GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

MAIN TANK
NORMAL BOILING POINT FILL
WITH PRE-COOL FROM MAIN TANK
AND WELL EVACUATED

THIS PROCEDURE CONTAINS HAZARDOUS OPERATIONS

P0441B
ECO1325
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REVISION RECORD

REVISION	ECO	PAGES	DATE
A	997	Section G.13 has been modified to reflect different valve opening/closing sequences	4/14/99
B	1325	Update Sections A through F to reflect new scope and QA requirements Section G: Remove operations dealing with liquid helium in Well Update QA signoffs Update valve configuration callouts	12/13/01

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LIST OF ABBREVIATIONS AND ACRONYMS

AG-x	Gauge x of Gas Module auxiliary section	MT	Main Tank
AMI	American Magnetics Inc.	MTVC	Main Tank Vent Cap
ATC	Advanced Technology Center	MTVC-G	Main Tank Vent Cap pressure gauge
APR-x	Pressure regulator x of Gas Module	MTVC-RV	Main Tank Vent Cap relief valve
AV-x	Valve x of Gas Module auxiliary section	MTVC-V	Main Tank Vent Cap valve
CG-x	Gauge x of portable helium pressurization source	NBP	Normal boiling point
CPR-x	Pressure regulator x of portable helium pressurization source	ONR	Office of Naval Research
CV-x	Valve x of portable helium pressurization source	PFCG	Fill Cap assembly pressure Gauge
CN [xx]	Data acquisition channel number	PFM	Pump equipment Flow Meter
DAS	Data Acquisition System	PG-x	Gauge x of Pump equipment
EFM	Exhaust gas Flow Meter	PM	Pump Module
EG-x	Gauge x of Gas Module exhaust section	psi	pounds per square inch
EH-x	Vent line heat exchanger in Gas Module	psig	pounds per square inch gauge
EM	Electrical Module		
ERV-x	Relief valve of Gas Module exhaust section	PV-x	Valve x of the Pump equipment
EV-x	Valve number x of Gas Module exhaust section	QA	Quality Assurance
FCV	Fill Cap Valve	RAV-x	Remote Actuated Valve-x
FIST	Full Integrated System Test	RGA	Residual Gas Analyzer
GHe	Gaseous Helium	SMD	Science Mission Dewar
GM	Gas Module	STV	SMD Thruster vent Valve
GP-B	Gravity Probe-B	SU	Stanford University
GSE	Ground Support Equipment	SV-x	SMD Valve number x
GT	Guard Tank	TG-x	Gauge x of Utility Turbo System
GTVC	Guard Tank Vent Cap	TV-x	Valve x of Utility Turbo System
GTVC-G	Guard Tank Vent Cap pressure gauge	UTS	Utility Turbo System
GTVC-RV	Guard Tank Vent Cap relief valve	Vac	Vacuum
GTVC-V	Guard Tank Vent Cap valve	VCP-x	Vent cap pressure gauge
GTV-G	Guard Tank vent pressure gauge	VCRV-x	Vent cap relief valve
GTV-RV	Guard Tank vent relief valve	VCV-x	Vent cap valve
GTV-V	Guard Tank vent valve	VDC	Volts Direct Current
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)	VF-x	Liquid helium Fill line valve
LHe	Liquid Helium	VG-x	Gauge x of Vacuum Module
LHSD	Liquid Helium Supply Dewar	VM	Vacuum Module
LHV-x	Liquid Helium Supply Dewar valves	VV-x	Valve x of Vacuum Module
LLS	Liquid level sensor	VW-x	Valve x of Dewar Adapter
LM	Lockheed Martin Co.		

A. Scope

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

Heating the Main Tank to raise its pressure when the level is low should be done judiciously to avoid overheating the ullage gas, hence raising the temperature at Station 200 and the top of the lead bag to unacceptable levels (> 6 K).

B. Safety

B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware. Examples include: positioning Dewar in tilt stand; integrating probe with airlock; positioning airlock on Dewar; removing airlock from Dewar; removing probe from Dewar; and positioning support equipment such as pressurized gas cylinders and supply dewars.

A number of undesired events may be associated with these operations. For example, personnel or equipment can be struck when hardware is being moved (e.g. by forklift or crane load). Personnel are subject to entrapment while positioning hardware, such as hands or feet caught between objects as hardware is moved into place. Suspended hardware may be dropped. Personnel can be caught between objects such as forklifts and walls or loads and building support columns.

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

The SMD Safety Compliance Assessment, document GPB-100153C discusses the safety design, operating requirements and the hazard analysis of the SMD.

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

The high bay, LM Building 205, has 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 line deflectors are installed over the four burst disks on the SMD vacuum shell.

Only authorized and trained LM and SU personnel are allowed In the high-bay without escort. All personnel working at a height 30 inches or more off the floor are required to have an LM approved air tank within

easy reach. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the room and contact LM 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 and full-face shields are to be worn whenever the possibility of splashing cryogens exists.

B.2.3. Other Hazards

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

B.3. Mishap Notification

B.3.1. Injury

In case of any injury obtain medical treatment by immediately calling LM Call 117

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.

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 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 Test Director 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 test director or QA Representative, experiment functionality may be affected.

C.3. Discrepancies

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

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. 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. Qualified Personnel

The names of those actually performing this procedure are to be initialed and the name of the person acting as Test Director should be circled.

Test Director	Test Engineer
Mike Taber Dave Murray	Tom Welsh Dave Hipkins Bruce Clarke Ned Calder

E. Requirements

E.1. Electrostatic Discharge Requirements

This procedure does not include any equipment sensitive to electrostatic discharge.

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

E.3.2. Ground Support Equipment

The Ground Support Equipment includes the Gas Module, the Pump Module, the Electrical Module, and the Vacuum Module. The Gas Module provides the capability to configure vent paths, read pressures and flow rates, and pump and backfill vent lines. The Pump Module provides greater pumping capacity than the Gas Module, together with additional flow metering capabilities. The vent output of the Gas Module flows through the Pump Module. The Electrical Module contains the instruments listed in Table 1(see the Electrical Module Manual for details), and provides remote control of valves in the Gas Module, Pump Module, and SMD. The Vacuum Module contains a turbo pump, backed by a vane pump, and provides the capability to pump out the SMD vacuum shell.

This procedure uses hardware located in the Gas Module (Figure 1), the Pump Module (Figure 2) and the Electrical Module (Table 1). However, the Pump Module may be omitted if a stand-alone gas meter (a substitute for PFM-1) is connected at the Gas Module Vent Output. The primary helium vent and all vane pump exhausts must be connected to an outside vent.

E.3.3. Computers and Software:

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

E.3.4. Additional Test Equipment

Description	Manufacturer	Model
AMI Level Sensor Readout for LHSD	AMI	110

E.3.5. Additional Hardware

Description	Manufacturer	Model
Filter Line assembly	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. Tools

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

E.3.7. Expendables

Description	Quantity	Mfr./Part No.
Ethyl alcohol	AR	N/A
99.99% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Braycote Micronic 601
500 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	User Name	Serial No.	Cal Required	Status Cal due date
1	DAS	Power Supply, H-P 6627A	A1, A2, A3, A4	3452A01975	Yes	
2	DAS	Power Supply, H-P 6627A	B1, B2, B3, B4	3452A01956	Yes	
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A245539	No	-
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	
5	EM	Vacuum Gauge Controller Granville-Phillips Model 316	EG-1a, -1b	2827	No	-
6	EM	Vacuum Gauge Controller Granville-Phillips Model 316	AG-2a, -2b	2826	No	-
7	EM	Vacuum Gauge Controller Granville-Phillips Model 316	EG-3	2828	No	-
8	EM	MKS PDR-C-2C	EG-2, FCG	92022108A	No	-
9	EM	Flow meter – Matheson 8170	EFM-1	96186	No	-
10	EM	Flow meter totalizer Matheson 8124	EFM-1	96174	No	-
11	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Main Tank	96-409-11	No	-
12	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Guard Tank	96-409-10	No	-
13	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Well	96-409-9	No	-
14	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Axial Lock	96-409-12	No	-
15	EM	Pressure Controller – MKS 152F-92	EV-7a, -7b	96203410A	No	-
16	EM	Power Supply HP 6038A	H08D Tank Heater	96023407A	Yes	
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	
19	EM	Vac Ion Pump power supply 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	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 switches the state that EV-9 defaults to, should a power failure occur. It should be placed in the "NBP." position, for this procedure, 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 > 0.3 torr above atmosphere. Care must be taken at all times to keep its pressure above atmospheric.

E.5.3. Well

The Well is evacuated and the Well pump-out at VTH may be in one of the following configurations:

1) closed with the VTH operator removed;
2) have the Well manifold connected to a closed VTH; or
3) have an open VTH with a pumpout valve, VW-3, and convectron, PW-2, making up the Well manifold.

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure should be less than 1 x 10-4 torr. However, if this procedure is being used in conjunction with up-righting the dewar (P0633) and the Main Tank liquid level is very low (< 30%), priority should be given to filling the Main Tank. The fill operation, by cooling the vapor cooled shields, will result in a vacuum shell pressure less than the required 1 x 10-4 torr, and pumping on the vacuum shell can be deferred to a later date. Document No. P0213 contains the procedure for connecting to and pumping on the SMD vacuum shell.

E.5.5. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
    a. Station 200 temperature (CN 01) set at $T < 6.5$ K.
    b. Top of lead bag temperature set (CN 28) at $T \leq 6.0$ K.
    c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 0.3$ torr.
2. The Watch Dog alarm must be armed.

E.5.6. GSE and Non-flight Hardware

1. A relief valve or flight-like burst disk may be installed in place of the SMD fill-line burst disk.
2. The ion-pump magnet must be installed.
3. GSE cabling must be connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811).
4. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line, use procedure P0674, Connect Main Tank Vent Line to Gas Module – Main Tank at NBP if this is not the case.
5. The Guard Tank vent line is connected to the Gas Module.
6. The thruster vent port may be opened to an Endevco pressure transducer, STG.
7. The Fill Cap Assembly must be installed at SV-13 (Figure 3)
8. 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. A foreign object and debris shield may cover the upper cone of the SMD. If it is not present, any object that could cause damage to the payload, if dropped, must be tethered.
3. The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be off, actively pumping the pumping line up to a closed SV-14, or actively pumping the vacuum shell

E.7. Verification/ Success Criteria

N/A

E.8. Payload Constraints and Restrictions

N/A

F. **Reference Documents**

F.1. Drawings

Drawing No.	Title
LMMS-5833394	Instrumentation Installation

F.2. Supporting documentation

Document No.	Title
LMMC-5835031	GP-B Magnetic Control Plan
GPB-100153C	SMD Safety Compliance Assessment
EM SYS229	Accident/Mishap/Incident Notification Process
LMSC-P088357	Science Mission Dewar Critical Design Review
SU/GP-B P0108	Quality Plan
LMMS GPB-100333	Science Mission Dewar Failure Effects and Causes Analysis
SU/GP-B P059	GP-B Contamination Control Plan

F.3. Additional Procedures

Document No.	Title
SU/GP-B P0213	Connect Vacuum Module/ Pump on SMD Vacuum Shell
SU/GP-B P0674	Connect Main Tank Vent Line to Gas Module – Main Tank at NBP
SU/GP-B P0875	GP-B Maintenance and Testing at all Facilities
SU/GP-B P0879	Accident/Incident/Mishap Notification Process

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

G. Operations

G.1. Verify Appropriate QA Notification

G.1.1. Verify SU QA notified.
Record: Individual notified _____,
Date/time _____/_____.

G.1.2. Verify NASA representative notified.
Record: Individual notified _____,

G.1.3. Record calibration due dates in Table 1 (Sec. E.4).

G.1.4. Verify that persons actually performing this procedure have initialed their names in Sec. D.3 and the name of the Test Director is circled.

G.1.5. Verify Pre-ops meeting with operations group has been conducted.

G.1.6. Verify Purity of All Sources of Helium Gas
Record serial number on helium bottle/s.
1. _____ 2._____ 3. _____
4. _____ 5 _____ 6. _____

G.1.7. Verify helium bottle/s have been tested for purity and record Op. Number. Op. Number:_____

Date/time _____/_____.

Quality _____

G.2. 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 temperatures at Station 200 and the top of the lead bag are appropriately alarmed and continuously monitored to detect trends prior to alarm. Corrective action for over temperature is given in Appendix 3.

G.2.1. Ensure DAS Watch Dog Alarm enabled.

G.2.2. Ensure that Top Plate heaters on SMD are operational.

G.2.3. Verify GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.4. Record MT pressure (EG-3 and/ or STG) ____ torr ____ torr.

G.2.5. 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. Station 200 temperature – verify [CN 01] on DAS alarm list and set to alarm at $T \leq 6.5$ K. Record set point _____K
4. Top of lead bag temperature – verify [CN 28] on DAS alarm list and set to alarm at $T \leq 6.0$ K. Record set point _____K
5. Relative Guard Tank Pressure – verify [CN46] on DAS alarm list and set to alarm at $\Delta P \geq 0.3$ torr. Record set point _____torr

G.2.6. Verify Main Tank vent line connected to Gas Module. If not perform procedure P0674, Connect Main Tank Vent Line to Gas Module – Main Tank at NBP, to connect Main Tank vent.

G.2.7. Verify Guard Tank vent line connected to Gas Module. If not, preform procedure Pxxxx, Connect Guard Tank Vent Line to Gas Module , to connect Guard Tank vent.

G.2.8.

G.2.9. Verify Fill Cap Assembly installed at SV-13.

G.2.10. Ensure ion-pump magnet installed.

G.2.11. 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 1×10^{-4} torr, perform procedure P0213, Connect of Vacuum Module / Pump on SMD Vacuum Shell, to connect Vacuum Module and pump out SMD vacuum shell.

Note: if performing this procedure as part of up-righting the SMD and the Main Tank level is < 30%, fill the MT first after up-righting and then pump on the 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.2.12. Verify liquid in Main Tank is at NBP ($4.2 < T < 4.3$) and record temperature at bottom of tank CN [9] _____K.

G.2.13. Verify Actuator Control for EV-9 set to "NBP" position.

Section G.2 Complete Quality _____

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

G.3.1. 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.3.2. Record initial temperatures

1. Station 200 CN [01] _____ K.
2. Top of Lead Bag CN [28] _____ K.
3. Temperature at bottom of Main Tank CN 09] _____K.

G.3.3. Record pressures.

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

G.3.4. Record liquid level in Main Tank _____ %.

G.3.5. 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.

G.3.6. Record status of Well pump-out:

- VTH closed and Well manifold not installed.
- Well manifold installed, record valve positions and pressure:

VTH ____ , VW-3 _____ , PW-1 _____ torr.

Section G.3 complete. Quality_____

G.4. Verify SMD in Standard Configuration

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

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

G.4.2. Verify SV-9 open.

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

Section G.4 complete. Quality_____

G.5. Set Up Data Acquisition System

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

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

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

G.5.3. Record directory and data file name _____ .

G.5.4. Start "Special Data Cycle" by using [Other Menus] + [Special Data Col] + [Use Pre-Selected] + [Init. Collectn] + [Enter] (=use default file).

G.5.5. Record directory and special data file name _____ .

G.5.6. Set Main Tank Liquid Level Sensor sampling interval to 1 min.

G.5.7. Ensure printer is displaying special Data Cycle data.

Section G.5 complete. Quality_____

G.6. Check Initial Pressure in Fill Line

G.6.1. Install a pumping line between valve FCV on the Fill Cap Assembly and the Access Port #1 of the Auxiliary gas section.

G.6.2. Turn on pump AP-1.

G.6.3. Open AV-8 and AV-3.

G.6.4. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.6.5. Close AV-8 and FCV.

G.6.6. Once the pressure in the Fill Cap Assembly has stabilized, record

Fill Cap Assembly pressure (PFCG): _____ torr.

G.6.7. Open valve SV-13 to bring Fill Cap Assembly up to SMD Fill line pressure and record

Fill line pressure (PFCG): _____ torr.

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Section G.6 complete. Quality_____

G.7. Raise Pressure in Fill Line to Main Tank Pressure

G.7.1. 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.7.2. 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.7.3. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

Section G.7 complete. Quality_____

G.8. **Installing Stinger in LHSD**

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

G.8.1. Reduce the pressure in the liquid helium supply to < 1.0 psig by opening the low pressure relief valve.

G.8.2. Open valve VF-1 (Liquid withdrawal valve) on the stinger

G.8.3. Slowly insert the stinger into the LHSD while allowing it to be purged.

G.8.4. Close valve VF-1 just as cold gas is expelled from stinger.

G.8.5. Close the primary (low pressure) relief valve on the LHSD.

G.8.6. Increase LHSD ullage pressure builder to 6 to 10 psig byattaching an external source of Ghe to the ullage inlet per the following:

a. Attach a GHe hose to the VENT outlet of the LHSD while purging the hose and the VENT outlet.

b. Adjust pressure regulator to required LHSD driving pressure.

G.8.7. Record LHSD data:

Date / time: _____

Liquid level _____%

LHSD serial number: _____

Section G.8 complete. Quality_____

G.9. Installing Fill Line Assembly

G.9.1. 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.9.2. Install the Filter Line Assembly (P/N 5833827) to the Dewar Fill Bayonet B3.

G.9.3. 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.10. Condition the Transfer Line/Filter/Stinger Assembly

G.10.1. 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.10.2. 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.10.3. 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.10.4. 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.10.5. 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.11. **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 Station 200 and the top of the lead bag are appropriately alarmed and continuously monitored to detect trends prior to alarm. Corrective action for over temperature is given in Appendix 3.

G.11.1. Close EV-9.

G.11.2. 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.11.3. 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.

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%.

G.11.4. 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.12. 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.12.1. Verify closed VF-3.

G.12.2. Open SV-13.

G.12.3. Open VF-2.

G.12.4. Record Main Tank pressure (EG-3): _____ torr.

G.12.5. Close EV-23, Open EV-20: Guard Tank is now venting to "Vent Out" via ERV-6.

G.12.6. Open VF-3.

G.12.7. Monitor Tank pressures, EG-3, and reduce tank heater to maintain pressure below 820 torr.

G.12.8. 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.12.9. When a dense plume is evident from VF-2

and

When Fill Valve (SV-13) temperature T-24D [42] is < 75K,

G.12.10. **Close SV-13**.

G.12.11. **Immediately** open VF-1.

G.12.12. Power off Main Tank heater.

G.12.13. Open EV-9

G.12.14. 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.12.15. When a dense plume is evident from VF-2,

G.12.16. Close VF-2 and

G.12.17. **Immediately** open SV-13.

G.12.18. Close VF-3 when valve has warmed sufficiently.

G.12.19. Open EV-6 and EV-18.

G.12.20. 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.13. Verify Start of Transfer

G.13.1. Verify tank flow meter (PFM-1) of 50 to 100 liquid liters/hour.

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.

PFM1 (B) reading: _____

Start Time: _____

G.13.2. Record LHe level of LHSD: _____ %

G.13.3. Record all fill data on the attached data sheets every 15 minutes.

G.13.4. 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.14. Termination of Transfer

Date: _____ Time: _____

G.14.1. 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.
3. Close EV-6 and EV-18.

G.14.2. Place the Well in bypass mode:

1. Open/verify open EV-19.
2. Close EV-11.

G.14.3. Remove the pumping line from the Gas Module at valve VF-3.

G.14.4. Remove the Transfer and Filter Lines from the Dewar fill bayonet B3.

G.14.5. Install the Fill Cap Assembly.

Section G.14 complete. Quality_____

G.15. Conditioning the Dewar Fill Line

G.15.1. Connect a pumping line between the Fill Cap Assembly at valve FC and the Auxiliary Gas Section access port no. 1.

G.15.2. Close/verify closed valve AV-1 and AV-9.

G.15.3. Open AV-8 and AV-3.

G.15.4. Open/verify open valve FCV and evacuate Fill Cap Assembly to <25 mtorr measured at AG-2B.

G.15.5. Close FCV.

G.15.6. Open SV-13.

G.15.7. 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.15.8. 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.15.9. Open FCV and evacuate the Dewar fill line to < 25 mtorr as measured at AG-2b.

G.15.10. Close SV-13 and torque to 60 +/- 5 in-lbs.

G.15.11. Close FCV.

G.15.12. Close AV-8.

G.15.13. Open AV-1.

G.15.14. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.15.15. Close AV-1.

G.15.16. 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.15.17. 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.16. Configuration of Dewar and GSE

G.16.1. Record the reading on flowmeter EFM-1 and verify that helium is venting.

EFM-1 reading _____

G.16.2. Record the Main Tank liquid level (LL-1D or LL-2D): _____ %

G.16.3. Record the following pressures:

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

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

Section G.16 complete. Quality_____

G.17. Setting up Data Acquisition

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

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

G.17.2. Set DAS to configuration choice 4M.

G.17.3. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.17.4. 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.17.5. Set DAS to normal scan mode using [other menus], [data config], [normal scan]

G.17.6. Set DAS data cycle interval to 15 minutes.

G.17.7. Set Main Tank Liquid Level sampling interval to 10 minutes.

G.17.8. Confirm that the liquid level sensors are set at a sampling rate of 10 minutes or turned off.

G.17.9. Confirm that Vac-ion pump is off.

G.17.10. Enable/verify enabled the alarms on the Main Tank and Well Liquid Level Sensors.

G.17.11. Verify enabled the DAS alarm and record the set points:

a) CN ____, Level _____
b) CN ____, Level _____
c) CN ____, Level _____
d) Main Tank Level: _____ %
e) Well Level: _____ %

G.17.12. Ensure DAS watchdog timer and alarm enabled.

Section G.17 complete. _____

G.18. Final Closure of SV-13 and Conditioning the Dewar Fill Cap Assembly

G.18.1. 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.18.2. Verify that the Fill Cap Assembly is still evacuated and record:

PFCG pressure: _____
Date/Time: _____

G.18.3. Retorque SV-13 to 60 +/- 5 in-lbs.

G.18.4. Open AV-8.

G.18.5. Open FCV and evacuate to < 25 mtorr as measured at AG-2b.

G.18.6. Close AV-8.

G.18.7. Close/verify closed EV-12 and AV-9.

G.18.8. Open AV-1.

G.18.9. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1, then close AV-9.

G.18.10. Close AV-1.

G.18.11. Close FCV and record:

G.18.12. PFCG pressure: _____

G.18.13. Date/Time: _____

G.18.14. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.18.15. Close AV-8.

G.18.16. 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.18.17. Open AV-1.

G.18.18. Open AV-9 until pressure reaches 0 psig as read on gauge AG-1 and then close AV-9.

G.18.19. Close AV-1.

G.18.20. Close AV-3.

G.18.21. Remove the pumping line from the Fill Cap Assembly.

G.18.22. Install a KF-25 blank-off cap on valve FCV:

G.18.23. 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

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)

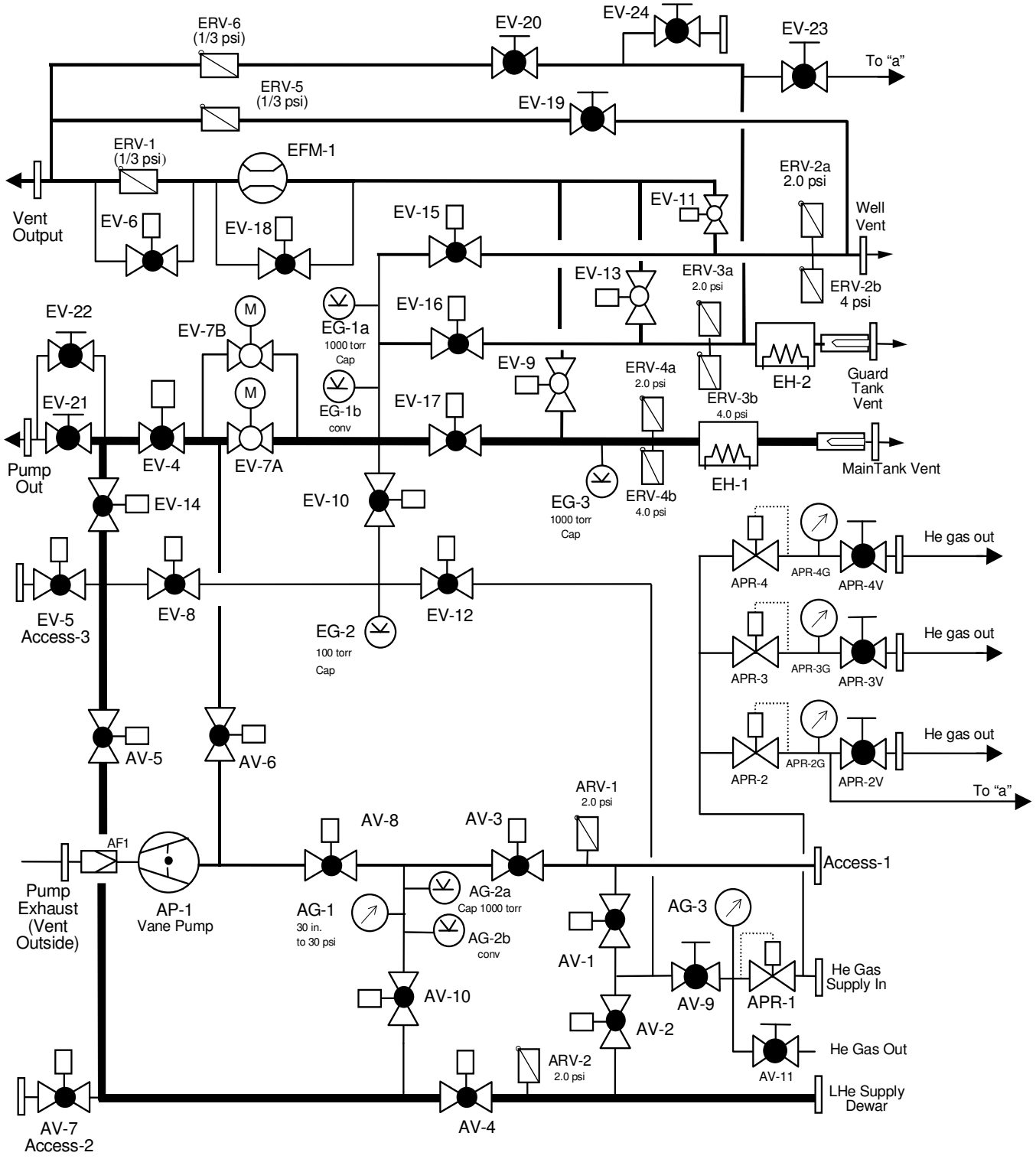

Figure 1. Schematic of Gas Module Plumbing. (GasModDwg4.doc)

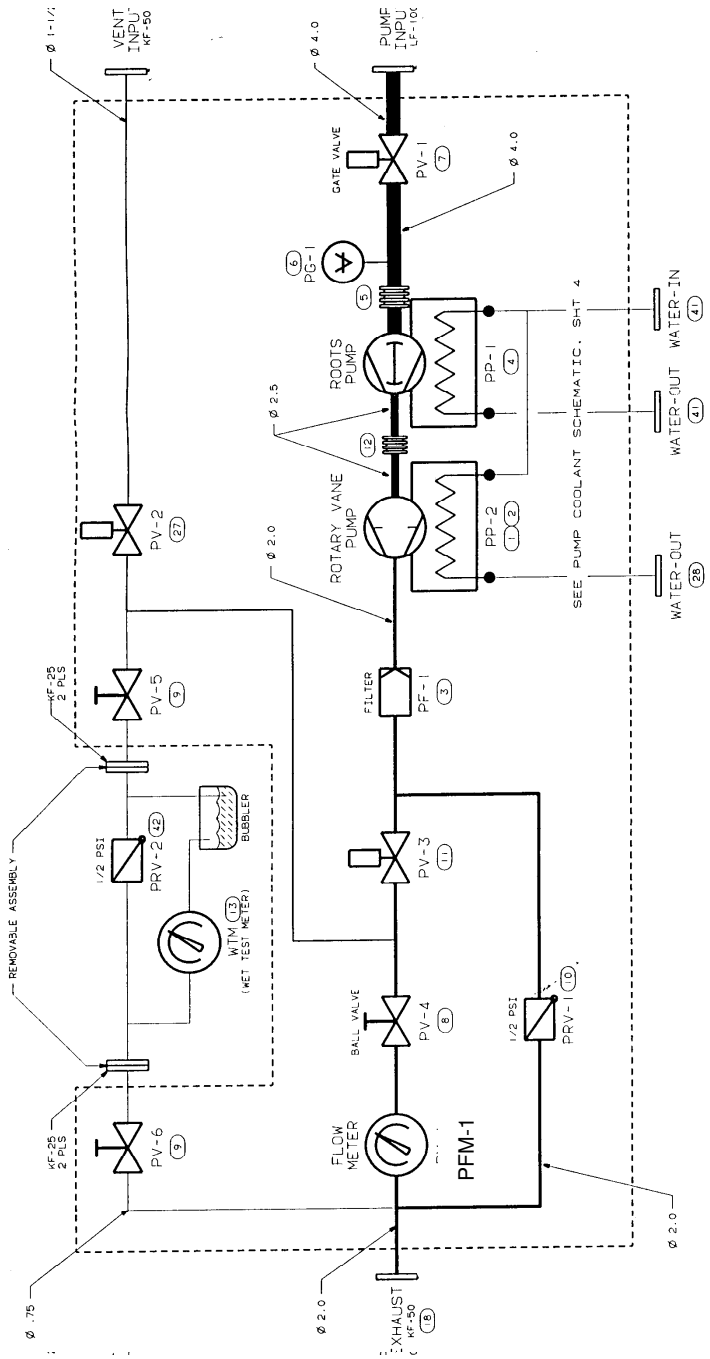

Figure 2. Schematic of Pump Module plumbing.

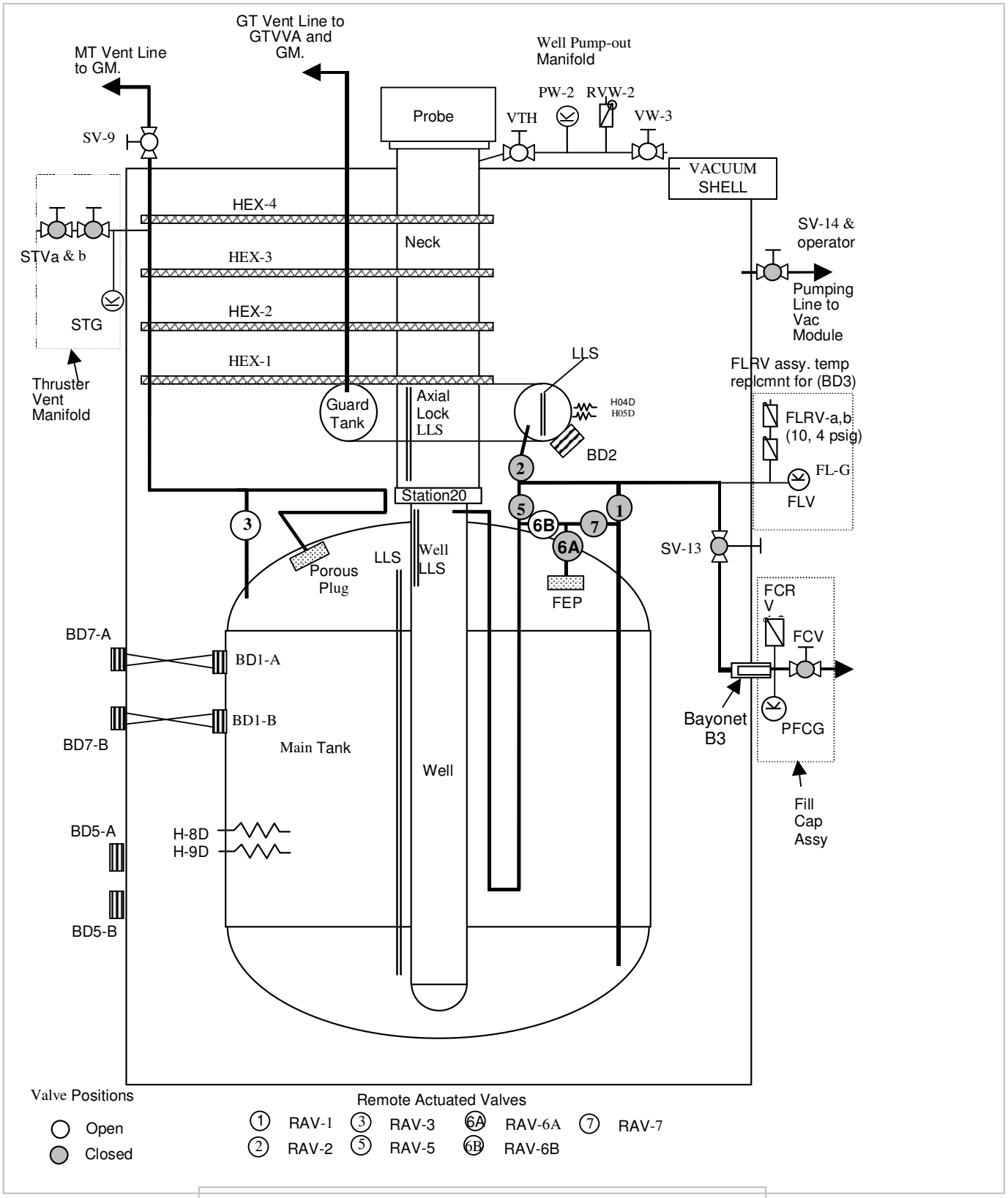

Figure 3. Schematic of Science Mission Dewar plumbing

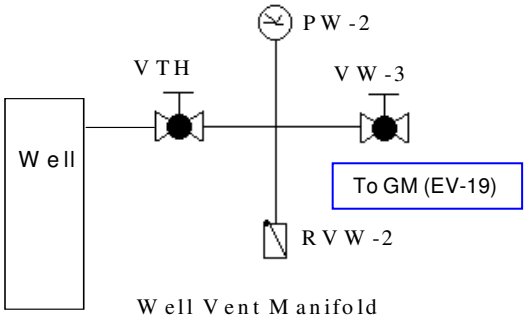

Figure 4 Well vent manifold.

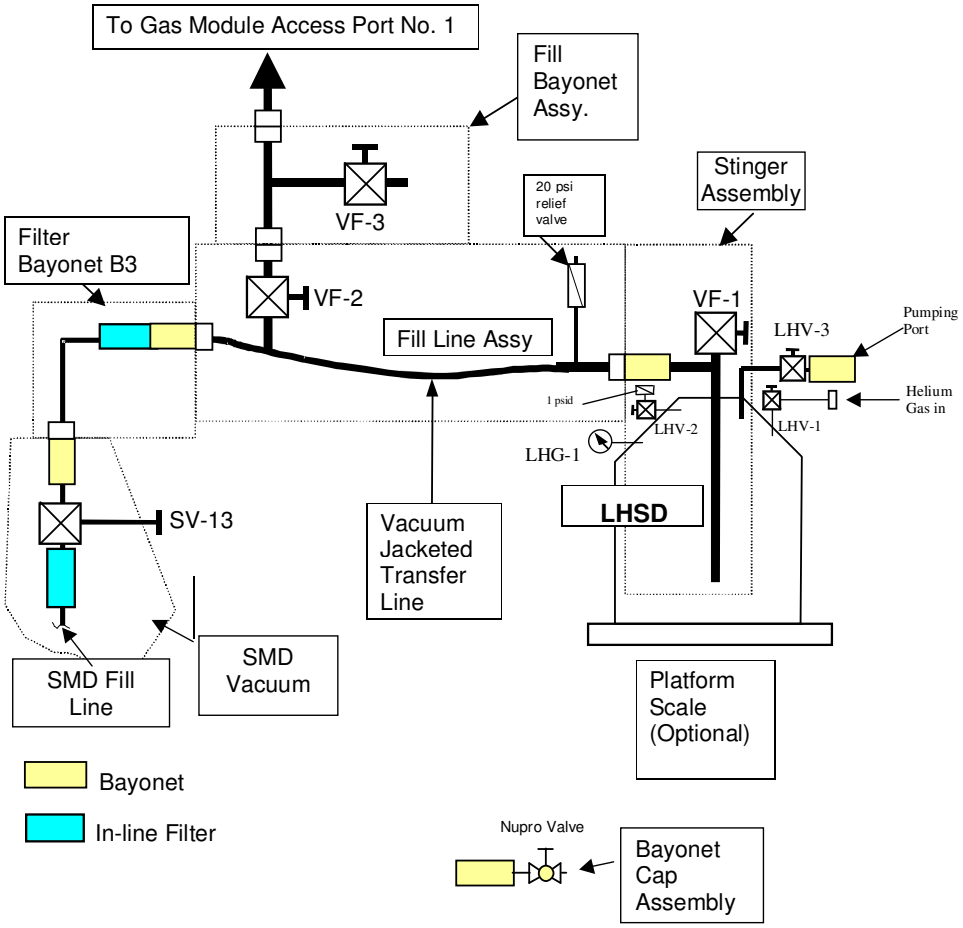

Figure 5. Schematic of liquid helium transfer plumbing

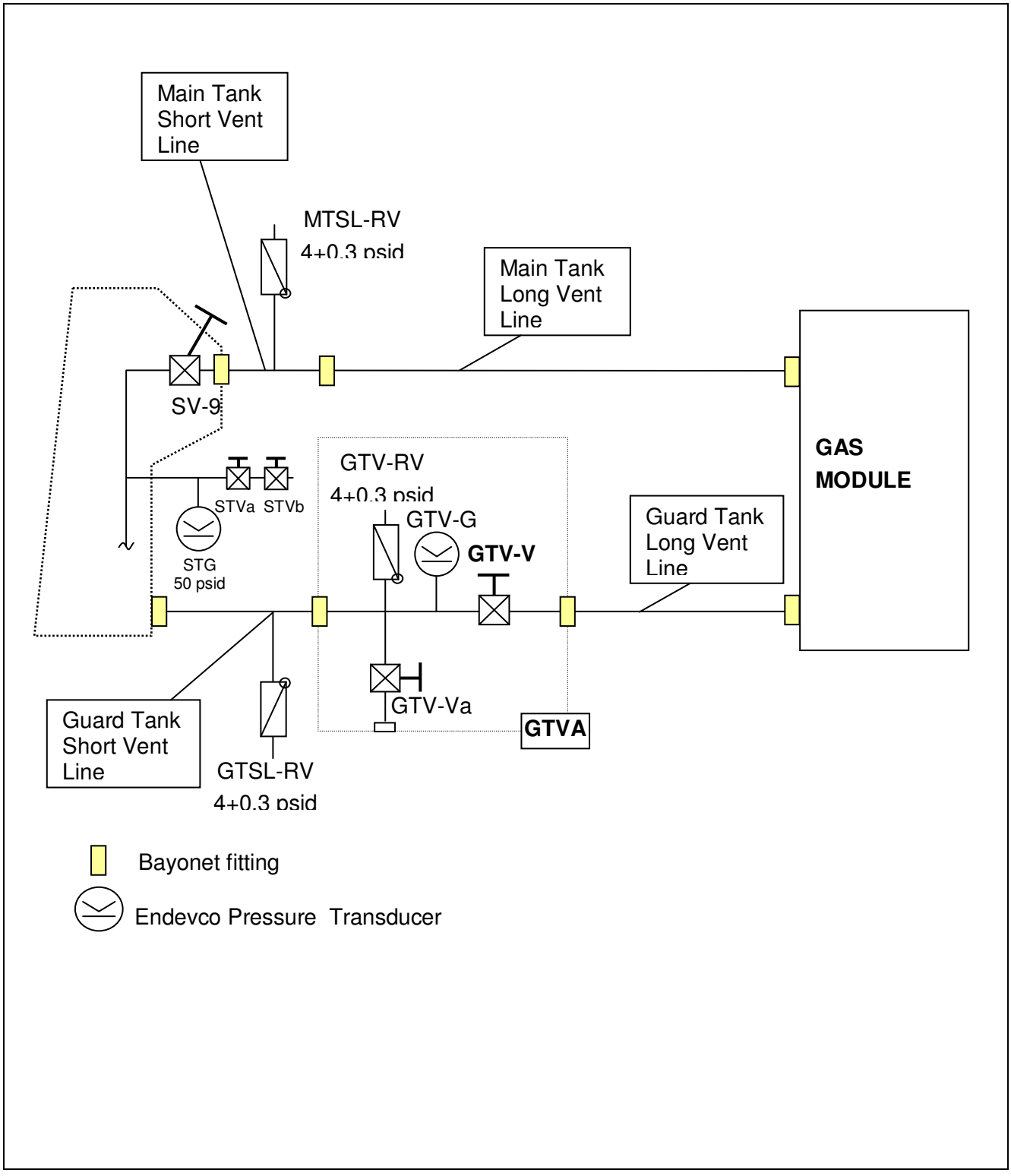

Figure 6. Main Tank and Guard Tank venting to Gas Module with Guard Tank Vent Assembly (GTVA) in place. (MT&GT_toGM_dwg.doc)

Appendix 1

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 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. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: _____		

Appendix 2

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: _____		

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)	ANY TIME	Evacuate room