GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Empty the Guard Tank – Drain to Main Tank

P0794 Rev-

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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.
ATC	Advanced Technology Center
Aux	Auxiliary
AV-x	Valve x of Gas Module auxiliary section
Bot	Bottom
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 perform an internal transfer of liquid from the Guard Tank to the Main Tank. The steps include:

Raise internal fill line pressure to Main Tank pressure – open RAV-1.

Adjust Guard Tank pressure.

Initiate transfer – open RAV-2.

Terminate transfer – close RAV-1 and RAV-2.

The procedure can be performed when there is liquid in the Well, or when the Well is evacuated. There are three possible vent line configurations for the Main and Guard Tanks. Both vent lines may be connected to the Gas Module, both disconnected with vent caps installed, or the Main Tank connected and the Guard Tank disconnected.

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 from the SMD shall be vented through the facility exhaust duct. In addition, 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. In addition, a foreign object and debris shield usually covers the upper cone of the SMD and is required whenever work is being performed above the SMD such that hard objects could fall and impact the apparatus.

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

This procedure does not include any equipment sensitive to electrostatic discharge.

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), Pump Module (Figure 2) and Electrical Module (Table 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. No additional computers or software are required.

E.3.4. Additional Test Equipment

No additional test equipment is required.

E.3.5. Additional Hardware

No additional hardware is required.

E.3.6. Tools

No tools are required for this operation.

E.3.7. Expendables

No expendables are required for this operation.

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.

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	-	3452A01975	Yes	
2	DAS	Power Supply, H-P 6627A	-	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 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	-	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	-	C-09920	No	-
25	VM	Vacuum Gauge readout, Granville-Phillips 316	VG-3 VG-4	2878	No	-
26	VM	Vacuum Gauge readout,	VG-1, VG-2	96021521	No	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
		Granville-Phillips 360	VG-5			

E.5. Configuration Requirements

E.5.1. Main Tank
Liquid in the Main Tank must be at its normal boiling point (NBP) and the level must be no greater than 95%.

E.5.2. Guard Tank
The Guard Tank contains liquid.

E.5.3. Well
The Well may contain liquid or be evacuated.

E.5.4. SMD Vacuum Shell
The Vacuum Shell pressure must be less than 1 x 10-5 torr. Document No. P0213 contains the procedure for connecting to and pumping on the SMD vacuum shell.

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 ion-pump magnet is installed.
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 Fill Cap Assembly must be installed at SV-13 (See Figure 3)

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.
2. A foreign object and debris shield covers the upper cone of the SMD.
3. The Main Tank vent line may be connected to the Gas Module or disconnected from the Gas Module with the vent cap installed.
4. The Guard Tank vent line may be connected to the Gas Module or disconnected from the Gas Module with the vent cap installed.

5. 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.
6. A Dewar Adapter, Shutter, and Shutter Cover are mounted to the Well of the SMD when the Probe is removed.
7. 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
8. 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.
9. A relief valve may be installed in place of the SMD fill-line burst disk.
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

Document No.	***Title***
SU/GP-B P0213	Connect Vacuum Module / Pump on SMD Vacuum Shell

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

G. OPERATIONS

G.1. Verify Appropriate QA Notification

- Verify SU QA notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Verify ONR representative notified.

  Record: Individual notified _____,

  Date/time _____/_____.

G.2. Verify Configuration Requirements

G.2.1. If procedure is to be performed outside the Fist Ops Lab, ensure Main Tank is vented to facility exhaust.

G.2.2. Ensure Facility Main Alarm System enabled.

G.2.3. Verify proper sealing of Well. Record closure (cover plate, Hole cutter, Probe etc.)._____

G.2.4. Verify liquid in Main Tank at NBP (4.2<T<4.5) and record temperature at bottom of tank CN [09] _____K.

G.2.5. Verify Main Tank liquid level ≤ 95% (LL-1D or LL-2D) _____ %.

G.2.6. Ensure ion-pump magnet installed.

G.2.7. Ensure Vacuum Shell Pressure < 1 x 10^{-5} torr.

1. Turn on Vac-ion pump and record time of day _____
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr.
4. If pressure is above 1x10^{-5} torr, turn off Vac-ion pump and perform procedure P0213 to pump out SMD vacuum shell with Vacuum Module. Record operation number _____.
5. Exit [Monitor Data] and collect data with [Set Data Interval] to 10 min.
6. When data cycle is complete, turn off Vac-ion pump.

G.2.8. Ensure GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.9. Ensure Fill Cap Assembly installed at SV-13.

G.2.10. Ensure DAS alarm system enabled and record set points.

1. ***Station 200 temperature*** – ensure CN [01] on DAS 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 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 $\Delta P \geq 0.3$ torr.
   Record set point. _____torr

G.2.11. Ensure liquid-level alarms enabled and record set points.

1. ***Main Tank*** – ensure liquid-level alarm set ≥ 20%.
   Record set point. _____%
2. ***Well*** – ensure liquid-level alarm set ≥ 20%.
   Record set point. _____%

G.3. Verify SMD in Standard Configuration

G.3.1. Using the RAV log book verify that the SMD internal valves are in the following positions. If not, investigate to ensure previous RAV operations properly recorded. If necessary, note resolution in D-log.

1. ***Open***: RAV-3, and RAV-6B.
2. ***Closed***: RAV-1, RAV-2, RAV-5, RAV-6A, and RAV-7.

G.3.2. Verify that SMD external valves are in the following positions.

1. ***Open***: SV-9.
2. ***Closed***: SV-13, FCV, STV, and FLV.

G.4. Record Initial Conditions

G.4.1. Record appropriate pressures:

1. Main Tank pressure if disconnected from GM MTVC-G (CN [49]) _____ torr diff.
2. Main Tank pressure if connected to GM (EG-3) _____ torr .
3. Guard Tank pressure GTV-G (CN [46]) _____ torr diff.
4. Well pressure (PW-1/PW-2) _____ oz/in^2 / torr.

G.4.2. Record liquid helium levels:

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

G.5. Verify Gas-Module Configuration

G.5.1. Record configuration and verify corresponding valve states.

	Verify Open	***Verify Closed***
1. Main Tank vent		
o Connected to GM	EV-9	EV-17
o Not connected to GM, venting independently through vent cap.	MTVC-Va	EV-9, EV-17, MTVC-V
o Not connected to GM, venting in common with Guard Tank (GT/MT manifold line installed per Fig. 3)	MTVC-V, MTVC-Va	EV-9, EV-17
2. Guard Tank vent		
o Connected to GM through GTV-V, venting independently.	GTV-V, EV-20, EV-16	EV-13, EV-23, EV-24 GTV-Va, APR-3V
o Connected to GM through GTV-V, venting in common with Main Tank.	GTV-V, EV-13, EV-16	EV-20, EV-23, EV-24 GTV-Va, APR-3V
o Connected to GM through GTV-V, pressure regulated.	GTV-V, EV-23, APR-2 set to 1 psig EV-16	EV-13, EV-20, EV-24 GTV-Va, APR-3V
o Not connected to GM, venting independently through vent cap installed at GTV-V.	GTV-V	EV-13, EV-16, EV-20, EV-23, EV-24, APR-3V, GTV-Va, GTVC-V, GTVC-Fill Vent
o Not connected to GM, venting in common with Main Tank through vent cap installed at GTV-V.(GT/MT manifold line installed per Fig. 3.)	GTV-V, GTVC-V	EV-13, EV-16, EV-20, EV-23, EV-24, APR-3V, GTV-Va, GTVC-Fill Vent
o Not connected to GM, pressure regulated.	GTV-Va, APR-3V, APR-3 set to 1 psig	EV-13, EV-16, EV-20, EV-23, EV-24 GTV-V, GTVC-V, GTVC-Fill Vent
3. Well Vent		
o Well evacuated		EV-19, VW-3, VTH
o Well not evacuated (Dewar Adapter installed)	DEV-15, DEV-16 EV-19	DEV-14, VW-1
o Well not evacuated (Probe installed)	VTH, VW-3, EV-19	
4. Remaining EV valves	EV-7a/b	EV-4, EV-5, EV-6, EV-8, EV-10, EV-11, EV-12, EV-14, EV-15, EV-18,

	Verify Open	***Verify Closed***
		EV-21/22
5. AV valves		All

G.6. Establish Independent Venting of Main and Guard Tanks

- o Main and Guard Tanks already venting independently.
  - G.6.1. Main Tank connected to GM ____ yes ____ no.
  - G.6.2. Guard Tank connected to GM ____ yes ____ no.
  - G.6.3. Go to next section (G.7).

- o Main and Guard Tanks venting in common – vent lines disconnected from GM.
  - G.6.4. Verify open/open MTVC-Va.
  - G.6.5. Close MTVC-V and GTVC-V.
  - G.6.6. Remove manifold line from GTVC-V and MTVC-V, and go to next section (G.7).

- o Main and Guard Tanks venting in common – vent lines connected to GM.
  - G.6.7. Close EV-13.
  - G.6.8. Open EV-20 and go to next section (G.7).

G.7. Regulate Guard Tank Pressure with External Source of He Gas

- o Guard Tank pressure already regulated – verify source of helium gas at APR-2 or APR-3, as appropriate and skip to next section (G.8).

- o Guard Tank pressure **not** regulated – venting through Gas Module.
  - G.7.1. Ensure EV-23 closed.
  - G.7.2. Ensure purged source of gaseous helium connected to APR-2.
  - G.7.3. Set Apr-2 to regulate at 2 psig.
  - G.7.4. Close EV-20.
  - G.7.5. Open EV-23 and go to next section (G.8).

- o Guard Tank pressure **not** regulated – venting through vent cap.
  - G.7.6. Ensure APR-3V closed.
  - G.7.7. Ensure purged source of gaseous helium connected to APR-3.
  - G.7.8. Set APR-3 to regulate at 2 psig.
  - G.7.9. Open APR-3V.
  - G.7.10. Close GTV-V.
  - G.7.11. Open GTV-Va, and go to next section (G.8).

G.8. Check Initial pressure in Fill Line

G.8.1. Turn on pump AP-1

G.8.2. Install a pumping line between valve FCV on the Fill Cap Assembly and the Access Port #1 of the Auxiliary gas section.

G.8.3. Open AV-8.

G.8.4. Open AV-3.

G.8.5. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.8.6. Close AV-8 and FCV.

G.8.7. Once the pressure in the Fill Cap Assembly (PFCG) has stabilized, record Fill Cap Assembly pressure (PFCG): _____ torr.

G.8.8. Open valve SV-13 and bring the Fill Cap Assembly up to the pressure in the SMD fill line and record fill line pressure (PFCG): _____ torr.

G.9. Raise Pressure in Fill Line by opening RAV-1

G.9.1. **Ensure all** RAV controller selection switches in OFF position.

G.9.2. Turn on RAV power supply and adjust current limit to 1.85 amps.

G.9.3. Adjust power supply to 28 VDC.

G.9.4. Power up controller #1.

G.9.5. Position controller #1 selection switch to RAV-1.

G.9.6. Record initial switch status: Open: θ θ Closed: θ θ

G.9.7. Activate controller #1 to open RAV-1 and record:

1. Run time: _____ seconds
2. Current draw: _____ amp
3. Time of day: _____

G.9.8. Record final switch status: Open: θ θ Closed: θ θ

G.9.9. When convenient, record operation in RAV log book.

NOTE: Do not power off controller.

G.9.10. Verify that the Fill Cap Assembly pressure (PFCG) rises to pressure > 760 torr.

Record fill line pressure (PFCG): _____ torr.

G.10. **Set up Data Acquisition**

Note: Refer to Operating Instructions for mechanics of DAS keyboard/mouse operations.

G.10.1. Set Main Tank liquid level sampling interval to 1 minute.

G.10.2. Set Guard Tank liquid level sampling interval to 1 minute.

G.10.3. Begin special data collection using channels [06, 20, 24, and 28].

G.10.4. Input comment to DAS "Start Internal transfer from Guard Tank to Main Tank".

G.11. Prepare to Transfer

G.11.1. Record Main Tank pressure:

1. Main Tank connected to GM, EG-3 _____ torr
2. Main Tank disconnected from GM, MTVC-G _____ torr diff.

G.11.2. Record Guard Tank pressure (GTV-G) _____ torr diff.

G.11.3. Record range of GT pressures (relative to atm.) desired for sustaining transfer: desired GTV-G range_____ torr diff.

Note: the MT pressure is typically about 10 torr greater than atm. The Guard Tank pressure should be at least 30 to 40 torr greater than the MT pressure. Therefore a typical GT pressure range would be 40 to 50 torr diff as read at GTV-G. However, if the GT pressure exceeds the range of GTV-G (> 140 torr diff) it should be bled down to bring GTV-G back on scale.

G.11.4. Adjust Guard Tank pressure as necessary.

- Guard Tank pressure is in desired range – proceed to "Initiate Transfer."

- Guard Tank pressure is higher than desired –

1. If Guard Tank vent disconnected from GM
   a. Close APR-3V.
   b. Reset APR-3 to 1 to 2 psig.
   c. Crack open GTV-V to reduce pressure to desired range.
   d. Open APR-3V.
2. If Guard Tank vent connected to GM
   a. Close EV-23.
   b. Reset APR-2 to 1 to 2 psig.
   c. Crack open EV-20 to reduce pressure to desired range.
   d. Open EV-23.

- Guard Tank pressure is lower than desired –

3. Increase regulating pressure at APR-2 or APR-3 as appropriate.
4. When Guard Tank pressure stabilizes, record GTV-G _____ torr diff.

G.12. Initiate Transfer

G.12.1. Open RAV-2 to initiate transfer as follows:

1. Ensure controller #2 selection switch in OFF position.
2. Power up controller #2.
3. Position controller #2 selection switch to RAV-2.
4. Record initial switch status: Open: θ θ Closed: θ θ
5. Activate controller #2 to open RAV-2 and record:
   a. Run time:_____ seconds
   b. Current draw:_____ amp
   c. Time of day: _____
6. Record final switch status: Open: θ θ Closed: θ θ
7. When convenient, record operation in RAV log book.

Note: Do not put RAV controller selection switches to OFF or power off RAV Controller.

G.12.2. If Main Tank connected to Gas Module, open EV-6 and EV-18.

G.12.3. If Main Tank not connected to Gas Module, open MTVC-V.

G.12.4. Adjust Guard Tank pressure at appropriate regulator (APR-2 or APR-3) as necessary to maintain desired transfer pressure. Record data in the following table.

Time	MT Pressure EG-3 (torr)	GT Pressure GTV-G (torr diff.)	Flow Rate PFM-1 (slpm)	MT LLS (%)	GT LLS (%)	Comments

G.13. Terminate Transfer

Note: an empty Guard Tank is indicated by a steady rise in the Guard Tank temperature, CH [24]. When the MT is connected to the Gas Module it is also indicated by a steadily rising flow rate, as read at PFM-1.

G.13.1. When the Guard Tank is empty, close RAV-2 as follows:

1. Verify controller #2 already powered up and controller #2 selection switch set to RAV-2. **If not**, perform the following steps:
   a. Ensure controller #2 selection switch in off position
   b. Power up controller #2.
   c. Position controller #2 selection switch to RAV-2.
2. Record initial switch status: Open: θ θ Closed: θ θ
3. Activate controller #2 to close RAV-2 and record:
   a. Run time:_____ seconds
   b. Current draw:_____ amp
   c. Time of day:_____
4. Record final switch status: Open: θ θ Closed: θ θ
5. Turn controller #2 selection switch to OFF.
6. Power off controller #2.
7. When convenient, record operation in RAV log book.

G.13.2. Record Guard Tank Pressure (GTV-G):_____ torr diff.

G.13.3. Record Main Tank pressure:

1. Main Tank connected to GM, EG-3 _____ torr
2. Main Tank disconnected from GM, (MTVC-G):_____ torr diff.

G.13.4. Record Well pressure PW-1/PW-2 _____ oz/in^2 / torr.

G.13.5. Record final liquid levels:

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

G.14. Condition Dewar Fill Line and Fill Cap Assembly.

G.14.1. Ensure pumping line installed between Fill Cap Assembly at valve FCV and Auxiliary Gas Section access port no. 1.

G.14.2. Ensure FCV closed.

G.14.3. Close/verify closed AV-1 and AV-9.

G.14.4. Ensure pump AP-1 on.

G.14.5. Open AV-8 and AV-3 and evacuate pumping line to <25 mtorr measured at AG-2b.

G.14.6. Close RAV-1 as follows :

Note: Relief of the Dewar fill line will be through the relief valve in the Fill Cap Assembly until the next operation.

1. Verify controller #1 already powered up and controller #1 selection switch set to RAV-1. If not, perform the following steps:
   a. Ensure controller #1 selection switch in off position
   b. Power up controller #1.
   c. Position controller #1 selection switch to RAV-1.
2. Record initial switch status: Open: θ θ Closed: θ θ
3. Activate controller #1 to close RAV-1 and record:
   a. Run time:_____ seconds
   b. Current draw:_____ amp
   c. Time of day:_____
4. Record final switch status: Open: θ θ Closed: θ θ
5. Turn controller #1 selection switch to OFF.
6. Power off controller #1.
7. Turn off RAV power supply.
8. When convenient, record operation in log book.

G.14.7. If Main Tank connected to GM, Close EV-6 and EV-18.

G.14.8. If Main Tank disconnected from GM, close MTVC-V.

G.14.9. Open FCV and evacuate Dewar fill line to < 25 mtorr as measured at AG-2b, and record AG-2b: _____ torr

G.14.10. Close SV-13 and torque to 60 +/- 5 in-lbs.

G.14.11. Close AV-8.

G.14.12. Open AV-1.

G.14.13. Open AV-9 until pressure reaches 1.5 psig at AG-1, then close AV-9.

G.14.14. Close AV-1 and AV-3.

G.14.15. Close FCV.

G.14.16. Record pressure PFCG and time of day:

1. PFCG pressure:_____
2. Time of day: _____

G.14.17. 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, record PFCG _____ torr and time of day _____ and wait another 30 minutes.

G.15. Verify Final Valve States

G.15.1. Record configuration in left-hand column, then verify corresponding valve states.

	Verify Open	***Verify Closed***
1. Main Tank vent		
o Connected to GM	EV-9	EV-17
o Not connected to GM, vent cap installed.	MTVC-Va	EV-9, EV-17, MTVC-V
2. Guard Tank vent		
o Connected to GM through GTV-V, pressure regulated at EV-23.	GTV-V, EV-23, APR-2 set to 1 psig EV-16	EV-13, EV-20, EV-24 GTV-Va, APR-3V
o Not connected to GM, pressure regulated at GTV-Va.	GTV-Va, APR-3V, APR-3 set to 1 psig	EV-13, EV-16, EV-20, EV-23, EV-24 GTV-V, GTVC-V, GTVC-Fill Vent
3. Well Vent		
o Well evacuated		EV-19, VW-3, VTH
o Well not evacuated (Dewar Adapter installed)	DEV-15, DEV-16 EV-19	DEV-14, VW-1
o Well not evacuated (Probe installed)	VTH, VW-3, EV-19	
4. Remaining EV valves	EV-7a/b	EV-4, EV-5, EV-6, EV-8, EV-10, EV-11, EV-12, EV-14, EV-15, EV-18, EV-21/22

	Verify Open	***Verify Closed***
5. AV valves		All

G.16. Configure the DAS and Liquid Level Sensors

G.16.1. Input comment to DAS “End Internal transfer from Guard Tank to Main Tank”.

G.16.2. Set the DAS data cycle to 15 minutes.

G.16.3. Set all the liquid level sampling intervals to 10 minutes or turn off.

G.16.4. Stop special data collection.

G.16.5. Ensure DAS alarm enabled and record set points if changed

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

G.16.6. Ensure liquid level sensor alarms enabled and record set points if changed.

1. Main Tank Level Set Point _____%
2. Well Level Set Point _____%

G.16.7. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential.

G.16.8. Ensure that power to Vac-Ion pump is off.

G.16.9. Ensure all RAV operations (open and close) recorded in log book

1. RAV-1
2. RAV-2

G.16.10. Ensure Facility Main Alarm System enabled.

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

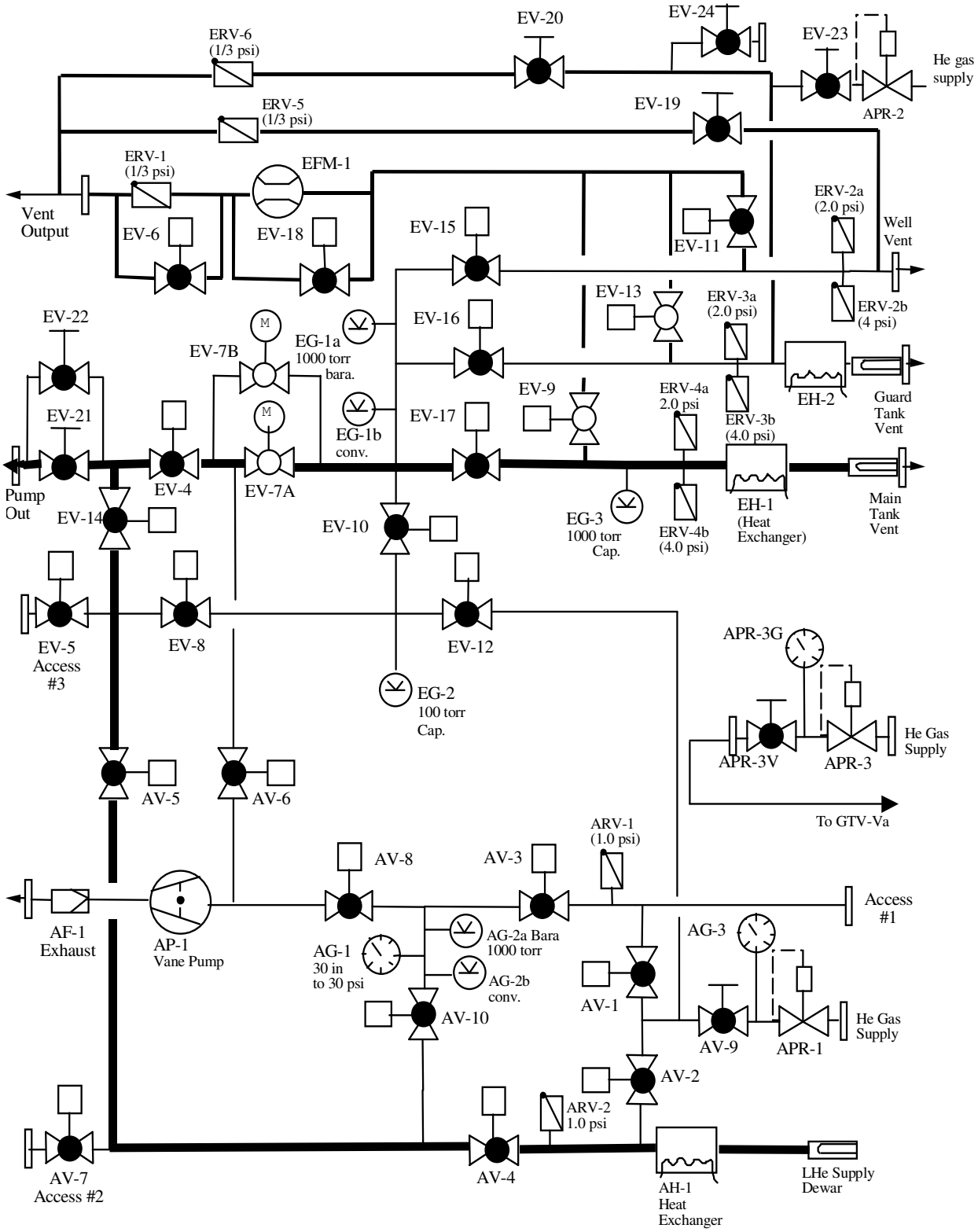

Figure 1. Schematic of Gas Module Plumbing.

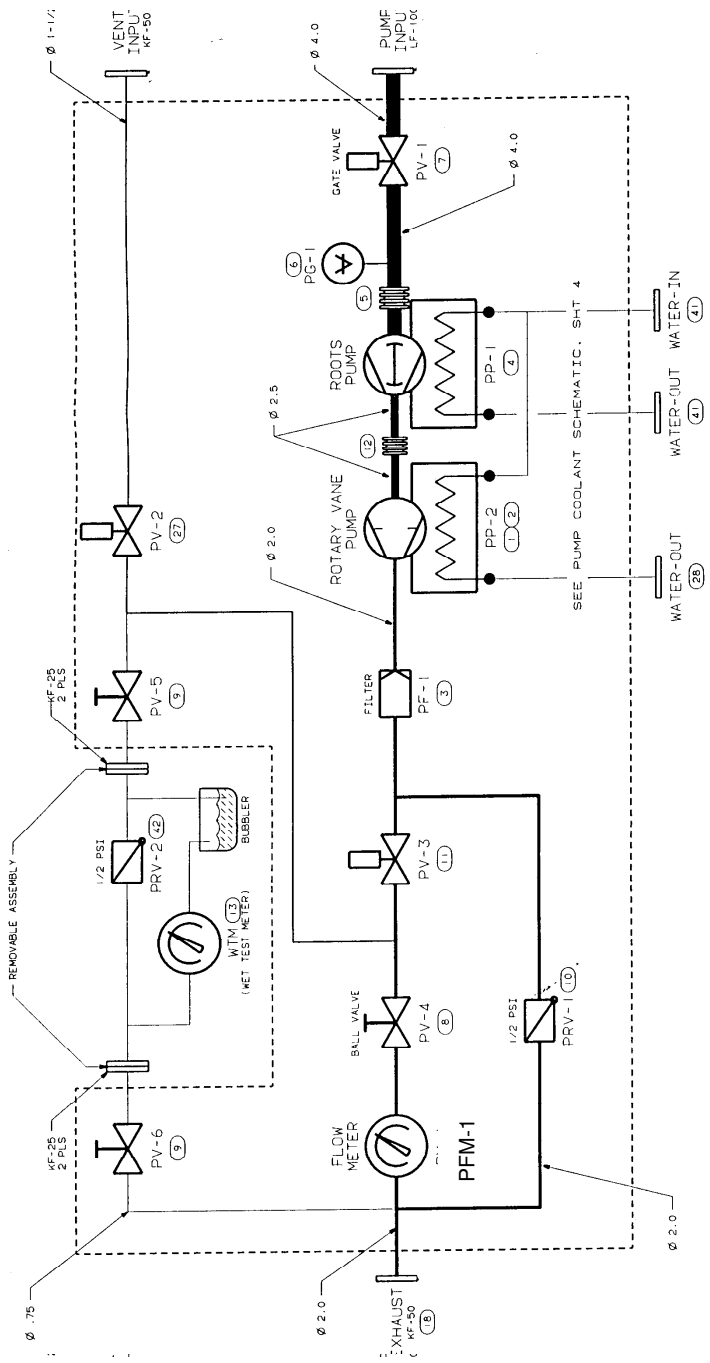

Figure 2. Schematic of Pump Module plumbing.

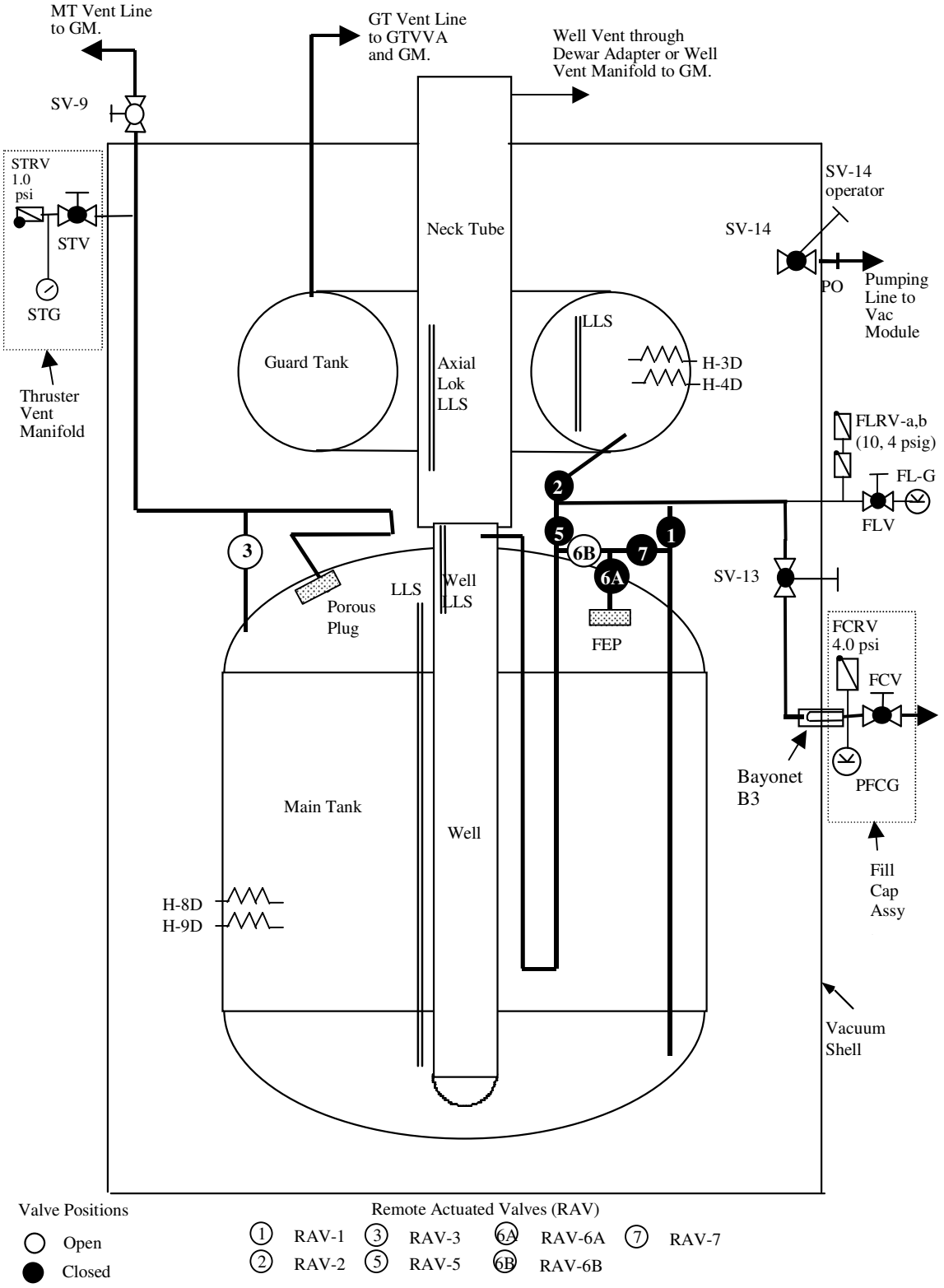

Figure 3. Schematic of Science Mission Dewar plumbing.

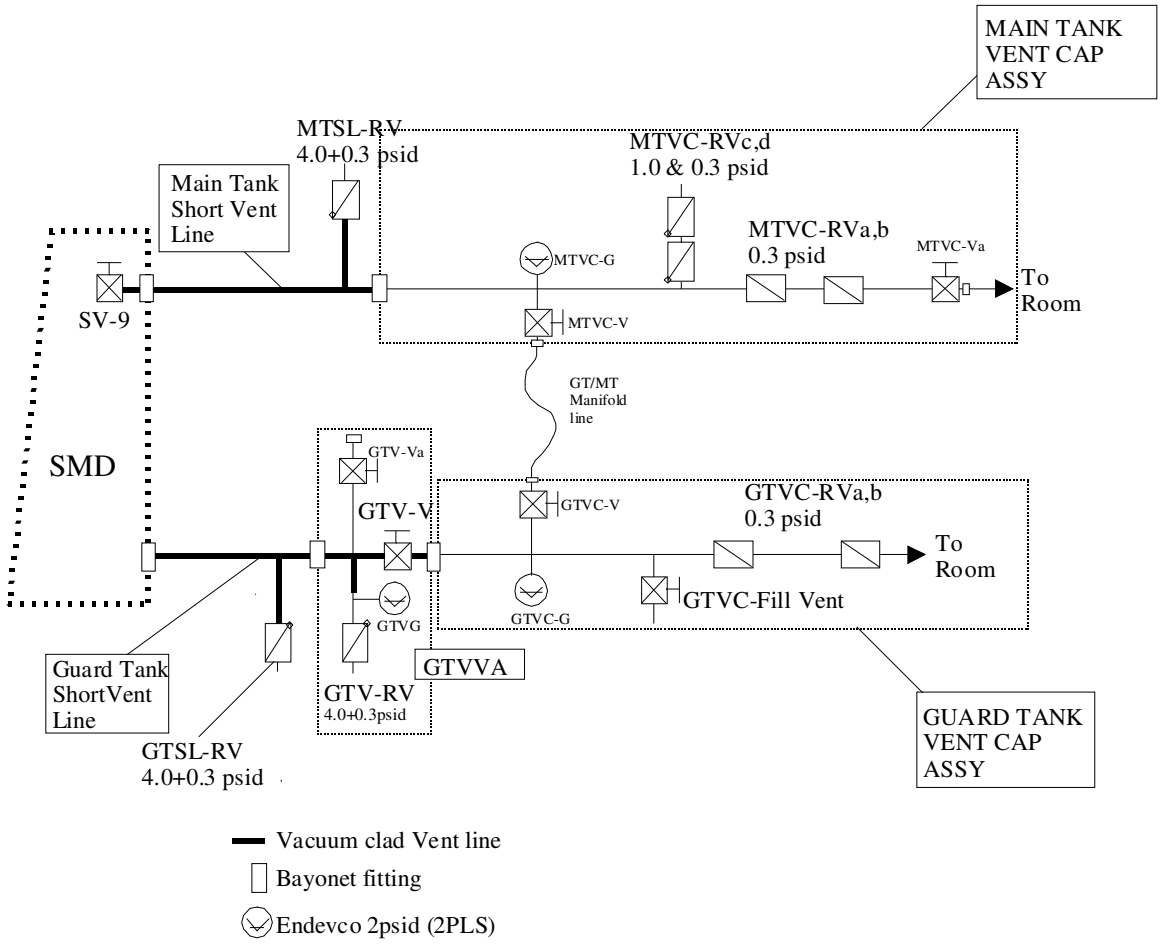

Figure 4. Schematic representation of Guard Tank Vent Valve Assembly (GTVVA) and Main Tank and Guard Tank vent cap assemblies. Common manifold capability is provided by the GT/MT manifold line.

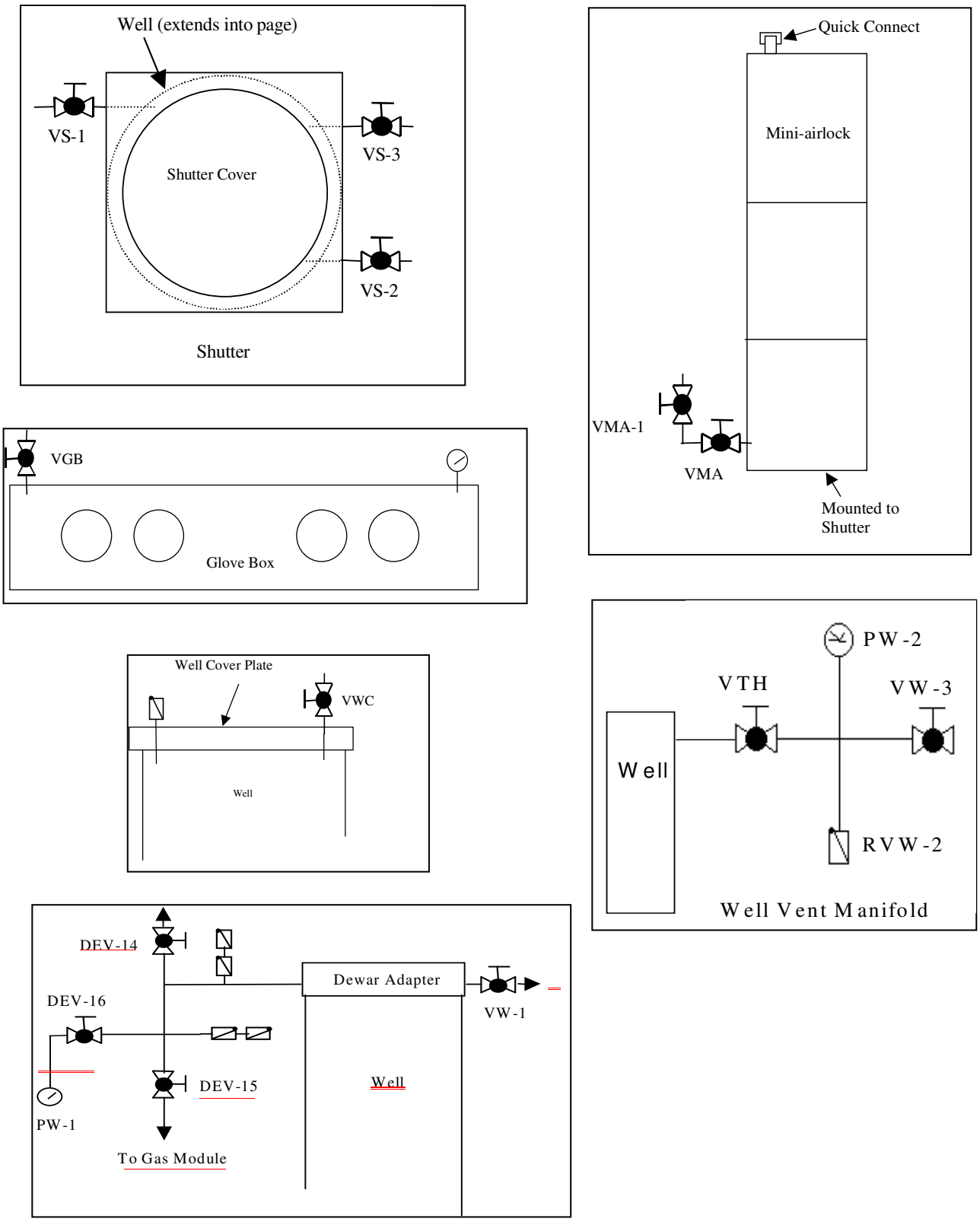

Figure 5. Well closures, manifolds, and associated plumbing.