GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

EXTERNAL GUARD TANK FILL – MAIN TANK SUBATMOSPHERIC

P0209d
ECO 1280

July 3, 2001

Revised by:

_____Date_____
Jim Maddocks
Cryogenic Test

Checked by:

_____Date_____
Dave Murray
Cryogenic Test

Approvals:

_____Date_____
Dorrene Ross
Quality Assurance

_____Date_____
Harv Moscowitz
LM Safety

_____Date_____
Robert Brumley
Payload Technical Manager

_____Date_____
Mike Taber
Payload Test Director

REVISION RECORD

REVISION	*ECO*	*PAGES*	*DATE*
A	1020	P6 add Well mandatory if Axial Lock = 0% P14 Change Guard Tank precool so that Main Tank is not manifolded with pressurized Guard Tank..	8/20/19
B	1161	Section A – Changed title and Scope to include only the case that the Main Tank is subatmospheric and initial precooling of the internal fill line is accomplished with liquid from the Guard Tank. 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. Since it is imperative that the Guard Tank level not go below 10-15% a setpoint of 20% is required. Section G.3 – Added section to verify Gas Module in Standard Configuration. G.4. – Added section to verify SMD in standard configuration. Added warnings to monitor temperatures at Station 200 and the top of the lead bag continuously while the Main Tank vent is closed. Added caution at end of procedure to monitor Guard Tank pressure and set DAS alarm to 0.3 torr differential. Update GSE plumbing schematics as required.	5/24/01
C	1278	Added configuration option to section G.3 for the possibility of the Main Tank being in an unvented condition (i.e. corresponding to the situation that will occur when the payload is on the rocket at Vandenberg Air Force Base. Included miscellaneous minor redlines.	6/22/01
D	1280	Included miscellaneous minor redlines	7/3/01

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
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
STG	SMD Thruster vent pressure guage
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 Guard Tank with normal boiling point liquid helium. The steps include:

Pre-cool SMD internal fill line from Guard Tank

Pre-cool external transfer line

Fill Guard Tank

Terminate transfer

The procedure is for use when the Main Tank is Subatmospheric, and the Well is evacuated. Precooling of the internal fill line is accomplished using liquid from the Guard Tank itself. For this reason it is imperative that the Guard Tank liquid level be maintained at a value greater than 15%. The procedure can be performed when the Main Tank is being pumped or when it is unvented (i.e., SV-9 is closed).

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 Technical 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	Ned Calder

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, Pump and Electrical Modules.

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

Description	***Manufacturer***	***Model***
AMI Level Sensor Readout for LHSD	AMI	110

E.3.5. Additional Hardware

Description	***Manufacturer***	***Model***
Filter Line assembly	LMMS	5833827
Liquid He Transfer Line	LMMS	5833804
Liquid He Stinger	LMMS	5833803
GHe supply fittings to LHSD	N/A	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.***
Alcohol	AR	N/A
99.99% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Braycote Micronic 601
Liter Liquid Helium Storage Dewar	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	A1, A2, A3, A4	3452A01975	Yes	
2	DAS	Power Supply, H-P 6627A	B1, B2, B3, B4	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	SIP	5004N	No	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
		Varian 929-0910, Minivac				
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	EH-1	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	EH-2	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 in the Main Tank 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

E.5.2. Guard Tank

The Guard-Tank liquid level (Guard Tank LLS-B) must be greater than 15% to adequately precool the internal fill line.

E.5.3. Well

The Well is evacuated.

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 1×10^{-4} torr. Document No. P0213, *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. Station 200 temperature (CN 01) set at $T \leq 2.2$ K.
   b. Top of lead bag temperature set (CN 28) at $T \leq 2.2$ 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 is installed in place of the SMD fill-line burst disk.
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 with a vacuum insulated line. Document No. P0674, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP,* contains the procedures for connecting the Main Tank vent line.
4. The Guard Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833813). Document No. P0676, *Connect Guard Tank Vent Line to Gas Module*, contains the procedures for connecting the Guard Tank vent line.
5. The Fill Cap Assembly must be installed at SV-13 (Figure 3)
6. The ion-pump magnet must be installed.
7. The thruster vent port may be flanged to a relief assembly.
8.

E.6. **Optional Non-flight Configurations**

The following non-flight modifications of the basic SMD and optional GSE configurations are incidental to the performance of this procedure. Any combination represents an acceptable configuration.

1. The SMD maybe installed in its transportation and test fixture.
2. A foreign object and debris shield may cover the upper cone of the SMD. If it is not present, any object that could cause damage to the payload, if dropped, must be tethered.
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 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.

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 P0213	*Connect Vacuum Module to SMD*
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*

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

G.2.3. Verify Main Tank vent line connected to Gas Module. If not perform procedure P0672, *Connect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric,* to connect Main Tank vent.

G.2.4. 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.2.5. Verify Fill Cap Assembly installed at SV-13.

G.2.6. Verify ion-pump magnet installed.

G.2.7. Verify Main Tank subatmospheric. Record Main Tank temperature, CN [09] _____ K and verify < 4.2 K.

G.2.8. 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 $T \leq 2.2$ K. Record set point. _____K
2. ***Top of lead bag temperature*** – verify CN [28] on DAS alarm list and set to alarm at $T \leq 2.2$ K. Record set point. _____K
3. ***Relative Guard Tank Pressure*** – verify CN [46] on DAS alarm list and set to alarm at $\Delta P \geq 0.3$ torr. Record set point. _____torr

G.2.9. Ensure DAS watchdog timer and alarm enabled.

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

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

G.2.11. If Guard Tank is expected to drop below 20% during precool, switch Guard Tank level alarm off

G.3. Verify Gas-Module Configuration and Record Initial Conditions

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

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o Main Tank pumped by Gas Module (AP-1)

1. Verify SV-9 open.
2. Verify open EV-7a/b, EV-10, EV-13, EV-17.
3. Verify all other EV valves closed.
4. Verify AP-1 on.
5. Verify AV-6 open.
6. Verify all other AV valves closed.
7. Verify open PV-2 and PV-4.
8. Verify closed PV-1, PV-3, PV-5 and PV-6.

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o Main Tank pumped by Pump Module (PP-1/2)

9. Verify SV-9 open.
10. Verify open EV-4, EV-7a/b, EV-10, EV-13, EV-17, EV-21/22.
11. Verify all other EV valves closed.
12. Verify all AV valves closed.
13. Verify PP-1/2 on.
14. Verify open PV-1, PV-2, PV-3, and PV-4.
15. Close/verify closed PV-5 and PV-6.

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o Main Tank not pumped (SV-9 closed).

16. Verify SV-9 closed.
17. Verify EV-10, EV-17, and EV-13 open.
18. Verify all other EV valves closed.
19. Verify all AV valves closed.
20. Verify open PV-2 and PV-4.

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21. Verify closed PV-1, PV-3, PV-5 and PV-6.

G.3.2. Record position of EV-7a: _____ % EV-7b _____%

G.3.3. Verify Actuator Control Valve for EV-9 in "Subatm He" position.

G.3.4. Record status of Well (e.g., manifold installation, valve positions etc.)

_____

_____

G.3.5. Verify Vacuum Shell Pressure < 1 x 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.

G.3.6. Record initial liquid helium levels.

1. ***Main Tank*** _____%
2. ***Guard Tank*** – verify level ≥ 15% to precool internal transfer line. _____%

G.3.7. Record initial temperatures

1. Station 200 CN [01] _____ K.
2. Top of Lead Bag CN [28] _____ K.

G.3.8. Record pressures.

1. Guard Tank (GTV-G):_____ torr (relative to atm.).
2. Main Tank (EG-2):_____ torr.
3. Main Tank (EG-1a) _____ torr.
4. Main Tank (STG) CN [49] _____ torr diff.

G.3.9. Record Fill Cap Assembly pressure and verify that it reads > 760 torr.
Fill Cap Assembly pressure (PFCG): _____ torr.

G.3.10. Record Vacuum Module Pressure (if connected): (VG-1):_____ torr.

G.4. **Verify SMD 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-6B.
2. ***Closed***: RAV-1, RAV-2, RAV-5, RAV-6A, and RAV-7.
3. ***Record*** position of Rav-3 _____.

G.4.2. Verify that SMD external valves are in the following positions.

Closed: SV-13 and FCV.

G.5. **Set Up Data Acquisition System**

Note: refer to DAS operating instructions for information on configurations and mechanics of keyboard/mouse operation.

G.5.1. Verify DAS configuration set to 4m.

G.5.2. Set DAS to fast scan mode using [other menus], [data config], [fast scan]

G.5.3. Start "Special Data Cycle" by using [Other Menus] + [Special Data Col] + [Select CN [01], [09], [28], [42], and [46]] + [Init. Collectn] + [Enter] (=use default file)

G.5.4. Set Guard Tank Liquid Level Sensor sampling interval to 1 min.

G.5.5. Ensure printer is displaying special Data Cycle data.

G.6. **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) and it is desired to transfer pumping to the Pump Module . It is assumed that the plumbing between the Pump Module the Gas Module has been successfully leak checked.

- Main Tank is pumped by AP-1, perform this section
- Main Tank is already pumped by Pump Module or is closed out, skip this section
- Main Tank is not vented (SV-9 closed), skip this section.

G.6.1. Verify open PV-2 and PV-4.

G.6.2. Verify closed PV-1, PV-3, PV-5, and PV-6.

G.6.3. Initiate the Pump Module

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

G.6.4. Transfer pumping to Pump Module.

1. Verify closed AV-8.
2. Open EV-21 and EV-4.
3. Close AV-6.
4. Open PV-3.
5. Record time of day : _____

G.6.5. 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 RAV-3, RAV-6b
Closed	All other EV, PV, and RAV valves All AV valves

G.7. **Check Initial Pressure in Fill Line**

G.7.1. Install a pumping line between valve FCV on the Fill Cap Assembly and the Access Port #1 of the Auxiliary gas section.

G.7.2. Turn on/verify on pump AP-1.

G.7.3. Open AV-8 and AV-3.

G.7.4. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.7.5. Close AV-8 and FCV.

G.7.6. Once the pressure in the Fill Cap Assembly has stabilized, record Fill Cap Assembly pressure (PFCG): _____ torr.

G.7.7. Open valve SV-13 to bring Fill Cap Assembly up to SMD Fill line

pressure and record PFCG _____ torr.

G.8. **Raise Pressure in Fill Line**

G.8.1. Open RAV-2 to bring Fill line up to Guard Tank pressure as follows.

1. Ensure all RAV selection switches in OFF position.
2. Turn on RAV power supply and adjust current limit to 1.95 A.
3. Adjust power supply to 28 VDC.
4. Power up RAV controller #2.
5. Position controller #2 RAV selection switch to RAV-2.
6. Record initial switch status: Open: θ θ Closed: θ θ.
7. Activate controller #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.8.2. Verify that the Fill Cap Assembly pressure rises to the Dewar Guard Tank pressure.

1. Record Fill line pressure (PFCG): _____ psig/torr.
2. Record Guard Tank Pressure (GTV-G) _____torr diff.

G.9. **Check Guard Tank Vent Line Flow Impedance:**

G.9.1. If necessary adjust SV-13 to minimize oscillations in the fill line as read at PFCG. Make sure, however, that SV-13 is still open enough to read the Guard Tank pressure.

G.9.2. Open EV-24 and remove/verify removed any cap on the atm. Side.

G.9.3. Verify that SV-13 is not fully closed by ensuring that the Guard Tank pressure measured at PFCG drops to ambient (approximately 760 torr) Record PFCG: _____ torr

G.9.4. Turn on power supply for Guard Tank heater (H-3D or H-4D)

G.9.5. Set power supply current limit to 0.07 amps.

G.9.6. Set to 50 VDC and record: V _____Vdc and I _____A.

G.9.7. When a steady state is reached, record the following

1. Guard Tank pressure as measured by PFCG: _____ torr
2. Atmospheric pressure _____ torr
3. SMD Hex-1 temperature _____ K
4. SMD Hex-2 temperature _____ K

5. SMD Hex-3 temperature _____ K
6. SMD Hex-4 temperature _____ K

When convenient, record results (a) through (f) in the *Guard Tank Vent Line Flow Impedance Log*

G.9.8. Close EV-24 and install the cap, if previously installed.

G.9.9. Set the Guard Tank heater power supply voltage to zero volts.

G.9.10. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

G.9.11. Open AV-1.

G.9.12. Open AV-9 until pressure at AG-1 is 0.5 torr, then close AV-9.

G.9.13. Close AV-1.

G.10. **Install Stinger in LHSD**

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

G.10.1. Reduce LHSD pressure to < 1.0 psig by opening low-pressure relief.

G.10.2. Open valve VF-1 (Liquid withdrawal valve) on the stinger.

G.10.3. Slowly insert the stinger into the LHSD while allowing it to be purged.

G.10.4. Close valve VF-1 just as cold gas is expelled from stinger.

G.10.5. Close the primary (low-pressure) relief valve on the LHSD.

G.10.6. Increase LHSD ullage pressure builder to 8 to 10 psig via one of:

1. Power on the electric pressure builder **or,**
2. Attach external source of GHe to ullage inlet per the following:
   a. Ensure that the external source of GHe is in fact helium gas.
   b. Attach a GHe hose to the VENT outlet of the LHSD while purging the hose and the VENT outlet.
   c. Adjust pressure regulator to obtain 8 to 10 psig LHSD driving pressure.

G.10.7. Record LHSD data:

Date / time: _____ / _____
Liquid level _____ %
LHSD serial number: _____

G.11. **Install Transfer Line Assembly**

Note: in the following steps the fill line is connected from the LHSD stinger at VF-1 to the SMD. 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.11.1. Remove the Fill Cap Assembly.

G.11.2. If using Transfer Line Filter, install it in Dewar Fill Bayonet B3.

G.11.3. Install Transfer Line as follows:

CAUTION
Be sure to provide adequate Fill Line support to avoid damaging Filter and Stinger.

1. Mate the Fill Line (P/N 5833804) with the LHSD Stinger at VF-1.
2. Mate VF-2 end of transfer line with Transfer Line Filter or B3 as appropriate.
3. Ensure VF-2 and relief valve stems pointed upward.
4.
5. (Opitional) Start chart recorder to record pressure-spike history at fill-line burst disk. Record pressure FLG.

G.12. **Condition Transfer Line/Filter/Stinger Assembly**

G.12.1. Configure Pumping Line as follows:

1. Ensure 1.5-in flexible pumping line mated to Access Port #1 of Auxiliary Gas section.
2. Mate other end to outlet of VF-2.

G.12.2. Evacuate Transfer Line:

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

G.12.3. 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.12.4. Evacuate Transfer 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.12.5. 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.

G.13. **Start Transfer**

Note: This section starts the transfer by pre-cooling the SMD internal Fill Line by pushing liquid up from the Guard Tank.

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.13.1. Turn on Guard Tank vent line heat exchanger (EH-2).

G.13.2. Ensure VF-3 closed.

G.13.3. Ensure VF-2 open.

G.13.4. Open SV-13.

G.13.5. Record Guard Tank pressure (GTV-G): _____ torr (relative to atm).

G.13.6. Turn on power supply for Guard-Tank heater (H-3D or H-4D)

1. Set power supply current limit to 0.07 amps.
2. Set to 50 VDC and record: V _____Vdc and I _____A.

G.13.7. Open VF-3.

G.13.8. Close EV-13

G.13.9. Enter comment to DAS “Start Precool.”

Note: Precool internal fill line until a dense plume is evident at VF-3 and Fill Valve (SV-13) temperature CN [42], is < 75 K. If the initial Guard Tank level is < 25% attempting to cool SV-13 below 75 K may result in depletion of the Guard Tank.

G.13.10. When a dense plume is evident from VF-3 and Fill Valve (SV-13) temperature T-24D, CN [42], is < 75 K,

1. Power off Guard Tank heaters.
2. Close SV-13.
3. Immediately open VF-1.

G.13.11. Open EV-13

G.13.12. When a dense plume is evident from VF-3:

1. Close VF-2 and immediately
2. Open SV-13.

G.13.13. Open EV-6 and EV-18.

G.13.14. Close VF-3 when it thaws out.

G.14. **Verify Start of Transfer**

CAUTION
Do not exceed 100 LL/hr transfer rate as read on PFM-1 (scale B) as this exceeds the capacity of the vent line heat exchanger (EH-2) in the Gas Module.

G.14.1. Verify flow meter (PFM-1) reading of 50 to 100 liquid liters/hour.
PFM-1 (scale B) reading: _____

Start Time: _____

G.14.2. Record LHe level of LHSD:_____ %

G.14.3. Input comment to DAS "Starting External Fill of Guard Tank".

G.14.4. Record all fill data on the attached data sheet every 5 minutes.

G.14.5. Adjust LHSD pressure:

1. Close pressurization valve at the LHSD and adjust the gas supply pressure regulator to the desired pressure not to exceed 8 psig.
2. Reopen pressurization valve at the LHSD.

G.14.6. Select desired Guard Tank fill level _____%

G.14.7. When Guard Tank is at desired level, record Guard Tank level and proceed to terminate transfer.
Guard Tank Level (LL-5D or LL-6D)_____%

G.15. **Terminate Transfer**

G.15.1. Stop the flow of liquid helium:

1. Close VF-1 and record time of day _____.
2. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs and **immediately open** VF-2.
3. Close EV-6 and EV-18.

G.15.2. Enter comment to DAS "Stop Transfer."

G.15.3. Remove the pumping line from the Gas Module at valve VF-3.

G.15.4. Remove the Transfer and Filter Lines from the Dewar fill bayonet B3 and immediately install the Fill Cap Assembly.

G.16. **Condition SMD Internal Fill Line**

G.16.1. Connect a pumping line between the Fill Cap Assembly at valve FCV and the Auxiliary Gas Section access port no. 1.

G.16.2. Ensure valves AV-1 and AV-9 closed.

G.16.3. Open AV-8 and AV-3.

G.16.4. Open valve FCV and evacuate Fill Cap Assembly to <25 mtorr measured at AG-2B.

G.16.5. Close FCV.

G.16.6. Open SV-13.

G.16.7. Close RAV-2 as follows: (**Note:** relief of fill line is through Fill Cap Assembly)

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

G.16.8. Turn OFF RAV controller #2 as follows:

1. Turn controller #2 selection switch to OFF.
2. Power off controller #2.
3. Turn off RAV power supply.

G.16.9. Open FCV and evacuate the Dewar fill line to < 25 mtorr as measured at AG-2b.

G.16.10. Record pressure AG-2b _____ torr.

G.16.11. Close SV-13 and torque to 60 +/- 5 in-lbs.

G.16.12. Close FCV.

G.16.13. Close AV-8.

G.16.14. Open AV-1.

G.16.15. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1

and then close AV-9.

G.16.16. Close AV-1.

G.16.17. Monitor the pressure in the Fill Cap Assembly PFC for 15 minutes to be assured that no gas is leaking into the Fill Cap Assembly (i.e. it maintains vacuum) and record:

Time of day _____. PFCG pressure: _____ torr.

Time of day _____. PFCG pressure: _____ torr.

G.17. **Place Data Acquisition System in Standard Configuration**

Note: refer to DAS operating instructions for information on configurations and mechanics of keyboard/mouse operation.

G.17.1. Input comment to DAS "Completed External fill of Guard Tank".

G.17.2. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.17.3. Set DAS to normal scan using [other menus], [data config], [normal scan].

G.17.4. Set DAS data cycle interval to 15 minutes.

G.17.5. Set Guard Tank liquid level sampling interval to 10 minutes.

G.17.6. Ensure Main Tank liquid level sampling interval set to 10 minutes.

G.17.7. Ensure Well and Axial Lock liquid level sensors are turned off.

G.17.8. Ensure the Vac-ion pump is off.

G.17.9. Ensure all RAV operations recorded in log book.

G.17.10. 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.17.11. Ensure liquid level sensor alarms enabled on Main Tank, Guard Tank, and Well **(if liquid in Well)** and record set points if changed.

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

G.17.12. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential.

G.17.13. Ensure DAS watchdog timer and alarm enabled.

G.17.14. Ensure Facility Main Alarm System enabled.

G.18. **Verify Gas-Module Final Configuration**

G.18.1. Verify valve states are as indicated in following Table. Record configuration by checking appropriate box, then verify corresponding valve states.

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

- o Main Tank not pumped (SV-9 closed).
  8. Verify SV-9 closed.
  9. Verify EV-10, EV-17, and EV-13 open.
  10. Verify all other EV valves closed.
  11. Verify all AV valves closed.
  12. Verify open PV-2 and PV-4.
  13. Verify closed PV-1, PV-3, PV-5 and PV-6.

G.19. **Perform Final Closure of SV-13 and Condition Dewar Fill Cap Assembly**

Once SV-13 has warmed sufficiently to try final closure perform the following steps. **Note**: The time required to warm upsufficiently may be a few hours.

G.19.1. Verify that the Fill Cap Assembly is still evacuated and record:
Date:_____ Time of day _____

PFCG pressure:_____

G.19.2. Retorque SV-13 to 60 ± 5 in-lbs.

G.19.3. Open FCV.

G.19.4. Open/Verify open AV-3.

G.19.5. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.19.6. Close AV-8.

G.19.7. Ensure EV-12 closed.

G.19.8. Open AV-1.

G.19.9. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.19.10. Close FCV.

G.19.11. Close AV-1 and record:
Time of day:_____ / PFCG pressure:_____

G.19.12. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.19.13. Close AV-8.

G.19.14. Verify closure of SV-13 by observing the pressure in the Fill Cap Assembly (PFCG) until satisfied that no gas is leaking into the Dewar Fill line. Record:
Time of day _____, PFCG pressure _____ torr

G.19.15. After 30 minutes record:
Time of day _____, PFCG pressure _____ torr.

Note: If PFCG drops by more than 0.5 torr in 30 minutes, repeat steps G.18.2 through G.18.14.

G.19.16. Open AV-1.

G.19.17. Open AV-9 until pressure reaches 0 psig as read on gauge AG-1 and close AV-9.

G.19.18. Close AV-1.

G.19.19. Close AV-3.

G.19.20. Turn off pump AP-1

G.19.21. Remove pumping line from Fill Cap Assembly.

G.19.22. Install KF-25 blank-off cap on valve FCV.

G.20. **Establish Final Configuration**

G.20.1. (Option) Return Pumping of SMD to Gas Module Pump :

- Main Tank is to be pumped by AP-1, perform this section
- Main Tank to continue being pumped by Pump Module or is not vented (SV-9 closed), skip this section

1. Verify closed all AV valves.
2. Verify on/turn on AP-1.
3. Open AV-8.
4. When AG-2b < 50 mtorr, open AV-6.
5. Close EV-4.
6. Shut down pump module
   a. Close EV-21.
   b. Close PV-1.
   c. Power down PP-1 and PP-2.
   d. Close PV-3.

G.20.2. Record final liquid levels:

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

G.20.3. Record Main Tank pressure (EG-2): _____ torr.

G.20.4. Record Guard Tank pressure (GTV-G) _____ torr (relative to atm).

G.20.5. Turn off Guard Tank vent line heat exchanger (EH-2).

G.20.6. Verify final valve configuration:

1. Verify open EV-7a/b, EV-10, EV-13, EV-17.
2. Record position of EV-7a _____ % EV-7b _____ %.
3. Verify all other EV valves closed.
4. Verify AV-6 open.
5. Verify all other AV valves closed.
6. Verify open PV-2 and PV-4.
7. Verify closed PV-1, PV-3, PV-5 and PV-6.

H. PROCEDURE COMPLETION

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

Data Sheet

Date Time	LHSD Level (%)	LHSD press (psig)	MT pressure EG-2 (Torr)	GT pressure GTV-G (Torr)	LHe Flow PFM-1 (LL/hr)	GT Liquid Level (%)	Sta. 200 Temp CN [01] (K)	Pb bag-top temp CN [28] (K)	GT Temp CN [24] (K)	HX-4 Temp CN [08] (K)	GT Vent LineHex EH-2 (^{o}C)

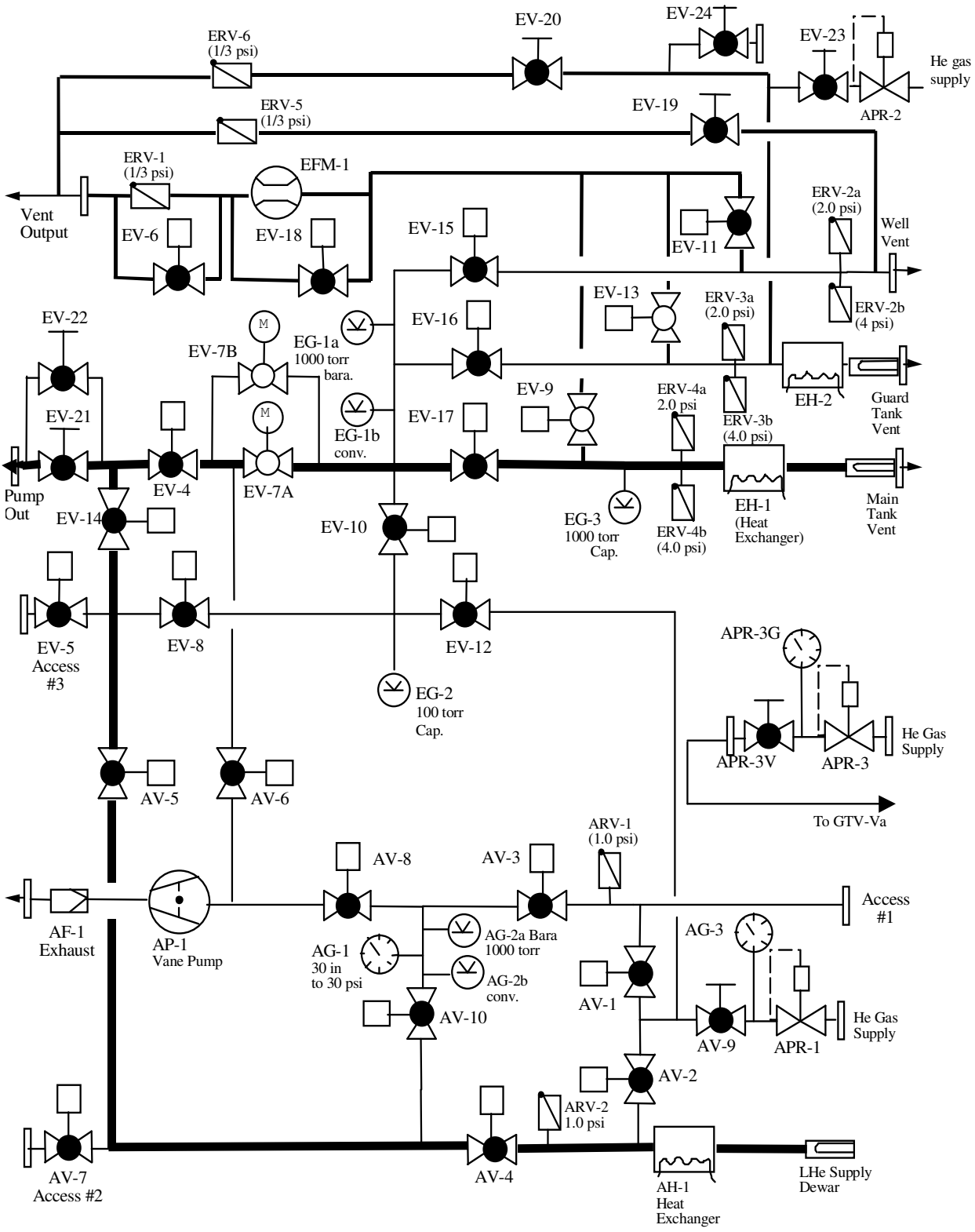

Figure 1. Schematic of Gas Module Plumbing.

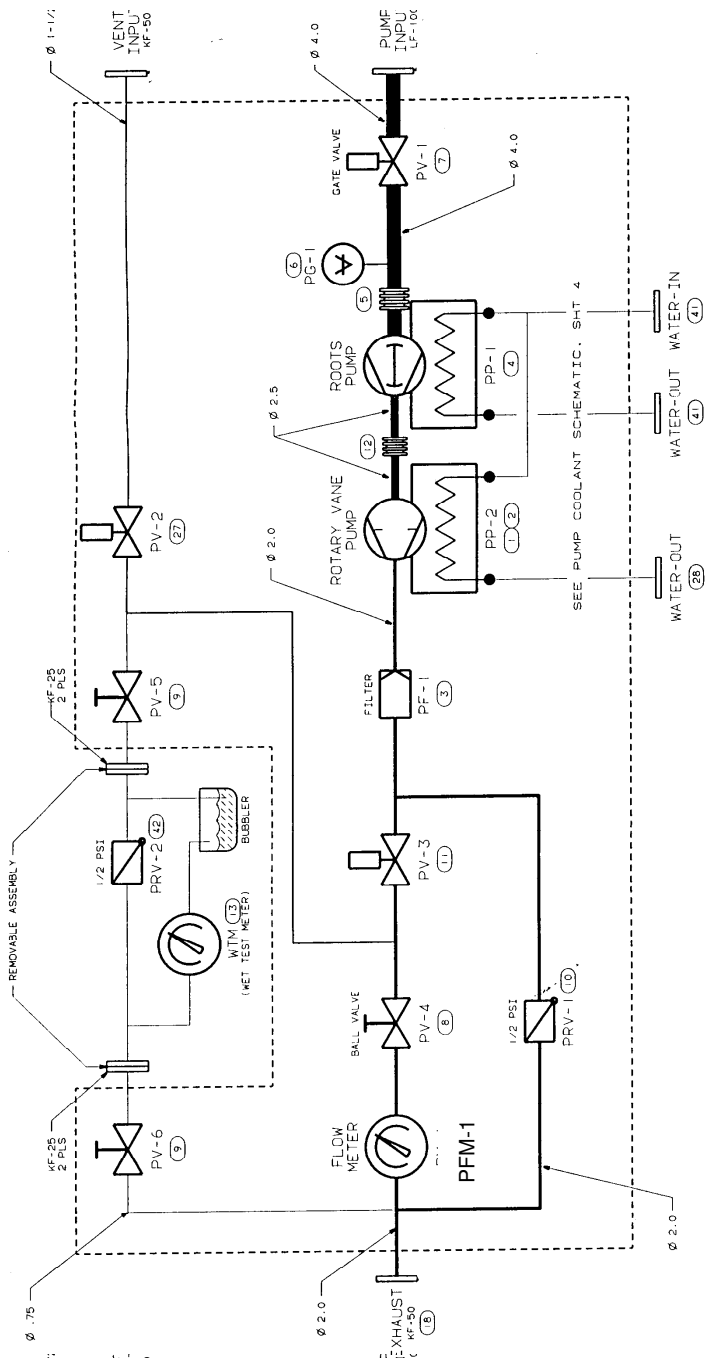

Figure 2. Schematic of Pump Module plumbing.

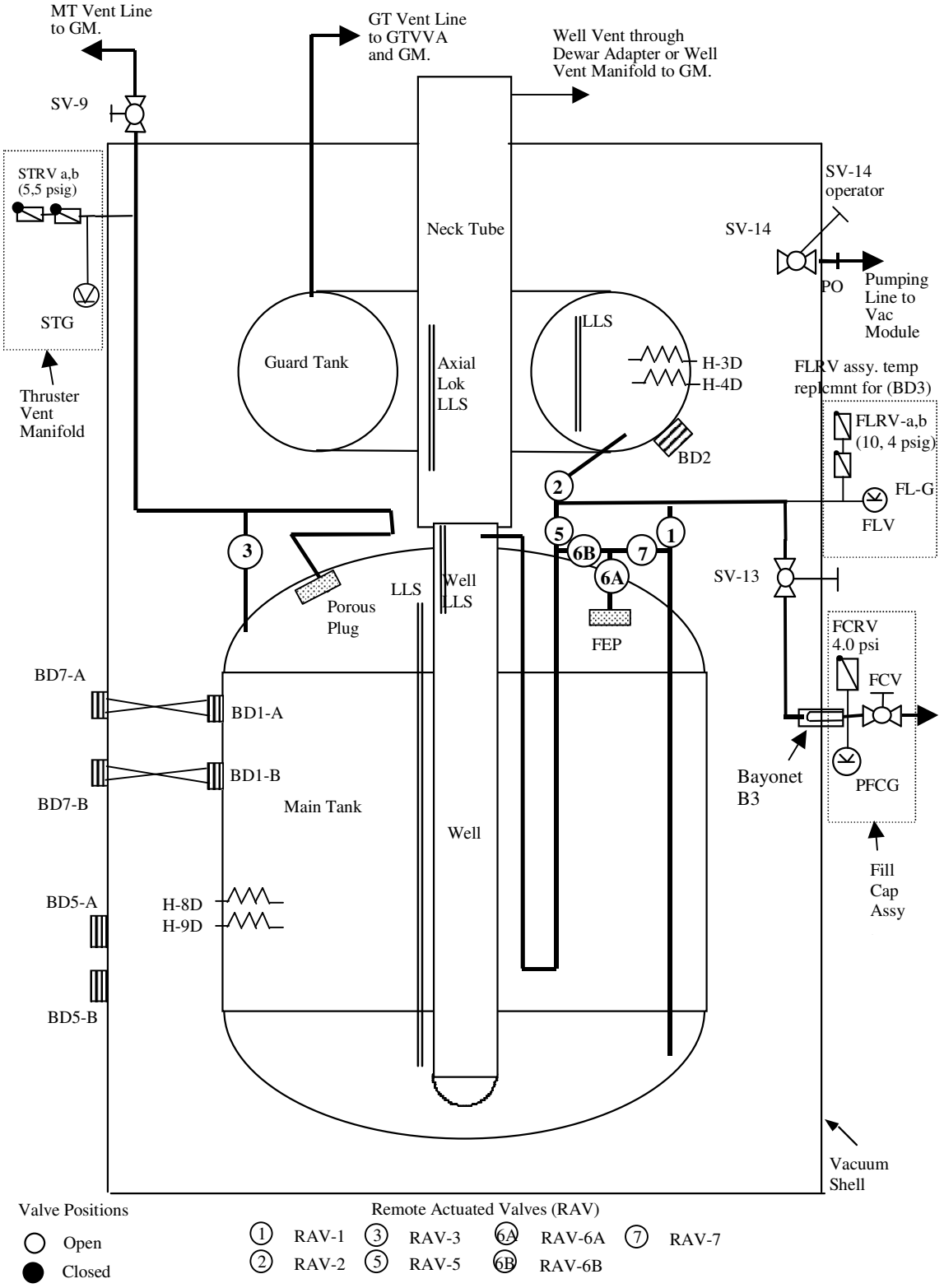

Figure 3. Schematic of Science Mission Dewar plumbing.

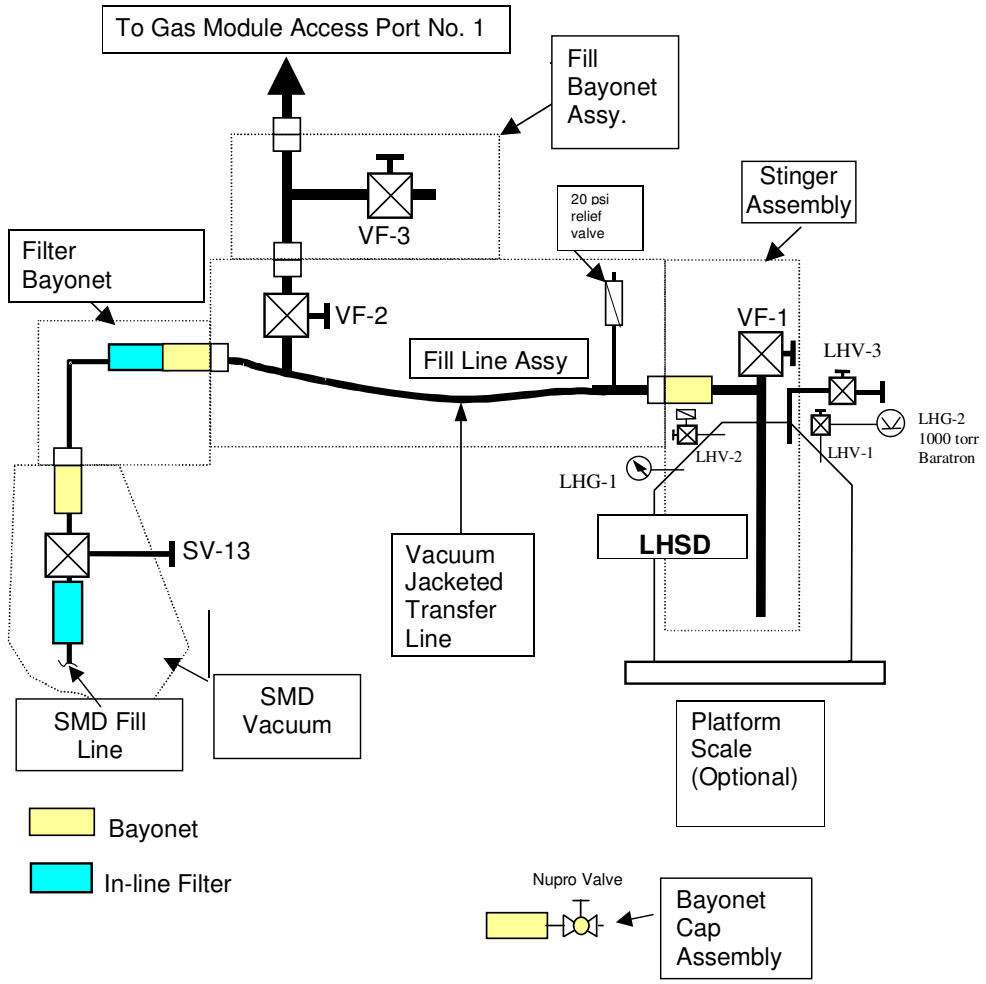

Figure 4 Schematic representation of LHSD and Transfer Line Plumbing