GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Configure SMD for Transport to SLC-2W

To be performed at Vandenberg Air Force Base building 1610

THIS DOCUMENT DOES NOT CONTAIN HAZARDOUS OPERATIONS

P1002 Rev A

ECO No. 1444

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Revision Record

Rev	***ECO***	***Revisions***	***Date***
A	1444	Changed liquid He requirement from 200 to 500 liters Updated procedure references Reordered sequence in section G Added table to record GT fill operations Added requirement that the PTD observe the critical operation of RAV-3 closure and verify the opening of SV-12 Changed securing of SV-12 from safety wire to epoxy stake Call for disconnecting vacuum and vent lines prior to SV rotation for solar array installation	

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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
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
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
FEE	Forward Equipment Enclosure
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.
MOC	Mission Operations Center
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
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
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
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 Dewar Adapter

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 transport to the SLC-2W launch site following the completion of P1001B, *Prepare Main Tank for Launch*. These steps include:

Perform P1027, *External Guard Tank Fill- Main Tank Subatmospheric (B1610)* as needed (nominally every four days)

Closeout of the Main Tank:

Perform procedure P1005, *Disconnect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric*

Close RAV-3

Perform additional preparations for FEE closure

Disconnect and secure cabling associated with top plate and main tank bayonet heaters

Open V12

Verify shorting plug installation

Close RAV-6B (commanded by the spacecraft)

Steps to be performed to allow SV rotation for Solar Array installation

If relevant, perform P1016, *Stop Pumping SMD / Disconnect Vacuum Module, and install cap on port*

Perform P1009, *Disconnect Guard Tank Vent Line from Gas Module*

Complete the performance of P1017, *Repump Well with UTS*, to terminate pumping and close out the Well

Steps To Be Performed Prior to Enclosure for Transport to MST

As needed, perform P1017, *Repump Well with UTS*

Perform P1010, *Disconnect Electrical GSE from SMD*

Remove emergency vent lines from burst disks

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.

See Figure 1 for the SMD plumbing configuration following the completion of 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.

During the performance of this procedure the main tank is at subatmospheric pressure. If the main tank fill or vent line is opened to atmosphere, air will be ingested into a cryogenic region where it will freeze with a high probability of blocking of the line. This could prevent proper venting of the main tank on orbit, consequent over temperature and over pressurization, and ultimately the rupturing of one of the main tank burst disks.

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

Mitigation of over pressurization hazard is primarily through the use of burst disks or relief valves. 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

When appropriate, tools or other items used with the potential to damage the SV shall be tethered.

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. Required Personnel

List below those personnel involved with the procedure

The following personnel are essential to the accomplishment of this procedure:

FUNCTIONAL TITLE	NUMBER	AFFILIATION
Test Director/Test Engineer	1	Stanford
GP-B Quality Assurance	1	Stanford
NASA Safety Rep	1	SFAO or ANALEX

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 than the Gas Module, together with additional flow metering capabilities. The vent output of the Gas Module flows through the Pump Module. 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).

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. No additional computers or software are required.

E.3.4. Spacecraft Support

With connector J802 connected to flight electronics, operation of RAV-2 and RAV-6B must be commanded through the spacecraft instead of the RAV controller in the Electrical Module. Spacecraft telemetry and EGSE support will also be needed.

E.3.5. Additional Test Equipment

Description	***Manufacturer***	***Model***
O_2 Monitor and Alarm	Alpha-Omega Instruments	1000

E.3.6. Additional Hardware

No additional hardware is required

E.3.7. Protective Clothing

None required.

E.3.8. Tools

No tools are required for this operation.

E.3.9. Expendables

Description	***Quantity***	***Mfr./Part No.***
Liquid Helium	≥ 500 liters.	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	

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
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 Granville-Phillips Model 316	EG-1a, -1b	2827	No	-
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) in the Assembly Stand with the FEE skins removed to allow to the vent boss region. The FEE skins and the solar panels may be installed for the latter part of this procedure.

E.5.2. Main Tank

The Main Tank liquid must be subatmospheric (1.65 K) with the liquid level ≥ 95% as obtained by the completion of P1001, *Prepare Main Tank for Launch*. The Main Tank is being pumped by AP-1 as specified in P1001, Sec. G.15. The actuator control valve for EV-9 (located on the Gas Module, this valve switches the state that EV-9 defaults to, should a power failure occur) should be verified in the "Subatm He" position, at the beginning of this procedure, ensuring that EV-9 closes in the event of power failure.

E.5.3. Guard Tank

The Guard Tank is filled with NBP liquid He and must be maintained above a minimum level of 20%. The Guard Tank pressure must not be allowed to drop below atmospheric.

E.5.4. Well

The Well must be evacuated with the UTS connected to the Well pumpout port per P1001, *Prepare the Main Tank for Launch*.

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.

E.5.6. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
    a. Top of lead bag temperature (CN 175) set at $T \leq 6.0$ K.
    b. Top of lead bag temperature set (CN 178) at $T \leq 6.0$ K.
    c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 30$ torr.
2. The DAS watchdog timer and alarm are enabled.

E.5.7. GSE and Non-flight Hardware

1. The ion-pump magnet is installed and ion pump is cabled to its readout.
2. GSE cabling must be connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811).
3. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833806).

4. The Guard Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833813).
5. The Fill Cap Assembly must be installed at SV-13.
6. The heaters on the SMD top plate, SV-9, and Main Tank vent bayonet are installed and connected to the External Temperature Control Unit.
7. The Pump Module is connected to the Gas module at EV-21.
8. The Utility Turbopump System is connected to the Well, but may be in a valved-off state per P1001.
9. Facility vent lines must be connected per P1000

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*
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*
SU/GP-B P1001B	*Prepare Main Tank for Launch (as-run copy)*

F.3. Additional Procedures

Document No.	***Title***
SU/GP-B P1005A	*Disconnect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric*

SU/GP-B P1017	*Repump Well with UTS*
SU/GP-B P1027	*External Guard Tank Fill- Main Tank Subatmospheric (B1610)*
SU/GP-B P1009	*Disconnect Guard Tank Vent Line from Gas Module*
SU/GP-B P1010	*Disconnect Electrical GSE from SMD*
SU/GP-B P1016	*Stop Pumping SMD / Disconnect Vacuum Module*

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 complete _____ QA.

G.2. Verify Preliminary SMD and GSE Preparations Complete

G.2.1. Verify that ~500 liters or more of liquid He is available.

G.2.2. Verify successful completion of P1001B, *Prepare Main Tank for Launch*. Record Op. No.: _____

Comment: This verifies that the Main Tank has been filled to 95% and cooled to 1.65 K or less. It also verifies that the vacuum shell and Well have been evacuated.

G.2.3. Verify operation of the GP-B portable oxygen monitor.

Section complete _____ QA.

G.3. Verify Configuration Requirements

G.3.1. Verify SV configuration: in Assembly Stand with FEE skins and solar panels not yet installed.

G.3.2. Main Tank: Verify the following by reference to P1001B, *Prepare Main Tank for Launch*:

1. Main Tank 95 ±1% full (94.3 ±1% indicated);
2. Main Tank bath at 1.65 K or less;
3. Main Tank pumped by AP-1;
4. EV-9 actuator control valve for EV-9 on "Subatm. He".

G.3.3. Verify the Guard Tank is filled with NBP liquid He and liquid level is above a minimum level of 20%:

Record GT liquid level: _____ %

G.3.4. Vacuum status: Verify the following by reference to P1001B, *Prepare Main Tank for Launch*:

1. Well is evacuated, and the UTS running and connected to the Well pumpout port; Record pumping status:

   _____

2. Verify that the vacuum shell pressure is less than 5×10^{-5} torr (G.16.15 of P1001B).

G.3.5. Ensure GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.3.6. Verify valve / pump status:

Open / On:	Closed / Off:
EV-7a/-7b, EV-10, EV-17, EV-13	All other EVs
AP-1, AV-6, AV-8 (opt.)	All other AVs
SV-9, GTV-V	FCV, SV-12, SV-13, all other GTV and GTVC valves
TP-1, TP-2, TV-1 (opt.), TV-2	All other TV valves
VW-1, VW-2, VW-3 (opt.)	–
RAV-3, RAV-6B	All other RAVs

G.3.7. 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 $T \leq 6.0$ K. Record set point. _____K
2. ***Top of lead bag* temperature** – ensure CN [178] on DAS alarm list and set to alarm at $T \leq 6.0$ K. Record set point. _____K
3. ***Relative Guard Tank Pressure*** – ensure CN [46] on DAS alarm list and set to alarm at $\Delta P \geq 30$ torr. Record set point. _____torr

G.3.8. Ensure DAS watchdog timer and alarm enabled.

G.3.9. Verify ion-pump magnet and cable are installed.

G.3.10. Verify Main Tank vent line connected to Gas Module.

G.3.11. Verify Guard Tank vent line connected to Gas Module.

G.3.12. Verify Fill Cap Assembly installed at SV-13

Section complete _____ QA.

G.4. Guard Tank Fill Operations

G.4.1. Perform P1027, *External Guard Tank Fill- Main Tank Subatmospheric (B1610)* or P1052, *External Guard Tank Fill – Main Tank Subatmospheric and No Vent Lines Connected* (as appropriate) when needed (nominally every four days). Record date and op. no. for each occasion:

Date	Op. Order No.

G.5. Closeout of the Main Tank

Comment: This section must be performed before FEE closeout.

G.5.1. Perform procedure P1005, *Disconnect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric.*
Record: Date _____ Op. No. _____.
Comment: P1005 closes SV-9, verifies closure, removes the vent line, installs flight cap, and evacuates and leak checks the cap.

G.5.2. Verify that the main tank vent cap is oriented per the mass properties tests (valve stem approximately in the X-Y plane).

Note:
Closure of RAV-3 shall be observed by the Payload Test Director.

G.5.3. Close RAV-3 as follows:

1. Verify that P803/J803 are connected.
2. Ensure all RAV controller selection switches in OFF position.
3. Turn on RAV power supply and adjust current limit to 1.85 amps.
4. Adjust power supply to 28 VDC.
5. Power up controller #3.

6. Position selection switch for controller #3 to RAV-3.
7. Record initial status lights (4) on: Open: θ θ Closed: θ θ
8. Activate controller #3 to close RAV-3 and record:
   a. Run time:_____ seconds.
   b. Current draw:_____ amps.
   c. Time of day: _____.
9. Record final status lights (4) on: θ θ Closed: θ θ
10. Verify that at least one of the closed status lights is illuminated.
11. Record operation in RAV log book.

RAV-3 closure complete _____ QA.

_____ PTD.

G.6. **Additional Preparations for FEE Closure**

G.6.1. Disconnect all cabling for the Main Tank vent and top plate heaters and secure with flight cable ties. Do not disturb the Guard Tank bayonet heater cabling.

Note:
Opening of V12 (SV-12) shall be observed or verified by the Payload Test Director.

G.6.2. Configure the thruster vent for FEE closeout (see Fig. 1) as follows:

1. Slowly open SV-12. (Comment: There is an atmosphere of helium in the volume between RAV4A/B and SV-12, whereas the main tank is subatmospheric.)
   a. LM to epoxy stake SV-12 open per drawing 8A00288. Record Op. No. _____.

SV-12 open and secured _____ QA.

_____ PTD.

G.6.3. Before installation of the solar panels, verify that the following dewar-related items have been performed:

1. Shorting plug is installed at P803A (spacecraft operation).
2. Shorting plug is installed at P6 (spacecraft operation).
3. Verify umbilical P800 and P804 are connected to the bottom of the FEE and are staked.

Section complete _____ QA.

G.7. **Closure of RAV-6B**

Comment: This section may be performed at any convenient time as is needed to coordinate with POD G.

G.7.1. Inform spacecraft operations personnel of impending RAV-6B operation.

G.7.2. Restart pumping on the Well as follows:

1. Verify the UTS turbopump is running and connected to the Well pumpout port.
2. Open / verify open TV-1.
3. Wait until TG-1 reads below 10^{-5} torr.
4. Open VW-3/4 to resume pumping on the Well.

G.7.3. Pump on the Well for a minimum of two hours before proceeding

G.7.4. Close RAV-6B as follows:

1. Verify that the Spacecraft is powered up, arming plug P222 is installed, and control personnel are prepared to command RAV-6B when requested.
2. Request spacecraft operations personnel to close RAV-6B and record date/time upon telemetry confirmation of valve closure _____/_____.
3. Verify removal of arming plug P222.

G.8. **Steps To Be Performed to Allow SV Rotation for Solar Array Installation**

G.8.1. If the Vacuum Module is connected to the vacuum shell pumpout port, PO, perform P1016, *Stop Pumping SMD / Disconnect Vacuum Module*, to discontinue pumping and completely disconnect the Vacuum Module.

G.8.2. Install the cap on the pumpout port PO, and request LM safety wire per MS33540. (Comment: It is not expected that the SMD vacuum shell will need further servicing before launch.)

_____ QA.

G.8.3. Perform P1009, *Disconnect Guard Tank Vent Line from Gas Module,* and record Op. No.: _____

G.8.4. Continue to pump on the Well for at least four hours after completion of the last Guard Tank fill procedure prior to SV rotation.

G.8.5. Complete the performance of P1017, *Repump Well with UTS*, to terminate pumping and close out the Well.

G.9. **Steps To Be Performed Prior to Enclosure for Transport to MST**

G.9.1. As needed, perform P1017, *Repump Well with UTS,* with pumping duration as long as practicable. Record date and op. order number for

each occasion:

Date	Op. Order No.

G.9.2. When needed to enclose the SV for transport, remove the emergency facility vent lines from the four burst disks, BD5A/B and BD7A/B leaving the manifolds in place. Install plastic protective covers.

Section complete _____ QA.

H. **PROCEDURE COMPLETION**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

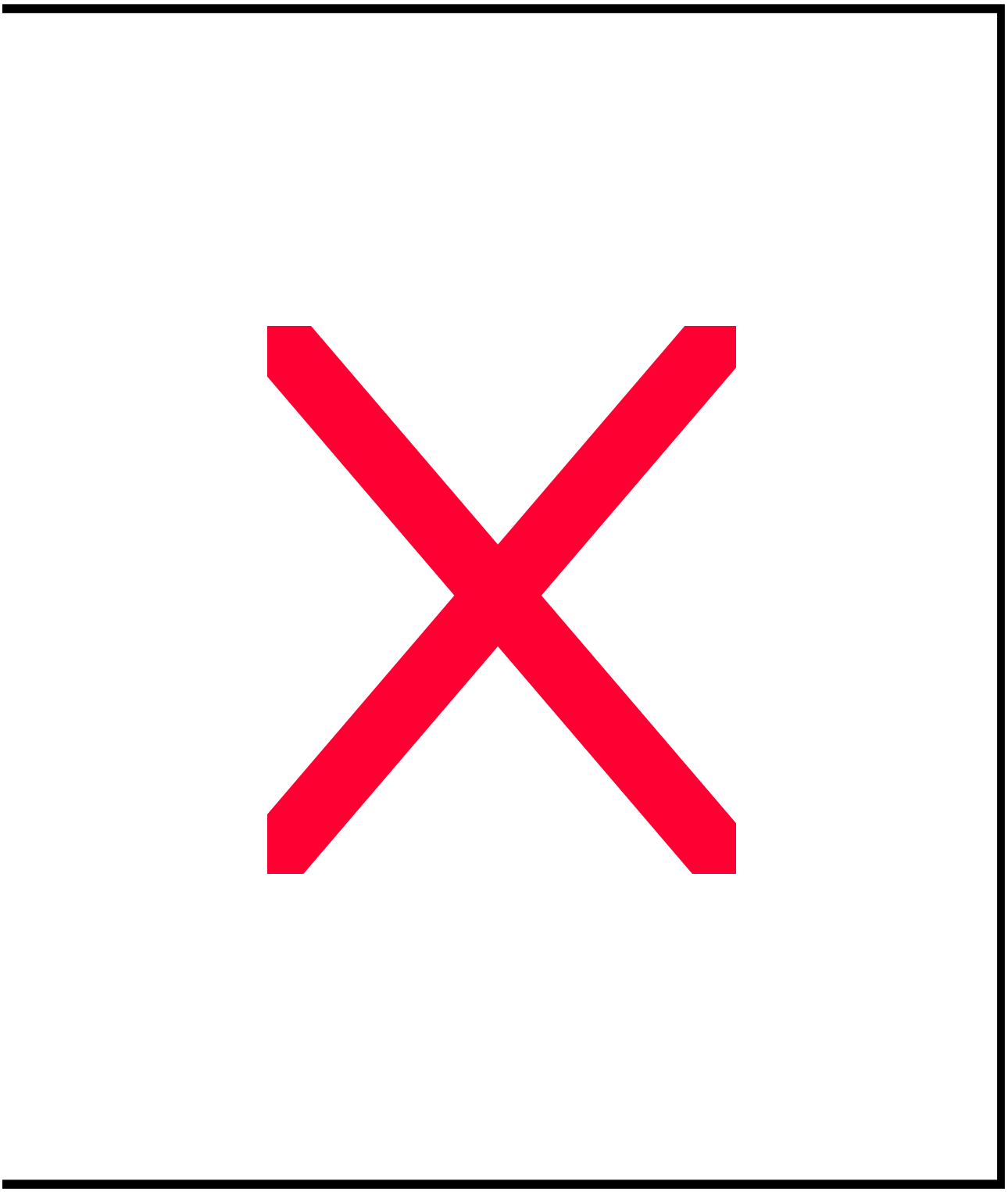

Figure 1 Schematic representation of SMD after completion of this procedure.

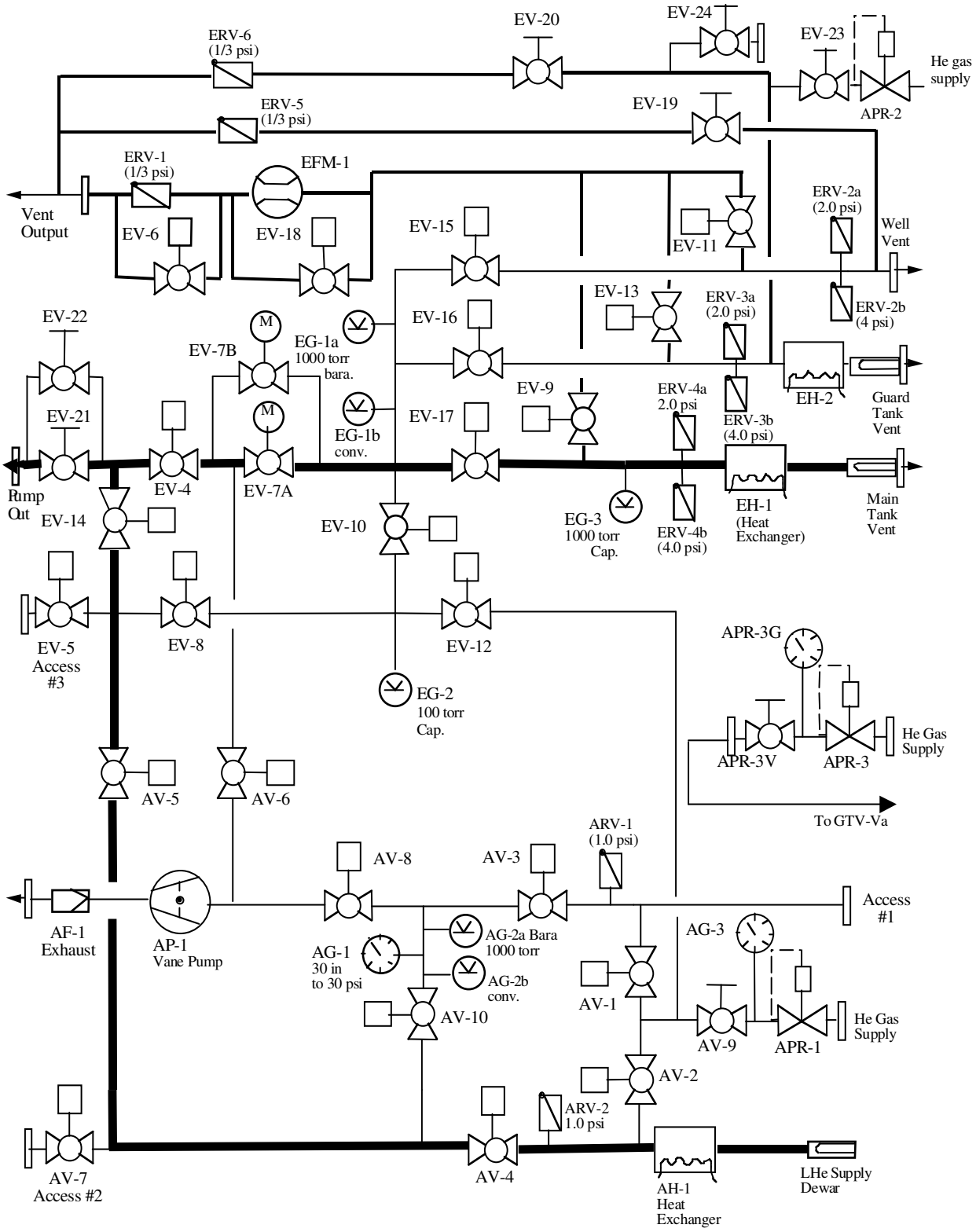

Figure 2. Schematic of Gas Module Plumbing.

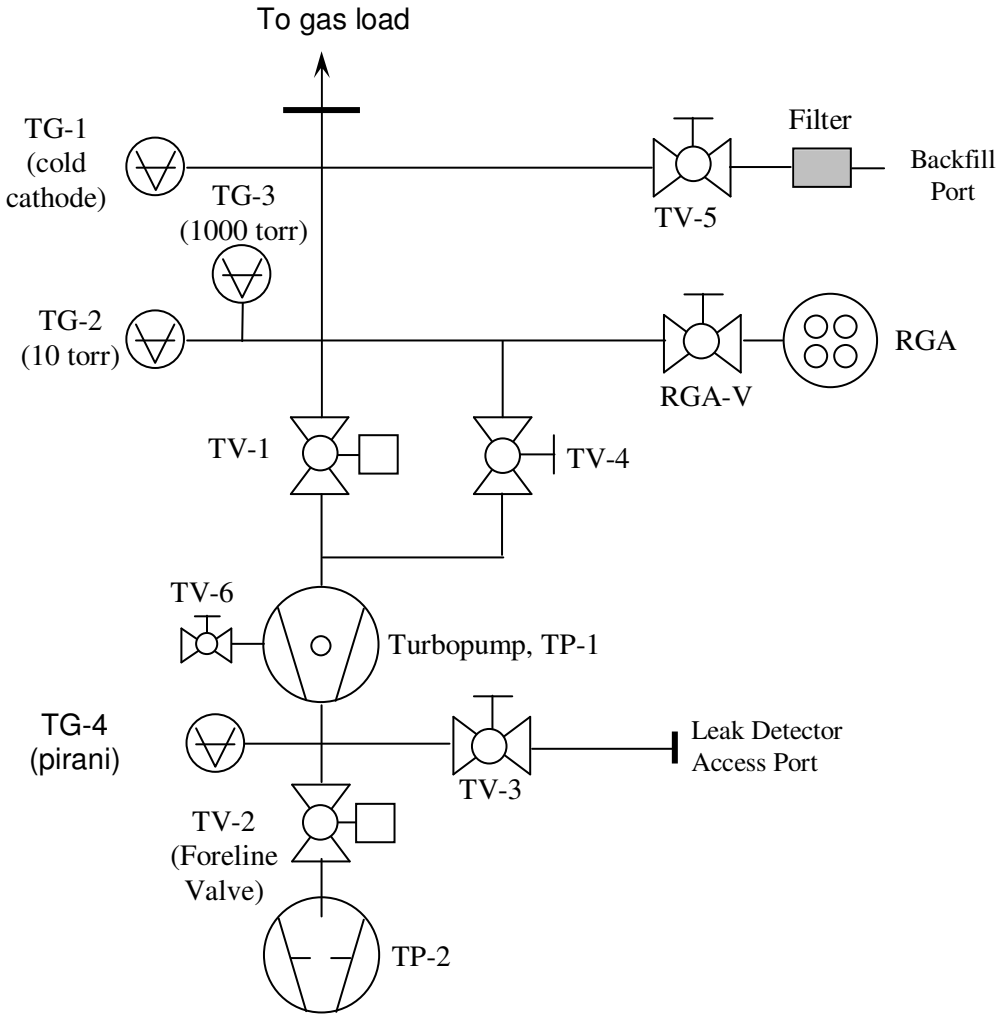

Figure 3. Schematic diagram of Utility Turbopump System (UTS)

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	Before closeout of the main tank, section G.4.1	1) Verify EV-9 and all other EVs and AVs are closed 2) Close / verify closed VW-3 3) Verify that all TVs are closed 4) Upon restoration of utility power, verify AP-1 is now running 5) Open AV-8 and verify that the pressure read by AG-2b is less than 0.1 torr 6) Open in sequence AV-6, EV-10, EV-17 to re-establish pumping on the MT 7) Reopen EV-13 8) Restart UTS per P1017 9) Continue with procedure
		After closeout of the MT per P1005	1) Verify that all TVs are closed 2) Close / verify closed VW-3 3) Upon restoration of utility power, restart UTS per P1017 4) Continue with procedure
2	Burst disk rupture (MT/GT)	Any time	Evacuate room
3	Oxygen depletion alarm	Any time	Evacuate room