GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

CONNECT MAIN TANK VENT LINE TO GAS MODULE – MAIN TANK SUBATMOSPHERIC

To be performed at Vandenberg Air Force Base building 1610

WARNING: THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

P1004

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REVISION RECORD

REVISION	ECO	PAGES	DATE

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List of Abbreviations and Acronyms

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

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 required to remove the Main Tank Vent Cap and connect the Main Tank vent line to the Gas Module, while liquid in the Main Tank is subatmospheric. The steps include:

Close and leak check Main Tank vent valve (SV-9)

Remove Vent Cap

Install and leak check vent line

Reestablish pumping on Main Tank (optional) with Pump Module or Gas Module.

The hazardous operation contained in this procedure is the handling of cryogenic nitrogen to service the leak detector.

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

In VAFB building 1610, 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 the 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 room 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 and full-face shields with eye goggles/glasses 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 space vehicle shall be tethered.

B.3. Mishap Notification

B.3.1. Injury

In case of any injury or illness requiring 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

Responses to contingencies/emergency (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.

1. If the discrepancy has minimal effect on procedure functionality (such as the state of a valve that is irrelevant to performance of the procedure) it shall be documented in the procedure, together with the resolution. Redlines to procedures are included in this category.
2. If the discrepancy is minor and affects procedure functionality but not flight hardware fit or function, it shall be recorded in the D-log. Resolution shall be in consultation with the PTD and approved by the QA representative.
3. All critical and major discrepancies, those that effect flight hardware fit or functions, shall be documented in a D-log and also in a Discrepancy Report, per P0108.

D. TEST PERSONNEL

D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. The 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

When working on the space vehicle, proper ESD protection is required. The wrist-strap will be checked using an appropriate calibrated checker 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) 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
Utility Turbo System (UTS) (see Figure 3)
Varian Helium leak detector calibrated leak S/N #:_____ cal. Due date:_____

E.3.5. Additional Hardware

1. Main Tank Vent Cap Assembly
2. Main Tank Vent Line
3. 4 liter cryogenic thermos (used for nitrogen fills)

E.3.6. Tools

Description
Torque Wrench, 1-1/4-in socket, 60 in-lb S/N #_____ Cal Due Date:_____

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. 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.*
Alcohol	AR	N/A
99.999% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Apeizon or Dow Corning High Vacuum grease

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.

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, 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	LLS Main	96-409-11	No	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
		American Magnetics, Inc. 136	Tank			
12	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Guard Tank	96-409-10	No	-
13	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Well	96-409-9	No	-
14	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Axial Lock	96-409-12	No	-
15	EM	Pressure Controller – MKS 152F-92	EV-7a, -7b	96203410A	No	-
16	EM	Power Supply HP 6038A	H08D Tank Heater	96023407A	Yes	
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	
19	EM	Vac Ion Pump power supply Varian 929-0910, Minivac	SIP	5004N	No	-
20	EM	Flow meter totalizer Veeder-Root	PFM-1	576013-716	No	-
21	GM	Pressure Gauge, Heise	AG-1	CC-122077	No	-
22	GM	Pressure Gauge, Marshall Town	AG-3	N/A	No	-
23	GM	Main Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	-	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	-	C-09920	No	-
25	VM	Vacuum Gauge readout, Granville-Phillips 316	VG-3 VG-4	2878	No	-
26	VM	Vacuum Gauge readout, Granville-Phillips 360	VG-1, VG-2 VG-5	96021521	No	-

E.5. Configuration Requirements

E.5.1. Main Tank

Liquid in the Main Tank is subatmospheric.

E.5.2. Guard Tank

The Guard-Tank may contain liquid, or be depleted. There is no required liquid level. When the Guard Tank is depleted, its pressure must be independently regulated from a source of 99.999% pure helium gas.

E.5.3. Well

The Well is evacuated

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure shall be <5 *10E-5.

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 (175) set at T ≤ 6.5 K.

b. Top of lead bag temperature set (CN 178) set at T ≤ 6.0 K.

c. Relative Guard Tank Pressure (CN 46) set at □P ≥ 0.3 torr.

2. The watchdog timer must be armed

E.5.6. GSE and Non-flight Hardware

1. 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).

E.6. Optional Non-flight Configurations

The following modifications or non-flight arrangement of the basic SMD configuration may also be in place. They are incidental to the performance of this procedure and not required.

1. The SMD is installed in its transportation and test fixture.
2. The ion-pump magnet is installed.
3. The Guard Tank may be connected to the Gas module via a vacuum insulated or line, or be disconnected at GTVVA with a Vent Cap installed.
4. 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 open or closed 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.
5. The Fill Cap Assembly is installed at SV-13 (See Figure 3)

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

G.2.1. Record serial number on helium bottle/s.

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

G.2.2. Verify helium bottle/s have been tested for purity and record Op. Number.
Op. Number:_____

QA Witness:_____

G.3. Verify Configuration Requirements

G.3.1. Ensure Electrical Module interlock override switch is off (blinking light off) to prevent accidental opening of EV-15 and EV-16.

G.3.2. Verify liquid in Main Tank subatmospheric and record:

1. Temperature at bottom of Main Tank CN [09] _____K.
2. Main Tank Pressure _____ torr

G.3.3. Ensure DAS alarm system enabled and record set points.

1. ***Top of lead bad temperature*** – ensure CN [175] on DAS alarm list and set to alarm at $T \leq 6.0$ K. Record set point. _____K
2. ***Top of lead bag temperature*** – ensure CN [178] on DAS alarm list and set to alarm at $T \leq 6.0$ K. Record set point. _____K
3. ***Relative Guard Tank pressure*** – ensure CN [46] on DAS alarm list and set to alarm at $\Delta P \geq 0.3$ torr. Record set point. _____torr

G.3.4. Ensure liquid-level alarms enabled and record set points.

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

Section Complete: QA Witness: _____

G.4. **Establish Gas Module Configuration and Record Initial Conditions**

G.4.1. Record Guard Tank pressure relative to atm. (GTV-G) _____ torr.

G.4.2. Record Guard Tank configuration:

- o Guard Tank contains liquid and is not connected to Gas Module.
  1. Ensure GTV-V open.
  2. Close/verify closed all EV valves.

- o Guard Tank is depleted and not connected to Gas Module.
  1. Ensure GTV-V closed.
  2. Ensure Guard Tank pressure regulated by APR-2 at GTV-Va.
  3. Close/verify closed all EV valves.

- o Guard Tank contains liquid, is connected to Gas module, and venting through EV-13.
  1. Ensure GTV-V open.
  2. Ensure EV-13 open.
  3. Ensure all other EV valves closed.

- Guard Tank contains liquid, is connected to Gas module, and venting through EV-20.
  1. Ensure GTV-V open.
  2. Ensure EV-20 open.
  3. Ensure all other EV valves closed.

- Guard Tank depleted and connected to Gas Module.
  1. Ensure GTV-V open.
  2. Ensure Guard Tank pressure regulated by APR-2 at EV-23.
  3. Ensure EV-23 open.
  4. Close/verify closed all other EV-valves.

G.4.3. Close/verify closed all AV valves.

G.4.4. Record status of Main Tank Vent Cap

1. Tank pressure (VCP-1):_____ torr
2. Seal pressure (VCP-2):_____ psig

Section Complete QA Witness:_____

G.5. Close and Leak Check Main Tank Vent Valve

CAUTION:
During the period of Main Tank vent closure the temperature at the top of the lead bag are to be continuously monitored by the test director. Failure to comply may result in equipment damage

G.5.1. Close SV-9 to 60 in-lbs and record date/time : _____/_____ .

QA Witness:_____

G.5.2. Install a pumping line between the Main Tank Vent Cap Assembly at valve VCV-1 and the Auxiliary Gas Section access port no. 1.

G.5.3. Turn on/verify on pump AP-1.

G.5.4. Open AV-3 and AV-8.

G.5.5. Open VCV-1 and evacuate to <25 mtorr measured at AG-2b.

G.5.6. Close AV-8.

G.5.7. Open AV-1.

G.5.8. Open AV-9 until pressure at AG-1 reaches 0.0 psig, and close AV-9.

G.5.9. Close VCV-1.

G.5.10. Verify that pressure VCP-1 does not change by more than 1 torr in 20 minutes while recording in 4 min. intervals

Time (min)	0	4	8	12	16	20

VCP-1 (torr)						

G.5.11. Pass/Fail: _____ torr/ 20 min: _____.

QA Witness:_____

G.5.12. If leak-back test fails, retorque SV-9 to 60 in-lbs and repeat test.

1. Verify that pressure VCP-1 does not change by more than 1 torr in 20 minutes while recording each minute:

Time (min)	0	4	8	12	16	20
VCP-1 (torr)						

2. Pass/Fail: _____ torr/ 20 min: _____.

QA Witness:_____

G.5.13. Close/verify closed all AV valves.

G.5.14. Remove pumping line from Main Tank Vent Cap Assembly.

Section Complete QA Witness:_____

G.6. **Connect Main Tank Vent Line**

G.6.1. Remove Vent Cap – record location:

- Bayonet at SV-9.
- Bayonet at end of short line opposite SV-9.

G.6.2. Remove o-ring from bayonet receptacle and inspect for defects or damage. Replace if any found and record in o-ring log.

G.6.3. Clean o-ring and lightly coat with Apiezon N before installation.

G.6.4. Install Main Tank vent line between Gas Module (at inlet to Main Tank heat exchanger) and location of Vent Cap removal. Install bags around new joint(s).

Section Complete QA Witness:_____

WARNING

The following operations involve steps that pose a cryogenic safety hazard. When filling the nitrogen trap in the leak detector, wear cryogenic safety apron, gloves, face shield with goggles/glasses, and non-absorbent shoes. Failure to comply may result in personal injury.

G.7. **Leak Check Main Tank Vent Line**

G.7.1. Ensure a six foot clear area is established around leak detector.

G.7.2. Make PA announcement for start of a hazardous operation.

G.7.3. Ensure all nonessential personnel depart the controlled area.

G.7.4. Ensure facility warning light is changed to amber.

G.7.5. Turn on and verify calibration of leak detector. Record

1. calibrated leak value _____ sccs
2. measured leak value _____ sccs

NOTE

The operations that involve steps that pose a cryogenic safety hazard are now complete. Make a PA announcement for end of the hazardous operation and to resume of normal operations. Turn Area Warning Lights to Green and disband controlled area.

G.7.6. Connect leak detector to the UTS at access port (LD).

G.7.7. Ensure EV-5 closed.

G.7.8. Install UTS/Leak detector to Access port #3 of Gas Module and start the UTS pumping up to closed EV-5, as follows:

1. Place valve interlock switch in “over-ride” position.
2. Turn on vane pump and converter (Note: converter switch provides power to turbopump controller and pirani and cold-cathode vacuum-gauge display.

3. Push the red “reset” button to activate the interlock over-ride circuit. (the yellow-orange indicator light will come on).
4. Turn “foreline” switch on, to open TV-2, and verify that the switch is illuminated.
5. Push the “Sensor” button on the vacuum gauge display to read the foreline pressure (TG-4). This is the pirani gauge. The “Pir” annunciator will appear in upper left corner of the display).
6. Open TV-4.
7. When foreline pressure (TG-4) < 1 torr, push “Start” button on turbo controller.
8. When the ”Normalbetrieb” light illuminates on turbo controller, indicating turbopump is up to speed, close TV-4 and open gate valve TV-1.
9. Switch the valve interlock switch to the “protected” position.
10. Push the “Sensor” button on the vacuum gauge readout so that the “Hi-Vac” annunciator shows, and push the “Emis” button to turn on the cold cathode gauge (TG-1).
11. Record the pumping line pressure (TG-1) _____ torr.

G.7.9. Open EV-4, EV-14, and EV-17.

G.7.10. Record settings of EV-7a _____ and EV-7b_____ and open fully.

G.7.11. Evacuate Main Tank vent plumbing with Gas Module

1. Open AV-6 and AV-8.
2. Once pressure is < 25 mtorr as measured at AG-2b, close AV-6 and AV-8.

G.7.12. Open EV-5 and evacuate with UTS/leak detector, as follows:

1. Verify that leak detector is operational and pumping up to closed valve TV-3.
2. Open TV-3 and close the foreline valve (TV-2)
3. Pump until background level is < $1x10^{-5}$ scc/s.

G.7.13. Purge bagged joints with GHe for 2 minutes and record:

1. O-ring location: _____

Time (min)	0	1/2	1	1 1/2	2
LD (ssc/s)					

2. Pass/Fail: _____ (Pass= **no** increase from initial background)
3. O-ring location: _____

Time (min)	0	1/2	1	1 1/2	2

LD (ssc/s)					

4. Pass/Fail: _____ (Pass= **no** increase from initial background)

5. O-ring location: _____

Time (min)	0	1/2	1	1 1/2	2
LD (ssc/s)					

6. Pass/Fail: _____ (Pass= **no** increase from initial background)

G.7.14. Close EV-4, EV-5, and EV-14 and remove UTS/Leak Detector if not going to use for more operations.

Section Complete QA Witness:_____

G.8. **Reestablish Initial Gas Module Configuration**

G.8.1. Place Gas Module valves in initial configuration:

Note:

Before reestablishing Main Tank venting place the Gas Module valves in the same states they were in to start with (i.e., the states established in Paragraph G.3.3. Those states are repeated below.

- Guard Tank contains liquid and is not connected to Gas Module.
  3. Ensure GTV-V open.
  4. Close/verify closed all EV valves.

- Guard Tank is depleted and not connected to Gas Module.
  4. Ensure GTV-V closed.
  5. Ensure Guard Tank pressure regulated by APR-2 at GTV-Va.
  6. Close/verify closed all EV valves.

- Guard Tank contains liquid, is connected to Gas module, and venting through EV-13.
  4. Ensure GTV-V open.
  5. Ensure EV-13 open.
  6. Ensure all other EV valves closed.

- Guard Tank contains liquid, is connected to Gas module, and venting through EV-20.
  4. Ensure GTV-V open.
  5. Ensure EV-20 open.
  6. Ensure all other EV valves closed.

- Guard Tank depleted and connected to Gas Module.
  5. Ensure GTV-V open.
  6. Ensure Guard Tank pressure regulated by APR-2 at EV-23.
  7. Ensure EV-23 open.
  8. Close/verify closed all other EV-valves.

G.8.2. Close/verify closed all AV valves.

Section Complete QA Witness:_____

G.9. **Resume Pumping on Main Tank**

G.9.1. Record desired Main Tank configuration

- Pump on Main Tank with Pump Module (PP-1/PP-2), perform Section

	G.8.2.
	o Pump on Main Tank with Gas Module (AP-1) perform Section G.8.3.

G.9.2. **(Option)** Establish Pumping on Main Tank With Pump Module

Note:

This operation assumes that the plumbing between the Pump Module and the Gas Module has been successfully leak checked.

1. Ensure PV-1, PV-2, and PV-4 open.
2. Ensure PV-3, PV-5, and PV-6 closed.
3. Initiate Pump Module:
    a. Turn on water cooling of pump module.
    b. Ensure EV-4 EV-21/22, EV-14 , EV-5, EV-8, and EV-12 closed.
    c. Turn on rotary vane pump PP-2 and Blower PP-1.
    d. Once pressure at PG-1 has come to equilibrium –

    Record pressure(PG-1) _____ torr.
4. Ensure EV-9, EV-15, and EV-16 closed.
5. Open EV-4 and EV-21.
6. Open EV-10 and EV-17.
7. Set EV-7 valves on manual control and adjust to full closure.
8. Record the following:
    a. Date/time of day _____/_____
    b. Main Tank Temp (T-9D):_____ K
    c. Guard Tank Temp (T-15D)_____ K
    d. Vacuum Module pressure (VG-1) if connected:_____ torr
9. Enter comment in DAS “Begin pumping on Main Tank with Pump Module.”
10. Open SV-9.
11. Adjust EV-7 valves to value previously recorded in Section G.6.6.
12. Open PV-3.
13. Once conditions have stabilized, record the following:
    a. Date/time of day:_____/_____
    b. Main Tank level:_____ %
    c. Flowrate (PFM-1, scale B):_____ Ll/hr
    d. Flow meter (PFM-1, scale C):_____ Ll x 60
    e. Main Tank Temp (T-9D):_____ K
    f. Guard Tank Temp (T-15D)_____ K
    g. Main Tank exit pressure (EG-2):_____ torr

h. Vacuum Module pressure (VG-1) if connected:_____ torr
i. Record EV-7a valve position:_____ %
j. Record EV-7b valve position:_____ %

14. Skip to Paragraph G.9.

G.9.3. **(Option)** Establish Pumping on Main Tank With Gas Module

1. Ensure EV-9, EV-15 and EV-16 closed.
2. Turn on/verify on AP-1.
3. Set EV-7 valves on manual control and adjust to full closure.
4. Open EV-10 and EV-17.
5. Open AV-6.
6. Record the following:
   a. Date/time of day _____/_____
   b. Main Tank Temp (T-9D) _____ K
   c. Guard Tank Temp (T-15D) _____ K
   d. Vacuum Module pressure (VG-1) if connected _____ torr
7. Enter comment in DAS “Begin pumping on Main Tank with AP-1.”
8. Open SV-9.
9. Adjust EV-7 valves to value previously recorded in Section G.6.6.
10. Once conditions have stabilized, record the following:
    a. Date/time of day _____/_____
    b. Main Tank level _____ %
    c. Main Tank Temp (T-9D) _____ K
    d. Guard Tank Temp (T-15D) _____ K
    e. Main Tank exit pressure (EG-2) _____ torr
    f. Vacuum Module pressure (VG-1) if connected _____ torr
    g. Record EV-7a valve position _____ %
    h. Record EV-7b valve position _____ %

G.9.4. Continue with Paragraph G.9.

Section Complete QA Witness:_____

G.10. **Establish Final Alarm Configuration**

G.10.1. Ensure DAS alarm enabled and record set points if changed

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

a. Top of Lead Bag set point [CN 175] _____ K (≤ 6.0 K)

b. Top of Lead Bag set point [CN 178] _____ K (≤ 6.0 K)

G.10.2. Ensure liquid level sensor alarms enabled, as appropriate, and record set points if changed.

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

G.10.3. Verify completion of the post operations checklist

G.10.4. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential.

Section Complete QA Witness:_____

H. **PROCEDURE COMPLETION SIGN OFF**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

I.

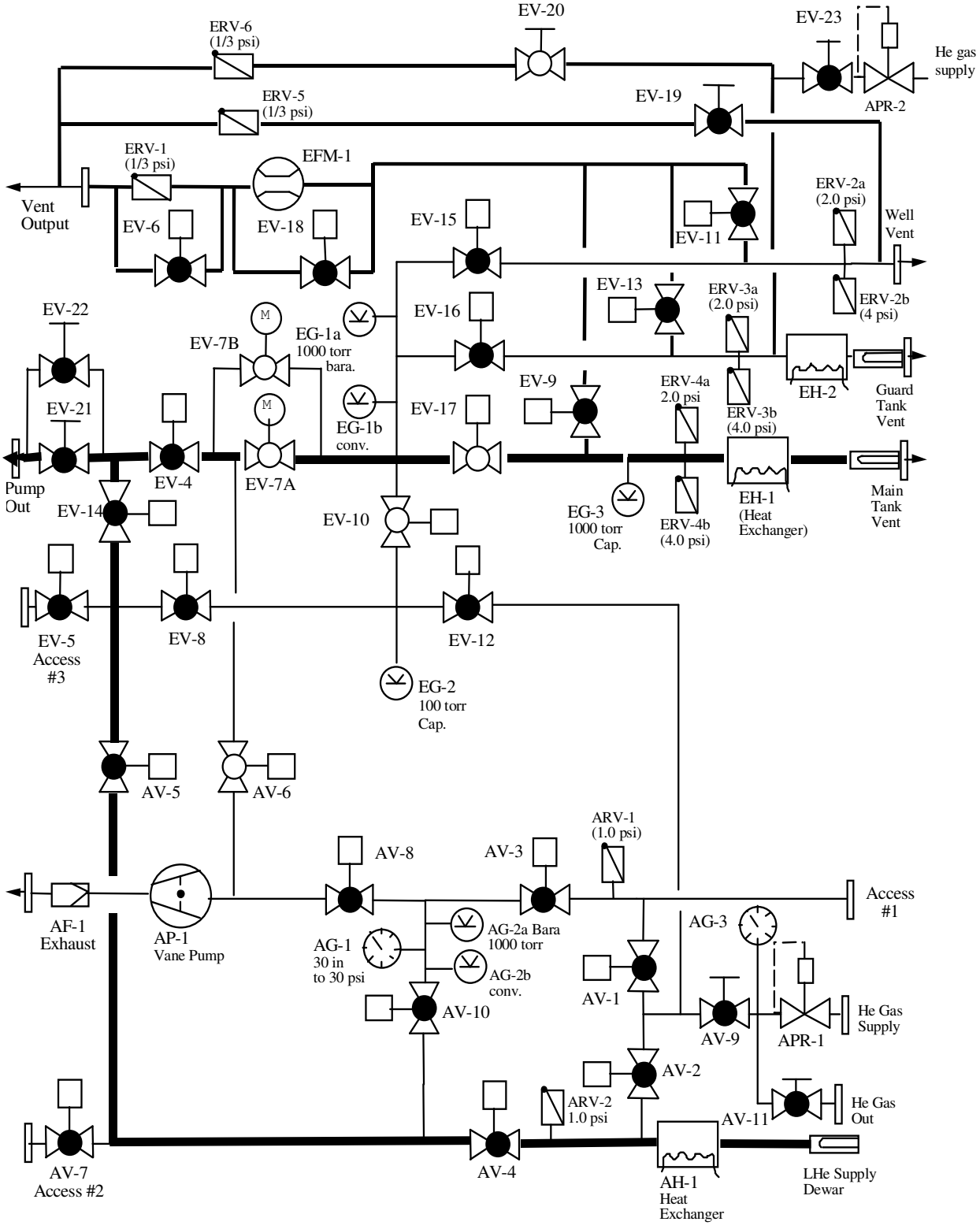

Figure 1. Schematic of Gas Module plumbing. Valve configuration corresponds to likely final configuration – Main Tank bath being pumped by AP-1 and the Guard Tank, with liquid, venting through EV-20.

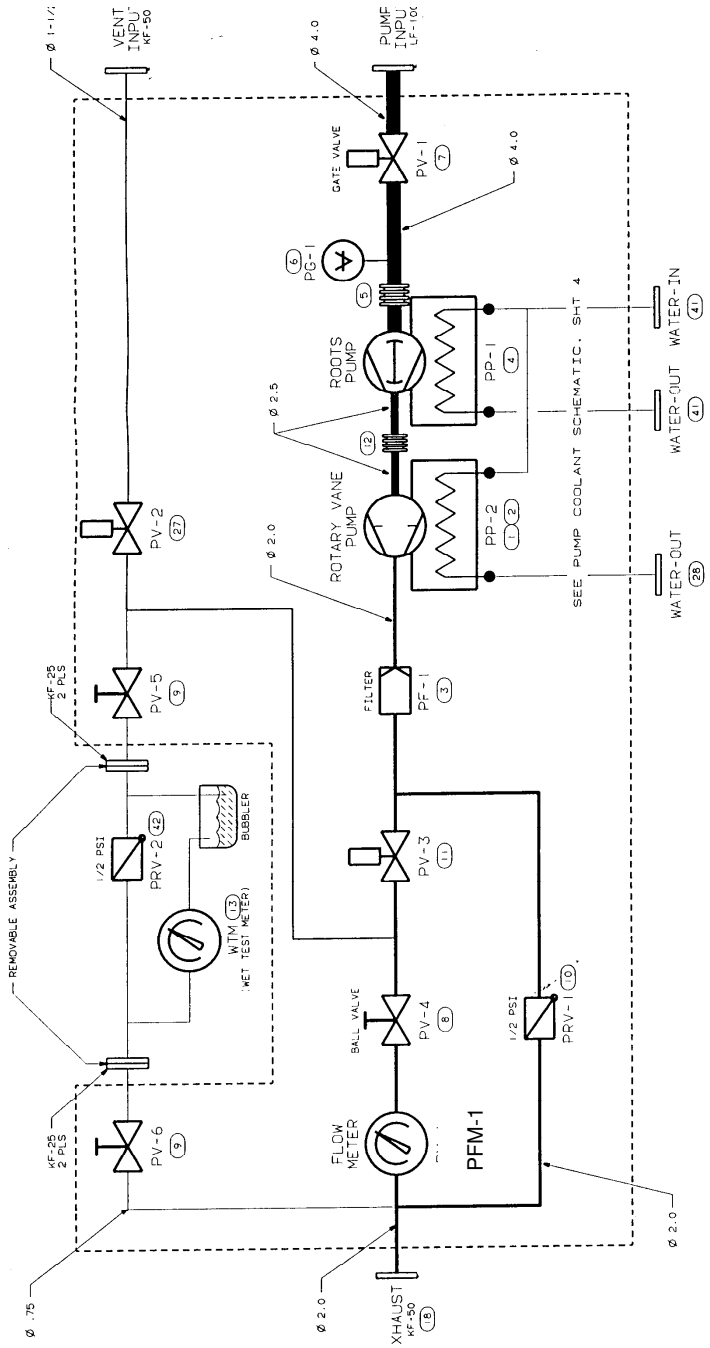

Figure 2. Schematic of Pump Module plumbing.

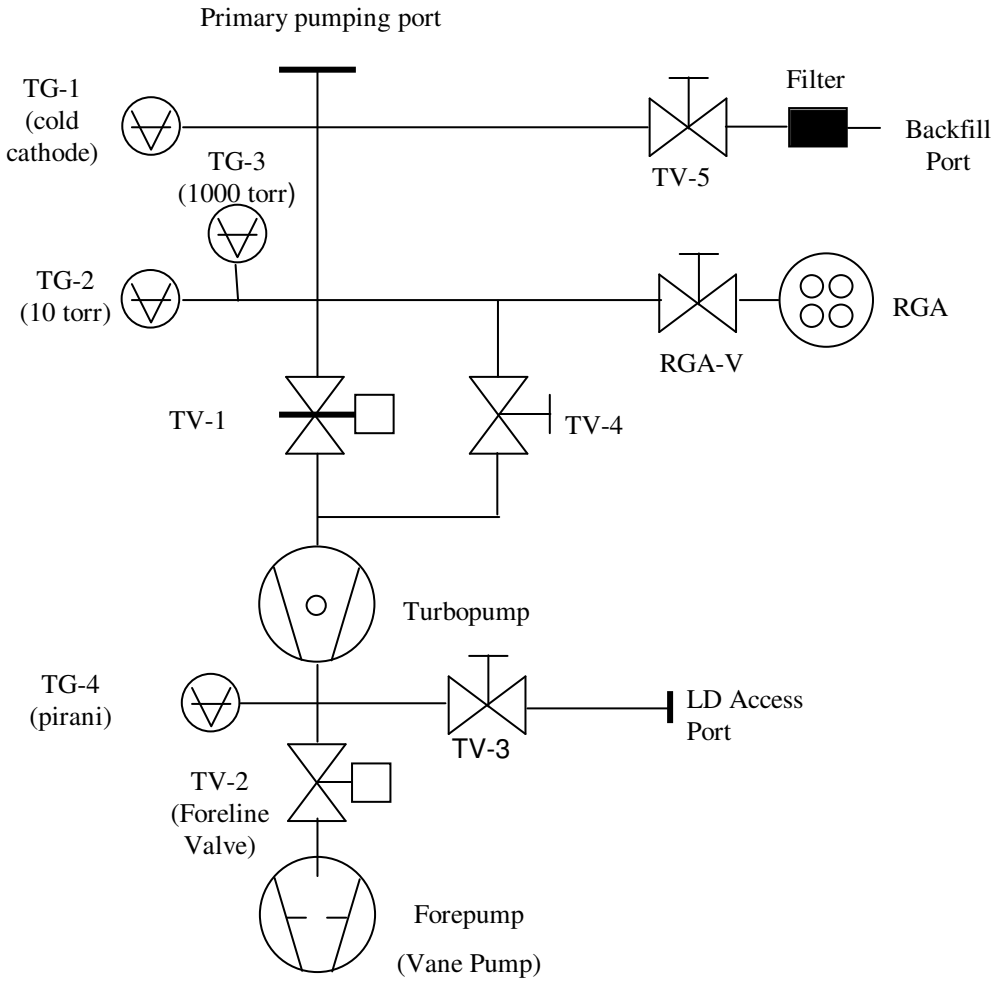

Figure 3. Schematic diagram of Utility Pumping System (UTS)

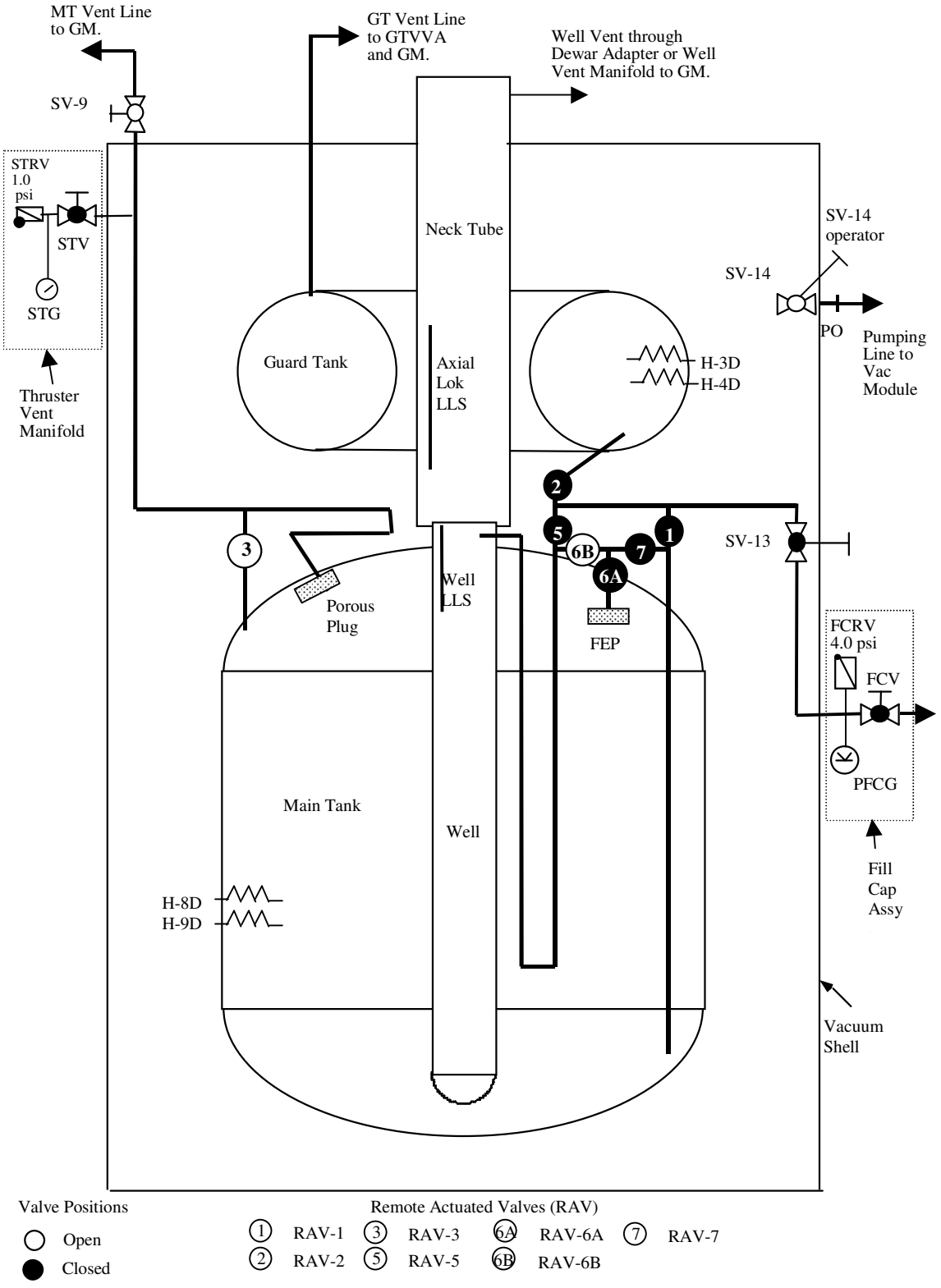

Figure 4. Schematic of Science Mission Dewar plumbing.

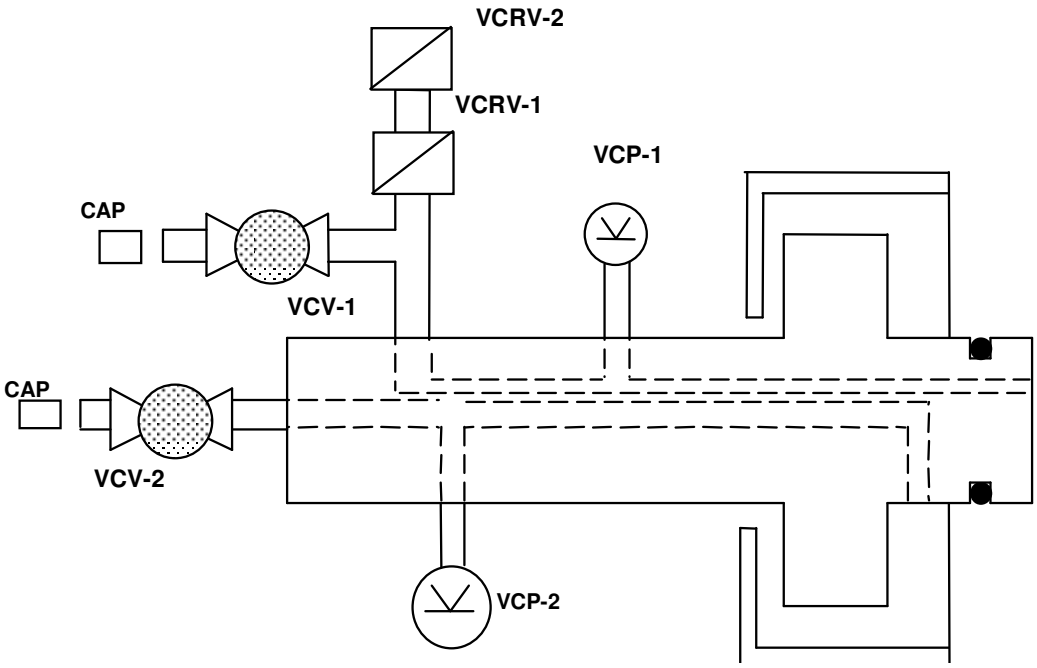

Figure 5. Main Tank Vent Cap Assembly for subatmospheric applications.

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 for the task being performed and knows their 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. Perform a pretest 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: _____		

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.		
	7. 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/EMERGENCY RESPONSES

Condition	Circumstance	Response
Power Failure	Anytime	Wait for power restoration, and resume procedure
Liquid nitrogen spill	Anytime	Clear area until all spilled liquid has evaporated
Burst disk rupture (MT/GT)	Any time	Evacuate room
Oxygen Monitor Alarm	Any time	Evacuate room