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Light Duty Utility Arm Equipment Qualification Test Procedure

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U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: The Equipment Qualification Test described in this test procedure document is the acceptance test procedure (ATP) for the LDUA Baseline System. It verifies that the equipment is complete and in working order, and demonstrates its readiness for being deployed into an actual underground storage tank.

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LDUA Equipment Qualification Test Procedure

1.0 INTRODUCTION

1.1 Purpose

The Equipment Qualification Test described in this test procedure document is the acceptance test procedure (ATP) for the LDUA Baseline System. It verifies that the equipment is complete and in working order, and demonstrates its readiness for being deployed into an actual underground storage tank.

1.2 Scope

The Equipment Qualification Test demonstrates the basic operation and key safety features of the LDUA Baseline System defined in "*Light Duty Utility Arm Baseline System Description*, WHC-SD-TD-ER-005" and as called for by the "*Light Duty Utility Arm System Pre-Operational (Cold Test) Test Plan*, WHC-SD-TD-TP-005".

1.3 Background

The LDUA program was initiated in 1992 by the Department of Energy's (DOE) Office of Science and Technology (then known as the Office of Technology Development) at the request of Hanford Tank Waste Remediation Systems (TWRS) as a development effort to provide a new capability to obtain information and support operations associated with underground storage tanks, and to aid in the remediation of those tanks at Hanford and throughout the DOE complex.

1.4 Overview Of LDUA Baseline System

The LDUA Baseline System deploys a family of tools and sensors, called end effectors, into underground storage tanks by means of a robotic arm on the end of a telescoping mast, and collects and manages the data that they generate. Access into the tank is gained through existing risers. A Mobile Deployment Subsystem transports the mast and arm between tanks and positions them over a 30.5 cm (12 inch) tank riser for deployment. Ancillary subsystems support the main deployment equipment, performing such functions as: maintaining confinement of the tank atmosphere; decontamination of mast, arm, and end effector; power distribution; and observation of in-tank operations. The LDUA Baseline System is operated from the remote Operations Control Trailer located outside the perimeter fence of the tank farm, up to 275 m (900-ft) from the deployment vehicle.

The LDUA Baseline System provides the capability to reach locations within the tank and waste surface that are not directly under the access risers. This capability has not been available to tank farm operations before and is one of the primary reasons that the LDUA Baseline System was developed. The LDUA Baseline System is designed to operate safely in the hazardous (high radiation, flammable gasses, corrosive chemicals) environment of underground storage tanks at the Hanford site as well as underground storage tanks located at other DOE sites. It is also designed to accept new end effectors and adapt to new missions with little disruption to the existing system.

1.5 Abbreviations, Acronyms, and Initialisms

ATIE	At-Tank Instrument Enclosure
CE	Cognizant Engineer
CTF	Cold Test Facility
CVEE	Common Video End Effector
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations
EE	end effector
F&R	Functions, Requirements & Assumptions
FMEF	Fuels and Materials Examination Facility
GEE	Gripper End Effector
HRSVS	High Resolution Stereo Video System
HVAC	Heating, Ventilation, and Air Conditioning
LDUA	Light-Duty Utility Arm
LVDT	Linear Variable Differential Transformer
MDS	Mobile Deployment System
MEEES	Manual End Effector Exchange System
NEC	National Electrical Code
OAS	Optical Alignment Scope
OOVS	Operations Overview Video System
ORR	Operational Readiness Review
OSVS	Overview Stereo Video System
OVS	Overview Video System
PASS	Purge Air Supply System
PDS	Power Distribution Skid
PIC	Person In Charge
QE	Quality Engineer
SCADAS	supervisory control and data acquisition system
SCS	Supervisory Control System
SDAS	Supervisory Data Acquisition System
TD	Test Director

TP	Test Performer
TE	Test Engineer
TFA	Tank Focus Area
TIP	Tool Interface Plate
TRIC	Tank Riser Interface Confinement System
TWRS	Tank Waste Remediation Systems
VAC	Volts, Alternating Current
VDRS	Video Display and Recording System
VPM	Vertical Positioning Mast
WHC	Westinghouse Hanford Company

2.0 TEST ITEM IDENTIFICATION

The item to be tested is the complete and integrated LDUA Baseline System as described in WHC-SD-TD-ER-005, Rev. 0, *Light Duty Utility Arm Baseline System Description*, with the exceptions noted in section 2.1 below.

2.1 LDUA Subsystem List

The following is a list of all subsystems in the LDUA Baseline System. Subsystems marked with an asterisk (*) are in the baseline system description document, but are not included in the LDUA Qualification Test. Subsystem marked with a double asterisk (**) are not in the baseline system description document, but are included in the LDUA Qualification Test

2000 LDUA and Deployment System

3000 Tank Riser Interface and Confinement (TRIC):

- 3150 Confinement Enclosure
- 3160 Mast Housing Adapter
- 3350 Decon Module (Water)
- 3340 Decon Water Supply System
- 3360 Riser Isolation Valve
- 3520 Radiation Monitor
- 3660 Manual End Effector Exchange System (MEEES)

4000 Operations Control Center:

- 4100 Operations Control Trailer (OCT)
- 4210 Supervisory Control System (SCS)
- 4220 Supervisory Data Acquisition System (SDAS)
- 4300 At-Tank Instrument Enclosure (ATIE)

5000 Utilities:

- 5120 Portable Generator*
- 5130 Power Distribution Skid (PDS)
- 5140 Power Interface Module (PIM)
- 5230 Purge Air Supply System (PASS)

6000 End Effectors:

- 6110 Topographical Mapping System*
- 6220 Overview Stereo Video System*
- 6210 Overview Video System (OVS)
- 6230 High Resolution Stereo Video System (HRSVS)
- 6250 Optical Alignment Scope (OAS)
- 6260 Common Video End Effector Support Equipment (CVEE)
- 6510 Gripper End Effector (GEE) (**)

8000 Other Equipment:

- 8200 Operations Overview Video System (OOVS)
- 8100 Riser Characterization Equipment*

2.2 Configuration Documentation

Configuration documents for each subsystem will be provided by the Cognizant Engineer prior to beginning the LDUA Qualification Test. A master set of these documents will be kept in locked file cabinets in room 601 of building 4706. The Test Director will control this master set during testing - no changes will be made without the knowledge and permission of the Test Director. A list of all the configuration documents will be included in the acceptance test report.

2.3 Software

Final validation of the LDUA software will occur by performing the detailed test procedures of the LDUA Qualification Test. LDUA software is embedded in many of the subsystems and cannot be validated except by the testing of the whole system into which it is integrated. This is as per WHC-SD-TD-SDP-001, *Light Duty Utility Arm Software Development Plan*. Software test specifications from the software test plan, WHC-SD-TD-TP-006, *Software Test Plan For The Integrated Light Duty Utility Arm System*, will be appended to the test report and correlated to specific detailed test procedures of the LDUA Qualification Test to document their applicability for validating the software.

3.0 GENERAL DESCRIPTION

3.1 Test Objectives

The objective of the LDUA Equipment Qualification Test is to demonstrate that the system is operational and that it can perform all the functions required to deploy it into the initial underground storage tank for operational testing, and that it can be operated safely.

3.2 Test Method

The LDUA Baseline System will be set up in the Cold Test Facility (see section 6) and will be functionally verified by test procedures that are as close the actual operating procedures as practicable. The organization of functions into tests is as near to an actual deployment campaign as is practicable. Testing will begin with the LDUA Baseline System fully set up and interconnected.

Unless otherwise stated in the test procedure, the LDUA Baseline System will be operated from the Operations Control Trailer using the LDUA Console, the Operations Workstation, and the Data Acquisition Workstation as appropriate.

The LDUA Equipment Qualification Test confines itself to demonstrating performance of the system within its specified parameters and does not attempt to measure or quantify the extent of the performance envelope. It also does not explicitly test all low level functions of the system (such testing will have been previously performed and documented at the subsystem and system integration level). It also does not expose the LDUA Baseline System to the external environment (temperature extremes, wind, dust, uneven terrain, etc.) or to a radiation environment.

It is understood that the setup and takedown of the system will be practiced by operations organization using an outdoor area just east of the Cold Test Facility, however, this is out of scope for the LDUA Equipment Qualification Test.

3.3 Overview of Test Procedures

The detailed test procedures that make up the LDUA Equipment Qualification Test are contained in section 12 (for normal operation) and section 13 (for off-normal operation). These detailed test procedures describe what is to be done by the test performer, but not how to do it. Accordingly, the test performers must be trained to operate the system, or must be under the direct supervision of a trained person or the Cognizant Engineer.

Each detailed test procedure is designed to be performed as a unit. The introduction for each detailed test procedure includes a description of the goal of the testing, any equipment that is required beyond that listed in section 6, and any prerequisites that must be met before it can be performed. The Test Director is free to schedule the detailed test procedure in any order so long as the prerequisites are satisfied.

3.4 Changes to Test Procedures

A master copy of this test procedure document shall be maintained by the Test Director. Field copies may be made and distributed as desired to facilitate testing. Changes to the detailed test procedures may be made during actual testing by suitably marking up the master copy. Changes must be approved and initialed by the Test Director, the Test Engineer, and the Cognizant Engineer. When such changes are made, the Test Director must assure that all earlier field copies are replaced by current copies.

3.5 Use Of Draft Operating Procedures

Some of the detailed test procedures call for the use of specific portions of the actual tank farm operating procedures that will be used for hot deployment of the LDUA Baseline System. These operating procedures are:

- TO-080-700, *LDUA Subsystem Staging/Interconnection/Energization*
- TO-080-701, *Mobile Deployment System Setup and Power*
- TO-080-702, *LDUA In-Tank Operations*
- TO-080-703, *LDUA System Power Down, Decon, and Equipment Removal*
- TO-080-704, *Off-Normal Events: Recovery of the LDUA*

The operating procedures will not be released until after LDUA Equipment Qualification Testing has been completed. They will be used in draft form to support the LDUA Equipment Qualification Test. A master copy of the draft operating procedures shall be maintained by the Test Director. Field copies may be made and distributed as desired to facilitate testing. The master copy of a draft operating procedure may be redlined to correct mistakes or where actual tank farm operating conditions or policies cannot be followed in the Cold Test Facility. Such changes must be approved and initialed by the Test Director, the Test Engineer, and the Cognizant Engineer. When such changes are made, the Test Director must assure that all earlier field copies are replaced by current copies.

4.0 TEST CONDITION LIMITS

4.1 Test Readiness Checklist

The LDUA Baseline System and the Cold Test Facility must be in the proper configuration and state before testing can begin. A test readiness review shall be performed by the Test Director and all the Cognizant Engineers prior to starting test activities. Appendix C lists the minimum required conditions to be verified and provides signature blanks for the Test Director and the Cognizant Engineers.

4.2 Test Interruption

Test conditions that could cause a test procedure to abort would be a loss of power in the facility, complete failure of the LDUA Baseline System to perform its intended function, or the identification of a health/safety concern. If any of these conditions occur, the test procedure will be suspended and a test exception will be recorded and resolved. After problem resolution, the test engineer and test director will review the specific event and determine where in the procedure testing should be resumed. If necessary, test sections may be repeated to meet retest requirements and insure conditions have not changed.

5.0 INSTRUMENTS AND CALIBRATION

The test instruments required for each Detailed test procedure are listed in its introduction. Unless specified otherwise, all test instruments will have a current calibration sticker from the Hanford Standards Laboratory. Record calibration data in the Test Instrumentation Record, Appendix E.

6.0 FACILITIES, EQUIPMENT, AND MATERIALS

The Equipment Qualification Test will take place in the Cold Test Facility(CTF), a portion of Building 427, the Fuels and Materials Examination Facility (FMEF), as documented in WHC-SD-TD-ES-003, *Light Duty Utility Arm Cold Test Facility Engineering Study*. The LDUA Baseline System equipment will be located on the mezzanine, CTF Test Cell, and truck lock as shown in Appendix A.

Support equipment will be required in addition to the LDUA Baseline System equipment in order to perform testing. The following support equipment will be required for the majority of detailed test procedures in this document:

- Cushions/tie-off straps for LDUA landings (planned and unplanned).
- Radio communication equipment.
- Overhead crane support.
- Emergency Stop buttons in Test Cell and on Mezzanine
- 12 inch (H-4-112295, Rev. 0) and 4 inch simulated risers.
- LVDTs and readouts for 12 inch simulated riser
- 480vac power.
- Decon water containment barriers.
- Purge flow check device (normally attached to TRIC by lanyard)
- Inclinometer (resolution and accuracy to 10 minutes of arc, or better)
- LDUA Test Connector for TIP Engagement & End Effector ID
- Force measuring device (range: 0 - 100 lbs) (dynamometer, load cell, etc.)
- Blank video tape
- HRSVS Inspection Test Article #1 (welded plate)
- HRSVS Inspection Test Article #2 (corroded wall section)
- GEE Test Article for GEE to grasp and lift.
- Contact thermometer (with range of at least 50F - 300F)

Individual test procedures may require equipment or materials in addition to those listed above. Such requirements are described in the introduction of each detailed test procedure section.

To reduce noise levels within the Cold Test Facility during this test:

- The ATIE HVAC may be turned off, and doors open for air circulation.
- The Purge Air Supply System will be operated only when the purge system is being tested (see section 13.2), building air will be used at other times.

7.0 SAFETY

A pre-job briefing will be performed by the Person In Charge (PIC) prior to the initiation of a test procedure. The Cold Test Facility Job Hazards Analysis (JHA) contains a list of Cold Test Facility hazards. The JHA shall be discussed during documented pre-job briefings. Warnings and Cautions are listed in this procedure at points where they apply. Standard operating procedures for the Fuels and Materials Examination Facility (FMEF), which contains the Cold Test Facility, shall apply to all situations not otherwise specifically addressed.

Test personnel should exercise proper work habits including use of Personal Protective Equipment while performing this test procedure. The following potential hazards exist during various sections of the test:

- Electrical power - 480, 208, 110 VAC
- Pressurized air - 125 psi
- Pressurize hydraulics - 3000 psi (fluid is non-toxic and non-hazardous)
- Gasoline in MDS vehicle fuel tank
- Access requirements to equipment 6 feet above the floor level
- Separate areas of CTF prevent direct visual observation and communications
- Trip hazard from cables on floor
- Moving mechanisms - pinch points
- Remotely controlled robot - bumping, pinching, crushing
- Suspended loads/devices
- Laser light (class IIIa)

8.0 MAINTENANCE AND FAILURES

8.1 Failures

Exceptions noted during the execution of the procedure shall be recorded in the test log and the exception sheet (Appendix G). If an exception is noted, testing must be suspended until approval to continue is obtained from the cognizant engineer and the test engineer. Approval to continue shall be documented by signature in the test log and test exception sheet.

8.2 Maintenance

There are no components in the LDUA System that are expected to require maintenance during the test period. If a component fails or requires adjustment during testing, the failure shall be documented as a test exception and testing suspended until the problem is corrected and approval to resume testing is obtained.

9.0 TEST DATA

All results and observations called for by the individual detailed test procedures will be recorded on copies of the appropriate test data sheets that are included in section 15 of this document. Additional information (test log, calibration records, exception records, etc.) as called for

elsewhere in this document shall be recorded on copies of the various supplemental record sheets in the appendices. Video tapes will be made during several of the detailed test procedures and will be considered to be test results. These video tapes shall be properly labeled and stored and noted in the test log. The Test Director shall maintain custody of all test records whenever they are not actually being used during testing.

The marked up master copy of the LDUA Equipment Qualification Test (see section 3.4) shall be considered part of the test data, as will the marked up master copies (see section 3.5) of the draft operating procedures.

An acceptance test report shall be prepared and issued as a WHC Supporting Document. This report will describe and summarize testing activity and will include copies of test data sheets and supplemental record sheets.

10.0 PERSONNEL REQUIREMENTS

Roles of test personnel are listed below.

Test Director (TD)

- Has overall responsibility and authority for the performance of this test
- Ensure the required personnel and equipment are present prior to performing a test
- Provides testing liaison between the LDUA and FMEF organizations.
- Approves testing schedule and notifies affected parties of schedule changes
- Provides liaison between Safety and QA organizations for testing activities.
- Reviews subsystem Job Safety Analysis (JSA) related to testing.
- Maintains the test documentation data base.
- Verifies that prerequisites for each detailed test procedure have been met.
- Reviews and approves all test procedure changes, and test reports.
- Establishes training requirements and coordinates training of cold test participants.
- Prepares CTF safety plan for cold testing.

Test Performer (TP)

- Performs the test in accordance with the test procedure.
- Collects test results as called for by the procedure.
- Reports test status for tracking testing.
- Implements QA and safety requirements.
- Participates in all required training and pre-job briefing activities.
- Reports details about testing in the test log.

Test Engineer (TE)

- Reviews and approves the test results
- Directs and/or monitors testing for compliance with testing requirements and procedures.
- Perform maintenance, calibration, adjustment, modification of equipment as required during testing using appropriate resources when required.

Person In Charge (PIC)

- Must have current FMEF PIC training and certification
- Conducts pre-job briefing.
- Oversees testing and rework activities at CTF.
- Ensure compliance with procedures and safety.
- Prepare work packages, etc., required to implement testing and other activities.
- Arrange and oversees craft and technician work at CTF.
- Maintains the test log.

Cognizant Engineer (CE)

- Approves test procedures, modifications, and subsystem documentation.
- Provides technical advice on the operation for the subsystem of responsibility.
- Reviews test logs for the subsystem of responsibility.
- Resolves non-conformance issues and determines corrective action.
- Prepares modification documentation as required.
- Establishes operator qualification requirements and maintains a list of qualified operators.

Quality Engineer (QE)

- Approves test procedures.
- Ensures that quality requirements are defined and satisfied for tests.
- Monitors test activities and approves test result documentation.

Safety Engineer (SE)

- Approves test procedures.
- Ensures that safety requirements are defined and satisfied for tests.
- Reviews and approves the CTF safety plan for cold (pre-operational) testing.

All personnel involved in the performance of this test shall print and sign their name, initials, position, and date of signature in the personnel record section of Appendix F prior to participating in the testing.

The LDUA training plan defines LDUA operator training, qualification, and documentation requirements. In general, only individuals who have been properly trained and certified to operate equipment shall do so for this procedure (unless they are operating per a procedure and under the direct supervision of a trainer for the purpose of qualifying the individual during this test). A list

of the qualified individuals will be posted on or near each piece of equipment.

In some cases, a single person may perform in more than one of the roles described above. In particular, the Test Engineer (TE), Test Performer (TP), and Cognizant Engineer (CE) roles may be shared in any combination by a single person. Also, the Person In Charge (PIC) role may be combined with any other role.

11.0 WITNESSES

There are no hold points for quality control in the LDUA Equipment Qualification Test, nor any other requirements for witnessing by any organizations not directly involved in the testing activities. It should be noted that representatives of the receiving organization (TWRS) are invited and expected to serve as Test Performers and Test Engineers for many of the actual tests, but are not required to.

12.0 TEST PROCEDURES FOR NORMAL OPERATION

This section contains detailed test procedures which cover situations considered to be within normal operation of the LDUA Baseline System. They will be performed in the Cold Test Facility (CTF) and will start with LDUA system components staged on the mezzanine or in truck lock, interconnected, and ready to power up using building power.

Each of the detailed test procedures is performed as a unit. The results are collected in the appropriate data records in the data sheet section (section 15) of this document. Each detailed test procedure has a completion record in the data sheet section and one or more data records. Each data record is associated with a specific step in a specific detailed test procedure.

The following information is to be recorded onto the completion record for a detailed test procedure:

- The completion of the pre-job briefing and the review of prerequisites (prior to starting the test)
- The completion of each step in the procedure
- The acceptance of the results by the Test Engineer (after all steps are completed)

- The acceptance of the test result documentation by the Quality Engineer (after steps are completed).
- The declaration that the procedure is complete by the Test Director (after all of the above is completed)

When all the detailed test procedures have been completed, the LDUA Equipment Qualification Test Completion Record is signed by the Test Director, the TWRS LDUA Cognizant Engineer, and the Quality Engineer.

12.1 Control System Setup Test Procedure

Goal: This test will verify the readiness of the LDUA control and data acquisition system and will establish some basic parameter setting to support the other detailed test procedures.

Equipment: None.

Prerequisites: None.

12.1.1 Power up the LDUA System (if necessary).

12.1.2 Verify that password protection is working properly for all workstations:

- Attempt to login to each workstation using an incorrect password and record results on data record for this step.
- Attempt to login to each workstation using the correct password for the operator's account and record results on data record for this step.

12.1.3 Set the purge response mode of the LDUA Subsystem Controller to be for non-flammable atmosphere tanks. Note: unless otherwise specifically stated in a detailed test procedure, all testing is to take place with system in this mode.

12.1.4 Establish the baseline purge pressure and flow parameters. At the discretion of the Test Director, these values may be obtained by a new measurement or may be copied from the results obtained during the Post Delivery Acceptance Test of the LDUA.

- Record the supply pressure of the purge air on the data record for this step. Purge air will be supplied from the building air supply (Note: the PASS will be tested in section 13.2).
- Record on the data record for this step the baseline pressure readings for the VPM inner tube/LDUA, and the VPM outer tube/VPM housing (measured by the on-board system purge pressure sensors).
- Record on the data record for this step the baseline flow value (measured at the TIP purge connector).
- Calculate the minimum pressure and flow thresholds and record the result as indicated on the data record for this step.

- 12.1.5 Obtain values for the general tank parameters as listed on the data record for this step from the Cognizant Engineer. Record them on the data record and enter them into the LDUA Subsystem Controller (via the LDUA Console). Note: some of these parameters will be changed by subsequent Detailed Test Procedures.

12.2 VPM Riser Alignment Test Procedure

Goal: This test demonstrates the ability of the LDUA System to be elevated and aligned to both plumb and tilted risers. It also demonstrates the ability of the MEEES to mount and dismount end effectors on both plumb and tilted risers. The function of the OAS end effector is also demonstrated.

Equipment: Purge flow check device (normally attached to TRIC by lanyard), inclinometer (or other means of measuring riser tilt), Blank video tape.

Prerequisites: Control System Test Procedure (section 12.1) must be complete.

12.2.1 Apply a tilt to the 12 inch simulated riser. Measure the azimuth (direction of tilt) and the elevation (magnitude of tilt) and record on the data record for this step.

12.2.2 Elevate the VPM housing, following section 5.5 of TO-080-701 (see section 3.5)

12.2.3 Verify the operation of the software locks on VPM axes. Attempt to move each of the VPM X, Y, Roll, and Pitch axes. Movement should be prevented by the LDUA Subsystem Controller and an appropriate message should be generated. Record the results on the data record for this step.

12.2.4 Attach the OAS end effector to the LDUA, following section 5.1 of TO-080-702 (see section 3.5).

- Prior to attaching the end effector, turn on the purge air supply and verify adequate flow rate at the TIP by pressing the pneumatic connector of the purge flow check device onto the purge supply connector at the TIP and observing the reading on the flow gage. Turn off the purge air flow and remove the purge flow check device. Record the results of the purge flow check on the data record for this step.
- Verify that the indicator for end effector engagement on the LDUA Console is off prior to mounting the end effector and on after mounting it. Record the results on the data record for this step.
- Verify that the LDUA Console displays the correct end effector ID for the OAS. Record the results on the data record for this step.
- Obtain the end effector weight and balance parameters from the Cognizant Engineer, record them on the data record for this step, and enter them into the

LDUA Subsystem Controller (via the LDUA Console).

CAUTION: The OAS end effector is designed for vertical operation only (it exceeds the nominal payload of the LDUA). To reduce wear and tear on the LDUA, do not operate the LDUA at more than 10 degrees from vertical whenever the OAS is attached.

12.2.5 Verify proper operation of the OAS with the LDUA purge system:

- Verify that the purge pressure reading for the inner mast tube and the VPM housing (as indicated on the LDUA Console) with the OAS mounted is above the minimum required level (record on data record for this step).
- Verify the proper response of the end effector support equipment to loss of purge pressure.
 - Set the LDUA Subsystem Controller to flammable tank mode to perform this step (CAUTION: LDUA will limp when purge pressure is lost).
 - Simulate a loss of purge event by stopping purge system air supply. The pressure inside the LDUA and VPM will drop. When the pressure falls below the threshold setting of its purge pressure sensing system, the LDUA control system will response with a loss of purge trip. Verify that the CVEE (6260A1) removes power from the end effector in response to this trip.
 - Record response on the data record for this step.
 - Set LDUA Subsystem Controller to non-flammable tank mode and restore purge pressure when step is complete.

12.2.6 Verify proper control of the OAS lighting by turning each set of lights on and then off, and then by turning each set on and leaving it on until all sets are on at once. Record results on the data record for this step. Turn lights off when done.

12.2.7 Verify the proper operation of the video system by observing the output from the OAS camera on VDRS monitor #1 (using input channel A) in the OCT. Verify that the images are stable, clear, and free of distortion and interference. Verify that the alignment reticle is visible. Record the results on the data sheet for this step.

12.2.8 Verify the proper operation of the spot lasers by turning set A on and off, then set B on and off, and then by turning both sets on and off. Record the results on the data sheet for

this step.

12.2.9 Verify the proper operation of the displacement lasers by turning them on and observing the indication (on the Data Acquisition Workstation) of each of the 8 units as a hand-held target (a piece of light cardboard, such as a business card, is acceptable) is moved slowly over the sensing range of the unit. The indication should change in a predictable manner and should display the approximate distance to the target (Note: this is a functional check only - the actual calibration of the units has been done prior to this test).

12.2.10 Align VPM with riser, following section 5.8 of TO-080-701 (see section 3.5).

- Prior to traversing the riser with the OAS, observe the readings of the inclinometers from the LDUA Subsystem Controller (via the LDUA Console) and record them on the data record for this step.
- Begin lowering the OAS through the riser. Stop if contact is made with the riser.
- Monitor the readings from the displacement lasers as the OAS is being lowered through the riser (it is acceptable to stop and restart the VPM motion to facilitate this). Record, on the data record for this step, the single minimum distance reading from the displacement lasers that is seen during the traverse of the riser with the OAS (scratch records of readings can be made during the traverse in the Test Log at the discretion of the Test Performer).
- Record, on the data record for this step, whether or not the traverse was successful (OAS passed completely through riser without touching wall). If the attempt was unsuccessful, the data record allows a total of 5 attempts to be made before an exception must be declared.
- Observe the clearance between the VPM housing and TRIC during and after alignment process. Verify that there is no contact or other mechanical interference between them. Record any interference as a test exception.

12.2.11 Return riser to plumb condition (may require temporarily disconnecting the coupling between the VPM housing and the TRIC and removing the OAS end effector). Measure the angle of tilt from plumb and record on the data record for this step.

12.2.12 Repeat step 12.2.10 Record results on the data record for this step. Produce a video tape record from the OAS camera using the VDRS. Note: The video tape should be started at the beginning of this step and should be a continuous record of

activities in the step. It may be interrupted if the flow of work in the step is interrupted, but must be resumed when the work resumes. Record the identification information from the label affixed to the video tape and the data record for this step.

12.2.13 Remove and store OAS end effector, following section 5.8 of TO-080-702 (see section 3.5).

12.2.14 Establish the riser parameters:

- Determine the distance between the bottom plate of the VPM housing and the top plate of the TRIC by measuring the distance at two points at opposite sides of the VPM (approximately equidistant from VPM centerline) and calculating the average of the two measurements. Record the measured values and the calculated value on the data record for this step.
- Calculate the Actual Riser Top Position using the calculated VPM housing to TRIC distance and record it in the data record for this step.
- Measure the actual length of the riser and record it in the data record for this step.
- Calculate the Adjusted Riser Top Position, record values in the data record for this step, and enter as the "Riser Top Position" parameter into the LDUA Subsystem Controller (via the LDUA Console).
- Calculate the Adjusted Riser Length, record values in the data record for this step, and enter as the "Riser Length" parameter into the LDUA Subsystem Controller (via the LDUA Console).

12.2.15 Verify the registration of the simulated SGCS LDUA to CTF Test Cell World Model (using the MDS azimuth angle, Actual Riser Top Position, and the inclinometer readings obtained in step 12.2.12).

12.3 Mobile Deployment System/Inclinometer Stability Test Procedure

Goal: This test will measure the stability over time of the MDS and the VPM inclinometers.

Equipment: Inclinometer (resolution and accuracy to 10 minutes of arc, or better).

Prerequisites: VPM Riser Alignment Test Procedure (section 12.2) must be complete.

12.3.1 This test will begin after the riser alignment process has established a stable locked position for the VPM. Readings from the VPM inclinometers and external inclinometers will be taken on a periodic schedule for the duration of the remainder of testing. This procedure will not be complete until all the other detailed test procedures are complete.

- Establish guide marks on the bottom plate of the VPM housing (tape is acceptable) to assure that the external inclinometer will be applied in exactly the same position for each reading. These marks should be at an accurate right angle to each other and reasonably aligned with the roll and pitch directions of the VPM (repeatability is the measurement is much more important than the absolute accuracy).
- Measurements should be taken on at least a daily basis (preferably before other testing activities begin) and should be recorded in the data record for this step. More frequent measurements may be taken at the discretion of the Test Director. The first measurements should be taken as soon after completion of the VPM Riser Alignment Test Procedure (section 12.2) in order to allow as many days as possible to run this test.

12.4 Tank Entry/Exit Test Procedure

Goal: This test will verify the ability of the LDUA to enter and exit the tank (CTF Test Cell) through the 12 inch riser under normal and minimum clearance conditions. It will demonstrate and verify the ability of the LDUA to operate with different mast tube sequence modes and to perform an autosequence move in joint mode. The deflection (if any) of the 12 inch simulated riser due to VPM flexing will be measured. The interlock between VPM motion and the Riser Isolation Valve will also be demonstrated.

Equipment: LDUA Test Connector for TIP Engagement & End Effector ID, LVDTs and readouts for 12 inch simulated riser.

Prerequisites: VPM Riser Alignment Test Procedure (section 12.2) must be complete.

12.4.1 Verify the function of the VPM motion interlock with the Riser Isolation Valve. VPM downward motion should be interrupted when the LDUA reaches the position defined by the Riser Top Position parameter if the Riser Isolation Valve is not open.

- Install the LDUA Test Connector for TIP Engagement & End Effector ID instead of mounting an end effector.
- Move the VPM downward slowly, starting from a VPM position where the TIP is well above the Riser Top Position.
- Observe the position of the TIP during motion. VPM motion should stop when the TIP reaches the plane of the joint between the TRIC Enclosure and the Decon Module (this point is 30 inches above the top of the Riser Isolation Valve gate, allowing for an end effector to be mounted). Stop the VPM motion manually if the TIP enters the Decon Module splash barrier. Record results on the data record for this step.
- Remove the LDUA Test Connector for TIP Engagement & End Effector ID.

12.4.2 Mount the HRSVS or GEE onto the LDUA, following section 5.1 of TO-080-702 (see section 3.5). Do not use the OAS end effector.

12.4.3 Verify that the LDUA, VPM, and end effector can be deployed to full extension into the CTF Test Cell through the 12 inch simulated riser using both modes of VPM mast tube sequencing.

- Begin with the VPM fully withdrawn to the stowed position (required in order for the LDUA control system to allow changes to the VPM tube sequence).
 - Set the VPM mast tube sequence and extension parameters as specified for the deployment #1 on the data record for this step. These will provide maximum deployment travel for the VPM.
 - Obtain the appropriate joint autosequence from the Cognizant Engineer, record it on a copy of the Joint Autosequence List (Appendix H), and enter it into the LDUA Subsystem Controller (via the LDUA Console). Record the cross-reference to the autosequence list and the starting VPM position on the data record for this step.
 - Execute the autosequence and observe the motion of the VPM and LDUA:
 - Verify that the correct tube moves first and that the transition occurs at the specified extension position.
 - Observe the passage of the VPM/LDUA/EE through the 12 inch simulated riser.
 - Stop the motion if there is significant interference with the riser, that is, hard contact sufficient to impede or slow the motion of the VPM or to damage the LDUA (especially the boots and boot clamps) or end effector. Monitor the LVDTs on the 12 inch simulated riser for gapping at the flange (i.e. VPM is dragging the flanges apart) in excess of 0.4 of an inch.
 - Stop the motion if there is danger of contact between the LDUA or end effector and any surfaces or objects in the CTF Test Cell.
 - Record the observations, and the final VPM position on the data record for this step.
 - Repeat the above for deployment #2.
- 12.4.4 Measure maximum deflection of bottom of the 12 inch simulated riser (if any) due to flexing of the VPM:
- Record LVDT readings with riser empty to establish the non-deflected condition, and record on the data record for this step.

- Deploy LDUA vertically into the CTF Test Cell until the TIP is within 12 inches of the floor. Record the VPM position and the LVDT readings and calculate the net riser deflection (if any). Record results on the data record for this step.
- Move the LDUA to the horizontal position and lower the VPM to its maximum extension. Record the VPM position and LVDT readings and calculate the net riser deflection (if any). Record results on the data record for this step.
- Leave the LDUA in the horizontal position and raise the VPM 10 feet. Record the VPM position and LVDT readings and calculate the net riser deflection (if any). Record results on the data record for this step.
- Leave the LDUA in the horizontal position and raise the VPM an additional 10 feet. Record the VPM position and LVDT readings and calculate the net riser deflection (if any). Record results on the data record for this step.
- Withdraw the LDUA from the CTF Test Cell.

12.4.5 Verify the ability of the LDUA to deploy into a minimum clearance tank. This test will be performed near the CTF Test Cell floor (to make observation easier) with the aid of an imaginary riser that will be established by means of a temporary artificial setting of the Riser Length parameter. The bottom of the imaginary riser will be 9 feet above the floor of the CTF Test Cell and the imaginary waste surface will be 3 feet above the floor.

- Set up boundary markers at 9 feet and 3 feet above the floor of the CTF Test Cell to aid the observers. These may be twine strung between supports.
- Obtain the temporary value for the "Riser Length" parameter from the Cognizant Engineer, record it on the data record for this step, and enter it into the LDUA Subsystem Controller (via the LDUA Console).
- Obtain the joint autosequence for a minimum clearance deployment from the Cognizant Engineer, record it on a copy of the Joint Autosequence List (Appendix H), and enter it into the LDUA Subsystem Controller (via the LDUA Console). Record the cross-reference to the autosequence list on the data record for this step.
- Execute the minimum clearance deployment autosequence while observing the motion of the LDUA with respect to the boundary markers. There should be two observers located on sight lines that intersect the VPM centerline at approximately a right angle. The LDUA should not go outside the boundary markers. Record the observations on the data record for this step.

- Withdraw the LDUA from the CTF Test Cell and restore the Riser Length parameter to its original value.

12.4.6 Remove and store the end effector, following section 5.8 of TO-080-702 (see section 3.5).

12.5 LDUA Motion Test Procedure

Goal: This test demonstrates manual control of motion of LDUA and VPM joints and of resolved (POR) motion. It verifies that the SGCS follows the actual motion of the LDUA and VPM and that it can be used for preview and collision checking of motion. The stability of the control system under conditions where LDUA is constrained from moving is also demonstrated.

Equipment: Force measuring device (range: 0 - 100 lbs) (dynamometer, load cell, etc.).

Prerequisites: Tank Entry Test Procedure (section 12.4) must be complete.

12.5.1 Attach GEE end effector, following section 5.1 of TO-080-702 (see section 3.5).

12.5.2 Deploy the LDUA and VPM into the CTF Test Cell.

12.5.3 Demonstrate manual control of individual joints and the ability of the SGCS to adequately depict actual position and follow actual motion:

- Position the VPM so that the TIP of the LDUA is approximately 12 inches above the floor of the CTF Test Cell when the LDUA is vertical.
- Select Single Joint Rate Mode
- With the joystick, command each joint to move in one direction and then the other (start with the shoulder pitch joint, and leave it at approximately 90 degrees when finished exercising it). Observe the LDUA and verify that each joint moves properly in response to the joystick inputs. Observe the SGCS and verify that the corresponding joint on the IGRIP model of LDUA follows the position and movement of the actual joint. Record observations on the data record for this step.

12.5.4 Demonstrate manually controlled resolved motion, using simulation mode for path preview and SGCS for collision checking of preview prior to actual motion.

- Position the LDUA so that the end effector is approximately 3 feet from and roughly perpendicular to the east wall of the CTF Test Cell. The position chosen should allow sufficient joint movement so that the end effector could be moved into contact with the wall. Record joint positions on the data record for this step.
- Select Manual POR mode and Tool Frame reference mode.

- Select simulation mode. Turn on collision checking in the SGCS. Move the simulated LDUA with the joystick and observe the simulated motion (preview) on the SGCS. Continue the simulated motion until a collision is indicated
- Reset the position of the simulated LDUA. Repeat the simulated motion of the end effector toward the wall, but stop just short of a collision. Select actual motion mode and execute the preview and observe the actual motion of the LDUA. Verify that the actual motion follows the preview. Record observations on the data record for this step.

12.5.5 Verify that LDUA remains stable when firm contact is made with an obstacle.

- Place the force measuring instrument onto the east wall of the CTF Test Cell where end effector can reach it.
- Move the LDUA slowly until the GEE fingers (jaws closed) is in contact with force measuring instrument and is perpendicular to the wall. Command the LDUA to move further into the wall (use a very slow speed) and observe LDUA and force sensor. Stop the LDUA if the force measuring instrument reaches 75 lbs. The LDUA control system may automatically stop the motion before that level of force is reached. This is acceptable. In either case, record the force that was reached on the data record for this step. The LDUA should remain stable and should not exhibit erratic motion of any kind while it is in contact with the force measuring instrument. Record the observation on the data record for this step. Move the LDUA away from wall.

12.5.6 Withdraw the LDUA from the CTF Test Cell.

12.5.7 Remove and store the end effector, following section 5.8 of TO-080-702 (see section 3.5).

12.6 Decon System Test Procedure

Goal: This test will demonstrate operation of the Decon system and verify that LDUA, VPM, and end effectors are not affected by the decon water spray. Function of the high radiation level interlock with the VPM will also be verified.

Equipment: Water containment barriers must be installed in the CTF Test Cell

Prerequisites: Tank Entry Test Procedure (section 12.4) must be complete. Boots must be installed on the LDUA and cover plates must be sealed.

12.6.1 Attach the HRSVS end effector to the LDUA, following section 5.1 of TO-080-702 (see section 3.5).

12.6.2 Verify proper operation of the high-radiation level interlock on the VPM:

- Lower the VPM, if necessary, to allow a few feet of upward travel.
- While raising the VPM at a slow speed, simulate a high-radiation level trip from the Radiation Monitors. Observe the behavior of the system and verify that VPM motion stops automatically. Bypass the interlock while maintaining the simulated trip and command the VPM to move upward. Observe its response and verify that motion occurs. Record the results on the data record for this step.

12.6.3 Verify that the water containment barriers have been installed in the CTF Test Cell. These will consist of a catch tank placed directly below the simulated 12 inch riser and a sleeve constructed of plastic drop cloth, or similar material. The sleeve will be wrapped around the bottom of the simulated 12 inch riser and carried down to the catch tank so as to form a rough cylinder with sufficient clearance for the LDUA and VPM to pass vertically through it with no interference. Plastic rope will be used to support the sleeving. A portable sump pump will be used to empty the catch tank into the FMEF building drains.

12.6.4 Verify that the DWSS is energized and that there is sufficient water in the water supply tank.

12.6.5 Lower the VPM until the end effector and LDUA have passed into the riser and the VPM inner mast tube cover plate is just below the bottom of the VPM outer tube, the bottom of the VPM outer tube is just below the level of the spray ring in the Decon Module.

12.6.6 Verify proper operation of Decon Module on LDUA, VPM, and HRSVS: CAUTION: If the HRSVS lights have been recently operated, make sure that enough time is taken to

allow the HRSVS windows to cool before applying decon spray.

- Purge flow should be on during this step
- Start the DWSS pump and allow pressure to come to equilibrium. Record pressure on data record for this step.
- Raise the VPM at a steady speed of approximately 1.5 in/sec while simultaneously spraying water in the Decon Module until the end effector is just above the decon splash barrier, then stop and shut off decon water spray. Record in the data record for this step the actual speed at which the VPM was operated and start and stop times that the spray was on, and the reading of the DWSS flow totalizer before and after the spray was on. Calculate the total net flow and the elapsed time and record them on the data record.
- The DWSS pump may be stopped at the discretion of the Test Engineer.

12.6.7 Verify that HRSVS is undamaged by the decon process:

- Verify that the components of the end effector are operational by performing a high level (go/no-go) functional check. Record the results on the data record for this step.
- Remove the end effector, following section 5.8 of TO-080-702 (see section 3.5). Examine the end effector for signs of moisture or water ingress. Record the observation on the data record for this step.

12.6.8 Position the OAS end effector for decon:

- Mount the OAS end effector on the LDUA to the LDUA, following section 5.1 of TO-080-702 (see section 3.5).
- Lower the VPM until the TIP is just below the level of the spray ring in the Decon Module.

12.6.9 Perform decon on OAS: Repeat Step 12.6.6 and record the results on the data record for this step. CAUTION: If the OAS lights have been recently operated, make sure that enough time is taken to allow the windows to cool before applying decon spray.

12.6.10 Verify that OAS is undamaged by the decon process:

- Verify that the components of the end effector are operational by performing a high level (go/no-go) functional check. Record the results on the data record for this step.
 - Remove the end effector, following section 5.8 of TO-080-702 (see section 3.5). Examine the end effector for signs of moisture or water ingress. Record the observation on the data record for this step.
- 12.6.11 Position the GEE end effector for decon:
- Mount the GEE end effector on the LDUA to the LDUA, following section 5.1 of TO-080-702 (see section 3.5).
 - Lower the VPM until the TIP is just below the level of the spray ring in the Decon Module.
- 12.6.12 Perform decon on GEE: Repeat Step 12.6.6 and record the results on the data record for this step. CAUTION: If the GEE lights have been recently operated, make sure that enough time is taken to allow the windows to cool before applying decon spray.
- 12.6.13 Verify that GEE is undamaged by the decon process:
- Verify that the components of the end effector are operational by performing a high level (go/no-go) functional check. Record the results on the data record for this step.
 - Remove the end effector, following section 5.8 of TO-080-702 (see section 3.5). Examine the end effector for signs of moisture or water ingress. Record the observation on the data record for this step.
- 12.6.14 Verify that the LDUA is undamaged by the decon process:
- Deploy the LDUA into the CTF Test Cell (may do so without an end effector mounted using a test connector to supply the TIP Engaged circuit). Perform a high-level functional check by operating it in resolved motion to verify that there are no visible anomalies in its motion.
 - Position the LDUA in a convenient location and configuration for accessing the boots, remove the boots and check for the presence of moisture or water under them. Record the observations in the data record for this step.

- If necessary, remove LDUA and VPM cover plates to ascertain the amount and extent of water ingress. Record the observations in the data record for this step.

12.7 High Resolution Stereo Video System (HRSVS) Deployment Test Procedure

Goal: This test will demonstrate HRSVS operation with the LDUA during deployment into the CTF Test Cell. The basic function of the HRSVS will be checked and also its ability to operate with the LDUA purge system. The ability of the HRSVS to perform visual inspections while on the LDUA (at rest and in motion) will also be demonstrated.

Equipment: Blank video tape, HRSVS Inspection Test Article #1 (welded plate) mounted on Test Cell wall, HRSVS Inspection Test Article #2 (corroded wall section) mounted on Test Cell wall.

Prerequisites: LDUA Motion Test Procedure (section 12.5) must be complete.

12.7.1 Mount the HRSVS end effector onto the LDUA, following section 5.1 of TO-080-702 (see section 3.5).

- Record the results of the purge flow check on the data record for this step.
- Verify that the TIP Engaged indicator is off prior to mounting the end effector and on after mounting it. Record the results on the data record for this step.
- Verify that the LDUA Console is displaying the correct end effector ID for the HRSVS. Record the results on the data record for this step.
- Obtain the end effector weight/balance parameters for the HRSVS from the Cognizant Engineer, enter them into the LDUA Subsystem Controller (via the LDUA Console) and record them on the data record for this step.
- Obtain the point-of-resolution (POR) transform parameters for the HRSVS from the Cognizant Engineer, enter them into the LDUA Subsystem Controller (via the LDUA Console), and record them on the data record for this step.

12.7.2 Verify proper operation of the HRSVS with the LDUA purge system:

- Verify that the purge pressure reading for the inner mast tube and the VPM housing (as indicated on the LDUA Console) with the HRSVS mounted is above the minimum required level (record on data record for this step).
- Verify the proper response of the end effector support equipment to loss of purge pressure:

- Set the LDUA Subsystem Controller to flammable tank mode to perform this step (CAUTION: LDUA will limp when purge pressure is lost).
- Simulate a loss of purge event by stopping purge system air supply. The pressure inside the LDUA and VPM will drop. When the pressure falls below the threshold setting of its purge pressure sensing system, the LDUA control system will response with a loss of purge trip. Verify that the CVEE (6260A1) removes power from the end effector in response to this trip.
- Record response on the data record for this step.
- Set LDUA Subsystem Controller to non-flammable tank mode and restore purge pressure when step is complete.

12.7.3 Verify the proper control of the HRSVS lighting by turning each set of lights on and then off, and then by turning each set on and leaving it on until all sets are on at once. Record results on the data record for this step. Turn all lights off when done.

12.7.4 Deploy the LDUA into the Test Cell

12.7.5 Verify the proper operation of the video system by selecting and observing the outputs from the HRSVS close up and distance cameras on the VDRS monitors in the OCT. Position the LDUA so that the HRSVS is observing objects that are between 3 feet and 30 feet away. Operate the camera controls and lighting as necessary to obtain the best image. Verify that the images from individual cameras are stable, clear, and free of distortion and interference. Verify that the stereo image from the HRSVS close up cameras is clear, free from doubling, and provides depth perception. Perform the HRSVS close up camera evaluation using all three lenses. Record the results on the data record for this step.

12.7.6 Verify the ability of the LDUA System to perform a suitable in-tank video survey by moving the LDUA and observing various features of the Test Cell while producing a video tape record using the VDRS.

Note: The video tape should be started at the beginning of this step and should be a continuous record of activities in the step. It may be interrupted if the flow of work in the step is interrupted, but must be resumed when the work resumes. Record the identification information from the label affixed to the video tape and the data record for this step. Continuous LDUA position information and time shall be overlaid onto the video record.

- Perform a close inspection of the flange on the simulated riser in the simulated waste tank section while operating the LDUA under manual control:
 - Use the HRSVS distance cameras to locate the flange and to help guide the LDUA until the HRSVS is within approximately 3 feet of the flange.
 - Use the HRSVS close up cameras to inspect the flange at close range using a stereo image. Control the lighting and other HRSVS parameters as needed to obtain good images.
 - Move the LDUA as required to observe as many areas as possible on the flange surface and interior.
 - Record observations as required on the data record for this step.
- Perform a close inspection of a simulated tank weld (HRSVS Inspection Test Article #1) while operating the LDUA under manual control.
 - Use the HRSVS distance cameras to locate the test article and to help guide the LDUA until the HRSVS is within approximately 3 feet of the test article.
 - Use the HRSVS close up cameras to inspect the test article at close range using a stereo image. Control the lighting and other HRSVS parameters as needed to obtain good images.
 - Move the LDUA as required to observe as many areas as possible on the test article surface.
 - Record observations as required on the data record for this step.
- Perform a close inspection of a simulated tank wall with corrosion (HRSVS Inspection Test Article #2) while operating the LDUA under manual control.
 - Use the HRSVS distance cameras to locate the test article and to help guide the LDUA until the HRSVS is within approximately 3 feet of the test article.
 - Use the HRSVS close up cameras to inspect the test article at close range using a stereo image. Control the lighting and other HRSVS parameters as needed to obtain good images.

- Move the LDUA as required to observe as many areas as possible on the test article surface.
- Record observations as required on the data record for this step.
- Perform an automated video scan of a wall section. A POR autosequence will be used to perform an automated zig-zag scan of an approximately 6 foot square section of the east wall of the CTF Test Cell.
 - Obtain the appropriate POR autosequence from the Cognizant Engineer, record it on a copy of the Joint Autosequence List (Appendix I), and enter it into the LDUA Subsystem Controller (via the LDUA Console). Record the cross-reference to the autosequence list on the data record for this step.
 - Position the LDUA near the starting point of the autosequence and orient the HRSVS to be perpendicular to the wall at approximately 36 inches from it.
 - Initiate execution of the autosequence. The LDUA should maintain the HRSVS approximately perpendicular to the wall at a distance of approximately 36 inches from the surface of the wall.
 - Use the 50 mm lenses and the close up video cameras in stereo mode.
 - Record observations as required on the data record for this step.
- Evaluate the quality of the video record by playing back the entire tape. Record the results of the evaluation on the data record for this step.

12.7.7 Withdraw LDUA from the Test Cell until the HRSVS is in the TRIC.

12.7.8 Remove and store the HRSVS, following section 5.8 of TO-080-702 (see section 3.5).

12.8 Gripper End Effector (GEE) Deployment Test Procedure

Goal: This test will verify the ability of the Gripper End Effector to grasp and pick up objects. The ability of the GEE stereo video cameras to provide an image with depth perception of the working area of the jaws will also be demonstrated. The proper response of the GEE subsystem to a loss of purge pressure will be demonstrated as will the ability to release the jaws under failure conditions to guarantee that the GEE will not trap the LDUA in the tank.

Equipment: GEE Test Article (one foot section of 2 inch steel pipe, or equivalent) for GEE to grasp and lift.

Prerequisites: LDUA Motion Test Procedure (section 12.5) must be complete.

12.8.1 Mount the GEE end effector onto the LDUA, following section 5.1 of TO-080-702 (see section 3.5).

- Record the results of the purge flow check on the data record for this step.
- Verify that the 'TIP Engaged' indicator is off prior to mounting the end effector and on after mounting it. Record the results on the data record for this step.
- Verify that the end effector ID display on the LDUA Console is correct for the GEE. Record the results on the data record for this step.
- Obtain the end effector weight/balance parameters for the GEE from the Cognizant Engineer, enter it into the LDUA Subsystem Controller (via the LDUA Console), and record them on the data record for this step.
- Obtain the point-of-resolution (POR) transform parameters for the GEE from the Cognizant Engineer, enter them into the LDUA Subsystem Controller (via the LDUA Console), and record them on the data record for this step.

12.8.2 Verify proper operation of the GEE with the LDUA purge system:

- Verify that the purge pressure reading for the inner mast tube and the VPM housing (as indicated on the LDUA Console) with the GEE mounted is above the minimum required level (record on data record for this step).
- Verify the proper response of the end effector support equipment to loss of purge

pressure:

- Set the LDUA Subsystem Controller to flammable tank mode to perform this step (CAUTION: LDUA will limp when purge pressure is lost).
- Simulate a loss of purge event by stopping purge system air supply. The pressure inside the LDUA and VPM will drop. When the pressure falls below the threshold setting of its purge pressure sensing system, the LDUA control system will response with a loss of purge trip. Verify that the GEE support equipment (6510A1) removes power from the end effector in response to this trip.
- Record response on the data record for this step.
- Set LDUA Subsystem Controller to non-flammable tank mode and restore purge pressure when step is complete.

12.8.3 Verify the basic functions of the GEE.

- Verify proper control of the lighting by turning the lights on and then off. Record results on the data record for this step.
- Verify the proper operation of the video system by selecting and observing the outputs from the GEE observation cameras on the VDRS monitors in the OCT. Verify that the images from individual cameras are stable, clear, and free of distortion and interference. Verify that the stereo image is clear and provides depth perception. Record the results on the data record for this step.
- Verify the proper operation of the jaws by moving them to the full open and full closed position. Record the results on the data record for this step.

12.8.4 Deploy the LDUA into the Test Cell

12.8.5 Demonstrate the ability of the GEE to grasp, hold, and lift the test article. Record results on data record for this step.

12.8.6 Demonstrate that the GEE will not trap the LDUA inside the tank:

- Grasp a substantial fixed object (something that is attached to the Test Cell or is very heavy, perhaps a dummy riser) and apply at least 90% of maximum gripping force.

- Simulate failure of GEE control by turning off power to the GEE pneumatic control panel (6510A1) in the ATIE.
- Release the jaws by using the manual override controls in the GEE pneumatic control panel in the ATIE. Verify that the LDUA can move the GEE away from the object.
- Record results on data record for this step.

12.8.7 Withdraw LDUA from the Test Cell until the GEE is in the TRIC.

12.8.8 Remove and store the GEE, following section 5.8 of TO-080-702 (see section 3.5).

12.9 LDUA Shoulder Camera Test Procedure

Goal: This test will verify that the LDUA shoulder camera is working properly and that it can be controlled by the operator and produce video displays and recordings. Time/Temperature characteristics of the lighting window are also determined.

Equipment: Blank video tape, contact thermometer (with range of at least 50F - 300F).

Prerequisites: Tank Entry Test Procedure (section 12.4) must be complete. Note: this test can be combined with one of the other detailed test procedures (especially section 12.5) that takes place with the arm in the CTF Test Cell, if desired.

- 12.9.1 Verify the operation of the LDUA shoulder camera. Verify that the basic control (lighting, lens, and pan/tilt) functions operate properly by exercising them from the OCT. Record results on the data record for this step. Operate the controls as necessary to obtain the best image on the VDRS monitors in the OCT. Verify that the images are stable, clear, and free of distortion and interference.
- 12.9.2 Attach HRSVS or GEE end effector, following section 5.1 of TO-080-702 (see section 3.5).
- 12.9.3 Deploy the LDUA and VPM into the CTF Test Cell.
- 12.9.4 Produce a video record from the shoulder camera while attempting to keep the end effector in view. The test performer should attempt to observe the end effector over as much of the LDUA operating envelope as possible (this would be good to combine with the joint motion test, Step 12.5.3). The video tape should be started at the beginning of this step and should be a continuous record of activities in the step. It may be interrupted if the flow of work in the step is interrupted, but must be resumed when the work resumes. Continuous LDUA position information and time shall be overlaid onto the video record. Rewind and playback the tape and evaluate for acceptability of image (stable, clear). Record the identification information from the label affixed to the video tape and the data record for this step.
- 12.9.5 Determine the external temperature versus time characteristics of the surface of the window for the shoulder camera lights.
- Window should be cool (near temperature of LDUA surface) to start.
 - Turn on shoulder camera lamps

- Measure surface temperature of window every 5 minutes and record on the data record for this step.
- When equilibrium temperature is reached, switch off the lamps (continue to take readings)
- Test is complete when temperature is within 5 degrees of starting temperature.

12.9.6 Remove and store the end effector, following section 5.8 of TO-080-702 (see section 3.5).

12.10 Auxiliary Viewing Systems Test Procedure

Goal : This test will verify the basic functions of the video systems that are deployed to provide the operator with in-tank and above-tank observation and will make a video record as part of the test data.

Equipment: None

Prerequisites: Control System Test Procedure (section 12.1) must be complete.

- 12.10.1 Verify the proper operation of each auxiliary viewing system by observing its video output on the VDRS monitors in the OCT. Verify that the images are stable, clear, and free of distortion and interference. Record the results on the data sheet for this step.

13.0 TEST PROCEDURES FOR OFF-NORMAL OPERATION

This section contains detailed test procedures that verify the behavior of the LDUA Baseline System under certain predicted failure modes, and that demonstrate and verify the proper recovery actions. These tests will be performed with the equipment in the same configuration as the System Test Procedures.

13.1 Loss of Power Recovery Test Procedure

Goal: This test will demonstrate the ability to restore LDUA System operation after a power failure while the arm is deployed and in motion. It will be conducted as though for a non-flammable tank so the LDUA will be demonstrated to hold position during power outage, and to be able to resume normal operation on restoration of power.

Equipment: None

Prerequisites: LDUA Motion Test Procedure (section 12.5) must be complete.

- 13.1.1 Attach HRSVS or GEE end effector, following section 5.1 of TO-080-702 (see section 3.5).
- 13.1.2 Deploy the LDUA into the CTF Test Cell. Position the VPM so that the end effector is between 2 and 3 feet above the floor of the CTF Test Cell when the LDUA is vertical. Then position the LDUA to be horizontal and fully extended in a direction away from the east wall of the CTF Test Cell in a position to prevent contact with structures or objects should the LDUA unexpectedly go into the limp mode.
- 13.1.3 Initiate motion along a path chosen so that the LDUA will not collide with the CTF Test Cell structures or any other objects.
- 13.1.4 During the motion, switch off MDS system power (PDS breaker# 5130CB2) and observe the behavior of the LDUA. Record observations on the data record for this step. Restore power and observe the behavior of the LDUA. Record observations on the data sheet for this step. Complete the start up sequence for the LDUA and attempt to move the LDUA. Observe the behavior of the LDUA. Record observations on the data sheet for this step.
- 13.1.5 Remove and store the end effector, following section 5.8 of TO-080-702 (see section 3.5).

13.2 Loss of Purge Recovery Test Procedure

Goal: This test verifies the proper operation of the PASS and demonstrates the behavior of the LDUA System under simulated loss of purge conditions in both flammable tank mode and non-flammable tank mode.

Equipment: None.

Prerequisites: LDUA Motion Test Procedure (section 12.5) must be complete.

13.2.1 Turn on the PASS and allow its pressure to reach equilibrium

13.2.2 Set LDUA Subsystem Controller to non-flammable tank mode

13.2.3 Attach HRSVS or GEE end effector, following section 5.1 of TO-080-702 (see section 3.5).

13.2.4 Deploy the LDUA and VPM into the CTF Test Cell. Position the VPM so that the end effector is between 2 and 3 feet above the floor of the CTF Test Cell when the LDUA is vertical. Then position the LDUA to be horizontal and fully extended in a direction roughly perpendicular to the east wall of the CTF Test Cell. This will prevent contact with structures or objects when the LDUA goes into the limp condition.

13.2.5 Simulate failure of PASS in non-flammable tank mode:

- Record the reading from the discharge pressure gage of the PASS on the data record for this step.
- Shut off power to the PASS. Begin measuring elapsed time and observe the LDUA purge pressure indications and status of the loss-of-purge alarm on the LDUA Console.
- When loss-of-purge alarm occurs, note the elapsed time, LDUA purge pressure indications, and PASS discharge pressure reading. Observe the behavior of the LDUA in response to the loss of purge, and then to attempt to operate it. Record these observations on the data record for this step.
- Restore power to the PASS. Begin measuring elapsed time. Observe the LDUA purge pressure indications and status of the loss-of-purge alarm on the LDUA Console.

- When the loss-of-purge alarm condition clears, note the elapsed time, LDUA purge pressure indications, and PASS discharge pressure reading. Attempt to operate the LDUA and observe its response. Record these observations on the data record for this step.

13.2.6 Set LDUA Subsystem Controller to flammable tank mode

13.2.7 Simulate failure of PASS in flammable tank mode:

- Repeat step 13.2.5 and record the observations in the data record for this step.
- Obtain, from the Cognizant Engineer, the required minimum time for 10 exchanges of air in the purged volume of the LDUA and VPM. Record in the data record for this step. Verify that the elapsed time from restoration of PASS power until clearance of purge trip is at least this long. Record in the data record for this step.

13.2.8 Demonstrate recovery of limp LDUA:

- Turn off power to PASS
- Wait for loss-of-purge alarm to occur and the LDUA to go into the limp condition
- Withdraw the LDUA from the CTF Test Cell using normal control of the VPM. CAUTION: perform this operation slowly and carefully observe the contact between the LDUA and simulated 12 inch riser - it is possible that the LDUA boots may be torn or otherwise damaged by this operation. If damage appears imminent, stop the operation and record an exception.

13.2.9 Remove and store the end effector, following section 5.8 of TO-080-702 (see section 3.5).

14.0 DISPOSITION OF TEST ITEMS

The LDUA Baseline System equipment will be left in place in the CTF following completion of this test procedure. The removal and staging of this equipment for further testing and operations training in the FMEF east yard, or removal and packaging for transport to the tank farm will be addressed by other procedures.

15.0 DATA SHEETS

This section contain the data sheets that record the results of performing the detailed test procedures in sections 12 and 13.

LDUA Equipment Qualification Test Completion Record

The LDUA Equipment Qualification Test is complete:

TD _____ Date _____, TWRS CE _____ Date _____, QE _____ Date _____,

Comments:

Completion Record for Detailed Test Procedure 12.1		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 12.1.1 TP: _____ Date: _____	Step: 12.1.2 TP: _____ Date: _____	Step: 12.1.3 TP: _____ Date: _____
Step: 12.1.4 TP: _____ Date: _____	Step: 12.1.5 TP: _____ Date: _____	Step: 12.1.6 TP: _____ Date: _____
Step: 12.1.7 TP: _____ Date: _____		
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 12.1.2		
Workstation login (acceptable result: answer yes to all y/n questions)		
Workstation	Result of Invalid Password Attempt	Result of Valid Password Attempt
Data Acquisition Workstation	Login attempt was rejected ____ (y/n), TP: ____ Date: ____	Login attempt was accepted ____ (y/n), TP: ____ Date: ____
Operations Workstation	Login attempt was rejected ____ (y/n), TP: ____ Date: ____	Login attempt was accepted ____ (y/n), TP: ____ Date: ____
LDUA Console	Login attempt was rejected ____ (y/n), TP: ____ Date: ____	Login attempt was accepted ____ (y/n), TP: ____ Date: ____
Auxiliary Workstation	Login attempt was rejected ____ (y/n), TP: ____ Date: ____	Login attempt was accepted ____ (y/n), TP: ____ Date: ____

Data Record for Step 12.1.4	
Baseline purge pressure/flow parameters (there are no required acceptance criteria for this data)	
Purge Air Supply pressure	Supply pressure reading (at VPM interface connector) _____ (psi), TP: _____ Date: _____
VPM Inner tube/LDUA purge pressure	Baseline pressure reading: _____ (in of water), Min. pressure threshold: _____ (in of water) (90% of baseline), TP: _____ Date: _____
VPM outer tube/VPM housing purge pressure	Baseline pressure reading: _____ (in of water), Min. pressure threshold: _____ (in of water) (90% of baseline), TP: _____ Date: _____
Purge flow at TIP connector	Baseline flow reading: _____ (SCFM), Min. flow threshold: _____ (SCFM) (90% of baseline), TP: _____ Date: _____
Source of data	Baseline values were obtained from: [] new measurement / [] LDUA Post Delivery Acceptance Test, TD: _____ Date: _____, TP: _____ Date: _____

Data Record for Step 12.1.5	
General System Parameter (information only)	
Parameter Group:	Set Value:
Tank Site	Tank ID _____
Base to World Coordinate Transform	X _____ (inches), Y _____ (inches), Z _____ (inches), Yaw _____ (degrees), Pitch _____ (degrees), Roll _____ (degrees)
VPM Data	Max. Extension for Active MDS _____ (inches), Min. Extension to Enable LDUA _____ (inches), Riser Top Position _____ (inches)
Global Position Data	Truck Azimuth _____ (degrees from true North), Riser Azimuth _____ (degrees from true North), Riser Elevation _____ (degrees from horizontal i.e. 90 = vertical), Riser Length _____ (inches)
	CE _____ Date _____, TP: _____ Date: _____

Procedure Step Completion Record For Detailed Test Procedure 12.2		
Pre-job briefing is complete: PIC: _____ Date: _____		
Prerequisites are complete: TD: _____ Date: _____		
Comments:		
Step: 12.2.1 TP: _____ Date: _____	Step: 12.2.2 TP: _____ Date: _____	Step: 12.2.3 TP: _____ Date: _____
Step: 12.2.4 TP: _____ Date: _____	Step: 12.2.5 TP: _____ Date: _____	Step: 12.2.6 TP: _____ Date: _____
Step: 12.2.7 TP: _____ Date: _____	Step: 12.2.8 TP: _____ Date: _____	Step: 12.2.9 TP: _____ Date: _____
Step: 12.2.10 TP: _____ Date: _____	Step: 12.2.11 TP: _____ Date: _____	Step: 12.2.12 TP: _____ Date: _____
Step: 12.2.13 TP: _____ Date: _____	Step: 12.2.14 TP: _____ Date: _____	Step: 12.2.15 TP: _____ Date: _____
Test results are acceptable: TE: _____ Date: _____		
Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____		
Comments:		
Test Procedure is complete: TD: _____ Date: _____		
Comments:		

Data Record for Step 12.2.3	
MDS software motion locks	
Axis:	Behavior (when software locks are set): (acceptable result: answer yes to all y/n questions)
X	Motion commands are rejected (y/n), TP: _____ Date: _____
Y	Motion commands are rejected (y/n), TP: _____ Date: _____
Roll	Motion commands are rejected (y/n), TP: _____ Date: _____
Pitch	Motion commands are rejected (y/n), TP: _____ Date: _____

Data Record for Step 12.2.1	
Tilted riser parameters	
Parameter:	Value:
Azimuth (direction of tilt) (for information only - no acceptance criteria)	TP: _____ Date: _____ (degrees from North, using CTF mezzanine wall as North/South reference line)
Elevation (magnitude of tilt) (acceptable value 85 - 89 degrees)	TP: _____ Date: _____ (degrees, measure relative to horizontal - dead plumb = 90 degrees)

Data Record for Step 12.2.4	
OAS mounting operation	
Parameter:	Value:
Purge Flow Check (acceptable result: answer yes to all y/n questions)	Purge Flow Check Value _____ (SCFM), Min. Flow threshold (data record for step 12.1.4) _____ (in water), Purge Flow Check Value greater then Min. Flow threshold _____ (y/n), TP: _____ Date: _____
TIP Engaged (acceptable result: answer yes to all y/n questions)	Indicator is 'off' prior to mounting end effector _____ (y/n), Indicator is 'on' after mounting end effector _____ (y/n), TP: _____ Date: _____
End Effector ID (acceptable result is 2)	End Effector ID _____, TP: _____ Date: _____
End Effector weight/balance Parameters (for information only)	Length _____ (in), Max. Diameter _____ (in), Mass _____ (lbs) Center of Gravity: X _____ (in); Y _____ (in); Z _____ (in), CE: _____ Date: _____, TP: _____ Date: _____

Data Record for Step 12.2.5	
OAS Purge Function (acceptable result: answer yes to all y/n questions)	
Parameter:	Result:
Inner VPM tube purge pressure	Pressure reading with OAS mounted: _____ (in of water), Min. pressure threshold (data record for step 12.1.4) _____ (in water), Is pressure reading with OAS greater then Min. Pres. threshold ____ (y/n), TP: _____ Date: _____
VPM housing purge pressure	Pressure reading with OAS: _____ (in of water), Min. pressure threshold (data record for step 12.1.4) _____ (in water), Is pressure reading with OAS greater then Min. pres. threshold ____ (y/n), TP: _____ Date: _____
Response to loss of purge pressure	Did CVEE shut down in response to loss of purge pressure ____ (y/n), TP: _____ Date: _____

Data Record for Step 12.2.6	
OAS lighting control functions (acceptable result: answer yes to all y/n questions)	
Lamp Set:	Controllability:
Lamp Set #1	On ____ (y/n), Off ____ (y/n), TP: _____ Date: _____
Lamp Set #2	On ____ (y/n), Off ____ (y/n), TP: _____ Date: _____
Lamp Set #3	On ____ (y/n), Off ____ (y/n), TP: _____ Date: _____
Lamp Set #4	On ____ (y/n), Off ____ (y/n), TP: _____ Date: _____
All Lamp Sets	On ____ (y/n), Off ____ (y/n), TP: _____ Date: _____

Data Record for Step 12.2.7	
OAS video functions (acceptable result: answer yes to all y/n questions)	
Component:	Video Performance:
OAS Main Camera	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
VDRS Monitor #1	Reticle is visible using input channel A _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.2.8	
OAS spot laser control functions (acceptable result: answer yes to all y/n questions)	
Laser Set:	Controllability:
Laser Set A	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____
Laser Set B	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____
Both Laser Sets	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.2.9	
OAS displacement laser control and monitoring functions (acceptable result: answer yes to all y/n questions)	
Laser:	Observation: (move hand-held target over a range of 0.25 - 1.0 inches)
Top Front	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____
Right Front	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____
Bottom Front	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____
Left Front	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____
Top Rear	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____
Right Rear	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____
Bottom Rear	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____
Left Rear	Display appears to follow target distance _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.2.10			
VPM Alignment process data (acceptable result: at least one attempt must be successful)			
Attempt #	Inclinometer Reading	Minimum Clearance Readings	Result
Attempt #1	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #2	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #3	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #4	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #5	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.2.11	
Plumb riser parameters	
Parameter:	Value:
Elevation (magnitude of tilt) (acceptable value 89.5 - 90 degrees)	_____ (degrees, measure relative to horizontal - dead plumb = 90 degrees), TP: _____ Date: _____

Data Record for Step 12.2.12			
VPM Alignment process data (acceptable result: at least one attempt must be successful)			
Video Tape	Tape ID _____ TP: _____ Date: _____		
Attempt #	Inclinometer Reading	Minimum Clearance Readings	Result
Attempt #1	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #2	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #3	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #4	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____
Attempt #5	Roll _____ (deg), Pitch _____ (deg)	Displ. Laser # _____ (in), Distance _____ (in), VPM Position _____ (in), Wrist Roll _____ (deg)	Attempt was successful _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.2.14	
Riser parameters	
Parameter:	Value:
VPM housing to TRIC distance	A. Distance measured at first point _____ (in) (info only), B. Distance measured at second point _____ (in) (info only), C. Calculated average distance: $(A+B)/2=$ _____ (in) (info only), TP: _____ Date: _____
Actual Riser Top Position	D. Calculated position of top of riser: $C + 79.25=$ _____ (in) (info only), TP: _____ Date: _____
Actual Riser Length	E. Measured length of riser _____ (in) (info only), TP: _____ Date: _____
Adjusted Riser Top Position	F. Calculated position of riser (allowing for EE and Riser Isolation valve): $D + 45.25=$ _____ (in) (info only), Value (F) was entered as "Riser Top Position" parameter into the LDUA Subsystem Controller _____ (y/n), TP: _____ Date: _____
Adjusted Riser Length	G. Calculated length of riser (allowing for adjustment made to Riser Top Position): $E + 33.75=$ _____ (in) (info only), Value (G) was entered as "Riser Top Position" parameter into the LDUA Subsystem Controller _____ (y/n), TP: _____ Date: _____

Completion Record for Detailed Test Procedure 12.3		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 12.3.1 TP: _____ Date: _____		
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 12.3.1			
MDS and VPM Inclinator stability			
Date/Time	VPM Inclinometers	External Inclinometers	Comments
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	
TP: _____	Roll _____ (deg) Pitch _____ (deg)	Roll _____ (deg) Pitch _____ (deg)	

Completion Record for Detailed Test Procedure 12.4		
Pre-job briefing is complete: PIC: _____ Date: _____		
Prerequisites are complete: TD: _____ Date: _____		
Comments:		
Step: 12.4.1 TP: _____ Date: _____	Step: 12.4.2 TP: _____ Date: _____	Step: 12.4.3 TP: _____ Date: _____
Step: 12.4.4 TP: _____ Date: _____	Step: 12.4.5 TP: _____ Date: _____	Step: 12.4.6 TP: _____ Date: _____
Test results are acceptable: TE: _____ Date: _____		
Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____		
Comments:		
Test Procedure is complete: TD: _____ Date: _____		
Comments:		

Data Record for Step 12.4.1		
VPM motion interlock with Riser Isolation Valve (acceptable result: answer yes to all y/n questions)		
Event	Conditions	Behavior:
LDUA TIP reaches plane of joint between TRIC enclosure and Decon Module	Riser Isolation Valve is not Open	VPM motion stops _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.4.3		
Deployment through 12 inch riser (acceptable result: answer yes to all y/n questions)		
Dep. #	VPM Tube Parameter settings:	Observations:
1	Sequence = Outer/Inner Outer Mast Extension = -363.12 (inches)	Joint Autosequence: ID _____ CE: _____ Date: _____, TP: _____ Date: _____ VPM starting position _____ (inches) (information only), VPM ending position _____ (inches) (information only), VPM/LDUA/EE did not interfere with riser _____ (y/n), VPM tube transition occurred at specified extension _____ (y/n), TP: _____ Date: _____
2	Sequence = Inner/Outer Inner Mast Extension = -187.65 (inches)	Joint Autosequence: ID _____ CE: _____ Date: _____, TP: _____ Date: _____ VPM starting position _____ (inches) (information only), VPM ending position _____ (inches) (information only), VPM/LDUA/EE did not interfere with riser _____ (y/n), VPM tube transition occurred at specified extension _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.4.4		
Maximum riser deflection (there are no acceptance criteria - data is for information only)		
Position:	LVDT Readings:	Results/Observations:
Riser empty	#1(A) _____ (in.) #2(B) _____ (in.) #3(C) _____ (in.)	(Establishes non-deflected baseline)
LDUA vertical with end effector within 12 inches of floor of CTF Test Cell	#1(A) _____ (in.) #2(B) _____ (in.) #3(C) _____ (in.)	VPM position _____ (inches), Calculated* deflection _____ (inches), TP: _____ Date: _____
LDUA Horizontal with:		
VPM at maximum extension	#1(A) _____ (in.) #2(B) _____ (in.) #3(C) _____ (in.)	VPM position _____ (inches), Calculated* deflection _____ (inches), TP: _____ Date: _____
VPM 10' above maximum extension	#1(A) _____ (in.) #2(B) _____ (in.) #3(C) _____ (in.)	VPM position _____ (inches), Calculated* deflection _____ (inches), TP: _____ Date: _____
VPM 20' above maximum extension	#1(A) _____ (in.) #2(B) _____ (in.) #3(C) _____ (in.)	VPM position _____ (inches), Calculated* deflection _____ (inches), TP: _____ Date: _____
*Formula used for calculation:		
$S = 100 \sqrt{1 - \frac{525625}{3364 (Z_A - Z_B)^2 + 10000 (Z_C - Z_B)^2 + 525625}}$		
<p>where: Z_A, Z_B, and Z_C are the readings (in inches) obtained by the LVDT's at a given instant.</p> <p>The physical relationship of the three LVDTs in the simulated riser flange is as shown below (viewed looking downward).</p> <div style="text-align: center;"> <p style="margin-left: 100px;">A B</p> <p style="margin-left: 200px;">• •</p> <p style="margin-left: 200px;">• C</p> </div>		

Data Record for Step 12.4.5	
LDUA deployment into minimum clearance (acceptable result: answer yes to all y/n questions)	
Parameter:	Results/Observations:
Imaginary Riser	Riser Length _____ (inches) (information only - no acceptance criteria), TP: _____ Date: _____
Minimum clearance joint autosequence	Joint Autosequence ID _____ CE: _____ Date: _____, TP: _____ Date: _____
Motion within boundaries	The LDUA remained within the boundaries during the minimum clearance deployment sequence: _____(y/n) - Observer #1 _____ Date _____, _____(y/n) - Observer #2 _____ Date _____, TP: _____ Date: _____

Completion Record for Detailed Test Procedure 12.5		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 12.5.1 TP: _____ Date: _____	Step: 12.5.2 TP: _____ Date: _____	Step: 12.5.3 TP: _____ Date: _____
Step: 12.5.4 TP: _____ Date: _____	Step: 12.5.5 TP: _____ Date: _____	Step: 12.5.6 TP: _____ Date: _____
Step: 12.5.7 TP: _____ Date: _____		
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 12.5.3	
Manual control of joints (acceptable result: answer yes to all y/n questions)	
Joint:	Observations:
Shoulder Yaw	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____
Shoulder Pitch	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____
Elbow 1	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____
Elbow 2	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____
Wrist Yaw	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____
Wrist Pitch	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____
Wrist Roll	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____
VPM	Actual joint answers command from joystick in both directions ____ (y/n), Corresponding joint on SGCS model of LDUA tracks actual joint ____ (y/n), TP: ____ Date: ____

Data Record for Step 12.5.4	
Manual control of resolved motion with preview and collision checking (acceptable result: answer yes to all y/n questions)	
Parameter:	Observations:
Starting position	VPM _____, SY _____, SP _____, E1 _____, E2 _____, WY _____, WP _____, WR _____, TP: _____ Date: _____
Preview (with collision)	Collision with wall is detected by SGCS _____ (y/n), TP: _____ Date: _____
Preview (without Collision)	Preview was completed _____ (y/n), TP: _____ Date: _____
Execution of previewed motion	Actual path followed previewed path (visual observation only) _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.5.5	
Stability while in contact with obstacle	
Parameter:	Observations:
Force exerted	Maximum force observed while end effector was in contact with obstacle _____ (lbs.) (0 - 75 lbs) TP: _____ Date: _____
Stability of LDUA	There was no erratic movement of LDUA while end effector was in contact with obstacle _____ (y/n), TP: _____ Date: _____

Procedure Step Completion Record For Detailed Test Procedure 12.6		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 12.6.1 TP: _____ Date: _____	Step: 12.6.2 TP: _____ Date: _____	Step: 12.6.3 TP: _____ Date: _____
Step: 12.6.4 TP: _____ Date: _____	Step: 12.6.5 TP: _____ Date: _____	Step: 12.6.6 TP: _____ Date: _____
Step: 12.6.7 TP: _____ Date: _____	Step: 12.6.8 TP: _____ Date: _____	Step: 12.6.9 TP: _____ Date: _____
Step: 12.6.10 TP: _____ Date: _____	Step: 12.6.11 TP: _____ Date: _____	Step: 12.6.12 TP: _____ Date: _____
Step: 12.6.13 TP: _____ Date: _____	Step: 12.6.14 TP: _____ Date: _____	
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 12.6.2		
VPM motion interlock with Radiation Monitor (acceptable result: answer yes to all y/n questions)		
Event:	Conditions:	Behavior:
High radiation alarm occurs	VPM is moving up	VPM motion stops ____ (y/n), TP: ____ Date: ____
VPM high radiation interlock is bypassed	High radiation alarm is still occurring	VPM can be moved up ____ (y/n), TP: ____ Date: ____

Data Record for Step 12.6.6	
Decon operation with LDUA, VPM, HRSVS	
Parameter:	Observed Value:
Pump	Pressure after equilibrium ____ (psig, acceptable: 450 - 500 psig), TP: ____ Date: ____
VPM	Speed of withdrawal ____ (ft/min, acceptable: 1.5 - 2.5), TP: ____ Date: ____
Flow (information only)	Totalizer reading at start ____ (gal), Totalizer reading at end ____ (gal), Total net flow ____ (gal), TP: ____ Date: ____
Time (information only)	Start time ____, Stop time ____, Elapsed time ____, TP: ____ Date: ____

Data Record for Step 12.6.7	
HRSVS post-decon evaluation (acceptable result: answer yes to all y/n questions)	
Evaluation:	Result:
Functional Check	Lights ____ (y/n), Camera ____ (y/n), Spot lasers ____ (y/n), Displacement lasers ____ (y/n), TP: ____ Date: ____
Leakage Check	Are the visible interior surfaces of the end effector free of water pools, beads, or drops ____ (y/n), TP: ____ Date: ____

Data Record for Step 12.6.9	
Decon operation with OAS	
Parameter:	Observed Value:
Pump	Pressure after equilibrium _____ (psig, acceptable: 450 -500 psig), TP: _____ Date: _____
VPM	Speed of withdrawal _____ (ft/min, acceptable: 1.5 - 2.5), TP: _____ Date: _____
Flow (information only)	Totalizer reading at start _____ (gal), Totalizer reading at end _____ (gal), Total net flow _____ (gal), TP: _____ Date: _____
Time (information only)	Start time _____, Stop time _____, Elapsed time _____, TP: _____ Date: _____

Data Record for Step 12.6.10	
OAS post-decon evaluation (acceptable result: answer yes to all y/n questions)	
Evaluation:	Result:
Functional Check	Lights _____ (y/n), Close up cameras _____ (y/n), Distance cameras _____ (y/n), TP: _____ Date: _____
Leakage Check	Are the visible interior surfaces of the end effector free of water pools, beads, or drops _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.6.12	
Decon operation with GEE	
Parameter:	Observed Value:
Pump	Pressure after equilibrium _____ (psig, acceptable: 450 - 500 psig), TP: _____ Date: _____
VPM	Speed of withdrawal _____ (ft/min, acceptable: 1.5 - 2.5), TP: _____ Date: _____
Flow (information only)	Totalizer reading at start _____ (gal), Totalizer reading at end _____ (gal), Total net flow _____ (gal), TP: _____ Date: _____
Time (information only)	Start time _____, Stop time _____, Elapsed time _____, TP: _____ Date: _____

Data Record for Step 12.6.13	
GEE post-decon evaluation (acceptable result: answer yes to all y/n questions)	
Evaluation:	Result:
Functional Check	Lights _____ (y/n), Cameras _____ (y/n), Jaws _____ (y/n), TP: _____ Date: _____
Leakage Check	Are the visible interior surfaces of the end effector free of water pools, beads, or drops _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.6.14	
LDUA post-decon evaluation (acceptable result: answer yes to all y/n questions)	
Evaluation:	Result:
Functional Check	Does LDUA operate in resolved motion with no visible anomalies _____ (y/n), TP: _____ Date: _____
Leakage Check	Remove boots: Are the visible interior surfaces of the LDUA free of water pools, beads, or drops _____ (y/n), TP: _____ Date: _____

Procedure Step Completion Record for Detailed Test Procedure 12.7		
Pre-job briefing is complete: PIC: _____ Date: _____		
Prerequisites are complete: TD: _____ Date: _____		
Comments:		
Step: 12.7.1 TP: _____ Date: _____	Step: 12.7.2 TP: _____ Date: _____	Step: 12.7.3 TP: _____ Date: _____
Step: 12.7.4 TP: _____ Date: _____	Step: 12.7.5 TP: _____ Date: _____	Step: 12.7.6 TP: _____ Date: _____
Step: 12.7.7 TP: _____ Date: _____	Step: 12.7.8 TP: _____ Date: _____	
Test results are acceptable: TE: _____ Date: _____		
Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____		
Comments:		
Test Procedure is complete: TD: _____ Date: _____		
Comments:		

Data Record for Step 12.7.1	
HRSVS mounting operation (acceptable result: answer yes to all y/n questions)	
Parameter:	Observation:
Purge Flow Check	Purge Flow Check Value _____ (SCFM), Min. Flow threshold (data record for step 12.1.4) _____ (in water), Purge Flow Check Value greater then Min. Flow threshold _____ (y/n), TP: _____ Date: _____
TIP Engaged	Indicator is 'off' prior to mounting end effector _____ (y/n), Indicator is 'on' after mounting end effector _____ (y/n), TP: _____ Date: _____
End Effector ID	Is End Effector ID = 0 _____ (y/n), if not, what _____ TP: _____ Date: _____
End Effector weight/balance Parameters (for information only)	Length _____ (in), Max. Diameter _____ (in), Mass _____ (lbs) Center of Gravity: X _____ (in); Y _____ (in); Z _____ (in), CE: _____ Date: _____, TP: _____ Date: _____
End Effector POR transform parameters (for information only)	X _____ (in), Y _____ (in), Z _____ (in), Roll _____ (deg), Pitch _____ (deg), Yaw _____ (deg), CE: _____ Date: _____, TP: _____ Date: _____

Data Record for Step 12.7.2	
HRSVS Purge Function (acceptable result: yes to all y/n questions)	
Parameter:	Value:
Inner VPM tube purge pressure	Pressure reading with HRSVS: _____ (in of water), Min. pressure threshold (data record for step 12.1.4) _____ (in water), Is pressure reading with HRSVS greater then minimum threshold _____ (y/n) TP: _____ Date: _____
VPM housing purge pressure	Pressure reading with HRSVS: _____ (in of water), Min. pressure threshold (data record for step 12.1.4) _____ (in water), Is pressure reading with HRSVS greater then minimum threshold _____ (y/n) TP: _____ Date: _____
Response to loss of purge pressure	Did CVEE shut down in response to loss of purge pressure _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.7.3	
HRSVS lighting control functions (acceptable result: answer yes to all y/n questions)	
Lamp Set:	Controllability:
Lamp Set #1	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____
Lamp Set #2	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____
Lamp Set #3	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____
Lamp Set #4	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____
Lamp Set #5	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____
All Lamp Sets	On _____ (y/n), Off _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.7.5	
HRSVS video functions (acceptable result: answer yes to all y/n questions)	
Camera(s):	Video Performance:
Left Distance Camera	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Right Distance Camera	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Left Close up camera with 16 mm lens	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Right Close up camera with 16 mm lens	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Close up stereo with 16 mm lens	Image free of doubling _____ (y/n), Image provides depth perception _____ (y/n), TP: _____ Date: _____
Left Close up camera with 25 mm lens	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Right Close up camera with 25 mm lens	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Close up stereo with 25 mm lens	Image free of doubling _____ (y/n), Image provides depth perception _____ (y/n), TP: _____ Date: _____
Left Close up camera with 50 mm lens	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Right Close up camera with 50 mm lens	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
Close up stereo with 50 mm lens	Image free of doubling _____ (y/n), Image provides depth perception _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.7.6	
HRSVS In-Tank Video Survey performance (acceptable result: answer yes to all y/n questions)	
Video Tape Information	Tape ID _____ TP: _____ Date: _____
Feature of Test Cell	Observation
Flange on simulated riser in simulated waste tank section	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), Image free of doubling _____ (y/n), Image provides depth perception _____ (y/n), TP: _____ Date: _____
HRSVS Test Article #1 on east wall of Test Cell	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), Image free of doubling _____ (y/n), Image provides depth perception _____ (y/n), TP: _____ Date: _____
HRSVS Test Article #2 on east wall of Test Cell	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), Image free of doubling _____ (y/n), Image provides depth perception _____ (y/n), TP: _____ Date: _____
Automated scan of area on east wall of CTF Test Cell	POR Autosequence ID: _____ Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), Image free of doubling _____ (y/n), Image provides depth perception _____ (y/n), TP: _____ Date: _____
Video Tape Record	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), Video image during movement is smooth and stable _____ (y/n), TP: _____ Date: _____

Completion Record for Detailed Test Procedure 12.8		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 12.8.1 TP: _____ Date: _____	Step: 12.8.2 TP: _____ Date: _____	Step: 12.8.3 TP: _____ Date: _____
Step: 12.8.4 TP: _____ Date: _____	Step: 12.8.5 TP: _____ Date: _____	Step: 12.8.6 TP: _____ Date: _____
Step: 12.8.7 TP: _____ Date: _____	Step: 12.8.8 TP: _____ Date: _____	
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 12.8.1	
GEE mounting operation (acceptable result: answer yes to all y/n questions)	
Parameter:	Value:
Purge Flow Check	Purge Flow Check Value _____ (SCFM), Min. Flow threshold (data record for step 12.1.4) _____ (in water), Purge Flow Check Value greater then Min. Flow threshold _____ (y/n), TP: _____ Date: _____
TIP Engaged	Indicator is 'off' prior to mounting end effector _____ (y/n), Indicator is 'on' after mounting end effector _____ (y/n), TP: _____ Date: _____
End Effector ID	Is End Effector ID = 5 _____ (y/n), if not, what _____ TP: _____ Date: _____
End Effector weight/balance Parameters (for information only)	Length _____ (in), Max. Diameter _____ (in), Mass _____ (lbs) Center of Gravity: X _____ (in); Y _____ (in); Z _____ (in), CE: _____ Date: _____, TP: _____ Date: _____
End Effector POR transform parameters (for information only)	X _____ (in), Y _____ (in), Z _____ (in), Roll _____ (deg), Pitch _____ (deg), Yaw _____ (deg), CE: _____ Date: _____, TP: _____ Date: _____

Data Record for Step 12.8.2	
GEE Purge Function (acceptable result: yes to all y/n questions)	
Parameter:	Observation:
Inner VPM tube purge pressure	Pressure reading with GEE mounted: _____ (in of water), Min. pressure threshold (data record for step 12.1.4) _____ (in water), Is pressure reading with GEE greater then minimum threshold ____ (y/n) TP: _____ Date: _____
VPM housing purge pressure	Pressure reading with GEE mounted: _____ (in of water), Min. pressure threshold (data record for step 12.1.4) _____ (in water), Is pressure reading with GEE greater then minimum threshold ____ (y/n) TP: _____ Date: _____
Response to loss of purge pressure	Did GEE support equipment shut down in response to loss of purge pressure ____ (y/n), TP: _____ Date: _____

Data Record for Step 12.8.3	
GEE basic functions (acceptable result: answer yes to all y/n questions)	
Component:	Observation:
Lamps	On ____ (y/n), Off ____ (y/n), TP: _____ Date: _____
Left Camera	Clear ____ (y/n), Stable ____ (y/n), Free of distortion ____ (y/n), Free of interference ____ (y/n), TP: _____ Date: _____
Right Camera	Clear ____ (y/n), Stable ____ (y/n), Free of distortion ____ (y/n), Free of interference ____ (y/n), TP: _____ Date: _____
Stereo Image	Image free of doubling ____ (y/n), Image provides depth perception ____ (y/n), TP: _____ Date: _____
Jaws	Move freely to full open ____ (y/n), Move freely to full close ____ (y/n), TP: _____ Date: _____

Data Record for Step 12.8.5	
GEE grasping, holding, and lifting (acceptable result: answer yes to all y/n questions)	
Component:	Observations:
Test article	Weight of test article _____ (lbs) (information only, no requirement), GEE was able to grasp, hold, and lift test article _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.8.6	
GEE recovery (acceptable result: answer yes to all y/n questions)	
Event:	Response:
Simulated failure of GEE	Jaws can be opened with manual override control in ATIE _____ (y/n), LDUA can be withdrawn _____ (y/n), TP: _____ Date: _____

Completion Record for Detailed Test Procedure 12.9		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 12.9.1 TP: _____ Date: _____	Step: 12.9.2 TP: _____ Date: _____	Step: 12.9.3 TP: _____ Date: _____
Step: 12.9.4 TP: _____ Date: _____	Step: 12.9.5 TP: _____ Date: _____	
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 12.9.1	
Shoulder camera basic functions	
Component:	Function/Observation:
Lights	On _____ (y/n), Off _____ (y/n), Step intensity _____ (y/n), TP: _____ Date: _____
Focus	In _____ (y/n), Out _____ (y/n), TP: _____ Date: _____
Iris	Open _____ (y/n), Close _____ (y/n), TP: _____ Date: _____
Zoom	Magnify _____ (y/n), Reduce _____ (y/n), TP: _____ Date: _____
Pan	Left _____ (y/n), Right _____ (y/n), TP: _____ Date: _____
Tilt	Up _____ (y/n), Down _____ (y/n), TP: _____ Date: _____
Camera	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____

Data Record for Step 12.9.4	
Shoulder Camera video tape record	
Component	Observations
Video Tape Information	Tape ID _____ TP: _____ Date: _____

Completion Record for Detailed Test Procedure 12.10		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 12.10.1 TP: _____ Date: _____		
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 12.10.1	
Auxiliary viewing systems evaluation (acceptable result: answer yes to all y/n questions)	
Name of Aux. Viewing System:	Video Performance:
	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____
	Clear _____ (y/n), Stable _____ (y/n), Free of distortion _____ (y/n), Free of interference _____ (y/n), TP: _____ Date: _____

Completion Record for Detailed Test Procedure 13.1		
Pre-job briefing is complete: PIC: _____ Date: _____		
Prerequisites are complete: TD: _____ Date: _____		
Comments:		
Step: 13.1.1 TP: _____ Date: _____	Step: 13.1.2 TP: _____ Date: _____	Step: 13.1.3 TP: _____ Date: _____
Step: 13.1.4 TP: _____ Date: _____	Step: 13.1.5 TP: _____ Date: _____	
Test results are acceptable: TE: _____ Date: _____		
Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____		
Comments:		
Test Procedure is complete: TD: _____ Date: _____		
Comments:		

Data Record for Step 13.1.4	
Loss of Power (acceptable result: answer yes to all y/n questions)	
Event:	Behavior/Observations:
Power to MDS is interrupted while LDUA is in motion	Does LDUA stop and hold position _____ (y/n), TP: _____ Date: _____
Power to MDS is restored after interruption	Does LDUA remain stable _____ (y/n), Can LDUA be operated _____ (y/n), TP: _____ Date: _____

Completion Record for Detailed Test Procedure 13.2		
Pre-job briefing is complete: PIC: _____ Date: _____ Prerequisites are complete: TD: _____ Date: _____ Comments:		
Step: 13.2.1 TP: _____ Date: _____	Step: 13.2.2 TP: _____ Date: _____	Step: 13.2.3 TP: _____ Date: _____
Step: 13.2.4 TP: _____ Date: _____	Step: 13.2.5 TP: _____ Date: _____	Step: 13.2.6 TP: _____ Date: _____
Step: 13.2.7 TP: _____ Date: _____	Step: 13.2.8 TP: _____ Date: _____	Step: 13.2.9 TP: _____ Date: _____
Test results are acceptable: TE: _____ Date: _____ Comments:		
Test result documentation is complete and acceptable: QE: _____ Date: _____ Comments:		
Test Procedure is complete: TD: _____ Date: _____ Comments:		

Data Record for Step 13.2.5	
Simulated PASS failure in non-flammable tank	
Event:	Observations:
PASS at equilibrium pressure	PASS discharge pressure _____ (psig) (acceptable: no lower than purge supply pressure recorded in step 12.1.4), TP: _____ Date: _____
PASS power off; loss-of-purge alarm occurs	PASS discharge pressure _____ (psig) (information only), VPM outer tube purge pressure _____ (in of water) (0.1 - 0.5 in of water), LDUA purge pressure _____ (in of water) (0.1 - 0.5 in of water), Elapsed time _____ (min) (information only), LDUA remains in position _____ (y/n) (acceptable: yes answer), LDUA is operable _____ (y/n) (acceptable: yes answer), TP: _____ Date: _____
PASS power restored, loss-of-pressure alarm clears	PASS discharge pressure _____ (psig) (information only), VPM outer tube purge pressure _____ (in of water) (0.25 - 3.5 in of water), LDUA purge pressure _____ (in of water) (0.25 - 3.5 in of water), Elapsed time _____ (min) (information only), LDUA is operable _____ (y/n) (acceptable: yes answer), TP: _____ Date: _____

Data Record for Step 13.2.7	
Simulated PASS failure in flammable tank	
Event:	Observations:
PASS at equilibrium pressure	PASS discharge pressure _____ (psig) (information only), TP: _____ Date: _____
PASS power off, loss-of-purge alarm occurs	PASS discharge pressure _____ (psig) (information only), VPM outer tube purge pressure _____ (in of water) (0.1 - 0.5 in of water), LDUA purge pressure _____ (in of water) (0.1 - 0.5 in of water), Elapsed time _____ (min) (information only), LDUA becomes limp _____ (y/n) (acceptable: yes answer), LDUA is not operable _____ (y/n) (acceptable: yes answer), TP: _____ Date: _____
PASS power restored, loss-of-pressure alarm clears	PASS discharge pressure _____ (psig) (information only), VPM outer tube purge pressure _____ (in of water) (0.25 - 3.5 in of water), LDUA purge pressure _____ (in of water) (0.25 - 3.5 in of water), Elapsed time _____ (min) (information - used below), Time required to exchange 10 volumes of LDUA/VPM _____ (min), Is elapsed time greater than time to exchange 10 volumes _____ (y/n) (acceptable: yes answer) LDUA becomes operable _____ (y/n) (acceptable: yes answer), TP: _____ Date: _____

APPENDIX A - EQUIPMENT LAYOUT

APPENDIX B - EQUIPMENT INTERCONNECTION

APPENDIX C - TEST READINESS CHECKLIST

- ☐ Post Delivery Acceptance Test (or equivalent) is complete for all LDUA subsystems
- ☐ Phase 1 Integration with SDAS is complete for all LDUA subsystems
- ☐ Phase 2 Integration with ATIE/OCT is complete for all LDUA subsystems - ATIE Integration Checklist and OCT Integration Checklist have been signed and delivered to Test Director
- ☐ Phase 3 Integration is complete for all LDUA subsystems
- ☐ Equipment to be tested is installed according to the layout in Appendix A and is interconnected according to Appendix B.
- ☐ 12 inch simulated riser is installed and deflection sensors are connected to readouts and lift-off switch is connected to the LDUA EStop circuit.
- ☐ Safety barriers for testing activities have been established or are ready to be placed as needed.
- ☐ Configuration documentation master file has been established and is under the control of the Test Director (see section 2.2).

Cog Engineer (LDUA and Deployment System)
 Cog Engineer (Tank Riser Interface and Confinement)
 Cog Engineer (Operations Control Center)
 Cog Engineer (Utilities)
 Cog Engineer (End Effectors)
 LDUA Technical Lead
 Test Director

____ Date: _____
 ____ Date: _____
 ____ Date: _____
 ____ Date: _____
 ____ Date: _____
 ____ Date: _____
 ____ Date: _____

APPENDIX F - PERSONNEL RECORD

Name (print)	Signature	Initials	Position	Date

APPENDIX G - TEST EXCEPTIONS

Sheet ____ of ____ Test Exception Sheets

#	Description	Resolution	Approvals
			CE _____ Date: _____ TE _____ Date: _____
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