

Sta 4. (2)

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		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

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(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	HWE - SR 12/27/96 WHE-SD-W026-ATP-020		0	Manipulator System Plan	Q	2	1	
2	HWE - SR 12/27/96 WHE-SD-W026-ATR-020		0	Manipulator System Report	Q	2	1	

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

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)											
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Proj. Mgr.: DR Lucas	<i>[Signature]</i>	12/19/96	T4-02						
1	1	Proj. Engr.: JB Payne	<i>[Signature]</i>	12/19/96	T4-02						
1	1	Cog.Eng.: KJ Leist	<i>[Signature]</i>	12/19/96	T4-52						
1	1	Cog. Mgr.: RJ Bottenus	<i>[Signature]</i>	12/19/96	T4-52						
1	1	QA: JR McGee	<i>[Signature]</i>	12/19/96	T4-02						
		Safety									
		Env.									

18. JB Payne <i>[Signature]</i> Signature of EDT Originator	19. RJ Bottenus <i>[Signature]</i> Authorized Representative Date for Receiving Organization	20. RJ Bottenus <i>[Signature]</i> Design Authority/ Cognizant Manager	21. DOE APPROVAL (if required) Ctrl. No. <input type="checkbox"/> Approved <input type="checkbox"/> Approved w/comments <input type="checkbox"/> Disapproved w/comments
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# W-026, Acceptance Test Report Manipulator System (Submittal # 748.1.F)

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

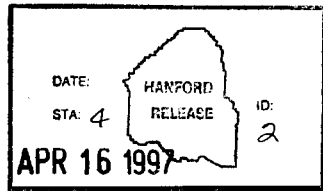
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Abstract: This test verified the manipulator system met all inspection requirements, demonstrated the functional tasks were performed and the performance requirements were achieved.

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*[Signature]*  
Release Approval

*4/10/97*  
Date

**Approved for Public Release**

PCL

ACCEPTANCE TEST PLAN  
FOR  
WASTE RECOVERY AND PROCESSING  
(WRAP)  
MANIPULATOR SYSTEM

Prepared For:  
WHC/CF-KH  
Contract 570 1007  
KEH 5366

March 19, 1995

TEST STARTED AT 1:30 PM on 3-22-96



Revision 2

ATR  
TAB. 1.1

1.0 INTRODUCTION

The purpose of the WRAP Manipulator System Acceptance Test Plan (ATP) is to verify that the four (4) glovebox sets of WRAP manipulator components, including rail/carriage, slave arm, master controller and auxiliary equipment, meets the requirements of the functional segments of 14590 specification. The demonstration of performance elements of the ATP are performed as a part of the Assembly (13021, 13027, 13031) specifications. Manipulator integration is integral to the performance testing of the gloveboxes. Each requirement of the Assembly (13021, 13027, 13031) specification will be carried out in conjunction with glovebox performance tests.

The basis for a satisfactory test is that the WRAP manipulator shall meet all inspection requirements, demonstrate that the functional tasks can be performed and verify that the performance requirements are achieved. If corrections or adjustments are made, the tests shall be repeated until completed consecutively.

1.1 Manipulator Tag No./Glovebox No. Legend

Tag #		Glovebox #
107-EM-07-101	=	GB 102
107-EM-07-201	=	GB 201
107-EM-07-301	=	GB 302
107-EM-07-401	=	GB 401

2.0 FUNCTIONAL

- 2.1 Preparation: Prior to the start of the test, the equipment shall be operated for ten minutes to allow the temperature of the fluid to stabilize. All functional testing is to be performed with no payload in the jaw and effector.
- 2.2 Verify by test that the manipulator horizontal carriage is free to translate from one end of the horizontal rail to the other end without resistance. The translation distance is defined in the glove box assembly drawing.

GB 102 Dwg ✓	Signature <u>[Signature]</u>	Date <u>4-16-96</u>	} Witness Acc. Kje
GB 201 Dwg ✓	Signature <u>[Signature]</u>	Date <u>4-17-96</u>	
st on 4-5-96 41% GB 302 Dwg ✓	Signature <u>[Signature]</u>	Date <u>4-4-96</u>	
GB 401 Dwg ✓	Signature <u>[Signature]</u>	Date <u>3-22-96</u>	

- 2.3 Verify by test that the master controller positioning carriage is free to translate from one end of the horizontal rail to the other end without resistance. The translation distance is defined in the Glove box assembly drawing.

GB 102 Dwg ✓	Signature <u>[Signature]</u>	Date <u>4-16-96</u>	} Witness Acpt. Kje
GB 201 Dwg ✓	Signature <u>[Signature]</u>	Date <u>4-17-96</u>	
GB 302 Dwg ✓	Signature <u>[Signature]</u>	Date <u>4-4-96</u>	
GB 401 Dwg ✓	Signature <u>[Signature]</u>	Date <u>3-22-96</u>	

2.4. Verify by test that the slave arrays are free to translate from one end of the vertical rail to the other end without resistance.

GB 102 Right Arm	Signature <u>RW</u>	Date <u>4-16-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>
GB 201 Right arm ✓	Signature <u>RW</u>	Date <u>4-17-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-17-96</u>
GB 302 Right Arm	Signature <u>N.S.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>N.S.</u>	Date <u>4-4-96</u>
✓ GB 401 Right Arm	Signature <u>N.S.</u>	Date <u>3-22-96</u>
Left Arm	Signature <u>N.S.</u>	Date <u>3-22-96</u>

Witness Accept?  
Kjc

2.5. Verify that each joint of the HV6F has full dexterity (i.e., can be commanded to move to throughout it's full range of motion)

GB 102 Right Arm	Signature <u>RW</u>	Date <u>4-16-96</u>
Left Arm	Signature <u>RW</u>	Date <u>4-16-96</u>
GB 201 Right arm ✓	Signature <u>RW</u>	Date <u>4-17-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-17-96</u>
GB 302 Right Arm	Signature <u>N.S.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>N.S.</u>	Date <u>4-4-96</u>
GB 401 Right Arm	Signature <u>N.S.</u>	Date <u>3-22-96</u>
Left Arm	Signature <u>N.S.</u>	Date <u>3-22-96</u>

Witness Accept?  
Kjc

Right wrist  
center  
w/CP

2.6. Actuate each degree-of-freedom of the HV6F manipulator independently of the others, throughout its full range of motion, once at maximum joint angular rate. The range of motion shall meet or exceed the following specified values:

- Shoulder Roll - 90 deg
- Shoulder Pitch - 90 deg
- Elbow Yaw - 120 deg
- Wrist Yaw - 120 deg
- Wrist Rotate - 270 deg slaved/360 deg continuous

GB 102 Right Arm	Shoulder Roll	Signature <u>RW</u>	Date <u>4-16-99</u>
	Shoulder Pitch	Signature <u>RW</u>	Date
	Elbow Yaw	Signature <u>RW</u>	Date
	Wrist Yaw	Signature <u>RW</u>	Date
	Wrist Rotate	Signature <u>RW</u>	Date
GB102 Left Arm	Shoulder Roll	Signature <u>RW</u>	Date
	Shoulder Pitch	Signature <u>RW</u>	Date
	Elbow Yaw	Signature <u>RW</u>	Date
	Wrist Yaw	Signature <u>RW</u>	Date
	Wrist Rotate	Signature <u>RW</u>	Date <u>4-16-96</u>

Angles measured in Ball tip Bench test (after iron) Witness Accept? Kjc

GB 201 Right Arm Shoulder Roll ✓	Signature	<u>R.H.</u>	Date	<u>4-17-96</u>
Shoulder Pitch ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
Elbow Yaw ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
Wrist Yaw ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
270° Wrist Rotate ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
GB 201 Left Arm Shoulder Roll ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
Shoulder Pitch ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
Elbow Yaw ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
Wrist Yaw ✓	Signature	<u>R.H.</u>	Date	<u>          </u>
270° Wrist Rotate ✓	Signature	<u>R.H.</u>	Date	<u>4-17-96</u>
GB 302 Right Arm Shoulder Roll	Signature	<u>N.S.</u>	Date	<u>4-4-96</u>
Shoulder Pitch	Signature	<u>N.S.</u>	Date	<u>          </u>
Elbow Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
Wrist Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
270° Wrist Rotate	Signature	<u>N.S.</u>	Date	<u>          </u>
GB 302 Left Arm Shoulder Roll	Signature	<u>N.S.</u>	Date	<u>          </u>
Shoulder Pitch	Signature	<u>N.S.</u>	Date	<u>          </u>
Elbow Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
Wrist Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
270° Wrist Rotate	Signature	<u>N.S.</u>	Date	<u>          </u>
GB 401 Right Arm Shoulder Roll	Signature	<u>N.S.</u>	Date	<u>3-22-96</u>
Shoulder Pitch	Signature	<u>N.S.</u>	Date	<u>3-22-96</u>
Elbow Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
Wrist Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
270° Wrist Rotate	Signature	<u>N.S.</u>	Date	<u>          </u>
GB 401 Left Arm Shoulder Roll	Signature	<u>N.S.</u>	Date	<u>          </u>
Shoulder Pitch	Signature	<u>N.S.</u>	Date	<u>          </u>
Elbow Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
Wrist Yaw	Signature	<u>N.S.</u>	Date	<u>          </u>
270° Wrist Rotate	Signature	<u>N.S.</u>	Date	<u>          </u>

2.7. Verify by test that two dynamic modes are provided: a fast mode for normal operation and a slow mode for tasks requiring slower speeds.

GB 102 Right Arm	Signature	<u>R.H.</u>	Date	<u>4-16-96</u>
Left Arm	Signature	<u>R.H.</u>	Date	<u>4-16-96</u>
GB 201 Right arm ✓	Signature	<u>R.H.</u>	Date	<u>4-17-96</u>
Left Arm ✓	Signature	<u>R.H.</u>	Date	<u>4-17-96</u>

Witness Acc.  
R.H.

GB 302 Right Arm  
Left Arm  
GB 401 Right Arm  
Left Arm

Signature M. Z. Date 4-4-96  
Signature M. Z. Date 4-4-96  
Signature M. Z. Date 3-22-96  
Signature M. Z. Date 3-22-96

2.8. Verify by test that two wrist control modes are provided; a position control mode providing accurate indexing of the end effector and a variable rate continuous mode for tasks requiring multiple rotation of the end effector.

GB 102 Right Arm  
Left Arm  
GB 201 Right arm ✓  
Left Arm ✓  
GB 302 Right Arm  
Left Arm  
GB 401 Right Arm  
Left Arm

Signature Rm Date 4-16-96  
Signature Rm Date 4-16-96  
Signature Rm Date 4-17-96  
Signature Rm Date 4-17-96  
Signature A. Z. Date 4-4-96  
Signature M. Z. Date 4-4-96  
Signature A. Z. Date 3-22-96  
Signature A. Z. Date 3-22-96

Witness  
Accepted  
Kjz

2.9. Verify that three jaw control modes are provided; An open mode shall maintain the jaws open until the operator deflects the jaw switch, a toggle mode where deflecting the switch will open the jaws and retoguling the switch will close the jaws and a position mode which allows incremental closing of the jaws with the ability to fix the position of the jaws by releasing the switch.

GB 102 Right Arm  
Left Arm  
GB 201 Right arm ✓  
Left Arm ✓  
GB 302 Right Arm  
Left Arm  
GB 401 Right Arm  
Left Arm

Signature Rm Date 4-16-96  
Signature Rm Date 4-16-96  
Signature Rm Date 4-17-96  
Signature Rm Date 4-17-96  
Signature M. Z. Date 4-4-96  
Signature M. Z. Date 4-4-96  
Signature A. Z. Date 3-22-96  
Signature A. Z. Date 3-22-96

Witness  
Accepted  
Kjz

2.10. Verify by test that a freeze mode electronically freezes the entire EV6F slave arm in the position it is in when the freeze mode is entered.

GB 102 Right Arm  
Left Arm  
GB 201 Right arm ✓  
Left Arm ✓  
GB 302 Right Arm  
Left Arm  
GB 401 Right Arm  
Left Arm

Signature Rm Date 4-16-96  
Signature Rm Date 4-16-96  
Signature Rm Date 4-17-96  
Signature Rm Date 4-17-96  
Signature M. Z. Date 4-4-96  
Signature A. Z. Date 4-4-96  
Signature M. Z. Date 3-22-96  
Signature M. Z. Date 3-22-96

Witness  
Accepted  
Kjz

2.11. Verify by test that the master controller is able to freeze individual joints of the HV6F sleeve arm.

GB 102 Right Arm	Signature <u>RJM</u>	Date <u>4-16-96</u>
Left Arm	Signature <u>RJM</u>	Date <u>4-16-96</u>
GB 201 Right arm ✓	Signature <u>RJM</u>	Date <u>4-17-96</u>
Left Arm ✓	Signature <u>RJM</u>	Date <u>4-17-96</u>
GB 302 Right Arm	Signature <u>M. R.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>M. R.</u>	Date <u>4-4-96</u>
GB 401 Right Arm	Signature <u>M. R.</u>	Date <u>3-22-96</u>
Left Arm	Signature <u>M. R.</u>	Date <u>3-22-96</u>

Witness Accepted  
KJL

2.12. Verify by test that the stow mode returns the HV6F to a predetermined stowed position via a pathway of 5 predetermined points.

GB 102 Right Arm	Signature <u>RJM</u>	Date <u>4-16-96</u>
Left Arm	Signature <u>RJM</u>	Date <u>4-16-96</u>
GB 201 Right arm ✓	Signature <u>RJM</u>	Date <u>4-17-96</u>
Left Arm -	Signature <u>RJM</u>	Date <u>4-17-96</u>
GB 302 Right Arm	Signature <u>M. R.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>M. R.</u>	Date <u>4-4-96</u>
GB 401 Right Arm	Signature <u>M. R.</u>	Date <u>3-22-96</u>
Left Arm	Signature <u>M. R.</u>	Date <u>3-22-96</u>

Witness Accepted  
KJL

2.13. Verify by test that the teach mode enables operators to program movements into the controller that the HV6F slave arm will repeat at a later time by reprogramming a new stow position.

GB 102 Right Arm	Signature <u>RJM</u>	Date <u>4-16-96</u>
Left Arm	Signature <u>RJM</u>	Date <u>4-16-96</u>
GB 302 Right Arm	Signature <u>M. R.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>M. R.</u>	Date <u>4-4-96</u>
GB 401 Right Arm	Signature <u>M. R.</u>	Date <u>4-2-96</u>
Left Arm	Signature <u>M. R.</u>	Date <u>4-2-96</u>
GB 201 RIGHT ARM	SIGNATURE <u>RJM</u>	Date <u>4-17-96</u>
LEFT ARM	SIGNATURE <u>RJM</u>	Date <u>4-17-96</u>

OK  
KJL

2.14. Verify that the Master Controller Positioning Carriage can support a 100 pound load from the front edge of the carriage and can translate back and forth across the face of the glovebox enclosure with weight attached.

GB 102 Dwg	Signature <u>SPA</u>	Date <u>4/16/96</u>
GB 201 Dwg	Signature <u>RJM</u>	Date <u>4-17-96</u>
GB 302 Dwg	Signature <u>M. R.</u>	Date <u>4-4-96</u>
GB 401 Dwg	Signature <u>M. R.</u>	Date <u>3-22-96</u>

Witness Accepted  
KJL

2.15. Verify by test that the park position and upper limit switches function properly.



GB 102 Right Arm	Signature <u>RM</u>	Date <u>9-20-96</u>
Left Arm	Signature <u>RM</u>	Date <u>9-20-96</u>
GB 201 Right arm	Signature <u>RM</u>	Date <u>6-14-96</u>
Left Arm	Signature <u>RM</u>	Date <u>6-14-96</u>
GB 302 Right Arm	Signature <u>RM</u>	Date <u>9-23-96</u>
Left Arm	Signature <u>RM</u>	Date <u>9-23-96</u>
GB 401 Right Arm	Signature <u>RM</u>	Date <u>6-14-96</u>
Left Arm	Signature <u>RM</u>	Date <u>6-14-96</u>

kg 2/9/96  
7/1/96  
9/23/96  
7/1/96

2.16. Verify by visual inspection that the manipulators are mounted to minimize 'bounce' of the end effector. Verify that the stability is sufficient to limit the amplitude of oscillation at the end effector, in any position, with 50% of the rated load, to 0.5 inches, and a decay time of 2 seconds or less.

End effector base  
# 434  
PERSONAL SIGNATURE  
DATED 7/1/96  
GL

GB 102 Right Arm ✓	Signature <u>RM</u>	Date <u>4-16-96</u>
Left Arm ✓	Signature <u>RM</u>	Date <u>4-16-96</u>
GB 201 Right arm ✓	Signature <u>RM</u>	Date <u>4-17-96</u>
Left Arm ✓	Signature <u>RM</u>	Date <u>4-17-96</u>
GB 302 Right Arm	Signature <u>RM</u>	Date <u>9-24-96</u>
Left Arm	Signature <u>RM</u>	Date <u>9-24-96</u>
GB 401 Right Arm	Signature <u>RM</u>	Date <u>4-2-96</u>
Left Arm	Signature <u>RM</u>	Date <u>4-2-96</u>

9/24/96  
ALL TEST VALUES IN EXCESS OF 50% SHALL BE VALUE. HOWEVER, WHEN TAKEN AT THE TEST SITE DEPT. TO WITHIN 5% ALLOWANCE (i.e., 95% RATED MAX AT 2.2.2.).

3.0 PERFORMANCE TESTING

3.1. Each slave arm shall pick up and hold an object weighing 60 lbs at full extension.

GB 102 Right Arm	Signature <u>RM</u>	Date <u>4-16-96</u>
Left Arm	Signature <u>RM</u>	Date <u>4-16-96</u>
GB 201 Right arm ✓	Signature <u>RM</u>	Date <u>4-17-96</u>
Left Arm ✓	Signature <u>RM</u>	Date <u>4-17-96</u>
GB 302 Right Arm	Signature <u>R. R.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>R. R.</u>	Date <u>4-4-96</u>
GB 401 Right Arm	Signature <u>R. R.</u>	Date <u>4-2-96</u>
Left Arm	Signature <u>R. R.</u>	Date <u>4-2-96</u>

3.1 - Used 60lb-100 LbD ONE INDICATOR. SW 8102 2. 60 LB TEST. LARGEST W/PT AND PROBABLY SAME TO 2100 LBS. CHECKING 60LB STANDARD AT MIDPOINT OF FAILURE (NOT AT 70). SEE 4.4.1. VALUES LISTED.

Witness Receipt  
Kyl 7/1/96

\* 3.2. Each slave arm end effector shall be opened and closed and the maximum closure force measured. The measured values shall be within ± 50 of the specified 200 lb

GB 102 Right Arm	Signature <u>RM</u>	Date <u>6-25-96</u>
Left Arm	Signature <u>RM</u>	Date <u>6-25-96</u>
GB 201 Right arm	Signature <u>RM</u>	Date <u>6-25-96</u>
Left Arm	Signature <u>RM</u>	Date <u>6-25-96</u>

296\*  
301\*  
283\*  
295\*  
4/25/96

✓ STOP TEST PROCEDURES TO SEE IF REQUIRED

270\*  
GB 302 Right Arm  
294\*  
Left Arm  
291\*  
GB 401 Right Arm  
305\*  
Left Arm

*OK*  
*4/17/96*

Signature *Rm* Date 6-25-96  
Signature *Rm* Date 6-25-96  
Signature *Rm* Date 6-25-96  
Signature *Rm* Date 6-25-96

3.3. Verify that the manipulator can retrieve, use and stow the broom/squeegee tool.

GB 102 Right Arm ✓ Signature *Rm* Date 4-16-96  
Left Arm ✓ Signature *Rm* Date 4-16-96  
GB 201 Right arm Signature *Rm* Date 4-17-96  
Left Arm ✓ Signature *Rm* Date 4-17-96  
GB 302 Right Arm Signature *M.G.* Date 4-4-96  
Left Arm Signature *N.Z.* Date 4-4-96  
GB 401 Right Arm Signature *N.Z.* Date 4-2-96  
Left Arm Signature *N.Z.* Date 4-2-96

*Test exception 433*  
*Tool racks still to*  
*be located with*  
*resp.*  
*Witness Accepted*  
*KPL 7/11/96*

3.4. Verify that the manipulator can retrieve, use and stow the shovel tool.

GB 102 Right Arm ✓ Signature *Rm* Date 4-16-96  
Left Arm ✓ Signature *Rm* Date 4-16-96  
GB 201 Right arm ✓ Signature *Rm* Date 4-17-96  
Left Arm ✓ Signature *Rm* Date 4-17-96  
GB 302 Right Arm Signature *M.G.* Date 4-4-96  
Left Arm Signature *N.Z.* Date 4-4-96  
GB 401 Right Arm Signature *N.Z.* Date 4-2-96  
Left Arm Signature *N.Z.* Date 4-2-96

*Test exception 433*  
*Witness Accepted*  
*KPL 7/11/96*

3.5. Verify that the manipulator can retrieve, use and stow the knife tool.

GB 102 Right Arm Signature *Rm* Date 9-20-96  
Left Arm Signature *Rm* Date 9-20-96  
GB 201 Right arm Signature *Rm* Date 9-20-96  
Left Arm Signature *Rm* Date 9-20-96  
GB 302 Right Arm Signature *Rm* Date 9-20-96  
Left Arm Signature *Rm* Date 9-20-96  
GB 401 Right Arm Signature *Rm* Date 9-20-96  
Left Arm Signature *Rm* Date 9-20-96

*KPL 9/20/96*

3.6. Verify that the manipulator can retrieve, use and stow the bottle clamp tool.

*NA*  
GB 102 Right Arm Signature \_\_\_\_\_ Date \_\_\_\_\_  
Left Arm Signature \_\_\_\_\_ Date \_\_\_\_\_

O/A  
 N/A  
 GB 201 Right arm  
 Left Arm  
 GB 302 Right Arm  
 Left Arm  
 GB 401 Right Arm  
 Left Arm

Signature RM Date 6-14-96  
 Signature RM Date 6-14-96  
 Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Signature RM Date 6-14-96  
 Signature RM Date 6-14-96

) DD 7/11/96  
 ) DD 7/11/96

3.7. Verify that the manipulator can remove, use and stow the aerosol can handling tool.

NA  
 GB 102 Right Arm  
 Left Arm  
 GB 201 Right arm  
 Left Arm  
 GB 302 Right Arm  
 Left Arm  
 GB 401 Right Arm  
 Left Arm

Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Signature RM Date 6-14-96  
 Signature RM Date 6-14-96  
 Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Signature RM Date 6-14-96  
 Signature RM Date 6-14-96

) DD 7/11/96  
 ) DD 7/11/96

3.8. Each slave arm wrist roll joint shall be actuated and the maximum torque measured for both directions of rotation. Verify that two wrist control modes are provided: a position control mode and a variable rate continuous mode.

extra data for  
 (recording of F wrists  
 back issue) RM  
 7/11/96

GB 102 Right Arm CW 25"  
 CCW 30  
 Left Arm CW 25"  
 CCW 25"  
 GB 201 Right arm CW 25"  
 CCW 25"  
 Left Arm CW 25"  
 CCW 25"  
 GB 302 Right Arm CW  
 CCW  
 Left Arm CW #25  
 CCW #25  
 GB 401 Right Arm CW 25"  
 CCW 25"  
 GB 401 Left Arm CW 25"  
 CCW 25"

Signature RM Date 4-16-96  
 Signature RM Date 4-16-96  
 Signature RM Date 4-17-96  
 Signature RM Date 4-17-96  
 Signature N.S. Date 4-4-96  
 Signature N.S. Date 4-4-96  
 Signature N.S. Date 4-2-96  
 Signature N.S. Date 4-2-96

3.9. The following performance tests were carried out and documented in the factory. As such, these tests will be carried out in the field and visually confirmed.

3.9.1. Each degree of freedom of the manipulator assembly shall be activated 10 times and its range of motion visually verified for compliance with specification requirements.

GE 102 Right Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>
GE 201 Right arm	Signature <u>RW</u>	Date <u>4-17-96</u>
Left Arm	Signature <u>RW</u>	Date <u>4-17-96</u>
GE 302 Right Arm	Signature <u>N.X.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>N.X.</u>	Date <u>4-4-96</u>
GE 401 Right Arm ✓	Signature <u>N.X.</u>	Date <u>4-2-96</u>
Left Arm	Signature <u>N.X.</u>	Date <u>4-2-96</u>

Witness  
Accepted  
RJE

3.9.2. Each degree of freedom shall be actuated 10 times and its slew rate will be visually verified for compliance with specification requirements.

GE 102 Right Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>
GE 201 Right arm	Signature <u>RW</u>	Date <u>4-17-96</u>
Left Arm	Signature <u>RW</u>	Date <u>4-17-96</u>
GE 302 Right Arm	Signature <u>N.X.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>N.X.</u>	Date <u>4-4-96</u>
GE 401 Right Arm	Signature <u>N.X.</u>	Date <u>4-2-96</u>
Left Arm ✓	Signature <u>N.X.</u>	Date <u>4-2-96</u>

Left wrist Jerky  
Right wrist Jerky  
Disposition: In slow speed, the wrists will not rotate smoothly. This is normal. RJE 4/16/96  
- Shows rates less than original spec notes, due to after 2000  
RJE disposition #1117

3.9.3. Both end effectors shall be opened and closed 10 times with visual verification.

GE 102 Right Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>
GE 201 Right arm ✓	Signature <u>RW</u>	Date <u>4-17-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-17-96</u>
GE 302 Right Arm	Signature <u>N.X.</u>	Date <u>4-4-96</u>
Left Arm	Signature <u>N.X.</u>	Date <u>4-4-96</u>
GE 401 Right Arm ✓	Signature <u>N.X.</u>	Date <u>4-2-96</u>
Left Arm	Signature <u>N.X.</u>	Date <u>4-2-96</u>

Right wrist  
Accepted  
RJE 4/16/96

3.9.4. With each jaw end effector carrying 60 lb. objects, each degree of freedom shall be actuated to its end of travel and visually verified.

GE 102 Right Arm	Signature <u>RW</u>	Date <u>4-16-96</u>
Left Arm ✓	Signature <u>RW</u>	Date <u>4-16-96</u>

GB 201 Right arm	Signature <u><i>RM</i></u>	Date <u>4-17-96</u>
Left Arm	Signature <u><i>RM</i></u>	Date <u>4-17-96</u>
GB 302 Right Arm	Signature <u><i>H.K.</i></u>	Date <u>4-4-96</u>
Left Arm	Signature <u><i>H.K.</i></u>	Date <u>4-4-96</u>
GB 401 Right Arm	Signature <u><i>H.K.</i></u>	Date <u>4-2-96</u>
Left Arm	Signature <u><i>H.K.</i></u>	Date <u>4-2-96</u>

*Recheck wrists @ 6016 to check for leaks. KJ 7/11/96*

3.9.5. Visually verify that the operational envelope conforms to the range of motion drawing.

GB 102 Right Arm	Signature <u><i>RM</i></u>	Date <u>9-20-96</u>
Left Arm	Signature <u><i>RM</i></u>	Date <u>9-20-96</u>
GB 201 Right arm	Signature <u><i>RM</i></u>	Date <u>6-14-96</u>
Left Arm	Signature <u><i>RM</i></u>	Date <u>6-16-96</u>
GB 302 Right Arm	Signature <u><i>RM</i></u>	Date <u>4-9-96</u>
Left Arm	Signature <u><i>RM</i></u>	Date <u>4-9-96</u>
GB 401 Right Arm	Signature <u><i>H.K.</i></u>	Date <u>4-2-96</u>
Left Arm	Signature <u><i>H.K.</i></u>	Date <u>4-2-96</u>

*exception is 67" vert envelope we are at 70" w/ hoses RM 4-9*

3.10. Verify that each manipulator assembly does not exert in excess of 180 lbs. to the reaction rail by implementation of a load cell test.

GB 102:	Signature <u><i>H.K.</i></u>	Date <u>4-5-96</u>
GB 201:	Signature <u><i>RM</i></u>	Date <u>4-24-96</u>
GB 302:	Signature <u><i>H.K.</i></u>	Date <u>4-5-96</u>
GB 401:	Signature <u><i>RM</i></u>	Date <u>4-24-96</u>

*Test exception #431 KJL 7/11/96*

4.0 INTEGRATION PERFORMANCE

4.1 Processing tasks to be verified in Sorting and Waste Loadout gloveboxes.

4.1.1 Translate Waste Sorting Manipulator over drum.

GB 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GB 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.2 Cut top of PVC bag liner off with manipulator's end effectors.

GB 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GB 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.3 Grab both halves of clamp band with manipulator's end effectors.

GB 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GB 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.4 Place clamp band pieces on sorting table.

*TO BE PERFORMED DURING GLOVEBOX ATO'S*

GE 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.5 Place waste packet sample in packet X-ray machine's packet tray.

GE 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.6 Remove waste packet sample from packet X-ray machine's packet tray.

GE 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.7 Place waste packet sample in packet assay monitor's packet tray.

GE 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.8 Remove waste packet sample from the packet assay monitor's packet tray.

GE 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.9 Open waste packet with manipulator tools.

GE 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.10 Place contents of waste packet on non-compliant item transfer stand (from RWM glovebox).

GE 102: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 302: Signature \_\_\_\_\_ Date \_\_\_\_\_

4.1.11 Using the manipulators, push the waste off each end of the sorting table into the waste loadout gloveboxes.

GE 308: Signature \_\_\_\_\_ Date \_\_\_\_\_  
 GE 309: Signature \_\_\_\_\_ Date \_\_\_\_\_

*TO BE PERFORMED  
 DURING GLOVEBOX ATP*

5.0 FLUSH/CLEANING AND PRESSURE TESTING

5.1. Flush system in accordance with astm d 4174-89.

5.2. The following pressure tests shall be carried out.

5.2.1. NFP(A) T3.4.7-80 - Accum. Press. Rating

Signature \_\_\_\_\_ Date \_\_\_\_\_

5.2.2. NFP(A) T3.9.33-82 -Pump/Motor Pressure Rating

Signature \_\_\_\_\_ Date \_\_\_\_\_

5.2.3. NFP(A) T3.10.5-75 -Hydraulic Filter/Sep.

Signature \_\_\_\_\_ Date \_\_\_\_\_

*9-24-96*

*Hydro TEST RESULTS TO  
 BE SUBMITTED BY 9-27-96  
 AS PART OF GLOVEBOX FIELD  
 TRAVELER PACKING.  
 OL*

6.0 CONCLUSION

6.1 QA EVALUATION

6.1.1 General statement as to whether the manipulator system has/has not met the objectives of this procedure.

Signature *Paul R. Bueck* Date 10-1-96  
 Inspector  
 PAUL R. BUECK

6.2 TEST COMPLETION

6.2.1 The manipulator system has successfully completed Acceptance Testing. *Section 1, 2, & 3 only. Exceptions*

Signature *K. J. L. 11/1/96* Date 9/25/96 *Entered on Exception Test Record.*  
 Operator's Representative  
 K. J. L. 11/1/96

ATP EXCEPTION RESOLUTION

- KJL-1 PERFORM REGRESSIVE TESTING OF MANIPULATOR WRISTS NOW THAT WRISTS HAVE BEEN REPAIRED

*Witness all regress  
 K. J. L. 11/1/96*

GB 102	RIGHT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>10/22/96</u>
GB 102	LEFT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
GB 201	RIGHT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
GB 201	LEFT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
GB 302	RIGHT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
GB 302	LEFT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
GB 401	RIGHT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
GB 401	LEFT WRIST	SIGNATURE X <u><i>Rue</i></u>	DATE <u>10/22/96</u>

- KJL-2 PERFORM HYDROSTATIC TESTS OF THE ARM ASSEMBLIES FROM THE Q/D'S ON THE HORIZONTAL CARRIAGE AT 3,000 psig.

<i>K. J. L. 11/1/96</i>	GB 102	RIGHT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>10/22/96</u>
	GB 102	LEFT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
<i>K. J. L. 11/1/96</i>	GB 201	RIGHT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
	GB 201	LEFT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
<i>K. J. L. 11/1/96</i>	GB 302	RIGHT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
	GB 302	LEFT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
<i>K. J. L. 11/1/96</i>	GB 401	RIGHT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>          </u>
	GB 401	LEFT ARM	SIGNATURE X <u><i>Rue</i></u>	DATE <u>10/22/96</u>



**FACTORY ACCEPTANCE TEST PLAN  
 FOR  
 WASTE RECEIVING AND PROCESSING  
 (WRAP)  
 MANIPULATOR SYSTEM  
 GB 102 EQUIPMENT SET  
 TAG NO 107-EM-07-101**

Prepared For:  
 PCL  
 Contract 570190 OM

Prepared By:

*Roop Bedard* 1/29/96  
 Project Manager, Schilling Robotic Systems, Inc.

*Michael J. Jeff* 1/29/96  
 Quality Assurance Manager, Schilling Robotic Systems, Inc.

Revised  
 Jan 29, 1996

Approved By:

*Geoff* 1-29-96  
 PCL

Engineering Systems Group



1.0 INTRODUCTION AND REFERENCE DOCUMENTS

The purpose of the WRAP Manipulator System Factory Acceptance Test (FAT) plan is to verify that the WRAP manipulator components, including rail/carriage, slave arm, master controller and auxiliary equipment, meet the requirements of the approved range of motion drawings and the non-kinematic aspects of the 14590 specification.

The three reference documents to this one are:

- a. PCL Contract 570190 OM including Specification 14590
- b. HV6F Manipulator Acceptance Test Plans/Results
- c. Range of Motion Drawings dated Feb 10, 1995 approved by PCL March 29, 1995.

The overall approach to assembling and testing the four (4) sets of WRAP glovebox manipulator systems is to:

1. First test the eight (8) HV6F manipulator systems (i.e., the slave arm, the valve package, the electronics package and the master controller) per the reference b. Acceptance Test Plan.
2. Fully assemble the complete WRAP manipulator set for glovebox 102 on the assembly and test fixture at Schilling Robotic Systems.
3. Fully test the set of equipment for glovebox 102 per inspection and test plan contained in this document. This testing will be representative of all four glovebox sets.
4. Verification of proper operation of the remaining three (3) glovebox sets of equipment will be accomplished after assembly in the gloveboxes on-site.

The basis for a satisfactory test is that the WRAP manipulator shall meet all inspection requirements, and demonstrate that the range of motion and performance requirements are achieved. If corrections or adjustments are made, the tests shall be repeated until completed consecutively.

2.0 TEST EQUIPMENT AND TEST PREREQUISITES


2.1 Calibrated Test Equipment

NOTE

All measuring devices used in this test to verify performance, dimensional or other specifications shall be calibrated in accordance with MIL-STD-45662.

DESCRIPTION	MFG #	S/N	CAL DUE	DATE USED	QA
Flowmeter, 0-5 gpm	<u>Hedland</u>	<u>001</u>	<u>9/28/96</u>	<u>1/29/96</u>	<u>MG</u>
Pressure Gauge, 0-5000 psig	<u>Noshok</u>	<u>11138</u>	<u>9/22/96</u>	<u>1/29/96</u>	<u>MG</u>
Digital Calipers 0-12"	<u>Mitutoyo</u>	<u>7007205</u>	<u>5/7/96</u>	<u>1/29/96</u>	<u>MG</u>
Multimeter	<u>Flyuke85</u>	<u>59330314</u>	<u>8/16/96</u>	<u>1/29/96</u>	<u>MG</u>

2.2. Prerequisite - HV6F Acceptance Test

- 2.2.1 Verify that the each of the eight (8) HV6f manipulators systems have successfully completed acceptance testing *excluding slew rates and two arms yaw range of motion was 114 and 114.5. 2002 states 120 ± 5°*
- Signature  Date 1/29/96

3.0 TEST PROCEDURES

3.1 ITEM DEFINITION

- 3.1.1 Verify that the WRAP manipulator components are in accordance with para 1.04. of the 14590 specification and that the items listed below (i.e., each loose piece to be assembled on site) has been permanently identified with a name plate stating at least part number, serial number, manufacturer's name and contract number. Record each of the serial numbers below.
- 3.1.2. Verify the workmanship by inspection; there shall be no sharp edges on any exposed surface; that there are no missing parts, that all threaded fasteners are tight. Fill in serial numbers for the following table

	GB 102
HV6F Slave Arm - Right P/N 101-2265	11956-1
HV6F Slave arm - Left P/N 101-2266	12139-3
Valve Package - Right arm P/N 101-2275	11957-1
Valve Package - Left Arm P/N 101-2275	12137-3
Master Controller P/N 101-2705	12136-2
Slave Control Electronics - Right Arm P/N 101-2308	12143-4
Slave Control Electronics - Left Arm P/N 101-2308	12143-1
Control and Instrumentation enclosure P/N 101-2653	16588-1
Signature and Date	
<i>[Signature]</i> 1/29/96	

- 3.1.3. Verify by inspection that nameplates of corrosion-resistant metal are permanently attached to the manipulator horizontal carriage and the hydraulic pump. In addition to the manufacturer's name, the following information, at a minimum, shall be included: 1) model number, 2) serial number, 3) contract number and date and 4) date of manufacture.

GB 102 Hor Carriage      Signature *[Signature]*      Date 1/29/96

HPU Pump      Signature *[Signature]*      Date 1/29/96

3.2. FUNCTIONAL

- 3.2.1. Preparation: A hydraulic power unit shall be flow regulated to 2000 psi during functional and operational testing. The hydraulic fluid shall be Cosmolubric HF-122 (E.F. Houghton). Pressure and flow shall be monitored by line gauges. Prior to the start of the test, the equipment shall be operated for ten minutes to allow the temperature of the fluid to stabilize. All functional testing is to be performed with no payload in the jaw end effector unless otherwise specified.
- 3.2.2. Verify by test that the manipulator horizontal carriage is free to translate from one end of the horizontal rail to the other end without resistance. Measure the travel stroke:

Travel Stroke 142 1/2      Stroke shown GB 102 Dwg 050-0645 = 140 in

Signature *[Signature]*      Date 1/29/96

3.2.3. Verify by test that the master controller positioning carriage is free to translate from one end of the horizontal rail to the other end without resistance. Measure the travel stroke.

Signature MG Date 1/29/96

3.2.4. Verify by test that the slave arms are free to translate from one end of the vertical rail to the other end without resistance. Measure the travel stroke.

Right Arm Travel Stroke 36.53 Stroke shown in GB 102 Dwg 050-0645 = 36.5 in

Signature MG Date 1/29/96

Left Arm Travel Stroke 36.53 Stroke shown in GB 102 Dwg 050-0645 = 36.5 in

Signature MG Date 1/29/96

3.2.5. Verify that each joint of the HV6F has full dexterity (i.e., can be commanded to move throughout its full range of motion)

GB 102 Right Arm Signature MG Date 1/29/96

Left Arm Signature MG Date 1/29/96

3.2.6. Actuate each degree-of-freedom of the HV6F manipulator independently of the others, throughout its range of motion, ten times at maximum joint angular rate.

GB 102 Right Arm Shoulder Roll Signature MG Date 1/29/96

Shoulder Pitch Signature MG Date 1/29/96

Elbow Yaw Signature MG Date 1/29/96

Wrist Yaw Signature MG Date 1/29/96

Wrist Rotate Signature MG Date 1/29/96

GB102 Left Arm Shoulder Roll Signature MG Date 1/29/96

Shoulder Pitch Signature MG Date 1/29/96

Elbow Yaw Signature MG Date 1/29/96

Wrist Yaw Signature MG Date 1/29/96

Wrist Rotate Signature MG Date 1/29/96

3.2.7. Verify by test that two dynamic modes are provided; a fast mode for normal operation and a slow mode for tasks requiring slower speeds.

GB 102 Right Arm Signature MG Date 1/29/96

Left Arm Signature MG Date 1/29/96

- 3.2.8. Verify by test that two wrist control modes are provided; a position control mode providing accurate indexing of the end effector and a variable rate continuous mode for tasks requiring multiple rotation of the end effector.

GB 102 Right Arm Signature MS Date 1/29/96  
 Left Arm Signature MS Date 1/29/96

- 3.2.9. Verify that three jaw control modes are provided; An open mode shall maintain the jaws open until the operator deflects the jaw switch, a toggle mode where deflecting the switch will open the jaws and retoggling the switch will close the jaws and a position mode which allows incremental closing of the jaws with the ability to fix the position of the jaws by releasing the switch.

GB 102 Right Arm Signature MS Date 1/29/96  
 Left Arm Signature MS Date 1/29/96

- 3.2.10. Verify by test that a freeze mode electronically freezes the entire HV6F slave arm in the position it is in when the freeze mode is entered.

GB 102 Right Arm Signature MS Date 1/29/96  
 Left Arm Signature MS Date 1/29/96

- 3.2.11. Verify by test that the master controller is able to freeze individual joints of the HV6F slave arm.

GB 102 Right Arm Signature MS Date 1/29/96  
 Left Arm Signature MS Date 1/29/96

- 3.2.12. Verify by test that the stow mode returns the HV6F to a predetermined stowed position via a pathway of up to 5 predetermined points.

GB 102 Right Arm Signature MS Date 1/29/96  
 Left Arm Signature MS Date 1/29/96

- 3.2.13. Verify by test that the teach mode enables operators to program movements into the controller that the HV6F slave arm will repeat at a later time by reprogramming a new stow position.

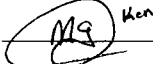
GB 102 Right Arm Signature MS Date 1/29/96  
 Left Arm Signature MS Date 1/29/96

### 3.3. PERFORMANCE TESTING


- 3.3.1. Each slave arm shall pick up and hold an object weighing  $60 \pm 2$  lbs at full extension

GB 102 Right Arm Signature MS Date 1/29/96  
 Left Arm Signature MS Date 1/29/96

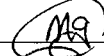

3.3.2. Measure the quiescent flow and flow rate while slewing the HV6F rapidly

GB 102 Pq 2 3/8 Ps 3 1/2 Signature  Date 1/29/96


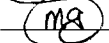
3.3.3. Activate each DOF of the HV6F independently of the others throughout its entire range of motion ten times with 60 ± 2 lbs payload

GB 102 Pq 2 1/2 Ps 2.7 Signature  Date 1/29/96



3.3.4. Verify by test that two dynamic modes are provided; a fast mode for normal operation and a slow mode for tasks requiring slower speeds, with 60 ± 2 lbs of weight held by the jaw end effector

GB 102 Right Arm Signature  Date 1/29/96  
Left Arm Signature  Date 1/29/96

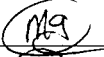
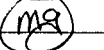
3.3.5. Verify by test that a freeze mode electronically freezes the entire HV6F slave arm in the position it is in when the freeze mode is entered, with 60 ± 2 lbs of weight held by the jaw end effector

GB 102 Right Arm Signature  Date 1/29/96  
Left Arm Signature  Date 1/29/96


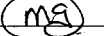
3.3.6. Verify by test that the master controller is able to freeze individual joints of the HV6F slave arm, with 60 ± 2 lbs of weight held by the jaw end effector

GB 102 Right Arm Signature  Date 1/29/96  
Left Arm Signature  Date 1/29/96


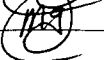
3.3.7. Verify by test that the stow mode returns the HV6F to a predetermined stowed position via a pathway of up to 5 predetermined points.

GB 102 Right Arm Signature  Date 1/29/96  
Left Arm Signature  Date 1/29/96

3.3.8. Verify by test that the teach mode enables operators to program movements into the controller that the HV6F slave arm will repeat at a later time by reprogramming a new stow position.

GB 102 Right Arm Signature  Date 1/29/96  
Left Arm Signature  Date 1/29/96

3.3.9. Verify that the manipulator can retrieve and stow the broom tool

GB 102 Right Arm Signature  Date 1/29/96  
Left Arm Signature  Date 1/29/96

3.3.10. Verify that the manipulator can retrieve and stow the shovel tool

GB 102 Right Arm Signature MG Date 1/29/96

Left Arm Signature MG Date 1/29/96

3.3.11. Verify that the manipulator can retrieve and stow the knife tool

GB 102 Right Arm Signature MG Date 1/29/96

Left Arm Signature MG Date 1/29/96

3.3.12. Verify that the manipulator can retrieve and stow the squeegee tool.

GB 102 Right Arm Signature MG Date 1/29/96

Left Arm Signature MG Date 1/29/96

3.3.13. Place a 100 lb weight on the master control. Verify that no hardware damage occurs.

Signature MG Date 1/29/96

3.3.14. Verify that the master control console provides 6 inch of vertical adjustment

Signature MG Date 1/29/96

3.3.15. Verify, by monitoring the signal at the appropriate terminal within the Control and Instrumentation Enclosure, that the limit switches function for right and left horizontal motion and raise and lower motion for each of the two vertical carriages

Signature MG Date 1/29/96

4.0 CONCLUSION

4.1 QA EVALUATION

4.1.1 General statement as to whether the manipulator system has/has not met the objectives of this procedure. *The system met this factory Acceptance Test plan, while taking measurement from the 030-0645 drawing we noticed that*

Signature MG Date 1/29/96  
 QA Inspector, Schilling Robotic Systems, Inc.

*some the 67" dimension zone E3 was being violated by the pressure and return, and slave cable, which measures 73" PCL to check acceptability*

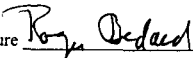
4.2 ENGINEERING EVALUATION

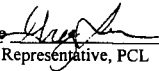
4.2.1 General statement as to whether the manipulator system has/has not met the objectives of this procedure. *For Ray Paynd*

Signature Roger Weddell Date 1/29/96  
 Lead Engineer, Schilling Robotic Systems, Inc.

4.3 TEST COMPLETION

4.3.1 The manipulator system has successfully completed Acceptance Testing.

Signature  Date 1/29/96  
Program Manager, Schilling Robotic Systems, Inc.

Signature  Date 1-29-96  
Representative, PCL

Acceptance Testing  
of an  
HV6F Manipulator System  
for  
PCL Construction, Inc.

Submitted by  
Schilling Development, Inc.

October 18, 1994





S.O. No.: 7731

Date: 1/20/96

1. PURPOSE

The purpose of this predelivery test is to verify that the HV6F manipulator system to be delivered to PCL Construction Services meets the requirements of purchase order number 5701900M and the Schilling Development Quality Assurance Program. The following is a summary of the major items included as part of this order:

- HV6F Slave Arm, P/Ns 11956-3 (Right Hand), and 12139-1 (Left Hand), S/N \_\_\_\_\_
- Master Console with Dual Master Control Arms and Electronics, P/N 101-2264, S/N 11955-2  
Right (11957-3) Left (12137-1)
- Valve Package Assembly, each with 6 servovalves, P/N 101-2275, S/N \_\_\_\_\_  
Right 11958-1 Left 11958-2
- Slave Controller including electronics, P/N 101-2308, S/N 11828-2
- Junction Box, P/N 101-2159, S/N 11828-2

2. SUPPORTING DOCUMENTS

Purchase Order No. 5701900M  
 SDI Bill of Material 300-0306A and/or B  
 SDI Sales Order No. 7731

3. TEST DESCRIPTION

The following sections describe the testing to be performed to verify certain features and functional requirements of the system being delivered. All tests are to be performed with required electrical input and 2000 psi hydraulic pressure.

3.1 System Components (SDI Req't)

Verify by checking that all of the components of the system called for on the Bill of Material are present.

OK?  Yes  No Comment \_\_\_\_\_

3.2 Physical Dimension Requirements (SDI Req't)

3.2.1 Arm Length (SDI Req't)

Measure and record the length of the slave arm to the center of the jaw gripping surfaces.

36+/-1 inches OK Right 36" Left 36"

3.2.2 Jaw Capacity (SDI Req't)

Measure and record the separation of the jaw gripping surfaces when the jaws are fully open.

3.0+/-0.1 inches OK R = 3" L = 3"

3.2.3 Jaw Closure (PCL Req't)

Verify by checking that the end effector contains hardstops which prevent the jaws from closing completely against each other. The jaw's gripping surfaces shall be padded with rubber sheeting held in place by side clips.

OK? Yes No Comment Rubber pads Contact. R = OK L = OK

3.3 Materials and Workmanship

3.3.1 Materials (SDI Req't)

Verify by checking that all exposed surfaces of the slave arm and slave controller are of corrosion resistant materials and that the slave arm segments have a low-glare anodized finish.

OK?  Yes No Comment \_\_\_\_\_ R L  
OK OK

3.3.2 Workmanship (SDI Req't)

Verify that there are no sharp edges on any exposed surfaces, and that there are no missing parts, that the hose routing is correct, and that all threaded fasteners are tight.

OK?  Yes No Comment \_\_\_\_\_ R L  
OK OK

3.3.3 Marking/Identification (SDI Req't)

Verify that each significant hardware item is identified with Schilling logo, name, and serial number. These items include: slave arm, master controller, slave controller, valve manifold, and j-box.

OK?  Yes No Comment \_\_\_\_\_ R = OK L = OK

3.4 Operation

3.4.1 Burn In (SDI Req't)

Operate the system in all modes for at least 30 minutes. Record any abnormality in system operation.

OK?  Yes No Comment \_\_\_\_\_ R = OK L = OK

3.4.2 Range of Motion (PCL Nominal Req't - SDI Tolerance)

Each degree-of-freedom of the Manipulator Assembly shall be actuated 10 times and its range of motion measured. The recorded values shall be compared to those specified below. The range of motion shall meet or exceed the specified values.

	Joint	Range (degrees)	R	L	
-1.5	Shoulder Roll:	90 degrees min., ± 5°	Actual <u>86.8</u>	<u>88.4</u>	1.2
+55.5	Shoulder Pitch:	90 degrees min., ± 5°	Actual <u>86.3</u>	<u>86.9</u>	56.2
27.1	Elbow Swing	120 degrees min., ± 5°	Actual <u>115.4</u>	<u>115.5</u>	
55.3	Wrist Yaw:	120 degrees min., ± 5°	Actual <u>116.7</u>	<u>116.5</u>	
	Wrist Rot.(slaved)	270 degrees min., + 50°/- 5°	Actual <u>276.5</u>	<u>284.5</u>	
	Wrist Rot.(cont.)	Unlimited both directions	<u>OK</u>		

3.4.3 Slew Rate

Each degree-of-freedom shall be actuated 10 times and its slew rate measured. The recorded values shall be compared to those specified below. The minimum slew rate shall enable satisfactory operator performance. The maximum slew rates shall be as specified below.

*Notes listed based on theoretical RFL reduced to 100/rev*

Joint	Maximum Slew Rate (degrees per second)	R	L
Shoulder Roll:	300 degrees/second.	Actual _____	
Shoulder Pitch:	300 degrees/second.	Actual _____	
Elbow Swing	400 degrees/second.	Actual _____	
Wrist Yaw:	600 degrees/second.	Actual _____	
Wrist Rot.(cont.)	90 revolutions/minute	Actual <u>72/68</u>	<u>74/70</u>

3.4.4 Payload (PCL Req't - SDI Tolerance)

Verify that the slave arm, with standard parallel acting jaws installed, is capable of lifting and holding a 60 ± 2 lb payload at full arm extension.

OK? (Yes) No	Comment	R	L
<input checked="" type="checkbox"/>	_____	<u>61.5</u>	<u>58.6</u>
		<u>OK</u>	<u>OK</u>

3.4.5 Jaw Closure Force (PCL Req't)

Both end effectors shall be opened and closed 10 times at the maximum gripping force. The recorded values shall be within 25% of the 200 pounds.

*Master unchanged through cycle*

OK? (Yes) No	Comment	R	L
<input checked="" type="checkbox"/>	_____	<u>184</u>	<u>203</u>
		<u>184</u>	<u>203</u>

3.4.6 Power Requirements (PCL Req't)

Verify electrical power inputs are to customer requirements. Customer requires 110 VAC, 1-Phase, 60Hz to the slave controller, and 110 VAC to the master consolette.

OK? (Yes) No	Comment
<input checked="" type="checkbox"/>	_____

3.5 Software Functions (PCL Req't)

Each of the control modes specified below shall be tested to verify functionality. The tests shall be conducted under the following conditions;

1. Jaw End Effector shall be carrying 60 lb object.
2. Each degree-of-freedom of the Manipulator Assembly shall be actuated to its ends of travel.

Dynamic Modes: Two dynamic modes shall be provided. A "Fast Mode" for normal operation and a "Slow Mode" for tasks requiring slower speeds.

OK?  Yes No Comment R=2 OK Wrist torque without effector at the end of travel slow mode L OK

Wrist Mode: Two wrist control modes shall be provided. A "Position Control Mode" providing accurate indexing of the end effector and a "Variable Rate Continuous Rotation Mode" for tasks requiring multiple rotation of the end effector in either direction.

OK?  Yes No Comment \_\_\_\_\_ R OK L OK (Position Control)

Three Jaw control modes for the Parallel Jaw end effector shall be provided. An "Open Mode" shall maintain the jaws open until the operator deflects the jaw switch (i.e. as long as the switch is held in a deflected position the jaws will remain closed). A "Toggle Mode" will be provided where deflecting the switch once will open the jaws and retoggle will close the jaws. A "Position Mode" which shall allow incremental closing of the jaws with ability to fix the position of the jaws by releasing switch, will be provided.

OK?  Yes No Comment \_\_\_\_\_ R OK L OK

Freeze Mode: The "Freeze Mode" electronically freezes the entire Slave Arm in the position it is in when the freeze mode is entered. The Master Controller shall be able to freeze individual Slave Arm joints.

OK?  Yes No Comment \_\_\_\_\_ R OK L OK

The "Stow Mode" returns the Slave Arm to a pre-determined stowed position. The Slave Arm shall return to this pre-determined position via a pathway of up to 5 pre-determined points. This shall be conducted without the payload.

OK?  Yes No Comment \_\_\_\_\_ R OK L OK

The "Teach Mode" shall be provided for operators to program movements into the controller that the Slave Arms will be required to repeat at later times (e.g. return to a stowed position). This shall be conducted without the payload.

OK?  Yes No Comment \_\_\_\_\_ R OK L OK

4. Acceptance Signoff *Roger Bedard* TEST 1/20/96

Refer to "EXECUTION AND TEST APPROVAL" form attached (V-W-026-C1; 01655-A-1; 6/19 Rev.)

WRIST POSITION  
 RIGHT = - 0701 → + 0640  
 LEFT = - 0677 → + 0675

Acceptance Testing  
of an  
HV6F Manipulator System  
for  
PCL Construction, Inc.

Submitted by  
Schilling Development, Inc.

October 18, 1994



S.O. No.: 7731

Date: 1/21/96

1. PURPOSE

The purpose of this predelivery test is to verify that the HV6F manipulator system to be delivered to PCL Construction Services meets the requirements of purchase order number 5701900M and the Schilling Development Quality Assurance Program. The following is a summary of the major items included as part of this order:

- HV6F Slave Arm, P/Ns 101-2265 (Right Hand), and 101-2266 (Left Hand), S/N 11956-2 12139-2
- Master Console with Dual Master Control Arms and Electronics, P/N 101-2264, S/N 11955-1  
Right: 11957-2 Left: 12137-2
- Valve Package Assembly, each with 6 servovalves, P/N 101-2275, S/N \_\_\_\_\_  
Right: 11958-2 Left: ~~12113-2~~
- Slave Controller including electronics, P/N 101-2308, S/N \_\_\_\_\_ 11958-3
- Junction Box, P/N 101-2159, S/N 11828-1

2. SUPPORTING DOCUMENTS

Purchase Order No. 5701900M  
 SDI Bill of Material 300-0306A and/or B  
 SDI Sales Order No. 7731

3. TEST DESCRIPTION

The following sections describe the testing to be performed to verify certain features and functional requirements of the system being delivered. All tests are to be performed with required electrical input and 2000 psi hydraulic pressure.

3.1 System Components (SDI Req't)

Verify by checking that all of the components of the system called for on the Bill of Material are present.

OK?  Yes  No Comment \_\_\_\_\_

3.2 Physical Dimension Requirements (SDI Req't)

3.2.1 Arm Length (SDI Req't)

Measure and record the length of the slave arm to the center of the jaw gripping surfaces.

36+/-1 inches \_\_\_\_\_ Right = 36" Left = 36"

3.2.2 Jaw Capacity (SDI Req't)

Measure and record the separation of the jaw gripping surfaces when the jaws are fully open.

3.0+/-0.1 inches \_\_\_\_\_ Right = 3 1/2" Left 3 1/2"

3.2.3 Jaw Closure (PCL Req't)

Verify by checking that the end effector contains hardstops which prevent the jaws from closing completely against each other. The jaw's gripping surfaces shall be padded with rubber sheeting held in place by side clips.

OK? Yes No Comment Rubber Pads Contact Right OK Left OK

3.3 Materials and Workmanship

3.3.1 Materials (SDI Req't)

Verify by checking that all exposed surfaces of the slave arm and slave controller are of corrosion resistant materials and that the slave arm segments have a low-glare anodized finish.

OK? Yes No Comment \_\_\_\_\_ R OK L OK

3.3.2 Workmanship (SDI Req't)

Verify that there are no sharp edges on any exposed surfaces, and that there are no missing parts, that the hose routing is correct, and that all threaded fasteners are tight.

OK? Yes No Comment \_\_\_\_\_ R OK L OK

3.3.3 Marking/Identification (SDI Req't)

Verify that each significant hardware item is identified with Schilling logo, name, and serial number. These items include: slave arm, master controller, slave controller, valve manifold, and j-box.

OK? Yes No Comment \_\_\_\_\_ R=OK L=OK

3.4 Operation

3.4.1 Bum In (SDI Req't)

Operate the system in all modes for at least 30 minutes. Record any abnormality in system operation.

OK? Yes No Comment \_\_\_\_\_ R=OK L=OK

3.4.2 Range of Motion (PCL Nominal Req't - SDI Tolerance)

Each degree-of-freedom of the Manipulator Assembly shall be actuated 10 times and its range of motion measured. The recorded values shall be compared to those specified below. The range of motion shall meet or exceed the specified values.

Joint	Range (degrees)	R	L
Shoulder Roll:	90 degrees min., ± 5°	Actual <u>88.7</u>	<u>87.8</u>
Shoulder Pitch:	90 degrees min., ± 5°	Actual <u>86.7</u>	<u>86.9</u>
Elbow Swing	120 degrees min., ± 5°	Actual <u>115.2</u>	<u>115.7</u>
Wrist Yaw:	120 degrees min., ± 5°	Actual <u>116.3</u>	<u>116.7</u>
Wrist Rot. (slaved)	270 degrees min., + 50%/- 5°	Actual <u>279.8</u>	<u>252.3</u>
Wrist Rot. (cont.)	Unlimited both directions	<u>OK</u>	

3.4.3 Slew Rate

Each degree-of-freedom shall be actuated 10 times and its slew rate measured. The recorded values shall be compared to those specified below. The minimum slew rate shall enable satisfactory operator performance. The maximum slew rates shall be as specified below.

Joint	Maximum Slew Rate (degrees per second)	R	L
Shoulder Roll:	300 degrees/second.	Actual _____	
Shoulder Pitch:	300 degrees/second.	Actual _____	
Elbow Swing	400 degrees/second.	Actual _____	
Wrist Yaw:	600 degrees/second.	Actual _____	
Wrist Rot. (cont.)	90 revolutions/minute	Actual <u>69/82</u>	<u>82/78</u>

3.4.4 Payload (PCL Req't - SDI Tolerance)

Verify that the slave arm, with standard parallel acting jaws installed, is capable of lifting and holding a 60 ± 2 lb payload at full arm extension.

OK? <input checked="" type="radio"/> Yes <input type="radio"/> No	Comment _____	R <u>58.6</u>	L <u>58.6</u>
		OK	OK

3.4.5 Jaw Closure Force (PCL Req't)

Both end effectors shall be opened and closed 10 times at the maximum gripping force. The recorded values shall be within 25% of the 200 pounds.

OK? <input checked="" type="radio"/> Yes <input type="radio"/> No	Comment _____	R <del>182</del> <u>182</u>	L <u>214</u>
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3.4.6 Power Requirements (PCL Req't)

Verify electrical power inputs are to customer requirements. Customer requires 110 VAC, 1-Phase, 60Hz to the slave controller, and 110 VAC to the master consolette.

OK? <input checked="" type="radio"/> Yes <input type="radio"/> No	Comment _____
---	---------------



3.5 Software Functions (PCL Req't)

Each of the control modes specified below shall be tested to verify functionality. The tests shall be conducted under the following conditions;

1. Jaw End Effector shall be carrying 60 lb object.
2. Each degree-of-freedom of the Manipulator Assembly shall be actuated to its ends of travel.

Dynamic Modes: Two dynamic modes shall be provided. A "Fast Mode" for normal operation and a "Slow Mode" for tasks requiring slower speeds.

OK?  Yes  No Comment \_\_\_\_\_ R L  
OK OK

Wrist Mode: Two wrist control modes shall be provided. A "Position Control Mode" providing accurate indexing of the end effector and a "Variable Rate Continuous Rotation Mode" for tasks requiring multiple rotation of the end effector in either direction.

OK?  Yes  No Comment \_\_\_\_\_ R L  
OK OK

Three Jaw control modes for the Parallel Jaw end effector shall be provided. An "Open Mode" shall maintain the jaws open until the operator deflects the jaw switch (i.e. as long as the switch is held in a deflected position the jaws will remain closed). A "Toggle Mode" will be provided where deflecting the switch once will open the jaws and retoggle will close the jaws. A "Position Mode" which shall allow incremental closing of the jaws with ability to fix the position of the jaws by releasing switch, will be provided.

OK?  Yes  No Comment \_\_\_\_\_ R L  
OK OK

Freeze Mode: The "Freeze Mode" electronically freezes the entire Slave Arm in the position it is in when the freeze mode is entered. The Master Controller shall be able to freeze individual Slave Arm joints.

OK?  Yes  No Comment \_\_\_\_\_ R L  
OK OK

The "Stow Mode" returns the Slave Arm to a pre-determined stowed position. The Slave Arm shall return to this pre-determined position via a pathway of up to 5 pre-determined points. This shall be conducted without the payload.

OK?  Yes  No Comment \_\_\_\_\_ R L  
OK OK

The "Teach Mode" shall be provided for operators to program movements into the controller that the Slave Arms will be required to repeat at later times (e.g. return to a stowed position). This shall be conducted without the payload.

OK?  Yes  No Comment \_\_\_\_\_ R L  
OK L

4. Acceptance Signoff MJ 1/21/96 slow rates not performed

Refer to "EXECUTION AND TEST APPROVAL" form attached (V-W-026-C1; 01655-A-1; 6/19 Rev.)

# Acceptance Testing of an HV6F Manipulator System for PCL Construction, Inc.

Submitted by  
Schilling Development, Inc.

October 18, 1994



S.O. No.: 7731

Date: 1/22/96

1. PURPOSE

The purpose of this predelivery test is to verify that the HV6F manipulator system to be delivered to PCL Construction Services meets the requirements of purchase order number 5701900M and the Schilling Development Quality Assurance Program. The following is a summary of the major items included as part of this order:

- HV6F Slave Arm, P/Ns 11956-4 (Right Hand), and 12139-4 (Left Hand), S/N \_\_\_\_\_
- Master Console with Dual Master Control Arms and Electronics, P/N 101-2264, S/N 12136-1  
Right - 11957-4    Left - 12137-4
- Valve Package Assembly, each with 8 servovalves, P/N 101-2275, S/N \_\_\_\_\_  
Right - 12143-3    Left - 12143-2
- Slave Controller including electronics, P/N 101-2308, S/N \_\_\_\_\_
- Junction Box, P/N 101-2159, S/N N/A

2. SUPPORTING DOCUMENTS

Purchase Order No. 5701900M  
 SDI Bill of Material 300-0306A and/or B  
 SDI Sales Order No. 7731

3. TEST DESCRIPTION

The following sections describe the testing to be performed to verify certain features and functional requirements of the system being delivered. All tests are to be performed with required electrical input and 2000 psi hydraulic pressure.

3.1 System Components (SDI Req't)

Verify by checking that all of the components of the system called for on the Bill of Material are present.

OK? Yes No Comment \_\_\_\_\_

3.2 Physical Dimension Requirements (SDI Req't)

3.2.1 Arm Length (SDI Req't)

Measure and record the length of the slave arm to the center of the jaw gripping surfaces.

36+/-1 inches OK    R = 36°    L = 36"

3.2.2 Jaw Capacity (SDI Req't)

Measure and record the separation of the jaw gripping surfaces when the jaws are fully open.

3.0+/-0.1 inches OK    R = 3 1/32"    L = 3 1/32"

3.2.3 Jaw Closure (PCL Req't)

Verify by checking that the end effector contains hardstops which prevent the jaws from closing completely against each other. The jaw's gripping surfaces shall be padded with rubber sheeting held in place by side clips.

R = OK L = OK

OK?  Yes  No Comment \_\_\_\_\_

3.3 Materials and Workmanship

3.3.1 Materials (SDI Req't)

Verify by checking that all exposed surfaces of the slave arm and slave controller are of corrosion resistant materials and that the slave arm segments have a low-glare anodized finish.

OK?  Yes  No Comment \_\_\_\_\_ R = OK L = OK

3.3.2 Workmanship (SDI Req't)

Verify that there are no sharp edges on any exposed surfaces, and that there are no missing parts, that the hose routing is correct, and that all threaded fasteners are tight.

OK?  Yes  No Comment \_\_\_\_\_ R = OK L = OK

3.3.3 Marking/Identification (SDI Req't)

Verify that each significant hardware item is identified with Schilling logo, name, and serial number. These items include: slave arm, master controller, slave controller, valve manifold, and j-box.

OK?  Yes  No Comment \_\_\_\_\_ R = OK L = OK

3.4 Operation

3.4.1 Burn In (SDI Req't)

Operate the system in all modes for at least 30 minutes. Record any abnormality in system operation.

OK?  Yes  No Comment \_\_\_\_\_ R = OK L = OK

3.4.2 Range of Motion (PCL Nominal Req't - SDI Tolerance)

Each degree-of-freedom of the Manipulator Assembly shall be actuated 10 times and its range of motion measured. The recorded values shall be compared to those specified below. The range of motion shall meet or exceed the specified values.

Joint	Range (degrees)	- R	L	
Shoulder Roll:	90 degrees min., ± 5°	Actual <u>88.2</u>	<u>88.5</u>	180 + 16.5
Shoulder Pitch:	90 degrees min., ± 5°	Actual <u>86.7</u>	<u>86.7</u>	
Elbow Swing	120 degrees min., ± 5°	Actual <u>115.5</u>	<u>115.7</u>	
* Wrist Yaw:	120 degrees min., ± 5°	Actual <u>114</u>	<u>116.6</u>	
Wrist Rot.(slaved)	270 degrees min., + 50°- 5°	Actual <u>283</u>	<u>273.5</u>	+ 735 - 726
Wrist Rot.(cont.)	Unlimited both directions	<u>OK</u>	<u>OK</u>	

3.4.3 Slew Rate

Each degree-of-freedom shall be actuated 10 times and its slew rate measured. The recorded values shall be compared to those specified below. The minimum slew rate shall enable satisfactory operator performance. The maximum slew rates shall be as specified below.

Joint	Maximum Slew Rate (degrees per second)	Actual	cw/ccw	L
Shoulder Roll:	300 degrees/second.	Actual _____		
Shoulder Pitch:	300 degrees/second.	Actual _____		
Elbow Swing	400 degrees/second.	Actual _____		
Wrist Yaw:	600 degrees/second.	Actual _____		
Wrist Rot.(cont.)	90 revolutions/minute	Actual <u>32/75</u>		<u>97/96</u>

3.4.4 Payload (PCL Req't - SDI Tolerance)

Verify that the slave arm, with standard parallel acting jaws installed, is capable of lifting and holding a 60 ± 2 lb payload at full arm extension.

OK? <input checked="" type="radio"/> Yes <input type="radio"/> No	Comment _____	R = <u>58.6</u>	L = <u>58.6</u>
		<u>OK</u>	<u>OK</u>

3.4.5 Jaw Closure Force (PCL Req't)

Both end effectors shall be opened and closed 10 times at the maximum gripping force. The recorded values shall be within 25% of the 200 pounds.

OK? <input checked="" type="radio"/> Yes <input type="radio"/> No	Comment _____	R = <u>228</u>	L = <u>235</u>
		<u>13542"</u>	<u>220</u>
		<u>225</u>	

3.4.6 Power Requirements (PCL Req't)

Verify electrical power inputs are to customer requirements. Customer requires 110 VAC, 1-Phase, 60Hz to the slave controller, and 110 VAC to the master consolette.

OK? <input checked="" type="radio"/> Yes <input type="radio"/> No	Comment _____
---	---------------

3.5 Software Functions (PCL Req't)

Each of the control modes specified below shall be tested to verify functionality. The tests shall be conducted under the following conditions;

- 1. Jaw End Effector shall be carrying 60 lb object.
- 2. Each degree-of-freedom of the Manipulator Assembly shall be actuated to its ends of travel.

Dynamic Modes: Two dynamic modes shall be provided. A "Fast Mode" for normal operation and a "Slow Mode" for tasks requiring slower speeds.

R = OK L = OK

OK?  Yes No Comment \_\_\_\_\_

Wrist Mode: Two wrist control modes shall be provided. A "Position Control Mode" providing accurate indexing of the end effector and a "Variable Rate Continuous Rotation Mode" for tasks requiring multiple rotation of the end effector in either direction.

R = OK L = OK

OK?  Yes No Comment \_\_\_\_\_

Three Jaw control modes for the Parallel Jaw end effector shall be provided. An "Open Mode" shall maintain the jaws open until the operator deflects the jaw switch (i.e. as long as the switch is held in a deflected position the jaws will remain closed). A "Toggle Mode" will be provided where deflecting the switch once will open the jaws and retoggle will close the jaws. A "Position Mode" which shall allow incremental closing of the jaws with ability to fix the position of the jaws by releasing switch, will be provided.

R = OK L = OK

OK?  Yes No Comment \_\_\_\_\_

Freeze Mode: The "Freeze Mode" electronically freezes the entire Slave Arm in the position it is in when the freeze mode is entered. The Master Controller shall be able to freeze individual Slave Arm joints.

R = OK L = OK

OK?  Yes No Comment \_\_\_\_\_

The "Stow Mode" returns the Slave Arm to a pre-determined stowed position. The Slave Arm shall return to this pre-determined position via a pathway of up to 5 pre-determined points. This shall be conducted without the payload.

R = OK L = OK

OK?  Yes No Comment \_\_\_\_\_

The "Teach Mode" shall be provided for operators to program movements into the controller that the Slave Arms will be required to repeat at later times (e.g. return to a stowed position). This shall be conducted without the payload.

R = OK L = OK

OK?  Yes No Comment \_\_\_\_\_

4. Acceptance Signoff *System meets spec, except for P 3.4.2 wrist + jaw*  
*M9 1/22/96 slow rates not performed*

Refer to "EXECUTION AND TEST APPROVAL" form attached (V-W-026-C1; 01655-A-1; 6/19 Rev.)

Acceptance Testing  
of an  
HV6F Manipulator System  
for  
PCL Construction, Inc.

Submitted by  
Schilling Development, Inc.

October 18, 1994



set that was on the test fixture

0

S.O. No.: 7731

Date: 1/26/96

1. PURPOSE

The purpose of this predelivery test is to verify that the HV6F manipulator system to be delivered to PCL Construction Services meets the requirements of purchase order number 5701900M and the Schilling Development Quality Assurance Program. The following is a summary of the major items included as part of this order:

- HV6F Slave Arm, P/Ns 11956-1 (Right Hand), and 12139-3 (Left Hand), S/N \_\_\_\_\_
- Master Console with Dual Master Control Arms and Electronics, P/N 101-2264, S/N 12136-2
- Valve Package Assembly, each with 6 servovalves, P/N 101-2275, S/N \_\_\_\_\_  
     Right = 11957-1      Left 12137-3
- Slave Controller including electronics, P/N 101-2308, S/N \_\_\_\_\_  
     Right = 12143-4      Left 12143-1
- Junction Box, P/N 101-2159, S/N N/A

2. SUPPORTING DOCUMENTS

Purchase Order No. 5701900M  
SDI Bill of Material 300-0306A and/or B  
SDI Sales Order No. 7731

3. TEST DESCRIPTION

The following sections describe the testing to be performed to verify certain features and functional requirements of the system being delivered. All tests are to be performed with required electrical input and 2000 psi hydraulic pressure.

3.1 System Components (SDI Req't)

Verify by checking that all of the components of the system called for on the Bill of Material are present.

OK? (Yes) No Comment \_\_\_\_\_

3.2 Physical Dimension Requirements (SDI Req't)

3.2.1 Arm Length (SDI Req't)

Measure and record the length of the slave arm to the center of the jaw gripping surfaces.

36+/-1 inches OK      R = 36"      L = 36"

3.2.2 Jaw Capacity (SDI Req't)

Measure and record the separation of the jaw gripping surfaces when the jaws are fully open.

3.0+/-0.1 inches OK      R = 3 1/2      L = 3 1/2



3.2.3 Jaw Closure (PCL Req't)

Verify by checking that the end effector contains hardstops which prevent the jaws from closing completely against each other. The jaw's gripping surfaces shall be padded with rubber sheeting held in place by side clips.

OK?  Yes  No Comment Rubber pads Contact

3.3 Materials and Workmanship

3.3.1 Materials (SDI Req't)

Verify by checking that all exposed surfaces of the slave arm and slave controller are of corrosion resistant materials and that the slave arm segments have a low-glare anodized finish.

OK?  Yes  No Comment \_\_\_\_\_

3.3.2 Workmanship (SDI Req't)

Verify that there are no sharp edges on any exposed surfaces, and that there are no missing parts, that the hose routing is correct, and that all threaded fasteners are tight.

R-OK L-OK

OK?  Yes  No Comment \_\_\_\_\_

3.3.3 Marking/Identification (SDI Req't)

Verify that each significant hardware item is identified with Schilling logo, name, and serial number. These items include: slave arm, master controller, slave controller, valve manifold, and j-box.

OK?  Yes  No Comment \_\_\_\_\_

3.4 Operation

3.4.1 Burn In (SDI Req't)

Operate the system in all modes for at least 30 minutes. Record any abnormality in system operation.

OK?  Yes  No Comment \_\_\_\_\_

3.4.2 Range of Motion (PCL Nominal Req't - SDI Tolerance)

Each degree-of-freedom of the Manipulator Assembly shall be actuated 10 times and its range of motion measured. The recorded values shall be compared to those specified below. The range of motion shall meet or exceed the specified values.

13.7

Joint	Range (degrees)	Right	Left
Shoulder Roll:	90 degrees min., ± 5°	Actual <u>88.6</u>	87.8
Shoulder Pitch:	90 degrees min., ± 5°	Actual <u>86.9</u>	87.
Elbow Swing	120 degrees min., ± 5°	Actual <u>115.1</u>	116.2
* Wrist Yaw:	120 degrees min., ± 5°	Actual <u>114.5</u>	116.6
Wrist Rot. (slaved)	270 degrees min., + 50% - 5°	Actual <u>285.7</u>	282.1
Wrist Rot. (cont.)	Unlimited both directions		

3.4.3 Slew Rate

Each degree-of-freedom shall be actuated 10 times and its slew rate measured. The recorded values shall be compared to those specified below. The minimum slew rate shall enable satisfactory operator performance. The maximum slew rates shall be as specified below.

Joint	Maximum Slew Rate (degrees per second)	Actual	Left
Shoulder Roll:	300 degrees/second.	Actual _____	
Shoulder Pitch:	300 degrees/second.	Actual _____	
Elbow Swing	400 degrees/second.	Actual _____	
Wrist Yaw:	600 degrees/second.	Actual _____	
Wrist Rot. (cont.)	90 revolutions/minute	Actual <u>102/15</u> <u>96 88</u>	92/80

3.4.4 Payload (PCL Req't - SDI Tolerance)

Verify that the slave arm, with standard parallel acting jaws installed, is capable of lifting and holding a 60 ± 2 lb payload at full arm extension.

OK?  Yes No Comment \_\_\_\_\_ R=OK L=OK  
58.6 58.6

3.4.5 Jaw Closure Force (PCL Req't)

Both end effectors shall be opened and closed 10 times at the maximum gripping force. The recorded values shall be within 25% of the 200 pounds.

OK?  Yes No Comment \_\_\_\_\_ 271 R 243 w/o Pads  
~~342~~ w/Pad 181 w/ Pads  
263 w/Pad 205

3.4.6 Power Requirements (PCL Req't)

Verify electrical power inputs are to customer requirements. Customer requires 110 VAC, 1-Phase, 60Hz to the slave controller, and 110 VAC to the master consolette.

OK?  Yes No Comment \_\_\_\_\_

3.5 Software Functions (PCL Req't)

Each of the control modes specified below shall be tested to verify functionality. The tests shall be conducted under the following conditions;

1. Jaw End Effector shall be carrying 60 lb object.
2. Each degree-of-freedom of the Manipulator Assembly shall be actuated to its ends of travel.

Dynamic Modes: Two dynamic modes shall be provided. A "Fast Mode" for normal operation and a "Slow Mode" for tasks requiring slower speeds.

OK?  Yes No Comment \_\_\_\_\_

R=OK L=OK

Wrist Mode: Two wrist control modes shall be provided. A "Position Control Mode" providing accurate indexing of the end effector and a "Variable Rate Continuous Rotation Mode" for tasks requiring multiple rotation of the end effector in either direction.

OK?  Yes No Comment \_\_\_\_\_

R=OK L=OK

Three Jaw control modes for the Parallel Jaw end effector shall be provided. An "Open Mode" shall maintain the jaws open until the operator deflects the jaw switch (i.e. as long as the switch is held in a deflected position the jaws will remain closed). A "Toggle Mode" will be provided where deflecting the switch once will open the jaws and retoggle will close the jaws. A "Position Mode" which shall allow incremental closing of the jaws with ability to fix the position of the jaws by releasing switch, will be provided.

OK?  Yes No Comment \_\_\_\_\_

R=OK L=OK

Freeze Mode: The "Freeze Mode" electronically freezes the entire Slave Arm in the position it is in when the freeze mode is entered. The Master Controller shall be able to freeze individual Slave Arm joints.

OK?  Yes No Comment \_\_\_\_\_

R=OK L=OK

The "Stow Mode" returns the Slave Arm to a pre-determined stowed position. The Slave Arm shall return to this pre-determined position via a pathway of up to 5 pre-determined points. This shall be conducted without the payload.

OK?  Yes No Comment \_\_\_\_\_

R=OK L=OK

The "Teach Mode" shall be provided for operators to program movements into the controller that the Slave Arms will be required to repeat at later times (e.g. return to a stowed position). This shall be conducted without the payload.

OK?  Yes No Comment \_\_\_\_\_

R=OK L=OK

4. Acceptance Signoff *System meets spec. except TP 3.4.2, wrist yaw slow rates not performed.*  
 *MS* *1/26/96*

Refer to "EXECUTION AND TEST APPROVAL" form attached (V-W-026-C1; 01655-A-1; 6/19 Rev.)

## DISTRIBUTION SHEET

To Distribution	From WRAP 1 Facility	Page 1 of 1
		Date 04/15/97
Project Title/Work Order Project W-026, Manipulator System ATP/ATR		EDT No. 161642
		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./Appendix Only	EDT/ECN Only
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