Operation No. _________

GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Install Fill Line Relief Assembly on SMD

P0823 Rev-

February 26, 2001

Written by	Checked by
_______________________Date_______	_______________________Date_______
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Approvals:

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REVISION RECORD

REV	ECO	PAGES	DATE

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List of Abbreviations and Acronyms

AG-x	Gauge x of Gas Module auxiliary section
AMI	American Magnetics Inc.
AV-x	Valve x of Gas Module auxiliary section
CG-x	Gauge x of portable pressurization system
CV-x	Valve x of portable pressurization system
CPR-x	Pressure regulator x of portable pressurization system
CN [xx]	Data acquisition channel number
DAS	Data Acquisition System
EFM	Exhaust gas Flow Meter
EG-x	Gauge x of Gas Module exhaust section
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
HX-x	Vent line heat exchanger in Gas Module
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
Liq	Liquid
LL	Liquid level
LLS	Liquid level sensor
LMMS	Lockheed Martin Missiles and Space
LMSC	Lockheed Missiles and Space Co.
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
ONR	Office of Naval Research
PFCG	Fill Cap assembly 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
PTD	Payload Test Director
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
STV	SMD Thruster vent Valve
SU	Stanford University
SV-x	SMD Valve number x
TG-x	Gauge x of Utility Turbo System
TV-x	Valve x of Utility Turbo System
UTS	Utility Turbo 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

A. SCOPE

This procedure describes the steps necessary to remove the fill line burst disk and install the fill line relief assembly to the SMD support ring using an 0-ring and 6 #10 nuts and washers. An option to leak check the burst disk prior to removal is included.

B. SAFETY

B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware. Examples include: positioning Dewar in tilt stand; integrating probe with airlock; positioning airlock on Dewar; removing airlock from Dewar; removing probe from Dewar; and positioning support equipment such as pressurized gas cylinders and supply dewars.

A number of undesired events may be associated with these operations. For example, personnel or equipment can be struck when hardware is being moved (e.g. by forklift or crane load). Personnel are subject to entrapment while positioning hardware, such as hands or feet caught between objects as hardware is moved into place. Suspended hardware may be dropped. Personnel can be caught between objects such as forklifts and walls or loads and building support columns.

In addition, 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

Helium gas venting from the SMD shall be vented through the facility exhaust duct. The facility has an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. Additional temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions. Emergency vent line deflectors are installed over the four burst disks on the SMD vacuum shell, and oxygen collection pans are on the floor beneath them.

The following requirements apply to personnel involved in cryogenic operations. Gloves that are impervious to liquid helium and liquid nitrogen are to be worn whenever the possibility of splashing or impingement of high-velocity cryogens exists or when handling equipment that has been cooled to cryogenic temperatures. Protective clothing and full-face shields are to be worn whenever the possibility of splashing cryogens exists.

The FIST Emergency Procedures document, SU/GP-B P0141, discusses emergency procedures. These documents should be reviewed for applicability at any facility where the hardware is operated.

B.2.3. Other Hazards

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

B.3. Injuries

In case of any injury obtain medical treatment as follows
LMMS **Call 117**; Stanford University **Call 9-911**

C. QUALITY ASSURANCE

C.1. QA Notification

The ONR representative 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 PTD or his designate and shall be approved by the QA Representative. Additionally, approval by the Hardware Manager shall be required, if in the judgement of the PTD or QA Representative, experiment 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.

1. 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.
2. 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 PTD and approved by the QA representative.

3. 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. The Test Director is the designated signer for the “witnessed by” sign-off located at the end of each procedure. The person in charge of the operation (Test Director or Test Engineer) is to sign the “completed by” sign-off.

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

Test Director	***Test Engineer***
Mike Taber	Tom Welsh
Dave Murray	Chris Gray
Jim Maddocks	Bruce Clarke
Dave Frank	

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

N/A

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, the Pump Module, the Electrical Module, and the Vacuum Module. 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, 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.

This procedure calls for use of hardware located in the Gas Module (Figure 1).

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 for alarm conditions. No additional computers or software are required.

E.3.4. Additional Test Equipment

Description	***Part Number***	***Number required***
Utility Turbo System (Figure 3)		1 ea.
Helium leak detector		1 ea.

E.3.5. Additional Hardware

Description	***Part Number***	***Number required***
Fill Line Relief Assembly (Figure 4)		1 ea.
O-ring	Parker 2-212 (viton)	1 ea.
#10 nuts and washers	MS-21043-3	6 ea.

E.3.6. Tools

Description
3/8 open end wrench
Calibrated torque wrench
½ inch rubber stopper

E.3.7. Expendables

Description
Q-tips
Alcohol
Source of 99.99 % pure helium gas.

E.4. Instrument Pretest Requirements

N/A

E.5. Configuration Requirements

E.5.1. Main Tank

Liquid in the Main Tank may be at any level and either subatmospheric or at its normal boiling point.

E.5.2. Guard Tank

The Guard Tank may contain liquid or be depleted. Whenever it is depleted its pressure must be independently regulated to maintain it at a positive value relative to the atmosphere and continuously monitored. Monitoring is accomplished by placing the relative pressure, as read at the Guard Tank Vent Valve Assembly (GTV-G), in the DAS alarm list. The pressure is kept positive by maintaining liquid in the tank or supplying a source of He gas for independent regulation.

E.5.3. Well

The Well may contain liquid or be evacuated.

E.5.4. SMD Vacuum Shell

The pressure in the SMD vacuum shell should generally be less than 1 x 10^{-4} torr. For this procedure, verification that the pressure is less than 1 x 10^{-4} torr is not required.

E.5.5. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
   a. Station 200 temperature (CN [01]) set at $T \leq 6.5$ K.
   b. Top of lead bag temperature set (CN [28]) at $T \leq 6.0$ K.
   c. Relative Guard Tank Pressure (CN [46]) set at $\Delta P \geq 0.3$ torr.
2. The Facility Main Alarm System must be armed.

E.5.6. GSE and Non-flight Hardware

1. The Fill Cap Assembly is installed at SV-13 (See Figure 2)

E.6. Optional Non-flight Configurations

The following modifications or non-flight arrangement of the basic SMD configuration may also be in place. They are incidental to the performance of this procedure and not required.

1. The SMD is installed in its transportation and test fixture, or it may be installed in the tilt dolly or other transportation fixture.
2. A foreign object and debris shield may cover the upper cone of the SMD.
3. The ion-pump magnet may be installed.
4. The Main Tank vent line may be connected to the Gas Module or it may be disconnected with a vent cap installed.
5. The Guard Tank vent line may be connected to the Gas Module or it may be disconnected with a vent cap installed.
6. The Airlock Support Plate may be installed on the SMD. This plate supports the Airlock that is used to keep air out of the Well during probe installation and removal. It is left in place while the Probe is removed.
7. A Dewar Adapter, Shutter, and Shutter Cover are mounted to the Well of the SMD when the Probe is removed
8. The Well often contains liquid. When it does, it vents through the Gas Module unless Well operations are being performed (e.g., Probe insertion). Venting through the Gas module is accomplished via a pumping line

attached to the Dewar Adapter interface flange at the Airlock Support Plate (Probe not installed), or via a pumping line attached to the Well vent manifold installed at the Well pump-out port (Probe installed). When performing Well operations, the Well vents to the room

9. The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve operator and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be; off, actively pumping the pumping line up to a closed SV-14, or actively pumping the vacuum shell.

10. The thruster vent port may be flanged to a shut-off valve.

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*
SU/GP-B P0141	*FIST Emergency Procedures*
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*

F.3. Additional Procedures

N/A

Operation Number:____________

Date Initiated:____________

Time Initiated:____________

G. OPERATIONS

G.1. Verify Appropriate QA Notification

- o Verify SU QA notified.

  Record: Individual notified __________________,

  Date/time ________/________.

- o Verify ONR representative notified.

  Record: Individual notified __________________,

  Date/time ________/________.

G.2. Verify Configuration Requirements

G.2.1. Ensure Facility Main Alarm System enabled.

G.2.2. Verify proper sealing of Well. Record closure (cover plate, Hole cutter, Probe etc.).____.

G.2.3. Record location of SMD (FIST test fixture, tilt dolly, etc.) _____________.

____.

G.2.4. Ensure DAS or TM&A alarm system enabled and record set points.

1. ***Station 200 temperature*** – ensure CN [01] on alarm list and set to alarm at $T \leq 6.5$ K. Record set point. ______K
2. ***Top of lead bag temperature*** – ensure CN [28] on 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 $\Delta P \geq 0.3$ torr. Record set point. ______torr

G.3. Record Initial Configuration

G.3.1. Record Guard Tank configuration (check all that apply).

- o Guard Tank contains liquid and is not currently pressure regulated.
- o Guard Tank contains liquid and is pressure regulated.
- o Guard Tank is empty and is pressure regulated.
- o Guard Tank vent line connected to Gas Module.
- o Guard Tank vent line disconnected.

G.3.2. Record liquid helium levels, as applicable:

1.	Main Tank level	(LL-1D or LL-2D)	__________%
2.	Well level	(LL-3LD or LL-4D)	__________%
3.	Guard Tank level	(LL-5D or LL-6D)	__________%
4.	Axial Lock level	(LL-7D or LL-8D)	__________%

G.3.3. Record Main Tank configuration (check all that apply).

o Main Tank vent line connected to Gas Module.

o Main Tank vent line disconnected.

o Main Tank at NBP.

o Main Tank subatmospheric.

G.3.4. Record Initial Configuration of SMD Valves.

1. Using the RAV log book verify that the dewar's internal valves are in the following positions. If not, investigate to ensure previous RAV operations properly recorded. If necessary, note resolution in D-log.
   a. ***Open***:RAV-3, and RAV-6B.
   b. ***Closed***:RAV-1, RAV-2, RAV-5, RAV-6A, and RAV-7.
2. Ensure that SV-13 and FCV are closed.

G.4. Start Up Leak Detector

G.4.1. Turn on and verify calibration of leak detector.

G.4.2. Record:

1. Value of calibrated leak __________ sccs.
2. Cal. expiration date:________
3. Indicated leak rate ____________ sccs

G.4.3. Connect leak detector to the UTS at access port (LD).

G.5. Pump and Leak Check Up to Closed SV-13

G.5.1. Record pressure in Fill Cap Assembly (PFCG) ________ torr.

G.5.2. Connect UTS primary pumping port to Fill Cap Assembly at FCV and start the UTS pumping up to closed FCV as follows:

1. Close/verify closed TV-1, -2, -3, -4, -5 and RGA-V.
2. Place valve interlock switch in "over-ride" position.
3. Turn on vane pump and converter (Note: converter switch provides power to turbopump controller and pirani and cold-cathode vacuum-gauge display.)
4. Push the red "reset" button to activate the interlock over-ride circuit. (the yellow-orange indicator light will come on).

5. Turn “foreline” switch on, to open TV-2, and verify that the switch is illuminated.
6. 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.)
7. Slowly open TV-4.
8. When TG-4 is approximately 1 torr, open FCV.
9. When foreline pressure (TG-4) < 1 torr, push “Start” button on turbo controller.
10. When the ”Normalbetrieb” light illuminates on turbo controller, indicating turbopump is up to speed, open gate valve TV-1 and close TV-4.
11. Switch the valve interlock switch to the “protected” position.
12. 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).
13. Record the pumping line pressure (TG-1) ________ torr.

G.5.3. Leak check pumping line up to SV-13.

1. Start Leak Detector pumping up to TV-3. Do not proceed until Leak Detector has crossed over and is stable.
2. When TG-1 is < 5 x 10^{-5} torr,
   a. Record TG-1 __________torr,
   b. Slowly open TV-3,
   c. Close TV-2.
3. Leak check all joints between SV-13 and Leak Detector.

   Note: no leaks greater than 1 x 10^{-7} sccs are allowed.
   a. Record background __________ sccs.
   b. Record Leak Rate __________sccs.
4. When finished with leak check,
   a. Open TV-2 and
   b. Close TV-3.

G.6. (Option) Leak Check Burst Disk before Removal.

Note: this leak check verifies that the fill line burst disk has not developed a leak since its installation. Because it is being removed, no maximum acceptable leak rate is specified.

G.6.1. Determine Fill Line Pressure.

1. Close FCV.
2. Open SV-13.
3. Record PFCG __________ torr.

G.6.2. Pump up to burst disk using one of the following procedures:

- PFCG < 1 torr:

1. Open FCV, now pumping up to burst disk with turbo.

- PFCG > 1 torr:

2. Close TV-1 and stop turbo pump.
3. When turbo is fully stopped, open TV-4 and FCV. Now pumping on fill line with forepump.
4. When TG-4 < 1 torr, turn on turbo.
5. When “normalbetrieb” light comes on open TV-1 and close TV-4. Now pumping up to burst disk with turbo.

G.6.3. Leak check burst disk

1. When TG-1 is $< 5 \times 10^{-5}$ torr,
   a. Slowly open TV-3 and
   b. Close TV-2.
2. Record background leak rate __________ sccs (should be on the 10^{-6} scale).
3. Spray leak check burst disk.
4. Record leak rate __________ sccs (no increase in leak rate should be observed).
5. (Option) Bag burst disk.
   a. Install bag over burst disk taped securely to support ring.
   b. Purge bag with gaseous helium for 3 minutes.
   c. Record leak rate __________ sccs.
6. When finished with leak check,
7. Open TV-2 and
8. Close TV-3.

G.7. Establish Fill Line Purge

G.7.1. Close/verify closed TV-4, TV-5, and RGA-V.

G.7.2. Close TV-1 and stop turbo pump.

G.7.3. Open valve to decelerate turbo.

G.7.4. Install purged source of helium gas at TV-5 on UTS.

G.7.5. Regulate source pressure to approximately 1 psig.

G.7.6. Open/verify open SV-13.

G.7.7. Open TV-5.

G.7.8. Record pressure PFCG ________ torr, when stabilized.

G.8. Remove Burst Disk Assembly

G.8.1. Using 3/8 inch wrench remove the 6 nuts holding the burst disk in place.

G.8.2. Remove washers and burst disk.

G.8.3. Plug orifice with piece of tape.

G.8.4. Return parts to stores per QA instruction.

G.9. Install Fill Line Relief Assembly

G.9.1. Clean o-ring with alcohol.

G.9.2. Inspect o-ring for contamination damage.

G.9.3. Clean flange surface of Support Ring (5833230-101).

G.9.4. Clean flange surface of relief valve assembly (5833415-101).

G.9.5. Inspect both surfaces with 10x magnification. Comments ___________
____.

G.9.6. Install o-ring into groove on Support Ring.

G.9.7. Attach relief valve assembly using 6 #10 nuts and washers.

G.9.8. Torque nuts to 25 – 40 in-lbs.

G.9.9. Record Tool ID # __________ and calibration date __________.

G.10. Leak Check Relief Assembly Installation.

G.10.1. Close TV-5.

G.10.2. Slowly open TV-4. Now pumping up to relief assembly with forepump.

G.10.3. When TG-4 < 1 torr, turn on turbo.

G.10.4. When “normalbetrieb” light comes on open TV-1 and close TV-4. Now pumping up to relief assembly with turbo.

G.10.5. Record Date/Time __________/__________.

G.10.6. Spray leak check relief valve assembly.

Note: no leaks greater than 1 x 10^{-7} sccs are allowed.

1. Record background __________ sccs.
2. Record Leak Rate __________sccs.

G.10.7. (Option) Bag relief valve assembly.

1. Install bag over relief assembly and tape securely to support ring.
2. Purge bag with gaseous helium for 3 minutes.
3. Record background __________ sccs.
4. Record leak rate __________ sccs.

G.10.8. Close SV-13 and torque to 60 $\pm$ 5 in-lbs.

G.10.9. Open TV-5 and backfill pumping line with 760 torr gaseous helium.

G.10.10. Record:

1. Time of day ________.
2. Pressure PFCG ________ torr
3. Pressure TG-2 ________ torr.

G.10.11. Close FCV.

G.11. Verify Closure of SV-13

G.11.1. Verify closure of SV-13 by observing the pressure in the Fill Cap Assembly (PFCG) until satisfied that no gas is leaking into the Dewar Fill line. After 30 minutes record:

Time of day:_________

PFCG pressure:_________

Note: If PFCG drops by more than 0.5 torr in 30 minutes, retorque SV-13 and repeat 30-minute test.

G.11.2. Remove pumping line from FCV.

G.12. Verify Final Alarm Configuration

G.12.1. Ensure DAS or TM&A alarm enabled and record set points if changed.

- o Thermal conditions substantially unchanged, alarm set points for Station 200 and lead bag unchanged.
- o Thermal conditions substantially changed, temperature alarm points reset as follows:
  1. Station 200 set point [CN 1] ________ K (≤ 6.5 K)
  2. Top of Lead Bag set point [CN 28] ________ K (≤ 6.0 K)

G.12.2. Ensure Guard Tank pressure on DAS or TM&A alarm list and set to alarm at 0.3 torr differential.

G.12.3. Ensure Facility Main Alarm System enabled.

Completed by:______________________

Witnessed by:______________________

Date: __________

Time:__________

Quality Manager____Date_________________

Payload Test Director___________________________________Date_________________

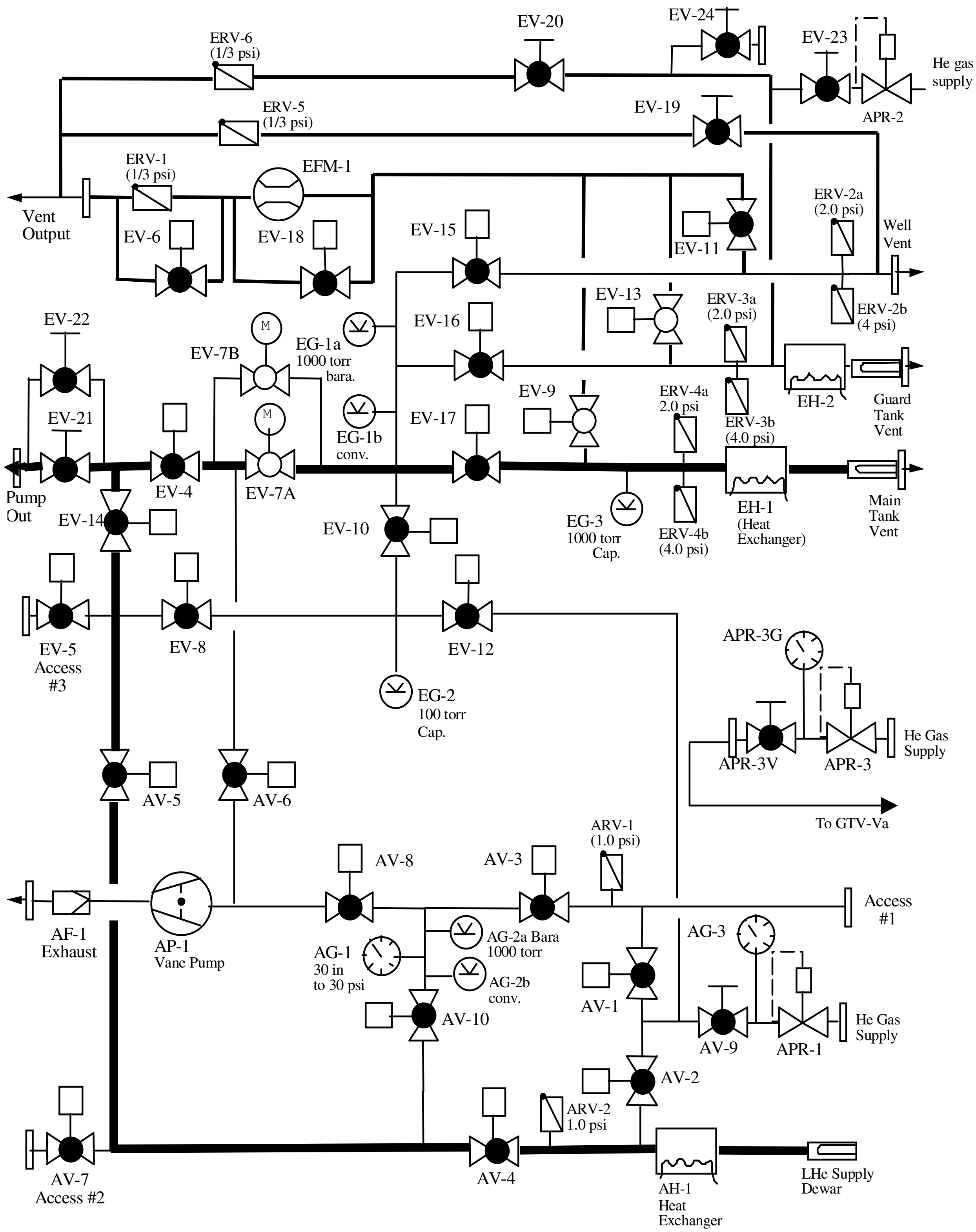

Figure 1. Schematic of Gas Module Plumbing.

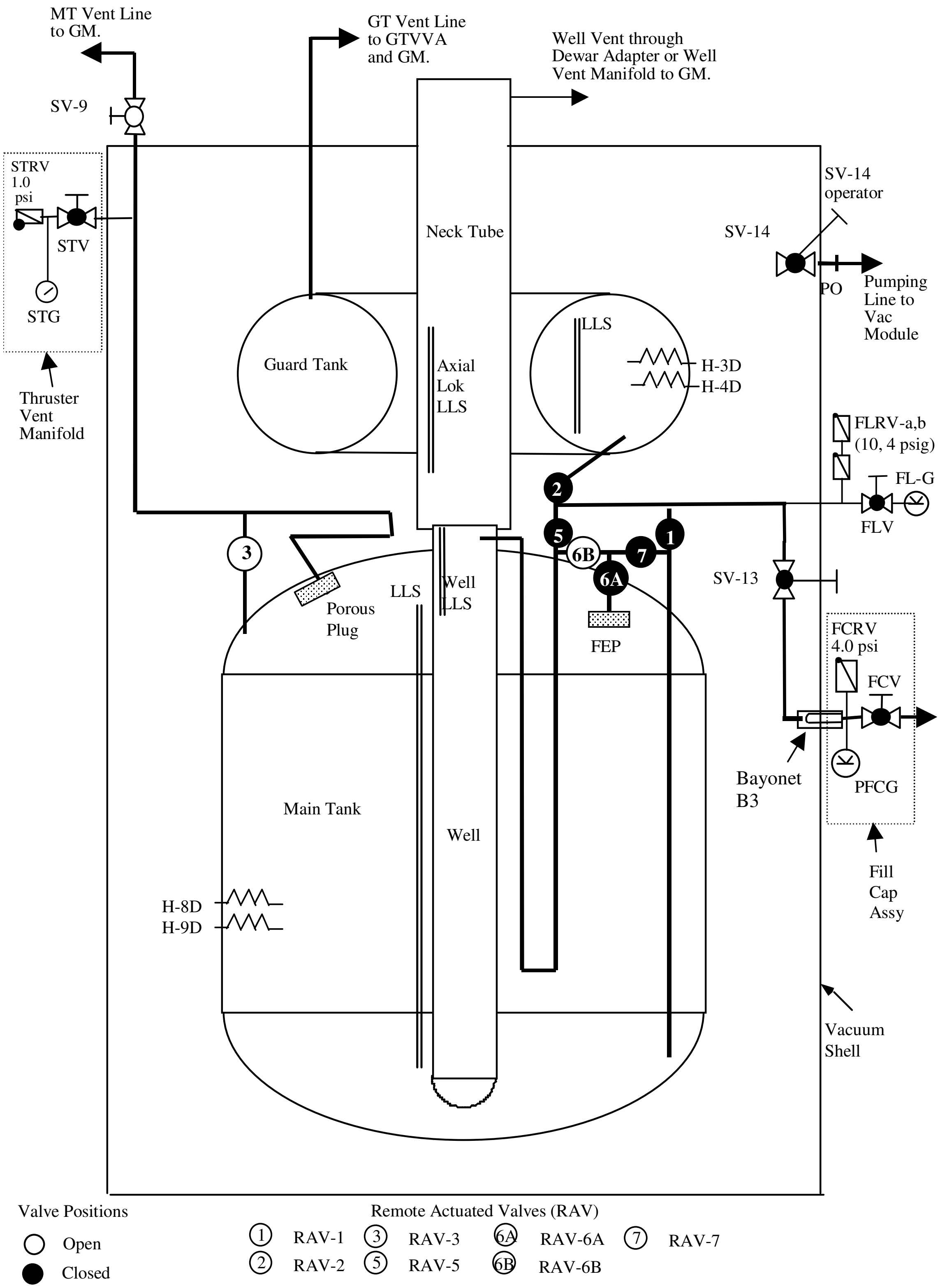

Figure 2. Schematic of Science Mission Dewar plumbing.

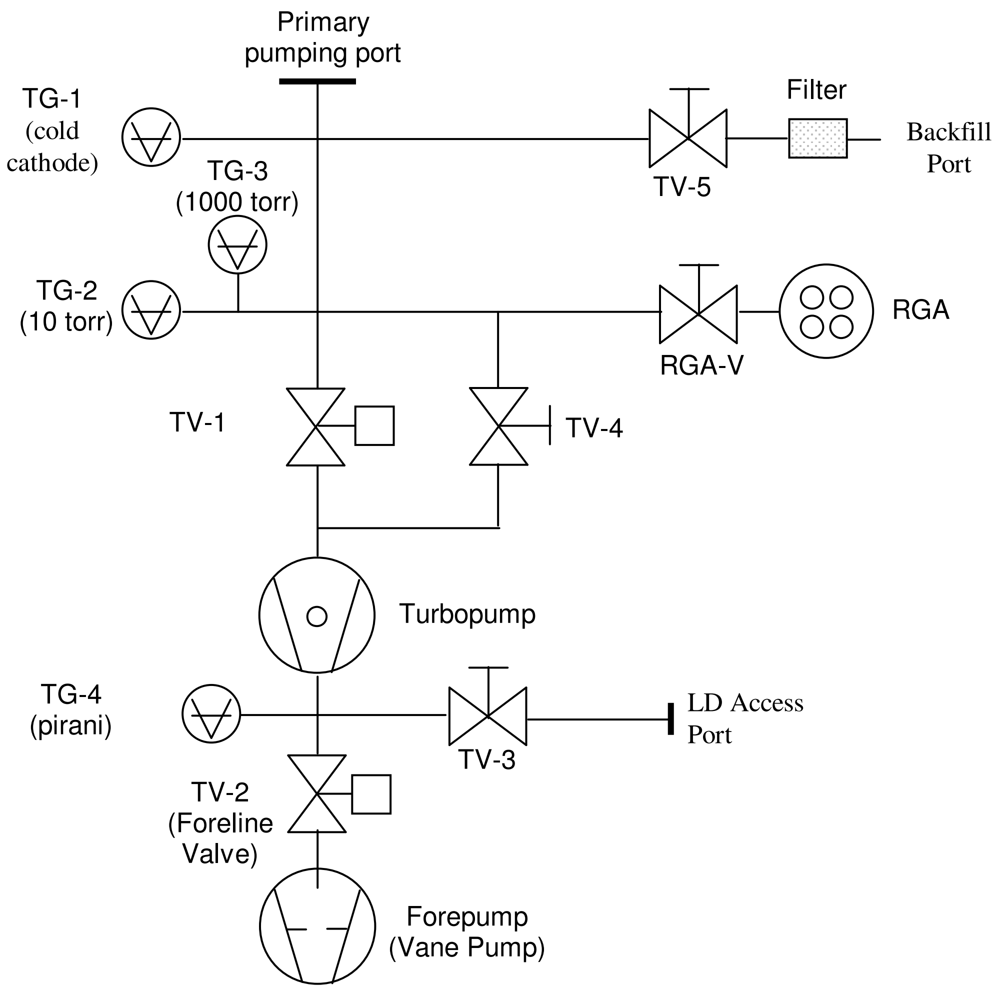

Figure 3. Schematic diagram of Utility Pumping System (UTS)

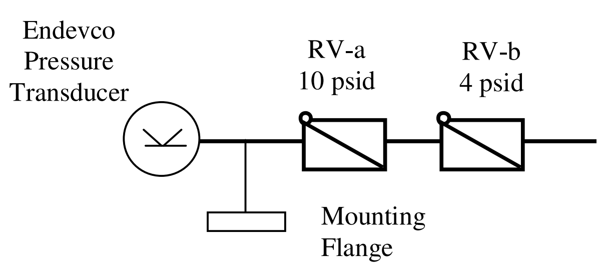

Figure 4. Fill line relief assembly