.59E-05)	5.41E+05 (1.46E-05)
Cs-137+	6.06E+10 (1.64E+00)	1.58E+10 (4.28E-01)	4.14E+09 (1.12E-01)	1.08E+09 (2.93E-02)
Pm-147	8.75E+05 (2.36E-05)	2.29E+05 (6.18E-06)	5.97E+04 (1.61E-06)	1.56E+04 (4.22E-[illegible]
Sm-151	1.69E+04 (4.58E-07)	4.43E+03 (1.20E-07)	1.16E+03 (3.13E-08)	3.03E+02 (8.18E-09)
Eu-154	1.53E+05 (4.14E-06)	4.00E+04 (1.08E-06)	1.05E+04 (2.83E-07)	2.73E+03 (7.39E-08)
Eu-155	2.08E+04 (5.61E-07)	5.43E+03 (1.47E-07)	1.42E+03 (3.84E-08)	3.71E+02 (1.00E-08)
U-233	7.11E+04 (1.92E-06)	1.86E+04 (5.02E-07)	4.85E+03 (1.31E-07)	1.27E+03 (3.43E-08)
U-234	4.26E+04 (1.15E-06)	1.11E+04 (3.01E-07)	2.91E+03 (7.87E-08)	7.61E+02 (2.06E-08)
U-235	9.29E+02 (2.51E-08)	2.43E+02 (6.56E-09)	6.35E+01 (1.72E-09)	1.66E+01 (4.48E-10)
U-238	8.75E+03 (2.36E-07)	2.29E+03 (6.18E-08)	5.97E+02 (1.61E-08)	1.56E+02 (4.22E-09)
Pu-238	1.84E+07 (4.96E-04)	4.80E+06 (1.30E-04)	1.25E+06 (3.39E-05)	3.28E+05 (8.86E-06)
Pu-239	3.55E+06 (9.60E-05)	9.29E+05 (2.51E-05)	2.43E+05 (6.56E-06)	6.34E+04 (1.71E-06)
Pu-240	2.68E+06 (7.24E-05)	7.00E+05 (1.89E-05)	1.83E+05 (4.95E-06)	4.78E+04 (1.29E-06)
Pu-241	1.74E+08 (4.72E-03)	4.56E+07 (1.23E-03)	1.19E+07 (3.22E-04)	3.12E+06 (8.42E-05)
Am-241	3.83E+05 (1.03E-05)	1.00E+05 (2.70E-06)	2.61E+04 (7.06E-07)	6.83E+03 (1.85E-07)
Am-243	2.73E+04 (7.39E-07)	7.14E+03 (1.93E-07)	1.87E+03 (5.05E-08)	6.88E+02 (1.32E-08)
Cm-244	1.09E+05 (2.95E-06)	2.86E+04 (7.72E-07)	7.47E+03 (2.02E-07)	1.95E+03 (5.28E-08)

Table D.8.3-1

STS PIPEWAY WALLS - SHIELDING ANALYSIS

(91 [illegible]6 in] Thicknesses of Concrete)

SUPERNATANT [illegible]AM - 230 MBq/mL (6210 μCi/mL) ^{137}Cs SOURCE

Concrete Density g/cc	nC/kg·h (mR/h)
2.24	123 (0.477)
2.35	62.7 (0.243)
2.50	25.0 (0.097)
2.85	2.8 (0.011)
3.00	1.0 (0.004)
3.20	0.26 (0.001)

Table D.8.3-2

STS PIPEWAY ROOF - SHIELDING ANALYSIS

(91 cm [36 in] Thicknesses of Concrete)

SUPERNATANT STREAM - 230 MBq/mL (6210 μCi/mL) ^{137}Cs SOURCE

Concrete Density g/cc	nC/kg-h (mR/h)
2.24	116 (0.450)
2.35	58.6 (0.227)
2.50	23.2 (0.090)
2.85	2.58 (0.010)
3.00	1.03 (0.004)
3.20	0.258 (0.001)

Table D.8.3-3

STS VALVE AISLE - FRONT WALL - SHIELDING ANALYSIS

(30 cm [12 in] Thicknesses of Steel)

76, 189, 379 L (20, 50, 100 gals) @ 230 MBq/mL (6210 μCi/mL) ^{137}Cs
SUPERNATANT SOURCE

Front Wall cm (in)	μSv/h 76 L	μSv/h 189 L	μSv/h* 379 L
30 (12)	5.900E-01	1.480E-00	2.950E-00

SOURCE GEOMETRY: (1.5 m [5 ft] X 1.8 m [6 ft] X 1.5 m [5 ft])

* 1 μSv/h = 0.1 mrem/h

Table D.8.3-4

STS VALVE AISLE - SIDE WALL - SHIELDING ANALYSIS

(30 cm [12 in] Thicknesses of steel)

76, 189, 379 L (20, 50, 100 gals) @ 230 MBq/mL (6210 μCi/mL) ^{137}Cs
SUPERNATANT SOURCE

Side Wall cm (in)	μSv/h 76 L	μSv/h 189 L	μSv/h* 379 L
30 (12)	5.600E-01	1.420E-00	2.830E-00

SOURCE GEOMETRY: (1.5 m [5 ft] X 1.8 m [6 ft] X 1.5 m [5 ft])

* 1 μSv/h = 0.1 mrem/h

Table D.8.3-5

STS VALVE AISLE ROOF - SHIELDING ANALYSIS

(30 cm [12 in] Thicknesses of Steel)
76, 189, 379 L (20, 50, 100 gals) @ 230 MBq/mL (6210 μCi/mL) ^{137}Cs
SUPERNATANT SOURCE

Roof cm (in)	μSv/h 76 L	μSv/h 189 L	μSv/h* 379 L
30 (12)	2.400E-02	52.980E-02	1.180E-01

SOURCE GEOMETRY: (1.5 m [5 ft] X 1.8 m [6 ft] X 1.5 m [5 ft])

* 1 μSv/h = 0.1 mrem/h

TABLE D.8.6-1 MAXIMUM NORMAL OPERATIONS AIR RELEASES

Nuclide	VOG Effluent Bq (Ci)		WTFVS Effluent Bq (Ci)	
H-3	1.25E+12	(3.38E+01)	9.02E+10	(2.44E+00)
C-14	2.21E+12	(5.97E+01)	1.59E+11	(4.30E+00)
Fe-55	6.38E+02	(1.73E-08)	4.60E+00	(1.24E-10)
Co-60	6.63E+04	(1.79E-06)	4.77E+02	(1.29E-08)
Ni-63	4.59E+06	(1.24E-04)	3.31E+04	(8.93E-07)
Sr-90	3.75E+06	(1.01E-04)	1.35E+05	(3.65E-06)
Tc-99	8.52E+06	(2.30E-04)	6.13E+04	(1.66E-06)
Ru-106	4.66E+03	(1.26E-07)	3.36E+01	(9.08E-10)
Sb-125	1.20E+06	(3.25E-05)	8.66E+03	(2.34E-07)
Te-125m	2.70E+05	(7.30E-06)	1.94E+03	(5.26E-08)
I-129	3.39E+09	(9.16E-02)	2.44E+08	(6.59E-03)
Cs-134	1.36E+04	(3.68E-07)	9.79E+04	(2.65E-06)
Cs-137	2.72E+07	(7.36E-04)	1.96E+08	(5.30E-03)
Pm-147	3.93E+05	(1.06E-05)	2.83E+03	(7.64E-08)
Sm-151	7.61E+03	(2.06E-07)	5.48E+01	(1.48E-09)
Eu-154	6.87E+04	(1.86E-06)	4.95E+02	(1.34E-08)
Eu-155	9.33E+03	(2.52E-07)	6.72E+01	(1.82E-09)
U-233	3.19E+04	(8.63E-07)	2.30E+02	(6.21E-09)
U-234	1.92E+04	(5.18E-07)	1.38E+02	(3.73E-09)
U-235	4.17E+02	(1.13E-08)	3.01E+00	(8.12E-11)
U-238	3.93E+03	(1.06E-07)	2.83E+01	(7.64E-10)
Pu-238	1.03E+06	(2.79E-05)	5.94E+04	(1.61E-06)
Pu-239	1.99E+05	(5.39E-06)	1.15E+04	(3.11E-07)
Pu-240	1.50E+05	(4.06E-06)	8.66E+03	(2.34E-07)
Pu-241	9.80E+06	(2.65E-04)	5.64E+05	(1.53E-05)
Am-241	1.72E+05	(4.64E-06)	1.24E+03	(3.34E-08)
Am-243	1.23E+04	(3.32E-07)	8.84E+01	(2.39E-09)
Cm-244	4.91E+04	(1.33E-06)	3.54E+02	(9.56E-09)

D.9.0 ACCIDENT SAFETY ANALYSIS

D.9.1 ABNORMAL OPERATIONS

Abnormal events are events that could occur from the malfunctioning of systems, operating conditions or operator error. Abnormal events are only of potential consequence for those systems in the STS and SMWS which process, control or confine radioactivity.

Some possible abnormal events are not discussed either because they do not pose a radiological or industrial hazard or because the effects are similar to or less than the abnormal events described below.

In the hazardous materials spills evaluated in WVDP-096, "Safety Assessment of WVDP Hazardous Substances," a major spill sufficient to escape off-site is not considered credible. Recognizing that major or even minor spills could result in hazards to WVDP personnel, the public, and the environment, the WVDP has implemented an Oil, Hazardous Substances, and Hazardous Wastes Spill Prevention, Control and Countermeasures Plan (WVDP-043, November 1989). This operating plan reviews in detail release flow paths, sources, system design, and the containment of possible spills or releases as well as prevention, preparedness, response, and notification procedures. Specifically, the plan conforms to the requirements of 40 CFR Part 112 and Part 151 (proposed), both dealing with facilities having a potential for hazardous substances releases.

D.9.1.1 LEAK IN STS COOLER/CHILLER SYSTEM

The sludge wash solution must be cooled to optimize the ion exchange process. This is accomplished by passing the sludge wash solution through a heat exchanger (supernatant cooler) within Tank 8D-1. The cooling fluid is a salt solution supplied from the STS chiller located in the STS support building. The salt solution is cooled in the chiller via an organic refrigerant loop.

Structural failure of the cooler heat exchanger could result in sludge wash solution coming into contact with the salt solution in the chiller/cooler loop. This failure could bring sludge wash solution into the STS support building, contaminate the chiller, and possibly result in increased exposure to workers if undetected.

This event is considered highly unlikely since two independent failures would be required. The structural barrier provided by the heat exchanger between the sludge wash solution and salt solution must be breached, and the pressure gradient maintained between these two fluids, which would normally force salt solution into the sludge wash solution (rather than vice versa), must become reversed.

Should sludge wash solution enter the chiller, the local area radiation monitor in the vicinity of the chiller would initiate an alarm, indicating the presence of abnormal levels of radioactivity. The cooler and chiller could be isolated, repaired, decontaminated, or replaced with minimum radiological effect on operating personnel. Radiological controls would be in accordance with the Radiological Controls Manual (WVDP-010).

D.9.1.2 REPLACE FAULTY (LEAKING) BLOCK CONNECTOR ASSEMBLY (EXAMPLE OF CONTACT MAINTENANCE IN VALVE AISLE)

The STS has been designed for remote operation and maintenance. Highly automated and instrumented control systems have been incorporated into the STS design (see Section D.4.3.3). The STS has been designed to accommodate remote removal and replacement of major processing components in radioactive service should an unexpected failure occur.

However, should a major leak develop in a block connector assembly (mates piping together in the valve aisle), it may be necessary for personnel to enter the valve aisle for repair/replacement of the failed assembly. This event is considered unlikely due to the extensive cold-testing, checkout and nondestructive examination procedures that were performed before STS hot operations to ensure proper construction and installation of this and similar STS hardware. Furthermore, if a leak should develop, it could probably be stopped by installing a different type of gasket or valve sealant using remote manipulators without entering the valve aisle.

Should this event occur, the leak would be quickly detected by visual inspection (from the operating area in front of the valve aisle) and/or by instrumented alarms in the control room identifying fluid collection in the valve aisle sump. The STS process would be shut down and the valve aisle piping/valves drained of fluids (returned to Tanks 8D-1 or 8D-2). Every component in 8D-1 can be worked around in some way via the valve aisle at the expense of operating efficiency but not at the expense of decontamination factor. Some cutting, welding, and replacement activities could be done remotely.

Calculations indicate that it would require two persons working 40 hours in an area of 26 nC/kg-h (0.1 mR/h) to remotely replace a faulty block connector assembly. This remote work would be performed under background radiation levels (less than those analyzed) because of the remote manipulators available in the valve aisle. This would result in a collective dose of 80 person-nSv (8 person-mrem).

The off-site radiological consequences of a major sludge wash solution spill in the valve aisle are discussed in Section D.9.2.

D.9.1.3 STICKING ("HANG-UP") OF A SLUDGE WASH SOLUTION ANALYTICAL SAMPLE IN THE PNEUMATIC TRANSFER SYSTEM

Samples of sludge wash solution and other process solutions of 50 mL (1.7 oz) at 61 GBq/L (1.6 Ci/L) are required for analysis of system function. These samples are remotely extracted from sampling ports in the valve aisle and sent via an automated pneumatic transfer system to the analytical chemistry cell of the main process plant. The liquid sample is transported in a plastic vial contained within a transfer "tube type" case known as a "rabbit."

A total volume of about 50 mL (1.7 oz) of supernatant is required for each analysis. Transfers may be 15 mL (0.5 oz) in volume, in which case three separate samples must be sent, or a single 50 mL (1.7 oz) sample may be sent in an identical rabbit. Spacers or shims are placed inside the 50 mL (1.7 oz) rabbit in order to accommodate the smaller 15 mL (0.5 oz) sample vials.

Loss of the system driving force (vacuum) during transfer or a misalignment of the transfer system tubing could result in the sample stopping somewhere between its origin (STS) and destination (analytical chemistry cell). Portions of the pneumatic transfer system piping run through potentially occupied areas of the main process plant.

Sample transfer requires coordination/communication between the sender (STS Operator) and the receiver (Analytical Chemistry Technician). The receiver must electronically initiate the transfer. Photocells located throughout the transfer system tubing follow the movement of the sample through the system.

Should a stoppage occur, it would be quickly detected by the receiver (no sample receipt despite a "sent" signal from the STS). The general location of the stuck sample can be identified by the photocell data and pinpointed by radiation survey of the transfer system tubing. The exposure rate from a 15 mL (0.5 oz) sludge wash solution sample through the stainless steel transfer system tubing is estimated to be approximately 1.3 μC/kg-h (5 mR/h) at 1 m (3.3 ft), and is 3.9 μC/kg-h (15 mR/h) at 1 m (3.3 ft) from a 50-mL (1.7 oz) sample.

Reversal of the system airflow is expected to dislodge the sample and return it to its origin (STS). However, if this does not free the sample, the section of pipe in which the sample is stuck can be located (up to 3.9 μC/kg-h [15 mR/h] at 1 m [3.3 ft]), isolated, and removed, if necessary, to recover the sample. The system also has audible alarms that will sound if a sample becomes stuck.

The relatively small sample size (low exposure rate) in combination with limited access to the affected area where the sample is stuck will minimize exposure to any personnel in the vicinity. Shielding of the affected pipe section during removal/repair and strict adherence to WVNS policies and procedures will control the exposure of workers involved in the actual cutting of piping (if necessary) and the removal of the sample.

It is estimated that it would require two persons working eight hours in an area of 3.9 μC/kg-h (15 mR/h) at 1 m (3.3 ft) from 50 mL (1.7oz) sample to remove a sample stuck in the pneumatic transfer system. This would result in a collective dose of 2.4 person-mSv (240 person-mrem).

D.9.1.4 CESIUM BREAKTHROUGH TO TANK 8D-3 (POTENTIAL BREAKTHROUGH OF HLW TO THE LWTS)

As the zeolite in the STS ion exchange system becomes fully loaded, extraction efficiency is reduced. Reduced extraction efficiency can also occur due to mechanical effects such as channeling (liquid forming flow channels in the ion exchange media, resulting in shorter residence time in the bed and reduced contact with the ion exchange surface area).

Channeling can result from cesium remaining in downstream ion exchange columns heating the zeolite between batch processing. Reduced ion exchange efficiency due to either loading or mechanical effects may result in the decontaminated sludge wash solution stream containing higher cesium concentrations. This condition is known as "breakthrough." Failure of STS analytical support systems (see Section D.6.7) could result in high concentrations passing through the ion exchange system and into the decontaminated sludge wash solution collection tank (8D-3). (From Tank 8D-3, the normally decontaminated solution is transferred in batches to the LWTS.)

The breakthrough condition would normally be quickly identified by analytical samples routinely extracted from the process and by on-line radiation monitors located between the ion exchange system and Tank 8D-3, and between Tank 8D-3 and Tank 35104 (LWTS collection). However, sudden postfilter failure or ion exchange column failure, on-line monitor failure and/or analytical sample error could result in unusually high (>185 mBq/mL [5 μCi/mL]) concentrations of cesium passing into Tank 8D-3 and being transferred to the LWTS. This unlikely event would require the failure of a column or postfilter and the failure of at least two on-line monitors to detect the cesium levels as well as an analytical error.

All transfers to the LWTS are monitored and sampled when received, no significant personnel exposure would be expected from this abnormal event. However, the transfer of off-specification, decontaminated sludge wash solution into Tank 8D-3 and/or subsequent transfer to the LWTS would require transfer back to the STS for rework of these solutions and potential process disruption of the STS and LWTS. Additionally, the receiving vessels (Tanks 8D-3 and 35104) might require flushing and decontaminating to minimize the contamination of future transfers of decontaminated sludge wash solution and/or other LLW solutions. This event, i.e., cesium breakthrough, is a variation of an anticipated operating event; systems are in place to recycle the liquid.

Because the IRTS is a remotely handled system, this abnormal event would require flushing and decontaminating of LLW solution and would result in a negligible collective dose.

D.9.1.5 FAILURE OF TANK 8D-2 SUPERNATANT TRANSFER PUMP

The removal of sludge wash solution from Tank 8D-2 is accomplished by means of floating suction pump. Damage to the pump could result in total pump failure or the transfer of undesirable quantities of sludge particles to the STS in Tank 8D-1. Under either of these circumstances, the pump may need to be replaced.

High solids, loss of fluid flow, or abnormal pressure indications in the STS control room would quickly alert operators to the problem. Depending on the nature of the pump failure, adjustment of this flow rate (e.g., reduced flow rate and/or no recycle) could fix a pump performance problem.

Depending on the specifics of the failure, it could be more desirable to remove the pump assembly and replace it. This would be done remotely and, therefore, no significant radiation exposure to personnel would be expected from the extraction and replacement of the failed pump from Tank 8D-2. (Radiological effects on workers involved in remote installation of equipment into Tank 8D-2 is discussed in Brown, 1986). Control and minimization of worker dose from the contaminated pump would be accomplished in accordance with the waste management requirements of the WVNS Radiological Controls Manual.

A hatch on the supernatant pump pit on the Tank 8D-2 vault would need to be opened to provide access to the failed pump and to insert the replacement pump. During the period of time this hatch is open (several hours), increased ventilation would be necessary to maintain airflow into the open hatch and tank. The ventilation would be similar to that which was in place for the original installation of Pump 50-G-001, a proven method with which WVDP personnel have experience. The additional off-site radiological impact (dose) above that projected in Section D.8.6 for normal operations of the STS and SMWS would be small.

It is estimated that five persons working 40 hours in an area of 645 nC/kg-h (2.5 mR/h) would be needed to repair or replace the Tank 8D-2 supernatant transfer pump. The analyzed exposure rate assumes adequate decontamination of the supernatant transfer pump and the installation of mobile shielding prior to pump removal from Tank 8D-2. This results in a collective dose of 5 person-mSv (500 person-mrem).

D.9.1.6 FAILURE OF A MAJOR STS PROCESSING COMPONENT IN TANK 8D-1 (EXAMPLE: ION EXCHANGE COLUMN)

Circumstances similar to those noted above (detection, corrective action) and potential consequences of the failure of any major piece of STS processing equipment in radioactive service within Tank 8D-1 would be expected. For illustrative purposes, the failure of an ion exchange column resulting in the need to replace the component, is described in this section.

Deviations from normal operating conditions are quickly detected by normal process instrumentation and alarms in the STS control room. For purposes of the ion exchange column example, the most likely failures include: 1) malfunctioning of the mechanical arm or bottom column plug, which could result in a sludge wash water leak into the bottom of Tank 8D-1 (solution on top of the loaded zeolite would require rework) or inability to dump (remove) spent zeolite; 2) failure of the Johnson screens, which could result in zeolite contaminating the decontaminated sludge wash solution outflow (Section D.9.1.3); 3) Failure of the sparge line, resulting in a sludge wash water leak into Tank 8D-1. In all cases, the column would be inoperable. However, it would not necessarily need to be replaced.

During component removal and replacement (in Tank 8D-1), additional ventilation beyond that which could be provided by the WTFVS would be required to maintain airflow from the pipeway through the temporarily open riser and into the tank. This additional ventilation would be provided by the STS PVS under similar circumstances as described in Section D.9.1.5. The short term increase in waste tank farm effluent releases through the STS PVS during the few hours required will not be significant relative to off-site radiological impacts for normal STS operations (see Section D.8.6). The major impact anticipated, should such an event occur, would be STS down-time until the component has been replaced (one to two weeks).

It is estimated five persons working 40 hours in an area of 645 nC/kg·h (2.5 mR/h) would be required to correct this abnormal event. The exposure rate analyzed assumes use of the mechanical arm installed in Tank 8D-1 to perform the necessary repairs, which is in keeping with the experience gained during installation of the bottom dump valves on the ion exchange columns. The dose rate in the area of the mechanical arm is less than 26 μC/kg·h (100 mR/h). This results in a collective dose of 5 person-mSv (500 person-mrem).

D.9.1.7 MOBILIZATION PUMP FAILURE

The replacement of major processing components in radioactive service should an unexpected failure (i.e., a mechanical seal failure) occur will be accomplished by semi-remote means.

Any failure severe enough to require replacement of a mobilization pump is considered unlikely because of the extensive testing, check-out, and nondestructive examination procedures that will be performed before installation. Also, replacement of a failed mobilization pump may not be necessary as spares could be installed in a spare riser with the failed pump remaining in place; it also may be possible to continue sludge washing with the remaining pumps.

During component removal and replacement in Tank 8D-2 additional ventilation would be required to maintain airflow through the temporarily open riser. The additional ventilation would be provided by the PVS. The short-term increase in WTF effluent releases through the PVS will not be significant to off-site doses.

The major effect anticipated should such an event occur would be SMWS down-time until the component could be replaced or repaired.

It is estimated that five persons working 40 hours in an area of 645 nC/kg·h (2.5 mR/h) would be needed to repair or replace a mobilization pump. The analyzed exposure rate assumes adequate decontamination of the sludge mobilization pump and the installation of mobile shielding prior to pump removal from Tank 8D-2. This would result in a collective dose of 5 person-mSv (500 person-mrem).

D.9.1.8 SPARGE LINE

Compressed air from the STS utility system is used to supply air to the sparge line. The normal air pressure in the STS utility system of 790 kPa (100 psig) is less than the ion exchange column design pressure of 1.8 MPa (250 psig) and is also less than the 1.1 MPa (150 psig) design pressure of the STS process piping. Therefore, there is no potential for over-pressurization of the ion exchange column.

Rupture/depressurization of the sparge line during zeolite discharge would not cause a significant problem because discharge through the "J" nozzle valve would continue and backflow through the sparge line would be unlikely. Rupture/depressurization of the sparge line below the installed check valves and air-operated stop valve during routine on-line supernatant processing would result in backflow of sludge wash solution through the sparge line. However, as the rupture/depressurization would have to be below the check valves to permit backflow, the backflow would be within the confines of Tank 8D-1 and its riser and below the level of the concrete tank vault roof.

Therefore, no release to the environment would occur. No increase in external radiation exposure would be experienced.

Backup of activity through the sparge line to the final isolation valve located outside of the riser penetration is not credible because it would require failure of the air-operated stop valve and the two ball-check valves. This event would also require a loss of system back pressure accompanied by either improper operator response to the low pressure alarm or failure of the back pressure alarm. Analysis of the safety impact of back leakage indicates that the sparge line can contain 1,600 mL (51 oz) of sludge wash solution in the 3 m (10 ft) of line from the concrete vault roof up to the operating station. Movement of zeolite into this section of the sparge line would be minimized by an orifice or screen in the fitting. The sludge wash solution was conservatively assumed to contain 122 GBq/L (3.3 Ci/L) of ^{137}Cs (only the 0.662 MeV gamma from the ^{137}Cs daughter ^{137m}Ba is of consequence). This would result in a line source containing 59 GBq (1.6 Ci) ^{137}Cs (^{137m}Ba) per 91 cm (3 ft) of length. Due to the shielding from the concrete vault roof, only the material in the 1.5 m (5 ft) of piping up to grade level and the 1.5 m (5 ft) of line from grade level to the operating station adds significantly to the resulting dose at the operating station. The calculated exposure rate would be 194 μC/kg-h (750 mR/h) in the general area (1 m [3.3 ft] from the line). While this would be a significant exposure rate, recovery from an accident of this magnitude would not represent shielding or engineering challenges beyond those experienced during previous site decontamination operations.

No credible accident can be identified that could result in a release of radioactive material outside of the STS system to the environment. Release of radioactive material would require the piping outside of the riser to be ruptured while a simultaneous not credible accident occurred, resulting in backflow of activity beyond the air-operated stop valve and two check valves to the point of rupture.

The ion exchange column zeolite heel that remains after the sparge line is used, does not pose a safety concern. The zeolite remaining is below the discharge point for the ion exchange column. Therefore, retention of radionuclides is minimal. In addition, the thinness of the heel (approximately 15 cm [6 in] height and 23 cm [9 in] radius) makes the heel critically safe. Residual radioactive contamination of the heel is not expected to result in any safety impact to the STS.

9.9.1.9 INADVERTENT ACID ADDITION

Violation of existing procedures and controls (OSR-IRTS-1) could be postulated to result in an acid being admitted to the HLW Tank 8D-2. The effect of this inadvertent acid addition would be possible increased local corrosion near the point of entry and a decrease in the excess hydroxide in the sludge wash solution. The change in hydroxide molarity would be important only if substantial quantities of uranium and plutonium were solubilized from the sludge and IRTS processed the solution. The analysis indicates that a minor increase in solubilized uranium and plutonium would result which would have no impact on criticality safety in the STS.

Chemical additions to Tank 8D-2 are expected for two distinct purposes. During the sludge washing phase of HLW processing, caustic soda solution will be added to the Tank to maintain high hydroxide concentration which suppresses plutonium and uranium solubility. A second path for chemical additions to Tank 8D-2 is via Tank 7D-2 in the main process building. This tank serves as a focal point through which all high-level wastes destined for Tank 8D-2 must be neutralized (OSR-IRTS-1) and jet-transferred. Although not routinely scheduled, past history shows about four transfers of neutralized waste per year.

For evaluation of this abnormal event, it is assumed Tank 8D-2 is at a minimum volume after sludge wash cycle number one (about 0.3 million liters) and at a hydroxide concentration of 0.032 M (comparable to the current condition in the tank).

No routine source is available to supply Tank 7D-2 with concentrated acid. If, however, the working volume of Tank 7D-2 (about 20,000 liters) was at pH 3 (Smith, 1992) and forwarded to Tank 8D-2, the hydroxide content of the sludge wash solution would be affected by less than 0.2%. Any change in uranium and plutonium levels in the wash solution would be negligible.

The other entry point for chemicals would be during the next cycle of sludge washing. Although the tanker truck with 20 wt% caustic solution is independently sampled and verified by both the vendor and the WVNS laboratory (per approved procedure), it is assumed for this example that a 20 wt% nitric acid solution is inadvertently added at the start of the next sludge wash cycle. It is then assumed that water additions are performed as planned, and that no samples of the tank are taken before processing solutions through STS.

Based on hydroxide consumption shown during the first sludge wash cycle in Tank 8D-2, the 7000 liters of acid followed by 1 million liters of wash water would drop the hydroxide level to 0.004 M (theoretically near pH 11.6). From sludge wash experiments in the laboratory and the first sludge wash cycle in Tank 8D-2, it is estimated that this change in hydroxide would result in an alpha Pu level of 0.13 μCi/mL of wash solution (Mahoney, 1992). Total fissile plutonium in 1 million liters of solution to pass through STS would be about 330 grams, which is well below the maximum safe mass discussed in Section D.9.2.4.

In the remaining 3 wash cycles, there is less than 845 g of fissile plutonium in solution (assuming 3 ML of solution to be processed) at the alpha plutonium concentration limit of 0.1 μCi/mL (OSR-IRTS-12). Fresh caustic solution will be added at the start of each sludge wash cycle. The accidental addition of acid would result in an increase of approximately 115 g fissile plutonium from the maximum concentration limit of 0.1 μCi alpha plutonium/mL. Therefore, the most plutonium that could be processed in the last three washes, assuming one entire wash was processed after the inadvertent acid addition, is less than 960 g of fissile plutonium which is less than the maximum safe mass for the STS (Section D.9.2.4).

D.9.1.10 FAILURE TO DUMP AN ION EXCHANGE COLUMN CONTAINING TI-TREATED ZEOLITE

Failure to dump an ion exchange column containing Ti-treated zeolite as directed by OSR-IRTS-12 could be postulated due to oversight. This event would have no impact on criticality safety in the STS as there are always a minimum of two contingencies against the potential loading of greater than the maximum safe mass of fissile plutonium (Section D.9.2.4).

In the first wash cycle, the first contingency is that the alpha plutonium concentration is limited (OSR-IRTS-12) such that less than 952 g of fissile plutonium will be soluble (Section D.9.1.9 addressed possible upsets which could increase the alpha plutonium concentration) and the second contingency is that at least 4 ion exchange columns will need to be discharged (an entire column rotation sequence) based on 200 kCi ^{137}Cs loaded on ion exchange column breakthrough loading as experienced during actual supernatant processing. Based upon operational history during supernatant processing, failure to discharge an ion exchange column at ^{137}Cs breakthrough is unlikely. The third contingency is that no more than 1 ML of sludge wash solution may be processed through an ion exchange column containing Ti-treated zeolite between discharges (OSR-IRTS-12). Failure to dump an ion exchange column containing Ti-treated zeolite does not affect the remaining 3 sludge wash cycles as there is less than 845 g of fissile plutonium at a concentration of 0.1 μCi alpha Pu/mL in the remaining 3 wash cycles combined. Also, the abnormal event analyzed in Section D.9.1.9 demonstrates that an inadvertent acid addition would only increase the concentration to slightly more than 0.1 μCi alpha Pu/mL. Therefore, the concentration would need to be greater than 0.1 μCi alpha Pu/mL and the surveillance requirement for alpha Pu concentration would have to be not performed or the limiting condition for operation not be met as required in OSR-IRTS-12.

D.9.2 ACCIDENTS

D.9.2.1 ACCIDENTS ANALYZED

Five hypothetical, bounding accidents were analyzed in detail for the STS and SMWS and are discussed in the following sections:

These accidents are:

1. Collapse of the Tank 8D-2 roof.
2. Rupture of the transfer pipeline between Tank 8D-2 and Tank 8D-1; sludge wash solution spill.
3. Spill of sludge wash solution within the valve aisle.
4. Inability to remove loaded zeolite from an ion exchange column.
5. HEPA filter fire.

Accidents 1 and 2 assume a severe external event has caused major structural damage. Such an event would require at least six times the design basis natural phenomena postulated for the WVDP and the resistance of SMWS confinement barriers to the associated loads. Nevertheless, these scenarios are presented to illustrate boundary case analyses.

Conservatism (including a safety factor of 2 on expected sludge wash inventories) was incorporated into all five accident analyses to provide a consequence envelope for the SMWS. Radiological consequences were analyzed for airborne pathways only. The accidental release of HLW in liquid form from STS/SMWS facilities to the environment has been determined to be unlikely either as a result of internally induced/man-caused events or as a result of design basis natural phenomena (earthquake, tornado) events (Section D.9.3).

WVNS has evaluated the generation and accumulation of hydrogen in the HLW Tank 8D-2 and concluded that it is highly improbable that hydrogen gas could accumulate to its lower flammability limit of 4.65 volume percent. The hydrogen generation rate for Tank 8D-2 under low salt conditions has been calculated to be 0.06 L/s (Prowse, 1991a). Tank 8D-1, though similar, generates much less hydrogen. At this rate of generation, Tank 8D-2 would require, under equilibrium conditions, an air ventilation flow rate of only 1.5 L/s (3 scfm) to maintain the hydrogen concentration below the 4.0 volume percent limit. If the nominal flow rate of 50 L/s (100 scfm) were completely stopped the time required to achieve this lower flammability limit would be fourteen days.

The induced fan blower servicing these tanks is part of the WVNS plant critical systems and as such not only has an alarm in the control room for an immediate response to failure, but power to this unit is also supplied by an emergency electric generator system. All of this equipment is operated under OSR-GP-3 (ventilation) and OSR-GP-5 (emergency power), which document the requirements to ensure the fan blower's continued high availability. Even if the ventilation system failed to operate, or was damaged by a common mode failure, there would be no immediate concern of a hydrogen explosion. Within a short time, much less than fourteen days, a portable ventilation fan with its own electric generator would be installed to provide up to 470 L/s (1,000 scfm) of tank ventilation.

In summary, because of the proven reliability of the installed ventilation system with its back-up provisions, and as a result of the time available for the substitution of an alternative system, a hydrogen explosion in the HLW Tanks has not been evaluated.

The concentration of hydrogen in the off-gas from the HLW tanks is continuously monitored. The amount of hydrogen present in the off-gas has always been very low (i.e., less than detection limits - 0.1 volume percent). The lower flammability limit for hydrogen in air is 4.65 volume percent. Through continuous sweeping (ventilation) of the tank vapor space and continuous monitoring, WVNS ensures hydrogen levels much less than 1 volume percent (Ploetz, 1990).

D.9.2.2 SOURCE TERMS

The source terms (quantity and distribution of radionuclide species released to the environment) used in the accident analysis depend on many factors, including the quantity and type of radioactive material available, ventilation conditions, and the performance of engineered and administrative barriers.

Tables D.9.2-1 through D.9.2-5 summarize the nature of the radioactive material and the nuclide distribution used in the analysis for each hypothetical accident scenario. All major radionuclides (those contributing >0.1% of the total CEDE) were used in the dose calculations. In the collapse of the Tank 8D-2 roof (Accident 1) and the sludge wash solution spills (Accidents 2 and 3), the radioactive material source has not been decontaminated by STS. The loaded zeolite itself is the source of radioactive material in the accident involving the ion exchange system (Accident 4). Radioactive particulate trapped in the filter medium is the radioactive material source for the HEPA filter fire (Accident 5).

All five of these hypothetical, bounding accidents result in the off-site release of radioactivity. The released material would probably be in the form of an aerosol or particulate.

A two-hour release is assumed as the basis for calculating maximum site boundary doses following accidents because it will be possible to control the source and/or remove any potentially exposed individuals within that time. In addition, this duration provides conservatism in selecting a value for the relative dispersion (χ/Q) of airborne releases. These values are calculated using measured meteorological parameters as input to the PAVAN (PAVAN, 1982) computer code. The maximum χ/Q value that would be exceeded only 40 h per year for a release of 0-2 h duration occurs at the boundary 2.4 km from the plant in the northern sector. For a release of duration of two to eight hours, PAVAN predicts a relative dispersion lower by a factor of two. Therefore, the estimated fence-line dose for a four-hour release would be the same as for a two hour release at the same rate because of the greater average dispersion during the longer time interval.

At the location of the nearest residence (1.4 km in the NW sector), the two-hour dispersion factor is less than the maximum fence-line value by a factor of six. In the sector in which the maximum zero to two hour dispersion factors occur, only one residence is within 2 km, four homes are within 3 km, and a total of eleven are inside 5 km. The total population in all sixteen sectors within the 5 km radius is estimated to be 1,243 persons. The actual site boundary is easily accessible for surveillance or, for most of its length, passes through rough, inaccessible terrain where a person would be extremely unlikely to be loitering.

Of the five accidents described as bounding scenarios (see Tables D.9.2-1 through D.9.2-5), numbers 1 and 2 are not credible and were described in order to emphasize the inherent safety of the operations. Accident 1 (collapse of the HLW tank roof) would require an earthquake six times the design basis of 0.1 g. Even this noncredible accident would result in a two-hour dose of less than 8 mSv (800 mrem) CEDE at the nearest residence. The dose from all other accidents would be significantly less. Accident 2 (rupture of the pipeline between 8D-2 and 8D-1) also requires extremely improbable events, including greater-than-design-basis natural phenomenon and blockage of natural downhill drainage back to 8D-2. Accident 3 (valve aisle leak) could conceivably result in a release of longer than two hours duration; however, it would result in a much lower dose than Accidents 1 or 2 and be subject to effective operator intervention to reduce the scope of radioactivity within two hours. Accident 4 (ion exchange column overpressurization) is considered to be highly unlikely and would result in much lower doses than Accidents 1 and 2. The duration of release is much shorter than two hours for this accident. The dose from accident 5 (HEPA fire) would be less than 5 μSv (0.5 mrem) regardless of the duration of the release. Because of the relatively small doses predicted from credible accidents, there is no recognized emergency protection zone (EPZ) nor has an off-site evacuation plan been developed.

For the accidents involving evaporation of solutions (Accidents 1-3), airborne effluents are estimated by assuming a release partition coefficient (PC) (ratio of concentration in liquid to that in vapor phase) of 1,000 for nonvolatile compounds (ANSI, 1981). Radiochemical analyses of condensate overheads indicates a PC of 50,000. In the accident involving the overpressurization of an ion exchange column of zeolite (Accident 4) and the HEPA filter fire (Accident 5) the radioactivity is released directly into the WTFVS. No credit is taken for plateout within systems.

For the tank roof collapse accident (Accident 1), it is assumed that the occurrence of a severe earthquake greater than six times the design basis (0.1 g) causes the roofs of the tank and vault to collapse, exposing the entire surface area of the radioactive material contents to the atmosphere. This results in a high evaporation rate of radioactive material from the tank (4,000 L/h [18 gpm]. The evaporation rate was calculated by assuming that the surface of the liquid was at 90°C (194°F), level with grade, and the entire surface area of the tank was exposed to a 5 m/s wind at zero percent absolute humidity. These exceptional assumptions exceed the consequences of any splashing and subsequent physical material spread to the environment that may occur during the collapse of the roofs. The evaporated sludge wash solution is assumed to be released directly to the environment without passing through any HEPA filters.

For the spill of sludge wash solution from the pipeline between Tank 8D-2 and Tank 8D-1 valve aisle (Accident 2), it is assumed that a severe natural phenomenon ruptures the pipeline (double-walled pipes) releasing the liquid into the conduit system. It is further assumed that the PVS experiences mechanical or structural damage. Evaporation of sludge wash solution occurs directly to the atmosphere from the damaged conduit system without filtration. The engineered slope of the pipeline and trench will drain the spilled material back into Tank 8D-2. (This has been ignored for a conservative analyses.)

For Accident 3 (spill of sludge wash solution within the valve aisle) it is assumed that a complete valve failure occurs that covers the floor of the valve aisle with sludge wash water. (Although spilled fluids would be returned to Tank 8D-2 via the valve aisle sump/pump system, this has been ignored during the two-hour release period.) The PVS will pass air exhausted from the valve aisle through a condensor and two HEPA filter banks prior to release to the environment. A DF of 100,000 is assumed for this arrangement (ANSI, 1981). For Accident 4 it is assumed that the inadvertent addition of concentrated caustic solution, which may need to be used in small amounts for hydroxide molarity control, (see Section D.6.4) or precipitation of aluminum due to a pH drop across a column causes the physical characteristics of the zeolite to change to a "mud." This makes it impossible to remove the zeolite from the column as the zeolite mud plugs the column outlets. (Note: Other scenarios can be postulated, including failure of the dump valves with similar results, i.e., zeolite cannot be removed from the ion exchange column.) The plugged outlets also make it impossible to maintain a flow of fluid through the column to cool the zeolite. It is assumed that the zeolite has been loaded with cesium beyond normal ion exchange capacity of the zeolite bed (assumed column inventory of approximately 15 PBq [400,000 Ci] ^{137}Cs) at the time of this accident. Under these conditions, it is estimated that the decay heat could ultimately overpressurize the column resulting in a release of approximately 1% of the zeolite. (Note: The time period required for decay heat to raise the column temperature to 100°C [212°F] is estimated to be >75 h). Credit for the PVS has been taken as described for Accident 3.

The fifth accident considers the effects of a HEPA filter fire in the WTFVS. It is assumed that the HEPA filters will be changed out when the radioactive material loading results in an exposure of 2.6 mC/kg-h (10 R/h) at 35 cm (1 ft). Analysis shows that 37 GBq (1 Ci) of ^{137}Cs uniformly distributed on a HEPA filter will result in an exposure rate of 361 μC/kg-h (1.4 R/h) at 350 cm (1 ft) from the filter face (Peterson, 1985). Thus, the filter is conservatively assumed to contain 280 GBq (7.5 Ci) of ^{137}Cs before changeout and this is the condition assumed at the time of the fire. Activity of other nuclides on the filter is assumed to be distributed according to the radionuclide distribution presented in Table D.9.2-5. HEPA filters are made of fire resistant material that chars rather than burns, and it has been conservatively calculated that 1% (ANSI, 1981) of the radionuclides on the loaded filter would be released. The total radioactivity loaded on the STS PVS filters is expected to be less than the WTFVS filters since the latter will contain filtration from Tank 8D-2 exhaust. (Radioactive material released through the STS PVS is expected to be small under normal operating conditions. See Section D.8.6.3). The HEPA filter fire described above is, therefore, considered a bounding case for HEPA filter loading relevant to SMWS accident analysis.

D.9.2.3 RADIATION DOSES

Assumptions for calculating radiation doses to workers and the public are presented in WVDP-065, "Radiological Parameters for Assessment of West Valley Demonstration Project Activities." In brief, the maximally exposed individual during an accident is assumed to be at the point on the perimeter where the largest airborne concentration of radioactivity would occur. The radioactivity concentration is based on the maximum sector χ/Q. The external and internal dose conversion factors are taken from DOE/EH-0070, "External Dose Rate Conversion Factors for Calculation of Dose to the Public," and DOE/EH-0071, "Internal Dose Conversion for Calculation of Dose to the Public." These dose factors are consistent with DOE Order 5480.11.

Unit dose conversion factors are from a unit release (e.g., Sv/Bq [rem/Ci]) of each isotope, as discussed in WVDP-065, and are used to calculate the total co[illegible]ective dose equivalent (CEDE). The total CEDE from a release is determ[illegible]umming the component doses received from each isotope in the [illegible]rce [illegible]e dose conversion factors are in accordance with DOE O[illegible]

D.[illegible]ADIATION DOSES TO THE PUBLIC

Using the source terms indicated in Section D.9.2.2, the projected dose to the maximally exposed off-site individual is presented in this section for each of the five SMWS hypothetical accident scenarios previously described. The meteorological dispersion and dose calculation methodology used is described in detail in "Radiological Parameters for Assessment of West Valley Demonstration Project Activities" (WVDP-065, 1990).

For the HEPA filter fire (Accident 5), unit dose conversion factors for a stack release were used because it was postulated that these releases to the environment would occur through the main process plant ventilation stack. For all other accident scenarios, a ground level release (≤10 m) was assumed to estimate meteorological dispersion.

Only those nuclides contributing greater than 0.1% of the dose to the maximally exposed off-site individual were included in the dose assessment. This was determined by multiplying the individual nuclide source term

(Bq [Ci]) by the appropriate dose conversion factor (WVDP-065, 1990 - Sv/Bq [rem/Ci] released) to determine the dose contribution for the individual radionuclide. Tables 9.2-1 through 9.2-5 present dose estimates for the significant radionuclides released for all accidents. The worst case hypothetical accident is calculated to result in a CEDE of 8 mSv (800 mrem).

D.9.2.3.2 RADIATION DOSES TO WORKERS

Postulated SMWS Accidents 1 and 2 involve releases directly to the environment and are considered to be the worst case scenarios for Tanks 8D-1 and 8D-2 respectively.

In no accident scenario is it considered credible that fundamental structural barriers are breached. There would be no direct external exposure of workers to HLW in an uncontrolled situation. (Mitigative measures and response actions would be accomplished in accordance with WVDP-010, "Radiological Controls Manual" and therefore potential external exposure would be controlled within WVNS limits.) Accordingly, the postulated effect on on-site personnel from the SMWS accidents evaluated here is limited to inhalation (internal) exposures to the airborne release.

Tables D.9.2-1 through D.9.2-5 present the estimated CEDEs to an on-site individual who remains continuously at 100 meters from the point of release for two hours during the accident. Since for Accident 5 (HEPA filter fire) the releases are elevated (main plant stack), the effluent plumes would not be expected to reach ground level within WVDP boundaries. Thus, no on-site radiological impacts are assigned to this event.

D.9.2.4 NUCLEAR CRITICALITY

Based upon documented criticality safety evaluations (Caldwell, 1990; Yuan, 1990), criticality during STS operations is not credible (Prowse, 1992). The initial concentration for alpha plutonium is expected to be less than 0.03 µCi/mL of sludge wash solution. This results in a maximum of 114 g of fissile plutonium in solution in Tank 8D-2 which is a safe mass per DOE Order 5480.5. The maximum safe mass for the ion exchange columns, the most restrictive vessel, was determined to be 1.0 kg of fissile plutonium. Therefore, to provide an operational envelope, the maximum concentration of alpha plutonium analyzed for purposes of criticality safety is 0.25 µCi/mL for the first wash cycle and 0.1 µCi/mL for the remaining 3 wash cycles. This value results in a maximum of 952 g of fissile plutonium in solution in Tank 8D-2 in the first wash cycle, less than the maximum safe mass, with a Tank 8D-2 volume of 1.35 ML and less than 845 g of fissile plutonium in solution (assuming 3 ML of sludge wash solution to be processed) in Tank 8D-2 in the remaining 3 wash cycles. Accidents (Section D.9.2) analyzed assume an alpha plutonium concentration of 0.664 µCi/mL for conservatism.

The criticality safety evaluation for the SMWS operation was performed considering the major vessels and components with significant usable volumes (e.g., Tanks 8D-1 and 8D-2, ion exchange column, prefilter reservoir, postfilter). The safe concentrations or total mass of plutonium were determined for each major component and/or vessel in the SMWS process (vessels/components all filled to capacity). The sludge wash solution was conservatively assumed to be ^{239}Pu in water. Uranium is not a criticality concern because of the small fissile mass that will be resident in the columns during the processing of sludge wash solutions. Table D.9.2-6 presents the total fissionable material inventory of the sludge in Tank 8D-2, the soluble mass of the first wash solution, and maximum ion exchange column inventory at cesium breakthrough for the first wash. To provide a conservative assessment, the effect of other nonfissile isotopes and neutron poison materials in the sludge wash solution and sludge were ignored in the calculation.

Suspension of the sludge in Tank 8D-2 by the sludge mobilization pumps was specifically analyzed (Caldwell, 1990). The analysis indicates that under conditions of homogenous mixing, as is expected during SMWS operations, an inventory of plutonium and uranium ten times that found in Tank 8D-2 is critically safe. Therefore, Tank 8D-2 can be considered critically safe under normal and expected abnormal conditions.

Favorable geometry control is enhanced in Tank 8D-1 by distributing the loaded ion exchange material over the tank bottom. This is assured through the use of zeolite mobilization pumps installed in Tank 8D-1. Tests on zeolite distribution within Tank 8D-1 have been performed using a one-sixth scale model (Schiffhauer, 1987) and the results indicate that the zeolite pile is effectively distributed by operating the mobilization pumps. These pumps will be operated during and/or following each discharge of zeolite from STS ion exchange columns. This will provide adequate mixing and distribution of zeolite.

The prefilter is intrinsically safe. Each prefilter is 305 cm (120 in) long and 10 cm (4 in) outside diameter, therefore, the surface to volume ratio is such that excessive neutron leakage makes it impossible to attain a k_{eff} as great as one. The prefilters are rigidly spaced 56 cm (22 in) apart, therefore, they are neutronically decoupled from each other.

Testing indicates that the Ti-treating does remain intact on the base zeolite. Wet attrition tests have been performed on the Ti-treated zeolite with very little (less than 2%) of the titanium being removed. Column testing of Ti-treated zeolite indicates that the column effluent is not measurably higher in titanium than the influent. In addition, further wet and dry attrition tests are planned on pilot-scale and production-scale Ti-treated zeolite to demonstrate the stability of the treatment. Additional column testing will include analyses for titanium in both the feed solution and the effluent to demonstrate material stability.

The allowable safe fissile material concentration for the entire SMWS process was established based on the vessel or component having the minimum critical concentration (i.e., the most restrictive vessel). It was determined that approximately 1.0 kg of ^{239}Pu loaded onto Ti-treated zeolite within an ion exchange column in a sphere, radius 22.5 cm, would result in an effective multiplication factor (k_{eff}) + 2σ = 0.95 (Caldwell, 1990 and Yuan, 1990). The ion exchange column is the most restrictive vessel.

However, it should be noted that based on currently available Tank 8D-2 inventory data, nuclear criticality during the entire SMWS operation under normal and abnormal operating conditions is not credible (Prowse, 1992). Abnormal events associated with nuclear criticality safety are analyzed in Sections D.9.1.9 and D.9.1.10.

The zeolite column of the STS will remain subcritical under normal or accident conditions if the mass of fissile Pu (^{239}Pu + ^{241}Pu) is limited to below 1.0 kg inside the column. A summary of the calculations that support this conclusion is given in Table D.9.2-7. This evaluation was made using the KENO-V code and various cross section data sets compiled at the Argonne National Laboratory's IBM mainframe computer systems (Yuan, 1990) and independently verified using TWODANT compiled at the Los Alamos National Laboratory's Cray mainframe computer system (Caldwell, 1990). All differences between calculational model and the actual configuration are conservative (i.e., result in an overestimate of k_{eff}). The dimensions and materials used for the KENO-V calculations are given in Table D.9.2-8.

The heel remaining from ion exchange column sparging (see Section D.6.1.6.b) will remain critically safe during normal and accident conditions. The mass of Pu which could accumulate on the heel is very small. The current heel is not Ti-treated zeolite. Additionally, calculations indicate that a cylinder of 20 cm (8 in) height and radius of 23 cm (9 in) in the center of an ion exchange column uniformly loaded with 1.0 kg of Pu-239 is subcritical (Yuan, 1991). A cylinder was analyzed because the most reactive sphere could not be placed within the 18 cm (7 in.) high heel (Thomas, 1990).

The k_{eff} for several configurations of plutonium loaded zeolite inside the column was calculated using the KENO-V Monte Carlo Code. KENO-V was used because of its universal acceptance in nuclear criticality safety calculations. The cross section sets used for nuclides are also given in Table D.9.2-8. Most of the cross section data used are the Hansen-Roach 16-group cross section set.

In all cases calculated, the ^{239}Pu was assumed homogeneously distributed in the interior volume of the sphere or cylinder.

K_{eff} factors were calculated for various sizes of 1.0 kg ^{239}Pu-loaded spheres in the center of the ion exchange column. A ^{239}Pu-loaded sphere in the center of the column is the optimum geometry with the highest k_{eff} for a fixed amount of ^{239}Pu retained. The results of these calculations are tabulated in Table D.9.2-9. The k_{eff} is plotted versus the radius of the sphere for each case in Figure D.9.2-1. These results show that the highest k_{eff} occurs for a radius of about 22.5 cm. To evaluate the limiting ^{239}Pu mass inside the zeolite column, additional calculations were performed with the same geometric configuration but varying the mass of ^{239}Pu in the sphere. Results of these additional calculations are tabulated in Table D.9.2-10 and plotted in Figure D.9.2-2. It is concluded from this figure that the limiting mass of ^{239}Pu inside the zeolite column is about 1.0 kg if $k_{eff} + 2\sigma$ is not to exceed 0.95.

The WVDP has extensively reviewed DOE Order 5480.5, Chapter 11, "Nuclear Criticality Safety Elements;" ANSI 8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors;" and ANSI 8.3-1986, "Criticality Accident Alarm System." This review, coupled with criticality assessments and laboratory analysis of the soluble fissile mass in Tank 8D-2, demonstrates that criticality monitors for STS ion exchange columns and the spent zeolite in Tank 8D-1 are not required because the annual probability of failure of the contingencies associated with OSR-IRTS-12 (Prowse, 1992) and the passive barriers of the system is less than 10^{-6}.

D.9.2.5 POTENTIAL FOR PRESSURE/TEMPERATURE EXCURSIONS AND EXPLOSION

The design operating conditions for the STS and SMWS process will produce well defined pressure and temperature loads that are adequately covered under normal industrial process codes. (See Section D.5.2.3 for a discussion of structural specifications, engineering codes, construction codes, and applicable standards.) Internal pressures and temperatures (piping, vessels, etc.) will be considerably less than those normally associated with nuclear power plants.

The highest temperatures and pressures expected within the STS process under normal operating conditions will be associated with the transfer of sludge wash solution between Tanks 8D-2 and 8D-1. Before cooling, the sludge wash solution and return lines (Streams #1 and #3 of Figure D.5.1-3) will involve temperatures of 80°C (176°F) - 90°C (194°F) and operating pressures of 550 kPa (80 psi) - 690 kPa (100 psi). The double-walled piping that will carry the sludge wash solution was been designed to 1.0 MPa (150 psi) and was pressure tested at 1.6 MPa (225 psi).

Tanks 8D-2 and 8D-1 were designed to be self-boiling tanks; however, they never contained enough waste heat to boil. In mid-1980 a temperature profile through the 8D-2 sludge was obtained through in-tank measurements. The temperature at the bottom layer of sludge was measured at approximately 98°C (209°F) while the liquid was at approximately 89°C (193°F). The only potential for system temperature excursions will be associated with decay heat from the loaded zeolite (in ion exchange columns as discussed in Accident 4). Temperatures inside Tank 8D-1 will be controlled via evaporative cooling and the WTFVS to maintain relatively low temperatures for these materials. Prolonged operation of the sludge mobilization pumps will cause Tank 8D-2 temperature to rise until the rate at which evaporated water vapor carries away heat through the ventilation system balances the rate of energy input (Winger, 1991). The design heat removal capacity of the condensers is about five times the load that this operation will impose. The volumetric capability of the off-gas ductwork is similarly oversized. The conditions potentially leading to an accidental temperature excursion associated with loaded zeolite and projections of radiological impact are discussed in Section D.9.2.2.

Evaluations have been made regarding the potential for a hydrogen explosion resulting from radiolytic decomposition of the HLW in Tank 8D-2. Samples collected from Tank 8D-2 have not shown the presence of organic material and gas samples collected from the tank have consistently been <1% hydrogen. The evolution rate of hydrogen in the tank is small relative to the steam production rate, and accordingly the creation of an explosive mixture within the tank is not considered credible (Prowse, 1991a). However, hydrogen concentrations within ventilation system off-gas lines are monitored during STS processing.

D.9.3 IMPACT OF DESIGN BASIS NATURAL PHENOMENA EVENTS AND OTHER EXTREME LOADS

An investigation was performed to assess the structural vulnerability of STS confinement barriers under a variety of loads (external and internal, natural and manmade) under a variety of service environments (Dames & Moore, 1986). The scope of this investigation included:

- Identification of confinement barriers for preventing or limiting the release of radioactive materials.

- Assessment of the performance of the confinement barriers under loads. These loads include the design basis seismic and tornadic event, internal loads from accidental temperature or pressure excursions, manmade (construction) loads and normal operating loads.

- Assessment of the performance of the confinement barriers under loads in excess of the design basis events in order to estimate the inherent safety factors and limits against ultimate failure.

- Assessment of leak rates from the confinement barrier under design basis loads.

The STS confinement barriers have been previously defined in Section D.4.3.2 and Table D.4.3-1. Each confinement barrier of the STS has been designed to meet a building code or standard consistent with the construction materials used and the level of safety associated with this form of construction. These design codes and standards are presented in Tables D.5.2-2 and D.5.2-3.

This section presents a summary of the Dames & Moore study regarding assessment of various loading conditions, with emphasis on extreme load conditions and the reserve capacity or safety factor against ultimate failure.

D.9.3.1 DESIGN BASIS EVENTS

The following design basis events have been used to assess the structural vulnerability of each of the primary barriers. Some of the design basis loads were not used in the design of the facilities if not specifically required under the building codes or standards of construction (see Tables D.5.2-2 and D.5.2-3), but were nevertheless analyzed for impacts to the primary barriers.

Effects of earthquakes have been a design consideration in all of the major reinforced concrete structures. Effects of tornado winds and missiles were not considered as a design requirement, yet the consequences of these events have been determined through subsequent analysis.

Additional information on design basis natural phenomena events for the WVDP can be found in Volume I, Section A.3.6 and A.4.2.

D.9.3.1.1 WIND LOADS

Design basis winds consist of a 100-year event with a design wind velocity of 145 kph (90 mph) with peak gust velocities of 190 kph (115 mph). (See Section A.4.2.1, Volume I.) The ANSI importance factor has already been included in this design wind velocity. Wind pressures from this event are analyzed using the method specified in ANSI A58.1, 1982, Section 6 with Exposure Condition C.

D.9.3.1.2 TORNADO

The design basis tornado has the following characteristics:

• Maximum Wind Speed	260 kph (160 mph)
• Rotational Speed	180 kph (110 mph)
• Translational Speed	80 kph (50 mph)
• Radius of Maximum Rotational Wind	46 m (150 ft)
• Total Pressure Drop	2.4 kPa (0.35 psi)
• Rate of Pressure Drop	1.0 kPa (0.15 psi)

The design basis for the site-specific tornado is developed in Section A.4.2.2, Volume I.

The total tornado load (w_t) consists of three components:

- Tornado wind load (W_w);
- Tornado differential pressure load (W_p); and

- Tornado missile load (W_m).

The total tornado load is determined by the following combinations:

$$W_t = W_w$$
$$W_t = W_p$$
$$W_t = W_m$$
$$W_t = W_w + 0.5W_p$$
$$W_t = W_w + W_m$$
$$W_t = W_w + 0.5W_p + W_m$$

Each structure or component of the STS confinement barrier was reviewed for the most severe of the above combinations.

The applied pressure loads are determined using the criteria in ANSI A58.1, 1982. The gust factors are taken as unity.

D.9.3.1.3 TORNADO MISSILE

The design basis tornado missiles include the following:

- Timber plank, 10 cm (4 in) by 30 cm (12 in) by 3.7 m (12 ft) weighing 63 kg (139 lbs).
- Steel pipe, 7.6 cm (3 in) in diameter by 3 m (10 ft) in length weighing 34 kg (76 lbs).

The impact velocity of the plank is 140 kph (85 mph) while the velocity of the pipe is 80 kph (50 mph). The design basis for these missiles is provided in Section A.4.2.4, Volume I. (Note: The impact velocity for the steel pipe is defined as 103 kph (64 mph) in Section A.4.2.4, Volume I, although a 80 kph (50 mph) impact velocity was later specified in Volume III, Section C.4.2.4 -

Vitrification Facility. The 103 kph (64 mph) impact velocity was originally ascribed to a 320 kph (200 mph) maximum wind speed tornado by McDonald, 1981. This was later reduced to 80 kph (50 mph) as more realistic for the 260 kph (160 mph) tornado. Regardless, this difference has virtually no effect on the large safety factors associated with tornado missile penetration of STS structures indicated in Table D.9.3-1).

D.9.3.1.4 SEISMIC

The site-specific design basis earthquake has been selected based on probabilistic assessments of the earthquake exposure (see Sections A.3.6.1 and A.4.2.5, Volume I). This event has a peak horizontal ground acceleration of 0.1 g, and a vertical component of two-thirds the horizontal (e.g., 0.067 g). Design review response spectra and associated damping values are in accordance with the NRC Regulatory Guides 1.60 (USNRC, 1973a) and 1.61 (USNRC, 1973b).

D.9.3.1.5 SNOW LOADING

Design basis snow loads for a 100-year event were taken as 4 kPa (80 psf). (See Section A.4.2.6, Volume I).

D.9.3.1.6 INTERNAL PRESSURE LOADS

All of the primary building ventilation barriers have been designed for a negative (partial vacuum pressure) condition. These internal pressure loads are a result of the use of ventilation systems required for temperature and contamination control (STS PVS and WTFVS - see Sections D.5.4 and D.7.4). The following typical pressure differentials and associated pressure loads are expected to be maintained during normal operations.

FACILITY	PRESSURE DIFFERENTIAL (Negative Atmospheres [in of Water Column])	PRESSURE LOAD (Pa) (psf)
Operation Aisle, STS Building	0.002 - 0.003 (0.6 - 1.0)	144 - 239 (3 - 5)
Valve Aisle	0.006 - 0.007 (2.4 - 3.0)	527 - 670 (11 - 14)
Pipeway/Shield Structure	0.006 - 0.007 (2.4 - 3.0)	527 - 670 (11 - 14)
Tanks 8D-1 and 8D-2	0.009 - 0.01 (3.5 - 4.0)	766 - 910 (16 - 19)

D.9.3.1.7 THERMAL LOADS

Thermal loads associated with facilities are:

- 38°C (100°F) for locations on the interior face of the building; and
- 13°C (55°F) for protected environmental locations on the exterior of the building.

The as-built temperature for both steel and concrete is 7°C (45°F).

D.9.3.1.8 SOIL PRESSURE LOAD

Vertical dead load of soil fill on top of structures is taken as 256 kg/m^3 (125 pcf).

Lateral static soil pressures for passive and active conditions are determined using the following equivalent fluid densities (Dames & Moore, 1983):

TYPE OF SOIL PRESSURE	INCLUDING WATER	EXCLUDING WATER
Passive Soil Pressure	492 kg/m^3 (240 pcf)	369 kg/m^3 (180 pcf)
Active Soil Pressure	164 kg/m^3 (80 pcf)	41 kg/m^3 (20 pcf)

D.9.3.1.9 DYNAMIC SOIL PRESSURES

Design soil pressures for the design basis earthquake (0.1 g horizontal and 0.067 g vertical) are based on at-rest conditions in the soil. The at-rest soil pressures are computed from an equivalent fluid density of 184 kg/m^3 (90 pcf) considering soil and water combined, or 61 kg/m^3 (30 pcf) for soil only.

The effects of surcharge on the soil from future adjacent buildings, backfilling, or construction loads are added to the static soil pressure load. Static and dynamic soil loads are additive.

D.9.3.1.10 PROCESS AND EQUIPMENT LOADS

The loads derived from the processes and equipment are divided into dead loads and live loads. Dead loads include the weight of structures and structural components, equipment, piping, walls, partitions, platforms, conduits, cable trays, and all other static gravity loads. Water or other fluids contained within the equipment or piping is also considered a dead load. The unit weights used in establishing dead loads for the typical materials include the following:

- Reinforced Concrete 2.40 g/cm^3 (150 pcf)
- Structural Steel 7.84 g/cm^3 (490 pcf)

- Water 1.0 g/cm^3 (62.4 pcf)

Live loads include floor and roof area loads, crane loads, lay-down loads due to temporary placement of movable equipment or structures, equipment handling loads, and vibratory and impact loads from equipment and other processing loads.

Design basis live loads are as follows:

- 7 kPa (150 psf) for all floor areas where equipment is not located.
- 4,536 kg (10,000 lbs) concentrated load located at any position on the floor in addition to the uniform live load of 7 kPa (150 psf).
- A 5 MT (5 ton) forklift on the STS building floor at Elevation +32.6 m (+107 ft).

D.9.3.1.11 CONSTRUCTION LOADS

Load limits on the construction modification to Tanks 8D-1 and 8D-2 included the following:

- 227 kg (500 lbs) concentrated load in cutting through the reinforced concrete vault lid.
- 51 MT (50 ton) crane at 3 m (10 ft) from the edge of Tank 8D-1 vault at Elevation +30.5 m (+100 ft).
- Pump riser installation load of 4,400 kg (9,700 lbs) (zeolite removal - Tank 8D-1) and of 5,262 kg (11,600 lbs) (waste mobilization - Tank 8D-2) on vault roofs.

- 5 kPa (100 psf) uniformly distributed live load on vault roofs.
- 1,814 kg (4,000 lbs) concentrated live load with minimum spacing of 3 m (10 ft) between concentrated loads on vault roof.
- 454 kg (1,000 lbs) concentrated moving live load on steel Tanks 8D-1 and 8D-2.

D.9.3.2 LOAD COMBINATION CRITERIA

The following nomenclature is used in this section to designate the various loading conditions used in the design review of the barriers under severe environmental conditions:

U = Required section strength for reinforced concrete to resist design loads based on strength methods of design;

S = Required strength for structural steel based on elastic design methods and allowable stresses;

D = Dead loads or related internal moments and forces;

L = Applicable live loads or related internal moments and forces;

T_o = Applicable thermal loads;

H = Soil pressure load consisting of two conditions:

H_{static} and $H_{dynamic}$;

W = Applicable wind loads;

W_t = Design basis tornado loads;

E_{sse} = Design basis seismic loads; and

P_o = Internal pressure loads.

Since the waste tank farm portion of the West Valley site is not subject to flooding, flood design loads have not been included. Reinforced concrete structural integrity under extreme environmental load conditions was reviewed for the following load combinations:

$$U = 1.0\ D + 1.0\ L + 1.0\ H_{static} + 1.0\ E_{sse} +$$

$$1.0\ H_{dynamic} + 1.0\ T_o + 1.0\ P_o$$

$$U = 1.0\ D + 1.0\ L + 1.0\ H_{static} + 1.0\ T_o + 1.0\ W_t + 1.0\ P_o$$

The following load combinations were used for steel structures under extreme environmental load conditions:

$$S = D + L + H_{static} + E_{sse} + H_{dynamic} + T_o + P_o$$

$$S = D + L + H_{static} + W_t + T_o + P_o$$

D.9.3.3 ASSESSMENT OF CONFINEMENT BARRIERS

Three separate methods of barrier vulnerability assessment were employed in this investigation. These included analytical, experimental, and judgmental procedures.

D.9.3.3.1 ANALYTICAL METHODS

Two methods of analytical review were used: review of existing designs and independent confirming analyses. Design documents prepared for the construction of the STS facilities and modifications to Tanks 8D-1 and 8D-2 were collected and reviewed. These documents included the structural calculations, design drawings, specifications, and design criteria. Vulnerability of the confinement barriers was assessed under code-specifi design load levels.

To assess the vulnerability of the confinement barriers under extreme environmental conditions such as earthquake and tornado, independent static and dynamic structural analyses were performed for critical confinement barriers. In the case of Tanks 8D-1 and 8D-2, such analyses had been conducted by LLL as part of a previous barrier vulnerability assessment (LLL, 1978). In the case of the new construction (e.g., STS building and shield structure over Tank 8D-1), Dames & Moore prepared simple analytical models for computer analysis.

D.9.3.3.2 EXPERIMENTAL METHODS

Experimental evidence through direct testing or documentation of past historic performance provided insight into the vulnerability of the barriers under extreme load conditions. Examples included the accident that occurred during construction of Tanks 8D-1 and 8D-2, which provided insight into the ultimate strength of the tank vault under flotation, followed by partial foundation settlement (Barnstein 1965 and 1966). Pressure tests (CB&I Specifications, 1966) and corrosion inspection of Tank 8D-1 (Duckworth, 1976) provided data on the strength of the original tanks. Tests of the waterstop between the STS building and the shield structure over Tank 8D-1 provided data on the cyclic strength of this critical barrier between the two structures.

D.9.3.3.3 ENGINEERING JUDGMENT

In some instances, detailed analytical or experimental investigations could not be justified to assess the ultimate strength or failure loads of the confinement barriers. In these instances, engineering judgment, based on the past observed performance of similar structures under similar extreme loads and environmental conditions, served as a basis for assessment. In other cases, past engineering experience in the design and failure analysis of similar loading conditions provided the basis for estimating the barrier vulnerability.

D.9.3.4 FAILURE ANALYSIS

D.9.3.4.1 CRITICAL LOADING CONDITIONS

There are four basic load regimes that have been considered in the design, construction, and operation of the STS facilities. These are the following:

- Construction or man-induced loads;
- Operational loading, such as temperature, pressure, dead load, live load, etc.
- Abnormal operating conditions or accidents, such as temperature/pressure excursions; and
- Extreme environmental loads, such as earthquake and tornado.

Construction or man-induced loads present an environmental risk only in the modification of Tank 8D-2 that currently stores the high-level wastes. Stringent limitations have been imposed on any loads that might impinge upon the reinforced concrete vault or steel tank that serve as confinement barriers to these HLW. Structural barrier reviews have been performed by several design and analysis teams to verify the integrity of these confinement barriers under construction operations (Ebasco, 1986; Rockwell, 1984, Rockwell, 1985; Brown, 1985a; Brown, 1986).

Operational conditions for the STS facility produce well-defined loads that are adequately covered under normal process industry safety codes. Internal pressures and temperatures are significantly lower than those normally associated with nuclear power plant operations.

Abnormal operating conditions or accidents, leading to the breaching of a confinement barrier, do not appear to be credible (see Section D.9.2.5). The process does not generate a high temperature or pressure source that could lead to vessel or pipe rupture, nor does it represent a potential threat from missile impingement or penetration commonly associated with high pressure and temperature processes.

The potential that Tank Vaults 8D-1 or 8D-2 might be dislodged due to runaway groundwater intrusion has already been demonstrated during the construction of these vaults (see Barnstein, 1965 and 1966). With heavy overburdens and precautionary measures to monitor and control groundwater levels around the vaults, the potential that this type of accident would occur is relatively remote. However, this potential risk exists whether the STS process is constructed or not.

Extreme environmental conditions, such as a tornado and earthquake, have not been directly addressed in all facets of barrier design for the STS process. The only structural barrier that has been consistently designed for earthquake throughout the STS process facilities is the reinforced concrete structures that serve as the second line of defense. The primary barriers (piping and vessels) generally have not been designed for earthquake.

Extreme tornado wind and missile loads have not been directly addressed as a design consideration. Environmental loading from tornado is moderate, in contrast to many sites. The massive shield walls and soil overburden used for radiation protection serves as a direct form of missile protection.

In summary, the critical loads for assessment of confinement barrier vulnerability are the extreme environmental conditions associated with earthquake and tornado.

D.9.3.4.2 MODES OF FAILURE

The support barriers or backup systems identified in Table D.4.3-1 (e.g., negative or positive internal or external pressures) may be lost following extreme environmental conditions such as earthquake or tornado. This is based on past experience in which process equipment that has not been designed for earthquake malfunctions either because of mechanical problems or because of the loss of electrical power. For purposes of barrier vulnerability assessment, it is assumed that the active support barriers, such as negative pressure supplied by electrical and mechanical systems, will fail under extreme environmental conditions.

Failure modes for the primary confinement barriers are summarized in Table D.9.3-1. Under extreme earthquake conditions, typical failure modes for steel process piping and vessels may include cracking, tearing at welded seams, or rupture. Both vapor and fluid may breach these confinement barriers under each of the failure modes.

For reinforced concrete vaults and shield walls, cracks may develop during the earthquake that will close after the earthquake, leaving little opportunity for leakage and radiation exposure. If the cracking is excessive, permanent dislocation may result, providing a path for vapor and fluid to breach the barrier. Under extreme conditions, the concrete may crush and ultimately lead to barrier collapse. For extreme earthquake load conditions outlined in Table D.9.3-1 for Tanks 8D-1 and 8D-2, column failure and progressive roof collapse is identified as the ultimate failure mode for the reinforced concrete tank vaults.

For soil backfills and overburden, extreme earthquake failure modes take the form of cracking, differential settlement, and permanent distortion. Pathways for liquid flow through the cracked soil media may develop.

Under extreme earthquake, large relative motions between buildings and adjacent components may cause rupture of water stops and interconnecting conduits or piping.

In summary, Table D.9.3-1 identifies the various forms of failure that the primary barriers may experience and also identifies the mitigative action or backup barrier that will prevent release of either vapor or liquid HLW to the environment.

D.9.3.4.3 BARRIER BEHAVIOR

The behavior of confinement barriers under varying levels of extreme environmental loading has also been identified in Table D.9.3-1. Various stages of barrier deterioration and modes of failure have been associated with levels of extreme event loading to describe the progressive failure scenario. Both engineering judgment and analytical or experimental data have been used in arriving at these barrier performance scenarios.

Perhaps the most significant element of the barrier vulnerability assessment is the recognition of interplay between barriers under extreme environmental loading. For example, if structural walls that support piping and vessels dislocate under earthquake motions, not only have the walls failed as a barrier, but in dislocating, they may also breach piping or vessels attached to the walls, thus violating an interior higher level barrier. An example of this is the potential lateral dislocation of the concrete walls of the shield structure that could lead to pipe support frame collapse and vessel or pipe rupture.

Another example is the potential dislocation of Tank 8D-2 on its perlite support blocks, resulting in tank vault column damage and ultimate vault roof collapse. In this case, the interaction of one barrier system with a second barrier system leads to the mutual failure of barriers (e.g., tank and vault).

A third example is the soil/structure interaction that takes place between the STS building and the shield structure on top of Tank Vault 8D-1. Under earthquake motions, these two independent structures may affect each other, inducing stresses in the PVC water stop that could ultimately lead to its failure. Under extreme earthquake pounding between these buildings, the nonseismically designed piping that traverses the expansion joint between these structures may also rupture, leading to a double barrier failure (e.g., water stop and piping).

D.9.3.4.4 SAFETY FACTORS

As shown in Table D.9.3-1, there is generally a relatively large safety factor between the design basis environmental loading and the ultimate failure capacity of the barriers. In most instances, if one of the barriers in the system has a low safety factor, then another concentric barrier has a significantly higher safety factor.

For earthquake, there are no significant weak links in the reinforced concrete structures that provide the secondary barrier for the STS process. Tests have shown that the PVC water stop between the STS building and the shield structure has sufficient deformability to accommodate the calculated deflections produced between these buildings under extreme earthquake conditions. Thus, the water stop has been shown to be an acceptable alternative to the more traditional flexible membrane expansion joint.

The piping system is too complex to fully assess its safety factors individually. Instead of a rigorous analysis of the entire piping system, individual lines, judged to be critical based on process specifics and engineering experience, were modeled and computer-analyzed to assess failure modes and safety factors (e.g., high-pressure lines carrying sludge wash solution). The weakest link in the piping system appears to be in the section that crosses the expansion joint between the STS building through the valve aisle and pipeway into the shield structure over Tank 8D-1 (e.g., differential movement between structures causes pipes to rupture).

For tornado loading and tornado missiles, there appear to be no weak links in the reinforced concrete buildings and their interconnecting underground piping.

D.9.3.4.5 LEAKAGE

For the design basis earthquake and tornado, there appears to be no credible failure mode that will lead to leakage through existing reinforced concrete barriers of the STS process facilities. (Leakage, in this case, refers to the flow of liquids.) Gaseous or vapor leaks may develop if the support barriers (e.g., negative internal pressure) are lost due to an earthquake or tornado. The potential source terms and radiological consequences associated with airborne pathways under these extreme conditions are discussed in Section D.9.2.

D.9.3.5 SUMMARY - STS AND SMWS BARRIER INTEGRITY ANALYSIS

The primary STS confinement barriers have sufficient reserve capacity, due to the inherent safety factors associated with this type of construction, to survive extreme environmental loading (e.g., design basis earthquake and tornado events) without structural failure and leakage of HLW into the environment.

The primary confinement barriers of highest reliability under earthquake and tornado loading are the reinforced concrete vaults and chambers that enclose the STS process vessels and piping. These buildings and tank vaults have been designed to higher structural safety standards than required for life safety by local building codes used in the design of industrial process plants in New York State. The radiological shielding requirements for these structures generally resulted in greater reserve strength than found in conventional industrial plant building design.

The margin of safety against failure of the reinforced concrete barriers is conservatively estimated at 2 to 4 times the design basis earthquake. The least predictable element in the building barrier is the PVC water stop between the STS building and the shield structure on Tank Vault 8D-1. Tests and analysis indicate the water stop has an estimated safety factor of 3 or greater against rupture under an earthquake.

In terms of the internal piping and vessel systems that confine the sludge wash solution in its path of processing, the connecting piping between the valve aisle, pipeway and shield structure appears to be the most vulnerable under earthquake. The safety factor appears to be on the order of three.

Extreme tornado winds and missile loads are not a significant safety consideration for the massive shield walls and roofs of the STS process facilities.

The primary SMWS confinement barriers have sufficient reserve capacity, due to the inherent safety factors associated with the original construction as well as the conservative design incorporated in new construction, to survive extreme environmental loading (e.g., design basis earthquake and tornado events) without structural failure and leakage of high-level radioactive liquid wastes into the environment.

SMWS abnormal operating conditions do not appear to represent a significant threat to the integrity of the existing confinement barriers in Tank 8D-2.

The primary confinement barrier of highest reliability under earthquake and tornado loading is the reinforced concrete vault that encloses Tank 8D-2. The radiological shielding requirements generally result in structural sizes and wall thicknesses that are larger than normally required under conventional industrial building design codes. As a result, the margin of safety in these structures against failure under extreme environmental loading is higher than one would normally expect in conventional construction.

The margin of safety against failure of the steel tank and concrete vault, which serve as the first and second line of confinement barrier for the HLW, is conservatively estimated at six times the design basis earthquake and more than 10 times the design basis tornado. Thus, there is little potential for leakage of the high-level radioactive liquid waste into the environment under extreme environmental loading.

The margi- of safety against poter .l vapor released to the environment is on the order of 0.5 to 1.5 times the sign basis tornado and 1.5 to 4 times the design basis earthquake, assuming the WTFVS is nonoperational. The most vulnerable link in the systems appears to be the flexible bellows connection that serves to accommodate lateral and vertical movements of the mobilization pump support structure above Tank 8D-2 and the tank access riser.

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TABLE D.9.2-1

Accident 1
Tank 8D-2 Roof Collapse - Direct to Environment - Ground Release
First Wash Water Solution

Evaporation Rate (L/h)	4.00E+03	
Accident Duration (h)	2.00E+00	
Partition Coefficient	1.00E+03	(for non-volatiles)

Total Off-site EDE (cSv or rem)	7.97E-01
Total On-site EDE (cSv or rem)	1.50E+01

* Nuclide	** First Wash Conc. Ci/L	** Release Rate Ci/h	Max. Ind. CEDE Off-site cSv or rem	Max. Ind. CEDE On-site cSv or rem	Off-site Contrib.
Pu-238	4.97E-04	1.99E-03	4.30E-01	8.09E+00	53.99%
Cs-137+	1.64E+00	6.55E+00	9.97E-02	1.87E+00	12.51%
Pu-239	9.60E-05	3.84E-04	9.22E-02	1.74E+00	11.58%
Pu-241	4.72E-03	1.89E-02	8.88E-02	1.67E+00	11.15%
Pu-240	7.24E-05	2.90E-04	6.95E-02	1.31E+00	8.73%
Am-241	1.03E-05	4.14E-05	1.01E-02	1.91E-01	1.27%
Sr-90+	1.13E-03	4.51E-03	2.78E-03	5.23E-02	0.35%
Cm-244	2.95E-06	1.18E-05	1.50E-03	2.83E-02	0.19%

* Those nuclides which contribute >0.1% of the Maximum Individual CEDE
** 1 Ci = 3.7E+10 Bq
\+ Includes the contribution from the daughter isotopes

TABLE D.9.2-2

Accident 2
Pipe Leak - Direct to Environment - Ground Release
First Wash Water Solution

Leak Rate (L/h)	1.50E+03	
Evaporation Rate (L/h)	1.50E+03	
Accident Duration (h)	2.00E+00	
Partition Coefficient	1.00E+03	(for non-volatiles)

Total Off-site EDE (cSv or rem)	2.99E-01
Total On-site EDE (cSv or rem)	5.62E+00

* Nuclide	** First Wash Conc. Ci/L	** Release Rate Ci/h	Max. Ind. EDE Off-site cSv or rem	Max. Ind. EDE On-site cSv or rem	Off-site Contrib.
Pu-238	4.96E-04	7.45E-04	1.61E-01	3.03E+00	53 99%
Cs-137+	1.64E+00	2.46E+00	3.74E-02	7.03E-01	12.51%
Pu-239	9.60E-05	1.44E-04	3.46E-02	6.51E 01	11.58%
Pu-241	4.72E-03	7.07E-03	3.33E-02	6.27E-01	11.15%
Pu-240	7.24E-05	1.09E-04	2.61E-02	4.90E-01	8.73%
Am-241	1.03E-05	1.55E-05	3.80E-03	7.14E-02	1.27%
Sr-90+	1.13E-03	1.69E-03	1.04E-03	1.96E-02	0.35%
Cm-244	2.95E-06	4.43E-06	5.63E-04	1.06E-02	0.19%

* Those nuclides which contribute >0.1% of the Maximum Individual CEDE
** 1 Ci = 3.7E+10 Bq
\+ Includes the contribution from the daughter isotopes

TABLE D.9.2-3

Accident 3
Valve Aisle Pipe Leak - Through PVS - Ground Release
First Wash Water Solution

Leak Rate (L/h)	1.50E+03	
Evaporation Rate (L/h)	1.50E+02	
Accident Duration (h)	2.00E+00	
Partition Coefficient	1.00E+00	(for volatiles)

Total Off-site EDE (cSv or rem)	7.56E-06
Total On-site EDE (cSv or rem)	1.42E-04

* Nuclide	** First Wash Conc. Ci/L	** Release Rate Ci/h	Max. Ind. EDE Off-site cSv or rem	Max. Ind. EDE On-site cSv or rem	Off-site Contrib.
C-14	4.43E-05	6.[illegible]-03	6.57E-06	1.24E-04	86.96%
I-129	6.80E-08	1.02E-05	8.64E-07	1.63E-05	11.43%
H-3	2.51E-05	3.77E-03	1.12E-07	2.10E-06	1.48%

* Those nuclides which contribute >0.1% of the Maximum Individual CEDE
** 1 Ci = 3.7E+10 Bq
\+ Includes the contribution from the daughter isotopes
Note: a DF of 3×10^9 was used for non-volatile species per ANSI-N46.1.

- Condensor DF=30
- 1st HEPA DF=1000
- 2nd HEPA DF=100
- Partition Coefficient PC=1000

TABLE D.9.2-4

Accident 4
Ti-IX Column Over-Pressurization - Through PVS - Ground Release
Maximum Loaded Ti-IX Column

Non-volatile Fraction Release 1.0%
Non-volatile DF from PVS 3.0E+06

Total Off-site EDE (cSv or rem) 1.89E-04
Total On-Site EDE (cSv or rem) 3.56E-03

* Nuclide	** STS Ti-Column Maximum Ci	** Accident Release Ci	Max. Ind. EDE Off-site cSv or rem	Max. Ind. EDE On-site cSv or rem	Off-site Contrib.
Pu-238	2.33E+02	7.78E-07	8.43E-05	1.59E-03	44.53%
C-14	7.98E-02	7.98E-02	3.94E-05	7.42E-04	20.83%
Pu-239	4.52E+01	1.51E-07	1.81E-05	3.40E-04	9.55%
Pu-241	2.22E+03	7.39E-06	1.74E-05	3.27E-04	9.20%
Pu-240	3.41E+01	1.14E-07	1.36E-05	2.56E-04	7.20%
Cs-137+	4.00E+05	1.33E-03	1.01E-05	1.91E-04	5.35%
I-129	1.22E-04	1.22E-04	5.18E-06	9.75E-05	2.74%
H-3	4.52E-02	4.52E-02	6.70E-07	1.26E-05	0.35%
Sr-90+	4.43E+02	1.48E-06	4.55E-07	8.56E-06	0.24%

* Those nuclides which contribute >0.1% of the Maximum Individual CEDE
** 1 Ci = 3.7E+10 Bq
\+ Includes the contribution from the daughter isotopes

Note: C-14, I-129, and H-3 are assumed to be completely released to the environment.

TABLE D.9.2-5

Accident 5
HEPA Fire - Elevated Release
Cs on Filter Ci 7.5 - 10 R/h @ 35 cm

Volatile Fraction Release 100%
Non-volatile Fraction Release 1.0%

Total Off '~e EDE (cSv or rem) 4.33E-04

* Nuclide	** Filter Activity Ci	** Release Ci	Max. Ind. EDE Off-site cSv or rem	Off-site Contrib.
Pu-238	2.27E-03	2.27E-05	2.34E-04	54.00%
Cs-137+	7.50E+00	7.50E-02	5.42E-05	12.52%
Pu-239	4.39E-04	4.39E-06	5.02E-05	11.58%
Pu-241	2.16E-02	2.16E-04	4.83E-05	11.15%
Pu-240	3.31E-04	3.31E-06	3.78E-05	8.73%
Am-241	4.73E-05	4.73E-07	5.51E-06	1.27%
Sr-90+	5.17E-03	5.17E-05	1.51E-06	0.35%
Cm-244	1.35E-05	1.35E-07	8.17E-07	0.19%

* Those nuclides which contribute >0.1% of the Maximum Individual CEDE
** 1 Ci = 3.7E+10 Bq
\+ Includes the contribution from the daughter isotopes

TABLE D.9.2-6 FISSIONABLE MATERIAL INVENTORY FOR TANK 8D-2 AND MAXIMUM ENVELOPE FOR ION EXCHANGE COLUMNS

Nuclide	Total Fissionable Mass in Tank 8D-2 g	Max. Soluble Fissionable Mass for First Wash g	* STS Fissionable Max. per Col. g
U-233	720	270	0.4
U-234	660	250	0.3
U-235	41,000	16,000	21
U-238	2,300,000	1,000,000	1,300
Pu-238	370	14	3.9
Pu-239	27,000	924	260
Pu-240	5,700	187	52
Pu-241	640	28	7.8
Am-241	20,000	4.1	0.0
Am-243	25,000	5.0	0.0
Cm-244	200	0.0	0.0

* Assumes Cs breakthrough after processing 375,000 L (100,000 gals.) of undiluted sludge wash solution at an alpha plutonium concentration of 0.73 µCi/mL. The maximum column is analyzed as an ion exchange column containing Ti-treated zeolite and envelopes non-treated zeolite usage.

TABLE D.9.2-7

SUMMARY OF CRITICALITY EVALUATION FOR THE ZEOLITE COLUMN OF SMWS

Geometry & Composition	Radius & Length Z(cylinder only) (cm) of Pu-239 Retained Vol.	K-effective $\pm\sigma$
0.44 kg of Pu-239, Pu uniformly distributed in the hemisphere	R=22.5 (hemisphere)	0.38137 ± 0.00161
1.0 kg of Pu-239, Pu uniformly distributed in the cylinder	R=45.5 (cylinder) Z=20	0.66491 ± 0.00305
1.0 kg of Pu-239, Pu uniformly distributed in the cylinder	R=23 (cylinder) Z=20	0.89920 ± 0.00464
1.0 kg of Pu-239, optimum geometry, Pu uniformly distributed in the sphere	R=22.5 (sphere)	[illegible]94748 ± 0.00505

TABLE D.9.2-8 PHYSICAL DESCRIPTION OF ZEOLITE COLUMN

Description of A Zeolite Column

Radius(R,cm)	Length(Z,cm)
45.50 (ID)	400
46.77 (OD)	402.54

Mat.rial Compositions and Atom Densities for KENO-V Calculations

Material	Density g/cc	Vol.Frac	Nuclide	Atomic Density atom/barn-cm	Cross-Section Source
Zeolite	1.75	0.4	Si	0.00440	XSDRN
(SiO2: 62%, Al2O3: 18.9%)			Al	0.00156	Hansen Roach
(Na2O: 6.31%, Fe2O3: 4.85%)			Na	0.00086	Hansen Roach
(TiO2: 4.0%, CaO: 1.46%)			K	0.00013	Hansen Roach
(K2O: 1.46%, MgO: 0.97%)			Fe	0.00040	Hansen Roach
			Ca	0.00011	GAM-2
			Ti	0.00031	GAM-2
			Mg	0.00010	XSDRN
			O	0.01300	Hansen Roach
Water	0.9982	0.6	H2O(X(E))	(KENO-V)	Hansen Roach
304 S.S.	7.9	1.0	SS	(KENO-V)	Hansen Roach
Plutonium	17.7	---	Pu-239	Varies	Hansen Roach

TABLE D.9.2-9

K_{EFF} FOR A 1.0 KG ^{239}PU SPHERE IN THE CENTER OF THE ZEOLITE COLUMN

Geometry	Radius,cm	K-effective ±σ
Sphere	15	0.84061 ± 0.00884
Sphere	18	0.91868 ± 0.00542
Sphere	20	0.94102 ± 0.00525
Sphere	21	0.94186 ± 0.00547
Sphere	22	0.94615 ± 0.00479
Sphere	22.5	0.94748 ± 0.00505
Sphere	23	0.94612 ± 0.00445
Sphere	24	0.93074 ± 0.00470
Sphere	26	0.91059 ± 0.00439
Sphere	30	0.83864 ± 0.00367

TABLE D.5.2-10

K_{EFF} FOR A 22.5 CM ^{239}PU SPHERE IN THE CENTER OF THE ZEOLITE COLUMN

Mass Pu-239, Kg	K-effective ±σ
0.8	0.88818 ± 0.00436
0.9	0.91380 ± 0.00503
1.0	0.94748 ± 0.00505
1.1	0.95440 ± 0.00517
1.2	0.98249 ± 0.00482

TABLE D.9.3-1

SLUDGE MOBILIZATION IN TANK 8D-2
CONFINEMENT BARRIER VULNERABILITY ASSESSMENT FOR EXTREME NATURAL HAZARDS

Structure or Component	Confinement Barrier	Failure Mode of Barrier	Basis of[1] Assessment	Intensity[2] of Event or Load	Mitigative Action or Backup System or Backup Barrier	Footnote
Tank 8D-1 or Tank 8D-2	Carbon steel tank	Uplift and crushing of perlite insulation blocks -- Possible tank rupture	Analysis, engineering judgment	>2 x DBEQ	Tank vault and pan (liquid and vapor barrier)	
		Tank slides on perlite blocks, impacts roof support columns	Analysis, engineering judgment	>4 x DBEQ	Tank vault and pan (liquid and vapor barrier)	(5)
		Tank motions lead to interior vault column and roof collapse	Engineering judgment, approximate analysis	>6 x DBEQ	Tank vault and pan (liquid barrier)	(3)
		Rupture of tank sidewall caused by fracture of pump column at tank top	Analysis, engineering judgment	>4 x DBEQ	Tank vault and pan (liquid and vapor barrier)	
		Collapse of tank roof column due to pump impact with column supports	Analysis, engineering judgment	>>4 x APOC >6 x DBEQ	Tank vault and pan (liquid and vapor barrier)	
		Rupture of carbo steel tank bottom due to collapsing shield plug	Engineering judgment, analysis	>6 x DBEQ >3 x DBT	Loss of primary liquid and vapor barrier. Tank vault steel liner pan provide liquid and vapor barrier.	
		Tornado missile penetrates tank roof	Analysis, engineering judgment	>>10 x DBT	Tank vault and pan (liquid barrier)	
	Reinforced concrete tank vault and steel liner pan	Local flexural cracking of wall from lateral soil-vault motion, no leakage	Analysis, engineering judgment	>2 x DBEQ	Soil excavation and positive hydrostatic pressure (liquid barrier) (vault as vapor barrier)	(4)
		Shearing of walls at foundation mat, leakage inward develops	Analysis, engineering judgment	>4 x DBEQ	Soil excavation (liquid barrier)	
		Roof of vault collapse	Analysis engineering judgment	>5 x DBEQ	Soil excavation (liquid barrier)	(3)

TABLE D.9.3-1 (continued)

SLUDGE MOBILIZATION IN TANK 8D-2
CONFINEMENT BARRIER VULNERABILITY ASSESSMENT FOR EXTREME NATURAL HAZARDS

Structure or Component	Confinement Barrier	Failure Mode of Barrier	Basis of[1] Assessment	Intensity[1] of Event or Load	Mitigative Action or Backup System or Backup Barrier	Footnote
		Tornado missile penetration of vault roof	Analysis, engineering judgment	>>10 x DBT	Steel tank barrier	
	Soil excavation in tight clayey till	Cracking or clayey till, leakage	Engineering judgment	>6 x DBEQ	None	(5)
	Reinforced concrete vault and liner pan	(Previously detailed)				
	Soil excavation in tight clayey till	(Previously detailed)				
Transition from top of vault roof to seal ring plate	Carbon steel riser sleeve	Tear, rupture	Engineering judgment	>12 x DBEQ	40" diameter steel casing provides liquid barrier	(6)
	40" diameter steel casing	Shear, rupture	Engineering judgment	>12 x DBEQ	Concrete/grout fill (liquid barrier)	(6)
	Soil backfill and tank excavation	Crack	Engineering judgment	>5 x DBEQ	None	
Transition from top of seal ring plate to bottom of bearing plate on spray chamber	Carbon steel riser sleeve	Shear, tear	Analysis, engineering judgment	>12 x DBEQ >3 x DBT	Vapor barrier is lost, carbon steel tank provides liquid barrier	(6)
	Expansion bellows	Tear	Test, analysis, engineering judgment	>2 x DBEQ >.5 to 1.5 x DBT	Vapor barrier is lost, carbon steel tank provides liquid barrier	(6)
	Carbon steel riser spray chamber	Tear, rupture	Engineering judgment	>12 x DBEQ >1.5 x DBT	Vapor barrier is lost, carbon steel tank provides liquid barrier	(6)
Upper and lower bearing plates	Carbon steel bottom bearing plate	Shear or yield flange bolts, break seal, leak vapor	Engineering judgment	>3 DBEQ	Carbon steel tank and riser (liquid barrier)	(6)

TABLE D.9.3-1 (continued)

SLUDGE MOBILIZATION IN TANK 8D-2
CONFINEMENT BARRIER VULNERABILITY ASSESSMENT FOR EXTREME NATURAL HAZARDS

Structure or Component	Confinement Barrier	Failure Mode of Barrier	Basis of[1] Assessment	Intensity[2] of Event or Load	Mitigative Action or Backup System or Backup Barrier	Footnote
Upper bearing plate, split support spacer, and pump mounting plate	Carbon steel bearing, and split support spacer pump mounting plates	Yield flange bolts lose vapor barrier	Engineering judgment, analysis	>5.5 X DBE	Carbon steel tanks and riser (liquid barrier)	
Pump column and shaft seal	Stainless steel pump column and fluid seals on drive shaft	Crack pump column, loose internal fluid pressure	Engineering judgment	>1.5 x DBEQ	Loss of operational liquid barrier on pump drive shaft only, carbon steel tank provides liquid barrier	(6), (7)
At Riser M-1	Pump column	Impact at top of tank at riser (no failure).	Analysis	>0.5 x DBEQ		
		Impact tank roof support column at bottom of tank, pump column failure	Analysis	>15 x DBEQ	Steel tank barrier	
At Risers M-3 and M-6	Pump column	Impact at top of tank (no failure)	Analysis	>1.2 x DBEQ		
		Impact at bottom of tank, pump column failure	Analysis	>7 x DBEQ	Steel tank barrier	
At Risers M-4, M-5, M-7	Pump column	Impact at top of tank (no failure)	Analysis	>1.2 x DBEQ		
		Impact at bottom of tank, pump column failure	Analysis	>13 x DBEQ	Steel tank barrier	
At Riser M-2	Pump column	Impact at top and bottom of tank, pump column failure	Analysis	>1.1 DBEQ	Steel tank barrier	
Shield Plug	Carbon steel plug with concrete and steel plate shielding	Collapse of plug through riser sleeve into tank	Analysis, engineering judgment	>6 x DBEQ >3 x DBT	Loss of vapor barrier, carbon steel tank provides liquid barrier	(6)
		Rupture of carbon steel tank bottom due to collapsing shield plug	Analysis, engineering judgment	>6 x DBEQ >3 x DBT	Loss of primary liquid and vapor barrier. Tank vault and steel liner pan provide liquid and vapor barrier.	
		Truss collapse on tank vault roof	Analysis, engineering judgment	>4 x DBEQ	No loss of barrier -- tank vault roof remains intact	

TABLE D.9.3-1 (concluded)

SLUDGE MOBILIZATION IN TANK 8D-2
CONFINEMENT BARRIER VULNERABILITY ASSESSMENT FOR EXTREME NATURAL HAZARDS

Structure or Component	Confinement Barrier	Failure Mode of Barrier	Basis of[1] Assessment	Intensity[2] of Event or Load	Mitigative Action or Backup System or Backup Barrier	Footnote
Pump Support Structure	Tank vault roof	Shear bolts at truss support	Analysis	>2 x DBEQ	No loss of barrier - tank vault roof remains intact	
		Truss collapse on tank vault	Analysis, engineering judgment	>4 x DBEQ	No loss of barrier - tank vault roof remains intact	

(1) Basis of vulnerability assessment may be through: analysis, experimental tests or engineering judgment based on experience.

(2) Intensity is expressed as a multiple of the design basis event as defined in Gates, 1986 (Section 3.2).
DBEQ = Design Basis Earthquake
DBT = Design Basis Tornado
APOC = Abnormal Pump Operating Condition

(3) Failure of tank barrier leads to failure of vault column and roof.

(4) Leakage of positive hydrostatic pressure inward should be minimal.

(5) Motion of tank is judged to exceed the flexural strength of the riser and its welded connection to the top of Tank 8D-2.

(6) It is assumed that the WTFVS does not remain functional during the extreme earthquake and tornado environment.

(7) Loss of water pressure in the pump column due to the leakage through the column casing will be detected and the pump motor shut down automatically. This migration of radioactive liquid up the pump drive shaft would not be possible. The primary barrier remain intact.

D.10.0 CONDUCT OF STS AND SMWS OPERATIONS

The STS and SMWS will undergo an Operational Readiness Review in accordance with WV-368 before start-up.

D.10.1 ORGANIZATIONAL STRUCTURE

The SMWS will be operated by the same organization that operates the STS today. The IRTS consists of four major subsystems: 1) the STS, 2) the LWTS, 3) the CSS, and 4) the DC. The operating organizations for the STS and SMWS, LWTS, and CSS report to the manager of IRTS Operations. The IRTS Operations Manager reports to the manager of Plant Operations who in turn reports to the WVNS President and General Manager. The operating organization for the Drum Cell reports to the Waste Management Operations Manager who reports to the Executive Vice President and Deputy General Manager who in turn reports to the WVNS President and General Manager. Engineering support for IRTS Operations is provided by the manager of Process Control Engineering who reports to the IRTS Operations Manager.

The shift manning levels for operation of the STS/SMWS as defined in Table D.10.1-1 are valid even though the control rooms are in two different buildings because the STS and the SMWS not operated concurrently. Operational plans for the SMWS call for washing the sludge followed by several days of settling, sampling, and analyses before the sludge wash solutions are processed through the STS.

The minimum manning level for each IRTS operating shift broken down by subsystem is summarized in Table D.10.1-1.

With the exception of the sludge mobilization pumps and the caustic addition equipment, the SMWS hardware is virtually identical to the STS. STS operators will be trained in the operation of the sludge mobilization pumps and the caustic addition system. The STS operators will also be trained on the contents of the SMWS Run Plan which will provide a process overview as well as the process sampling plan necessary for processing the sludge wash solutions. The training will be conducted in accordance with the requirements of the SMWS operator qualification program described in Section 10.3 It is planned that the current shift manning used in the STS will be extended to SMWS operations. The IRTS organizational structure is shown in Figure D10.1-1.

See Section A.10.1 of Volume I for a general WVNS organizational structure discussion.

D.10.2 PREOPERATIONAL TESTING AND OPERATION

D.10.2.1 ADMINISTRATIVE PROCEDURES FOR CONDUCTING THE TEST PROGRAM

All procedures and instructions for conducting the test program and for evaluating, documenting and approving the test results will be developed, reviewed and approved in accordance with WVNS Policies, Quality Manual, and implementing procedures. Hazards associated with the testing are evaluated in accordance with WVNS policies and procedures and the safety review programs. Such reviews are conducted in accordance with WVNS procedures and consist of independent safety reviews, Radiation and Safety Committee reviews, or Operational Readiness Review Board reviews.

D.10.2.2 TEST PROGRAM DESCRIPTION

The test program for the STS and SMWS will verify that the installation was accomplished in accordance with the plans and specifications prepared for that purpose and that the system operates as designed to reduce the volume of HLW contained in Tank 8D-2 consistent with STS and WVDP design objectives. The preoperational test program will culminate in a formal readiness review that will be approved by DOE before STS start-up.

The test program for the SMWS will verify that the mobilization pumps were installed in accordance with the plans and specifications prepared for that purpose and that the system operates as designed to mobilize the PUREX sludge in HLW Tank 8D-2 and according to WVDP design objectives. The preoperational test program will culminate in a formal readiness review that will be approved by DOE before SMWS start-up.

D.10.2.2.1 PHYSICAL FACILITIES

All mechanical and electrical components, including piping and wiring, will be tested during installation to ensure proper installation and operation.

D.10.2.2.1.1 PIPING

All process piping systems were hydrostatically tested and nondestructively examined in accordance with ANSI-B31.3 requirements.

D.10.2.2.1.2 WIRING

Electrical wire was spot-checked for installation and continuity.

D.10.2.2.1.3 POWER

Control panels, electrical outlets, MCC, welding receptacles, etc. were tested to ensure the presence of proper AC power.

D.10.2.2.1.4 MOTORS

Motors were tested for proper operation and correct rotations.

D.10.2.2.1.5 VALVES

Solenoid valves and actuators were tested to ensure proper operation of automatic valves and limit switches.

D.10.2.2.1.6 PROCESS INSTRUMENTATION

Switches were tested for proper operation. Flow switches, level switches, level sensors, and thermocouples were functionally tested and calibrated.

D.10.2.2.1.7 PROCESS COMPONENTS

Process components/vessels were hydrostatically tested in accordance with the requirements of ASME Section VIII or individual equipment specifications.

D.10.2.2.1.8 INTERFACE SIGNALS

All required interface signals between control panels from different systems were tested to ensure proper operation.

D.10.2.2.1.9 RADIATION MONITORS

Operation of on-line process monitors, continuous air monitors, and area radiation monitors was checked. Alarm signal functions were checked.

D.10.2.2.1.10 COOLING SYSTEM

Isolation between cooler and chiller loops was verified.

D.10.2.2.1.11 CONTROL ROOM INSTRUMENTS

Control room instruments were tested in the control panel fabricator shop. Field testing was via loop checks during cold operations.

D.10.2.2.2 PROCESS OPERATIONS

The STS was fully tested using zeolite and water to ensure operation of the system as designed. A surrogate supernatant was also used during cold testing and check-out.

D.10.2.2.2.1 PRELIMINARY TESTING

The components of the STS are operated manually and automatically from the control panel using plant water initially to ensure proper operation of all subsystem components, i.e., Filtration system (preliminary and final), Supernatant Feed, Cooling System, Ion Exchange, Decontaminated Supernatant Collection, and Transfer and Fresh Zeolite Fill. This testing included the flushing.

D.10.2.2.2.2 REMOTE HANDLING SYSTEM

Test manipulators, Air locks, Zeolite Sluicing Systems, and all other mechanical equipment were tested for proper function.

Interface With Other Systems: the STS has been tested to verify proper interface with the LWTS, Ventilation System, Analytical Cell, and Utility Services.

D.10.2.2.2.3 INTEGRATED TESTING

The final test was a continuous integrated test of the entire system:

- Continuous feed of surrogate supernatant into the feed tank.

- Continuous processing of surrogate supernatant through the ion exchange column(s).

- Batch feeding of surrogate decontaminated supernatant from collection tank (8D-3) to LWTS after sample verification.

- Batch feeding of fresh zeolite into the ion exchange columns.

D.10.2.3 TEST DISCUSSION

D.10.2.3.1 PIPING TESTS

Purpose - Confirm that the piping systems as installed are leak-tight.

Response and Acceptance Criteria - Process piping was tested in accordance with ANSI B31.3 requirements.

D.10.2.3.2 WIRING TESTS

Purpose - Confirm that there are no breaks in the electrical wiring.

Response and Acceptance Criteria - Electrical power and instrument wiring were spot checked for installation continuity. Control circuits were functionally verified. Power cables were meggered and each connection inspected.

D.10.2.3.3 MOTOR TESTS

Purpose - Confirm that motors are wired properly.

Response and Acceptance Criterion - Each motor in the system was bump tested to verify rotation in the correct direction and at the design rpms.

D.10.2.3.4 VALVE TESTS

Purpose - Confirm correct operation of each valve.

Response and Acceptance Criteria - Each valve was operated from a manual switch and solenoid valves adjusted to regulate automatic valve response rates. The acceptance criterion was a valve response in the correct direction (open/close) in the required time.

D.10.2.3.5 PROCESS COMPONENTS

Purpose - Confirm that process components have been built and installed properly.

Response and Acceptance Criteria - All process components/vessels were tested in accordance with the requirements of ASME Section VIII or the equipment specifications, current checkout procedures, and for proper functional operation.

D.10.2.3.6 PROCESS INSTRUMENTATION TEST

Purpose - Confirm correct operations and connections of each instrument loop.

Response and Acceptance Criterion - Each instrument loop was checked to confirm correct connections. Loops were then operated to check performance and response. Acceptance and response criteria varied with specific instrumentation and applications.

D.10.2.3.7 ZEOLITE BATCH TANK TESTS

Purpose - Adjust actuators to ensure proper operation.

Response and Acceptance Criterion - The zeolite in the batch tank was sluiced to an empty ion exchange column. Acceptance criterion was met by the ability to sluice to the empty column at a rate compatible with column dewatering rates.

D.10.2.3.8 PNEUMATIC SAMPLE TRANSFER SYSTEM

Purpose - Confirm correct operation of the system.

Response and Acceptance Criteria - Were met by the ability to remotely send samples to the Analytical Cell, including proper transmission and receipt of signals by sender and receiver and sample tracking enroute by the photocells.

D.10.2.3.9 RADIATION MONITORS

Purpose - Confirm the adequate response of radiation monitors.

Response and Acceptance Criterion - Acceptance criterion was met by adequate response (alarm signal at designated set point) to appropriate check/calibration sources of known activity, concentration and/or exposure rate.

D.10.2.3.10 ION EXCHANGE COLUMNS

Purpose - Verify the proper operation of the ion exchange columns.

Response and Acceptance Criteria - Acceptance criterion was an extraction efficiency of 99.9% of the cesium based on scale model tests and a zeolite sluice-out efficiency of 99.99%.

D.10.2.3.11 FILTRATION SYSTEM

Purpose - Verify proper performance of the supernatant pre- and postfilters.

Response and Acceptance Criteria - Acceptance criterion was met by the ability to remove 99% by weight of particles having a size greater than 1 μm (10,000 Å). Verification was by scale model tests.

D.10.2.3.12 COOLING SYSTEM

Purpose - Verify ability of cooling system to reduce surrogate supernatant temperature.

Response and Acceptance Criteria - Achieved by monitoring temperature of surrogate supernatant feed to ion exchange. Met if cooling system can reduce temperature of surrogate supernatant to less than 10°C (50°F) at a surrogate supernatant feed rate in the range of 225 (1) - 680 L/h (3 gpm).

D.10.2.3.13 OPERATIONAL TESTING

Purpose - Confirm the ability to operate the STS as a continuous process.

Response and Acceptance Criterion - Met by achieving an uninterrupted flow rate compatible with the capacity of the CSS to receive and solidify decontaminated supernatant and to produce decontaminated supernatant and loaded zeolite exhibiting characteristics consistent with laboratory scale results and design criteria.

D.10.2.3.14 SLUDGE MOBILIZATION PUMPS

Purpose - Verify the proper installation and operation of the sludge mobilization pumps in Tank 8D-2.

Response and Acceptance Criteria - After final assembly, each mobilization pump has been extensively tested: minimum six-hour performance run test, hydro tested, and seal leak test. After tank installation, the pump motor and its controller are run through a series of tests and are fine-tuned with critical operating frequencies locked out. Pump seal water low pressure and high flow switches checked to verify equipment interlock functions are operational.

D.10.3 TRAINING PROGRAMS

D.10.3.1 SCOPE, OBJECTIVES, AND GOALS OF THE SMWS OPERATOR QUALIFICATION PROGRAM

The overall objective of the qualification program is to provide qualified personnel to operate the STS and SMWS safely in such areas as equipment operation, process flows, control instrumentation, Radiological/Industrial Safety, and emergency response in accordance with DOE Order 5480.5 "Safety of Nuclear Facilities" and DOE order 5480.20 "Personnel Selection, Qualification Training and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities." Qualified personnel will be provided by training and testing operator candidates who meet the prerequisites for the qualification program.

The STS and SMWS Qualification Program will fulfill the specific needs determined for personnel to operate the facility and process in a safe and efficient manner.

At the completion of the training/qualification program the operator shall be able to:

- Explain the theory and function of the system process, equipment, and controls for generation of an acceptable product.
- Perform the normal modes of operation for the STS and SMWS Standard Operating Procedures and OSRs.
- Detect abnormal or emergency conditions using the instrumentation available and visual monitoring of the components.
- Mitigate emergency situations using appropriate procedures and bring the system to a safe shut-down mode.
- Demonstrate sufficient motor skills to operate manipulators and related mechanical process equipment proficiently.
- Operate the facility safely in accordance with DOE Order 5480.5 and DOE Order 5480.20.

The contents of the training program for specific operations of the STS and SMWS are based on a needs analysis using presently available information (SAR, Design Criteria, Process Narrative, and P&IDs). WVNS management also assessed the cognitive and physical demands upon operators of controlling the process a' e equipment.

D.10.3.2 OPERATION PREREQUISITES

Personnel selected and assigned to the STS and SMWS Operations group will possess, as a minimum, a Plant Systems "B" Operator Qualification. Such personnel will have completed training in the following prerequisites:

- Radiation Worker Training
- Respiratory Protection Training
- Procedural Compliance Training
- Quality Assurance Training
- Radioactive Materials Handling Training
- Lifting and Handling Training
- Nuclear Criticality Safety Training
- General Plant and Chemical Safety
- General Plant Emergency Plan and Procedures

Successful completion of a "B" Qualification in Plant Systems denotes the documented training of personnel in areas relating to radiological and nuclear safety, administrative policies and procedures, emergency actions, industrial health and safety, and areas of process control relating to instrumentation, plant components, and surveillance. Following a minimum four-month training period, a comprehensive written examination and walkthrough are administered before the trainee is considered fully qualified to perform the duties associated with the position. A passing grade of 80% is the minimum requirement. Verification of training is made by a cognizant manager following a finding that the candidate's proficiency is satisfactory after completion of the training program and receipt of a satisfactory statement of the trainee's passing grade of 80% or greater. Currently this qualification is a prerequisite to "A" operator training positions for the Main Plant, LWTS, STS, CSS, Vitrification, Waste Management, and Radiological Projects.

D.10.3.3 TRAINING RESOURCES

The WVNS Training and Development Department will have the responsibility for overall coordination and documentation of the qualification program. The department will employ the expertise of the IRTS Engineering Group to provide classroom instruction on the basic theory, process concepts, subsystems, components, and procedures that comprise the STS and SMWS processes. This training will be supplemented by the use of vendor prepared materials related to basic functions of valves, pumps, instruments, process controllers and/or other vendor material specific to the STS and SMWS systems. Further training reference material and information on the WVNS and Training Procedures, Temporary Operating Procedures, Standard Operating Procedures, TRs/OSRs, and applicable Occurrence Reports will be kept in the Training Resource Center. Training and Development Department personnel will develop the qualification standard and training aids and videotape lectures. Training will also provide instruction, tutorial activities and operator qualification guidance.

D.10.3.4 TRAINING CONTENT OUTLINE

The following outlines the fundamentals of the Qualification Standard for Supernatant Treatment System (STS) Operator "A":

A. Basic System Knowledge
   1. STS Qualification Program Introduction
   2. Process Concepts and Control Introduction

3. Instrumentation Diagrams and Symbols
4. Programmable Controllers
5. STS Motive Devices
6. STS Theory and Interfaces
7. Master - Slave Manipulator Operation Techniques
8. Operation of Valve Aisle Job Crane

B. Operations
1. Liquid Transfer from 8D-2 to D-001 (Feed Tank)
2. Processing from D-001 8D-3
3. STS-LWTS Process Interface
4. STS Ventilation Systems
5. Utility Service/Interface with Main Plant
6. STS Air Compressor
7. STS Instrumentation and Controls
8. Auxiliary Generator - Description, Operation
9. STS Alarm Responses
10. Sample Transfer to Analytical Lab
11. WTF Operation and Surveillance

C. Plant Safety
1. Operational Safety and Technical Requirements
2. STS Fire Protection

D. Emergency Plans and Procedures

The following outlines the fundamentals for the WTF/SMWS Operator "A" Qualification Standard:

A. Operations
1. Corrosion Coupons

2. Valve Aisle Equipment Installation/Removal and Housekeeping
3. Mechanical Arm
4. Dump Valve Air Sparge and "J" Nozzle
5. Mobilization Pump Installation
6. DOP Testing and Filter Changeouts for PVS and STS
7. Hydrogen Monitoring System
8. Zeolite Mobilization
9. Sludge Mobilization and Wash System
10. 8D-1 Chemical Addition
11. Tickle File Card System

B. General Plant Safety and Emergency Procedures
   1. Fire Brigade Training
   2. SAR (STS/SMWS)
   3. Emergency Transfer of HLW Tanks

Both the STS and SMWS Operators Qualification Standards include both knowledge and skill objectives. Supervisors oversee the on-the-job training program, which requires demonstration of proficiencies set forth in the qualification standard. As required in DOE Orders 5480.5 and 5480.20 on-the-job training will continue to provide personnel with familiarity in all aspects of the position. Such training includes normal procedures, emergency actions, radiation control practices, location and function of the pertinent safety systems, configuration control procedures and TRs/OSRs. Continuous training on new material is injected into both the qualification program and the required annual requalification program. Included in this program in the ongoing job training which is specific to performance of job skills.

D.10.3.5 QUALIFICATION VERIFICATION/DOCUMENTATION

D.10.3.5.1 EXAMINATIONS

Before becoming a qualified SMWS Operator, verification is required to ensure that the stated learning objectives and skill objectives have been achieved. The stated objectives will be used in the development of the following evaluation methods:

A written examination covering all aspects of the qualification program with a passing grade of 80%.

An operational walk-through examination performed by SMWS Engineering, Training or Supervisory personnel with a passing grade of 80%. Existing and/or organizational entities (i.e. engineering, training, and supervisory personnel) have been established to support SMWS operations.

D.10.3.5.2 DOCUMENTATION

The qualification program shall be documented in sufficient detail to permit independent evaluation of the scope of the training program. Procedures specific to training are found in WV-538, and the Training Policies and Procedures.

Documentation for each module of the training program will include identification of performance goals, and objectives.

A qualification standard will be kept for each trainee that documents all significant steps of training.

D.10.3.5.3 QUALITY ASSURANCE

QA reviews operator compliance with procedures and that operators are trained to perform the activity for which they are responsible. This is done as a regularly scheduled QA function but surveillance frequency or schedule is unknown to Operations personnel.

Periodic QA audits are performed on the Training and Development Department where qualification standards, training materials, and classroom presentations are subject to surveillance. Content of training media and presentations is reviewed for compliance with quality requirements.

D.10.3.6 REQUALIFICATION

DOE Orders 5480.5 and 5480.20 state that "Retraining and reexamination shall be required at least annually on all procedures for handling abnormal nuclear facility conditions and emergency situations relative to the employe's assigned responsibilities, and at least every two years on all other subjects in which the fissionable material handler, operator, or supervisor is expected to be proficient."

The reexamination program will be designed to review yearly:

- Changes to procedures;
- Modifications to equipment;
- Subject matter not reinforced by direct use (e.g., fundamentals and operation of seldom used equipment and procedures); and
- All procedures for handling abnormal nuclear facility conditions and emergency situations.

The requalification program will provide for maintaining current knowledge and skills of the applicable operators. The requalification program will be conducted every two years and will include but not be limited to:

- Equipment and Plant Modifications;
- SARs and OSRs/TRs;
- Operating Procedures;
- Occurrence Reports, accidents, or near misses which occur locally or elsewhere if appropriate;
- Changing sources of radioactivity, criticality potentials or other potential environmental hazards;
- New outlooks or methods regarding the ALARA concept; and
- Safety (fire, personnel injury, etc.).

Drills on abnormal or emergency procedures will be incorporated into the continuing training program. The drills will be used to assess the operators' knowledge of the procedures to follow in emergency or abnormal operating conditions. The drills will be as realistic as possible without endangering property or personal welfare.

Additional information on the STS Operator Training and Qualification Program can be found in McKenzie, 1986.

D.10.4 NORMAL STS/SMWS OPERATIONS

The STS/SMWS will be operated using procedures prepared, implemented, reviewed, revised, maintained and approved per the requirements of the WVNS Policy and Procedures Manual and in accordance with DOE Orders, directives, regulations, and guidance necessary for the operation of the WVDP and conduct of personnel.

Review and revision of procedures is in a controlled fashion. The cognizant manager or designee forwards the procedure to appropriate reviewers for approval or comment. If a procedure affects only those activities in the department, approval minimally includes cognizant staff and department manager, the Quality Assurance Manger, and the Project Records and Publications Manager. However, if the procedure imposes requirements upon other departments, those department managers are required to review the procedure for approval.

D.10.5 EMERGENCY PLANNING

An emergency plan has been developed for the WVDP. This plan is described in Section A.10.5 of Volume I. Operation of the STS/SMWS will not require any modification to the procedural requirements of this plan. Specific emergency response provisions to deal with STS/SMWS contingencies will be developed in accordance with the existing emergency plan.

REFERENCES FOR SECTION D.10.0

McKenzie, 1986 McKenzie, S. P. March 25, 1986. "Supernatant Treatment System Operator Qualification Program.' Transmitted via WVNS memo EC:86:0023. J. C. Cwynar to Distribution.

TABLE D.10.1-1

Minimum Shift Manning Levels for Operation of the IRTS

Subsystem	Operators "A"	Operators "B"	Supervisor	Shift Engineer
STS/SMWS	2	0	1	1
LWTS	1	1	1	1
CSS	2	1	1	1
DC	2	1	1	1

D.11.0 OPERATIONAL SAFETY REQUIREMENTS

The OSR section of this volume has been deleted in its entirety. The following list of OSRs/TRs apply to the STS and SMWS and can be found in Volume VI:

WVDP Identifier	Title/Contents
OSR-GP-1	WVDP Airborne Radioactivity Release Limits
OSR-GP-2	Radioactivity Content of Liquid Effluents Released from the WVDP
OSR-GP-3	Building and Vessel Ventilation Systems Operability
OSR-GP-4	Effluent and Environmental Monitoring
OSR-GP-5	WVDP Emergency Power Requirements
TR-GP-9	Control of Plant Equipment Function and Configuration
OSR-GP-10	Airborne Effluent Monitoring System Operability
TR-GP-13	Evacuation Alarm and Emergency Paging System Operability
TR-GP-15	Fire Brigade and Emergency Response Team Training
TR-GP-16	Plant Fire Protection Systems
OSR-IRTS-1	Maintenance of Carbon Steel High Level Waste Tank Integrity
OSR-IRTS-3	Maintenance of Spare HLW Storage Capacity
TR-IRTS-4	Depressurization of STS for Maintenance
TR-IRTS-5	STS Process Limits
OSR-IRTS-12	STS Feed Requirements

D.12.0 QUALITY ASSURANCE

The Quality Assurance Program implemented for operation of the Supernatant Treatment System (STS) and for construction and operation of the Sludge Mobilization/Wash System (SMWS) forms part of the overall WVNS Quality Assurance Program. The QA program requirements and implementing procedures are prescribed in a controlled document hierarchy that includes the WVNS Policies and Procedures (WVPP) Manual, the Quality Management Manual (QMM), and Quality Assurance Procedures (QAP). These WVNS documents conform to and translate the requirements of ANSI/ASME NQA-1 and DOE 5700.6B into a graded system for Quality Assurance applied to the systems, structures, components, and operation of the STS and SMWS.

D.12.1 QUALITY ASSURANCE PROGRAM

Organization charts and their descriptions for construction and operation of the STS and SMWS denoting lines of responsibility, authority, and communication are provided in part D.10.1 of this SAR. As described in this referenced section and in the QMM, the personnel responsible for verifying conformance, auditing, inspecting have the organizational freedom and authority to perform these functions without undue external influences imposed on them.

D.12.2 IMPLEMENTATION

Section A.12.2 of Volume I discusses the implementation of the Quality Assurance Program based on DOE order 5700.6B, DOE-ID order 5700.6C and the eighteen criteria of ANSI/ASME NQA-1. As these standards are revised, the WVNS Quality Assurance Program is updated at customer direction to address changed requirements or add new ones. Currently the QA program conforms to the 1986 edition of NQA-1.

All of the policies, procedures, and instructions required to implement the QA program have been produced and are in effect. Audits by outside agencies and on site personnel are scheduled by procedure, and conducted to assure the implementation of the QA program.

The WVNS QMM addresses the descriptive requirements of those Quality Assurance program elements required by NRC Regulatory Guide 3.26.

As described in the WVNS Quality Assurance Program Plan (WVDP-002), the QA program applied to the STS/SMWS is a graded system. Section D.4.4 presents information concerning the safety classifications which are used in conjunction with the service classes to define the quality levels. Table D.4.4-1 presents safety class, service class, and quality level for the structures, systems and components associated with the STS and SMWS. The criteria and procedures used to determine quality level designation and the classification of structures, systems and components are presented in detail in Section A.4.4 of Volume I.

No credible SMWS equipment failure is expected to result in a loss of STS or SMWS operating capability for a period in excess of six months or a radiation exposure resultant from repair/replacement in excess of 50 mSv/y (5 rem/y) and therefore, no STS or SMWS structure, system, or component is designated as Service Class I.

Structures, systems and components assigned Service Class II are so designated since their repair/replacement could result in a loss of SMWS operating capability of one to six months and/or a radiation exposure to repair/replace of 1-5 cSv (1-5 rem). No STS or SMWS structure, system, or component is so designated.

Service Class III is assigned to those structures, systems or components whose repair/replacement could result in a loss of operating capability of one to four weeks and/or an exposure to repair/replace of up to 1 rem. The SMWS mobilization pump support structure, mobilization pumps, and support equipment are so designated. The STS valve aisle and HLW tanks are examples of this designation.

Structures, systems and components which by nature are reliable, normally available, and compatible with their required service based on a history of proven industrial performance are assigned Service Class IV.

Whenever practical, equipment/component spares will be maintained on-site to minimize impact on operating capabilities should failures occur (Section D.6.5.3)

Section A.12.2 of Volume I discusses the implementation of the Quality Assurance Program based on DOE Order 5700.6B, DOE-ID Order 5700.6C and the eighteen criteria of ANSI/ASME NQA-1, 1986.

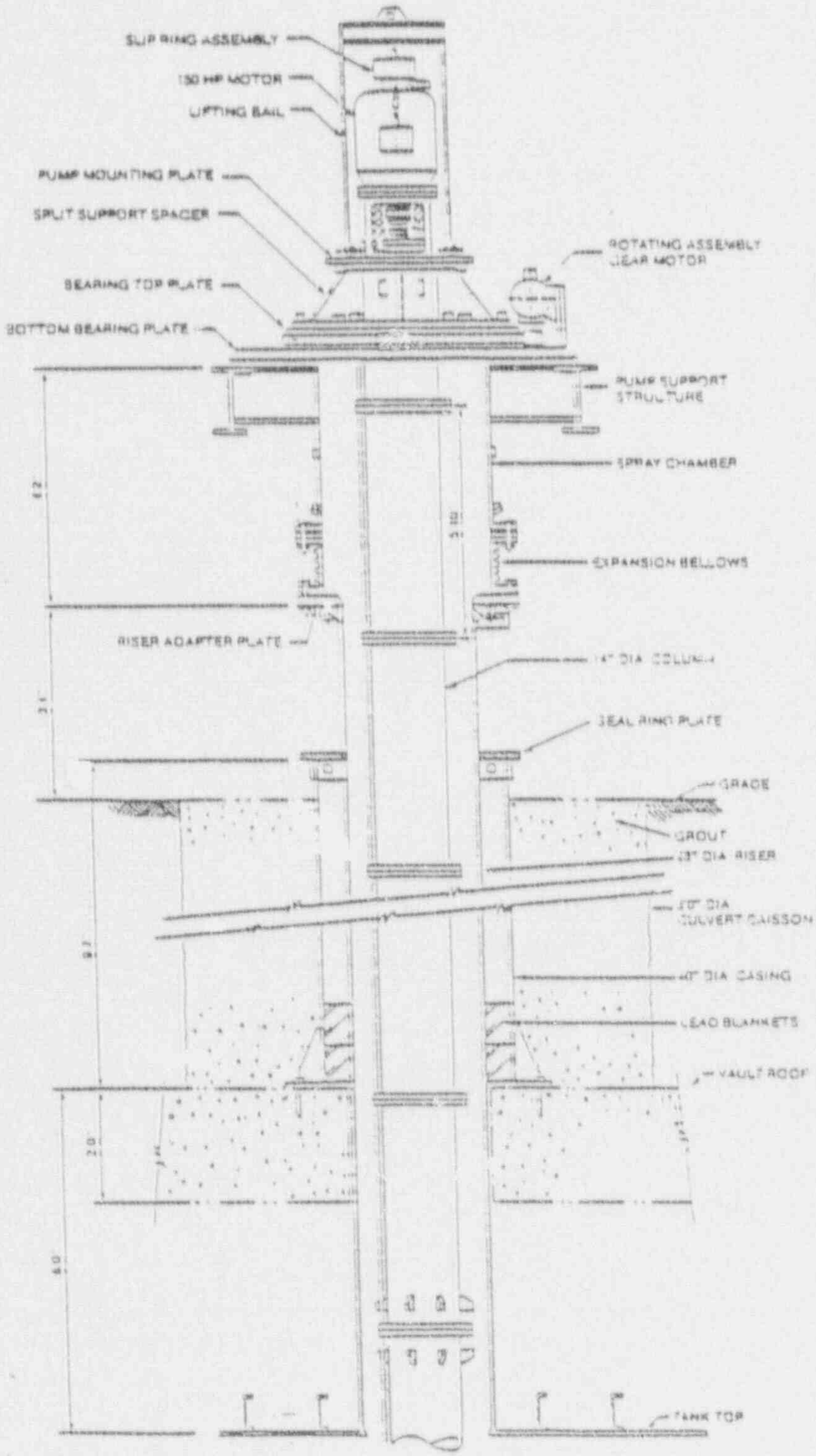
REFERENCES FOR SECTION D.12.0

DOE 5700.6B U.S. Department of Energy, "Quality Assurance," September 1986.

NQA-1 American Society of Mechanical Engineers, "Quality Assurance Program Requirements for Nuclear Facilities," ASME NQA-1-1986, September 1986.

QMM West Valley Nuclear Services Quality Management Program, April 1990.

WVDP-002 WVNS Quality Assurance Program Plan (QAPP), April, 199



Waste Mobilization Pump Installed For Operation

Figure D.4.1-1. Sludge Mobilization Pump

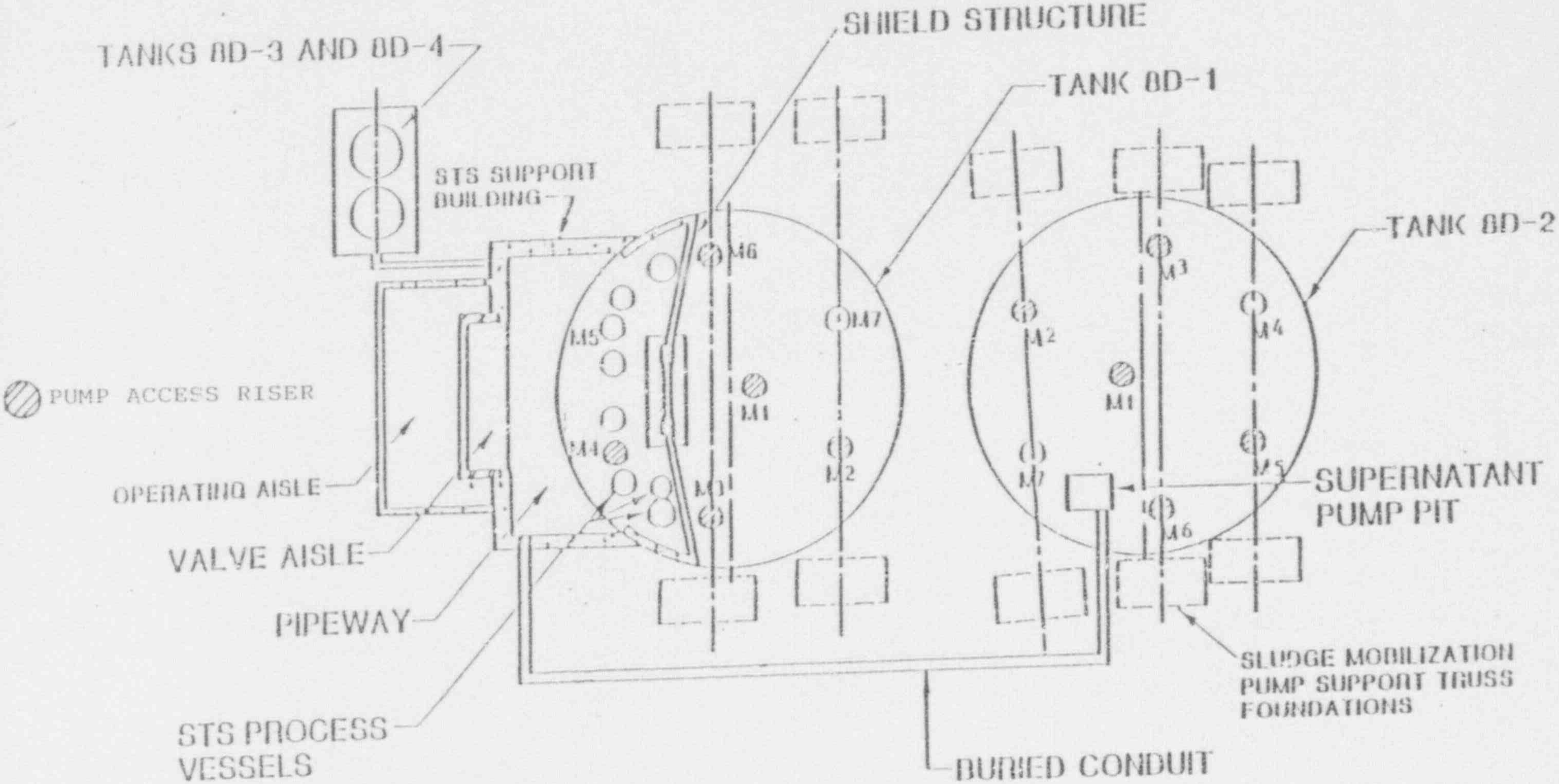


Figure D.4.1-2. Tank Risers for Sludge [illegible]zation Pump Access

TANK 8D-1/8D-2
PLAN AND ELEVATION
ABOVE INTERNAL GRIDWORK

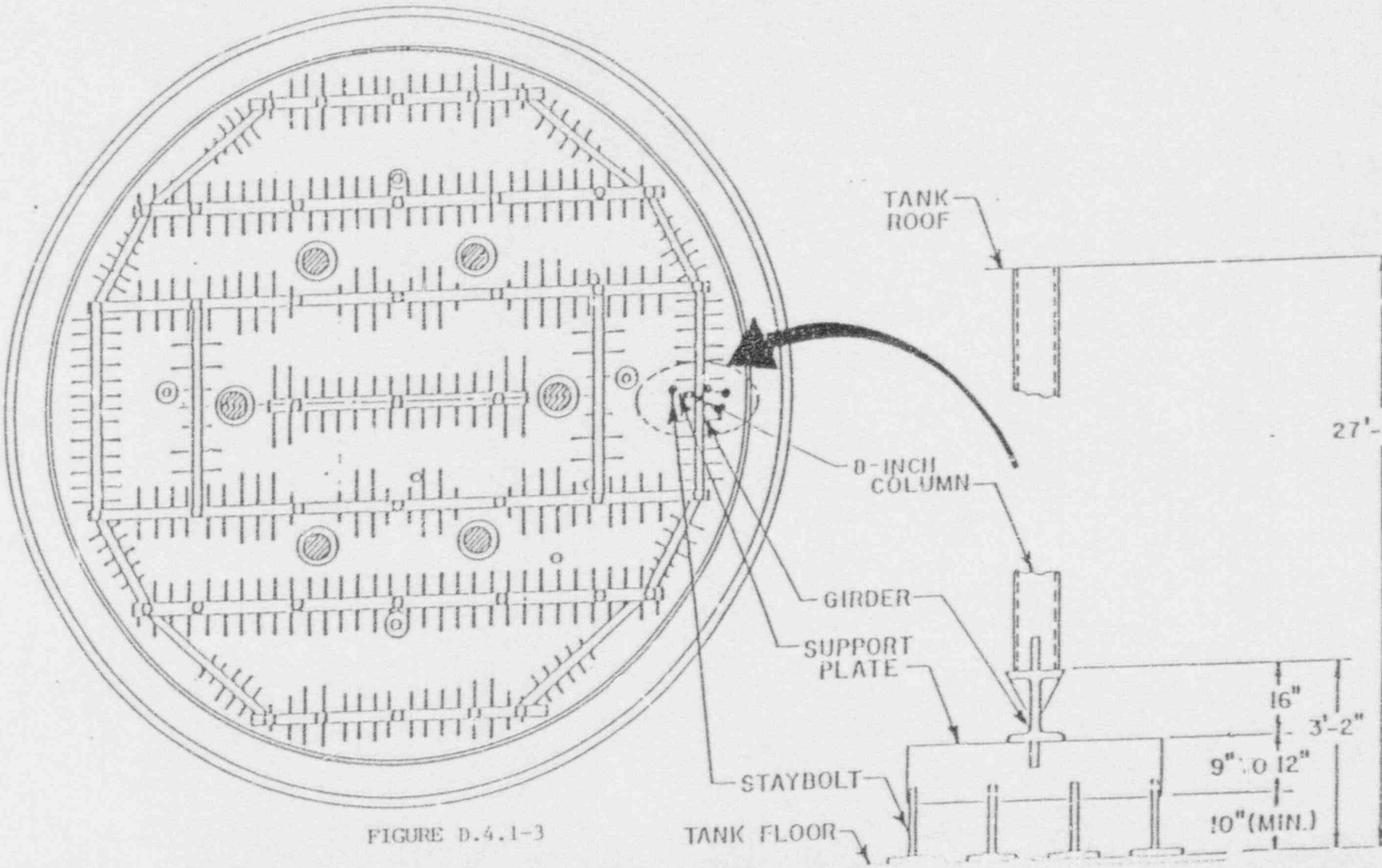


FIGURE D.4.1-3

SUPERNATANT TREATMENT SYSTEM PROCESS FACILITIES

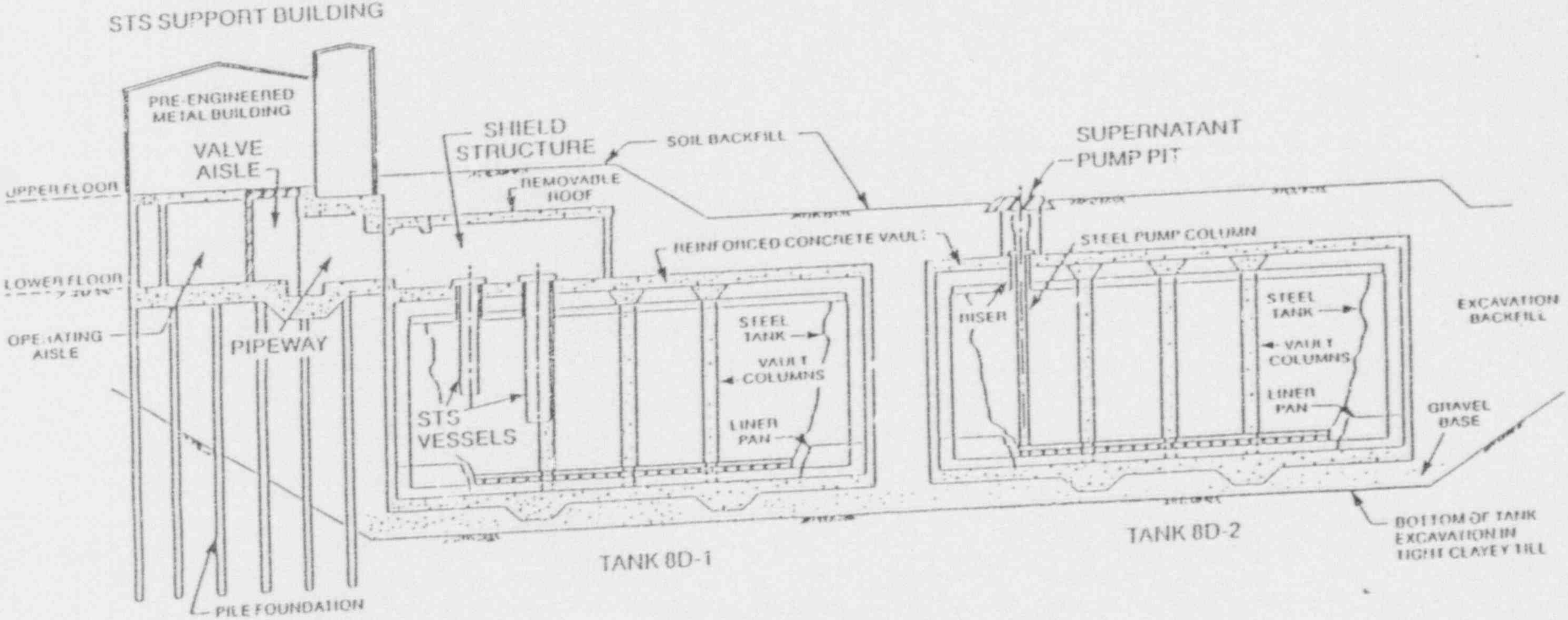


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FIGURE
D.4.2-1

SUPERNATANT TREATMENT SYSTEM SHIELD STRUCTURES

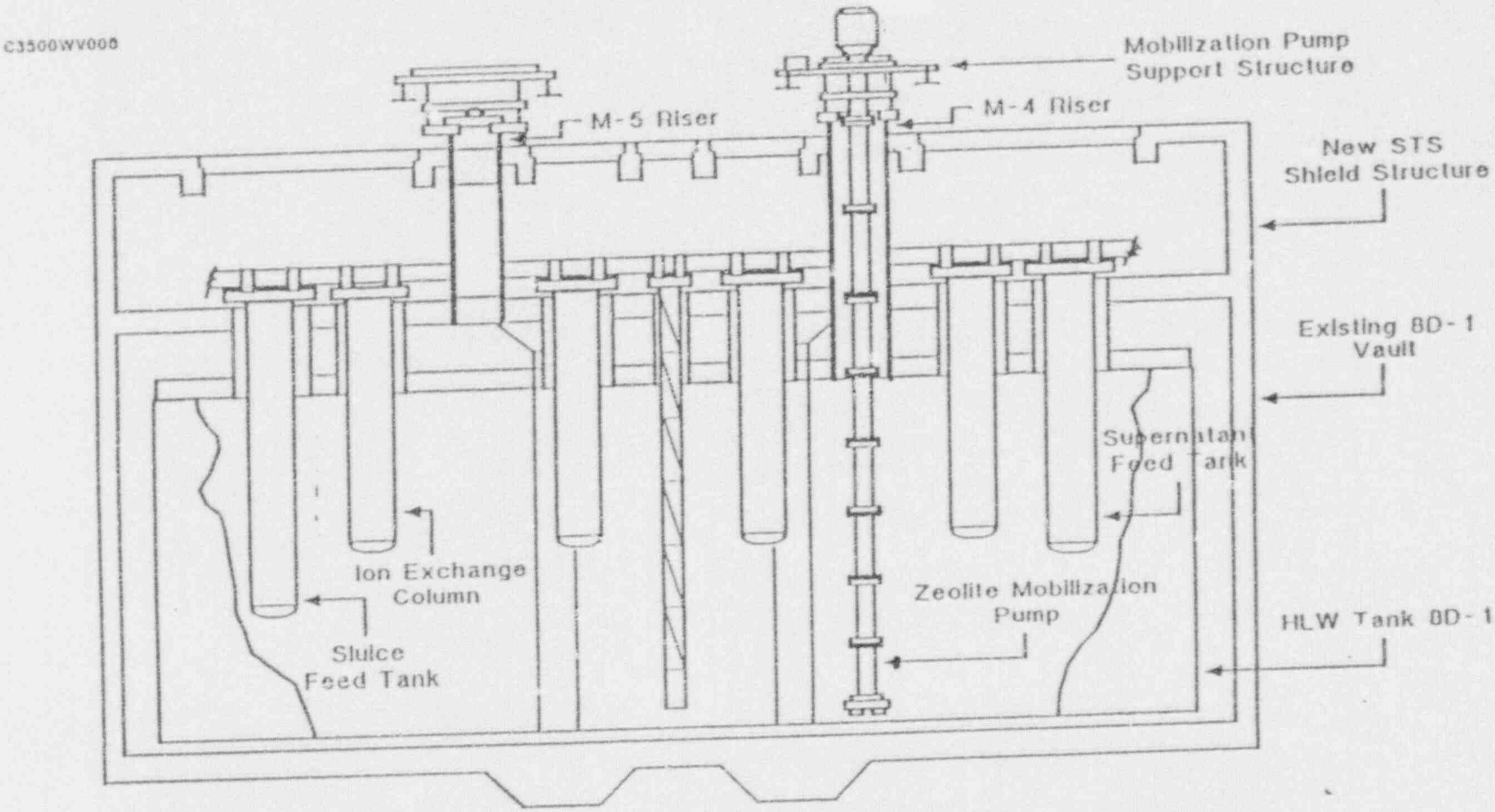

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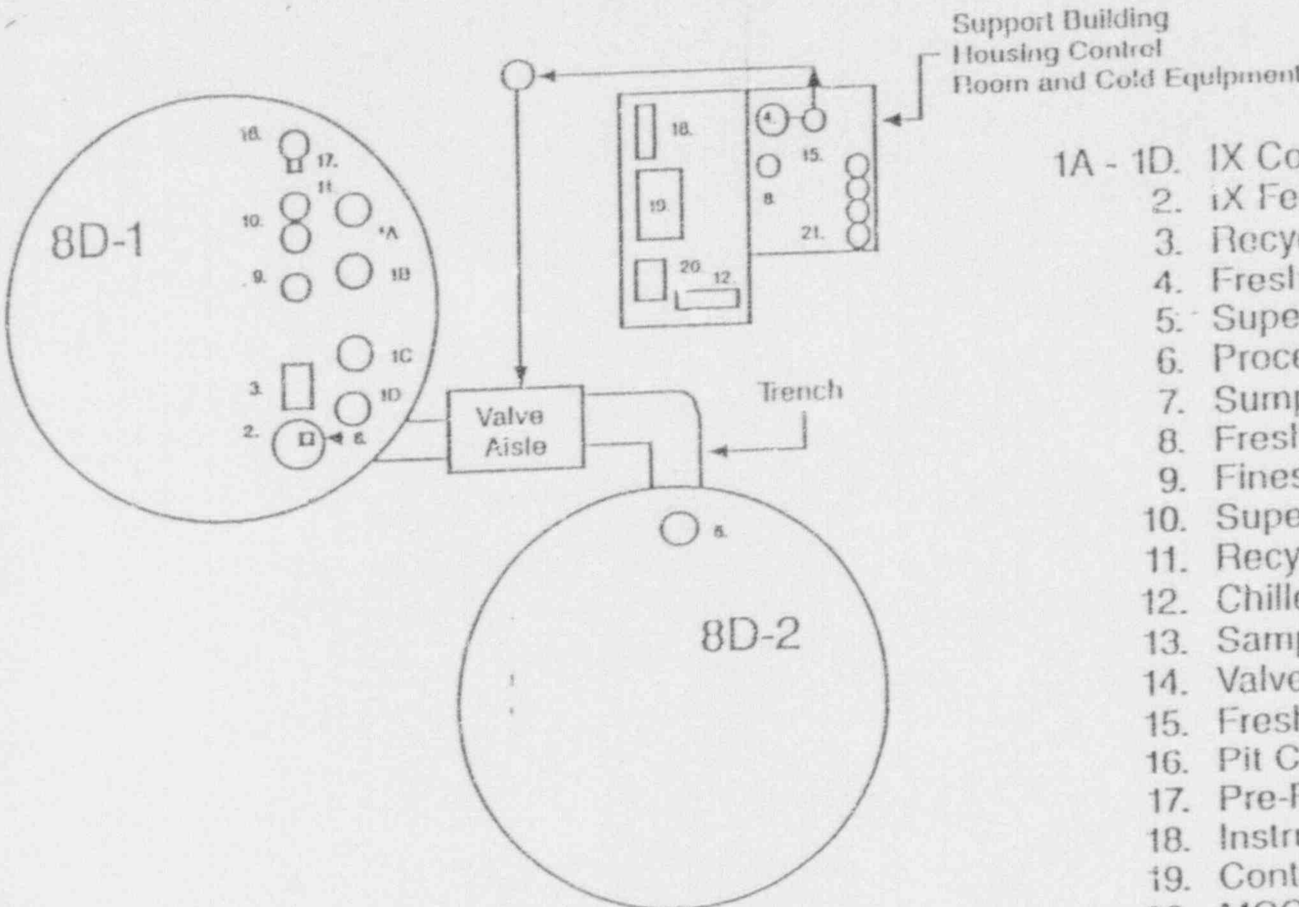
FIGURE
D 4 [illegible]

SUPERNATANT TREATMENT SYSTEM LAYOUT



1A - 1D. IX Columns
2. IX Feed Tank
3. Recycle Water Pump
4. Fresh Water Tank
5. Supernatant Pump
6. Process Feed Pump
7. Sump Pump
8. Fresh Water Filter
9. Fines Post Filter
10. Supernatant Cooler
11. Recycle Cooler
12. Chiller Assembly
13. Sampling Box
14. Valve Maintenance Box (Aisle)
15. Fresh Zeolite Tank
16. Pit Cooler
17. Pre-Filter
18. Instrument Rack
19. Control Panel
20. MCC
21. Zeolite Storage

FIGURE
D.4.3-1


HAZARDOUS WASTE STORAGE
WASTE TANK FARM
STORAGE
REST ROOMS
CONSTRUCTION FIELD OFFICE
OFFICE
PROCESS BUILDING
SECTION A-A

900E-1983

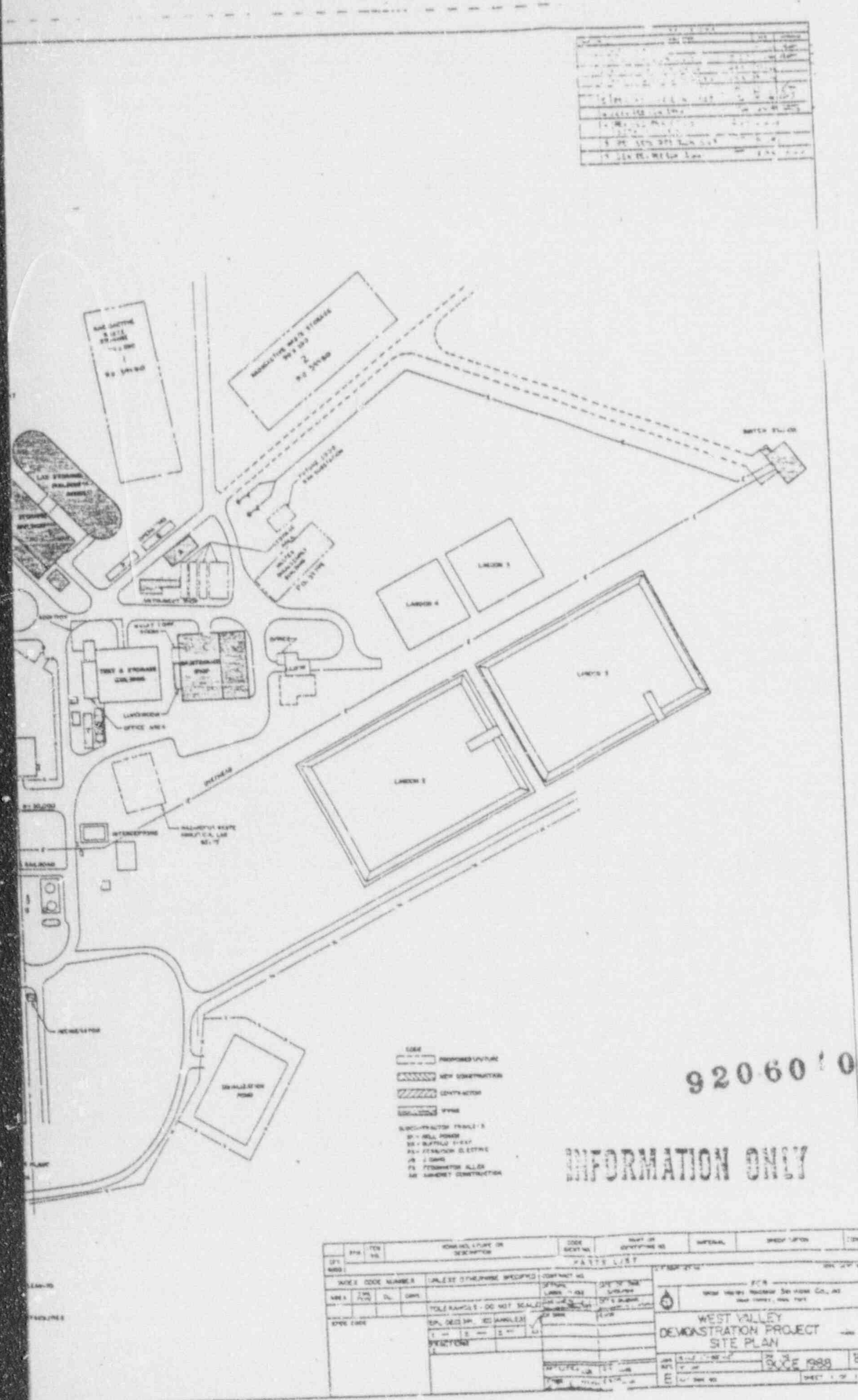


FIGURE D.5.1-1

SLUDGE MOBILIZATION PUMPS AND SUPERNATANT REMOVAL PUMP LOCATION

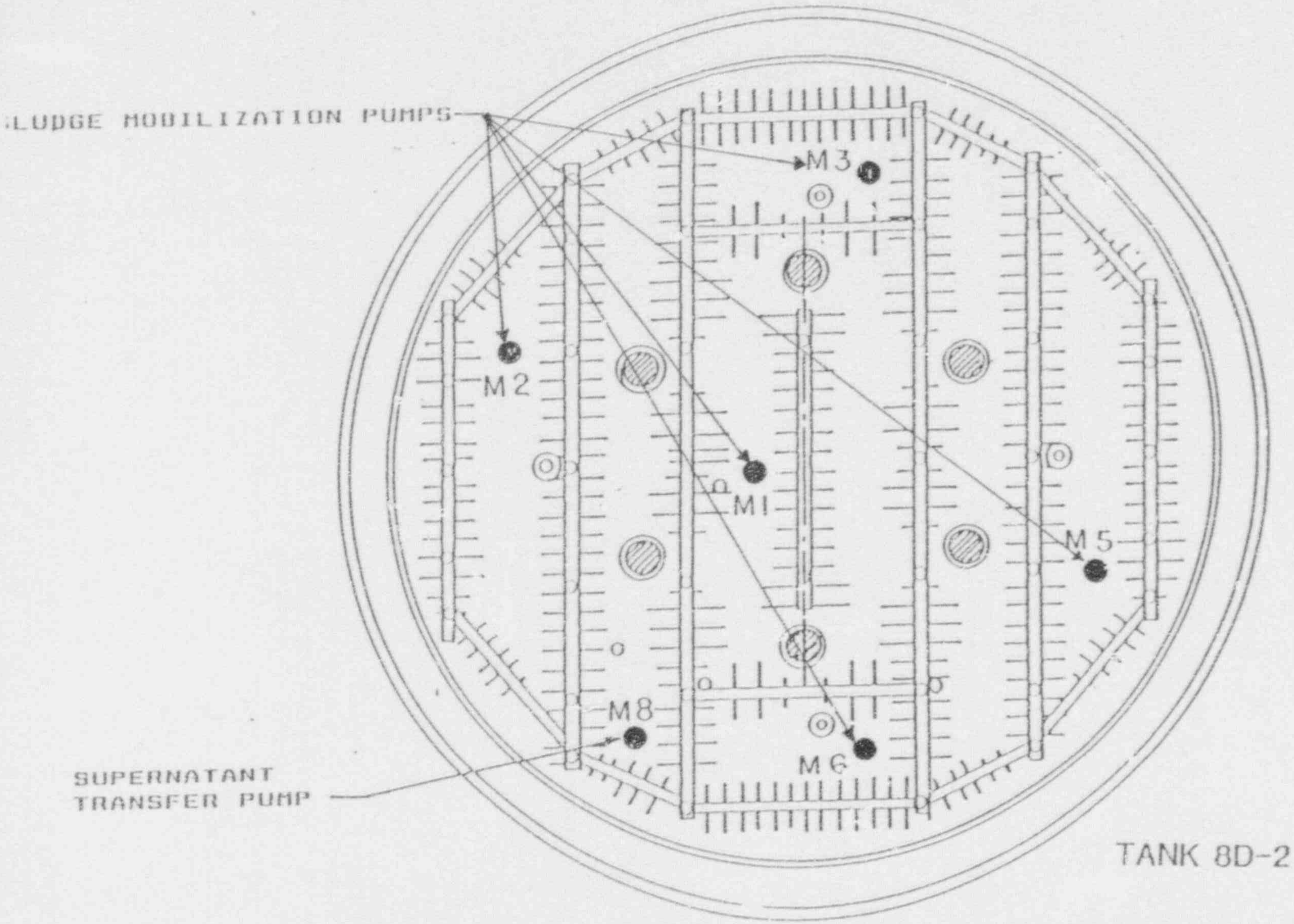
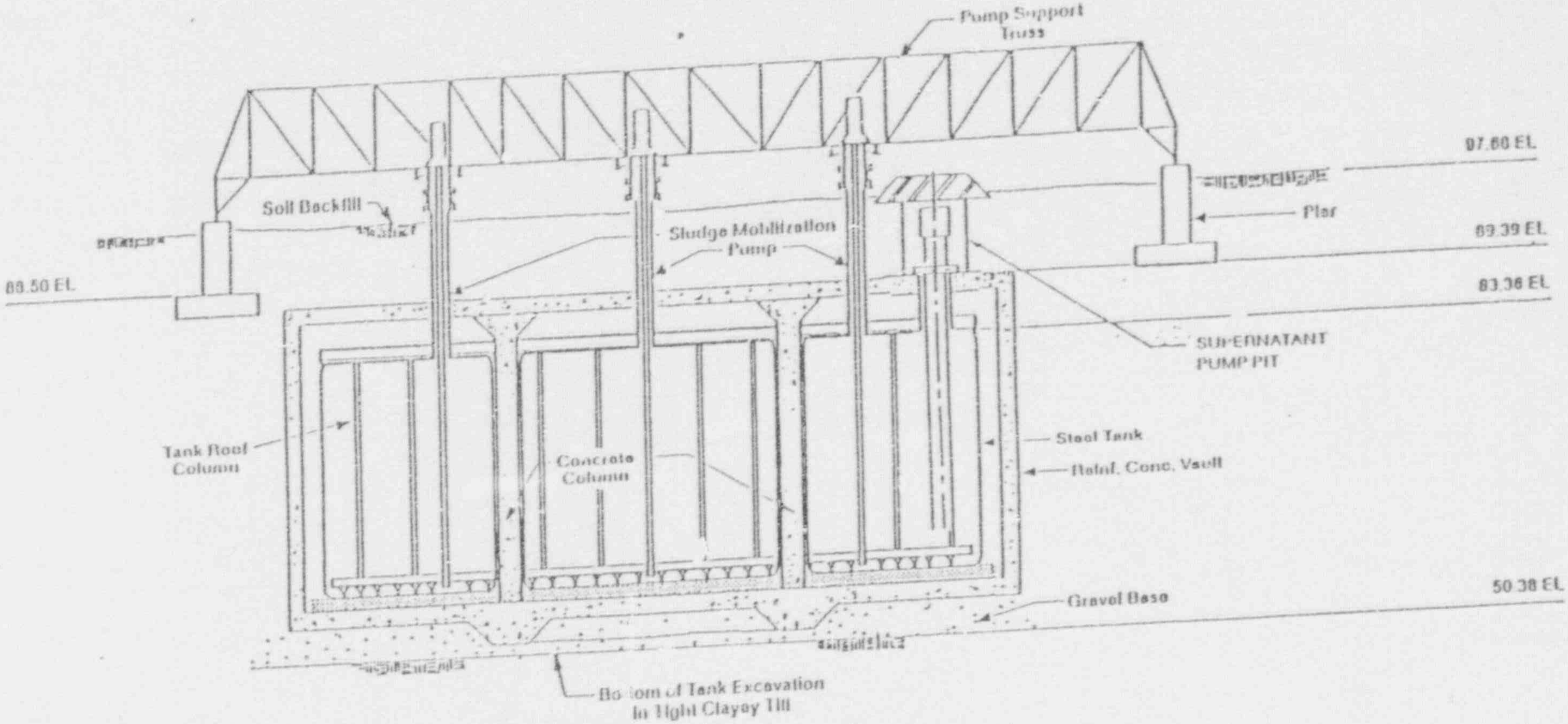


FIGURE D.5.1-2

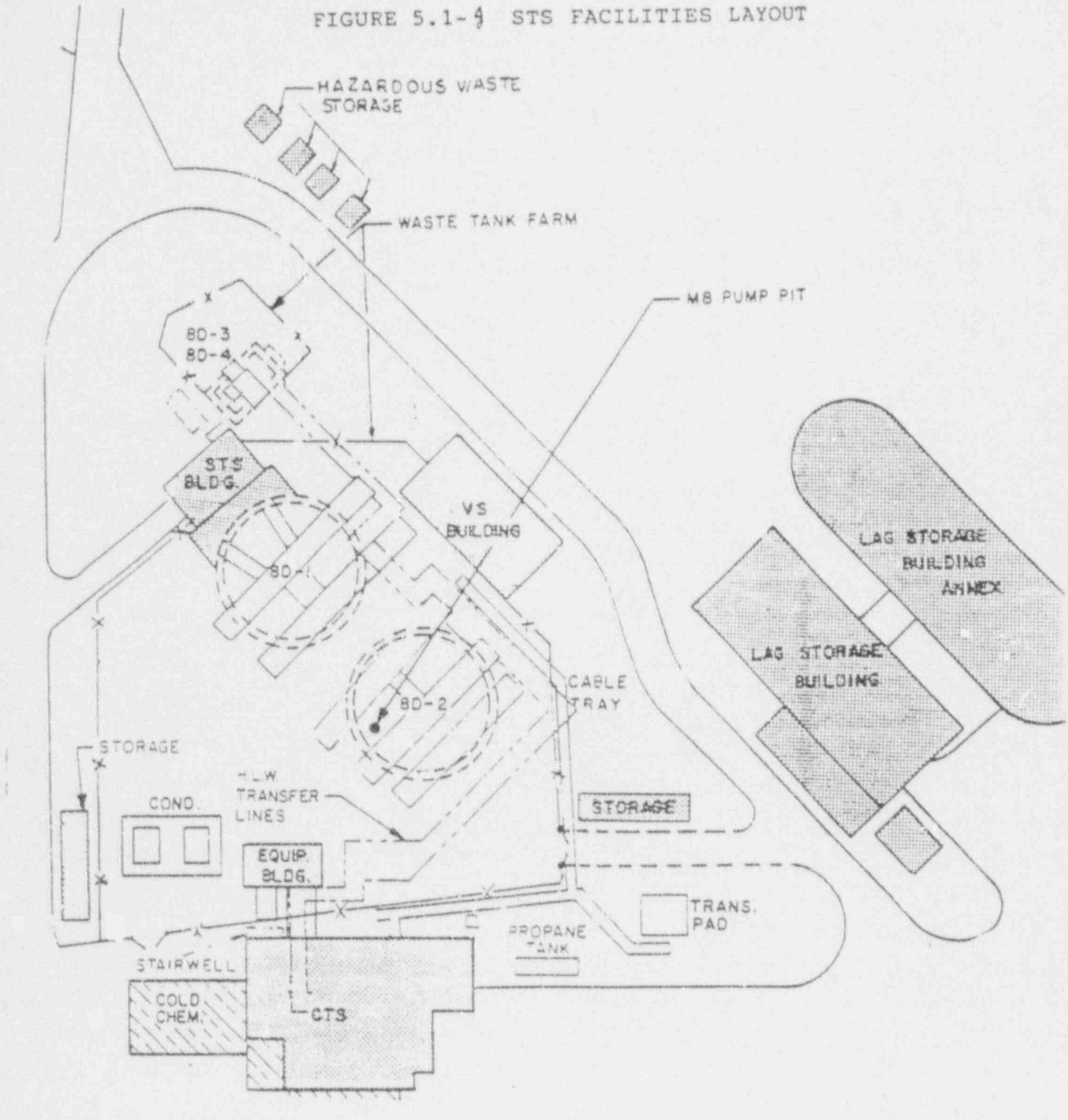
TANK 8D-2 SECTION



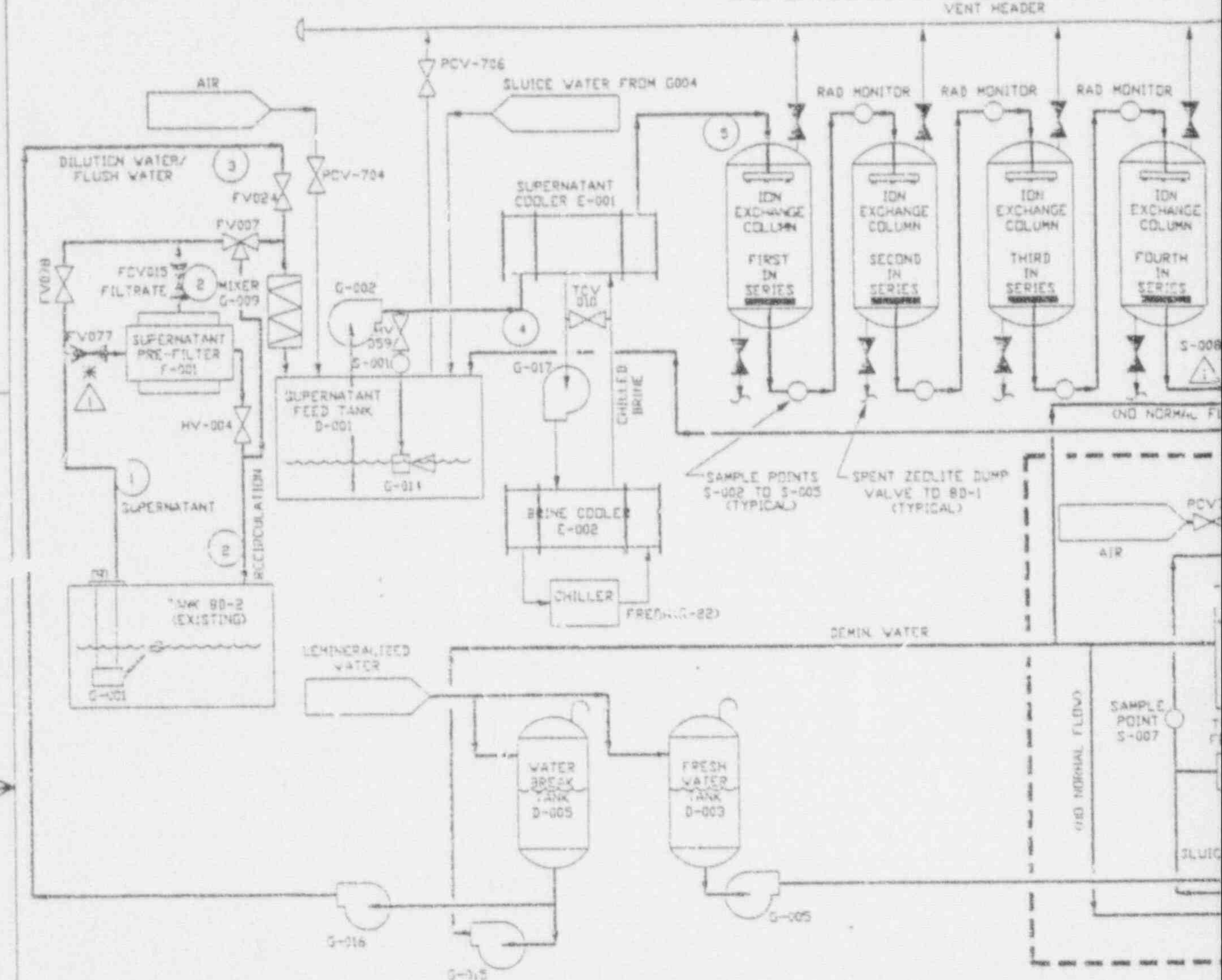
Elements of the Sludge Mobilization Wash

FIGURE D.5.1-3

FIGURE 5.1-9 STS FACILITIES LAYOUT



SUPERNATANT PROCESSING



1	2	3	4	5	6	7	8	
SUPERNATANT TRANSFER FROM 8D-2 TO STS * SOP 50-36 NOMINAL FLOW: 10-40 GPM	OPERATION OF PREFILTER 50-F-001 SOP 50-36 LIMITS: ΔPK 30 PSID TSS < 200 PPM TO BYPASS PREFILTER NOMINAL FLOW: 40 GPM PRODUCES 2-6 GPM OF FILTRATE	DILUTION WATER OR FLUSHWATER TO 50-D-001 SOP 50-36 LIMITS: Na < 1000PPM AFTER FLUSHING NOMINAL FLOW: (FLUSHING) 5GPM TOTAL FLUSH VOLUME 5000 GAL NOMINAL FLOW: (DILUTION) 1X TO 2X SUPERNATANT FLOW FIC 024	OPERATION OF SUPERNATANT COOLING SYSTEM SOP 50-36 SOP 50-15 ⚠1 LIMITS: OUTLET TEMP<12°C BRINE PRESSURE > SUPERNATANT PRESSURE NOMINAL FLOW: (SUPERNATANT) 2-6 GPM NOMINAL FLOW (BRINE) 120 GPM	OPERATION OF ION EXCHANGE COLUMNS SOP 50-36 SOP 50-33 OSR'S GP-3,GP-5 TR IRTS-4 LIMITS: MINIMUM VOLUME PROCESSED: 15,300 GAL NOMINAL FLOW: (SUPERNATANT) 2-6 GPM NOMINAL FLOW (FLUSHING) 2-6 GPM NOMINAL FLOW: (RECYCLE WATER) COLUMN VOL. 450 GAL (3600 LBS OF ZEOLITE)	OPERATION OF DECONTAMINATED SUPERNATANT FILTER F-002 SOP 50-36 LIMITS: ΔPK 10 PSID	COLLECTION OF DECONTAMINATED SUPERNATANT PRODUCT IN 8D-3 SOP 50-36 SOP 50-33 TR IRTS-5 LIMITS: CESIUM CONC. VS SALT CONC. SEE FIG. 1 OF TR IRTS-5 NOMINAL FLOW: 2-6 GPM	DECONTAMINATED SUPERNATANT TRANSFER FROM 8D-3 TO 5D15B SOP 50-23 (LWTS SOP 71-_ 71-10) TR IRTS-5 LIMITS: CESIUM DF >1000 CESIUM CONC. VS SALT CONC. SEE FIG.1 OF OSR NOMINAL FLOW: 20-25 GPM TOTAL VOLUME TRANSFERRED EACH BATCH 8000 GAL	ZEOL SPENT DIS SOP LIMITS QTY 3600 CO QTY 10

REVISIONS

0	ER 1418	
1	ECN 4136	1/30/87

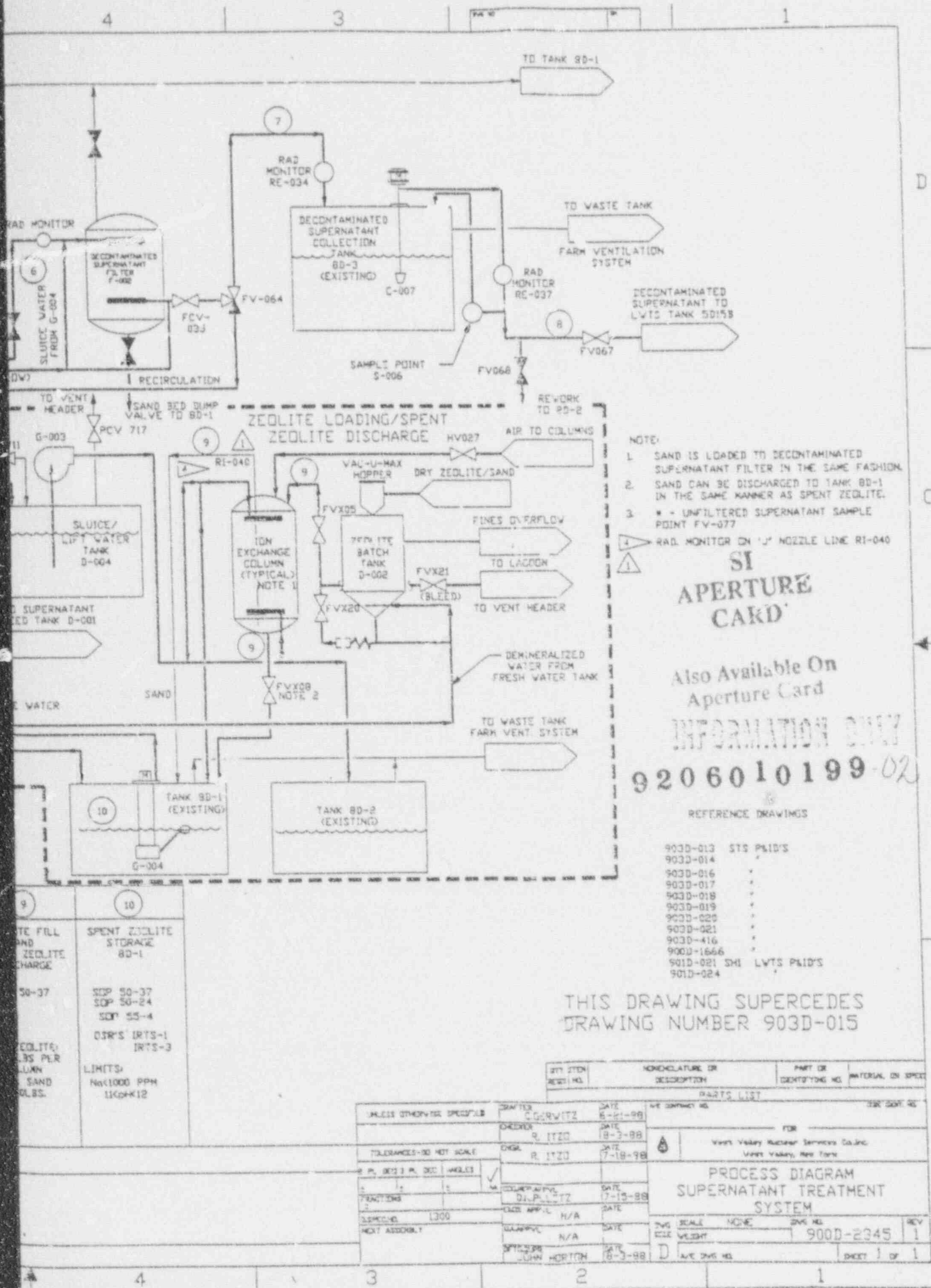
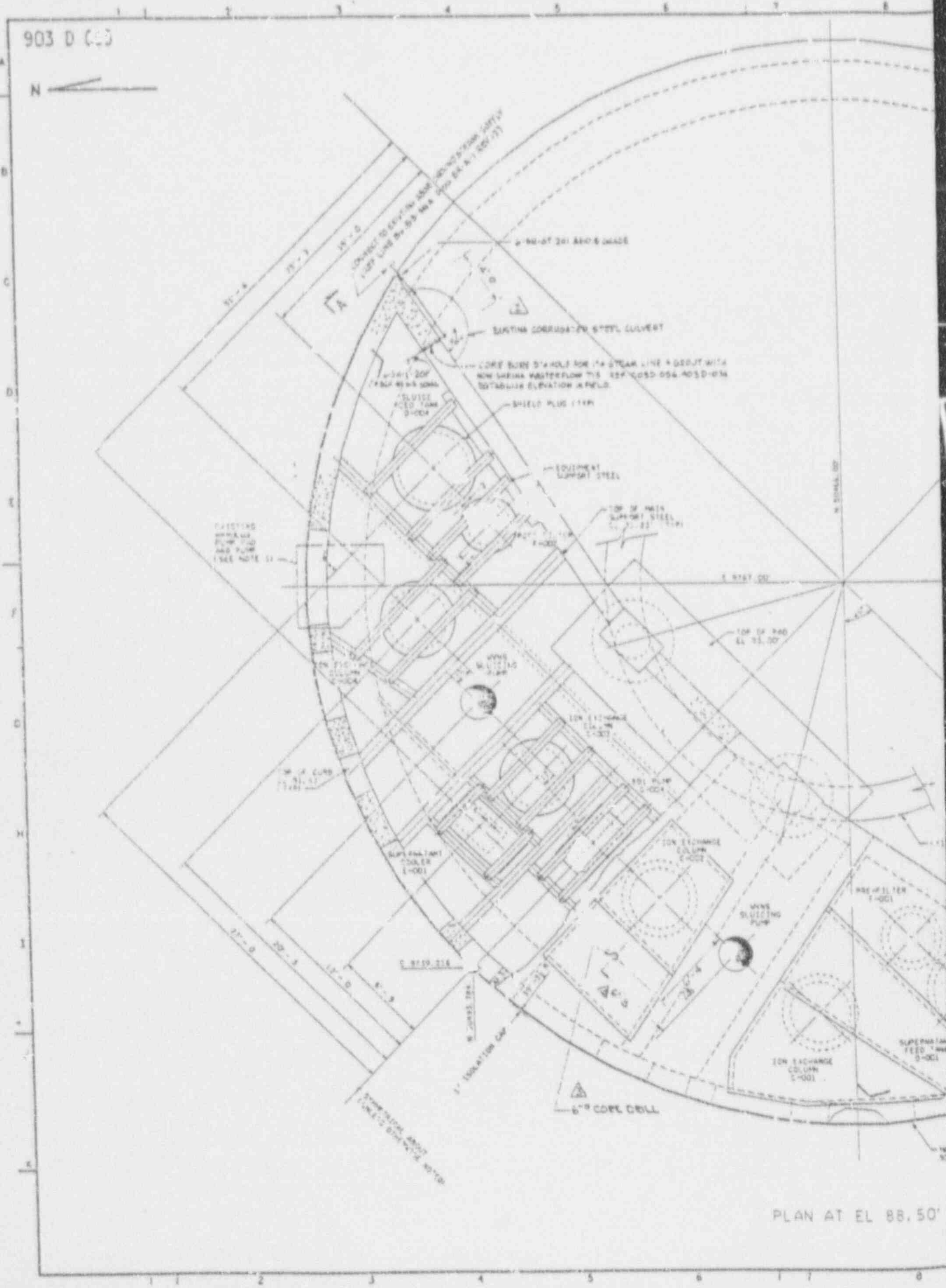
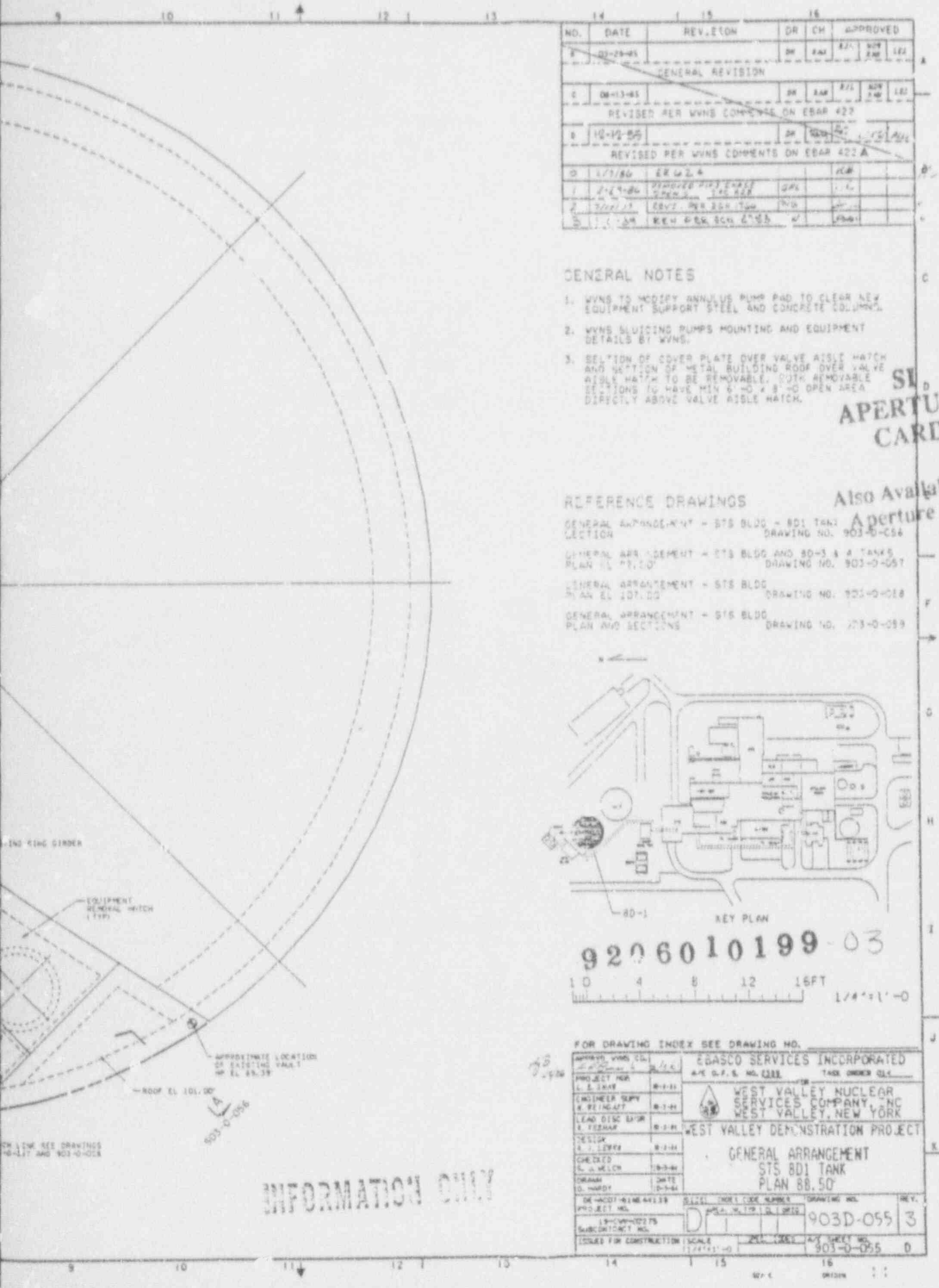

TO TANK 8D-1
RAD MONITOR RE-034
DECONTAMINATED SUPERNATANT COLLECTION TANK 8D-3 (EXISTING)
C-007
TO WASTE TANK FARM VENTILATION SYSTEM
RAD MONITOR RE-037
DECONTAMINATED SUPERNATANT TO LWTS TANK 5D15B
FV-064
FCV-033
FV067
FV068
SAMPLE POINT S-006
RAD MONITOR
DECONTAMINATED SUPERNATANT FILTER F-002
SLUICE WATER FROM G-004
RECIRCULATION
TO VENT HEADER
SAND BED DUMP VALVE TO 8D-1
PCV 717
REWORK TO 8D-2
ZEOLITE LOADING/SPENT ZEOLITE DISCHARGE
G-003
RI-040
HV027
AIR TO COLUMNS
VAC-U-MAX HOPPER
DRY ZEOLITE/SAND
FVX05
ION EXCHANGE COLUMN (TYPICAL) NOTE 1
ZEOLITE BATCH TANK D-002
FINES OVERFLOW
FVX21 (BLEED)
TO LAGOON
FVX20
TO VENT HEADER
SLUICE/ LIFT WATER TANK D-004
SUPERNATANT FEED TANK D-001
DEMINERALIZED WATER FROM FRESH WATER TANK
FVX08 NOTE 2
SAND
TO WASTE TANK FARM VENT. SYSTEM
TANK 8D-1 (EXISTING)
G-004
TANK 8D-2 (EXISTING)
NOTE:
1. SAND IS LOADED TO DECONTAMINATED SUPERNATANT FILTER IN THE SAME FASHION.
2. SAND CAN BE DISCHARGED TO TANK 8D-1 IN THE SAME MANNER AS SPENT ZEOLITE.
3. * - UNFILTERED SUPERNATANT SAMPLE POINT FV-077
4 RAD. MONITOR ON 'J' NOZZLE LINE RI-040
SI
APERTURE CARD
Also Available On Aperture Card
9206010199-02
REFERENCE DRAWINGS
903D-013 STS P&ID'S
903D-014
903D-016
903D-017
903D-018
903D-019
903D-020
903D-021
903D-416
900D-1666
901D-021 SH1 LWTS P&ID'S
901D-024
SPENT ZEOLITE STORAGE 8D-1
SOP 50-37
SOP 50-24
SOP 55-4
OSR'S IRTS-1 IRTS-3
LIMITS:
Na<1000 PPM
11<pH<12
THIS DRAWING SUPERCEDES DRAWING NUMBER 903D-015
PARTS LIST
West Valley Nuclear Services Co.,Inc.
West Valley, New York
PROCESS DIAGRAM SUPERNATANT TREATMENT SYSTEM
900D-2345
CAD DRAWING-DO NOT REVISE THIS ORIGINAL

FIGURE D.5.1-5


903 D
N
SUSTINA CORRUGATED STEEL CULVERT
SHIELD PLUG (TYP)
EQUIPMENT SUPPORT STEEL
ION EXCHANGE COLUMN
SUPERNATANT COOLER E-001
ION EXCHANGE COLUMN C-002
WVNS SLUICING PUMP
PRE-FILTER F-001
ION EXCHANGE COLUMN C-001
6" CORE DRILL
1" ISOLATION GAP
PLAN AT EL 88.50'

903-D-055



NO.	DATE	REVISION	DR	CH	APPROVED
B	03-29-85	GENERAL REVISION			
C	08-13-85	REVISED PER WVNS COMMENTS ON EBAR 422			
D	12-12-85	REVISED PER WVNS COMMENTS ON EBAR 422			
0	1/7/86	ER 424			
1					
2					
3					

GENERAL NOTES

1. WVNS TO MODIFY ANNULUS PUMP PAD TO CLEAR NEW EQUIPMENT SUPPORT STEEL AND CONCRETE COLUMNS.
2. WVNS SLUICING PUMPS MOUNTING AND EQUIPMENT DETAILS BY WVNS.
3. SECTION OF COVER PLATE OVER VALVE AISLE HATCH AND SECTION OF METAL BUILDING ROOF OVER VALVE AISLE HATCH TO BE REMOVABLE. BOTH REMOVABLE SECTIONS TO HAVE MIN 6'-0 x 8'-0 OPEN AREA DIRECTLY ABOVE VALVE AISLE HATCH.

SI APERTURE CARD

Also Available On Aperture Card

REFERENCE DRAWINGS

GENERAL ARRANGEMENT - STS BLDG - 8D1 TANK SECTION DRAWING NO. 903-D-056

GENERAL ARRANGEMENT - STS BLDG AND 8D-3 & 4 TANKS PLAN EL 98.50' DRAWING NO. 903-D-057

GENERAL ARRANGEMENT - STS BLDG PLAN EL 107.00' DRAWING NO. 903-D-058

GENERAL ARRANGEMENT - STS BLDG PLAN AND SECTIONS DRAWING NO. 903-D-059

9206010199-03

FIGURE D.5.2-1

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

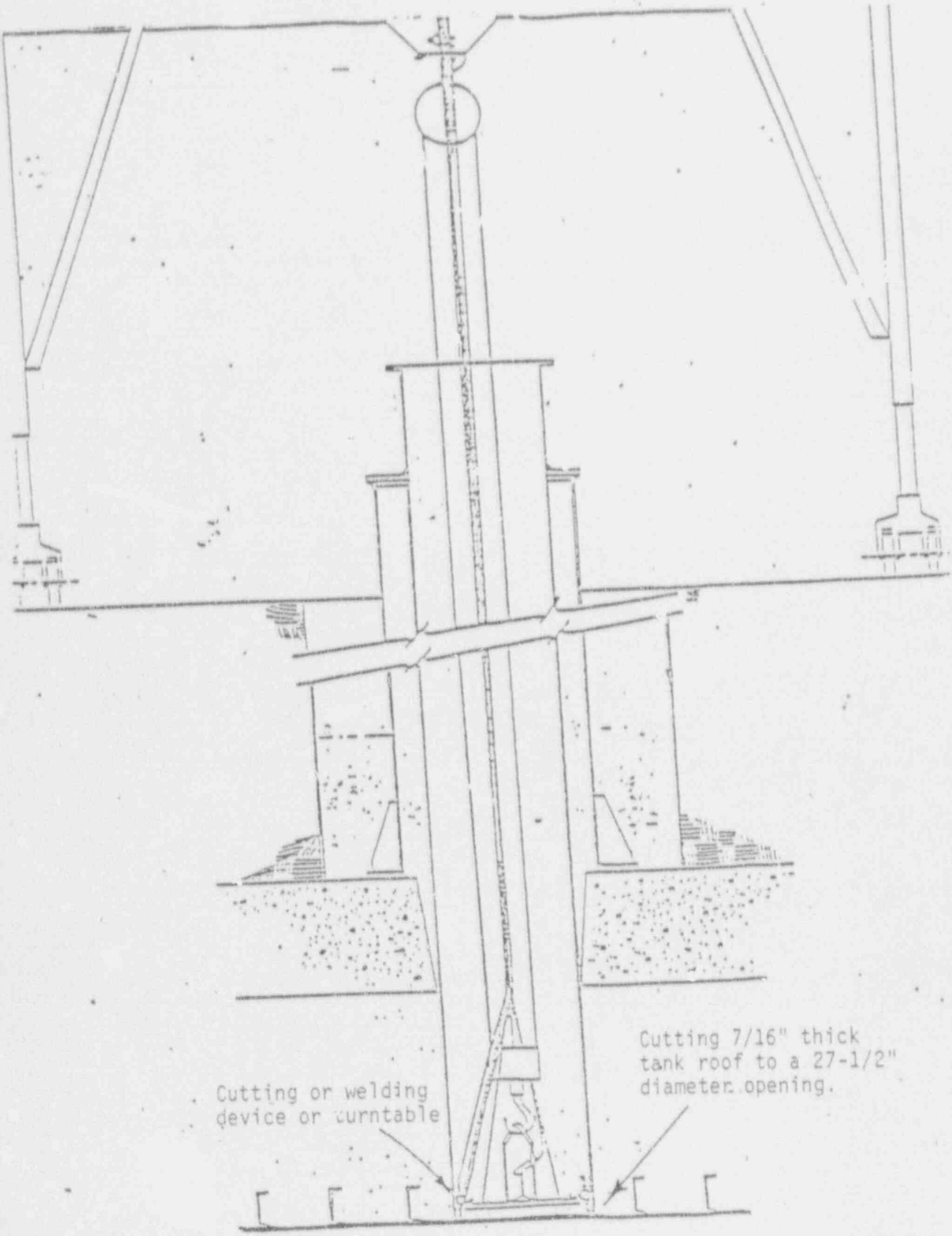
WEST VALLEY DEMONSTRATION PROJECT

GENERAL ARRANGEMENT
STS 8D1 TANK
PLAN 88.50'

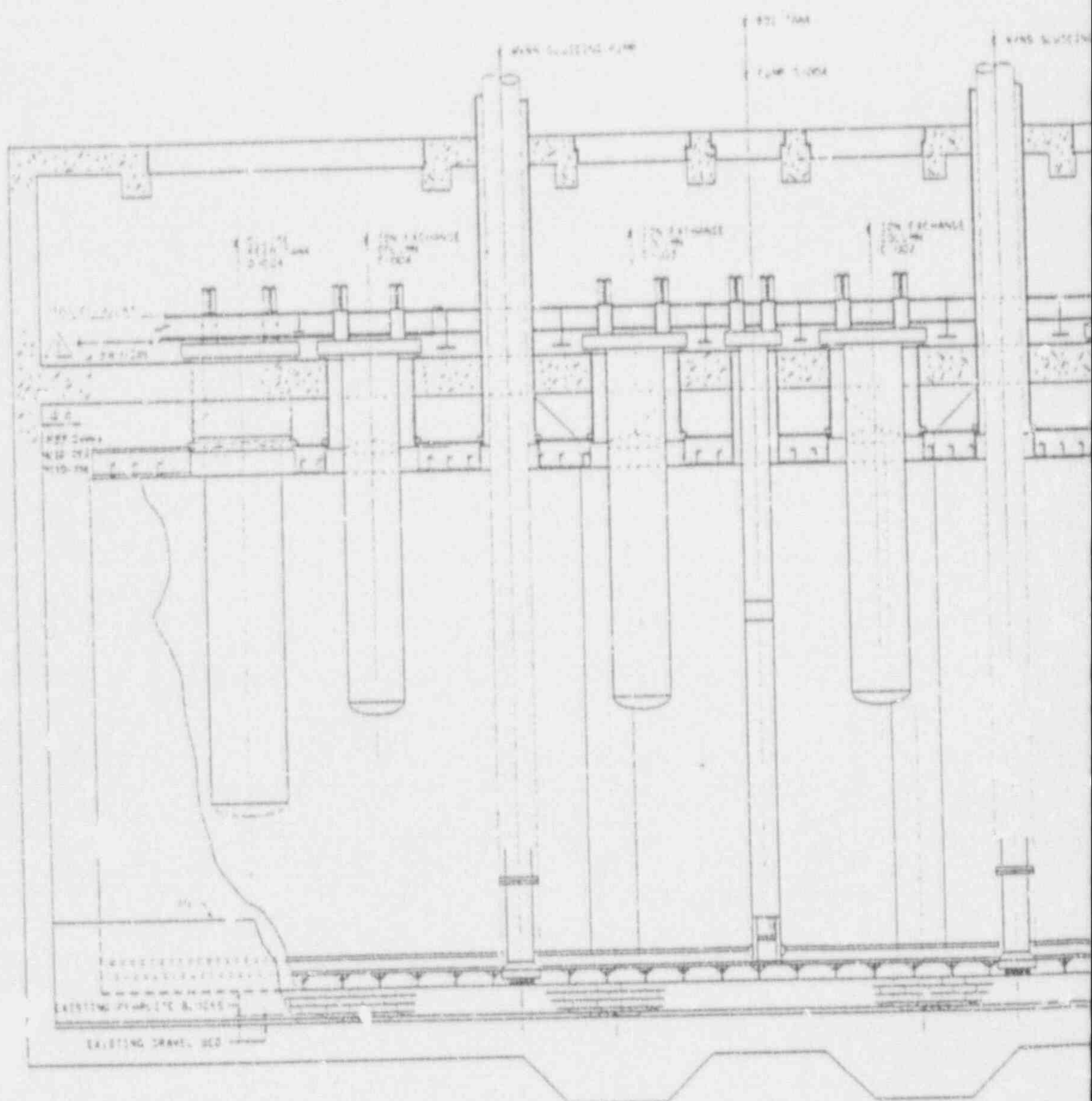
DRAWING NO. 903D-055 REV. 3

INFORMATION ONLY

FIGURE 5.2-2: Remote Installation of Pumps in HLW Tanks



903 D 056



SECTION A-A

903-D-056

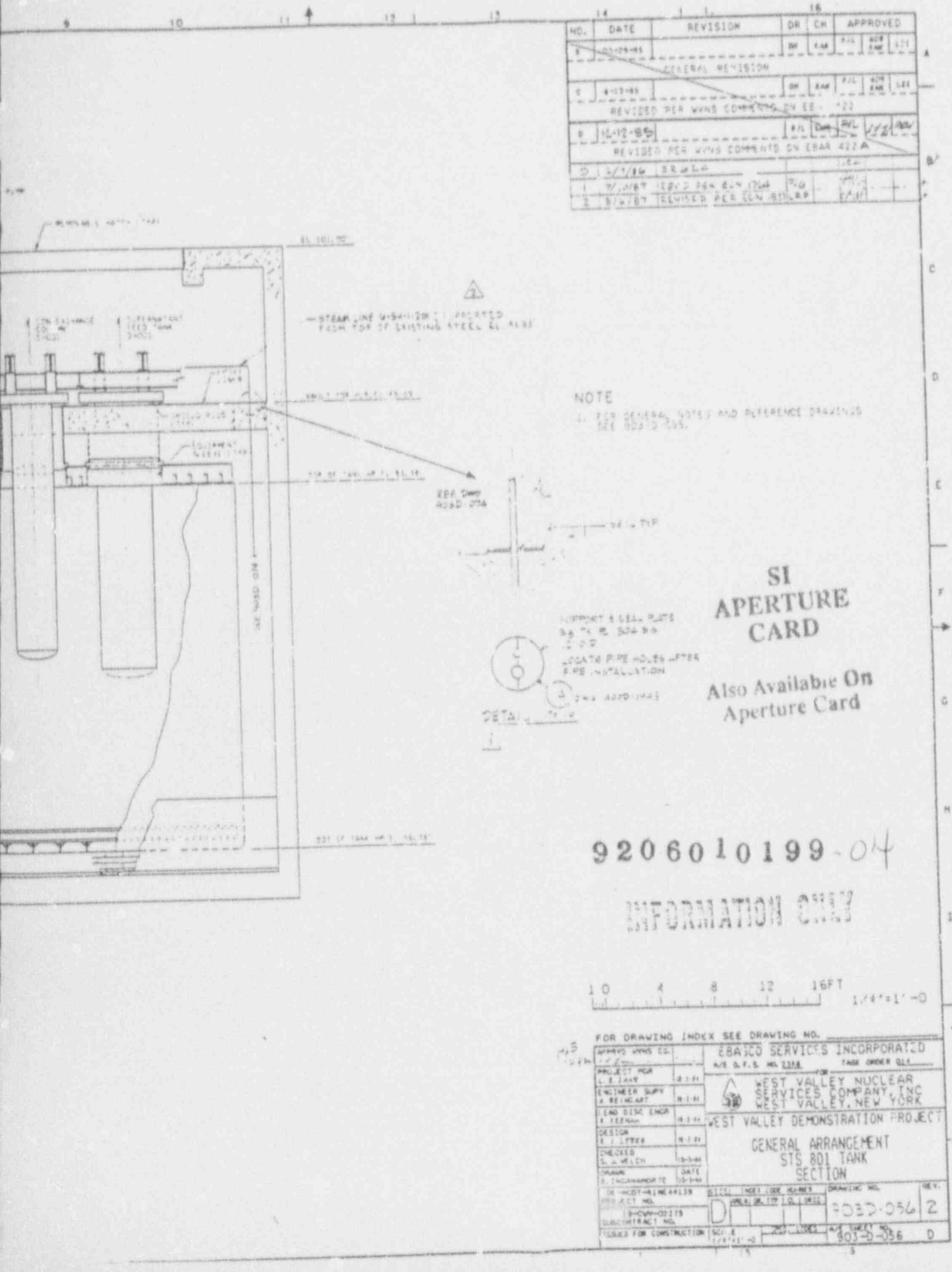
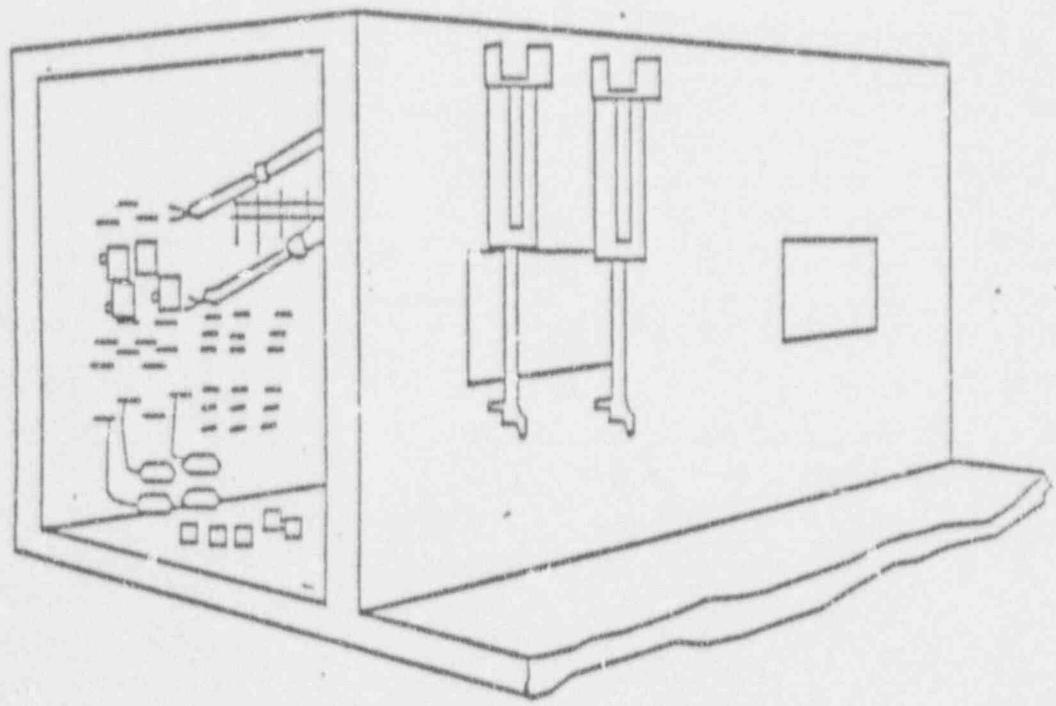
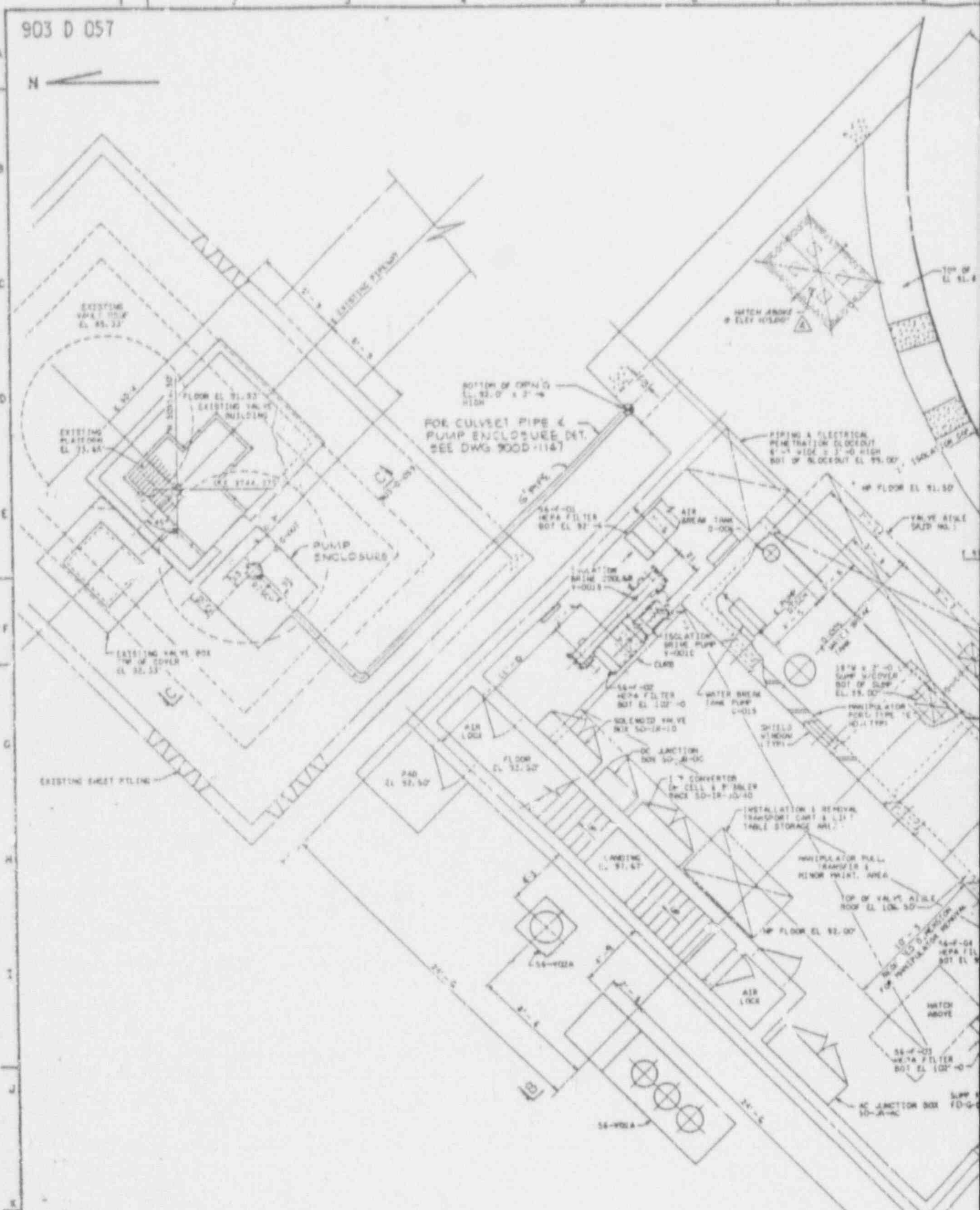


FIGURE D.5.2-3

FIGURE 5.2-4: The STS Valve Aisle




903 D 057
N
PUMP ENCLOSURE
FOR CULVSET PIPE & PUMP ENCLOSURE DET. SEE DWG. 900D-1147
AIR LOCK
LANDING
HATCH ABOVE
EXISTING SHEET PILING
MANIPULATOR PULL, TRANSFER & MINOR MAINT. AREA

903-D-057

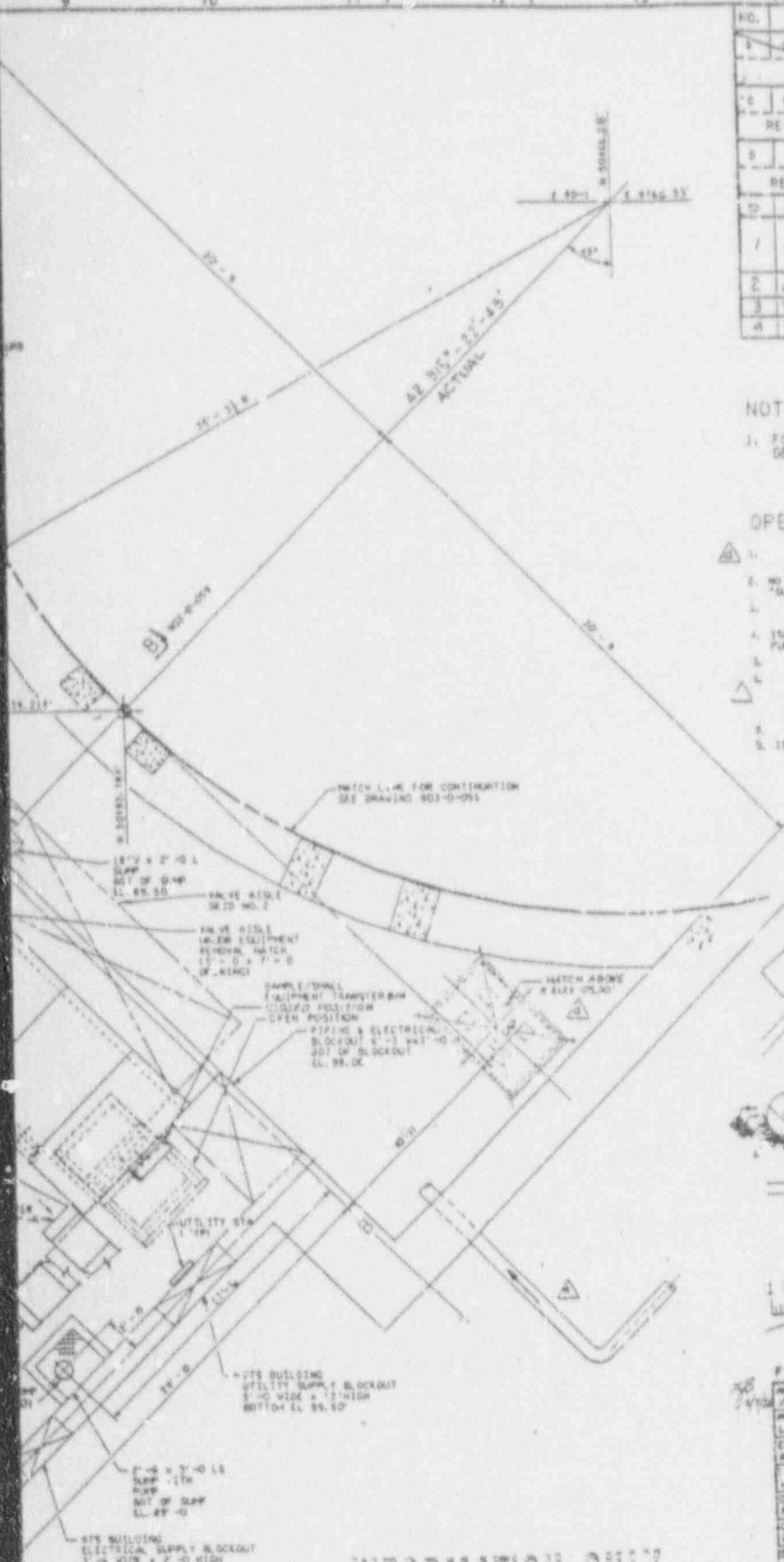
NO.	DATE	REVISION	DR	CH	APPROVED		
B	01-15-85	GENERAL REVISION	DW	[illegible]	[illegible]	[illegible]	[illegible]
C	08-13-85	REVISED PER WVNS COMMENTS ON EBAR 442 & 508	DW	[illegible]	[illegible]	[illegible]	[illegible]
D	12-2-85	REVISED PER WVNS COMMENTS ON EBAR 442 A...	DW	[illegible]	[illegible]	[illegible]	[illegible]
D?	2/7/86?	ER 624			[illegible]		
1	2-3-86	[illegible] ... VALVE AISLE HATCH REDUCED, MAINT HATCH REDUCED ...	GPL		DRB?		
2	6-11-86	REV. PER DFC 680	[illegible]	[illegible]	[illegible]		
3	9-24-86	ADDED NOTE/ECN # 643	DRB	[illegible]	[illegible]		
4	9-23-86	ECN 899	CH	[illegible]	[illegible]		

NOTES

1. FOR GENERAL NOTES AND REFERENCE DRAWINGS SEE DRAWING 903-D-055.

OPEN ITEMS

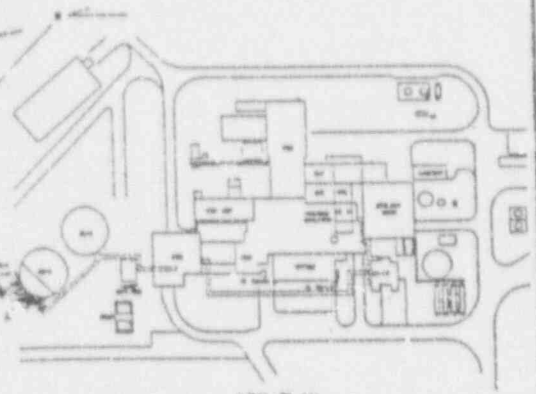
1.
2. NO CONSIDERATION HAS BEEN GIVEN TO PIPING REQUIRED FOR "SLUDGE MOBILIZATION".
3.
4. ISOLATION COOLER TUBE BUNDLE CAN NOT BE PULLED IN PLACE DUE TO LIMITED SPACE.
5.
6.
8.
9. ISOLATION BRINE PUMP HEAD TANK NOT LOCATED.



SI APERTURE CARD

Also Available On Aperture Card

9206010199-05



KEY PLAN

1 0 4 8 12 16FT 1/4"=1'-0

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

WEST VALLEY NUCLEAR SERVICES COMPANY, INC. WEST VALLEY, NEW YORK

WEST VALLEY DEMONSTRATION PROJECT

GENERAL ARRANGEMENT
STS BLDG AND 8D-3&4 TANKS
PLAN EL 92.00'

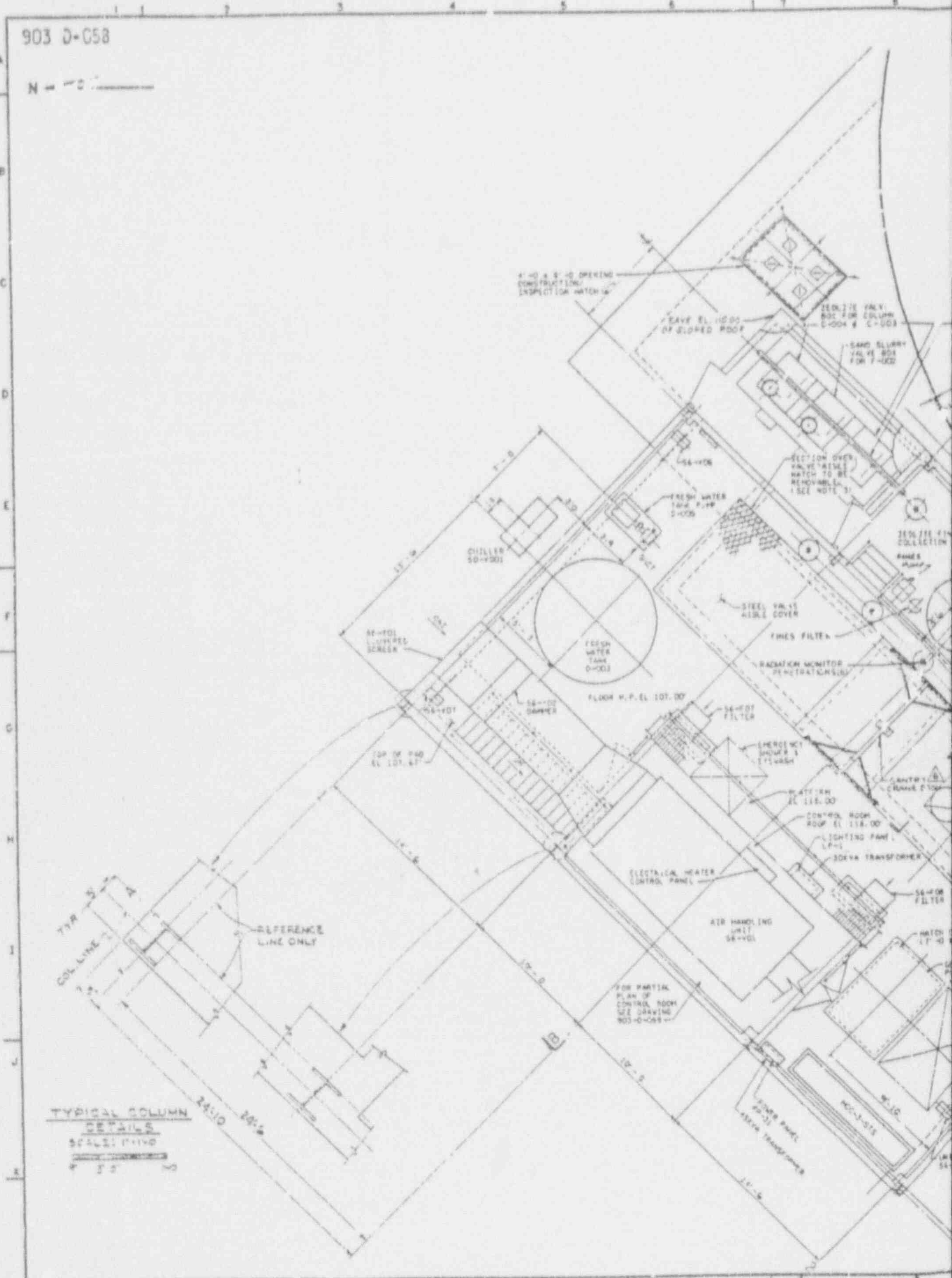
DRAWING NO. 903D-057 REV. 4

SIZE D

SCALE 1/4"=1'-0

INFORMATION ONLY

FIGURE D.5.2-5



903 D-058
4'-0 x 5'-0 OPENING CONSTRUCTION/ INSPECTION HATCH
EAVE EL 110.00 OF SLOPED ROOF
ZEOLITE VALVE BOX FOR COLUMN
SAND SLURRY VALVE BOX
FRESH WATER TANK PUMP
CHILLER
STEEL VALVE AISLE COVER
FINES FILTER
RADIATION MONITOR PENETRATIONS
FRESH WATER TANK
FLOOR H.P. EL 107.00
DAMPER
FILTER
EMERGENCY SHOWER & EYEWASH
TOP OF PAD EL 107.67
PLATFORM EL 116.00
CONTROL ROOM ROOF EL 118.00
LIGHTING PANEL
30KVA TRANSFORMER
ELECTRICAL HEATER CONTROL PANEL
AIR HANDLING UNIT
REFERENCE LINE ONLY
FOR PARTIAL PLAN OF CONTROL ROOM SEE DRAWING
TYPICAL COLUMN DETAILS

NO.	DATE	REVISION	DR	CH	APPROVED		
~~5~~	~~10-11-85~~		~~DM~~	~~AAM~~			
		~~GENERAL REVISION & WVNS COMMENTS ON EBAR 508~~					
~~T~~	~~12-1-86~~						
		~~GENERAL REVISION & WVNS COMMENTS ON EBAR~~					
0	2/7/86	ERG24					
1	3-3-86	REMOVED ZEOLITE CONV. & HOPPER, MOD. ZEOLITE TANK, RELOCD INSPECTION HATCH & ADD RAD MONIT PENETRATION DRC-528	GPL				
2	7/24/86	CHGD COL LINES ...					
3	9-21-86	ECN 899	CH				
4	10/15/86	REV PER ECN 1034	LAW				
5	1/15/88	REV PER ECN 2150					
6	4/13/88 5-3-88	REV PER ECN 2153 " " + #7385					

NOTE

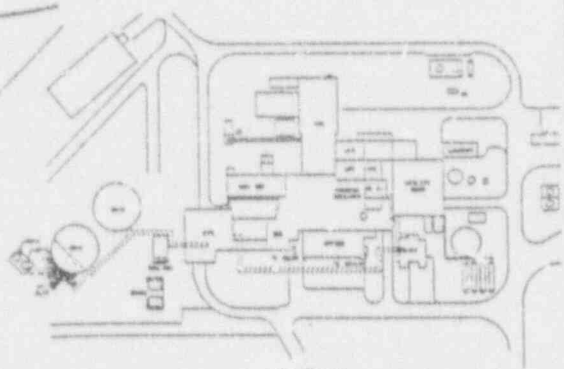
1. FOR GENERAL NOTES AND REFERENCE DRAWINGS SEE DRAWING 903-D-055.

INFORMATION ONLY

SI
APERTURE
CARD

Also Available On
Aperture Card

9206010199-06

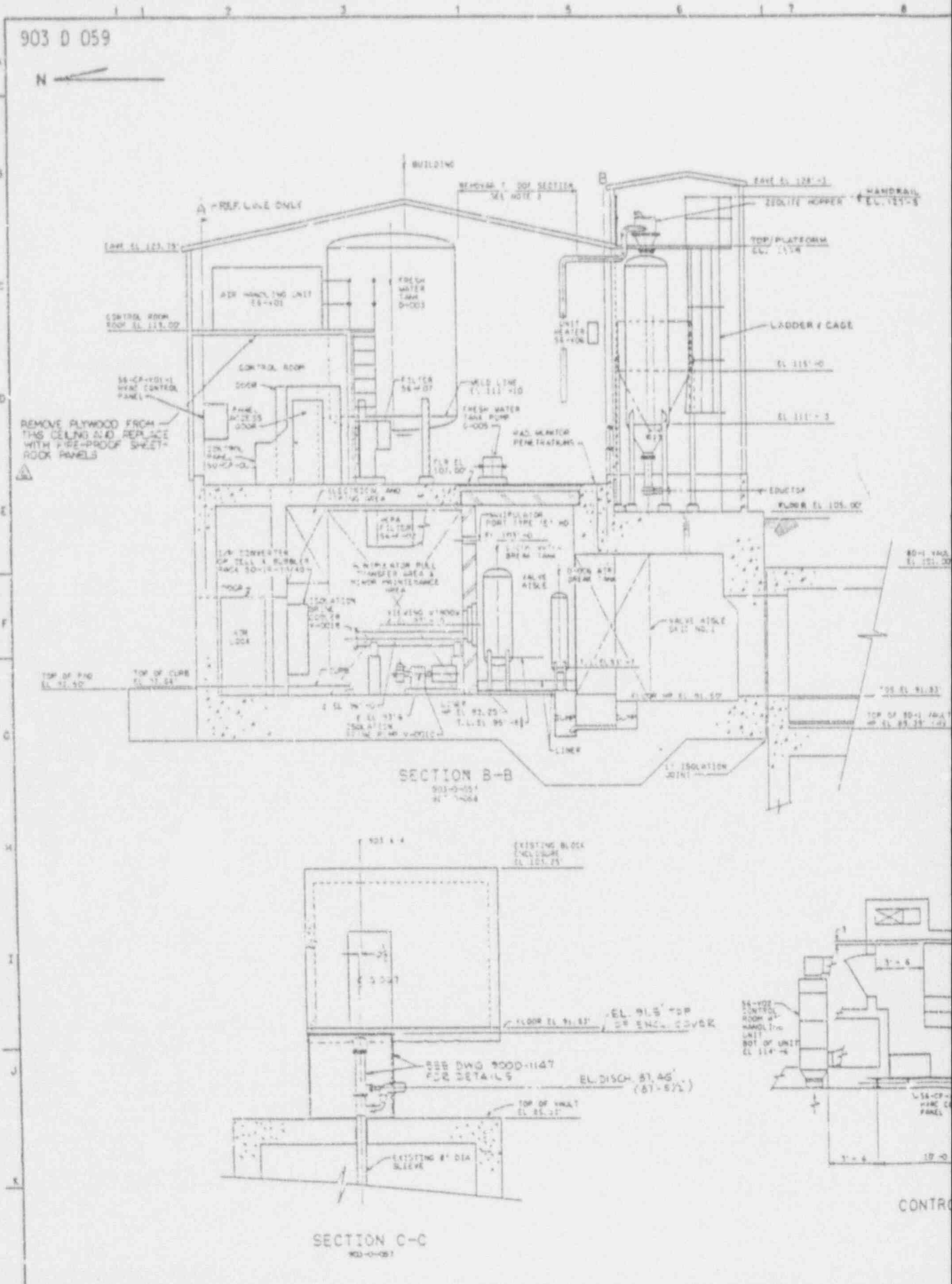

KEY PLAN

1 0 4 8 12 16FT
1/4" 1'-0

FOR DRAWING INDEX SEE DRAWING NO.

APPRVD WVNS CO.	EBASCO SERVICES INCORPORATED A/E G.F.S. NO. 7388 TASK ORDER 014 FOR WEST VALLEY NUCLEAR SERVICES COMPANY, INC WEST VALLEY, NEW YORK
PROJECT MGR	WEST VALLEY DEMONSTRATION PROJECT
ENGINEER SUPV	GENERAL ARRANGEMENT STS BUILDING PLAN EL 107.00'
LEAD DISC ENGR	
DESIGN	
CHECKED	
DRAWN	
PROJECT NO.	SIZE: D — DRAWING NO. 903D-058 — REV. 6
19-CWM-02175 SUBCONTRACT NO.	
ISSUED FOR CONSTRUCTION	SCALE 1/4"=1'-0 — A/E SHEET NO. 903-D-058

FIGURE D.5.2-6


903 D 059
N
BUILDING
REF. LINE ONLY
AIR HANDLING UNIT
FRESH WATER TANK
CONTROL ROOM
REMOVE PLYWOOD FROM THIS CEILING AND REPLACE WITH FIRE-PROOF SHEET-ROCK PANELS
ZEOLITE HOPPER
HANDRAIL
TOP PLATFORM
LADDER & CAGE
EDUCTOR
FLOOR EL 105.00'
VALVE AISLE
LINER
1" ISOLATION JOINT
SECTION B-B
EXISTING BLOCK ENCLOSURE
EL. 91.5' TOP OF ENCL COVER
SEE DWG 9000-1147 FOR DETAILS
EL. DISCH. 87.46' (87'-5½")
TOP OF VAULT
EXISTING 8" DIA SLEEVE
SECTION C-C
CONTRO

903-D-059

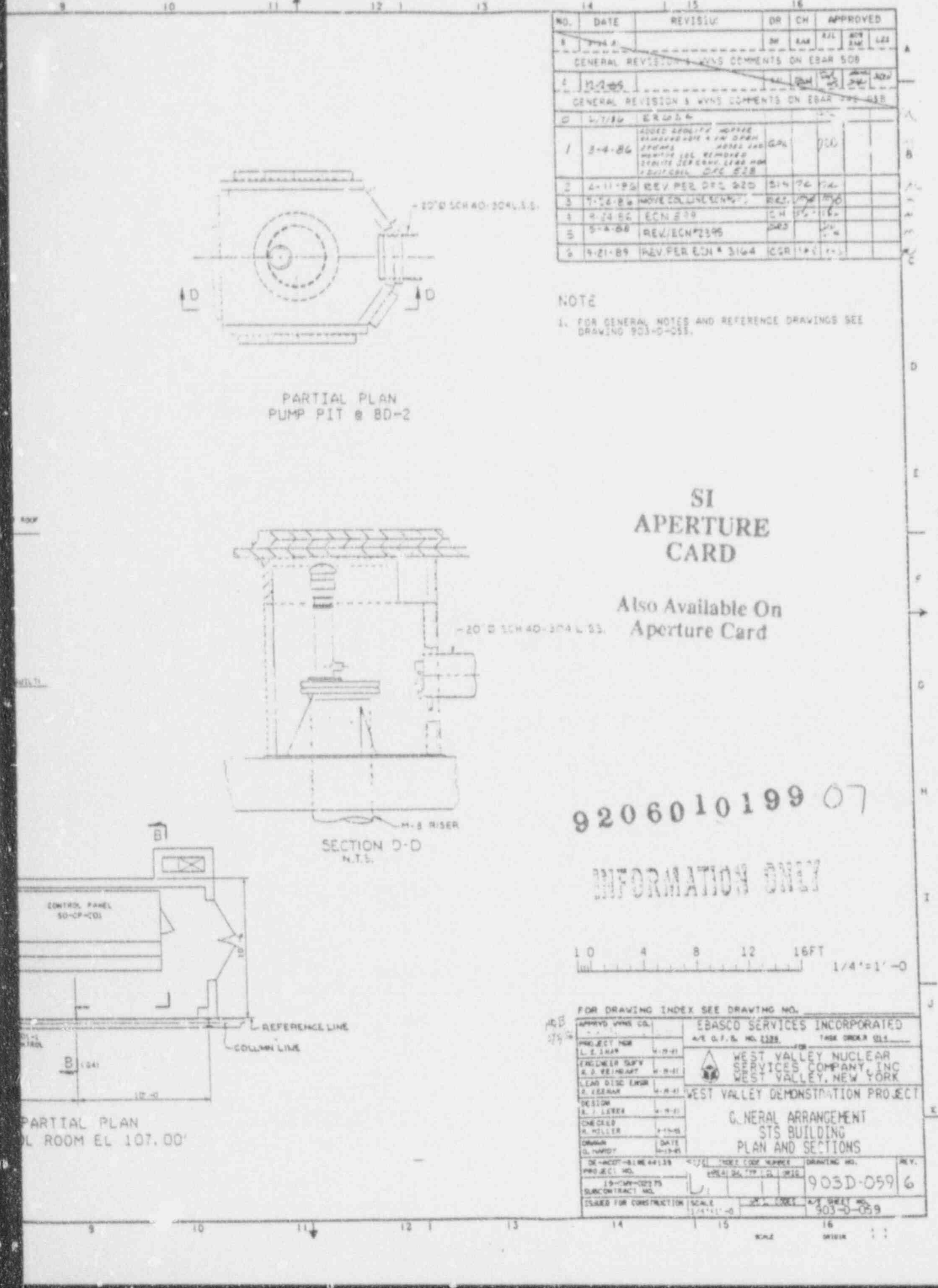
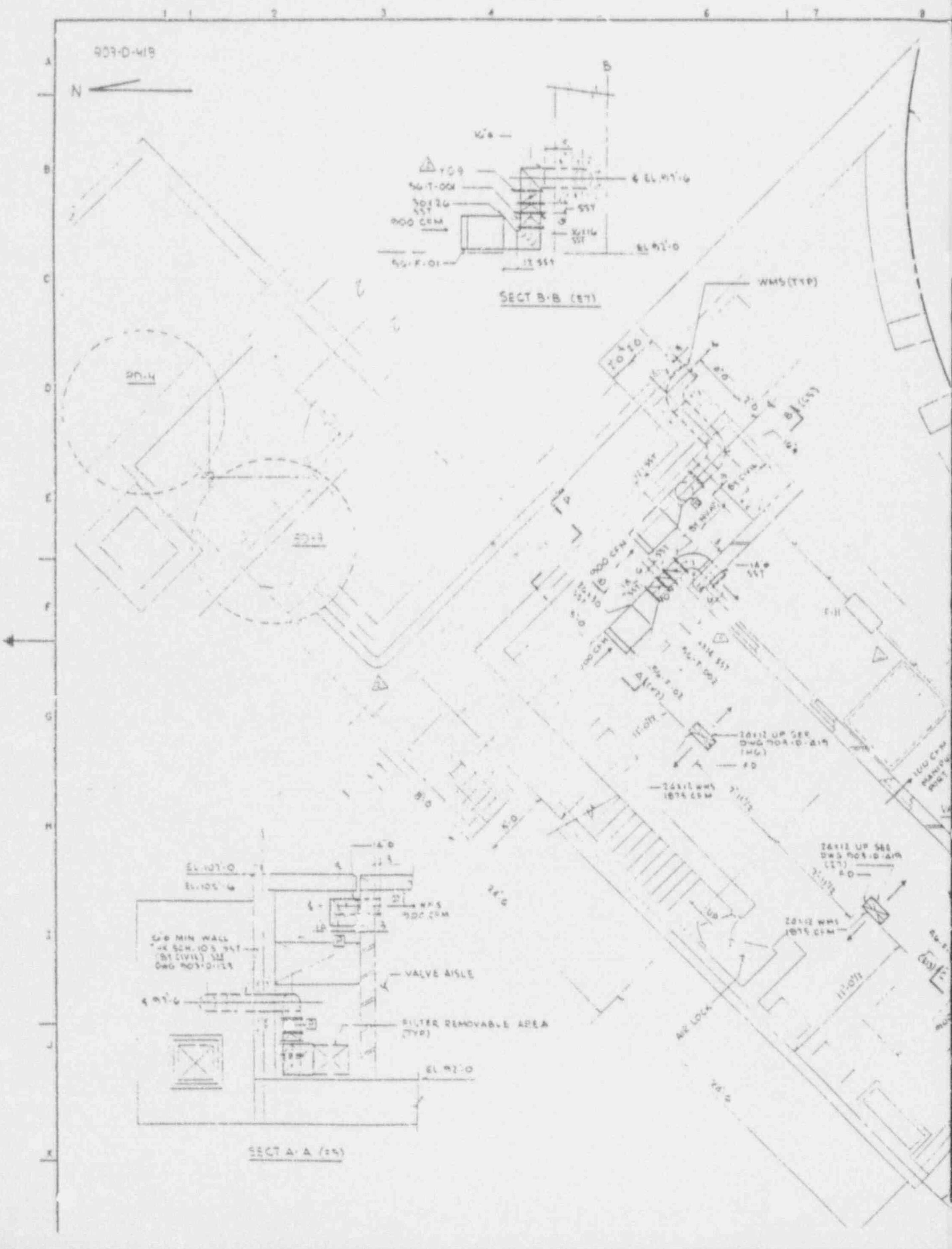


FIGURE D.5.2-7



903-D-413
N
SECT B-B
SECT A-A
WMS (TYP)
VALVE AISLE
FILTER REMOVABLE AREA (TYP)
AIR LOCK

903-D-418

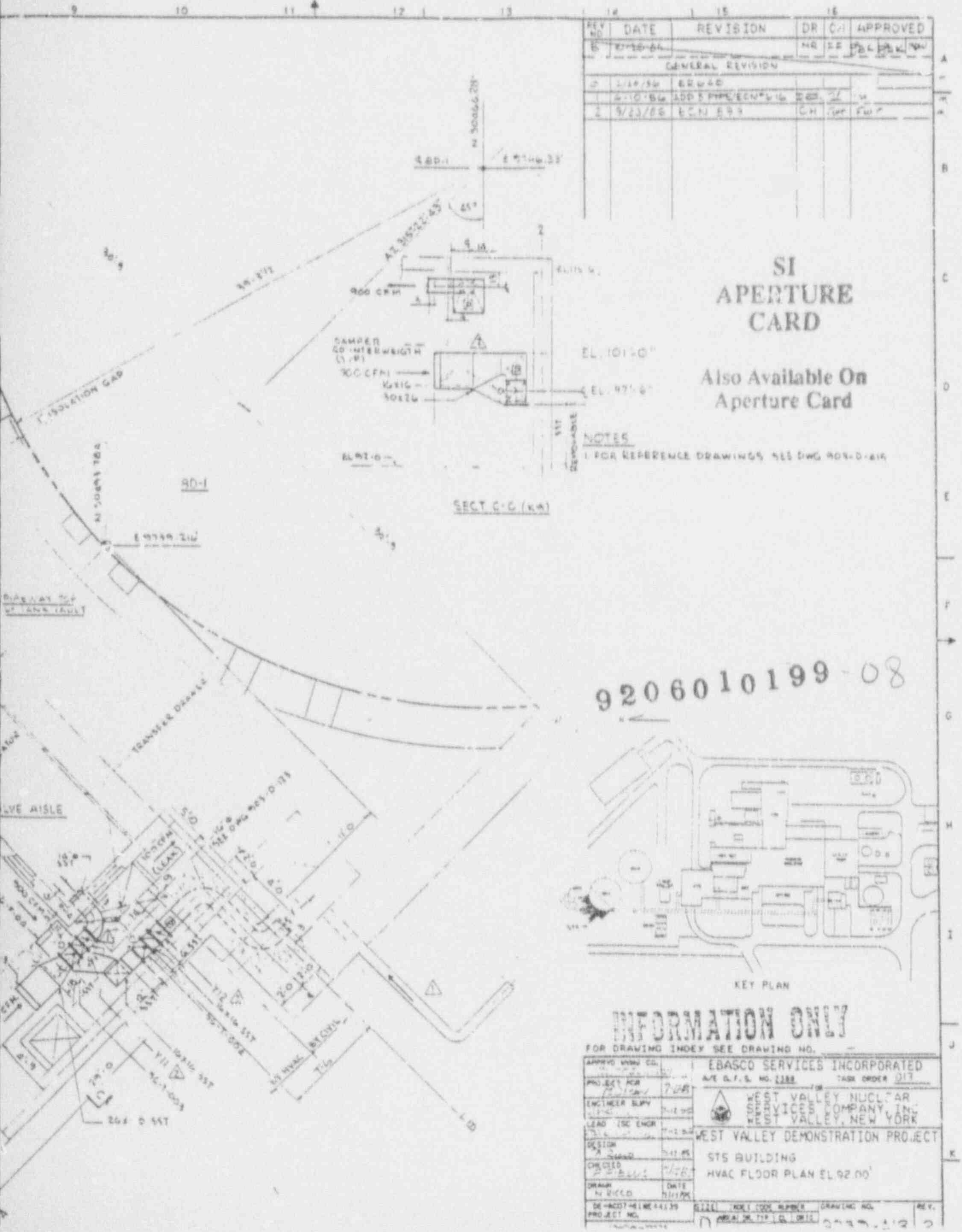
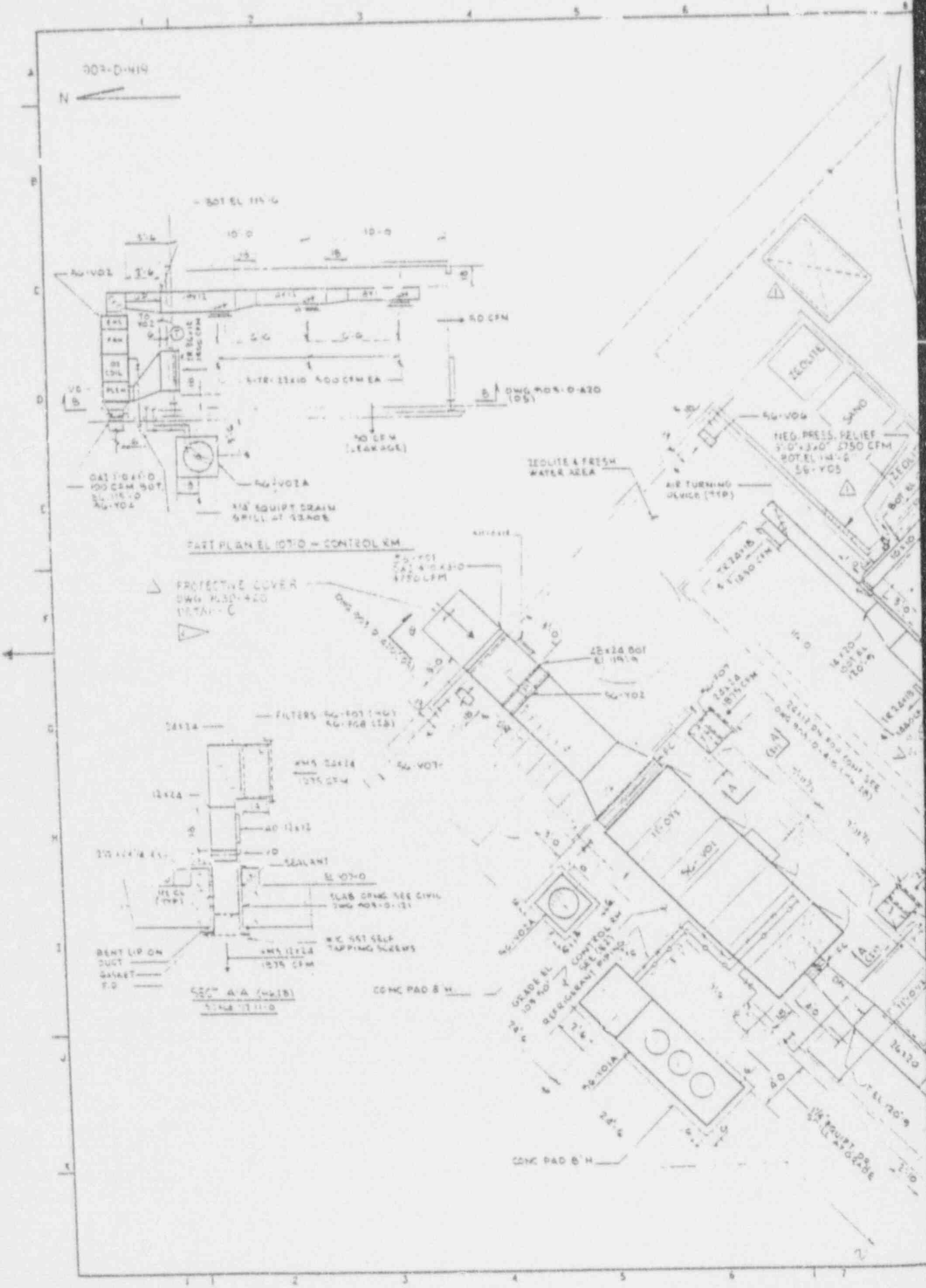


FIGURE D.5.4-1



N
PART PLAN EL 107'-0 — CONTROL RM
PROTECTIVE COVER
ZEOLITE & FRESH WATER AREA
AIR TURNING DEVICE (TYP)
ZEOLITE
SAND
NEG. PRESS. RELIEF
50 CFM (LEAKAGE)
FILTERS
SEALANT
BENT LIP ON DUCT
GASKET
SECT A-A
CONC PAD 8" H
CONTROL RM
REFRIGERANT PIPING
CONC PAD 8" H

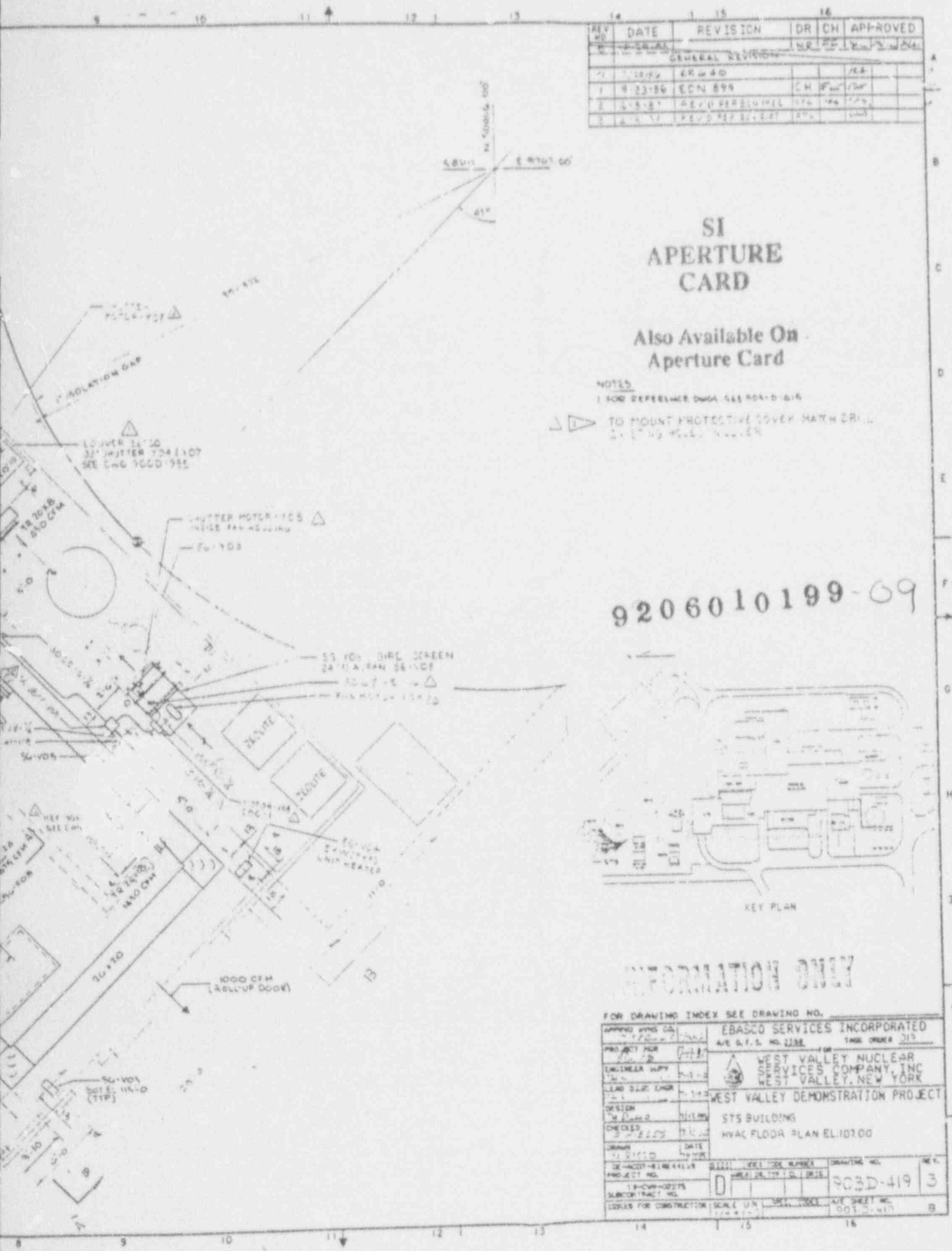
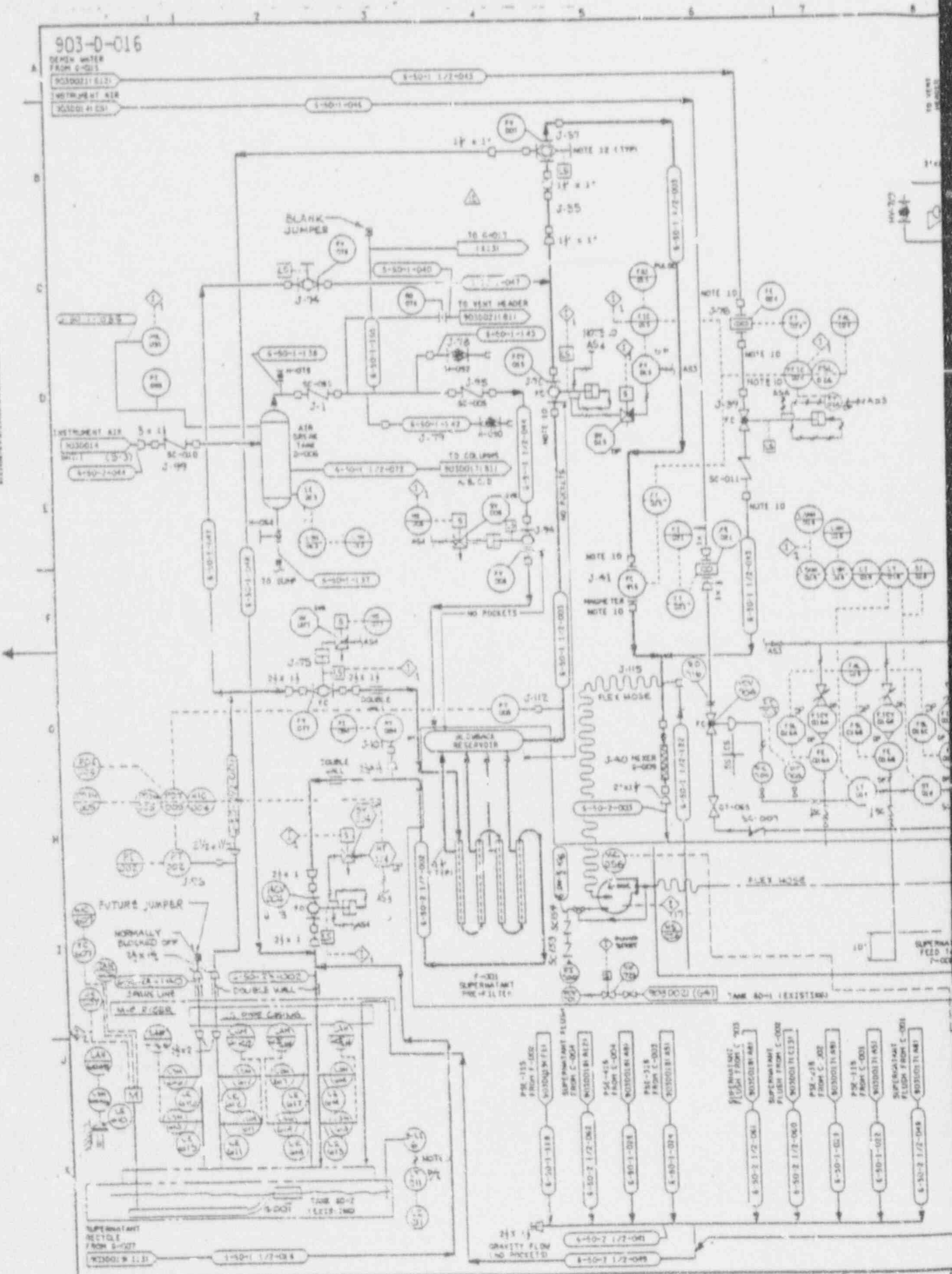
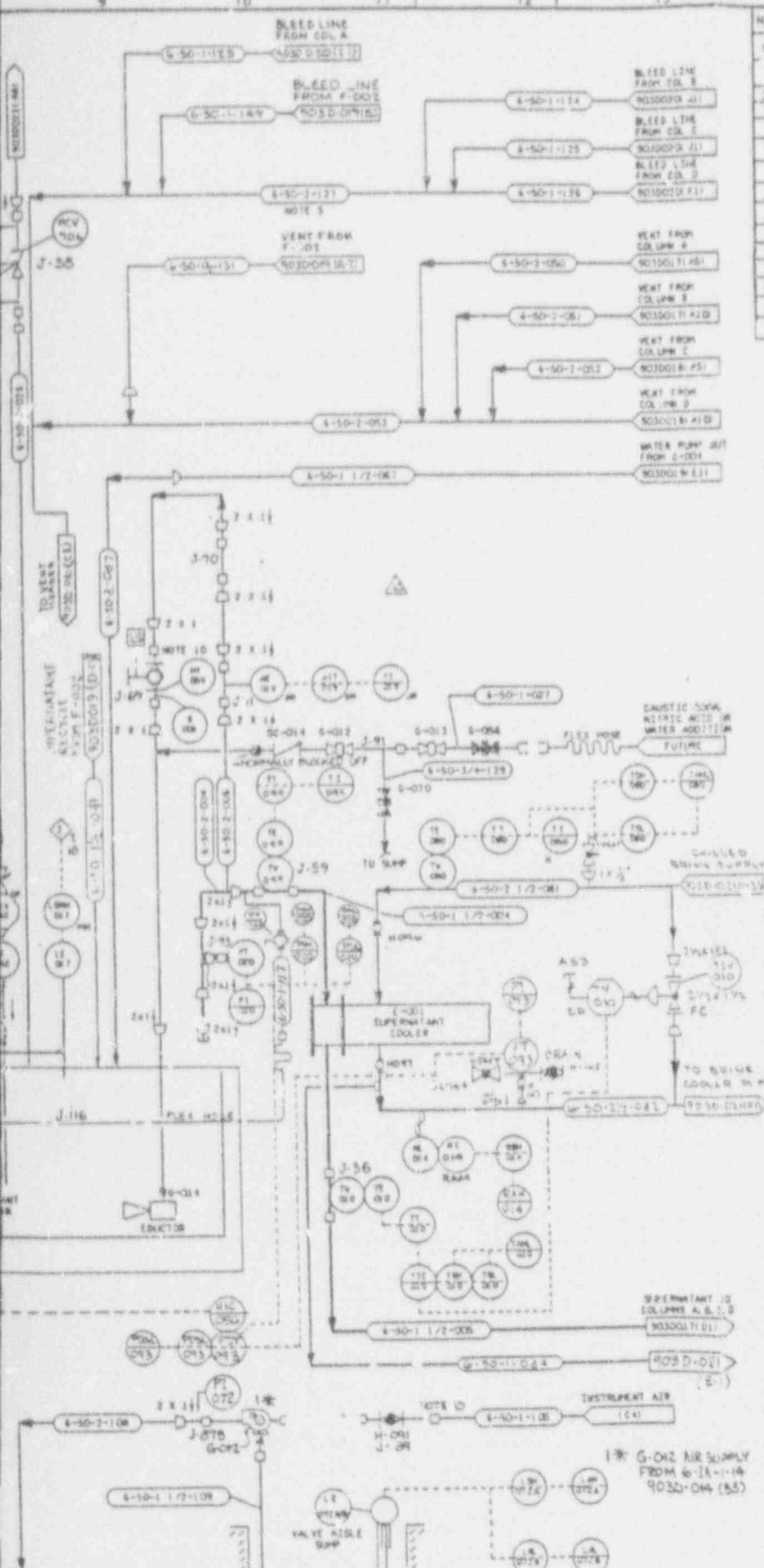

SI
APERTURE
CARD
Also Available On
Aperture Card
NOTES
9206010199-09
SHUTTER MOTOR
ISOLATION GAP
LOUVER
ZEOLITE
ZEOLITE
1000 CFM
(ROLL-UP DOOR)
KEY PLAN
INFORMATION ONLY
FOR DRAWING INDEX SEE DRAWING NO.
EBASCO SERVICES INCORPORATED
WEST VALLEY NUCLEAR
SERVICES COMPANY, INC
WEST VALLEY, NEW YORK
WEST VALLEY DEMONSTRATION PROJECT
STS BUILDING
HVAC FLOOR PLAN EL.107.00
903D-419
3

FIGURE D.5.4-2



903-D-016
DEMIN WATER
INSTRUMENT AIR
BLANK JUMPER
TO VENT HEADER
INSTRUMENT AIR
AIR SPARGE TANK
TO COLUMNS
TO SUMP
NO POCKETS
FLEX HOSE
DOUBLE WALL
FUTURE JUMPER
NORMALLY BLOCKED OFF
DOUBLE WALL
SUPERNATANT PRE-FILTER
TANK 80-1 (EXISTING)
FLEX HOSE
SUPERNATANT RECYCLE
GRAVITY FLOW (NO POCKETS)
MAGMETER
NOTE 10

903D-016



NO.	DATE	REVISION	DR	CH	APPROVED
0	9-5-86				
		GENERAL REVISION			
0	[illegible]	[illegible]			
1	6/11/86	REV PER ECN [illegible]			
2	2/11/87	REV PER ECN #1443			
3	3/25/87	REV PER ECN 1539			
4	7/31/87	REV. PER ECN 1737			
5	11-5-87	REV. PER ECN 2024	GW		
6	12-10-87	REV. PER ECN 2087	CCG		
7	1-25-88	REV'D PER ECN 2136			
8	3-22-88	REV'D PER ECN 2320			
9	6/8/88	REVISED PER ECN 2458			
10	6/26/89	REVISED PER ECN 3005			
11	1-29-91	REVISED PER ECN 4433	GW	HAB	
12	[illegible]	PER ECN 4210		HAB	

INFORMATION ONLY

SI APERTURE CARD

Also Available On Aperture Card

NOTES:

1. FOR SYMBOLS, NOTES AND LEGEND SEE DRAWINGS 900D-436 SHT 1-4
2. OPERATING VALVE POSITIONS ARE SHOWN IN THE PROCESS NARRATIVE AND CONTROL CONCEPTS DOCUMENT.
3. EXISTING INSTRUMENT.
4. DELETED
5. SELF-DRAINING PIPE SYSTEM TO TANK D-001.
6. DELETED
7. AIR LEGEND AS FOLLOWS:
   AS1 = 100 psig - UTILITY AIR
   AS2 = 50 psig - INSTRUMENT AIR
   AS3 = 20 psig - INSTRUMENT AIR
   AS4 = 100 psig - INSTRUMENT AIR
8. LINE TO BE SELF-DRAINING, NO POCKETS FROM FCV-015 TO F-001 MODULES.
10. BLOCK CONNECTOR MUST BE BORED TO ".

9206010199-10

12. T DENOTES HANDWHEEL FOR MANUAL VALVES THAT ARE OPERATED REMOTELY WITH MANIPULATOR ARMS.
13. INSTRUMENT PACK LEGEND
    SVB: SOLENOID VALVE BOX 50-IR-010
    D = I/P CONVERTER, DP CELLS AND BUBBLER RACK 50-IR-040, DC: DC JUNCTION BOX 50-IR-030
    WM: WALL MOUNTED
14. THE SYSTEM DESIGNATION FOR STS IS 50. ALL INSTRUMENT LOOP NUMBERS ARE PRECEDED BY A 50-. ALL VALVE TAG NUMBERS ARE PRECEDED BY 6-50.
16. LIMIT SWITCH SYMBOLS - [LS] SHOWN WITH VALVES ARE ALL INTERLOCKED WITH THE PROGRAMMABLE CONTROLLER PLC 2030
17. INTERLOCKS: (I) — THIS SYMBOL INDICATES A PROCESS CONTROL INTERLOCK EXISTS WITH THAT PARTICULAR ELEMENT THRU THE PROGRAMMABLE CONTROLLER PLC 2/30 FOR INTERLOCK DETAIL DESCRIPTION SEE WVNS-EQ-238

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED
A/E S.F.S. NO. 1288 TASK ORDER 013

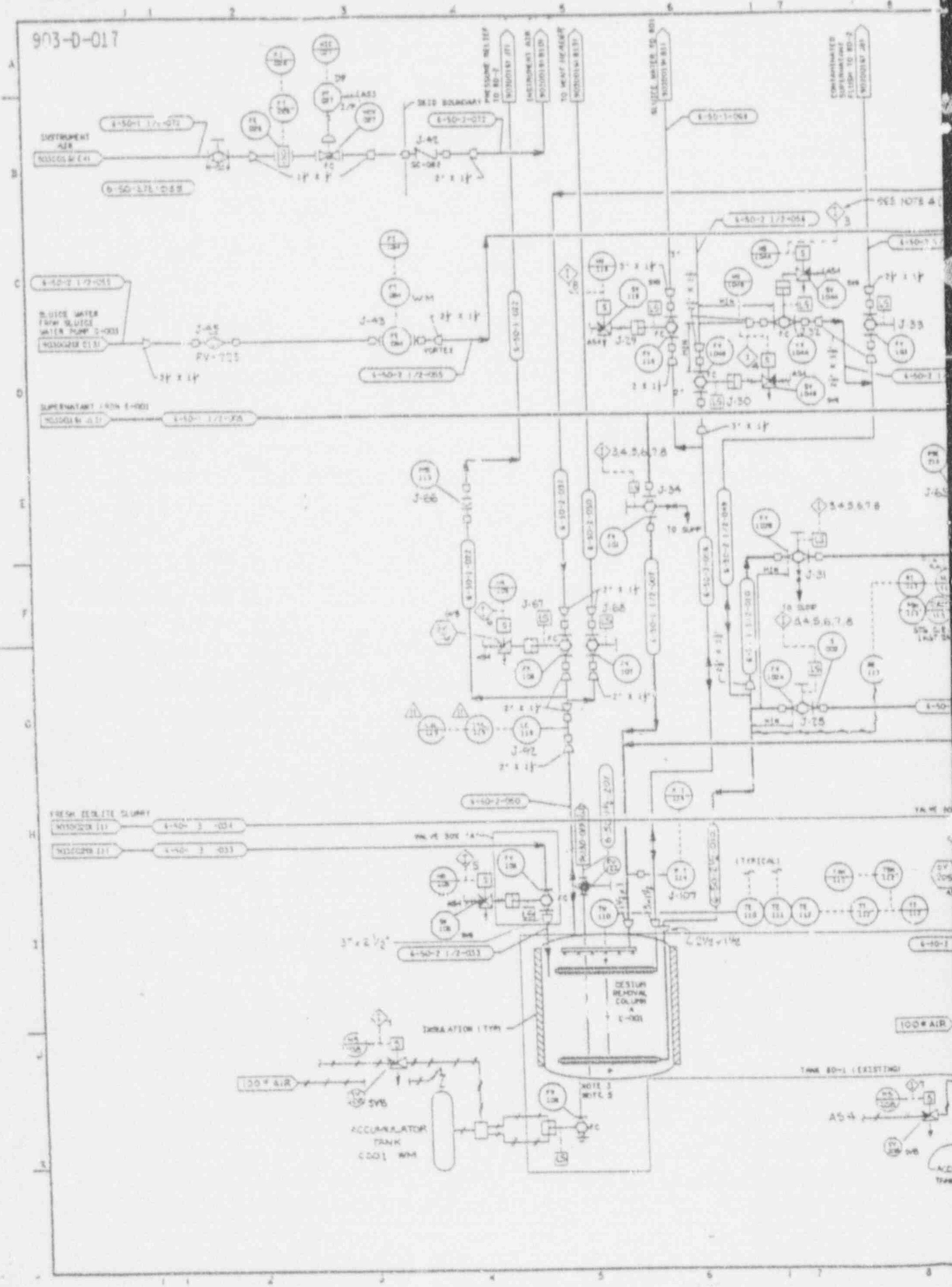
WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

WEST VALLEY DEMONSTRATION PROJECT

P & ID
SUPERNATANT TREATMENT SYSTEM
FILTRATION AND COOLING SECTION

PROJECT MGR	L. E. IKAR
ENGINEER SUPV	R. /IEMAN
LEAD DISC ENGR	R. LAMTARE
DESIGN	R. J. LEMEV
CHECKED	A. FISHER
DRAWN	D. HARDT
PROJECT NO.	
SUBCONTRACT NO.	19-CWP-0227S
ISSUED FOR CONSTRUCTION	SCALE NONE
DRAWING NO.	903D-016
REV.	12
A/E SHEET NO.	903-D-016

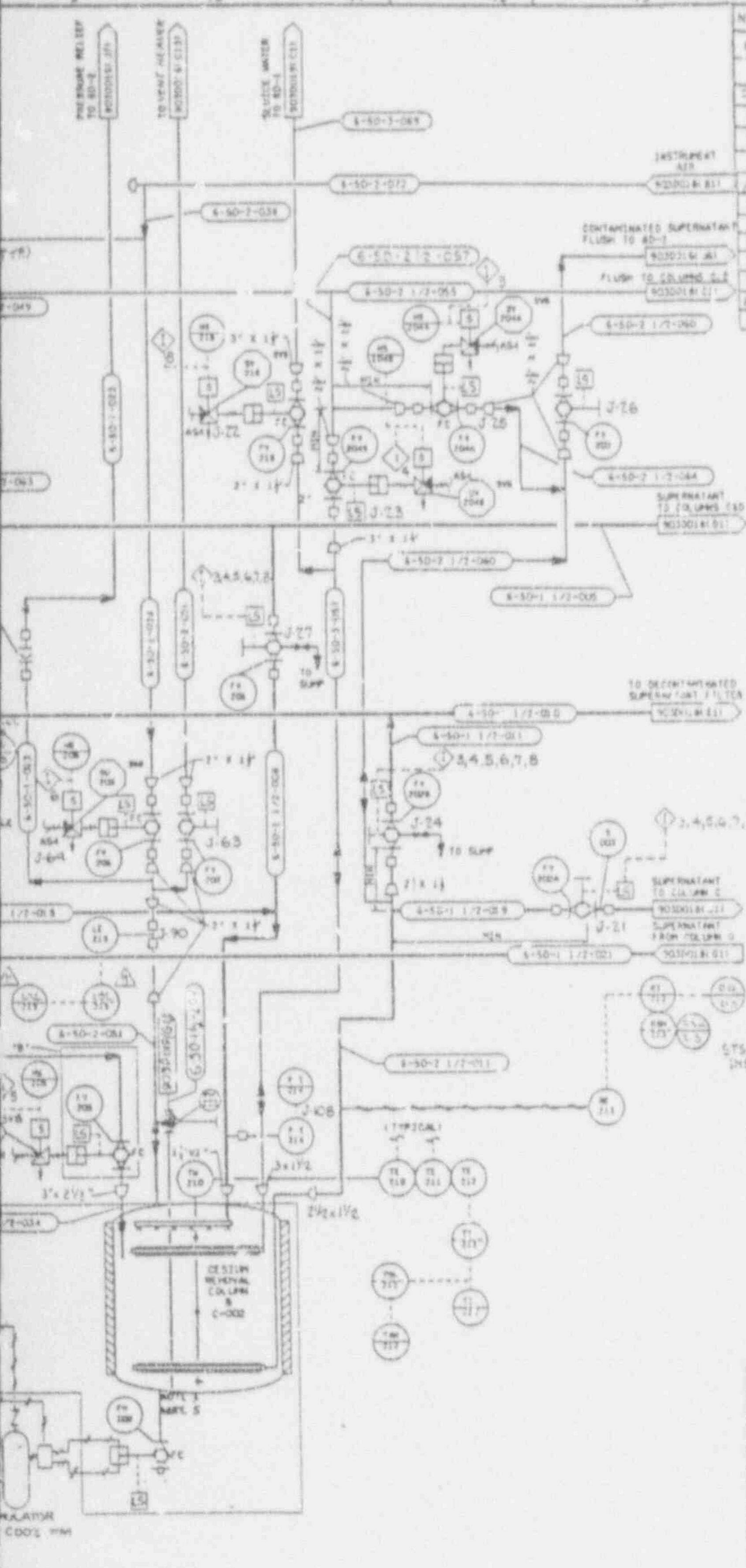
FIGURE D.6.1-1



903-D-017
INSTRUMENT AIR
SKID BOUNDARY
PRESSURE RELIEF TO RD-2
INSTRUMENT AIR
TO VENT HEADER
SLUICE WATER TO RD-1
CONTAMINATED SUPERNATANT FLUSH TO RD-2
SLUICE WATER FROM SLUICE WATER PUMP
SUPERNATANT FROM E-001
FRESH ZEOLITE SLURRY
VALVE BOX "A"
CESIUM REMOVAL COLUMN A
INSULATION (TYP)
ACCUMULATOR TANK
100 # AIR
TANK RD-1 (EXISTING)
TO SUMP
(TYPICAL)
NOTE 3
NOTE 5
SEE NOTE 4
D
C
B
A

903D-017

NO.	DATE	REVISION	DR	CH	APPROVED		
8	9-15-84	GENERAL REVISION					
0	7/25/85	ER 554					
1	6-10-86	REV. PER ECN 751	C.H.				
2	2/21/87	ECN #1443					
3	3/25/87	REV PER ECN 1534					
4	11-4-87	REV PER ECN 2024	GW				
5	12-10-87	REV. PER ECN 2087	CCG				
6	3-14-88	REVISED PER ECN 2297	LWN				
7	6-17-88	REV. PER ECN #2688					
8		REV PER ECN 3904					
9	3-21-90	REV. PER ECN 3537	CGR				
10	1-30-91	REV PER ECN 4107	GW				
11		REV PER ECN 4157					



NOTES:

1. FOR SYMBOLS, NOTES AND LEGEND SEE DRAWINGS 101-M-008/-010 AND 903-D-016.
2. OPERATING VALVE POSITIONS ARE SHOWN IN THE PROCESS NARRATIVE AND CONTROL CONCEPTS DOCUMENT.
3. FV-108 AND FV-208 ARE WELDED DIRECTLY TO THE BOTTOM HEAD OF THE COLUMN ON THE CENTERLINE.
4. FOR INTERLOCKING DETAILS OF COLUMN VALVES FOR VARIOUS SYSTEM OPERATIONS & CHANGEOUT SEQUENCING, SEE SKETCHES PER WVNS-EQ-268.
5. COLUMN A AND B DUMP VALVES ARE ABANDONED IN THE OPEN POSITION WITH A PLUG ATTACHED TO THE BOTTOM OF EACH VALVE.

FIGURE D.6.1-2

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INFORMATION ONLY

FOR DRAWING INDEX SEE DRAWING NO.

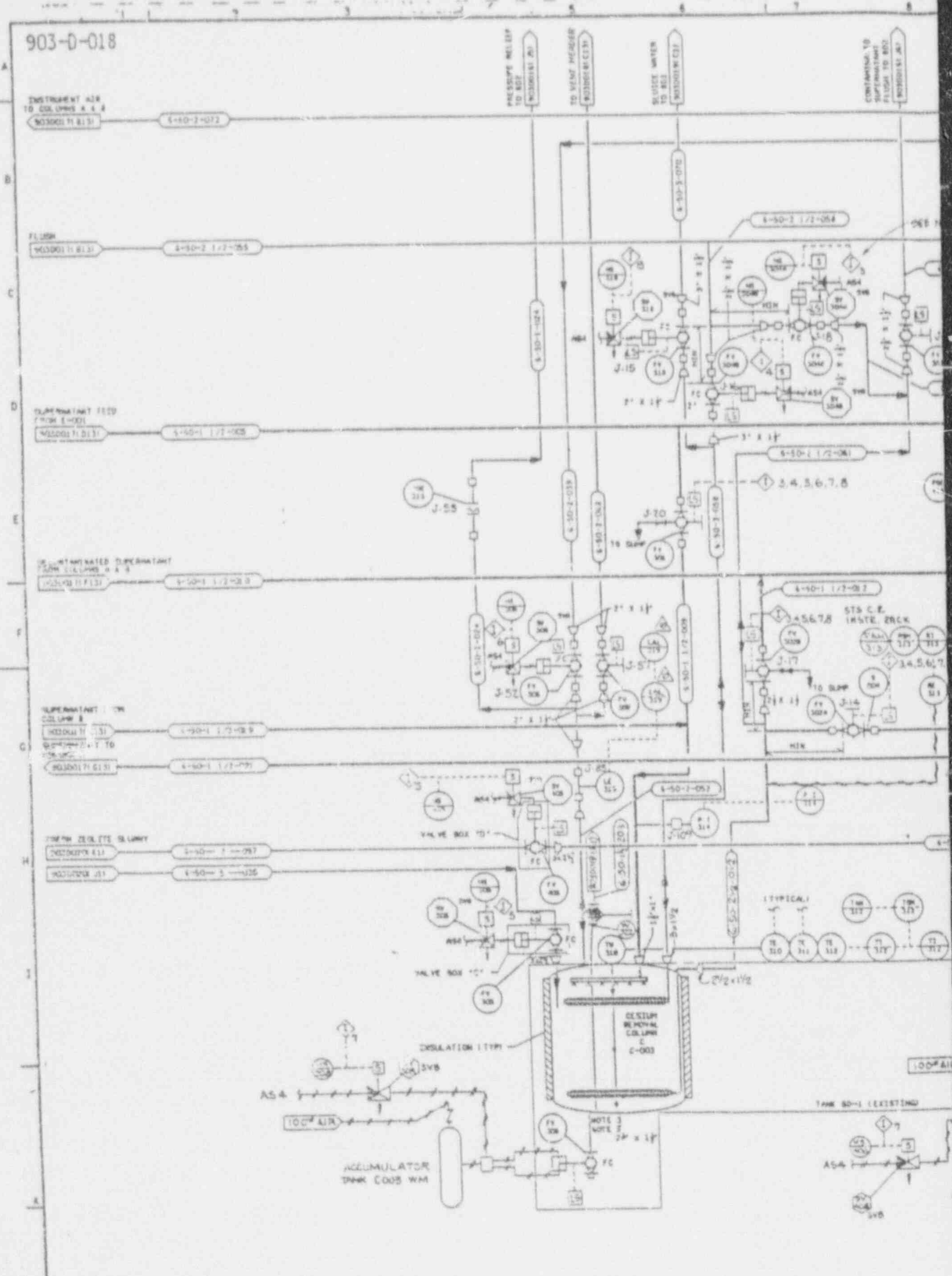
EBASCO SERVICES INCORPORATED

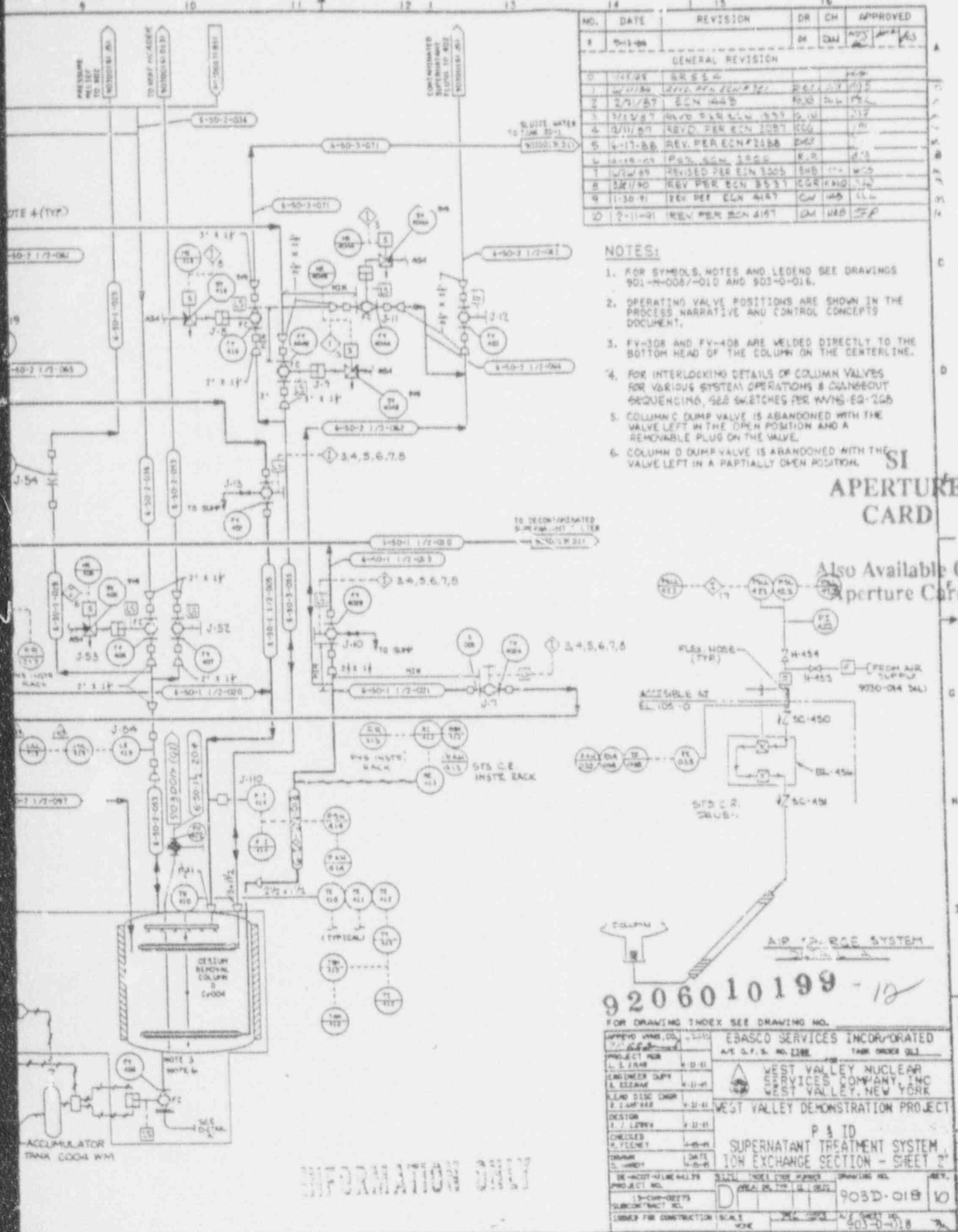
WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

WEST VALLEY DEMONSTRATION PROJECT

P & ID
SUPERNATANT TREATMENT SYSTEM
ION EXCHANGE SECTION - SHEET 1

DRAWING NO. 903D-017 REV. 11


903-D-018
INSTRUMENT AIR TO COLUMNS A & B
FLUSH
SUPERNATANT FEED FROM E-001
FRESH ZEOLITE SLURRY
CESIUM REMOVAL COLUMN C C-003
INSULATION (TYP)
VALVE BOX "D"
VALVE BOX "C"
ACCUMULATOR TANK C005 WM
100# AIR
AS4
SVB
TANK 60-1 (EXISTING)
(TYPICAL)
TO SUMP
J-55
J-20
J-52
J-57
J-15
J-17
J-14
3,4,5,6,7,8
D
C
B
A



NO.	DATE	REVISION	DR	CH	APPROVED
1	9-13-84		84	DAW	
		GENERAL REVISION			
0		GRSSA			
1		REVD PER ECN #321			
2	2/11/87	ECN 1443			
3	3/13/87	REVD PER ECN 1559			
4	12/11/87	REVD PER ECN 2087	CCG		
5	4-17-88	REV. PER ECN #2188			
6		PER ECN 1566	R.R.		
7		REVISED PER ECN 3005	SHB		WCS
8	5/21/90	REV PER ECN 3537	CGR	KMQ	
9	1-30-91	REV PER ECN 4147	CW	HAB	
10	2-11-91	REV PER ECN 4157	CM	HAB	

NOTES:

1. FOR SYMBOLS, NOTES AND LEGEND SEE DRAWINGS 901-M-008/-010 AND 903-D-016.
2. OPERATING VALVE POSITIONS ARE SHOWN IN THE PROCESS NARRATIVE AND CONTROL CONCEPTS DOCUMENT.
3. FV-308 AND FV-408 ARE WELDED DIRECTLY TO THE BOTTOM HEAD OF THE COLUMN ON THE CENTERLINE.
4. FOR INTERLOCKING DETAILS OF COLUMN VALVES FOR VARIOUS SYSTEM OPERATIONS & CHANGEOUT SEQUENCING, SEE SKETCHES PER WVNS-EQ-268
5. COLUMN C DUMP VALVE IS ABANDONED WITH THE VALVE LEFT IN THE OPEN POSITION AND A REMOVABLE PLUG ON THE VALVE.
6. COLUMN D DUMP VALVE IS ABANDONED WITH THE VALVE LEFT IN A PARTIALLY OPEN POSITION.

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FIGURE D.6.1-3

9206010199 - 12

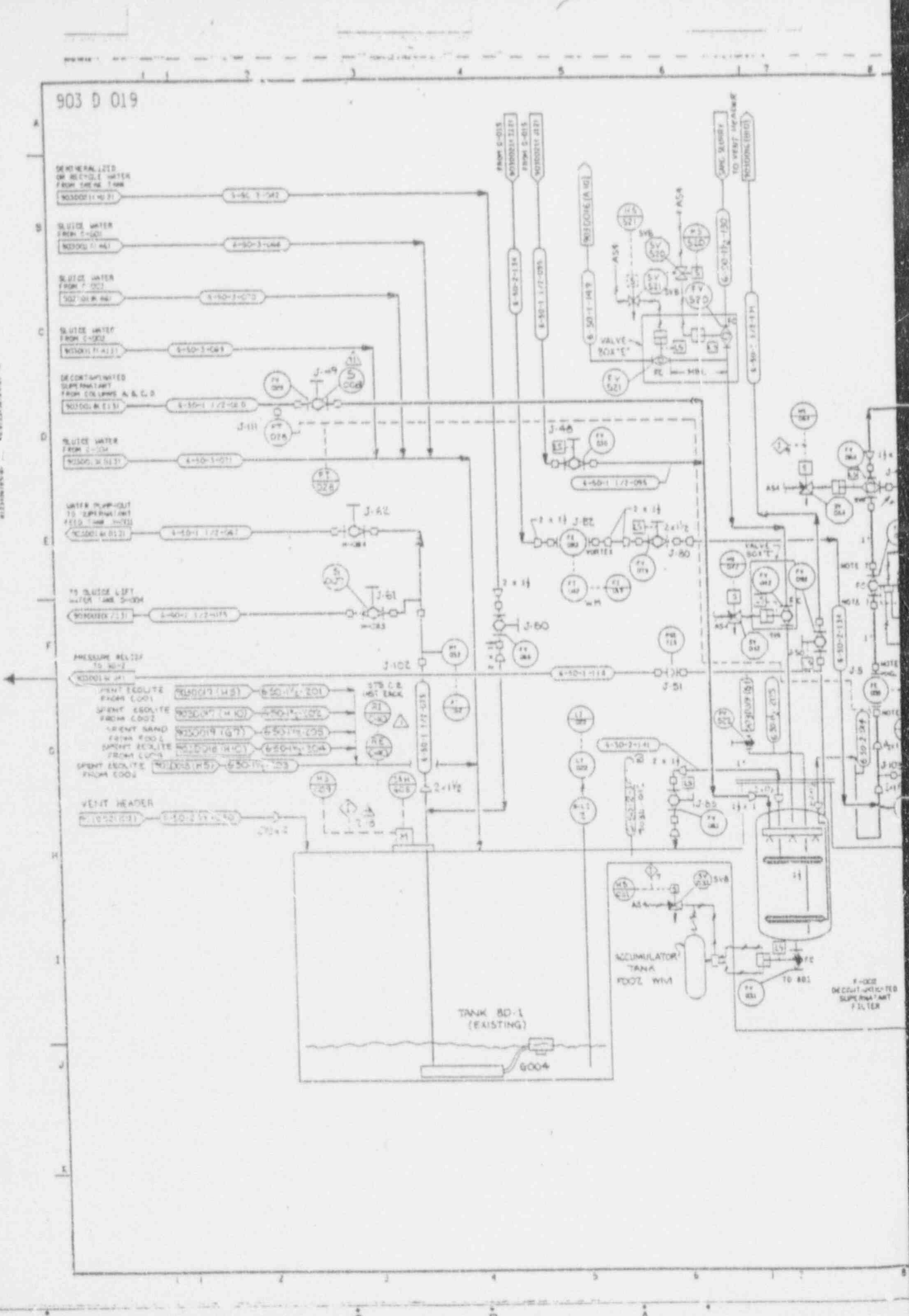
FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED
A/E G.F.S. NO. 1386 TASK ORDER 013
FOR
WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK
WEST VALLEY DEMONSTRATION PROJECT

P & ID
SUPERNATANT TREATMENT SYSTEM
ION EXCHANGE SECTION - SHEET 2

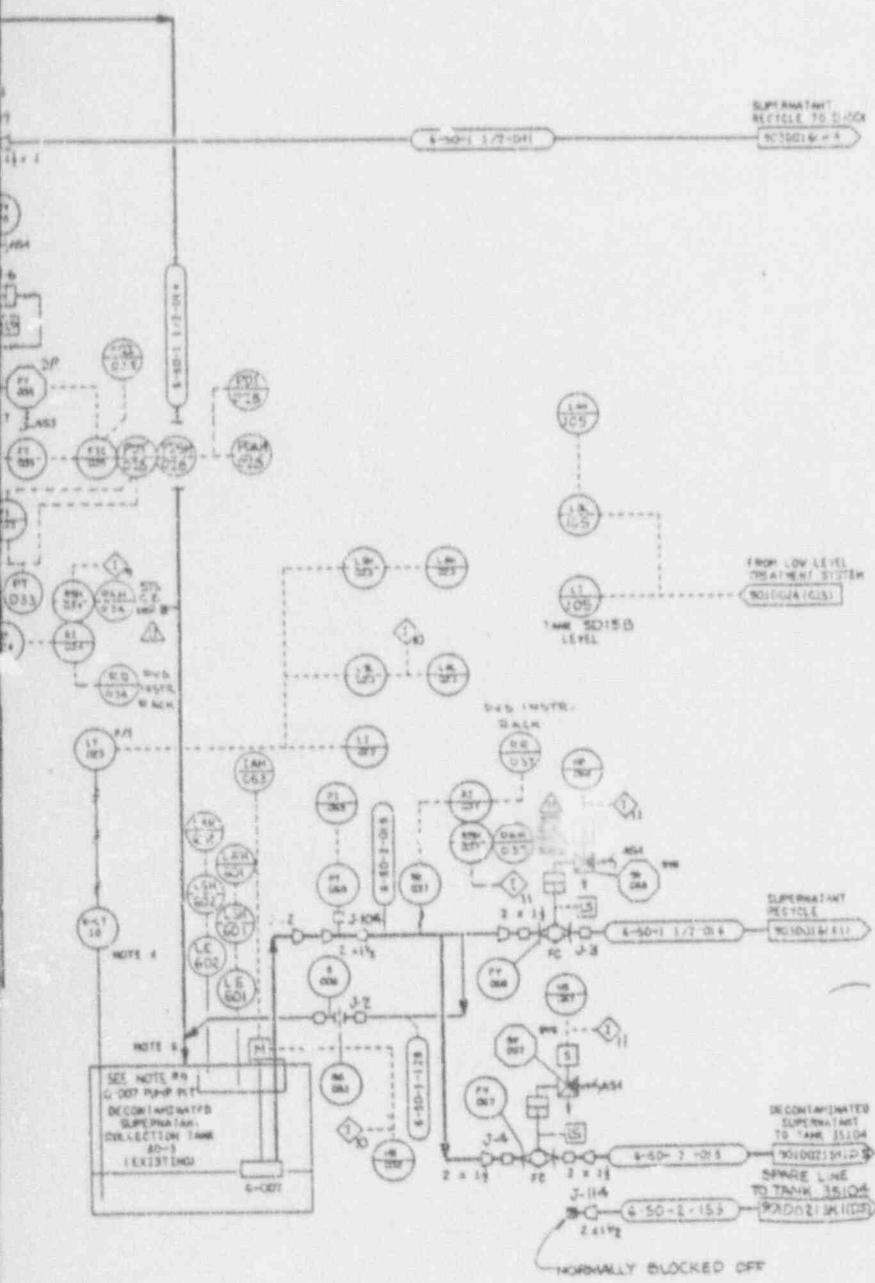
PROJECT NO. 13-CHM-02273
SIZE D
DRAWING NO. 903D-018
REV. 10
A/E SHEET NO. 903-D-018

INFORMATION ONLY


903 D 019
SLUICE WATER
DECONTAMINATED SUPERNATANT FROM COLUMNS A, B, C, D
WATER PUMP-OUT TO SUPERNATANT FEED TANK
TO SLUICE LIFT WATER TANK
PRESSURE RELIEF
SPENT ZEOLITE FROM C001
SPENT ZEOLITE FROM C002
SPENT SAND FROM F001
VENT HEADER
VALVE BOX "E"
TANK BD-1 (EXISTING)
6004
ACCUMULATOR TANK
D
C
B
A

9030-019

NO.	DATE	REVISION	DR	CH	APPROVED		
8	9-3-86	GENERAL REVISION					
0	7/25/85						
1	6-10-86	ECN 751	C.H.				
2	2/21/87	ECN #1245		DLL			
3	3/25/87	REVD. PER ECN 1559					
4	12-14-87	REV'D. PER ECN 2087	CCG				
5	1-25-88	REV'D PER ECN 2133	LWN				
6	7-14-88	REV'D PER ECN 2513	CCG				
7	8-2-88	REV'D PER ECN 2545					
8	6/26/89	REVISED PER ECN 3005	EHB				
9	9-19-89	REVISED PER ECN 3125	GW	KWO			
10	11-21-90	REV. PER ECN 4058	KCG				
11	1-29-91	REV. PER ECN 4154	GW				



NOTES:

1. FOR SYMBOLS, NOTES AND LEGEND SEE DRAWINGS 901-M-008/-010 AND 903-D-016.
2. OPERATING VALVE POSITIONS ARE SHOWN IN THE PROCESS NARRATIVE AND CONTROL CONCEPTS DOCUMENT.
3. DELETED.
4. DELETED
5. DELETED.
6. PUMP RECIRCULATION LINE 6-50-128 SHOULD BE TIED INTO VERTICAL SECTION AS CLOSE TO TANK 8D-3 AS POSSIBLE.
7. BLOCK CONNECTOR MUST BE BORED TO 1/2 INCH
8. OSBL=OUTSIDE BATTERY LIMITS.
9. LEVEL LOOP 601 PUMP PIT LEVEL
   LEVEL LOOP 602 PIPE CASING LEVEL

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INFORMATION ONLY

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

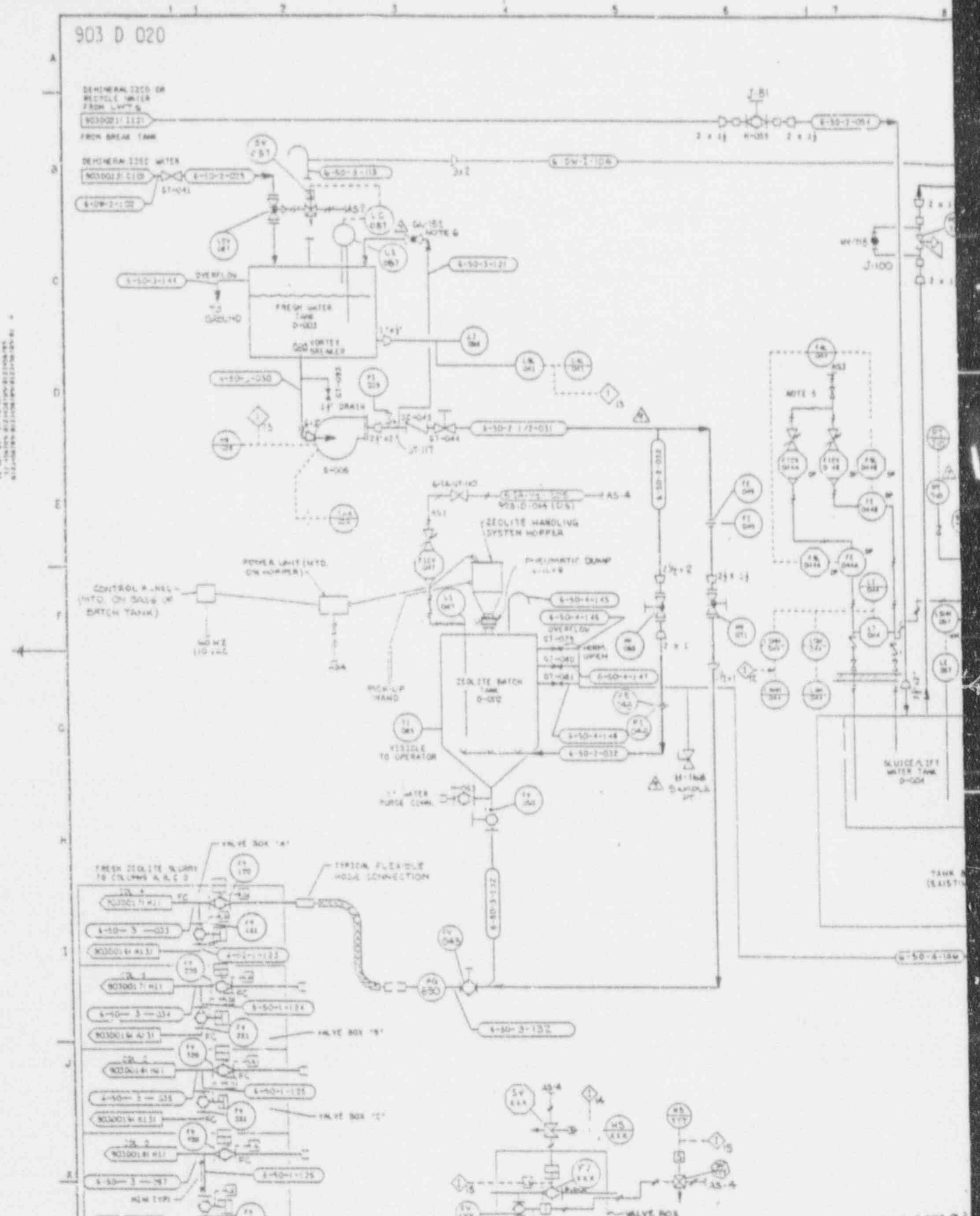
WEST VALLEY DEMONSTRATION PROJECT

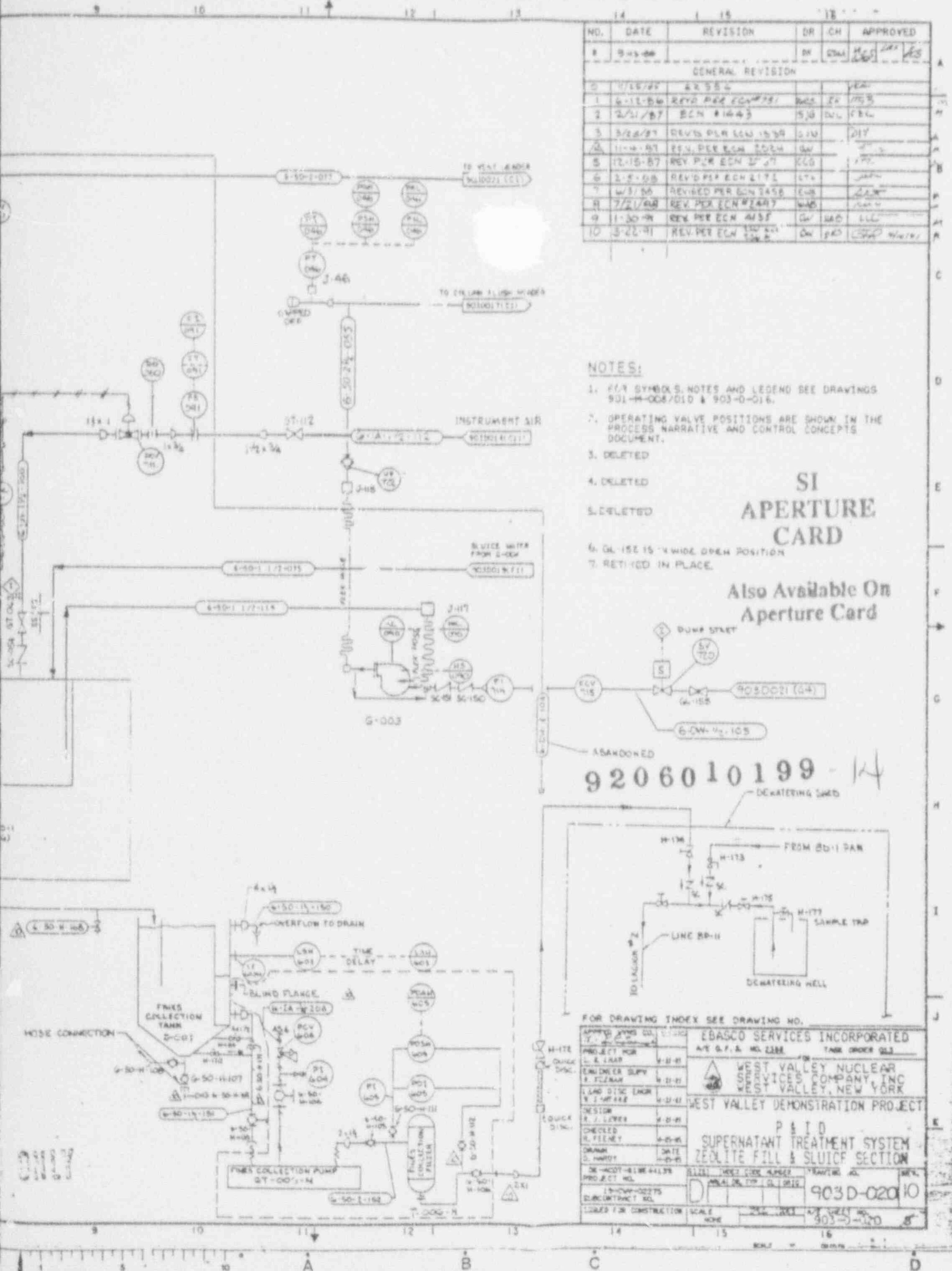
P & ID
SUPERNATANT TREATMENT SYSTEM
FINAL FILTRATION & STORAGE

DRAWING NO. 903D-019 REV. 11

ISSUED FOR CONSTRUCTION — SCALE NONE — A/E SHEET NO. 903-D-019

FIGURE D.6.1-4


903 D 020
FRESH WATER TANK D-003
VORTEX BREAKER
OVERFLOW
TO GROUND
ZEOLITE HANDLING SYSTEM HOPPER
PNEUMATIC DUMP
POWER UNIT (MTD. ON HOPPER)
CONTROL PANEL (MTD. ON BASE OF BATCH TANK)
ZEOLITE BATCH TANK D-012
VISIBLE TO OPERATOR
SAMPLE PT
FRESH ZEOLITE SLURRY TO COLUMNS A, B, C, D
TYPICAL FLEXIBLE HOSE CONNECTION
VALVE BOX "A"
VALVE BOX "B"
VALVE BOX "C"
VALVE BOX "D"
TYPICAL AUTOMATIC VALVE IN VALVE BOXES A, B, C, D & E
VALVE BOX
SLUICE/LIFT WATER TANK D-004
J-100
NOTE 5
NOTE 6



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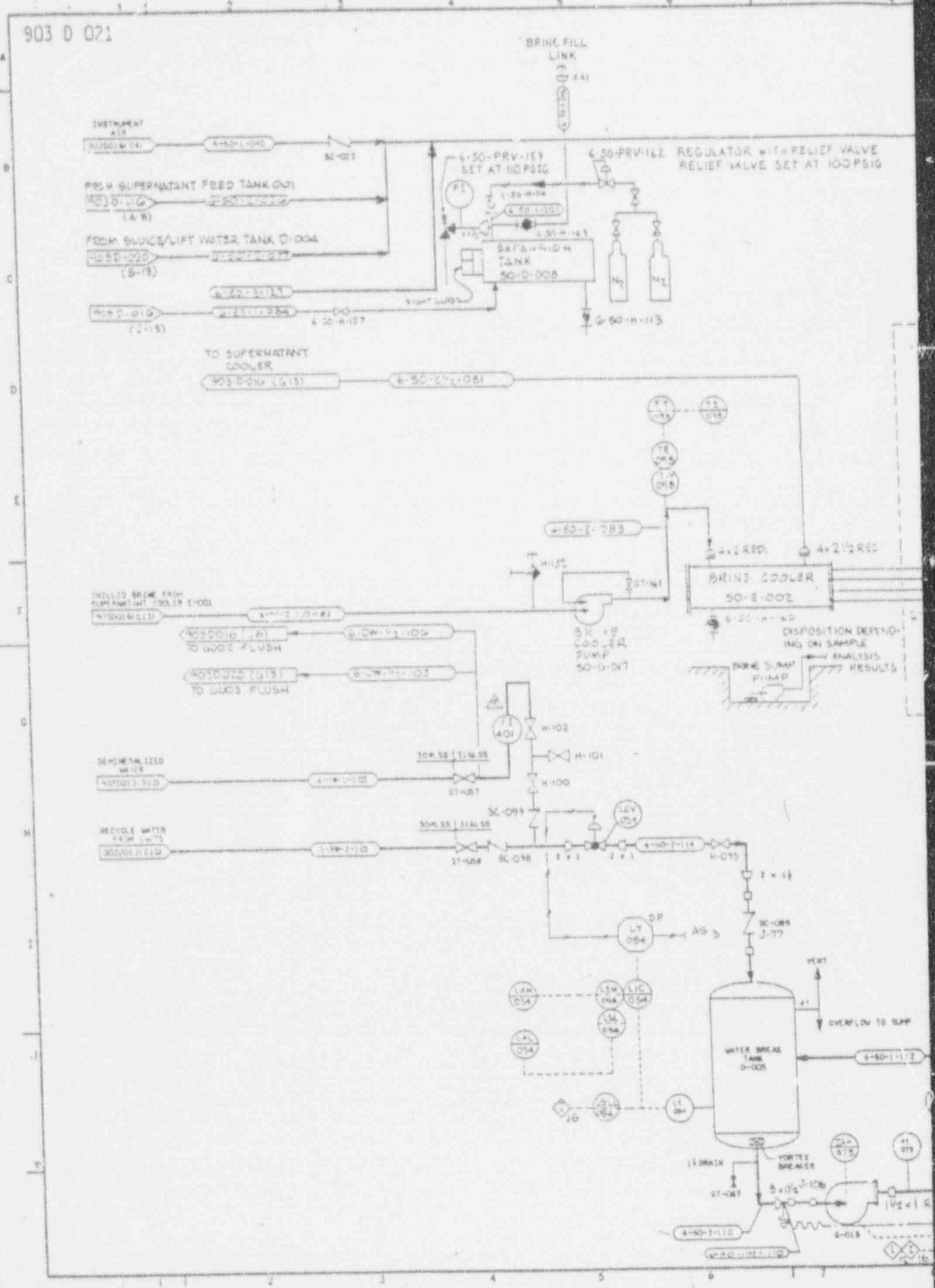
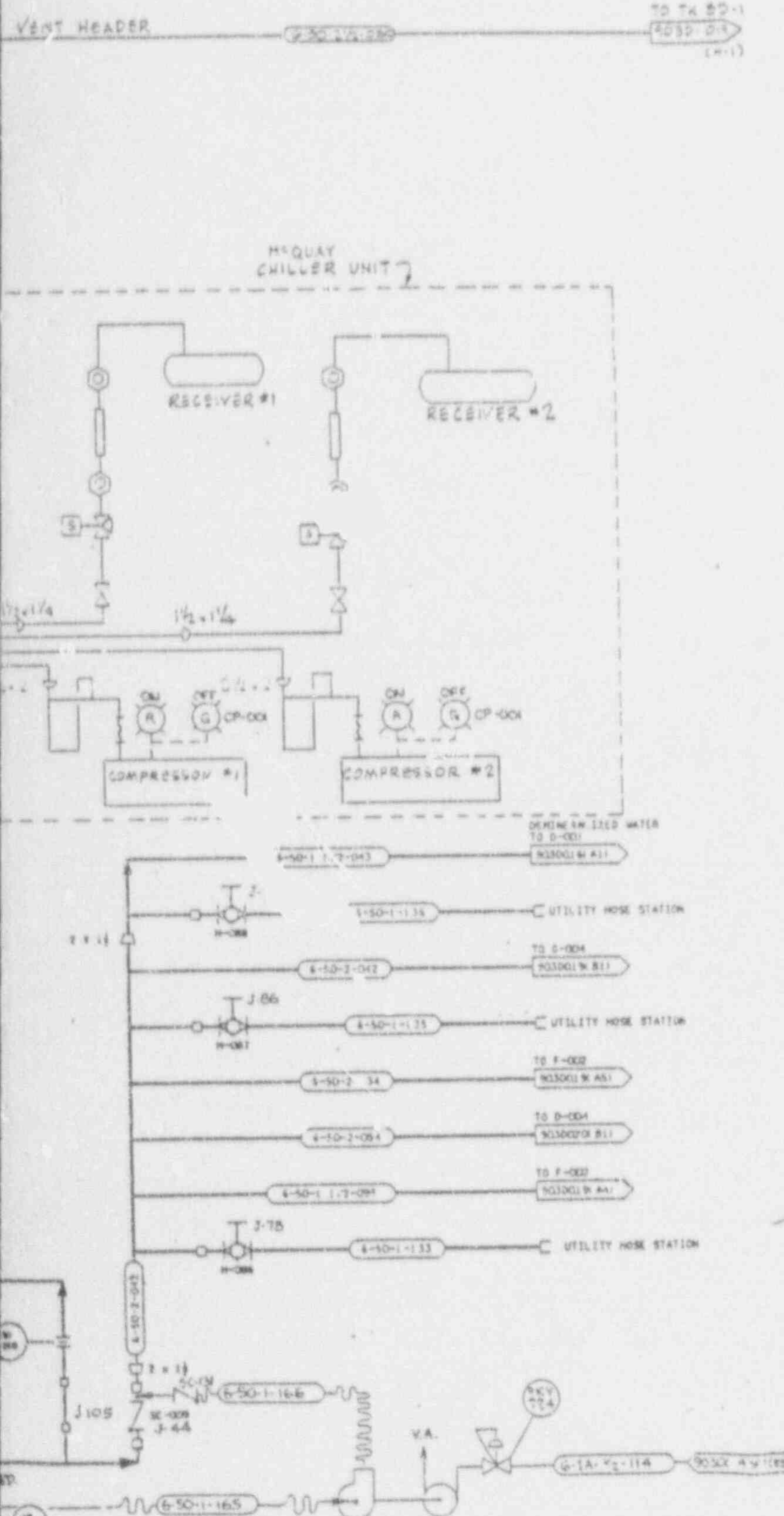
9206010199 - 14

FIGURE D.6.1-5



903 D 021
BRINE FILL LINK
INSTRUMENT AIR
6-50-PRV-159 SET AT 110 PSIG
6-50-PRV-162 REGULATOR WITH RELIEF VALVE
RELIEF VALVE SET AT 100 PSIG
FROM SUPERNATANT FEED TANK D-001
FROM SLUICE/LIFT WATER TANK D-004
PI
EXPANSION TANK 50-D-008
SIGHT GLASS
6-50-H-157
6-50-H-113
N_2
N_2
TO SUPERNATANT COOLER
6-50-2½-081
TE 095
4-50-2-083
4x2 RED.
4x2½ RED.
BRINE COOLER 50-E-002
CHILLED BRINE FROM SUPERNATANT COOLER E-001
BRINE COOLER PUMP 50-G-017
TO SLUICE FLUSH
TO SLUICE FLUSH
DISPOSITION DEPENDING ON SAMPLE ANALYSIS RESULTS
BRINE SUMP PUMP
DEMINERALIZED WATER
FI 401
H-102
H-101
H-100
ST-057
RECYCLE WATER
SC-099
SC-098
LCV 054
H-095
DP
LY 054
SC-089
VENT
LAH 054
LSH 054
LIC 054
LSL 054
LAL 054
OVERFLOW TO SUMP
WATER BREAK TANK D-005
VORTEX BREAKER
DRAIN
ST-067
G-013

NO.	DATE	REVISION	DR	CH	APPROVED		
8	5-13-85	GENERAL REVISION					
0	1/15/85	ERSSA					
1	6-10-86	ECN 751	CH				
2	2/20/87	ECN 1443					
3	3/25/87	REV. PER ECN 1539					
4	11-4-87	REV. PER ECN 2054	DW				
5	12-15-87	REV. PER ECN 2097	ECG				
6	3-13-88	REV. PER ECN 2310					
7	8-10-88	REV. PER ECN 3095	GW				
8	8-24-89	REV. PER ECN 3101	CGR				
9	1-29-91	REV. PER ECN 4131	DW				



NOTES:

1. FOR SYMBOLS, NOTES AND LEGEND SEE DRAWINGS 901-M-008/-010 & 903-D-016.
2. OPERATING VALVE POSITIONS ARE SHOWN IN THE PROCESS NARRATIVE AND CONTROL CONCEPTS DOCUMENT.
3. LINE 50-2-122 TIES IN JUST ABOVE TOP OF 8D-1 VAULT.

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INFORMATION ONLY

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

FOR

WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

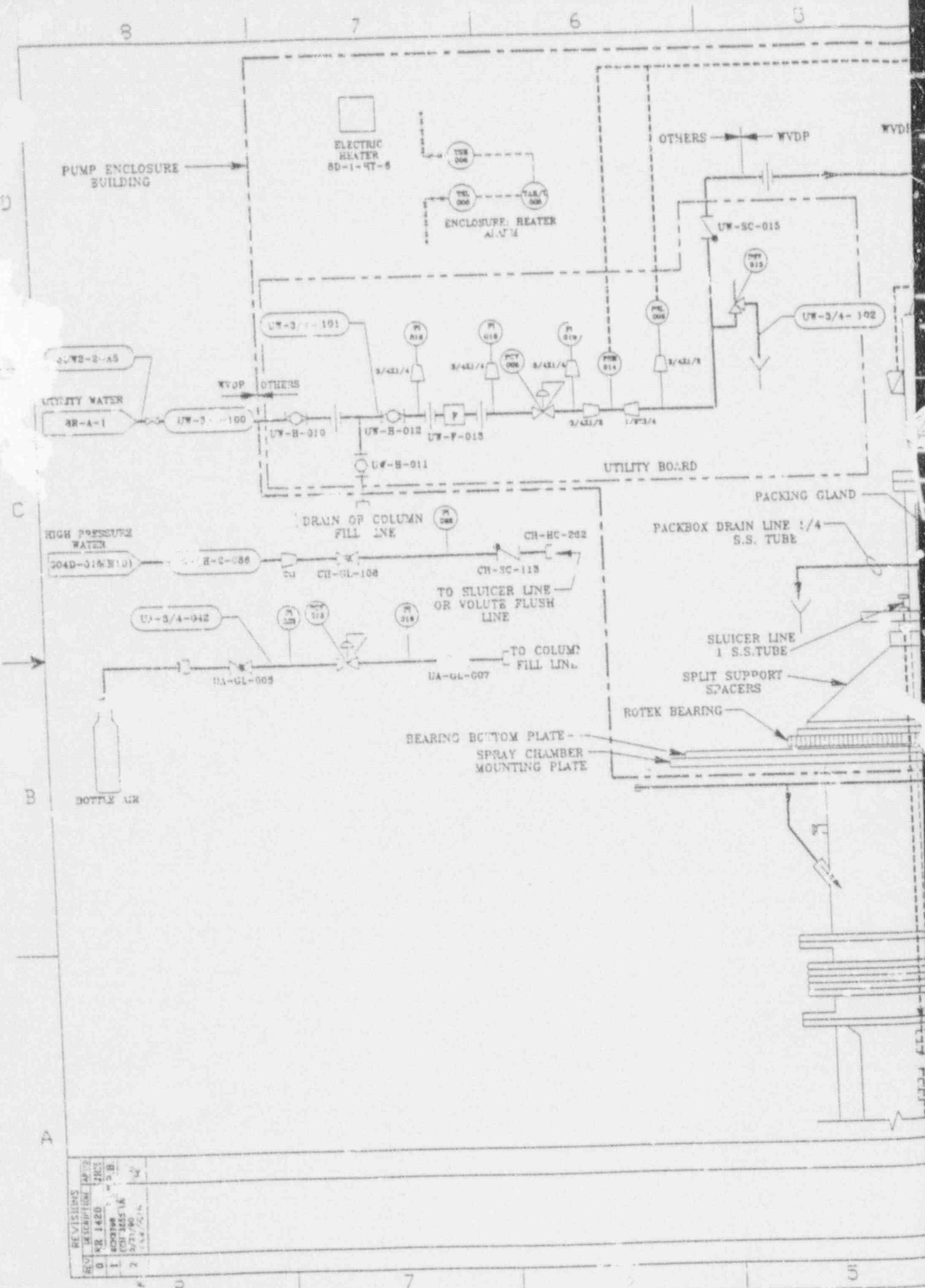
WEST VALLEY DEMONSTRATION PROJECT

P & ID
SUPERNATANT TREATMENT SYSTEM
VENTING / CHILLER SECTION

SIZE D | DRAWING NO. 903D-021 | REV. 9

ISSUED FOR CONSTRUCTION | SCALE NONE | A/E SHEET NO. 903-D-021

FIGURE D.6.1-6


PUMP ENCLOSURE BUILDING
ELECTRIC HEATER
ENCLOSURE HEATER ALARM
OTHERS
WVDP
UW-SC-015
UW-3/4-102
UTILITY WATER
UW-H-010
UW-H-012
UW-F-013
UW-H-011
UTILITY BOARD
PACKING GLAND
PACKBOX DRAIN LINE 1/4 S.S. TUBE
DRAIN OF COLUMN FILL LINE
HIGH PRESSURE WATER
CH-GL-108
CH-SC-113
CH-HC-262
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-005
UA-GL-007
TO COLUMN FILL LINE
SLUICER LINE 1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
BOTTLE UR
REVISIONS
REV
DESCRIPTION
APVD

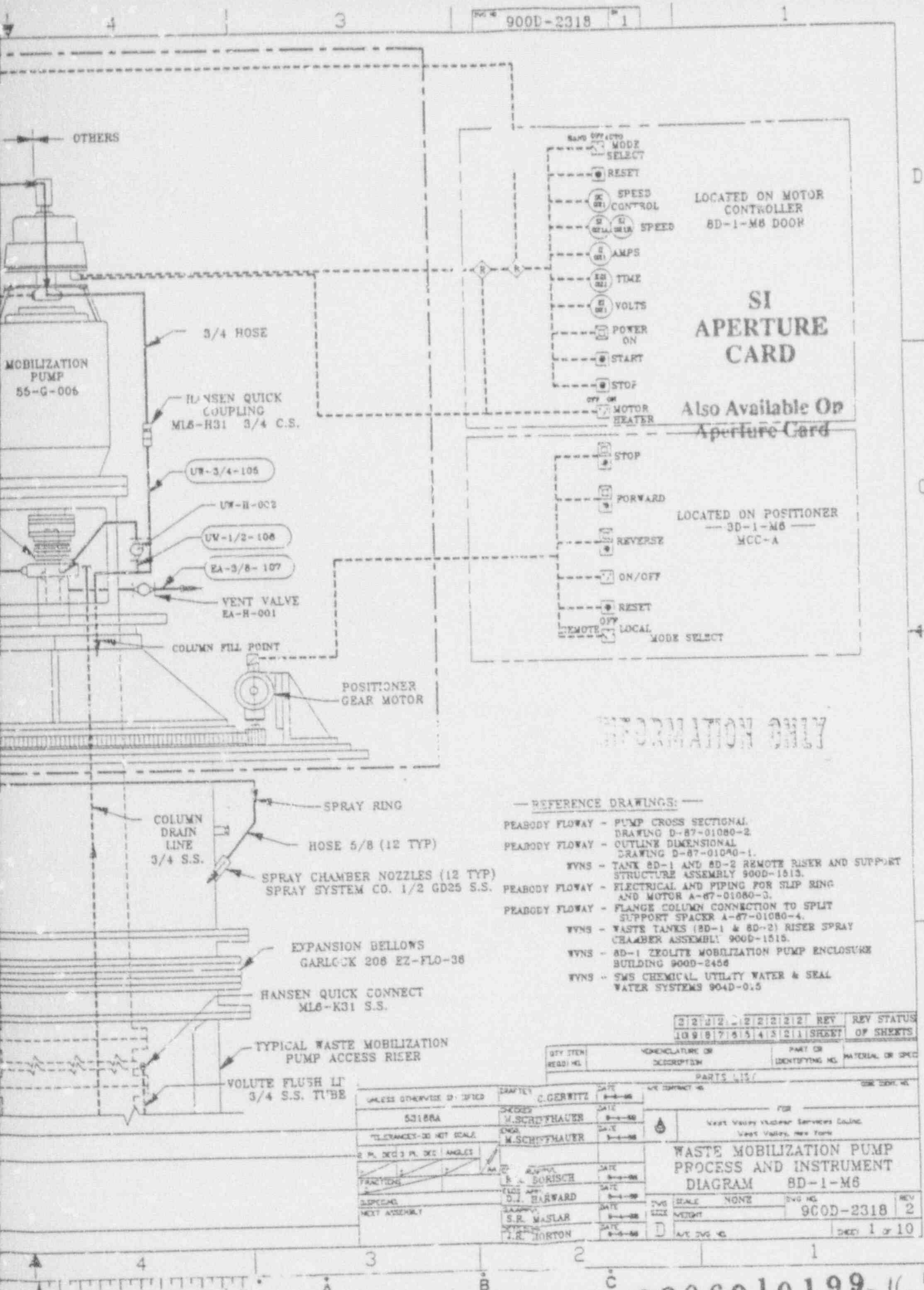
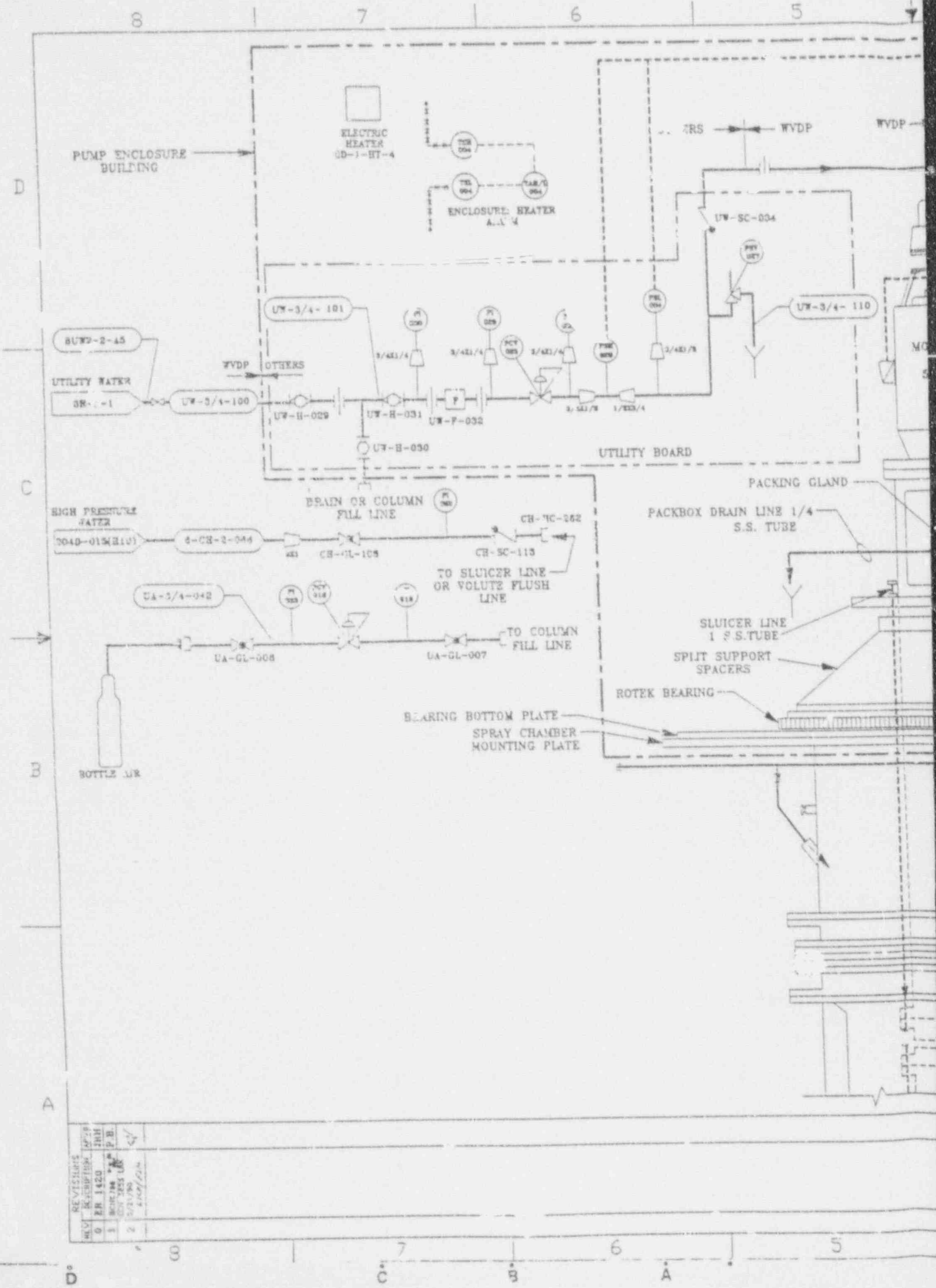


FIGURE D.6.1-7

9206010199-16



8
7
6
5
D
C
B
A
PUMP ENCLOSURE BUILDING
ELECTRIC HEATER
ENCLOSURE HEATER
WVDP
UW-SC-004
UW-3/4- 110
UW-3/4- 101
UTILITY WATER
UW-3/4-100
WVDP
OTHERS
UW-H-029
UW-H-031
UW-F-032
UW-H-030
UTILITY BOARD
DRAIN OR COLUMN FILL LINE
HIGH PRESSURE WATER
CH-SC-113
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-006
UA-GL-007
TO COLUMN FILL LINE
BOTTLE AIR
PACKING GLAND
PACKBOX DRAIN LINE 1/4 S.S. TUBE
SLUICER LINE 1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
SPRAY CHAMBER MOUNTING PLATE
REVISIONS
ER 1420

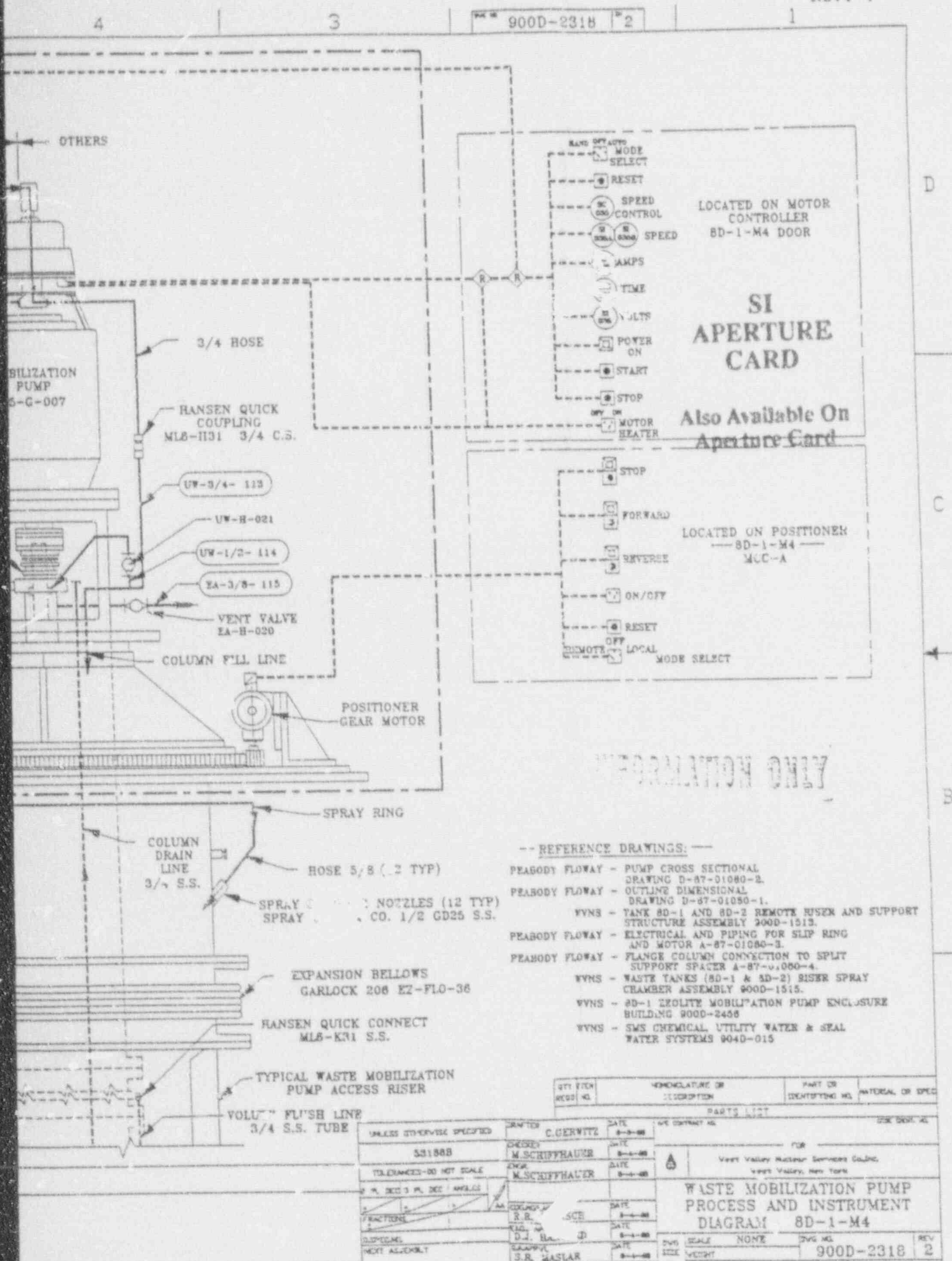
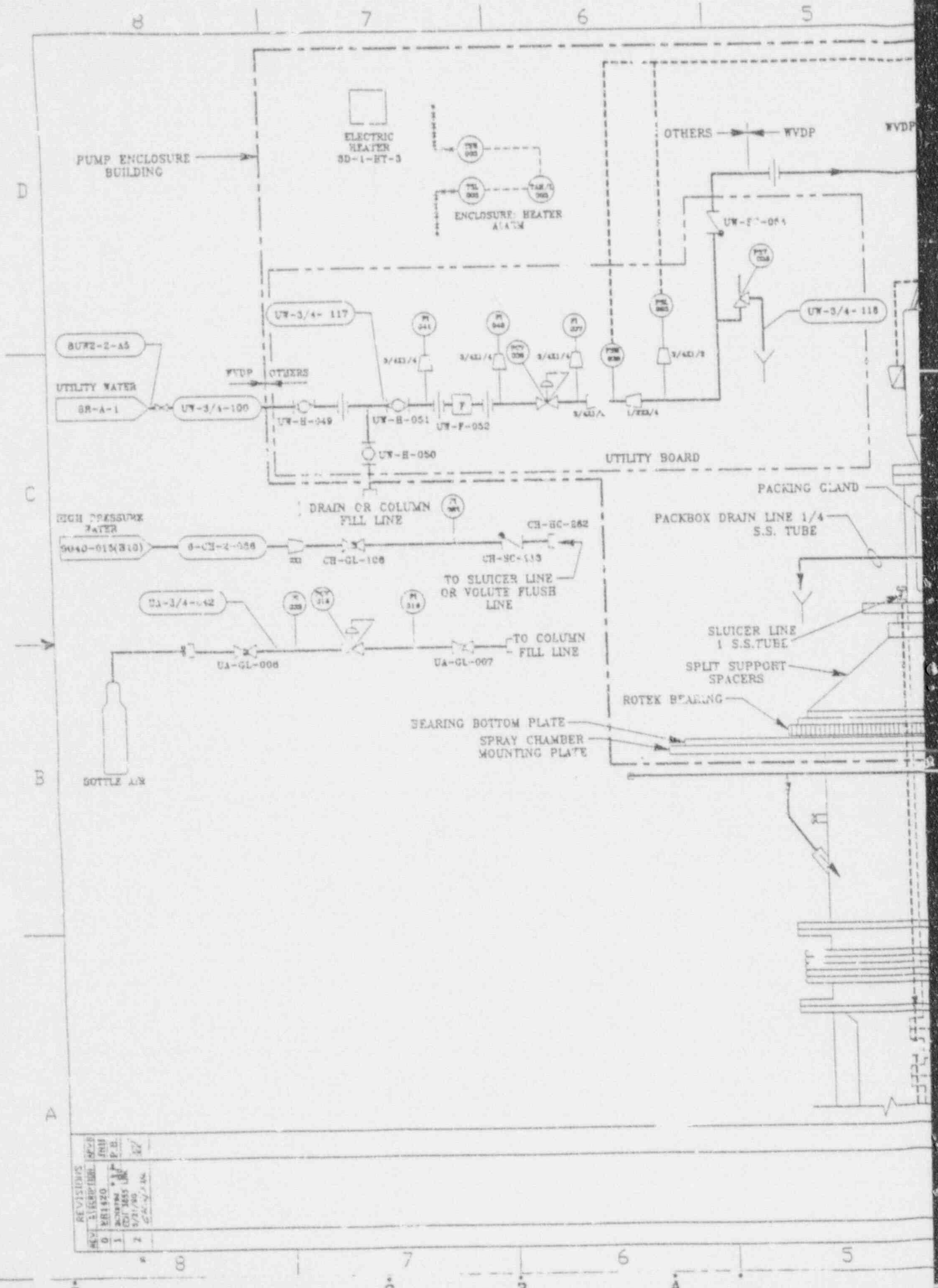


FIGURE D.6.1-8

9206010199-17



PUMP ENCLOSURE BUILDING
ELECTRIC HEATER
ENCLOSURE HEATER ALARM
OTHERS
WVDP
UTILITY WATER
UW-3/4-117
UW-3/4-100
UW-3/4-118
UTILITY BOARD
DRAIN OR COLUMN FILL LINE
HIGH PRESSURE WATER
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-006
UA-GL-007
TO COLUMN FILL LINE
BOTTLE AIR
PACKING GLAND
PACKBOX DRAIN LINE 1/4 S.S. TUBE
SLUICER LINE 1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
REVISIONS

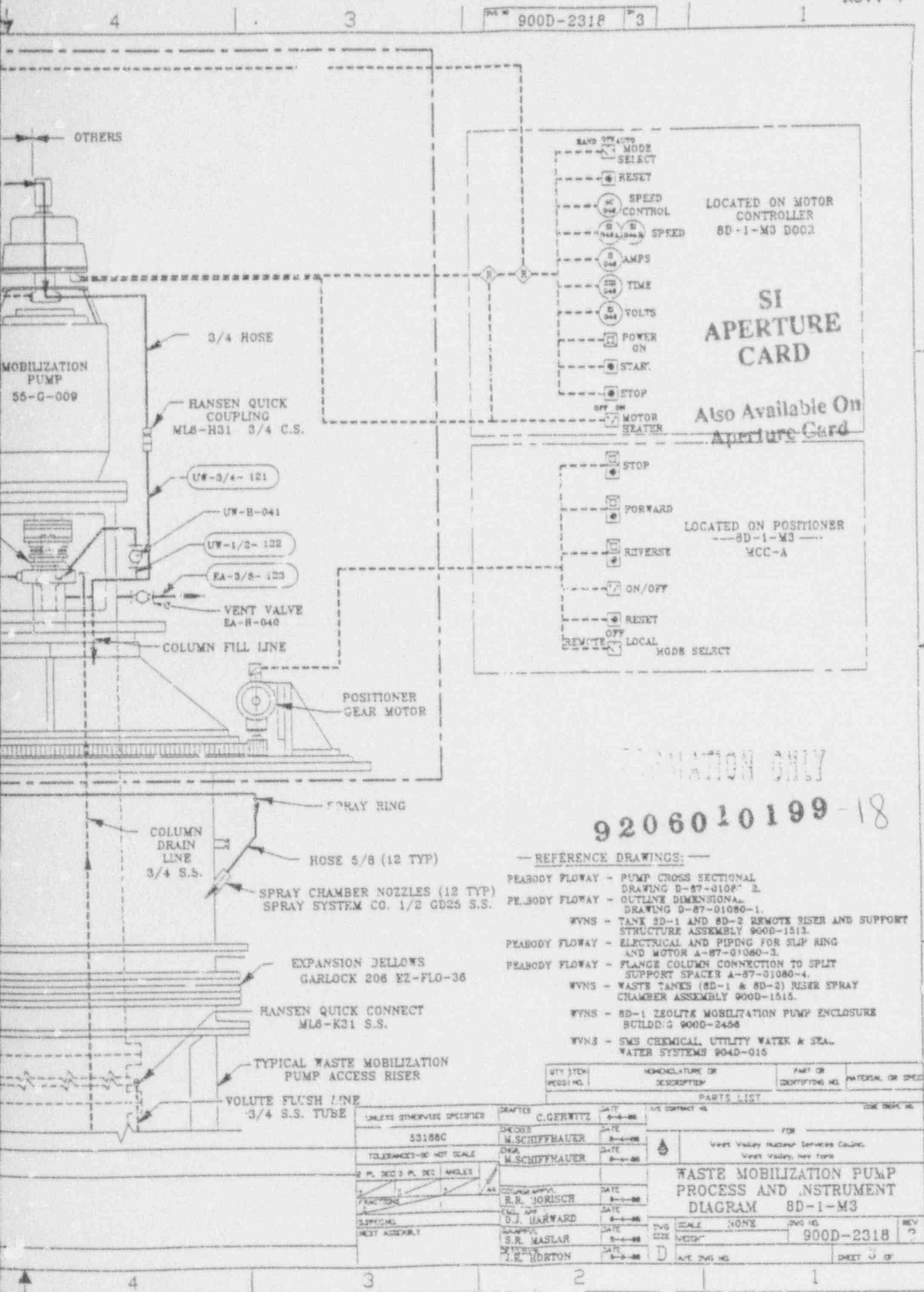
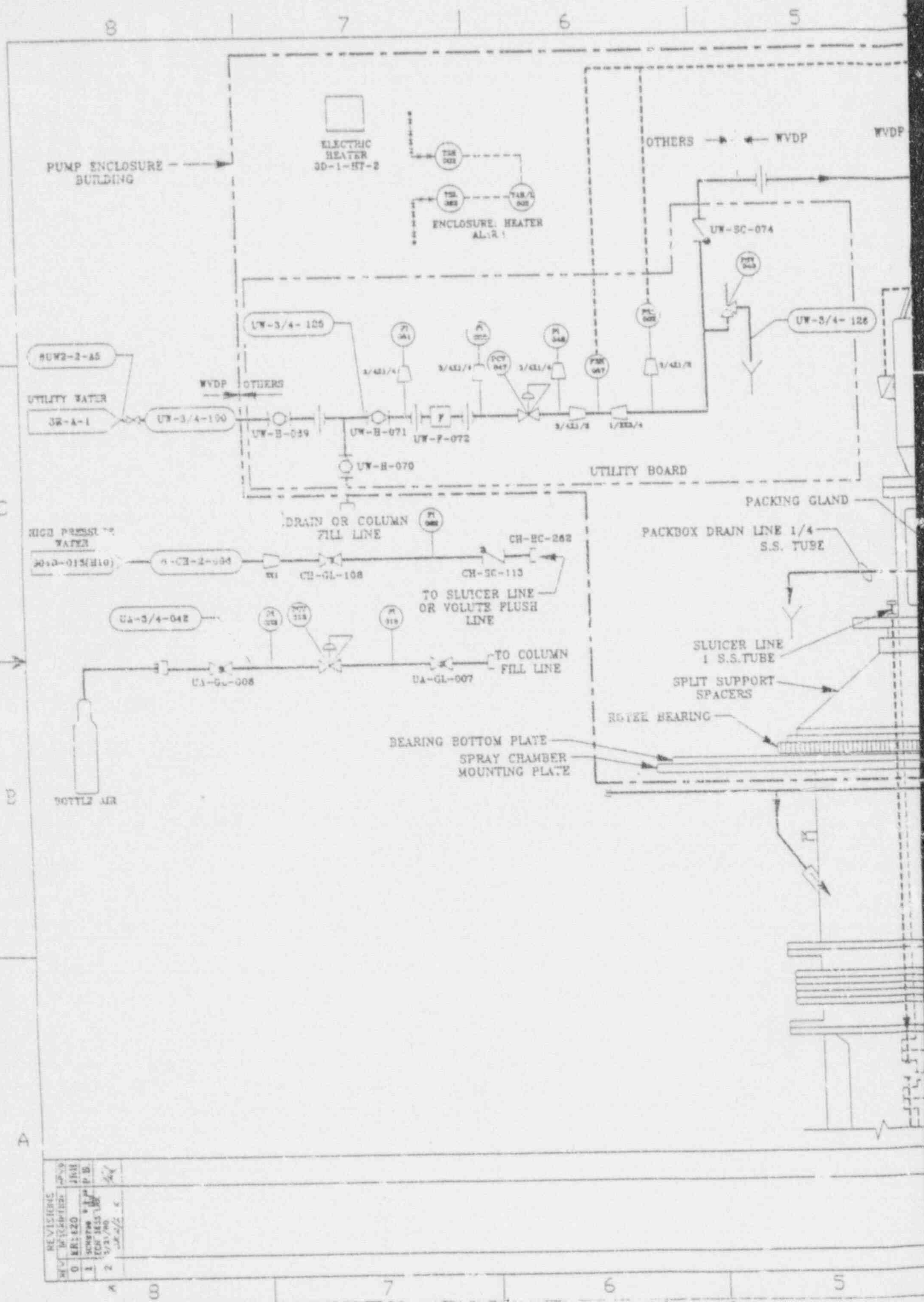

900D-2318
3
OTHERS
MODE SELECT
RESET
SPEED CONTROL
SPEED
AMPS
TIME
VOLTS
POWER ON
START
STOP
MOTOR HEATER
LOCATED ON MOTOR CONTROLLER 8D-1-M3 D003
SI APERTURE CARD
Also Available On Aperture Card
STOP
FORWARD
REVERSE
ON/OFF
RESET
REMOTE OFF LOCAL MODE SELECT
LOCATED ON POSITIONER ---8D-1-M3--- MCC-A
3/4 HOSE
MOBILIZATION PUMP 55-G-009
HANSEN QUICK COUPLING ML6-H31 3/4 C.S.
UW-3/4- 121
UW-H-041
UW-1/2- 122
EA-3/8- 123
VENT VALVE EA-H-040
COLUMN FILL LINE
POSITIONER GEAR MOTOR
SPRAY RING
COLUMN DRAIN LINE 3/4 S.S.
HOSE 5/8 (12 TYP)
SPRAY CHAMBER NOZZLES (12 TYP) SPRAY SYSTEM CO. 1/2 GD25 S.S.
EXPANSION BELLOWS GARLOCK 206 EZ-FLO-36
HANSEN QUICK CONNECT ML6-K31 S.S.
TYPICAL WASTE MOBILIZATION PUMP ACCESS RISER
VOLUTE FLUSH LINE 3/4 S.S. TUBE
9206010199-18
REFERENCE DRAWINGS:
PEABODY FLOWAY - PUMP CROSS SECTIONAL DRAWING D-87-01080-2.
PEABODY FLOWAY - OUTLINE DIMENSIONAL DRAWING D-87-01080-1.
WVNS - TANK 8D-1 AND 8D-2 REMOTE RISER AND SUPPORT STRUCTURE ASSEMBLY 900D-1513.
PEABODY FLOWAY - ELECTRICAL AND PIPING FOR SLIP RING AND MOTOR A-87-01080-3.
PEABODY FLOWAY - FLANGE COLUMN CONNECTION TO SPLIT SUPPORT SPACER A-87-01080-4.
WVNS - WASTE TANKS (8D-1 & 8D-2) RISER SPRAY CHAMBER ASSEMBLY 900D-1515.
WVNS - 8D-1 ZEOLITE MOBILIZATION PUMP ENCLOSURE BUILDING 900D-2456
WVNS - SMS CHEMICAL, UTILITY WATER & SEAL WATER SYSTEMS 904D-015
PARTS LIST
C.GERWITZ
M.SCHIFFHAUER
M.SCHIFFHAUER
R.R. JORISCH
D.J. HARWARD
S.R. MASLAR
J.E. HORTON
53188C
West Valley Nuclear Services Co.,Inc.
West Valley, New York
WASTE MOBILIZATION PUMP PROCESS AND INSTRUMENT DIAGRAM 8D-1-M3
NONE
900D-2318
CAD DRAWING-DO NOT REVISE THIS ORIGINAL

FIGURE D.6.1-9



PUMP ENCLOSURE BUILDING
ELECTRIC HEATER 3D-1-HT-2
ENCLOSURE HEATER ALARM
OTHERS
WVDP
UW-SC-074
UW-3/4-126
UW-3/4-125
8UW2-2-A5
UTILITY WATER
3R-A-1
UW-3/4-100
UW-H-069
UW-H-071
UW-F-072
UW-H-070
UTILITY BOARD
DRAIN OR COLUMN FILL LINE
PACKING GLAND
PACKBOX DRAIN LINE 1/4 S.S. TUBE
HIGH PRESSURE WATER
CH-SC-113
CH-GL-108
CH-SC-262
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-006
UA-GL-007
TO COLUMN FILL LINE
SLUICER LINE 1 S.S.TUBE
SPLIT SUPPORT SPACERS
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
BOTTLE AIR
REVISIONS

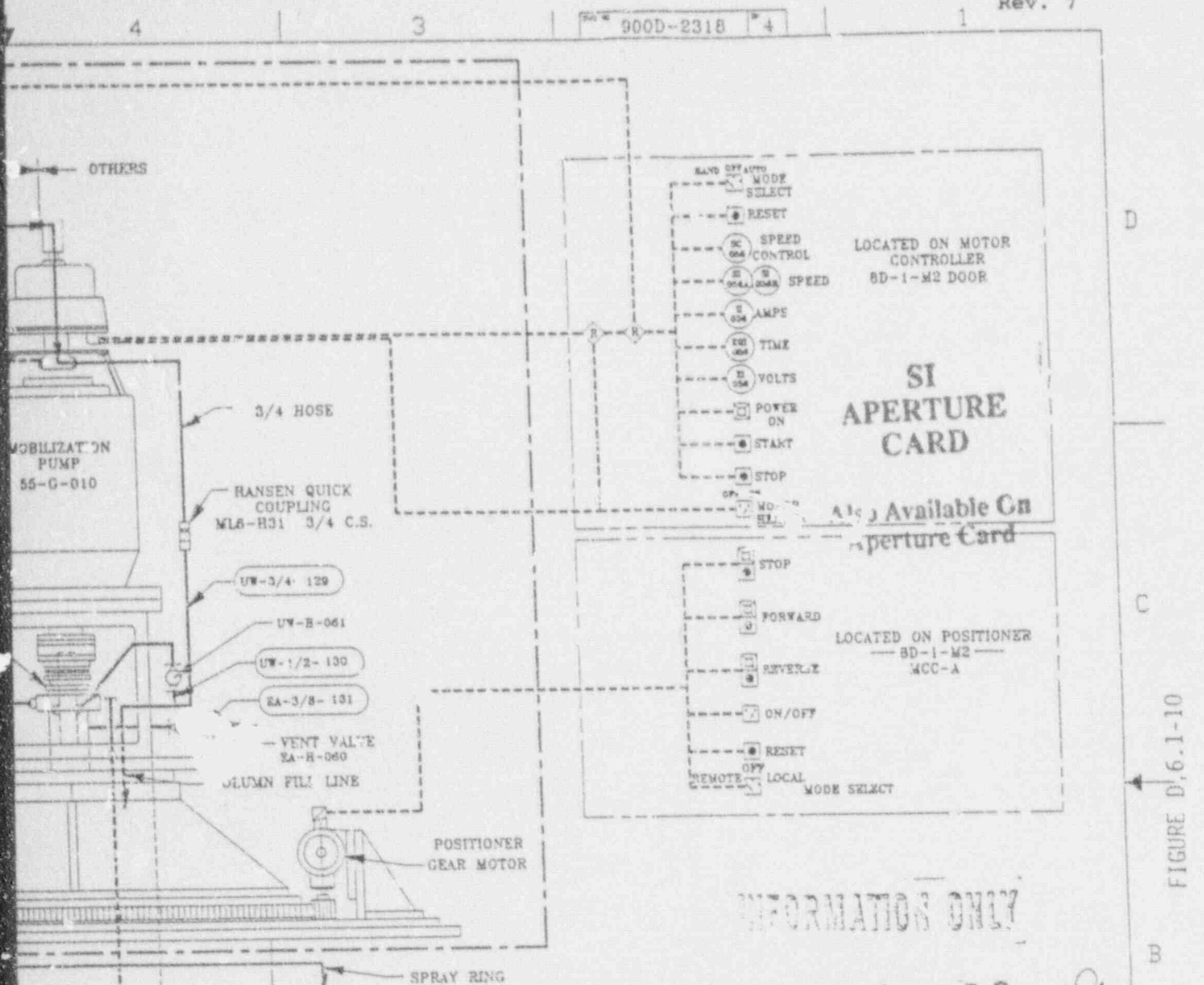
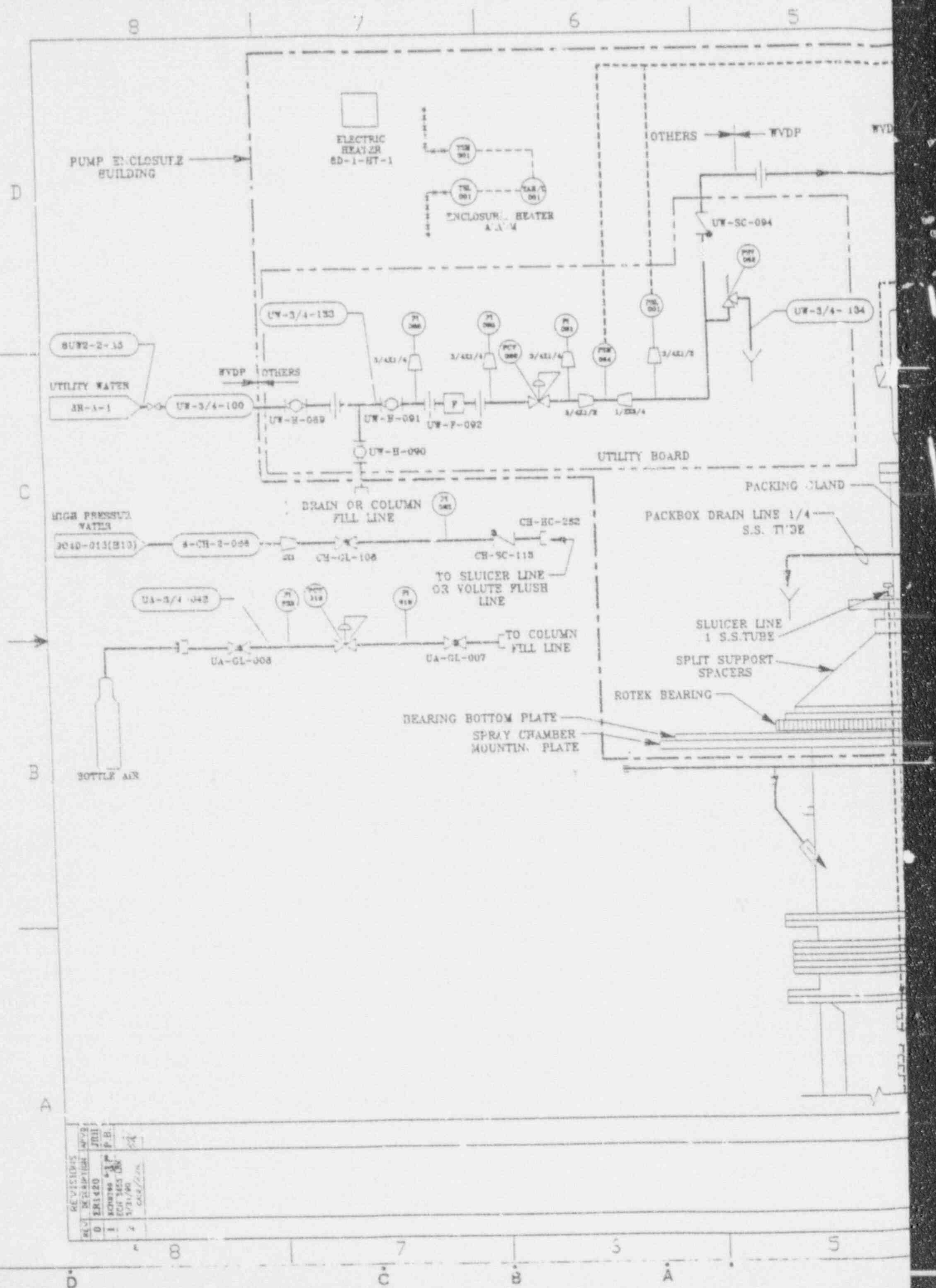


FIGURE D.6.1-10



PUMP ENCLOSURE BUILDING
ELECTRIC HEATER
ENCLOSURE HEATER ALARM
OTHERS
WVDP
UW-SC-094
UW-3/4-133
UW-3/4-134
BUW2-2-35
UTILITY WATER
UW-3/4-100
UW-H-089
UW-H-091
UW-F-092
UW-H-090
UTILITY BOARD
DRAIN OR COLUMN FILL LINE
HIGH PRESSURE WATER
CH-GL-108
CH-SC-113
CH-HC-252
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-008
UA-GL-007
TO COLUMN FILL LINE
BOTTLE AIR
PACKING GLAND
PACKBOX DRAIN LINE 1/4 S.S. TUBE
SLUICER LINE 1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
REVISIONS
ER1420

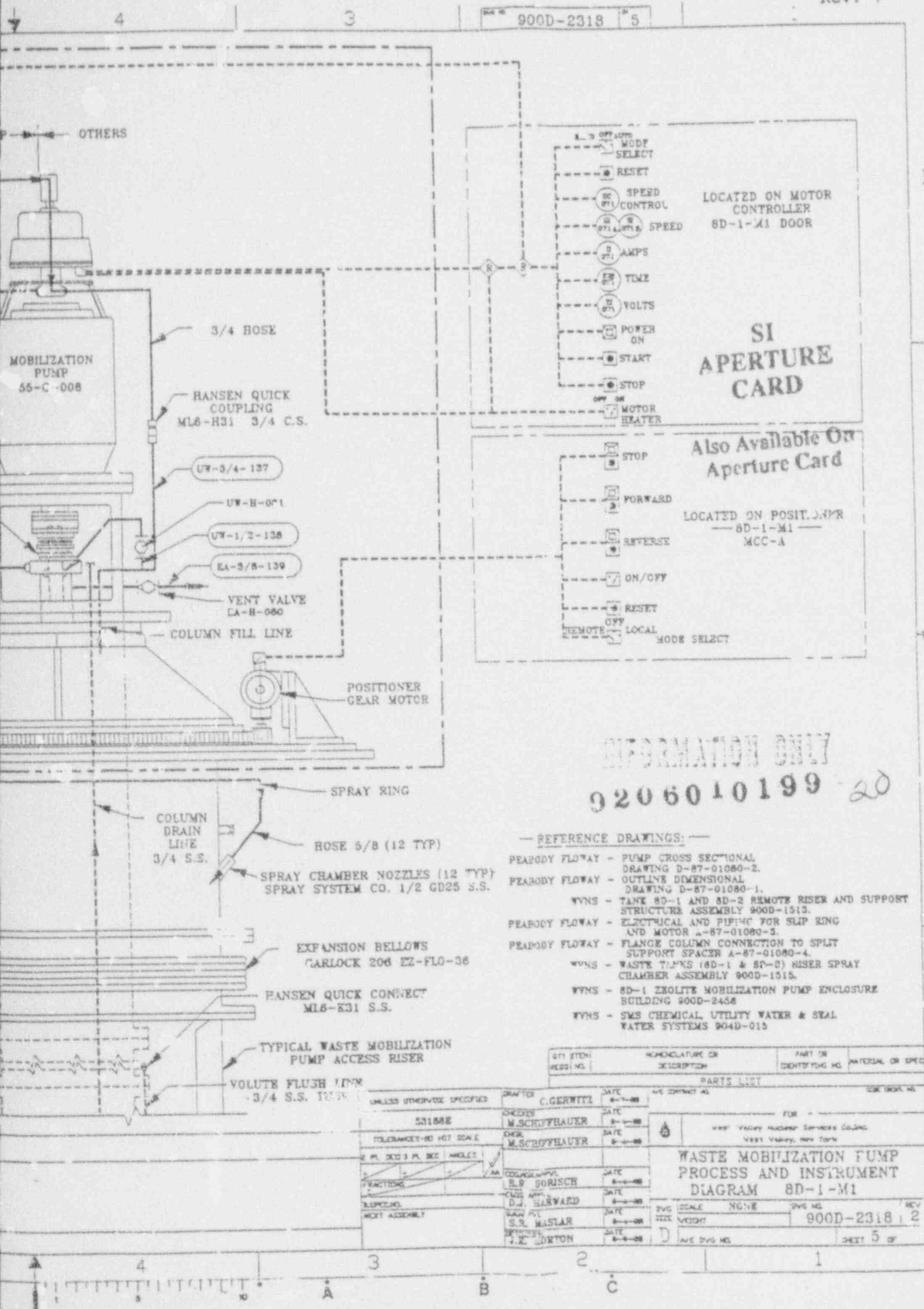
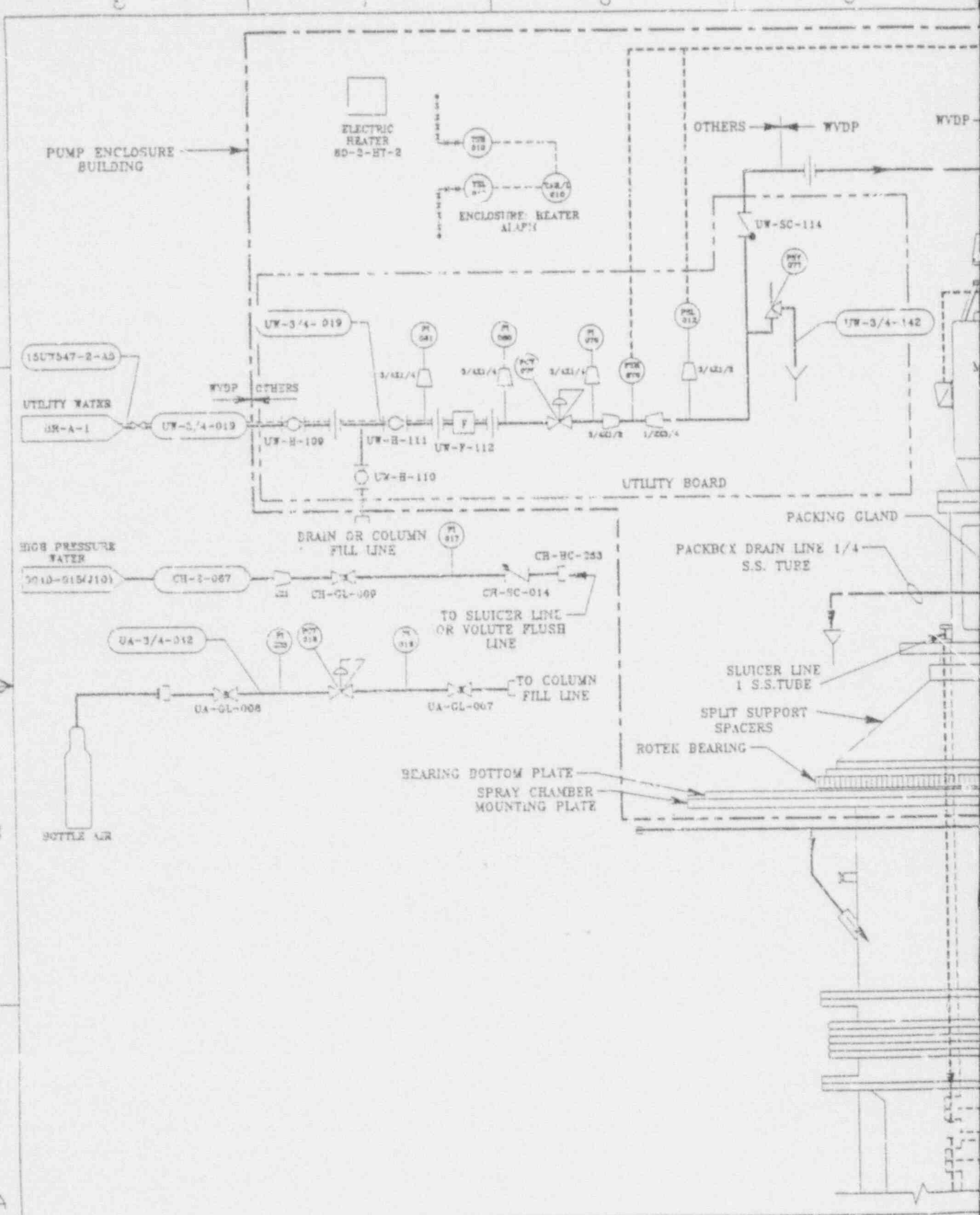


FIGURE D.6.1-11



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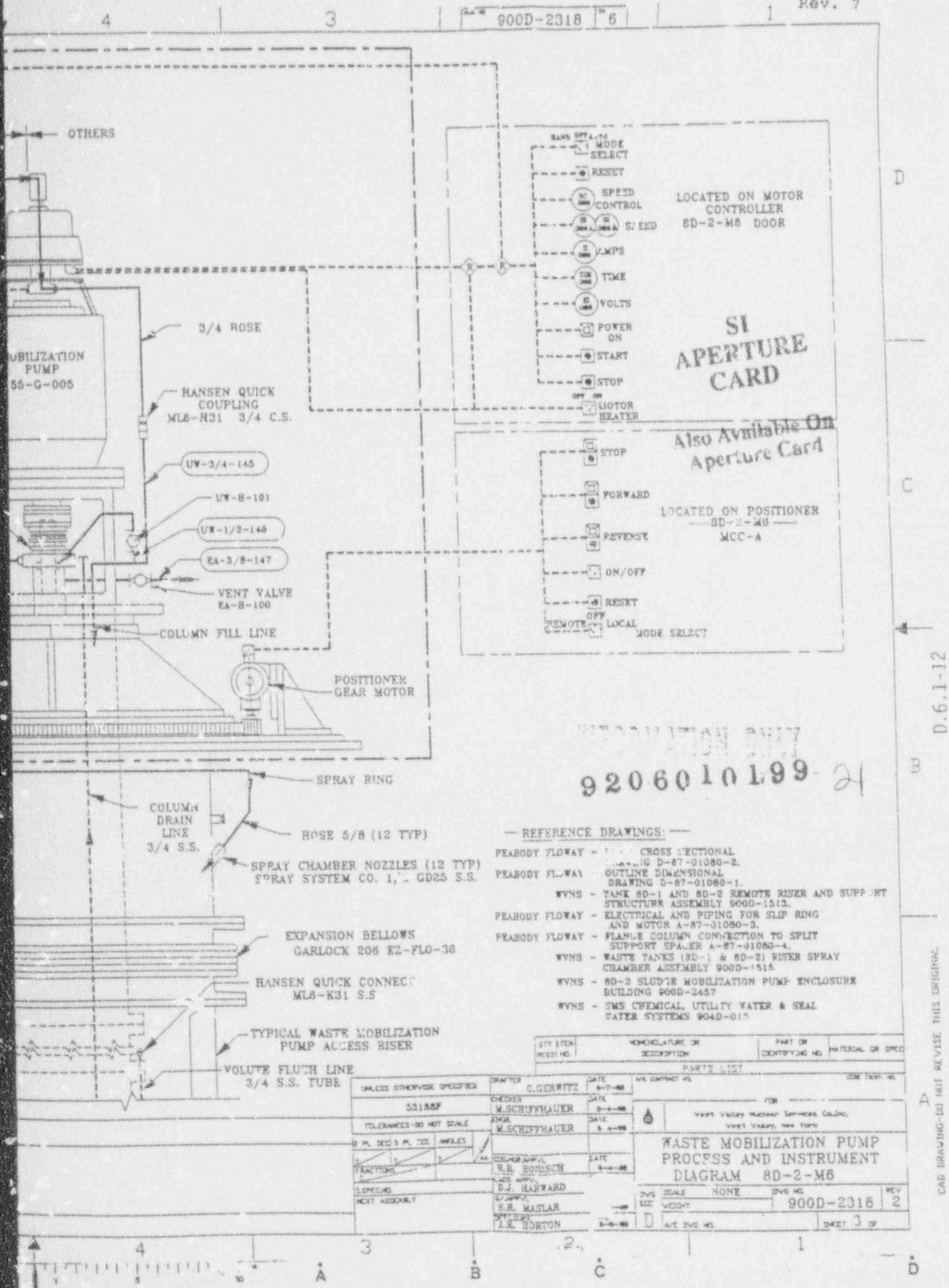
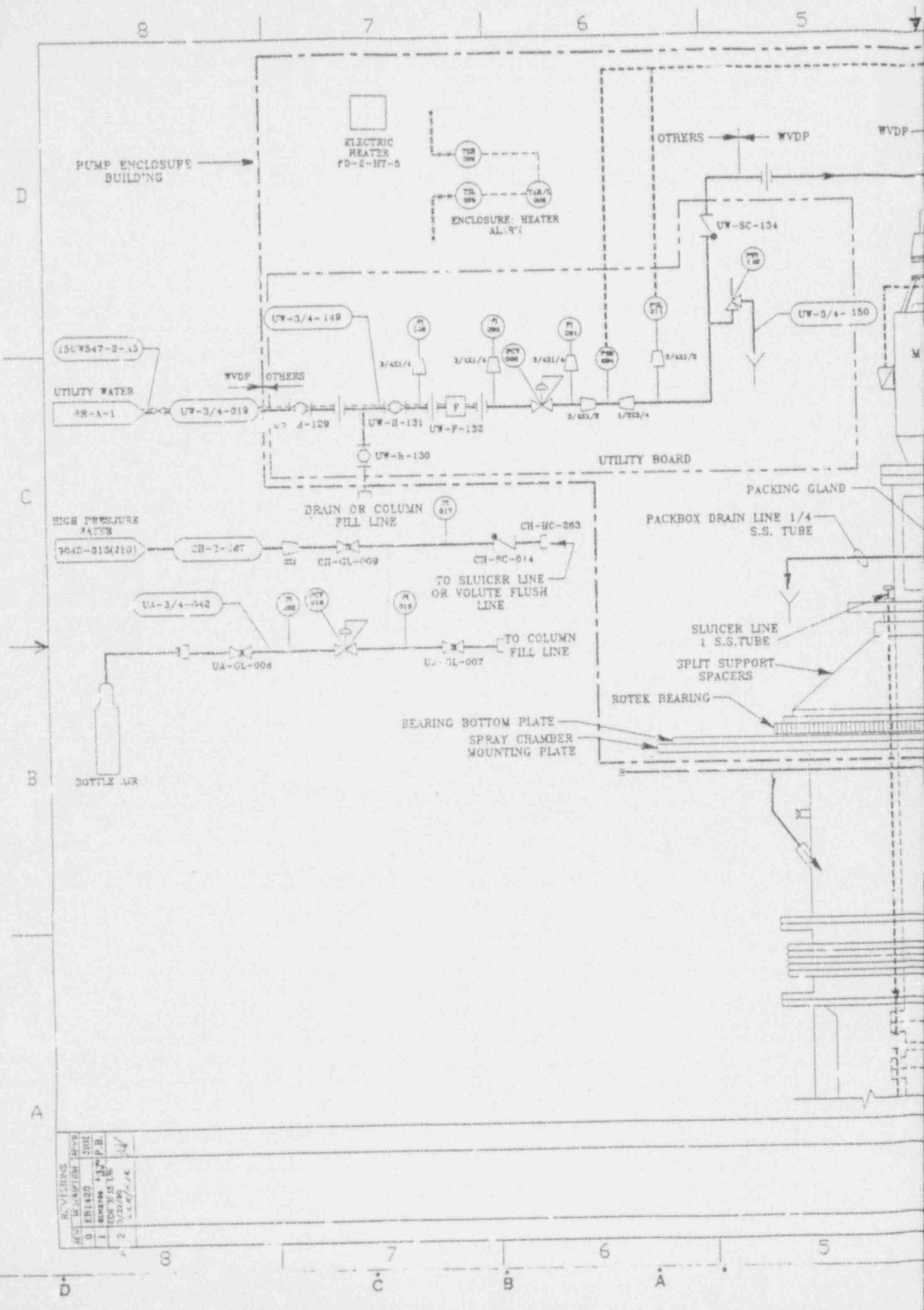
2	ECN 5653 [illegible] 5/21/90	[illegible]


900D-2318
6
OTHERS
MODE SELECT
RESET
SPEED CONTROL
SPEED
AMPS
TIME
VOLTS
POWER ON
START
STOP
MOTOR HEATER
LOCATED ON MOTOR CONTROLLER 8D-2-M6 DOOR
SI APERTURE CARD
Also Available On Aperture Card
STOP
FORWARD
REVERSE
ON/OFF
RESET
REMOTE OFF LOCAL
MODE SELECT
LOCATED ON POSITIONER 8D-2-M6 MCC-A
3/4 HOSE
MOBILIZATION PUMP 55-G-005
HANSEN QUICK COUPLING ML6-R31 3/4 C.S.
UW-3/4-145
UW-H-101
UW-1/2-146
EA-3/8-147
VENT VALVE EA-H-100
COLUMN FILL LINE
POSITIONER GEAR MOTOR
SPRAY RING
COLUMN DRAIN LINE 3/4 S.S.
HOSE 5/8 (12 TYP)
SPRAY CHAMBER NOZZLES (12 TYP)
EXPANSION BELLOWS GARLOCK 206 EZ-FLO-36
HANSEN QUICK CONNECT ML6-K31 S.S
TYPICAL WASTE MOBILIZATION PUMP ACCESS RISER
VOLUTE FLUSH LINE 3/4 S.S. TUBE
9206010199
REFERENCE DRAWINGS:
PEABODY FLOWAY - CROSS SECTIONAL D-67-01080-2.
PEABODY FLOWAY - OUTLINE DIMENSIONAL DRAWING D-67-01080-1.
WVNS - TANK 8D-1 AND 8D-2 REMOTE RISER AND SUPPORT STRUCTURE ASSEMBLY 900D-1513.
PEABODY FLOWAY - ELECTRICAL AND PIPING FOR SLIP RING AND MOTOR A-67-01080-3.
PEABODY FLOWAY - FLANGE COLUMN CONNECTION TO SPLIT SUPPORT SPACER A-67-01080-4.
WVNS - WASTE TANKS (8D-1 & 8D-2) RISER SPRAY CHAMBER ASSEMBLY 900D-1515
WVNS - 8D-2 SLUDGE MOBILIZATION PUMP ENCLOSURE BUILDING 900D-2457
WVNS - SMS CHEMICAL, UTILITY WATER & SEAL WATER SYSTEMS 904D-015
PARTS LIST
C.GERWITZ
M.SCHIFFHAUER
M.SCHIFFHAUER
R.R. BOBISCH
D.J. HARWARD
R.R. MASLAR
J.E. HORTON
West Valley Nuclear Services Co.,Inc.
West Valley, New York
WASTE MOBILIZATION PUMP PROCESS AND INSTRUMENT DIAGRAM 8D-2-M6
SCALE NONE
900D-2318
REV 2
D
SHEET 3
CAD DRAWING-DO NOT REVISE THIS ORIGINAL



PUMP ENCLOSURE BUILDING
ELECTRIC HEATER FD-2-HT-5
ENCLOSURE HEATER ALARM
OTHERS
WVDP
UW-SC-134
UW-3/4-149
UW-3/4-150
15UW547-2-A5
UTILITY WATER
8R-A-1
UW-3/4-019
UW-H-131
UW-F-132
UW-H-130
UTILITY BOARD
PACKING GLAND
PACKBOX DRAIN LINE 1/4 S.S. TUBE
DRAIN OR COLUMN FILL LINE
HIGH PRESSURE WATER
CH-2-147
CH-GL-009
CH-SC-014
CH-HC-263
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-006
UA-GL-007
TO COLUMN FILL LINE
SLUICER LINE 1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
BOTTLE AIR
REVISIONS
REV
DESCRIPTION
APP'D
DATE

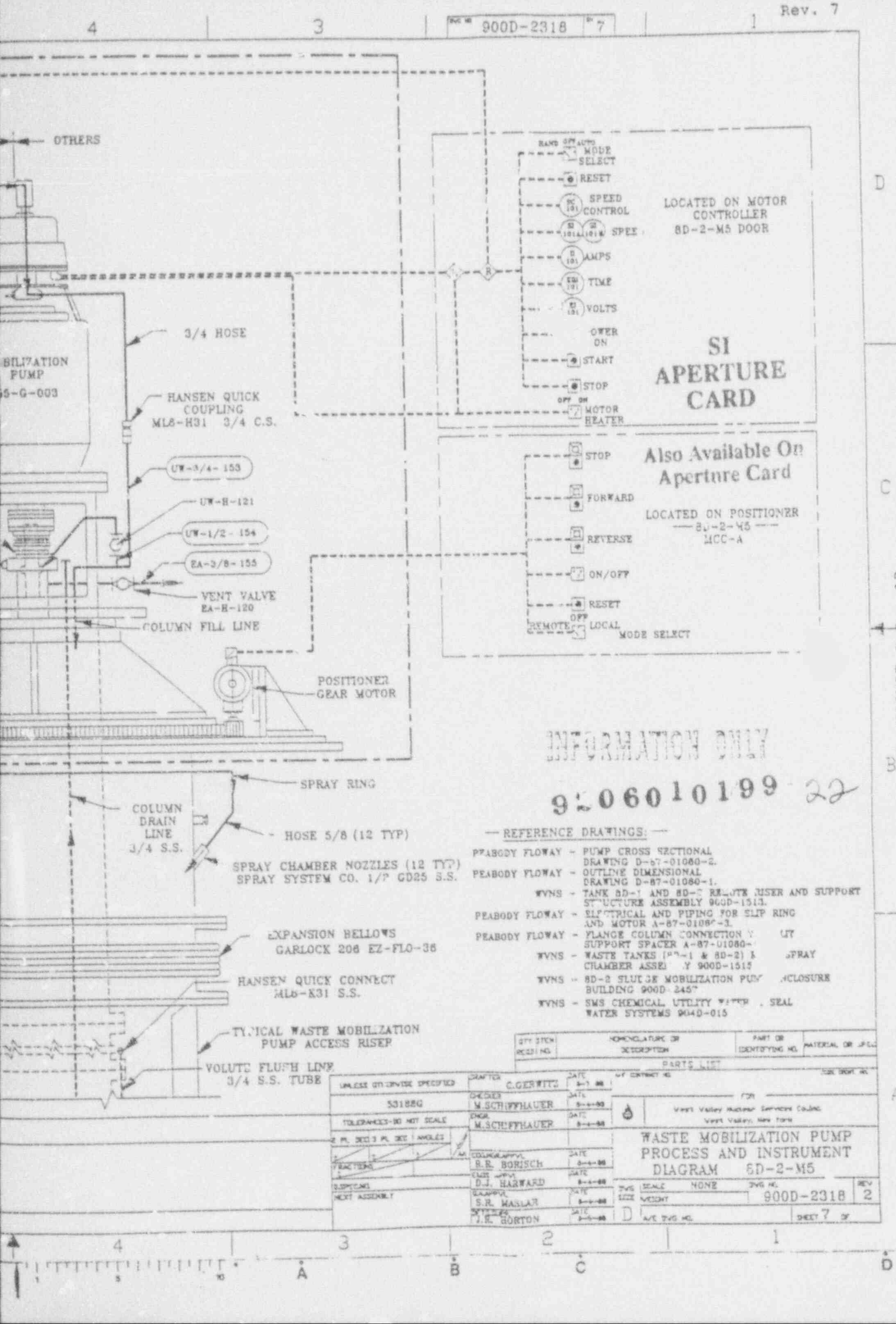
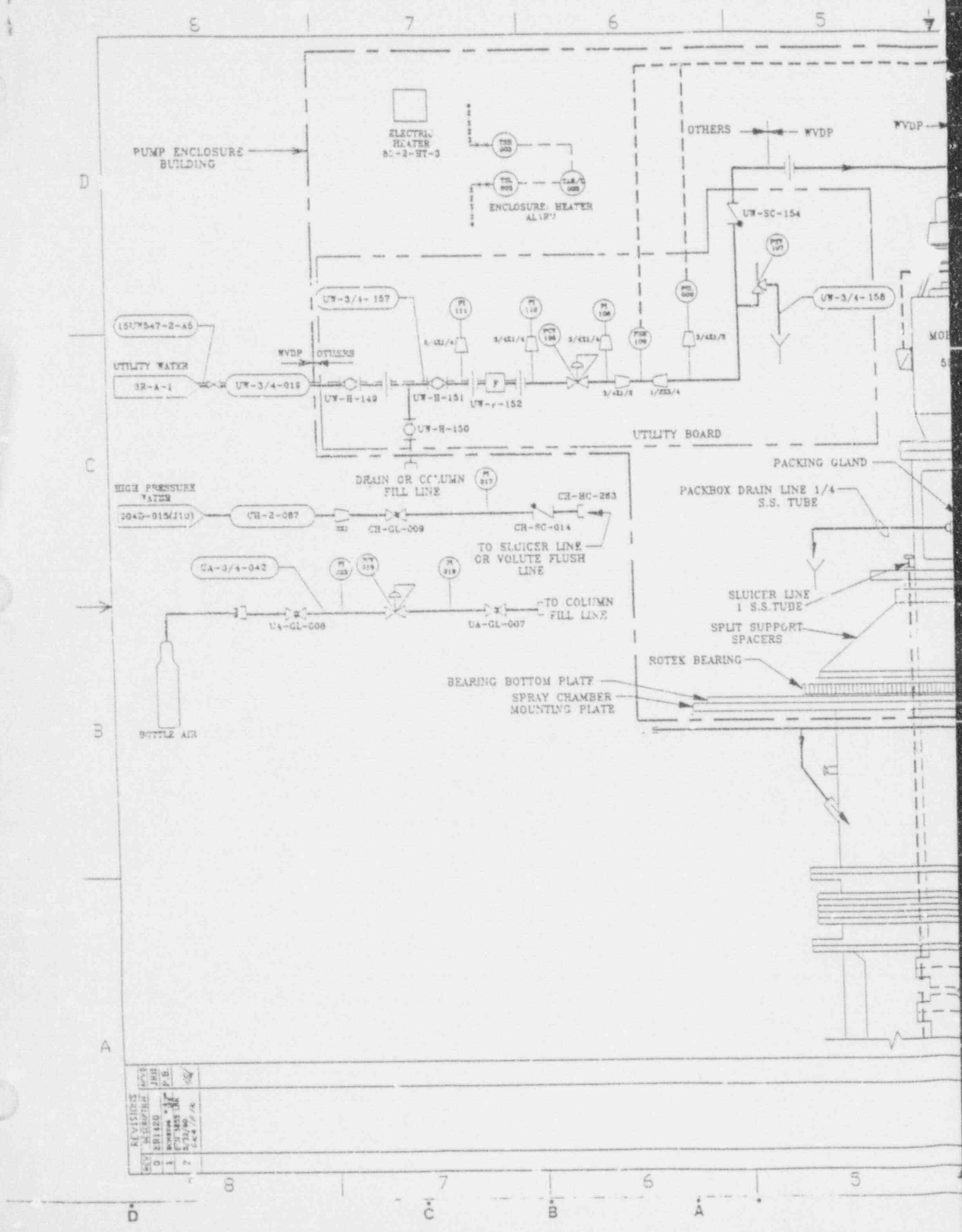


FIGURE D.6.1-13


8
7
6
5
D
C
B
A
PUMP ENCLOSURE BUILDING
ELECTRIC HEATER
TSH
TSL
ENCLOSURE HEATER
OTHERS
WVDP
UW-SC-154
UW-3/4-157
UW-3/4-158
15UW547-2-A5
UTILITY WATER
3R-A-1
UW-3/4-019
UW-H-149
UW-H-151
UW-F-152
UW-H-150
UTILITY BOARD
DRAIN OR COLUMN FILL LINE
HIGH PRESSURE WATER
CH-2-087
CH-GL-009
CH-SC-014
CH-HC-263
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-006
UA-GL-007
TO COLUMN FILL LINE
BOTTLE AIR
PACKING GLAND
PACKBOX DRAIN LINE 1/4 S.S. TUBE
SLUICER LINE 1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
REVISIONS
REV
DESCRIPTION
ER1420
P.B.

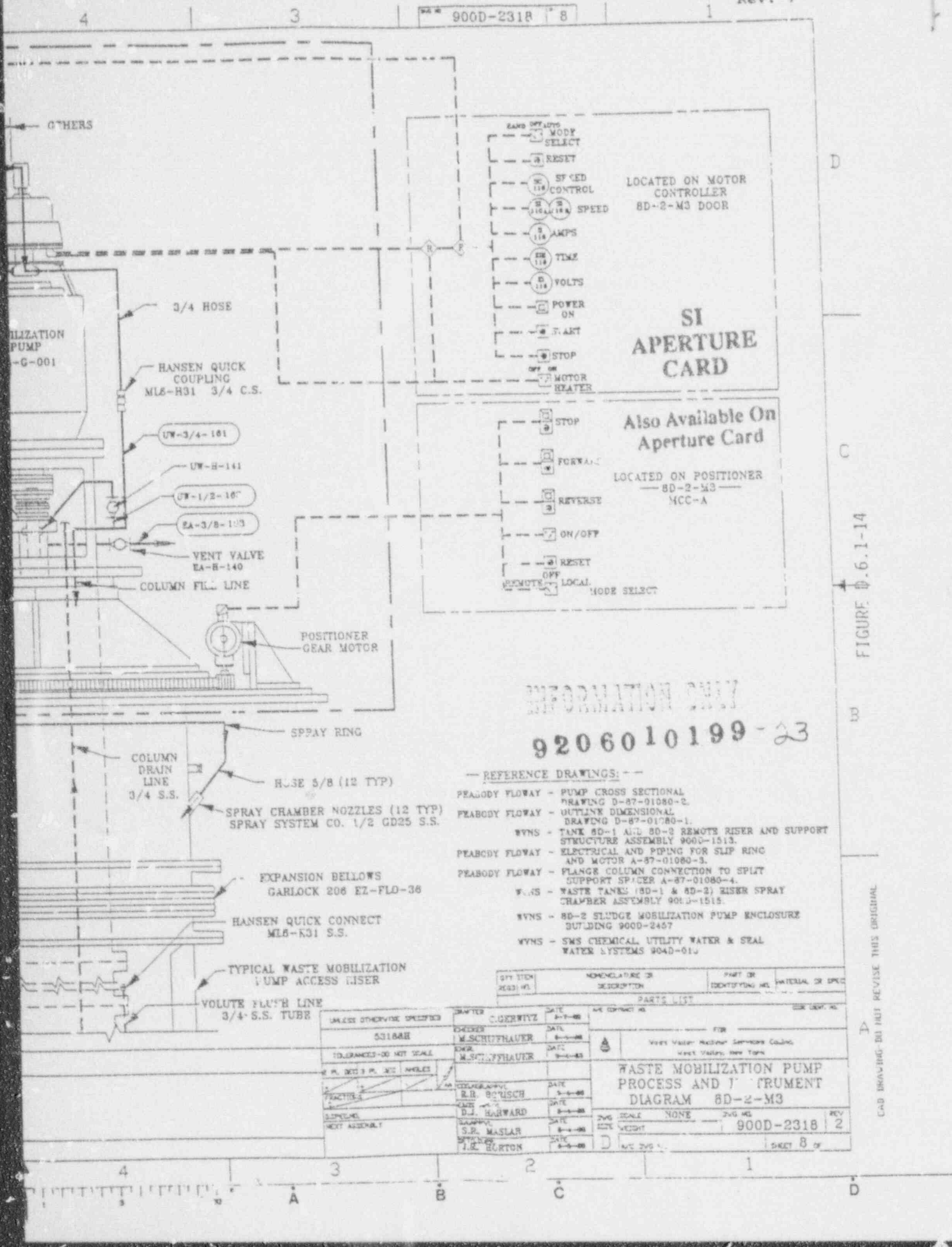
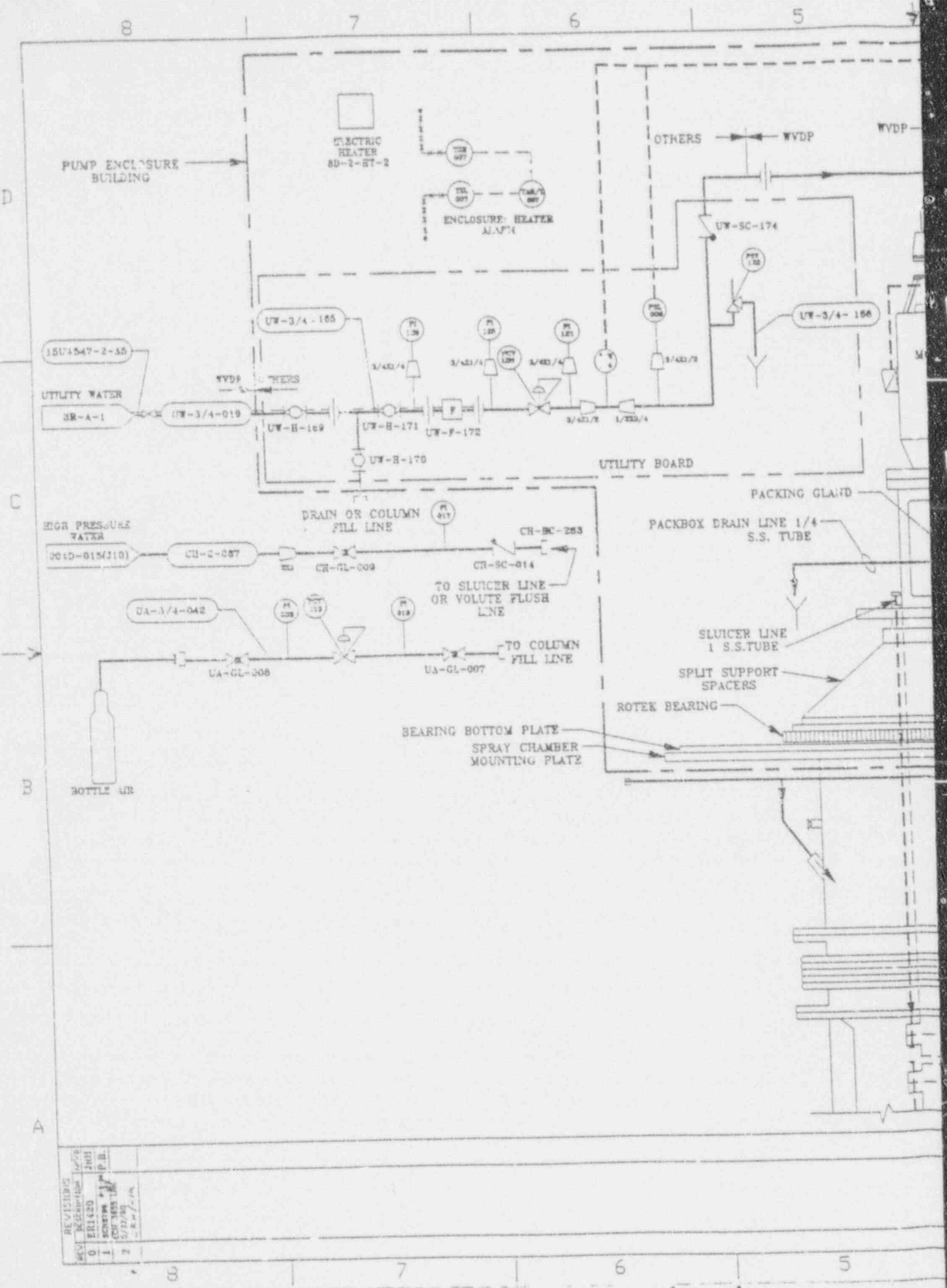


FIGURE D.6.1-14


PUMP ENCLOSURE BUILDING
ELECTRIC HEATER
8D-2-HT-2
ENCLOSURE HEATER ALARM
OTHERS
WVDP
UW-SC-174
UW-3/4-165
UW-3/4-166
UTILITY WATER
UW-3/4-019
UW-H-169
UW-H-171
UW-F-172
UW-H-170
UTILITY BOARD
PACKING GLAND
PACKBOX DRAIN LINE 1/4
S.S. TUBE
HIGH PRESSURE WATER
DRAIN OR COLUMN FILL LINE
CH-GL-009
CH-SC-014
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-3/4-042
UA-GL-008
UA-GL-007
TO COLUMN FILL LINE
SLUICER LINE
1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
BOTTLE AIR
REVISIONS
ER1420

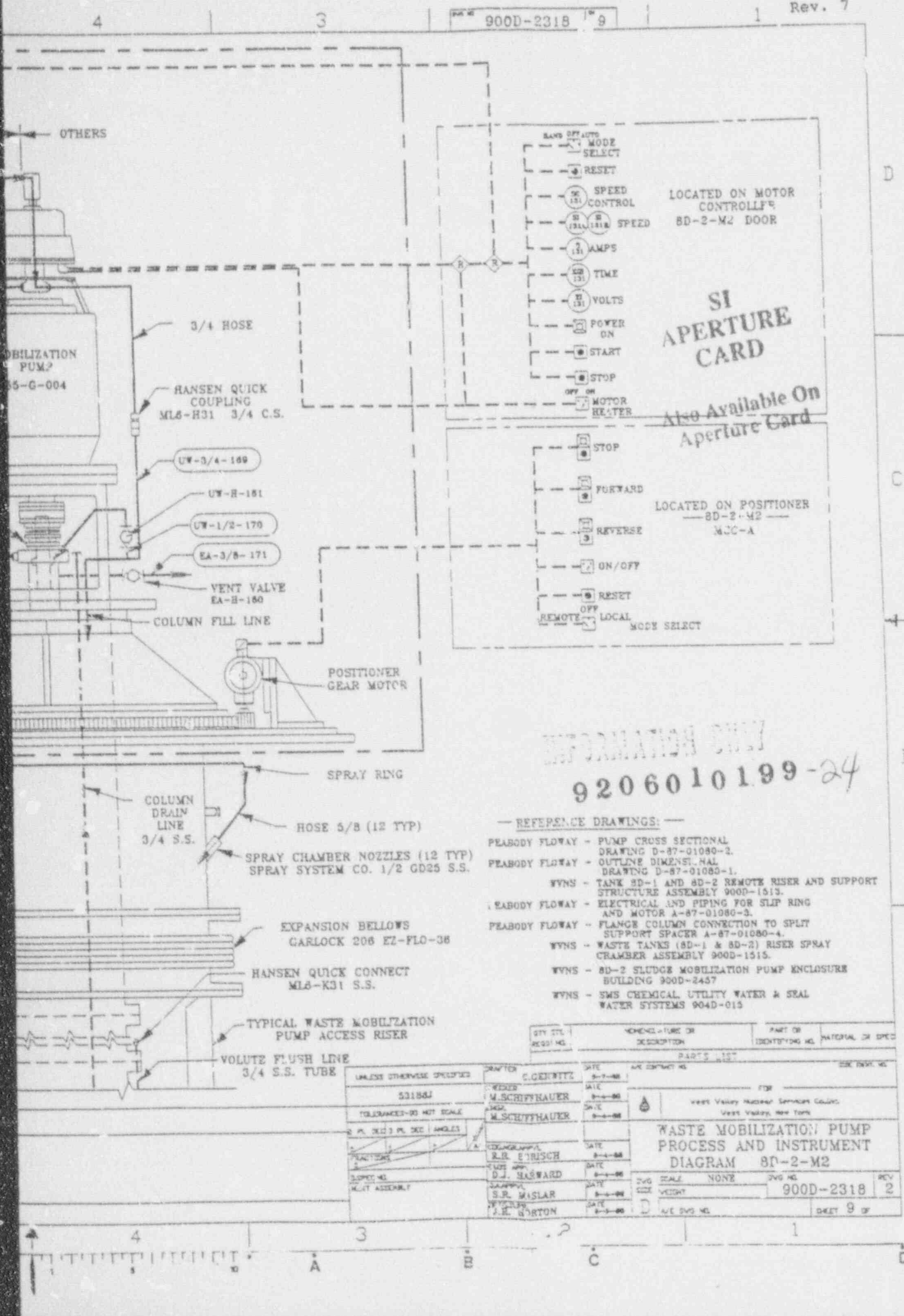
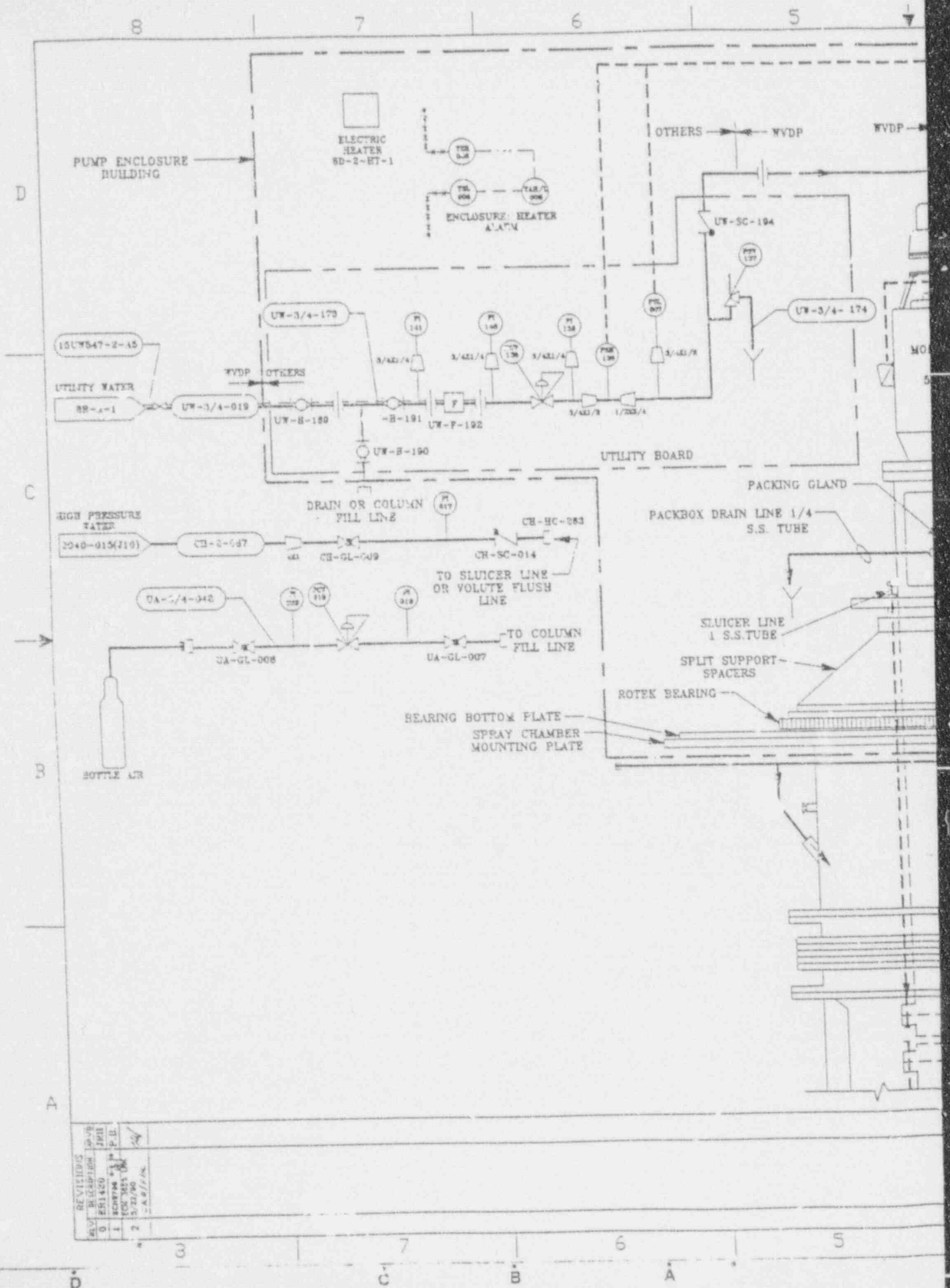


FIGURE D.6.1-15


PUMP ENCLOSURE BUILDING
ELECTRIC HEATER
ENCLOSURE HEATER ALARM
OTHERS
WVDP
UW-SC-194
UW-3/4-174
UW-3/4-170
15UW547-2-A5
UTILITY WATER
UW-3/4-019
OTHERS
UW-B-189
UW-B-191
UW-F-192
UW-B-190
UTILITY BOARD
PACKING GLAND
PACKBOX DRAIN LINE 1/4
S.S. TUBE
DRAIN OR COLUMN FILL LINE
HIGH PRESSURE WATER
CH-SC-014
TO SLUICER LINE OR VOLUTE FLUSH LINE
UA-GL-008
UA-GL-007
TO COLUMN FILL LINE
SLUICER LINE
1 S.S.TUBE
SPLIT SUPPORT SPACERS
ROTEK BEARING
BEARING BOTTOM PLATE
SPRAY CHAMBER MOUNTING PLATE
BOTTLE AIR
REVISIONS

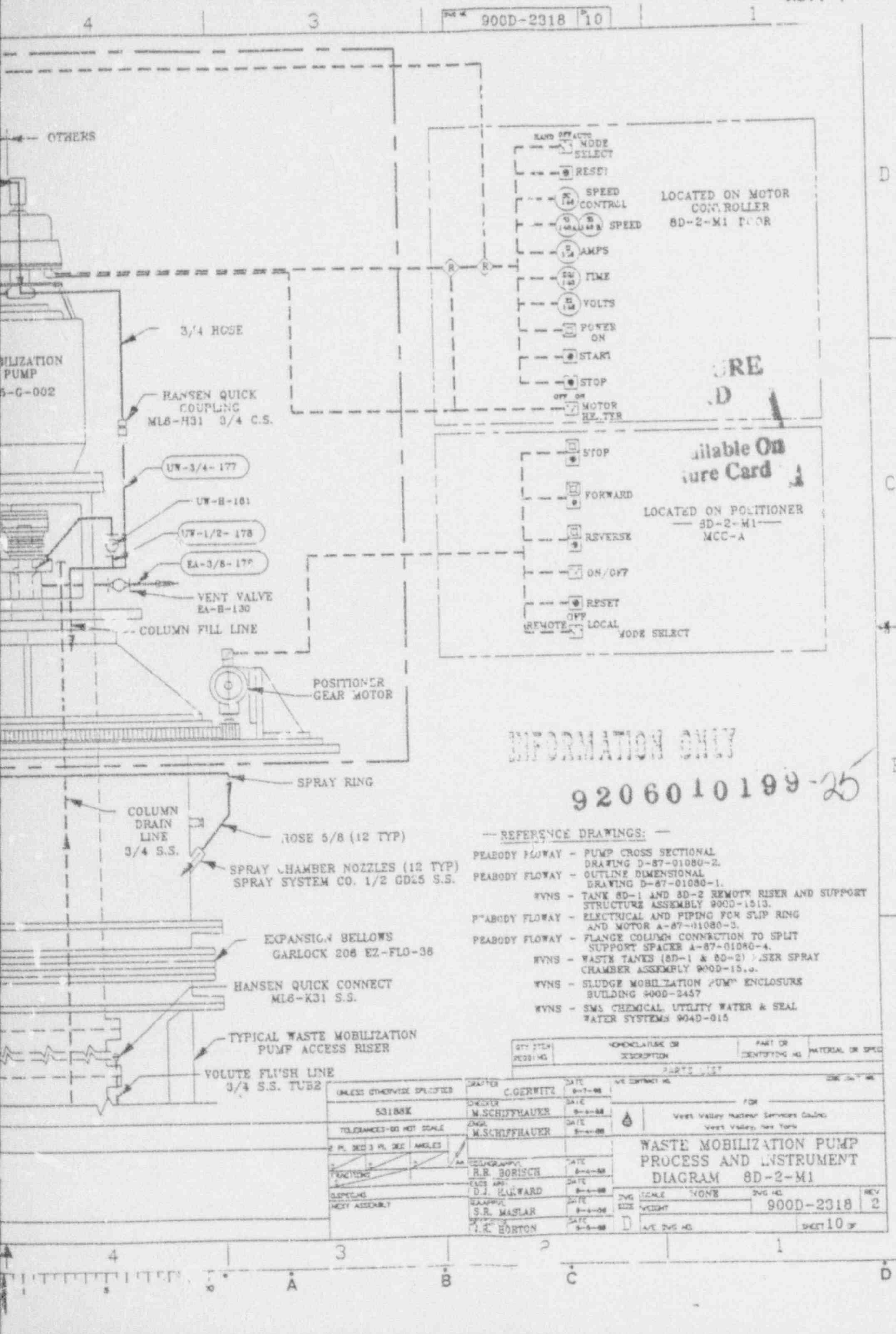
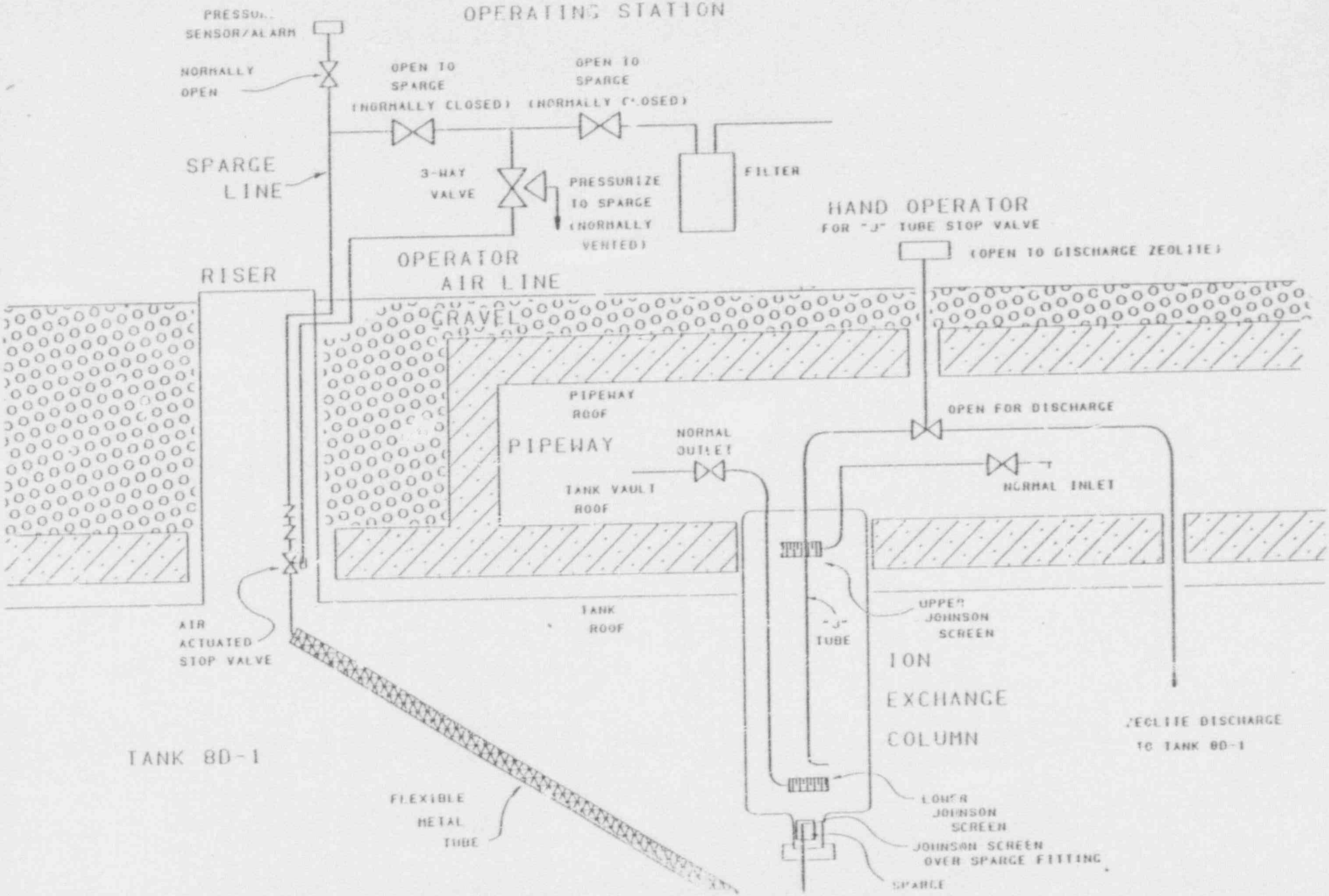
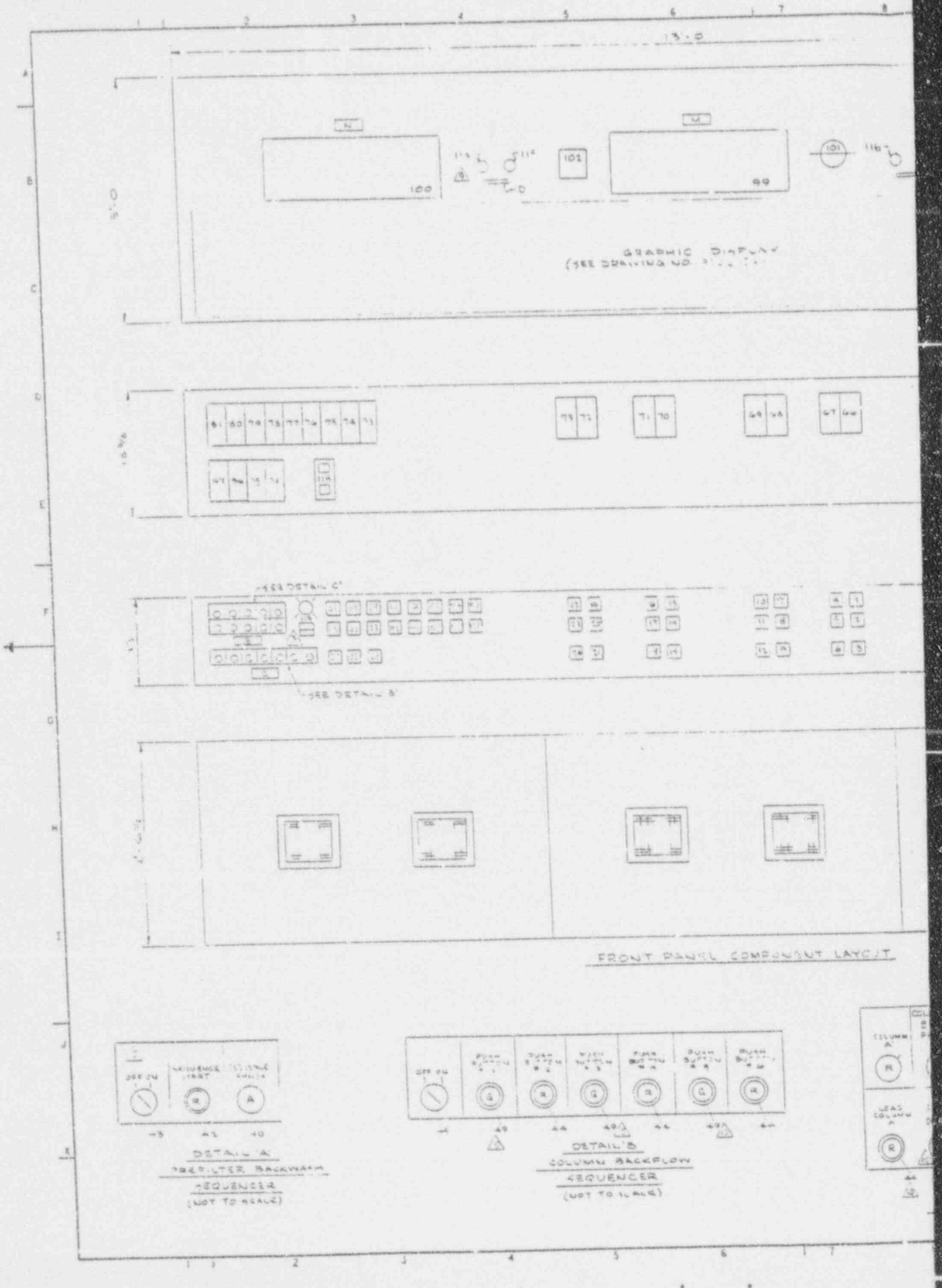


FIGURE D.6.1-16

FIGURE D.6.1-17

SPARGE LINE ADDITION FOR ALTERNATIVE ZEOLITE DISCHARGE METHOD




GRAPHIC DISPLAY
SEE DETAIL 'C'
SEE DETAIL 'B'
FRONT PANEL COMPONENT LAYOUT
DETAIL 'A'
PREFILTER BACKWASH
SEQUENCER
(NOT TO SCALE)
DETAIL 'B'
COLUMN BACKFLOW
SEQUENCER
(NOT TO SCALE)

903-D-372
Sh 1

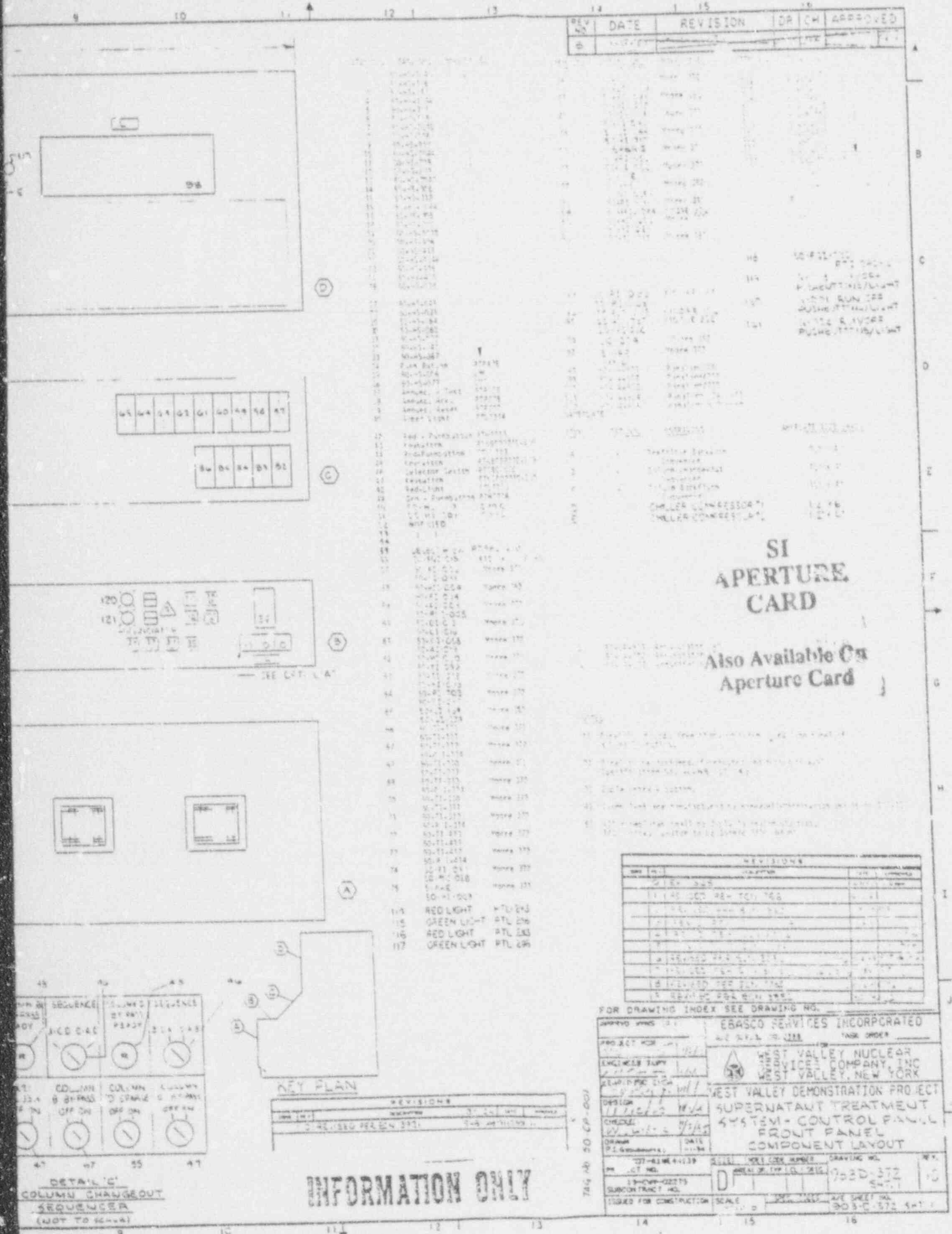
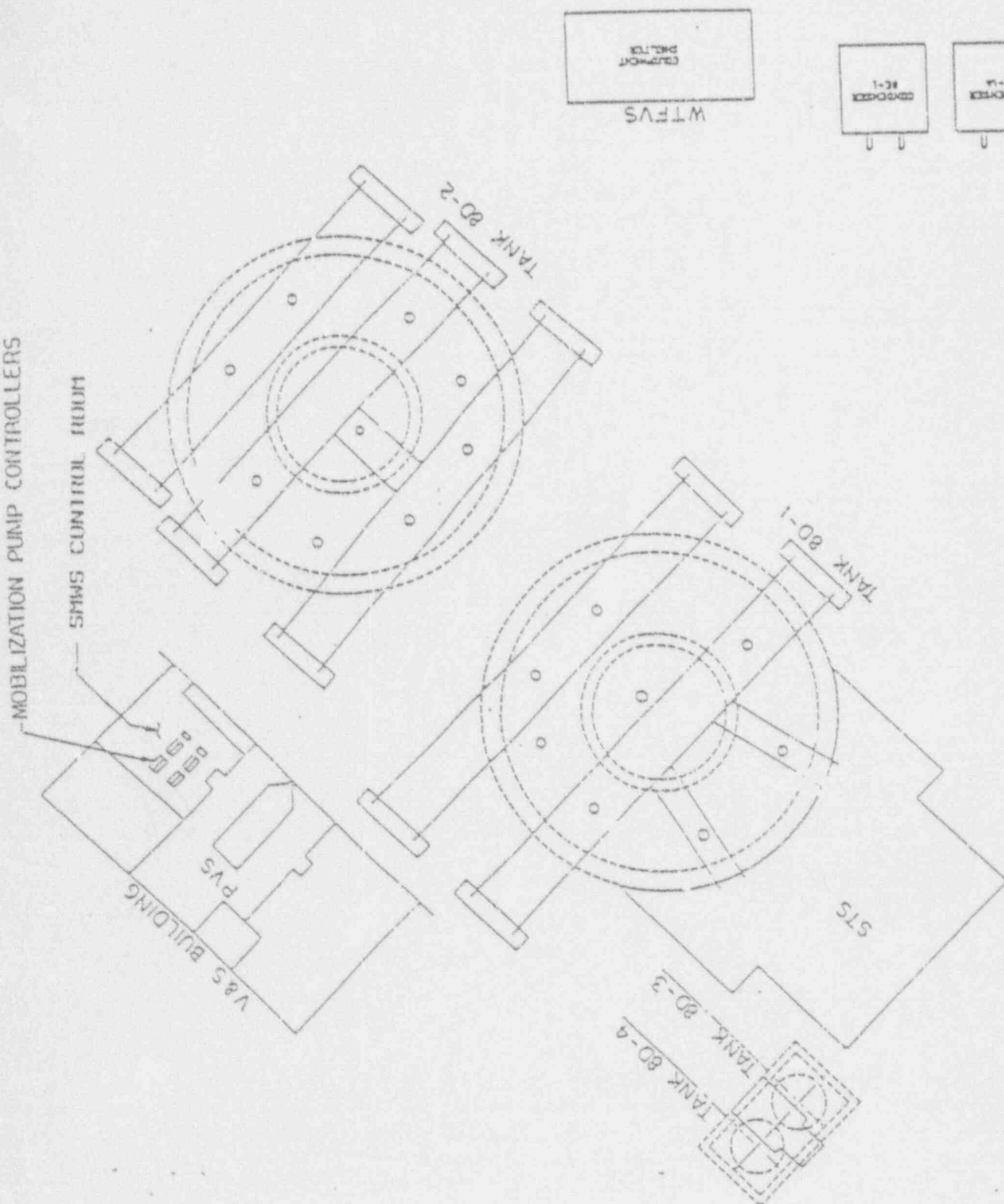


FIGURE D.6.6-1

9206010199-26



V & S BUILDING AND SMWS CONTROL ROOM

FIGURE D.6.6-2

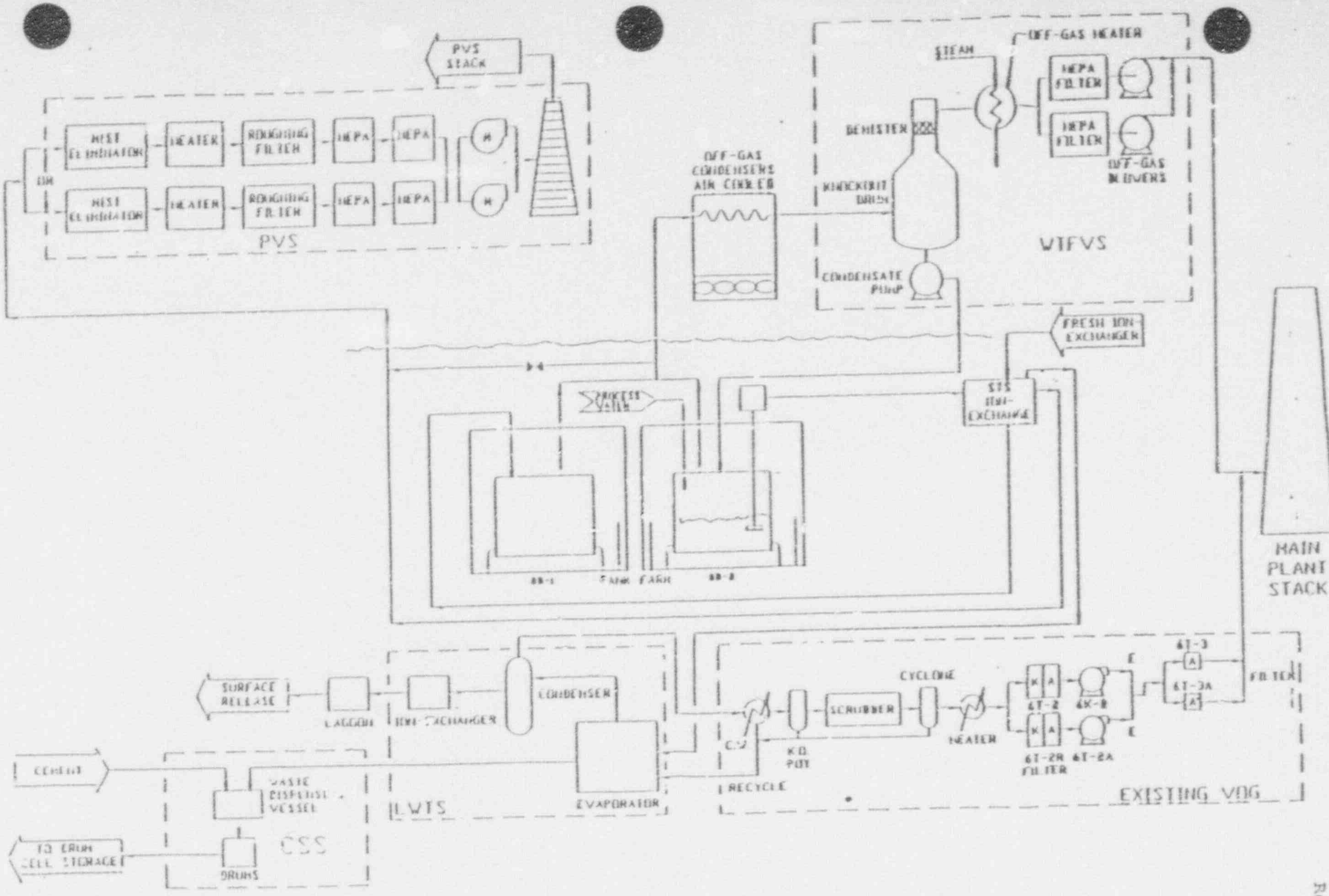


FIGURE D.7.4-1 COMBINED PVS/WTFVS SCHEMATIC

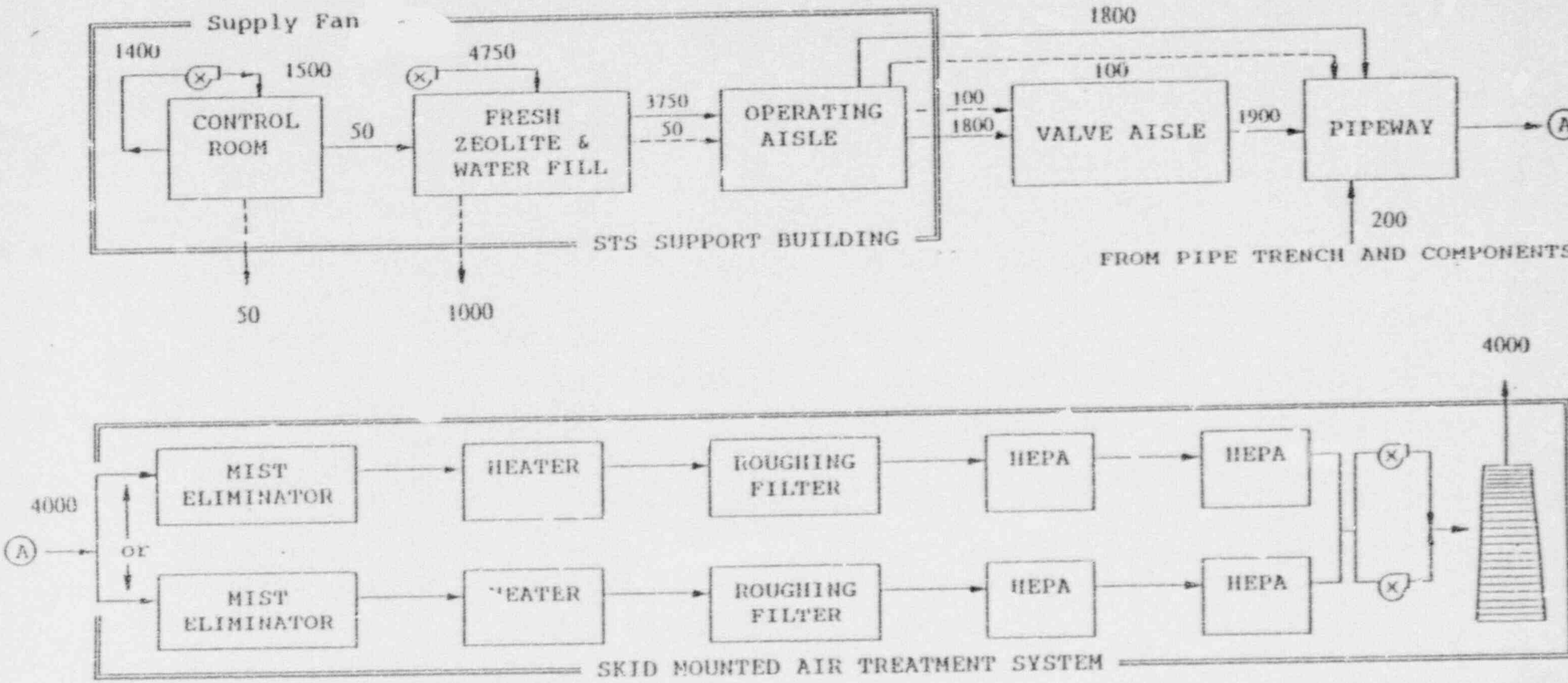


FIGURE D.7.4-2 FLOW DIAGRAM FOR THE STS PERMANENT VENTILATION SYSTEM

(All values in cubic feet per minute)

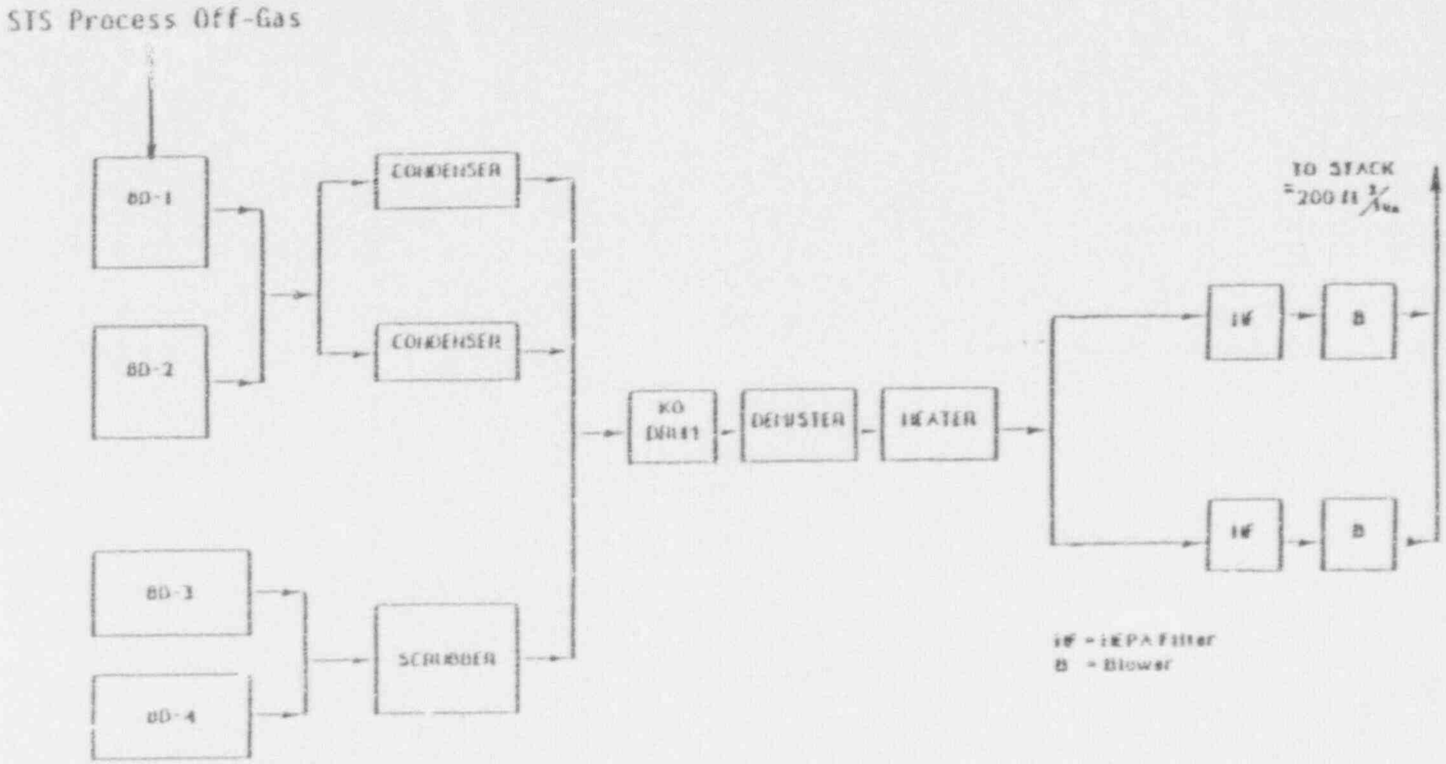
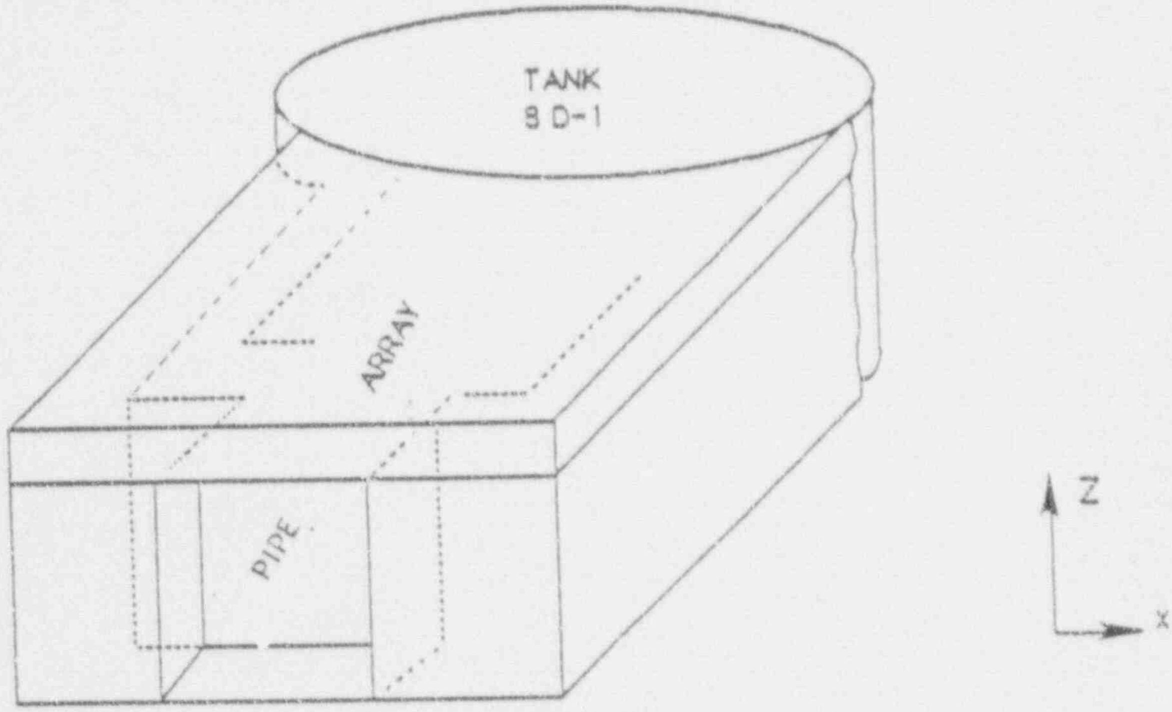
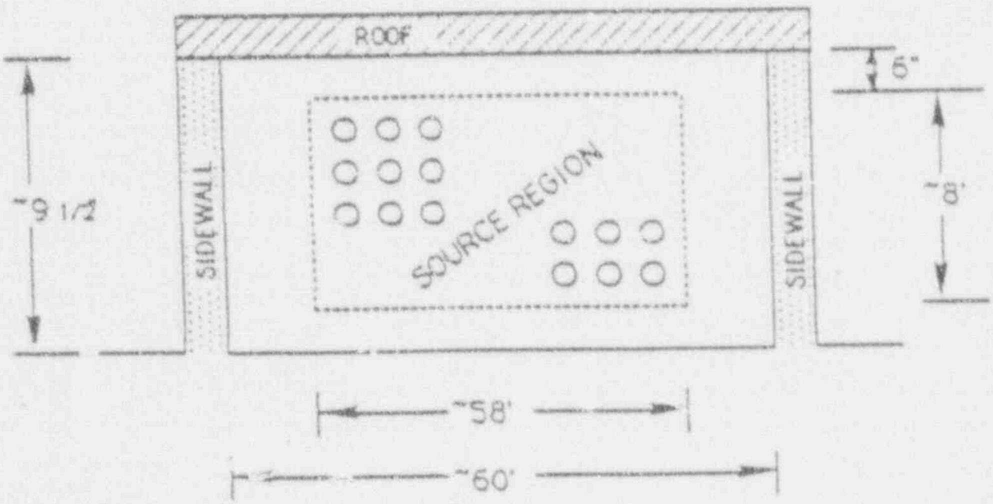


Figure D.7.4-3 Waste Tank Farm Ventilation System

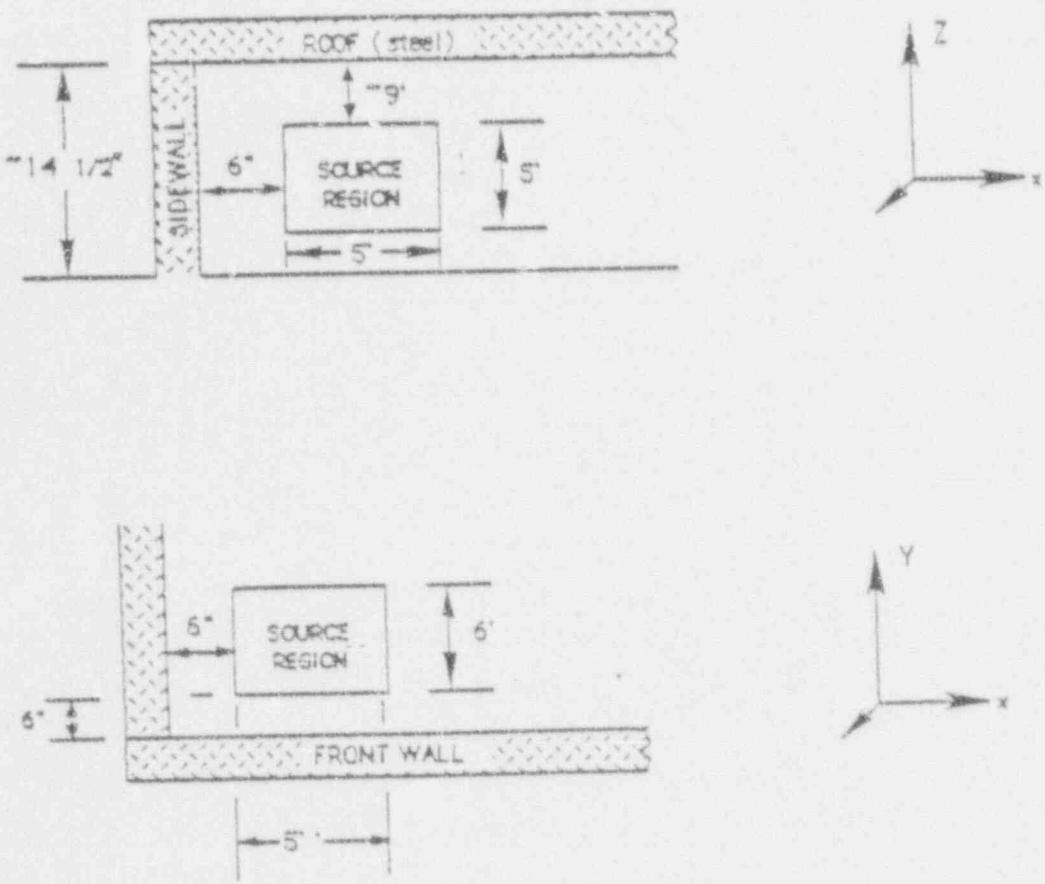


A: STS PIPEWAY STRUCTURE



B: MODEL USED IN ANALYSIS [Concrete walls and roof]

FIGURE D 8.3 -1: SHIELDING MODEL - STS PIPEWAY AREA



STEEL (Iron) SHIELDS

FIGURE D.8.3-2 SHIELDING MODEL - STS VALVE AISLE

FIGURE D.9.2-1
K_{EFF} VERSUS SPHERE RADIUS FOR 1.0 KG ^{239}PU

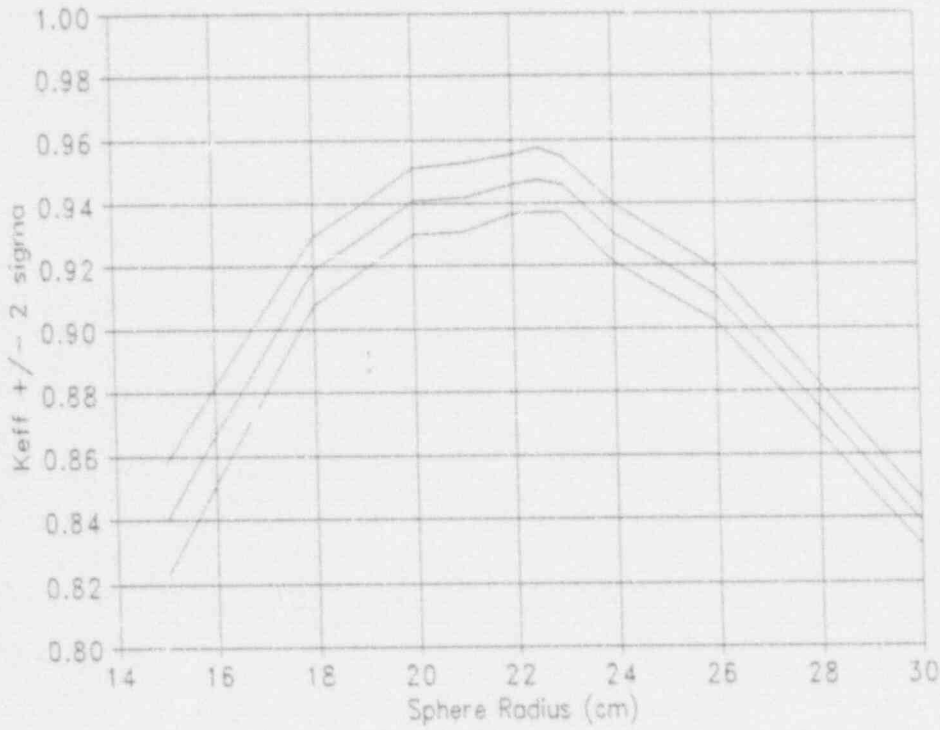


FIGURE D.9.2-2
K_{EFF} VERSUS ^{239}PU MASS IN A 22.5 CM SPHERE

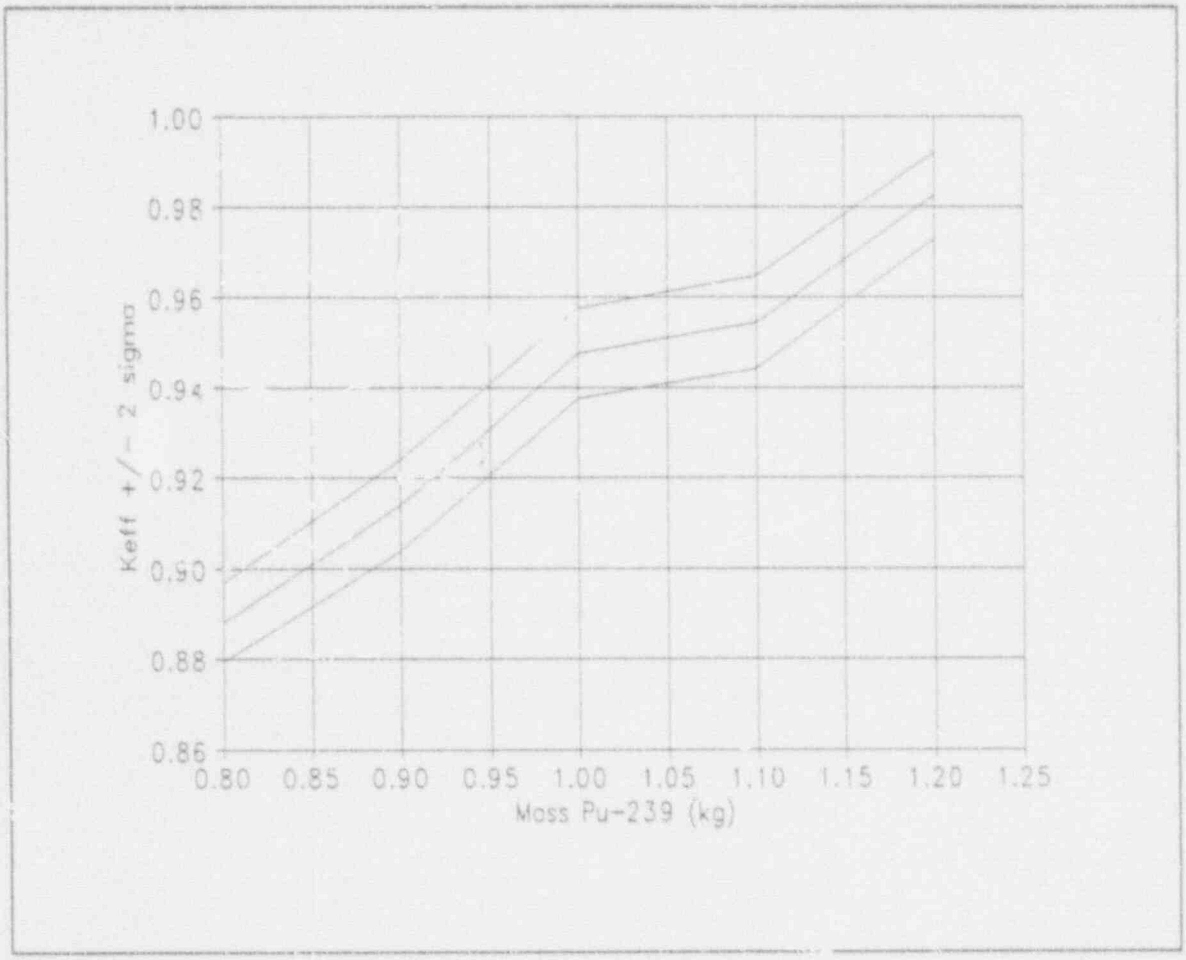


FIGURE D.10.1-1 IRTS ORGANIZATIONAL STRUCTURE