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1. EDT 610252

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Thermal & Fluid Mechanics Engineering	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: W236A	6. Cog. Engr.: for S. C. Chang	7. Purchase Order No.: N/A
8. Originator Remarks: APPROVAL/RELEASE		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: 5/5/95

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-W236A-ER-022		0	Using Tank 107-AN Caustic Addition for Confirmation of Mixing Scale Relationship	N/A			

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

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RELEASE AUTHORIZATION

Document Number:	WHC-SD-W236A-ER-022, Rev. 0
Document Title:	USING TANK 107-AN CAUSTIC ADDITION FOR CONFIRMATION OF MIXING SCALE RELATIONSHIP
Release Date:	5/3/95

This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

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SUPPORTING DOCUMENT

1. Total Pages 16

2. Title	3. Number	4. Rev No.
Using Tank 107-AN Caustic Addition for Confirmation of Mixing Scale Relationship	WHC-SD-W236A-ER-022	0

5. Key Words

Subscale Mixing, Full Scale Mixing, Jet Mixing, waste uniformity, uniformity scaling, MWTF

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Signature

Organization/Charge Code 71410/DTTC7

7. Abstract

A subscale jet mixing program was carried out in two scale tanks to extend the basis of previous subscale tests to include in-tank geometry associated with tank AN-107. The laboratory data will be correlated with the data to be collected in the upcoming tank AN-107 mixing and caustic addition test. The objective is to verify the scaling relationship used in the MWTF mixer design

8. RELEASE STAMP

USING TANK 107-AN CAUSTIC ADDITION FOR CONFIRMATION OF MIXING SCALE RELATIONSHIP

May 1995

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Issued by

WESTINGHOUSE HANFORD COMPANY

for the

U.S. Department of Energy
Richland Operations Office
Richland, Washington

USING TANK 107-AN CAUSTIC ADDITION FOR CONFIRMATION OF MIXING SCALE RELATIONSHIP

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USING TANK 107-AN CAUSTIC ADDITION FOR CONFIRMATION OF MIXING SCALE RELATIONSHIP

1.0 INTRODUCTION

The jet mixer pump in the Multifunction Waste Tank Facility (MWTF) was designed based on tests conducted in 1/25, 1/10 and 1/6.3 scale tanks. The scaling relationship obtained from these test data predicts that the pump power required to maintain mixture uniformity is approximately proportional to the second power of the tank diameter (Chang and Beaver, 1993). This scaling relationship has not been verified in full scale operation, because up-to-date no mixing operation has been conducted in a full scale waste tank with adequate instrumentation for measuring mixing uniformity. The anticipated mixing test for caustic addition to tank 241-AN-107 will provide the first mixing data in an actual waste tank which can be used for verification of this scaling relationship. However, the in-tank geometry for AN-107 includes 21 air-lift circulators which were not included in the previous subscale tests.

This test program extends the basis of the previous subscale tests to include the AN-107 in-tank geometry. The tests were conducted in the existing 1/10 and 1/6.5 scale test tanks. The laboratory data will be correlated with the data to be collected in the upcoming tank AN-107 mixing and caustic addition test. The objective is to verify the scaling relationship used in the MWTF mixer design.

2.0 MIXING AND CAUSTIC ADDITION TEST IN TANK AN-107

The anticipated mixing and caustic addition test is to install a submersible pump driven by a 75 hp motor in the center of tank AN-107. The pump would drive two opposing horizontal jets to first mobilize the settled solids and then mix the added caustic solution to the suspended solids. A mixing test is planned prior to the caustic addition and will determine mixture uniformity as a function of mixer pump power. The pump power input will be controlled by a variable speed drive. Tank AN-107 will be equipped with two ENRAF 854 ATG densitometers, which will be used for determining the uniformity of the mixed slurry.

3.0 TEST LOOP AND INSTRUMENTATION

The test tanks used in this project are translucent plastic of 90 inch diameter and 144 inch diameter. Since the actual waste tank has a 900 inch diameter, the scale factors for the 144 and 90 inch tanks are 1:6.25 and 1:10 respectively. The test loop for each test tank includes an intake nozzle, recirculation piping, a recirculation pump and a jet mixer assembly. The mixer assembly consists of a turn table located on top of the tank, a standpipe which extends into the tank, and two horizontal nozzles that are affixed to the lower end of the standpipe. The turntable, which controls the angular direction of the mixing jets, is supported by two cross beams attached to the top of the tank wall. The nozzles are parallel to the tank floor and horizontally opposed (see Figure 1).

Both test tanks are constructed of semi-transparent polyethylene, which allows visualization of the initial supernate/solids interface as well as the mixing interface between the slurry and supernate during the transient tests. The twenty one (21) air lift circulators in AN-107 are scaled linearly and are simulated with PVC pipe. Each simulated air lift circulator is in the same relative position in the test tank that the actual air lift circulators are in the full scale waste tank.

The recirculation pump takes liquid from the loop inlet, which is submerged in the tank liquid adjacent to the central stand pipe. The pressurized discharge from the pump is sent to the jet nozzles. A ball valve located upstream of the stand pipe is used to control the jet flow rate. The test loop is instrumented with a flowmeter, a pressure gage, and a pressure transducer.

A special densitometer developed and fabricated in-house was used to determine the uniformity of the mixed slurry. This instrument measures the local bulk density by sensing the liquid buoyancy. The liquid buoyancy, which is a function of the particle concentration, was determined by measuring the force on a submerged float with a load cell. The electrical signal from the load cell was sent to the data acquisition system and recorded continuously during the mixing tests.

4.0 TEST PARAMETERS

Typical test parameters compared with the actual mixer design are given in Table 1.

Table 1. Key Parameters for Tank AN-107 Caustic Addition Test.

Component	Actual	Test in 1/6.3 Scale Tank	Test in 1/10 Scale tank
Tank diameter (in.)	900	144	90
Air Lift Circulators			
Number of circulators	21	21	21
Air circulator dia. (in.)	30	4.5	3
Length lower section (in.)	204	32.64	20.4
Diameter upper pipe (in.)	6	0.96	.6
Distance from bottom (in.)	30	4.8	3
Radial location - row 1 (in.)	172	27.52	17.2
Radial location - row 2 (in.)	327	52.32	32.7
Jet height from bottom (in.)	6 - 9	1.0	.625
Jet nozzle diameter (in.)	1.5	0.24	.15
Liquid height (in.)	386	63	39

The dimensions of tank AN-107 were obtained from the following drawings.

- H-2-72037 Engineering Flow Diagram Tank 241-AN-107
- H-2-71998 Piping Plan Central Pump Pit 241-AN-01A through -07A
- H-2-72041 Tank 107 Air Lift Circulator Assembly and Details
- H-2-72043 Tank 107 Air Lift Circulator Horizontal Restraints
- H-2-71161 Plan Tank Penetrations 241-AN-107 Tank
- H-2-71162 Tank Penetrations and Riser Details 241-AN-107 Tank
- H-2-71912 Structural Central Pump Pits 241-AN-01A through -07A

5.0 SIMULANT

The particulate simulant used for the current test program is the same calcium hydroxide and water material that was used during the previous scale test program for the MWTF (Chang and Beaver, 1993). The material properties of primary importance are particle size and the density ratio between particles and supernate. The viscosity of the fluidized slurry and the settling velocity depends on these parameters.

Laboratory measurements of the material properties for calcium hydroxide in water (Chang, 1993) have shown that particle sizes range from less than 0.5 microns to 100 microns with the log normal peak in the 3 to 5 micron range. This overall particle size distribution is somewhat larger than the approximately 1 micron average that is expected to exist in AN-107, based on a limited set of measurements (Prignano, 1988). For the calcium hydroxide simulant the density of the supernate is 0.996 g/ml, and the density of the settled solids is 1.4 gr/ml. This gives a density ratio of 1.41 which should compare favorably with the real waste. Viscosity measurements of the fluidized slurry provided values from 7 to 90 cp in the range from 12% to 45% solids. Settling time, based on change of the supernate/sludge interface, was measured at 1.25 inch/hr. Because of the particle size difference this settling rate is expected to be very conservative with respect to the real waste.

6.0 TEST PROCEDURE

The following steps were performed with the appropriately scaled mixer and air lift circulators installed in the test tanks. Tests were performed to determine the minimum jet velocity (pump power) necessary to maintain a 90% mixture uniformity.

1. Before the start of the mixing test record the density of the clear supernate then mix the tank liquid thoroughly with excessive

mixing power to obtain 100% homogeneity. Record the local bulk density of the mixed slurry.

2. Select a test condition (jet flow rate and jet indexing time) and run the mixer for a predetermined time to determine whether uniformity can be maintained by the selected condition. Homogeneity is determined by monitoring the local density variation during the test.

3. Stop the mixer for a predetermined time to allow the solids to start to settle.

4. Repeat Step 2 with the same test parameters to determine whether the selected mixing condition can recover the uniformity from the partially settled condition.

5. Analyze the data and determine the test condition for the next test; if mixing was satisfactory, reduce the jet velocity, otherwise increase the jet velocity.

6. Repeat steps 1-5 until the jet velocities are at least able to maintain 90% uniformity and to recover the settled condition to within 90%.

Steps 1-6 were repeated in each of the two scale test tanks. The data from this series of tests were then evaluated to determine the scaling relationship for maintaining uniformity in tank AN-107.

7.0 TEST RESULTS

7.1 Test Results in 1/10 Scale Tank

Test data for 1/10 scale tank are presented in Figures 2-4. Figure 2 presents the data obtained from Test# A. The test started at time zero with a bottom layer of settled solids and a clear supernate layer above the solids layer. The tank was first mixed with full pump power to achieve a uniform mixture, as indicated in Zone 1 in Figure 2. After the tank was completely mixed, the pump was shut off momentarily to take data. Then the mixing jets were adjusted to 5.2 gpm flowrate and 14 psi jet back pressure. This test condition was maintained for about 100 minutes. The data clearly show that the relative uniformity at the top layer in the tank decreased continuously during this period of mixing and had dropped to 90% by the end of the period, as shown in Zone 2. This indicates that the mixing power was insufficient to maintain mixture uniformity and the solids in the top layer are settling out gradually. The uniformity decreased further after the mixer pump was temporarily shut off (zone 3). Restart of the mixer pump (Zone 4) did not recover any mixture uniformity of the top layer.

In Test# B, mixing effectiveness was tested with a 6 gpm jet flow and 17 psi jet back pressure. The data, as presented in Figure 3, shows that mixture uniformity of the top layer also decreases continuously, however, at a slower rate compared to Test A. This indicates that the tested mixing power was insufficient.

Figure 4 present the results of Test# C which was performed with still higher mixing power. For this test, uniformity was maintained at near 100 percent during the entire mixing period. The jet flow was above 7 gpm and the back pressure was above 21 psi.

The results of Test# D (Figure 5) indicate again that uniform mixing can be maintained with a back pressure above 20 psi and that uniformity decreases only slightly when mixed with 19 psi back pressure.

From the above test results we can determine that the minimum condition to maintain uniform mixing requires approximately 20 psi jet back pressure and a resultant 6.7 gpm jet flow. The mixing power is calculated to be:

$$6.7 \times 20/1714 = 0.078 \text{ Hp.}$$

7.2 Test Results in 1/6.3 Scale Tank

Data for tests in the 1/6.3 scale tank are designated Test #E and Test #F and are presented graphically in Figures 6 and 7 respectively. Figure 6 shows that mixing with 13 psi jet back pressure, 15 psi and then 18 psi jet back pressure is insufficient to either maintain or recover uniformity in the top layer. Figure 7 shows that uniformity of the top layer declines slowly when mixed with jet pressure slightly blow 20 psi and that uniformity is maintained at nearly 100% when mixed with a jet back pressure slightly above 20 psi. The flowrate of the jet at 20 psi back pressure was measured at 16 gpm.

7.3 Scale Correlation and prediction for Tank AN-107

It is very interesting to observe that the minimum mixing conditions in both 1/10 scale and 1/6.3 scale tanks require approximately the same back pressure for the mixing jets (20 psi). This is consistent with the MWTF Title II test results (Chang, 1994). Since the jet nozzle is scaled with the tank scale, the jet flowrate at the same back pressure is proportional to the nozzle area, which is proportional to the second power of the jet diameter. Therefore the conclusion is that the required jet mixing power for uniformity is proportional to the second power of the tank diameter. This conclusion is again in agreement with the findings in MWTF tests.

Since the jet diameters used in the current tests were scaled to the jet diameter for the AN-107 mixer pump, the prediction can be reasonably made that slurry uniformity in AN-107 will require the equivalent of 20 psi jet back pressure (26 psi when corrected for the difference in slurry density between tank waste and test simulant). This predicted pressure can be achieved by reducing the AN-107 pump speed to approximately 1060 rpm.

8.0 REFERENCE

Chang, S. C., 1993, Subscale Mixing Test for Tank 101-SY, WHC-SD-WM-ER-178, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Chang, S. C. and T. R. Beaver, Multifunction Waste Tank Facility Subscale Mixing Report, WHC-SD-W236A-ER-005, 1993, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Chang, S. C., 1994, Engineering Scale Mixing Systems Tests for MWTF Title II Design, WHC-SD-W236A-ER-008, 1994, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Prignano, A. L., 1988, Tanks 102-AN and 107-AN Viscosity and Percent Settled Solids Determination, to D. E. Scully and E. C. Vogt, Westinghouse Hanford Company, Richland, Washington.

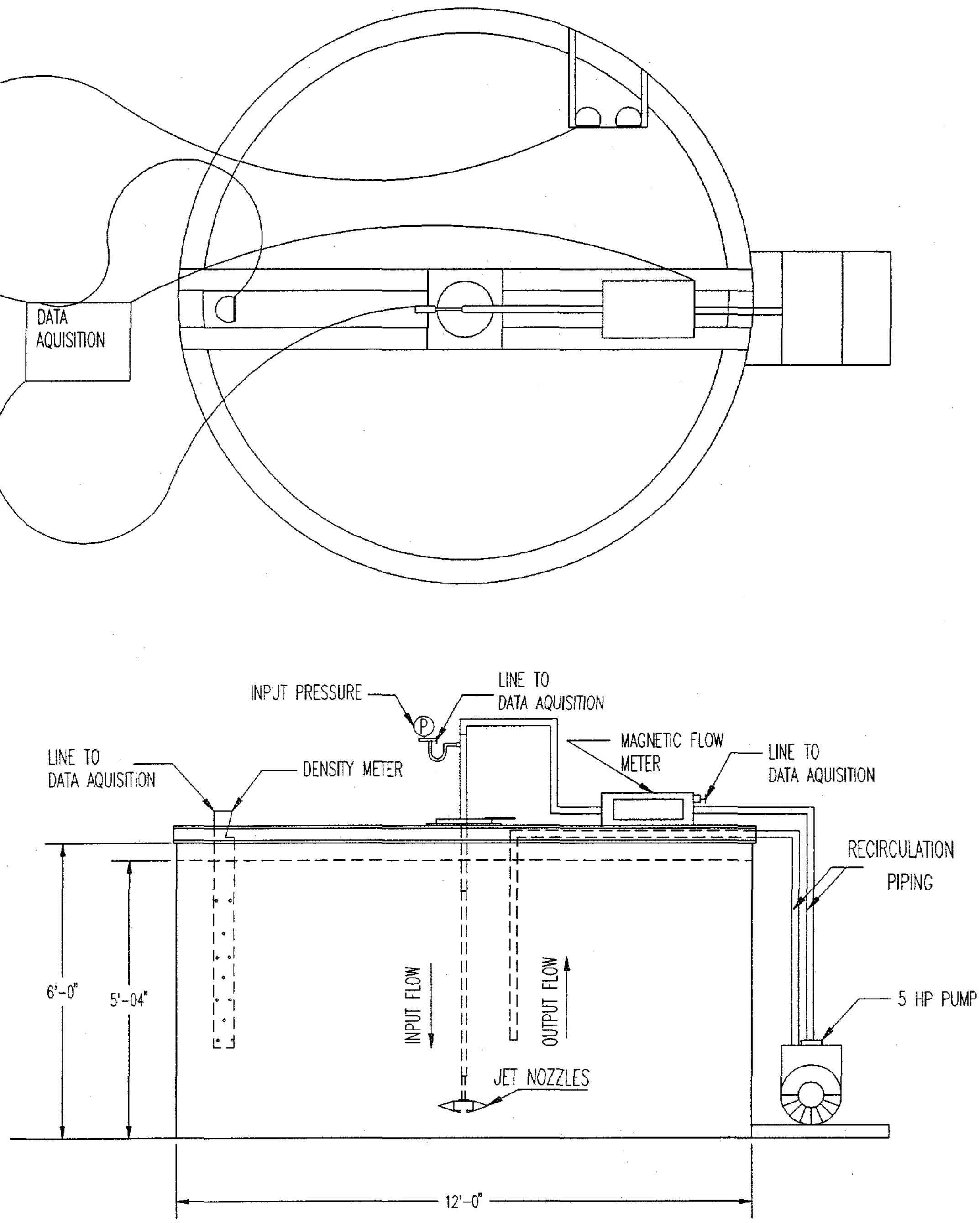
DATA
AQUISITION
INPUT PRESSURE
LINE TO
DATA AQUISITION
MAGNETIC FLOW
METER
LINE TO
DATA AQUISITION
LINE TO
DATA AQUISITION
DENSITY METER
RECIRCULATION
PIPING
6'-0"
5'-04"
INPUT FLOW
OUTPUT FLOW
5 HP PUMP
JET NOZZLES
12'-0"

Figure 1

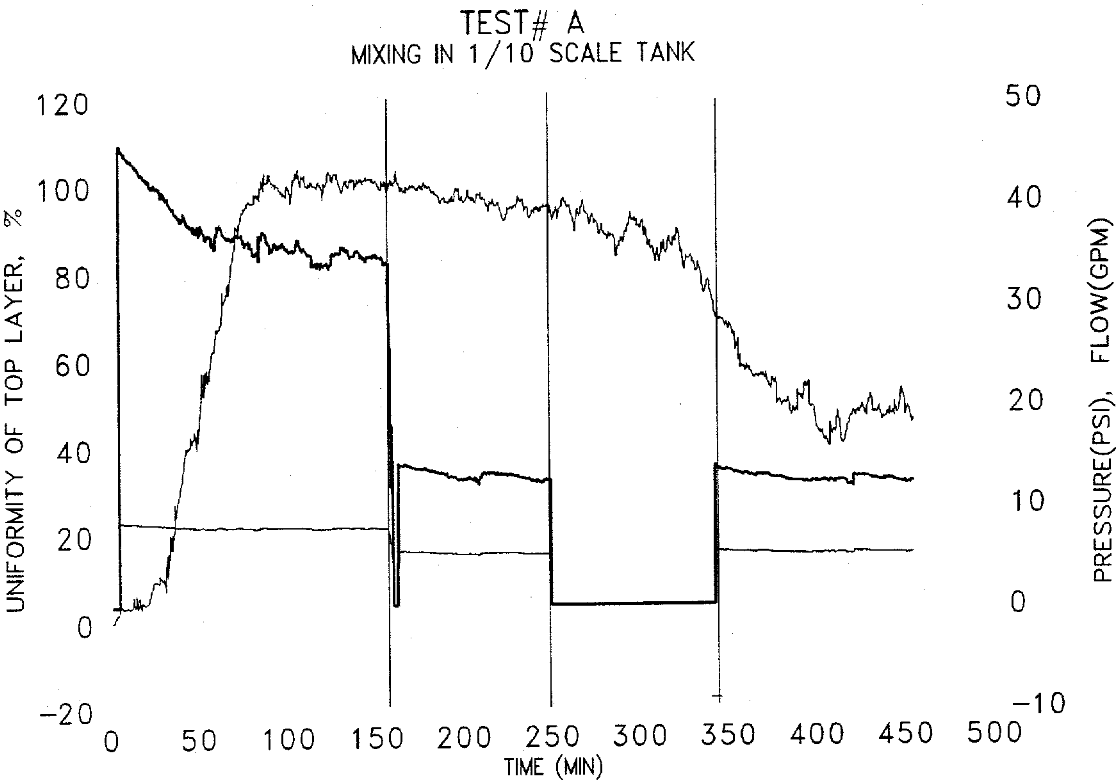
TEST# A
MIXING IN 1/10 SCALE TANK
UNIFORMITY OF TOP LAYER, %
PRESSURE(PSI), FLOW(GPM)
TIME (MIN)
120
100
80
60
40
20
0
-20
50
40
30
20
10
0
-10
0
50
100
150
200
250
300
350
400
450
500

Figure 2

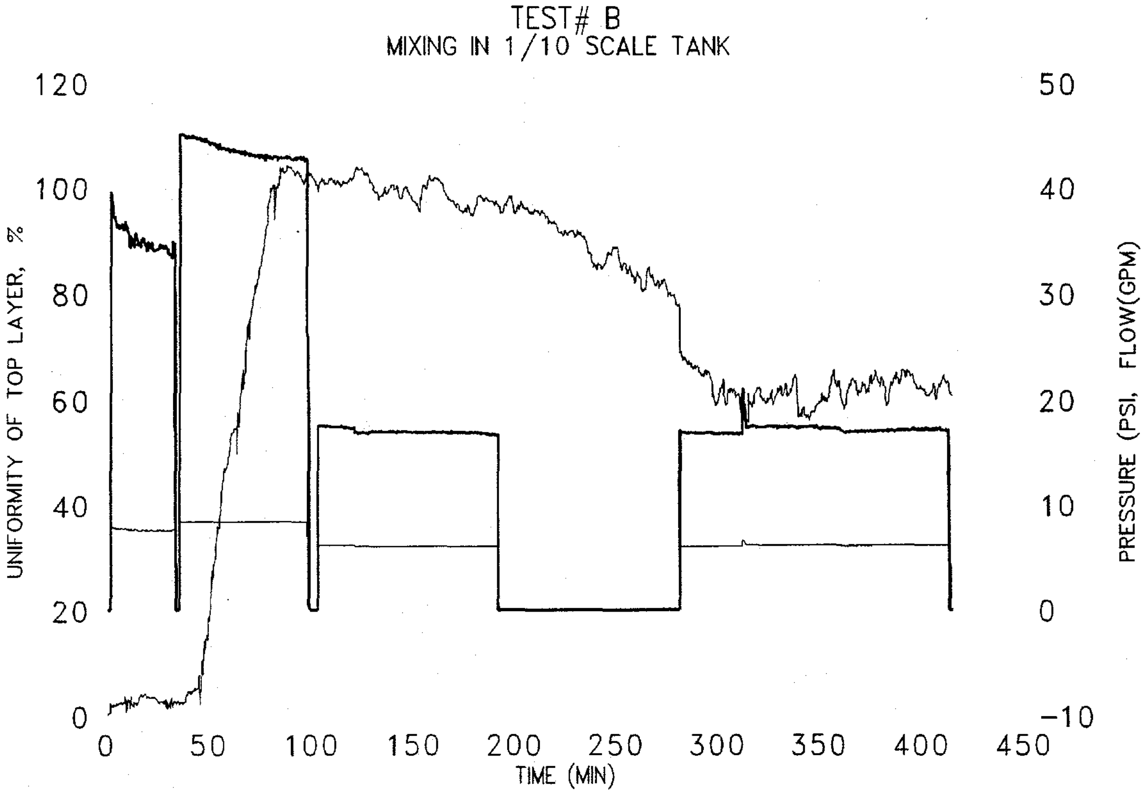
TEST# B
MIXING IN 1/10 SCALE TANK
UNIFORMITY OF TOP LAYER, %
PRESSURE (PSI, FLOW(GPM)
TIME (MIN)
0
20
40
60
80
100
120
-10
0
10
20
30
40
50
0
50
100
150
200
250
300
350
400
450

Figure 3

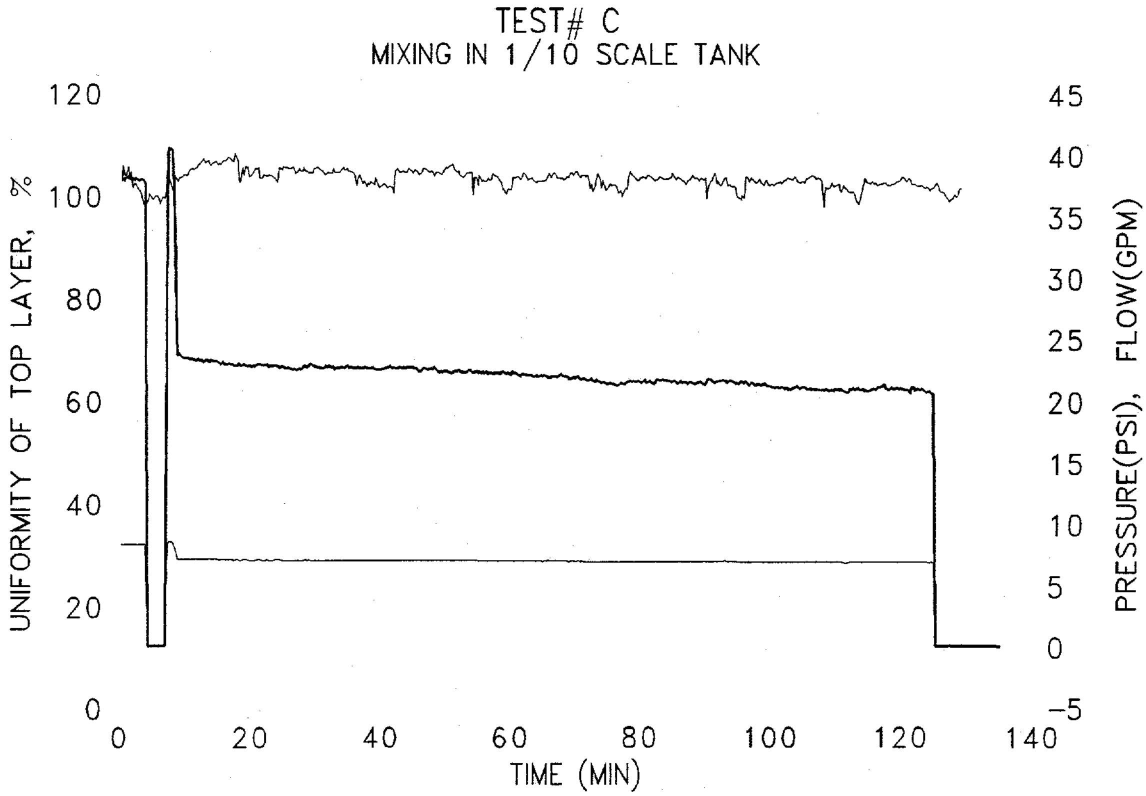
TEST# C
MIXING IN 1/10 SCALE TANK
UNIFORMITY OF TOP LAYER, %
PRESSURE(PSI), FLOW(GPM)
TIME (MIN)
0
20
40
60
80
100
120
140
45
40
35
30
25
20
15
10
5
-5

Figure 4

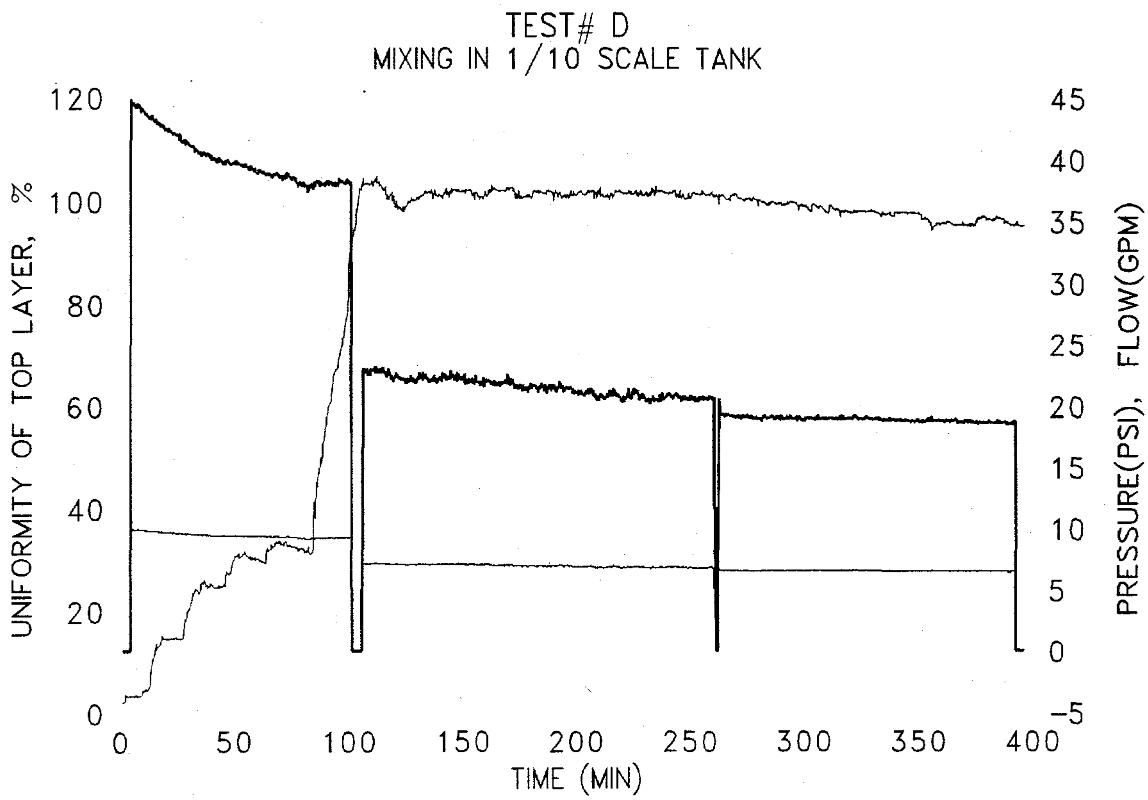
TEST# D
MIXING IN 1/10 SCALE TANK
UNIFORMITY OF TOP LAYER, %
PRESSURE(PSI), FLOW(GPM)
TIME (MIN)
0
20
40
60
80
100
120
-5
0
5
10
15
20
25
30
35
40
45
0
50
100
150
200
250
300
350
400

Figure 5

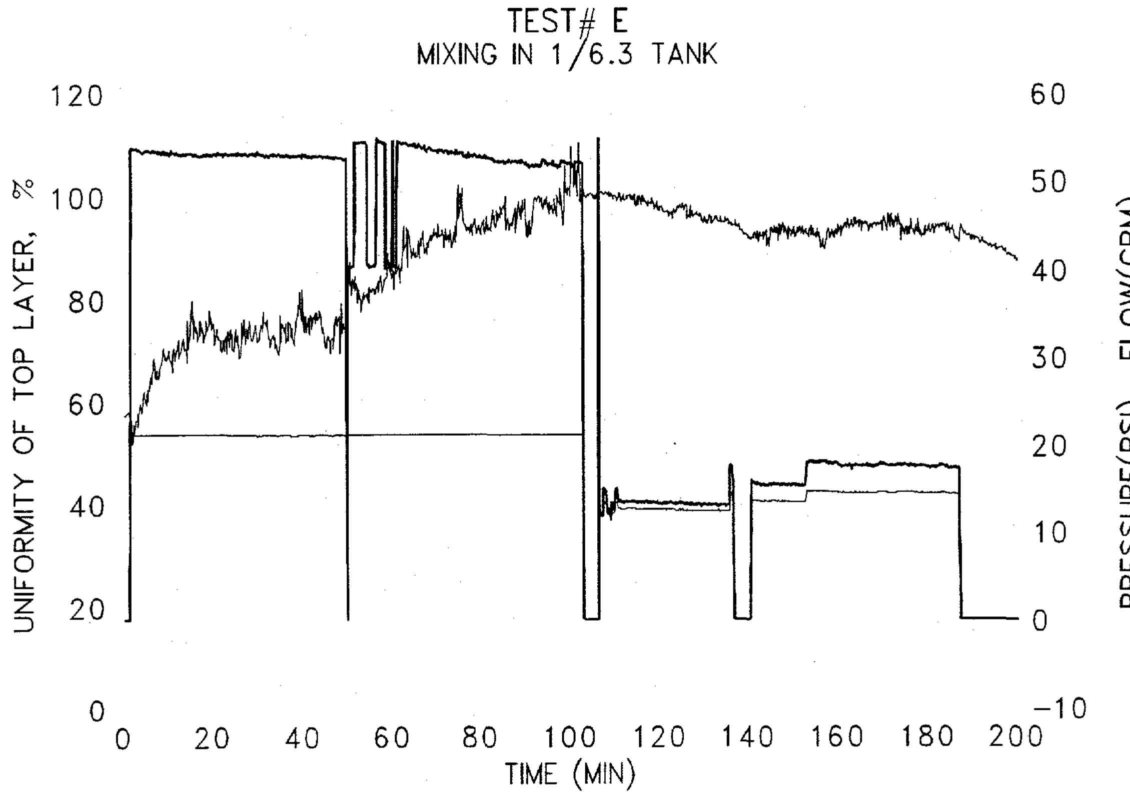
TEST# E
MIXING IN 1/6.3 TANK
UNIFORMITY OF TOP LAYER, %
PRESSURE(PSI), FLOW(GPM)
TIME (MIN)
0
20
40
60
80
100
120
140
160
180
200
-10
0
10
20
30
40
50
60

Figure 6

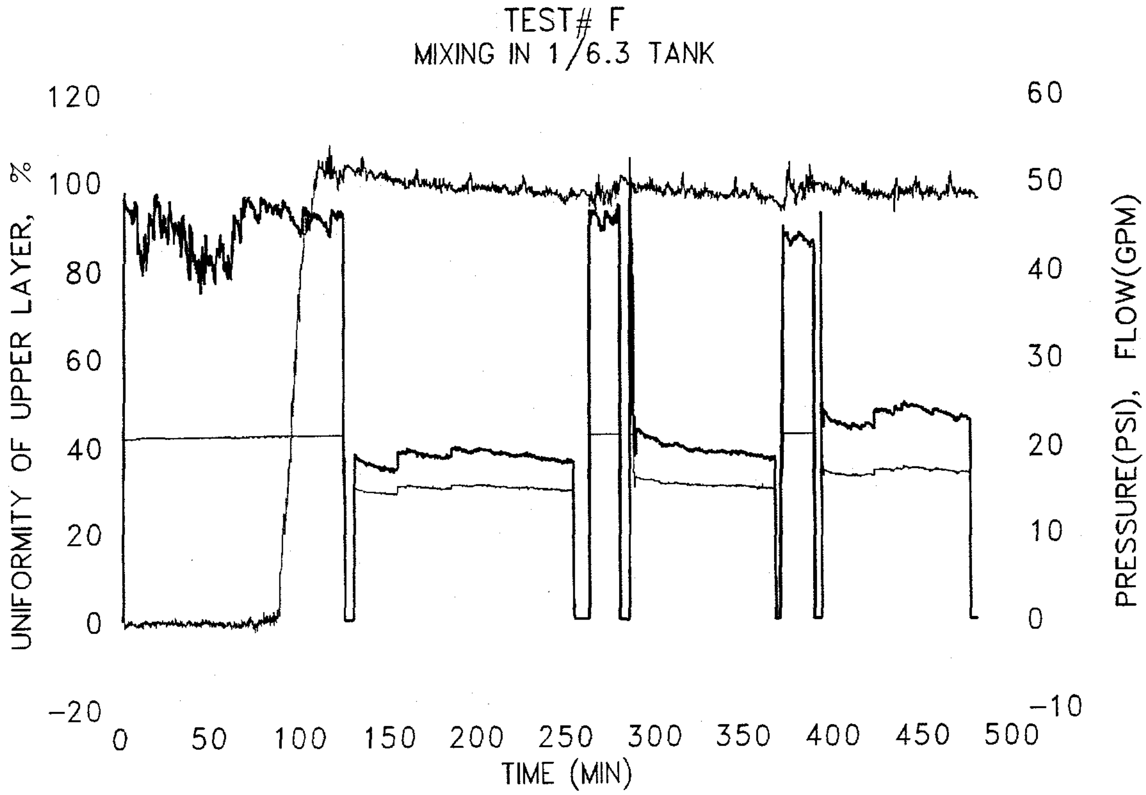
TEST# F
MIXING IN 1/6.3 TANK
UNIFORMITY OF UPPER LAYER, %
PRESSURE(PSI), FLOW(GPM)
TIME (MIN)
120
100
80
60
40
20
0
-20
60
50
40
30
20
10
0
-10
0 50 100 150 200 250 300 350 400 450 500

Figure 7