GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

PUMP DOWN MAIN TANK TO SUBATMOSPHERIC CONDITION

P0215A
ECO 1093

June 21, 2000

Revised by

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Revision Record

Rev	***ECO***	***Pages***	***Date***
A	1093	Section A – Revised scope to accurately summarize content of procedure. Section B – Divided into two sections, addressing safety issues (new Section B) and test personnel (new Section D). Reorganized safety paragraphs into: hazards, mitigation, injuries. Content of both new sections essentially unchanged. Added Quality Assurance Section (new Section C) Section C, D, and E – Consolidated all requirements into new Section E entitled Requirements. Added Configuration requirements, GSE/SMD interface requirements, alarm setup requirements, vacuum requirements, and non-flight hardware requirements. Section G – added sections to verify QA notification and verify configuration requirements. Added steps to heat Guard Tank during pump-down to maintain positive GT pressure. Added caution to monitor and maintain positive Guard Tank pressure, added sections to verify DAS and facility main alarms enabled. Removed requirement to have RGA connected to high-vacuum pumping system.	6/21/00

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
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

A. SCOPE

This procedure describes the steps necessary to pump down the Main Tank of the Science Mission Dewar to a subatmospheric condition. The steps include:

Ensure Vacuum Module pumping up to closed SV-14.

Pump on Main Tank with Pump Module.

Control pumping rate with EV-21/22, switching to EV-7a/b at low pressures

Pump down to superfluid temperature

Switch pumping to Gas Module (AP-1) to maintain constant temperature and pressure.

B. SAFETY

B.1. Potential Hazards

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

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

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

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

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

The FIST OPS laboratory has an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. Additional temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions. Emergency vent line deflectors are installed over the four burst disks on the SMD vacuum shell, and oxygen collection pans are on the floor beneath them.

The following requirements apply to personnel involved in cryogenic operations. Gloves that are impervious to liquid helium and liquid nitrogen are to be worn whenever the possibility of splashing or impingement of high-velocity cryogens exists or when handling equipment that has been cooled to cryogenic temperatures. Protective clothing and full-face shields are to be worn whenever the possibility of splashing cryogens exists.

The FIST Emergency Procedures document, SU/GP-B P0141, discusses emergency procedures. These documents should be reviewed for applicability at any facility where the hardware is operated.

B.3. Injuries

In case of any injury obtain medical treatment as follows
LMMS **Call 117;** Stanford University **Call 9-911**

C. QUALITY ASSURANCE

C.1. QA Notification

The ONR representative and SU QA shall be notified 24 hours prior to the start of this procedure. Upon completion of this procedure, the QE Manager will certify his/her concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating in the designated place(s) in this document.

C.2. Red-line Authority

Authority to red-line (make minor changes during execution) this procedure is given solely to the PTD or his designate and shall be approved by the QA Representative. Additionally, approval by the Hardware Manager shall be required, if in the judgement of the PTD or QA Representative, experiment functionality may be affected.

C.3. Discrepancies

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

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

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

D. TEST PERSONNEL

D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. The Test Director is the designated signer for the “witnessed by” sign-off located at the end of each procedure. The person in charge of the operation (Test Director or Test Engineer) is to sign the “completed by” sign-off.

D.2. Personnel Qualifications

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

D.3. Qualified Personnel

Test Director	***Test Engineer***
Mike Taber	Tom Welsh
Dave Murray	Chris Gray
Jim Maddocks	Bruce Clarke
Dave Frank	

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 and provides remote control of valves in the Gas Module, Pump Module, and SMD. The Vacuum Module contains a turbo pump, backed by a vane pump and provides the capability to pump out the SMD vacuum shell.

This procedure calls for use of hardware located in the Gas Module (Figure 1), the Pump Module (Figure 2), the Vacuum Module (Figure 3), and the Electrical Module (Table 1).

E.3.3. Computers and Software

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

E.3.4. Additional Test Equipment

No additional test equipment is required.

E.3.5. Additional Hardware

No additional hardware is required

E.3.6. Tools

No tools are required for this operation.

E.3.7. Expendables

No expendables are required for this operation.

E.4. **Instrument Pretest Requirements**

The GSE instruments required to perform this procedure are listed in Table 1, together with their serial numbers, where available. Instruments that are required to have current calibrations are indicated in the Cal-Required column. Instruments that do not require calibration are those not used to verify performance requirements and are not connected to flight instrumentation. The status column is to be filled in with the due date of the instrument calibration sticker and verified to be in calibration by QE or QE designee. Serial numbers are to be updated as appropriate.

Table 1. Required Instrumentation and Calibration Status

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
1	DAS	Power Supply, H-P 6627A	-	3452A01975	Yes	
2	DAS	Power Supply, H-P 6627A	-	3452A01956	Yes	
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A245539	No	-
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	
5	EM	Vacuum Gauge Controller Granville-Phillips Model 316	EG-1a, -1b	2827	No	-
6	EM	Vacuum Gauge Controller Granville-Phillips Model 316	AG-2a, -2b	2826	No	-
7	EM	Vacuum Gauge Controller Granville-Phillips Model 316	EG-3	2828	No	-
8	EM	MKS PDR-C-2C	EG-2, 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	-	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	-	C-09920	No	-
25	VM	Vacuum Gauge readout, Granville-Phillips 316	VG-3 VG-4	2878	No	-
26	VM	Vacuum Gauge readout, Granville-Phillips 360	VG-1, VG-2 VG-5	96021521	No	-

E.5. **Configuration Requirements**

E.5.1. Main Tank

The Main Tank liquid must be at NBP with the liquid level ≥ 80%.

E.5.2. Guard Tank

The Guard Tank must contain liquid, and the level must be ≥ 50%.

E.5.3. Well

The Well must be evacuated

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 1×10^{-4} torr. Procedure P0213, contains the steps for connecting to and pumping on the SMD vacuum shell.

E.5.5. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
   a. Station 200 temperature (CN 01) set at $T \leq 6.5$ 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 Facility Main Alarm System must be armed.

E.5.6. GSE and Non-flight Hardware

1. The ion-pump magnet is installed.
2. GSE cabling must be connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811).
3. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833806). Procedures P0674, and P0672 contain the procedures for connecting Main Tank vent lines.
4. The Guard Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833813). Procedure No. P0676 contains the steps for connecting the Guard Tank vent line.
5. The high-vacuum pumping line must be connected between the SMD at SV-14 and the inlet port of the Vacuum Module and be pumping up to a closed valve SV-14. Procedure No. P0213 contains the procedure for connecting to and pumping on the SMD vacuum shell.
6. The heaters on the SMD top plate, SV-9, and Main Tank vent bayonet must be installed and operational.

E.6. Optional Non-flight Configurations

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

1. The SMD is installed in its transportation and test fixture.
2. A relief valve is installed in place of the SMD fill-line burst disk.
3. A foreign object and debris shield covers the upper cone of the SMD.
4. The Airlock Support Plate may be installed on the SMD. This plate supports the Airlock that is used to keep air out of the Well during probe installation and removal. It is left in place while the Probe is removed.
5. A Dewar Adapter, Shutter, and Shutter Cover are mounted to the Well of the SMD when the Probe is removed
6. The Guard Tank vent line may be connected to the Gas Module with a vacuum insulated line (P/N 5833813), or disconnected, with a vent cap installed.
7. The Well Vent Manifold may be installed.
8. The Fill Cap Assembly may be installed at SV-13 (see Figure 4)
9. The thruster vent port is flanged to a shut-off valve.

F. REFERENCE DOCUMENTS

F.1. Drawings

Drawing No.	***Title***
LMMS-5833394	*Instrumentation Installation*

F.2. Supporting documentation

Document No.	***Title***
LMMC-5835031	*GP-B Magnetic Control Plan*
GPB-100153C	*SMD Safety Compliance Assessment*
SU/GP-B P0141	*FIST Emergency Procedures*
LMSC-P088357	*Science Mission Dewar Critical Design Review*
SU/GP-B P0108	*Quality Plan*
LMMS GPB-100333	*Science Mission Dewar Failure Effects and Causes Analysis*
SU/GP-B P059	*GP-B Contamination Control Plan*

F.3. Additional Procedures

Document No.	***Title***
SU/GP-B P0674	*Connect Main Tank Vent Line to Gas Module – Main Tank at NBP*
SU/GP-B P0676	*Connect Guard Tank Vent Line to Gas Module*
SU/GP-B P0213	*Connect Vacuum Module / Pump on SMD Vacuum Shell*
SU/GP-B P0214	*Stop Pumping on SMD Vacuum Shell / Disconnect Vacuum Module*
SU/GP-B P0211	*Internal Guard Tank Fill – Vent Lines Connected*
SU/GP-B P0442	*Main Tank Fill With Guard Tank Precool – Main Tank at NBP*

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

G. OPERATIONS

G.1. Verify Appropriate QA Notification

- Verify SU QA notified.
  Record: Individual notified _____,
  Date/time _____/_____.
- Verify ONR representative notified.
  Record: Individual notified _____,
  Date/time _____/_____.

G.2. Verify Configuration Requirements

G.2.1. Ensure Facility Main Alarm System enabled.

G.2.2. Ensure heaters on SMD are operational:

- Top plate
- SV-9
- Main Tank vent bayonet

G.2.3. Verify Vacuum Module is pumping on high-vacuum pumping line up to closed valve SV-14.

1. Verify high-vacuum pumping line connected to SMD and Vacuum Module and SV-14 closed.
2. Verify turbo pump on.
3. Verify pressure in high-vacuum pumping line (VG-1) < 5×10^{-5} torr. Record pressure (VG-1) _____ torr.

Note: If Vacuum Module not pumping up to SV-14, perform procedure P0213 to connect and pump up to SV-14. Record Op No. _____.

G.2.4. Verify ion-pump magnet installed.

G.2.5. Verify Vacuum Shell Pressure < 1×10^{-4} torr:

1. Turn on Vac-ion pump and record time of day _____
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr. If pressure is above 1×10^{-4} torr, turn off Vac-ion pump and complete procedure P0213, *Pump SMD Vacuum Space with Vacuum Module*, to pump out SMD vacuum shell. Record Op No. _____.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.

5. When data cycle is complete, turn off Vac-ion pump.

G.2.6. Ensure GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.7. Ensure DAS alarm system enabled and record set points.

1. ***Station 200 temperature*** – ensure CN [01] on DAS alarm list and set to alarm at T ≤ 6.5 K. Record set point. _____K
2. ***Top of lead bag temperature*** – ensure CN [28] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. _____K
3. ***Relative Guard Tank Pressure*** – ensure CN [46] on DAS alarm list and set to alarm at ΔP ≥ 0.3 torr. Record set point. _____torr

G.2.8. 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%. Record set point. _____ %

G.2.9. Verify required liquid helium levels:

1. ***Main Tank*** – verify liquid level ≥ 80%. If not perform procedure P0442 and record Operation. No. _____. _____ %
2. ***Guard Tank*** – verify liquid level ≥ 50%. If not, perform procedure P0211 and record Operation No. _____. _____ %

G.2.10. Ensure 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.2.11. Ensure Guard Tank vent line connected to Gas Module. If not, perform procedure P0676, *Connect Guard Tank Vent Line to Gas Module,* to connect Guard Tank vent.

G.3. Establish Initial Condition of SMD

G.3.1. 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.3.2. Ensure that SMD external valves are in the following positions.

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

G.3.3. Record pressures:

1. Guard Tank (EG-1a) _____ torr.
2. Guard Tank relative to atm. (GTV-G) _____ torr.
3. Main Tank (EG-3) _____ torr.
4. Vacuum Module Pressure (VG-1): _____ torr

G.4. **Establish Initial Configuration of Gas Module**

G.4.1. Verify closed/close all AV valves.

G.4.2. Open/verify open EV-7a/b EV-9, EV-13, and EV-16.

G.4.3. Close/verify closed all other EV valves.

G.4.4. Turn on Main Tank, vent-line heat exchanger (EH-1) in Gas Module.

G.4.5. Position “Actuator Control EV-9” on Gas Module to “Subatmospheric He.”

G.5. **Establish Initial Configuration of Pump Module**

G.5.1. Verify open PV-2 and PV-4.

G.5.2. Verify closed PV-1, PV-3, PV-5, and PV-6.

G.5.3. Open PV-1.

G.5.4. Verify on/Turn on water cooling of pump module.

G.5.5. Verify closed EV-21/22, EV-14, and EV-10.

G.5.6. Verify closed AV-6.

G.5.7. Turn on rotary vane pump PP-2 and blower PP-1.

G.5.8. Once pressure PG-1 comes to equilibrium record (PG-1): _____ torr.

G.5.9. Open PV-3.

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

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

G.6.1. Input comment to DAS “Start Main Tank Pump-down”.

G.6.2. Set the Main Tank liquid-level sampling interval to 1 minute.

G.6.3. Set the Guard Tank liquid-level sampling interval to 1 minute.

G.7. **Initiate Pump-down**

CAUTION
For the pumping operation, a heater has been placed on the Main Tank vent bayonet. Monitor (record on attached data sheets) the temperature of this bayonet to ensure that the heater can maintain the o-ring above 0°C in order to prevent leakage. The heater, however, cannot heat its zone above 52°C or it will automatically shut off. If the temperature of the o-ring drops below 0°C, immediately slow pumping by partially closing EV-21/22.

G.7.1. Close EV-9 and EV-16 and record:

1. Date: _____
2. Time of day:_____

G.7.2. Ensure EV-21/22 closed.

G.7.3. Open EV-4 and EV-17.

G.7.4. Slowly open EV-22 to begin pumping on Main Tank.

G.7.5. Manually adjust EV-22 to control cool-down rate. Flow rate should not exceed 100 liquid liters per hour, as read on PFM-1 (scale B).

G.7.6. Open EV-10; EG-2 now reads Main Tank pressure.

CAUTION
The high flow rate produced by the initial pumpdown of the Main Tank will cause substantial migration of oil from the rotary vane pump, PP-2, into the mist separator unit. When the oil level starts to show on the mist separator sight gauge, pumping should be paused by closing EV-17 and the excess oil should be drained from the mist separator and returned to the vane pump. A comment should be entered into the DAS and the log sheet whenever this is done.

CAUTION
Pumping on the Main Tank will cause the Guard Tank to subcool. Monitor and maintain positive pressure in the Guard Tank (relative to atmospheric pressure) for the duration of the Main Tank pump-down. Positive pressure is maintained by adding heat as described in the following steps. Monitor pressure at GTV-G and record on attached data sheets.

G.7.7. Add heat to Guard Tank to maintain positive pressure:

1. Close EV-13.
2. Turn on power supply for Guard-Tank heater (H-3D or H-4D)
3. Set power supply current limit to 0.07 amps.
4. Set voltage limit to 50 VDC and record:
   V _____Vdc and I _____A.
5. Adjust heater voltage as necessary to maintain Guard Tank pressure (GTV-G). in the range 15 torr < ΔP < 30 torr.
6. Monitor and maintain positive Guard Tank pressure throughout the pump-down. Record data on attached data sheets.

G.7.8. When Main Tank pressure (EG-2) stalls and EV-22 is fully open, switch control of pumping rate to EV-7a/b as follows:

1. Close EV-7a/b
2. Open EV-21
3. Resume pumping by slowly opening EV-7a/b to achieve desired pumping rate.
4. Continue pumping with Pump Module until desired pressure is reached (e.g., EG-2 = 12.5 torr).

G.7.9. As pumping nears completion (i.e., Main Tank pressure EG-2 approaches target value)

1. Reduce Guard Tank heater voltage to zero.
2. Open EV-13 to vent Guard Tank.
3. Continue to monitor and maintain positive pressure in Guard Tank, increasing Guard Tank heater voltage as required.

G.8. **Switch Pumping to Gas Module (AP-1)**

G.8.1. When EG-2 reaches desired pressure, turn on AP-1

G.8.2. Open AV-6.

G.8.3. Close EV-4 and EV-21/22.

G.8.4. Close PV-1.

G.8.5. Turn off Pumps PP-1, and PP-2.

G.8.6. (Option)Turn off coolant water in Pump Module.

G.8.7. Continue monitoring Dewar instrumentation to verify that temperatures have stabilized.

G.9. **Establish Final Configuration**

G.9.1. Verify EV-7a/b, EV-10, EV-13, and EV-17 open.

G.9.2. Verify all other EV-valves closed

G.9.3. Verify AV-6 open.

G.9.4. Ensure all other AV valves closed.

G.9.5. Input comment to DAS “End of Main Tank Pump-down”.

G.9.6. Set the DAS data cycle to 15 minutes.

G.9.7. Set the Main Tank liquid level sampling interval to 10 minutes.

G.9.8. Set the Guard Tank liquid level sampling interval to 10 minutes.

G.9.9. Ensure DAS alarm enabled and record set points if changed

- Thermal conditions substantially unchanged, alarm set points for Station 200 and lead bag unchanged
- Thermal conditions substantially changed, temperature alarm points reset as follows:

a. Station 200 set point [CN 1] _____ K (≤ 6.5 K)

b. Top of Lead Bag set point [CN 28] _____ K (≤ 6.0 K)

G.9.10. Ensure liquid level sensor alarms enabled and record set points if changed.

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

CAUTION
The Guard Tank may tend to subcool following the completion of this procedure. Establish continuous monitoring of the Guard Tank pressure by placing it on the DAS alarm list.

G.9.11. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential.

G.9.12. Continue to monitor Guard Tank pressure until HEX-1 temperature CN [05] reaches steady state. Be prepared to add heat as necessary.

G.9.13. Once HEX-1 temperature reaches steady value, turn off Guard Tank heater power supply.

G.9.14. Record the following:

1. Date: _____
2. Time of day: _____
3. Vacuum Module Pressure (VG-1): _____ torr
4. Main Tank pressure (EG-2) _____ torr.
5. Guard Tank pressure relative to atm (GTV-G) _____ torr.

G.9.15. (Option) Disconnect Vacuum Module. Perform Procedure P0214, and record Operation No. _____.

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

Data Sheet 1

Date/ Time	***Main Tank LHe level (%)***	***Main Tank pressure EG-3 (Torr)***	***Vacuum pressure VG-1 (torr)***	***Gas Module pressure PG-1/PG-2 (torr)***	***Flowrate PFM-1 (ll/hr)***	***Guard Tank pressure GTV_G (torr)***	***Guard Tank Heater Voltage (V)***
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Data Sheet 2

Date/ Time	*EV-7a setting (%)*	*EV-7b setting (%)*	*Main Tank bottom T-9D [09] (K)*	*Sta. 200 T-1D [01] (K)*	*Guard Tank bottom T-15D [24] (K)*	*HX-4 T-8D [08] (K)*	*Valve SV-9 Temp (^{o}C)*	*Main Tank Bayonet Temp (^{o}C)*	*Main Tank Gas Mod HX (^{o}C)*

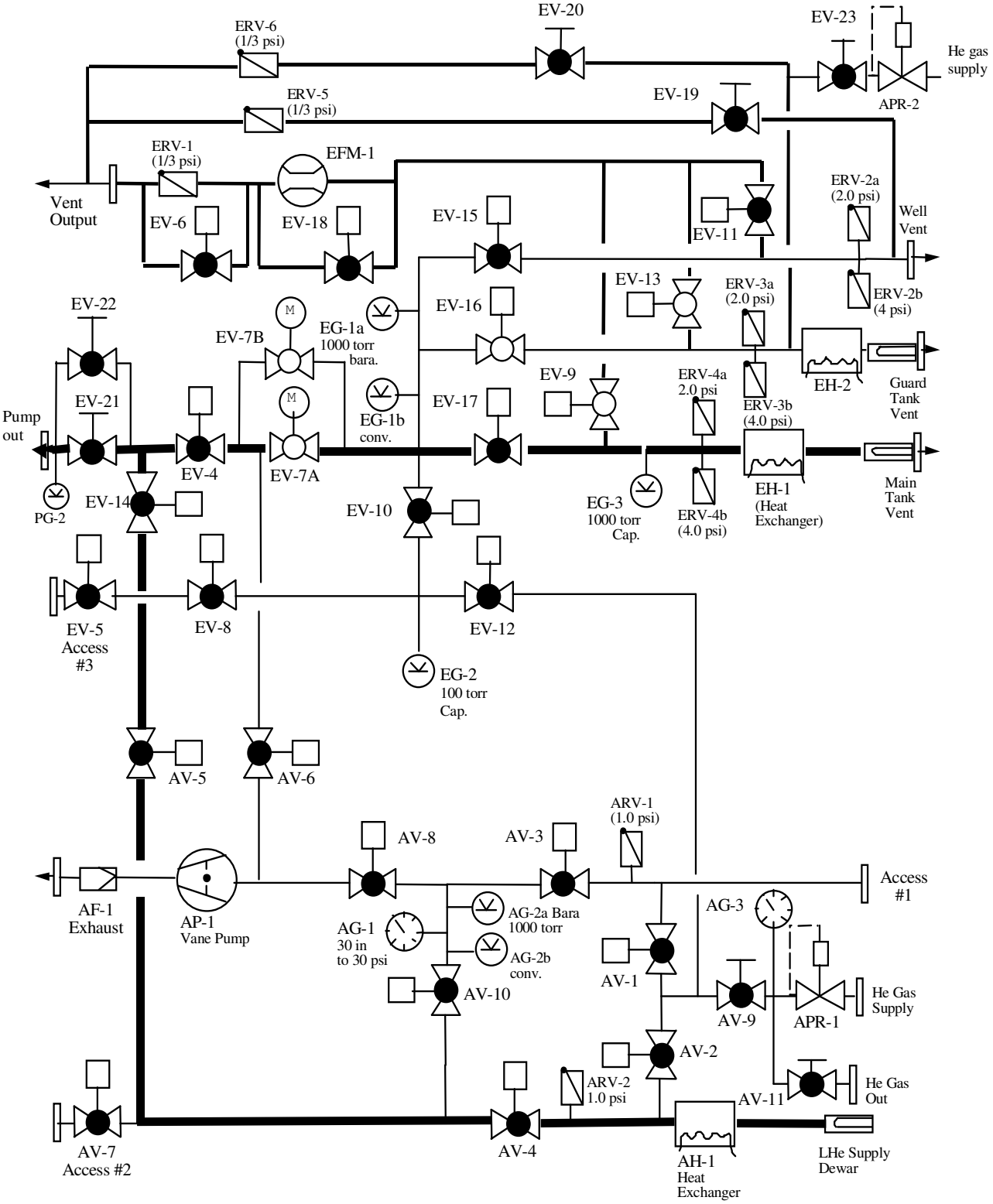

Figure1. Schematic of Gas Module Plumbing. The valve configuration corresponds to the initial configuration with the Main and Guard Tank vent lines both venting through ERV-1. The Guard Tank pressure is read at EG-1a.The Well is evacuated.

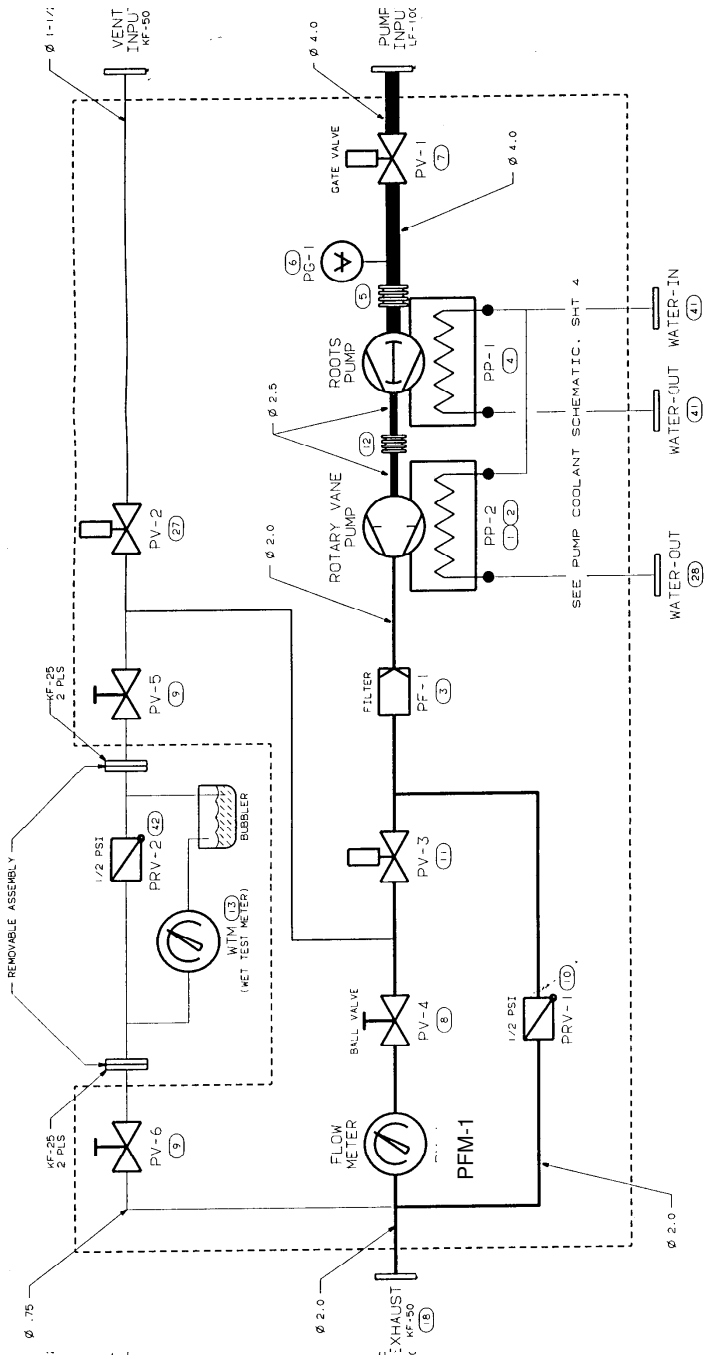

Figure 2. Schematic diagram of Pump Module plumbing.

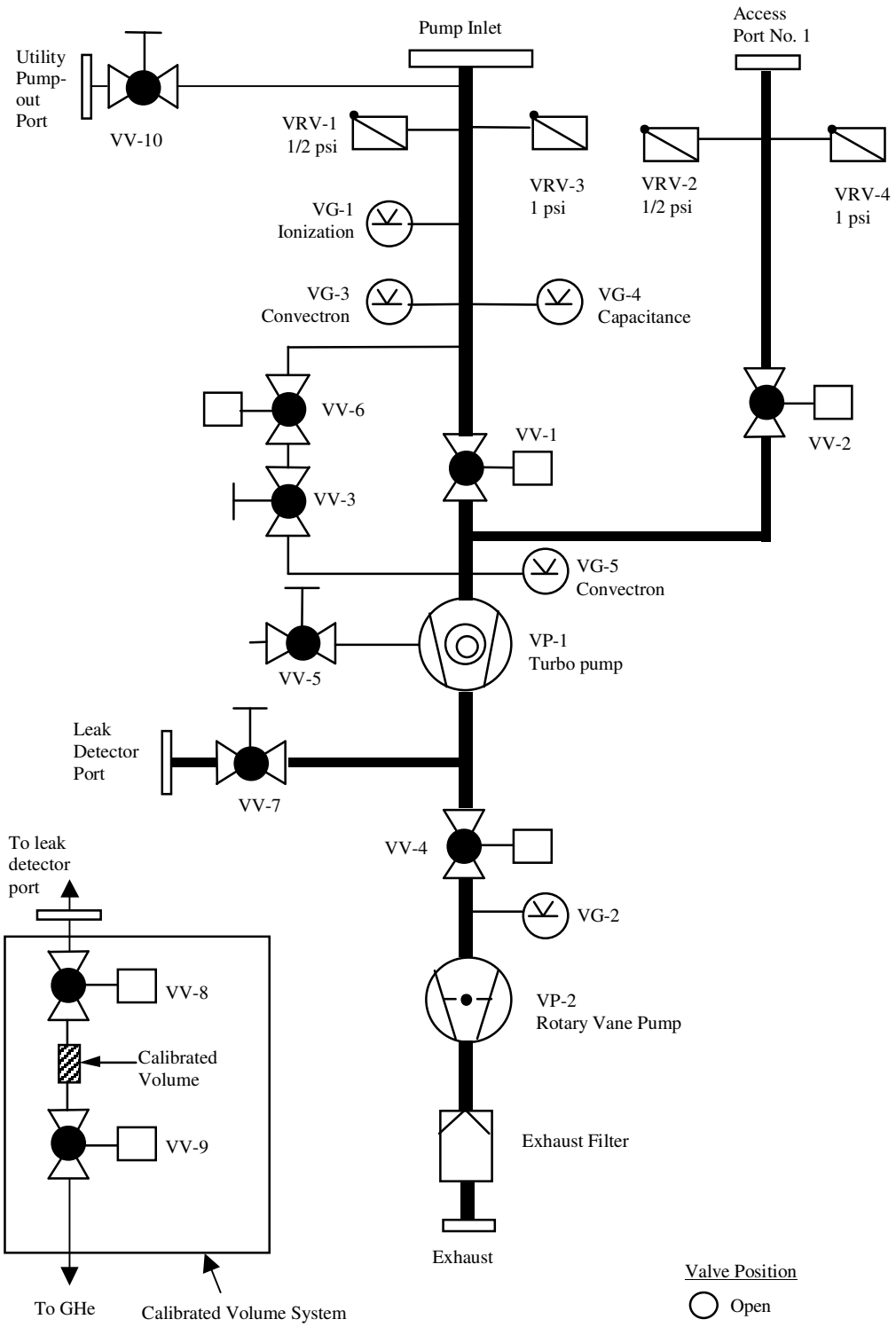

Figure 3. Schematic representation of Vacuum Module plumbing.

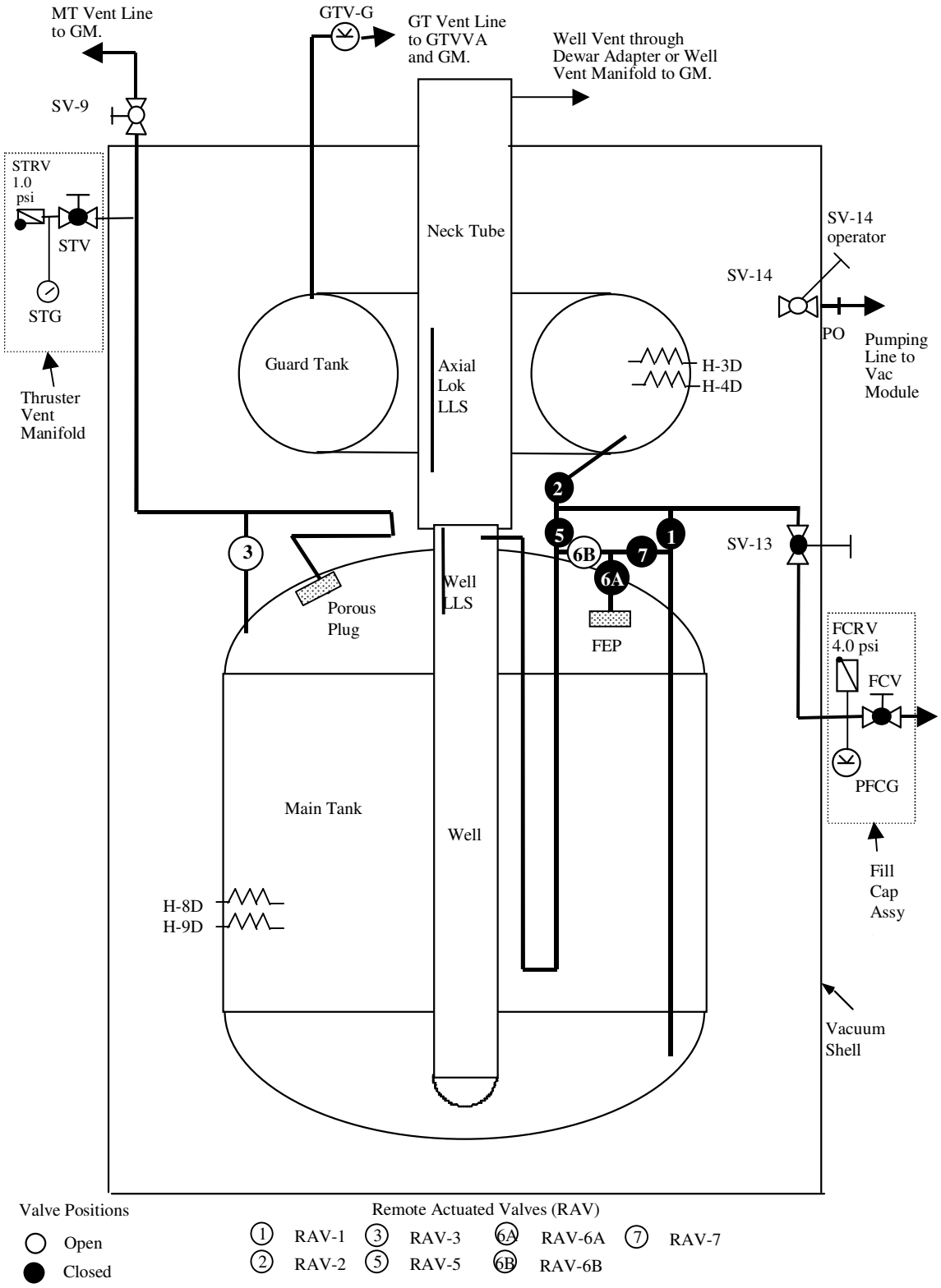

Figure 4. Schematic of Science Mission Dewar plumbing.