GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

PRESSURIZE MAIN TANK FROM SUBATMOSPHERIC TO NORMAL BOILING POINT

To be performed at Vandenberg Air Force Base building 1610

THIS DOCUMENT CONTAINS NON HAZARDOUS OPERATIONS

P1043

November 15, 2002

Written by	Checked by
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REVISION RECORD

REVISION	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
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
FIST	Full Integrated System Test
GHe	Gaseous Helium
GM	Gas Module
GP-B	Gravity Probe-B
GSE	Ground Support Equipment
GT	Guard Tank
GTVC	Guard Tank Vent Cap
GTVC-G	Guard Tank Vent Cap pressure gauge
GTVC-RV	Guard Tank Vent Cap relief valve
GTVC-V	Guard Tank Vent Cap valve
GTV-G	Guard Tank vent pressure gauge
GTV-RV	Guard Tank vent relief valve
GTV-V	Guard Tank vent valve
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
LHV-x	Liquid Helium Supply Dewar valves
LLS	Liquid level sensor
LM	Lockheed Martin Co.
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

LIST OF SPECIFIC HEADING DEFINITIONS

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

1. NOTE: Used to indicate an operating procedure of such importance that it must be emphasized
2. CAUTION: Used to identify hazards to equipment
3. WARNING: Used to identify hazards to personnel

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.

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 and the Missile System Prelaunch Safety Package, LM/P479945 discuss 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

In VAFB building 1610 and the MST, the GP-B cryogenic team provides 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 lines are installed over the four burst disks to direct any flow to an outside area.

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 ladder. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the building and contact NASA and VAFB safety.

The following additional requirements apply to all personnel involved directly 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, non-absorbent shoes and full-face shields with goggles/glasses are to be worn whenever the possibility of splashing cryogens exists.

B.2.3. Other Hazards

All tools or other items used with the potential to damage the space vehicle shall be tethered.

B.3. Mishap Notification

B.3.1. Injury

In case of any injury or illness requiring emergency medical treatment **<u>DIAL 911</u>**

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 Space Wing Safety will be notified as required..

B.3.3. Contingency Response

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

C. QUALITY ASSURANCE

C.1. QA Notification

The NASA program 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 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 judgement of the TD or QA Representative, experiment functionality may be affected. Within hazardous portions of this procedure, all steps shall be worked in sequence. Out-of-sequence work shall be approved by NASA Safety prior to their performance.

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 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

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

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

When working on the space vehicle, an ESD wrist strap is required. A calibrated continuity checker is provided to verify any wrist strap.

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 Electrical 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.

E.3.3. Computers and Software:

The Data Acquisition System (DAS) is 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

1. No additional test equipment is required

E.3.5. Additional Hardware

1. No additional hardware is required

E.3.6. Tools

Description
ESD wrist strap

E.3.7. Expendables

Description	***Quantity***	***Mfr./Part No.***
N/A	NA	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.

Table 1. Required Instrumentation and Calibration Status

No.	***Location***	***Description***	***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:	-	C-09920	No	-

No.	***Location***	***Description*** a) Thermocouple, b) Current meter, c) Temperature set point controller	***Name***	***Serial No.***	***Cal Required***	***Status Cal due date***
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 in the Main Tank must be at its normal boiling point (NBP) or Subatmospheric

E.5.2. Guard Tank
The Guard Tank may contain liquid or be depleted.

E.5.3. Well
The Well must be evacuated.

E.5.4. SMD Vacuum Shell
The Vacuum Shell pressure must be less than 5x 10-5 torr. Document No. P1015, *Connect Vacuum Module to SMD*, 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. Top of lead bag temperature set (CN 175 and CN178) at $T \leq 6.0$ K.
    b. Relative Guard Tank Pressure (CN 46) set at □P ≥ 10 torr.

E.5.6. GSE and Non-flight Hardware

1. N/A

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 SMV may be installed in its transportation and test fixture.
2. The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve 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-6, or actively pumping the vacuum shell.

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
LM/P479945	Missile System Prelaunch Safety Package
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
EM SYS229	Accident/Mishap/Incident Notification Process
EWR 127-1,	Eastern and Western Range Safety Requirements
KHB 1710.2 rev E	Kennedy Space Center Safety Practices Handbook

F.3. Additional Procedures

Document No.	*Title*
SU/GP-B P0879	Accident/Incident/Mishap Notification Process
SU/GP-B P1015	Connect Vacuum Module to SMD
SU/GP-B P0875	GP-B Maintenance and Testing at all Facilities

Operation Number:____________

Date Initiated:____________

Time Initiated:____________

G. OPERATIONS

G.1. Pr e-Operations Verifications

- o Verify SU QA notified.
  Record: Individual notified __________________,
  Date/time ________/________.
- o Verify NASA program representative notified.
  Record: Individual notified __________________,
- o Record calibration due dates in Table 1 (Sections. E.3.4, E.4)
- o Persons actually performing this procedure should list their names in Sec D.3.
- o Verify completion of the pre-operations checklist (Appendix 1).
- o Verify proper operation of GP-B Cryogenic Team oxygen monitor
- o Verify availability and functioning of emergency shower

Section Complete QA Witness:__________

G.2. Verify Configuration Requirements

G.2.1. Ensure heaters on SMD are operational (i.e., power supplies on):

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

G.2.2. Ensure Actuator control valve for EV-9 set to “Subatm He” position.

G.2.3. Ensure DAS alarm system enabled and record set points.

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

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

Record set point. _________K

3. ***Relative Guard Tank Pressure*** – ensure CN [46] on DAS alarm list and set to alarm at ΔP ≥ 0.3 torr. Record set point. _________torr

G.2.4. 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.2.5. Ensure DAS watchdog timer and alarm enabled.

G.2.6. Ensure ion-pump magnet installed.

G.2.7. Verify Main Tank vent line connected to SMD. If not, perform Procedure P1004, *Connect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric*, and record Operation No. ________.

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	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.
1. Verify Vacuum Shell Pressure < 5 x 10-5 torr. If not, turn off Vac-ion pump and perform procedure P1015, Pump SMD Vacuum Space with Vacuum Module, to pump out SMD vacuum shell. Record Op No. _______.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
5. 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.

- o Already pumping with Pump Module, skip this section.
- o 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. Failure to comply may result in equipment damage

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. Failure to comply may result in equipment damage

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 lead bag unchanged
- Thermal conditions substantially changed, temperature alarm points reset as follows:
  a. Top of Lead Bag set point [CN 175] ________ K (≤ 6.0 K)
  b. Top of Lead Bag set point [CN 178] ________ 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 10 torr differential.

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

G.8.12. Verify completion of the post operations checklist

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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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

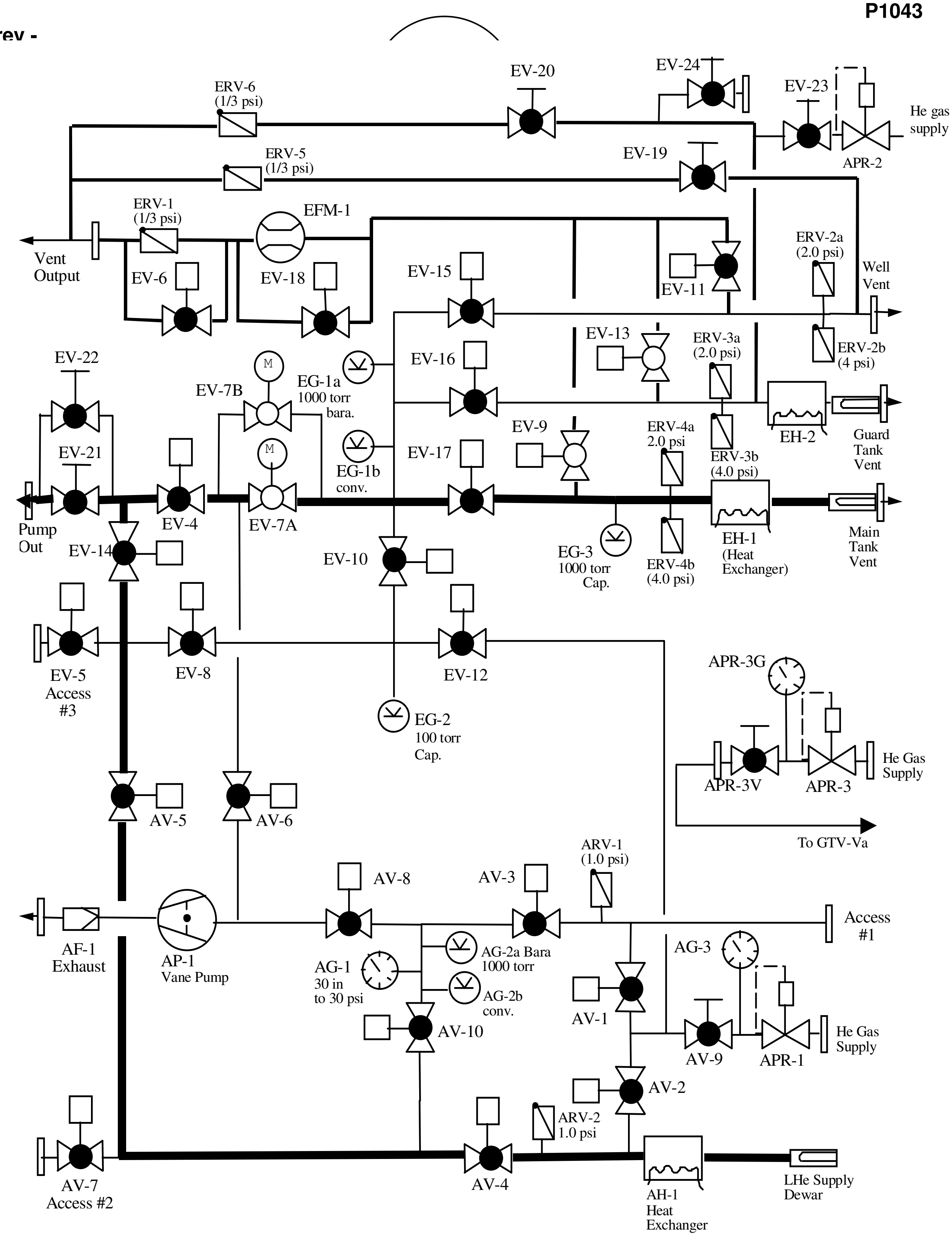

Figure 1. Schematic of Gas Module Plumbing.

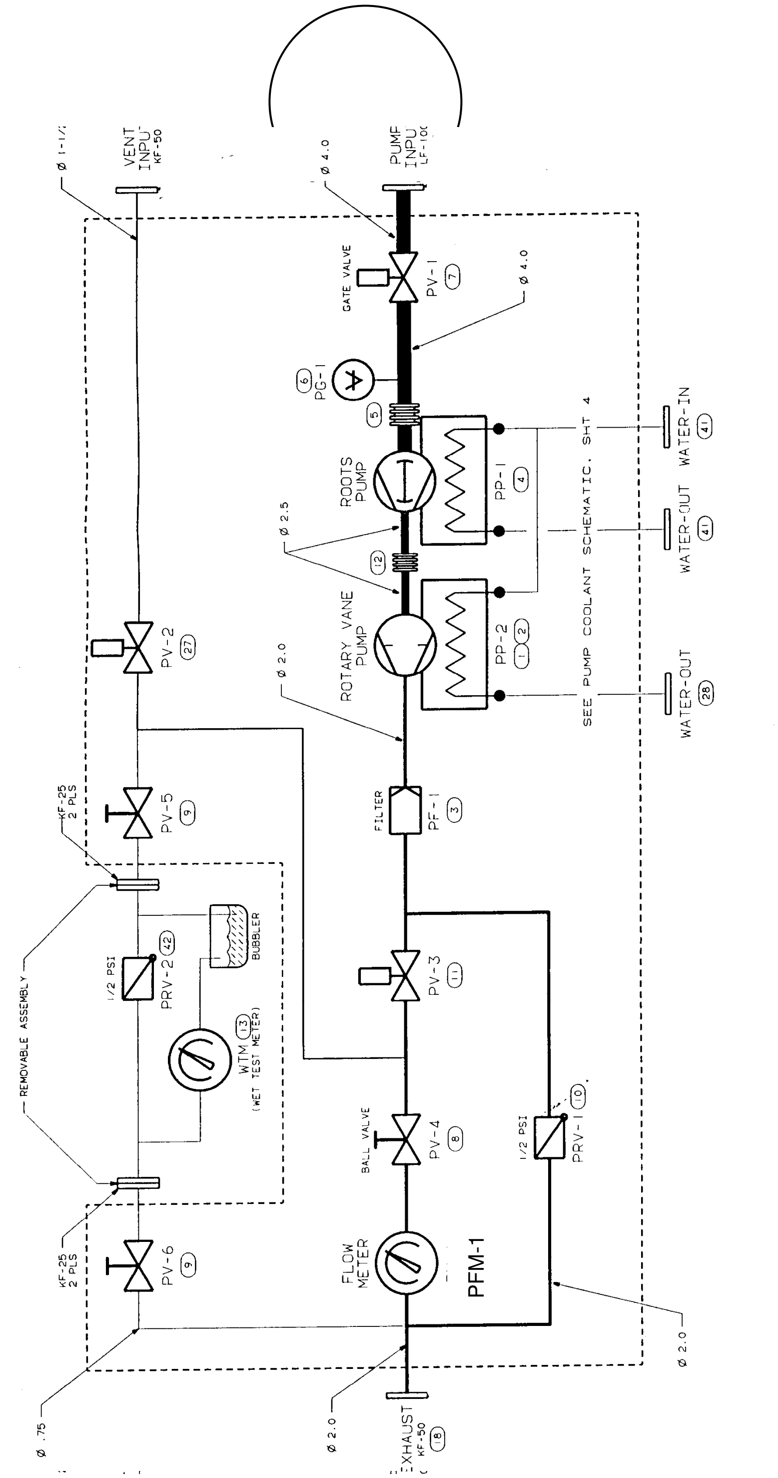

Figure 2. Schematic of Pump Module plumbing.

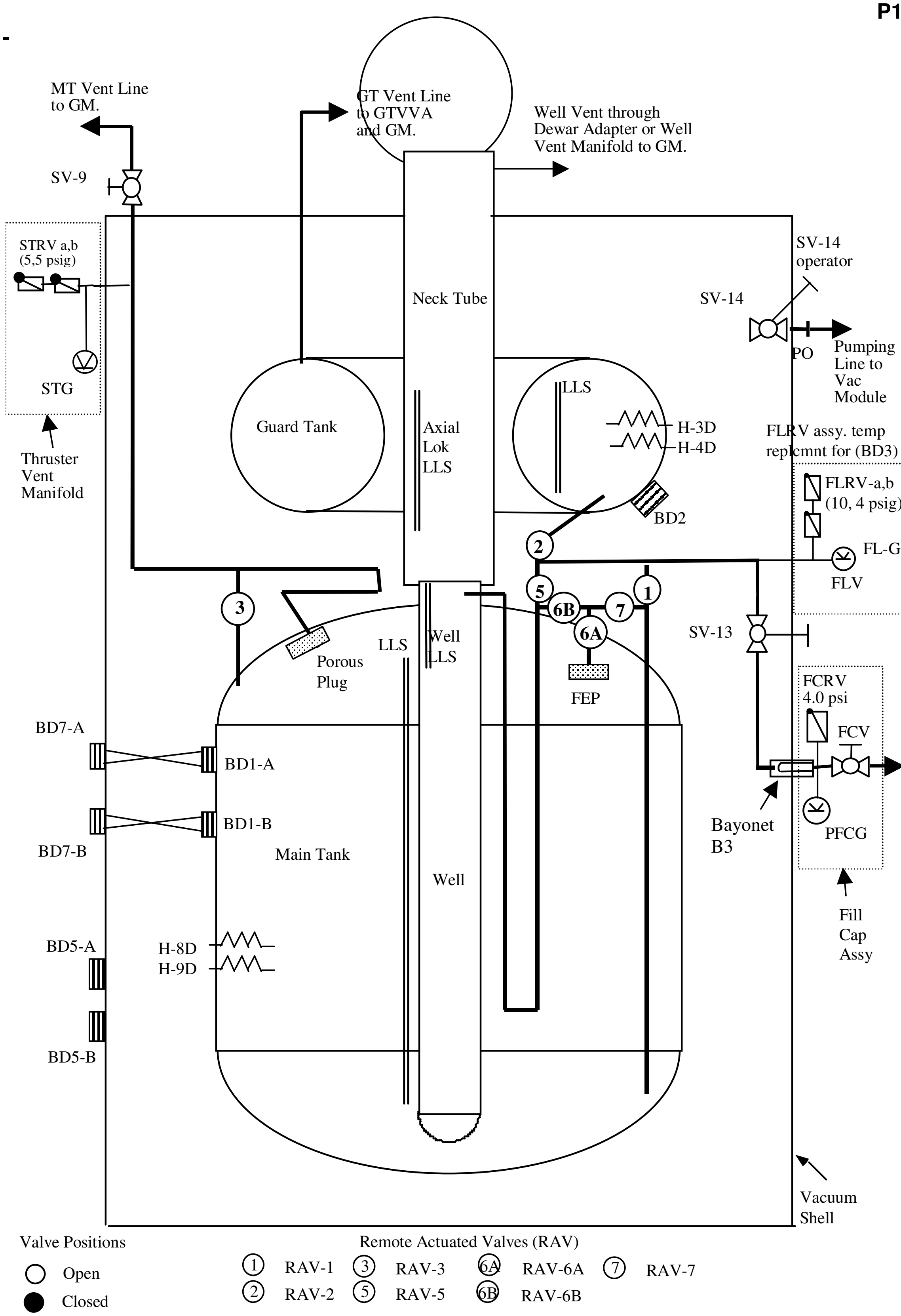

Figure 3. Schematic of Science Mission Dewar plumbing.

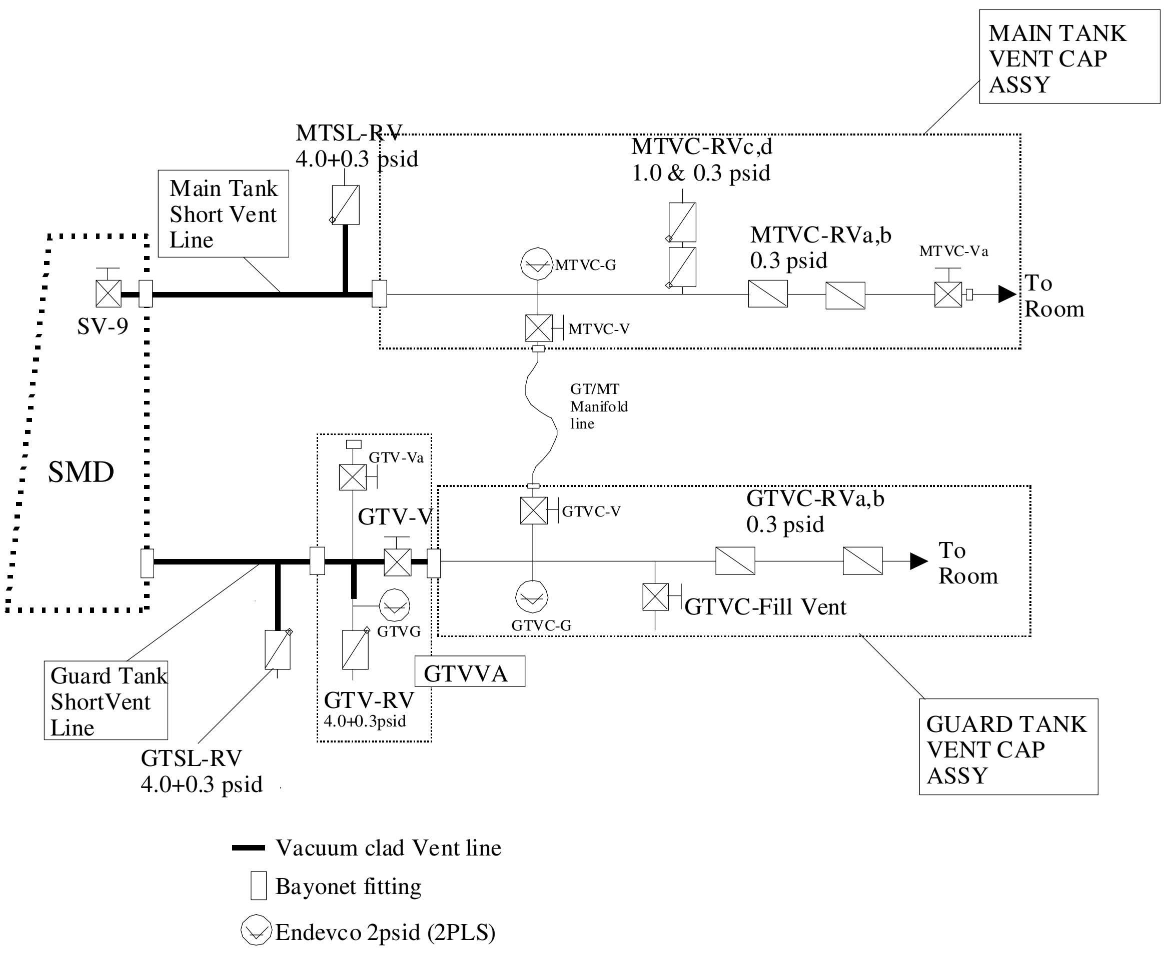

Figure 4. Schematic representation of Guard Tank Vent Valve Assembly (GTVVA) and Main Tank and Guard Tank vent cap assemblies. Common manifold capability is provided by the GT/MT manifold line.

APPENDIX 1 PRE OPERATIONS 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 is certified and know 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. Verify/perform pre-task engineering/safety high-bay walk down. Verify noted discrepancies have been corrected.		
	11. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: ______________________		

J. APPENDIX 2 POST OPERATIONS 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/EMERGENCY RESPONSES

Condition	Circumstance	Response
Power Failure	Anytime	Wait for power restoration and resume procedure
Liquid nitrogen spill	Anytime	Clear area until all spilled liquid has evaporated
Temperature limits (CN 29 or 28) exceeded	Any time	Increase Main Tank venting
Burst disk rupture (MT/GT)	Any time	Evacuate room
Pressure in Main Tank exceeds limit	Anytime	Increase Main Tank venting to relieve pressure in Main Tank
Oxygen Monitor Alarm	Anytime	Evacuate building