GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Prepare Main Tank for Launch

To be performed at Vandenberg Air Force Base building 1610

THIS DOCUMENT DOES NOT CONTAIN HAZARDOUS OPERATIONS

P1001 Rev B

ECO No. 1429

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Revision Record

Rev	***ECO***	***Description***	***Date***
A	1423	Added steps for testing of RAV4A/B and leak check of their closure before commencing with pumpdown of main tank. Added two-valve GSE to Well pumpout port to minimize use of metal-sealed flight valves. Adjusted main tank fill sequence during the conditioning process to conform to the results of the main tank top-off and conditioning rehearsal performed during PL Test II. Made minor miscellaneous corrections	7/7/03
B	1429	Minor changes made in steps supporting RAV4A/B test (G.5.3) to make them consistent with test procedure. Section added (G.6.9) to verify proper operation of EV-9 during power failure.	

Table of Contents

List of Abbreviations and Acronyms

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

LIST OF SPECIFIC HEADING DEFINITIONS

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

Note:
Used to indicate an operating procedure of such importance that it must be emphasized.

CAUTION:
Used to identify hazards to equipment.

WARNING:
Used to identify hazards to personnel.

A. SCOPE

This master procedure describes the steps necessary to prepare the Main Tank of the SMD for launch. These steps include:

Fill Main Tank at NBP. Requires initial execution of P1034, *NBP Main Tank Fill – Guard Tank Initially Depleted and Connected To Gas Module*.

Support RAV4A/B test

Perform leak check of RAV4A/B closure.

Continue to fill Main Tank to capacity at NBP. Requires execution of P1032, *Main Tank Fill With Guard Tank Precool – Main Tank at NBP.* Repeat this procedure until Main Tank is filled to 95%.

Begin Pumping on Main Tank.

Begin sequence of transfers – NBP LHe to Subatmospheric Main Tank. Requires execution of P1036 *Main Tank Subatmospheric Fill from NBP Supply Dewar – GT Precool*

Continue pumping on Main Tank throughout sequence.

Continue pumping and transferring NBP LHe to subatmospheric Main Tank until the Main Tank is 95% full and at 6.5 K.

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.

During the performance of this procedure the main tank will be reduced to subatmospheric pressure. If the main tank fill or vent line is then opened to atmosphere, air will be ingested into a cryogenic region where it will freeze with a high probability of blocking of the line. This could prevent proper venting of the main tank on orbit, consequent over temperature and over pressurization, and ultimately the rupturing of one of the main tank burst disks.

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

Mitigation of over pressurization hazard is primarily through the use of burst disks or relief valves. A rupture of the main tank burst disk(s) will

be obvious due to the plume of cold gas. Emergency vent lines are installed over the burst disks on the SMD vacuum shell to eliminate the possibility of direct plume impingement on personnel. Orderly evacuation shall be performed in the event one or more of these burst disks rupture. An oxygen deficiency monitor (provided by GP-B) that alarms when the oxygen level is reduced to 19.5% will be utilized as an added precaution. Temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions.

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 a 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: Insulated gloves when handling equipment that has been cooled to cryogenic temperatures. A protective apron, gloves impervious to liquid cryogens, impermeable shoes, and full-face shields are to be worn whenever the possibility of splashing or impingement of high velocity cryogens exists.

B.2.3. Other Hazards

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

B.3. **Mishap Notification**

B.3.1. Injury

In case of any injury obtain medical treatment as follows
VAFB Call 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 Spacewing Safety will be notified as required.

B.3.3. Contingency Response

Responses to contingencies (e.g., power failure, burst disk failure) are listed in Appendix 3.

C. **QUALITY ASSURANCE**

C.1. **QA Notification**

The NASA program and NASA safety representatives 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 judgment of the TD or QA Representative, mission 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.

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.

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.

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, procedures called by this procedure may have additional requirements. 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**

List below those personnel involved with the procedure

Test Director	Test Engineer	Safety Engineer
1.	1. 2. 3. 4.	1.

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

Any person who comes in contact with the SV must use a grounding wrist strap that has been tested that day. Appropriate attachment points are positioned around the SV.

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 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. Spacecraft Support

With connector J802 connected to flight electronics, operation of RAV-2 must be commanded through the spacecraft instead of the RAV controller in the Electrical Module.

E.3.5. Additional Test Equipment

Description	*Manufacturer*	*Model*
O_2 Monitor and Alarm	Alpha-Omega Instruments	1000

E.3.6. Additional Hardware

A special thruster cap with an isolation valve is required for leak check of RAV4A/B after final testing of these valves (see G.5). In addtition, a pumping line with an interface to the two thruster manifold pressure transducer pressure reference ports is also needed for this activity.

E.3.7. Protective Clothing

None required.

E.3.8. Tools

Description
Torque Wrench, 1-1/4-in socket, 60 +/- 5 in-lb Cal Due Date:_____S/N_____

E.3.9. Expendables

Description	*Quantity*	*Mfr./Part No.*
Liquid Helium	~ 2000 gal.	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	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
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	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. Space Vehicle

The SV must be mounted vertical (+Z up) in the Assembly Stand with the FEE skins removed to allow to the vent boss region. All SV thrusters must be capped with the thruster pressure transducer reference ports connected to their respective thruster caps.

E.5.2. Main Tank

The Main Tank liquid must be at NBP with the liquid level ≥ 30%. The actuator control valve for EV-9 (located on the Gas Module, this valve

switches the state that EV-9 defaults to, should a power failure occur) should be verified in the "NBP." position, at the beginning of this procedure, ensuring that EV-9 remains open in the event of power failure. Before pumping on the Main Tank commences, it must be switched to the "Subatm He" position.

E.5.3. Guard Tank

The Guard Tank is depleted and regulated to a pressure > 30 torr above atmosphere. Care must be taken at all times to keep its pressure above atmospheric.

E.5.4. Well

The Well must be evacuated.

E.5.5. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 5×10^{-5} torr. Procedure P1015, *Connect Vacuum Module to SMD*, contains the steps for connecting to and pumping on the SMD vacuum shell.

E.5.6. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
    a. Top of lead bag temperature (CN 175) set 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 DAS watchdog timer and alarm are enabled.

E.5.7. GSE and Non-flight Hardware

1. The ion-pump magnet is installed and ion pump is cabled to its readout.
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). Procedure P1006 contains the steps for connecting Main Tank vent line.
4. The Guard Tank vent line must be connected to the Gas Module with a vacuum insulated line (P/N 5833813). Procedure No. P1008 contains the steps for connecting the Guard Tank vent line.
5. The Fill Cap Assembly must be installed at SV-13.
6. The heaters on the SMD top plate, SV-9, and Main Tank vent bayonet must be installed, connected to the External Temperature Control Unit, and operational.
7. The Pump Module must be connected to the Gas module at EV-21.
8. Dewar burst disk vent lines must be connected per P1000

E.6. Optional Non-flight Configurations

N/A

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*
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*
LM EM SYS229	*Accident/Incident/Mishap Notification Process*
EWR 127-1, 31 March 1995, Eastern and Western Range Safety Requirements	*Hazardous and Safety Critical Procedures*
KHB 1710, rev D	*Kennedy Space Center Safety Practices Handbook*

F.3. Additional Procedures

Document No.	*Title*
SU/GP-B P1006	*Connect Main Tank Vent Line to Gas Module – Main Tank at NBP*
SU/GP-B P1008	*Connect Guard Tank Vent Line to Gas Module*
SU/GP-B P1015	*Connect Vacuum Module / Pump on SMD Vacuum Shell*
SU/GP-B P1016	*Stop Pumping on SMD Vacuum Shell / Disconnect Vacuum Module*
SU/GP-B P1017	*Repump Well with UTS*
SU/GP-B P1029	*Internal Guard Tank Fill – Vent Lines Connected*
SU/GP-B P1032	*Main Tank Fill With Guard Tank Precool – Main Tank at NBP*
SU/GP-B P1034	*NBP Main Tank Fill – Guard Tank Initially Depleted*
SU/GP-B P1036	*Main Tank Subatmospheric Fill from NBP Supply Dewar – GT Precool*
SU/GP-B P1040	*Fill LHSD from LHe Tanker*

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 _____,

  Date/time _____/_____.

- ❑ Verify NASA Safety representative has been notified and has given concurrence to proceed.

  Record: Individual notified _____,

  Date/time _____/_____.

- ❑ Verify that the persons performing this procedure, the test director, and safety engineer are identified in Sec. D.3.

- ❑ Verify performance of pre-operations checklist (Appendix 1).

Section complete _____ QA.

Comment: Section G.5, *Support RAV-4A/B testing and leak check RAV4A/B closure,* may be performed at any time from this point on prior to the start of main tank conditioning.

G.2. Verify Preliminary SMD and GSE Preparations Complete

G.2.1. Verify that an adequate supply of liquid helium is available when needed. Nominal plan is for 2x 1000 gal. tankers staged sequentially.

G.2.2. Verify successful completion of P1000, *Prepare for Cryo Ops following Transport to B1610*. Record Op. No.: _____

Comment: This verifies that the Pump Module, the Gas Module, and the pumping line between them have been tested and leak checked.

G.2.3. Perform procedure P1017, *Repump Well with UTS*. Record Op. No./Date _____/_____.

Comment: The GSE cap on the Well pumping line must be removed and replaced with two series GSE isolation valves, VW-3, -4 prior to the performance of this procedure. After initial pumpout of the Well, the UTS may be valved off (by closing both TV-1 and VW-3, -4) but left connected for additional pumping throughout the duration of this procedure.

G.2.4. If the transfer line and stinger vacuum shields have not been pumped out within the previous 6 months, pump out all transfer equipment to be used during this procedure. (If any of this equipment shows signs of be excessively soft, a helium leak check should also be performed.)

Record Date _____.

G.2.5. Verify operation of the GP-B portable oxygen monitor.

G.2.6. Verify current calibrations by entering cal due dates in sections E.3.8 and E.4

Section complete _____ QA.

G.3. **Verify Configuration Requirements**

G.3.1. Verify SV configuration: in Assembly Stand with FEE skins removed.

G.3.2. Verify that SV-12 and SV-9 are accessible.

G.3.3. Ensure GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.3.4. Verify Main Tank at NBP (4.1 K < T < 4.3 K) with the liquid level ≥ 30%:

Record MT liquid level: _____%

Record MT bottom temperature (CN [171]) _____ K

G.3.5. Verify Guard Tank depleted (T > 4.3 K) and pressurized > 30 torr above atmosphere:

Record GT temperature (CN [170]) _____ K

Record GT pressure (CN 46) _____ torr above atm.

G.3.6. Verify ion-pump magnet and cable are installed.

G.3.7. Ensure DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – ensure 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** – ensure CN [178] 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 ≥ 30 torr. Record set point. _____torr

G.3.8. Ensure DAS watchdog timer and alarm enabled.

G.3.9. Ensure Main Tank vent line connected to Gas Module. If not, perform procedure P1006, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP,* to connect Main Tank vent.

Record Date _____ and Operation number _____.

G.3.10. Ensure Guard Tank vent line connected to Gas Module. If not, perform

procedure P1008, *Connect Guard Tank Vent Line to Gas Module,* to connect Guard Tank vent.

Record Date _____ and Operation number _____.

G.3.11. Ensure Fill Cap Assembly installed at SV-13

G.3.12. Verify actuator control valve for EV-9, located on Gas Module, set to "NBP" position.

G.3.13. Verify Pump Module connected to Gas Module at EV-21/22.

Section complete _____ QA.

G.4. **Fill Main Tank to Capacity (NBP)**

Comment: Fill operations called out by this procedure will require transferring LHe from either 500 l or 1000 l LHSDs. These LHSDs are in turn filled from a 1000 gal. tanker per P1040, *Fill LHSD from LHe Tanker*. These operations are not otherwise explicitly called out in this procedure but should be logged in the SMD Ops Log. Comment: G.4.2 need not be performed immediately after G.4.1.

G.4.1. Perform procedure P1034, *NBP Main Tank Fill – Guard Tank Initially Depleted And Connected To Gas Module*. Record:

Date _____ Op. No. _____. Final MT level _____ %.

G.4.2. Perform procedure P1032, *Main Tank Fill With Guard Tank Precool – Main Tank at NBP*. Repeat until MT liquid level ≥ 95%.

Note: on last fill operation bring Guard Tank liquid level to ≥ 90%.

Record:

1. Date _____ Op. No. _____. Final MT level _____ %.
2. Date _____ Op. No. _____. Final MT level _____ %.
3. Date _____ Op. No. _____. Final MT level _____ %.
4. Date _____ Op. No. _____. Final MT level _____ %.
5. When Main Tank is > 95 %, record liquid helium levels.
    a. Main Tank: _____%
    b. Guard Tank: _____%
6. Verify Guard Tank level ≥ 90 %

Section complete _____ QA.

G.5. **Support RAV-4A/B testing and leak check RAV4A/B closure**

Comment: This section may be performed at any time prior to the start of main tank conditioning.

G.5.1. Verify that RAV4A/B test operations have been reviewed and coordinated with POD G.

G.5.2. Verify that all thrusters are capped and that the thruster pressure transducers have their reference ports connected to their respective thruster ports.

G.5.3. Support RAV4A/B testing as follows:

1. Verify SV-12 is closed.
2. Verify the main tank is at NBP and that its pressure is above atmospheric. Record STG (CN 49): _____ torr relative to atm.
3. With the cognizance of spacecraft mechanical personnel, remove the cap from an accessible thruster at a convenient location.
4. When requested by POD G, crack open SV-12 to verify flow signifying that RAV4A/B have opened. (This should be done approximately 30 seconds before POD G closes RAV4A/B to provide a purge without excessively blowing down the main tank.)
5. Record date/time of RAV-4A/B operation: _____
6. After RAV4A/B have been closed, verify closure by noting that gas flow has stopped.
7. Close SV-12.
8. Record the RAV operations in the RAV logbook.

G.5.4. To leak check RAV4A/B closure, perform the following:

1. Verify leak checker calibration:
    a. Calibrated leak value: _____sccs
    b. Cal. leak S/N: _____
    c. Cal. due date: _____
    d. LD indicated value of cal. leak: _____ sccs
2. Install a special thruster cap with an equalization line for the thruster pressure transducer reference port (see Fig. 6). Also tee into this an equalization line to the reference ports on the two thruster manifold pressure sensors.
3. Connect pumping line with an isolation/throttle valve(V-LD) from LD to the thruster cap.
4. Place the vent disable switch in the “disable” position.
5. Place the “To Fine Test Mode” switch on the LD to “No”.
6. Close V-LD and start LD.
7. Very slowly crack open V-LD until only one additional LED unit illuminates on the test port pressure gauge. The intention is to pump slowly enough to prevent the thruster actuator from moving to its closed position and producing a large pressure drop. As the pressure declines in the manifold, slowly open V-LD to maintain a constant

indication on the test port pressure gauge. Pumpdown may take several hours.

8. When V-LD is fully open, allow the LD to transition to fine test mode.
9. When leak detector transitions to fine leak check mode and the helium background has stabilized, record the He background: _____sccs
10. Verify that the background is < 10^{-4} sccs

_____ QA.

11. Close V-LD.
12. Switch off the vent disable switch and vent the leak detector.
13. Disconnect V-LD from the LD and connect a purged He gas line.
14. Slowly backfill the thruster manifold with 1 atm. of He gas.
15. After the thruster manifold reaches 1 atm., close V-LD and disconnect the He line.
16. Remove all pressure transducer equalization lines installed for this operation.
17. Remove the GSE cap from the thruster and quickly install the original cap. Reconnect the original pressure transducer equalization line. Minimize the convection of He out of the manifold during this operation.

Section complete _____ QA.

G.6. **Prepare to Pump on Main Tank**

G.6.1. Verify Vacuum Module configuration.

o Vacuum Module not pumping on high-vacuum pumping line up to closed SV-14 Perform procedure P1015 to connect and pump up to SV-14. Record Date: _____, Op No _____.
o Vacuum Module already pumping on high-vacuum pumping line up to closed SV-14 1. Verify high-vacuum pumping line connected to SMD and Vacuum Module. 2. Verify SV-14 closed 3. Verify turbo pump on and in Standby Mode (Standby light is on) and the interlock switch is in the override position 4. Turn on ionization gauge and verify pressure in high-vacuum pumping line (VG-1) < $5x10^{-5}$ torr. Record pressure (VG-1) _____Torr. Record Date/Time _____/_____.

Comment: This configuration allows the user to pump on the vacuum shell immediately if this becomes necessary at any time during the procedure. To pump on the vacuum shell in this configuration the user should open valve SV-14, take the turbo out of Standby Mode, and set / verify set the override switch in the off position. See Contingency Responses in Appendix 3.

G.6.2. Ensure DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – ensure 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** – ensure CN [178] 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 ≥ 30 torr. Record set point. _____torr

G.6.3. Ensure DAS watchdog timer and alarm enabled.

G.6.4. 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%. Record set point. _____%

G.6.5. Ensure Dialer Alarm System enabled.

G.6.6. Ensure Top-plate heaters on SMD are connected to the External Temperature Control Unit, which is on and functioning.

G.6.7. Verify V12 is closed by visual and mechanical inspection.

G.6.8. Establish Initial Valve Configuration

1. Using the RAV logbook 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.
    a. ***Open:*** RAV-3, and RAV-6B.
    b. ***Closed***: RAV-1, RAV-2, RAV-5, RAV-6A, and RAV-7.
2. Ensure that SMD external valves are in the following positions.
    a. ***Open***: SV-9.
    b. ***Closed***: SV-12, SV-13 and FCV.
3. Verify all other valve states as indicated in following Table. Record configuration in left-hand column, then verify corresponding states.

Verify Initial Valve States		
	Verify Open	***Verify Closed***
o Main Tank connected to GM	EV-9	EV-17
o Guard Tank connected to GM – liquid level ≥ 15%	EV-16, EV-13 GTV-V	EV-20, EV-23, EV-24 GTV-Va
o Well evacuated – Pumping with UTS	TV-1, VW-1, VW–2, VW-3, VW-4	
o Well evacuated – valved off	VW-1, VW–2	VW-3, -4, TV-1
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
AV valves		All

4. Turn on Main Tank vent-line heat exchanger (EH-1) in Gas Module.
5. Position "Actuator Control EV-9" on Gas Module to "Subatm He."

G.6.9. Verify proper operation of EV-9 as follows:

1. Close EV-16.
2. Close SV-9 and torque to 60 in-lbs.
3. Close EV-9.
4. Open EV-17.

5. Turn on AP-1.
6. Open AV-6 and evacuate main tank vent plumbing to <100 mtorr as measured by EG-1B.
7. Close AV-6.
8. Record EB-1B: _____ mtorr. Time: _____
9. After 30 minutes, record EG-1B again: _____ mtorr
10. Remove power to the Gas Module. (Do not remove power to the Electrical Module.)
11. Turn off the power to the programmable logic controller (PLC, in the EM)
12. After 30 minutes, restore power to the Gas Module and the PLC.
13. Verify that all GM valves are closed.
14. Re-open EV-17.
15. Record EG-1B again: _____ mtorr
16. Verify rate of rise does not exceed initial rate of rise by more than 15 mtorr in 30 min. (30 mtorr/hr.)
17. Slowly open SV-9 to repressurize the main tank manifold.
18. Close EV-17.
19. Open EV-16.
20. Open EV-9.

G.6.10. Record Initial Conditions

1. Record initial SMD vacuum shell pressure as follows:
    a. Turn on Vac-ion pump and record date/time _____/_____
    b. Use DAS [Monitor Data] for CN 99.
    c. When value is steady, record pressure (IP) _____ torr.
    d. Also record results in SMD Vacuum Shell Health Log.
    e. Verify Vacuum Shell Pressure < 5 x 10^{-5} torr. If not, turn off Vac-ion pump and perform procedure P1015, *Pump SMD Vacuum Space with Vacuum Module*, to pump out SMD vacuum shell. Record Op No. _____.
    f. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
    g. When data cycle is complete, turn off Vac-ion pump.
2. Record initial pressures:
    a. Guard Tank (EG-1a) _____ torr.
    b. Guard Tank relative to atm. (GTV-G) _____ torr.

c. Main Tank (EG-3) _____ torr.

d. Vacuum Module Pressure (VG-1): _____ torr.

3. Record initial temperatures

a. Main Tank bottom (CN [171]) _____ K.

b. Guard Tank (CN [170]) _____ K.

c. Top of lead bag (CN [175]) _____ K.

d. Top of lead bag (CN [178]) _____ K.

G.6.11. Establish Configuration of Pump Module (First Pump-down)

1. Verify open PV-2 and PV-4.
2. Verify closed PV-1, PV-3, PV-5, and PV-6.
3. Verify on/turn on water cooling (chiller unit) of pump module.
4. Verify cooling fans are operating.
5. Verify sound enclosure is installed.
6. Turn on rotary vane pump PP-2 and blower PP-1.
7. Open PV-1.
8. Once pressure PG-1 in steady state record (PG-1): _____ torr.
9. Open PV-3.

G.6.12. Set up Data Acquisition System

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

1. Verify DAS set to configuration 4ae
2. Set the Main Tank liquid-level sampling interval to 1 minute.
3. Set the Guard Tank liquid-level sampling interval to 1 minute.

Section complete _____ QA.

G.7. **Begin Pumping on Main Tank**

CAUTION
For the pumping operation, a heater has been placed on the Main Tank vent bayonet. Monitor (record on Data Sheets 1 and 2) the temperature of this bayonet to ensure that the heater can maintain the o-ring above 0° C in order to prevent leakage. 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:

Date _____ Time _____.

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

G.7.3. Verify that “Actuator Control EV-9” on Gas Module is set to “Subatm He.”

G.7.4. Open EV-4 and EV-17.

G.7.5. Input comment to DAS “Start Main Tank Pump-down”.

G.7.6. Slowly open EV-22 to begin pumping on Main Tank.

G.7.7. 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), or the ability of EH-1 to maintain the output gas temperature at its set point (10° C).

Record PFM-1 _____ LL/hr.

G.7.8. Open EV-10; EG-2 will now read approximate Main Tank pressure for pressures below 100 torr.

Comment: The high flow rate produced by initial pump-down of the Main Tank causes a substantial migration of oil from the rotary vane pump, PP-2, into the mist separator, which can result in damage to the pump. An automatic oil return unit has been added to PP-2 to eliminate this problem. However, as a precaution, the proper operation of this assembly should be monitored throughout the initial pump-down phase.

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 Data Sheets 1 and 2.

G.7.9. 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.7.10. 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. Record Date _____ and Time _____.

G.7.11. Resume pumping by slowly opening EV-7a/b to maintain desired maximum pumping rate of < 100 LL/hr as read at PFM-1 (scale B).

G.7.12. When EV-7a/b fully open and flow rate remains below 100 LL/hr:

Record Date _____ and Time_____.

G.7.13. Continue to monitor and maintain positive pressure in Guard Tank, adjusting Guard Tank heater voltage as required.

G.7.14. When heater power required to maintain positive pressure in the Guard Tank is zero:

1. Turn off GT heater power supply.
2. Open EV-13 to vent Guard Tank.

G.7.15. Verify valve configurations

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

Verify Final Valve States		
	Verify Open	***Verify Closed***
o Main Tank connected to GM		EV-9
o Guard Tank connected to GM – liquid level ≥ 15%	EV-13 GTV-V	EV-20, EV-23, EV-24 GTV-Va, EV-16,
o Well evacuated – Pumping with UTS	TV-1, VW-1, VW–2 VW-3, VW-4	
o Well evacuated – valved off	VW-1, VW-2	VW-3, VW-4, TV-1
Remaining EV valves	EV-4, EV-17, EV-21/22, EV-7a/b, EV-10	EV-5, EV-6, EV-8, EV-11, EV-12, EV-14, EV-15, EV-18,
AV valves		All

G.7.16. Set Up Data Acquisition

1. Set Main Tank liquid level sensor to 10 minute sampling interval.
2. Set Guard Tank liquid level sensor to 10 minute sampling interval.
3. Set Data interval to 15 min.

G.7.17. Continue pumping on Main Tank with pump module for a total of 20 – 24 hours. When Main Tank liquid level ≤ 65% perform the vacuum shell pressure check below and proceed to next section.

1. Record SMD vacuum shell pressure as follows:
    a. Turn on Vac-ion pump and record date/time _____/_____
    b. Use DAS [Monitor Data] for CN 99.
    c. When value is steady, record pressure (IP) _____ torr.
    d. Also record results in SMD Vacuum Shell Health Log
    e. Verify Vacuum Shell Pressure < 5 x 10^{-5} torr. If not, turn off

Vac-ion pump and perform procedure P1015, *Pump SMD Vacuum Space with Vacuum Module*, to pump out SMD vacuum shell. Record Op No. _____.

f. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.

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

Section complete _____ QA.

G.8. **Transfer NBP LHe to Subatmospheric Main Tank – I**

G.8.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.8.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.8.3. Using a 1000 liter LHSD perform, procedure P1036, *Main Tank Subatmospheric Fill from NBP Supply Dewar – GT Precool.* Bring Guard Tank liquid level to 100%

G.8.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.8.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.8.6. Continue pumping on Main Tank with pump module for 16-18 hours.

When Main Tank liquid level ≤ 75% proceed to next section.

Section complete _____ QA.

G.9. **Transfer NBP LHe to Subatmospheric Main Tank – II**

G.9.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.9.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.9.3. Using a 1000 liter LHSD, perform procedure P1036, *Main Tank Subatmospheric Fill from NBP Supply Dewar – GT Precool*. Bring Guard Tank liquid level to 100%

G.9.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.9.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (GTV-G) _____ torr.

G.9.6. Continue pumping on Main Tank with pump module for ~70 hours. When Main Tank liquid level ≤ 82% proceed to next section.

Section complete _____ QA.

G.10. **Transfer NBP LHe to Subatmospheric Main Tank – III**

G.10.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.10.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.10.3. Using a 1000 liter LHSD, perform procedure P1036, *Main Tank Subatmospheric Fill from NBP Supply Dewar – GT Precool*. Bring Guard Tank liquid level to 100%

G.10.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.10.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.10.6. Continue pumping on Main Tank with pump module for ~25 hours. When Main Tank liquid level ≤ 92% proceed to next section.

Section complete _____ QA.

G.11. **Transfer NBP LHe to Subatmospheric Main Tank – IV**

G.11.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [171] _____ K.

3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.11.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.11.3. Using a 500 liter LHSD, perform procedure P1036, *Main Tank Subatmospheric Fill from NBP Supply Dewar – GT Precool*. Bring Guard Tank liquid level to 100%

G.11.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.11.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.11.6. Continue pumping on Main Tank with pump module for ~70 hours. When Main Tank liquid level ≤ 92% proceed to next section.

Section complete _____ QA.

G.12. **Transfer NBP LHe to Subatmospheric Main Tank – V**

G.12.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.

5. Guard Tank pressure (EG-1a) _____ torr.

G.12.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.12.3. Using a 500 liter LHSD, perform procedure P1036, *Main Tank Subatmospheric Fill. From NBP Supply Dewar – GT Precool*

G.12.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.12.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (EG-1a) _____ torr.

G.12.6. Continue pumping on Main Tank with pump module for ~4 days. When Main Tank liquid level ≤ 94% proceed to next section.

Section complete _____ QA.

G.13. **Transfer NBP LHe to Subatmospheric Main Tank – VI**

G.13.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure GTV-G) _____ torr.

G.13.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.13.3. Using a 500 liter LHSD, perform procedure P1036, SMD Main Tank

Subatmospheric Fill From NBP Supply Dewar – GT Precool

G.13.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.13.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (GTV-G) _____ torr.

G.13.6. Continue pumping on Main Tank with pump module until the main tank is 94.3 - 95% full indicated (95 - 95.5% full by volume). If the main tank temperature is ≤1.65 K, proceed with G.14, otherwise proceed with the next section.

Section complete _____ QA.

G.14. **(Option) Transfer NBP LHe to Subatmospheric Main Tank – VII**

G.14.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure GTV-G) _____ torr.

G.14.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.14.3. Using a 500 liter LHSD, perform procedure P1036, *SMD Main Tank Subatmospheric Fill From NBP Supply Dewar – GT Precool*

G.14.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____

3. Final MT level _____ %.

G.14.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (GTV-G) _____ torr.

G.14.6. Continue pumping on Main Tank with pump module until the main tank is 94.3 - 95% full indicated (95 - 95.5% full by volume). If the main tank temperature is ≤1.65 K, proceed with the next section, otherwise proceed as directed by the TD.

Section complete _____ QA.

G.15. **Switch Pumping to Gas Module (AP-1)**

G.15.1. Record Date/time: _____

G.15.2. Enter comment in the DAS: “Complete conditioning of MT; switch to AP–1”

G.15.3. Turn on AP-1

G.15.4. Open AV-6.

G.15.5. Adjust both EV-7a/b to 0% (these valves do not completely close).

G.15.6. Close EV-4 and EV-21/22.

G.15.7. Close PV-1.

G.15.8. Turn off Pumps PP-1, and PP-2.

G.15.9. (Option)Turn off coolant water in Pump Module.

G.15.10. Continue monitoring Dewar instrumentation to verify that temperatures have stabilized.

G.15.11. Proceed without undue delay with the completion of this procedure and the commencement of P1002, *Configure SMD for Transport to SLC-2W*, and P1005, *Disconnect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric* (called by P1002) to close out the main tank for launch.

Section complete _____ QA.

G.16. **Establish Final Configuration**

G.16.1. Verify EV-10, EV-13, and EV-17 open.

G.16.2. Verify all other EV-valves closed

G.16.3. Verify AV-6 open.

G.16.4. Ensure all other AV valves closed.

G.16.5. Input comment to DAS “End of Main Tank Top-Off”.

G.16.6. Set the DAS data cycle to 15 minutes.

G.16.7. Set the Main Tank liquid level sampling interval to 60 minutes.

G.16.8. Set the Guard Tank liquid level sampling interval to 10 minutes.

G.16.9. 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. 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.16.10. Ensure liquid level sensor alarms enabled and record set points if changed.

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

G.16.11. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 30 torr differential.

G.16.12. Ensure DAS watchdog timer and alarm enabled.

G.16.13. Verify that the Guard Tank heater is turned off and that the pressure is stable.

G.16.14. Record the following:

1. Date: _____
2. Time of day: _____
3. Vacuum Module Pressure (VG-1): _____ torr
4. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
5. Main Tank temperature:
    a. T-9D (CN [175]):_____ K.
6. Main Tank indicated liquid level (≥ 94.3% for 95% volumetric fill): _____%
7. Guard Tank pressure relative to atm (GTV-G) _____ torr.

G.16.15. Record SMD vacuum shell pressure as follows:

1. Turn on Vac-ion pump and record date/time _____/_____
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr.
4. Record this result in the SMD Vacuum Shell Health Log.
5. Verify Vacuum Shell Pressure < 5 x 10^{-5} torr.
6. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
7. When data cycle is complete, turn off Vac-ion pump.

G.16.16. Disconnect Vacuum Module. Perform Procedure P1016, and record Operation No. _____.

Comment: This procedure does not call for closing out P1017, *Repump Well with UTS.* That will be done in the following procedure, P1002.

Sections G.16, complete _____ QA.

H. **PROCEDURE COMPLETE**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Test Director_____**Date**_____

Data Sheet 1

Date/ Time	Comments	Main Tank LHe level (%)	Main Tank pressure EG-2/ EG-3 (Torr)	Vacuum pressure VG-1 (torr)	PM pressure PG-1 (torr)	Flowrate PFM-1 (ll/hr)

Data Sheet 2

Date/ Time	GT pressure GTV_G (torr)	GT Heater Voltage (V)	EV-7a setting (%)	EV-7b setting (%)	MT bottom T-9D [09] (K)	Top LB CN [175] (K)	GT bottom CN [170] (K)	HX-4 T-8D CN [08] (K)	Gas Mod Hx MT (^{o}C)	MT Vent Bayonet/ Bay Nut (^{o}C/ ^{o}C)	Valve SV9/ Top Plate (^{o}C/ ^{o}C))	SV-9 Knob (^{o}C)

Data Sheet 1 (cont'd)

Date/ Time	Comments	Main Tank LHe level (%)	Main Tank pressure EG-2/EG-3 (Torr)	Vacuum pressure VG-1 (torr)	PM pressure PG-1/PG-2 (torr)	Flowrate PFM-1 (ll/hr)
					/	
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Data Sheet 2 (cont'd)

Date/ Time	GT pressure GTV_G (torr)	GT Heater Voltage (V)	EV-7a setting (%)	EV-7b setting (%)	MT bottom T-9D [171] (K)	Top LB CN [175] (K)	GT bottom CN [170] (K)	HX-4 T-8D CN [08] (K)	Gas Mod Hx MT (^{o}C)	MT Vent Bayonet/ Bay Nut (^{o}C/ ^{o}C)	Valve SV9/ Top Plate (^{o}C/ ^{o}C))	SV-9 Knob (^{o}C)

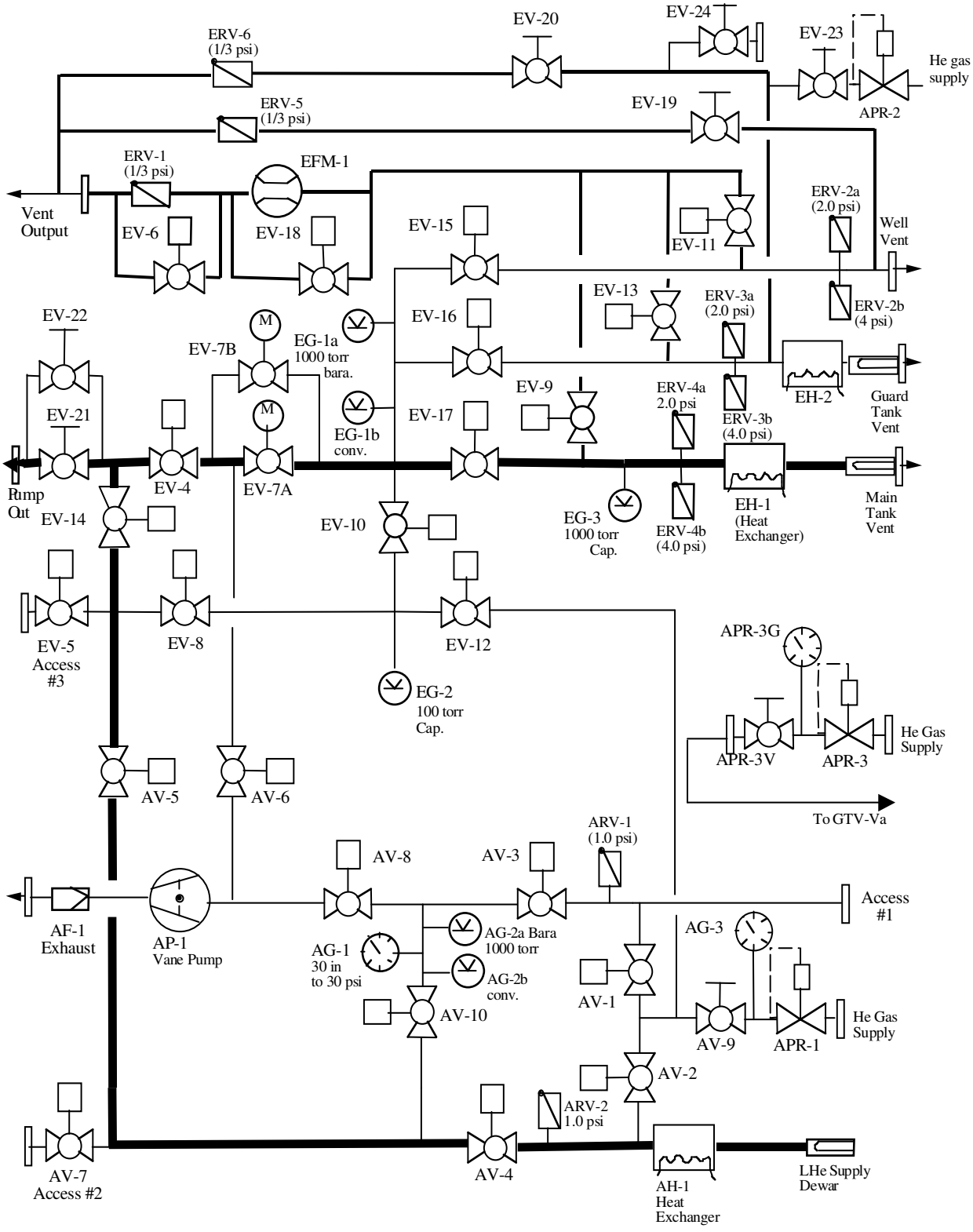

Figure 1. Schematic of Gas Module Plumbing.

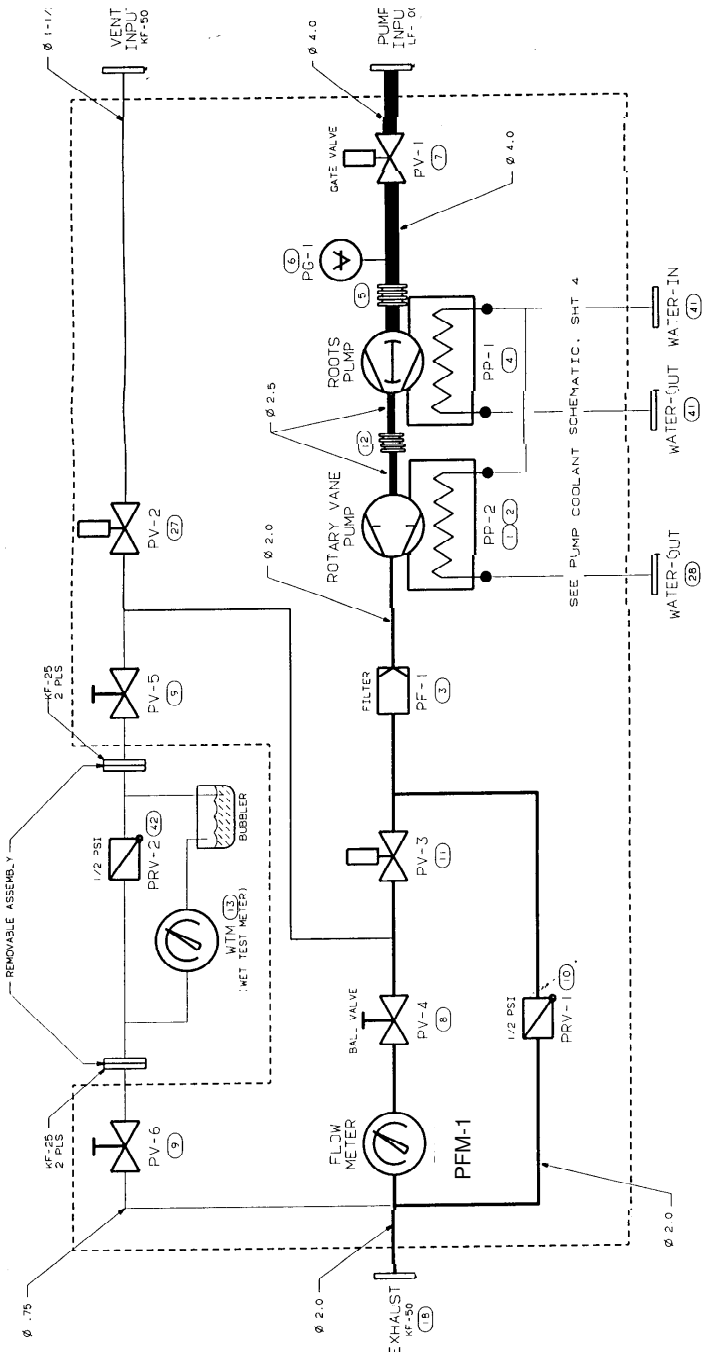

Figure 2. Schematic diagram of Pump Module plumbing.

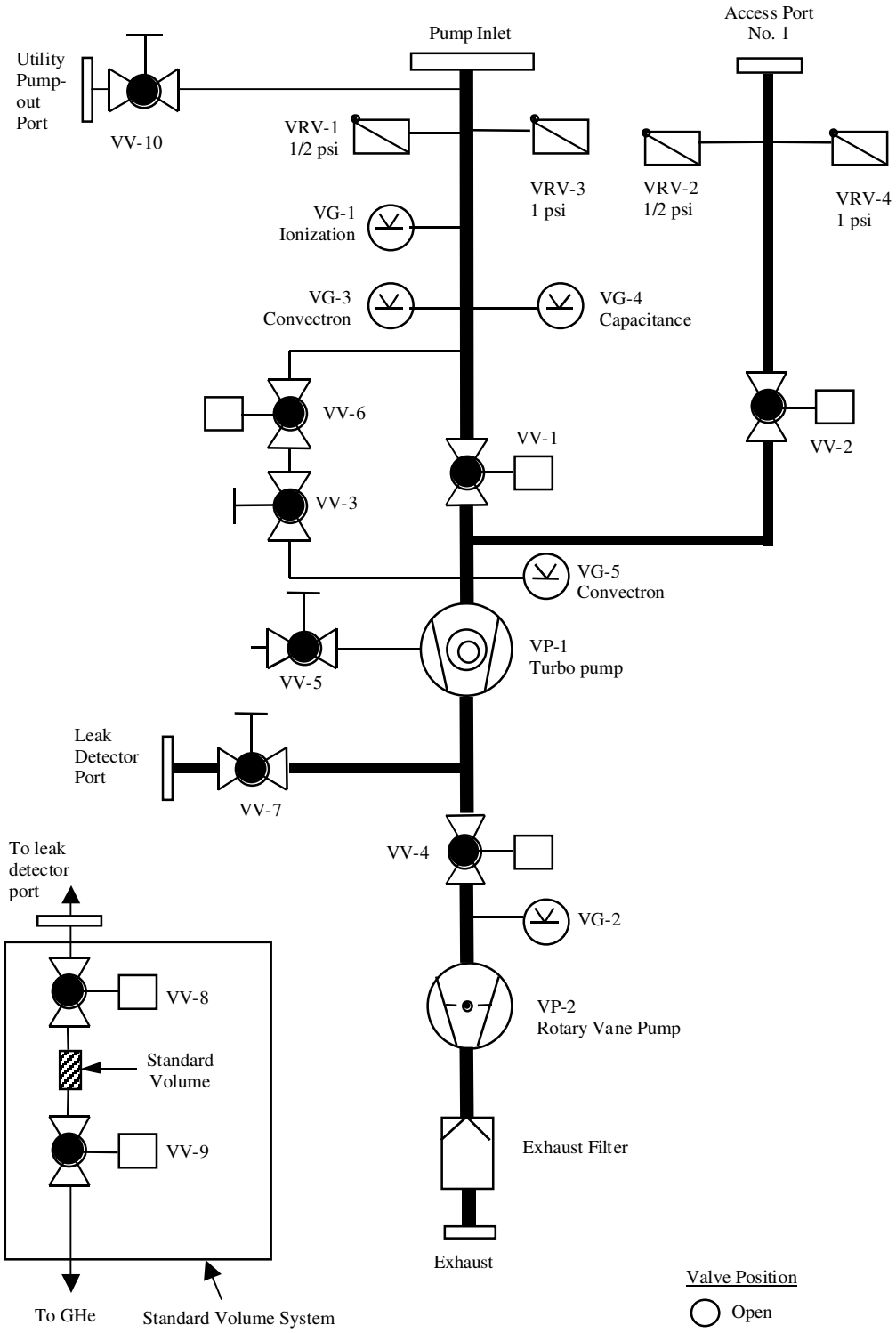

Figure 3. Schematic representation of Vacuum Module plumbing.

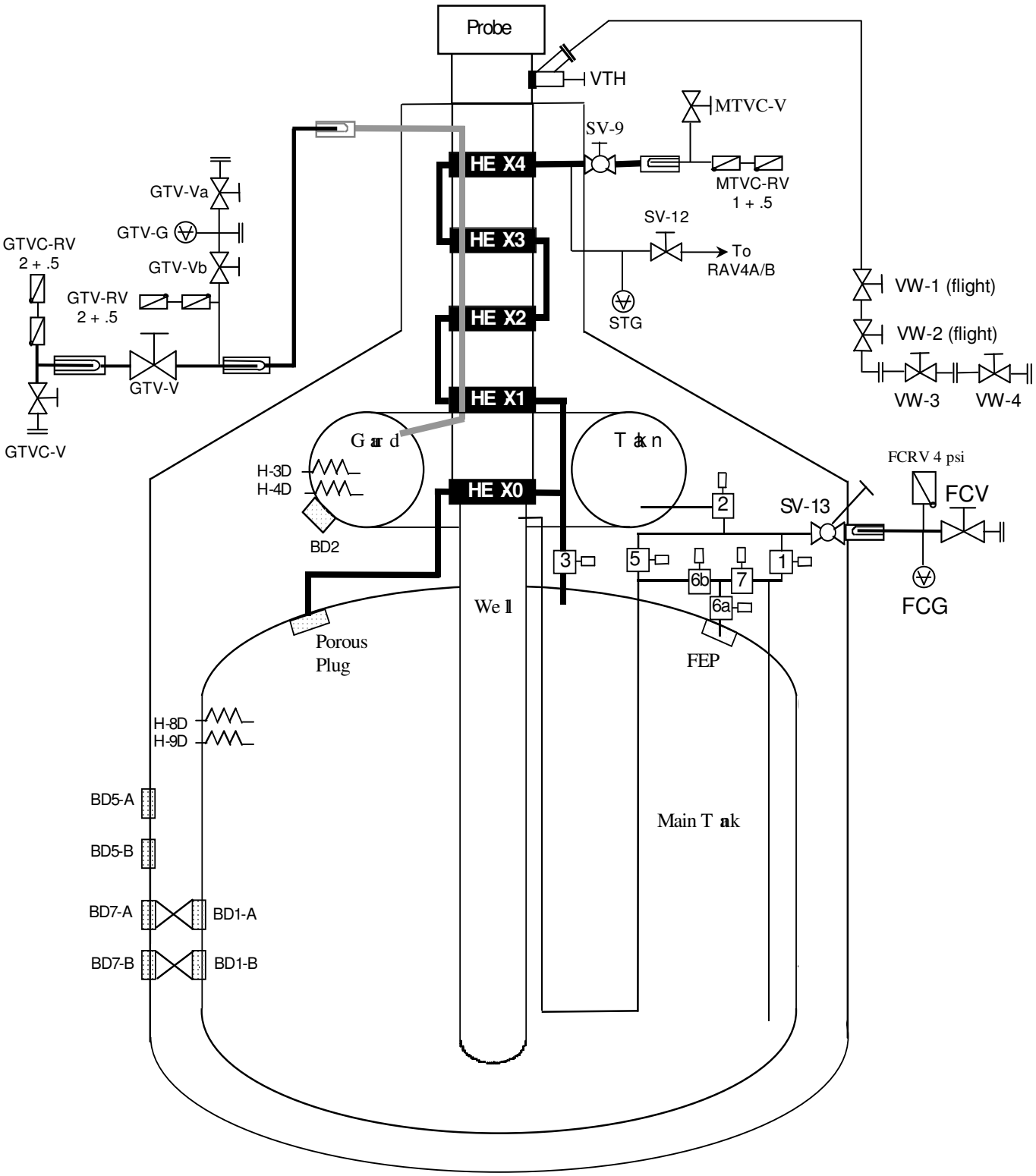

Figure 4 Schematic representation of SMD and GSE plumbing.

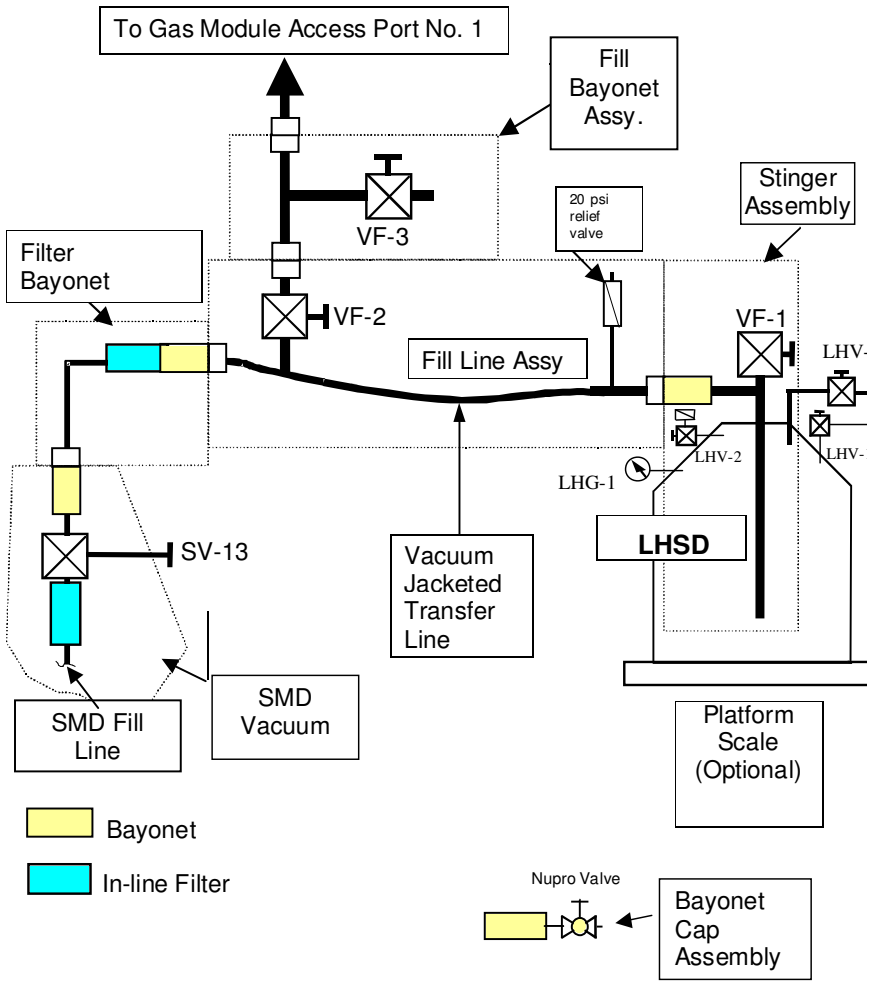

Figure 5 Liquid helium transfer setup.

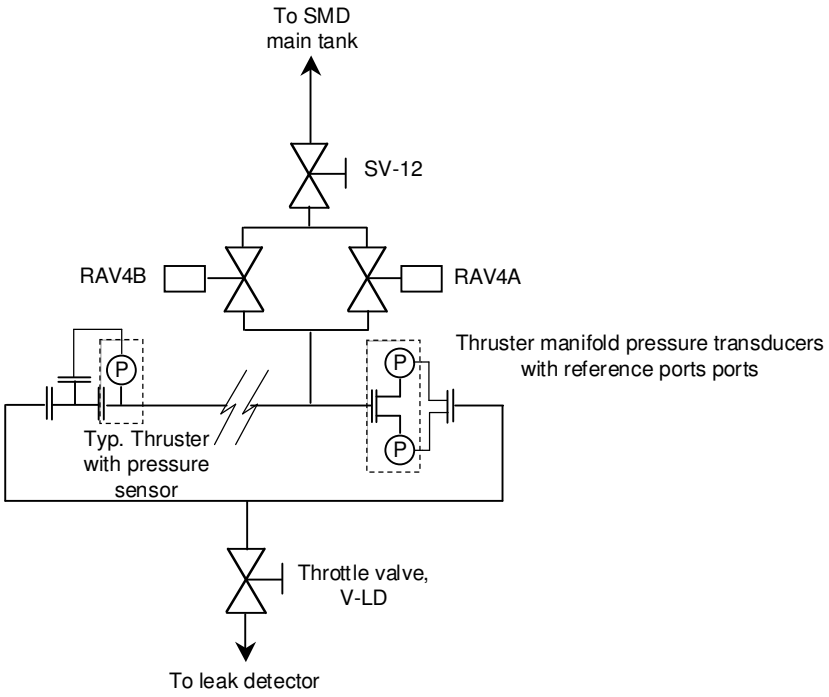

Figure 6 RAV4A/4B leak check setup.

I. APPENDIX 1 – PRE-PROCEDURE 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 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: _____		

Figure 5 Schematic representation of LHSD and Transfer Line

J. APPENDIX 2 – POST-PROCEDURE CHECKLIST

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

K. APPENDIX 3– CONTINGENCY RESPONSES

	Condition	Circumstance	Response
1	Power Failure	Momentary outage during initial pumpdown, section G.6, or later	1) Verify EV-9 is closed 2) Close EV-21/22 3) Restart pumping by commencing at G.5.9
		Extended outage during initial pumpdown, section G.6, or later (except when operating under another procedure)	1) Secure the Main Tank vent by closing EV-21/22 and SV-9 2) If possible, monitor Main Tank pressure with TM&A 3) When power is restored, restart the PM by commencing at G.5.9 (the DAS may need to be restarted) 4) After EV-22 is opened at G.6.5, reopen SV-9
2	Burst disk rupture (MT/GT)	Any time	Evacuate room
3	Oxygen depletion alarm	Any time	Evacuate room
4	Degradation of vacuum shell pressure (>5 x 10^{-5} torr at the VIP)	Any time	1) Verify that the VM is operating in standby mode with VG-1 < 10^{-5} torr, the interlock switch is in the override position, and VV-1 is open 2) Take turbopump out of standby and wait for the pump to reach full speed 3) Take the interlock out of override 4) Open SV-14 to initiate pumping on the vacuum shell