GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

INSTALLATION OF
FEE GUARD TANK VENT LINE
AND LEAK CHECK

P0894 Rev-

April 10, 2002

Prepared by: 

______________________ Date ________

Dave Murray
Cryogenic Test

Checked by: 

______________________ Date ________

Mike Taber
Payload Test Director

Approvals:

______________________ Date ________

Dorrene Ross
Quality Assurance

______________________ Date ________

Robert Brumley
Payload Technical Manager
## REVISION RECORD

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

This procedure describes the steps to effect the removal and replacement of the Guard Tank Short Vent Line with the FEE Guard Tank Vent Line. This process assumes a dry Guard Tank and the SV in a horizontal orientation. The installation steps for installing the FEE Guard Tank Vent Line are given in a LM Operations Order No. INT-251 and will be carried out by LM personnel.

B. **Safety**

B.1. **Potential Hazards**

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**

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 proximity to the SV without escort. All personnel working at a height 30 inches or more off the floor are required to have a 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 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, QA 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 judgment 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.

D.3. Qualified Personnel

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

<table>
<thead>
<tr>
<th>Test Director</th>
<th>Test Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mike Taber</td>
<td>Tom Welsh</td>
</tr>
<tr>
<td>Dave Murray</td>
<td>Ned Calder</td>
</tr>
</tbody>
</table>

E. Requirements

E.1. Electrostatic Discharge Requirements

All work on the SV requires the use of grounding wrist straps attached to grounding points on the SV per LM requirement.

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

Leak Detector
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 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. Additional Test Equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
</tr>
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<tbody>
<tr>
<td>AMI Level Sensor Readout for LHSD</td>
<td>AMI</td>
<td>110</td>
</tr>
</tbody>
</table>

E.3.5. Additional Hardware

<table>
<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMD Vent Bayonet O-rings</td>
<td>Parker</td>
<td>2-027</td>
</tr>
<tr>
<td>SMD Bayonet fit check tool</td>
<td>SU</td>
<td>N/A</td>
</tr>
<tr>
<td>Apiezon</td>
<td>MI Products Ltd</td>
<td>Model N</td>
</tr>
<tr>
<td>No. 5 rubber stopper with .5 psid relief valve</td>
<td>N/A</td>
<td>N/A</td>
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</table>

E.3.6. Tools

<table>
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<tr>
<th>Description</th>
<th>Serial No.</th>
<th>Cal Due</th>
</tr>
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<tbody>
<tr>
<td>Strap wrench 2-in.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
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E.3.7. Expendables

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Mfr./Part No.</th>
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</thead>
<tbody>
<tr>
<td>Ethyl alcohol</td>
<td>AR</td>
<td>N/A</td>
</tr>
<tr>
<td>99.99% pure gaseous helium</td>
<td>AR</td>
<td>N/A</td>
</tr>
<tr>
<td>Tie wraps – large size</td>
<td>AR</td>
<td>N/A</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Description</th>
<th>User Name</th>
<th>Serial No.</th>
<th>Cal Required</th>
<th>Status Cal due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DAS</td>
<td>Power Supply, H-P 6627A</td>
<td>A1, A2, A3, A4</td>
<td>3452A01975</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>DAS</td>
<td>Power Supply, H-P 6627A</td>
<td>B1, B2, B3, B4</td>
<td>3452A01956</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DAS</td>
<td>Data Acquisition/Control Unit H-P 3497A</td>
<td>-</td>
<td>2936A245539</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>DAS</td>
<td>Digital Multimeter H-P 3458A</td>
<td>-</td>
<td>2823A15047</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>EM</td>
<td>Vacuum Gauge Controller Granville-Phillips Model 316</td>
<td>EG-1a, -1b</td>
<td>2827</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>EM</td>
<td>Vacuum Gauge Controller Granville-Phillips Model 316</td>
<td>AG-2a, -2b</td>
<td>2826</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>EM</td>
<td>Vacuum Gauge Controller Granville-Phillips Model 316</td>
<td>EG-3</td>
<td>2828</td>
<td>No</td>
<td>-</td>
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<tr>
<td>8</td>
<td>EM</td>
<td>MKS PDR-C-2C</td>
<td>EG-2, FCG</td>
<td>92022108A</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>EM</td>
<td>Flow meter – Matheson 8170</td>
<td>EFM-1</td>
<td>96186</td>
<td>No</td>
<td>-</td>
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<tr>
<td>10</td>
<td>EM</td>
<td>Flow meter totalizer Matheson 8124</td>
<td>EFM-1</td>
<td>96174</td>
<td>No</td>
<td>-</td>
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<tr>
<td>11</td>
<td>EM</td>
<td>Liquid Helium Level Controller American Magnetics, Inc. 136</td>
<td>LLS Main Tank</td>
<td>96-409-11</td>
<td>No</td>
<td>-</td>
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<tr>
<td>12</td>
<td>EM</td>
<td>Liquid Helium Level Controller American Magnetics, Inc. 136</td>
<td>LLS Guard Tank</td>
<td>96-409-10</td>
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<td>-</td>
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<tr>
<td>13</td>
<td>EM</td>
<td>Liquid Helium Level Controller American Magnetics, Inc. 136</td>
<td>LLS Well</td>
<td>96-409-9</td>
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<td>EM</td>
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<td>LLS Axial Lock</td>
<td>96-409-12</td>
<td>No</td>
<td>-</td>
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<td>15</td>
<td>EM</td>
<td>Pressure Controller – MKS 152F-92</td>
<td>EV-7a, -7b</td>
<td>96203410A</td>
<td>No</td>
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<td>16</td>
<td>EM</td>
<td>Power Supply HP 6038A</td>
<td>H08D Tank Heater</td>
<td>96023407A</td>
<td>Yes</td>
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</table>
### Installation of FEE Guard Tank Vent Line and Leak Check

#### Gravity Probe-B Program

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Description</th>
<th>User Name</th>
<th>Serial No.</th>
<th>Cal Required</th>
<th>Status Cal due date</th>
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</thead>
<tbody>
<tr>
<td>17</td>
<td>EM</td>
<td>Power Supply HP 6038A</td>
<td>H09D Tank Heater</td>
<td>3511A-13332</td>
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<td>18</td>
<td>EM</td>
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<td>RAV Power Supply</td>
<td>3329A-12486</td>
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<tr>
<td>19</td>
<td>EM</td>
<td>Vac Ion Pump power supply Varian 929-0910, Minivac</td>
<td>SIP</td>
<td>5004N</td>
<td>No</td>
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<td>20</td>
<td>EM</td>
<td>Flow meter totalizer Veeder-Root</td>
<td>PFM-1</td>
<td>576013-716</td>
<td>No</td>
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<tr>
<td>21</td>
<td>GM</td>
<td>Pressure Gauge, Heise</td>
<td>AG-1</td>
<td>CC-122077</td>
<td>No</td>
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<td>22</td>
<td>GM</td>
<td>Pressure Gauge, Marshall Town</td>
<td>AG-3</td>
<td>N/A</td>
<td>No</td>
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<tr>
<td>23</td>
<td>GM</td>
<td>Main Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller</td>
<td>EH-1</td>
<td>C-19950</td>
<td>No</td>
<td>-</td>
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<tr>
<td>24</td>
<td>GM</td>
<td>Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller</td>
<td>EH-2</td>
<td>C-09920</td>
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<td>-</td>
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<tr>
<td>25</td>
<td>VM</td>
<td>Vacuum Gauge readout, Granville-Phillips 316</td>
<td>VG-3, VG-4</td>
<td>2878</td>
<td>No</td>
<td>-</td>
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<tr>
<td>26</td>
<td>VM</td>
<td>Vacuum Gauge readout, Granville-Phillips 360</td>
<td>VG-1, VG-2, VG-5</td>
<td>96021521</td>
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<td>-</td>
</tr>
<tr>
<td>27</td>
<td>Leak Detector</td>
<td>Standard leak internal to leak detector</td>
<td>N/A</td>
<td>-</td>
<td>N/A</td>
<td>Yes</td>
</tr>
</tbody>
</table>

#### 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 horizontal with the -X 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 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 of liquid helium and regulated to a pressure > 0.3 torr above atmosphere.
E.5.3. Well

The Well is evacuated and the Well pump-out at VTH may be in one of the following configurations:

1) closed with the VTH operator removed;

2) have the Well manifold connected to a closed VTH; or

3) have an open VTH with a pumpout valve, VW-3, and convectron, PW-2, making up the Well manifold.

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure should be less than $1 \times 10^{-4}$ torr.

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 watchdog 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).

4. The Main Tank is venting to the room via the Main Tank vent cap assembly.

5. The Guard Tank is pressurized at the GTVA via the GTV-Va valve and then to the GM helium source at APR-2V.

6. The thruster vent port must be plumbed to an 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 SV is installed in: the SMD transportation and test fixture or in 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 valve operator 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.

4. If the Vacuum shell operator is not installed, then the vacuum shell valve is closed and capped off.

E.7. Verification/Success Criteria

N/A

E.8. Payload Constraints and Restrictions

N/A
F. Reference Documents

F.1. Drawings

<table>
<thead>
<tr>
<th>Drawing No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMMS-5833394</td>
<td>Instrumentation Installation</td>
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</table>

F.2. Supporting documentation

<table>
<thead>
<tr>
<th>Document No.</th>
<th>Title</th>
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<tr>
<td>LMMC-5835031</td>
<td>GP-B Magnetic Control Plan</td>
</tr>
<tr>
<td>GPB-100153C</td>
<td>SMD Safety Compliance Assessment</td>
</tr>
<tr>
<td>EM SYS229</td>
<td>Accident/Mishap/Incident Notification Process</td>
</tr>
<tr>
<td>LMSC-P088357</td>
<td>Science Mission Dewar Critical Design Review</td>
</tr>
<tr>
<td>SU/GP-B P0108</td>
<td>Quality Plan</td>
</tr>
<tr>
<td>LMMC GPB-100333</td>
<td>Science Mission Dewar Failure Effects and Causes Analysis</td>
</tr>
<tr>
<td>SU/GP-B P059</td>
<td>GP-B Contamination Control Plan</td>
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F.3. Additional Procedures

<table>
<thead>
<tr>
<th>Document No.</th>
<th>Title</th>
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<tbody>
<tr>
<td>SU/GP-B P0213</td>
<td>Connect Vacuum Module/ Pump on SMD Vacuum Shell</td>
</tr>
<tr>
<td>SU/GP-B P0676</td>
<td>Connect Guard Tank Vent Line to Gas Module</td>
</tr>
<tr>
<td>SU/GP-B P0875</td>
<td>GP-B Maintenance and Testing at all Facilities</td>
</tr>
<tr>
<td>SU/GP-B P0879</td>
<td>Accident/Incident/Mishap Notification Process</td>
</tr>
</tbody>
</table>
G. **Operations**

G.1. **Perform Preparatory Operations**

G.1.1. Verify SU QA notified.

Record: Individual notified __________________, 
Date/time ________/________.

G.1.2. Verify NASA representative notified.

Record: Individual notified __________________, 

G.1.3. Verify LM SV Operations representative (Frank Mendoza, Norm Bennett) notified of approximate time for RAV-2 operations.

Record: Individual notified __________________, 
Date/time ________/________.

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.

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

Record serial number on helium bottle/s.

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


Date/time ________/________.

Quality _______________

G.2. **Verify Configuration Requirements**

G.2.1. Ensure DAS Watch Dog Alarm enabled.

G.2.2. Ensure that Top Plate heaters on SMD are operational.
G.2.3. Verify GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.4. Record MT pressure (STG) ____ torr.

G.2.5. Verify DAS and liquid level alarms enabled and record set points.
   1. Main Tank level ("A" or "B"): Record set point _________%
   2. Top of lead bag temperature/a – verify [CN 28] on DAS alarm list and set to alarm at $T \leq 6.5$ K. Record set point _________K
   3. Top of lead bag temperature/b – verify [CN 29] on DAS alarm list and set to alarm at $T \leq 6.5$ K. Record set point _________K
   4. Relative Guard Tank Pressure – verify [CN46] on DAS alarm list and set to alarm at $\Delta P \geq 0.3$ torr. Record set point ________torr
   5. Relative Main Tank Pressure – verify [CN49] on DAS alarm list and set to alarm at $\Delta P \geq 4.0$ torr. Record set point ________torr

G.2.6. Verify orientation of SMD/SV: is horizontal with –X up.

G.2.7. Verify Main Tank is venting to the room via the Main Tank Vent Cap Assembly (MTVCA) relief valve.

G.2.8. **Verify Guard Tank is pressurize with helium gas via regulator from APR2-V at GTV-Va with GTV-V closed.**

G.2.9. Verify EFM-3 flow meter is mounted and measuring Gas Module helium input flow.

G.2.10. Verify connected/connect the DAS Endevco read out to GTV-G and verify read out and DAS receive appropriate indicated values.

G.2.11. Ensure ion-pump magnet and signal cable installed.

G.2.12. Record Vacuum Shell Pressure.
   1. Turn on Vac-ion pump and record time of day _______
   3. When value is steady, record pressure (IP) ________ torr. If pressure is above $1\times10^{-4}$ torr, perform procedure P0213, Connect of Vacuum Module / Pump on SMD Vacuum Shell, to connect Vacuum Module and pump out SMD vacuum shell.
   4. Exit [Monitor Data] and collect data with [Set Data Interval] to 10 min.
   5. When data cycle is complete, turn off Vac-ion pump.


Section G.2 Complete Quality ____________
G.3. **Verify Gas-Module 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.

<table>
<thead>
<tr>
<th>Verify Initial Valve States</th>
<th>Verify Open/Active</th>
<th>Verify Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Connected to GM</td>
<td>SV-9, MTVC-RV</td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td>APR-2, APR-2V, GTV-Va</td>
<td>GTV-V</td>
</tr>
<tr>
<td>Connected to regulated helium supply at GM and empty of liquid helium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td>EV-7a/b</td>
<td>EV-4, EV-5, EV-6, EV-8, EV-9, EV-10, EV-11, EV-12, EV-13, EV-14, EV-15, EV-16 EV-17, EV-18, EV-19, EV-20, EV-21/22, EV-23, EV-24</td>
</tr>
<tr>
<td>AV valves</td>
<td>All</td>
<td></td>
</tr>
</tbody>
</table>

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 09] ________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 calculated liquid level in Main Tank ________ %.

G.3.5. Verify Main Tank liquid level is below 55% to ensure Main Tank fill line is in the vapor and it is OK to open and close RAV-1. (Note: The calculated liquid level at which the liquid is just below the Main Tank inlet is 61%, 55% is used for conservativism)

**Note:** The Main Tank will be used as a source of cold vapor to backfill the GT near the end of this procedure.

G.3.6. and OK to open and close RAV-1.

G.3.7. 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 (FCG): __________ torr.

G.3.8. Record status of Well pump-out:
   o VTH closed and Well manifold not installed.
   o Well manifold installed, record valve positions and pressure:
     VTH ____ , VW-3 _____ , PW-1 _____ torr.

Section G.3 complete. Quality__________

G.4. Verify SMD Valves in Standard Configuration

G.4.1. Using the RAV log book verify that the dewar 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.

G.4.2. Verify SV-13, and FCV closed.

Section G.4 complete. Quality__________

G.5. Set Up Purge Gas via SMD Fill Line

G.5.1. Install a pumping line between valve FCV on the Fill Cap Assembly and the Access Port #1 of the Auxiliary gas section.

G.5.2. Turn on pump AP-1.

G.5.3. Open AV-8 and AV-3.

G.5.4. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.5.5. Close AV-8.

G.5.6. Open AV-1 and adjust AV-9 to give 1 psig at AG-1.

G.5.7. Close AV-1

G.5.8. Open AV-8 and evacuate to 20 mtorr. as measured at AG-2.

G.5.9. Close AV-8 and FCV.

G.5.10. Once the pressure in the Fill Cap Assembly has stabilized, record

Fill Cap Assembly pressure (FCG): __________ torr.

G.5.11. Open valve SV-13 to bring Fill Cap Assembly up to SMD Fill line pressure and record

Fill line pressure (FCG): _______ torr.
Section G.5 complete. Quality__________

G.6. **Adjust Guard Tank Pressure**

G.6.1. Record Guard Tank pressure:
GTV-G _______ torr (relative to atm.)

G.6.2. Adjust/verify adjusted guard tank pressure to atmospheric + 20 to 30 torr as indicated by GTV-G adjusting APR-2 and using GTV-V to bleed off excess pressure as needed.

G.6.3. Record Guard Tank pressure:
GTV-G _______ torr (relative to atm.).


Section G.6 complete. Quality__________

G.7. **Raise Pressure in Fill Line to Guard Tank Pressure**

G.7.1. Open FCV.

**CAUTION**

*In the following, watch the special data output to protect against producing over temperature (>6.5K) at the Lead Bag sensors, CNs 28 and 29. Stopping or slowing the input of helium gas will prevent excessive heating in this area.*

G.7.2. Open AV-1.

G.7.3. Gradually build the pressure at FCG to be 20 torr above GTV-V+Atm


Record:
Atmospheric pressure (CN84) _______ torr.
Guard Tank pressure (GTV-G) _______ (relative to atm.)
Record Fill line pressure (FCG) _______ torr.

Section G.7 complete. Quality__________
G.8. Open RAV-2

G.8.1. Request LM personnel install arming plug for RAV-2
G.8.3. Verify RAV-2 is open by observing initial increase flow at EFM-3 and then decay and a decrease in pressure at FCG.
G.8.4. Record FCG __________ torr, GTV-G ______ torr
G.8.5. Record initial (maximum) flow on RAV-2 activation ______ slpm
record flow at 5 mins. from start ______ slpm

Section G.8 complete. Quality__________

G.9. Set Up Data Acquisition System

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

G.9.1. Verify DAS set to configuration 4Y.
G.9.2. Set DAS to fast scan mode using [other menus], [data config], [fast scan]
G.9.3. Record directory and data file name ____________________________.
G.9.4. Start “Special Data Cycle” by using [Other Menus] + [Special Data Col].
G.9.5. Enter CNs: 28, 29, 24, 46 (GTV-G) and 49 (ST-G, Thruster Vent) and 114 (EG-1a).
G.9.6. [Init. Collectn]
G.9.7. [Enter] use default file name.
G.9.8. Record directory and special data file name ____________________________.
G.9.9. Ensure printer is displaying special Data Cycle data.

Section G.9 complete. Quality__________
G.10. **Prepare FEE Guard Tank Vent Line (FGTVL)**

G.10.1. Record the bayonet female fit check gap measurements made in LM operations order No. INT-251 for the inboard FEE Guard Tank Vent Line.

1. Maximum gap _________
2. Minimum gap _________

G.10.2. Record the bayonet male fit check gap measurements made in LM operations order No. INT-251 for the outboard end of the FEE Guard Tank Vent Line.

1. Maximum gap _________
2. Minimum gap _________

G.10.3. Prepare a new bayonet O-ring (Parker Viton 2-027) with a thin layer of Apiezon N vacuum grease.

G.10.4. Install the O-ring into the outlet bayonet O-ring groove of the FGTVL.

Section G.10 complete. Quality__________

G.10.5. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Connected to GM</td>
<td>SV-9, MTVC-RV</td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected to regulated helium supply at GM and empty of liquid helium</td>
<td>APR-2,</td>
<td>GTV-V, GTV-Va</td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td>EV-7a/b</td>
<td>All other EVs</td>
</tr>
<tr>
<td>Fill line purge</td>
<td>AV-1, AV-3, AV-9, APR-1 FCV, SV-13</td>
<td>All other AV valves</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-2, RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

P0894 Rev -
G.11. **Remove GT short vent line**

G.11.1. Prepare a No. 5 rubber stopper with a 1 psid relief valve (1/8-in NPT size)

**CAUTION**

In the following steps the Guard Tank pressure indicated by FCG must be monitored closely to prevent subatmospheric conditions in the Guard Tank which could result in air contamination and plugging of the internal Guard Tank venting. Corrective action is to increase the flow rate by adjusting APR-1/AV-9 to higher pressures.

G.11.2. Verify GT pressure at GTV-G is 20 to 30 torr (relative to atm.) adjust AV-9/APR-1 as required.

**NOTE:** This will require approximately 785 to 795 torr at FCG.

G.11.3. Remove GTSVL from SMD GT vent port (B2) and **Immediately** install No. 5 stopper/relief valve.

G.11.4. Remove O-ring from SMD bayonet and clean O-ring groove with clean room wipes and ethyl/isopropyl alcohol.

G.11.5. Remove stopper assembly and:

**Immediately** insert the male bayonet gauge fit check and using feeler gauges measure gap and record:

Maximum gap _________ Minimum gap _________

G.11.6. Remove tool and reinstall stopper.

G.11.7. Prepare a new bayonet O-ring (Viton 2-027) with a thin layer of Apiezon N vacuum grease.

G.11.8. Install the O-ring into the SMD Guard Tank vent bayonet O-ring.

G.11.9. Remove the Guard Tank Vent Assembly from the GTSVL and install onto the bayonet outlet for FGTVL. Remove the GTVCA from the GTVA. Keep helium purge hose on closed GTV-Va and signal cable on GTV-G.

G.11.10. Open/verify open GTV-V.

Section G.11 complete. Quality_________
**G.12. Install FGTVL**

**CAUTION**

In the following steps the GT must not be allowed to depressurize to atmospheric pressure or air condensate may form in and plug the internal Guard Tank vent line. If pressure becomes low, as evidenced by low flow at EFM-3, increase flow from APR-1 or plug all vent paths and allow GT to re-pressurize.

**CAUTION**

Watch the special data collection output to warn of excessive lead bag temperatures caused by high purge flow rates. Corrective action is to slow the flow rate by adjusting APR-1 to lower pressures.

---

G.12.1. Perform LM operations order No. INT 251 “Install Guard Tank Vent Line …” up to the point of removing B2 rubber stopper.

G.12.2. Open AV-9 and adjust APR-1 to obtain Atm. + 15 torr at FCG.

G.12.3. Prepare to adjust APR-1 to maintain a low flow, 2-4 slpm as indicated by EFM-3, into the fill line.

G.12.4. Continue with the LM operation.

G.12.5. When the operation is completed verify FGTVL has been purged by Guard Tank outflow and the valve GTV-V is closed with vent path supplied by GTV-RV and GTV-Va is closed.

Section G.12 complete. Quality___________

---

**G.13. Close RAV-2**

G.13.1. Record initial flow into fill line

EFM-3(initial) _________slpm.

G.13.2. Record pressures

1. FCG _________torr
2. EG-1a _________torr

G.13.3. Request LM personnel remove arming plug for RAV-2


G.13.5. Record pressures
1. Record FCG _______ torr
2. Record EG-1a _______ torr

G.13.6. Record final fill line flow
EFM-3(initial) _______ slpm.

G.13.7. Verify closure by decrease in flow rate at EFM-3; record
EFM-3(max) _______ slpm.

G.13.8. Request LM personnel remove arming plug for RAV-2

G.13.9. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Connected to GM</td>
<td>SV-9, MTVC-RV</td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected to regulated helium supply at GM and empty of liquid helium</td>
<td>GTV-RV</td>
<td>GTV-V, GTV-Va</td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td>EV-7a/b</td>
<td>All other EV valves</td>
</tr>
<tr>
<td>Fill line purge</td>
<td>AV-1, AV-3, AV-9, APR-1, FCV, SV-13</td>
<td>All other AV valves</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

Section G.13 complete. Quality__________

G.14. **Pump Fill Line**

G.14.1. Verify AP-1 is on.

G.14.2. Close AV-1 and AV-9

G.14.3. Open AV-8

G.14.4. When AG-2b < 20 mtorr,
1. Record AG-2b _______ torr.
2. Close SV-13, torquing to 60 in-lb.

G.14.5. Backfill with helium gas via AV-1 and AV-9 to 1.5 psig as indicated by AG-1, ending with AV-9 closed.

G.14.6. Close FCV.

G.14.8. Open AV-8: pump line to vacuum.


G.14.10. Record FCG pressure for 30 minutes:

G.14.11. Date:__________.

G.14.12. Time ____________

G.14.13. FCG (torr) ____________


G.14.15. Turn AP-1 off.

G.15. **Final Configuration**

G.15.1. Verify all AVs closed and AP-1 off.

G.15.2. FCV and SV-13 closed.

G.15.3. Input comment to DAS “GT fill line closed off”.

G.15.4. Stop DAS Special Data Cycle.

G.15.5. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Connected to GM</td>
<td>SV-9, MTVC-RV</td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected to regulated helium</td>
<td>GTV-RV</td>
<td>GTV-V, GTV-Va</td>
</tr>
<tr>
<td>supply at GM and empty of liquid helium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td>EV-7a/b</td>
<td>All other EV valves</td>
</tr>
<tr>
<td>Fill line purge</td>
<td></td>
<td>All fill line valves</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

Section G.14 & 15 complete. Quality____________
G.16. **Preparing Equipment for Leak Detection**

G.16.1. Verify SV is horizontal, Main Tank is venting to room via SV-9 and Main Tank Vent Cap Assembly relief valve, MTVC-RV.

G.16.2. Connect GTVA to GM using procedure “Connect Guard Tank Vent to Gas Module, P0676, Record Op number _______. **Note:** Stop the procedure at the completion of para. G.6.11, the point at which the UTS is pumping up to a closed GTV-V and with the Guard Tank pressurized at GTV-Va from the Gas Module.

G.16.3. Ensure ‘pump exhaust’ of Gas Module is vented to outside of facility.

G.16.4. Close verify/closed SLAV.

G.16.5. Adjust APR-2 to ensure GTV-G is greater than 100 torr.

G.16.6. Install Neon Standard Leak at GTV-Va opening GTV-Va to allow purging of NSL flex hose before making plumbing connection.


G.16.8. Verify the configuration of the Vacuum Module, Gas Module, UTS, RGA, Neon Standard Leak and SMD is as shown in Figures 1 with valve configuration as given below.

G.16.9. Verify configuration is as given in Fig. 1b and valves as given below.

G.16.10. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
<td>SV-9, MTVC-RV</td>
<td></td>
</tr>
<tr>
<td>Not Connected to GM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td>TV-1, TV-2, EV-5, EV-14, EV-4, EV-7A/B, EV-16</td>
<td>GTV-V</td>
</tr>
<tr>
<td>Connected to GM at “Guard Tank Vent” and pumped by the UTS up to GTV-V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td>All other EV valves</td>
<td></td>
</tr>
<tr>
<td>Neon leak valves</td>
<td>GTV-Va</td>
<td>RGA-SOV, RGA-LV, NSL-V</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

Section G.16 complete.  Quality__________
G.17. **Pump Guard Tank with AP-1**

G.17.1. Put Gas Module control panel into INTLK DEFECT.

G.17.2. Turn on/verify on AP-1.

G.17.3. Close EV-5.

G.17.4. Verify RGA-LV closed.

G.17.5. Open RGA-SOV slowly.

G.17.6. Open RGA-V slowly.

G.17.7. Open AV-6: AP-1 now pumping up to closed GTV-V.

G.17.8. Open GTV-V gradually, keeping pressure at EG-1a to less than 20 torr.

G.17.9. Enter comment to DAS: “Begin pumping Guard Tank”.

G.17.10. Valve configuration:

<table>
<thead>
<tr>
<th>Valve Configuration</th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
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<tr>
<td>Not Connected to GM</td>
<td>SV-9, MTVC-RV</td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected to GM at “Guard Tank Vent” and pumped by the AP-1</td>
<td>AV-6, EV-14, EV-4, EV-7A/B, <strong>EV-16</strong>, GTV-V</td>
<td></td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td></td>
<td>All other EV valves</td>
</tr>
<tr>
<td>RGA &amp; Neon leak valves</td>
<td>TV-1, TV-2, RGA-SOV, RGA-V, GTV-Va</td>
<td>RGA-LV, NSL-V</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

**NOTE:**

The UTS turbo is now pumping up to RGA-LV, EV-21, -22, EV-4, EV-8 and AV-5.

AP-1 is pumping Guard Tank through a partially open GTV-V

Section G.17 complete. Quality__________
G.18. **Configure for Neon Leak Detection**

G.18.1. Enter comment to DAS “Start neon cal 50 torr”.

G.18.2. Power-on RGA.

G.18.3. Verify RGA-SOV is open.

G.18.4. Adjust RGA-LV to maintain TG-1 between 1E-5 to 8E-5 torr.

G.18.5. Set up RGA in leak detect mode for mass 20.

G.18.6. Start data recording in Table 1.


G.18.8. Install/verify installed regulator on Neon supply Bottle.

G.18.9. When GTV-G is approximately 50 torr proceed with the following steps

G.18.10. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
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<td>SV-9, MTVC-RV</td>
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<td>Guard Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected to GM at “Guard Tank Vent” and pumped by the UTS</td>
<td>AV-6, EV-14, EV-4, EV-7A/B, EV-16, GTV-V</td>
<td></td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td></td>
<td></td>
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<tr>
<td>All other EV valves</td>
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<td></td>
</tr>
<tr>
<td>RGA &amp; Neon leak valves</td>
<td>TV-1, TV-2, RGA-V, RGA-SOV, RGA-LV</td>
<td>GTV-Va, NSL-V</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

Section G.18 complete. Quality__________
G.19. **Leak Check at 50 Torr**

G.19.1. **Leak Check GTVA/GTLVL Bayonet at 50 Torr**

   Date/Time __________

   1. Record data in Table 2.
   2. Open/verify open RGA-SOV.
   3. Adjust RGA-LV to maintain TG-1 to 5 +/- 1x10⁻⁵
   4. Verify RGA is in leak check mode for mass 20.
   5. Record steady state data in Table 1 and below:
      Record TG-1 ____________ torr, I_{RGA} __________ amp.
   6. Introduce neon gas into bagged GTV bayonet for 2 mins.
   7. Record steady state data in Table 1 and below:
      Record TG-1 ____________ torr, I_{RGA} __________ amp.
   8. Comments: __________________________

G.19.2. **Leak Check FGTVL/GTVA bayonet at 50 Torr**

   Date/Time __________

   1. Open/verify open RGA-SOV.
   2. Adjust RGA-LV to maintain TG-1 to 5 +/- 1x10⁻⁵
   3. Verify RGA is in leak check mode for mass 20.
   4. Record steady state data in Table 2 and below:
      Record TG-1 ____________ torr, I_{RGA} __________ amp.
   5. Introduce neon gas into bagged FGTVL/GTVA bayonet for 2 mins.
   6. Record reading _______ amps.
   7. Comments: __________________________

G.19.3. **Leak Check FGTVL/B2 bayonet at 50 Torr**

   Date/Time __________

   1. Adjust RGA-LV to maintain TG-1 to 5 +/- 1x10⁻⁵
   2. Introduce neon gas into bagged FGTVL/B2 bayonet for 2 mins.
   3. Record steady state data in Table 2 and below:
      Record TG-1 ____________ torr, I_{RGA} __________ amp.
   4. Comments: __________________________
   5. Enter comment to DAS “End 50 Torr Leak Test”.

Section G.19 complete. Quality___________
G.20. **Pumping Guard Tank to Vacuum and Leak Check**

G.20.1. Pumping Guard Tank with Turbo:

G.20.2. When EG-1a is between 1 and 10 torr, and GTV-V is fully open:
   1. Power off RGA and TG-1.
   2. Close RGA-LV and RGA-SOV.

G.20.3. Open EV-5: now pumping Guard Tank with UTS turbo.

G.20.4. When TG-3 < 1 torr power on TG-1.

G.20.5. Power on TG-1.

G.20.6. Record: TG-1 _______ torr, VG-4 _______ torr Date/Time _______

G.20.7. When TG-1 is less than 8E-5 proceed.

G.20.8. Record TG-1 ________ torr. Date/Time _______________________


**Calibrate RGA at Low Pressure**

*Note:* The neon standard leak has a value of 1.5x10^-6 sccs Ne.

G.20.10. Open NSL-V.

G.20.11. Record steady state data in Table 1 and below:
   Record TG-1 ___________ torr, I_{RGA} __________ amp.

G.20.12. Close NSL-V

G.20.13. Record steady state data in Table 1 and below:
   Record TG-1 ___________ torr, I_{RGA} __________ amp.

G.20.14. Open NSL-V.

G.20.15. Record steady state data in Table 1 and below:
   Record TG-1 ___________ torr, I_{RGA} __________ amp.

G.20.16. Close NSL-V

G.20.17. Record steady state data in Table 1 and below:
   Record TG-1 ___________ torr, I_{RGA} __________ amp.

G.20.18. When time allows calculate RGA sensitivity, 1.5X10^-6 sccs/change in amps, ____________ sccs/amp.

Section G.20 complete. Quality__________
G.21. **Leak Check at low pressure**

**NOTE:**
Maximum Leak rate shall be less than $1 \times 10^{-6}$ sccs Neon

G.21.1. Leak Check GTVA/GTLVL Bayonet  Date/Time _____________

1. Open/verify open RGA-SOV.
2. Adjust RGA-LV to maintain TG-1 on same value as used for low pressure calibration above.
3. Verify RGA is in leak check mode for mass 20.
4. Record steady state data in Table 1 and below:
   - Record TG-1 ________ torr, $I_{RGA}$ ________ amp.
5. Introduce neon gas into bagged GTV bayonet for 2 mins.
6. Record steady state data in Table 1 and below:
   - Record TG-1 ________ torr, $I_{RGA}$ ________ amp.
7. Calculate leak rate using RGA sensitivity determined above ________ sccs Ne.
8. Calculate leak rate: ________ sccs Ne
9. Verify leak rate is less than $1 \times 10^{-6}$ sccs Ne.
10. Comments: ____________________________________________

G.21.2. Leak Check FGTVL/GTVA bayonet  Date/Time ____________.

1. Verify RGA is in leak check mode for mass 20.
2. Record steady state data in Table 2 and below:
   - Record TG-1 ________ torr, $I_{RGA}$ ________ amp.
3. Introduce neon gas into bagged FGTVL/GTVA bayonet for 2 mins.
4. Record reading ________ amps.
5. Calculate leak rate: ________ sccs Ne
6. Verify leak rate is less than $1 \times 10^{-6}$
7. Comments: ____________________________________________
G.21.3. Leak Check FGTVL/B2 bayonet

Date/Time ____________.

1. Adjust RGA-LV to maintain TG-1 on same value as used for low pressure calibration above.

2. Introduce neon gas into bagged FGTVL/B2 bayonet for 2 mins.

3. Record steady state data in Table 1 and below:
   Record TG-1 ____________ torr, I_{RGA} ____________ amp.

4. Calculate leak rate: ____________ sccs Ne

5. Verify leak rate is less than 1x10^{-6} sccs.

6. Comments: __________________________________________

G.21.4. Enter comment to DAS “End low pressure Ne Leak Test”.

G.21.5. Spray Ne around the GTLVL/HEX bayonet and adjacent GM joints up to EV-13 and EV-16.

G.21.6. Record steady state data in Table 1 and below:
   Record TG-1 ____________ torr, I_{RGA} ____________ amp.

G.21.7. Enter comment to DAS “Complete low pressure leak checks”.

G.21.8. Turn off RGA.

G.21.9. Close/verify closed RGA-SOV, RGA-V.

G.21.10. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Connected to GM</td>
<td>SV-9, MTVC-RV</td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected to GM at “Guard Tank Vent” and pumped by the UTS</td>
<td>TV-1, TV-2, EV-5, EV-14, EV-4, EV-7A/B, EV-16, GTV-V</td>
<td>All other EV valves</td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RGA &amp; Neon leak valves</td>
<td></td>
<td>GTV-Va, NSL-V, RGA-SOV, RGA-SOV, RGA-LV, RGA-V</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

Section G.21 complete. Quality____________
G.22. **Helium Leak Check**

G.22.1. Put RGA in spectrum mode to monitor He, H₂O, O₂, N₂ and CO₂

G.22.2. Continue pumping with UTS until the leak detector shows a background of less than 1X10⁻⁵ sccs He.

G.22.3. Maintain data entries in Table 1.

G.22.4. Remove leak detector from UTS, cap the pumping port, put leak detector in test mode and record:
   - Std leak size _______ sccs
   - Std leak signal _______ sccs
   - Std leak S/N ________
   - Std leak call due date ________

G.22.5. Verify agreement to within 5%.

G.22.6. Connect leak detector to TV-3.

G.22.7. Leak check all plumbing up to closed TV-3.

G.22.8. Perform periodic leak detector hookups to determine the leak detector background using:
   1. Activate leak detector using leak detector instructions
   2. Close TV-2 open TV-3.
   3. Record background in Table 1.

G.22.9. When background is less than 1X10⁻⁵ proceed.

G.22.10. Record leak detector background _______ sccs He

G.22.11. **Leak Check GTVA/GTLVL Bayonet**

Date/Time ________

1. Verify leak detector backing UTS turbo pump.

2. Record steady state data in Table 1 and below:
   - Record TG-1 ________ torr, He background ________ sccs He

3. Introduce helium gas into bagged GTVA bayonet for 2 mins.

4. Record steady state data in Table 1 and below:
   - Record TG-1 ________ torr, He leak rate ________ sccs He

5. Verify helium leak rate is less than 1x10⁻⁸ sccs.
   Comments: __________________________

Comments:
Installation of FEE Guard Tank Vent Line and Leak Check

Gravity Probe-B Program

G.22.12. Leak Check FGTVL/GTVA bayonet

1. Verify leak detector backing UTS turbo pump.
2. Record steady state data in Table 1 and below:
   Record TG-1 ____________ torr, He background ____________ sccs He
3. Introduce helium gas into bagged FGTVL/GTVA bayonet for 2 mins.
4. Record steady state data in Table 1 and below:
   Record TG-1 ____________ torr, He leak rate ____________ sccs He
5. Verify helium leak rate is less than \(1 \times 10^{-6}\) sccs.
   Comments:

G.22.13. Leak Check FGTVL/B2 bayonet

1. Verify leak detector backing UTS turbo pump.
2. Record steady state data in Table 1 and below:
   Record TG-1 ____________ torr, He background ____________ sccs He
3. Introduce helium gas into bagged FGTVL/B2 bayonet for 2 mins.
4. Record steady state data in Table 1 and below:
   Record TG-1 ____________ torr, He leak rate ____________ sccs He
5. Verify helium leak rate is less than \(1 \times 10^{-6}\) sccs
   Comments:

G.22.14. Enter comment to DAS “End helium leak test”.

G.22.15. Spray He around the GTLVL/HEX bayonet and adjacent GM joints up to EV-13 and EV-16.

G.22.16. Verify helium leak rate is less than \(1 \times 10^{-6}\)

G.22.17. Remove leak detector from UTS, cap the pumping port, put leak detector in test mode and record:
   Std leak size ____________ sccs
   Std leak signal ____________ sccs

G.22.18. Verify agreement to within 5%.

G.22.19. Shut down leak detector

G.22.20. Power down RGA and close RGA-V, Date/Time ________________.

Section G.21 complete. Quality__________
G.23. **Re-pressurize Guard Tank with Helium Gas from Main Tank**

Date/Time________________

G.23.1. Record: EG1b ________ torr.


G.23.3. Close TV-1 and shut down UTS.

G.23.4. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
<td></td>
<td>SV-9, MTVC-RV</td>
</tr>
<tr>
<td>Not Connected to GM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guard Tank vent</td>
<td></td>
<td>EV-16, GTV-V</td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td>EV-7A/B</td>
<td>All other EV valves</td>
</tr>
<tr>
<td>RGA &amp; Neon leak valves</td>
<td>GTV-Va, NSL-V, RGA-SOV, RGA-LV, RGA-V</td>
<td></td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

Section G.23 complete. Quality____________

G.24. **Prepare Fill Line**

G.24.1. Turn on pump AP-1.

G.24.2. Open AV-8 and AV-3.

G.24.3. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.


G.24.5. Open AV-1 and adjust AV-9 to give 1 psig at AG-1.

G.24.6. Close AV-1

G.24.7. Open AV-8 and evacuate to 20 mtorr. as measured at AG-2.

G.24.8. Close AV-8 and FCV.

G.24.9. Once the pressure in the Fill Cap Assembly has stabilized, record Fill Cap Assembly pressure (FCG): __________ torr.

G.24.10. Open valve SV-13 to bring Fill Cap Assembly up to SMD Fill line pressure and record Fill line pressure (FCG): ________ torr.

Section G.24 complete. Quality____________
G.25. **Open RAV-1**

G.25.1. Enter comment to DAS “Start repress of GT”. Date/Time ________.

G.25.2. Verify all selector switches are off.

G.25.3. Power up RAV power supply to 28 volt at 1.9 a.

G.25.4. Power up RAV controller No. 1.

G.25.5. Position selection switch to RAV-1.

G.25.6. Record initial switch status: Open: θ θ Closed: θ θ

G.25.7. Activate controller No. 1 and record:

1. run time: ________ seconds
2. current draw: ______ amp
3. time of day: ______ hrs

G.25.8. Record final switch status: Open: θ θ Closed: θ θ


G.25.10. Record FCG ___________ torr

G.25.11. Record EG-1a ___________ torr

Section G.25 complete. Quality__________

G.26. **Open RAV-2**

G.26.1. Verify closed FCV.

G.26.2. Request LM personnel install arming plug for RAV-2


G.26.4. Record FCG ___________ torr

G.26.5. Record EG-1a ___________ torr

G.26.6. Verify RAV-2 is open by near coincident with SV open command of rise of Guard Tank pressure to the Main Tank pressure (FCG).

G.26.7. Record FCG ___________ torr

G.26.8. Record EG-1a ___________ torr

Section G.26 complete. Quality__________

G.27. **Close RAV-2**


G.27.2. Request LM personnel remove arming plug for RAV-2
G.27.3. Verify by pressure rise in FCG that RAV-2 is closed.

G.27.4. Record:
   1. FCG ___ torr
   2. EG-1a _______ torr

G.27.5. Verify APR-2 is adjusted to ~.5 psig.

G.27.6. Verify open EV-23 to regulate pressure to Guard Tank.

G.27.7. Valve configuration:

<table>
<thead>
<tr>
<th></th>
<th>Open/Active</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Tank vent</td>
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<tr>
<td>Guard Tank vent</td>
<td>EV-16, EV-23, APR-2, GTV-V</td>
<td>GTV-Va</td>
</tr>
<tr>
<td>Remaining EV valves</td>
<td>EV-7A/B</td>
<td>All other EV valves</td>
</tr>
<tr>
<td>Fill line</td>
<td></td>
<td>FCG, SV-13, AV-1, AV-9</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-1, RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>

Section G.27 complete. Quality________

G.28. Close RAV-1 and Pump Fill Line

G.28.1. Verify FCV and all AVs closed.


G.28.3. Open FCV.

G.28.4. When FCG < 20 mtorr, close FCV.

G.28.5. Open SV-13, record PFCG ________.

1. Record initial switch status: Open: θ θ  Closed: θ θ

2. Activate controller No. 1 and record:
   a. run time: ________ seconds
   b. current draw: ______ amp
   c. time of day: ______

   Immediately:

3. Verify SV-13 open
4. Record FCG ______ torr
5. Open FCV: now pumping fill line with AP-1.
6. Record final switch status: Open: θ θ  Closed: θ θ
7. Record operation in RAV log book.
8. Position selection switch to off.
10. Power off RAV power supply.

G.28.7. Record FCG ______ torr, EG-1a ______ torr.
G.28.8. **Pump Fill Line**

1. When AG-2b < 20 mtorr,
2. Record AG-2b _______ torr.
3. Close SV-13, torquing to 60 in-lb.

G.28.9. Backfill with helium gas via AV-1 and AV-9 to 1.5 psig as indicated by AG-1

G.28.10. Close FCV.


G.28.13. When AG-2b < 20 mtorr
   1. Close AV-8
   2. Close AV-3.

G.28.14. Record FCG pressure for 30 minutes:

G.28.15. Date:

G.28.16. Time _______ _______ _______ _______ _______

G.28.17. FCG (torr) _______ _______ _______ _______ _______

G.28.18. Verify no leakage at SV-13 into fill line.

Section G.28 complete.  Quality__________

G.29. **Final Configuration**

G.29.1. Valve configuration:

<table>
<thead>
<tr>
<th></th>
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<td>Guard Tank vent</td>
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<td>GTV-Va</td>
</tr>
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<td>Remaining EV valves</td>
<td>EV-7A/B</td>
<td>All other EV valves</td>
</tr>
<tr>
<td>Fill line</td>
<td></td>
<td>FCV, SV-13, AV-1, AV-9</td>
</tr>
<tr>
<td>RAVs</td>
<td>RAV-1, RAV-3, RAV-6B</td>
<td>All other RAVs</td>
</tr>
</tbody>
</table>
G.29.2. Input comment to DAS “GT leak check completed”.

G.29.3. Stop DAS Special Data Cycle.

G.29.4. Remove pumping line between Access 1 and FCV.

Section G.29 complete. Quality__________

G.30. Configuration of Dewar and GSE

G.30.1. Record the Main Tank liquid level (LL-1D or LL-2D): _________ %

G.30.2. Record the following pressures:
1. Main Tank pressure (EG-3): ______ torr
2. Guard Tank pressure (EG-1a/GTVG): ______ torr

Section G.30 complete. Quality__________

G.31. Setting up Data Acquisition

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

G.31.1. Set DAS to configuration choice 4Y.

G.31.2. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.31.3. Record Vacuum Shell Pressure.
1. Turn on Vac-ion pump and record time of day _________.
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.31.4. Set DAS data cycle interval to 15 minutes.

G.31.5. Set Main Tank Liquid Level sampling interval to 10 minutes.

G.31.6. Confirm that the liquid level sensors are set at a sampling rate of 10 minutes or turned off.

G.31.7. Confirm that Vac-ion pump is off.

G.31.8. Enable/verify enabled the alarms on the Main Tank and Well Liquid Level Sensors.
G.31.9. Verify enabled the DAS alarm and record the set points:
   a) CN ____, Level _____
   b) CN ____, Level _____
   c) CN ____, Level _____
   d) Main Tank Level: ______ %
   e) Guard Tank Level:______ %

G.31.10. Ensure DAS watchdog timer and alarm enabled.

Section G.31 complete _______.

H. **Procedure Completion**
Completed by:________________________
Witnessed by:_______________________
Date: __________
Time: __________
Quality Manager:_____________________ Date __________________________
Payload Test Director:_______________ Date __________________________
## Table 1 Neon leak Data

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Neon Amp</th>
<th>EG-1a Torr</th>
<th>TG-1 torr</th>
<th>EG-1a torr</th>
<th>FCG Torr-diff</th>
<th>Comments</th>
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Figure 1a. Schematic of Gas Module Plumbing at Start of FEE Guard Tank Vent Line Install
Figure 1b. Schematic of Gas Module Plumbing for Neon Leak Detection of Guard Tank Vent
Figure 2  Gas Module and Vent lines connected to SMD
Figure 2  Utility Pump System with RGA for Neon leak detection
Figure 3. Schematic of Science Mission Dewar plumbing.
## Appendix 1

<table>
<thead>
<tr>
<th>DATE</th>
<th>CHECKLIST ITEM</th>
<th>COMPLETED</th>
<th>REMARKS</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Verify the test procedure being used is the latest revision.</td>
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<td>2.</td>
<td>Verify all critical items in the test are identified and discussed with the test team.</td>
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<td>3.</td>
<td>Verify all required materials and tools are available in the test area.</td>
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<td>4.</td>
<td>Verify all hazardous materials involved in the test are identified to the test team.</td>
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<td>5.</td>
<td>Verify all hazardous steps to be performed are identified to the test team.</td>
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<td>6.</td>
<td>Verify each team member knows their individual responsibilities.</td>
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<td>7.</td>
<td>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.</td>
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<td>8.</td>
<td>Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly.</td>
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<td>9.</td>
<td>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.</td>
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<td>10.</td>
<td>Confirm that each test team member understands that there will be a post-test team meeting.</td>
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Team Lead Signature: ____________________
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<th>DATE</th>
<th>CHECKLIST ITEM</th>
<th>COMPLETED</th>
<th>REMARKS</th>
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<tr>
<td></td>
<td>1. Verify all steps in the procedure were successfully completed.</td>
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<td>2. Verify all anomalies discovered during testing are properly documented.</td>
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<td>3. Ensure management has been notified of all major or minor discrepancies.</td>
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<td>4. Ensure that all steps that were not required to be performed are properly identified.</td>
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<td>5. If applicable sign-off test completion.</td>
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<td>6. Verify all RAV valve operations have been entered in log book</td>
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<td>7. Verify the as-run copy of procedure has been filed in the appropriate binder</td>
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Team Lead Signature: ________________________
### Appendix 3– Contingency Responses

<table>
<thead>
<tr>
<th>Condition</th>
<th>Circumstance</th>
<th>Response</th>
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| 1 Power Failure | Any time | Wait for power restoration  
Note: the DAS computer will continue to function for several hours, however no data will be collected  
DAS computer still operating:  
Reset GM valving per the last configuration in procedure and resume procedure  
DAS computer not operating:  
Reboot computer and launch DRP_SMD and select auto startup option  
Reset GM valving per the last configuration in procedure and resume procedure |
| 2 Temperature limits (CN 28 or 29) exceeded | ANY TIME | Lower inflow of helium gas to Guard Tank  
OR,  
INCREASE MAIN TANK VENTING  
Open MTVC-V momentarily or if problem persists see 3 below |
| 3 | ANY TIME | PROMOTE INCREASE IN MAIN TANK VENTING  
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 |