GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

MAIN TANK NORMAL BOILING POINT FILL WITH PRE-COOL FROM MAIN TANK

To be performed at Vandenberg Air Force Base building 1610

WARNING: THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

P1031

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REVISION RECORD

REVISION	ECO	PAGES	DATE

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
PV-x	Valve x of the Pump equipment
QA	Quality Assurance
RAV-x	Remote Actuated Valve-x
RGA	Residual Gas Analyzer
SMD	Science Mission Dewar
STV	SMD Thruster vent Valve
SU	Stanford University
SV-x	SMD Valve number x
TG-x	Gauge x of Utility Turbo System
TV-x	Valve x of Utility Turbo System
UTS	Utility Turbo System
Vac	Vacuum
VCP-x	Vent cap pressure gauge
VCRV-x	Vent cap relief valve
VCV-x	Vent cap valve
VDC	Volts Direct Current
VF-x	Liquid helium Fill line valve
VG-x	Gauge x of Vacuum Module
VM	Vacuum Module
VV-x	Valve x of Vacuum Module
VW-x	Valve x of Dewar Adapter

LIST OF SPECIFIC HEADING DEFINITIONS

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

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

A. Scope

This procedure describes the steps necessary to perform an external fill of the Main Tank of the Science Mission Dewar with normal boiling point liquid helium. This procedure is to be used when the Fill Line is to be pre-cooled from the Main Tank. The Guard Tank is empty and attached to a pressurization source to maintain a positive pressure.

The cryogenic hazard in this operation is stinging and destinging the liquid helium supply dewar.

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 discuss the safety design, operating requirements and the hazard analysis of the SMD.

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

In VAFB building 1610 and the MST, the GP-B cryogenic team provides an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. Additional temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions. Emergency vent lines are installed over the four burst disks to direct any flow to an outside area.

Only authorized and trained personnel are allowed in VAFB facilities without escort. All personnel working on platforms at a height 30 inches or more off the floor are required to have an approved air tank (emergency breathing apparatus) within easy reach. Note that tank need not be kept available when working from ladder. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the building and contact NASA and VAFB safety.

The following additional requirements apply to all personnel involved directly in cryogenic operations. Gloves that are impervious to liquid helium and liquid nitrogen are to be worn whenever the possibility of splashing or impingement of high-velocity cryogens exists or when

handling equipment that has been cooled to cryogenic temperatures. Protective clothing, non-absorbent shoes, goggles/glasses, and full-face shields are to be worn whenever the possibility of splashing cryogens exists.

B.2.3. Other Hazards

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

B.3. **Mishap Notification**

B.3.1. Injury

In case of any injury or illness requiring emergency medical treatment **DIAL 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

Contingency responses to possible equipment troubles or irregularities (e.g., power failure) are listed in Appendix 3.

C. **Quality Assurance**

C.1. **QA Notification**

The NASA program and the 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 TD or his designate and shall be approved by the QA Representative. Additionally, approval by the Payload Technical Manager shall be required, if in the judgement of the TD or QA Representative, experiment functionality may be affected. Within hazardous portions of this procedure, all steps shall be worked in sequence. Out-of-sequence work 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.

C.3.1. 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.

C.3.2. 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 Test Director and approved by the QA representative.

C.3.3. All critical and major discrepancies, those that effect flight hardware fit or functions, shall be documented in a D-log and also in a Discrepancy Report, per P0108.

D. Test Personnel

D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. The person performing the operations (Test Director or Test Engineer) is to sign the "Completed by" sign-off. Any other qualified person or QA person who can attest to the successful performance of this procedure may sign the "Witnessed by" sign-off. The Test Director will perform Pre-Test and Post-Test Briefings in accordance with P0875 "GP-B Maintenance and Testing at all Facilities." Checklists will be used as directed by P0875.

D.2. Personnel Qualifications

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

D.3. Required Personnel

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

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

E. Requirements

E.1. Electrostatic Discharge Requirements

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

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

E.3.2. Ground Support Equipment

The Ground Support Equipment includes the Gas Module, the Electrical Module. The Gas Module provides the capability to configure vent paths, read pressures and flow rates, and pump and backfill vent lines. The Pump Module provides greater pumping capacity than the Gas Module, together with additional flow metering capabilities. The vent output of the Gas Module flows through the Pump Module. The Electrical Module contains the instruments listed in Table 1, and provides remote control of valves in the Gas Module, Pump Module, and SMD.

E.3.3. Computers and Software:

The Data Acquisition System (DAS) is required for this procedure. The DAS reads and displays pressures, temperatures, and flow rates and monitors critical parameters. No additional computers or software are required.

E.3.4. Additional Test Equipment

Description	Manufacturer	Model
AMI Level Sensor Readout for LHSD	AMI	110

E.3.5. Additional Hardware

Description	Manufacturer	Model
Filter Line assembly	LM	5833827
Liquid He Transfer Line	LM	5833804
Liquid He Stinger	LM	5833803
GHe supply fittings to LHSD	N/A	N/A

E.3.6. Personal Protective Equipment

1. Safety goggles/glasses
2. Cryogenic safety apron
3. Cryogenic safety gloves
4. Face Shield
5. Non-porous shoes
6. Rubber/latex gloves

E.3.7. Tools

Description	Serial No.	Cal Due
Torque Wrench, 1-1/4-in socket, 60 in-lb		
1-1/4 adjustable wrench		

E.3.8. 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.
Isopropyl Alcohol	AR	N/A
99.999% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Apiezon N or Dow Corning High Vacuum Grease
500 or 1000 Liter Liquid Helium Supply 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	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	-

No.	Location	Description	Name	Serial No.	Cal Required	Status Cal due date
8	EM	MKS PDR-C-2C	EG-2, FCG	92022108A	No	-
9	EM	Flow meter – Matheson 8170	EFM-1	96186	No	-
10	EM	Flow meter totalizer Matheson 8124	EFM-1	96174	No	-
11	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Main Tank	96-409-11	No	-
12	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Guard Tank	96-409-10	No	-
13	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Well	96-409-9	No	-
14	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Axial Lock	96-409-12	No	-
15	EM	Pressure Controller – MKS 152F-92	EV-7a, -7b	96203410A	No	-
16	EM	Power Supply HP 6038A	H08D Tank Heater	96023407A	Yes	
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	
19	EM	Vac Ion Pump power supply Varian 929-0910, Minivac	SIP	5004N	No	-
20	EM	Flow meter totalizer Veeder-Root	PFM-1	576013-716	No	-
21	GM	Pressure Gauge, Heise	AG-1	CC-122077	No	-
22	GM	Pressure Gauge, Marshall Town	AG-3	N/A	No	-
23	GM	Main Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	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 must be at its normal boiling point (NBP), ~4.2 K. The SMD is vertical with the +z axis up. The actuator control valve for EV-9 should be placed in the "NBP." position, ensuring that EV-9 remains open in the event of power failure.

E.5.2. Guard Tank

The Guard Tank is depleted and regulated to a pressure > 10 torr above atmosphere. Care must be taken at all times to keep its pressure above atmospheric.

E.5.3. Well

The Well is evacuated.

E.5.4. SMD Vacuum Shell

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

E.5.5. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:

    a. Top of lead bag temperatures set (CN 175 and CN 178) at $T \leq 6.0$ K.

    b. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 10$ torr.

2. The Watch Dog alarm must be armed.

E.5.6. GSE and Non-flight Hardware

1. The ion-pump magnet must be installed.
2. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line, use procedure P1006, Connect Main Tank Vent Line to Gas Module – Main Tank at NBP if this is not the case.
3. The Guard Tank vent line is connected to the Gas Module.
4. The Fill Cap Assembly must be installed at SV-13 (Figure 3)
5. Top Plate heaters must be installed on SMD and be operational.

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 (with Probe) is installed in: the SMD transportation and test fixture or in the space vehicle assembly fixture; or the space vehicle tilt dolly.

2. The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be off, actively pumping the pumping line up to a closed SV-14, or actively pumping the vacuum shell

F. Reference Documents

F.1. Drawings

Drawing No.	Title
LMMS-5833394	Instrumentation Installation

F.2. Supporting documentation

Document No.	***Title***
LMMC-5835031	GP-B Magnetic Control Plan
GPB-100153C	SMD Safety Compliance Assessment
LM/P479945	Missile System Prelaunch Safety Package
SU/GP-B P0141	FIST Emergency Procedures
LMSC-P088357	Science Mission Dewar Critical Design Review
SU/GP-B P0108	Quality Plan
LMMS GPB-100333	Science Mission Dewar Failure Effects and Causes Analysis
SU/GP-B P059	GP-B Contamination Control Plan
EM SYS229	Accident/Mishap/Incident Notification Process
EWR 127-1	Eastern and Western Range Safety Requirements
KHB 1710.2 rev E	Kennedy Space Center Safety Practices Handbook

F.3. Additional Procedures

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

Operation Number:_____
Date Initiated:_____
Time Initiated:_____

G. Operations

G.1. Pre-Operations Verifications

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

Section Complete QA Witness:_____

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 Witness:_____

G.3. **Verify Configuration Requirements**

CAUTION:

The Main Tank vent path is closed at EV-9 during the initial stages of this procedure to allow pressure for the transfer to build. During this period of closure, the temperature at the top of the lead bags should be continuously monitored to detect trends prior to alarm. Corrective action for over temperature is given in Appendix 3. Failure to comply may result in equipment damage.

G.3.1. Ensure DAS Watch Dog Alarm enabled.

G.3.2. Ensure that Top Plate heaters on SMD are operational.

G.3.3. Record MT pressure (EG-3 and/ or STG) ____ torr ____ torr.

G.3.4. Verify DAS and liquid level alarms enabled and record set points.

1. Main Tank level ("A" or "B"): Record set point _____%
2. Guard Tank Level ("A" or "B"): Record set point _____%
3. Top of lead bag temperature [CN 175] Record set point _____K
4. Top of lead bag temperature [CN 178] Record set point _____K
5. Relative Guard Tank Pressure [CN46] Record set point _____torr

G.3.5. Verify Main Tank vent line connected to Gas Module. If not perform procedure P1006, "Connect Main Tank Vent Line to Gas Module – Main Tank at NBP", to connect Main Tank vent.

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

G.3.7. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day _____
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr. If pressure is above $5x10^{-5}$ torr, perform procedure P1015,"Connect of Vacuum Module / Pump on SMD Vacuum Shell", 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.3.8. Verify Actuator Control for EV-9 set to "NBP" position.

Section G.2 Complete Quality _____

G.4. **Verify Gas-Module Configuration and Record Initial Conditions**

G.4.1. Verify valve states as indicated in following Table. Record configuration in left-hand column, then verify corresponding valve states.

Verify Initial Valve States		
	Verify Open	Verify Closed
1. Main Tank vent		
Connected to GM	EV-9	EV-17
2. Guard Tank vent		
Connected to GM; depleted of LHe and pressure regulated at EV-23 (verify source of He gas at APR-2)	EV-16, EV-23 GTV-V, APR-2	EV-13, EV-20, EV-24 GTV-Va
3. Remaining EV valves	EV-7a/b	EV-4, EV-5, EV-6, EV-8, EV-10, EV-11, EV-12, EV-14, EV-15, EV-18, EV-19, EV-21/22
4. AV valves		All

G.4.2. Record initial temperatures

1. Top of Lead Bag CN [28] _____ K.
2. Temperature at bottom of Main Tank CN 09] _____K.

G.4.3. Record pressures.

1. Guard Tank (GTV-G) CN[46]:_____ torr (relative to atm.).
2. Main Tank (STG) CN[49]:_____ torr.

G.4.4. Record liquid level in Main Tank _____ %.

G.4.5. Record Fill Cap Assembly pressure and verify that it reads >760 torr. If not, enter in D-log and consult Payload Test Director.

Fill Cap Assembly (PFCG): _____ torr.

Section G.3 complete. Quality_____

G.5. **Verify SMD in Standard Configuration**

G.5.1. Using the RAV log book verify that the dewar's internal valves are in the following positions. If not, investigate to ensure previous RAV operations properly recorded. If necessary, note resolution in D-log.

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

G.5.2. Verify SV-9 open.

G.5.3. Verify SV-13, and FCV closed.

Section complete. Quality_____

G.6. **Set Up Data Acquisition System**

G.6.1. Verify DAS set to configuration 4aa.

G.6.2. Set DAS to fast scan mode using [other menus], [data config], [fast scan]

G.6.3. Record directory and data file name _____ .

G.6.4. Start "Special Data Cycle" by using [Other Menus] + [Special Data Col] + [Use Pre-Selected] + [Init. Collectn] + [Enter] (=use default file).

G.6.5. Record directory and special data file name _____ .

G.6.6. Set Main Tank Liquid Level Sensor sampling interval to 1 min.

G.6.7. Ensure printer is displaying special Data Cycle data.

Section complete. Quality_____

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 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
Fill line pressure (PFCG): _____ torr.

`

Section complete. Quality_____

G.8. **Raise Pressure in Fill Line to Main Tank Pressure**

G.8.1. Open RAV-1 using:

1. Ensure all RAV controller selection switches in OFF position.
2. Turn on RAV power supply and adjust current limit to 1.85 amps.
3. Adjust power supply to 28 VDC.
4. Power up controller #1.
5. Position selection switch for controller #1 to RAV-1.
6. Record initial status lights(4) on: Open: θ θ Closed: θ θ
7. Activate controller #1 to open RAV-1 and record:
    a. Run time:_____ seconds.
    b. Current draw:_____ amps.
    c. Time of day: _____.
8. Record final status lights(4) on: 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 (PFCG) rises to Main Tank pressure

1. Record Main Tank pressure (EG-3) _____ torr
2. Record Fill line pressure (PFCG): _____ torr.

G.8.3. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

Section complete. Quality_____

WARNING:

The following operation poses a cryogenic safety hazard. The individual performing the following operation must wear cryogenic safety gloves, a cryogenic safety apron, goggles, a face shield and non-porous shoes. Failure to comply may result in personal injury.

G.9. **Installing Stinger in LHSD**

Note:

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

G.9.1. Establish a 15 foot controlled area around the hazardous operation

G.9.2. Make PA announcement that the GP-B cryogenic group is now performing a hazardous operation

G.9.3. Turn on amber warning light

G.9.4. Ensure all nonessential personnel are clear of controlled area.

G.9.5. Reduce the pressure in the liquid helium supply to < 1.0 psig by opening the low pressure relief valve.

G.9.6. Open valve VF-1 (Liquid withdrawal valve) on the stinger

G.9.7. Slowly insert the stinger into the LHSD while allowing it to be purged.

G.9.8. Close valve VF-1 just as cold gas is expelled from stinger.

G.9.9. Close the primary (low pressure) relief valve on the LHSD.

G.9.10. Increase LHSD ullage pressure builder to 6 to 10 psig byattaching an external source of Ghe to the ullage inlet 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 required LHSD driving pressure.

G.9.11. Record LHSD data:

Date / time: _____

Liquid level _____%

LHSD serial number: _____

Note:

The hazardous operation is now complete

G.9.12. Disband control area

G.9.13. Make PA announcement stating the hazardous operation is now complete

G.9.14. Ensure amber warning light is returned to green

Section G.8 complete. Quality_____

G.10. **Installing Fill Line Assembly**

G.10.1. Removal of Pumping line and the Fill Cap Assembly

1. Close/verify closed AV-8.
2. Open AV-1
3. Open AV-9 until pressure reaches 0 psig at AG-1 and then close AV-9.
4. Close AV-1.
5. Remove the pumping line from the fill cap assembly.

G.10.2. Install the Filter Line Assembly (P/N 5833827) to the Dewar Fill Bayonet B3.

G.10.3. Installing Fill Line Assembly

Note:
Be sure to provide adequate support to the Fill Line so as not to load the Filter Assembly and Stinger.

1. Mate the Fill Line (P/N 5833804) with the Stinger in the LHSD.
2. Mate the VF-2 end of the transfer line with the Filter Line Assembly.
3. Ensure that the valve stem of VF-2 and stem of relief valve are pointed upwards.
4. Close/verify closed VF-3.

Section G.9 complete. Quality_____

G.11. **Condition the Transfer Line/Filter/Stinger Assembly**

G.11.1. Configure Pumping Line:

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

G.11.2. Evacuating 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.11.3. Backfilling 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.11.4. Evacuating 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.11.5. Backfilling 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 valve VF-2.

Section G.10 complete. Quality_____

G.12. **Raise Main Tank Pressure**

CAUTION
The Main Tank vent path will be closed off at EV-9 during the initial stages of this procedure to allow pressure for the precooling transfer to build. During this period of closure the temperatures at the top of the lead bag should be continuously monitored to detect trends prior to alarm. Corrective action for over temperature is given in Appendix 3. Failure to comply may result in hardware damage.

G.12.1. Close EV-9.

CAUTION
Use of the Main Tank heater will heat the MT ullage as well as the liquid and should be done sparingly when the Main Tank level is < 40%. Failure to comply may result in equipment damage.

G.12.2. Turn on Main Tank heater power supply, (H08D or H09D) as follows.

- Pressure in Main Tank to be raised by adding heat.

1. Verify liquid level of Main tank is > 40 %, if not, use the alternate process below; build pressure gradually
2. Adjust current limit to 1.25 amps.
3. Adjust voltage output to 15 volts.

- Pressure in Main Tank is to be raised gradually.

4. Adjust current limit to 0.5 amps.
5. Adjust voltage output to zero volts.

G.12.3. Adjust Main Tank heater voltage, as necessary, to maintain transfer pressure of approximately 790 torr. Observe the following limits:

1. Building pressure gradually– Do not exceed 20 volts.
2. Building pressure by adding heat – Do not exceed 35 volts.

G.12.4. Record data in Table G.12.

Table G.12 Main Tank Heater Data

Time	MT Pressure EG-3 (torr)	GT Pressure GTV-G (torr)	GT Temp CN [24]	MT Heater Voltage (V)	MT LLS (%)	GT LLS (%)	Comments

G.13. Starting Pre-cool from the Main Tank and transfer into Main Tank

Note:

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

G.13.1. Verify closed VF-3.

G.13.2. Open SV-13.

G.13.3. Open VF-2.

G.13.4. Record Main Tank pressure (EG-3): _____ torr.

G.13.5. Close EV-23, Open EV-20: Guard Tank is now venting to "Vent Out" via ERV-6.

G.13.6. Open VF-3.

G.13.7. Monitor Tank pressures, EG-3, and reduce tank heater to maintain pressure below 820 torr.

G.13.8. Monitor CN 28 [T20D] or CN29 [T21D] and if they exceed 5.7K, induce vent gas cooling from the Main Tank by performing the following.

1. Close VF-3.
2. Open Main Tank vent EV-9.
3. Once temperature is below 5.2K, close EV-9 and open VF-3.

G.13.9. When a dense plume is evident from VF-2 and when Fill Valve (SV-13) temperature T-24D [42] is < 75K,

G.13.10. Close SV-13.

G.13.11. Immediately open VF-1.

G.13.12. Power off Main Tank heater.

G.13.13. Open EV-9

G.13.14. When EG-3 and Eg1a are within 5 torr of each other open EV-13 and close EV-20: Main Tank and Guard Tank have common vent.

G.13.15. When a dense plume is evident from VF-2,

G.13.16. Close VF-2 and

G.13.17. Immediately open SV-13.

G.13.18. Close VF-3 when valve has warmed sufficiently.

G.13.19. Open EV-6 and EV-18.

G.13.20. Valve configuration:

	Open	Closed
EV valves	EV-7a/-b, EV-6, EV-8, EV-9, EV-13, EV-16	All other
AV valves	AV-3, APR-2	All other
Dewar valves	GTV-V, SV-9, SV-13	GTV-Va, ST-Va/Vb
RAV valves	RAV-1, RAV-3, RAV-6B	All other
VF valves	VF-1	N/A

Section G.12 complete. Quality_____

G.14. Verify Start of Transfer

G.14.1. Verify tank flow meter (PFM-1) of 50 to 100 liquid liters/hour.

CAUTION

Do not exceed 100 l/hr transfer rate as read on PFM-1(B) as this exceeds the capacity of the heat exchanger in the gas module. Failure to comply may result in equipment damage.

PFM1 (B) reading: _____

Start Time: _____

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

G.14.3. Record all fill data on the attached data sheets every 15 minutes.

G.14.4. Adjust LHSD pressure:

1. Close pressurization valve at the LHSD and adjust the gas supply pressure regulator to the desired pressure not to exceed 12 psig.
2. Reopen pressurization valve at the LHSD.

Section G.13 complete. Quality_____

G.15. **Termination of Transfer**

Date: _____ Time: _____

G.15.1. Stopping the flow of liquid helium:

Note:
A full Dewar or empty LHSD is indicated by a rapid and consistent increase in the flow rate.

1. Close VF-1.
2. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs and immediately open VF-2.

QA Witness:_____

3. Close EV-6 and EV-18.

G.15.2. Remove the pumping line from the Gas Module at valve VF-3.

G.15.3. Remove the Transfer and Filter Lines from the Dewar fill bayonet B3.

G.15.4. Install the Fill Cap Assembly.

Section G.14 complete. Quality_____

G.16. **Conditioning the Dewar Fill Line**

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

G.16.2. Close/verify closed valve AV-1 and AV-9.

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

G.16.4. Open/verify 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-1:

Note:
Relieving of the Dewar fill line will be through the relief valve in the Fill Cap Assembly until the next operation.

1. Verify that RAV controller No. 1 is already on and that RAV selection switch is already set to RAV-1.
2. Record initial switch status: Open: θ θ Closed: θ θ
3. Activate controller No. 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.16.8. Turning OFF all RAV controllers:

1. Turn all RAV selection switches to OFF.

2. Power off all controllers.

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

Quality_____

G.16.11. Close FCV.

G.16.12. Close AV-8.

G.16.13. Open AV-1.

G.16.14. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.16.15. Close AV-1.

G.16.16. 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:

PFCG pressure: _____ _____ _____

Date/Time: _____ _____ _____

G.16.17. Valve configuration:

	Open	Closed
EV valves	EV-7a/-b, EV-16	All other
AV valves	APR-2	All other
Dewar valves	GTV-V, SV-9	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-3, RAV-6B	All other
VF valves	N/A	N/A

Section G.15 complete. Quality_____

G.17. **Configuration of Dewar and GSE**

G.17.1. Record the reading on flowmeter EFM-1 and verify that helium is venting.

EFM-1 reading _____

G.17.2. Record the Main Tank liquid level (LL-1D or LL-2D): _____ %

G.17.3. Record the following pressures:

a. Main Tank pressure (EG-3): _____ torr

b. Guard Tank pressure (EG-1a/GTVG): _____ torr

Section complete. Quality_____

G.18. **Configure Data Acquisition System**

G.18.1. Input comment to DAS "Completed External NBP fill of Main Tank".

G.18.2. Set DAS to configuration choice 4aa.

G.18.3. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.18.4. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day _____ .
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 15 min.
5. When data cycle is complete, turn off Vac-ion pump.

G.18.5. Set DAS to normal scan mode using [other menus], [data config], [normal scan]

G.18.6. Set DAS data cycle interval to 15 minutes.

G.18.7. Set Main Tank Liquid Level sampling interval to 10 minutes.

G.18.8. Confirm that the liquid level sensors are set at a sampling rate of 10 minutes or turned off.

G.18.9. Confirm that Vac-ion pump is off.

G.18.10. Enable/verify enabled the alarms on the Main Tank

G.18.11. Verify enabled the DAS alarm and record the set points:

a) CN ____, Level _____ d) Main Tank Level: _____ %

b) CN ____, Level _____ c) CN ____, Level _____

G.18.12. Ensure DAS watchdog timer and alarm enabled.

Section G.17 complete. _____

WARNING:

The following operation poses a cryogenic safety hazard. The individual performing the following operations must wear cryogenic safety gloves, a cryogenic safety apron, goggles, a face shield and non-porous shoes. Failure to comply may result in personal injury.

G.19. **Desting Liquid Helium Supply Dewar**

G.19.1. Establish a 15 foot controlled area around hazardous operation

G.19.2. Make PA announcement stating that the GP-B cryogenic team is now performing a hazardous operation

G.19.3. Turn on amber warning light

G.19.4. Clear area of all nonessential personnel.

G.19.5. Reduce pressure in liquid helium supply dewar to <1psig

G.19.6. Remove stinger from supply dewar and immediately close VF-1

Note:
The hazardous operation is now complete.

G.19.7. Disband controlled area

G.19.8. Make PA announcement stating the hazardous operation is now over

G.19.9. Ensure amber warning light is returned to green.

G.20. **Final Closure of SV-13 and Conditioning the Dewar Fill Cap Assembly**

G.20.1. Once SV-13 has warmed sufficiently to try final closure perform the following:

Note:
The time required to warm up until the valve seals correctly may be several hours**.**

G.20.2. Verify that the Fill Cap Assembly is still evacuated and record:

PFCG pressure: _____
Date/Time: _____

G.20.3. Retorque SV-13 to 60 +/- 5 in-lbs.

QA Witness:_____

G.20.4. Open AV-8.

G.20.5. Open FCV and evacuate to < 25 mtorr as measured at AG-2b.

G.20.6. Close AV-8.

G.20.7. Close/verify closed EV-12 and AV-9.

G.20.8. Open AV-1.

G.20.9. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1, then close AV-9.

G.20.10. Close AV-1.

G.20.11. Close FCV and record:

G.20.12. PFCG pressure: _____

G.20.13. Date/Time: _____

G.20.14. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.20.15. Close AV-8.

G.20.16. Verify closure of SV-13 by observing the pressure in the Fill Cap Assembly PFC until satisfied that no gas is leaking into the Dewar Fill line. After 30 minutes record:

PFCG pressure: _____

Date/Time: _____

G.20.17. Open AV-1.

G.20.18. Open AV-9 until pressure reaches 0 psig as read on gauge AG-1 and then close AV-9.

G.20.19. Close AV-1.

G.20.20. Close AV-3.

G.20.21. Remove the pumping line from the Fill Cap Assembly.

G.20.22. Install a KF-25 blank-off cap on valve FCV:

G.20.23.

G.20.24. Valve configuration

	Open	Closed
EV valves	EV-7a/-b, EV-9, EV-16, EV-23	All other
AV valves	APR-2	All other
Dewar valves	GTV-V, SV-9	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-3, RAV-6B	All other

G.20.25. Verify Completion of post operations checklist (appendix 2)

Section G.18 complete. Quality_____

H. **Procedure Completion**

Completed by: _____

Witnessed by: _____

Date: _____

Time:_____

Quality Manager Date _____

Payload Test Director Date _____

Data Sheet 1

Date/Time	LHSD Level (%)	LHSD Press (psig)	Main Tank pressure EG-3 (Torr)	Guard Tank pressure EG-1a (Torr)	LHe Flow PFM-1 (Ll/hr)	Main Tank Liquid He Level (%)	Guard Tank Liquid He Level(%)	

Data Sheet 2

Date Time	Sta. 200 T-1D [1] (K)	Lead bag Top T-20D [28] (K)	G.T.Bott T-15D [24] (K)	HX-4 T-08D[8] (K)	M.T. bottom T-09D [9] (K)	Vac-Ion Pump (torr)	Gas Mod HX GT/MT (^{o}C/ ^{o}C)	MT Vent Bayonet/ Baynt Nut (^{o}C/ ^{o}C)	SV-9 Valve/ Top Plate (^{o}C/ ^{o}C)	Top-Plate Cyl(2) (^{o}C/ ^{o}C)

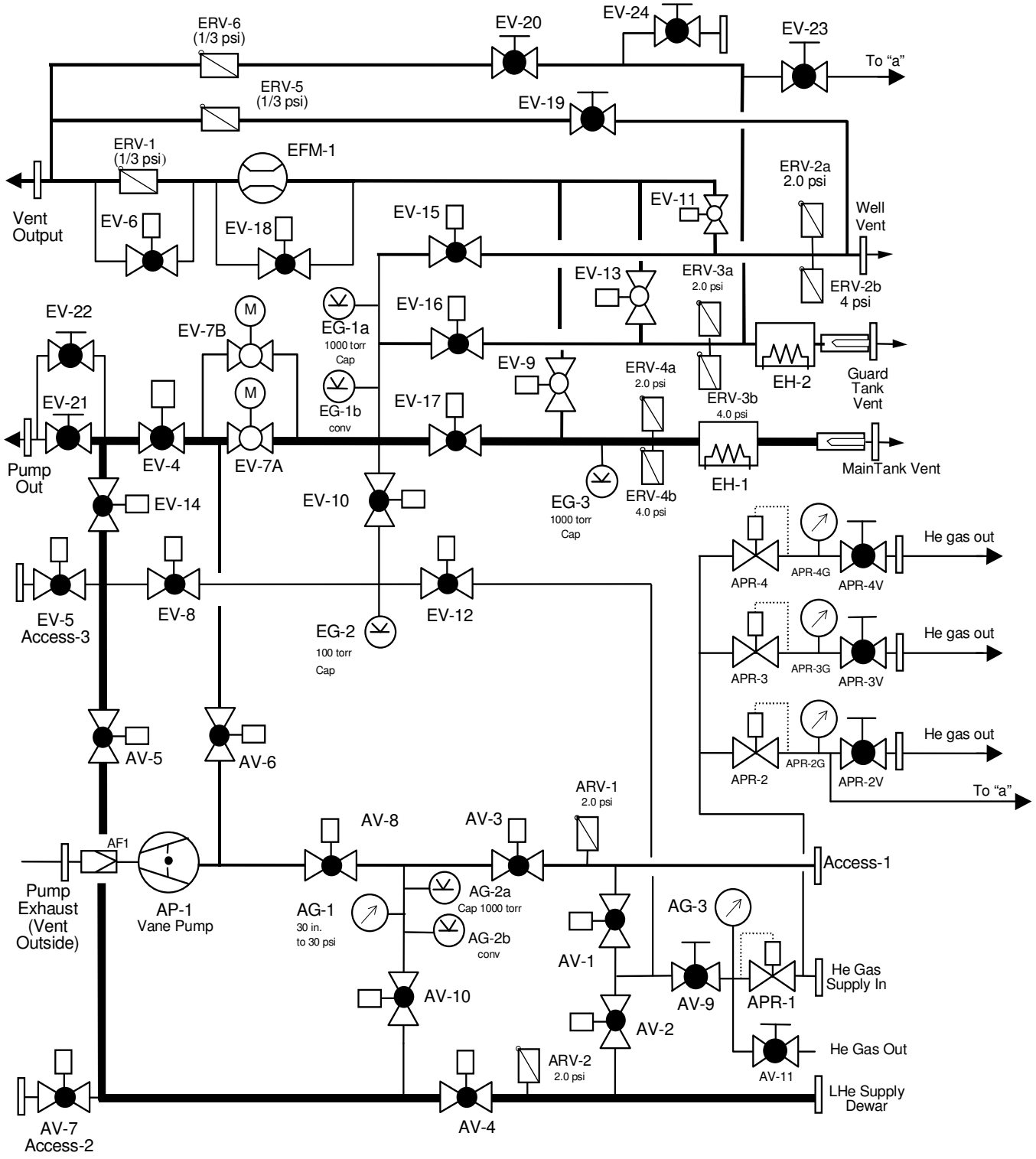

Figure 1. Schematic of Gas Module Plumbing. (GasModDwg4.doc)

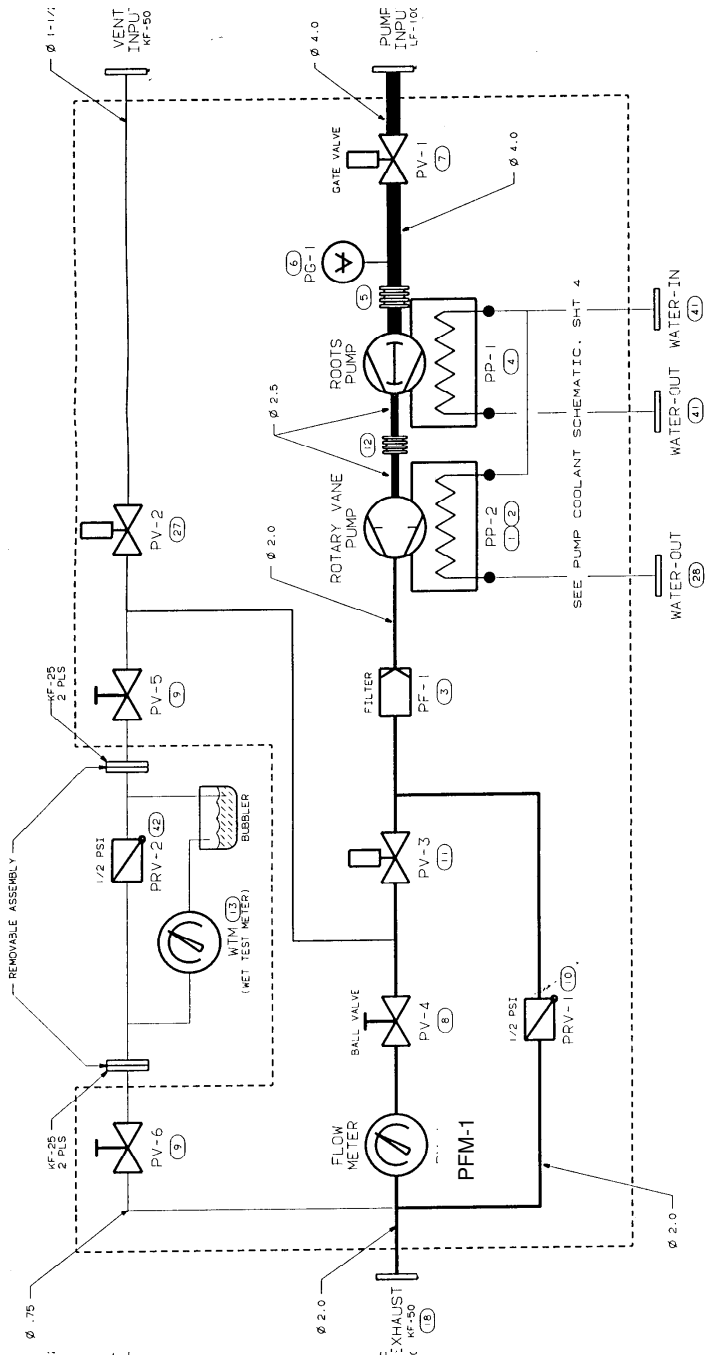

Figure 2. Schematic of Pump Module plumbing.

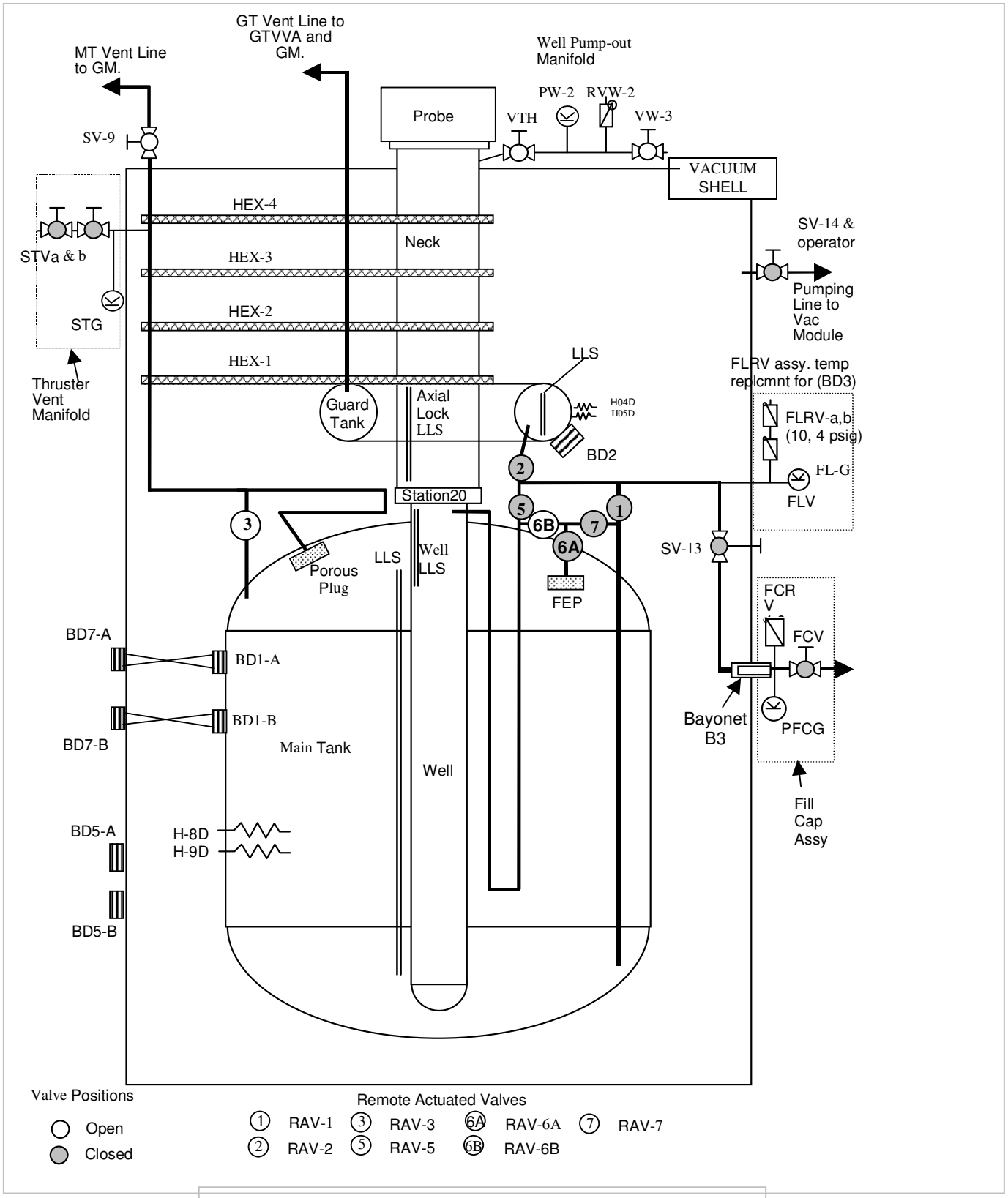

Figure 3. Schematic of Science Mission Dewar plumbing

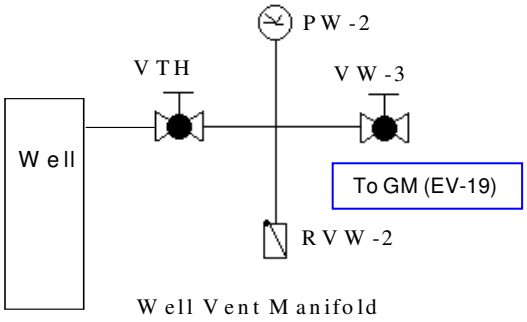

Figure 4 Well vent manifold.

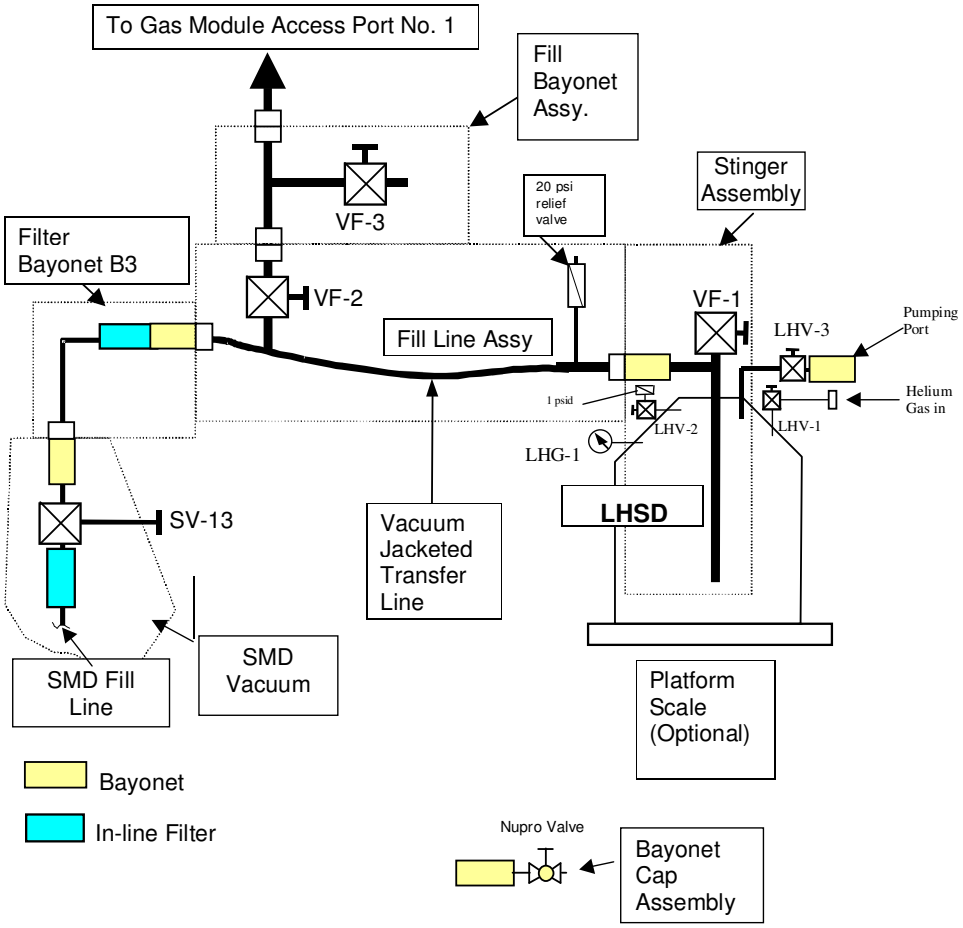

Figure 5. Schematic of liquid helium transfer plumbing

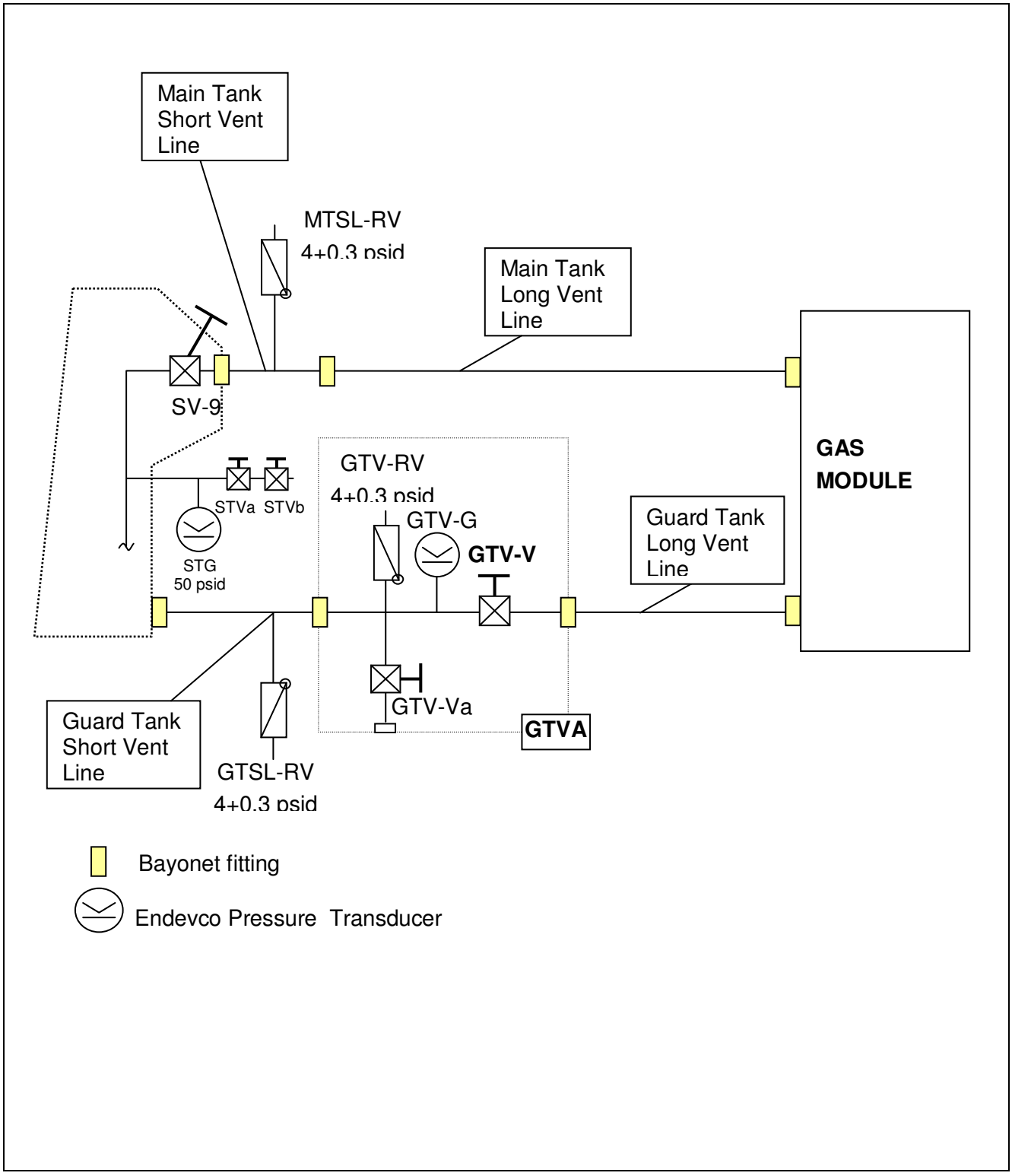

Figure 6. Main Tank and Guard Tank venting to Gas Module with Guard Tank Vent Assembly (GTVA) in place. (MT&GT_toGM_dwg.doc)

I. Appendix 1- Pre-Operations Checklist

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.		
	2. Verify all critical items in the test are identified and discussed with the test team.		
	3. Verify all required materials and tools are available in the test area.		
	4. Verify all hazardous materials involved in the test are identified to the test team.		
	5. Verify all hazardous steps to be performed are identified to the test team.		
	6. Verify each team member is certified and knows 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 pretask 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: _____		

J. Appendix 2- Post Operations Checklist

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

K. Appendix 3– Contingency Responses

	Condition	Circumstance	Response
1	Power Failure	Before. G.12 (start of transfer)	Wait for power restoration: Re-establish valve configuration, and resume procedure
		Section G.12 through G.16	Go to Safemode: Close VF-1, SV-13, if open; Immediately open VF-2; Open EV-20; Close VF-3, when possible.
		After G.16	Wait for power restoration: Re-establish valve configuration , and resume procedure
		Any time	Wait for power restoration Note: the DAS computer will continue to function for several hours, however no data will be collected DAS computer still operating: Reset GM valving per the last configuration in procedure and resume procedure DAS computer not operating: Reboot computer and launch DRP_SMD and select auto startup option Reset GM valving per the last configuration in procedure and resume procedure
2	Temperature limits (CN 1 or 28) exceeded	MAIN TANK IS NOT VENTING	ALLOW MAIN TANK TO VENT If SV-9 is closed: Close EV-17 (if open) and verify EV-9 open, crack open SV-9 to allow MT to vent. Adjust SV-9 as necessary to restore temperature(s) below alarm limits. Open EV-6 and EV-18 if higher flow rate is needed. If SV-9 open and EV-9 closed: Open EV-9 for short periods (~15 sec) and allow increased flow from Main tank; in addition, Open EV-6 and EV-18 if higher flow rate is needed. If SV-9 and EV-9 open Open EV-6 and EV-18 for higher flow If problem persists see item 3

3		MAIN TANK IS VENTING	PROMOTE INCREASE IN MAIN TANK VENTING Power up heater at H08D or H0-9D and starting at 15 vdc input increase power until increased flow has cooled the problem area
4	Burst disk rupture (MT/GT)	ANYTIME	Evacuate building
5	Oxygen Monitor Alarm	ANYTIME	Evacuate building
6	Liquid Nitrogen or Liquid Helium Spill	ANYTIME	Clear area until all spilled liquid has evaporated.