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MOBILE, VARIABLE DEPTH SAMPLING SYSTEM DESIGN STUDY

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U.S. Department of Energy Contract DE-AC06-96RL13200

Key Words: Sampling system, Tank waste, At-tank analysis, Pre-Conceptual Design, RCRA Sampler, Mobile, variable depth sampler, double-shell, LAW, HLW.

Abstract: A design study is presented for a mobile, variable depth sampling system (MVDSS) that will support the treatment and immobilization of Hanford LAW and HLW. The sampler can be deployed in a 4-inch tank riser and has a design that is based on requirements identified in the Level 2 Specification (latest revision). The waste feed sequence for the MVDSS is based on Phase I, Case 3S6 waste feed sequence. Technical information is also presented that supports the design study.
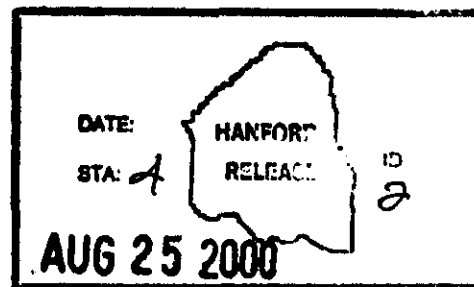
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MOBILE, VARIABLE DEPTH SAMPLING SYSTEM DESIGN STUDY

HNF 6735 Revision 0

Prepared For
River Protection Project
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Richland, Washington

August 2000

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ACRONYMS AND ABBREVIATIONS

ALARA – As low as reasonably achievable.
ATAS – At-tank analysis system
AEAT – AEA Technology Engineering Services, Inc.
Barg – Bar, gauge (one bar equals 1 atmosphere)
cp – Centipoise (10^{-2} poise)
DST – Double-shell tank
HLAN – Hanford Local Area Network
HLW – High level waste
ID – Inside diameter
KVA – 10^3 volt-ampere
LAW – Low activity waste
LLCE – Long length contaminated equipment
MVDSS – Mobile, variable depth sampling system
OD – Outside diameter
PWSS – Process waste sample subsystem
RCRA – Resource Conservation Recovery Act
RFD – Reverse flow diverter.
RPP – River Protection Project
TBD – To be determined
WFD – Waste feed delivery
wt% - Percent by weight

Acknowledgement

1.0 Introduction

The River Protection Program (RPP) has the responsibility to treat and immobilize the highly radioactive Hanford Site tank waste (Tanks Waste Remediation System Privatization Contract DE-AC06-96RL13308, Mod. No. A006, 1998, U.S. Department of Energy, Richland, Washington). Prior to transfer to the treatment and immobilization plant, waste samples of waste batches will be taken and sample material will be analyzed in the 222S laboratory to verify the waste batches meet the low activity waste (LAW) and high level waste (HLW) envelopes (waste envelopes A, B, C, and D), archived, and provided to the LAW/LAW plant operator, as required by the vitrification project (BNFL-5193-ID-19, Rev. 4e, 2000 and BNFL-5193-ID-20, Rev. 4f, 2000).

A design study has been completed for a mobile, variable depth sampling system (MVDSS) that will provide this sampling function. This sampling system will be part of the DST Process Waste Sampling Subsystem (PWSS) that provides sampling support for Waste Feed Delivery (WFD) (Rassmussen, 2000a). The PWSS consists of structures and components that obtain samples of DST contents, perform any field observations or analyses of the samples, and deliver samples to laboratories for subsequent detailed analysis. The overall definitions for performance requirements and the requisite codes and standards to be applied to this MVDSS are identified in the Level 2 Specification (Reich, 1999) that flow down from, *Double-Shell Tank Process Waste Sampling Subsystem Specification* (Rassmussen, 2000b).

This document describes a concept for an MVDSS and also contains technical information that was identified during the completion of the design study. Portions of this concept borrow on equipment already in use for core sampling of Hanford's tank wastes. This document is not a requirements document. The design study was based on the current Level 2 Specification (Reich, 1999). The technical information in this document will be used to revise the current Level 2 Specification.

2.0 MVDSS Design Study Concept

The MVDSS is based on a modular concept that includes both in-tank and above ground hardware modules as indicated in Figure 1. The main include:

- Segmented mast
- Fluidic pumping system charge vessel and reverse flow diverter (RFD)
- Tank riser interface
- Sampling system platform
- Variable depth sampling system
- Sample bottle filling system
- Utility trailer(s)

The MVDSS will also provide an interface for an at-tank analysis system (ATAS). The ATAS was not part of this design study and will be addressed in future conceptual design activities.

The above-ground modules are moveable and will be capable of being used with any of the LAW and HLW feed tanks with changes in interface hardware that will accommodate variations in tank risers (diameter and flange elevations). The in-tank mast, charge vessel and RFD, riser interface, and support platform can remain installed on a specific tank until all sampling needs are met. The in-tank components will then be disposed of as contaminated hardware when they are removed from a tank. However, the riser interface and its supporting platform may be re-used on other tanks.

The specifications and criteria for the MVDSS are contained in the Level 2 Specification (Reich, 1999). This includes the following:

- Provide LAW and HLW waste samples from Phase 1 DST feed staging tanks that are chemically and physically representative of the waste contents in a feed batch as required for DST waste processing and final disposal
- Allow relatively large volumes of sample material to be obtained with minimal impact from weather conditions currently affecting the baseline, grab sampling method, and without adverse impacts from other in-tank operations, including mixer pumps, decanting operations, etc.
- Fill 500-mL sample bottles capable of meeting RCRA criteria for volatile and semi-volatile organics and package them for shipping with the Hanford Site Pig transportation (Steel Pig, Shipping Pig, and N55 over-pack) system.
- While the DST mixer pumps are operating, provide representative samples from any elevation in the waste, with a sample elevation positioning accuracy of ± 1.0-inch.
- Provide sampling at a rate such that 10 liters of samples may be obtained within an 8-hour period, consisting of at least two 500-mL samples obtained from at least 8 different tank waste elevations.
- Include spray wash, waste flushing hardware to decontaminate waste contacting surfaces and waste disposal via a drain system back into the waste tank.

- Provide a design, with construction and deployment methods, that is compatible with the waste, the tank dome airspace, tank farm environments and meets all tank farm requirements including dimensional limits, riser and dome loading limits and environmental, safety, and regulatory criteria.
- Provide radiation shielding and contamination control as required by tank farms system deployed in LAW and HLW tanks.
- Provide a waste loop and utilities interface for the operation of an at-tank analysis system (ATAS).

2.1 Sample Bottle Filling System

The sample bottle filling system and the fluidic pumping system, including the charge vessel and RFD and its Jet-Pump air pressure/vacuum driver system will be provided by AEAT. These modules will be installed in the MVDSS and will require coordination of interfaces to assure that the system requirements in the Level 2 Specification can be met.

2.2 Segmented Mast

The segmented mast is designed to be deployed in a 4-inch tank riser which will allow sampling for all of the LAW and HLW waste batches in the feed tanks defined by the Phase I, Case 3S6 waste feed sequence (see Figures 5 and 6) (Kirkbride, 2000). This segmented mast is similar in structure to the drill string that the current core truck system deploys.

A proposed mast concept is indicated in Figure 2. The segmented mast is made up of 5-foot long sections of 3½ inch outside diameter drill rod. These sections will be attached to each other with 4 pitch square thread and then tightened (torque level is TBD). The fluidic pumping system charge vessel and RFD will ride up and down inside the segmented mast, which is open and clear, with "clothes-line" cable concept. The lowest mast section will have a pulley unit to guide the "pay-out" cable that is connected to the bottom of the charge vessel/fluidic pump and is used to pull these components downward. The flexible hoses connected to the top of the charge vessel (waste and air/vacuum hoses) will pull the charge vessel upward (hose bundle may include a cable member). The cable and the hoses will act like a "clothes-line" pulley system and provide sampling (positive positioning) from any tank waste batch elevation.

The mast sections that are below the maximum anticipated waste level will have a slot in the side, as indicated in Figure 2, so the RFD sampling inlet has direct access to the tank waste. The mast segments will be fabricated and assembled so that their slots are vertically aligned when installed. A rail or pins, on the inside of the mast, will prevent the rotation of the RFD and charge vessel so that it is aligned with the slit for access to tank waste.

The weight of the mast will be supported by the sampling system platform through the riser interface. The upper, last mast segment will be a transition piece that connects the mast to the riser interface. The length of this upper mast segment can be modified so that the bottom of the

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mast is located just above the bottom of a waste tank. The riser interface will provide lateral and vertical support for the mast. The mast will experience lateral forces from the mixer pumps that will also be installed in the feed tanks (see Appendix A).

The mast will be deployed using a hoist that will lower the mast into the tank as each section is added (see Figure 3). A footclamp assembly will support the deployed sections while additional sections are attached. The transition piece and the fluidic pump will be installed to complete the mast installation process. The hoist system will also be used to recover the contaminated mast segments, charge vessel, and RFD in the manner currently used with the core truck sampling system drill string. As an option, the long length contaminated equipment (LLCE) system could also be used for recovery and disposal without the need to dismantle the mast into short segments.

2.3 Riser Interface

A riser interface module (see Figure 3) is the interface between the segmented mast and the variable depth sampling module and provides horizontal and lateral support for the mast. The tank riser interface contains a large valve or a plug, a drill rod spray washer with a pipe wiper that provides a seal between the mast and the drill rod washer, a foot-clamp assembly, and adapters to interface with the tank riser, as indicated in Figure 4. The valve will allow the MVDSS, with the exception of the sampling system platform and riser interface to be removed from the tank while maintaining tank containment. A drill rod washer provides the means to wash the mast and the charge vessel and RFD components as they are removed for disposal. The foot-clamp is used to support the mast or mast sections during deployment, sampling operations, and retrieval

Interface hardware, including riser spool piece, will be custom designed for each waste tank riser and will accommodate riser size and flange elevation variations between the waste tanks as some of the risers are below grade. This riser interface will allow the MVDSS to be deployed in different sized risers (the minimum riser size is 4 inches)..

2.4 Sampling System Platform

As indicated in Figure 1, the sampling system platform provides the support base for the following modules:
- Sample bottle filling system
- Variable depth hose reel system
- At-tank analysis system
- Control system

The sampling system platform is positioned over a tank riser and can be supported by adjustable height legs setting on dunnage that can be installed at grade level around the riser.

This will enable the platform to be leveled and adjusted for variations in riser flange elevations. The sampling platform interfaces with the mast through the riser interface module. An operator "cat-walk" or man-lift may be provided on the platform. The structural strength of the sampling platform supports the total weight of the modules located on it.

2.4.1 Variable Depth Hose Reel

The variable depth hose reel module interfaces with the waste tank through the tank riser interface module, as shown in Figure 4. The variable depth hose reel module contains two reel systems. This module provides waste, utility, and structural interfaces for the at-tank analysis system and the sample bottle filling system. The vertical drum reel contains a flexible waste sampling hose and flexible fluidic pump drive hose (air and vacuum to drive the charge vessel). It provides a hose "take-up" function that raises and lowers the charge vessel and RFD inside the mast. A second reel provides a "pay-out" function for the cable that is attached to the bottom of the charge vessel and wrapped around on the lowest mast segment. The two reels are synchronized so that there is minimal slack in the flexible hoses and cable.

The flexible waste hose that is attached to the charge vessel is used to position the RFD to sample waste at any elevation within the tank. The hose reel is oriented vertically to allow it to self-drain. Waste loop piping is included in the variable depth sampling system so that waste can be pumped through the system without porting it through the sample bottle filling system or the at-tank analysis system. The variable depth hose reel enclosure also includes piping for drain waste and flush water that is used to remove residual waste from the sample bottle filling system and ATAS, back into the waste tank (a single return/drain pipe may be sufficient). Valve manifolds in this module control the porting of waste, flush water, and residual waste.

The variable depth hose reel housing is shielded to limit the dose that operators will acquire when operating the system. The AEAT furnished jet pump drive and its valve control manifold are also located in this housing.

2.4.2 Control System

The MVDSS is operated from a control panel mounted on the sampling platform. The control system is mounted in an environmentally controlled enclosure. All operational functions of the MVDSS, with the exception of sample bottle handling, will be controlled by the locally mounted control system. The operator interfaces with the sampling system through the discrete control devices that are mounted on the control panel. A ruggedized operator interface panel may be required. The MVDSS operations controlled from the local control system include the following:

- Fluidic pumping system monitoring and control.
- At-tank sensor system data readout

- All interlocks, actuators, and status indicators required to support safe operation and waste containment.
- Data acquisition and interfacing. Data will be stored locally on a temporary basis. Data ports mounted in or on the control enclosure will be provided for electronic data transfer and hardcopy generation. A Hanford Local Area Network (HLAN) connection will also be provided.
- Electrical power monitoring.
- Flush water control and monitoring.

Control System power conditioning equipment for buffering and fusing the electrical power will be included in the control panel.

2.4.3 Fluidic Pumping System - Charge Vessel and RFD

The waste sampling uses the AEAT pumping system that is based on their fluidic RFD pumping technology. The design of the fluidic pumping system will be completed by AEAT and is not part of this design study. The mast provides the "rail" on which the fluidic pump charge vessel and RFD components will ride up and down inside the tank. The outlet from the fluidic pump will be connected to flexible hose on the variable hose reel system. The charge vessel pumping drive is from a AEAT provided jet-pump system. As indicated in Figure 4, the jet-pump system is housed in the variable depth sampling system enclosure.

2.5 Utility Trailers

The electrical power source for the utility support module is provided by a motor-driven electrical generator: 110 volt, 60 Hz power for light duty power needs and potentially 480 volt, 60 Hz for heavy-duty power needs. The utility trailers provide a portable platform for the power distribution panel, for the air compressor (size is TBD) and accumulator, and the 150 gal water supply tank and a high pressure pump. The utility trailers may also provide storage for tools and mast sections. The utilities that are required to operate the MVDSS include electrical power, compressed air, and flush water.

An environmental enclosure protects the electrical systems from adverse tank farm environmental conditions. A separate electrical connection is provided to enable the MVDSS to use tank farm electrical power when the system is in extended standby (maintain temperature control and etc.). Sensors and transducers provide status for the utilities during the operation of the sampling and at-tank analysis systems that is input to the data acquisition system.

Water for flushing and/or decontamination is provided from a temperature-controlled water reservoir mounted on a separate trailer. The water level in the reservoir and the rate of flow from the reservoir are some of the data that will be input to the data acquisition system.
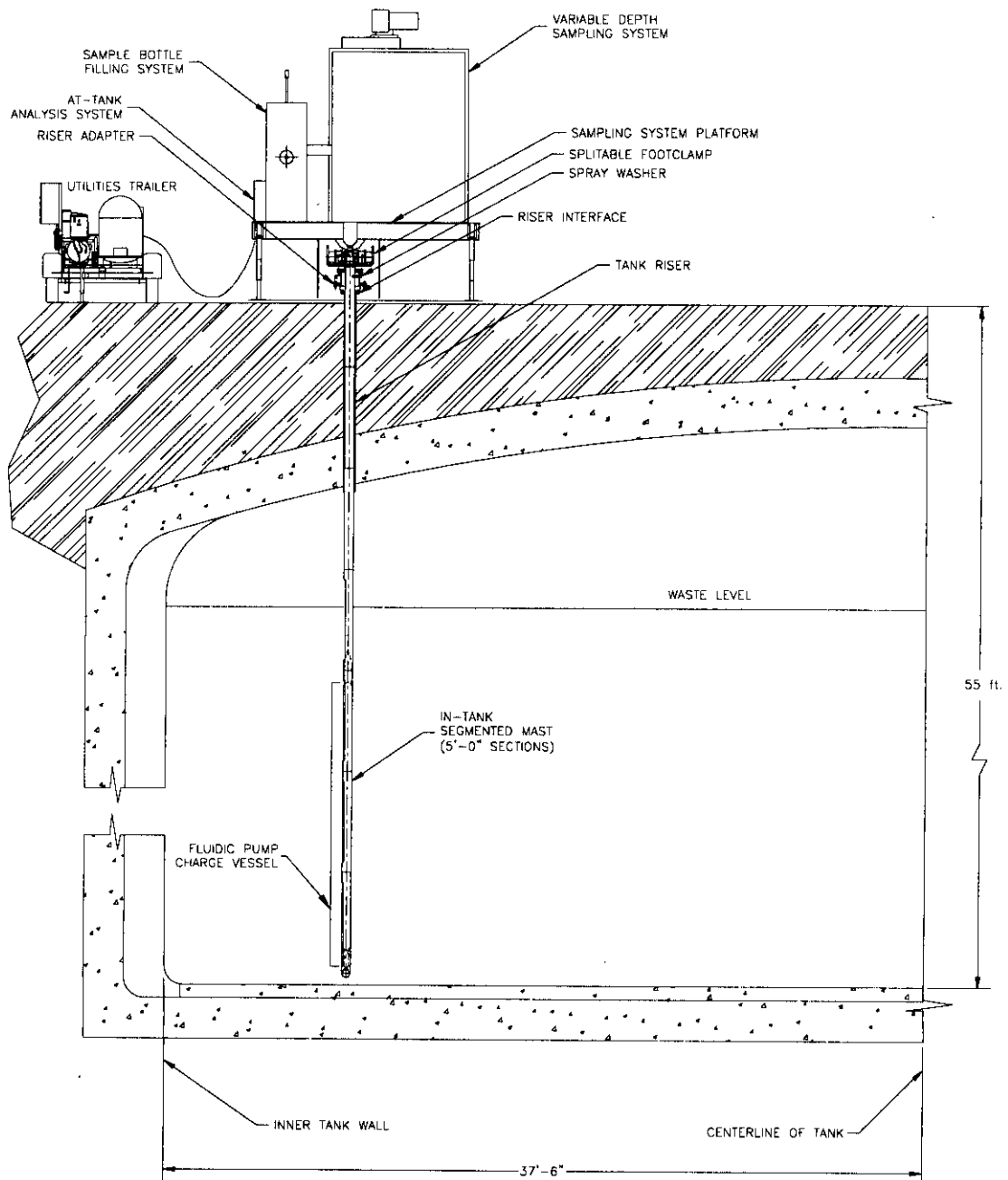
Figure 1 Mobile, Variable Depth Sampling System with an At-Tank Analysis System deployed in a Double-Shell Tank

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4 PITCH
MALE SQUARE THREAD

5'-0"

4 PITCH
FEMALE SQUARE THREAD

3 1/2 OD DRILL ROD
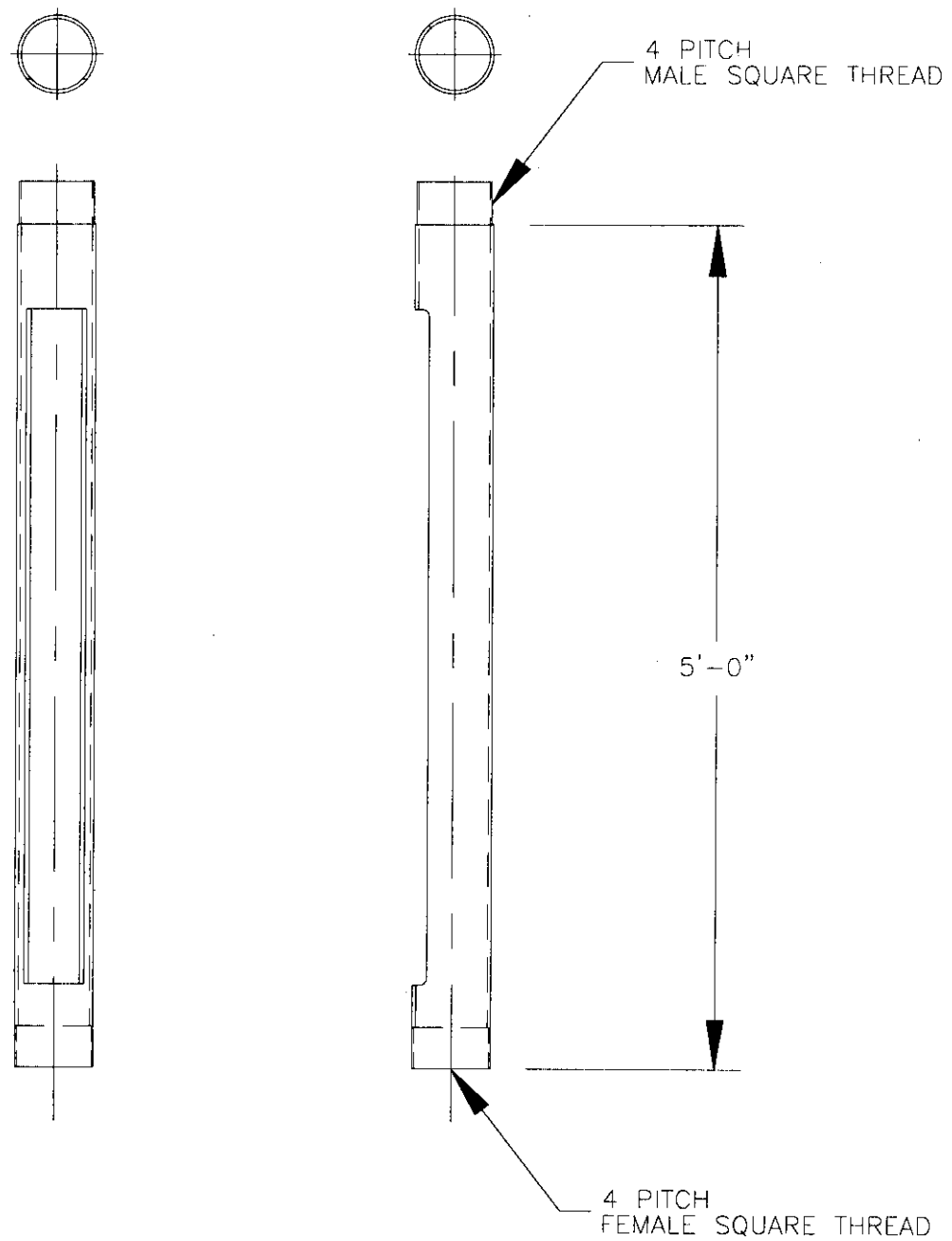
Figure 2 Typical MVDSS mast segment constructed from 3 ½ -inch outside diameter drill rod
that has a slot for access to tank waste.

CHAIN HOIST

CABLE SLING

5000 LB CAPACITY
A-FRAME WITH CHAIN
HOIST

SPLITABLE FOOTCLAMP
(REMOVED WHEN
LAST SECTION INSERTED)

SPRAY WASHER

4" RISER

SEGMENTED MAST
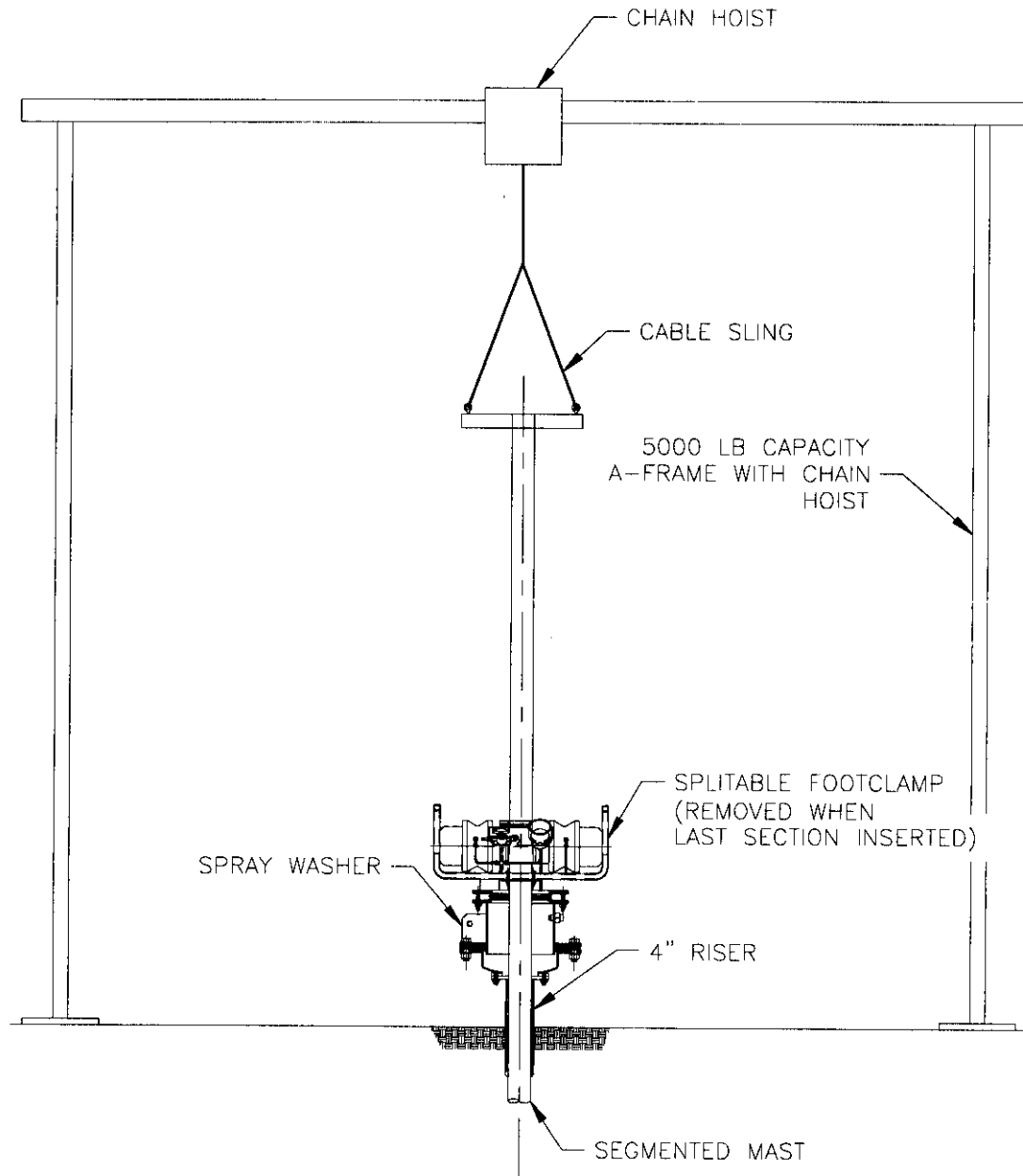
Figure 3 Installation (and removal) of the in-tank mast using an" A-Frame" hoist.
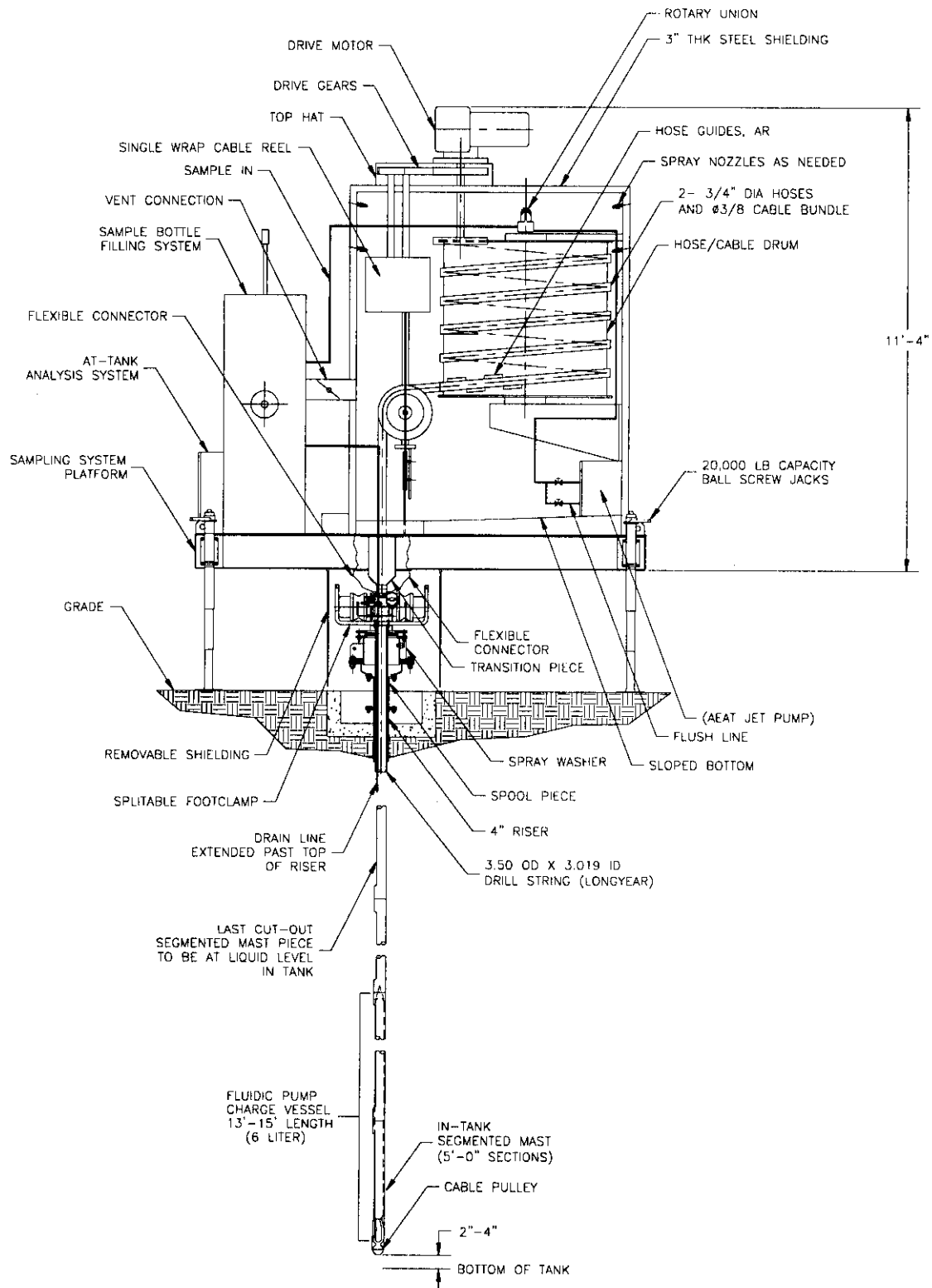
Figure 4 Side view of the MVDSS showing the details of its modules.

3.0 Technical Data

The MVDSS concept, shown in Section 2.0, is based on the Level 2 Specification (Reich, 1999) and technical information included in this section. The technical information in this section does not constitute design requirements at this juncture. However, it will be used, as appropriate, to revise and update the Level 2 Specification.

The LAW and HLW waste batch feed staging sequences that this MVDSS will provide waste sampling is the Phase 1, Case 3S6 shown in Figures 5 and 6 (Kirkbride, 2000). The sampling system would be installed in the staging tanks where the waste is staged just prior to transfer to the LAW/HLW plant.

LOW-ACTIVITY WASTE FEED STAGING SEQUENCECASE 3S6 PHASE I

ENVELOPE	SOURCE TANK		STAGING TANK	BATCH
A	AP-101			1
A			PRETREAT B' WASTE	2
C	AN-102	SUPERNATE		3
		SUPERNATE		4
A	AN-104	DISSOLVED SOLIDS		5
		SUPERNATE	AN-101	6
C	AN-107	SUPERNATE		7
A	AN-105	SUPERNATE	AN-102	8
		DISSOLVED SOLIDS		9
A	SY-101	SUPERNATE	SY-102 → AP-104	10
		SUPERNATE	SY-102 → AN-101	11
A	AN-103	SUPERNATE	AN-102	12
		DISSOLVED SOLIDS		13
A	AW-101	SUPERNATE	AN-105	14
		DISSOLVED SOLIDS		15
A	AW-104 (SWL)	SUPERNATE	AP-104	16
A	SY-103	SUPERNATE	AN-101	17
A	AP-106 (SWL)	SUPERNATE	AN-102	18
		SUPERNATE		19
C	S-102 (S-103, S-105)	SALTCAKE DISSOLUTION	SY-103 → AN-104 → AP-101	20
C	S-105 (S-106, S-108)	SALTCAKE DISSOLUTION	SY-103 → AN-104 → AN-105	21
A	AP-105 (SWL)	SUPERNATE	AP-104	22
				23
A	AP-108			24

MINIMUM ORDER
EXTENDED

Figure 5 Low-Activity Waste Feed Staging Sequence for Phase 1, Case 3S6 (HNF-SD-WM-SP-012).

HIGH-LEVEL WASTE FEED STAGING SEQUENCE-CASE 3S6 PHASE 1
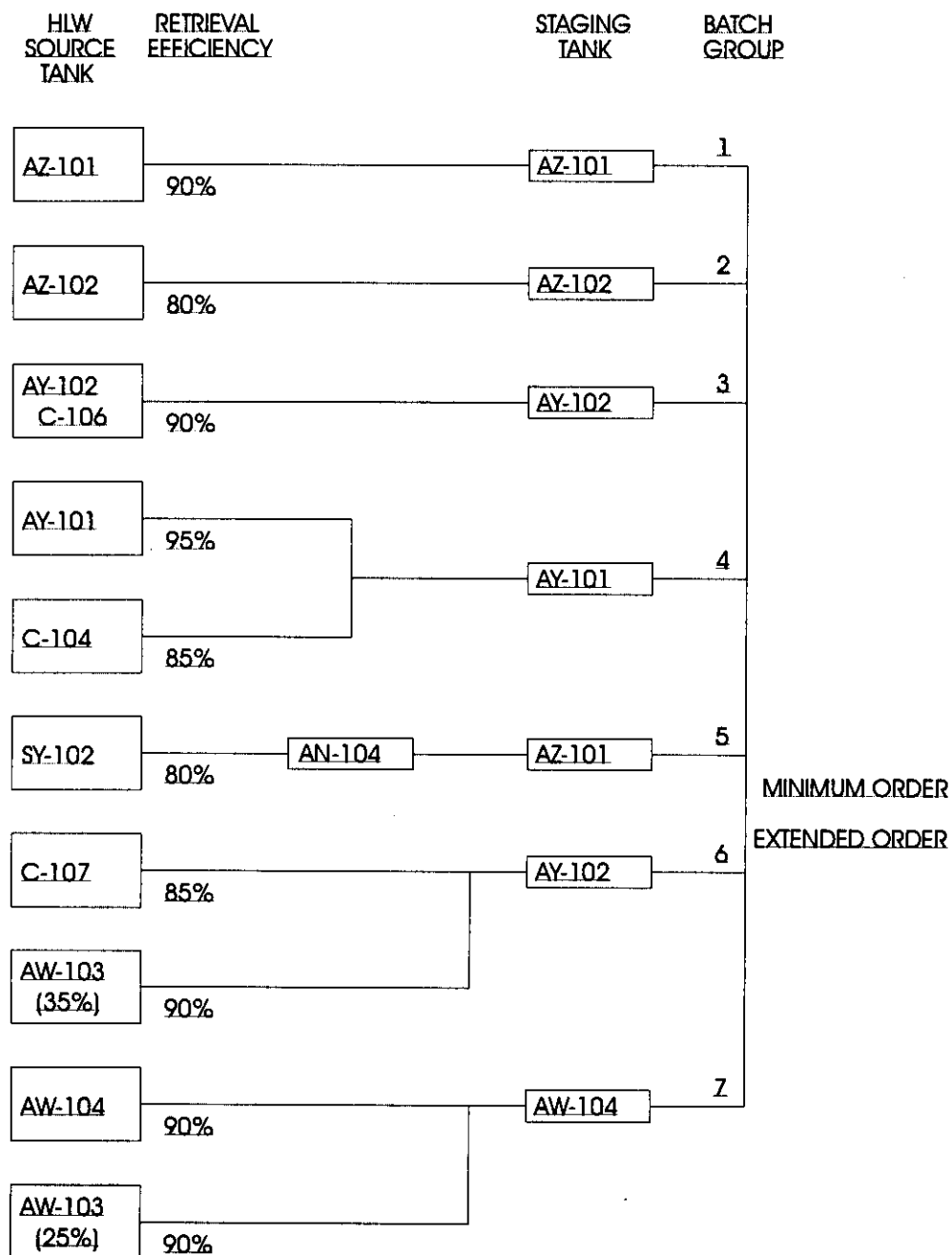
Figure 6 High-Level Waste Feed Staging Sequence for Phase 1, Case 3S6 (HNF-SD-WM-SP-012, Rev. 2).

3.1   Mast Force Calculations

Table A-1, in Appendix A, shows the mixer pumps that are planned to be deployed for the Case 3S6 Phase 1 LAW and HLW DST feed tanks. The effluent from these mixer pumps will impart horizontal forces to a sampling system deployed in these waste tanks. The calculated data, shown below, are based on a segmented mast constructed from 3 ½-in outside diameter (OD) drill rod segments, as indicated in Figure 2.

3.1.1   Mast Horizontal Force

The lower end of the MVDSS mast will be subjected to a horizontal cyclical load induced by the effluent from the tank mixer pumps. The actual horizontal cyclical end load on the MVDSS mast was determined in two ways:
- Reviewing an existing analysis and
- Observation of actual deflections of existing equipment deployed in a tank with operating mixer pumps.

The analysis *Evaluation of the Effect of Project W-151 Mixer Pump Jets on In-Tank Equipment Considering Potential Sludge Buildup on Equipment in Waste Tank 241-AZ-101*, Hanford Site, Richland, Washington (FDNW, 1997) determined the pump jet forces on various in-tank equipment by the use of a 1/6 scale mo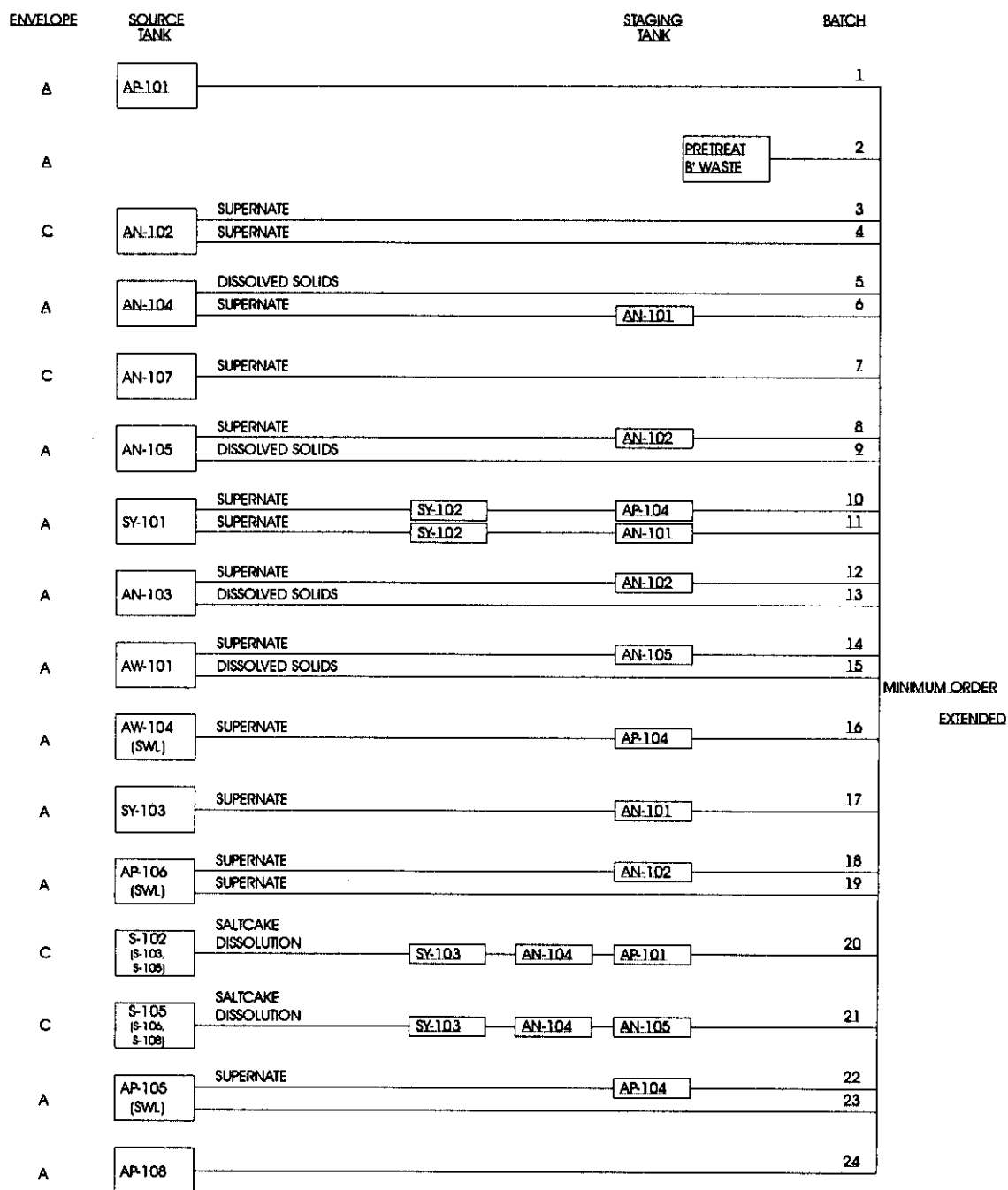del. The analysis contained in FDNW 1997 was modified to determine the jet pump forces on the MVDSS mast. Figure 7 shows a graph of the horizontal force on the MVDSS mast vs. distance from the Jet Pump for various thickness of sludge that could buildup on the mast.

Based on the revised analysis from FDNW 1997, the maximum force expected from the mixer pump is approximately 200-lbs for a mast will be placed no closer than 14.5-ft. from the mixer pump,.

The second analysis used actual operational deflection data obtained from the 241-AZ-101 mixer pump test. This test aimed the mixer pump directly at a 6-in. Dry Well located approximately 10-ft. from the mixer pump. The mixer pump was then started and the pump speed increased as the deflection of the Dry Well was observed. At 857 RPM, the Dry Well was observed to deflect 1.9-in. at the Dry Well, tank waste interface. Based on this data, the actual force on the Dry Well was determined to be 39.5-lbs. At 110% of rated pump RPM, the maximum force on the Dry Well was determined to be 50.7-lbs.

Since the cyclical horizontal force data from the theoretical analysis significantly differs from the actual in-tank deflection data, a logical, final force level needed to be chosen. The horizontal cyclical force was chosen to be 120-lb. This force is 60% smaller than the theoretical loading from FDNW 1997 but is 237% larger than the forces from the above in-tank analysis.

3.1.2 Minimum Allowable Bend Radius

As indicate above, the mast may be subjected to a cyclical horizontal end loading from the mixer pump effluent. In order for the mast internal components to move freely up and down, a minimum bend radius for the mast was be specified.

The minimum allowable bend radius for the mast was determined in the following manner:
  1.) The cyclical horizontal end loading was applied to the mast.
  2.) The location of the largest moment was determined (at the riser bottom).
  3.) The bend radius at that location was calculated.

The calculations determined that minimum bend radius is 176-ft.

3.1.3 Segmented Mast Fatigue Strength

In order to determine the fatigue strength of the mast two items must be known; the number of cycles and the maximum cyclical stress. Given that the life span of a mixer pump is approximately 5000-hours and that the mixer pump rotates through a 180-degree span at about 0.1 revolutions/minute the number of cycles is determined by multiplication of the life span times the number of cycles per minute (in the proper units). This results in a 30,000 cycles. The maximum cyclical stress due to the 120-lb end cyclical end load occurs 48-feet from the bottom of the mast. Knowing this information and that the section modulus of the mast is 1.72-in^3, the maximum cyclical stress was calculated to be 40,186-psi.

Since the number of stress cycles is greater than 10^3 this is considered *high-cycle fatigue*. From Figure 7-3, Page 273 of Shigley and Mitchell 1983 and given that the mast will be constructed from 4130 steel, the endurance limit is approximately 49,000-psi. Since the endurance limit is greater than the maximum cyclical stress, the mast will not fail due to fatigue.
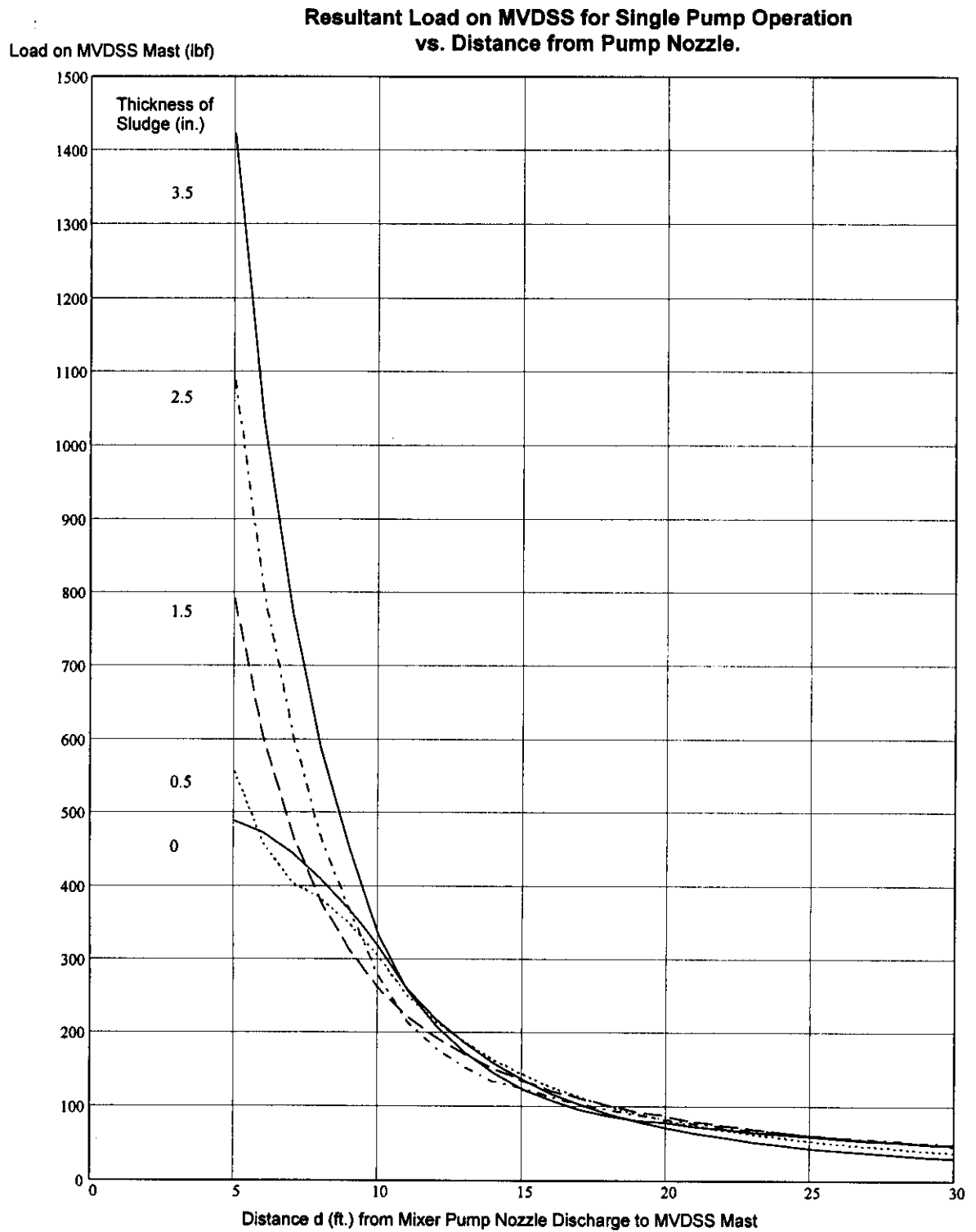
Figure 7 Graph of horizontal force vs. distance for various sludge buildup thickness levels.

3.2   Tank Riser and Dome Load Limits

The MVDSS will be setup over a tank riser so that its total weight is supported by the tank dome structure. The mast will impart some vertical and horizontal loads to the tank riser. The horizontal loading will be from the impact of the mixer pump effluent impacting the bottom of the mast structure when the mixer pumps are operating.

The information in Table 1 lists the currently allowable loads that can be safely supported by each of the feed tanks for the Phase 1 Case 3S6 waste feed staging sequence. These total load limits were obtained from the Cognizant Engineer for each Tank and/or the applicable 200 East or 200 West Area Shift Office. It should be noted that Tank Farms requires that a Tank Dome Loading Calculation be completed prior to the placement of any temporary equipment over the dome area of a waste tank. The load limits in Table 1 do not include temporary loads.

Mixer pump force calculations indicate that the in-tank mast structure will be subjected to a 120-lb cyclic horizontal load one foot from the bottom of the tank caused by the action of the tank mixer pumps. This cyclical horizontal load is based on the mast being located, at all times, no closer than 10-ft from the tank mixer pump outlet nozzle.

It has been Characterization Engineering's experience that inclusion of temporary loads and using the lowest allowable load limit will result in a maximum usable load of approximately 30,000-lbs for a sampling system.

The following load limits are based on this data:

- The maximum allowed vertical load that could be transferred to the tank riser is less than 2,200-lbs.
- The maximum moment that could be imparted to the top of the riser is less than 6,400-ft-lbs.
- In no case will the sampling system impart loads to the tank riser that exceed 10% of these riser limits.
- The maximum load on the tank dome from all of the sampling system hardware is less than or equal to 30,000 -lbs. This load limit is based on Characterization Engineering's sampling experience. A larger load limit may be feasible, however, it is not recommended. Before setup of sampling system hardware, a tank dome loading calculation would be completed to ensure that the allowable tank dome loading is not exceeded by the addition of temporary equipment.

Table 1 Waste feed tank (Case 3S6) and corresponding allowable dome loading

Tank	Total Allowable Load (lbs)
241-AP-101	157,013
241-AN-102	164,118
241-AN-104	164,118
241-AN-107	164,118
241-AN-105	164,118
241-SY-101	70,000
241-AN-103	164,118
241-AW-101	164,118
241-AP-102	164,118
241-AP-104	164,118
241-AN-101	164,118
241-AZ-101	96,163
241-AZ-102	96,433
241-AY-102/(C-106)*	164,118
241-AY-101/(C-104)*	164,118
241-SY-102	176,000

*Data for C-106 and C-104

3.3 Tank Waste Physical, Chemical, and Radiological Properties

The sampling system will encounter wastes in which it must provide representative samples as well as wastes in which the sampling system must survive and then be able to resume normal sampling operation. The normal operation of the sampling system and the at-tank analysis system is based on the most severe parameters from LAW or HLW. The waste and waste tank environmental parameters are from:

- HNF-1507, *Initial Tank Retrieval Systems Data for Waste Transfer System,*
- Published Tank Characterization Reports (TCRs), such as WHC-SD-WM-ER-411. Rev. 0, *Tank Characterization Report for Double-Shell Tank 241-AZ-102.*
- SACS Tank Temperature data from the Tank Waste Information Network System (TWINS) data base (network address is http://twins.pnl.gov:8001/twins.htm).

Representative sampling would be from waste having the following LAW and HLW property ranges:

a.) HLW waste properties:
- Temperature range: 50 °F to 200 °F
- pH: 8 to 14
- Specific Gravity:
  - ♦ Liquid – 1.2 to 1.4
  - ♦ Slurry - 1.1 to 1.55
- Viscosity: 10 Centipoise (cp) (Non-Newtonian)
- Radioactivity 500 rad/hour (2.2×10^{07} rads over 5 years)
- Particle size (also see Appendix B, Level 2 Component Specification):

Size	fraction of total solids
♦ > 4000 μm	0 wt.%
♦ 500 to 4000 μm	< 1 wt.%
♦ 50 to 500 μm	< 5 wt.%
♦ < 50 μm	94 wt.%

- Solids content: up to 10% by wt (potential maximum).
- Chemical constituents (see Level 2 Component Specification (Reich, 1999), Appendix A)

b.) LAW properties:
- Temperature range: 50 °F to 120 °F
- pH: 8 to 15.
- Specific Gravity: 1.3 to 1.55
- Viscosity: less than 10 cp
- Radioactivity 500 rad/hour (2.2×10^{07} rads over 5 years)
- Particle size:

Size	fraction of total solids
♦ > 4000 μm	<1.0 wt.%
♦ 500 to 4000 μm	< 1.0 wt.%
♦ 50 to 500 μm	50 wt.%
♦ < 50 μm	50 wt.%

- Solids content: up to 2 wt%
- Chemical composition: (see Level 2 Specification (Reich, 1999) Appendix A)

The sampling system could contact wastes having properties that are outside of the ranges of the LAW and HLW that is to be representative sampled. The sampling system should be capable of surviving this more severe waste environment and then resume normal, representative sampling operations with the LAW and HLW having the above properties. The resumption of normal sampling operations would be accomplished without requiring special containment or containment intrusive maintenance and without replacement of sampling system

components. Sampling at any performance level with wastes having these more severe physical properties is desired/preferred but is not a requirement for the sampling system.

c.) LAW and HLW waste parameters in which the sampling system would survive and then resume normal LAW and HLW sampling include:

- Temperature range: 50 °F to 260 °F
- pH: 8 to 15
- Specific Gravity: 1.8
- Viscosity: 50-60 cp
- Radioactivity   >2,000 rad/hour (2.2x10^{07} rads over 5 years)
- Particle size: < 50 µm to > 4000 µm
- Solids content: 30-35 wt%
- Chemical·composition: (see Level 2 Specification (Reich, 1999) Appendix A)

3.4 Dome Space (Physical and Chemical) Environment

All sampling system components that are in the waste tank but reside in the air space above the waste would encounter the following ranges of environmental conditions:

- Temperature range: 50 to 200 °F
- Relative humidity: 10 to 100%
- Radiological: 10-1000 rad/hr (see Level 2 specification, HNF-Appendix C)
- Dripping liquid from dome
- Aerosols and airborne waste solids and liquids.

The specific chemical environment for airborne waste solids and liquids are defined in the Best Basis Inventory (database) for each waste tank.

3.5 Tank Farm (Above Grade) Environment

The components and modules that reside above grade level over the waste tank would encounter the following ranges of environmental conditions:

- Temperature Range:
  - ◆ Operating: -15 to 120 °F
  - ◆ Non-operating (system in standby): -20 to 150 °F
- Relative humidity: 4 to 100%
- Wind speed: Maximum of 85 mph, standby condition, 25 mph maximum operating condition, average of 8.8-mph.

- Moisture:
  - ◆ Rainfall up to 2-in/hr, annual average precipitation of 6.3 -in.
  - ◆ Snow accumulation of up to 2-ft, snowfall loading of 15-lb/ft^2.
- Dust: Capable of withstanding blowing sand and dust, and volcanic ash fallout, ashfall loading of 30-lb/ft^2.
- Dose rate of 0.5-mR/hr.

3.6 Fluidic Pump Design Envelope Parameters for 4.0-Inch Riser Deployment

The Case 3S6 Phase 1 feed tanks have slightly different dimensions that includes the height from the bottom of the tank to the top of the riser flange. The mast would be deployed in a 4-in riser, as indicated in Section 3.7. Table 2 shows the parameters for sampling in these feed tanks. Column 2 of Table 2 shows the AEAT fluidic pump data that has been confirmed by testing and by model calculations. Column 3 shows the parameters that will be required by the system for sampling the feed tanks. Additional dimensional parameters include the following:
- 58-ft maximum distance from tank bottom to the top of a riser.
- 4-in tank riser. However, the free diameter inside the tank riser will be between 3.5 to 4-inches.
- 1-ft. (empty) to 35-ft. (full tank) tank waste depth range.
- 23-ft maximum distance from the bottom of the riser to the waste
- The above ground, surface space around the tank riser that is available for the sampling system is a circle with a diameter less than 10-ft. (Note: The support utilities modules, such as the power and compressor skids, may be located outside of the tank farm or in another area adjacent to the feed tank.).
- 70-ft maximum waste lift provided by the sampling system.
- 90-ft maximum piping length between the charge vessel and the bottle filling station
- The desired inside diameter of the exit hose from the charge vessel is 5/8-inch.

The 90-ft length of pipe includes a 70-ft lift and 20-ft horizontal distance, as indicate in Table 2. This is the anticipated maximum pipe length between the RFD and the sample bottle filling station where the 500-mL sample bottles will be filled.

Figure 8 shows a cross-section of a conceptual mast and charge vessel deployed in a 4-in riser inside a mast. A 2.75-inch maximum outside-diameter charge vessel would provide a total clearance space of 0.25-inch between the charge vessel and the inside-diameter of the drill string mast. The cross-section area included in Figure 8 is the calculated area in the charge vessel that would be occupied by tank waste. The cable tube, that passes through the charge vessel, carries the cable that will be used to pull the charge vessel downward, providing positive vertical (elevation) placement of the charge vessel RFD inlet for sample acquisition. The "flats" on the sides of the charge are representative of features that will prevent the charge vessel from rotating inside the mast so that the RFD is "pointed" at the slot in the drill string segments.

Table 2 Fluidic pump design parameters

Function	AEAT - Base data on simulations	CHG Team – Parameters required to fit inside a mast that can be deployed in a 4-inch tank riser.
Drive pressure	4.2-Barg	TBD
Suction pressure	4.2-Barg	TBD
Vertical Pipe Length	18.0-m	70-ft (21.3-m)
Horizontal Pipe Length	2.0-m	20-ft (6.1-m)
Density of Fluid	1400-kg/m³	(See waste physical property tables)
Waste Viscosity		10-cp (See waste physical property tables)
Charge vessel diameter, ID	0.063-m	2.75-in (0.06985-m) maximum outside diameter [1]
Charge vessel length	3.6-m	TBD
Pipe Diameter	19.05-mm	5/8-inch (15.9-mm) maximum hose inside diameter [2]

Notes: **(1)** This is the outside envelope that the mast, which will deploy in a 4-inch tank riser, will accommodate. A deployment cable and the exit piping from bottom of the charge vessel must be inside this diameter limit. The conceptual design drawings of the mast and charge vessel cross-sections show additional dimensional details.

(2) This is the hose that connects to the bottom of the charge vessel that will connect the charge vessel with the sample container filling hardware and will be wrapped around the drum in the sampling system module.
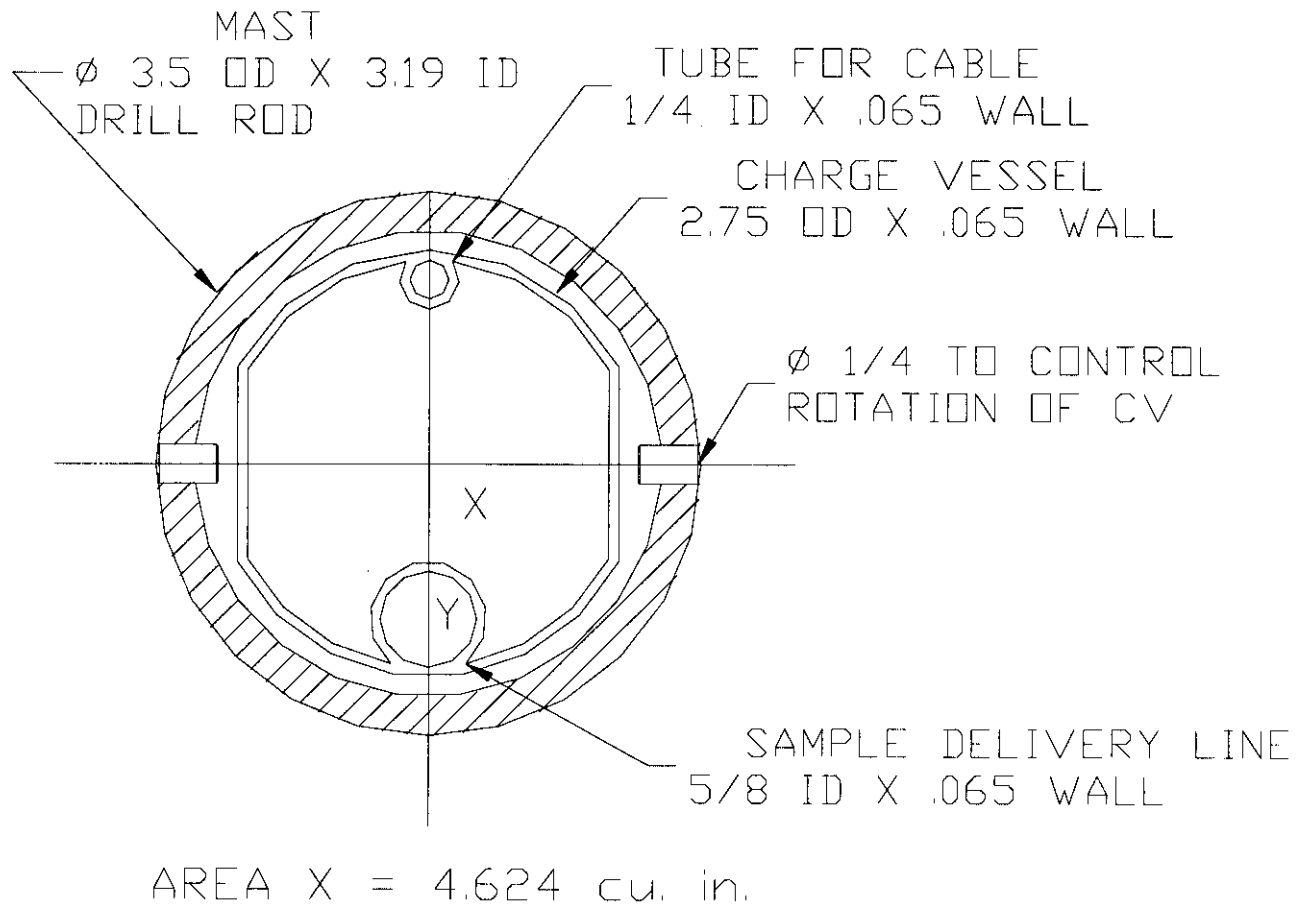
Figure 8 Cross-section of mast and charge vessel for 4-inch riser deployment showing integrated cable and piping.

3.7   Tank Riser Size Availability

Table 3 shows the riser availability data for the Case 3S6 LAW and HLW DST feed tanks. The basis for the data in Table 3 and for assessing riser size and availability includes the following:
- 16 waste tanks identified in R.T. French letter, 00-OPD-013, *CONTRACT NO. DE-AC06-99RL14047 – MODIFICATION OF FEED DELIVERY SEQUENCE,* January 26, 2000.
- Case 3S6, Phase 1 LAW and HLW feed tank sequence (Kirkbride, 2000).
- Current and planned riser occupancy status and the available surface space around a riser

A sampling system foot-print of 10-ft diameter was also assumed based on:
- Interference with other risers, deployed hardware, and pits.
- Hanford H-2 tank drawings, such as H-14-010501, *Dome Penetration Schedules (WST/WSTA) Tank 241-AN-101.*
- 14-ft minimum distance to the nearest mixer pump
  - ♦ Riser and mixer pump data from the current schedule for mixer pump deployment.
  - ♦ Limits the force on the deployed mast from the mixer pump effluent

Appendix A, Table A-1 that shows the risers in which mixer pumps are planned to be deployed for each of the Phase 1, Case 3S6 staging tanks. Table 3 contains the following columns of data:
1. Name of the Case 3S6 Phase 1 LAW or HLW tank
2. Size of riser available for deploying the sampling system (inches)
3. Available riser number
4. Risers (riser number) that will contain mixer pumps
5. Distance (feet) from the riser containing the mixer pumps to the riser that the sampler may be deployed (RAD is radius in feet)
6. General notes about the riser.
7. Waste type (low activity waste or high level waste)

The conclusions of this riser assessment for the Case 3S6 feed sequence are:
- 13 of the planned 24 batches for Phase 1 pass through one of the AN tanks that have only 4-inch risers available for deploying a sampling system.
- 7 of the 16 LAW and HLW tanks only have 4-inch risers available for deploying a sampling system. These include AN-101, -102, -103, -104, -105, and SY-101, -102. Tanks. The remaining tanks have potentially larger available risers.
  - ♦ 7 of the 16 tanks have 6- or 12-inch riser(s) available - AP-101, -102, -104, AY-101, -102, and AZ-101, -102
  - ♦ AN-107 – 12 inch available if the camera assembly can be moved
  - ♦ AW-101 – 12 inch available are < 14.5 ft from mixer pump that may produce excessive bending forces on a mast from the nearest mixer pump.

To support the WFD needs, the MVDSS should be deployable and operable in a 4-inch waste tank riser.

Table 3 Available Phase 1 Case 3S6 LAW and HLW tank risers for MVDSS deployment

TANK	RISER SIZE	RISER NUMBER	MIXER PUMP RISER	RISER DISTANCE FROM PUMP (feet)	NOTES	WASTE TYPE
AN-101	4	-016	007, 008	25, 42.7		LAW
	4	-021		30, 39.6		
	12	-013		11, 29	OBSERVATION PORT, NEXT TO CENTRAL PUMP PIT.	
AN-102	4	-017	007, 008	14.6, 45.8		LAW
	12	-013		11, 29	OBSERVATION PORT, NEXT TO CENTRAL PUMP PIT.	
AN-103	4	-020	007, 008	14.6, 46.9		LAW
	12	-013		11, 29	OBSERVATION PORT, NEXT TO CENTRAL PUMP PIT.	
AN-104	4	-021	007, 008	30, 39.6		LAW
	12	-013		11, 29	SPARE OBSERVATION PORT	
AN-105	4	-021	007, 008	30, 39.6		LAW
	12	-013		11, 29	OBSERVATION PORT, NEXT TO CENTRAL PUMP PIT.	
AN-107	12	-009	NONE	20 (RAD)	CAMERA ASSEMBLY	LAW
	12	-013		9 (RAD)	OBSERVATION PORT, NEXT TO CENTRAL PUMP PIT.	
	42	-007		20 (RAD)		
	42	-008		20 (RAD)		
AP-101	4	-021	TBD	28 (RAD)		LAW
	12	-010		20 (RAD)		
	12	-011		30 (RAD)		
	12	-012		30 (RAD)		
	12	-018		30 (RAD)		
	12	-019		30 (RAD)		
	12	-020		30 (RAD)		
AW-101	4	-011	007, 008	21.5, 44.5		LAW
	12	-013		9	OBSERVATION PORT, NEXT TO CENTRAL PUMP PIT.	
	12	-023		11, 29		
	12	-024		11.9, 49.3		
	20	-025		38.6, 40		
	20	-026		38.6, 37		
	36	-027		35.4, 41.2		

TANK	RISER SIZE	RISER NUMBER	MIXER PUMP RISER	RISER DISTANCE FROM PUMP (feet)	NOTES	WASTE TYPE
SY-101	4	-006	007, 008	20, 34.6		LAW
	4	-011		25, 41.8		
	4	-012		25, 41.8		
	4	-021		20, 34.6		
	4	-022		22.4, 22.4		
	12	-005		17, 23	IN CENTRAL PUMP PIT	
	12	-014		11, 29		
AP-104	4	-021	-013	28		LAW
	4	-026		15		
	4	-027		15		
	4	-028		15		
	4	-029		33		
	12	-009		20		
	12	-011		30		
	12	-018		30		
	12	-019		30		
	12	-020		30		
AP-102	4	-021	-013	28		LAW
	4	-026		15		
	4	-027		15		
	4	-028		15		
	4	-029		33		
	12	-009		20		
	12	-011		30		
	12	-018		30		
	12	-019		30		
	12	-020		30		
AY-102	4	-005A	1A, 1B, 1C, 1D	10, 38.8, 38.8, 52		HLW
	6	-015A		13.7, 18, 30, 33		
	6	-015E		9.4, 30.3, 40.4, 49.6		
	6	-015G		16.3, 34, 47.4, 56		
	6	-015I		17.3, 32.8, 48.2, 55.7		
	6	-015K		16.3, 34, 47.4, 56		
	6	-015M		17.3, 32.8, 48.2, 55.7		
	6	-015Q		17.3, 32.8, 48.2, 55.7		
	16	-022A		12, 20.1, 36.9, 40.3	CONTAINS LIT, LIMITED SPACE	

TANK	RISER SIZE	RISER NUMBER	MIXER PUMP RISER	RISER DISTANCE FROM PUMP (feet)	NOTES	WASTE TYPE
AZ-101	4	-013B	-1A, -1C	27.1, 51.6		HLW
	4	-013C		22.6, 53.8		
	4	-013D		27.1, 51.6		
	6	-015A		20.7, 54.5		
	6	-015D		34.3, 47.2		
	6	-015G		11.9, 56		
	6	-015H		29, 50.6		
	16	-022A		16.2, 51.2	SURFACE SPACE	
AZ-102	6	-015A	-1A, -1C	20.7, 54.5		HLW
	6	-015C		37.2, 44.9		
	6	-015E		20.7, 54.5		
	6	-015F		14.1, 56.6		
	6	-015G		11.9, 56		
	6	-015H		29, 50.6		
	6	-015I		37.2, 44.9		
	6	-015J		34.3, 47.1		
	6	-015K		20.7, 54.5		
	6	-015L		14.1, 56.6		
	16	-022A		16.2, 51.2	SURFACE SPACE	
SY-102	4	-003	007, 008	10.3, 38.6		HLW
	4	-012		25, 41.8		
	4	-021		20, 34.6		
	4	-022		22.4, 22.4		
	12	-014		11, 29		
AY-101	4	-032	1A, 1B, 1C, 1D	10 ,38.8, 38.8, 52		HLW
	6	-015A		13.7, 18, 30, 33		
	6	.-015D		12.8, 40.1, 42.1, 56.8		
	6	-015G		13.7, 37.8, 44.3, 56.6		
	6	-015I		17.5, 32.4, 44.3, 56.6		
	6	-015K		16, 34, 47, 56		
	6	-015M		16, 34, 47, 56		
	6	-015O		17.5, 32.4, 44.3, 56.6		
	6	-015Q		13.7, 37.8, 44.3, 56.6		
	16	-022A		8.2, 23.5, 34.8, 41.2	CONTAINS LIT, LIMITED SPACE	

3.8 Hanford Steel Pig Sample Carrier

The filled and capped 500-mL sample bottles will be shipped to the laboratories using the shipping system currently used with the base-line grab sampling. The steel pig provides radiation shielding and structural protection for the glass sample bottles. The samples are currently shipped two at a time on a Hanford Cask Truck (reference Hanford drawing H-2-74812). The N-55 transport container, that holds the filled sample bottles and shipping enclosures, (reference Hanford drawing H-2-92738) contains an inner drum assembly (reference Hanford drawing H-2-74449) that cradles the Pig Shipping Container in which the Steel Pig Sample Carrier is located.

The Steel Pig Sampler Carrier is loaded with the filled 500-mL sample bottles in the sample bottle filling module. The loading operation includes a "bag-out" to prevent contaminating the inside of the Steel Pig. A drawing of the Steel Pig is shown in Figure 9 (Waste Management Federal Services drawing No. E-F-001). The dimensions in brackets in Figure 10 are the current Steel Pig dimensions in which a filled, capped, and bagged 500-mL bottle is packaged. The maximum dimensions are those that the Steel Pig may have and still potentially fit into the Steel Pig shipping system. The vertical dimension of the Steel Pig must accommodate any special cap that a sample bottle may be sealed with and any excess plastic from the "bag-out" of the sample bottle. At the present time, this modified container does not exist and has not been approved for use.

The weight of the sample pig is currently 82-lbs without the sample bottle. A filed 500-mL sample bottle is estimated to weigh 3-lb. The cover for the sample pig is attached with two ½ inch UNC bolts (recommended torque of 5 to 10-ft lbs). The bail on the cover may be used to handle the Steel Pig lid.
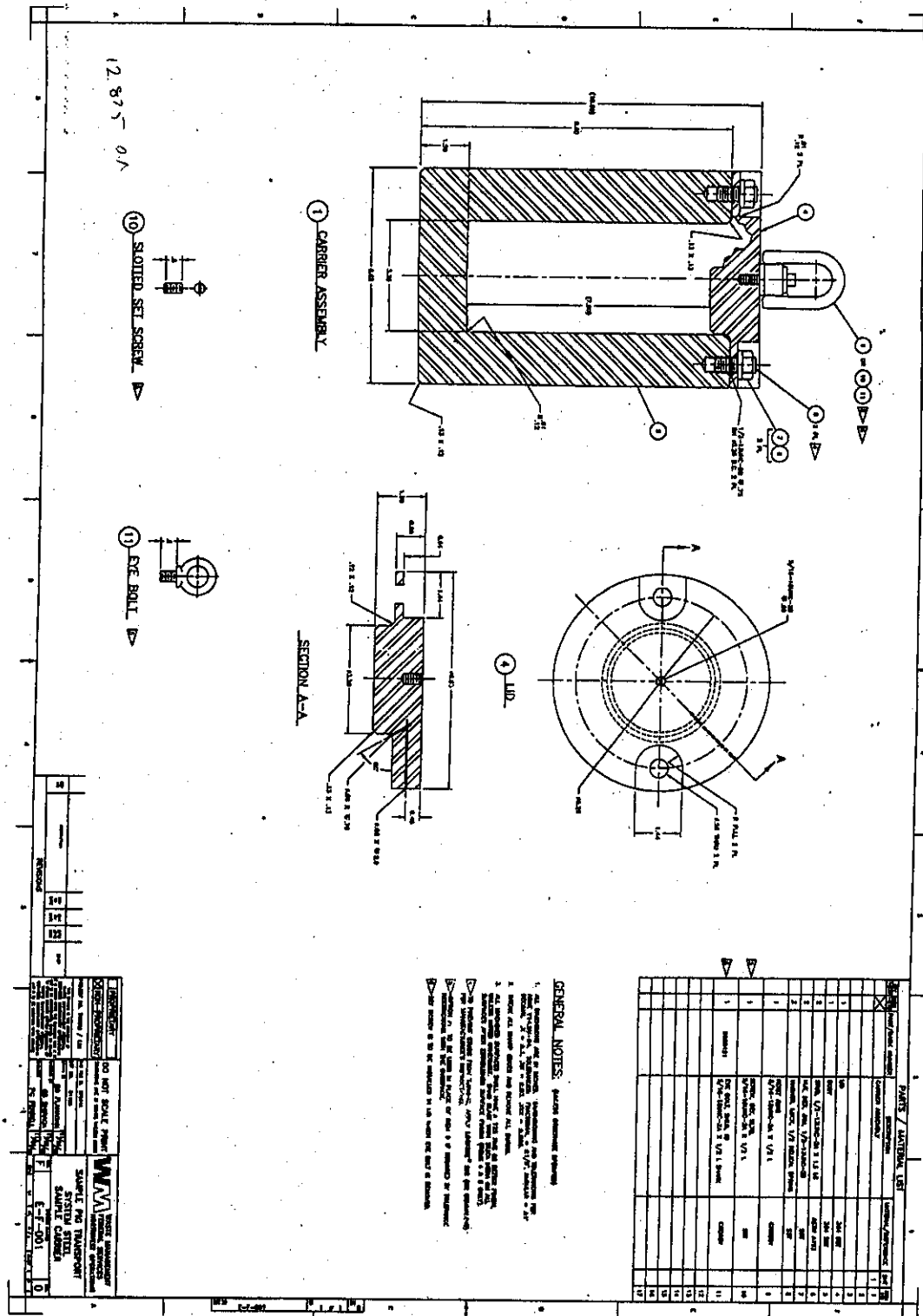
Figure 9   Hanford Steel Pig sample carrier currently used for shipping waste sample bottles, including the 500-mL sample bottle.

HOIST RING, PIVOTS TO
HORIZONTAL POSITION

1/2-13UNC-2B
2 PLS (5-10 FT LBS)

(11.7)
12.5 MAX

(10.5)

(7.5)

(Ø 3.36)

(Ø 6.63)
Ø 7.73 MAX
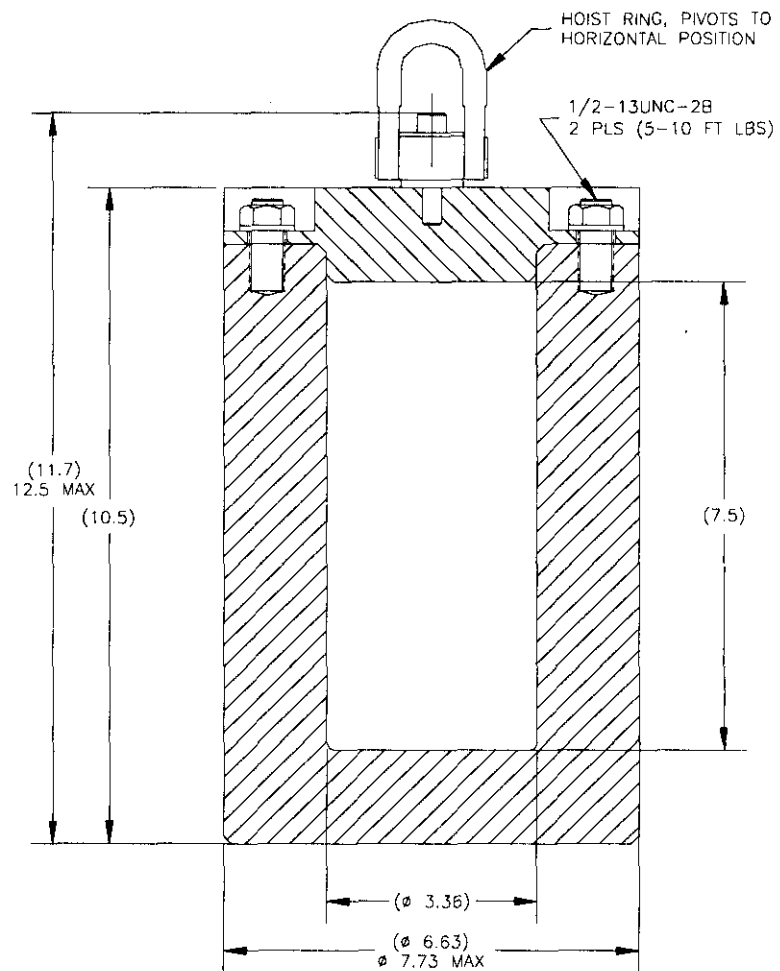
SAMPLE PIG

NOTE: The Sample Pig dimensions shown in ( )
are the current dimensions

Figure 10 Hanford Steel Pig Sample Carrier showing potential dimensions that would increase
radiation shielding.

3.9   500-mL Sample Bottle

Figure 11 shows the 500-mL sample that is an Owens-Brockway bottle; C-7651 (drawing FR-16990-A-2) brown-glass, wide-mouth, 500-ml bottle. The bottle dimensions do not include the bottle cap. The total height of the bottle will depend on the cap that is used in the MVDSS.

Figure 11 500-mL brown-glass, wide-mouth sample bottle (Owens-Brockway bottle, C-7651 (drawing FR-16990-A-2)
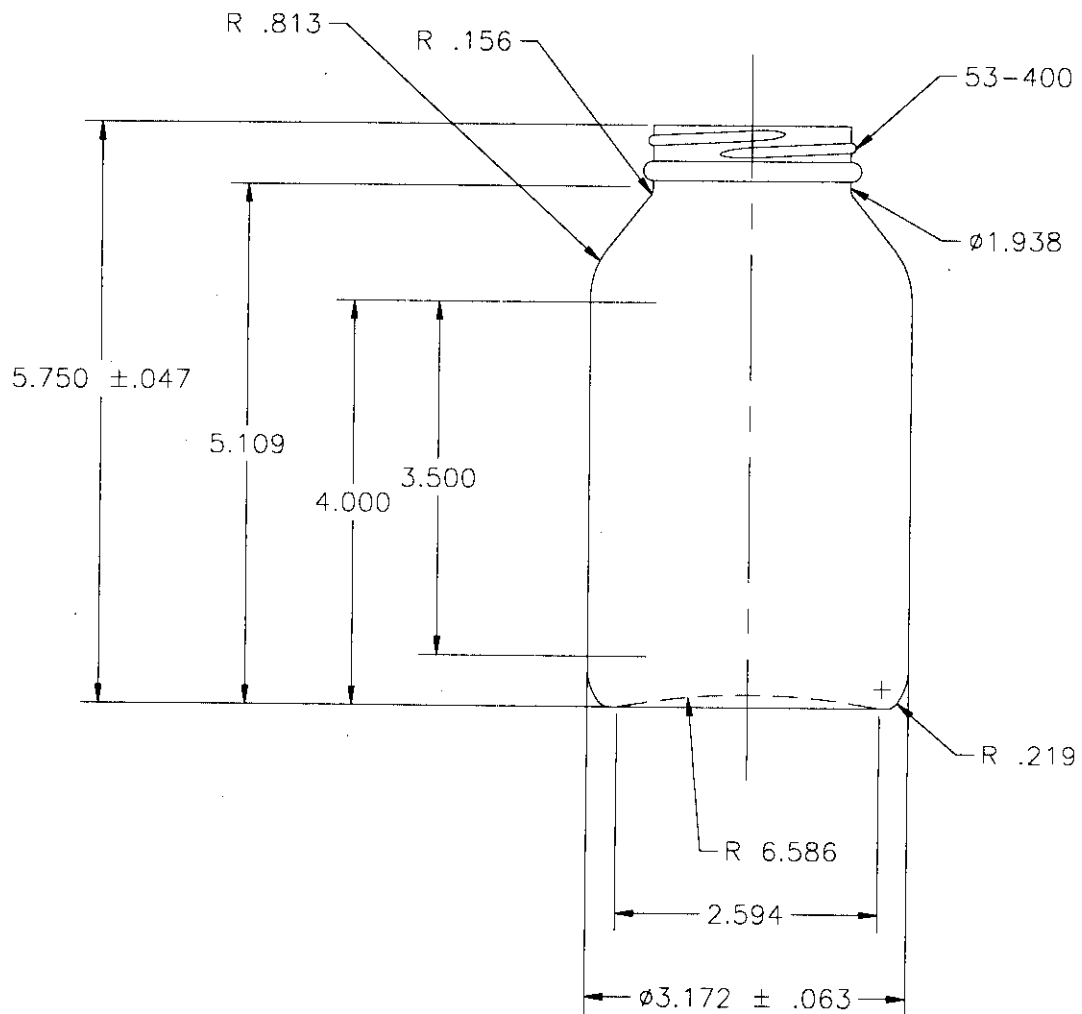
The filled and capped (sealed) 500-mL bottle, including the sealed plastic bag (for contamination control), would fit within the inside dimensions of Hanford Steel without the use of insertion forces that could damage the cap or the bottle.

In order to determine the bursting pressure of the 500-ml glass sample bottle a simple linear elastic Finite Element Analysis (FEA) model was created as indicate in Figure 12. This model assumed that the entire bottle is a uniform 0.1 in. thick borosilicate glass. Due to the lack of ductility and the high rate of local irregularities and flaws, the tensile strength of glass rarely exceeds 1000 psi. Given this information, the bursting pressure was conservatively determined to be 10-psi. The bottle manufacturer (Owens Illinois Inc.) was then contacted to verify the sample bottle bursting pressure. Owens Illinois stipulated that this 500-mL bottle is not pressure rated, has no safety coating, and has a burst pressure of approximately 20-psi.
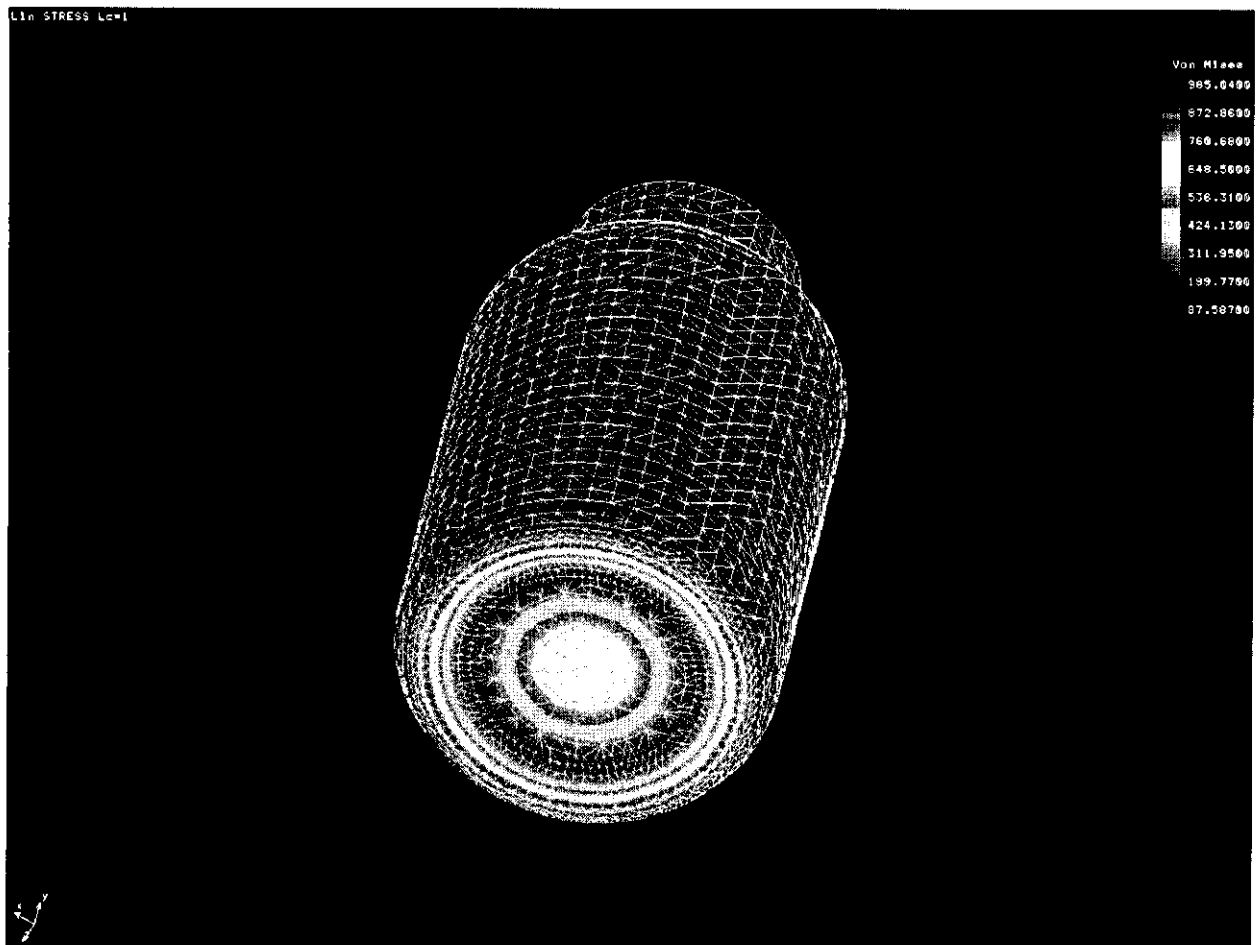

Figure 12 Von Mises stress plot for 10-psi internal pressure for the 500-mL wide-mouth sample bottle.

Human Engineering

The MVDSS will have mechanical manipulators, controls, and electrical controls, actuators, and readouts that will be accessed during the operation of the sampling system. The human factor parameters associated with the MVDSS are included in the Level 2 Specification and are based on MIL-Std 1472D and NUREG 0700.

3.10 Utility Support for Sampling System

The sampling system requires electrical power, water, and potentially, vacuum/pressure utilities. The primary electrical power, raw water and air/vacuum are provided by portable equipment.

A portable electrical generator provides the primary power for the Mobile Variable Depth Sampler System and the at-tank analysis system. This generator would have an excess, reserve capacity of approximately 25% above that required to supply all system power requirements.

Tank farm electrical power would be used to support power needs when the system is in an extended standby condition. Only minor upgrades to the utility distribution system may be required to support extended stand by conditions. Major upgrades to the tank farm utilities will not be provided by this project.

The utilities will be mounted on portable trailers that can be easily moved. Two trailers may be needed for this system:
1.   Electrical, air and potentially tank farm power conditioning, if needed for standby operation.
2.   Flush water system, including reservoir, pump, gauges (flow, pressure, totalizer), and controls. Replenish water with a portable water tank or directly with this trailer.

The umbilicals would be long enough to allow the trailers to be positioned at least 10-ft beyond the edge of a waste tank where their weight will not contribute to the total load on the tank dome.

A portable air pressure system would provide the compressed air for the MVDSS. The vacuum/pressure drive for the fluidic pumping would be provided by a dedicated air-jet system that is not part of these utilities (AEAT furnished system). The air-jet is powered by compressed air and provides the pressure and vacuum power needed to cycle the charge vessel and RFD fluidic pumping system. The compressor system would be mounted on the electrical utility trailer along with the electrical generator.

A portable pressurized water system will probably be used to provide water to the sampling system and the at-tank analysis system for flushing of the piping, hoses and decontamination of equipment. Pressure and flow requirements will be defined during the detailed design.

4.0 References

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BNFL-5193-ID-20, Rev. 4f, February 2000, *Tank Waste Remediation System Privatization Project, Interface Control Document ICD-20, between DOE and BNFL Inc. for High-Level Waste*, prepared for the U.S. Department of Energy, Richland Operations under Contract DE-AC06-RL13308 by BNFL, Inc., Richland, Washington.

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APPENDIX A

Mixer Pump Data
for Phase 1 Case 3S6
LAW and HLW DST Feed Tanks

Mixer Pump Data for
Phase 1 Case 3S6 LAW and HLW DST Feed Tanks

Table A-1 shows the mixer pumps that are planned to be deployed in the Case 3S6 Phase 1
LAW and HLW DST feed tanks. This mixer pump data is based on the following:

- HNF-1057 Revision 1, Interface Document Project W-211 Initial Tank Retrieval
  Systems
- WHC-SD-W151-ER-001 Rev 0, Stress Cycles and Forces on In-tank Components
  Resulting from Mixer Pump Operation in DST 101-AZ
- W-211-P5, Procurement Spec Waste Mobilization Mixer Pump
- HNF-SD-W151-DA-008, Evaluation of Effect of Project W-151 Mixer Pump Jets
  on In-Tank Equipment Considering Potential Sludge Buildup on Equipment in
  Waste Tank 241-AZ-101

The mixer pumps have the following characteristics:
- Each pump has two horizontally opposed (6-inch) diameter outlet nozzles.
- Each nozzle is located 15 to 18 inches off the tank floor.
- Nozzle orientation with respect to the Mixer Pump shaft (and column) centerline
  will be 90 (+5, - 0 degrees) or slightly towards the tank floor (+5 degrees).
- The design flow capacity for each nozzle is approximately 5,182-gpm such that a
  velocity diameter product of 29.4-ft^2/sec is achieved.
- The suction inlet will be 8.25 inches from the tank bottom.
- The 150 horse power (hp) pump is identical with the exception of the gpm which is
  half the 300 hp value.

The columns in table A-1 contain the following information:
1. LAW or HLW DST feed tank
2. Number of pumps to be deployed in the tank
3. Pump size (150 or 300 hp)
4. Nozzle size
5. Nozzle orientation (180° means that there are two 180° opposed outlet nozzles).
6. Maximum flow rate for each mixer pump
7. Outlet nozzle height from the bottom of the tank.
8. Tank riser that each pump is deployed in
9. WFD project number.

Table A-1 Mixer-pumps data for Case 3S6 Phase 1 LAW and HLW DST feed tanks.

TANK #	# PUMPS	PUMP SIZE (1)	NOZZLE SIZE	NOZZLE ORIENT.	FLOW RATE PER PUMP (2.)	HEIGHT FROM TANK BOTTOM	RISER NUMBER	PROJECT #
AP-101	0	No Pump						W-521
AP-102	1	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	13	W-521
AP-104	1	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	13	W-521
AP-105	1	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 or 8	W-522
AP-106	1	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 or 8	W-522
AP-108	1	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 or 8	W-522
AW-101	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-521
AW-103	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-521
AW-104	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-521
AN-101	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-211
AN-102	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-211
AN-103	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-211
AN-104	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-211
AN-105	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-211
AN-107	0	No Pump						W-211
SY-101	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-521
SY-102	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-521
SY-103	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	7 and 8	W-521
AY-101	4	150 hp	2 @ 6 inch	180º	7,950 gpm	15-18 inches	1A, 1B, 1C, 1D	W-521
AY-102	4	150 hp	2 @ 6 inch	180º	7,950 gpm	15-18 inches	1A, 1B, 1C, 1D	W-521
AZ-101	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	1A and 1C	W-211
AZ-102	2	300 hp	2 @ 6 inch	180º	11,600 gpm	15-18 inches	1A and 1C	W-211

Notes: 1.) hp – horse-power

2.) gpm – gallons per minute

APPENDIX B

Tank Waste Temperature Data For
Phase 1 Case 3S6 LAW and HLW DST Feed Tanks

Tank Waste Temperature Data For
Phase 1 Case 3S6 LAW and HLW DST Feed Tanks

The temperature of the LAW and HLW in the DST varies according to a number factors, including the waste type and age. Table B-1 shows maximum waste temperatures for the Case 3S6 Phase 1 LAW and HLW DSTs. This data was extracted from the SACS Tank Temperature Data contained in the Tank Waste Information Network Systems (TWINS) data base. This data base can be found at network address. The data columns in Table B-1 are:

Waste tank

Maximum waste temperature recorded over a 12 month time period

Minimum waste temperature recorded over a 12 month time period

In-tank thermocouple that produces the maximum waste temperature reading.

In-tank thermocouple that produced the minimum waste temperature reading.

For the LAW, AN-103 and AN-104 have the highest waste temperatures. For HLW, AZ-101 and AZ-102 have the highest waste temperatures. The bounding temperature ranges for representative sampling of HLW and LAW are:

- HLW Temperature range: 50 °F to 200 °F
- LAW Temperature range: 50 °F to 120 °F

These bounding temperatures are 20 °F higher than the highest LAW and HLW temperatures recorded in Table B-1 for the 12 month time period. The bounding temperature range which the sampling system must survive and then resume normal sampling operations is

- Temperature range: 50 °F to 260 °F

Table B-1 Maximum and minimum waste temperatures for the Case 3S6 Phase 1 LAW and
HLW DSTs recorded over a 12 month period.

Tank Waste Information Network System (TWINS)				
Waste Tank	SACS Tank Temperature(1) :			
	Maximum (°F)	Minimum (°F)	Thermocouple Number:	
AN-101	77.4	53.2	2	1
AN-102	91	70.5	16	1
AN-103	**106.9**	**65.8**	**8**	**1**
AN-104	**107.2**	**66.7**	7	**1**
AN-105	102.4	68.7	5	1
AN-107	107.6	6537	1	1
AP-101	70.8	59	12	18
AP-104	19.7	54.2	8	18
AP-105	71.1	60.1	18	18
AP-106	82.4	56.3	12	17
AP-108	72	55.4	14	12
AW-101	99.8	66.5	4	1
AW-103	71.7	60.9	1	1
AW-104	80.7	59.7	2	1
AY-101	119.37	74.7	1	1
AY-102	140	69.6	1	1
AZ-101	**179.6**	**117.5**	**1**	**1**
AZ-102	**163.9**	**89.2**	**1**	**1**
C-104	96.6	81	1	8
C-106	147.9	43.7	1	3
C-107	119.3	101	3	6
S-102	102.9	76.1	3	6
S-103	88	69.4	1	6
S-105	77.7	63.1	1	12
S-106	77.9	61.7	4	12
S-108	82.4	63	3	10
SY-101	126.3	61.2	15	18
SY-102	109.6	62	14	1
SY-103	95.2	73	4	1

Notes: (1) Maximum and minimum temperature over a 12 month time period (7/18/99 to
7/18/00). Bold type shows the highest temperatures for LAW and HLW.

APPENDIX C

Maximum Designed Waste Depth in
Phase 1 Case 3S6 LAW and HLW DST Feed Tanks

Maximum Designed Waste Depth in
Phase 1 Case 3S6 LAW and HLW DST Feed Tanks

The Phase 1, Case 3S6 waste tanks vary in dimensions and in the amount of waste each tank
can hold. Table C-1 shows the design waste depth for each of the waste tanks. The sampling
system must be capable of obtaining representative samples at any specific waste elevation over
this waste depth span, within ± 1.0-inches.

Table C-1 Maximum depth of waste that each of the Phase 1 Case 3S6 waste tanks can hold.

Waste Tank	Maximum Waste Depth	
	(inches)	(feet)
AP-101	422	35.17
AP-102	422	35.17
AP-104	422	35.17
AN-101	422	35.17
AN-102	422	35.17
AN-103	422	35.17
AN-104	422	35.17
AN-105	422	35.17
AN-107	422	35.17
AW-101	422	35.17
SY-101	422	35.17
SY-102	422	35.17
AY-101	377	30.83
AY-102	377	30.83
AZ-101	377	30.83
AZ-102	377	30.83