# GRAVITY PROBE B
# PROCEDURE FOR
# SCIENCE MISSION DEWAR

## NBP MAIN TANK FILL –
## GUARD TANK INITIALLY DEPLETED
## AND CONNECTED TO GAS MODULE

THIS PROCEDURE CONTAINS HAZARDOUS OPERATIONS

P0648E
ECO 1352
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## REVISION RECORD

| REVISION | ECO | PAGES | DATE |
|---|---|---|---|
| A | 1158 | Changed title to reflect content more accurately<br>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.<br>Added Quality Assurance Section (new Section C)<br>Section C, D, and E – Consolidated all requirements into new Section E entitled Requirements. Added Configuration requirements to include minimum GT and Well liquid levels, GSE/SMD interface requirements, alarm setup requirements, vacuum requirements, and non-flight hardware requirements.<br>Section G.1 Added section to verify notification of QA.<br>Section G.2 – Added steps to verify configuration requirements and alarm setup. Added GT to level alarm list (setpoint = 10%)<br>Section G.3 – Added section to verify Gas Module in Standard Configuration.<br>G.4. – Added section to verify SMD in standard configuration.<br>Added warnings to monitor temperatures at Station 200 and the top of the lead bag continuously while the Main Tank vent is closed.<br>Section G.18 – changed to require Manifolding of Guard Tank vent with Main Tank vent, following completion of procedure.<br>Added caution at end of procedure to monitor Guard Tank pressure and set DAS alarm to 0.3 torr differential. | |
| B | 1253 | Changed to allow use in more cases than just following an SMD upright procedure (P0633).<br>Changed title to reflect this change.<br>Changed scope to include any fill operation in which the GT is initially depleted and pressure regulated.<br>Changed section G.8 to allow MT pressure to be built in one of two ways: (1) by turning on the MT heater (2) by allowing the pressure to build passively as is done with P0633. | 3/27/01 |
| C | 1292 | Changed DAS setup to include switch the fast scan mode at beginning of procedure and return to normal scan mode at end of procedure.<br>Updated list of qualified personnel and added other minor updates | 8/8/01 |
| D | 1308 | Remove operations dealing with Well not evacuated, add QA inspect points, add additional valve configuration callouts. Remove option for Guard Tank not connected to Gas Module. (For latter case, Guard Tank not connected to Gas Module, see P00877).<br>Added Hazardous Materials comment to title Page.<br>Added step to verify purity of helium gas<br>Modified Sections B2.2 and B3.1 to reflect new location of SMD dewar in Lockheed Martin building 205<br>Added Appendix Contingency Responses<br>Added pre/post checklist tables | 9/1/01 |
| E | 1352 | Added option for RAV-2 operation by spacecraft command if ECU is connected to J802;<br>Added requirement to use cryogenic safety gear during stinger installation or removal;<br>Added installation of vent line from VF-3 to facility vent;<br>Replaced references to CN [1] (STA 200 temperature) with references to CN [29] (top of lead bag temperature, redundant to CN [28]) | |

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## LIST OF ABBREVIATIONS AND ACRONYMS

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

## A. Scope

This procedure describes the steps necessary to perform an external fill of the SMD Main Tank with normal boiling point liquid helium with the Guard Tank initially depleted of liquid helium. (For Guard Tank initially with liquid helium, see P0442.) The Guard Tank and Main Tank are connected to the Gas Module via their vent lines. (For Guard Tank vent not connected to Gas Module, see P0877) The Well is evacuated and the Well pump-out manifold may be installed.

The steps include:

1. Fill Guard Tank to 15% from Main Tank
2. Pre-cool SMD internal fill line from Guard Tank
3. Pre-cool external transfer line from storage dewar
4. Fill Guard Tank
5. Switch from Guard Tank fill to Main Tank fill
6. Terminate transfer

Heating the Main Tank to raise its pressure when the level is low should be done judiciously to avoid overheating the ullage gas, hence raising the temperature at Station 200 and the top of the lead bag to unacceptable levels (> 6 K). If fill operation is to be performed as part of P0633, *Upright SMD Rotate from Horizontal to Vertical Orientation,* the pressure has already been built passively while still horizontal. If not, EV-9 may be closed well in advance of performing the actual fill operation (e.g., overnight) as the pressure may take some time to build this way. Note, however, that leaving EV-9 closed for extended periods of time while the SMD is vertical may also cause the temperatures at Station 200 and the top of the lead bag to rise to unacceptable levels. It should also be noted that since the installation of the flight fill line burst disk, the temperature at the top of the main tank rises fairly rapidly when RAV-1 is opened for the internal transfer. This phenomenon should be taken into account in the planning and execution of this procedure.

## 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 LM Building may have an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. Additional temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions. Emergency vent line deflectors are installed over the four burst disks on the SMD vacuum shell.

Only authorized and trained LM and SU personnel are allowed In the high-bay without escort. All personnel working at a height 30 inches or more off the floor are required to have an LM approved air tank within easy reach. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the room and contact LM safety.

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

### B.2.3. Other Hazards

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

## B.3. Mishap Notification

### B.3.1. Injury

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

### B.3.2. Hardware Mishap

In case of an accident, incident, or mishap, notification is to proceed per the procedures outlined in Lockheed Martin Engineering Memorandum EM SYS229.

B.3.3. Contingency Response

Contingency responses to possible equipment troubles or irregularities (e.g., power failure) are listed in Appendix 3.

## C. Quality Assurance

### C.1. QA Notification

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

### C.2. Red-line Authority

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

### C.3. Discrepancies

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

C.3.1. If the discrepancy has minimal effect on procedure functionality (such as the state of a valve that is irrelevant to performance of the procedure) it shall be documented in the procedure, together with the resolution. Redlines to procedures are included in this category.

C.3.2. If the discrepancy is minor and affects procedure functionality but not flight hardware fit or function, it shall be recorded in the D-log. Resolution shall be in consultation with the Test Director and approved by the QA representative.

C.3.3. All critical and major discrepancies, those that effect flight hardware fit or functions, shall be documented in a D-log and also in a Discrepancy Report, per P0108.

## D. Test Personnel

### D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. However, during the startup of the transfer (Sec. G.14), there are to be a minimum of two qualified persons (Sec. D.3) in attendance. The person performing the operations (Test Director or Test Engineer) is to sign the “Completed by” sign-off. Any other qualified person or QA person who can attest to the successful performance of this procedure may

sign the "Witnessed by" sign-off. **The Test Director will perform pre-test and Post-Test briefings in accordance with P0875 "GP-B Maintenance and Testing at all Facilities". Checklists will be used as directed by P0875.**

### D.2. Personnel Qualifications

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

Qualified Personnel

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

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

## E. Requirements

### E.1. Electrostatic Discharge Requirements

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

### E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

### E.3. Hardware/Software Requirements

#### E.3.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

#### E.3.2. Ground Support Equipment

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

Pump Module, and SMD. The Vacuum Module contains a turbo pump, backed by a vane pump, and provides the capability to pump out the SMD vacuum shell.

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

E.3.3. Computers and Software:

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

E.3.4. Spacecraft Support:

If connector J802 is connected to the Experiment Control Unit (ECU), 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*** |
|---|---|---|
| AMI Level Sensor Readout for LHSD | AMI | 110 |

E.3.6. Additional Hardware

| ***Description*** | ***Manufacturer*** | ***Model*** |
|---|---|---|
| Filter Line assembly | LM | 5833827 |
| Liquid He Transfer Line | LM | 5833804 |
| Liquid He Stinger | LM | 5833803 |
| GHe supply fittings to LHSD | N/A | N/A |
| **500 or 1000 Liter Liquid Helium Supply Dewar** | **Cryofab** | **CMSH-500, -1000** |
| Protective face shield or googles | N/A | N/A |
| Cryo gloves | N/A | N/A |
| Impermeable apron | N/A | N/A |

E.3.7. Tools

| ***Description*** |
|---|
| Torque Wrench, 1-1/4-in socket, 60 in-lb |
| 1-1/4 adjustable wrench |

E.3.8. Expendables

| *Description* | *Quantity* | *Mfr./Part No.* |
|---|---|---|
| Ethyl alcohol | AR | N/A |
| 99.999% pure gaseous helium | AR | N/A |
| Vacuum Grease | AR | Dow Corning High Vacuum or Apiezon N |
| Tie wraps – large size | AR | N/A |
| Liquid helium | AR | N/A |

## E.4. Instrument Pretest Requirements

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

Table 1. Required Instrumentation and Calibration Status

| No. | Location | Description | User Name | Serial No. | Cal Required | Status Cal due date |
|---|---|---|---|---|---|---|
| 1 | DAS | Power Supply, H-P 6627A | A1, A2, A3, A4 | 3452A01975 | Yes | |
| 2 | DAS | Power Supply, H-P 6627A | B1, B2, B3, B4 | 3452A01956 | Yes | |
| 3 | DAS | Data Acquisition/Control Unit H-P 3497A | - | 2936A24553 9 | No | - |
| 4 | DAS | Digital Multimeter H-P 3458A | - | 2823A15047 | Yes | |
| 5 | EM | Vacuum Gauge Controller Granville-Phillips Model 316 | EG-1a, -1b | 2827 | No | - |
| 6 | EM | Vacuum Gauge Controller Granville-Phillips Model 316 | AG-2a, -2b | 2826 | No | - |
| 7 | EM | Vacuum Gauge Controller Granville-Phillips Model 316 | EG-3 | 2828 | No | - |
| 8 | EM | MKS PDR-C-2C | EG-2, FCG | 92022108A | No | - |
| 9 | EM | Flow meter – Matheson 8170 | EFM-1 | 96186 | No | - |
| 10 | EM | Flow meter totalizer Matheson 8124 | EFM-1 | 96174 | No | - |
| 11 | EM | Liquid Helium Level Controller | LLS Main Tank | 96-409-11 | No | - |

| No. | Location | Description | User Name | Serial No. | Cal Required | Status Cal due date |
|---|---|---|---|---|---|---|
| | | American Magnetics, Inc. 136 | | | | |
| 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. Main Tank

Liquid in the Main Tank must be at its normal boiling point (NBP), 4.2 K. The SMD is vertical with the +z axis up. The actuator control valve for EV-9 switches the state that EV-9 defaults to, should a power failure occur. It should be placed in the “NBP.” position, for this procedure, ensuring that EV-9 remains open in the event of power failure.

E.5.2. Guard Tank

The Guard Tank is depleted and regulated to a pressure > 0.3 torr above atmosphere. Care must be taken at all times to keep its pressure above atmospheric.

E.5.3. Well

The Well is evacuated and the Well pump-out at VTH may be in one of the following configurations: 1) VTH closed with the VTH operator removed; 2) the Well manifold connected to a closed VTH; or 3) the Well manifold connected to an open VTH while the Well is being pumped through the manifold per procedure P0613 “Repump Well with Probe Installed”.

E.5.4. SMD Vacuum Shell

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

E.5.5. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:

   **a.** Top of lead bag temperature set (CN 28) at $T \leq 6.0$ K.

   b. Top of lead bag temperature set (CN 29) at $T \leq 6.0$ K.

   c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 0.3$ torr.

2. The Watch Dog alarm must be armed.

E.5.6. GSE and Non-flight Hardware

1. A relief valve or flight-like burst disk may be installed in place of the SMD fill-line burst disk.

2. The ion-pump magnet must be installed.

3. GSE cabling must be connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811). J801 and J802 (of the SMD) may be connected either to the ECU or to the Electrical Module.

4. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line, use procedure P0674, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP* if this is not the case.

5. The Guard Tank vent line is connected to the Gas Module.
6. The thruster vent port may be opened to a Endevco pressure transducer, STG.
7. The Fill Cap Assembly must be installed at SV-13 (Figure 3)
8. Top Plate heaters must be installed on SMD and be operational.

### E.6. Optional Non-flight Configurations

The following non-flight modifications of the basic SMD and optional GSE configurations are incidental to the performance of this procedure. Any combination represents an acceptable configuration.

1. The SMD is installed in: the SMD transportation and test fixture or the space vehicle assembly fixture; or the space vehicle tilt dolly.
2. A foreign object and debris shield may cover the upper cone of the SMD. If it is not present, any object that could cause damage to the payload, if dropped, must be tethered.
3. The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be off, actively pumping the pumping line up to a closed SV-14, or actively pumping the vacuum shell

### E.7. Verification/ Success Criteria

N/A

### E.8. Payload Constraints and Restrictions

N/A

## F. Reference Documents

### F.1. Drawings

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

### F.2. Supporting documentation

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

| | |
|---|---|
| SU/GP-B P059 | *GP-B Contamination Control Plan* |

### F.3. Additional Procedures

| ***Document No.*** | ***Title*** |
|---|---|
| SU/GP-B P0213 | *Connect Vacuum Module/ Pump on SMD Vacuum Shell* |
| SU/GP-B P0674 | *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP* |

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. If SMD connector J802 is connected to the ECU, verify that the Spacecraft is prepared to command RAV-2 when requested.

G.1.4. Record calibration due dates in Table 1 (Sec. E.4).

G.1.5. 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.1.6. Verify Pre-ops meeting with operations group has been conducted. (Checklist is in Appendix 1.)

G.1.7. Verify Purity of All Sources of Helium Gas

Record serial number on helium bottle/s.

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

G.1.8. Verify helium bottle/s have been tested for purity and record Op. Number. Op. Number:_____

Date/time _____/_____.

Quality _____

### G.2. Verify Configuration Requirements

**CAUTION**

The Main Tank vent path is closed at EV-9 during the initial stages of this procedure to allow pressure for the transfer to build. During this period of closure the temperature at the top of the lead bag is appropriately alarmed and continuously monitored to detect trends prior to alarm. Corrective action for over temperature is given in Appendix 3.

G.2.1. Verify that the SMD is vertical. This procedure may be performed only in the vertical orientation.

G.2.2. Ensure DAS Watch Dog Alarm enabled.

G.2.3. Ensure that Top Plate heaters on SMD are operational.

G.2.4. Verify GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.5. Record MT pressure (EG-3 and/ or STG) ____ torr ____ torr.

**Note**: if allowing pressure to build passively (see G.8.2) , Main Tank pressure must be greater than 15 torr above atmospheric before proceeding with initial Guard Tank fill.

G.2.6. Verify Main Tank vent line connected to Gas Module. If not perform procedure P0674, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP,* to connect Main Tank vent. Complete P0674 through paragraph G.6.6 step 1 only (i.e., open SV-9 but **do not** reestablish Main Tank venting by opening EV-9).

G.2.7. Close /Verify closed EV-9 Date/Time _____/_____

G.2.8. Verify DAS alarm system enabled and record set points.

1. Main Tank level ("A" or "B"): Record set point _____%
2. Guard Tank Level ("A" or "B"): Record set point _____%
3. Top of lead bag temperature – verify [CN 28] on DAS alarm list and set to alarm at $T \leq 6.0$ K. Record set point _____K
4. Top of lead bag temperature – verify [CN 29] on DAS alarm list and set to alarm at $T \leq 6.0$ K. Record set point _____K
5. Relative Guard Tank Pressure – verify [CN 46] on DAS alarm list and set to alarm at $\Delta P \geq 0.3$ torr. Record set point _____torr

G.2.9. Ensure Main Tank liquid-level alarm enabled.

G.2.10. Ensure Main Tank liquid-level alarm set ≥ 20%: Record. _____%

G.2.11. Verify Fill Cap Assembly installed at SV-13.

G.2.12. Ensure ion-pump magnet installed.

G.2.13. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day _____
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr. If pressure is above $1 \times 10^{-4}$ torr, perform procedure P0213, *Connect of Vacuum Module / Pump on SMD Vacuum Shell*, to connect Vacuum Module and pump out SMD vacuum shell.

**Note**: if performing this procedure as part of up-righting the SMD and the Main Tank level is < 30%, fill the MT first after up-righting and then pump on the vacuum shell.

4. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
5. When data cycle is complete, turn off Vac-ion pump.

G.2.14. Verify liquid in Main Tank is at NBP (4.2<T<4.3) and record temperature at bottom of tank CN [9] _____K.

G.2.15. Verify Actuator Control for EV-9 set to "NBP" position.

Section G.2 Complete Quality _____

### G.3. Verify Valve Configuration and Record Initial Conditions

G.3.1. Verify valve states as indicated in following Table. Record configuration in left-hand column, then verify corresponding valve states.

| **Verify Initial Valve States** | | |
|---|---|---|
| | **Verify Open** | **Verify Closed** |
| 1. Main Tank vent<br>Connected to GM | | EV-9, EV-17 |
| Guard Tank vent<br>Connected to GM; depleted of LHe and pressure regulated at EV-23 (verify source of He gas at APR-2) | EV-16, EV-23<br>GTV-V, APR-2 | EV-13, EV-20, EV-24<br>GTV-Va |
| 2. 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 |
| 3. AV valves | | All |
| 4. Dewar Valves | GTV-V, SV-9 | GTV-Va, V-12 (or STVa and STVb), SV-13, FCV |

G.3.2. Record initial temperatures

1. Top of Lead Bag CN [28] _____ K.
2. Top of Lead Bag CN [29] _____ K.
3. Temperature at bottom of Main Tank CN [9] _____K.

G.3.3. Record pressures.

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

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

G.3.5. Record Fill Cap Assembly pressure and verify that it reads >760 torr. If not, enter in D-log and consult Payload Test Director.

Fill Cap Assembly (PFCG): _____ torr.

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

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

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

Section G.3 complete. Quality_____

### G.4. Verify SMD in Standard Configuration

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

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

G.4.2. Verify SV-9 open.

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

G.4.4. Valve configuration:

| | Open | Closed |
|---|---|---|
| EV valves | EV-7a/-b, EV-16, EV-23 | All other |
| AV valves | APR-2 | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-3, RAV-6B | All other |
| VF valves | N/A | N/A |

**Note:** The regulator valves APR-1 and APR-2 are included in the open column when appropriate to indicate that they are actively involved in supplying gas at a regulated pressure. APR-1 feeds AV-9 and APR-2 feeds EV-23, the latter for GT pressurization.

Section G.4 complete. Quality_____

### G.5. Set Up Data Acquisition System

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

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

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

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

G.5.4. Start "Special Data Cycle" by using [Other Menus] + [Special Data Col] + [Use Pre-Selected], and from menu select "1 = Main Tank fill with Guard Tank empty", + [Init. Collectn] + [Enter] (=use default file). Use 0.1 minute cycle time.

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

G.5.6. Set Main Tank and Guard Tank Liquid Level Sensor sampling intervals to 1 min.

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

### G.6. Check Initial Pressure in Fill Line

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

G.6.2. Turn on pump AP-1.

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

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

G.6.5. Close AV-8 and FCV.

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

Fill Cap Assembly pressure (PFCG): _____ torr.

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

Fill line pressure (PFCG): _____ torr.

`

Section G.6 complete. Quality_____

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

**CAUTION**:
Opening RAV-1 in the following steps may cause heating of the top of the Main Tank. Be prepared to proceed to the opening of RAV-2 to start the transfer without undue delay. The rate of temperature rise at the top of the lead bag (CN [28], CN [29]) should be monitored by the test director. If the temperature limit at the top of the lead bag is reached, be prepared to undertake Contingency Response #2 in Appendix 3.

G.7.1. Discontinue normal data cycles by using [D.C. off]

G.7.2. Verify that the Special Data Cycle is rolling over at 0.1 minute intervals.

G.7.3. Open RAV-1 using:

1. Ensure all RAV controller selection switches in OFF position.
2. Turn on RAV power supply and adjust current limit to 1.85 amps.
3. Adjust power supply to 28 VDC.
4. Power up controller #1.
5. Position selection switch for controller #1 to RAV-1.
6. Record initial status lights(4) on: Open: θ θ Closed: θ θ
7. Activate controller #1 to open RAV-1 and record:
   a. Run time:_____ seconds.
   b. Current draw:_____ amps.
   c. Time of day: _____.
8. Record final status lights(4) on: θ θ Closed: θ θ
9. When convenient, record operation in RAV log book.

G.7.4. Verify that the Fill Cap Assembly pressure (PFCG) rises to Main Tank pressure

1. Record Main Tank pressure (EG-3) _____ torr
2. Record Fill line pressure (PFCG): _____ torr.

G.7.5. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

## G.8. Prepare for Internal Transfer to Guard Tank

G.8.1. Prepare RAV-2 for activation

---

o J802 connected to Electrical Module:

1. Ensure selection switch for controller #2 in OFF position.
2. Power up controller #2.
3. Position selection switch for controller #2 to RAV-2.
4. Record status lights(4) on: Open: θ θ Closed: θ θ

---

o J802 connected to the ECU:

5. Verify that operations personnel are prepared to operate RAV-2 on request.

---

G.8.2. Turn on Main Tank heater power supply, (H-8D or H-9D) as follows.

- Pressure in Main Tank to be raised by adding heat.

1. Verify liquid level of Main tank is > 40 % and the temperature at the top of the lead bag (CN[28]) is stable, if not, use the alternate process below; build pressure passively
2. Adjust current limit to 1.25 amps.
3. Starting the voltage at zero volts, incrementally increase the voltage to a maximum of 15 volts. Record heater settings and other data in the table at G.9.6

- Pressure in Main Tank is to be raised "passively".

4. Adjust current limit to 0.5 amps.
5. Adjust voltage output to zero volts.
6. If necessary, incrementally raise the heater voltage in one-volt steps. Record heater settings and other data in the table at G.9.7.

G.8.3. Verify Main Tank pressure (STG) > 15 torr above atmospheric pressure and record STG: _____ torr diff.

G.8.4. Valve configuration:

| | Open | Closed |
|---|---|---|
| EV valves | EV-7a/-b, EV-16, EV-23 | All other |
| AV valves | AV-3, APR-2 | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-1, RAV-3, RAV-6B | All other |
| VF valves | N/A | N/A |

Section G.8 complete. Quality_____

### G.9. Initiate Transfer to Guard Tank

**CAUTION**
Pay close attention to the top of the lead bag temperatures as opening RAV-2 may further increase the rate of rise. Prepare to open EV-9 briefly (see contingency 2 of Appendix 3) if this happens.

G.9.1. Input comment to DAS "Start Internal transfer to Guard Tank".

G.9.2. Establish Guard Tank vent path.

1. Close EV-23

2. Open EV-13 and record time _____.

G.9.3. When Guard Tank pressure as read at (CN [46]) ≤ 5 torr diff, :

1. Record Guard Tank pressure (GTV-G), CN [46] _____torr diff.
2. Immediately open RAV 2 (next step).

---

o J802 connected to Electrical Module:

3. Activate controller #2 to open RAV-2 and record:
   a. Run time:_____ seconds
   b. Current draw:_____ amp
   c. Time of day: _____
4. Record final status lights(4) on: Open: θ θ Closed: θ θ
5. When convenient, record operation in RAV log book.

---

o J802 connected to the ECU:

6. Request operations personnel to <u>open</u> RAV-2 and record time of day: _____.
7. Record valve status indication from operations personnel when the information is available: _____
8. When convenient, record operation in RAV log book.

---

G.9.4. When RAV-2 operation is completed, immediately open EV-6 and EV-18.

G.9.5. Confirm transfer by noting Guard Tank vent gas flow and, ultimately, an increase in the Guard Tank liquid level.

G.9.6. Adjust Main Tank heater voltage, as necessary, to maintain a reasonable transfer rate.

**CAUTION**

Use of the Main Tank heater will heat the MT ullage as well as the liquid and should be done sparingly when the Main Tank level is < 40%.

G.9.7. Record data in the following table.

| Time | MT Pressure EG-3 (torr) | GT Pressure GTV-G (torr) | GT Temp CN [24] | MT Heater Voltage (V) | MT LLS (%) | GT LLS (%) | Comments |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
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G.9.8. When the Guard Tank liquid level reaches 15%:

1. Turn off Main Tank heater
2. Terminate transfer (perform following section).

| | Open | Closed |
|---|---|---|
| EV valves | EV-6, EV-7a/-b, EV-13, EV-16, EV-18 | All other |
| AV valves | AV-3 | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-1, RAV-2, RAV-3, RAV-6B | All other |
| VF valves | N/A | N/A |

Section G.9 complete. Quality_____

### G.10. Terminate Transfer to Guard Tank

G.10.1. Close RAV-1 as follows:

1. Verify controller #1 powered up and selection switch set to RAV-1.

1. Controller #1 powered up and set to RAV-1.
2. Controller #1 not powered up — perform the following steps:
   a. Ensure selection switch for controller #1 in off position
   b. Power up controller #1.
   c. Position selection switch for controller #1 to RAV-1.

2. Record initial status lights(4) on: Open: θ θ Closed: θ θ
3. Activate controller #1 to close RAV-1 and record:
   a. Run time:_____ seconds
   b. Current draw:_____ amp
   c. Time of day:_____
4. Record final status lights(4) on: θ θ Closed: θ θ
5. Turn selection switch for controller #1 to OFF.
6. Power off controller #1.
7. When convenient, record operation in RAV log book.

G.10.2. Configure Guard Tank vent valves as follows

1. Close EV-6, and EV-18.
2. Close EV-13.
3. Open EV-20.

G.10.3. Open EV-9 and record time _____

G.10.4. Enter comment to DAS “Open EV-9 - end internal GT transfer.”

G.10.5. Once conditions have stabilized, record:

1. Guard Tank Pressure (GTV-G):_____ torr (relative to atm.).
2. Main Tank pressure (EG-3):_____ torr.
3. Flow rate EFM-1 _____slpm.

G.10.6. Record liquid levels:

1. Main Tank level ("A" or "B"): _____%
2. Guard Tank Level ("A" or "B"): _____%

### G.11. Install Stinger in LHSD

**CAUTION**
The following operations involve steps that pose cryogenic safety hazard. To prevent injury, the person performing the stinging operation must wear protective gloves, face shield, and apron.

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

G.11.1. Reduce LHSD pressure to < 1.0 psig by opening low-pressure relief. LHV-2.

G.11.2. Open valve VF-1 (Liquid withdrawal valve) on the stinger.

G.11.3. Slowly insert stinger into LHSD while purging. Position stinger withdrawal end approx. 1-in. above bottom of LHSD and tighten quick disconnect.

G.11.4. Close valve VF-1 just as cold gas is expelled from stinger.

G.11.5. Close the primary (low-pressure) relief valve, LHV-2, on the LHSD.

G.11.6. Increase LHSD ullage pressure builder to 8 to 10 psig by performing the following steps:

1. Attach a GHe hose to the VENT outlet (LHV-1) of the LHSD while purging the hose and the VENT outlet.
2. Adjust pressure regulator to obtain 8 to 10 psig in LHSD.

G.11.7. Record LHSD data:

Date / time: _____ / _____
Liquid level _____ %
LHSD serial number: _____

G.11.8. LHSD valve positions:

Open: LHV-1; Closed: all other

Section G.11 complete. Quality_____

### G.12. Install Fill Line Assembly

**Note:** Two transfer lines are available for use. One has an integrated filter and connects directly to bayonet B3 at the dewar. The other has a separate filter that is first installed at bayonet B3 (the latter case is shown in Fig. 5), after which the fill line is connected to the filter.

G.12.1. Record fill line used:

- o Fill line with integrated filter
- o Fill line and separate filter

G.12.2. Backfill Pumping line and Fill Cap Assembly as follows:

1. Ensure AV-8 closed.
2. Open AV-1
3. Open AV-9 until pressure reaches 0 psig at AG-1, then close AV-9.
4. Close AV-1.

G.12.3. Remove the pumping line from the fill cap assembly.

G.12.4. Remove fill cap assembly from bayonet B2.

G.12.5. Install Filter Line Assembly (P/N 5833827) to Dewar Fill Bayonet B3 if used.

G.12.6. Install Fill Line Assembly as follows:

1. Mate the Fill Line (P/N 5833804) with the LHSD Stinger at VF-1.
2. Mate VF-2 end of transfer line with Filter Line Assembly or B3 as appropriate.
3. Ensure VF-2 and relief valve stems pointed upwards.
4. Ensure VF-3 closed.
5. Connect a low-impedance facility vent line to the KF fitting at VF-3.

G.12.7. Valve configuration:

| | Open | Closed |
|---|---|---|
| EV valves | EV-7a/-b, EV-9, EV-16, EV-20 | All other |
| AV valves | AV-3, APR-1 | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-2, RAV-3, RAV-6B | All other |
| VF/VH valves | LHV-1 | VF-1, VF-2, VF-3, LHV-2, LHV-3 |

Section G.12 complete. Quality_____

### G.13. Condition Transfer Line/Filter/Stinger Assembly

G.13.1. Configure Pumping Line as follows:

1. Connect 1.5-in diameter flexible pumping line mated to Access-1 of Gas Module to VF-3.

G.13.2. Evacuate Transfer Line:

1. Open valve VF-2.
2. Open/verify open AV-3.
3. Open AV-8.
4. Close AV-8 when pressure reaches less than 50 mtorr as read on gauge AG-2.

G.13.3. Backfill Transfer Line:

1. Open AV-1.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.
3. Close AV-1.

G.13.4. Evacuate Transfer Line (second time):

1. Open AV-8.
2. Close AV-8 when pressure reaches less than 50 mtorr as read on gauge AG-2.

G.13.5. Backfill Transfer Line (second time):

1. Open AV-1.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.
3. Close AV-1

G.13.6. Valve configuration

| | Open | Closed |
|---|---|---|
| EV valves | EV-7a/-b, EV-9, EV-16, EV-20 | All other |
| AV valves | AV-3, APR-1 | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-2, RAV-3, RAV-6B | All other |
| VF/LH valves | VF-2, LHV-1 | VF-1, VF-3, LHV-2, LHV-3 |

Section G.13 complete. Quality_____

### G.14. Start Guard Tank Transfer

**Note:** This section starts the transfer by precooling the SMD internal Fill Line by pushing liquid up from the Guard Tank.

**CAUTION**
Transfer startup is a critical operation. All potentially interfering operations must be suspended. A qualified test director/engineer must be assigned to monitor temperatures at the top of the lead bag during pre-cool and initial startup of transfer.

G.14.1. Turn on Main and Guard Tank vent line heat exchangers (EH-1, EH-2).

G.14.2. Ensure VF-3 closed

G.14.3. Open/verify open VF-2.

G.14.4. Open SV-13.

G.14.5. Ensure Guard Tank pressure is grater than atmospheric pressure and :

Record Guard Tank pressure CN[46] (GTV-G): _____ torr diff.

G.14.6. Verify EV-17 closed.

G.14.7. Verify EV-9 open.

G.14.8. Close EV-20.

G.14.9. Turn on power supply for Guard Tank heater (H-3D or H-4D).

1. Set power supply current limit to 0.07 amps.
2. Set power supply voltage to 50 volts.

G.14.10. Record voltage _____ vdc, and current _____ amps.

G.14.11. Open VF-3: starting precool of fill line.

G.14.12. When Fill Valve (SV-13) temperature T-24D [CN 42} is <73 K:

1. Power off Guard Tank heaters.

2. Close SV-13.
3. **Immediately** open VF-1 to start pre-cooling of transfer line.

G.14.13. Configure Guard Tank venting

1. Close EV-9.
2. Open EV-13.

G.14.14. When the facility vent line connected to VF-3 indicates adequate cooling of the transfer line, initiate transfer to Guard Tank as follows:

1. Close VF-2 and immediately.
2. Open SV-13.
3. Record time of day _____.

G.14.15. Open EV-6 and EV-18.

G.14.16. When Guard Tank pressure (EG-1a) drops to less than 3 torr above the Main Tank pressure (EG-3), then,

1. Open EV-9.

G.14.17. Verify start of transfer by observing an increasing flow rate at PFM-1 and record PFM-1 _____ Liquid liters/hr.

G.14.18. Input comment to DAS “Starting external fill of GT”.

G.14.19. Record all fill data on the attached data sheets every 15 minutes.

G.14.20. Adjust LHSD pressure:

1. Close pressurization valve, LHV-1, at the LHSD.
2. Adjust the gas supply pressure regulator, APR-3, to the desired pressure (as high as possible without exceeding 10 psig at the LHSD).
3. Reopen pressurization valve at LHSD.

G.14.21. Close VF-3 when it thaws out.

G.14.22. When Guard Tank is filled to desired level:

1. Record Guard Tank level (circle unit used “A” or “B”) _____ %
2. If J802 is connected to the ECU, verify that operations personnel are prepared to operate RAV-2 on request.
3. Switch to Main Tank fill: perform following section.

G.14.23. Valve configuration:

| | Open | Closed |
|---|---|---|
| EV valves | EV-6, EV-7a/-b, EV-9, EV-13, EV-16, EV-18 | All other |
| AV valves | AV-3, APR-1 | All other |
| Dewar valves | GTV-V, SV-9, SV-13 | GTV-Va, ST-Va/Vb, FCV |
| RAV valves | RAV-2, RAV-3, RAV-6B | All other |
| VF valves | VF-1, VF-3 | VF-2 |

Section G.14 complete. Quality_____

## G.15. Switch from Guard Tank to Main Tank Fill

G.15.1. Open RAV-1 (MT fill valve) by performing the following steps:

1. Ensure selection switch for controller #1 is in OFF position.
2. Power up controller #1.
3. Position selection switch for controller #1 to RAV-1.
4. Record initial switch status: Open: π π Closed: π π
5. Activate controller #1 to open RAV-1 and record:
   a. Run time: _____ seconds
   b. Current draw: _____ amps
   c. Time of day: _____ .
6. Record initial status lights(4) on: π π Closed: π π
7. When convenient, record operation in RAV log book.

G.15.2. Open/verify open EV-6 and EV-18.

G.15.3. Close RAV-2 (GT fill valve) by performing the following steps:

- o J802 connected to Electrical Module:

1. Setup controller #2 :

- o Controller #2 is powered up and set to RAV-2 go to step 2.
- o Controller #2 is not powered up do the following steps:
  a. Ensure selection switch for controller #2 is in OFF position.
  b. Power up controller #2.
  c. Position selection switch for controller #1 to RAV-2.

2. Record initial status lights(4) on: π π Closed: π π
3. Activate controller #2 to close RAV-2 and record:
   a. Run time: _____ seconds
   b. Current draw: _____ amps
   c. Time of day: _____ .
4. When convenient, record operation in RAV log book.

- o J802 connected to the ECU:

5. Request operations personnel to <u>close</u> RAV-2 and record time of day: _____.
6. Record valve status indication from operations personnel when the information is available: _____
7. When convenient, record operation in RAV log book.

G.15.4. Input comment to DAS “Switch from GT to MT fill”.

G.15.5. Valve configuration:

| | Open | Closed |
|---|---|---|
| EV valves | EV-6, EV-7a/-b, EV-9, EV-13, EV-16, EV-18 | All other |
| AV valves | AV-3, APR-1 | All other |
| Dewar valves | GTV-V, SV-9, SV-13 | GTV-Va, ST-Va/Vb, FCV |
| RAV valves | RAV-1, RAV-3, RAV-6B | All other |
| VF valves | VF-1 | VF-2, VF-3 |

Section G.15 complete. Quality_____

### G.16. Monitor Main Tank Fill

G.16.1. Continue recording data in Data Sheets.

G.16.2. Maintain LHSD ullage pressure between 6 and 10 psig.

G.16.3. **Note:** A full Dewar or empty LHSD is indicated by a rapid and consistent increase in the flow rate.

G.16.4. Verify the transfer is complete, LHSD empty, when the LHSD level is zero and a rapid and consistent increase in the flow rate is observed.

G.16.5. Proceed **IMMEDIATELY** to the next section.

### G.17. Terminate Transfer

**CAUTION**
The Guard Tank may tend to subcool following the completion of this procedure. Maintain positive pressure in the Guard Tank by ensuring the Guard Tank and Main Tank are venting in common.

G.17.1. Stop the flow of liquid helium

1. Close VF-1.
2. Close SV-13 and torque to 60 ± 5 in-lbs and immediately open VF-2.
3. Close EV-6 and EV-18.

G.17.2. Establish Guard Tank vent configuration.

1. Verify GTV-V open.

2. Verify EV-9, EV-13 and EV-16 open.

3. Record CN [46] (GTV-G) _____ torr (relative to atm.)

G.17.3. Remove the pumping line at valve VF-3.

G.17.4. Remove the Transfer/ Filter Lines from the Dewar fill bayonet B3 and;

G.17.5. **Immediately** install the Fill Cap Assembly with FCV closed.

G.17.6. Valve configuration:

| | Open | Closed |
|---|---|---|
| EV valves | EV-7a/-b, EV-9, EV-13, EV-16 | All other |
| AV valves | AV-3, APR-1 | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-1, RAV-3, RAV-6B | All other |
| VF valves | N/A | N/A |

Section G.17 complete. Quality_____

### G.18. Remove Stinger from LHSD

**CAUTION**
The following operations involve steps that pose cryogenic safety hazard. To prevent injury, the person handling the stinger must wear protective gloves, face shield, and apron.

G.18.1. Shut off the GHe supply used to pressurize the LHSD.

G.18.2. Close LHV-1 (VENT outlet valve of the LHSD), and disconnect the pressurization line.

G.18.3. Crack open LHV-1 and LHV-2, the primary (low-pressure) relief valve, to allow the LHSD to depressurize.

G.18.4. When the primary relief valve at LHV-2 stops venting, completely open LHV-1 and carefully remove the stinger from the LHSD.

G.18.5. Close LHV-1 (the VENT outlet valve).

G.18.6. Ensure that LHV-2, the primary (low-pressure) relief valve, is fully open

Section G.18 complete. Quality_____

### G.19. Condition Dewar Fill Line

G.19.1. Connect a pumping line between the Fill Cap Assembly at valve FCV and the Auxiliary Gas Section access port no. 1.

G.19.2. Ensure valves AV-1 and AV-9 closed.

G.19.3. Ensure AP-1 on.

G.19.4. Open AV-8 and AV-3.

G.19.5. Open valve FCV and evacuate Fill Cap Assembly to <25 mtorr measured at AG-2B.

G.19.6. Close FCV.

G.19.7. Open SV-13.

G.19.8. Close RAV-1

(**Note:** At this time, relief of fill line is through Fill Cap Assembly)

1. Verify that RAV controller #1 is already on and that controller #1 selection switch is already set to RAV-1. if not perform the following steps:

- Controller #1 powered up and set to RAV-1.
- Controller #1 not powered up — perform the following steps:
  a. Ensure selection switch for controller #1 in off position
  b. Power up controller #1.
  c. Position selection switch for controller #1 to RAV-1.

2. Record initial status lights(4) on: Open: θ θ Closed: θ θ
3. Activate controller #1 to close RAV-1 and record:
   a. Run time: _____ seconds
   b. Current draw: _____ amp
   c. Time of day: _____
4. Record final status lights(4) on: Open: θ θ Closed: θ θ
5. When convenient, record operation in RAV log book.

G.19.9. Turn OFF all RAV controllers as follows:

1. Turn all RAV selection switches to OFF.
2. Power off all controllers.
3. Turn off RAV power supply.

G.19.10. Open FCV and evacuate the Dewar fill line to < 25 mtorr as measured

at AG-2b.

G.19.11. Close SV-13 and torque to 60 +/- 5 in-lbs.

G.19.12. Close FCV

G.19.13. Close AV-8.

G.19.14. Open AV-1.

G.19.15. Open AV-9 until pressure reaches 1.5 psig on AG-1, then close AV-9.

G.19.16. Close AV-1.

G.19.17. Monitor the pressure in the Fill Cap Assembly for 15 minutes to be sure it maintains vacuum and record:

Initial PFCG pressure: _____ torr Date/Time: _____/_____

Final PFCG pressure: _____ torr Date/Time: _____/_____

**Note:** If PFCG drops by more than 2.0 torr in 30 minutes, open FCV and AV-8 and pump until AG-2b is less than 25 mtorr then repeat steps G.18.13 through G.18.17.

Section G.19 complete. Quality_____

### G.20. Record Configuration of Dewar and GSE

G.20.1. Verify valve states are as indicated in following Table

| | Open | Closed |
|---|---|---|
| EV valves | EV-7a/-b, EV-9, EV-13, EV-16 | All other |
| AV valves | AV-3, APR-1 | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-3, RAV-6B | All other |
| VF valves | N/A | N/A |

G.20.2. Record the final liquid levels as appropriate:

1. Main Tank level (“A” or “B”): _____ %
2. Guard Tank Level (“A” or “B”): _____ %

G.20.3. Record Main Tank pressure (EG-3): _____ torr:

G.20.4. Turn off Main and Guard Tank vent-line heat exchangers (EH-1, EH-2).

G.20.5. Ensure all RAV operations recorded in log book.

Section G.20 complete. Quality_____

### G.21. Place Data Acquisition System in Standard Configuration

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

G.21.1. Input comment to DAS "Completed External NBP fill of Main Tank".

G.21.2. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [ Stop Data Col].

G.21.3. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day _____ .
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 15 min.
5. When data cycle is complete, turn off Vac-ion pump.

G.21.4. Set DAS to normal scan mode using [other menus], [data config], [normal scan]

G.21.5. Set Main Tank liquid level sampling interval to 10 minutes.

G.21.6. Set Guard Tank liquid level sampling interval to 10 minutes.

G.21.7. Ensure that Vac-ion pump is off.

G.21.8. Ensure DAS alarm enabled and record set points if changed

3. Thermal conditions substantially unchanged, alarm set points for Station 200 and lead bag are unchanged and set to alarm.
4. Thermal conditions substantially changed, temperature alarm points reset as follows:
   a. Top of Lead Bag set point [CN 28] _____ K (≤ 6.0 K)
   b. Top of Lead Bag set point [CN 29] _____ K ( ≤ 6.0 K)

G.21.9. Ensure liquid level sensor alarms enabled on Main Tank and Guard Tank 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.21.10. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr diff.

G.21.11. Ensure Facility Main Alarm System enabled.

G.21.12. Ensure DAS watchdog timer and alarm enabled.

Section G.20 complete. _____

## G.22. Perform Final Closure of SV-13 and Conditioning the Dewar Fill Cap Assembly

G.22.1. Once SV-13 has warmed sufficiently to try final closure perform the following steps.

**Note**: The time required may be a few hours.

G.22.2. Verify that the Fill Cap Assembly is still evacuated and record:

Date:_____ Time of day _____

PFCG pressure:_____

G.22.3. Retorque SV-13 to 60 ± 5 in-lbs.

G.22.4. Open FCV.

G.22.5. Open/Verify open AV-3.

G.22.6. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.22.7. Close AV-8.

G.22.8. Ensure EV-12 closed.

G.22.9. Open AV-1.

G.22.10. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.22.11. Close FCV.

G.22.12. Close AV-1 and record:

1. Time of day:_____
2. Initial PFCG pressure:_____

G.22.13. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.22.14. Close AV-8.

G.22.15. Verify closure of SV-13 and FCV by verifying the pressure in the Fill Cap Assembly (PFCG) does not drop by more than 1.0 torr over 30 minutes.. After 30 minutes record:

1. Time of day:_____
2. Final PFCG pressure:_____

**Note:** If PFCG drops by more than 1.0 torr in 30 minutes, repeat steps G.21.2 through G.21.14.

G.22.16. Open AV-1.

G.22.17. Open AV-9 until pressure reaches 0 psig as read on gauge AG-1 and close AV-9.

G.22.18. Close AV-1.

G.22.19. Close AV-3.

G.22.20. Turn off pump AP-1

G.22.21. (Optional) Remove pumping line from Fill Cap Assembly.

G.22.22. (Optional) Install KF-25 blank-off cap on valve FCV.

G.22.23. Valve configuration:

| | Open | Closed |
|---|---|---|
| EV valves | EV-7a/-b, EV-9, EV-13, EV-16 | All other |
| AV valves | None | All other |
| Dewar valves | GTV-V, SV-9 | GTV-Va, ST-Va/Vb, SV-13, FCV |
| RAV valves | RAV-3, RAV-6B | All other |
| VF valves | N/A | N/A |

G.22.24. Perform Post-Operations Checklist (Appendix 2)

Section G.22 complete. Quality_____

## H. Procedure Completion

**Completed by:** _____

**Witnessed by:** _____

**Date:** _____

**Time:** _____

**Quality Manager** _____ **Date** _____

**Payload Test Director** _____ **Date** _____

**Data Sheet 1**

| Date/Time | LHSD Level (%) | LHSD press (psig) | Main Tank pressure EG-3 (Torr) | Guard Tank pressure EG-1a (Torr) | LHe Flow PFM-1 [B] (l/hr) | Main Tank Liquid He Level (%) | Guard Tank Liquid He Level (%) | |
|---|---|---|---|---|---|---|---|---|
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**Data Sheet 2**

| Date Time | Lead bag top T-20D [28] (K) | Lead bag top T-21D [29] (K) | G.T. bottom T-15D [24] (K) | HX-4 T-08D[8] (K) | M.T. bottom T-09D [9] (K) | Vac-Ion Pump (torr) | Gas Mod HX GT/MT ($^{o}$C/ $^{o}$C) | MT Vent Bayonet/ Baynt Nut ($^{o}$C/ $^{o}$C) | SV-9 Valve/ Top Plate ($^{o}$C/ $^{o}$C) | Top-Plate Cyl(2) ($^{o}$C/ $^{o}$C) |
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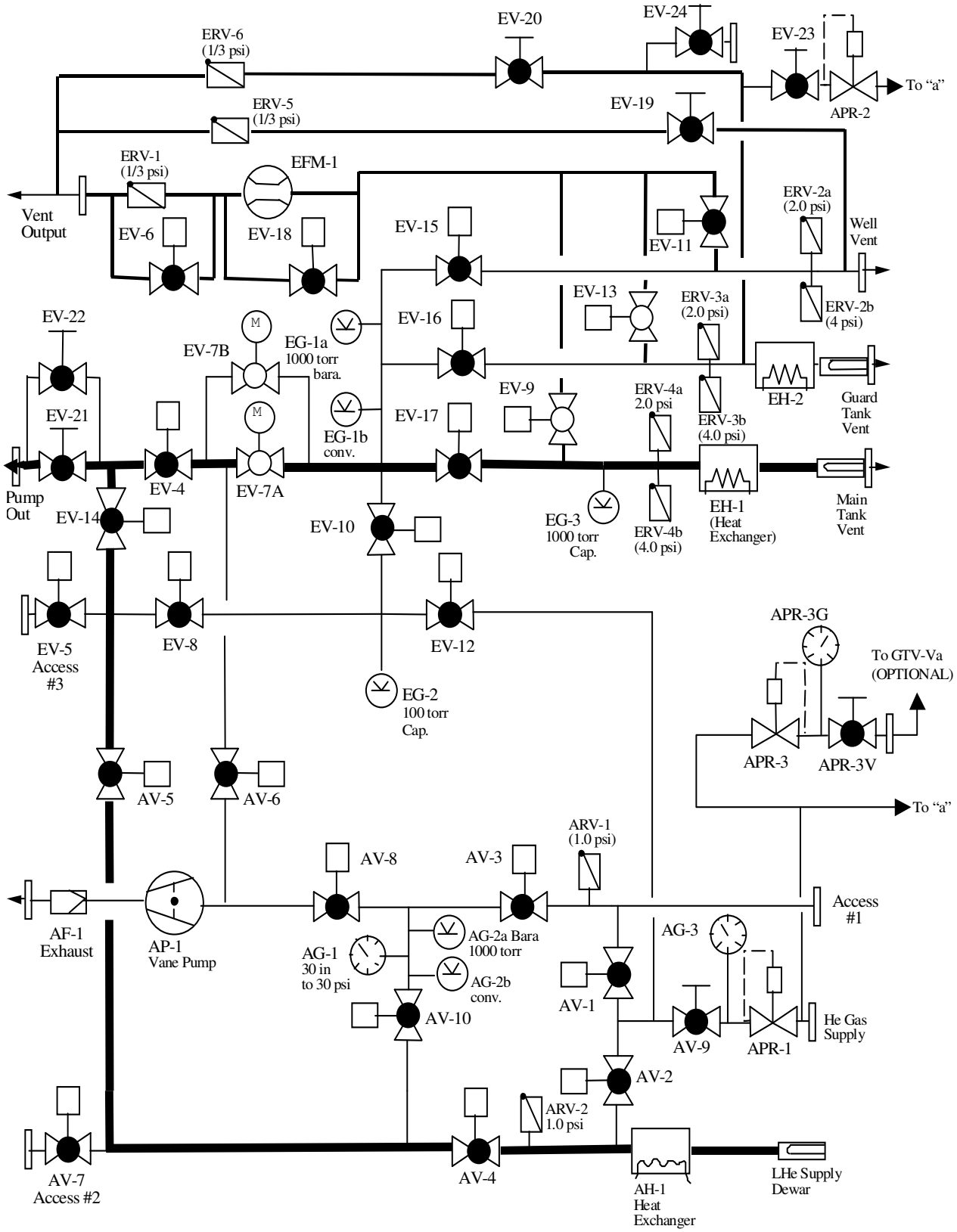


**Figure 1.** Schematic of Gas Module Plumbing.

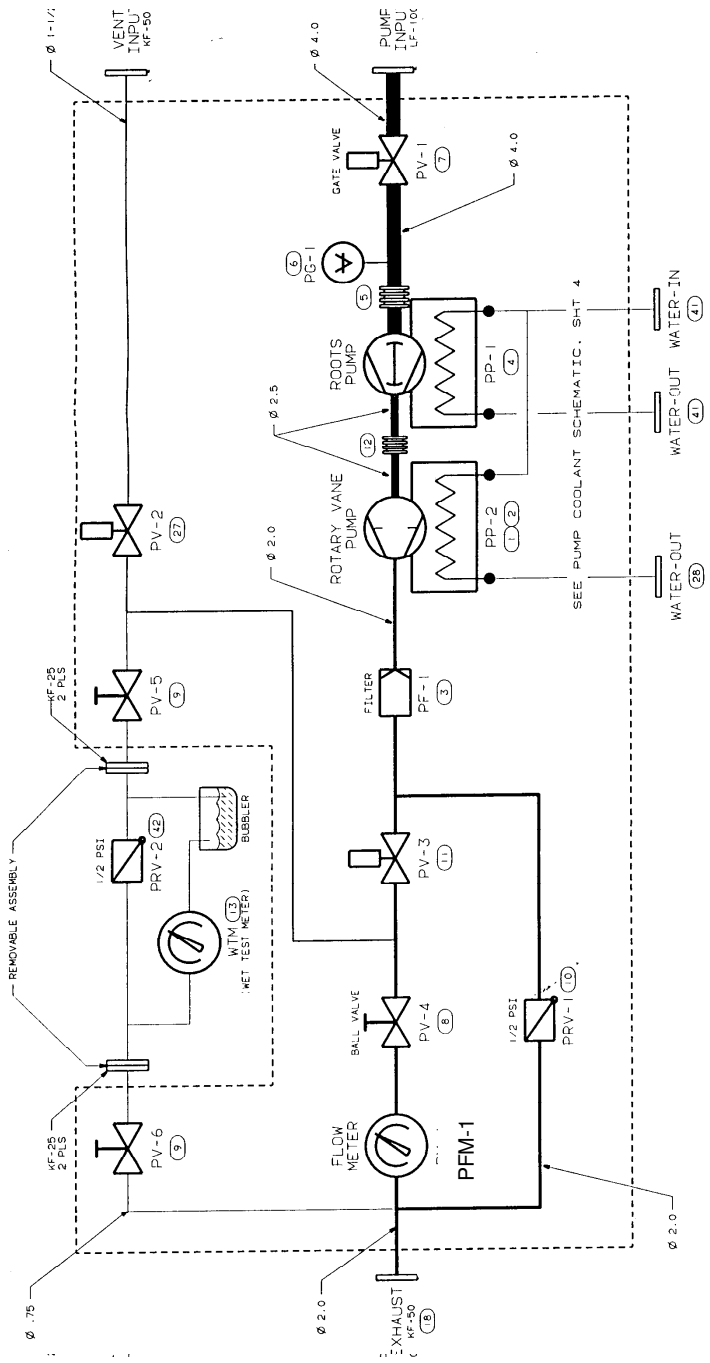


**Figure 2**. Schematic of Pump Module plumbing.

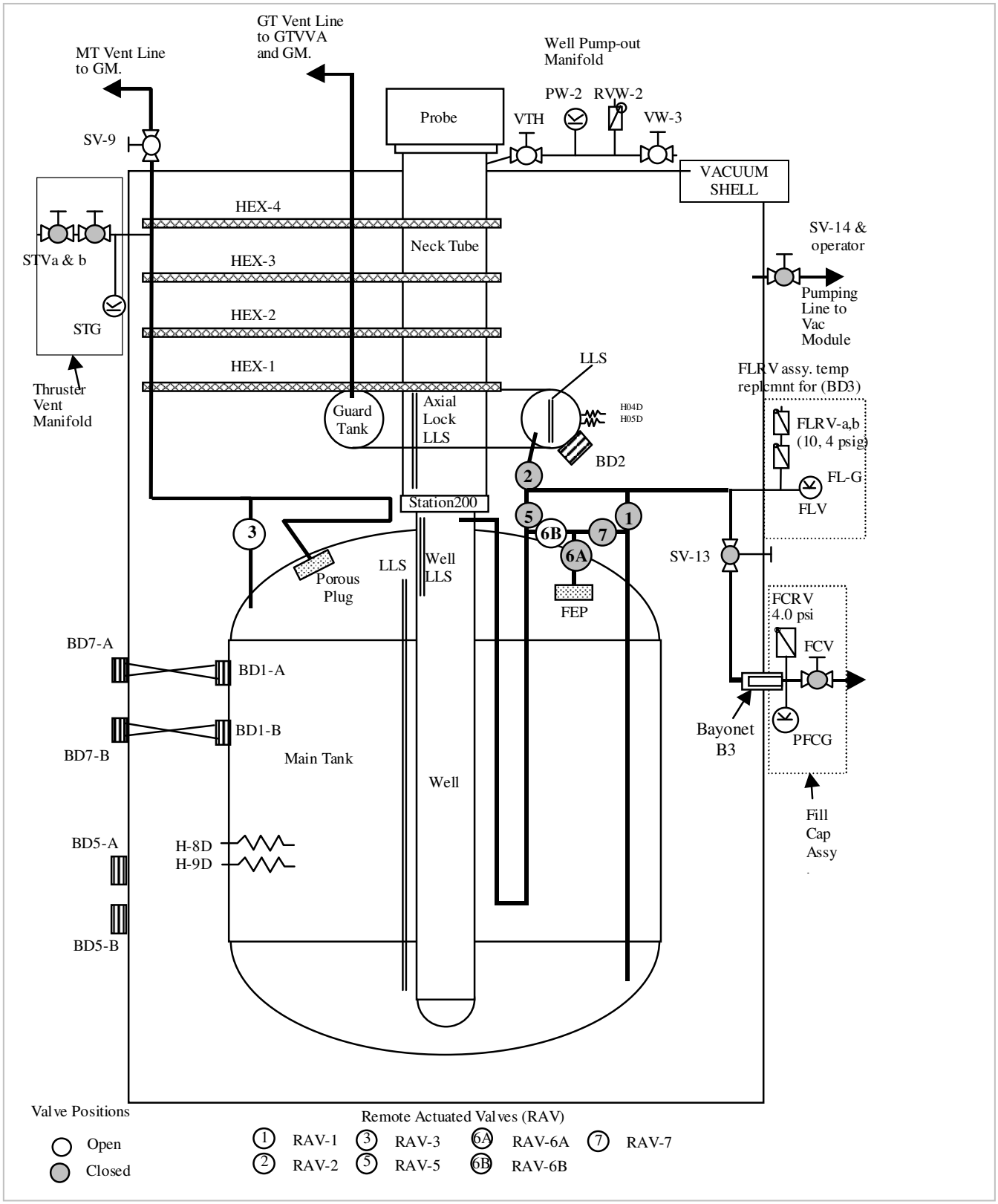


**Figure 3.** Schematic of Science Mission Dewar plumbing

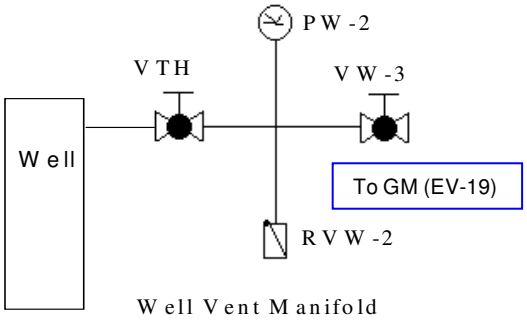


**Figure 4** Well vent manifold.

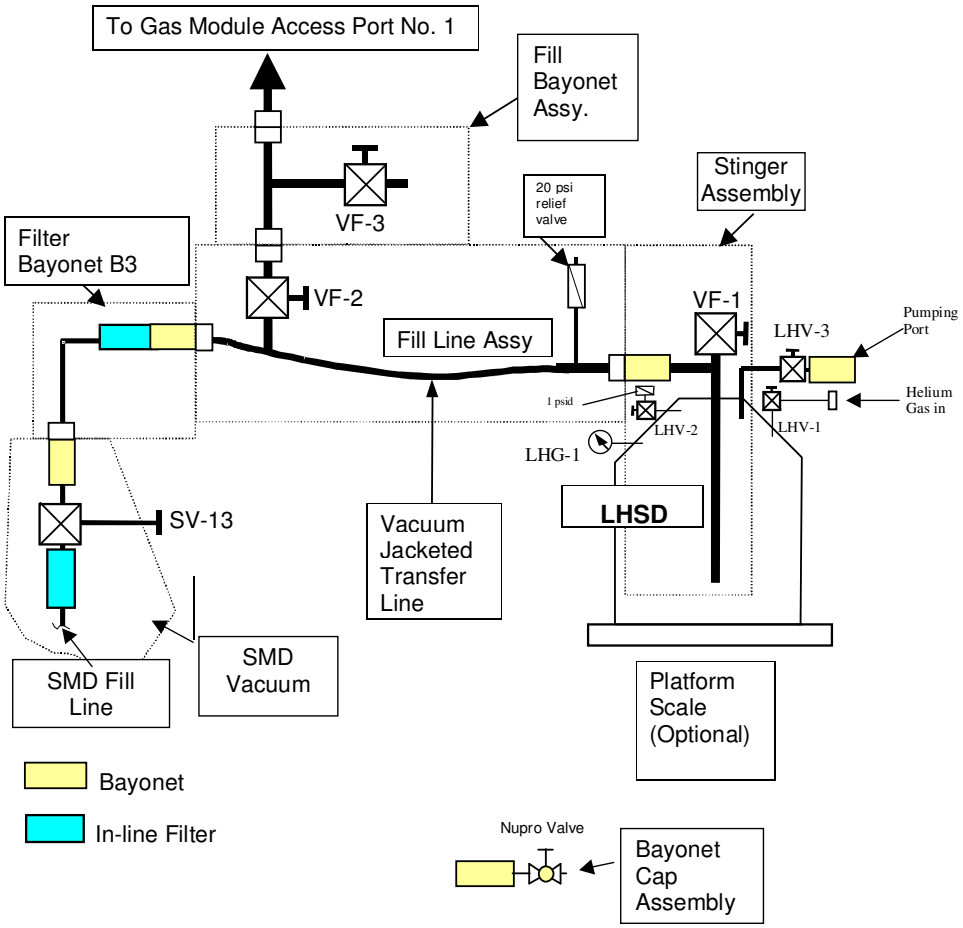


**Figure 5**. Schematic of liquid helium transfer plumbing

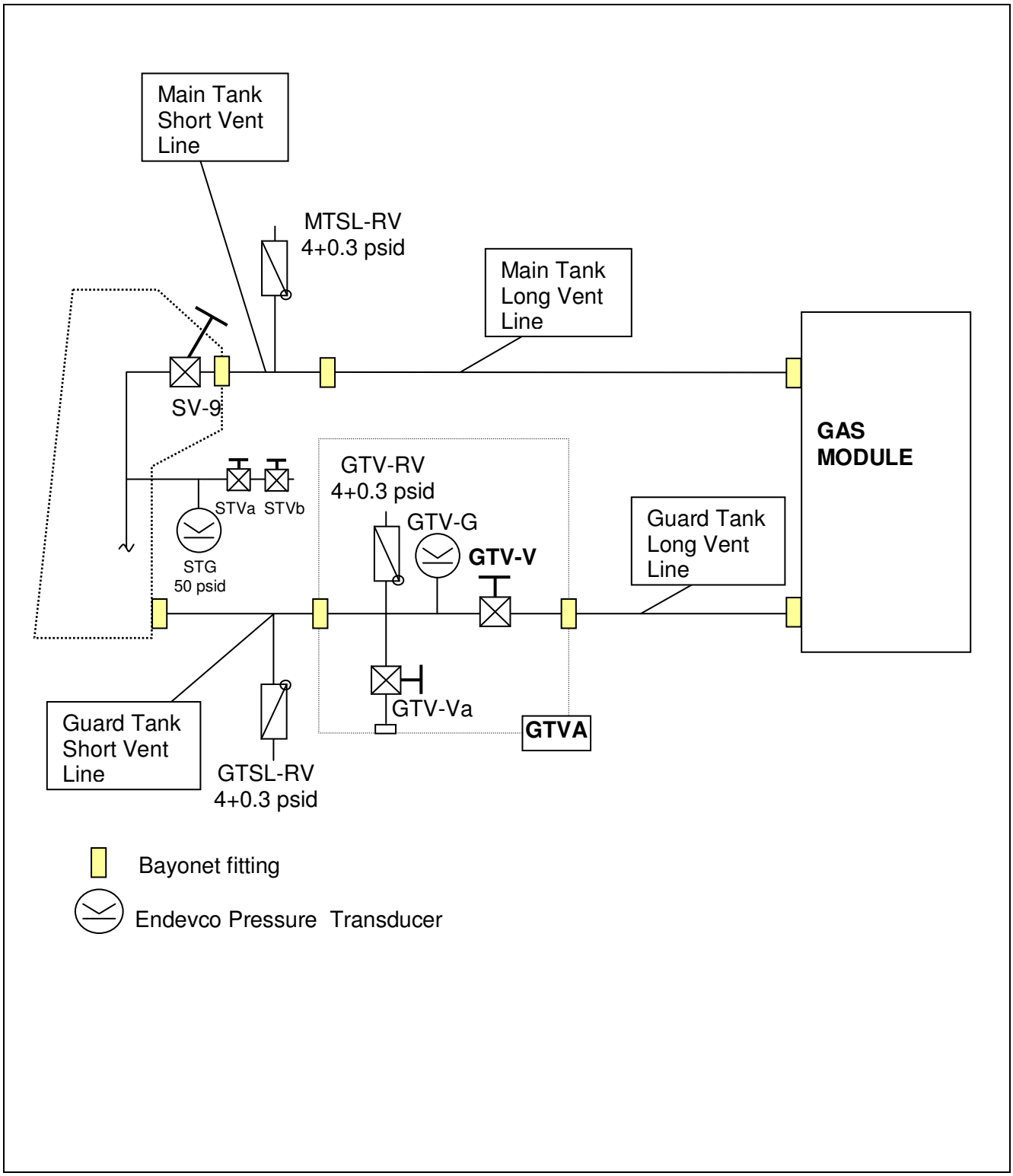


Figure 6. Main Tank and Guard Tank venting to Gas Module with Guard Tank Vent Assembly (GTVA) in place. **(MT&GT_toGM_dwg.doc)**

**Appendix 1**

| DATE | CHECKLIST ITEM | COMPLETED | REMARKS |
|---|---|---|---|
| | | | |
| | 1. Verify the test procedure being used is the latest revision. | | |
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| | 2. Verify all critical items in the test are identified and discussed with the test team. | | |
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| | 3. Verify all required materials and tools are available in the test area. | | |
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| | 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. | | |
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| | 3. Ensure management has been notified of all major or minor discrepancies. | | |
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| | 4. Ensure that all steps that were not required to be performed are properly identified. | | |
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| | 5. If applicable sign-off test completion. | | |
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| | 6. Verify all RAV valve operations have been entered in log book | | |
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| | 7. Verify the as-run copy of procedure has been filed in the appropriate binder | | |
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| | Team Lead Signature: _____ | | |

## Appendix 3– Contingency Responses

| | Condition | Circumstance | Response |
|---|---|---|---|
| 1 | Power Failure | Before. G.12 (start of transfer) | **Wait for power restoration:**<br>Re-establish valve configuration, and resume procedure |
| | | Section G.12 through G.16 | **Go to Safemode:**<br>Close VF-1, SV-13, if open;<br>Immediately open VF-2;<br>Open EV-20;<br>Close VF-3, when possible. |
| | | After G.16 | **Wait for power restoration:**<br>Re-establish valve configuration , and resume procedure |
| | | Any time | **Wait for power restoration**<br>**Note**: the DAS computer will continue to function for several hours, however no data will be collected<br>DAS computer still operating:<br>Reset GM valving per the last configuration in procedure and resume procedure<br>DAS computer not operating:<br>Reboot computer and launch DRP_SMD and select auto startup option<br>Reset GM valving per the last configuration in procedure and resume procedure |
| 2 | Temperature limits (CN 28) exceeded | MAIN TANK IS NOT VENTING | **ALLOW MAIN TANK TO VENT**<br>**If SV-9 is closed:**<br>Close EV-17 (if open) and verify EV-9 open, crack open SV-9 to allow MT to vent. Adjust SV-9 as necessary to restore temperature(s) below alarm limits. Open EV-6 and EV-18 if higher flow rate is needed.<br>**If SV-9 open and EV-9 closed:**<br>Open EV-9 for short periods (~15 sec) and allow increased flow from Main tank; in addition, Open EV-6 and EV-18 if higher flow rate is needed.<br>**If SV-9 and EV-9 open**<br>Open EV-6 and EV-18 for higher flow<br>If problem persists see item 3 |

| | Condition | Circumstance | Response |
|---|---|---|---|
| 3 | | MAIN TANK IS VENTING | **PROMOTE INCREASE IN MAIN TANK VENTING**<br>Power up heater at H08D or H0-9D and starting at 15 vdc input increase power until increased flow has cooled the problem area |
| 4 | Burst disk rupture (MT/GT) | ANY TIME | Evacuate room |