GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Discontinue Pump-out Probe with Vacuum Module

THIS PROCEDURE CONTAINS HAZARDOUS OPERATIONS

P0967
January 9, 2003

Written by
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REVISION RECORD

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

A. SCOPE

This procedure describes the steps necessary to discontinue pumping on the Probe and disconnect the Vacuum Module from one of the Probe Leakage Valves. The steps include

-Discontinue active pumping

-Perform leak back test to ensure valve closure

-Remove plumbing and install protective closeout

-Evacuate and leak check protective closeout

This procedure is hazardous due to the use of liquid 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.

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

Stanford University may provide 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 LM facilities without escort. All personnel working at a height 30 inches or more off the floor are required to have an LM-approved Emergency Escape Breathing Apparatus (EEBA) 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 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.

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 as follows
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

Responses to contingencies (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 Hardware 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.

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

D. TEST PERSONNEL

D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. 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***
Ned Calder Mike Taber Dave Murray	Tom Welsh

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

When working on the space vehicle, proper ESD grounding is required

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

Description
Varian Leak Detector Model #_____ Cal Due Date:_____
Met One Particle Counter

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 Electrical Module (Table 1), as well as the Vacuum Module.

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
Probe pump-out manifold with 10 torr Baratron (Fig. 2)

E.3.5. Additional Hardware

Description
N/A

E.3.6. Tools

Description
N/A

E.3.7. Expendables

Description	***Quantity***	***Mfr./Part No.***
Alcohol	AR	N/A
99.999% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Dow Corning High Vacuum or Apiezon N

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 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. Space Vehicle

The Space Vehicle is mounted in the tilt dolly and in the horizontal orientation.

E.5.2. Probe

The Probe is being actively pumped by the Vacuum Module per successful completion of P0966, *Pump-Out Probe with Vacuum Module.*

E.5.3. Main Tank

Liquid in the Main Tank may be either subatmospheric or at NBP.

E.5.4. Guard Tank

The Guard Tank is depleted of liquid.

E.5.5. Well

There are no requirements on the Well pressure.

E.5.6. SMD Vacuum Shell

There is no requirement on the vacuum shell pressure.

E.5.7. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
   a. Top of lead bag temperature set (CN 175) at $T \leq 6.0$ K.
   b. Top of lead bag temperature set (CN 178) at $T \leq 6.0$ K.
   c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 30$ torr.
2. The Watch Dog alarm must be armed.

E.5.8. 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 ion-pump magnet is installed.
2. The Main Tank vent line may be connected to the Gas Module or disconnected with a vent cap installed.
3. The Guard Tank vent line may be connected to the Gas Module or disconnected with a vent cap installed.
4. The thruster vent port is flanged to a shut-off valve.
5. The Fill Cap Assembly is installed at SV-13 (See Figure 1)

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*
EM SYS229	*Accident/Mishap/Incident Notification Process*
SU/GP-B P0875	GP-B Maintenance and Testing at all Facilities
SU/GP-B P0879	Accident/ Incident/Mishap Notification Process
SU/GP-B P059	*GP-B Contamination Control Plan*
SU/GP-B P0966	*Pump-Out Probe with Vacuum Module*

F.3. Additional Procedures

N/A

Document No.	*Title*

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

G. OPERATIONS

G.1. Verify Preparations

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

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

G.1.3. 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.1.4. Verify completion of pre-operations checklist

G.1.5. Ensure Space Craft powered up and prepared to operate Vatterfly valve and read P9 gauge.

Section Complete Quality _____

G.2. Initial Operations

G.2.1. Record serial number on helium bottle/s to be used in this procedure.
1. _____ 2._____ 3. _____
4. _____ 5 _____ 6. _____

G.2.2. Verify Helium cylinder content has been tested and record operation number.
Op. Number: _____

QA Witnesss:_____

G.3. Verify Configuration Requirements

G.3.1. Ensure Watch Dog Timer enabled.

G.3.2. Verify DAS alarm system enabled and record set points.
1. ***Top of lead bag temperature*** – verify CN [175] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. _____K
2. ***Top of lead bag temperature*** – verify CN [178] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. _____K

3. ***Relative Guard Tank Pressure*** – verify CN [46] on DAS alarm list and set to alarm at $\Delta P \geq$ 30 torr. Record set point. _____torr

G.3.3. Verify liquid-level alarms set, as appropriate, and record set points.

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

Section Complete Quality _____

G.4. Prepare/ Verify Prepared HEPA Down Flow Booth

G.4.1. Ensure HEPA down flow booth installed over Vatterfly Valve and has been running for at least 30 minutes

G.4.2. Using particle counter ensure Class 10 environment

1. Record Particle Counter S/N#:_____ and Cal Due Date:_____
2. Record particle count:_____

QA Witness:_____

G.5. Verify Initial Configuration

G.5.1. Verify completion of P0966, *Pump-Out of Probe with Vacuum Module.*

G.5.2. Verify open: VV-1, VV-4, VV-10

G.5.3. Verify closed: VV-2, VV-3, VV-5, VV-11, and VV-RGA

G.5.4. Verify Vacuum Module Override is off (down)

G.6. Discontinue Active Pumping

G.6.1. Command/Verify Commanded Spacecraft telemetry indicates that the proper Vatterfly Valve is closed

G.6.2. Record VG-1:_____torr

G.6.3. Turn off VG-1

G.6.4. Close VV-10

G.6.5. Close VV-1

G.6.6. Press Stop on the Turbo controller and verify that VV-4 closes

G.7. Perform Leak Back Test of Vatterfly Valve

G.7.1. Install helium source to VV-11, ensuring connection is purged while making the connection

G.7.2. Record VG-0_____torr

G.7.3. Verify VG-3 is reading below 100 mtorr.

G.7.4. Open VV-10

G.7.5. Slowly open VV-11 until 7-8 torr is read on VG-0, then close VV-11

G.7.6. Close VV-10

G.7.7. Observe pressure at VG-0 for 30 minutes

Time				
VG-0				
P-9 (optional)				

G.7.8. Verify pressure change at VG-0 less than 1mTorr/minute

QA Witness:_____

G.8. Remove Pumping Line and Hardware

G.8.1. Remove He supply from VV-11, and slowly open VV-11 to vent pumping line.

G.8.2. Remove pumping line and hardware from adapter flange

G.8.3. Remove adapter flange and store in two clean room bags

G.8.4. Install Vatterfly ISO 150 protective closeout

G.8.5. Connect Vacuum Module to protective closeout

G.8.6. Start up leak detector and verify calibration

1. Record calibrated leak rate: _____sccs
2. Record measured value of calibrated leak: _____sccs

G.8.7. Leak Check and Evacuate closeout

1. Turn override switch to on position (up) and press reset
2. Turn on VP-2
3. Open VV-4
4. Open VV-3, VV-6, and VV-10
5. When VG-3 reads less than 25 mtorr press Start on turbo controller
6. When turbo up to speed, Open VV-1
7. Close VV-3 and VV-6
8. Connect leak detector to leak detector access port
9. Slowly open VV-7 and close VV-4
10. Ensure background on E-6 range and leak check protective closeout. Record background He level: _____sccs
11. Ensure no rise detected
12. Close VV-7 and open VV-4
13. Close closeout valve on Vatterfly cover
14. Close VV-1, VV-4, and VV-10
15. Press stop on turbo controller and spin down turbo
16. Remove pumping line and install VCR plug on Vatterfly cover.

G.9. Establish Final Configuration

G.9.1. Ensure Watch Dog Timer is armed.

G.9.2. Perform Post-Operations Checklist (Appendix 2)

Section Complete Quality _____

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Test Director_____**Date**_____

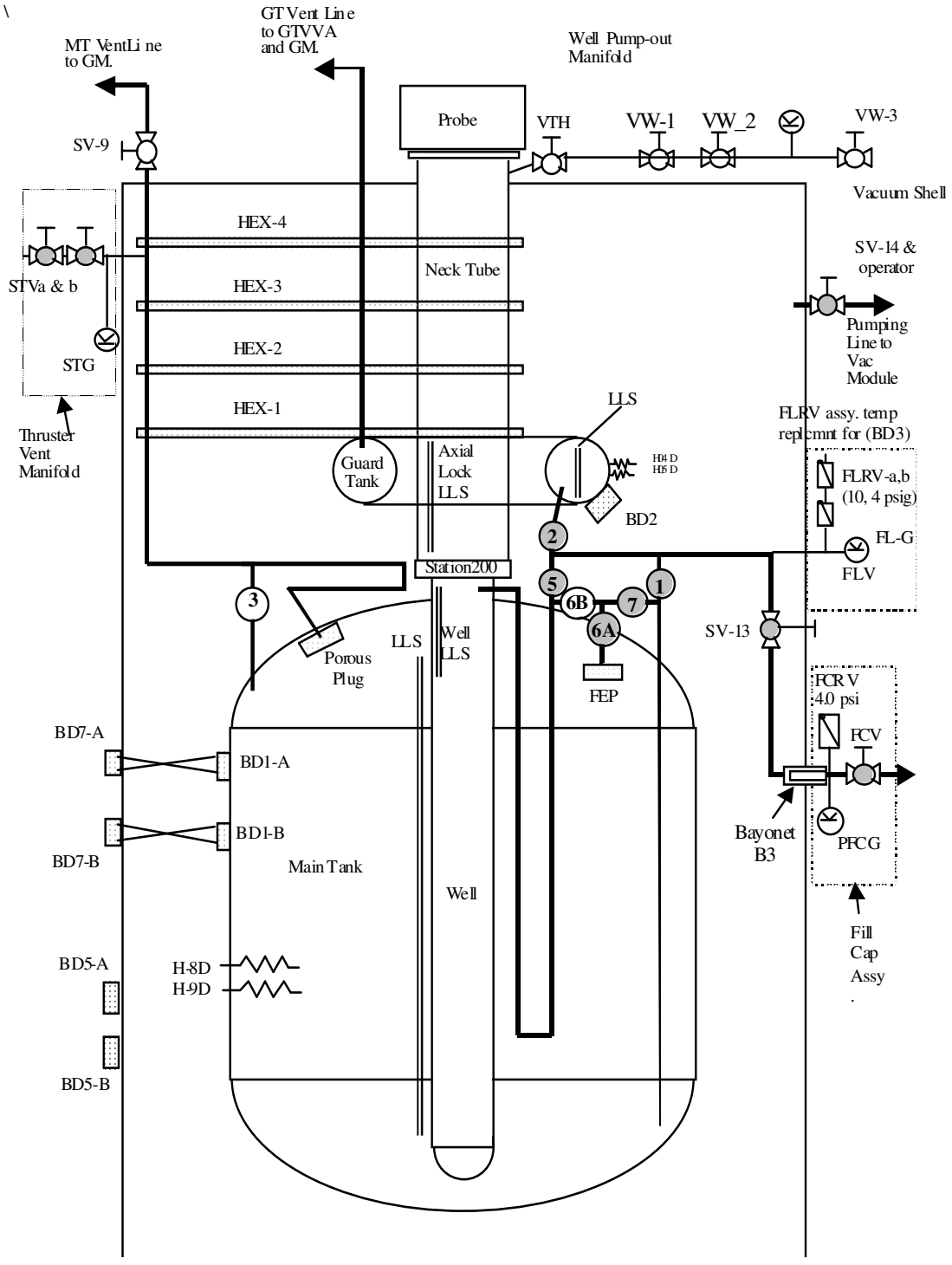

Figure 1. Schematic of Science Mission Dewar plumbing.

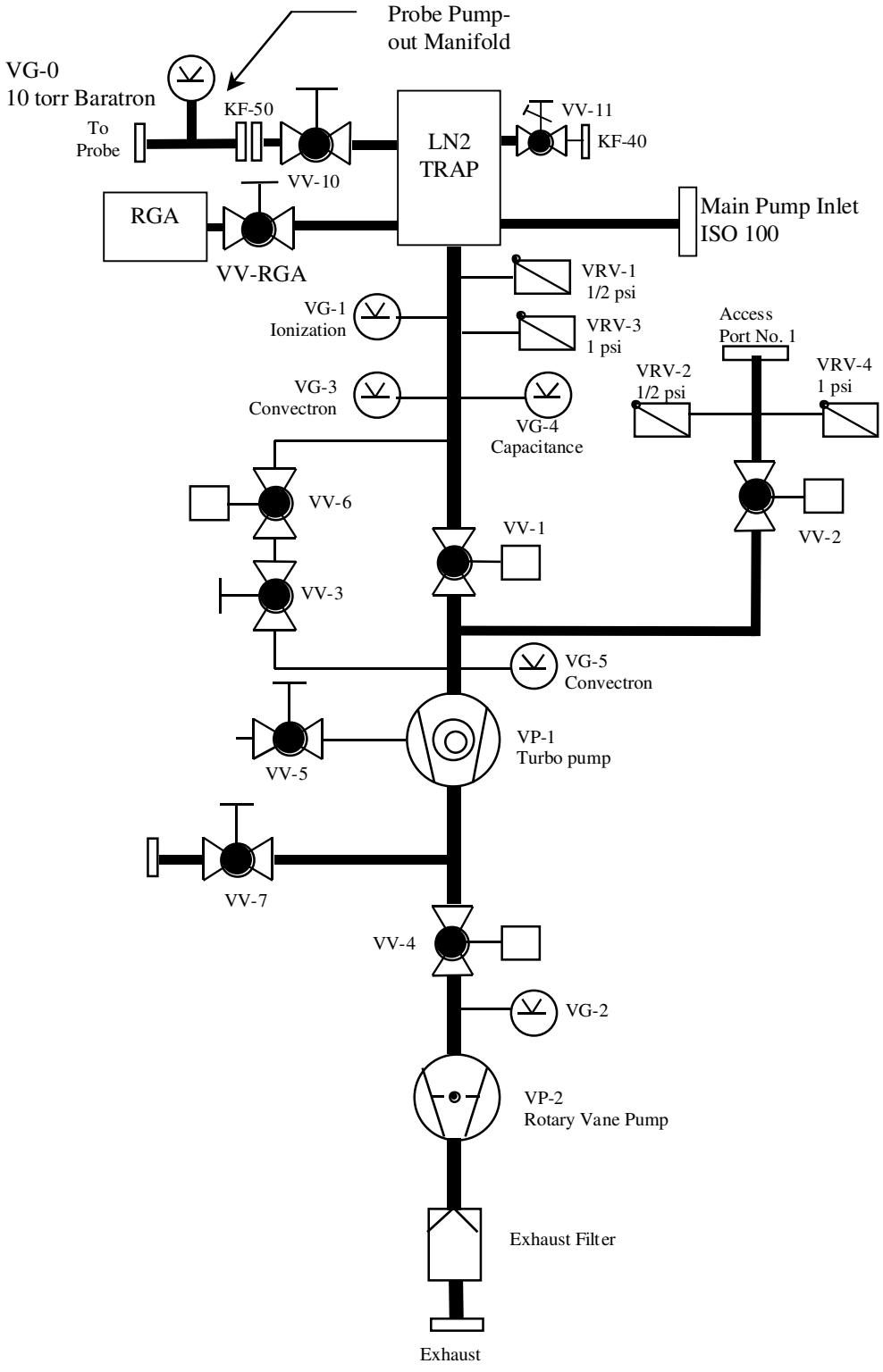

Figure 2. Schematic diagram of Vacuum Module

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	Burst disk rupture (MT/GT)	Any time	Evacuate room