GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Prepare SMD for Launch

To be performed at Vandenberg Air Force Base SLC-2W

THIS DOCUMENT DOES NOT CONTAIN HAZARDOUS OPERATIONS

P1003 Rev B
ECO No. 1482

March 27, 2004

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Revision Record

Rev	*ECO*	*Description*	*Date*
A	1456	Deleted reference to P1013, *Connect Electrical GSE to SMD* Deleted reference to P1008, *Connect GT Vent Line to GM* Specified pumping of well prior to guard tank fill operations (both before and after fairing installation) Replaced references to P1028, *External Guard Tank Fill- Main Tank Subatmospheric (MST)* with P1052, *External Guard Tank Fill- Main Tank Subatmospheric and No Vent Lines Connected* Deleted references to P1009, *Disconnect GT Vent Line from GM* Specified the use of plastic drapes underneath the fill bayonet and the guard tank vent valve assembly to prevent condensation from impinging on the SV Specified that the next-to-last GT fill operation be such that the liquid level will be in the range of 20 – 50% at the time of the final fill operation. Corrected fill line relief valve plug installation torque	10/29/03
B	1482	Add installation of Black Box Network Power Switches (2x) to control power to guard tank liquid level readout and the guard tank vent bayonet heater power supply at time of setup in the EEB. Record device IP addresses. Add note requiring that vane pump exhausts be ducted outside Verify operation of both Black Box Network Power Switches. Add steps needed to connect and disconnect guard tank vent line without leak checks. Add a warning restricting the use of heat guns on the MST. Change references to guard tank fill procedure from P1052 (without vent line connection) to P1028B (with vent line connection). Add reminders to turn off GHe cylinder after completion of fill operations. Add steps to power down the cryogenic GSE when the MST will be unattended by cryogenic personnel. Add steps power up cryogenic GSE as needed for fill operations. Specify when power is to be shut off to guard tank heater and liquid level sensor.	3/27/04

Table of Contents

List of Abbreviations and Acronyms

AG-x	Gauge x of Gas Module auxiliary section
AMI	American Magnetics Inc.
APR-x	Pressure regulator x of Gas Module
AV-x	Valve x of Gas Module auxiliary section
CGSE	Cryogenic GSE
CG-x	Gauge x of portable helium pressurization source
CPR-x	Pressure regulator x of portable helium pressurization source
CV-x	Valve x of portable helium pressurization source
CN [xx]	Data acquisition channel number
DAS	Data Acquisition System
EEB	Electrical Equipment Building
EFM	Exhaust gas Flow Meter
EG-x	Gauge x of Gas Module exhaust section
EH-x	Vent line heat exchanger in Gas Module
EM	Electrical Module
ERV-x	Relief valve of Gas Module exhaust section
EV-x	Valve number x of Gas Module exhaust section
FCV	Fill Cap Valve
FIST	Full Integrated System Test
GHe	Gaseous Helium
GM	Gas Module
GP-B	Gravity Probe-B
GSE	Ground Support Equipment
GT	Guard Tank
GTVC	Guard Tank Vent Cap
GTVC-G	Guard Tank Vent Cap pressure gauge
GTVC-RV	Guard Tank Vent Cap relief valve
GTVC-V	Guard Tank Vent Cap valve
GTV-G	Guard Tank vent pressure gauge
GTV-RV	Guard Tank vent relief valve
GTV-V	Guard Tank vent valve
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
LHV-x	Liquid Helium Supply Dewar valves
LLS	Liquid level sensor
LM	Lockheed Martin Co.
LV	Launch Vehicle
MST	Mobile Service Tower (of SLC-2W)
MT	Main Tank
MTVC	Main Tank Vent Cap
MTVC-G	Main Tank Vent Cap pressure gauge
MTVC-RV	Main Tank Vent Cap relief valve
MTVC-V	Main Tank Vent Cap valve
NBP	Normal boiling point
PAF	Payload Adapter Flange
PFCG	Fill Cap ass'y pressure Gauge
PFM	Pump equipment Flow Meter
PG-x	Gauge x of Pump equipment
PM	Pump Module
PRT	Platinum resistance thermometer
psi	pounds per square inch
psig	pounds per square inch gauge
PV-x	Valve x of the Pump equipment
QA	Quality Assurance
RAV-x	Remote Actuated Valve-x
RGA	Residual Gas Analyzer
SLC-2W	Space Launch Complex 2W (Vandenberg AFB)
SMD	Science Mission Dewar
STG	SMD Thruster vent pressure gauge
SU	Stanford University
SV	Space Vehicle
SV-x	SMD Valve number x
TD	Test Director
TG-x	Gauge x of Utility Turbo System
TN	Thrust Nullifier

List of Abbreviations and Acronyms (cont'd)

TV-x	Valve x of Utility Turbo System
UTS	Utility Turbopump System
Vac	Vacuum
VCP-x	Vent cap pressure gauge
VCRV-x	Vent cap relief valve
VCV-x	Vent cap valve
VDC	Volts Direct Current
VF-x	Liquid helium Fill line valve
VG-x	Gauge x of Vacuum Module
VM	Vacuum Module
VV-x	Valve x of Vacuum Module
VW-x	Valve x of Well pumping line

LIST OF SPECIFIC HEADING DEFINITIONS

Each type of alert message will precede the procedural step to which it applies

Note:
Used to indicate an operating procedure of such importance that it must be emphasized.

CAUTION:
Used to identify hazards to equipment.

WARNING:
Used to identify hazards to personnel.

A. SCOPE

This master procedure describes the steps necessary to prepare the SMD for launch at the SLC-2W launch site. These steps include:

After transport of the GSE to the MST/EEB and before arrival of the SV:

Perform P1020, *Certify Electrical Module, Gas Module, and DAS.*

Perform P1023, *Certify UTS*

Pre-pump the Gas Module with the UTS

Perform P1022, *Certify Vacuum Module*

After transport of the SV to the MST and removal of the canister:

Connect the burst disk vent line to SMD burst disks

Connect DAS and the SMD External Temperature Control Module (in the EEB) to umbilical and verify operation. Install and check out Black Box Network Power Switches.

Check the GT liquid level and the vacuum shell pressure

Perform P1017, *Repump Well with UTS*

Perform P1028B, *External Guard Tank Fill- Main Tank Subatmospheric* (as needed). Turn off power to CGSE when unattended.

Monitor temperature of main tank

Disconnect burst disk vent and guard tank vent lines for fairing installation

Remove ion pump magnet

Reconnect burst disk vent and guard tank vent lines after fairing installation

Perform P1028B, *External Guard Tank Fill- Main Tank Subatmospheric* as needed to bring guard tank level to 50% at launch (The GSE fill cap assembly is replaced by the flight fill cap.) Turn off power to CGSE when unattended.

Remove guard tank vent line and Guard Tank Vent Valve Ass'y and install thrust nullifier

Install fill line relief valve plug

Close redundant well pumpout valve and torque

Disconnect burst disk vent lines for launch

Note that this procedure is classified as non-hazardous. That classification does not necessarily apply, however, to other procedures that are called by this procedure.

B. SAFETY

B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware.

Liquid helium used in the SMD represents a hazardous material for the personnel involved in the operations. Cryogenic burns can be caused by contact with the

cold liquid or gas, high pressures can result if boiling liquid or cold gas is confined without a vent path, and asphyxiation can result if the vent gas is allowed to accumulate.

The SMD Safety Compliance Assessment, document GPB-100153C discusses the safety design, operating requirements and the hazard analysis of the SMD.

B.2. **Mitigation of Hazards**

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

A rupture of the main tank burst disk(s) will be obvious due to the plume of cold gas. Emergency vent lines are installed over the burst disks on the SMD vacuum shell to eliminate the possibility of direct plume impingement on personnel. Orderly evacuation shall be performed in the event one or more of these burst disks rupture. An oxygen deficiency monitor (provided by GP-B) that alarms when the oxygen level is reduced to 19.5% will be utilized as an added precaution. Temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions.

Only authorized and trained personnel are allowed in VAFB facilities without escort. All personnel working on platforms at a height 30 inches or more off the floor are required to have an approved air tank (emergency breathing apparatus) within easy reach. Note that tank need not be kept available when working from a ladder. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the room and contact NASA and VAFB safety. The following additional requirements apply to all personnel involved directly in cryogenic operations: Insulated gloves when handling equipment that has been cooled to cryogenic temperatures. A protective apron, gloves impervious to liquid cryogens, impermeable shoes, and full-face shields are to be worn whenever the possibility of splashing or impingement of high velocity cryogens exists.

B.2.3. Other Hazards

Tools or other items with the potential to damage the SV or launch vehicle if dropped shall be tethered. Aprons or other means of catching or deflecting small parts, condensation, etc. shall be used to shield the flight hardware.

B.3. **Mishap Notification**

B.3.1. Injury

In case of any injury obtain medical treatment as follows
VAFB Call 911

B.3.2. Hardware Mishap

In case of an accident, incident, or mishap, notification is to proceed per the procedures outlined in Lockheed Martin Engineering Memorandum

EM SYS229 and Stanford University GP-B P0879. Additionally, VAFB NASA Safety and 30th Spacewing Safety will be notified as required.

B.3.3. Contingency Response

Responses to contingencies (e.g., power failure, burst disk failure) are listed in Appendix 3.

C. QUALITY ASSURANCE

C.1. QA Notification

The NASA program and NASA safety representatives and SU QA shall be notified 24 hours prior to the start of this procedure. Upon completion of this procedure, the QE Manager will certify his/her concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating in the designated place(s) in this document.

C.2. Red-line Authority

Authority to red-line (make minor changes during execution) this procedure is given solely to the TD or his designate and shall be approved by the QA Representative. Additionally, approval by the Payload Technical Manager shall be required, if in the judgment of the TD or QA Representative, mission functionality may be affected.

C.3. Discrepancies

A Quality Assurance Representative designated by D. Ross shall review any discrepancy noted during this procedure, and approve its disposition. Discrepancies will be recorded in a D-log or a DR per Quality Plan P0108. Any time a procedure calls for verification of a specific configuration and that configuration is not the current configuration, it represents a discrepancy of one of three types. These types are to be dealt with as described below.

If the discrepancy has minimal effect on procedure functionality (such as the state of a valve that is irrelevant to performance of the procedure) it shall be documented in the procedure, together with the resolution. Redlines to procedures are included in this category.

If the discrepancy is minor and affects procedure functionality but not flight hardware fit or function, it shall be recorded in the D-log. Resolution shall be in consultation with the TD and approved by the QA representative.

All critical and major discrepancies, those that effect flight hardware fit or functions, shall be documented in a D-log and also in a Discrepancy Report, per P0108.

D. TEST PERSONNEL

D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. However, procedures called by this procedure may have additional requirements. The person performing the operations (Test Director or Test Engineer) is to sign the “Completed by” sign-off. Any other qualified person or QA person who can attest to the successful

performance of this procedure may sign the "Witnessed by" sign-off. **The Test Director will perform pre-test and Post-Test briefings in accordance with P0875 "GP-B Maintenance and Testing at all Facilities". Checklists will be used as directed by P0875.**

D.2. Personnel Qualifications

The Test Director must have a detailed understanding of all procedures and facility operations and experience in all of the SMD operations. Test Engineers must have SMD Cryogenic operations experience and an understanding of the operations and procedures used for the cryogenic servicing/maintenance of the Dewar.

D.3. Qualified Personnel

List below those personnel involved with the procedure

Test Director	Test Engineer	Safety Engineer
1.	1. 2. 3. 4.	1.

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

Any person who comes in contact with the SV must use a grounding wrist strap that has been tested that day. Appropriate attachment points are positioned around the SV.

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

E.3.2. Ground Support Equipment

The Ground Support Equipment includes the Gas Module (GM), the Pump Module (PM), the Electrical Module (EM), the Vacuum Module (VM), and the Utility Turbopump System (UTS). The Gas Module provides the capability to configure vent paths, read pressures and flow rates, and pump and backfill vent lines. The Pump Module provides greater pumping capacity (when needed for pumping on the Main Tank) than the Gas Module, together with additional flow metering capabilities. The vent output of the Gas Module flows through the Pump Module when it is in use. The Pump Module is not needed for this procedure. The Electrical Module contains the instruments listed in Table 1 (see the Electrical Module Manual for details) and provides remote control of valves in the Gas Module, Pump Module, and SMD. The Vacuum Module

contains a turbo pump, backed by a vane pump and provides the capability to pump out the SMD vacuum shell. The UTS is a smaller version of the Vacuum Module.

This procedure calls for use of hardware located in the Gas Module (Figure 2), the Electrical Module (Table 1), and the UTS (Figure 3). Additionally, the SMD External Temperature Control Module, the Power Distribution Unit and Leak Detector are needed. The Pump Module is not needed.

E.3.3. Computers and Software

The Data Acquisition System (DAS) and data acquisition software are required for this procedure. The DAS reads and displays pressures, temperatures, and flow rates and monitors critical parameters. It also provides power to operate heaters associated with the Guard Tank and its vent. No additional computers or software are required.

E.3.4. Spacecraft Support

With connector J802 connected to flight electronics, operation of RAV2 and RAV6B must be commanded through the spacecraft instead of the RAV controller in the Electrical Module.

E.3.5. Additional Test Equipment

Description	***Manufacturer***	***Model***
(2x) Network Power Switch	Black Box	SWI080A
O_2 Monitor and Alarm	Alpha-Omega Instruments	1000
Handheld digital multimeter	Fluke	85 or similar
AMI Level Sensor Readout for LHSD*	American Magnetics, Inc.	110
Leak Detector*	Varian	960

*(Ref.) Required by called procedure.

E.3.6. Additional Hardware

Description	***Manufacturer***	***Model***
Filter Line assembly*	LMMS	5833827
Liquid He Transfer Line*	LMMS	5833804
Liquid He Stinger*	LMMS	5833803
GHe supply fittings to LHSD*	N/A	N/A
Bayonet Cap with Nupro Valve*	LMMS	N/A
(2x) 500 Liter Dewars, Liquid Helium*	Cryofab	CMSH-500
(2x) 4 liter LN2 flask*	Taylor-Wharton	4 LD
Vacuum flex hose and KF hardware	Various	-

*(Ref.) Required by called procedure.

E.3.7. Flight Hardware

Description	***Part Number***
Fill Valve Weldment Assembly	65113-5833270-101
Passive (Thrust) Nullifier Assembly	06887-8A03510-101
Fill line relief valve plug	8A03009E, FN 21

O-ring for fill line relief valve plug	4904-32 (8A03009E, FN 22)

E.3.8. Protective Clothing

(Ref.) The following is required for use in called procedure P1028B, *External Guard Tank Fill- Main Tank Subatmospheric (MST)*

1. Cryogenic safety gloves and apron
2. Face shield
3. Non-absorbent shoes

E.3.9. Tools

Description	***Manufacturer***	***Model***
Torque wrench	Sturtevant Richmont or sim.	50 in-lb
Torque wrench	Sturtevant Richmont or sim	150 in-lb
Torque wrench	AR	>15 ft-lb

E.3.10. Expendables

(Ref.) The following is required for use in called procedure P1028B, *External Guard Tank Fill- Main Tank Subatmospheric (MST),* in addition to other minor items listed in that procedure.

Description	***Quantity***	***Mfr./Part No.***
Liquid helium	2x 500 liters.	N/A
Compressed helium gas	2x “T” bottles	N/A
Liquid Nitrogen	160 liter cylinder	N/A

E.4. Instrument Pretest Requirements

The GSE instruments required to perform this procedure are listed in Table 1, together with their serial numbers, where available. Instruments that are required to have current calibrations are indicated in the Cal-Required column. Instruments that do not require calibration are those not used to verify performance requirements and are not connected to flight instrumentation. The status column is to be filled in with the due date of the instrument calibration sticker and verified to be in calibration by QE or QE designee. Serial numbers are to be updated as appropriate.

Table 1. Required Instrumentation and Calibration Status

No.	***Location***	***Description***	***User Name***	***Serial No.***	***Cal Required***	***Status Cal due date***
1	DAS	Power Supply, H-P 6627A	- A1, A2, A3, A4	3452A01975	Yes	
2	DAS	Power Supply, H-P 6627A	B1, B2, B3, B4-	3452A01956	Yes	
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A245539	No	-
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	
5	EM	Vacuum Gauge Controller	EG-1a, -1b	2827	No	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
		Granville-Phillips Model 316				
6	EM	Vacuum Gauge Controller Granville-Phillips Model 316	AG-2a, -2b	2826	No	-
7	EM	Vacuum Gauge Controller Granville-Phillips Model 316	EG-3	2828	No	-
8	EM	MKS PDR-C-2C	EG-2, FCG	92022108A	No	-
9	EM	Flow meter – Matheson 8170	EFM-1	96186	No	-
10	EM	Flow meter totalizer Matheson 8124	EFM-1	96174	No	-
11	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Main Tank	96-409-11	No	-
12	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Guard Tank	96-409-10	No	-
13	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Well	96-409-9	No	-
14	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Axial Lock	96-409-12	No	-
15	EM	Pressure Controller – MKS 152F-92	EV-7a, -7b	96203410A	No	-
16	EM	Power Supply HP 6038A	H08D Tank Heater	96023407A	Yes	
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	
19	EM	Vac Ion Pump power supply Varian 929-0910, Minivac	SIP	5004N	No	-
20	EM	Flow meter totalizer Veeder-Root	PFM-1	576013-716	No	-
21	GM	Pressure Gauge, Heise	AG-1	CC-122077	No	-
22	GM	Pressure Gauge, Marshall Town	AG-3	N/A	No	-
23	GM	Main Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	EH-1	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	EH-2	C-09920	No	-
25	VM	Vacuum Gauge readout, Granville-Phillips 316	VG-3 VG-4	2878	No	-
26	VM	Vacuum Gauge readout, Granville-Phillips 360	VG-1, VG-2 VG-5	96021521	No	-

E.5. **Configuration Requirements**

E.5.1. Space Vehicle

The SV must be mounted vertical (+Z up) and in preparation for transport from B1610 to SLC-2W. It will progress from B1610 to being mated to the launch vehicle before any operations involving the SV take place in this procedure.

E.5.2. Main Tank

The Main Tank liquid must be subatmospheric (~1.7 K) with the liquid level ≥ 95%. The Main Tank vent is isolated by closure of SV-9 and the installation of the Main Tank flight cap as obtained by the completion of P1002, *Configure SMD for Transport to SLC-2W* (Fig. 1).

E.5.3. Guard Tank

The Guard Tank is filled with NBP liquid He and must be maintained above a minimum level of 20%. Venting of the Guard Tank is through the flight Guard Tank vent line with the Guard Tank Vent Assembly (GSE) installed in place of the flight Guard Tank thrust nullifier (Fig. 1). The Guard Tank pressure must not be allowed to drop below atmospheric.

E.5.4. Well

The Well must be evacuated per successful completion of P1002, *Configure SMD for Transport to SLC-2W*.

E.5.5. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 5×10^{-5} torr. Procedure P1015, *Connect Vacuum Module to SMD*, contains the steps for connecting to and pumping on the SMD vacuum shell, if needed.

E.5.6. GSE and Non-flight Hardware

1. The ion-pump magnet is installed.
2. The Guard Tank vent valve assembly with vent cap is installed as noted in E.5.3.
3. The Fill Cap Assembly (Fig. 1) must be installed at SV-13.

E.6. Optional Non-flight Configurations

N/A

E.7. Verification/Success Criteria

N/A

E.8. Payload Constraints and Restrictions

N/A

F. REFERENCE DOCUMENTS

F.1. Drawings

Drawing No.	***Title***
LMMS-5833394	*Instrumentation Installation*

F.2. Supporting documentation

Document No.	***Title***
LMMC-5835031	*GP-B Magnetic Control Plan*
GPB-100153C	*SMD Safety Compliance Assessment*
LMSC-P088357	*Science Mission Dewar Critical Design Review*

Document No.	***Title***
SU/GP-B P0108	*Quality Plan*
LMMS GPB-100333	*Science Mission Dewar Failure Effects and Causes Analysis*
SU/GP-B P059	*GP-B Contamination Control Plan*
LM EM SYS229	*Accident/Incident/Mishap Notification Process*
EWR 127-1, 31 March 1995, Eastern and Western Range Safety Requirements	*Hazardous and Safety Critical Procedures*
KHB 1710, rev D	*Kennedy Space Center Safety Practices Handbook*

F.3. Additional Procedures

Document No.	***Title***
SU/GP-B P1015	*Connect Vacuum Module to SMD*
SU/GP-B P1016	*Stop Pumping on SMD Vacuum Shell / Disconnect Vacuum Module*
SU/GP-B P1017A	*Repump Well with UTS*
SU/GP-B P1020	*Certify Electrical Module, Gas Module, and DAS*
SU/GP-B P1022	*Certify Vacuum Module*
SU/GP-B P1023	*Certify UTS*
SU/GP-B P1030	*SMD Guard Tank Depletion*
SU/GP-B P1028B	*External Guard Tank Fill- Main Tank Subatmospheric*

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

G. OPERATIONS

G.1. Pre-Operations Verifications

- ❑ Verify SU QA notified.

  Record: Individual notified _____,

  Date/time _____/_____.
- ❑ Verify NASA program representative notified.

  Record: Individual notified _____,

  Date/time _____/_____.
- ❑ Verify NASA Safety representative has been notified and has given concurrence to proceed.

  Record: Individual notified _____,

  Date/time _____/_____.
- ❑ Verify that the persons performing this procedure, the test director, and safety engineer are identified in Sec. D.3.
- ❑ Verify performance of pre-operations checklist (Appendix 1).

Section G.1 complete _____ QA.

G.2. Verify Preliminary SMD and GSE Preparations Complete

G.2.1. Verify that the following items have been transported to level 5 of the MST and secured:

1. Gas Module
2. Electrical Module
3. Vacuum Module
4. Utility Turbopump System
5. Power Distribution Unit
6. Items listed in sections E.3.5 through E.3.10

G.2.2. Verify Purity of All Sources of Helium Gas

1. Record serial number on helium bottle/s.
   1. _____ 2._____
2. Verify helium bottle/s have been tested for content and record Op. Number.
   Op. Number:_____

_____ QA.

G.2.3. Verify that the DAS and the SMD External Temperature Control Module have been transported to the EEB.

G.2.4. Power the guard tank liquid level sensor and the guard tank vent bayonet heater through a common power strip that is powered via the two Black Box Network Power Switches connected in series. Connect the two network power switches to the Stanford network switch provided in the EEB.

G.2.5. Record the IP addresses of the two network power switches _____, and _____.

G.2.6. Verify successful completion of P1002, *Configure SMD for Transport to SLC-2W*. Record Op. No.: _____

Note:
The exhausts of all vane pumps are to be ducted outside the MST.

Section G.2 complete _____ QA.

G.3. **Set Up and Verify GSE**

G.3.1. Perform P1020, *Certify Electrical Module, Gas Module, and DAS,* and record the Op. Order No.: _____. Comment: At this point, the DAS is set up separately in the EEB and can serve umbilical functions only.

G.3.2. Access a computer with a web browser on the Stanford network in Building 836. Verify that it is able to access both network power switches in the EEB and that each network power switch can be remotely controlled from 836.

G.3.3. Perform P1023, *Certify UTS.* and record the Op. Order No.:
_____

G.3.4. Pre-pump the Gas Module (to reduce He background in preparation for connection of the GT vent line to the GM) as follows:

1. Connect a pumping line from the GM at access port 3 (Fig. 2) to the UTS (Fig. 3).

2. Ensure that all other ports on the GM are capped except the vent output, the AP-1 exhaust, the pumping port at EV-21/22, and the GHe output ports.
3. Open all electro-pneumatically-operated EV and AV valves except EV-5, and open EV-20.
4. Ensure that the manual valves EV-19, -20, -21, -22, -23, -24 are closed.
5. Turn on AP-1 and evacuate the GM until AG-2b is less than 25 mtorr.
6. Close AV-8, AV-6, and turn off AP-1.
7. Start the UTS (Figure 3) pumping up to closed EV-5, as follows:
    a. Place valve interlock switch in “over-ride” position.
    b. Turn on vane pump and converter (Note: converter switch provides power to turbopump controller and pirani and cold-cathode vacuum-gauge display.
    c. Push the red “reset” button to activate the interlock over-ride circuit. (the yellow-orange indicator light will come on).
    d. Turn “foreline” switch on, to open TV-2, and verify that the switch is illuminated.
    e. Push the “Sensor” button on the vacuum gauge display to read the foreline pressure (TG-4). This is the pirani gauge. The “Pir” annunciator will appear in upper left corner of the display).
    f. Slowly open TV-4.
    g. When foreline pressure (TG-4) < 1 torr, push “Start” button on turbo controller.
    h. When the ”Normalbetrieb” light illuminates on turbo controller, indicating turbopump is up to speed, close TV-4 and open gate valve TV-1.
    i. Switch the valve interlock switch to the “protected” position.
    j. Push the “Sensor” button on the vacuum gauge readout so that the “Hi-Vac” annunciator shows, and push the “Emis” button to turn on the cold cathode gauge (TG-1).
    k. Record the pumping line pressure (TG-1) _____ torr.
8. Open EV-5 to pump on the GM with the UTS.

G.3.5. Perform P1022, *Certify Vacuum Module,* and record the Op. Order No.: _____

G.3.6. Set up portable Alpha Omega oxygen monitor and perform calibration per manufacturer’s instructions.

G.3.7. After the SV has been transported to the launch site and integrated with the launch vehicle, proceed with the following.

Section G.3 complete _____ QA.

WARNING:
The use of an electric heat gun is prohibited on the MST except under the following conditions: 1) The LV second stage is not fueled; 2) There are no flammable materials in the area of use; 3) Use is approved by on-site NASA and Boeing safety.

G.4. Guard Tank Maintenance Before Fairing Installation

G.4.1. Request that level 6 of the MST be set at Delta station 442. (This may be adjusted later if necessary.)

G.4.2. Connect emergency vent lines from the SMD burst disks to a facility vent location. (These lines should be connected as soon as is feasible after the shipping canister is removed.*)*

G.4.3. *Connect the guard tank vent line as follows:*

1. Close GTV-V (Fig. 1).
2. Remove the guard tank vent cap.
3. Inspect the o-ring on the GTVVA bayonet receptacle and service as needed.
4. Connect the guard tank vent line between GTVVA and the GT heat exchanger on the Gas Module.
5. Verify that a purged source of He gas is connected to the GM at the He inlet port.
6. Turn on AP-1 and open AV-8, AV-6, EV-7A/B, EV-13, EV-16 to evacuate up to a closed GTV-V.
7. Verify that AG-2b drops to below 10 mtorr.
8. Close AV-8 and AV-6, and turn off AP-1.
9. Backfill the GT vent plumbing with He gas through EV-23 and APR-2 until EG-3a reads 1 atm. Close EV-23.
10. Open GTV-V to allow the Guard Tank to vent through the GM.

G.4.4. Connect the dewar EGSE as follows:

1. Connect GSE cabling between SMD and Electrical Module (GTV-G and vac-ion pump only)
2. Connect the Data Acquisition System and the SMD External Temperature Control Module (located in the EEB) to the umbilical.
3. Verify that the umbilical is connected to the SV.
4. Verify operation of the instrumentation and heaters.
5. Connect the GT pressure transducer (GTV-G) to an Endevco readout. The output of the readout should be monitored with a handheld digital multimeter in order to determine signal polarity Record results in Table 2.

G.4.5. Verify the Guard Tank contains NBP liquid He and liquid level is above a minimum level of 20%:

Record GT liquid level: _____ %

G.4.6. Vacuum status:

1. Verify that the ion pump magnet and cable are installed.
2. Verify that the vacuum shell pressure is less than 5 x 10^{-5} torr as follows:
    a. Turn on ion pump controller.
    b. Measure the recorder output voltage (pin 2 relative to pin 6).
    c. After the voltage has stabilized, record: _____ V.
    d. Convert voltage to torr by multiplying by 6.7 x 10^{-5} torr/volt and record: _____torr.
3. Turn off the ion pump controller.

G.4.7. Ensure DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – ensure CN [175] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. _____K
2. ***Top of lead bag* temperature** – ensure CN [178] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. _____K

G.4.8. Ensure DAS watchdog timer and alarm enabled.

G.4.9. Perform P1017A, *Repump Well with UTS,* and record the Op. Order No.: _____ and date/time: _____/_____. This procedure will be kept open until after the last Guard Tank fill before fairing installation is completed. Pumping will be temporarily discontinued, however, between fill operations.

G.4.10. Install plastic drapes underneath the fill bayonet and the guard tank vent valve assembly to prevent condensation from impinging on the SV. This material may be removed between fill procedures if needed.

G.4.11. Perform P1028B, *External Guard Tank Fill- Main Tank Subatmospheric,* and record the Op. Order No.: _____ and date/time: _____/_____

G.4.12. Upon completion of the guard tank fill procedure, turn off the He gas supply at the gas bottle.

G.4.13. As late as possible after completion of the guard tank fill, but not less than 5 hours after the evacuation of the internal fill line, power down the cryogenic GSE on the MST as follows. This must be done before the GSE can be left unattended.

1. Record date/time: _____/_____.
2. Verify that powering down the PDU will not impact EGSE or GMA equipment.

3. Close / verify closed valves EV-13 and EV-16.
4. Verify that all EV and AV valves are indicated closed on the control panel and that AP-1 is off.
5. Open EV-20.
6. Close VW-3 and VW-4.
7. Close TV-1 and TV-2.
8. Turn off both power switches on the UTS (vane pump and converter).
9. Turn off the main breakers on the PDU.

G.4.14. Prior to the next guard tank fill operation, perform the following power-up sequence:

1. Record date/time: _____/_____.
2. Turn on main breakers on the PDU
3. Close EV-20.
4. Open EV-13.
5. Turn on the vane pump and converter on the UTS.
6. Push the “reset” button on the UTS.
7. Open TV-2.
8. Start the turbopump.
9. When the turbopump controller indicates normal speed, open TV-1.
10. When TG-1 indicates a pressure < 10^{-4} torr, open VW-4 and VW-3.

G.4.15. Per schedule, repeat P1028B, *External Guard Tank Fill- Main Tank Subatmospheric*, and record the Op. Order No.: _____ and date/time: _____/_____

G.4.16. Upon completion of the guard tank fill procedure, turn off the He gas supply at the gas bottle.

G.4.17. After completion of the last guard tank fill prior to fairing installation, perform the following preparations:

1. Perform the following to remove the Ion Pump magnet:
    a. Verify that the power is off to the Ion Pump controller.
    b. Disconnect temporary EGSE connections: ion pump cable, and cable to the GT pressure transducer, GTV-G.
    c. Using a tether on the magnet and a temporary apron to catch any loose hardware, remove the magnet and the ion pump shield.
2. Disconnect the guard tank vent line as follows:
    a. Close GTV-V
    b. Disconnect the guard tank vent line at GTV-V

c. Install the guard tank vent cap at GTV-V

d. Open GTV-V

3. Remove any plastic drape material installed to protect the SV from condensation.
4. As late as possible before fairing installation, but no sooner than 5 hours after the evacuation of the internal fill line in the last guard tank fill, complete P1017A, *Repump Well with UTS*, and disconnect the pumping line.
5. Power down the cryogenic GSE as follows:
    a. Record date/time: _____/_____.
    b. Verify that powering down the PDU will not impact EGSE or GMA equipment.
    c. Turn off the main breakers on the PDU.
6. As close to time of fairing installation as is feasible, disconnect the vent lines from the SMD burst disks.

Section G.4 complete _____ QA.

G.5. **Guard Tank Maintenance After Fairing Installation**

G.5.1. After completion of the fairing installation and access through the fairing access covers is available, perform the following:

1. Reconnect the emergency vent lines to the SMD burst disks.
2. Reconnect GTV-G.

G.5.2. Prior to the next guard tank fill operation, power up the GSE:

1. Record date/time: _____/_____.
2. Turn on main breakers on the PDU

G.5.3. *Connect the guard tank vent line as follows:*

1. Close GTV-V (Fig. 1).
2. Remove the guard tank vent cap.
3. Inspect the o-ring on the GTVVA bayonet receptacle and service as needed.
4. Connect the guard tank vent line between GTVVA and the GT heat exchanger on the Gas Module.
5. Verify that a purged source of He gas is connected to the GM at the He inlet port.
6. Turn on AP-1 and open AV-8, AV-6, EV-7A/B, EV-16 to evacuate up to a closed GTV-V.
7. Verify that AG-2b drops to below 10 mtorr.
8. Close AV-8 and AV-6, and turn off AP-1.

9. Backfill the GT vent plumbing with He gas through EV-23 and APR-2 until EG-3a reads 1 atm. Close EV-23.
10. Open GTV-V to allow the Guard Tank to vent through the GM.

G.5.4. Perform P1017A, *Repump Well with UTS,* and record the Op. Order No.: _____ and date/time: _____/_____. This procedure will be kept open until after the last Guard Tank fill before launch. Pumping will be temporarily discontinued, however, between fill operations.

G.5.5. *Install plastic drapes underneath the fill bayonet and the guard tank vent valve assembly to prevent condensation from impinging on the SV. This material may be removed between fill procedures if needed.*

G.5.6. Per schedule, perform P1028B, *External Guard Tank Fill- Main Tank Subatmospheric*, and record the Op. Order No.: _____ and date/time: _____/_____

G.5.7. Upon completion of the guard tank fill procedure, turn off the He gas supply at the gas bottle.

G.5.8. As late as possible after completion of the guard tank fill, but not less than 5 hours after the evacuation of the internal fill line, power down the cryogenic GSE on the MST as follows. This must be done before the GSE can be left unattended.

1. Record date/time: _____/_____.
2. Verify that powering down the PDU will not impact EGSE or GMA equipment.
3. Close / verify closed valves EV-13 and EV-16.
4. Verify that all EV and AV valves are indicated closed on the control panel and that AP-1 is off.
5. Open EV-20.
6. Close VW-3 and VW-4.
7. Close TV-1 and TV-2.
8. Turn off both power switches on the UTS (vane pump and converter).
9. Turn off the main breakers on the PDU.

G.5.9. Prior to the next guard tank fill operation, perform the following power-up sequence:

1. Record date/time: _____/_____.
2. Turn on main breakers on the PDU
3. Close EV-20.
4. Open EV-13.
5. Turn on the vane pump and converter on the UTS.
6. Push the “reset” button on the UTS.
7. Open TV-2.

8. Start the turbopump.
9. When the turbopump controller indicates normal speed, open TV-1.
10. When TG-1 indicates a pressure < 10^{-4} torr, open VW-4 and VW-3.

G.5.10. Per schedule, repeat P1028B, *External Guard Tank Fill- Main Tank Subatmospheric*, and record the Op. Order No.: _____ and date/time: _____/_____. If this fill operation takes place within 72 hours of expected launch, this will be the final fill. In that case, the guard tank fill level at the completion of this operation should be such that it is projected to be the range of 50 – 55% at the time of launch. Otherwise, guard tank fill level at the completion of this operation should be such that it is projected to be in the range of 20 – 50% at the time of the final fill operation.

G.5.11. Upon completion of the guard tank fill procedure, turn off the He gas supply at the gas bottle.

G.5.12. As late as possible after completion of the guard tank fill, but not less than 5 hours after the evacuation of the internal fill line, power down the cryogenic GSE on the MST as follows. This must be done before the GSE can be left unattended.

1. Record date/time: _____/_____.
2. Verify that powering down the PDU will not impact EGSE or GMA equipment.
3. Close / verify closed valves EV-13 and EV-16.
4. Verify that all EV and AV valves are indicated closed on the control panel and that AP-1 is off.
5. Open EV-20.
6. Close VW-3 and VW-4.
7. Close TV-1 and TV-2.
8. Turn off both power switches on the UTS (vane pump and converter).
9. Turn off the main breakers on the PDU.

G.5.13. Prior to continuation of this procedure, perform the following power-up sequence:

1. Record date/time: _____/_____.
2. Turn on main breakers on the PDU
3. Close EV-20.
4. Open EV-13.
5. Turn on the vane pump and converter on the UTS.
6. Push the “reset” button on the UTS.
7. Open TV-2.
8. Start the turbopump.

9. When the turbopump controller indicates normal speed, open TV-1.
10. When TG-1 indicates a pressure < 10^{-4} torr, open VW-4 and VW-3.

G.5.14. Optional: Perform P1028B, *External Guard Tank Fill- Main Tank Subatmospheric*, to achieve a level that is projected to be 50 - 55% at launch and record the Op. Order No.: _____ and date/time: _____/_____. Comment: In performing this procedure, do NOT reinstall the fill cap, but proceed to G.6.2(5) below to install the flight fill cap assembly.

G.5.15. Upon completion of the guard tank fill procedure, turn off the He gas supply at the gas bottle.

Section G.5 complete _____ QA.

G.6. **Final Launch Preparations**

After final GT fill, perform the following:

G.6.1. Remove any plastic drape installed to protect the SV from condensation.

G.6.2. Replace the GSE fill cap assembly with the flight fill cap as follows:

1. Connect the Fill Cap pressure gauge, PFCG, to its readout.
2. Record Fill Cap pressure (PFCG): _____torr, and record date / time:_____.
3. Verify that the pressure at PFCG is still above one atmosphere.
4. Remove the installed Fill Cap.
5. Install the flight fill cap, “Fill Valve Weldment Assembly” (65113-5833270-101) per 65113-5833500C. Utilize a flight o-ring, part number 02697-2-212V747-75, lightly lubricated with Dow Corning silicone vacuum grease. The valve stem should be oriented in the direction shown in the drawing (in the +Y direction, to the left). LM to safety wire the fill cap nut per MS 33540. Use safety glasses or face shield while clipping safety wire.
6. Install a pumping line between the Nupro valve on the Fill Cap Assembly and the Access Port #1 of the Auxiliary gas section. Provide strain relief as necessary.
7. Turn on pump AP-1.
8. Ensure EV-12 closed.
9. Open AV-8 and AV-3.
10. Open Nupro valve on the Fill Cap Assembly and evacuate to <25 mtorr as measured at AG-2B.
11. Close AV-8.
12. Open AV-1.
13. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

14. Close AV-1.
15. Open AV-8 evacuate to <25 mtorr as measured at AG-2B.
16. Close the Nupro valve on the fill cap and torque 25 ± 2 in-lb. Record torque wrench S/N _____ and cal. due date: _____.

_____ QA.

17. Close AV-8.
18. Close AV-3.
19. Turn off AP-1.
20. Disconnect the pumping line at the Nupro valve on the fill cap.
21. Install a Swagelok plug on the port at the Nupro valve on the fill cap.

G.6.3. Request LM to safety wire the Swagelok nut and Nupro valve per MS 33540. Use safety glasses or face shield while clipping safety wire.

G.6.4. After at least 5 hours have elapsed following evacuation of the internal fill line in the last guard tank fill, complete P1017A, *Repump Well with UTS*, and disconnect the pumping line. Note that it i*s preferable to pump the well as long as possible*. *In closing out this procedure, use the options of closing VW-2 (G.6) and removing the Well Vent Manifold from VW-2 (G.8). Do not cap the port at VW-2.*

G.6.5. Secure Well pump out plumbing as follows:

1. Close VW-1 and torque to 72-84 in-lbs (6-7 ft-lbs)
    a. Record torque wrench cal due date: _____
    b. Record torque wrench serial number: _____
    c. Record valve closure in Well pump-out valve logbook
2. Verify that VW-2 is closed and torqued to 72-84 in-lbs.
3. Verify that there is no cap installed on the port at VW-2.
4. LM to epoxy stake both valves per notes 10 and 4 of drawing 8A03503:
    a. Lot date: _____
    b. Mixing date/time: _____
    c. Shore D hardness: _____
    d. Measurement date/time: _____

_____ QA.

G.6.6. Assist LM in the installation of the Guard Tank Passive (Thrust) Nullifier as follows:

1. Disconnect GTV-G.
2. Close GTV-V and disconnect the guard tank vent line from GTVVA.

3. Remove GTVVA and lightly install a #5 rubber stopper in the female bayonet.
4. Remove the o-ring on the female bayonet, and inspect and clean the o-ring groove. Install a flight o-ring, part number 02697-2-027V747-75.
5. Record serial number of Thrust Nullifier being installed: _____
6. Remove the rubber stopper and mount the Guard Tank Thrust Nullifier by engaging the bayonet nut and hand tightening. LM personnel will complete the mechanical installation.
7. Connect the heater and PRT leads and verify operation of the thrust nullifier heater.

G.6.7. Install the fill line relief valve plug per drawing 8A03009E as follows:

1. Remove the vendor-supplied o-ring from FN 21 (P/N SS-4-PST) and replace it with FN 22 (P/N 4904-32) prior to final installation.
2. Install FN 21 and torque to 13-15 ft-lbs. Record torque wrench S/N: _____, and cal. due date: _____.
3. LM to epoxy stake per Note 10 of drawing 8A03009E:
    a. Lot date: _____
    b. Mixing date/time: _____
    c. Shore D hardness: _____
    d. Measurement date/time: _____

_____ QA.

.

G.6.8. Verify installation of RAV arming plug P222 per LM op order.

G.6.9. Remove and stow the SMD emergency burst disk vent lines, centering rings, and clamps.

G.6.10. Perform a census of all tools used in this procedure and verify that they have been properly stowed.

G.6.11. Turn off the main breakers on the PDU.

G.6.12. Before vacating the EEB, perform the following:

1. Verify sufficient printer paper
2. Verify that the DAS computer has been rebooted within the previous 10 days. If not, shut down the DAS program, reboot the computer and restart the data acquisition program.
3. Verify that the plotter is working and the paper has sufficient space for plotting.

Section G.6 complete _____ QA.

G.7. **Power Down Guard Tank GSE During Launch Sequence**

G.7.1. After the second Flight Director Go/No-Go poll at approximately L-2h09m. command the Black Box Network Power Switch to power down the guard tank GSE. Verify that the power is off using the CCTV monitor and/or the DAS web page. If guard tank GSE cannot be powered down, report this fact to the Flight Director.

Section G.7 complete _____ QA.

H. **PROCEDURE COMPLETION**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Test Director_____**Date**_____

Table 2 Main Tank temperature and Guard Tank pressure

Date	Time	GTV-G (torr rel. to atm.)	T-9D [48] (K)	T-20D [175] (K)	ΔT/Δt (mK/day)	Comments

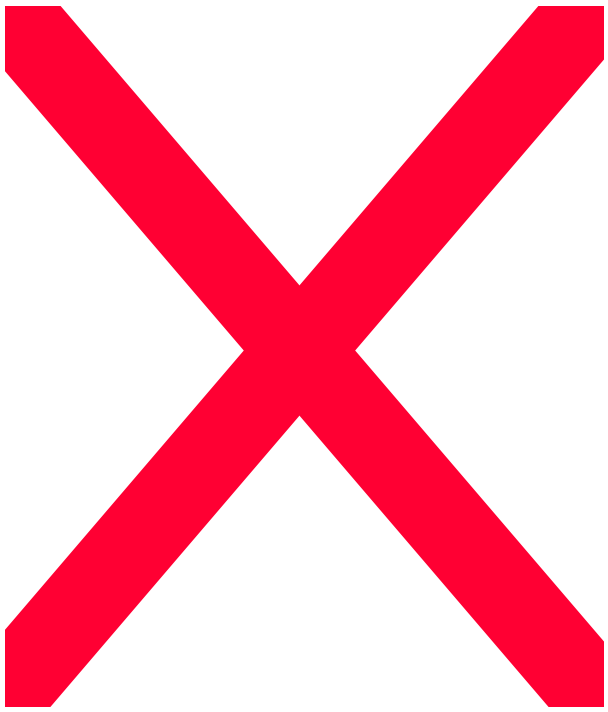
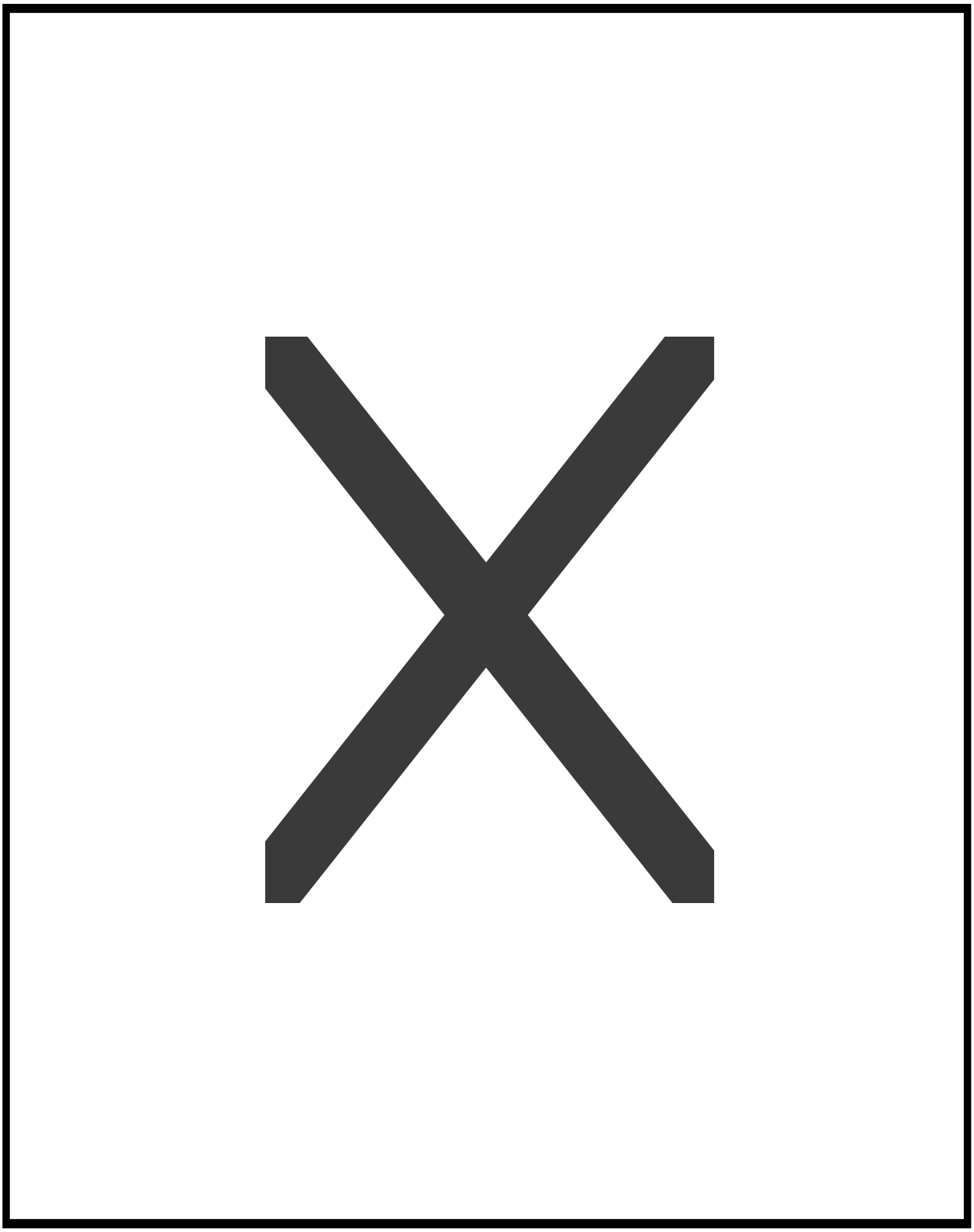


Figure 1 Schematic representation of SMD at the start of this procedure.



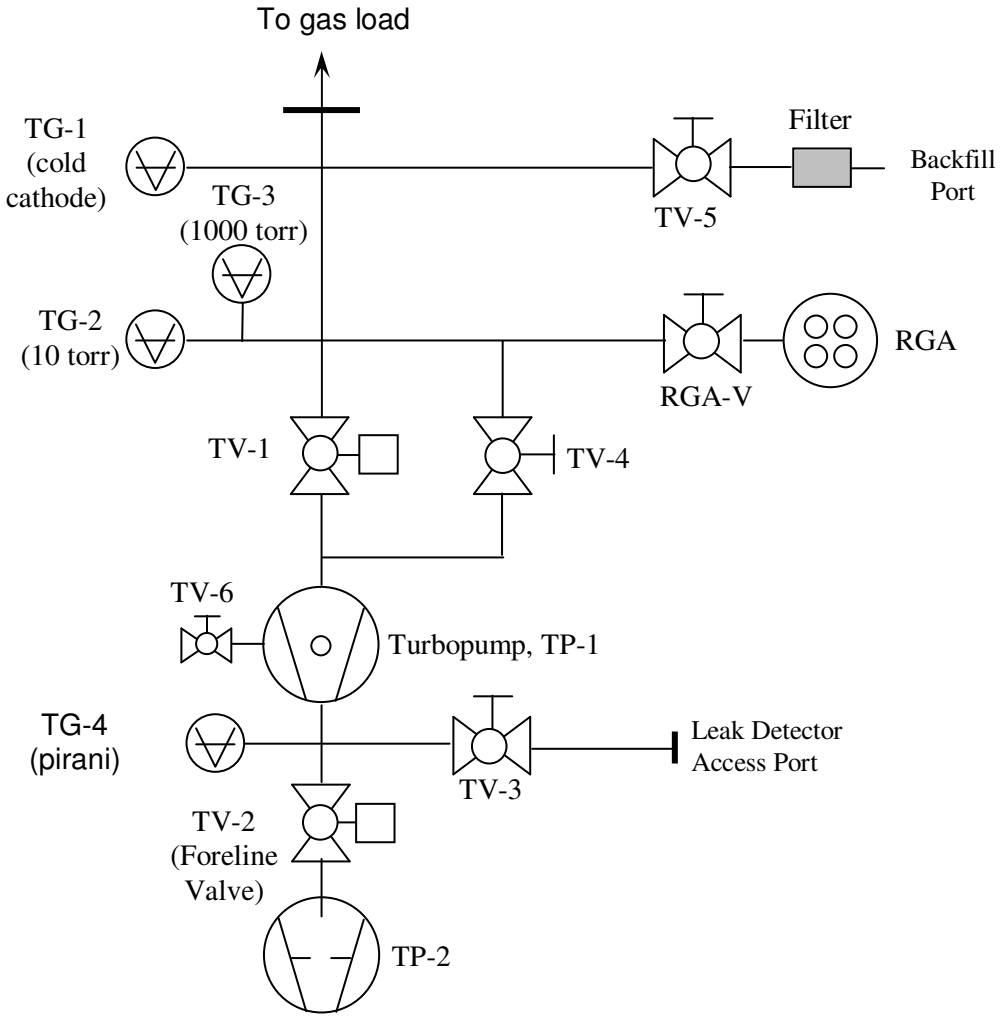


Figure 3. Schematic diagram of Utility Turbopump System (UTS)

I. APPENDIX 1 – PRE-PROCEDURE CHECKLIST

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.		
	2. Verify all critical items in the test are identified and discussed with the test team.		
	3. Verify all required materials and tools are available in the test area.		
	4. Verify all hazardous materials involved in the test are identified to the test team.		
	5. Verify all hazardous steps to be performed are identified to the test team.		
	6. Verify each team member knows their individual responsibilities.		
	7. CONFIRM THAT EACH TEST TEAM MEMBER CLEARLY UNDERSTANDS THAT HE/SHE HAS THE AUTHORITY TO STOP THE TEST IF AN ITEM IN THE PROCEDURE IS NOT CLEAR.		
	8. Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly.		
	9. NOTIFY MANAGEMENT OF ALL DISCREPANCY REPORTS OR D-LOG ITEMS IDENTIFIED DURING PROCEDURE PERFORMANCE. IN THE EVENT AN INCIDENT OR MAJOR DISCREPANCY OCCURS DURING PROCEDURE PERFORMANCE MANAGEMENT WILL BE NOTIFIED IMMEDIATELY.		
	10. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: _____		

J. APPENDIX 2 – POST-PROCEDURE CHECKLIST

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify all steps in the procedure were successfully completed.		
	2. Verify all anomalies discovered during testing are properly documented.		
	3. Ensure management has been notified of all major or minor discrepancies.		
	4. Ensure that all steps that were not required to be performed are properly identified.		
	5. If applicable sign-off test completion.		
	6. Verify all RAV valve operations have been entered in log book		
	7. Verify the as-run copy of procedure has been filed in the appropriate binder		
	Team Lead Signature: _____		

K. APPENDIX 3– CONTINGENCY RESPONSES

	Condition	Circumstance	Response
1	Power Failure	Any time	Wait for power restoration and restore valve status
2	Burst disk rupture (MT/GT)	Any time	Evacuate room
3	Oxygen depletion alarm	Any time	Evacuate room

Instrumentation available through the umbilical:

Designator	Description	SMD Connector	DAS Channel No.
T-09D	Bottom Main Tank – SDT	P800	171
T-15D	Guard Tank/a - SDT	P800	170
T-24D	Fill Valve SV-13 – SDT	P800	177
T-20D	Top Lead Bag/a – GRT	P804	175
T-21D	Top Lead Bag/b – GRT	P804	178
H-03D	GT Heater/a	P804	150 (V) 151 (I)
H-04D	GT Heater/b	P804	152 (V) 153 (I)
LL-5D	GT Liquid Level/a (manually switched; primary)	P804	103
LL-6D	GT Liquid Level/b (manually switched; secondary)	P804	103
H-20D	GT Vent Heater	P1 of W604	–
T-26D	GT Vent/a – PRT	P1 of W604	–
T-27D	GT Vent/b – PRT	P1 of W604	–
H-20D	GT Thrust Null. Htr	P1 of W604	–
T-25D	GT Thrust Null. – PRT	P1 of W604	–