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7. Abstract <p>This document presents the results of the acceptance test for the mechanical and electrical features (not specifically addressed by the software acceptance test procedure) of the void fraction instrument.</p> <p>The testing concluded that the mechanical and electrical features are operating as designed and that the unit is ready for field service.</p>		
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**VOID FRACTION INSTRUMENT
ACCEPTANCE TEST REPORT**

T. I. Stokes
K. L. Pearce

October 1994

MASTER

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for

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VOID FRACTION INSTRUMENT ACCEPTANCE TEST REPORT

1.0 INTRODUCTION

1.1 PURPOSE

This document presents the results of the acceptance test for the mechanical and electrical features (not specifically addressed by the software ATP) of the void fraction instrument (VFI). This document and the ATP satisfy the requirements in EP-4.1, "Design Verification Requirements." The selected mode of design verification is qualification testing.

1.2 SCOPE

The testing described in this document verifies that the mechanical and electrical features are operating as designed and that the unit is ready for field service.

2.0 DESCRIPTION OF TEST

Acceptance testing of the VFI, control console, and decontamination spray assembly was conducted in the 306E building high bay and area adjacent to the facility. The VFI was tested in the horizontal position supported in multiple locations on rolling tables. The control console was located next to the VFI pneumatic control assembly. The VFI system was operated exactly as is expected in the tank farm, with the following exceptions: power was provided from a building outlet and the VFI was horizontal. Personnel who performed the ATP are listed on the attached prejob meeting attendance form (Attachment 1).

Additional test descriptions and procedures are discussed in WHC-SD-WM-ATP-103, "Void Fraction Instrument Acceptance Test Procedure" (see Attachment 1).

3.0 TEST RESULTS

3.1 TEST SECTION 6.2 - ELECTRICAL SYSTEMS PREOPERATIONAL CHECKOUT

Using a calibrated multimeter, the QC representative measured the resistance between the mounting bus bar (of the intrinsic safety barriers) and the VFI mast (3-inch stainless steel pipe). The reading was 0 ohm.

The intrinsic barriers were inspected by the Fire Protection engineer and found to be adequately installed.

No exceptions were found. Signatures on the test procedure indicate successful test completion.

CONCLUSIONS:

- 1) Equipment connects as per design.
- 2) Power distribution equipment ready for field service.
- 3) VFI heater operates correctly.
- 4) Intrinsic barriers are ready for field service.

3.2 TEST SECTION 6.3 - LEAK TESTS

The procedures for leak testing were developed to allow flexibility of testing in the lab. These tests were conducted to verify that the control and measurement system leak rates were minimal. The design mission is to take 34 samples from a given riser within a 16-hour time period without running out of nitrogen gas. The acceptance criteria for leak checking was not specifically specified in the test procedure but was left up to the cognizant mechanical engineer (ME) to accept or reject.

The test setup for leak testing the VFI piping, valves, fittings, actuators, seals, and other pressure-containing components bypassed the nitrogen supply cylinder (TK-1). TK-1 is a G3 sized bottle, and only one full spare is available, so TK-1 was bypassed to save the G3 gas supply. An external nitrogen source was connected using a tee into the VFI piping downstream of TK-1 and its associated regulator. The volume of the copper tubing connecting the external source to the VFI piping was calculated to be 40 cc. A manual valve was installed downstream of the source regulator. This valve was bubble checked to assure that when it was closed, no gas leaked through. Any through leakage would significantly muddle leak test data.

The exhaust valve (HV-3) was opened 1/8th of a turn (45° rotation from the fully closed position). This valve restricts exhaust flow and its setting is critical to machine performance. The flow control valve (HV-2) was opened 3.5 turns from the fully closed position. This valve meters all system flows. The nitrogen cylinder supply access valve (HV-1) is inherent to the cylinder.

The doors on all three enclosures were open for all tests, unless specifically stated otherwise. The tests were conducted with ambient air temperature in the 306E lab at approximately 21°C.

3.2.1 Pressurization Chamber/Water Tank/ Solenoid Valve Leak Tests

To test the integrity of the pressurization chamber, water tank (TK-2), and solenoid valves YV-7, -8, -9, -10, and -11 (see Figure 1 for valve locations), the water tank (TK-2) was first fully filled with water. The

Figure 1. Valve Locations

pressurization chamber was then fully pressurized. Once the pressure in the pressurization chamber stabilized, the sample chamber was opened to atmospheric pressure.

The initial conditions were stabilized at:

PIT 1	PIT 2	PE 8	PE 9 (Reference only)
497.7	497.8	198.92	498.3

Then, the valve line-ups were changed to:

HV-1	YV-1	YV-7	YV-8	YV-9	YV-10	YV-11
Clsd	Clsd	Clsd	Clsd	Clsd	Clsd	Clsd

Pressure Sensors PIT 1, PIT 2, PE 8, and PE 9 were manually observed. The decay rate was relatively uniform. The lower arm was actuated to quickly bleed PE 9 system pressure to atmospheric. This actuation did not lower pressure as rapidly as was desired, so the nitrogen bottle piping was opened to atmospheric conditions to very quickly reach equilibrium. After 6 minutes and 45 seconds, PE 9 indicated 14.85 psi. The following data points were taken after 10 minutes had passed:

TIME	PIT 1	PIT 2	PE 8	PE 9
10 minutes	490.9	491.1	67.42	13.85

The approximate volume between YV-10 and -11 is 6.2 cubic inches.

PIT 1 and PIT 2 pressure decay average: 0.68 psi/minute

A small leak rate from the water tank would show up as a large change in pressure (as indicated on PE 8) due to the small pressurized volume within the tank. An estimate of the pressurized volume was not prepared. Accordingly, the exact leak rate and leak location from Tank TK-2 were not determined. No water leakage occurred, which indicates that YV-8 was not the leak path. During field operation, the YV-8 line will be mechanically plugged to satisfy a safety assessment control. The leak may have come from YV-7 or YV-9 or any fittings/connections in between. YV-9 had water against it which indicates that the leak rate was primarily caused by YV-7 or some other component of the gas system near YV-7. (Informal testing indicates that YV-7 effectively seals gas from entering the water tank, as the water tank will not pressurize when PE 3 reads 200 psi and YV-7 is closed.)

To determine if the gas was leaking through YV-7 or -10, the nitrogen supply cylinder was reconnected to the VFI system and HV-1 was opened. The pressure in the supply line to the pressurizing chamber increased to a reading of 497.79 (as displayed on PE 9). Timing was continued from the previous test (i.e., 10 minutes is the start time for the following set of data points).

TIME	PIT 1	PIT 2	PE8	PE 9
14 minutes	487.1	487.3	65.25	487.79
16 minutes	485.6	485.9	64.84	487.79

20 minutes 483.0 483.3 63.96 487.28

The leak rate (as determined from PIT 1 and PIT 2) now averages 0.68 psi/minute. This leak rate average is unchanged from the previous tests. This indicates the leak rate is not through YV-10. The exact leak location was not determined, as a stabilization criteria of 2 psi/30 seconds is all that is required for acceptable data quality.

The average water tank pressure leak rate (as determined by PE 8) is now 0.22 psi/minute. The associated volume is small; therefore, the corresponding mass loss leak rate is very small.

CONCLUSION: Leak rates are acceptable.

3.2.2 Sample Chamber/Pressurization Chamber Combined Leak Tests

After the pressurization chamber was characterized, the sample chamber was filled with solid blocks to approximate 20 percent void fraction. The pressurization chamber and sample chamber were then pressurized to approximately 500 psig. YV-7 was left closed. The volume of the sample chamber is approximately 22 cubic inches. The volume of the chamber pressurizing line is approximately 1.6 cubic inch.

The initial conditions were stabilized at:

TIME	PIT 1	PIT 2	PE 8	PE 9	PIT 3
0 minutes	496.6	496.9	62.32	498.54	--

Then, the valve line-ups were changed to (or left at):

HV-1	YV-1	YV-7	YV-8	YV-9	YV-10	YV-11
Open	Open	Clsd	Clsd	Clsd	Clsd	Open

The pressure decays were then watched and recorded as below:

TIME	PIT 1	PIT 2	PE 8	PE 9	PIT 3
2.5 minutes	--	--	--	--	495.7
8 minutes	496.5	496.8	60.80	497.79	495.7

Valve YV-11 was closed after 8 minutes.

TIME	PIT 1	PIT 2	PE 8	PE 9	PIT 3
10 minutes	496.5	496.8	60.33	497.79	495.6
15 minutes	496.3	496.6	59.49	498.54	495.5
17 minutes	496.2	496.5	59.13	497.79	495.5

HV-1 was closed. The piping between valves HV-1 through YV-10 was vented to atmosphere over the 3 minute time period. (17 to 20 minutes)

TIME	PIT 1	PIT 2	PE 8	PE 9	PIT 3
20 minutes	496.0	496.3	58.73	14.35	495.4

22 minutes	495.6	495.9	58.01	14.35	495.3
24 minutes	495.4	495.7	57.79	14.35	495.2
29 minutes	494.9	495.1	57.00	14.35	495.1
30 minutes	494.8	495.1	56.82	14.35	495.1
31 minutes	494.7	494.9	56.73	14.35	495.1

Average leak rate with YV-11 closed:

Pressurization chamber: 0.09 psi/minute
Sample chamber and chamber pressurizing line: 0.02 psi/minute

CONCLUSION: Leak rates are acceptable.

3.2.3 Solenoid Valves (YV-9, -11)/Elbow Joint Leak Tests

Leak tests were performed to determine if there was in-leakage from YV-9 or -11 or from the elbow joint into the chamber pressurizing line. The sample chamber cover was closed to allow removal of the chamber pressurizing line. The chamber pressurizing line was disconnected from the sample chamber check valve and vented to atmospheric pressure. The line was then securely plugged with a swagelock fitting at this location. The pressurization chamber was charged, then YV-10 and -11 were closed. The water tank (TK-2) was charged. Valves YV-7, YV-1, and HV-1 were open.

TIME	PIT 3	PE 8	PE 4	PE 5	PE 6	PE 7	PIT 1	PIT 2
Initial	13.9	201.98	499.95	40.74	44.39	498.92	491.9	492.2
2 minutes	13.95	201.71	500.09	40.74	44.88	498.92	--	--
3 minutes	14.0	201.64	500.09	40.74	44.88	498.92	--	--
5 minutes	14.0	201.51	500.09	40.74	44.88	498.92	491.7	492.0

After 6 minutes, the sample chamber cover was opened.

7 minutes	14.0	199.26	499.59	41.26	502.82	41.47	491.4	491.6
9 minutes	14.0	199.23	499.59	41.26	502.82	41.47	491.1	491.4

Pressure in the connecting line did not increase. Solenoid Valves YV-9 and YV-11 do not leak into the chamber pressurizing line. The elbow rotation joint did not leak into the chamber pressurizing line passage.

CONCLUSION: No recordable leak rates.

3.2.4 Sample Chamber/Check Valve Leak Test

The chamber pressurizing line was reconnected to the check valve. The sample chamber was then charged per the steps in Section 6.3.6 of the test procedure (see Attachment 1). The chamber pressurizing line was disconnected

again, then a bubble solution was applied to the exposed check valve fitting. Zero bubbles were detected after 1 minute observation.

The chamber pressurizing line was reconnected, then pressurized to 500 psig. The fitting was externally bubble checked to verify a good connection had been achieved. Again, zero bubble leakage after 1 minute observation.

CONCLUSION: Check valve is bubble tight, which is acceptable.

3.2.5 Actuators Leak Test

These tests were conducted to characterize any actuator leakage. YV-10 was left open to provide a large volume (~ 101.6 cc (6.2 cubic inches)) from which the leak rate data could be easily interpreted. The water tank was full for these tests and YV-7 was opened. The actuator line volumes also served as a nitrogen reservoir.

YV-1 was opened to fully charge the system. After charging pressures had stabilized, YV-1 was closed. The first test was conducted with the SCC open and the arm rotated 90° to the mast. The following data were recorded:

TIME	PIT 1	PIT 2	PE 9	PE 4	PE 5	PE 6	PE 7
Initial	491.1	489.3	488.73	488.20	41.26	490.05	40.96
2 minutes	437.3	436.6	435.66	435.83	41.26	436.72	40.96
5 minutes	382.5	381.2	--	381.94	41.26	383.14	40.96
End test							

The system was recharged. The test configuration was changed to SCC closed and arm in alignment with the mast. The following data were recorded:

TIME	PIT 1	PIT 2	PE 9	PE 4	PE 5	PE 6	PE 7
Initial	498.5	498.8	500.56	41.43	500	44.39	500.99
2 minutes	486.0	486.2	486.47	41.43	486.07	43.3	486.51
5 minutes	465.2	465.5	466	41.43	466.57	43.3	465.04
End test							

The above data indicated one of the two variables caused a much larger leak rate. It was suspected one of the three-way valves had excessive internal leakage as no external leakage could be located. The following test was run to determine which system, SCC opening/closing, or arm rotation caused the noticeably larger leak. Each of the systems was alternately isolated.

The forearm was rotated to the 90° position with the SCC in the closed position. The volumes were recharged. YV-1 was closed after a steady-state condition was achieved. The following data were recorded:

TIME	PIT 1	PIT 2	PE 9	PE 4	PE 5	PE 6	PE 7
Initial	497.5	497.8	499.55	500.6	40.7	44.39	500.22
2 minutes	454.9	--	--	456.32	--	--	454.19
5 minutes	396.8	--	--	397.88	--	--	396.0
End test							

This test showed that the excessive leak was associated with the arm being rotated to the 90° position. A troubleshoot and isolate process was performed by plugging the lines associated with YV-2 and YV-3. It was determined that YV-2 was the leak source. YV-2 was disassembled and inspected. No obvious damage or contamination was present. The valve has a needle and seat design using no elastomers. One bronze seat and stainless needle did not show a good strike pattern and were lapped until a good strike pattern was observed. The valve was reassembled and reinstalled into the piping system.

The test was repeated with the arm at 90° and the SCC open. The volumes were recharged. YV-1 was closed after the pressures stabilized.

TIME	PIT 1	PIT 2	PE 9	PE 4	PE 5	PE 6	PE 7
Initial	498.4	--	--	501.62	40.74	502.61	40.44
2 minutes	472.2	--	--	472.78	--	474.02	--
5 minutes	439.0	--	--	440.38	--	442.0	--
End test							

The test was repeated with the SCC closed and the arm in alignment with the mast.

TIME	PIT 1	PIT 2	PE 9	PE 4	PE 5	PE 6	PE 7
Initial	498.5	--	--	--	500.80	--	500.73
2 minutes	486.0	--	--	--	487.37	--	488.06
5 minutes	464.2	--	--	--	465.31	--	464.53
End test							

The repair to YV-2 obviously decreased the leak rates as observed by the above retests. During YV-2 repair, it became obvious that this type valve would never seal bubble tight, so a small leak rate was deemed acceptable. It was determined that the leak rate was not caused by the actuators (cylinders), lines, or other components. The leak rate was entirely due to leakage from the pressurized side of the three-way solenoid valve to the vent side. During the troubleshoot process, the exhaust lines of the three-way valves were plugged; a small pressure decay of approximately 3 psi over 10 minutes was observed.

CONCLUSION: The cylinders and associated tubing runs have extremely small leak rates which are acceptable.

3.3 TEST SECTION 6.4 - OPERATIONAL TESTS

3.3.1 Motion of Forearm (Section 6.4.1)

Performance tests of the forearm were conducted with the VFI nitrogen supply cylinder as the gas source. The nitrogen supply cylinder is a size G-3 which contains approximately 1.13E6 cc (40 cubic feet) of nitrogen gas. The pressure reading for the nitrogen supply cylinder is displayed on PE 1. The

pressure decay observed during these performance tests was attributed to the gas consumed during the actuation cycle being studied. The small leakage through the three-way valves was considered negligible for these tests.

The forearm was rotated and retracted five times each way. To determine the average consumption of nitrogen for one rotate/retract cycle, the initial pressure in the supply cylinder was recorded. Additionally, the gas flow rate (displayed on FE 1) and pressure (displayed on PE 1) were recorded after the completion of each singular motion. During rotation (drive), the forearm is moved 90° to the support mast. Retraction brings the forearm back into alignment with the mast. The flow and pressure data was utilized in the ideal gas law equation to calculate the average amount of nitrogen consumed.

The amount of time required to drive the forearm was determined by clocking the motion of the arm from when motion was first observed until motion stopped. The amount of time to retract the forearm was similarly determined. Drive and retract times were recorded after the completion of each singular motion.

Actuation	TIME	FE 1	PE 1
Initial	--	--	1840.70
Retract 1	27 seconds	2952.0	1814.54
Drive 1	8 seconds	2713.2	1797.33
Retract 2	25 seconds	2947.5	1774.17
Drive 2	9 seconds	2724.0	1762.21
Retract 3	26 seconds	2946.8	1740.54
Drive 3	9 seconds	2712.8	1727.09
Retract 4	26 seconds	2943.2	1709.88
Drive 4	8 seconds	2733.2	1691.22
Retract 5	26 seconds	2949.2	1677.01
Drive 5	8 seconds	2731.6	1661.31

The gas flow rate from the supply cylinder to the actuator is displayed on FE 1. The flow indicator integrates the flow over a period of time, then outputs the integrated flow volume in cubic centimeters. If the forearm is restrained for some reason, the flow rate will decrease quicker and the total flow volume will be less. To simulate this condition, the forearm was physically restrained from movement once each direction. Several tests were run to determine the optimum time for integrating the flow. The flowmeter integration time was optimized to 45 seconds which gave a notable difference between a deployed versus a stuck cylinder while minimizing measurement time.

Data for unrestrained forearm:

<u>MOTION</u>	<u>FE 1</u>
Drive	2627.6
Retract	2878.0
Drive 2	2608.0
Retract 2	2859.6

Data for restraining forearm in horizontal position (0° to mast):

<u>MOTION</u>	<u>FE 1</u>
Drive	1286.0
Retract	2806.4
Drive 2	1309.6
Retract 2	2786.8

Data for restraining forearm in vertical position (90° to mast):

<u>MOTION</u>	<u>FE 1</u>
Retract	1845.6
Drive	2534.0
Retract 2	1812.4
Drive 2	2534.8

Results:

Minimum time for retract/drive cycle:	34 seconds
Average N ₂ use for a retract/drive cycle:	1.65E4 cc
Average FE 1 reading for drive:	2617.8 cc
Average FE 1 reading for retract:	2868.8 cc
Average FE 1 reading for drive - horizontally restrained:	1297.8 cc
Average FE 1 reading for drive - vertically restrained:	1829.0 cc

A load cell was connected to the tip of the sample chamber and a load applied until the forearm started to move. The transverse load required to start arm rotation from the aligned position measured 16 pounds. The transverse load to start arm rotation from the 90° position measured 72 pounds at the tip; the load increased to 90 pounds at an arm rotation of 70° from mast. Loads were measured with a digital weight indicator, Calibration Sticker No. 678-67-26-001, exp. 1/24/95, range 1000 pounds ± 2.5 pounds.

3.3.2 Water and Nitrogen Consumption (Section 6.4.2)

To determine the amount of nitrogen and water consumed during the wash-and-dry process, seven automated wash-and-dry sequences were performed. the pressure in the supply cylinder (TK-1) was recorded prior to running the first sequence and recorded again at the end of each sequence. The SCC was opened and a small beaker was placed inside the sample chamber to catch the water. The average amount of water used during one wash-and-dry sequence was calculated to be 17.5 ml. The average amount of nitrogen consumed during one sequence was 1.67E4 cc (.590 ft³).

The flow rate of the water was determined by allowing water to flow through the lines for 2 minutes and then again for 4 minutes. After 2 minutes, the amount of water captured in the beaker was 35 ml. The line was then intermittently purged with nitrogen. The amount of water in the beaker increased to 50 ml. After 4 minutes, the amount of water captured was 75 ml.

Amount increased to 91 ml after the intermittent purge process. The average flow rate was calculated to be 20 ml/minute.

3.3.3 Verification of Void Fraction Calculation (Section 6.4.3)

In order to test the void fraction measurement device with different void fractions, plastic blocks were used to fill some of the space inside the sample chamber. Plastic blocks were used that left approximately 5, 10, 15, 20, and 50 percent of the sample chamber empty. For all combinations of plastic blocks, the sample chamber cover was closed while submerged in a bucket of water. A minimum of three tests were run for each combination of plastic filler blocks. Tests were also run with the sample chamber empty (100 percent void) and with the sample chamber completely submerged in water (0 percent void).

For each test, a data file was written which recorded the temperatures and pressures from the relevant sensors for the duration of the tests. The data required to make void fraction measurement predictions were the initial and final equilibrium temperatures and pressures. These data were extracted from the data files and entered into a spreadsheet for analysis. A detailed description of the test setup and data analysis will be documented in a letter report from PNL.

CONCLUSION: The tests have shown that the void fraction measurement system is capable of meeting the system design accuracy requirement of ± 2 percent void fraction over the range of 0-20 percent. The final PNL report is required to confirm that the VFI meets this design requirement.

3.3.4 Opening/Closing of Sample Chamber (ATP Section 6.4.4)

Performance tests of the sample chamber cover were conducted with the VFI nitrogen supply cylinder as the gas source. The pressure decay observed during these performance tests was attributed to the gas consumed during the actuation cycle being studied. The small leakage through the three-way valves was considered negligible for these tests.

The sample chamber cover was opened and closed five times each way. To determine the average consumption of nitrogen for one open/close cycle, the initial pressure in the supply cylinder was recorded. Additionally, the gas flow rate (displayed on FE 1) and pressure (displayed on PE 1) were recorded after the completion of each singular motion. The flow and pressure data was utilized in the ideal gas law equation to calculate the average amount of nitrogen consumed.

The amount of time required to open the SCC was determined by clocking the motion of the cover from when motion was first observed until motion

stopped. The amount of time to close the SCC was similarly determined. Open and close times were recorded after the completion of each singular motion.

Actuation	Time	FE 1	PE 1
Initial	--	--	1550.70
Open 1	5.5 seconds	2308.4	1537.99
Close 1	10 seconds	2073.2	1529.78
Open 2	5.5 seconds	2252.4	1514.82
Close 2	10 seconds	2073.2	1502.12
Open 3	5.5 seconds	2290.8	1493.16
Close 3	10 seconds	2086.0	1481.95
Open 4	5.5 seconds	2266.8	1472.25
Close 4	10 seconds	2059.6	1460.29
Open 5	5.5 seconds	2272.0	1440.08
Close 5	10 seconds	2080.4	1433.38

Tests similar to those which restrained the forearm from movement were performed on the sample chamber cover. To simulate a condition where the cover is stuck in either the open or closed position, the sample chamber cover was physically restrained from movement once each direction.

Data for restraining SCC shut:

MOTION	FLOWMETER READING (FE 1)			
	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Test 4</u>
Open	1569.6	1601.6	1582.8	1563.6
Close	1970.8	1981.2	1985.6	1995.2

Data for restraining SCC open:

MOTION	FLOWMETER READING (FE 1)			
	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Test 4</u>
Open	2182.4	2191.2	2160.4	2175.6
Close	1188.8	1172.0	1170.4	1182.0

Results:

Minimum time for open/close cycle: 15.5 seconds
Average N₂ use for an open/close cycle: 1.08E4 cc
Average FE 1 reading for open: 2278.08 cc
Average FE 1 reading for close: 2074.48 cc
Average FE 1 reading for open - SCC restrained shut: 1579.4 cc
Average FE 1 reading for close - SCC restrained open: 1178.3 cc

3.3.5 Test Section 6.4.4.3

Since the O-rings are being used on the VFI in a nonstandard configuration, acceptance testing was conducted for the worst-case condition of 100 percent void fraction pressurized to 500 psia. To simulate 100 percent void fraction, the sample chamber cover was closed over an empty chamber.

After chamber pressure reached 500 psia, the cover was opened. Several tests were performed. During some of the tests, the inner O-ring was ejected when the cover was opened. It was determined that the inner pressure was not adequately vented before the O-ring was exposed.

Three design changes which would prevent the O-ring from being ejected were evaluated. The design change chosen increased the number of vent holes in the sample chamber cover from 12 to 50. Increasing the number of holes increased the area for the internal pressure to escape. With the design change implemented, the O-ring remained on the SCC during testing with 100 percent void pressurized to 500 psia. High-speed video recordings of the final cover design showed no detectable motion of the O-ring cross section.

Additional testing for 35 double pressurizations in the waste simulant with various void fractions following normal test procedures resulted in no O-ring failures due to either O-ring loss or physical damage to the O-rings by the vent holes.

An additional test to simulate plugging of the vent holes by waste was conducted. While this is considered an unlikely event, the test was performed to further characterize the VFI. Gray sealant was placed over the vent holes and held in place with a hose clamp. The sample chamber (with 100 percent simulated void fraction) was pressurized twice, then the SCC was opened. Slight O-ring motion was detected on the high-speed video camera. Despite several attempts to completely plug the vent holes, some venting was observed. This test indicated that the internal pressure against the vents during cover opening will effectively clear the vents and that even with severe plugging of the vents, O-ring failure under normally expected testing is highly unlikely. A detailed discussion of the O-ring tests will be documented in a PNL letter report.

CONCLUSION: O-rings will remain on the sample chamber during operation of the VFI. The final PNL report is required to confirm that the VFI meets this design requirement.

3.3.6 Test Section 6.4.4.4

Thirty-five test cycles were performed with the sample chamber immersed in the chemical simulant. Repressurization of the sample chamber was selected for most of these test cycles. The tests were completed without any problems encountered. At the end of 35 complete tests, the O-rings were inspected. No O-ring damage was observed and no excess leakage had occurred.

3.3.7 Test Section 6.4.4.5

At the end of the 35 test cycles discussed above, the sample chamber was left in the waste. The cover was closed, then the chamber was pressurized to 500 psig. Power to the VFI was cut. The chamber cover did not open. It was

concluded that opening the sample chamber cover, driven by the spring alone, is insufficient to guarantee the SCC will open at all times.

In an attempt to see "how stuck" the SCC was, the VFI system was repressurized to drive the SCC open and the following data were taken. The SCC back pressure was about 40 psig, and the SCC did not open until PE 5 indicated about 300 psig. With a differential pressure of about 260 psig across the SCC driving cylinder corresponding to about 200-pound force, the SCC opened.

In the unlikely event that the sample chamber cover does not open, (in-tank cameras would detect) the VFI will be lowered to tank bottom while a recovery plan is developed. No safety controls will be violated by the above action, therefore, in-tank operation of the VFI is deemed acceptable.

However, a design change was implemented so that the SCC can be opened remotely prior to lifting a potentially jammed shut and pressurized SCC out of the tank. ECN 198511 adds an internally threaded boss to the side of the decontamination spool piece. If the SCC becomes jammed, a long bolt can be screwed through this boss to wedge the SCC lid between the bolt tip and the decontamination spool piece internal wall. With the SCC captured in this manner, the entire VFI could be lowered slightly with the crane and the SCC would open. This feature can not be used without thorough safety evaluation, some more equipment development, and detailed procedures, but is a potential solution to safely retrieve the VFI with a stuck SCC.

CONCLUSION: Performance of the SCC is acceptable.

If the SCC becomes stuck shut in the tank, the VFI must be lowered to tank bottom while recovery plans, procedures, and safety analysis is performed.

3.4 MISCELLANEOUS TESTING NOT DEFINED BY THE ATP

3.4.1 Chemical Simulant Endurance Testing

The VFI was operated two days in a row. A total of 35 tests were performed on each day. The first set of 35 tests was conducted while the sample chamber was submerged in a chemical simulant. These tests were all done using the "Test Sequence" screen icon, which is exactly how the VFI will be operated in the field. The three enclosures on the VFI were closed and sealed to allow heat buildup and potential effects to be witnessed in the lab. The enclosure internal temperature approached 35°C. The lab temperature was about 70°F. No problems occurred.

3.4.2 Endurance Testing in Air

During day two, the second set of 35 tests was conducted with the sample chamber in air. After 8 tests, sample chamber leakage was evident. The rear

single O-ring had not sealed appropriately. The SCC was not actuated again to see if the rear seal could be reattained. The SCC was immediately removed for O-ring inspection. No damage was evident. The groove, however, contained a slight residual of simulant from the previous day's testing (the SCC was not removed during the previous day while the simulant was washed off). The SCC was removed and internal surfaces were washed clean. Testing resumed. No further leakage was detected.

3.4.3 Gas Consumption Order of Magnitude Estimate

Several gas consumption measurements of individual systems were taken during performance of the ATP. The following data was taken to provide a rough approximation of overall gas usage during a test day. The pressure data is ± 50 psi as read from the regulator.

The VFI was connected to a large N_2 cylinder with a starting pressure of 1300 psig. Thirty-five tests cycles with double pressurizations were performed. The sample chamber was filled with plastic blocks to simulate 10 percent void fraction. The final cylinder pressure was about 1000 psig. The consumption rate of nitrogen averaged 7.88 cc (27.8 cubic feet).

Software control and pressure transducers functioned as designed during both days of testing.

3.4.4 Impact Limiter Leakage

The impact limiters have aluminum inside of a sealed stainless steel shell. LANL is overwhelmingly concerned that somehow waste would get out of the tank, through the stainless shell, cause a runaway exothermic reaction, and increase the radioactive aerosol release quantity higher than what is currently analyzed within the safety assessment.

A test was conducted to verify the impact limiters do not leak. The limiters were pressurized to 0.5 psi. The leak rate is less than or within the 10^{-4} atm-cc/sec range.

3.5 TEST SECTION 6.5 - MEASUREMENTS

3.5.1 Volume Measurements (Section 6.5.1)

Four methods were used to measure and confirm the volumes of the pressurization chamber, sample chamber, and nitrogen supply lines. The volume measurements were performed by J. M. Alzheimer (PNL R&D engineer). A detailed description of the methods used and the results obtained will be documented in a PNL letter report.

CONCLUSION: Preliminary results from PNL indicate that the volume measurements are acceptable.

3.5.2 Component Weights (Section 6.5.2)

The VFI weight was measured with the instrument in a horizontal position. The VFI was supported at the three design pick points, then the elevation of each point was referenced to a fixed elevation. Only one dynamometer (calibration sticker 678-67-26-001, expiration 1/24/95) was available, so it was alternately located at the three lift points to obtain three weights--which were then added together to give the total weight of the VFI. The elevations were maintained within .030 inch. To determine the sensitivity to elevation variance, the mid-lift point was elevated about 1 inch too high; the dynamometer reading increased from 278.7 to 298.7 pounds. It was concluded that the measurement technique was valid and precise enough. The VFI weighs 1465.6 pounds.

The 4-inch plug gauge was measured using a calibrated load cell attached to the overhead crane. The gauge weighs 176.3 pounds.

The decontamination spool piece was weighed using a spring scale-type dynamometer. A 50-pound load was used to field verify the scale. The decontamination spool piece weighs 188 pounds with no hoses attached. The weight includes the rubber wiper, two spacers and split guide flange.

One half section of each impact limiter was weighed using the same spring scale used in weighing the decontamination spool piece. The short and tall impact limiter half-sections weighed 57 and 100 lbs, respectively.

CONCLUSION: Reference information only.

3.6 TEST SECTION 6.6 - DECONTAMINATION SYSTEM TEST

This test verifies that the decontamination system operates as designed. The nozzles were installed in the correct orientation. No nozzles were plugged. The cognizant engineer visually observed the spray patterns and found the patterns were as designed. The nozzles tend to create a low pressure area in the spool piece above the nozzle outlets.

When the inlet valve (DV-4) to the decontamination spool piece upper rings was open, the hot water pump exit pressure was around 1400 psig. When DV-4 was shut, the pump output was about 3000 psig. The flow rate was approximately 3.5 gpm under all flow conditions.

When the cold water pump was not running, it was observed that water would flow through the cold water pump if the inlet valve (DV-3) was open. Therefore, DV-3 should be closed until the cold water pump is run. The cold water pump output was approximately 4.5 gpm at 2000 psig.

A test was conducted to determine the load required to push a 3 inch SCH 80 pipe (weighing 12.5 lbs) through the rubber wiper. The rubber wiper was sandwiched between two rubber spacers (1/2" thick one on top, 3/4" one on the

bottom) then bolted between a 4" 150 lb. flange and a 6" 150 lb split guide flange. A 3" stainless steel pipe was manually pushed through the rubber wiper, then a load was placed on top of the pipe until it began to move through the wiper. For a dry wiper the drag load required to initiate movement was 87.5 lbs. (includes load plus pipe weight) The pipe and wiper were wetted with water then the test was repeated. The load required for a wet wiper was 62.5 lbs. (includes load plus pipe weight).

CONCLUSION: Accept; system is ready for field service.

3.7 TEST SECTION 6.7 - SOFTWARE

The software alarms were tested artificially. Cognizant engineering personnel did not want to overpressure the tubing system. The cognizant electrical engineer lowered the software alarm set points and observed whether an alarm occurred. When the alarm occurred, the test was considered successful. The software was reentered and the alarm value reset. The software value reset was witnessed by another engineer, as well as the cognizant electrical engineer to assure correct setting. Signed sheets in the ATP indicate successful completion of the tests of this section.

4.0 CONCLUSIONS

The final PNL letter reports for O-ring, volume, and void fraction tests are required to confirm that the VFI will accurately and precisely obtain the required data. The final PNL reports will be reviewed during the readiness review process.

The hardware and electrical acceptance testing for the void fraction instrument was successfully completed. The instrument is ready for field installation and operation.

5.0 TEST RESULTS SHEETS

Section 6.0 and Appendices B and C of the ATP (WHC-SD-WM-ATP-103) are presented in Attachment 1. Test data sheets are given in Attachment 2.

ATTACHMENT 1 - ATP PROCEDURE, SECTION 6.0
APPENDICES B AND C

6.0 TEST PROCEDURE

6.1 PREREQUISITES

6.1.1 Prejob Briefing

Conduct a "prejob meeting" of operations including a review of all procedures, drawings, safety hazards, and other engineering documents required to complete the test. Personnel who have attended the prejob meeting shall sign the attendance form given in Appendix C.

6.1.2 Stage Equipment

Verify that the void fraction instrument has been installed horizontally in the test area and the power distribution skids, interconnecting cable and hose assemblies, control console, and decontamination spray system are staged in the test area. Verify no interconnections have been made.

Test Engineer's signature K.L. Pearce

Date 9-17-94

6.2 ELECTRICAL SYSTEMS PREOPERATIONAL CHECKOUT

A local disconnect will be used in the SY tank farm to lower a 480 VAC, 3-phase, 60 amp service to 35 amp service. A distribution panel is used to convert one input line of 480 VAC, 3-phase, 35 amp service into several other components. The control console, feed pump, and hot water high-pressure pump are all electrically connected to the distribution skid during field service.

6.2.1 Switches and Disconnects

6.2.1.1 Verify the switch labeled VISC INST and located on the inside right wall of the console (access from the rear) is in the OFF position.

6.2.1.2 Verify that the following circuit breakers and disconnect switches are in the OFF position:

1. Service disconnect switch.
2. Power distribution skids: CB1, CB2, DS1, DS2, and MS1 (see Figure 1).
3. Control console: CB2, CB6, and CB8 (see Figure 2).

Test Engineer's signature K.L. Pearce

Date 9/17/94

POWER DISTRIBUTION SKID
H-2-B21314-010

DISCONNECT SKID
H-2-B21314-020

Figure 1. Power Distribution and Disconnect Skids

Figure 2. Circuit Breaker Panel (1A8) Layout

6.2.2 Interconnections

Two cables connect the void fraction instrument (VFI) to the control console. One cable supplies power from the control console to the VFI. The other cable provides the communication link between the VFI and the control console. Each cable is made of two lengths with a connector in the middle.

*Note: Electrical cabling interconnections are shown in Figures 3 and 4.
Decontamination water hose interconnections are detailed in SK-2-61342.*

6.2.2.1 Electrical Connections

Connect the electrical cables to the equipment as follows:

- W6 to W8P1. In the field, the cable support grips on W6 and W8 are connected together using a threaded chain coupler. This is not necessary for lab testing.
- W7 to W9P1. In the field, the cable support grips on W7 and W9 are connected together using a threaded chain coupler. This is not necessary for lab testing.
- W8 to Void Fraction Instrument J1. Connect the cable support grip to the nearby eye bolt using a threaded chain coupler.
- W9 to Void Fraction Instrument J2. Connect the cable support grip to the nearby eye bolt using a threaded chain coupler.
- W7 to Control Console J7.
- W6 to Control Console J6.
- W1 to Control Console J1.
- W1 to Power Distribution Skid J4.
- Hot water high-pressure washer to Power Distribution Skid J2.
- Feed pump to Power Distribution Skid J3.
- W10 to Power Distribution Skid J1.
- W10 to Disconnect Skid J5.

Figure 3. VFI Cable Connections

Figure 4. VFI System Interconnections

- Disconnect Skid P6 to a service receptacle. Disconnect skid is currently wired to use a 480 VAC, 3-phase, 60 amp, 4-wire receptacle.

Test Engineer's signature K.L. Pearce

Date 9/17/94

6.2.3 Applying Instrument Power

Lights on the annunciator panel shown in Figure 5 provide status indications for power.

- 6.2.3.1 With circuit breakers and switches identified in Section 6.2.1.2 still in the OFF position, move the service disconnect switch to the ON position. Verify that all lights on the annunciator panel remain off.

Test Engineer's signature K.L. Pearce

Date 9/17/94

Power for the computer and other instrumentation within the control console is controlled by Circuit Breaker CB2. Power for instrumentation within the void fraction enclosures is controlled by Circuit Breaker CB8.

- 6.2.3.2 Move CB2 on the circuit breaker panel (Figure 2) from the OFF to the ON position.

- 6.2.3.3 Verify that the following lamps are illuminated and that all other lamps remain off:

CONSOLE
INSTRUMENT

Test Engineer's signature K.L. Pearce

Date 9/17/94

- 6.2.3.4 Move CB8 on the circuit breaker panel (Figure 2) from the OFF to the ON position. Verify that the VOID FRACTION lamp is illuminated.

Test Engineer's signature K.L. Pearce

Date 9/17/94

6.2.4 Enclosure Temperature Control

The pneumatic system enclosure contains a stand-alone heater and temperature controller. The I&C enclosure has a temperature-controlled fan for cooling only.

Note: For testing purposes, it is not necessary to lower or raise the temperature of the entire enclosure. It is sufficient to cool or heat the temperature sensor by blowing temperature-controlled air over it.

Figure 5. Annunciator Panel 1 (1A1) Layout

- 6.2.4.1 Verify that the heater turns on when the temperature of the enclosure drops below 50°F and turns off when the temperature is above 60°F (temperature sensor is TE11).

Accept/Reject Accept

Cognizant EE's signature Michael Limera

Date 9/17/94

6.2.5 Intrinsic Safety Barrier

- 6.2.5.1 Measure the resistance between the intrinsic safety barriers mounting bus bar and the VFI mast. Record equipment calibration information. QC verify reading.

Instrument #: 674-45-08-023
3-9-95 12xP

QC Stamp/Date 9-19-94

Reading 0 ~

QC Stamp/Date 9-19-94

- 6.2.5.2 Visually inspect the intrinsic barriers and verify that they are adequately installed and ready for field service.

Fire Protection Engineer's signature P. A. Huppel

Date 10/14/94

6.3 LEAK TESTS

All welds on the lines inside the VFI were leak tested per Fabrication Travelers VFI-002 and VFI-003. System leak checks will be made of the void fraction piping, valves, fittings, actuators, seals, and other pressure-containing components. Excessive leaks, as determined by the cognizant ME, shall be repaired and retested. The procedure below is presented as guidance for this test and may be deviated from per the cognizant ME's direction.

- 6.3.1 Visually verify that all pneumatic connections have been made. Verify closed or close YV9 and YV8. Fill water tank as full as possible.

Note: Fill the sample chamber with some hard object (plug) to minimize the gas usage during compressions of that space.

- 6.3.2 Leak check void fraction piping, valves, fittings, cylinders, etc. by isolating one section of the system at a time. Also verify that the sample chamber check valve seats properly. Use the nitrogen supply cylinder for the gas source. Perform Steps 6.3.2.1 and 6.3.2.2 until all sections of the system have been checked. Record all results on Observation/Results sheet or equivalent.

- 6.3.2.1 Open HV1 on the nitrogen supply bottle. Verify the bottle has at least 1000 psig. Isolate section of system to be leak checked using the front panel icons to open and close the appropriate valves.
- 6.3.2.2 Close the nitrogen supply bottle. Record the start and end pressures of the appropriate indicators for a 10-minute duration. Record all pressure decay findings (i.e., zero leak rate, etc.). Determine the leak rate or repair leaking systems/components.

Initial Pressure _____ Pressure @ > 10 min. _____

Accept/Reject See ATR For details.

Cognizant ME's signature [Signature]

Date 9-18-94

6.3.3 Pressurization Chamber--Inlet Valve (YV10)

- 6.3.3.1 Open HV-1.
- 6.3.3.2 Vent the pressurization chamber to atmosphere pressure by closing solenoid valve YV10, then opening YV11 and the sample chamber cover.
- 6.3.3.3 Record initial pressures from PIT1 and PIT2, then close YV11.
- 6.3.3.4 Wait 10 minutes, then record final pressures from PIT1 and PIT2.

6.3.4 Pressurization Chamber--Outlet Valve (YV11)

- 6.3.4.1 Close YV11, then pressurize the pressurization chamber to approximately 500 psia. Then close YV10 to isolate the pressurization chamber. Vent sample chamber to atmosphere by opening the chamber cover.
- 6.3.4.2 Record initial pressures from PIT1, PIT2, and PIT3 on Observation/Results sheet.
- 6.3.4.4 Wait 10 minutes, then record final pressures from PIT1, PIT2, and PIT3 on Observation/Results sheet.

6.3.5 Chamber Pressurizing Line--YV9 and Elbow

- 6.3.5.1 Vent chamber pressurizing line to atmosphere by closing YV9 and YV11; open or verify open sample chamber cover.
- 6.3.5.2 Disconnect chamber pressurizing line from sample chamber check valve. Install Swagelock plug on end of chamber pressurizing line.

- 6.3.5.3 Verify HV4 and HV5 are closed. Record initial pressure from PIT3. Pressurize water tank to approximately 200 psia.
- 6.3.5.4 Wait 10 minutes, then record final pressure from PIT3.
- 6.3.5.5 Close sample chamber cover. Wait 5 minutes, then record PIT3 reading.
- 6.3.5.6 Open sample chamber cover. Wait 5 minutes, then record PIT3 reading.
- 6.3.6 Sample Chamber
 - 6.3.6.1 Remove Swagelok plug from end of chamber pressurizing line and reconnect line to sample chamber check valve. Close sample chamber cover.
 - 6.3.6.2 Open YV10 until pressure in the pressurization chamber approximately reaches equilibrium, then close YV10.
 - 6.3.6.3 Open YV11 until pressure approximately reaches equilibrium, then close YV11 and record reading on PIT3.
 - 6.3.6.4 Wait approximately 10 minutes, then record final pressure on PIT3.
 - 6.3.6.5 Loosen the end of the pressurizing line from check valve. Wait for PIT3 to reach atmosphere.
 - 6.3.6.6 Use a bubble solution to characterize any leakage back from the check valve.
 - 6.3.6.7 Retighten the pressurizing line.
- 6.3.7 Actuators
 - 6.3.7.1 Open sample chamber cover. Verify lower arm is in the deployed position. Close HV1, then record readings from PE4, PE5, PE6, and PE7.
 - 6.3.7.2 Wait approximately 5 minutes, then record readings from PE4, PE5, PE6, and PE7.
 - 6.3.7.3 Open HV1 and sample chamber cover. Retract lower arm.
 - 6.3.7.4 Close HV1, then record readings from PE4, PE5, PE6, and PE7.
 - 6.3.7.5 Wait approximately 5 minutes, then record readings from PE4, PE5, PE6, and PE7.

6.4 OPERATIONAL TESTS

6.4.1 Motion of Lower Arm

A pneumatic cylinder rotates the lower arm by 90°. If power fails to the VFI, the lower arm is designed to spring return to a vertical position when the VFI is in the vertical position.

6.4.1.1 Rotate and retract the lower arm approximately 15 times as directed by the cognizant mechanical engineer.

1. Determine the minimum time from start to stop of each rotate/retract cycle.
2. Record the flowmeter indication after each cycle.
3. Record start and end reading on PEI for each rotate/retract cycle.
4. Mechanically prevent arm motion (once each direction). Actuate arm and record flow indicator reading.
5. Record the transverse load required to start motion of the arm against the pneumatic cylinders in both directions.

Observe whether the following conditions are met:

- a) The rotational motion is smooth.
- b) The mechanism does not jam.
- c) The mechanical parts are not damaged or galled and that the fasteners do not show excessive wear or looseness.

*S.C.C. cylinder + Tightened
Jam nut was ~~removed~~ Tightened
prior to test. Nut was tightened
at end of testing.*

Accept/Reject: a) Accept b) Accept c) Accept
Cognizant ME's signature H. Stokes Date 9-18-94

6.4.1.2 Utilize the data recorded during Step 6.4.1.1 to determine the average consumption of nitrogen for the arm rotation/retraction cycle.

Rotate/Retract Cycle Nitrogen Consumption 97.07 in³

Test Engineer's signature H. L. Pearce Date 9-28-94

6.4.1.3 With the lower arm in the 90° position, remove power. Verify that the arm returns towards alignment with the upper arm and is free to return to the aligned position.

Note: The VFI will be tested in a horizontal position and, therefore, the arm will not fully return to the vertical position (i.e., not be aligned with the upper arm and VFI mast).

Accept/Reject _____

Cognizant ME's signature _____

Date 9-18-94

6.4.2 Water and Nitrogen Consumption

Water and nitrogen are used to clean and dry the lines, through an automated sequence (wash and dry). This test is intended to establish how much water and nitrogen are used in a wash and dry operation.

- 6.4.2.1 Measure the pressure in the nitrogen bottle (initially 2200 psi). Measure the level of the water in the tank (from the computer display).
- 6.4.2.2 Perform approximately 32 automated wash and dry sequences.
- 6.4.2.3 Measure the pressure in the nitrogen tank and the level in the water tank again. Record the number of "actual" cycles performed.
- 6.4.2.4 Determine nitrogen and water usage utilizing the data recorded during the wash and dry cycle.

Average wash and dry operation
uses:

1.07 cubic inch water

98.24 cubic inch nitrogen

Cognizant ME's signature _____

Date 9-22-94

6.4.3 Verification of Void Fraction Calculation

The software acquires the data required to calculate void fraction. The purpose of this test is to introduce a known void fraction in the sampling chamber and compare the known value to the value obtained by reducing the data. Testing will be performed with three void simulants: air, water, and some filler with known volume.

- 6.4.3.1 Perform three void fraction test sequences each at 0, 20, and 100 percent simulated void fraction. This can be done with the lower arm in a rotated position.
- 6.4.3.2 Compare the calculated void fraction (based on the measured pressures and temperatures) with the actual void in the sample chamber. Record results below or on attached Observation/Results sheet.
- 6.4.3.3 Repeat Steps 6.4.4.1 through 6.4.4.3, as required.

TEST NO./SIMULANT	ACTUAL VOID FRACTION (cc)	CALCULATED VOID FRACTION (cc)

Accept/Reject See ATR for all data & discussion

Cognizant ME's signature [Signature]

Date 10-6-94

PNL R&D Engineer's signature [Signature]

Date 10-6-94

6.4.4 Opening/Closing of Sample Chamber

A pneumatic cylinder opens and closes the sample chamber cover that contains the waste sample. If power fails while the chamber is closed, the chamber is designed to open. Opening and closing the cover while in the waste has the potential to wear or damage the O-ring seals. Any initial lubrication on the seals might be removed during operation. In order to test these effects, the sample chamber will be submerged in a container of PNL-supplied chemical simulant.

6.4.4.1 Lubricate the O-ring seals. Operate the device 5 times with the sample chamber suspended in air.

1. Determine the minimum time from start to stop of each open/close cycle.
2. Record the flowmeter indication after each cycle.
3. Record start and end reading on PEI for each open/close cycle.
4. Mechanically prevent sample chamber motion (once each direction). Actuate chamber and record flow indicator reading.

Observe whether the following conditions are met:

- a) The motion of the sample chamber cover is smooth.
- b) The mechanism does not jam.
- c) The mechanical parts are not damaged or galled. The fasteners do not show excessive wear or looseness.

Accept/Reject: a) Accept b) Accept c) Accept
Cognizant ME's signature [Signature] Date 9-18-94

- 6.4.4.2 Utilize the data recorded during Step 6.4.2.1 to determine the average consumption of nitrogen for opening and closing the sample chamber.

Chamber Open/Close Cycle Nitrogen Consumption 63.52 in³ @ S.T.P.
Cognizant ME's signature [Signature] Date 10-6-94

- 6.4.4.3 Verify the chamber is empty. Close the chamber cover. Pressurize the chamber pressurizing line to 500 psia. Open the chamber cover and verify that the O-rings remain on the VFI sample chamber.

Note: This test shall be done with well lubricated O-rings to simulate the most rapid movement that would ever be encountered in the tank.

Accept/Reject See attached for further discussion.
Cognizant ME's signature [Signature] Date 10-6-94

CAUTION

FOR THE FOLLOWING TESTS, SPECIAL CARE MUST BE TAKEN TO PREVENT UNCONTROLLED SPLASHING OF THE CHEMICAL SIMULANT. PERSONNEL PROTECTIVE EQUIPMENT (FACE SHIELD AND GLOVES) ARE REQUIRED FOR PERSONNEL WORKING WITHIN TEST AREA.

- 6.4.4.4 Submerge the sample chamber into the chemical simulant.
- 1. Close chamber cover, then pressurize the sample chamber twice without sequencing through the wash/dry cycle.
 - 2. Open chamber cover.
 - 3. Repeat sequence approximately 30 times.

Observe whether the following conditions are met:

- a) The initial pressure in the pressurization chamber and the final system pressure stabilizes and there is no indication of pressure leaks in the system. If leaks occur, record leak rate and path on Observation/Results sheet.
- b) The cover opens and closes each cycle.
- c) The O-ring seals remain functional for the entire test sequence. Visually inspect O-rings for damage.

Accept/Reject: a) Accept b) Accept c) Accept
Cognizant ME's signature [Signature] Date 9-18-94

6.4.4.6 With the sampling chamber closed, remove power. Verify that the sampling chamber opens.

~~Accept/Reject~~ The lid does not open. An alternate lid (emergency) opening device will be developed.
Cognizant ME's signature [Signature] Date 10-6-94

6.5 MEASUREMENTS

6.5.1 Volume Measurements

The sample chamber, pressurization chamber, and nitrogen line volumes need to be measured in order to calculate the void fraction. The volumes of the sample chamber, pressurization chamber, and lines should be about 22, 5, and 3 cubic inches, respectively. Volume measurements will be performed by PNL. Instrument calibration information, sketches, and results will be documented in the ATR.

Volume of sampling chamber: 22.26 cubic inches

Volume of pressurization chamber: 6.254 cubic inches

Volume of nitrogen lines: 1.84 cubic inches

PNL R&D Engineer's signature [Signature] Date 10-3-94

Test Engineer's signature [Signature] Date 10/3/94

6.5.2 Void Fraction Instrument, Decontamination Spool Piece Weights

6.5.2.1 Weigh void fraction instrument, decontamination spool piece (including wipers and flanges), impact limiters, and plug gauge. Record results.

Void Fraction Instrument: 1465.6 1bs
Decontamination Spool Piece: 160.0 1bs
Short Impact Limiter, 1/2: 57 1bs
Tall Impact Limiter, 1/2: 100 1bs
Plug Gauge: 176.3 1bs

1bs (188 lbs w
rubber wiper
and split
guide flange)

Test Engineer's signature K. R. Pearce Date 9/30/94

6.6 DECONTAMINATION SYSTEM TEST

The decontamination system provides hot and cold water for washing the mast and arms. A rubber wiper is used during withdrawal of the VFI.

6.6.1 Prepare a testing area on the concrete pad outside the 306E building.

6.6.2 Water Hose Connections

- Interconnect the pump (hot and cold high pressure) and flow meter per SK-2-61342.
- Connect the hoses to the decontamination spool piece and the pumps per SK-2-61342.
- Connect a hose from a potable water source to the intake of the feed pump.

Test Engineer's signature K. R. Pearce Date 9/29/94

6.6.3 Visually observe the spray patterns, leakage, flow rates, nozzle convergence, and spray efficiency. Compare observations to design basis for acceptance.

Accept Reject

Cognizant ME's signature J. J. Stokes Date 9/29/94

6.6.4 Attach rubber wiper to the decontamination spool piece. Insert a 3-inch dummy pipe through the rubber wiper and record the drag loads observed on the Observation/Results sheet.

Drag load (dry) 75 lb.

Cognizant ME's signature Thomas H. Hane Date 10-3-94

6.6.5 Wet the rubber wiper with water and repeat Step 6.6.4.

Drag load (wet with water) 50 lb.

Cognizant ME's signature

Dennis Francis

Date 10-3-94

6.7 SOFTWARE

6.7.1 Nitrogen Supply Alarm

Note: External nitrogen source may be used to characterize this portion of the testing.

6.7.1.1 Close or verify closed nitrogen supply cylinder valve, HV1. Start software. Software should display dialog box that warns that the nitrogen supply is not full.

6.7.1.2 Click OK on the dialog box. The dialog box should reappear continually until the start pressure is greater than 2000 psia.

6.7.1.3 Terminate the program. *Design change to software prevents dialog box from reappearing. may 9/17/94*

6.7.1.4 Attach a supply pressure greater than 2200 psia. Start the software. Software should display a dialog box that warns the nitrogen supply is overfull.

6.7.1.5 Click OK on the dialog box. The box should reappear continually until the start pressure is less than 2200 psia.

Accept/Reject Accept

up Software
9/17/94

Test Engineer's signature

Michael Limera

Date 9/17/94

6.7.2 Three-way Solenoid Valve Alarms (PE4 through PE7)

6.7.2.1 Observe that PE4 through PE7 read above 35 psia.

6.7.2.2 Open valve YV6. Software should display a dialog box that warns that pressure on PE4, PE5, PE6, and PE7 has dropped below 35 psia.

Accept/Reject Accept

Software Engineer's signature

Michael Limera

Date 9/17/94

6.7.2.3 Close YV6 and click on OK in dialog box.

- 6.7.3 Software developer will temporarily change the alarming thresholds for the 660, 550, and 220 psi lines.
- 6.7.3.1 Run software with 660 psi alarm changed to 400 psi. Software should display a dialog box warning that the pressure has exceeded the limit for PE2.
- 6.7.3.2 Stop software and change 550 psi alarm to 400 psi. Change 660 psi alarm back to 660 psi.
- 6.7.3.3 Run software. Dialog box should warn that the pressure was exceeded on PE9.
- 6.7.3.4 Stop software and change 220 psi alarm to 100 psi. Change 550 psi alarm back to 550 psi.
- 6.7.3.5 Run software. Dialog box should warn that the pressure was exceeded on PE3.
- 6.7.3.6 Stop software and change 220 psi alarm back to 220 psi.

Accept/Reject 660 Alarm (Step 6.7.3.1) Accept

Accept/Reject 550 Alarm (Step 6.7.3.3) Accept

Accept/Reject 220 Alarm (Step 6.7.3.5) Accept

Software Engineer's signature Michael J. Amis Date 9/17/94

- 6.7.3.7 Verify all alarms are set to operating values 660, 550, and 220 psi, respectively.

Software Engineer's signature Michael J. Amis Date 9/17/94

- 6.7.4 Additional acceptance criteria for software-related aspects (and some additional electromechanical features) are documented in the software ATP (WHC-SD-WM-ATP-081)

APPENDIX B

EXCEPTION TO VFI ACCEPTANCE TEST

EXCEPTION TO VFI ACCEPTANCE TEST

Title of Test Void Fraction Instrument Test

EXCEPTIONS			CORRECTION APPROVAL		
PARAGRAPH NO.	DATE	DESCRIPTION	ORGANIZATION	INITIALS	DATE
6.4.4.5	10-6-94	Sample Chamber Cover does not open upon power failure. Test was conducted after a full day of testing in chemical simulant & w/ the sampler pressurized to 500 psig. Nothing can be done to correct the exceptions.			
<p><u>TEST APPROVED - NO EXCEPTIONS:</u></p> <p>_____ Cognizant Engineer Date</p> <p>_____ Quality Assurance Date</p> <p>_____ Test Witness Date</p>			<p><u>TEST APPROVED - WITH EXCEPTIONS:</u></p> <p><u>M. J. Hickey</u> 10-13-94 Cognizant Engineer Date</p> <p><u>M. E. McEwen</u> 10-13-94 Quality Assurance Date</p> <p><u>Maria L. Limer</u> 10-13-94 Test Witness Date</p>		

APPENDIX C

**PREJOB SAFETY MEETING FORM
AND ATTENDANCE ROSTER**

PREJOB SAFETY MEETING FORM
AND ATTENDANCE ROSTER

PRE-JOB SAFETY MEETING FORM		Page 1 of 2
Job Description/Title Void Fraction Instrument Acceptance Test		Date 9-17-94
Work Package No.: WHC-SD-WM-ATP-103	Person in Charge (PIC): D. B. Graves/K. L. Pearce	
First Aid Qualified Person:		
Check Items Discussed		
☒ Procedures/Plans to be Used	No.	WHC-SD-WM-ATP-103
☐ Applicable OSR's	No.	
☐ Radiation Work Permit	No.	
☒ Job Hazard Analysis	No.	
☐ Construction Permit (as needed)	No.	
☐ Additional Permits (i.e., confined space, excavation, etc.)	No.	
☒ Review All Applicable Safety Precautions and Prestart Conditions per Procedures/Plans to be used		
☐ Components Locked and Tagged		
☒ ALARA Considerations (applicable MSDS's)		
☐ Respiratory Protection (fresh air, PAPR's, chemical filters, etc.)		
☐ Radioactive Contamination Containment Device		
☒ Emergency Response and Actions		
☒ Summary of Job Sequence (or steps)		
☐ Work Area Conditions (high/low temperatures, lighting, etc.)		
☒ All Equipment Functionally Checked and at Work Site		
Special Circumstances or COMMENTS:		
Chairman Signature:		
Operations	_____	
Maintenance	_____	
Other	K.L. Pearce	

[illegible]

ATTACHMENT 2 - TEST DATA SHEETS

connected to copper tube, I - 19A
in air circulation
VAL-10, 11, 12

#1/

	FE1 Reading #1	#2	#3	#4	#5	#6	#7
Drive	1469		1477		1476.0		1476.0
Retract		1475		1476.2		1472	
	arm was already driven @ 90° before start	arm restricted					

Settings HV-3 1/4 turn open HV-2 from closed open 3 1/2 turns not strapped down

Open HV-1, 1/1-1
full, charge press. chamber T-2
close YV-10, YV-11, YV7, YV9, YV8

	Read	PIT1	PIT2	PE8	PE9 (REF)
Init	497.7	497.8	188.92	14.6	14.6
Final	490.9	491.1	67.42	13.85	13.85
10 min					

cracked line @ 1/2" H₂ lines open to bleed

	4 min	6 min	10 min
Read	487.1	485.6	483.0
PIT1	487.3	485.9	483.3
PIT2	65.25	61.84	63.76
PE8	497.2879	497.79	497.28

Install 2nd VF blocks in S.C., close S.C.C., charge S.C. & sys to 500 psi

	4 min	8 min	10 min	15 min	17 min
Read	496.6	496.5	496.5	496.3	496.2
PIT1	496.9	496.8	496.8	496.6	496.5
PIT2	62.32	60.80	60.33	59.44	59.13
PE8	498.54	497.79	497.79	498.54	497.79
PE9 (REF)	495.7	495.7	495.6	495.5	495.5

	0 min	2 min	4 min	9 min	10 min	11 min
Read	496.0	495.6	495.4	494.9	494.8	494.7
PIT1	496.3	495.9	495.7	495.1	495.1	494.9
PIT2	58.73	58.01	57.79	57.00	56.82	56.73
PE8	495.4	495.3	495.2	495.1	495.1	495.1
PE9 (REF)	13.51	13.30				
PE1	15.6	15.6				

POOR COPY REPRODUCED
DOCUMENT PREPARED

Section 6.3.5

6.3.5.3	PIT 3	PE 8	PE 4	PE 5	PE 6	PE 7	PIT 1	PIT 2
0 min	13.9	201.98	S.C. closed 499.95	40.74	44.39	498.92	492.9	492.2
2 min	13.95	201.71	506.09	40.74	44.88	498.92		
3 min	14.0	201.64	"	"	"	"		
5 min	14.0	201.51	"	"	"	"	491.7	492.0
open S.C.C. 7 min	14.0	199.26	499.59	41.26	502.82	491.47	491.4	491.6
9 min	14.0	199.23	"	"	"	"	491.1	491.4

YV1 shut #2/

6.3.6 mostly done

6.3.6.5 pressurize S.C.

6.6 open line, bubble check, 7:1 bubbles over 1 minute
re made connection, re bubble checked

6.3.7 - note YV10 open,

(YV 7 open
T-2 full through)
YV1 closed

S.C. open
arm @ 90°

end test

close S.C.C.
straighten arm
open YV-1. todo

close YV-1

end test

leave S.C.C. shut
bend arm to 90°

	PIT 1	PIT 2	PE 7	PE 4	5	6	7
0 min	491.1	487.3	488.73	488.20	41.26	490.08	40.96
2 min	437.3	436.6	435.66	435.83	41.26	488.72	40.96
5 min	382.5	381.2		381.94		383.14	
0 min	498.5	498.8	500.56	41.43	500	44.39	500.99
2 min	486.0	486.2	486.47	41.43	486.07	43.3	486.51
5 min	465.2	465.5	466.5		466.57		465.84
0 min	497.5	497.8	500.55	500.6	40.7	44.39	500.22
2 min	454.9	-	-	456.32	-	-	454.19
5 min	396.8	-	-	397.88	-	-	396.0
Repair YV-2 Red test arm @ 90° S.C. open	0 min	498.4	-	-	501.62	40.74	502.61
	2 min	472.2	-	-	472.78	-	474.02
	5 min	439.0	-	-	440.38	-	442.0
arm straight S.C. shut	0 min	498.5	-	-	500.80	-	500.73
	2 min	486.0	-	-	487.37	-	488.06
	5 min	464.2	-	-	465.31	-	464.53

[illegible]

Restained horizontally	mm Drive	Retract
FEI	897.6	262.4
	835.2	
		2079.6

278.8	1309.6	2806.4	1286.0	2559.1	2608.0	2878.0	2627.6	2878.0
-------	--------	--------	--------	--------	--------	--------	--------	--------

2534,8	2534,0	1845,6	1812,4
--------	--------	--------	--------

restenue verbalement

drive retract

Asses.

* Time from shift of motion to motion of motion

Time*	FET	PET	Time	FET	PET
retract @ 27 (sec.)	2952.0	1836.95	25	2947.5	1774.17
drive	2713.2	1797.33	9	2724.0	1762.21
retract	2946.8	1740.54	26	2943.2	1709.88
drive	2712.8	1771.09	8	2733.2	1691.22
retract	2949.2	1677.01	26	2949.2	1677.01
drive	2731.4	1661.31	8	2731.4	1661.31

transverse load to move arm to C° to most = 16.11.
Transverse load to move arm to C° to most = 72.11^{±25}
@20° from 90° = 90.16^{±25}

Digital Weight Indicator 675-67-26-001 exp. 1/24/95
1000 lbs ± 2.5 lbs.

PE1 initial = 1575.36 1550.70

6.4.4.1	① OPEN	CLOSE	② OPEN	CLOSE	③ OPEN	CLOSE	④ OPEN	CLOSE
*TIME	5.5 sec	10.0	5.5	10.0	5.5	10.0	—	—
PE1	1531.99	1529.78	1514.82	1502.12	1493.16	1481.95	1468.25	1460.29
FE1	2308.4	2073.2	2252.4	2073.2	2290.8	2086.0	2266.8	2059.6
*TIME ⑤	—	—	*Time from start of cover motion to end of motion.					
PE1	1440.08	1433.38						
FE1	2272.0	2080.4						

Clamped sample chamber cover shut.

open FE1 = 1569.62

15 sec. open	1569.6	1601.6	1582.8	1563.6
close	1970.8	1981.2	1985.6	1995.2

blocked sample chamber cover open.

15 sec. close

close	1188.8	1172.0	1170.4	1182.0
open	2182.4	2191.2	2160.4	2175.6

6.5.2

Void Fraction Instrument weight
zero point = 3.2
zero point = 4.0

#1.5

12:25 pm, 12-7-94

f.1 SCL w/ water
manually suck water from check valve recess
2 O-rings, 2 pressurizations opened under the water @ end of test.

Goal:
c. 1.1 L
initial volume
of
... T, 1/10

Pressurization:
Chamber
Volume

Tests run 1, 2, 3

6.26, 3 pm T. A. 1/2

(ex) effects
S. check
volume

Tests 4 & 5 do not remove check valve trapped air pocket
submerge S.C. under ~1" water, run tests again
Top of.

Wash & Dry 25 seconds each.
Note PIT3 did not decay after 90 seconds to 13.9 psi
was at about 24.9 psi

6.4.4.4 Sample chamber immersed in chemical simulant
M. M. Tested with new O-ring
M. M. changed new O-ring back to old O-ring

6.4.2 Wash and Dry Sequences
+295.85 = PE initial

PE initial = 1223.36

PE₁ = 1189.74 (20mls) PE₂ = 1154.33 PE₃ = 1126.21 (53mls)

lost some water; alcohol tube (16mls)
PE₄ = 1068.32 (15mls) PE₅ = 1038.01 (20mls) PE₆ = 1002.14 (16mls)
PE₇ = 964.23 (16mls)

after two minutes 35ml of water
50ml after blowing out line.
after four minutes 75ml of water
89ml after blowing out line

20 ml/min flow rate
15-16 ml in line

#6

1.13

1.14

1:27.07

Run ^{three} ~~two~~ test sequences in air (two o-rings).
~~100%~~ Void, filename 09-19-94.001 - .003
20% void filename 09-20-94.001 - .003

51:40

02:40

11 minutes
@ 20%

Nitrogen Consumed During Rotate/Retract Cycle:

Nitrogen supply cylinder : G3 size bottle
approximately .36 ft³ @ 2200 psig.

$$X = \frac{P (.36 \text{ ft}^3)}{2214.7 \text{ psia}} = P(.0163) \text{ ft}^3$$

$$V_{\text{initial}} = (1840.70)(.0163) = 29.921 \text{ ft}^3$$

$$V_{R1} = (1814.54)(.0163) = 29.495 \text{ ft}^3$$

$$V_{D1} = (1797.33)(.0163) = 29.216 \text{ ft}^3$$

$$V_{R2} = (1774.17)(.0163) = 28.839 \text{ ft}^3$$

$$V_{D2} = (1762.21)(.0163) = 28.645 \text{ ft}^3$$

$$V_{R3} = (1740.54)(.0163) = 28.293 \text{ ft}^3$$

$$V_{D3} = (1727.09)(.0163) = 28.074 \text{ ft}^3$$

$$V_{R4} = (1709.88)(.0163) = 27.794 \text{ ft}^3$$

$$V_{D4} = (1691.22)(.0163) = 27.491 \text{ ft}^3$$

$$V_{R5} = (1677.01)(.0163) = 27.260 \text{ ft}^3$$

$$V_{D5} = (1661.31)(.0163) = 27.005 \text{ ft}^3$$

	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Test 4</u>	<u>Test 5</u>
Retract	.426	.377	.352	.280	.231
Drive	.279	.194	.219	.303	.255
Total	.705	.571	.571	.583	.486

avg. consumption per cycle: .583 ft³

K R Pearce

10-4-94

Nitrogen Consumed During Open/Close Cycle

$$V_{initial} = (1550.70)(.0163) = 25.207$$

$$V_{o1} = (1537.99)(.0163) = 25.001$$

$$V_{c1} = (1529.78)(.0163) = 24.867$$

$$V_{o2} = (1514.82)(.0163) = 24.623$$

$$V_{c2} = (1502.12)(.0163) = 24.417$$

$$V_{o3} = (1493.16)(.0163) = 24.271$$

$$V_{c3} = (1481.95)(.0163) = 24.089$$

$$V_{o4} = (1472.25)(.0163) = 23.932$$

$$V_{c4} = (1460.29)(.0163) = 23.737$$

$$V_{o5} = (1440.08)(.0163) = 23.409$$

$$V_{c5} = (1433.38)(.0163) = 23.300$$

	<u>Test 1</u>	<u>Test 2</u>	<u>Test 3</u>	<u>Test 4</u>	<u>Test 5</u>
Open	.206	.244	.146	.157	.328
Close	.134	.206	.182	.195	.109
Total	.340	.450	.328	.352	.437

Avg. N₂ Consumed per Open/Close Cycle: .381 ft³

K. R. Pearce
10-4-94

Nitrogen Consumed During Wash and Dry Cycle.

	Gas Used (ft ³)
$V_{\text{initial}} = (1223.36)(.0163) = 19.886$	
$V_1 = (1189.74)(.0163) = 19.339$	.547
$V_2 = (1158.33)(.0163) = 18.829$	.510
$V_3 = (1126.21)(.0163) = 18.307$	.522
$V_4 = (1068.32)(.0163) = 17.366$	.941
$V_5 = (1038.01)(.0163) = 16.873$	.493
$V_6 = (1002.14)(.0163) = 16.290$	.583
$V_7 = (969.23)(.0163) = 15.755$	.535

Avg Consumption of N₂ per Wash/Dry Cycle: .590 ft³

Nitrogen Consumed During 35 Test Run

$$P_i = 1300 \text{ psig} \quad P_e = 1000 \text{ psig} \quad P_{\text{cyl}} = 2250 \text{ psig}$$

$$V_{\text{gasL}} = 210 \text{ ft}^3$$

$$V_i = \frac{(210)(1314.7)}{2264.7} = 121.91 \text{ ft}^3$$

$$V_e = \frac{(210)(1014.7)}{2264.7} = 94.09 \text{ ft}^3$$

$$V_{\text{consumed}} = V_i - V_e = 27.8 \text{ ft}^3 = 7.88 \text{ E5 cc}$$

ICR Pearce
10-4-94

1/1

Independent check of VFI gas consumption:

- Data: - Tested VFI thru 35 Test Sequences
- Used Large External N_2 bottle for tests
- Starting bottle pressure: 1300 psig
ending : 1000 psig

Large Bottle Volume - rated @ 210 s.c.f. @ S.T.P. (1.4 ft³ @ 2200 psig)

Find mass of N_2 in a full bottle:

$$P_1 V_1 = m_1 R_1 T_1$$

$$2200 \frac{\text{lb}}{\text{in}^2} \cdot \frac{144 \text{ in}^2}{\text{ft}^2} \cdot (1.4 \text{ ft}^3) = m_1 \left(55.15 \frac{\text{ft} \cdot \text{lb}_f}{\text{lbm} \cdot ^\circ\text{R}} \right) (530^\circ\text{R})$$

$$m_1 = \cancel{8.9} 15.21 \text{ lbm}$$

Find mass of N_2 @ start of test day:

$$(1300)(144)(1.4) = m_{\text{START}} (55.15)(530)$$

$$m_{\text{start}} = 8.96 \text{ lbm}$$

Similarly, $m_{\text{final}} = 6.897 \text{ lbm}$

Gas used during test day:

$$m_{\text{start}} - m_{\text{final}} = 2.06 \text{ lbm}$$

Find Volume Gas used @ S.T.P.:

$$(14.7)(144)(V_?) = (2.06)(55.15)(530)$$

$$V_? = \underline{\underline{28.48 \text{ ft}^3}}$$

(Note: G3 bottle contains 40 s.c.f. @ S.T.P. when full.)

Troy Stokes
10-13-94