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Cold Pump Test, Training, and Mock-Up Facility Feasibility and Need Study

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A cold pump test, training, and mock-up facility needs to be acquired and installed to support Tank Waste Retrieval and Disposal (TWR&D). Such a facility would serve useful purposes for the TWR&D, and would also have the capability to provide similar services for other Hanford Site activities.

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COLD PUMP TEST, TRAINING, AND MOCK-UP FACILITY FEASIBILITY AND NEED STUDY

January 2000

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Prepared for:
U.S. Department of Energy
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CONTENTS

TERMS

ADMP	Advanced design mixer pump
CPTTM	Cold Pump Test, Training, and Mock-Up
FFTF	Fast Flux Test Facility
FY	Fiscal year
HAMMER	Hazardous Materials Management and Emergency Response
HLW	High-level waste
LAW	Low-activity waste
MASF	Maintenance and Storage Facility
O&M	Operations and maintenance
ORP	Office of River Protection
RAM	Reliability, availability, and maintainability
RPP	River Protection Project
SWP	Special work permit
TBR	Technical Baseline Requirement
TWR&D	Tank Waste Retrieval and Disposal
URSILLA	Ultrasonic interface level analyzer
WFD	Waste Feed Delivery

COLD PUMP TEST, TRAINING, AND MOCK-UP FACILITY FEASIBILITY AND NEED STUDY

1.0 EXECUTIVE SUMMARY

A Cold Pump Test, Training, and Mock-Up (CPTTM) Facility will allow the testing and evaluation of waste transfer components in simulated tank conditions. This may include system run-in in caustic, abrasive, and viscous materials heated to tank temperatures. Existing and new pump designs will be tested in a simulated operating environment rather than operated in water only. The facility will also provide a simulated environment for training the crews that remove/install waste transfer systems and components. The ability to mock-up and operate entire systems will assist in the procedure development, certification, maintenance scheduling, and troubleshooting system problems in a nonradiation environment.

Anticipated new pump needs through 2013 are estimated at 80 pumps of various types. The Reliability, Availability, and Maintainability (RAM) Analysis (PLG 1999a,b) has estimated pump related failures of all types will be the cause of 144 equipment outages during transfer operations. Additionally, 24 pump related failures are anticipated during pre-transfer operations. Of the 168 pump related failures, 5 to 10 percent will require a pump replacement. This means approximately 17 replacement pumps will be needed. All new or replacement pumps should be tested and proven ready for use before in-tank insertion and contamination.

Using the results of *Cold Pump Test, Training, and Mock-Up Facility Functions and Requirements* (Pickett and Vickery 2000), 13 Hanford area facilities are being evaluated as locations for a CPTTM Facility. This evaluation, or site selection analysis, is scheduled for issue in February 2000 and will describe each site, modifications required to meet a consistent requirements set, acquisition cost, and life-cycle cost.

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2.0 COLD PUMP TEST, TRAINING, AND MOCK-UP FACILITY

A CPTTM Facility needs to be acquired and installed to support Tank Waste Retrieval and Disposal (TWR&D). Such a facility would serve useful purposes for the TWR&D, and would also have the capability to provide similar services for other Hanford Site activities.

This facility could be utilized to serve the following needs:

- Operational testing, training, and mock-up
- Pump development and complete system testing
- Verify maintenance replacement schedules.

Existing facilities are simply inadequate to support required testing, forcing start-up and full-scale testing to be performed following installation in the tank. Representative projects that would have benefited from the availability of a mock-up facility include the following.

- W-320 Sluicer
  - No facility was available to support simulant testing. Therefore, it was not performed.
- W-320 Immersible Pump/Winch
  - Limited testing was performed at Lawrence Pump; however, testing was limited to water only. Had a mock-up facility been available, most, if not all, problems encountered with the equipment following installation could have been avoided (e.g., pump priming problems, hose kinking problems, etc.). These problems were not identified until equipment was installed in the tank and it was too late to do anything to correct them.
- 241-AY-102 ENRAF Densitometer
  - This equipment was installed on the tank and tested following installation. It could never be made to work properly. Many hours were spent trouble-shooting in the rad-zone. This could have been avoided had a tank mock-up facility been available for testing.
- 241-C-106 Mag Flowmeter
  - This equipment was installed in the pit and was never made operational. If it could have been tested before installation, the problem could have been identified and corrected. Testing was not performed because a facility was not available to accommodate it.

- 241-C-106 Ventilation System (W-320)
  - This equipment was skid mounted and could have been tested in a mock-up tank (facility). This would have greatly expedited start-up of the system. Unanticipated interaction problems were encountered that could have been corrected in advance if they had been known.
- 241-C-106 and 241-AZ-101 Camera Systems
  - Both of these systems could have benefited from a mock-up facility. Testing was performed in a shop; however, conditions were not representative of in-tank conditions. In-tank lighting, light reflection off the liquid surface are not possible to simulate in the current facilities, which can accommodate a 40-ft piece of equipment.
- 241-AZ-101 Ultrasonic Interface Level Analyzers (URSILLAs), Strain Gauges, Suspended Solids Profiler
  - Testing of the equipment was accommodated on site before installation. However, testing would have been improved if performed in a tank mock-up.

2.1 OPERATIONAL TESTING

2.1.1 Mock-Ups

Site activities that involve remote operations, component replacement or maintenance, radioactive contamination, personnel radiation exposures or hazardous substances could be mocked up and demonstrated in the CPTTM Facility before designs are finalized or equipment is procured. Initial mock-ups could be less than full-scale and could be fabricated of paper, cardboard, wood, etc. Once a concept is proved through models and mock-ups, then design can be finalized and procurement initiated. "Proven" will vary with each concept being mocked up, but could include several abilities: accessibility, visibility, maintainability, replaceability, and reachability.

The ability to first mock-up and prove is valuable in that resources no longer have to be used to demonstrate a "real component" in a "real-life situation." Rather, concepts can be proven to the extent that one can be confident there will be only minor problems when the item is procured and installed. Proof of principle is also valuable in that the proof can be obtained in a clean, warm, comfortable, controlled, nonhazardous environment instead of using "real equipment" in a "real environment." By doing this, accident potential is reduced, personnel exposures are eliminated and implementation costs are significantly reduced.

As an added benefit, extensive job planning, access permits, approvals, special tools and equipment, protective clothing, special work permit (SWP) protective clothing, and the associated supporting personnel are also no longer necessary to conduct mock-up/testing.

2.1.2 Demonstration

A cold mock-up facility also permits proof of principle to those personnel not directly involved in the test, but nevertheless, persons responsible to approve procurement and installation of special equipment, to view and witness the acceptability of the item before granting permission.

2.1.3 Risk Reduction

A mock-up/modeling facility permits conducting extensive tests with essentially no risk to field personnel or operational equipment, structures, or facilities. In addition, the tests can be performed much more rapidly than performing in the field under actual conditions.

2.1.4 Procedure Validation

A mock-up facility permits personnel to prepare and then validate operating, maintenance, emergency, and recovery procedures and schedules before implementing them under actual conditions.

2.1.5 Special Tools and Equipment

A cold demonstration facility permits recognition of a need for and development of special tools and equipment to support the installation, operation, maintenance and removal of items of equipment under very favorable conditions.

2.1.6 Documentation of Processes

A demonstration facility permits documenting all needed efforts during installation, operations, maintenance, and removal through photographs, videos, CDs, tape recorders, etc. These resources can then be used to study special problems and devise and prove recovery actions. In addition, once generated, the documentation will always remain available for reuse in any special or emergency situation.

2.1.7 Supporting Personnel

A mock-up facility, once staffed and operating, provides support personnel who can quickly assist operations/maintenance in developing responses to new and frequently unforeseen situations.

2.1.8 Training

One of the most important aspects of a mock-up facility is its usefulness as a training tool. Again, the mock-up atmosphere is ideal for training activities. Personnel being trained are in a nonthreatening environment, are under the guidance of experts, can perform the desired training at their own speed, and can repeat uncertain aspects as often and as many times as needed. Trainees can also be familiarized with performance-based training before being faced with this prospect in a "real life" situation.

2.1.9 Equipment Familiarization

A cold test facility provides the opportunity for operations/maintenance personnel to examine, handle, operate, replace, etc., "real" equipment before its being installed in the field. Depending upon TWR&D desires, the facility could also include equipment run-in capabilities, maintenance facilities, remote handling capabilities, etc. This would require coordination with the various projects and the pump vendors and resolution of the jurisdictional issues between building trades and plant forces.

2.2 PUMP DEVELOPMENT AND SYSTEM TESTING

TWRS pumps are the active components in all process steps. Pumps have many missions:

- Mobilize insoluble waste
- Degas waste
- Dissolve salt
- Add and distribute dilution water
- Homogenize waste for sampling
- Transfer waste to other tanks
- Motive power for sluicing
- Decant supernatant.

Often these functions must be performed simultaneously and it is challenging to optimize a single pump for all missions. Pumps to accomplish these tasks are, by definition, prototypes.

2.3 NEED FOR TEST FACILITY

Historically, no individual program or project had either the budget or inclination to fund such a test facility. Those programs and projects always relied on the abbreviated proof testing provided by the pump manufacturer. (NOTE: Extensive testing at vendor's plant is very expensive.) This lack of a test facility drives the use of operational data as the basis for pump development and modifications.

The concept of standardized or "one size fits all" pumps is likely to fail because of the great variation in tank wastes and specific retrieval need. In the pump industry, the best results are obtained when the pump is married to the application. For example. 241-AZ-101 is a completely different pumping mission than 241-AN-105; however, the preliminary selected mixer design is the same. The AZ pump is trying to mobilize and suspend insoluble solids and the AN pump is trying to dissolve salt. The AN pump has to contend with very viscous material at the suction and AZ does not. The same design won't work well for both.

The present Hanford baseline mixer pump design was borrowed from Savannah River. Savannah River has found this design to be problematic and decided to fund the testing of the advanced design mixer pump (ADMP). Hanford funded the design and fabrication of the ADMP, and it will be our property after testing at Savannah River. However, this testing has been done only in a shallow (6 ft) water pool, which does not reflect in-tank conditions.

The historical use of "off the shelf" vertical turbine pumps for waste transfer is no longer a viable option. With the addition of mixer pumps into the process, these vertical turbine pumps are simply too fragile. New transfer pumps have been designed and built, which by definition makes them prototypes. They have been tested in water at the vendor's plant.

None of the pumps have really been designed with the starting conditions in the tank considered, e.g., how do you stick a pump into 15 ft of goo and start; how do you initially dilute the waste enough to start the mixer pump? Our current pump procurement specifications describe the viscosity and density of the waste after it's mixed or diluted, not at initial startup.

The 241-SY-101 mixer pump has operated successfully for 5½ years with over 1000 successful start/stop cycles. However, the 241-SY-101 waste has a very low viscosity, almost water–like consistency and does not provide the information to answer the problems of the higher viscosity wastes. Completing the start-up testing of the AZ mixer pumps installed by Project W-151 will give additional data for evaluation and design modifications.

2.4 PUMP DEVELOPMENT PLANNING

Proper pump conceptual design follows from each WFD tank's ingredients and retrieval scenario. These scenarios are currently developing as a result of the BNFL Inc. contract. Some "open questions" in these developing scenarios impacting pump design are listed below. These open issues are not independent, but rather highly interrelated in selecting the simplest, most likely to succeed concept.

- Is a variable suction level transfer pump needed? If yes, how many levels?
- Are insoluble solids in LAW tanks to be mobilized?
- Is degassing before removal of some supernatant a pre-requirement in all flammable gas tanks?
- Will the BNFL Inc. contract require complete homogeneity of a tank; i.e., does the last batch out need to be exactly the same as the first batch out? If so, concurrent operation of transfer and mixer pumps may be required which has not been confirmed.
- Determination of pumping requirements from tank waste, flowsheets, and the BNFL Inc. contract.

Pump development must proceed in the following order:

- Establish pump requirements
- Tank-by-tank retrieval scenario baseline selected
- Pump concept selection, design, and prototype fabrication completed
- Pump prototype development.
- Test in simulated tank environment.

2.5 QUANTITY OF NEW PUMPS

The *Waste Feed Delivery Technical Basis, Volume IV, Waste Feed Delivery Operations and Maintenance Concept* (Carlson et al. 1999) and the RAM Analysis (PLG 1999a, b) attributes 144 equipment failures during transfer operations to be due to pump related problems. In addition, 24 pumps are anticipated to be effected by pump related failures during pre-treatment operations. Of the pump related failures, 5 to 10 percent will require a replacement of the pump. This means approximately 17 pumps that will need replacement during the mission life cycle.

The *Draft WFD Management and Technical Strategy* (Treat 1999) lists approximately 80 pumps that will be newly installed. This number will vary as transfer design matures. Attachment 1, which is an excerpt from Treat (1999), shows the year of need.

2.6 FACILITY DESCRIPTION

A pump testing, development, and storage facility must fulfill a number of functions to support WFD. At a high level, it breaks down to a place for developing hardware and a place to support Operations and Maintenance (O&M) concept development and training. A hardware development facility is needed now since there are already prototype pump systems on site that need more testing and development. An O&M support facility is needed by FY 2004. As the O&M concept develops, it is very likely the importance of this facility and its functions will greatly increase. The primary facility functions are as follows:

- Verify design requirements

- Provide a facility to develop pumping systems. This facility would not only provide for long-term operation of pumps in simulants, but also a means to develop the installation, deployment, and removal phases and ancillary hardware of a pump's life. An area of particular need is to replicate the initial conditions pumps encounter in a particular tank. The AN Farm represents a completely different set of initial conditions than the AP or AZ Farms.

- Provide a facility for pump run-in before installation. This will be a recurring function throughout the WFD effort, both for the initial installation of pumps and to support replacement of failed pumps when a rapid response is required.

- Provide spare pump storage

- Provide the ability to calibrate pump installation

- Run in new pumps
- Provide a location to make repairs to pumps that flunk run-in
- Provide a training facility for crews that remove and replace failed pumps.

The ideal facility for developing pumping systems and training crews would be a full-scale underground tank with human access. This tank must hold water and/or simulants and be able to be filled or emptied easily. This tank needs to be underground because everything is installed using mobile cranes and this feature is essential to develop installation and removal hardware. The repair, calibration, and storage functions are to be co-located to minimize pump handling.

2.7 POSSIBLE SITES

Sites are being evaluated using the *Cold Pump Test, Training, and Mock-Up Facility Functions and Requirements,* RPP-5566, Rev. 0 (Pickett and Vickery 2000).

Facilities evaluated include the following:

1. Applied Engineering Laboratory, 3000 Area
2. CENEX Building, Pasco
3. 200W Fabrication Shop
4. 336 Lab, 300 Area
5. 305 Lab, 300 Area
6. 306 Lab, 300 Area
7. 337-B High Bay, 300 Area
8. Maintenance and Storage Facility (MASF), Fast Flux Test Facility (FFTF), 400 Area
9. 105-A Test Tank, 200E
10. Hazardous Materials Management and Emergency Response (HAMMER), 600 Area
11. Caison Test Site, 600 Area
12. 277W Fab Services High Bay
13. Spray Pond, Unit 4, Energy Systems Northwest (The Supply System).

This site selection analysis is scheduled for issue in February 2000.

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ATTACHMENT 1

Table 1a. Low-Activity Waste Source Tank Planning Assumptions.
(Note: Tank sequence shown may not be optimal for construction/retrieval)

[redacted]

05/04	AN-107	C	LAW source	LAW storage/staging	LAW storage/staging	(1) Decant pump (DP)	N/A
09/02	AP-102	N/A	LAW staging	LAW staging	LAW staging	(1) Mixer pump (MP) (1) Transfer pump (TP)	N/A
09/02	AP-104	N/A	LAW staging	LAW staging	LAW staging	(1) MP (1) TP	N/A
03/05	AN-104	A	Law source and HLW cross-site receiver	HLW cross-site receiver and HLW staging	HLW cross-site receiver	(1) MP (1) TP	N/A
04/04	AN-106	N/A	LAW staging	LAW staging	LAW staging	(1) MP (1) TP	N/A

Table 1a. Low-Activity Waste Source Tank Planning Assumptions.
(Note: Tank sequence shown may not be optimal for construction/retrieval)

[redacted]							
09/05	AN-102	C	LAW source	LAW storage/staging	LAW storage/staging	(1) DP	N/A
03/06	AN-105	A	Law source	LAW staging	HLW staging	(2) MP (1) TP	N/A
09/02	AN-101	N/A	LAW staging	LAW staging	LAW cross-site receiver/stagin g	(1) MP (1) TP	N/A
04/08	SY-101	A	LAW source	None	HLW/LAW receipt/transfer	(2) MP (1) TP (1) Skimmer?	
01/09	AN-103	A	LAW source	None	HLW staging	(1) MP (1) TP	N/A
	AZ-101	B – A	LAW/HLW source	See Table 2	See Table 2	See Table 2	See Table 2

Table 1a. Low-Activity Waste Source Tank Planning Assumptions.
(Note: Tank sequence shown may not be optimal for construction/retrieval)

[redacted]

04/04	AZ-102						

NOTE: Subject to continued change in mission needs, funding, DOE direction. Best information as of 5/25/99.

HLW = High-level waste
LAW = Low-activity waste.

ATTACHMENT 1

Table 1b. Low-Activity Waste Source Tank Planning Assumptions.
(Note: Tank sequence may not be optimal for construction/retrieval)

[redacted]

08/10	AW-101	A	None	LAW storage/source	LAW staging	(1) Mixer Pump (MP) (1) Transfer Pump (TP)	N/A
07/13	AP-101	C	None	LAW storage/source	LAW storage/staging		(1) TP
01/03	SY-103	A	None	LAW source	HLW/LAW receipt/transfer	(1) MP (1) TP (1) Skimmer?	
08/10	AW-104	C	None	See Table 2	See Table 2	See Table 2	See Table 2
02/08	S-102	A?	None	LAW source	None	(2) Sluicers (1) TP	N/A
09/02	AP-104	C	None	LAW storage/source	LAW storage/staging	(1) Mixer?	(1) TP

Table 1b. Low-Activity Waste Source Tank Planning Assumptions.
(Note: Tank sequence may not be optimal for construction/retrieval)

[redacted]							
10/09	S-105	A?	None	LAW source	None	(2) Sluicers (1) TP	N/A
05/06	AP-105	C	None	LAW storage/source	LAW staging	None	(1) TP
No info	S-106	A?	None	LAW source	None	(2) Sluicers (1) TP	N/A
No info	A-101	?	None	None	LAW source	(2) Sluicers (1) TP	N/A
12/02	S-103	A?	None	None	LAW source	(2) Sluicers (1) TP	N/A
No info	AX-101	?	None	None	LAW source	(2) Sluicers (1) TP	N/A
No info	AX-103	?	None	None	LAW source	(2) Sluicers	N/A

Table 1b. Low-Activity Waste Source Tank Planning Assumptions.
(Note: Tank sequence may not be optimal for construction/retrieval)

[redacted]

						(1) TP	
Others?							

HLW= High-level waste
LAW = Low-activity waste.

ATTACHMENT 1

Table 2. High-Level Waste Source Tank Planning Assumptions.
(Note: tank sequence shown may not be optimal for construction/retrieval)

[redacted]						
07/03	AZ-101	HLW/LAW source	HLW staging	HLW staging	(1) Transfer Pump (TP) (1) Skimmer?	(2) MP
04/04	AZ-102	HLW/LAW source	LAW receipt/transfer	HLW staging and LAW receipt/transfe r	(2) Mixer Pump (MP) (1) TP (1) Skimmer	N/A
07/04	AY-102 (with C-106)	HLW source	HLW staging	HLW staging	(4) MP (1) TP (1) Skimmer	Sluicing pump
08/04	AW-103	HLW source	None	HLW staging	(1) MP (1) TP	N/A

Table 2. High-Level Waste Source Tank Planning Assumptions.
(Note: tank sequence shown may not be optimal for construction/retrieval)

					(1) Flygt mixer (1) Skimmer?	
08/04	AY-101	HLW source	HLW staging	HLW staging	(4) MP (1) TP	N/A
10/07	SY-102	HLW source	None	HLW/LAW receipt/transfe r	(2) MP (1) TP (2) Flygt mixer	N/A
08/09	C-104	None	HLW source	None	(1) Sluicers (1) TP (1) Booster pumps	N/A
08/10	AW-104	None	HLW source	HLW staging	(1) MP (1) TP	N/A
08/13	C-107	None	HLW source	None	(2) Sluicers	N/A

Table 2. High-Level Waste Source Tank Planning Assumptions.
(Note: tank sequence shown may not be optimal for construction/retrieval)

[redacted]						
					(1) TP (1) Booster pumps	
08/10	AW-105	None	HLW source	HLW staging	(2) MP (1) TP	N/A
Out	C-102	None	None	HLW source	(2) Sluicers (1) TP (1) Booster pumps	N/A
Out	C-103	None	None	HLW source	2) Sluicers (1) TP (1) Booster pumps	

HLW = High-level waste
LAW = Low-activity waste.

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