GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

PRESSURIZE MAIN TANK FROM SUBATMOSPHERIC TO NORMAL BOILING POINT

P0216 Rev. B
ECO 1156

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REVISION RECORD

REVISION	ECO	PAGES	DATE
A	1012	Update of the procedure to allow more options, as well as have greater temperature monitoring and control of the lead bag.	6/23/99
B	1156	Changed scope to include case that SMD is horizontal. Added Quality Assurance Section (new Section C) Section C, D, and E – Consolidated all requirements into new Section E entitled Requirements. Added Configuration requirements to include minimum GT and Well liquid levels, GSE/SMD interface requirements, alarm setup requirements, vacuum requirements, and non-flight hardware requirements. Added section to verify notification of QA. Added steps to verify configuration requirements and alarm setup. Added option to have GT vent line connected to or disconnected from Gas Module. Added initial and final valve-state tables. Added steps to ensure Guard Tank pressure kept positive relative to atmospheric pressure – independently regulate pressure if depleted, add heat if not depleted. Added caution at end of procedure to monitor Guard Tank pressure and set DAS alarm to 0.3 torr differential. Update schematic drawings of GSE where appropriate.	5/24/01

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List of Abbreviations and Acronyms

AG-x	Gauge x of Gas Module auxiliary section	MT	Main Tank
AMI	American Magnetics Inc.	MTVC	Main Tank Vent Cap
ATC	Advanced Technology Center	MTVC-G	Main Tank Vent Cap pressure gauge
APR-x	Pressure regulator x of Gas Module	MTVC-RV	Main Tank Vent Cap relief valve
AV-x	Valve x of Gas Module auxiliary section	MTVC-V	Main Tank Vent Cap valve
CG-x	Gauge x of portable helium pressurization source	NBP	Normal boiling point
CPR-x	Pressure regulator x of portable helium pressurization source	ONR	Office of Naval Research
CV-x	Valve x of portable helium pressurization source	PFCG	Fill Cap assembly pressure Gauge
CN [xx]	Data acquisition channel number	PFM	Pump equipment Flow Meter
DAS	Data Acquisition System	PG-x	Gauge x of Pump equipment
EFM	Exhaust gas Flow Meter	PM	Pump Module
EG-x	Gauge x of Gas Module exhaust section	psi	pounds per square inch
EH-x	Vent line heat exchanger in Gas Module	psig	pounds per square inch gauge
EM	Electrical Module	PTD	Payload Test Director
ERV-x	Relief valve of Gas Module exhaust section	PV-x	Valve x of the Pump equipment
EV-x	Valve number x of Gas Module exhaust section	QA	Quality Assurance
FCV	Fill Cap Valve	RAV-x	Remote Actuated Valve-x
FIST	Full Integrated System Test	RGA	Residual Gas Analyzer
GHe	Gaseous Helium	SMD	Science Mission Dewar
GM	Gas Module	STV	SMD Thruster vent Valve
GP-B	Gravity Probe-B	SU	Stanford University
GSE	Ground Support Equipment	SV-x	SMD Valve number x
GT	Guard Tank	TG-x	Gauge x of Utility Turbo System
GTVC	Guard Tank Vent Cap	TV-x	Valve x of Utility Turbo System
GTVC-G	Guard Tank Vent Cap pressure gauge	UTS	Utility Turbo System
GTVC-RV	Guard Tank Vent Cap relief valve	Vac	Vacuum
GTVC-V	Guard Tank Vent Cap valve	VCP-x	Vent cap pressure gauge
GTV-G	Guard Tank vent pressure gauge	VCRV-x	Vent cap relief valve
GTV-RV	Guard Tank vent relief valve	VCV-x	Vent cap valve
GTV-V	Guard Tank vent valve	VDC	Volts Direct Current
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)	VF-x	Liquid helium Fill line valve
LHe	Liquid Helium	VG-x	Gauge x of Vacuum Module
LHSD	Liquid Helium Supply Dewar	VM	Vacuum Module
LHV-x	Liquid Helium Supply Dewar valves	VV-x	Valve x of Vacuum Module
LLS	Liquid level sensor	VW-x	Valve x of Dewar Adapter
LM	Lockheed Martin Co.		

A. SCOPE

This procedure describes the steps necessary to return the Main Tank liquid to its normal boiling point from the superfluid state, by raising the temperature of the liquid from approximately 1.8 K to 4.2K. The pressure increases simultaneously from approximately 12 torr to 760 torr. It can be performed when the tank is vertical or horizontal. The steps include

Heat liquid to raise temperature

Continue pumping on bath with pumps PP-1/2; throttle pumping with EV-7a/b or EV-21/22 to maintain lead bag temperature between 5 and 6 K

Terminate pumping when NBP is reached

Reestablish MT venting and terminate heating.

Experience indicates that the time to atmospheric pressure is approximately 8 hours. The liquid is highly stratified at this point (4.2 K at the top, 2.2 K at the bottom). The time required to reach equilibrium is on the order of 4 days when the Main Tank is 75% full.

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

The FIST OPS laboratory has an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. Prior to beginning this procedure in any facility other than the FIST OPS Lab, the presence of a similar oxygen monitor must be verified by safety and operations personnel. 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 Payload Tachnical 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, (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.

This procedure calls for use of hardware located in the Gas Module (Figure 1) Pump Module (Figure 2) and the 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

Description
Torque wrench, 1 ¼-in. socket, 60 in-lb.

E.3.7. Expendables

Description	***Quantity***	***Mfr./Part No.***
Alcohol	AR	N/A
99.99% pure gaseous helium	AR	N/A
Tie wraps – large size	AR	N/A
Vacuum grease	AR	Braycote Micronic 601

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	-	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	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
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, Granville-Phillips 360	VG-1, VG-2 VG-5	96021521	No	-

E.5. **Configuration Requirements**

E.5.1. Main Tank

Liquid is subatmospheric (nominal temperature of 1.8 K). 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) is in the "Subatm He." position, at the beginning of this procedure, ensuring that EV-9 remains open in the event of power failure. Once reaching NBP in the Main Tank , it is switched to the "NBP" position.

E.5.2. Guard Tank

The Guard-Tank may contain liquid or be depleted.

E.5.3. Well

The Well is evacuated whenever the Main Tank is subatmospheric.

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 1×10^{-4} torr. Procedure P0213, contains the steps 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 must be 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 Main Tank Vent Line must be connected to the Gas Module.
4. The Thruster vent is flanged to a shutoff valve (STV).
5. The heaters on the SMD top plate, SV-9, and Main Tank vent bayonet must be installed and operational.

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 relief valve is installed in place of the SMD internal fill-line burst disk.
3. A foreign object and debris shield covers the upper cone of the SMD.
4. The Guard Tank Vent Line may be connected to the Gas Module, or it may be disconnected at GTV-V. If disconnected, the Vent Cap Assembly is installed.
5. 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 the closed position or in the open position with the Vacuum Module actively pumping the vacuum shell.
6. The Well-vent manifold assembly may be installed at VTH.
7. The Fill Cap Assembly may be installed at SV-13.

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*
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_P0672	*Connect Main Tank Vent Line to Gas Module– Main Tank Subatmospheric*

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. Ensure Facility Main Alarm System enabled.

G.2.2. Ensure heaters on SMD are operational (i.e., power supplies on):

- Top plate
- SV-9 stem
- Main Tank vent bayonet
- SV-9 knob
- Bayonet nut

G.2.3. Ensure GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.4. Ensure Actuator control valve for EV-9 set to “Subatm He” position.

G.2.5. 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.2.6. Ensure liquid-level alarms set, as appropriate, and record set points.

1. ***Main Tank*** – ensure liquid-level alarm set ≥ 20%.
   Record set point. _____%
2. ***Guard Tank*** – ensure liquid level alarm set ≥ 10% if liquid in GT. Record set point. _____%

G.2.7. Ensure DAS watchdog timer and alarm enabled.

G.2.8. Ensure ion-pump magnet installed.

G.2.9. Verify Main Tank vent line connected to SMD. If not, perform Procedure P0672, *Connect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric*, and record Operation No. _____.

G.2.10. Verify that the Thruster Vent is flanged to a relief assembly.

G.3. **Establish Initial Configuration of GSE**

G.3.1. Verify valve states are as indicated in following Table. Record configuration in left-hand column, then verify corresponding valve states.

Configure Initial Valve States		
	Verify Open	***Verify Closed***
1. Main Tank vent		
o Pumping w/ AP-1	EV-7a/b, EV-10, EV-17, AV-6 PV-2	EV-4, EV-5, EV-6, EV-8, EV-9, EV-11, EV-12, EV-14, EV-15, EV-16, EV-18, EV-19, EV-21/22 All AV valves except AV-6
o Pumping w/ PP-1/PP-2	EV-4, EV-7a/b, EV-10, EV-17, EV-21, PV-1, PV-2, PV-3, PV-4	EV-5, EV-6, EV-8, EV-9, EV-11, EV-12, EV-14, EV-15 EV-16, EV-18 EV-19, EV-22 All AV valves PV-5, PV-6
2. Guard Tank vent connected to GM		
o With liquid	EV-13, GTV-V	EV-20, EV-23, EV-24, GTV-Va
o Depleted and pressure regulated at EV-23	EV-23, GTV-V, Ensure source of gas at APR-2.	EV-13, EV-20, EV-24 GTV-Va
3. Guard Tank vent **not** connected to GM		
o With liquid	GTV-V	EV-13, EV-20, EV-23, EV-24 GTV-Va, GTVC-V GTVC-Fill Vent
o Depleted and pressure regulated at GTV-Va	GTV-Va, APR-3V Ensure source of gas at APR-3.	EV-13, EV-20, EV-23, EV-24 GTV-V, GTVC-V GTVC-Fill Vent

G.4. **Establish Initial Condition of SMD:**

G.4.1. Record orientation of SMD.

- o Vertical.
- o Horizontal (record the axis that is up _____)

G.4.2. Record SMD Vacuum Shell Pressure.

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. Verify Vacuum Shell Pressure < 1 x 10-4 torr. If not, turn off Vac-ion pump and perform procedure P0213, Pump SMD Vacuum Space with Vacuum Module, to pump out SMD vacuum shell. Record Op No. _____.
5. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
6. When data cycle is complete, turn off Vac-ion pump.

G.4.3. Record Main and Guard Tank pressures:

1. Main Tank (EG-2):_____ torr
2. Main Tank (EG-3):_____ torr
3. Guard Tank (GTV-G, CN [46]):_____ torr (relative to atm.)

G.4.4. If the SMD is vertical, record initial liquid helium levels, as appropriate:

1. ***Main Tank*** (LL-1D or LL-2D) _____%
2. ***Guard Tank*** (LL-5D or LL-6D) _____%

G.4.5. Record Fill Cap Assembly pressure.
Fill Cap Assy (FCG): _____ psig / torr.

G.4.6. 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.

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

G.4.7. Verify that SMD external valves are in the following positions.

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

G.5. **Transfer Pumping to Pump Module.**

- Already pumping with Pump Module, skip this section.
- Currently pumping with AP-1, perform this section.

G.5.1. Verify that PV-2 is open.

G.5.2. If PP-1, and PP-2 are off, perform the following:

1. Close/verify closed PV-3.
2. Verify on/turn on cooling water to pump module.
3. Turn on rotary vane pump PP-2
4. Open PV-1.
5. Turn on PP-1.
6. Verify operation of pumps. Record pressure at PG-1: _____.
7. Open PV-3.

G.5.3. Open EV-21 and EV-4.

G.5.4. Close AV-6

G.5.5. Open/verify open PV-4

G.5.6. Close/verify closed PV-5 and PV-6.

G.6. **Heat Main-Tank Helium to Normal Boiling Point**

G.6.1. Enter comment to DAS, “Begin MT re-pressurization.”

G.6.2. Record initial tank conditions:

1. Time: _____
2. Main Tank LLS (if vertical): _____%
3. Bottom Tank Temperature (CN [09])_____
4. Guard Tank Temperature (CN [24])_____
5. Top Lead Bag Temperature (CN [28])_____
6. Station 200 Temperature (CN [01])_____
7. EG-1B Pressure _____

G.6.3. Turn on Main Tank vent line Heat Exchanger (EH-1) in Gas Module.

G.6.4. Begin to warm the helium in the main tank using the main tank heater.

1. Set MT Heater power supply (for H-8D) current limit to 1.25 A
2. Gradually increase MT Heater power, recording in data sheet.
3. Do not exceed 50 VDC on MT Heater.

G.6.5. Monitor the top lead bag temperature (CN28) during the course of the warm-up, using EV-7a, EV-7b, EV-21, and EV-22 to maintain this

temperature between 5K and 6K.

CAUTION!
DO NOT allow the lead bag temperature to exceed 6.5 K at any time!

G.6.6. Record data every 15 minutes on attached data sheets.

Caution
The Guard Tank pressure will tend to go subatmospheric during the course of this procedure. Monitor GTV-G and Maintain positive pressure in Guard Tank throughout the warm-up process. Ensure adequate He gas supply available if GT is depleted. Turn on GT heaters to maintain a constant GT temperature regardless of whether the GT has liquid or is depleted.

G.6.7. Add heat to Guard Tank to maintain positive pressure:

1. Close EV-13.
2. Turn on power supply for Guard-Tank heater (H-3D or H-4D)
3. Set power supply current limit to 0.07 amps.
4. Set voltage limit to 50 VDC and record:

   V _____Vdc and I _____A.
5. Adjust heater voltage as necessary to maintain a constant Guard Tank temperature.
6. Monitor and maintain positive Guard Tank pressure throughout the pump-down. Record data on attached data sheets.

G.7. **Terminate Repressurization of Main Tank**

G.7.1. When EG-3 rises above 780 torr:

1. Record Main Tank liquid level and pressure.
   a. Liquid Level (if vertical) _____%
   b. Pressure (EG-3) _____ torr
2. Record Data, and comment in attached data sheets.
3. Close EV-4
4. Shut off Main Tank heat exchanger – if it was on.

G.7.2. Switch Actuator Control Valve for EV-9 to “NBP" position.

G.7.3. Close EV-21, and EV-22.

G.7.4. Verify PV-2, and PV-4 open.

G.7.5. Open EV-9.

G.7.6. Close EV-10 and EV-17

G.7.7. Once Main Tank temperature(CN [09]) has reached 4.22 K, turn off power to Main Tank Heater(s)

G.7.8. Continue monitoring data for one hour, and recording in data sheet. Monitor Main Tank pressure with EG-3. Turn on Main Tank heater if necessary to maintain EG-3 above atmospheric pressure.

G.8. **Establish Final Configuration**

G.8.1. Shut down the Pump Module.

1. Close PV-1
2. Turn off PP-1 and PP-2.
3. Close PV-3, PV-5, and PV-6.

G.8.2. Configure final valve status.

Configure Final Valve States		
	Verify Open	***Verify Closed***
1. Main Tank vent	EV-7a/b, EV-9, PV-2	EV-4, EV-5, EV-6, EV-8, EV-10, EV-11, EV-12, EV-14, EV-15, EV-18, EV-19 All AV valves PV-1, PV-3, PV-4, PV-5, PV-6
2. Guard Tank vent connected to GM		
o With liquid	EV-13, EV-16, GTV-V	EV-20, EV-23, EV-24, GTV-Va
o Depleted and pressure regulated at EV-23	EV-16, EV-23, GTV-V	EV-13, EV-20, EV-24 GTV-Va
3. Guard Tank vent **not** connected to GM		
o With liquid	GTV-V	EV-13, EV-16, EV-20, EV-23, EV-24, GTV-Va, GTVC-V GTVC-Fill Vent
o Depleted and pressure regulated at GTV-Va	GTV-Va	EV-13, EV-16, EV-20, EV-23, EV-24, GTV-V, GTVC-V GTVC-Fill Vent

G.8.3. If Guard Tank depleted, verify source of helium gas at APR-2.

G.8.4. Verify that the Guard Tank heater (H-3D or H-4D) is turned off.

G.8.5. Set data cycle on DAS to 15 minutes.

G.8.6. Enter comment to DAS, “Repressurization of Main Tank Complete.”

G.8.7. Set all liquid level sampling intervals to 10 minutes.

G.8.8. 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.8.9. Ensure liquid level sensor alarms enabled and record set points if changed.

1. Main Tank Level Set Point _____%
2. Guard Tank Level (if liquid in GT) Set Point _____%

G.8.10. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential.

G.8.11. Ensure DAS watchdog timer and alarm enabled.

G.8.12. Ensure Facility main Alarm enabled.

H. PROCEDURE COMPLETION

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

Data Sheet – Pressurization to NBP

Time	Top Pb Bag Temp CN [28] (K)	MT Top Temp CN [20] (K)	MT Bot. Temp CN [09] (K)	EV-7a (%)	EV-7b (%)	MT Pressure EG-2 or-3 (torr)	MT LLS %	MT Heater Volts	MT Heater Amps	GT Pressure GTV-G CN [46] (torr diff)	GT Heater (V)	Comments

Data Sheet – Pressurization to NBP

Time	Top Pb Bag Temp CN [28] (K)	MT Top Temp CN [20] (K)	MT Bot. Temp CN [09] (K)	EV-7a (%)	EV-7b (%)	MT Pressure EG-2 or-3 (torr)	MT LLS %	MT Heater Volts	MT Heater Amps	GT Pressure GTV-G CN [46] (torr diff)	GT Heater (V)	Comments

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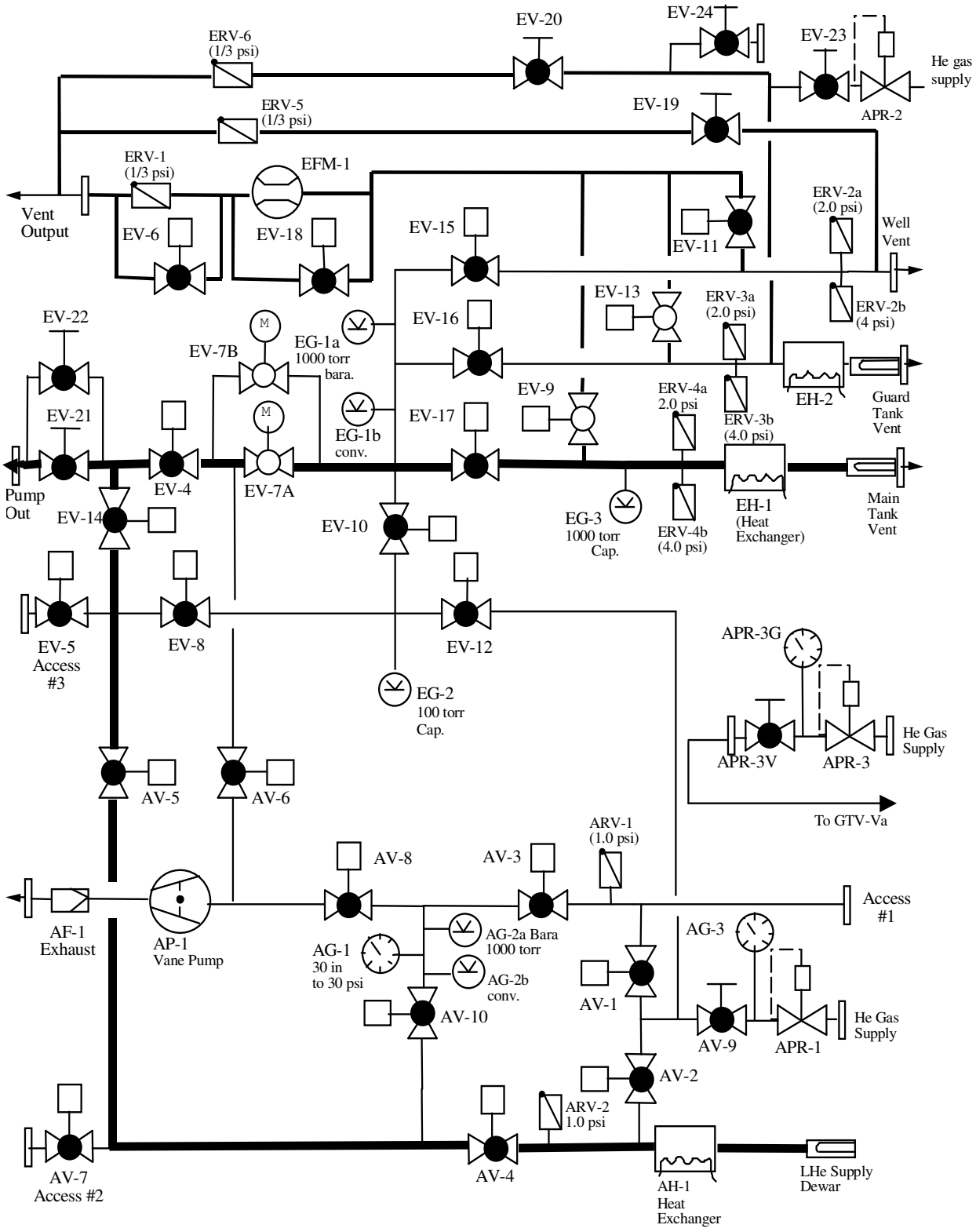

Figure 1. Schematic of Gas Module Plumbing.

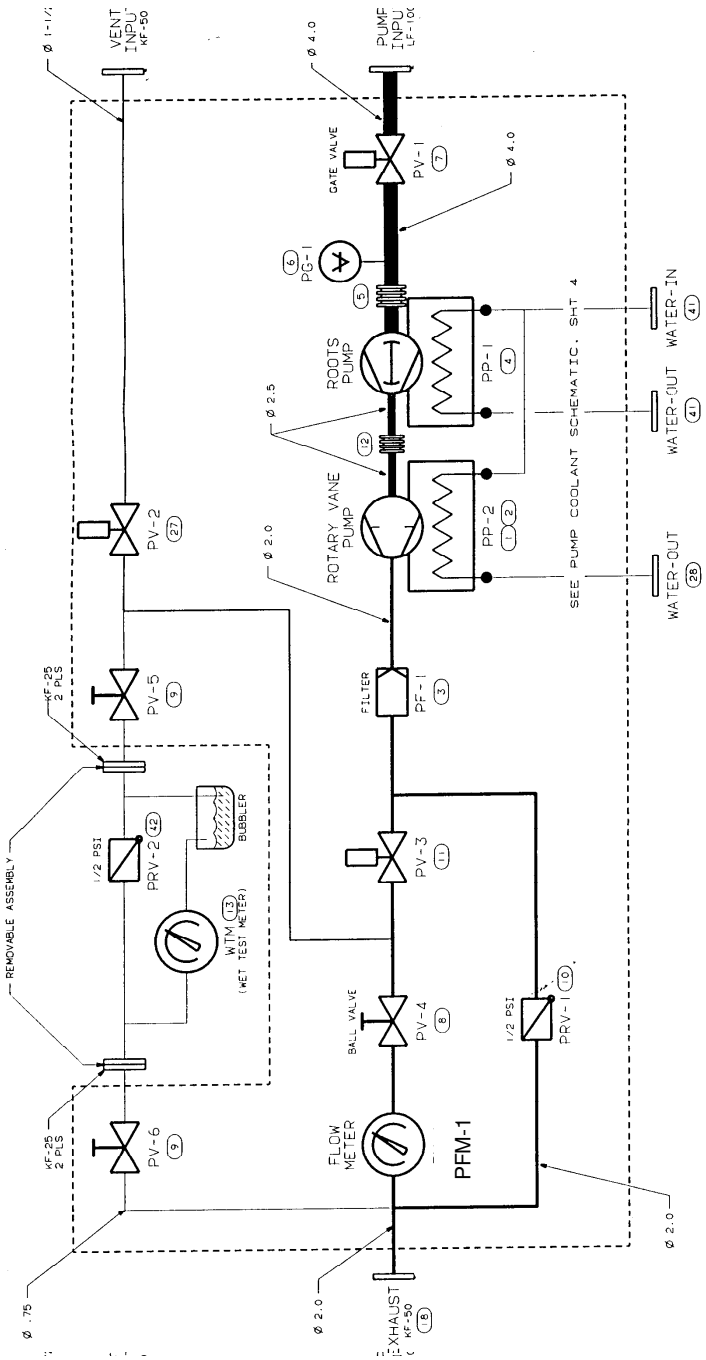

Figure 2. Schematic of Pump Module plumbing.

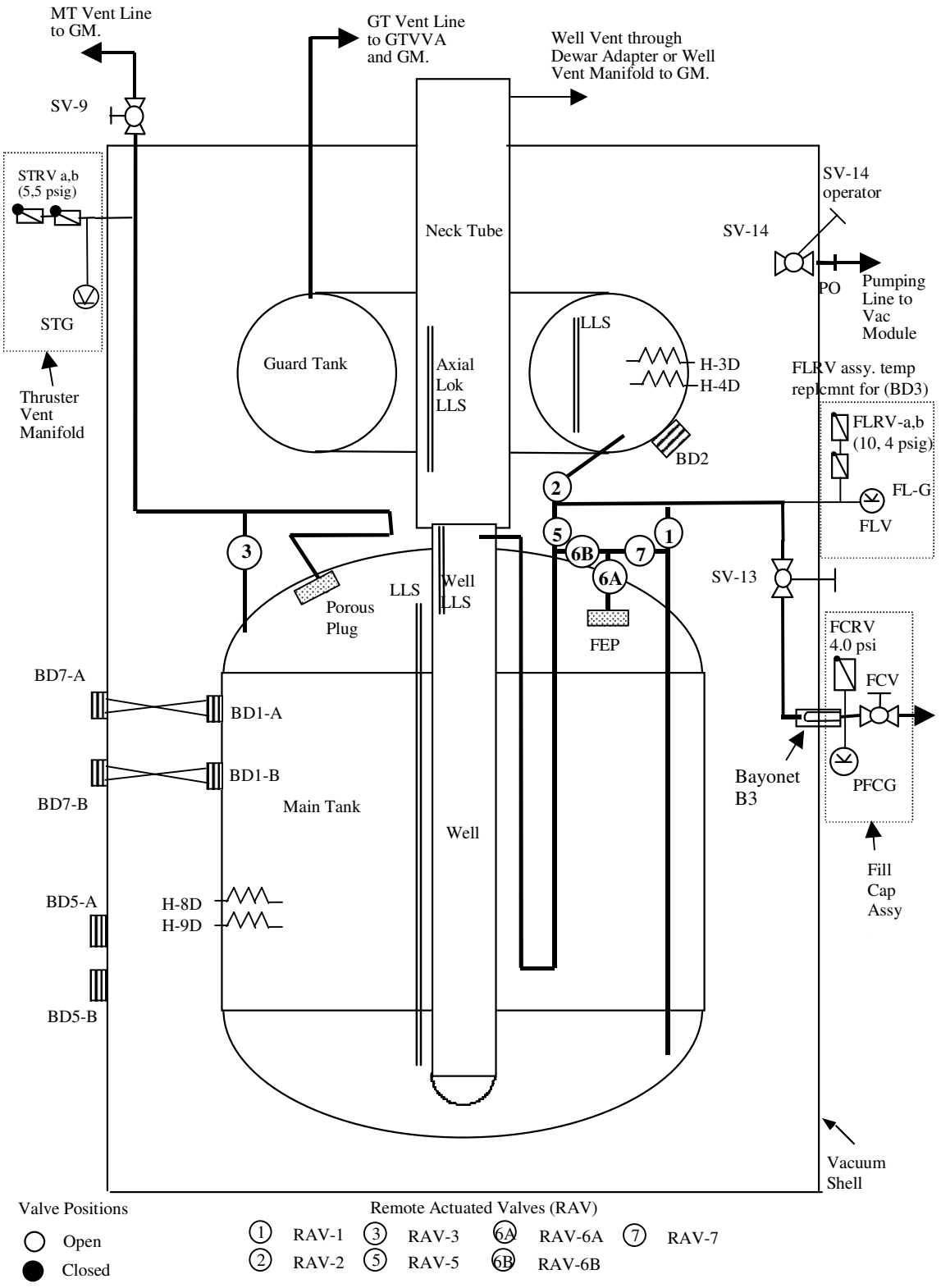

Figure 3. Schematic of Science Mission Dewar plumbing.

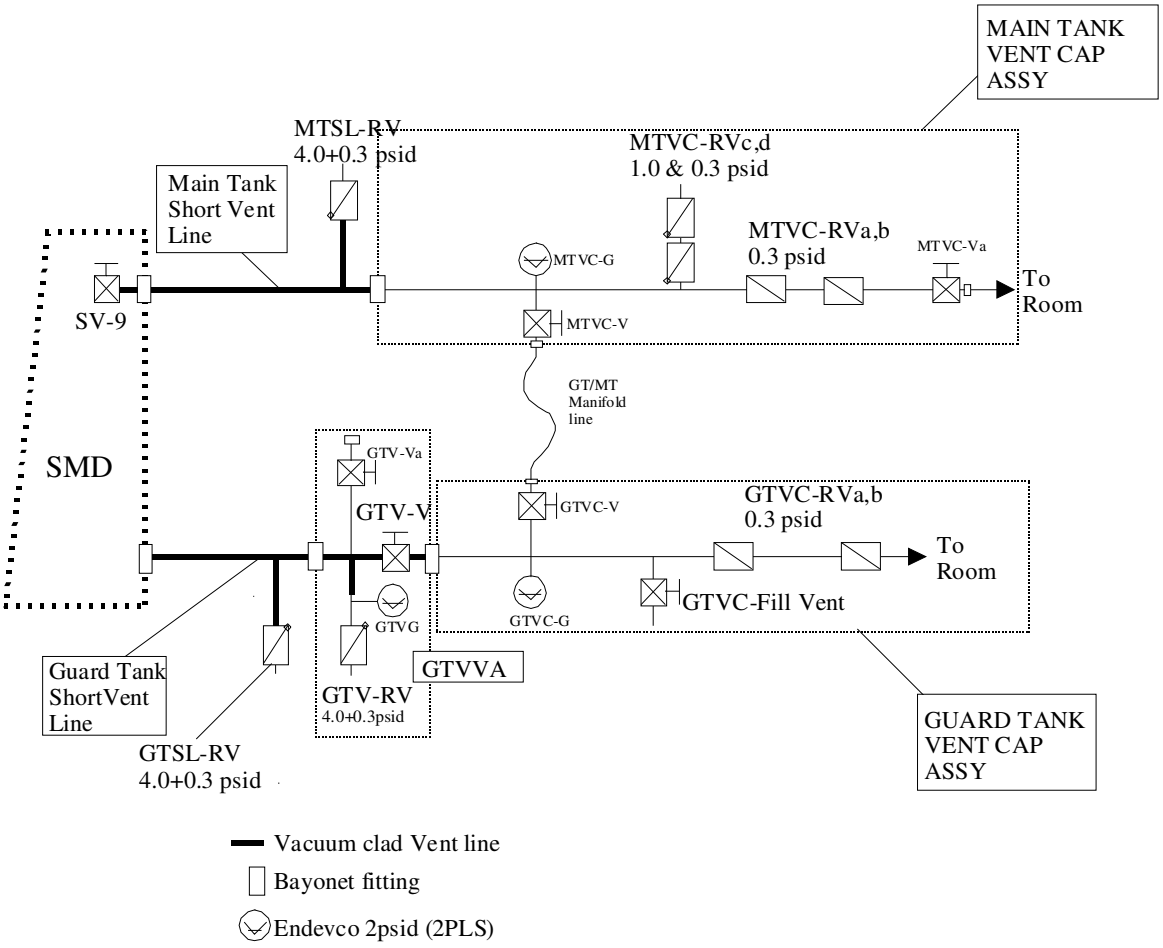

Figure 4. Schematic representation of Guard Tank Vent Valve Assembly (GTVVA) and Main Tank and Guard Tank vent cap assemblies. Common manifold capability is provided by the GT/MT manifold line.