GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

MAIN TANK
SUBATMOSPHERIC FILL

P0217A

ECO 1160

April 24, 2001

Revised by

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REVISION CHANGES

REVISION	ECO	PAGES	DATE
A	1160	Changes include redlines from: 1st attempt at a subatmospheric fill with precool from GT. This was aborted. 2nd attempt at subatmospheric fill with iterative precool This worked. 3rd attempt and second successful subatmospheric fill using redlines from 2nd attempt. Additional changes include: Section A revised scope to reflect contents more accurately. Section B – Divided into two sections, addressing safety issues (new Section B) and test personnel (new Section D). Reorganized safety paragraphs into: hazards, mitigation, injuries. Content of both new sections essentially unchanged. 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. Section G.1 Added section to verify notification of QA. Section G.2 – Added steps to verify configuration requirements and alarm setup. Added GT to level alarm list (setpoint = 10%) Section G.3 – Added section to establish GSE Configuration. Section G.4 – Added section to verify initial configuration of SMD valves. Added requirement to have test engineer on hand and dedicated to monitoring temperatures at the top of the lead bag and at station 200 during critical operations. Added caution at end of procedure to monitor Guard Tank pressure and set DAS alarm to 0.3 torr differential.	

Table of Contents

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
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
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

A. SCOPE

This procedure describes the steps necessary to perform an external fill of the SMD Main Tank, while it is subatmospheric, using subatmospheric liquid helium from a Liquid Helium Supply Dewar (LHSD). Precooling the SMD fill-line is performed using a reverse transfer from the Guard Tank. The steps include:

Pump down liquid in LHSD to < 100 torr

Pre-cool SMD internal fill line from Guard Tank

Pre-cool external transfer line from storage dewar

Pre-cool SMD internal fill line from Guard Tank (second time)

Pre-cool external transfer line from storage dewar (second time)

Fill Main Tank

Terminate transfer

Leak check SV-13 closure

Resume pumping on Main Tank with Gas Module (AP-1).

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 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 (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), the 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

Item	***Description***	***Manuf.***	***Model***
1	Filter Line assembly	LMMS	5833827
2	Liquid He Transfer Line	LMMS	5833804
3	Liquid He LHSD stinger	LMMS	5833803
4	AMI Level Sensor Readout for LHSD	AMI	110
5	GHe supply fittings to LHSD	N/A	N/A

Item	*Description*	*Manuf.*	*Model*
6	Bayonet Cap with Nupro Valve	LMMS	N/A

E.3.6. Tools

Description
Torque Wrench
1-1/4-in socket, 60 in-lb

E.3.7. Expendables

Description	*Quantity*	*Mfr./Part No.*
Ethyl Alcohol	AR	N/A
99.99% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Braycote Micronic 601
500/1000 Liter Dewars Liquid Helium	AR	SU or commercial
Tie wraps - large size	AR	N/A

E.4. **Instrument Pretest Requirements**

The GSE instruments required to perform this procedure are listed in Table 1, together with their serial numbers, where available. Instruments that are required to have current calibrations are indicated in the Cal-Required column. Instruments that do not require calibration are those not used to verify performance requirements and are not connected to flight instrumentation. The status column is to be filled in with the due date of the instrument calibration sticker and verified to be in calibration by QE or QE designee. Serial numbers are to be updated as appropriate.

Table 1. Required Instrumentation and Calibration Status

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
1	DAS	Power Supply, H-P 6627A	-	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, PFCG	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	-

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

E.5. **Configuration Requirements**

E.5.1. Main Tank

The Main Tank liquid is subatmospheric. The actuator control valve for EV-9 (located on the Gas Module, this valve switches the state that EV-9 defaults to, should a power failure occur) should be placed in the “Subatm He.” position, at the beginning of this procedure, ensuring that EV-9 remains open in the event of power failure.

E.5.2. Guard Tank

The Guard Tank must contain liquid, and the level must be ≥ 45%.

E.5.3. Well

The Well must be evacuated

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 1×10^{-4} 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. A relief valve assembly or flight-like burst disk is installed in place of the SMD fill-line burst disk.
2. The ion-pump magnet is installed.
3. 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).
4. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833806). Procedures P0672 contains the procedure for connecting Main Tank vent line.
5. The Guard Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833813). Procedure No. P0676 contains the steps for connecting the Guard Tank vent line.
6. The thruster vent port may be flanged to a relief valve assembly if the flight thruster manifold assembly is not installed.
7. The Fill Cap Assembly must be installed at SV-13 (See Figure 3)
8. 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 foreign object and debris shield covers the upper cone of the SMD and is required whenever work is being performed above the SMD such that hard objects could be dropped and impact the SMD or Probe.
3. 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.
4. The Well Vent Manifold may be installed.

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*
SU/GP-B P0676	*Connect Guard Tank Vent Line to Gas Module*
SU/GP-B P0213	*Connect Vacuum Module / Pump on SMD Vacuum Shell*
SU-GP-B-P0209	*External Guard Tank Fill*

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

G.2.3. Verify heaters on SMD are operational:

- Top plate
- SV-9
- Main Tank vent bayonet

G.2.4. Verify GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.5. Verify Main Tank vent line connected to Gas Module. If not, perform procedure P0672, Connect MT Vent Line to Gas Module - MT Subatmospheric, to connect Main Tank vent.

G.2.6. Verify Guard Tank vent line connected to Gas Module. If not, perform procedure P0676, Connect Guard Tank Vent Line to Gas Module, to connect Guard Tank vent.

G.2.7. Verify Main Tank is being pumped and is below 2.1 K as indicated by Main Tank Temperature.

Record Main Tank bottom temperature CN [09]. _____ K.

G.2.8. Record initial liquid helium levels.

1. ***Main Tank*** _____%
2. ***Guard Tank*** – Verify level ≥ 45% to precool internal transfer line. If necessary, perform procedure P0209, *External Guard Tank Fill*, to raise level. _____%

G.2.9. Verify DAS alarm system enabled and record set points.

1. ***Station 200 temperature*** – verify CN [01] on DAS alarm list and set to alarm at T ≤ 6.5 K. Record set point. _____K
2. ***Top of lead bag temperature*** – verify CN [28] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. _____K
3. ***Relative Guard Tank Pressure*** – verify CN [46] on DAS alarm list and set to alarm at ΔP ≥ 0.3 torr. Record set point. _____torr

G.2.10. Verify liquid-level alarms enabled and record set points.

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

G.2.11. Verify DAS watchdog timer and alarm enabled.

G.2.12. Verify relief valve assembly or flight-like burst disk installed in place of the SMD fill-line burst disk.

G.2.13. Verify Fill Cap Assembly installed at SV-13.

G.2.14. Verify ion pump magnet installed.

G.2.15. Verify Vacuum Shell Pressure < 1×10^{-4} 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. If pressure is above 1x10-4 torr, turn off Vac-ion pump and perform procedure P0213, Connection of High Vacuum Pumping Module, to connect Vacuum Module and pump out SMD vacuum shell.
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.

Note: Vac-ion pump should be turned on/off periodically during this transfer and reading recorded on Data Sheet.

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

G.3.1. Verify valve states are as indicated in following Table. Record configuration by checking the appropriate box, then verify corresponding valve states.

- o Main Tank pumped by Gas Module (AP-1)
  1. Verify open EV-7a/b, EV-10, EV-13, EV-17.
  2. Verify all other EV valves closed.
  3. Verify AP-1 on.
  4. Verify AV-6 open.
  5. Verify closed/close all other AV valves.
  6. Verify open PV-2 and PV-4.
  7. Verify closed PV-1, PV-3, PV-5 and PV-6.

- o Main Tank pumped by Pump Module (PP-1/2)
  8. Verify open EV-4, EV-7a/b, EV-10, EV-13, EV-17, EV-21/22.
  9. Verify all other EV valves closed.
  10. Verify all AV valves closed.
  11. Verify PP-1/2 on.
  12. Verify open PV-1, PV-2, PV-3, PV-4.
  13. Verify closed PV-5 and PV-6.

G.3.2. Record pressures:

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

Note: Verify EV-8 and EV-12 are closed and EV-10 is open for proper reading of EG-2.

G.3.3. Record Fill Cap Assembly pressure and verify that it reads >760 torr.

Fill Cap Assembly (PFCG): _____ torr

G.3.4. Record EV-7a valve position: _____ %

G.3.5. Record EV-7b valve position: _____ %

G.3.6. Turn on Main and Guard Tank vent-line heat exchangers (EH-1&2)..

G.3.7. Verify Actuator Control valve EACV-9 is in “subatm He” position.

G.4. Verify SMD in Standard Configuration

G.4.1. Using the RAV log book verify that the dewar's internal valves are in the following positions. If not, investigate to ensure previous RAV operations properly recorded. If necessary, note resolution in D-log.

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

G.4.2. Verify SV-9 open.

G.4.3. Verify SV-13, and FCV closed.

G.5. Transfer Pumping of Main Tank to Pump Module

Note: this operation is to be performed if Main Tank is being pumped by Gas Module pump AP-1. It is assumed that the plumbing between the Pump Module the Gas Module has been successfully leaked checked.

- o Main Tank is pumped by AP-1, perform this section
- o Main Tank is pumped by Pump Module, skip this section

G.5.1. Verify open PV-2 and PV-4.

G.5.2. Verify closed PV-1, PV-3, PV-5, and PV-6.

G.5.3. Initiate the Pump Module

1. Turn on/verify on water cooling of pump module.
2. Check oil level in Vane Pump (PP-2), record time _____ and initial _____. If oil level is low, add new oil to PP-2 per specification in Pump Module Manual.
3. Verify closed EV-4, EV-14, and EV-21/22.
4. Turn on rotary vane pump PP-2.
5. Open PV-1.
6. Once pressure PG-1 has come to equilibrium (< 1 torr), turn on roots pump PP-1 and verify PG-1 < 15 mtorr.

   Record PG-1 _____ mtorr.

G.5.4. Transfer pumping to Pump Module.

1. Verify closed AV-8 or if AV-8 is open, verify closed AV-3 and AV-10.
2. Open EV-21 and EV-4.
3. Close AV-6.
4. Open PV-3.
5. Record time of day : _____

G.5.5. Verify valve configuration:

Open	EV-4, EV-10, EV-17, EV-13, EV-21, EV-7b (partial) PV-1, PV-2, PV-3, PV-4 SV-9 RAV-3, RAV-6b
Closed	All other EV, PV, and RAV valves All AV valves SV-13, and FCV

G.6. **Check initial pressure in Fill Line**

G.6.1. Install a pumping line between valve FCV on the Fill Cap Assembly and the Access Port #2 of the Auxiliary gas section.

G.6.2. Install/verify installed a cap on Access #1.

G.6.3. Turn on / verify on AP-1.

G.6.4. Open AV-8.

G.6.5. Open valves AV-10 and AV-7.

G.6.6. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.6.7. Close AV-8 and FCV.

G.6.8. Once the pressure in the Fill Cap Assembly. as measured at PFCG has stabilized, record Pumping line pressure (PFCG): _____ torr.

G.6.9. Open valve SV-13 to bring the Fill Cap Assembly. up to the pressure in the SMD fill line

G.6.10. Record fill line pressure (PFCG): _____ torr.

G.7. **Raise Pressure in Internal Fill Line**

G.7.1. Verify Guard Tank pressure greater than atmospheric pressure.

Record Guard Tank pressure GTV-G (CN [46])_____ torr diff.

G.7.2. Open RAV-2 to bring the Fill Line up to Guard Tank pressure as follows and record:

1. Verify all RAV selection switches are in the OFF position.
2. Turn on RAV power supply and adjust current limit to 1.85 amps.
3. Adjust power supply to 28 VDC.
4. Power up RAV controller No. 2.
5. Position controller No. 2 selection switch to RAV-2.
6. Record initial switch status: Open: θ θ Closed: θ θ

7. Activate controller No. 2 to open RAV-2 and record:
   a. Run time: _____ seconds.
   b. Current draw: _____ amp.
   c. Time of day: _____
8. Record final switch status: Open: θ θ Closed: θ θ
9. When convenient, record operation in RAV log book.

G.7.3. Verify that Fill Cap Assembly pressure rises to Guard Tank pressure as measured by PFCG. Record pressure (PFCG): _____torr.

G.7.4. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

G.7.5. Verify current valve configuration

Open	EV-4, EV-10, EV-17, EV-13, EV-21,EV-7a/b AV-10, AV-7 PV-1, PV-2, PV-3, and PV-4, RAV-2, RAV-3, RAV-6b SV-9
Closed	All other EV, AV, PV, and RAV valves SV-13, FCV

G.8. **Install Stinger in LHSD**

Note: Use appropriate extension for the LHSD being used. Inspect and clean all O-rings and mating surfaces as necessary.

G.8.1. Weigh the LHSD (without LLS readout) using the platform scale and record:

1. Total weight: _____ lbs.
2. Enter tare weight _____ lbs (on tag)
3. Enter net weight: _____ lbs (total-tare)

G.8.2. Reduce the pressure in the liquid helium supply to < 1.0 psig by opening the low pressure relief valve LHV-2.

G.8.3. Open valve VF-1 (Liquid withdrawal valve) on the stinger

G.8.4. Slowly insert the stinger into the LHSD while allowing it to be purged.

G.8.5. Close valve VF-1 just as cold gas is expelled from stinger.

G.8.6. Record LHSD data:

1. Date / time:_____
2. Liquid level_____ %
3. LHSD serial number:_____

G.9. **Install Transfer Line Assembly**

Note: Two transfer lines are available for use. One has an integrated filter and connects directly to bayonet B3 at the dewar. The other has a separate filter that is first installed at bayonet B3, after which the fill line is connected to the filter.

G.9.1. Backfill Pumping line as follows:

1. Ensure AV-8 closed.
2. Open AV-1 and AV-3.
3. Open AV-9 until pressure reaches 0 psig at AG-1, then close AV-9.
4. Close AV-1 and AV-7.

G.9.2. Remove the pumping line from the fill cap assembly.

G.9.3. Remove fill cap assembly

G.9.4. Install Filter Line Assembly (P/N 5833827) to Dewar Fill Bayonet B3 if used.

G.9.5. Install Fill Line Assembly as follows:

1. Mate the Fill Line (P/N 5833804) with the LHSD Stinger at VF-1.
2. Mate VF-2 end of transfer line with Filter Line Assembly or B3 as appropriate.

   Note: Be sure to provide adequate support to the transfer line so as not to load the filter assembly and stinger.
3. Ensure VF-2 and relief valve stems pointed upwards.
4. Ensure VF-3 closed.

G.10. **Condition Transfer Line/Filter/Stinger Assembly**

G.10.1. Configure Pumping Line:

1. Verify mated, the 1-1/2-in flexible pumping line to Access Port #2 of Auxiliary Gas Module section.
2. Mate other end to outlet of VF-2.

G.10.2. Evacuate transfer line:

1. Open valve VF-2.
2. Open/verify open AV-3 and AV-10.
3. Open AV-7.
4. Open AV-8.
5. Close AV-8 when pressure reaches less than 50 mtorr as read on gauge AG-2.

G.10.3. Backfill transfer line:

1. Open AV-1.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.
3. Close AV-1.

G.10.4. Evacuate transfer line (second time) and perform leak-back test:

1. Open AV-8.
2. Close AV-8 when pressure reaches less than 20 mtorr as read on gauge AG-2.
3. Verify that pressure AG-2 does not rise by more than 50 mtorr in two minutes while recording:

Time (min)	_____	_____	_____	_____	_____
P(AG-2) (mtorr)	_____	_____	_____	_____	_____

Pass/Fail _____ mtorr/min _____

G.10.5. Backfill Transfer Line (second time):

1. Open AV-1.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then close AV-9.
3. Close AV-1.
4. Close AV-3, -7.
5. Close valve VF-2.

G.10.6. Verify current valve configuration

Open	EV-4, EV-10, EV-17, EV-13, EV-21, EV-7b(partial), AV-10, PV-1, PV-2, PV-3, PV-4, LHV-2 SV-9, RAV-2, RAV-3, RAV-6b
Closed	All other EV, AV, PV, and RAV valves LHV-1, LHV-3 VF-1, VF-2, VF-3 SV-13

G.11. **Condition the LHSD pumping line**

G.11.1. Install the vacuum jacket pumping line between the LHSD at valve LHV3 and the AH-1 portable heat exchanger.

G.11.2. Install a 1-1/2" pumping line between the output of the portable heat exchanger and the port labeled "LHe Supply Dewar" on the Gas Module.

G.11.3. Install a 1000 torr Baratron pressure gauge (LHG-2) on the LHSD vent port at LHV-1.

G.11.4. Open LHV-1 and record:

LHSD pressure (LHG-2):_____ torr

G.11.5. Verify that gauge LHG-2 is connected to DAS.

G.11.6. Weigh the LHSD using a platform scale and record:

1. Total weight: _____ lbs.
2. Enter net weight: _____ lbs. (from Par. G.8.1)
3. Weight at 0% full: _____ lbs. (new tare: [total-net])

G.11.7. Evacuate LHSD Pumping line:

1. Verify open/open AV-10.
2. Close/verify closed all other AV valves.
3. Close/verify closed EV-5, EV-8, and EV-14.
4. Open AV-4 and AV-5.
5. Open AV-8: now pumping LHSD pumping line to LHV-3 with AP-1.
6. Close AV-8 when pressure reaches less than 50 mtorr as read on gauge AG-2.

G.11.8. Backfill LHSD Pumping Line:

1. Open AV-2.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.
3. Close AV-2.

G.11.9. Evacuate LHSD Pumping line (second time):

1. Open AV-8.
2. Close AV-8 when pressure reaches less than 50 mtorr as read on gauge AG-2.

G.11.10. Backfill LHSD Pumping line (second time):

1. Open AV-2.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.
3. Close AV-2.

G.11.11. Perform leak-back test of LHSD pumping line:

1. Open AV-8.
2. Close AV-8 when pressure reaches less than 20 mtorr as read on gauge AG-2.
3. Verify that pressure AG-2 does not rise by more than 50 mtorr in two minutes while recording:

Time (min)	_____	_____	_____	_____	_____
P(AG-2) (mtorr)	_____	_____	_____	_____	_____

Pass/Fail _____ mtorr/min _____

G.12. **Switch pumps Between Main Tank and LHSD**

G.12.1. Verify closed AV-8.

G.12.2. Open AV-6 to put Main Tank on pump AP-1 of Gas Module

G.12.3. Close EV-4.

G.12.4. Open EV-14 to put LHSD pumping line on Pump Module.

G.12.5. Record time of day: _____

G.12.6. Verify current valve configuration

Open	EV-10, EV-17, EV-13, EV-21, EV-14 EV-7b(partial), AV-5, AV-10, AV-4, and AV-6 PV-1, PV-2, PV-3, PV-4, LHV-1, LHV-2 SV-9, RAV-2, RAV-3, RAV-6b
Closed	All other EV, AV, PV, and RAV valves LHV-3, VF-1, VF-2, VF-3 SV-13

G.13. **Set Up Data Acquisition**

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

G.13.1. Set DAS to configuration choice 4b.

G.13.2. Start “Special Data Cycle” by using [Other Menus] + [Special Data Col]. Set up the special data collection to include channel numbers 9, 1, 28,

42, ,24, 46.

G.13.3. Input comment to DAS “Start Main Tank sub-atmospheric transfer”.

G.13.4. Set the Main Tank Liquid Level Sensors (LL-1D or LL-2D) to 1 minute sampling interval, and the Guard Tank Liquid Level Sensors (LL-5D or LL-6D) to 5 minute interval.

G.14. **Pump Down LHSD**

G.14.1. Close/verify closed the small Nupro valve leading to the dewar bleed vent flow meter on the LHSD.

G.14.2. Close LHV-2 to the primary (low pressure) relief valve on the LHSD.

G.14.3. Crack open valve LHV3 to begin pumping on the LHSD.

G.14.4. Adjust valve LHV-3 to control the rate of pump-down of the LHSD by maintaining the pressure at AG-2a (capacitance) at ~100 torr.

G.14.5. Turn on power to heat exchanger AH-1. Adjust LHV-3 as necessary to avoid exceeding the capacity of AH-1.

G.14.6. Enter comment to DAS “Now pumping LHSD”.

Note: throughout the LHSD pump-down monitor the following:

1. Adjust heat exchanger AH-1 as required to keep frost to a minimum.
2. Use heat gun in any areas where O-rings are in danger of freezing.
3. Inspect the oil level in PP-2 and the mist filter on a regular basis to verify that oil in the mist filter is being automatically returned to the pump .

G.14.7. Verify current valve configuration

Open	EV-14, EV-10, EV-17, EV-13, EV-21, EV-7b(partial), AV-5, AV-10, AV-4, and AV-6 PV-1, PV-2, PV-3, PV-4, LHV-1, LHV-3(partial) SV-9, RAV-2, RAV-3, RAV-6b
Closed	All other EV, AV, PV, and RAV valves LHV-2 VF-1, VF-2, VF-3 SV-13

G.14.8. Record the following during LHSD pump-down:

Time	PG-1 (torr)	AG-2 (torr)	LGH-2 (torr)	EG-2 (torr)	LHSD weight (lbs)	PFM-1 (Ll/hr)	Temp LHSD HEX (C)

G.14.9. When pressure LHG-2 is between 40 to 50 torr and/or LHG-1 shows -29 in-Hg, turn off the power to the LHSD heat exchanger (AH-1).

G.14.10. Close AV-4

G.14.11. Close LHV-3 completely and then open one turn . (NOTE: ThIs operation helps suppress TAOs in the LHSD.)

G.14.12. Record the following:

a. Time of day:_____

b. LHSD weight: _____ lbs

c. LHSD pressure (LHG-2): _____ torr

G.15. **Set Up For Transfer**

G.15.1. Record the following instrumentation and time of day:

1. Time of day:_____.
2. Vac-ion Pump (IP):_____ torr
3. Main Tank vent pressure:EG-2_____ torr
4. Main Tank temperature (CN [09])_____ K
5. Guard Tank temperature (CN [24])_____ K

G.15.2. Set up EV-7 control valves

1. Verify that EV-7 valves are on manual control.
2. Record EV-7a valve position:_____ %
3. Record EV-7b valve position:_____ %

G.15.3. Close Guard Tank atmospheric vent path EV-13.

G.15.4. Record date/time of day _____ / _____

G.16. **Perform First Guard Tank Precool of Fill Line**

CAUTION
Transfer startup is a critical operation. All potentially interfering operations must be suspended. A qualified test director/engineer must be assigned to monitor temperatures at Station 200 and the top of the lead bag during precool and initial startup of transfer.

G.16.1. Turn on/verify on Guard Tank heater power supply (H-3D or H-4D).

G.16.2. Set power supply current limit to 0.07 amps

G.16.3. Set heater to 50 Vdc and record:

V:_____vdc, and I:_____a

G.16.4. Open VF-2 and VF-3.

G.16.5. Close/ verify closed Guard Tank vent EV-13.

G.16.6. Input comment to DAS “Start first Fill line pre-cool from GT”.

G.16.7. When a dense plume is evident at VF-3 **and** when Fill Valve (SV-13) temperature T-24D [42] is < 75 K, proceed with the following steps.

G.16.8. Reduce Guard Tank heaters as required to maintain Guard Tank pressure ~15 torr above atmospheric.. Record Heater Voltage and current _____V _____A.

G.16.9. Close SV-13.

G.16.10. Using heat gun, warm up VF-3 and then close VF-3.

G.16.11. Verify current valve configuration:

Open	EV-10, EV-17, EV-21, EV-14 EV-7b (partial) AV-6, AV-5, AV-10 PV-1, PV-2, PV-3, PV-4 LHV-1, LHV-3(1 turn) VF-2 SV-9, RAV-2, RAV-3, RAV-6b
Closed	All other EV, AV, PV and RAV valves VF-1, VF-3 LHV-2 SV-13

G.17. **Perform First Precooling of Transfer Line:**

G.17.1. Open AV-7 to begin pumping on transfer line.

G.17.2. Open VF-1 fully, adjust VF-2 to control pumping rate (AG-2 < 120 torr)

G.17.3. Record time: _____.

G.17.4. Enter comment into DAS: "Starting first precool of transfer line".

G.17.5. Raising pressure in LHSD:

NOTE: Gas pressurization **must** be used (Do **not** use LHSD electric pressure builder).

1. Open LHV-3 ~ 3 turns.
2. Open AV-2.
3. Slowly open AV-9 to raise pressure in LHSD to 300 torr as indicated by LHG-2 (18 in. Hg at LHG-1).
4. When LHSD pressure reaches 300 torr:
   a. Time of day _____
   b. Pressure LHG-2_____ torr
5. Close AV-2.
6. Return LHV-3 to one turn open.

G.17.6. When the Transfer Line is judged to be sufficiently cooled proceed to the next step and record method of judgment:

- Condensation of air on pumping line, **or**
- Pressure at AG-1 rising above 30-40 torr, **or**
- other: _____

G.17.7. Verify AV-2 closed.

G.17.8. Verify valve configuration:

Open	EV-10, EV-17, EV-21, EV-14 AV-6, AV-5, AV-7, AV-10 PV-1, PV-2, PV-3, PV-4 LHV-1, LHV-3(1 turn) VF-1, VF-2 (partial) SV-9, RAV-2, RAV-3, RAV-6b
Closed	All other EV, AV, PV, and RAV valves VF-3 LHV-2 SV-13

G.18. **Perform 2nd Guard Tank Precool of Fill Line**

G.18.1. Close VF-1.

G.18.2. Open SV-13 : now pumping Guard Tank and precooling fill line.

G.18.3. Monitor GTV-G and adjust Guard Tank heater to maintain GTV-G > 5 torr relative to atmosphere.

G.18.4. Adust VF-2 to maintain AG-2 < ~120 torr.

G.18.5. Input comment to DAS "Start 2nd GT precool by pumping"

G.18.6. When SV-13 temperature (CN [42]) < 70 K proceed.

G.18.7. Close RAV-2:

1. Verify that controller No.2 is already powered up and that RAV selection switch is already set to RAV-2. If not, perform the following steps:
   a. Ensure controller no. 2 selection switch in off position
   b. Power up controller no. 2.
   c. Position controller no. 2 selection switch to RAV-2.
2. Record initial switch status: Open: θ θ Closed: θ θ
3. Activate controller no.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. When convenient, record operation in RAV log book.

G.18.8. Verify valve configuration:

Open	EV-10, EV-17, EV-21, EV-14, EV-7b (partial) AV-6, AV-5, AV-7, AV-10 LHV-1, LHV-3(partial) VF-2 (partial) SV-13 SV-9, RAV-3, RAV-6b
Closed	All other EV, AV, PV, and RAV valves VF-1, VF-3, LHV-2

G.19. **Perform 2nd Precooling of Transfer Line**

G.19.1. Close/verify closed AV-1, AV-4

G.19.2. Open/verify open EV-21, -14 and AV-5, -7, -10

G.19.3. Open fully VF-1 and **immediately:**

G.19.4. Adust VF-2 to initate pumping of LHSD (approx. 120 taorr at AG-2) via the transfer line and record: Time _____.

G.19.5. Enter comment to DAS "Start 2nd Xfer line precool"

G.19.6. Raise pressure in LHSD, using helium gas source, to ~ 300 torr and record LHG-2 _____ torr

NOTE: Gas pressurization **must** be used (Do **not** use LHSD electric pressure builder).

1. Open LHV-3 ~ 3 turns.
2. Open AV-2.
3. Slowly open AV-9 to raise pressure in LHSD to 300 torr as indicated by LHG-2 (18 in. Hg at LHG-1).
4. When LHSD pressure reaches 300 torr record :
   a. Time of day _____
   b. Pressure LHG-2_____ torr
5. Close AV-2.
6. Return LHV-3 to one turn open.

G.19.7. When cooling at VF-2 is judged to be sufficient, proceed.

G.20. **Initiate Transfer to Main Tank**

G.20.1. Close VF-2.

G.20.2. Return Main Tank pumping to Pump Module **(quickly)**:

1. Close AV-7, -5, -10 and EV-14.
2. Open EV-4.
3. Close AV-6.

CAUTION
In the following step, there is a possibility that a temperature spike might occur in the Main Tank ullage. Be prepared to close SV-13 if the temperature at the top of the lead bag, CN [28] or CN [29], reaches 6.3 K.

G.20.3. Open RAV-1 starting transfer to Main Tank:

1. Verify controller no. 1 selection switch is in the off position.
2. Power up RAV controller no.1.
3. Position selection switch to RAV-1.
4. Record initial switch status: Open: θ θ Closed: θ θ
5. Activate controller no. 1 to open RAV-1 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.

G.20.4. Open EV-7a fully.

G.20.5. Watch temperatures of lead bag, CN28, and STA 200, CN01, carefully and keep temperatures < 6 K.

G.20.6. Prepare to close SV-13 immediately if temperature approaches 6 K.

G.20.7. Adjust LHSD pressure:

1. Open LHV-3 4 turns.
2. Close/verify closed all AV valves.
3. Open AV-2, -4, -10.
4. Slowly open AV-9, admitting helium gas into LHSD and bring ullage pressure up to 500 torr as measured by LHG-2.

   NOTE: Use AG-1/AG-2a to aid in adjusting this pressure.

G.20.8. Record LHG-2 _____ torr.

G.20.9. Record time of day _____.

G.20.10. Set Guard Tank heater to zero volts.

G.20.11. Adjust Guard Tank heater power to stabilize Guard Tank pressure >5 torr and < 30 torr relative to atmosphere.

G.20.12. Comment to DAS “Start Subatm transfer to MT”, the input time for this comment is the time of day from the preceeding ‘Open RAV-1’ operation.

G.20.13. Verify valve configuration:

Open	EV-4, EV-10, EV-17, EV-21, EV-7a/b AV-2, AV-4, AV-10, and AV-9 (partial) LHV-1, LHV-3(4 turns) VF-1 SV-13 SV-9, RAV-1, RAV-3, RAV-6b
Closed	All other EV, AV, PV, and RAV valves VF-2, VF-3 LHV-2

G.21. **Verify Start of Transfer:**

G.21.1. Verify flow by verifying increase in Main Tank liquid level.

1. Time of day:_____
2. Record Main Tank liquid level _____ %
3. Record LHSD weight:_____ lbs

G.21.2. Record initial flow rate PFM-1:_____ LL/hr (scale B)

Note: As fill proceeds, do not exceed 100 Ll/hr transfer rate as read on PFM-1(scale B) so as not to exceed capacity of heat exchanger in Gas Module.

G.21.3. Record all fill data on the attached data sheets every 15 minutes.

G.21.4. Confirm that the liquid level in the Main Tank is rising, and if it is not, increase the LHSD pressure as necessary.

G.21.5. Continue to adjust LHSD pressure as described above.

G.21.6. **If it is necessary** to reduce the pressure in the LHSD, perform the following:

1. Close AV-9.
2. Open AV-8 until pressure LHG-2 has been reduced to desired value, then close AV-8
3. Slowly open AV-9 and adjust to maintain 500 torr pressure in LHSD, as measured at LHG-2.

G.21.7. During the Main Tank fill operation, monitor the Guard Tank pressure relative to atmosphere (Endevco at GTV-G, CN [46]) and record on Data Sheet 1. If pressure approaches 0.0 torr, apply power to Guard Tank heater and record power on Data Sheet 1.

G.21.8. When the LHSD is near depletion, proceed to next section.

G.22. **Terminate Transfer**

Note: An empty LHSD is indicated by a rapid drop in LHSD ullage pressure.

G.22.1. Stop the flow of liquid helium:

1. Verify closed AV-3 and AV-1.
2. Close VF-1.
3. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.
4. Open VF-2.

G.22.2. Close LHV-3 completely.

G.22.3. Record the following

1. Date/time of day:_____ /_____.
2. LHSD weight:_____ lbs
3. Main Tank level:_____ %
4. Flowrate PFM-1 (scale B):_____ Ll/hr
5. Flow meter PFM-1 (scale C):_____ Ll x 60
6. Main Tank Temp (T-9D):_____ K
7. Guard Tank Temp (T-15D)_____ K
8. Main Tank exit pressure (EG-2):_____ torr
9. Vac-ion pump(IP):_____ torr
10. Vacuum Module pressure (VG-1):_____ torr

G.23. **Configure GSE**

G.23.1. Ensure EV-7a and EV-7b open.

1. Record EV-7a valve position:_____ %
2. Record EV-7b valve position:_____ %
3. Date/time of day_____/_____

G.23.2. Verify open EV-4, EV-10, EV-17, and EV-21.

G.23.3. Verify all other EV valves are closed.

G.23.4. Continue to monitor and maintain positive Guard Tank pressure relative to atmosphere (Endevco at GTV-G, CN [46]) Record Data in Data Sheet. Adjust heater voltage as necessary, gradually reducing to avoid excessive (> 30 torr) pressure.

G.24. **Condition LHSD and LHSD Pumping Line**

G.24.1. Verify Open AV-4 and AV-10.

G.24.2. Open/verify open AV-2.

G.24.3. Verify that LHV-3 is closed.

G.24.4. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then close AV-9.

G.24.5. Close AV-2 and AV-4.

G.24.6. Remove vacuum clad LHSD pumping line from the LHSD at LHV-3.

G.24.7. Turn on electric pressure builder and bring the pressure LHG-2 to 800 torr (LP-1 to 1 psig). This should take about 10 minutes.

G.24.8. Turn off the electric pressure builder.

G.24.9. When LHG-2 reaches 1psig Open LHV-2 on the LHSD.

G.24.10. Close LHV-1 and remove Baratron pressure gauge.

Note: the following 3 steps may be performed after section G.25

G.24.11. Remove stinger from LHSD.

G.24.12. Remove LHSD from scale.

G.24.13. Verify closed **all valves** on the LHSD except for the primary (low pressure) relief valve LHV-2 which is left open.

G.25. **Switch Pumping Line From Access 2 to Access-1.**

G.25.1. Verify AV-10 open and all other AV valves closed.

G.25.2. Open AV-7, AV-3, and AV-1.

G.25.3. Adjust AV-9 for 0.5 psig.

G.25.4. Close all AV valves

G.25.5. Move pumping line from Access 2 to Access 1.

G.26. **Verify Closure of SV-13**

G.26.1. Close/verify closed all AV valves.

G.26.2. Verify open VF-2.

G.26.3. Open AV-8 and AV-3 to pump up to SV-13 and VF-1.

G.26.4. When AG-2b is < 50 mtorr close AV-8.

G.26.5. Open AV-1.

G.26.6. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then close AV-9.

G.26.7. Perform leak-back test of SV-13.

1. Open AV-8.
2. Close AV-8 when pressure reaches less than 10 mtorr as read on gauge AG-2.
3. Verify that pressure AG-2 does not rise by more than 50 mtorr in four minutes while recording:

Date/Time of Day: _____/_____

Time (min)	_____	_____	_____	_____	_____
P(AG-2) (mtorr)	_____	_____	_____	_____	_____

Pass/Fail _____ mtorr/min _____

G.26.8. In the case the leak-back test fails, perform the following:

1. Open AV-8 and evacuate the Transfer line.
2. Close AV-8 when pressure reaches less than 10 mtorr as read on gauge AG-2.
3. When SV-13 and Transfer line are judged to be warmed sufficiently (which may be a few hours) to pass a leak -back test, perform the following:
4. Retorque SV-13 to 60 +/- 5 in-lbs.
5. Open AV-8.
6. Close AV-8 when pressure reaches less than 10 mtorr as read on gauge AG-2.
7. Verify that pressure AG-2 does not rise by more than 50 mtorr in four minutes while recording:

Date/Time of Day: _____ _____

Time (min)	_____	_____	_____	_____	_____

P(AG-2) (mtorr)	_____	_____	_____	_____	_____

Pass/Fail _____ mtorr/min _____

G.27. **Remove Transfer Line and Filter Assembly**

G.27.1. Open/verify open AV-1.

G.27.2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.

G.27.3. Close AV-1.

G.27.4. Close VF-2 and disconnect pumping line from VF-2.

G.27.5. Verify closed **all valves** on the LHSD except for the primary (low pressure) relief valve LHV-2 which is left open.

G.27.6. Remove the Transfer/ Filter Lines from the Dewar fill bayonet B3 and immediately install the Fill Cap Assembly.

G.27.7. Verify pressure in LHSD is > 1 atm and remove the Stinger from the LHSD.

G.27.8. Verify closed all LHV valves except primary (1 psig) relief valve LHV-2.

G.28. **Evacuate Internal Fill Line**

G.28.1. Connect a pumping line between the Fill Cap Assembly at valve FCV and the Auxiliary Gas Section access port no. 1.

G.28.2. Verify AV-3 open and all other AV valves closed.

G.28.3. Open AV-8.

G.28.4. Open/verify open valve FCV and evacuate Fill Cap Assembly to <25 mtorr measured at AG-2B.

G.28.5. Close FCV.

G.28.6. Open SV-13.

G.28.7. Close RAV-1:

1. Verify that RAV controller no.1 is already on and that RAV selection switch is already set to RAV-1. If not, perform the following steps:
   a. Ensure controller no. 1 selection switch in off position
   b. Power up controller no. 1.
   c. Position controller no. 1 selection switch to RAV-1.
2. Record initial switch status: Open: θ θ Closed: θ θ
3. Activate controller no.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. When convenient record operation in RAV log book.

G.28.8. Deactivate RAV system:

1. Turn all RAV selection switches to OFF.
2. Power off all controllers.
3. Turn off RAV power supply.

G.28.9. Open FCV and evacuate the Dewar fill line to < 25 mtorr as measured at AG-2b.

G.28.10. Input comment to DAS “RAV-1 closed and Fill Line pumped”.

G.28.11. Close SV-13 and torque to 60 +/- 5 in-lbs.

G.28.12. Close FCV.

G.28.13. Close AV-8.

G.28.14. Open AV-1.

G.28.15. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.28.16. Close AV-1.

G.28.17. Monitor the pressure in the Fill Cap Assembly, FCA, for 15 minutes to be assured that no gas is leaking into the Fill Cap Assembly (i.e. it maintains vacuum) and record:

1. PFCG pressure:_____
2. Date/Time:_____

G.28.18. When pressure in Guard Tank is stabilized: open EV-13 and maintain Guard Tank heater power as necessary to keep GTVVG >5 torr.

G.28.19. Turn off Guard Tank vent-line heat exchanger.

G.28.20. When Main Tank vent-line heat exchanger power demand is lower than 0.3 amps turn off and record time: _____.

G.29. **Place Data Acquisition System in Standard Configuration**

G.29.1. Input comment to DAS “Completed Subatmospheric fill of Main Tank”.

G.29.2. Set Main Tank and Guard Tank Liquid Level sampling interval to 10 minutes.

G.29.3. Confirm that the liquid level sensors are set at a sampling rate of 10 minutes or turned off.

G.29.4. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.29.5. Record 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. If pressure is above 1x10-4 torr, turn off Vac-ion pump and perform procedure P0213, Connection of High Vacuum Pumping Module, to connect Vacuum Module and pump out SMD vacuum shell.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 15 min.
5. When data cycle is complete, turn off Vac-ion pump.

G.29.6. Ensure DAS alarm enabled and record set points if changed

- Thermal conditions substantially unchanged, alarm set points for Station 200 and lead bag are unchanged and set to alarm.
- 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.29.7. Ensure liquid level sensor alarms enabled on Main Tank and Guard Tank and record set points if changed.

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

CAUTION
The Guard Tank may tend to subcool following the completion of this procedure. Establish continuous monitoring of the Guard Tank pressure by placing it on the DAS alarm list.

G.29.8. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential.

G.29.9. Ensure DAS watchdog timer and alarm enabled.

G.29.10. Ensure all RAV operations recorded in log book.

G.29.11. Ensure Facility Main Alarm System enabled.

G.30. **Perform Final Closure of SV-13**

Note: Once SV-13 has warmed sufficiently to try final closure perform the following:

G.30.1. Verify that the Fill Cap Assembly is still evacuated and record:

1. PFCG pressure:_____ torr.
2. Date/Time:_____/_____

G.30.2. Retorque SV-13 to 60 +/- 5 in-lbs.

G.30.3. Open AV-8 and open/verify open AV-3.

G.30.4. Open FCV and evacuate to < 25 mtorr as measured at AG-2b.

G.30.5. Close AV-8.

G.30.6. Open AV-1.

G.30.7. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.30.8. Close AV-1.

G.30.9. Close FCV and record:

1. PFCG pressure:_____ torr.
2. Date/Time: _____/ _____

G.30.10. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.30.11. Close AV-8.

G.30.12. Verify closure of SV-13 and FCV by observing the pressure in the Fill Cap Assembly (PFCG) until satisfied that no gas is leaking into the Dewar Fill line or pump line. After 30 minutes record:

1. PFCG pressure: _____ torr.
2. Date/Time: _____/_____

G.30.13. Open AV-1.

G.30.14. Open AV-9 until pressure reaches 0 psig as read on gauge AG-1 and then close AV-9.

G.30.15. Close AV-1.

G.30.16. Close AV-3.

G.30.17. Remove the pumping line from the Fill Cap Assembly.

G.30.18. Install a KF-25 blank-off cap on valve FCV.

G.31. **(Option) Return Pumping of SMD to Gas Module Pump**

G.31.1. Once temperatures and pressures have stabilized, and T_{09} (Main Tank) is at the desired level, record the following

1. Date/time of day:_____/_____
2. Main Tank level:_____ %
3. Flowrate PFM-1 (B):_____ Ll/hr
4. Flow meter PFM (C):_____ Ll x 60
5. Tank Temp (T-9D):_____ K
6. Main Tank exit pressure (EG-2):_____ torr
7. Vac-ion pump(IP):_____ torr
8. Vacuum Module pressure (VG-1):_____ torr

G.31.2. Record EV-7a valve position: _____ %

G.31.3. Record EV-7b valve position: _____ %

G.31.4. Verify closed all AV valves.

G.31.5. Verify AP-1 on.

G.31.6. Open AV-8.

G.31.7. When AG-2b < 50 mtorr proceed.

G.31.8. Open AV-6.

G.31.9. Close EV-4.

G.31.10. Verify Main Tank heat exchanger is off.

G.31.11. Shut down pump module

1. Close EV-21.
2. Close PV-1.
3. Power down PP-1 and PP-2.
4. Close PV-3.

H. **PROCEDURE COMPLETION**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

SMD SUB-ATMOSPHERIC TRANSFER DATA SHEET

DATE / TIME	Main Tank Press EG-2	Vac Press VG-1/ VIP	GT Press GTV-G CN [46]	Pump Press PG-1	Flow Rate PFM-1 (B)	MT Vent Bayonet/ Bayonet Nut	SV-9 Valve/ Top Plate	Top-Plate Cyl(2)	GM Hex GT/MT	Main Tank Temp CN [09]	Sta. 200 Temp CN [01]	Guard Tank Temp CN [24]	Hex-4 Temp CH [08]	LHSD Press CN [83]	LHSD LLS/ Wt	MT/GT LLS	GT Heater Power	Extern. Gas Sup. ea shift	Comments
	Torr	torr	torr	torr	LL/Hr	$^0C/^0C$	$^0C/^0C$	$^0C/^0C$	$^0C/^0C$	K	K	K	K	torr	%/lb	%	W	psi	

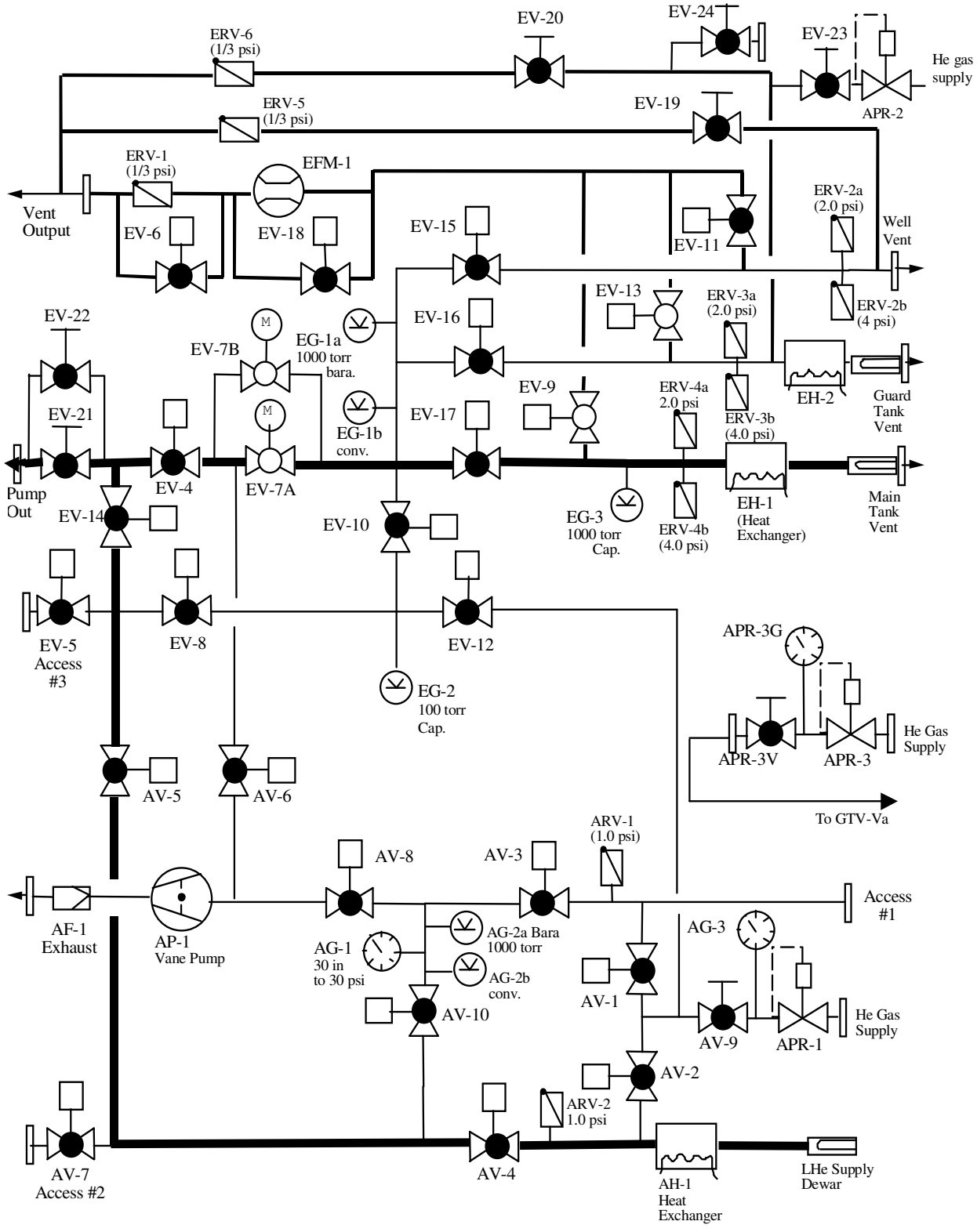

Figure 1. Schematic of Gas Module Plumbing.

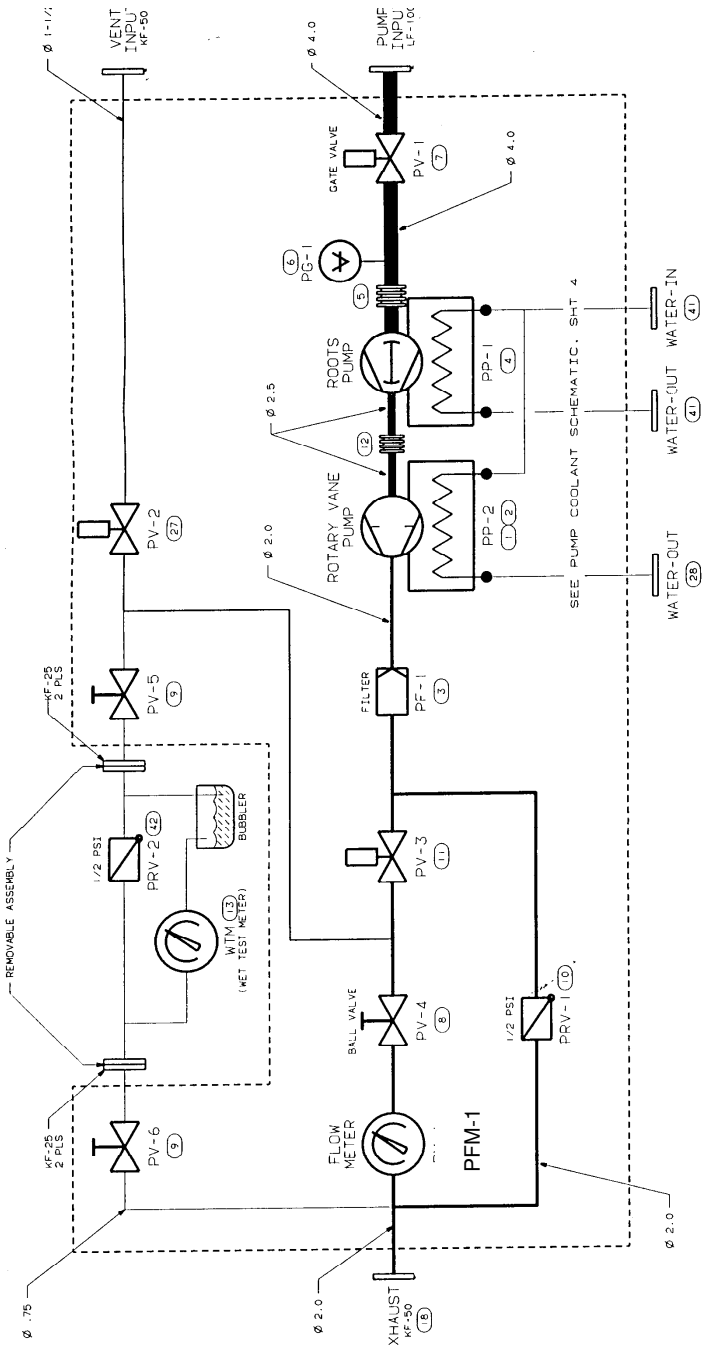

Figure 2. Schematic of Pump Module plumbing.

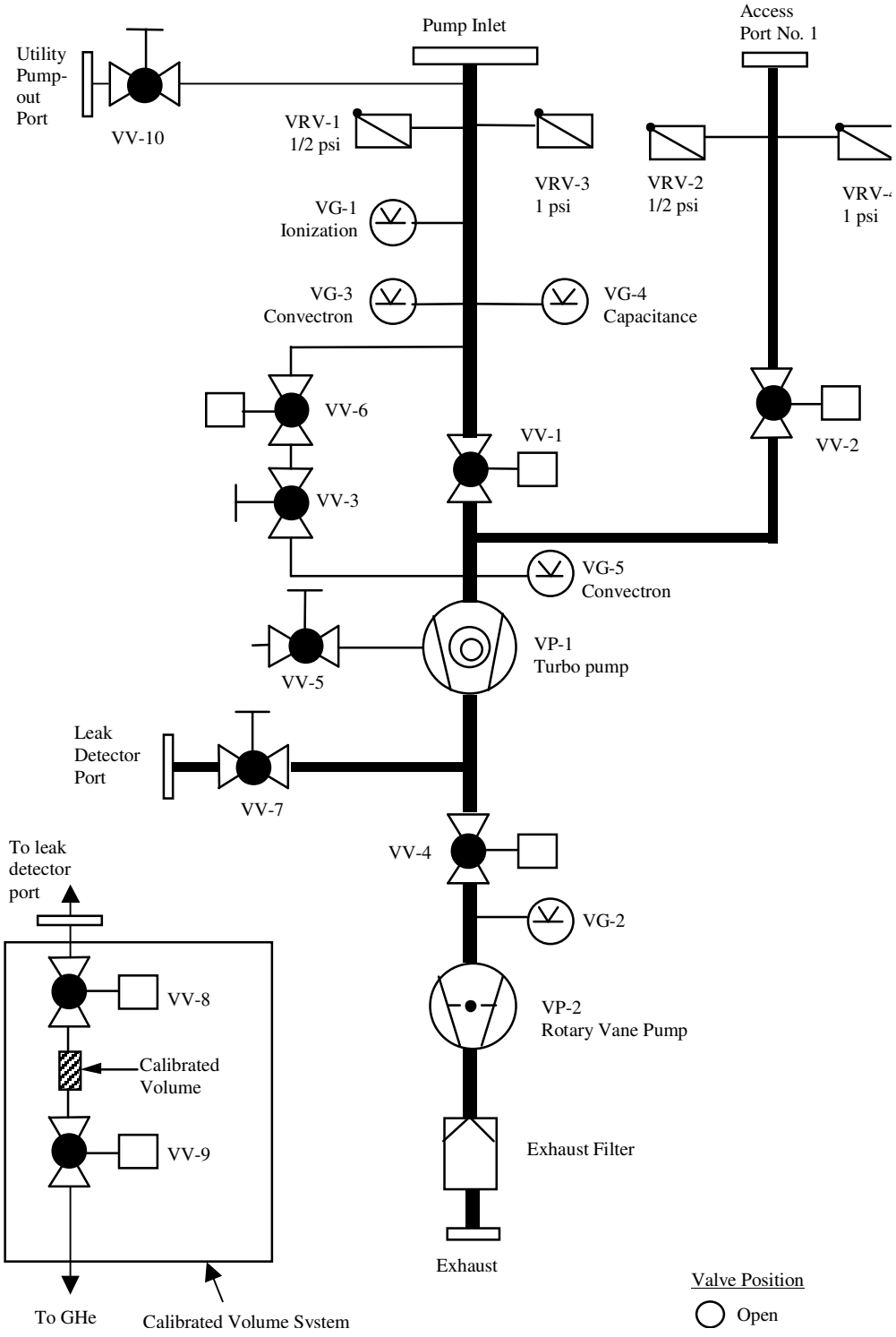

Figure 3. Schematic representation of Vacuum Module plumbing.

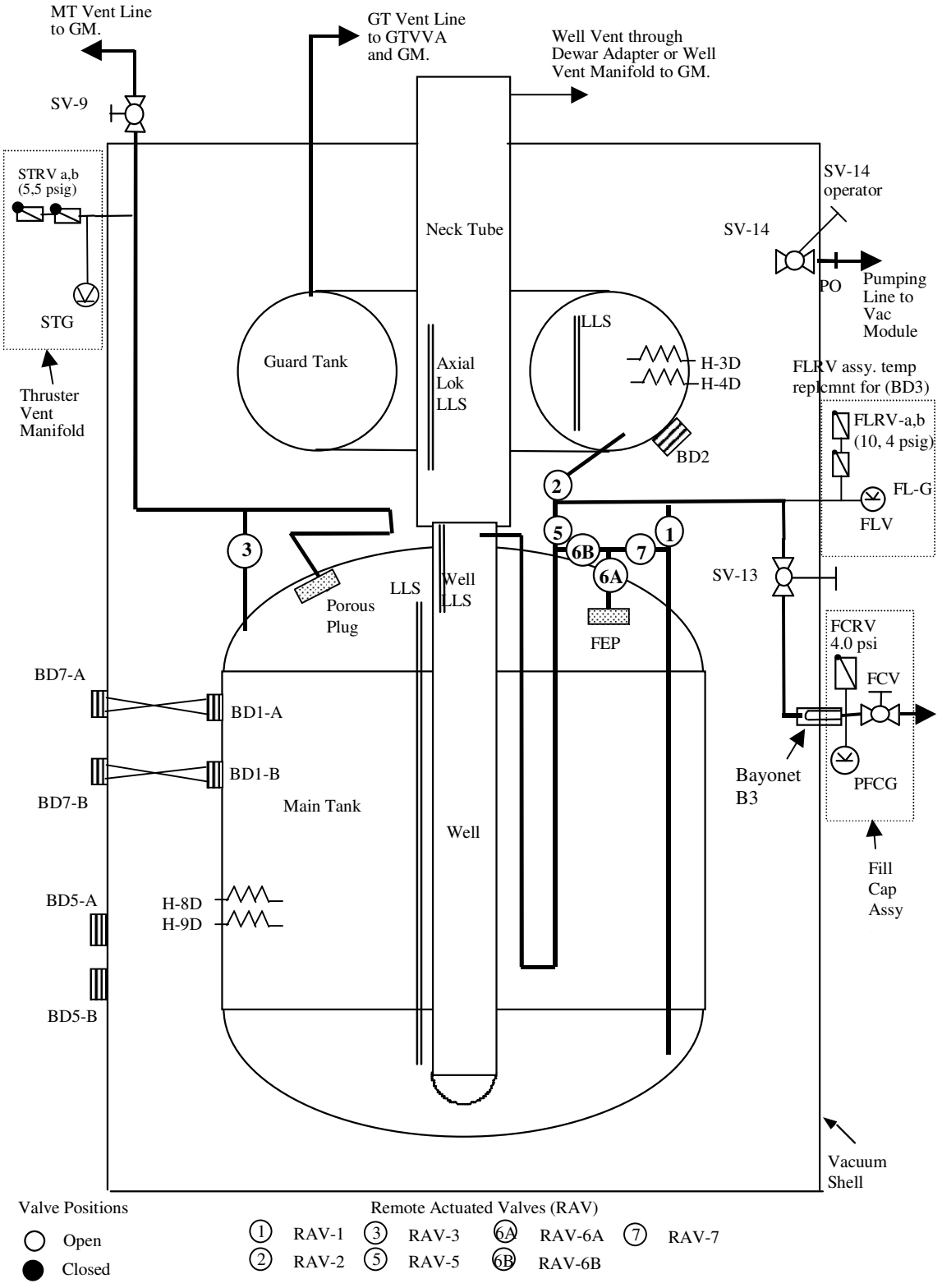

Figure4. Schematic of Science Mission Dewar plumbing.

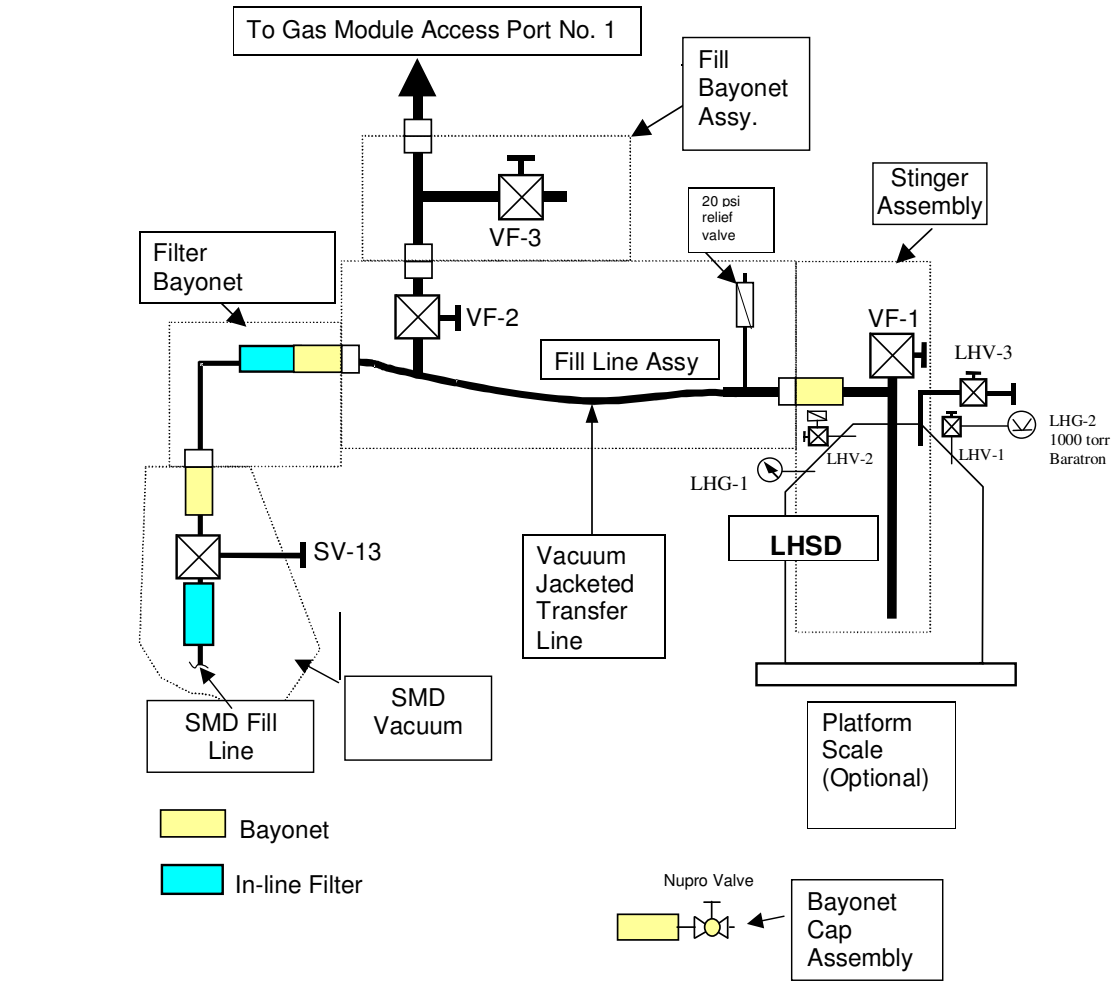

Figure 5 Schematic representation of LHSD and Transfer Line Plumbing

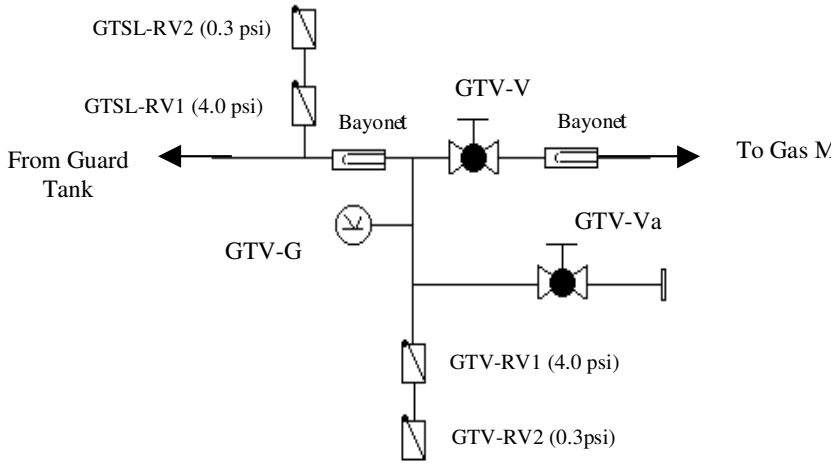

Figure 6. Guard Tank Vent Valve Assembly (GTVVA)