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Reason	Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	Reason	Disp.
1	1	Cog. Eng. J.D. Potter	<i>J.D. Potter</i>	5/20/96	N1-21						
1	1	Cog. Mgr. D.S. Dutt	<i>D.S. Dutt</i>	5/22/96	N1-21						
3		QA M.E. Riste			N2-11						
3		Safety T.M. Amundson			N2-10						
1	1	B.A. Carteret	<i>B.A. Carteret</i>	5/20/96	N1-21						
1	1	G.R. Kiebel	<i>G.R. Kiebel</i>	5/22/96	N1-21						

18. J.D. Potter <i>J.D. Potter</i> 5/20/96 Signature of EDT Originator		19. D.S. Dutt <i>D.S. Dutt</i> 5-22-96 Authorized Representative Date for Receiving Organization		20. D.S. Dutt <i>D.S. Dutt</i> 5-22-96 Cognizant Manager Date		21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
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Test Report for Calibration Grooming and Alignment of the LDUA Purge Air Supply (LDUA System 5230)

J.D. Potter

Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: The Light Duty Utility Arm (LDUA) is a remotely operated manipulator used to enter into underground waste tanks through one of the tank risers. National Electric Code requirements mandate that the in-tank portions of the LDUA be maintained at a positive pressure for entrance into a flammable atmosphere. The LDUA Purge Air Supply System (PASS) uses small portable air compressors to provide a constant low flow of instrument grade air for this purpose. This document contains the results, conclusions and recommendations arrived at by the calibration grooming and alignment tests performed on the PASS in accordance with WHC-SD-WM-TC-070.

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J.D. Potter
Release Approval

5-21-96
Date

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TEST REPORT
for
CALIBRATION, GROOMING AND ALIGNMENT
OF THE LDUA Purge Air Supply
(LDUA System 5230)

May 20, 1996

by

J.D. POTTER

Remote System and Sensor Applications
Westinghouse Hanford Company
Richland, Washington

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Calibration, Grooming and Alignment
of the LDUA Purge Air Supply

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1.0 INTRODUCTION

This report documents the results of the Component Grooming and Alignment (CG&A) tests performed on the LDUA Purge Air Supply System (PASS) as authorized in WHC-SD-TD-TP-005, revision 0, Light Duty Utility Arm System Pre-Operational (Cold Test) Test Plan. The CG&A test addressed in this report was performed in accordance with test procedure WHC-SD-WM-TC-071, revision 1. PASS compressor units serial numbers 001 and 002 were each subjected to this test. Tests were performed by WHC Remote Systems and Sensor Applications personnel, between December 15, 1995 to May 2, 1996.

The function of the LDUA Purge Air Supply System (PASS) is to provide a constant flow of instrument grade (clean, low moisture) purge air to the LDUA at a flow rate of at least 3.5 SCFM at pressures of not less than 70 psig nor more than 100 psig. This purge enables the in-tank portions of the LDUA to comply with National Electric Code requirements for operation in Class 1, Division 1, Group B flammable atmospheres by maintaining the internal pressure of the end effector, LDUA, and VPM above the pressure of the external atmosphere. This pressure differential also keeps the interior surfaces of these components from becoming contaminated in the event of seal leakage. In addition, the PASS will provide limited compressed air at the LDUA Tool Interface Plate (TIP) for use by some end effectors requiring low demand pneumatics. Purge pressure of less than 70 psig may result in emergency shutdown of the LDUA, with the arm becoming limp. The PASS is a separate stand-alone subsystem of the LDUA. Sensors, alarms, and controls responding to low LDUA purge pressure, are part of the LDUA I&C and are not included in the PASS.

To provide redundancy, the PASS utilizes two identical compressor units with their outlets plumbed together to a single hose to provide the purge air supplied to the LDUA. In normal operation only one compressor unit will be active to supply the purge air. The other unit will be in a standby mode, and will automatically start operation and maintain purge air pressure in the event that the active unit should fail. Each compressor unit has a dual pressure control capability allowing it to be operated either in a "continuous run" mode or a "start/stop" mode, as selected by the operator. In the "continuous run" mode the compressor output pressure is controlled between 100 to 135 psig by an unloader valve. In the "start/stop" mode the output pressure is controlled between 85 to 120 psig by a pressure switch. For normal LDUA operations the active compressor unit will be placed in the "continuous run" mode, while the standby compressor unit will be placed in the "start/stop" mode. Should the active unit fail, the purge pressure will decay until the pressure switch in the standby unit commands it to become active. The standby will then operate in a "start/stop" mode until it is placed into the "continuous run" mode, thereby allowing sufficient time for LDUA operations to be completed and/or safed. A pressure regulator at the end of the supply hose assures that the pressure of the purge air delivered to the LDUA is limited to 75 to 80 psig.

Both PASS compressor units are designed for outdoor use and have wheels and a handle for easy portability as shown in figure 1.

2.0 DESCRIPTION OF TEST

The ability of the PASS to supply purge air to the LDUA at the required pressure and flow rate is essential for assurance that the sensors of the LDUA do not initiate emergency shutdown of the LDUA because of low purge pressure. Therefore the objectives of this test were to adjust the system as required and test to verify that it delivers adequate flow at the proper pressures at its point of interface with the LDUA, adjust system pressure control and pressure relief valves to their proper settings, and verification of PASS purge flow back-up capabilities.

The two PASS compressor units tested were the actual units that will be deployed in the field with the LDUA. The two compressor units are identical, with one unit being identified as serial number 001 and the other as serial number 002. The actual hose assembly was not available at the time of this test. However, the hose assembly used was of the same size and approximate lengths as the actual hose assembly, and included the actual regulator, check valves, and many of the fittings to be used in the actual hose assembly as shown in figure 2.

Each of the two PASS compressor units were designed and fabricated in accordance with PR 414302, by Portland Compressor, Portland, Oregon (503) 235-0200. For parts list and equipment arrangement of the PASS see drawing H-6-14099, LDUA Purge Air Supply. See figure 3, for a schematic showing the mechanical relationship of the components comprising a PASS compressor unit, with an electrical schematic as shown in figure 4. A 50 foot long power cord is used to furnish electrical power of 115 vac, 60 Hz, 22 amp to the compressor motors. A 35 foot long air hose assembly is used to interface the two compressor units to the purge inlet of the LDUA, with a 50 foot branch going to the ATIE. The quick connects used in the hose assembly are color coded and keyed to avoid inadvertent misconnections.

3.0 TEST METHOD AND TEST EQUIPMENT

The PASS CG&A tests were performed on the mezzanine at the 42'-6" level of the 427 Building (FMEF) using electrical power provided by the facility. For details on how the test was performed see LDUA PASS CG&A Test Procedure, WHC-SD-WM-TC-071, revision 1. PASS pressure control and flow capabilities were verified under conditions closely simulating actual operating demands.

3.1 DESCRIPTION OF TEST METHODS

In general, the testing performed on the two PASS compressor units consisted of six portions as outlined below:

- 1) Removal of pressure relief valves (RV-1), verification of their proper relief pressure followed by their re-installation. These relief valves are required to relieve at pressures of 140 to 144 psig.
- 2) Individual operation of each unit in both the "continuous run" mode and the "start/stop" mode and setting the upper and lower boundaries of the pressure in their air receiver tank. The allowable pressure control bands are 100 to 135 psig in the continuous run mode, and 85 to 120 psig in the start/stop mode.
- 3) Measurement of the pressure and flow at the end of the air hose at required delivery pressure. The required flow is to be not less than 3.5 SCFM at a relatively constant pressure between 70 psig to 100 psig.
- 4) Removal of check valves (CV-2) and (CV-3), performance of reverse pressure leak check followed by their re-installation. As a goal, allowable leakage should not exceed 3.0 SCIM with a reverse differential pressure of 5 to 10 psig applied.
- 5) Chilling down the heat strip thermostat with ice and verifying operation of heat strip. The heat strip should be automatically energized when temperatures approach freezing.
- 6) System operation verification by attaching the outlet of each compressor unit to a common hose and operating in a manner as in the field. Should one of the PASS compressor units be shutdown system delivery pressure and flow should be uninterrupted with an automatic transition to the other compressor unit.

3.2 EQUIPMENT USED

The test hand valves were common manually operated valves of 1/2" nominal size. The only calibrated equipment used were the flow meters and pressure test gage, as follows:

Flow meter:

The flow measuring device used in this test consisted of three flow meters manifolded together at their inlets and outlets. Each flow meter had an isolation valve at its inlet and outlet to allow flow to pass through one, two, or all three flow meters in parallel at the test performers option for best flow measurement. The flow meters were each calibrated in the manifolded configuration used in the test. The particulars of the three flow meters are:

- 1) F&P Model 10A3565, Serial No. FP090878-3, Rotameter, 0 to 2 SCFM, calibration due date 11/22/96, Standards Lab Code No. 545-28-13-013, reference No. 395353
- 2) F&P Model 10A3565, Serial No. FP090878-4, Rotameter, 0 to 2 SCFM, calibration due date 11/22/96, Standards Lab Code No. 545-28-13-014, reference No. 395356
- 3) Wallace & Tiernan Model 3/8-40-G-10 (02V14), Rotameter, 0 to 3 SCFM, calibration due date 11/22/96, Standards Lab Code No. 646-28-13-041, reference No. 395355

Pressure Test gage:

Heise, 0 to 200 psig, Serial No. C72964, Calibration due date 11/14/96, Standards Lab Code No. 679-31-04-020, reference No. 395352

4.0 TEST RESULTS

Not long after PASS testing was initiated, a decision was made by LDUA engineering to change the PASS baseline design from a system having only a single compressor unit to a system having two compressor units plumbed in parallel for redundancy. Revision 1, of the test procedure was issued to accommodate this design change. This change to a redundant system required the pressure set points of the unloader valve and the pressure switch to be re-adjusted for each compressor unit, and the addition of check valves to the hose assembly at the outlet of each compressor unit to assure that the two units will each operate independent of the other.

Listed below, is a brief description of each section of the test procedure and the results obtained:

4.1 RECEIVER TANK RELIEF VALVE TEST, (Section 10.1)

The relief valve (RV-1) was removed from each compressor unit and sent to WHC Calibration Services for testing. The relief valve used in compressor unit serial number 001 was found to relieve at 142.51 psig and that used in compressor unit serial number 002 relieved at 143.6 psig. Both relief valves were within the allowed pressure of 140 to 144 psig, and are therefore acceptable. No problems were encountered.

4.2 OPERATING PRESSURE TEST, START/STOP MODE (Section 10.2)

Adjustments were made to the Pressure Switch (PS-1) of each PASS compressor unit as required to maintain the air receiver pressure within overall limits of 85 to 120 psig when the compressor unit is operating in the Start/Stop mode. In accomplishing this the pressure switch of both units were adjusted so they turned the compressor on when receiver pressures decay to be within a range of 85 to 90 psig and turn the compressor off before pressures reach 120 psig. A calibrated test gage was used to verify proper pressure. No problems were encountered.

4.3 OPERATING PRESSURE TEST, CONTINUOUS RUN MODE (Section 10.3)

Adjustments were made to the unloader valve (PR-1) of each PASS compressor unit as required to maintain the air receiver pressure within overall limits of 100 to 135 psig when the compressor unit is operating in the Continuous Run mode. In accomplishing this the unloader valve of both units were adjusted so they cease venting (i.e. unloading) when receiver pressures decay to 100 to 105 psig and vent (i.e. unload) when pressures reach 10 to 15 psig above the observed dropout pressure of their respective pressure switch. A calibrated test gage was used to verify proper pressure. No problems were encountered.

4.4 PURGE AIR DELIVERY PRESSURE, (Section 10.4.1)

The regulator unit (PC-1), located at the end of the hose assembly, was adjusted to control the air pressure delivered at the end of the hose assembly to be 75 to 80 psig. A calibrated test gage was used to verify proper pressure. No problems were encountered.

4.5 PURGE AIR RELIEF VALVE TEST, (Section 10.4.2)

A test was performed to verify the capability of the internal relief feature of regulator unit (PC-1) to limit the maximum air pressure delivered at the end of the hose to be 85 psig or less, in the event that the regulator should fail open. A calibrated test gage was used to verify proper pressure. No problems were encountered.

4.6 FLOW TEST, (Section 10.5)

Flow tests were performed to determine the capability of each PASS compressor unit to deliver at least 3.5 SCFM of air flow at the end of the hose assembly, at pressures of 75 to 80 psig. All flow measurements were made using a calibrated rotameter flowmeter.

Problems were encountered in achieving the required flow rate when the compressor units were first tested in their as-received condition. The flow rates then measured ranged from 1.4 SCFM at 107 psig to 3.2 SCFM at 74 psig. The low flow problem was found to be due to the vendor improperly selecting a membrane dryer for the available flow from the compressor units. The membrane dryers used were too large a capacity for the size of compressors. Membrane dryers are expected to typically waste no more than 18% to 20% of the flow through them in the drying process. These dryers were obviously wasting far more than that. Further testing found that the membrane dryers were allowing more flow to escape from their bleed ports that was passing through outlet of the dryer (see the flow graphs in figure 5). Discussions with the supplier confirmed that the dryers supplied with the compressor units should have been the next size smaller to be compatible with the flow capacity of the compressors.

The supplier sent us the proper size of membrane dryer to replace the dryers originally furnished. The flow tests were reran and found acceptable. The flow was now found to be more than 4.0 SCFM at 75 to 80 psig regulated pressure. No further flow problems were encountered.

4.7 CHECK VALVE TEST, (Section 10.6)

A reverse flow leakage test was performed on check valves (CV-2) and (CV-3) located in the inlets branches of the air supply hose. The test was performed with a pressure of 5 to 10 psig at the outlet of the check valve while checking at the inlet using soap solution. No visible leakage was observed. No problems were encountered.

4.8 HEAT STRIP THERMOSTAT TEST, (Section 10.7)

Proper operation of the heat strip and its thermostat was verified for each PASS compressor unit. An ice bag was applied to the thermostat which controls the heat strip wrapped around the filter element housing and along the bottom of the receiver, to determine if the heat strip energized at near freezing temperatures. The heat strip operated properly, no problems were encountered.

4.9 DUAL OPERATION TEST, (Section 10.8)

A functional test was performed to provide assurance that the two PASS compressor units will function as intended when their outlets are connected together to a common hose as a purge source to the LDUA. In this test a calibrated flow meter was attached to the outlet of the supply hose and was adjusted to obtain a steady flow of approximately 3.5 SCFM at 75 to 80 psig regulated pressure. One of the compressor units was setup in the "continuous run" mode (i.e. the active unit) with the other unit setup in the "start/stop" mode (i.e. the standby unit). The active unit cycled as necessary to keep up the air flow, while the standby unit cycled only to make up for the bleed from its air dryer. When the active unit was turned off (to simulate a failure) the receiver pressure of both compressors decayed until the pressure switch of the standby unit assumed control. No fluctuations of flow rate or regulator outlet pressure was observed during this transition. The entire test was repeated with the roles of the two compressor units as active and standby being exchanged, and the same results were observed. No problems were encountered in this test.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The CG&A testing performed on the PASS, per WHC-SD-WM-TC-071, was successfully completed and the PASS is now considered ready to support LDUA integrated cold testing as defined in other procedures. For instructions on how to operate and maintain the PASS in support of LDUA operations, see the PASS Operation and Maintenance Manual, WHC-SD-WM-OMM-025.

It should be noted that the PASS compressor unit in the standby mode will occasionally cycle on and off, even though the active compressor is working normally to provide the purge air to the LDUA. The reason the standby unit cycles is to make up for the air lost from its receiver tank because of the bleed air wasted through its membrane dryer. To eliminate this unnecessary cycling (thereby extending the life of the compressor units) a pilot operated solenoid controlled shutoff valve could be added upstream of the membrane dryer. Such a solenoid valve could be wired to come open whenever the compressor is energized, and close when the compressor is de-energized. When closed, the standby unit would then not lose air through the membrane dryer unnecessarily. It is recommended that such a solenoid valve be incorporated into each compressor unit should it be found justifiable in order to increase the life expectancy of the compressors and electric motors.

6.0 DISPOSITION OF TEST ITEM

After completion of the PASS CG&A activities the test item (i.e. PASS) will be stored indoors in an environmentally controlled room. At a later date, the PASS will be subjected to an integrated LDUA system cold test as defined in the LDUA Equipment Qualification Test Procedure (not issued at this time). After all cold testing has been completed the PASS will be turned over to TWRS for hot testing in an actual single-shell waste tank.

7.0 REFERENCES

- WHC-SD-WM-TC-071, revision 1, Test Procedure for Calibration, Grooming and Alignment of the LDUA Purge Air Supply
- WHC-SD-TD-TP-005, revision 0, Light Duty Utility Arm System Pre-Operational (Cold Test) Test Plan
- WHC-SD-WM-OMM-025, revision 0, Operation and Maintenance Manual for the LDUA Purge Air Supply
- H-6-14099-1, revision 0, LDUA Purge Air Supply Assembly

APPENDIX

FINAL DATA SHEET, S/N 001

DATA SHEET

CG&A TESTING OF LDU A PURGE AIR SUPPLY SYSTEM (PASS)

Part Number H-6-14099-1Comp. Unit Serial Number 001

Step No.	Value	Units	Name of person entering data	Date	Requirements/Comments
10.1.2	142.51	psig	J.D. Potter	12/15/95	s/b 140 to 144 psig
10.2.7 stops	TG PI-1		G.W. Lanham	3/18/96	s/b 120 psig max
run #1	106 104	psig			
run #2	106 104	psig			
run #3	106 104	psig			
10.2.7 starts	TG PI-1		G.W. Lanham	3/18/96	s/b 85 to 90 psig
run #1	86 84	psig			
run #2	86 84	psig			
run #3	86 84	psig			
10.3.7 unloads	TG PI-1		G.W. Lanham	3/19/96	s/b 10 to 15 psig above press switch setting
run #1	116 113	psig			
run #2	116 113	psig			
run #3	116 113	psig			
10.3.7 loads	TG PI-1		G.W. Lanham	3/19/96	s/b 100 to 105 psig
run #1	104 100	psig			
run #2	104 100	psig			
run #3	104 100	psig			
10.4.1.3	TG PI-3		G.W. Lanham	4/19/96	s/b 75 to 80 psig
	77 77	psig			
10.4.2.4	83	psig	G.W. Lanham	4/19/96	s/b 85 psig max (crack pressure)
10.5.4	77 4.2	psig SCFM	G.W. Lanham	5/2/96	s/b 3.5 SCFM min at 75 to 80 psig
10.6.2.c	N/A	N/A	G.W. Lanham	4/22/96	observation:
(CV-2)	no leakage				
(CV-3)	no leakage				
10.7.3	heat strip came on	yes/no	G.W. Lanham	1/24/96	heat strip should come on

FINAL DATA SHEET, S/N 002

DATA SHEET

CG&A TESTING OF LDU A PURGE AIR SUPPLY SYSTEM (PASS)

Part Number	H-6-14099-1		Comp. Unit Serial Number		002
Step No.	Value	Units	Name of person entering data	Date	Requirements/Comments
10.1.2	143.6	psig	J.D. Potter	12/15/95	s/b 140 to 144 psig
10.2.7 stops	<u>TG</u> <u>PI-1</u>		G.W. Lanham	3/18/96	s/b 120 psig max
run #1	114 114	psig			
run #2	114 114	psig			
run #3	114 114	psig			
10.2.7 starts	<u>TG</u> <u>PI-1</u>		G.W. Lanham	3/18/96	s/b 85 to 90 psig
run #1	87 87	psig			
run #2	87 87	psig			
run #3	87 87	psig			
10.3.7 unloads	<u>TG</u> <u>PI-1</u>		G.W. Lanham	3/18/96	s/b 10 to 15 psig above press switch setting
run #1	124 124	psig			
run #2	124 124	psig			
run #3	124 124	psig			
10.3.7 loads	<u>TG</u> <u>PI-1</u>		G.W. Lanham	3/18/96	s/b 100 to 105 psig
run #1	105 105	psig			
run #2	105 105	psig			
run #3	105 105	psig			
10.4.1.3	<u>TG</u> <u>PI-3</u>		G.W. Lanham	4/19/96	s/b 75 to 80 psig
	77 77	psig			
10.4.2.4	83	psig	G.W. Lanham	4/19/96	s/b 85 psig max (crack pressure)
10.5.4	77 4.0	psig SCFM	G.W. Lanham	4/19/96	s/b 3.5 SCFM min at 75 to 80 psig
10.6.2.c		N/A	G.W. Lanham	4/22/96	observation:
(CV-2)	no leakage				
(CV-3)	no leakage				
10.7.3	heat strip came on	yes/no	G.W. Lanham	1/24/96	heat strip should come on

FIGURE 1

LDUA Purge Air Supply System (PASS)
(hose assembly not shown)

FIGURE 2
LDUA PURGE AIR SUPPLY SYSTEM (PASS)
HOSE ROUTING SCHEMATIC

FIGURE 3
Mechanical Schematic of PASS

LDUA Purge Compressor Schematic

Electrical Schematic of PASS

FIGURE 4

FIGURE 5

Flow Test Results

(with old air dryer, no air dryer, and new air dryer)

DISTRIBUTION SHEET

To	From	Page 1 of 1
8A800	J.D. Potter	Date 5/2/96
Project Title/Work Order		EDT No. 612366
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B.A. Carteret	N1-21				X
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R.B. Conrad	H5-09	X			
D.S. Dutt	N1-21				X
G.R. Kiebel	N1-21	X			
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