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Testing of Scavenger Systems Dislodging & Conveyance Devices

David C. Ramsower
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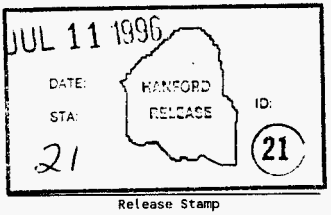
Abstract: Testing of ARD vehicles with mechanical dislodging devices and both air and liquid conveyance systems.



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Testing of Scavenger Systems Dislodging & Conveyance Devices

P.O.# MCE-SVW-394283

June 1996

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Testing of Scavenger Systems Dislodging & Conveyance Devices

Executive Summary

The objective of the proposed test series was to evaluate and quantify the performance of ARD Environmental's (ARD) SCAVENGER® robotic systems on simulated waste materials that have been characterized as those typically found in the single shell tanks at the Hanford, Washington DOE site. The scope of the effort was to: (1) develop a detailed test methodology, using simulants defined by Westinghouse, to evaluate the capability of ARD's existing remotely-operated vehicles, equipped with a variety of toolheads, to break up and convey the simulants; (2) instrument ARD's equipment to provide meaningful engineering data to characterize performance; and (3) perform the tests, document, analyze and report the results and provide recommendations for any follow-on effort. It should be noted that no optimization of systems was to be performed under this test plan. The focus was testing existing technologies against materials likely to be encountered during actual tank cleaning.

The test methodology was as follows: ARD XT2000 and XT1000 vehicles, fitted with standard rotary cutter and pump, a modified scabbler, and jackhammer with standard and custom blades were tested for their ability to break up and convey the various simulants. Both air conveyance and a positive displacement pump were tested as means for moving the material. The equipment was instrumented to measure hydraulic pressure and flow rate, diluent water pressure and flow rate, acceleration, preloads and tool position, and electrical current and voltage. The purpose of the instrumentation was to determine if there were any significant engineering parameters, the measurement of which would aid materially in understanding the factors governing the breakup and removal process. In addition, qualitative parameters were also observed, and provided meaningful performance information that will guide future efforts. The general test matrix, and parameters evaluated are summarized below:

TEST TYPE	TEST TOOL	VEHICLE	SIMULANT
SLUDGE SUCTION, LOW PRESSURE SLURRY	ROTATING CUTTER AND PUMP, DILUENT INJECTION	XT2000	WET SLUDGE
SLUDGE BREAKUP AND CONVEYANCE, NO SLURRY	ROTATING CUTTER HEAD AND SUCTION	XT2000	SALTCAKE / DRIED SLUDGE, 2 RECIPES
SLUDGE BREAKUP AND CONVEYANCE, LOW PRESSURE SLURRY	ROTATING CUTTER HEAD AND PUMP LP SPRAY BAR	XT2000	DRIED HARDPAN SLUDGE, 2 RECIPES
SLUDGE BREAKUP AND CONVEYANCE, LOW PRESSURE SLURRY	ROTATING CUTTER HEAD AND SUCTION SYSTEM	XT2000	DRIED HARDPAN SLUDGE, 2 RECIPES
SLUDGE BREAKUP AND CONVEYANCE, NO SLURRY	SCABBLER, SUCTION HEAD AND PUMP	XT1000	HARDPAN / DRIED SLUDGE, 2 RECIPES; SALTCAKE, 5 RECIPES
SLUDGE BREAKUP AND CONVEYANCE, NO SLURRY	HYDRAULIC JACKHAMMER SUCTION HEAD AND PUMP	XT1000	HARDPAN / DRIED SLUDGE, 2 RECIPES; SALTCAKE, 5 RECIPES
SLUDGE BREAKUP AND CONVEYANCE, NO SLURRY	ROTATING CUTTER HEAD AND PUMP	XT2000	SALTCAKE, 2 RECIPES

The specific test matrix was modified during testing, based on observation of the testing and discussion with Westinghouse personnel. The details of the testing are addressed in a subsequent section of this report.

The qualitative operational parameters observed were:

- Ease of deployment and retrieval
- Traction and maneuverability of the vehicle
- Ability of operator to observe and guide operation
- Ability to break up or dislodge material
- Clogging of the system
- Ability to remove materials from the site to the containment

The quantitative parameters observed were:

- Equipment configuration
- Gross material removal rate (includes any injected water)
- Net material removal rate
- Maximum removable particle size
- Cutter head blade and tooth configuration
- Cutter head hydraulic pressure (P(t))
- Cutter head hydraulic flow (Q(t))
- Jackhammer tool configuration
- Jackhammer hydraulic pressure (P(t))
- Scabbler tool configuration
- Scabbler current (I(t))
- Scabbler voltage (V(t))
- Temperature at workface
- Ambient temperature
- Tool pre-load force
- Volume and rate of injected water

Qualitative observations are contained in the individual test data sheets, and representative samples of the quantitative data are contained in printouts from the Labview files generated during the tests. In addition, representative sections of video are included with the report as an enclosure.

The results of this test program are as follows:

1. ARD's tracked vehicles, although designed for other applications, are viable platforms for various end effectors, and dislodging and conveying equipment. The vehicles could negotiate all materials except the very soft sludges. This came as no surprise, as the vehicles were specifically designed for materials that could either support the vehicle while it maneuvered, or were thin enough to allow the vehicle to sink to the bottom and gain a footing there. The XT1000 vehicle became mired in the 4.6 psi shear hardpan, where the material only allows the tracks to sink to the level of the deck plate. Note that tracked vehicles are available which can negotiate even the softest materials, since they will float at some point.

2. The off-the-shelf equipment used to dislodge the simulants all worked to some extent. The ARD cutter head, although designed specifically for hydrocarbon sludges and moderately compacted sediments, was moderately effective at breaking up the high strength saltcake, highly effective at dislodging and moving the low strength saltcake, and effective at breaking up the 2 hardpan simulants. It also easily dislodged the original sticky, wet sludge, however diluent water was required to assist in the transfer of material.

   The Scabbler was quite effective at powdering the high strength saltcake but not useful in the dried or wet sludges. The jackhammer easily broke up the saltcake into large chunks, and with a modified tool, was able to pulverize the saltcake into small pieces that would be easier to convey.

3. The conveyance methods tested also were effective to varying degrees. The positive displacement pump that is a standard component of the XT2000 was capable of pumping every material that could be fed to it by the cutter head. The difficulty encountered was related to the space between the cutter head and the pump. Normally, this system operates with the cutter head and pump intake submerged, and feeding the pump is not a problem. Where they are not submerged, as was the situation in the testing, there is no positive feed to the pump and the 5 psi suction the pump generates is ineffective. A separate pumping test was run by filling a barrel with the wet sludge and immersing the pump. This test was successful and demonstrated the ability of the pump to convey the sticky, wet sludge.

   The air conveyance was quite effective in moving relatively dry material when the particle size was less than 1/3 the diameter of the conveyance hose. Larger particles would clog the hose, however, the clogs were relatively easy to clear. The air conveyance worked best with the scabbler on the high strength saltcake and the cutter head on the low strength saltcake. Wet sludge tended to accumulate on the walls of the hose, reducing the diameter until it clogged. These clogs were also readily cleared and may have been avoided with additional water.

4. The quantitative parameters relating to the measurement of pressures, flows and the like were not especially significant, with the exception of the jackhammer. The high levels of acceleration, in excess of 15,000 G's, lead us to believe that the frequency of repair for a jackhammer would be relatively high. This may preclude extended use of a jackhammer of conventional design in the tank environment at Hanford.

5. The ability of the operator to manipulate the equipment and observe the work area was excellent. The size of the test tubs precluded extensive maneuvering, however, the operator was able to move the vehicles and orient the end effector tooling without difficulty.

Several conclusions were arrived at based on the results of this test program.

First, it is clear that commercially available tools can be effective against all types of materials, from the hardest saltcake to the softest sludges. There are a number of commercially available end effectors, not tested as part of this project, which might be suitable for the dislodging process, and which could be optimized at reasonable cost. Second, the diverse nature of the materials significantly affects the efficiency of the dislodging and removal methods. The more homogeneous the materials can be made during the dislodging process, in terms of their mechanical conveyance characteristics, the more effective the removal method. Third, the tests performed as part of this project are not representative of conditions in a tank, where the various materials are present in combination.

It is recommended that integrated testing of commercially available or scalable devices for dislodging and conveying be preformed. This effort would involve the identification of promising hardware, an analysis of each to determine suitability, and may be divided into groups according to delivery mechanism. Those devices which appear to offer promise should be tested in a follow-on effort to this project. Larger-scale testing should be done to more nearly replicate the operational environment in the tanks, including scaling up the test beds and using mixed materials. Finally, as a follow-on to additional testing, an analysis of the most promising techniques should be done to determine what modifications may optimize performance, improve operations, and what the resultant costs and improvements in performance would be. A thorough knowledge of tank cleaning dynamics and logistics involving nuclear materials will remain important to assessing the promise of technologies and their application to in-tank work.

Analytical data, technical descriptions, and videos are available on request.

Test Data & Observations

TEST #: T1

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT2000, rotating cutter head and suction system.

TEST MATERIAL: Saltcake 2, 1500 psi compressive.

TEST TUB: R1

DATE: April 8, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature.(Complete)
C. Check vehicle drive functions.(Complete)
D. Check lift arm function.(Complete)
E. Check cutter head function.(Complete)
F. Check suction system function.(Complete)

Pre-Test Checkout: Data Logging

A. Stop HPU.(Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate cutter head, read Pa, Ps, Pr, flow, accelerometer.
J. Stop cutter head. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (No I/R Thermometer used for this test)

Equipment Insertion

A. Remove end form from tub. (Complete)
B. Position ramp. (No ramp used)
C. Drive vehicle into appropriate tub. (Complete)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check. (Complete)

DATA FILE NAME: T1_1 & T1_2 &T1_3
START TIME: 2:49:05, 2:53:04, 2:55:12
STOP TIME: 2:53:02, 2:55:16, 2:55:48
DURATION IN MINUTES: 6 Minutes 05 Seconds
OFFBOARD VIDEO TAPE #:

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The vehicle appeared to handle the terrain created by the cutter head blades well. The face of material, approximately 11 inches was attacked with the cutter blades. Following initial removal of material from the face, the vehicle was able to climb onto the test bed and continue to remove material. The rough rock-like surface created a good traction area for maneuverability. The operator interface was acceptable for this configuration. The rotating cutter blades were capable of breaking up and dislodging the salt cake for transfer. The particle size of the waste material varied significantly during the project. It appeared that when the cutter blades were working on thick uniform material it scraped the surface of the cake creating fine granular particles. When working on shallow cake thickness (> 2 inches) the cutter blades would shear large chunks of the material 1" to 4" in size. The larger pieces could not be transferred with the air conveyance system available. The system used during this test was a batch cycle vacuum truck. Capable of moving approximately 1800 cfm of air. The larger chunks would clog the discharge line and could not be cleared remotely. NOTE: Triaxial Accelerometer was not powered during the demonstration.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	67	**POUNDS**
CONTAINER GROSS WEIGHT:	385	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	0	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):		**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	318	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = 52 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = 0.424 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 100%

TEST #: T2

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT2000, rotating cutter head and suction system.

TEST MATERIAL: Saltcake 1, 3000 psi compressive.

TEST TUB: R2

DATE: April 9, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature.(Complete)
C. Check vehicle drive functions.(Complete)
D. Check lift arm function.(Complete)
E. Check cutter head function.(Complete)
F. Check suction system function.(Complete)

Pre-Test Checkout: Data Logging

A. Stop HPU.(Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate cutter head, read Pa, Ps, Pr, flow, accelerometer
J. Stop cutter head. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (No I/R Thermometer used for this test)

Equipment Insertion

A. Remove end form from tub. (Complete)
B. Position ramp. (No ramp used)
C. Drive vehicle into appropriate tub. (Complete)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check. (Complete)

DATA FILE NAME: T2_1 & T2_2 & T2_3
START TIME: 12:54:06, 1:00:46, 1:03:45
STOP TIME: 12:59:06, 1:03:42, 1:04:56
DURATION IN MINUTES: 9 Minutes 07 Seconds
OFFBOARD VIDEO TAPE #:

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The 3000 psi saltcake mix was visibly more difficult to dislodge. The vehicle was able to attack the face of the saltcake and also climb on to the top of the cake surface. The surface of the saltcake provided excellent traction and maneuverability. Operator interface for guidance and operation was adequate for this configuration. The material dislodged similar to the 1500 psi saltcake but the rate of dislodging was noticeably slower. The particle size distribution was also similar to the 1500 psi saltcake with slightly more fine material and the largest pieces being larger up to 6" in size. The removal interface was identical to T1 in that the conveyance system was excellent for the fine material (< 1" diameter) but ineffective for larger particles due to line clogs. NOTE: The rpm monitor gear came off early in the testing. This was caused by the gear coming into contact with the saltcake and unscrewing due to the rotation of the cutter head. RPM was then determined from flow rate to the motor.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	69	**POUNDS**
CONTAINER GROSS WEIGHT:	253	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	0	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	184	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = 20.22 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) =.245 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) =100 %

TEST DELETED

TEST #: T3

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, hydraulic jackhammer, suction head and suction system.

TEST MATERIAL: Saltcake 5, 1.5 psi compressive.

TEST TUB: L1

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check jackhammer function.
F. Check suction system function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate jackhammer, read Pa, Ps, Pr, flow, accelerometer.
J. Stop jackhammer.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____ **POUNDS**
CONTAINER GROSS WEIGHT: _____ **POUNDS**
WATER VOLUME, (IF APPLICABLE): _____ **GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____ **POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____ **POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____**LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

MODIFIED TEST

TEST #: T4

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT2000, rotating cutterhead, and suction system.

TEST MATERIAL: Saltcake 4, 8 psi compressive.

TEST TUB: L2

DATE: April 9, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature.(Complete)
C. Check vehicle drive functions.(Complete)
D. Check lift arm function.(Complete)
E. Check cutter head function.(Complete)
F. Check suction system function.(Complete)

Pre-Test Checkout: Data Logging

A. Stop HPU.(Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate cutter head, read Pa, Ps, Pr, flow, accelerometer.
J. Stop cutter head. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer.

Equipment Insertion

A. Remove end form from tub. (Complete)
B. Position ramp. (No ramp used)
C. Drive vehicle into appropriate tub. (Complete)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check. (Complete)

DATA FILE NAME: T4_1 & T4_2 & T4_3
START TIME: 1:43:52, 1:48:39, 1:50:04
STOP TIME: 1:46:44, 1:49:50, 1:52:22
DURATION IN MINUTES: 6 minutes 21 seconds
OFFBOARD VIDEO TAPE #:

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The vehicle was able to easily move into the 8 psi saltcake. Traction and mobility were good and the surface did not appear to offer any significant obstacles. Operator interface did not create any problems with vehicle guidance or removal efficiency. The material comprising the 8 psi saltcake has limited compressive attributes but almost no cohesive properties. This enabled the rotating cutter blades to shear the material at a high rate of speed. The conveyance system was in fact overrun by the cutters ability to break up material and transport it to the suction opening. When the material was attacked aggressively the suction line clogged. Two clogs were experienced early in data T4_1 and T4_2. The conveyance method was well suited but undersized.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	77	**POUNDS**
CONTAINER GROSS WEIGHT:	697	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	0	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	620	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = 103.3 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = 1.05 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 100 %

TEST #: T5

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, hydraulic jackhammer, suction head and suction system.

TEST MATERIAL: Saltcake 3, 1500 psi compressive.

TEST TUB: L4

DATE: April 10, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check jackhammer function. (Complete)
F. Check suction system function. (Suction was not mounted on the vehicle)

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate jackhammer, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop jackhammer. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (Complete)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check. (Complete)
B. Conduct operational check of on-board video system. (N/A)

DATA FILE NAME: T5_1 & T5_2 & T5_3 See Also T5A_1& T5A_2
START TIME: 2:09:07, 2:12:42, 2:17:31, 3:08:48, 3:13:50
STOP TIME: 2:11:46, 2:17:20, 2:18:34, 3:09:54, 3:14:46
DURATION IN MINUTES: 9 Minutes 42 Seconds
OFFBOARD VIDEO TAPE #:

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The XT1000 could move on the surface of the saltcake with little or no difficulty. The jackhammer configuration moved the center of gravity on the vehicle to the rear, compared to the scabbler or cutter head configurations, reducing the climbing ability of the unit. The operator was able to successfully guide the vehicle in this configuration, however the difference in CG required pressure to be applied to the front of the system when climbing a 12" high material face. The jackhammer was capable of breaking the saltcake easily into large chunks. These pieces, between six and twelve inches were too large for the air conveyance system with the 4" diameter hose. During the early part of the testing we experienced leakage in the hydraulic fittings on the jackhammer. Following repair the test continued without further leakage. The 500 p.s.i pressure transmitter was damaged in test T5_1 and, although repaired, was damaged again during later parts of the test.

Following the completion of the initial testing, the conclusion was that although the jackhammer broke the saltcake easily, other configurations of end effector may be more suitable to pulverizing the cake. A modified tool was fabricated and produced smaller more manageable pieces (dust to 2 inches). If left in one place too long, the tool would fracture the entire bed into large pieces (1 foot to 3 feet) NOTE: Material removal results were based on dislodging material only, material was gathered and weighed by hand.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	74	**POUNDS**
CONTAINER GROSS WEIGHT:	560	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	486	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = 81 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = .648 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 100%

TEST #: T6

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, hydraulic jackhammer, suction head and suction system.

TEST MATERIAL: Saltcake 2, 1500 psi compressive.

TEST TUB: R1

DATE: April 10, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check jackhammer function. (Complete)
F. Check suction system function. (Suction was not mounted on the vehicle)

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate jackhammer, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop jackhammer. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (Complete)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check. (Complete)
B. Conduct operational check of on-board video system. (N/A)

DATA FILE NAME: T6_1
START TIME: 1:37:44
STOP TIME: 1:40:30
DURATION IN MINUTES: 2 Minutes 46 Seconds
OFFBOARD VIDEO TAPE #: Summary Tape 0.29.08

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The results in this test were identical to that of T-5. Removal efficiencies were determined to be comparable and could not provide any new significant data. Test T-6 and T-7 were modified accordingly.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	N/A	**POUNDS**
CONTAINER GROSS WEIGHT:	N/A	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	N/A	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = N/A **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = N/A **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = N/A %

TEST #: T7

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, hydraulic jackhammer, suction head and suction system.

TEST MATERIAL: Saltcake 1, 3000 psi compressive.

TEST TUB: R2

DATE: April 10, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check jackhammer function. (Complete)
F. Check suction system function. (Suction was not mounted on the vehicle)

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate jackhammer, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop jackhammer. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (No IR used for this test)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: T7_1
START TIME: 10:04:59
STOP TIME: 10:07:34
DURATION IN MINUTES: 2 Minutes 35 Seconds
OFFBOARD VIDEO TAPE #: Summary Tape 0.31.31

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The results in this test were identical to that of T-5. Removal efficiencies were determined to be comparable and could not provide any new significant data. Test T-6 and T-7 were modified accordingly.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	N/A	**POUNDS**
CONTAINER GROSS WEIGHT:	N/A	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	N/A	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = N/A **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = N/A **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = N/A %

TEST MODIFIED

TEST #: T8

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, hydraulic jackhammer, modified tool head

TEST MATERIAL: Hardpan 2, 21.8 psi shear.

TEST TUB: R4

DATE: April 8, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check jackhammer function. (Complete)
F. Check suction system function. (Suction was not mounted on the vehicle)

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate jackhammer, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop jackhammer. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (Complete)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check. (Complete)
B. Conduct operational check of on-board video system. (N/A)

DATA FILE NAME: T8_1
START TIME: 3:58:19
STOP TIME: 4:00:04
DURATION IN MINUTES: 1 Minute 45 Seconds
OFFBOARD VIDEO TAPE #:

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The XT1000 vehicle equipped with the jackhammer climbed easily into the bed of material. The contact pressure on the tracks of the XT1000 is designed to be between 5 and 7 psi dependant on the equipment being mounted on the system. Unlike the 4.6 psi Hardpan 1, the vehicle was able to maintain adequate mobility throughout the work. Lateral mobility was much improved and traction on Hardpan 2 was much improved. The jack hammer was configured with the pulverizing head. Upon activation the hammer struck the surface and liquified the material to its hydrated state. Examination of the material which sprayed from the test area resembled the initial mix prior to curing. This would indicate that the test simulant is thixotropic in nature and releases its entrained water when energy is injected. The manner in which material sprayed from the test bed upon energy injection made the capture of removal volumes impractical. This method did not yield a removal option.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	N/A	**POUNDS**
CONTAINER GROSS WEIGHT:	N/A	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	N/A	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = N/A **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = N/A **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = N/A %

TEST #: T9

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, hydraulic jackhammer
TEST MATERIAL: Hardpan 1, 4.6 psi shear.

TEST TUB: R3

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check jackhammer function. (Complete)
F. Check suction system function. (Suction was not mounted on the vehicle)

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate jackhammer, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop jackhammer. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (Complete)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check. (Complete)
B. Conduct operational check of on-board video system. (N/A)

DATA FILE NAME: T9_1
START TIME: 3:39:58
STOP TIME: 3:41:22
DURATION IN MINUTES: 1 Minute 24 Seconds
OFFBOARD VIDEO TAPE #: Summary Tape 0.35.31

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The XT1000 vehicle equipped with the jackhammer climbed easily into the bed of material. The contact pressure on the tracks of the XT1000 is designed to be between 5 and 7 psi dependant on the equipment being mounted on the system. The vehicle moved forward and backward on the soft surface but with each pass sunk deeper into the surface. Lateral mobility was limited due to the low shear pressure. The operator lost traction and mobility 45 seconds into the test when the center plate of the vehicle came in contact with the surface and stopped the vehicle from sinking further to the bottom. The jack hammer was configured with the pulverizing head. Upon activation the hammer struck the surface and liquified the material to its hydrated state. Examination of the material which sprayed from the test area resembled the initial mix prior to curing. This would indicate that the test simulant is thixotropic in nature and releases its entrained water when energy is injected.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	N/A	**POUNDS**
CONTAINER GROSS WEIGHT:	N/A	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	N/A	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = N/A **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = N/A **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = N/A %

TEST DELETED

TEST #: T10

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Scabbler, suction head and suction system.

TEST MATERIAL: Saltcake 5, 1.5 psi compressive.

TEST TUB: L1

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check scabbler function.
F. Check suction system function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate scabbler, read Pa, Vs, Is, accelerometer.
J. Stop scabbler.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and scabbler, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____**POUNDS**
CONTAINER GROSS WEIGHT: _____**POUNDS**
WATER VOLUME, (IF APPLICABLE): _____**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____LBS/MIN

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST DELETED

NOTE: The 8 psi saltcake was removed using the rotating cutter and was not determined to provide a significant technical challenge to other material dislodging methods.

TEST #: T11

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Scabbler, suction head and suction system.

TEST MATERIAL: Saltcake 4, 8 psi compressive.

TEST TUB: L2

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check scabbler function.
F. Check suction system function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate scabbler, read Pa, Vs, Is, accelerometer.
J. Stop scabbler.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and scabbler, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____ **POUNDS**
CONTAINER GROSS WEIGHT: _____ **POUNDS**
WATER VOLUME, (IF APPLICABLE): _____ **GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____ **POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____ **POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____ **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST #: T12

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Scabbler, suction head and suction system.

TEST MATERIAL: Saltcake 3, 1500 psi compressive.

TEST TUB: L4

DATE: April 11, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check scabbler function. (Complete)
F. Check suction system function. (Complete))

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate scabbler, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop Scabbler. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (Complete)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check. (Complete)
B. Conduct operational check of on-board video system. (N/A)

DATA FILE NAME: T12_1 & T12_2
START TIME: 1:47:21, 2:01:11
STOP TIME: 1:50:28, 2:03:44
DURATION IN MINUTES: 5 Minutes 40 Seconds
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

This configuration of the vehicle created the opposite effect from that of the jackhammer. The center of gravity on the vehicle was shifted far forward because of the weight of the scabbler system, impacting the function of the tracks. The vehicle approached the saltcake bed with the lift arms in the up position. The tracks continued to work indicating ample torque, however, the salt cake could not provide enough shear strength to lift the additional weight before breaking apart. Thus the vehicle would start to climb onto the bed but then the cake would shear and the vehicle would fall back down. The operator was capable of guiding the vehicle and performing operations. However, the scabbler shroud configuration made observation of the work in progress difficult. The scabbler head broke the saltcake into a fine powder and provided good interface with the air conveyance system. The shroud once again hindered the scabbler from attacking the saltcake surface more aggressively. The scabbler blade surface heated from 71 degrees at the beginning of test file T12_1 to 79 degrees at the end of the file. The first portion of the testing was shortened by an overload of the electric motor and a thermal shutdown. The second test file T12_2 began at 78 degrees and finished at 91 degrees with a motor case temperature of 133 degrees.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	94	**POUNDS**
CONTAINER GROSS WEIGHT:	142	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	48	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = 12 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = .96 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 100%

TEST #: T13

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Scabbler, suction head and suction system.

TEST MATERIAL: Saltcake 2, 1500 psi compressive.

TEST TUB: R1

DATE: April 11, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check scabbler function. (Complete)
F. Check suction system function. (Complete))

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate scabbler, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop Scabbler. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (Complete)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check. (Complete)
B. Conduct operational check of on-board video system. (N/A)

DATA FILE NAME: T13_1& T13_2 & T13_3
START TIME: 1:02:28, 1:07:48, 1:10:00
STOP TIME: 1:07:46, 1:09:56, 1:12:10
DURATION IN MINUTES: 9 Minutes 36 Seconds
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

This configuration of the vehicle created the opposite effect from that of the jackhammer. The center of gravity on the vehicle was shifted far forward because of the weight of the scabbler system, impacting the function of the tracks. The vehicle was driven on top of the saltcake to begin the test. The operator was capable of guiding the vehicle and performing operations however the scabbler shroud configuration made observation of the work in progress difficult. The scabbler head broke the saltcake into a fine powder and provided good interface with the air conveyance system. During this test the operational pattern was different from TEST 12, the Scabbler worked from the flat surface on the top of the salt cake as opposed to attacking the face of the cake as in T-12. The shroud once presented difficulty, enabling only 1/8" to 1/4" removal per pass. The scabbler blade surface heated from 71 degrees at the beginning of test file T13_1 to 73 degrees at the end of the file T13_3.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	111	**POUNDS**
CONTAINER GROSS WEIGHT:	125	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	0	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	0	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	14	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = 2.8 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = .0224 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 100%

TEST #: T14

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Scabbler, suction head and suction system.

TEST MATERIAL: Saltcake 1, 3000 psi compressive.

TEST TUB: R2

DATE: April 11, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature. (Complete)
C. Check vehicle drive functions. (Complete)
D. Check lift arm function. (Complete)
E. Check scabbler function. (Complete)
F. Check suction system function. (Complete))

Pre-Test Checkout: Data Logging

A. Stop HPU. (Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate scabbler, read Pa, Ps, Pr, flow, accelerometer. (Complete)
J. Stop Scabbler. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (Complete)

Equipment Insertion

A. Lift vehicle with gantry. (Vehicle worked from floor)
B. Move to appropriate tub. (N/A)
C. Lower vehicle into the tub. (N/A)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer, conduct operational check. (Complete)
B. Conduct operational check of on-board video system. (N/A)

DATA FILE NAME: T14_1& T14_2 & T14_3
START TIME: 11:05:08, 11:08:55, 11:11:12
STOP TIME: 11:08:44, 11:11:08, 11:13:24
DURATION IN MINUTES: 8 Minutes 01 Second
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

This configuration of the vehicle created the opposite C/G effect from that of the jackhammer. The center of gravity on the vehicle was shifted far forward because of the weight of the scabbler system, impacting the function of the tracks. The vehicle approached the saltcake bed with the lift arms in the up position. The tracks continued to work indicating ample torque however the salt cake could not provide enough shear strength to lift the additional weight before breaking apart. Thus the vehicle would start to climb onto the bed but then the cake would shear and the vehicle would fall back down. The operator was capable of guiding the vehicle and performing operations however the shroud configuration made observation of the work in progress difficult. The Scabbler head broke the saltcake into a fine powder and provided good interface with the air conveyance system. The shroud once again prevented the scabbler from attacking the saltcake surface more aggressively. The scabbler blade surface heated from 76 degrees at the beginning of test file T14_1 to 83 degrees at the end of the file T14_3. The voltage draw of the Scabbler was also of note. The Breakout Box = 480 Vrms (678.8 Peak) Output Scaling Board = 1.505 Vrms (2.13 Peak).

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	79	**POUNDS**
CONTAINER GROSS WEIGHT:	111	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	0	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	0	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	32	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =

6.4 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = .0512 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 100%

TEST DELETED

TEST #: T15

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Scabbler, suction head and suction system.

TEST MATERIAL: Hardpan 2, 21.8 psi shear.

TEST TUB: R4

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check scabbler function.
F. Check suction system function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate scabbler, read Pa, Vs, Is, accelerometer. Stop scabbler.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and jackhammer scabbler, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____ **POUNDS**
CONTAINER GROSS WEIGHT: _____ **POUNDS**
WATER VOLUME, (IF APPLICABLE): _____ **GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____ **POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____ **POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____ **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST DELETED

TEST #: T16

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Scabbler, suction head and suction system.

TEST MATERIAL: Hardpan 1, 4.6 psi shear.

TEST TUB: R3

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check scabbler function.
F. Check suction system function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate scabbler, read Pa, Vs, Is, accelerometer. Stop scabbler.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and scabbler, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____ **POUNDS**
CONTAINER GROSS WEIGHT: _____ **POUNDS**
WATER VOLUME, (IF APPLICABLE): _____ **GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____ **POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____ **POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____ **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST #: T17

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT1100, Rotating Cutter Head and suction system.

TEST MATERIAL: Hardpan 1, 4.6 psi shear.

TEST TUB: R3

DATE: April 17, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature.(Complete)
C. Check vehicle drive functions.(Complete)
D. Check lift arm function.(Complete)
E. Check cutter head function.(Complete)
F. Check suction system function.(Complete)

Pre-Test Checkout: Data Logging

A. Stop HPU.(Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate cutter head, read Pa, Ps, Pr, flow, accelerometer
J. Stop cutter head. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (No I/R Thermometer used for this test)

Equipment Insertion

A. Remove end form from tub. (Complete)
B. Position ramp. (No ramp used)
C. Drive vehicle into appropriate tub. (Complete)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check. (Complete)

DATA FILE NAME: T17_N.BIN
START TIME: 11:24:25, 11:28:06, 11:30:17, 11:35:02, 11:36:37
STOP TIME: 11:28:02, 11:30:14, 11:31:48, 11:36:12, 11:38:22
DURATION IN MINUTES: 10 Minutes 01 Seconds
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

This material has the consistency of semi-hardened clay and accordingly provided mobility during earlier tests. The XT2000 was able to move into this material with little effort. Water injection was performed through the shroud and was minimized to simulate actual field operations. Nine gallons of water were added to the mixture during initial energy injection. The air conveyance system was turned on and initially transferred material effectively. After three minutes of transfer the hose began to display significant signs of internal buildup. After five minutes the hose clogged. With the air conveyance running the hose was eventually cleared manually by picking up and dropping the hose, stimulating the sludge to move. Following water injection and use of the rotating cutterhead the consistency of the material was that of drywall compound. An additional Nine gallons of water was provided to determine its effect on transfer . The results indicate that although the material thinned, significant improvement could not be achieved with such limited addition of water. The material appeared to be retaining water at the beginning of the test. This was determined by the effect of the rotating cutter blades on the material surface prior to water injection. Due to this observation, Test T-18 was modified to remove material with no water injected for slurry.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	76	**POUNDS**
CONTAINER GROSS WEIGHT:	386	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	18	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	0	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	159	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
26.5 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = .27 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 51.45%

TEST #: T18

TEST DESCRIPTION: Sludge breakup and conveyance, no slurry

EQUIPMENT CONFIGURATION: XT2000, Rotating Cutter Head and suction system.

TEST MATERIAL: Hardpan 2, 21.8 psi shear.

TEST TUB: R4

DATE: April 17, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature.(Complete)
C. Check vehicle drive functions.(Complete)
D. Check lift arm function.(Complete)
E. Check cutter head function.(Complete)
F. Check suction system function.(Complete)

Pre-Test Checkout: Data Logging

A. Stop HPU.(Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate cutter head, read Pa, Ps, Pr, flow, accelerometer
J. Stop cutter head. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (No I/R Thermometer used for this test)

Equipment Insertion

A. Remove end form from tub. (Complete)
B. Position ramp. (No ramp used)
C. Drive vehicle into appropriate tub. (Complete)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check. (Complete)

DATA FILE NAME: T18_N.BIN
START TIME: 12:01:28, 12:16:13
STOP TIME: 12:16:08, 12:18:22
DURATION IN MINUTES: 16 Minutes 49 Seconds
OFFBOARD VIDEO TAPE #: Summary Tape 1.00.47

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

This material has the consistency of semi-hardened clay. It is significantly harder than the 4.6 shear material but has many of the same handling characteristics. The XT2000 was able to move into this material with little effort. The rotating cutter head was used to inject energy into the material and free entrained water to mix and re-slurry the material. The air conveyance system was turned on and initially transferred material effectively. After one minute of transfer the hose began to display significant signs of internal buildup. After three minutes the hose clogged. With the air conveyance running the hose was eventually cleared manually by picking up and dropping the hose stimulating the sludge to move. Based upon the results of this test it appears that although water injection is not necessary to mobilize the material long term consistent transfer may be aided by moderate additions of water.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	84	**POUNDS**
CONTAINER GROSS WEIGHT:	275	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	0	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	0	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	191	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = 31.83 **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = .32 **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = 100%

MODIFIED TEST

Note: See Test Numbers

TEST #: T19, T20, T21, T22
Due to the transfer issues surrounding the operation of the Foilex pump all four tests were completed using the same method of operation. No significant changes took place regarding the performance of the vehicle in the various test materials.

TEST DESCRIPTION: Sludge breakup and conveyance, low pressure slurry

EQUIPMENT CONFIGURATION: XT1100, Rotating Cutter Head and foilex pump, LP spray bar.

TEST MATERIAL: Hardpan 2, 21.8 psi shear.

TEST TUB: R4

DATE: April 17, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:
Pre-Test Checkout: Vehicle and Tools
A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature.(Complete)
C. Check vehicle drive functions.(Complete)
D. Check lift arm function.(Complete)
E. Check cutter head function.(Complete)
F. Check suction system function.(Complete)

Pre-Test Checkout: Data Logging
A. Stop HPU.(Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate cutter head, read Pa, Ps, Pr, flow, accelerometer
J. Stop cutter head. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (No I/R Thermometer used for this test)

Equipment Insertion
A. Remove end form from tub. (Complete)
B. Position ramp. (No ramp used)
C. Drive vehicle into appropriate tub. (Complete)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check. (Complete)

DATA FILE NAME: T19_1, T19_2, T19_3, T19_4, T19_5
START TIME: 11:14:08, 11:16:38, 11:20:11, 11:22:22, 11:24:12
STOP TIME: 11:16:34, 11:17:34, 11:22:20, 11:23:38, 11:25:58
DURATION IN MINUTES: 7 Minutes 55 Seconds
OFFBOARD VIDEO TAPE #: Summary Tape 1.03.18

OBSERVATIONS AND COMMENTS:

A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

The XT2000 was driven into the Hardpan material and began to homogenize the material into a pumpable form. The onboard foilex pump was activated. No material was observed coming from the discharge point of the hose. After brief discussions it was apparent that the pump suction intake point would not remain flooded due to the thick consistency of the material. In order to determine if the problem was caused by air entering the pump or if the material was simply too thick to transfer, a second test was conducted. This test involved transferring the hardpan which had been homogenized by the cutter into a 55 gallon drum. The pump was then lowered into the drum and the intake buried in the hardpan sludge. When the pump was activated the sludge was rapidly transferred through the hose to the discharge point. Based on this information it was determined that the current mounting configuration of the pump would not enable transfer do to air entering the pump. The vehicle had little problem maintaining mobility in the hardpan and broke up and or dislodged material effectively with the rotating cutterhead.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	N/A	**POUNDS**
CONTAINER GROSS WEIGHT:	N/A	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	N/A	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = N/A **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = N/A **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST #: T20

TEST DESCRIPTION: Sludge breakup and conveyance, low pressure slurry

EQUIPMENT CONFIGURATION: XT1100, Rotating Cutter Head and foilex pump, LP spray bar.

TEST MATERIAL: Hardpan 1, 4.6 psi shear.

TEST TUB: R3

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check cutter head function.
F. Check pump function.
G. Check spray bar function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate cutter head and spray bar, read Pa, Ps, Pr, Flow, and accelerometer.
J. Stop cutter head and spray.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____ **POUNDS**
CONTAINER GROSS WEIGHT: _____ **POUNDS**
WATER VOLUME, (IF APPLICABLE): _____ **GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____ **POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____ **POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____ **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST #: T21

TEST DESCRIPTION: Sludge breakup and conveyance, high pressure slurry

EQUIPMENT CONFIGURATION: XT1100, Rotating Cutter Head and foilex pump, HP spray bar.

TEST MATERIAL: Hardpan 1, 4.6 psi shear.

TEST TUB: R3

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check cutter head function.
F. Check pump function.
G. Check spray bar function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate cutter head and spray bar, read Pa, Ps, Pr, Flow, and accelerometer.
J. Stop cutter head and spray.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____ **POUNDS**
CONTAINER GROSS WEIGHT: _____ **POUNDS**
WATER VOLUME, (IF APPLICABLE): _____ **GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____ **POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____ **POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____ **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST #: T22

TEST DESCRIPTION: Sludge breakup and conveyance, high pressure slurry

EQUIPMENT CONFIGURATION: XT1100, Rotating Cutter Head and foilex pump, HP spray bar.

TEST MATERIAL: Hardpan 2, 21.8 psi shear.

TEST TUB: R4

DATE:

TEST MANAGER:

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU.
B. Start HPU and bring to operating temperature.
C. Check vehicle drive functions.
D. Check lift arm function.
E. Check cutter head function.
F. Check pump function.
G. Check spray bar function.

Pre-Test Checkout: Data Logging

A. Stop HPU.
B. Start and initialize data logger.
C. Read shorted input channel on A/D converter.
D. Read reference input channel on A/D converter.
E. Read accelerometer output with all equipment off.
F. Start HPU.
G. Lower lift arms to bottom of stroke and read LVDT sensor.
H. Raise lift arms and read LVDT sensor as head moves to top of stroke.
I. With lift arms raised, activate cutter head and spray bar, read Pa, Ps, Pr, Flow, and accelerometer.
J. Stop cutter head and spray.
K. Stop data logging, review data to insure logging is correct.
L. Check operation of the IR thermometer.

Equipment Insertion

A. Lift vehicle with gantry.
B. Move to appropriate tub.
C. Lower vehicle into the tub.

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check.
B. Conduct operational check of on-board video system.

DATA FILE NAME: _____
START TIME: _____
STOP TIME: _____
DURATION IN MINUTES: _____
ONBOARD VIDEO TAPE #: _____
OFFBOARD VIDEO TAPE #: _____

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT: _____ **POUNDS**
CONTAINER GROSS WEIGHT: _____ **POUNDS**
WATER VOLUME, (IF APPLICABLE): _____ **GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE): _____ **POUNDS**
NET MATERIAL OR FILTRATE WEIGHT: _____ **POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION =
_____ **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE =
NET WEIGHT/(DURATION x DENSITY) = _____ **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%

TEST #: T23

TEST DESCRIPTION: Sludge suction, low pressure slurry

EQUIPMENT CONFIGURATION: XT1100, Rotating Cutter Head and foilex pump, diluent injection.

TEST MATERIAL: Wet sludge, 0.5 psi shear.

TEST TUB: L3

DATE: April 19, 1996

TEST MANAGER: Jim Ridgely

PRETEST CHECKLIST:

Pre-Test Checkout: Vehicle and Tools

A. Check all hydraulic and electrical connections at the vehicle and HPU. (Complete)
B. Start HPU and bring to operating temperature.(Complete)
C. Check vehicle drive functions.(Complete)
D. Check lift arm function.(Complete)
E. Check cutter head function.(Complete)
F. Check suction system function.(Complete)

Pre-Test Checkout: Data Logging

A. Stop HPU.(Complete)
B. Start and initialize data logger. (Complete)
C. Read shorted input channel on A/D converter. (Complete)
D. Read reference input channel on A/D converter. (Complete)
E. Read accelerometer output with all equipment off. (Complete)
F. Start HPU. (Complete)
G. Lower lift arms to bottom of stroke and read LVDT sensor. (Complete)
H. Raise lift arms and read LVDT sensor as head moves to top of stroke. (Complete)
I. With lift arms raised, activate cutter head, read Pa, Ps, Pr, flow, accelerometer
J. Stop cutter head. (Complete)
K. Stop data logging, review data to insure logging is correct. (Complete)
L. Check operation of the IR thermometer. (No I/R Thermometer used for this test)

Equipment Insertion

A. Remove end form from tub. (Complete)
B. Position ramp. (No ramp used)
C. Drive vehicle into appropriate tub. (Complete)

Video Equipment Check

A. Position external video camera to record actions of the vehicle and cutter head, conduct operational check. (Complete)

DATA FILE NAME: T23_1
START TIME: 11:14:40
STOP TIME: 11:16:38
DURATION IN MINUTES: 1 Minute 58 Seconds
OFFBOARD VIDEO TAPE #: Summary Tape 1.09.52

OBSERVATIONS AND COMMENTS:
A. Ease of deployment and retrieval
B. Traction and maneuverability of the vehicle
C. Ability of the operator to observe and guide operation
D. Ability to break up or dislodge material
E. The propensity of the system to clog, and ease of clearing clogs.
F: Other:

After viewing the capability of the XT2000 vehicle in the other simulant materials it was determined that the soft sludge should be modified to more closely resemble in tank conditions. Debris from the previous tests including chunks of 1500 psi and 3000 psi saltcake were added to the soft sludge. Additional debris including wire, wire-ties and steel strapping were added to and imbedded in the sludge. The vehicle with the rotating cutterhead in operation drove into the face of the sludge. The forward motion of the vehicle was not slowed by the sludge. The debris in the sludge was blended in with the sludge and in the case of the salt cake and or rock simulant would have been transferrable. The strapping debris wound around the cutter blade shaft. The cutter blades and or the performance of the cutter did not appear to be significantly impacted by the limited quantities present but additional testing would be required to determine the impact of large volumes of such debris.

MATERIAL REMOVAL RESULTS:

WEIGHING CONTAINER EMPTY WEIGHT:	N/A	**POUNDS**
CONTAINER GROSS WEIGHT:	N/A	**POUNDS**
WATER VOLUME, (IF APPLICABLE):	N/A	**GALLONS**
FILTER MATERIAL WEIGHT (IF APPLICABLE):	N/A	**POUNDS**
NET MATERIAL OR FILTRATE WEIGHT:	N/A	**POUNDS**

MATERIAL WEIGHT REMOVAL RATE = NET WEIGHT/DURATION = N/A **LBS/MIN**

MATERIAL VOLUME REMOVAL RATE = NET WEIGHT/(DURATION x DENSITY) = N/A **CU.FT./MIN**

SOLIDS RATIO = (NET MATERIAL WEIGHT)*(100)/ (WATER VOLUME x 62.4 + NET MATERIAL WEIGHT) = _____%