GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

MAIN TANK SUBATMOSPHERIC FILL FROM NBP SUPPLY DEWAR – GUARD TANK PRECOOL

To be performed at Vandenberg Air Force Base building 1610

WARNING: THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

P1036 Rev A

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ECO 1450

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REVISION CHANGES

REVISION	***ECO***	***Description***	***DATE***
A	1450	Incorporated minor redlines. Add requirement (in G.10) that spacecraft operations personnel be informed that RAV-2 closure is time-critical. Changed sequence of steps: sting LHSD before opening RAV-2. Added warning (in G.15) and contingency response (in Appendix 3) regarding failure to re-establish liquid flow in a timely fashion after depressurization of the LHSD.	9/15/03

Table of Contents

List of Abbreviations and Acronyms

AG-x	Gauge x of Gas Module auxiliary section	MTVC-G	Main Tank Vent Cap pressure gauge
AMI	American Magnetics Inc.	MTVC-RV	Main Tank Vent Cap relief valve
ATC	Advanced Technology Center	MTVC-V	Main Tank Vent Cap valve
Aux	Auxiliary	NBP	Normal boiling point
AV-x	Valve x of Gas Module auxiliary section	ONR	Office of Naval Research
Bot	Bottom	PCI	PDU Circuit Instrumentation (Console)
CN [xx]	Data acquisition channel number	PDU	Power Distribution Unit
DAS	Data Acquisition System	PFCG	Fill Cap assembly pressure Gauge
EFM	Exhaust gas Flow Meter	PFM	Pump equipment Flow Meter
EG-x	Gauge x of Gas Module exhaust section	PG-x	Gauge x of Pump equipment
EM	Electrical Module	PM	Pump Module
ERV-x	Relief valve of Gas Module exhaust section	psi	pounds per square inch
EV-x	Valve number x of Gas Module exhaust section	psig	pounds per square inch gauge
FCV	Fill Cap Valve	PV-x	Valve x of the Pump equipment
FIST	Full Integrated System Test	QA	Quality Assurance
GHe	Gaseous Helium	RAV-x	Remote Actuated Valve-x
GM	Gas Module	RGA	Residual Gas Analyzer
GP-B	Gravity Probe-B	SMD	Science Mission Dewar
GSE	Ground Support Equipment	STV	SMD Thruster vent Valve
GT	Guard Tank	SU	Stanford University
GTVC	Guard Tank Vent Cap	SV	Space Vehicle
GTVC-G	Guard Tank Vent Cap pressure gauge	SV-x	SMD Valve number x
GTVC-RV	Guard Tank Vent Cap relief valve	TD	Test Director
GTVC-V	Guard Tank Vent Cap valve	TG-x	Gauge x of Utility Turbo System
GTV-G	Guard Tank vent pressure gauge	TV-x	Valve x of Utility Turbo System
GTV-RV	Guard Tank vent relief valve	UTS	Utility Turbo System
GTV-V	Guard Tank vent valve	Vac	Vacuum
HX-x	Vent line heat exchanger in Gas Module	VCP-x	Vent cap pressure gauge
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)	VCRV-x	Vent cap relief valve

LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
Liq	Liquid
LL	Liquid level
LLS	Liquid level sensor
LMMS	Lockheed Martin Missiles and Space
LMSC	Lockheed Missiles and Space Co.
MT	Main Tank
MTVC	Main Tank Vent Cap
VCV-x	Vent cap valve
VDC	Volts Direct Current
VF-x	Liquid helium Fill line valve
VG-x	Gauge x of Vacuum Module
VM	Vacuum Module
VV-x	Valve x of Vacuum Module
VW-x	Valve x of Dewar Adapter

LIST OF SPECIFIC HEADING DEFINITIONS

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

Note:
Used to indicate an operating procedure of such importance that it must be emphasized.

CAUTION:
Used to identify hazards to equipment.

WARNING:
Used to identify hazards to personnel.

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A. SCOPE

This procedure describes the steps necessary to perform an external fill of the SMD Main Tank, while it is subatmospheric, using NBP 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:

Pre-cool SMD internal fill line from Guard Tank

Pre-cool external transfer line from storage dewar

Fill Guard Tank

Fill Main Tank

Terminate transfer.

Note that when the Main Tank is subatmospheric, the Guard Tank liquid level must be maintained at a value greater than 15%. This guarantees that it contains enough liquid to precool the internal transfer line, a necessary step for Main Tank fill operations. This procedure is classified as hazardous because it involves the use of liquid helium, which is a cryogenic asphyxiant (see Sec. B.1, below).

B. SAFETY

B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware.

Liquid helium used in the SMD represents a hazardous material for the personnel involved in the operations. Cryogenic burns can be caused by contact with the cold liquid or gas, high pressures can result if boiling liquid or cold gas is confined without a vent path, and asphyxiation can result if the vent gas is allowed to accumulate.

The SMD Safety Compliance Assessment, document GPB-100153C and the Missile System Prelaunch Safety Package, LM/P479945 discuss the safety design, operating requirements and the hazard analysis of the SMD.

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

A rupture of the main tank burst disk(s) will be obvious due to the plume of cold gas. Emergency vent lines are installed over the burst disks on the SMD vacuum shell to eliminate the possibility of direct plume impingement on personnel. Orderly evacuation shall be performed in the event one or more of these burst disks rupture. An oxygen deficiency monitor (provided by GP-B) that alarms when the oxygen level is reduced to 19.5% will be utilized as an added precaution. Temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions.

Only authorized and trained personnel are allowed in VAFB facilities without escort. All personnel working on platforms at a height 30 inches or more off the floor are required to have an approved air tank (emergency breathing apparatus) within easy reach. Note that tank need not be kept available when working from a ladder. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the room and contact NASA and VAFB safety. The following additional requirements apply to all personnel involved directly in cryogenic operations: Insulated gloves when handling equipment that has been cooled to cryogenic temperatures. A protective apron, gloves impervious to liquid cryogens, impermeable shoes, and full-face shields with goggles/glasses are to be worn whenever the possibility of splashing or impingement of high velocity cryogens exists.

B.2.3. Other Hazards

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

B.3. **Mishap Notification**

B.3.1. Injury

In case of any injury or illness requiring emergence medical treatment **DAIL 911.**

B.3.2. Hardware Mishap

In case of an accident, incident, or mishap, notification is to proceed per the procedures outlined in Lockheed Martin Engineering Memorandum EM SYS229 and Stanford University GP-B P0879. Additionally, VAFB NASA Safety and 30th Space Wing Safety will be notified as required.

B.3.3. Contingency Response

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

C. **QUALITY ASSURANCE**

C.1. **QA Notification**

The NASA program and NASA safety 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 TD or QA Representative, mission

functionality may be affected. Within hazardous portions of this procedure, all steps shall be worked in sequence. Out-of-sequence work or redlines shall be approved by NASA Safety prior to their performance

C.3. **Discrepancies**

A Quality Assurance Representative designated by D. Ross shall review any discrepancy noted during this procedure, and approve its disposition. Discrepancies will be recorded in a D-log or a DR per Quality Plan P0108. Any time a procedure calls for verification of a specific configuration and that configuration is not the current configuration, it represents a discrepancy of one of three types. These types are to be dealt with as described below.

1. If the discrepancy has minimal effect on procedure functionality (such as the state of a valve that is irrelevant to performance of the procedure) it shall be documented in the procedure, together with the resolution. Redlines to procedures are included in this category.
2. If the discrepancy is minor and affects procedure functionality but not flight hardware fit or function, it shall be recorded in the D-log. Resolution shall be in consultation with the TD 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. However, during the startup of the transfer (Sec. G.14), there are to be a minimum of two qualified persons (Sec. D.3) in attendance. The person performing the operations (Test Director or Test Engineer) is to sign the “Completed by” sign-off. Any other qualified person or QA person who can attest to the successful performance of this procedure may sign the “Witnessed by” sign-off. The Test Director will perform pre-test and Post-Test briefings in accordance with P0875 “GP-B Maintenance and Testing at all Facilities”. Checklists will be used as directed by P0875.

D.2. **Personnel Qualifications**

The Test Director must have a detailed understanding of all procedures and facility operations and experience in all of the SMD operations. Test Engineers must have SMD Cryogenic operations experience and an understanding of the operations and procedures used for the cryogenic servicing/maintenance of the Dewar.

D.3. **Required Personnel**

The following personnel are essential to the accomplishment of this procedure:

FUNCTIONAL TITLE	NUMBER	AFFILIATION
Test Director/Test Engineer	1	Stanford
GP-B Quality Assurance	1	Stanford
NASA Safety Rep	1	SFAO or ANALEX

E. **REQUIREMENTS**

E.1. **Electrostatic Discharge Requirements**

Any person who comes in contact with the SV must use a grounding wrist strap that has been tested using a calibrated wrist strap checker. Appropriate attachment points are positioned around the SV.

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), the Vacuum Module (Figure 3), 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. Spacecraft Support:

With connector J802 connected to flight electronics, operation of RAV-2 must be commanded through the spacecraft instead of the RAV controller in the Electrical Module.

E.3.5. Additional Test Equipment

Description	***Manufacturer***	***Model***
O_2 Monitor and Alarm	Alpha-Omega Instruments	1000

E.3.6. 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
6	Bayonet Cap with Nupro Valve	LMMS	N/A
7	500/1000 Liter Dewars, Liquid Helium	Cryofab	CMSH-500/1000

E.3.7. Personnel Protective Equipment

1. Cryogenic safety gloves and apron
2. Face shield
3. Goggles/glasses
4. Non-absorbent shoes

E.3.8. Tools

Description
Torque Wrench, 1-1/4-in socket, 60 +/- 5 in-lb Cal Due Date: _____S/N: _____

E.3.9. Expendables

WARNING

Alcohol is a skin irritant, potentially toxic if skin absorbed, and flammable. All hazardous waste will be placed into approved waste containers.

Description	***Quantity***	***Mfr./Part No.***
Ethyl or isopropyl Alcohol	AR	N/A
99.999% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Dow Corning High Vacuum or Apiezon N
Liquid Helium	AR	N/A
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	-
12	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Guard Tank	96-409-10	No	-
13	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Well	96-409-9	No	-
14	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Axial Lock	96-409-12	No	-
15	EM	Pressure Controller – MKS 152F-92	EV-7a, -7b	96203410A	No	-
16	EM	Power Supply HP 6038A	H08D Tank Heater	96023407A	Yes	
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	
19	EM	Vac Ion Pump power supply Varian 929-0910, Minivac	SIP	5004N	No	-
20	EM	Flow meter totalizer Veeder-Root	PFM-1	576013-716	No	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
21	GM	Pressure Gauge, Heise	AG-1	CC-122077	No	-
22	GM	Pressure Gauge, Marshall Town	AG-3	N/A	No	-
23	GM	Main Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	-	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	-	C-09920	No	-
25	VM	Vacuum Gauge readout, Granville-Phillips 316	VG-3 VG-4	2878	No	-
26	VM	Vacuum Gauge readout, Granville-Phillips 360	VG-1, VG-2 VG-5	96021521	No	-

E.5. **Configuration Requirements**

E.5.1. Main Tank

The Main Tank liquid is subatmospheric. The actuator control valve for EV-9 switches the state that EV-9 defaults to, should a power failure occur. It should be placed in the “Subatm He.” position, for this procedure, ensuring that EV-9 remains closed in the event of power failure.

E.5.2. Guard Tank

The Guard Tank must contain liquid, and the level must be ≥ 15% to adequately precool the internal fill line at the startup of an external fill operation. If the level is less than 15%, the Main Tank must be brought to NBP conditions and an internal transfer to the Guard Tank performed. Document No. P1029, *Internal Main Tank to Guard Tank Transfer*, contains the procedure for raising the Guard Tank level, if this should be necessary.

E.5.3. Well

The Well must be evacuated

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 5×10^{-5} torr. Document No. P1015, *Connect Vacuum Module to SMD*, contains the procedure for connecting to and pumping on the SMD vacuum shell.

E.5.5. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
   a. Top of lead bag temperature set (CN 40) at $T \leq 6.0$ K.
   b. Top of lead bag temperature set (CN 41) at $T \leq 6.0$ K.
   c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 0.3$ torr.

2. The DAS watchdog timer and alarm are enabled.

E.5.6. GSE and Non-flight Hardware

1. The ion-pump magnet is installed.
2. GSE cabling must be connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811).
3. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line. Documents No. P1006, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP,* and P1004, *Connect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric*, contain 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. P1006, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP,* contains the procedure for connecting the Main Tank vent line.
5. The Fill Cap Assembly must be installed at SV-13 (See Figure 4)
6. The External Temperature Control Unit must be connected 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 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.

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

F.3. Additional Procedures

Document No.	***Title***
SU/GP-B P1004	Connect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric
SU/GP-B P1006	Connect Main Tank Vent Line to Gas Module – Main Tank at NBP
SU/GP-B P1008	Connect Guard Tank Vent Line to Gas Module
SU/GP-B P1015	Connect Vacuum Module / Pump on SMD Vacuum Shell
SU/GP-B P1016	Stop Pumping on SMD Vacuum Shell / Disconnect Vacuum Module
SU/GP-B P1029	Internal Guard Tank Fill – Guard Tank Vent Line Connected
SU/GP-B P0216	*Pressurize Main Tank from Subatmospheric to NBP*

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

G. OPERATIONS

G.1. Pre-Operations Verifications

- Verify SU QA notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Verify NASA representative notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Verify NASA Safety representative has been notified and has given concurrence to proceed.

  Record: Individual notified _____,

  Date/time _____/_____.

- Record calibration information in Table 1 (Sec. E.4) and Sec. E.3.8.
- Verify that the persons performing this procedure, the test director, and safety engineer are identified in Sec. D.3.
- Verify performance of pre-operations checklist (Appendix 1).
- Verify availability of equipment, hardware, tools, and expendables listed in sections E.3.5 through E.3.9.
- Verify proper operation of the GP-B Cryogenic Group oxygen monitor
- Verify that the Spacecraft is powered up, arming plug P222 is installed, and control personnel are prepared to command RAV-2 when requested.
- Verify emergency vent lines are connected to the burst disks and vented to the outside.
- Verify availability and functioning of the emergency shower.
- If appropriate, verify that the master procedure calling this procedure is current. Enter calling procedure number: _____, and Op. order no.: _____

Section complete _____ QA.

G.2. **Verify Purity of All Sources of Helium Gas**

Record serial number on helium bottle/s.

1. _____ 2._____ 3. _____
4. _____ 5 _____ 6. _____

Verify helium bottle/s have been tested for purity and record Op. Number.
Op. Number:_____

Section complete _____ QA.

G.3. **Verify Configuration Requirements**

G.3.1. Verify dewar is in the proper orientation (+z up).

G.3.2. Verify that the External Temperature Controller Unit is connected and operational.

G.3.3. Verify Fill Cap Assembly installed at SV-13.

G.3.4. Verify ion pump magnet installed and readout is connected.

G.3.5. Verify Main Tank vent line connected to Gas Module. If not, perform procedure P1004, *Connect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric,* to connect Main Tank vent.

G.3.6. Verify Guard Tank vent line connected to Gas Module. If not, perform procedure P1008, Connect Guard Tank Vent Line to Gas Module, to connect Guard Tank vent.

G.3.7. Verify that the helium and pump exhaust vents are ducted outside.

G.3.8. Verify Main Tank is subatmospheric, as indicated by Main Tank temperature (< 4.2 K) and pressure (< 760 torr).

1. Record Main Tank bottom temperature CN [09]. _____ K.
2. Record Main Tank pressure (EG-2 / EG-3) _____ torr.

G.3.9. Record initial liquid helium levels.

1. ***Main Tank*** _____%
2. ***Guard Tank*** – Verify level ≥ 15% to precool internal transfer line. If necessary, warm Main Tank to NBP using procedure P1043 and perform procedure P1029, *Internal Guard Tank Fill – Guard Tank Vent Line Connected*, to raise level. _____%

G.3.10. 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 ≥ 20%. Record set point. _____ %

G.3.11. Verify DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – verify CN 40] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. _____K
2. ***Top of lead bag temperature*** – verify CN [41] 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. _____tor r

G.3.12. Verify DAS watchdog timer and alarm enabled.

G.3.13. Verify DAS configuration is set to 4ae.

G.3.14. Verify Vacuum Shell Pressure < 5 x 10^{-5} torr.

1. Turn on Vac-ion pump and record time of day _____
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr. If pressure is above 5x10^{-5} torr, turn off Vac-ion pump and perform procedure P1015, Connection of High Vacuum Pumping Module, to connect Vacuum Module and pump out SMD vacuum shell. Record Op. No._____.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
5. When data cycle is complete, turn off Vac-ion pump.

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

Section complete _____ QA.

G.4. **Verify SMD in Standard Configuration**

G.4.1. Using the RAV logbook 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 that SMD external valves are in the following positions.

1. ***Open***: SV-9.
2. ***Closed***: SV-12, SV-13 and FCV.

G.5. **Establish Initial Condition of GSE**

G.5.1. Verify actuator control valve for EV-9 is turned to "Subatm He" position ensuring that EV-9 will close in the event of a power failure.

G.5.2. 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 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 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.

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

G.5.3. Record pressures:

1. Guard Tank (GTV-G, CN [46]) _____ torr gauge
2. Main Tank (EG-2) _____ torr

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

G.5.4. Record Fill Cap Assembly pressure and verify that it reads > 0.0 psig.

Fill Cap Assy (PFCG): _____ psig/torr

G.5.5. Record EV-7a valve position:_____ %

G.5.6. Record EV-7b valve position:_____ %

G.5.7. Turn on Main and Guard Tank Heat Exchangers EH-1/2.

Sections G.4, 5 complete _____ QA.

G.6. Transfer Pumping of Main Tank to Pump Module

Comment: This operation is to be performed if Main Tank is being pumped by Gas Module pump AP-1 and Pump Module is turned off.

- Main Tank is pumped by AP-1, perform this section
- Main Tank is pumped by Pump Module, 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. Start 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. Turn on roots pump PP-1 and verify PG-1 drops to < 15 mtorr.

   Record PG-1 _____ mtorr

G.6.4. Transfer pumping of Main Tank to Pump Module

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

G.6.5. Verify current valve configuration

Open	EV-4, EV-10, EV-17, EV-13, EV-21/22, EV-7b(partial) PV-1, PV-2, PV-4,
Closed	All other EV, PV valves All AV valves

Section complete _____ QA.

G.7. **Set Up Data Acquisition**

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

G.7.1. Set DAS to configuration choice 4ae.

G.7.2. Start “Special Data Cycle” by using [Other Menus] + [Special Data Col]. Set up the special data collection to include channel numbers 9, 40, 42, 24, 46

G.7.3. Adjust roll over of Special Data Cycle to 1 minute.

G.7.4. Set the Main Tank Liquid Level Sensors (LL-1D or LL-2D) and the Guard Tank Liquid Level Sensors (LL-5D or LL-6D) to 1 minute sampling interval.

Section complete _____ QA.

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

WARNING:
A hazardous operation is about to begin. In the following steps cold helium gas will be expelled from the stinger and transfer lines. The operator performing the operation must wear a face shield with goggles/glasses, apron, non-absorbent shoes, and cryogenic gloves. Failure to comply may result in personal injury.

Note:
Use appropriate extension for the LHSD being used and clean all O-rings and mating surfaces. See Fig. 5 for transfer plumbing configuration.

G.8.1. Turn on the amber warning light and make a PA announcement stating, "Attention all personnel, the GP-B program is now performing a hazardous cryogenic operation". Verify that the area is clear of nonessential personnel.

G.8.2. Establish a controlled area of 15 feet.

G.8.3. Reduce the pressure in the liquid helium supply to < 1.0 psig by opening the LHSD vent valve LHV-1.

G.8.4. Open valve VF-1 (Liquid withdrawal valve) on the stinger

G.8.5. Slowly insert the stinger into the LHSD while allowing it to be purged.

G.8.6. Close valve VF-1 just as cold gas is expelled from stinger.

G.8.7. Close the primary (low-pressure) relief valve on the LHSD (LHV-2).

G.8.8. Increase LHSD ullage pressure to 8 to 10 psig by attaching an external source of GHe to ullage inlet (LHV-1, labeled VENT on LHSD) per the following:

1. Attach a GHe hose to the VENT outlet of the LHSD while purging the hose and the VENT outlet.
2. Adjust pressure regulator to obtain 8 to 10 psig LHSD driving pressure.

G.8.9. Record LHSD data:

1. Date / time_____
2. Liquid level _____ %
3. LHSD serial number _____

G.8.10. Request PA announcement that the hazardous operation is now complete.

G.8.11. Ensure area operation light is returned to green.

G.8.12. Disband controlled area.

NOTE
The hazardous operation is now complete.

Section complete _____ QA.

G.9. **Check Initial Pressure in Fill Line:**

G.9.1. Install a pumping line between valve FCV on the Fill Cap Assembly and the Access Port # 1 of the Gas Module.

G.9.2. Verify valve FCV is closed.

G.9.3. Turn on/verify on AP-1.

G.9.4. Open AV-8.

G.9.5. Open AV-3.

G.9.6. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.9.7. Close AV-8 and FCV.

G.9.8. Once the pressure in the Fill Cap Assy. as measured at PFCG has stabilized, record:

Pumping line pressure (PFCG): _____ torr.

G.9.9. Open valve SV-13 and bring the Fill Cap Assembly up to the pressure in the SMD Fill line and record:

(PFCG): _____ torr.

Section complete _____ QA.

G.10. **Raise pressure in Fill Line:**

G.10.1. Record the pressure in Guard Tank at GTV-G (CN [46]) _____torr (relative to atm.).

G.10.2. Confirm that spacecraft operations personnel are ready to operate RAV–2, and inform them that RAV-2 closure is time-critical.

G.10.3. Open RAV-2 as follows:

1. Request spacecraft operations personnel to open RAV-2 and record time of day: _____.
2. Have spacecraft operations personnel confirm valve has opened.
3. When convenient, record operation in RAV log book.

G.10.4. Verify that the Fill Cap Assembly pressure rises to the Dewar Guard Tank pressure.

Record Fill line pressure (PFCG): _____ torr.

G.10.5. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

G.10.6. Verify closure of SV-13.

1. Open AV-8.
2. Open FCV and evacuate to < 25 mtorr as measured at AG-2b: now pumping with AP-1 up to SV-13.
3. Close FCV.
4. Close AV-8.
5. Open AV-1.
6. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then close AV-9.
7. Close AV-1.
8. Record:
   a. PFCG pressure:_____ torr
   b. Time of day:_____
9. Verify closure of SV-13 by observing the pressure in the Fill Cap Assembly PFCG until satisfied that no gas is leaking into the Dewar Fill line. After 10 minutes record:
   a. PFCG pressure:_____ torr
   b. Time of day:_____
10. Open AV-1
11. Open FCV.
12. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then close AV-9.
13. Close AV-1.
14. Remove the pumping line from the fill cap assembly.

G.10.7. Verify current valve configuration

Open	EV-4, EV-10, EV-17, EV-21/22, EV-7a/b, AV-3 PV-1, PV-2, PV-3, and PV-4,
Closed	All other EV, PV valves All AV valves SV-13

Section complete _____ QA.

G.11. **Install Fill Line Assembly**

G.11.1. Remove the Fill Cap 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.11.2. Install Filter Line Assembly (P/N 5833827) to Dewar Fill Bayonet B3 if used.

G.11.3. Install Fill Line Assembly as follows:

CAUTION
Be sure to provide adequate Fill Line support to avoid damaging Filter and Stinger. Failure to comply may result in equipment damage.

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.
3. Ensure VF-2 and relief valve stems pointed upwards.
4. Close/verify closed VF-3.
5. Connect a low-impedance facility vent line to the KF fitting at VF-3.

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

G.12.1. Configure Pumping Line:

1. Mate a 1-1/2-in flexible pumping line to Access #1 port of the Gas Module.
2. Mate other end to outlet of VF-2.

G.12.2. Evacuate Transfer Line:

1. Open valve VF-2.
2. Open/verify open AV-3.
3. Open AV-8.
4. 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) and leak-back test of Transfer 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 25 mtorr per minute in a two minute period while recording:

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

Pass/Fail _____ mtorr/min _____

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.
4. Close AV-3.
5. Close valve VF-2.

Section complete _____ QA.

G.13. **Precool Internal Fill Line From Guard Tank:**

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

G.13.1. E
nsure plastic sheeting placed appropriately on the Guard Tank vent to

ensure no condensation falls onto the Space Vehicle

G.13.2. Record the following instrumentation and time of day:

1. Time of day:_____.
2. Main Tank LLS_____ %
3. Guard Tank LLS_____ %
4. Main Tank vent pressure, (EG-2)_____ torr.
5. Main Tank temperature (CN [09])_____.K
6. Guard Tank temperature (CN [24]) _____ K.

G.13.3. Set up EV-7 control valves

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

G.13.4. Close Guard Tank atmospheric vent path EV-13.

G.13.5. Record time/date _____/_____.

G.13.6. Input comment to DAS “Start MT subatmospheric Fill with NBP LHSD.

G.13.7. Verify closed VF-3.

G.13.8. Open SV-13.

G.13.9. Open VF-2.

G.13.10. Record relative Guard Tank pressure (GTV-G, CN [46]) _____torr.

G.13.11. Turn on Guard Tank Heater (H-3D or H-4D)

1. Set power supply current limit to 0.07 amps.
2. Set heater to 50 VDC and record:

V: _____ vdc and I: _____ a

G.13.12. Open VF-3.

Section complete _____ QA.

G.14. **Start Transfer**

G.14.1. When air condensation is evident at VF-3 and when Fill Valve (SV-13) temperature T-24D, CN [42], is < 75K, proceed with the following:

G.14.2. Power off Guard Tank heater.Close SV-13.

G.14.3. Immediately open VF-1.

Note:
During the startup of the transfer, have one person watching the Special Data Cycle output and prepare to call for shutting of SV-13 if temperatures or pressures indicate excessive heating or pressure surges.

G.14.4. When heavy air condensation is evident at VF-3, close VF-2 and immediately open SV-13.

G.14.5. Open EV-13.

G.14.6. Open EV-6 and EV-18.

G.14.7. Close VF-3 when it is warm enough.

G.14.8. Verify AV-1 closed.

G.14.9. Verify current valve configuration

Open	EV-4, EV-6, EV-10, EV-17, EV-18, EV-13, EV-21/22, EV-7b(partial) VF-1VF-3 (until warm) SV-13 PV-1, PV-2, PV-3, PV-4,
Closed	All other EV, PV, and VF valves. All AV valves

G.14.10. Verify Start of Guard Tank Transfer

1. Verify flow through PFM-1 (scale B) of ~100 liquid liters/hour.

Note:
Except during the startup transient, do not exceed 100 LL/hr transfer rate as read on PFM-1 (Scale B) to avoid exceeding the capacity of the heat exchanger (EH-2) in the Gas Module.

a. Record PFM1 (Scale B) reading _____

b. Record Start Time _____

G.14.11. Record LHe level of LHSD:_____ %

G.14.12. Input comment to DAS “Start External Fill of GT”.

G.14.13. Record all fill data on the attached data sheets every 15 minutes.

G.14.14. Adjust LHSD pressure as required:

1. Close pressurization valve at the LHSD and adjust the gas supply pressure regulator to the desired pressure not to exceed 10 psig.
2. Reopen pressurization valve at the LHSD.

G.14.15. Prepare for RAV-1 operation (next section) by performing the following:

1. Ensure all RAV controller selection switches in OFF position.
2. Turn on RAV power supply and adjust current limit to 1.85 A.
3. Adjust power supply to 28 VDC.
4. Power up controller #1.
5. Position controller #1 selection switch to RAV-1.
6. Record RAV status lights (4): Open: θ θ Closed: θ θ

G.14.16. Confirm that operations personnel are ready to operate RAV-2.

G.14.17. When Guard Tank is at desired level, record Guard Tank level:

Guard Tank Level (LL-5D or LL-6D): _____ %

G.14.18. Proceed to the next section immediately.

Section complete _____ QA.

G.15. **Switch from Guard Tank to Main Tank Fill:**

CAUTION
After the LHSD is depressurized, the fill plumbing will start to warm. If flow is not re-established (by closing RAV-2 and opening RAV-1) within 4 minutes, close SV-13 and follow the appropriate Contingency Response in Appendix 3. Failure to comply may result in equipment damage.

G.15.1. Close LHV-1 to shut off LHSD pressurization.

G.15.2. Quickly reduce ullage pressure in LHSD to atmospheric pressure via LHV-2. Leave LHV-2 (normal pressure relief) open.
Record time: _____

G.15.3. C
lose RAV-2 (GT fill valve) by performing the following operations:

1. Request spacecraft operations personnel to close RAV-2 and record time of day: _____.
2. When convenient, record operation in RAV logbook.

G.15.4. Input comment in DAS “Switch from GT to MT”.

CAUTION
Watch temperatures of lead bag, CN [40] and CN [41], carefully. Keep temperatures < 6K. Be prepared to close SV-13 immediately if temperatures approach 6 K. Failure to comply may result in equipment damage.

G.15.5. Immediately open RAV-1 by performing the following operations:

1. Verify that controller No. 1 is already powered up and that RAV selection switch is already set to RAV-1.
2. Activate controller No. 1 to open RAV-1 and record:
   a. run time: _____ seconds
   b. current draw: _____ amp
   c. time of day: _____
3. Record final switch status: Open: θ θ Closed: θ θ
4. When convenient, record operation in RAV log book.

G.15.6. Open EV-7a fully.

G.15.7. Close EV-6 and EV-18 (GT is now protected from backflow).

G.15.8. Verify current valve configuration

Open	EV-4, EV-10, EV-17, EV-13, EV-21/22, EV-7a/b(fully) VF-1 SV-13 PV-1, PV-2, PV-3, PV-4,
Closed	All other EV, AV, and PV valves.

G.15.9. Verify Start of Transfer:

1. Verify flow through PFM-1 (scale B)
   Record PFM-1:_____ LL/hr. Time of day: _____

Note:
Do not exceed 100 LL/hr transfer rate as read on PFM-1 (scale B) as this exceeds the capacity of the heat exchanger in the gas module. The flow rate is nominally controlled by maintaining the ullage pressure (LHG-1) between 8” and 12” Hg.

G.15.10. Maintain LHSD Pressure

During Main Tank fill, keep careful track of LHSD ullage pressure LHG-1

1. Allow it to drop subatmospheric.
2. Keep it between 12” to 8” Hg vac. using LHSD pressurization heater or the Ghe supply through LHV-1 as required

G.15.11. Record all fill data on the attached data sheets every 15 minutes.

CAUTION
The Guard Tank may tend to subcool during this procedure. Maintain continuous monitoring of the Guard Tank pressure throughout the remainder of this procedure. Use the Guard Tank heater (H-3D) to counteract this tendency. Failure to comply may result in equipment damage.

G.15.12. Monitor pressure in Guard Tank and maintain Guard Tank heater power to keep GTV-G > +5 torr relative to atmospheric pressure.

G.15.13. When the LHSD is near depletion or the Main Tank is full, proceed to next section.

Section complete _____ QA.

G.16. **Terminate Transfer**

G.16.1. Close VF-1.

G.16.2. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

G.16.3. Open VF-2.

G.16.4. Open VF-3.

G.16.5. Record the following:

1. Date/time of day:_____ .
2. Main Tank level: _____%.
3. Flowrate PFM-1 (B): _____ Ll/hr.
4. Main Tank Temp (T-9D): _____ K.
5. Guard Tank Temp (T-15D) _____ K.
6. Main Tank exit pressure (EG-2): _____ torr.
7. Vacuum Module pressure (VG-1): _____ torr.

G.16.6. 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.

Section complete _____ QA.

G.17. **Configure GSE**

G.17.1. Record:

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

G.17.2. Verify open EV-4, EV-7a/b, EV-10, EV-13, EV-17, and EV-21/22.

G.17.3. Verify all other EV valves are closed.

G.17.4. Verify all AV valves closed.

G.18. **Verify Closure of SV-13**

G.18.1. Close/verify closed all AV valves.

G.18.2. Verify open VF-2.

G.18.3. Close VF-3.

G.18.4. Open AV-8 and AV-3.

G.18.5. When AG-2b is < 50 mtorr close AV-8.

G.18.6. Open AV-1.

G.18.7. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then close AV-9.

G.18.8. Perform leak-back test of SV-13.

1. Verify that pressure AG-2a does not fall by more than 1.0 torr per minute while recording pressures for 4 minutes:

Date/Time of Day: _____/_____

Time (min)	_____	_____	_____	_____	_____
P(AG-2a) (torr)	_____	_____	_____	_____	_____

Pass/Fail _____ torr/min _____

Comment: Pressure should rise due to warm-up of the transfer line.

G.18.9. 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-2b.
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:
   a. Retorque SV-13 to 60 +/- 5 in-lbs.
   b. Open AV-8.

c. Close AV-8 when pressure reaches less than 10 mtorr as read on gauge AG-2b.

d. Verify that pressure AG-2b does not rise by more than 50 mtorr in four minutes while recording:

Date/Time of Day: _____/_____

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

Pass/Fail _____ mtorr incr. _____

4. When satisfied that SV-13 is leak tight, open AV-1.
5. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then close AV-9.
6. Close AV-1.

Sections complete _____ QA.

G.19. **Remove Transfer Line and Filter Assembly**

G.19.1. Ensure AG-2 > 760 torr.

G.19.2. Close VF-2 and disconnect pumping and vent lines at VF-3.

G.19.3. Remove the Transfer/ Filter Lines from the Dewar fill bayonet B3.

G.19.4. Immediately install the Fill Cap Assembly at the Dewar fill bayonet B3.

G.19.5. Connect a pumping line between the Fill Cap Assembly at valve FCV and the Auxiliary Gas Section access port no. 1.

G.19.6. Open/verify open AV-3.

G.19.7. Close/verify closed all other AV valves.

G.19.8. Open AV-8.

G.19.9. Open/verify open valve FCV

G.19.10. Evacuate Fill Cap Assembly to <25 mtorr as measured at AG-2B.

G.19.11. Close FCV.

G.20. **Evacuate Internal Fill Line**

G.20.1. Record PFCG _____ torr.

G.20.2. Open SV-13.

G.20.3. Record PFCG _____ torr.

G.20.4. 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
   a. Verify 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. Record operation in RAV log book.

G.20.5. Deactivating RAV system:

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

G.20.6. Open FCV and evacuate the Dewar fill line to < 25 mtorr as measured at AG-2b.

G.20.7. Input comment to DAS “RAV-1 closed and Fill Line pumped”.

G.20.8. Close SV-13 and torque to 60 +/- 5 in-lbs.

G.20.9. Close FCV.

G.20.10. Close AV-8.

G.20.11. Open AV-1.

G.20.12. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.20.13. Close AV-1.

G.20.14. 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:

Date/Time: _____ PFCG pressure: _____

Date/Time: _____ PFCG pressure: _____

G.20.15. When Main Tank heat exchanger (EH-1) power demand is lower than 0.3 amps turn off heat exchanger and record time: _____

G.20.16. When Guard Tank heat exchanger (EH-2) power demand is lower than 0.3 amps turn off heat exchanger and record time: _____.

Sections complete _____ QA.

G.21. **Condition the LHSD**

G.21.1. Turn on electric pressure builder and bring the pressure LHG-1 to 1 psig. This should take about 10 minutes.

G.21.2. Turn off the electric pressure builder.

G.21.3. When LHG-1 reaches 1 psig, open low pressure relief valve, LHV-2 on the LHSD.

G.21.4. Close LHV-1 and remove pressurization line.

WARNING:
A hazardous operation is about to begin. In the following step cold helium gas will be briefly expelled from the LHSD stinger port. In addition, removal of the stinger involves handling of a cold surface. Both the cold gas and the stinger surface are capable of quickly causing severe frostbite. The operator performing the operation must wear a face shield with goggles/glasses, apron, non-absorbent shoes, and cryogenic gloves. All other personnel must be clear of the immediate vicinity. Failure to comply may result in personal injury.

G.21.5. Verify amber warning light is operating and that the area is clear of extraneous personnel.

G.21.6. Establish a controlled area of 15 feet.

G.21.7. Remove stinger from LHSD and close the stinger access ball valve.

G.21.8. Verify closed all valves on the LHSD except for the primary (low pressure) relief valve LHV-2, which is left open.

G.21.9. Make a PA announcement stating, "Attention all personnel, the GP-B program has completed the hazardous cryogenic operation".

G.21.10. Ensure area warning light is returned to Green.

G.21.11. Disband Controlled area

NOTE:

The hazardous operation is now complete.

Section complete _____ QA.

G.22. **Place Data Acquisition System in Standard Configuration**

G.22.1. Input comment to DAS “Complete NBP/Subamospheric fill of MT”.

G.22.2. Set DAS data cycle interval to 15 minutes.

G.22.3. Set Main Tank and Guard Tank Liquid Level sampling interval to 10 minutes.

G.22.4. Confirm that the liquid level sensors are set at a sampling rate of 10 minutes or turned off.

G.22.5. Confirm that Vac-ion pump is off.

G.22.6. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.22.7. Ensure DAS alarm enabled and record set points if changed

- Thermal conditions substantially unchanged, alarm set points for lead bag are unchanged and set to alarm.
- Thermal conditions substantially changed, temperature alarm points reset as follows:

  a. Top of Lead Bag set point [CN 40] _____ K (≤ 6.0 K)

  b. Top of Lead Bag set point [CN 41] _____ K (≤ 6.0 K)

G.22.8. Ensure DAS watchdog timer and alarm enabled.

G.22.9. Ensure liquid level sensor alarms enabled on Main Tank and Guard Tank, and record set points if changed.

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

2. ***Guard Tank*** – verify liquid-level alarm set ≥ 20%. Record 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. Failure to comply may result in equipment damage.

G.22.10. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential or higher.

Section complete _____ QA.

G.23. **Final Closure of SV-13 and Conditioning the Dewar Fill Cap Assembly**

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

G.23.1. Verify that the Fill Cap Assembly is still evacuated and record:

PFCG pressure: _____

Date/Time: _____

G.23.2. Retorque SV-13 to 60 +/- 5 in-lbs.

G.23.3. Open AV-8 and open/verify open AV-3.

G.23.4. Open FCV and evacuate to < 25 mtorr as measured at AG-2b.

G.23.5. Close AV-8.

G.23.6. Open AV-1.

G.23.7. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.23.8. Close AV-1.

G.23.9. Close FCV and record:

PFCG pressure:_____

Date/Time:_____/_____

G.23.10. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.23.11. Close AV-8.

G.23.12. Verify closure of SV-13 and FCV by observing the pressure in the Fill Cap Assembly until satisfied that no gas is leaking into the Dewar Fill line or pump line. After 30 minutes record:

PFCG pressure:_____

Date/Time:_____/_____

Note: If PFCG drops by more than 0.5 torr in 30 minutes, repeat steps G.23.2 through G.23.12.

G.23.13. Open AV-1.

G.23.14. Open AV-9 until pressure reaches 0 psig as read on gauge AG-1 and then close AV-9.

G.23.15. Close AV-1.

G.23.16. Close AV-3.

G.23.17. Remove the pumping line from the Fill Cap Assembly.

G.23.18. Install a KF-25 blank-off cap on valve FCV.

Section complete _____ QA.

G.24. (Option) Returning Pumping of SMD to Gas Module Pump

G.24.1. Continue adjusting valves EV-7a/b until desired Main Tank temperature is reached. Record data on attached data sheets.

G.24.2. Once temperatures and pressures have stabilized, and the Main Tank temperature, CN [09] is at the desired level, record the following

1. Date/time of day:_____/_____
2. Main Tank level:_____ %
3. Flowrate PFM-1 (CN110):_____ Ll/hr
4. Tank Temp (T09D):_____ K
5. Main Tank exit pressure (EG-2):_____ torr
6. Vac-ion pump (IP):_____ torr

G.24.3. Record EV-7a valve position:_____ %

G.24.4. Record EV-7b valve position:_____ %

Comment: Nominally these valves should be set at the values recorded near the beginning of this procedure at G.5.5 and G.5.6.

G.24.5. Verify closed all AV valves.

G.24.6. Verify on/turn on AP-1.

G.24.7. Open AV-8.

G.24.8. When AG-2b < 50 mtorr proceed.

G.24.9. Open AV-6.

G.24.10. Close EV-4.

G.24.11. Verify Main and Guard Tank heat exchangers (EH-1/2) off.

G.24.12. Shut down pump module

1. Close EV-21/-22.
2. Close PV-1.
3. Power down PP-1 and PP-2.
4. Close PV-3.

G.24.13. Put/verify DAS on 15-minute data cycle.

G.24.14. Gas Module valve configuration:

a. ***Open:*** EV-10, EV-17, EV-13 and AV-6, and AV-8.

b. ***Closed:*** All other Gas Module valves.

G.24.15. Perform Post-Operations Checklist (Appendix 2)

H. **PROCEDURE COMPLETION**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

Data Sheet

DATE / TIME	LHSD LLS	LHSD Press	GM Hex GT/MT	MT Vent Bayonet/ Bayonet Nut	SV-9 Valve/ Top Plate	Top-Plate Cyl(2)	MT LLS	GT LLS	Main Tank Press EG-2	Pump Press PG-1	Flow Rate PFM-1 (B)	GT Press GTV-G CN [46]	Main Tank Temp CN [09]	Lead Bag Temp CN [40]	Guard Tank Temp CN [24]	Vac Shell Press VIP	GT Heater Voltage	Extern. Gas Sup. ea shift	Comments
	%	psig	^{0}C/^{0}C	^{0}C/^{0}C	^{0}C/^{0}C	^{0}C/^{0}C	%	%	Torr	torr	LL/Hr	torr	K	K	K	torr	V	psig	

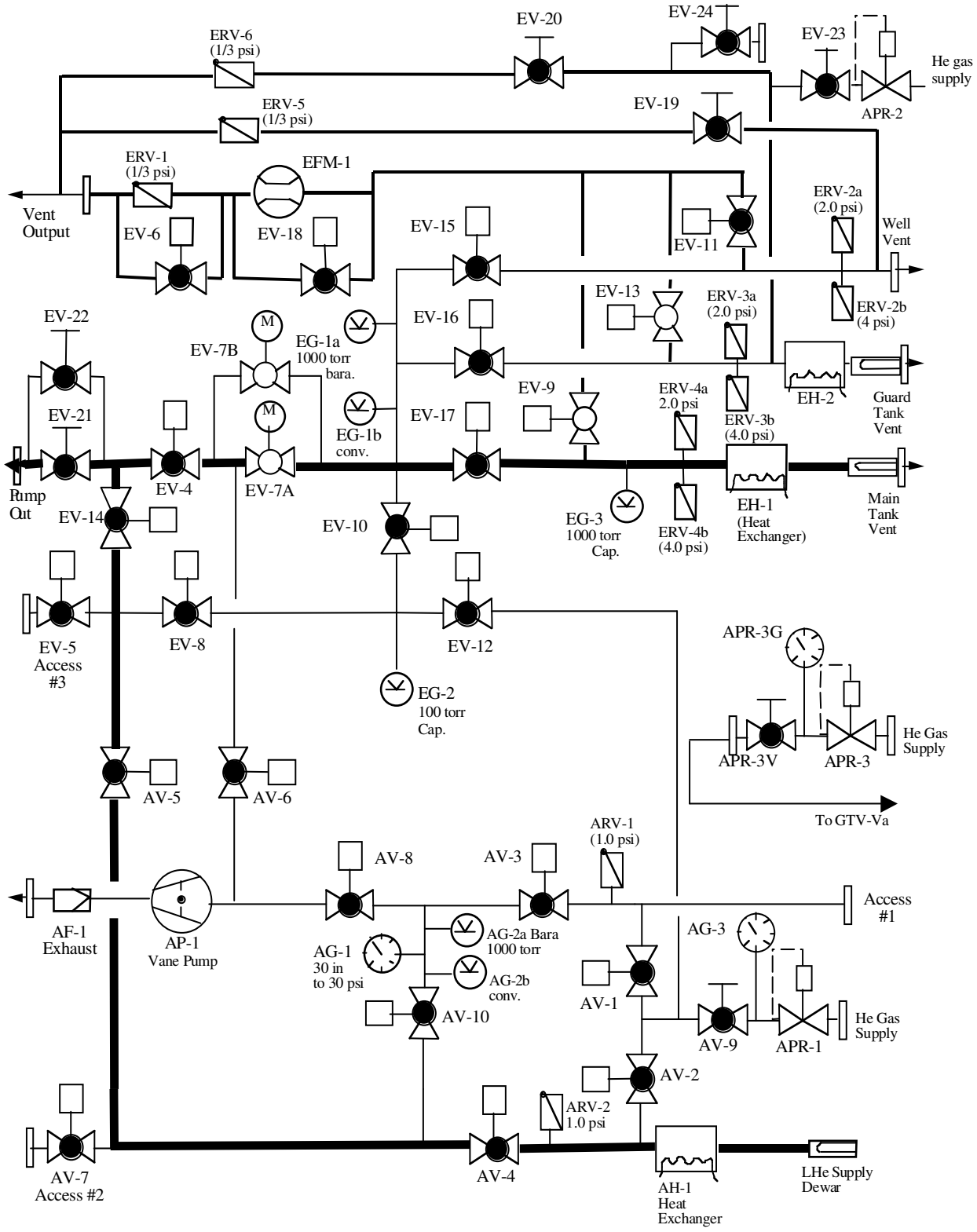

Figure 1. Schematic of Gas Module Plumbing.

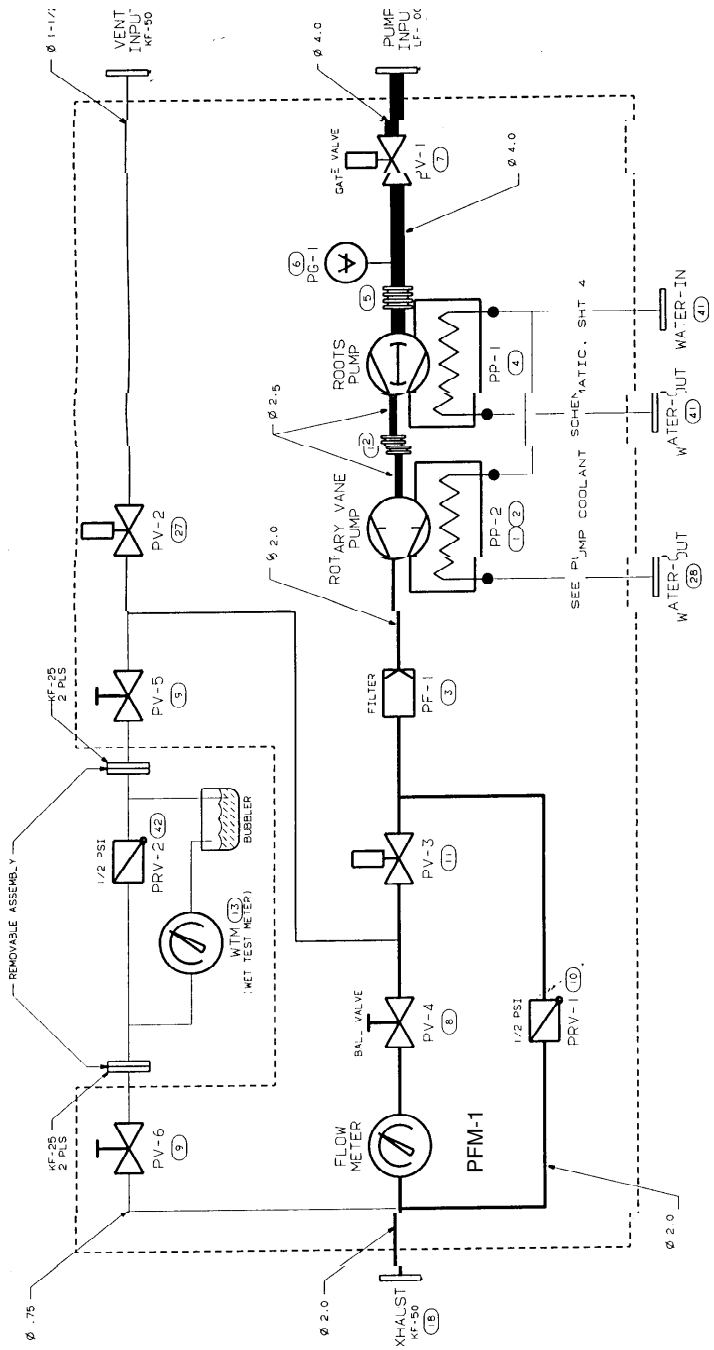

Figure 2. Schematic of Pump Module plumbing.

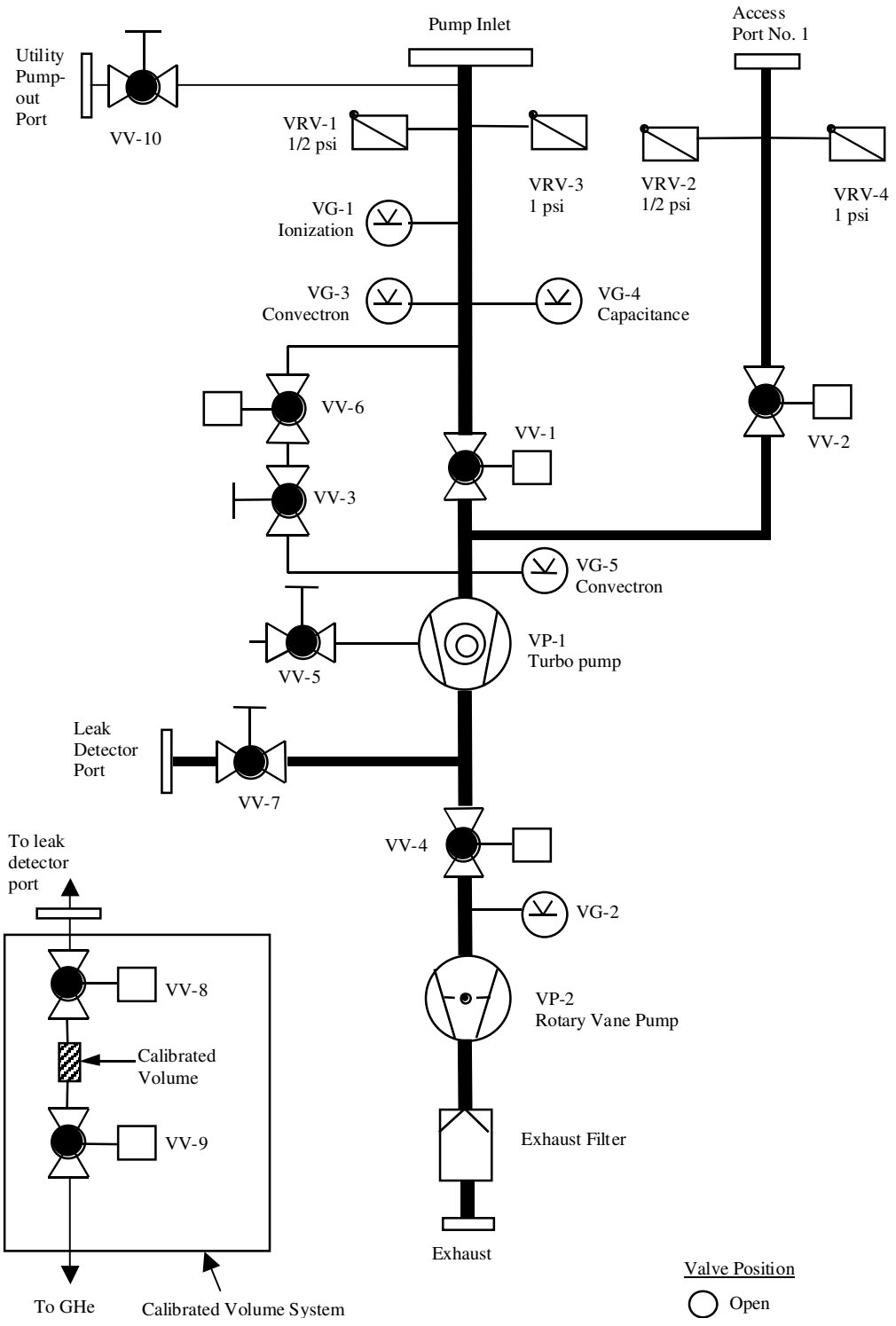

Figure 3. Schematic representation of Vacuum Module plumbing.

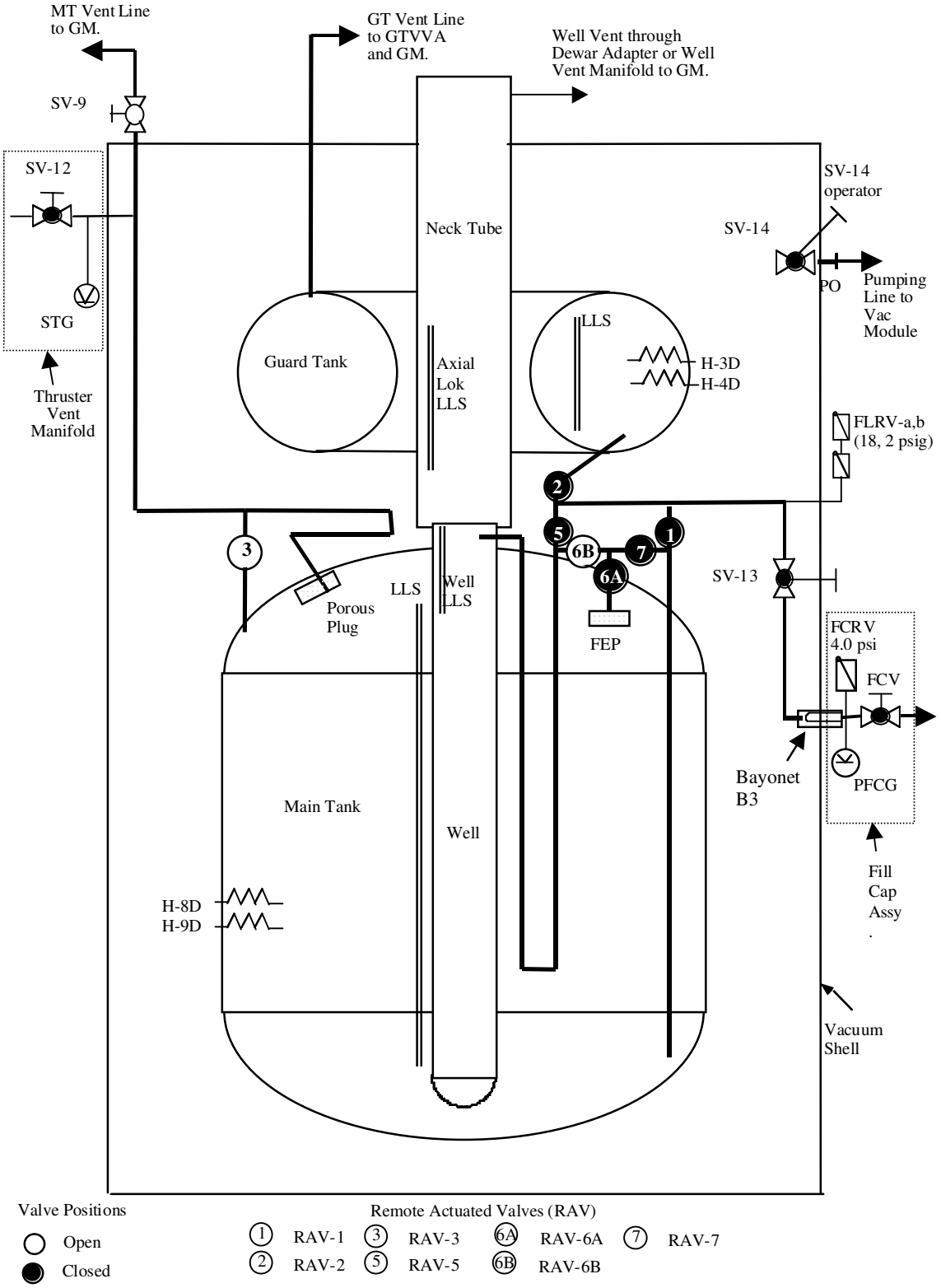

Figure 4. Schematic of Science Mission Dewar plumbing.

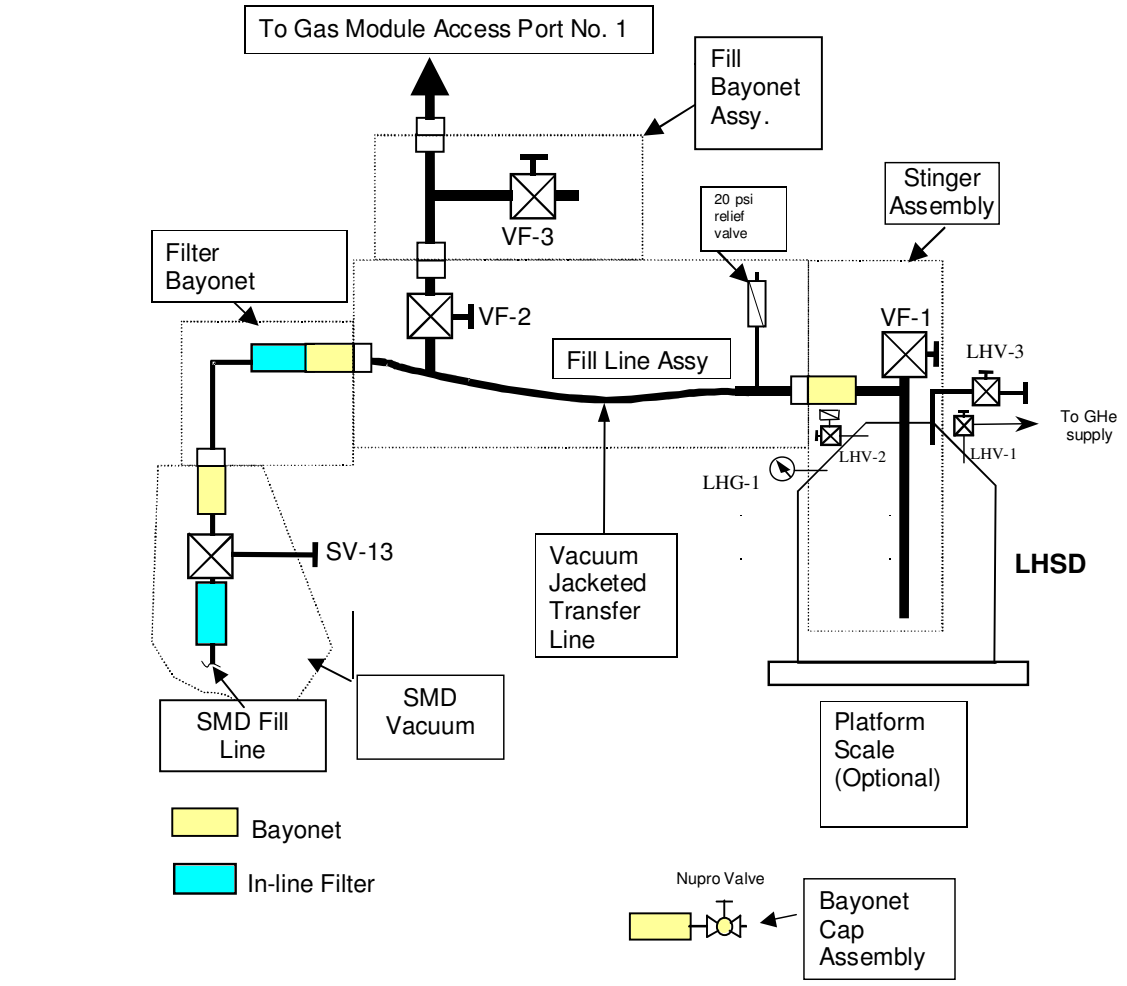

Figure 5 Schematic representation of LHSD and Transfer Line Plumbing

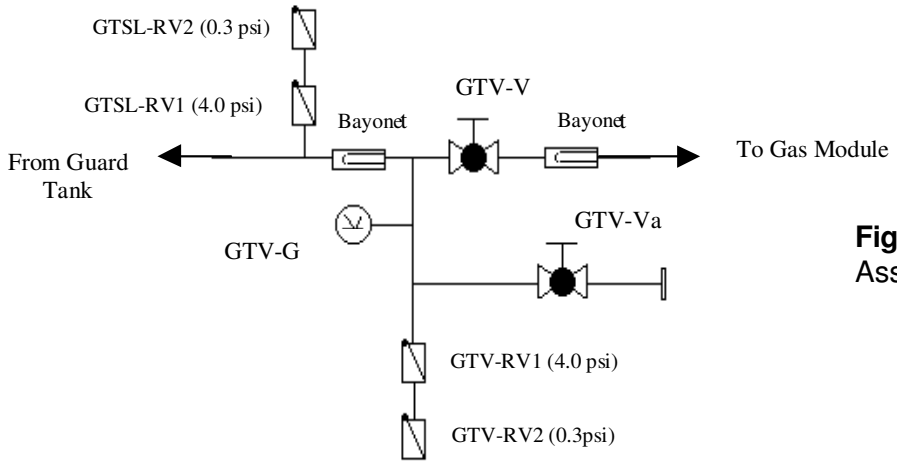

Figure 6. Guard Tank Vent Valve Assembly (GTVVA)

APPENDIX 1 – PRE-OPERATIONS CHECKLIST

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.		
	2. Verify all critical items in the test are identified and discussed with the test team.		
	3. Verify all required materials and tools are available in the test area.		
	4. Verify all hazardous materials involved in the test are identified to the test team.		
	5. Verify all hazardous steps to be performed are identified to the test team.		
	6. Verify team members know their individual responsibilities.		
	7. Confirm that each test team member clearly understands that he/she has the authority to stop the test if an item in the procedure is not clear.		
	8. Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly.		
	9. Notify management of all discrepancy reports or d-log items identified during procedure performance. In the event an incident or major discrepancy occurs during procedure performance management will be notified immediately.		
	10. Verify/perform an Engineering and Safety High-bay walk down. Ensure all discrepancies are corrected prior to start of operations.		
	11. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: _____		

APPENDIX 2 – POST OPERATIONS CHECKLIST

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify all steps in the procedure were successfully completed.		
	2. Verify all anomalies discovered during testing are properly documented.		
	3. Ensure management has been notified of all major or minor discrepancies.		
	4. Ensure that all steps that were not required to be performed are properly identified.		
	5. Verify all RAV operations recorded in logbook.		
	6. If applicable sign-off test completion.		
	Team Lead Signature: _____		

APPENDIX 3 – CONTINGENCY RESPONSES

Condition	Circumstance	Response
Power Failure	Before Sec. G.14 (start of transfer)	Close SV-9, if accessible Close EV-21, if open Wait for power restoration, re-establish valve and pump configuration, and resume procedure
	Section G.14 through G.15	Safemode: Close VF-1, SV-13, if open; Immediately open VF-2; Open EV-20; Close SV-9, if accessible; Close EV-21 Close VF-3, when possible.
	After G.15	Close SV-9, if accessible Close EV-21, if open Wait for power restoration, re-establish valve and pump configuration, and resume procedure
Failure to establish liquid flow into the Main Tank within 4 minutes of depressurizing LHSD	Section G.15	Safemode: Close VF-1, SV-13, if open; Immediately open VF-2;
Temperature limits (CN 40 or 41) exceeded	Step G.15.5	Safemode: Close VF-1, SV-13, if open; Immediately open VF-2;
Guard tank subcools causing the GT pressure to drop below atmospheric	Section G.15	Use Guard Tank heater (H-3D, or H-4D, or both) to prevent subcooling.
Cryogenic burn	**Any time**	Warm the affected area with tepid water. Seek immediate medical care.
Burst disk rupture (MT/GT)	**Any time**	Request 100% facility make-up air purge **Evacuate facility**