# GRAVITY PROBE B
# PROCEDURE FOR
# SCIENCE MISSION DEWAR

## Installation and Testing of the Guard Tank Thrust Nullifier

**THIS DOCUMENT CONTAINS THE USE OF HAZARDOUS MATERIALS**

P0990

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## REVISION RECORD

| REVISION | ECO | PAGES | DATE |
|---|---|---|---|
| | | | |

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## List of Abbreviations and Acronyms

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

## A. SCOPE

This procedure provides the necessary steps to install and perform engineering tests on one and fit checks on two flight Guard Tank Thrust Nullifiers.

## B. SAFETY

### B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware

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

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

### B.2. Mitigation of Hazards

#### B.2.1. Lifting hazards

There are no lifting operations in this procedure

#### B.2.2. Cryogenic Hazards

In LM Building 156, an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5% will be utilized. Additional temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions. Emergency vent deflectors are installed over the four burst disks on the SMD vacuum shell except during test operations.

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 as follows
LM **Call 117**

#### B.3.2. Hardware Mishap

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

#### B.3.3. Contingency Response

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

## C. QUALITY ASSURANCE

### C.1. QA Notification

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

### C.2. Red-line Authority

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

### C.3. Discrepancies

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

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

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

## D. TEST PERSONNEL

### D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. The person in charge of the operation (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

| *Test Director* | *Test Engineer* |
|---|---|
| Ned Calder<br>Mike Taber<br>Dave Murray | Tom Welsh |

## E. REQUIREMENTS

### E.1. Electrostatic Discharge Requirements

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

### E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

### E.3. Hardware/Software Requirements

#### E.3.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

#### E.3.2. Ground Support Equipment

The Ground Support Equipment includes the Gas Module, the Electrical Module, and the Vacuum Module. The Gas Module provides the capability to configure vent paths, read pressures and flow rates, and pump and backfill vent lines. The Pump Module provides greater pumping capacity than the Gas Module, together with additional flow metering capabilities. The vent output of the Gas Module flows through the Pump Module. The Electrical Module contains the instruments listed in Table 1, and provides remote control of valves in the Gas Module, Pump Module, and SMD. The Vacuum Module contains a turbo pump, backed by a vane pump, and provides the capability to pump out the SMD vacuum shell.

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

E.3.3. Computers and Software:

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

E.3.4. Test Equipment

| ***Description*** |
|---|
| N/A |
| |
| : |

E.3.5. Flight Hardware

Two Guard Tank Thrust Nullifier (LM P/N 8A03510-101, S/N 001 and 002) and associated o-rings (Parker 2-027).

E.3.6. Tools

#5 stopper with 1psig relief valve

E.3.7. Expendables

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

## E.4. Instrument Pretest Requirements

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

***Table 1. Required Instrumentation and Calibration Status***

| *No.* | *Location* | *Description* | *Name* | *Serial No.* | *Cal Required* | *Status Cal due date* |
|---|---|---|---|---|---|---|
| 1 | DAS | Power Supply, H-P 6627A | - | 3452A01975 | Yes | |
| 2 | DAS | Power Supply, H-P 6627A | - | 3452A01956 | Yes | |
| 3 | DAS | Data Acquisition/Control Unit H-P 3497A | - | 2936A245539 | No | - |
| 4 | DAS | Digital Multimeter H-P 3458A | - | 2823A15047 | Yes | |
| 5 | EM | Vacuum Gauge Controller Granville-Phillips Model 316 | EG-1a, -1b | 2827 | No | - |
| 6 | EM | Vacuum Gauge Controller Granville-Phillips Model 316 | AG-2a, -2b | 2826 | No | - |
| 7 | EM | Vacuum Gauge Controller Granville-Phillips Model 316 | EG-3 | 2828 | No | - |
| 8 | EM | MKS PDR-C-2C | EG-2, FCG | 92022108A | No | - |
| 9 | EM | Flow meter – Matheson 8170 | EFM-1 | 96186 | No | - |
| 10 | EM | Flow meter totalizer Matheson 8124 | EFM-1 | 96174 | No | - |
| 11 | EM | Liquid Helium Level Controller American Magnetics, Inc. 136 | LLS Main Tank | 96-409-11 | No | - |
| 12 | EM | Liquid Helium Level Controller American Magnetics, Inc. 136 | LLS Guard Tank | 96-409-10 | No | - |
| 13 | EM | Liquid Helium Level Controller American Magnetics, Inc. 136 | LLS Well | 96-409-9 | No | - |
| 14 | EM | Liquid Helium Level Controller American Magnetics, Inc. 136 | LLS Axial Lock | 96-409-12 | No | - |
| 15 | EM | Pressure Controller – MKS 152F-92 | EV-7a, -7b | 96203410A | No | - |
| 16 | EM | Power Supply HP 6038A | H08D Tank Heater | 96023407A | Yes | |
| 17 | EM | Power Supply HP 6038A | H09D Tank Heater | 3511A-13332 | Yes | |
| 18 | EM | Power Supply HP 6038A | RAV Power Supply | 3329A-12486 | Yes | |
| 19 | EM | Vac Ion Pump power supply Varian 929-0910, Minivac | SIP | 5004N | No | - |
| 20 | EM | Flow meter totalizer Veeder-Root | PFM-1 | 576013-716 | No | - |
| 21 | GM | Pressure Gauge, Heise | AG-1 | CC-122077 | No | - |
| 22 | GM | Pressure Gauge, Marshall Town | AG-3 | N/A | No | - |
| 23 | GM | Main Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller | - | C-19950 | No | - |
| 24 | GM | Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller | - | C-09920 | No | - |
| 25 | VM | Vacuum Gauge readout, Granville-Phillips 316 | VG-3 VG-4 | 2878 | No | - |
| 26 | VM | Vacuum Gauge readout, | VG-1, VG-2 | 96021521 | No | - |

| *No.* | *Location* | *Description* | *Name* | *Serial No.* | *Cal Required* | *Status Cal due date* |
|---|---|---|---|---|---|---|
| | | Granville-Phillips 360 | VG-5 | | | |

### E.5. Configuration Requirements

#### E.5.1. Main Tank

Liquid in the Main Tank is at normal boiling point (NBP).

#### E.5.2. Guard Tank

The Guard-Tank must contain liquid helium at NBP. The Guard Tank liquid level must be >90%. The Guard Tank Spin Balance vent assembly is installed.

#### E.5.3. Well

The Well is evacuated.

#### E.5.4. SMD Vacuum Shell

This procedure places no requirement on the vacuum shell pressure.

#### 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 (CN 175) set at $T \leq 6.0$ K.
    b. Top of lead bag temperature set (CN 178) at $T \leq 6.0$ K.
    c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 30$torr.

#### E.5.6. GSE and Non-flight Hardware

1. GSE cabling must be connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811).

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

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

1. The GSE Fill Cap Assembly is installed at SV-13.

## F. REFERENCE DOCUMENTS

### F.1. Drawings

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

### F.2. Supporting documentation

| ***Document No.*** | ***Title*** |
|---|---|
| LMMC-5835031 | *GP-B Magnetic Control Plan* |
| GPB-100153C | *SMD Safety Compliance Assessment* |
| SU/GP-B P0141 | *FIST Emergency Procedures* |

| | |
|---|---|
| LMSC-P088357 | *Science Mission Dewar Critical Design Review* |
| SU/GP-B P0108 | *Quality Plan* |
| LMMS GPB-100333 | *Science Mission Dewar Failure Effects and Causes Analysis* |
| EM SYS229 | Accident/Mishap/Incident Notification Process |
| SU/GP-B P059 | *GP-B Contamination Control Plan* |
| SU/GP-B P0875 | *GP-B Maintenance and Testing at all Facilities* |

## F.3. Additional Procedures

| | |
|---|---|
| SU/GP-B P0879 | *Accident/Incident/Mishap Notification Process* |
| SU/GP-B P0669 | *Internal Guard Tank Fill, vent lines disconnected* |
| SU/GP-B P0916 | *Installation of FEE Guard Tank Vent Line and Leak Check with SV Vertical* |

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

# G. OPERATIONS

## G.1. Pre-Operations Verifications

- Verify SU QA notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Verify NASA representative notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Record calibration due dates in Table 1 (Sections. E.3.4, E.4)
- Persons actually performing this procedure should initial their names in Sec D.3 and the name of the Test Director should be circled.
- Verify completion of the Pre-Operations Checklist (Appendix 1).
- Ensure two Guard Tank Thrust Nullifier and associated o-rings (Parker 2-027) present

Section Complete QA Witness:_____

## G.2. Verify Configuration Requirements

G.2.1. Ensure DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – ensure CN [175] on DAS alarm list with alarm limit at T ≤ 6.0 K. Record set point. _____K
2. ***Top of lead bag temperature*** – ensure CN [178] on DAS alarm list with alarm limit at T ≤ 6.0 K. Record set point. _____K

G.2.2. Record initial pressures, as appropriate.

1. Main Tank – NBP (STG):_____ torr.
2. Guard Tank – (GTV-G) _____ torr relative to 1 atm.

G.2.3. Record initial temperatures

1. Top of Lead Bag _____K

2. Top of Lead Bag _____K
3. Guard Tank _____K
4. Bottom of the Main Tank _____K

G.2.4. Ensure Guard Tank liquid level >80%

1. If Guard Tank liquid level <80%, perform procedure P0669, “Internal Guard Tank Fill, vent lines disconnected”
    a. Record Opt Number:_____
2. Record final Guard Tank liquid helium level:_____

Section Complete QA Witness:_____

## G.3. Set Up Data Acquisition System

G.3.1. Set DAS to fast scan mode using [other menus], [data config], [fast scan] and [Remove MultScan]

G.3.2. Start “Special Data Cycle” by using [Other Menus] + [Special Data Col].

G.3.3. Enter CNs: 175, 171, 64, 46 (GTV-G) and 49 (ST-G, Thruster Vent)

G.3.4. [Init. Collectn]

G.3.5. [Enter] use default file name.

G.3.6. Ensure printer is displaying special Data Cycle data.

G.3.7. Connect/verify connected power supply A3 and A4 to Guard Tank heaters H03D and H-04D via Umbilical.

G.3.8. Turn on power supply A and set outputs A3 and A4 to 0.08 amp current limit.

**Quality_____**

## G.4. Install Thrust Nullifier S/N 002 on Space Vehicle

G.4.1. Record Thrust Nullifier serial number:_____

G.4.2. Prepare Thrust Nullifier

1. Inspect Thrust Nullifier and associated o-rings
2. Record Thrust Nullifier Gauge (TNG) zero
    a. Record TNG serial number:_____
    b. Connect TNG to endevco readout
    c. Record Unit/Channel numbers:_____/_____
    d. Set auto zero function to ‘On”
    e. Record offset on DAS CN46:_____

**CAUTION**

**In the following steps the Guard Tank pressure must be prevented from going subatmospheric which could result in air contamination and plugging of the internal Guard Tank vent. Corrective action is to increase the flow rate by raising the Guard Tank heater voltages.**

G.4.3. Lightly grease a Parker 2-027 o-ring with Apiezon N grease

G.4.4. Verify available a number 5 rubber stopper with 1 psi relief valve

Note:

The rubber stopper is provided for contingency if the Thrust Nullifier does not immediately fit. The Test Director should assess the situation and decide on the appropriate course of action (i.e reinstall GTVA, the second thrust nullifier, etc). The Guard Tank should not be left with the rubber stopper for extended periods of time

G.4.5. Open GTV-Va and reduce pressure in the Guard Tank to ~50-100 torr and then close GTV-Va

G.4.6. Remove Guard Tank Vent Assembly and immediately install Thrust Nullifier

G.4.7. Turn on Guard Tank internal heaters if necessary to properly purge the thrust nullifier

G.4.8. Allow LM mechanical team to complete Thrust Nullifier installation

G.4.9. Record TNG:_____torr

G.4.10. Set DAS alarm on TNG CN 46 to 5 torr

G.4.11. Verify Thruster Nullifier S/N 002 heaters and thermometers are connected to Space Vehicle via Umbilical connector P807.

G.4.12. Verify Thrust Nullifier S/N 002 heaters and thermometers are connected to External Temp Control Unit and Unit is functioning .

1. Record PRT A:_____ C
2. Record PRT B:_____ C

Note:

The nominal cracking pressure for the Thrust Nullifier is 12-15 torr.

Note:

The first Thrust Nullifier will now be aligned.

Section Complete QA Witness:_____

G.5. **Install Thrust Nullifier S/N 001 on Space Vehicle**

G.5.1. Record Guard Tank liquid level:_____%

1. Ensure Guard Tank liquid level greater than 60%

G.5.2. Ensure alignment of first Thrust Nullifier successfully completed

G.5.3. Record Thrust Nullifier serial number:_____

G.5.4. Prepare Thrust Nullifier

1. Inspect Thrust Nullifier and associated o-rings
2. Record Thrust Nullifier Gauge (TNG) zero
    a. Record TNG serial number:_____
    b. Connect TNG to endevco readout
    c. Record Unit/Channel numbers:_____/_____
    d. Set auto zero function to 'On"
    e. Record offset on DAS CN46:_____

**CAUTION**

**In the following steps the Guard Tank pressure must be prevented from going subatmospheric which could result in air contamination and plugging of the internal Guard Tank vent. Corrective action is to increase the flow rate by raising the Guard Tank heater voltages.**

G.5.5. Request LM mechanical to remove brackets securing Thrust Nullifier S/N 002

G.5.6. Lightly grease a Parker 2-027 o-ring with Apiezon N grease

G.5.7. Verify available a number 5 rubber stopper with 1 psi relief valve

Note:

The rubber stopper is provided for contingency if the Thrust Nullifier does not immediately fit. The Test Director should assess the situation and decide on appropriate course of action. The Guard Tank should not be left with the rubber stopper for extended periods of time

G.5.8. Raise Guard Tank pressure

1. Turn on Guard Tank heaters H03D
2. Set current limit to .08A
3. Adjust voltage to raise Guard Tank pressure to ~50-100 torr

G.5.9. Remove Spin Balance Guard Tank Vent Assembly and immediately install second Thrust Nullifier

G.5.10. Turn off Guard Tank heaters

G.5.11. Allow LM mechanical team to complete mechanical installation.

G.5.12. Record TNG:_____torr

G.5.13. Set DAS alarm on TNG CN 46 to 5 torr

| Note: |
| --- |
| The second Thrust Nullifier will now be aligned. |

Section Complete QA Witness:_____

## G.6. **Reduction of Guard Tank Liquid Level with Thrust Nullifier Installed**

| NOTE: |
| --- |
| This section is designed to represent the reduction in liquid level that may be performed on the MST prior to launch. |

G.6.1. Ensure Guard Tank bayonet vent heaters operational

G.6.2. Verify Thruster Nullifier heaters and thermometers are connected to Space Vehicle via Umbilical connector P807.

G.6.3. Verify Thrust Nullifier heaters and thermometers are connected to External Temp Control Unit and Unit is functioning.

1. Record PRT A:_____ C
2. Record PRT B:_____ C

G.6.4. Record initial Guard Tank liquid level:_____%

G.6.5. Reduce Guard Tank Level by 20% from starting value without dropping below 30%:

1. Turn on Guard Tank heaters and set current limits to .08A
2. Set Voltage on Guard Tank Heaters H03D and H04D to 50V
    a. Record V/I for H03D: _____V _____A
    b. Record V/I for H04D: _____V _____A
3. Turn on Guard Tank Thrust Nullifier heater and record settings
    a. Voltage: _____V
    b. Current: _____A
4. Enter comment to DAS, “Begin reducing GT level by 20%”
5. Beginning recording data for level reduction

| Date/Time | GT LL % | PRT A/B | TN Heater V/I (V/A) | H03D/H04D (V) |
| --- | --- | --- | --- | --- |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

6. When Guard Tank level has been reduced by 20% from G.5.3, turn off Guard Tank heaters
    a. Record Date/Time:_____
    b. Record Guard Tank liquid level:_____%
7. Input comment to DAS, “End Guard Tank liquid level reduction”
8. Leave Guard Tank Bayonet heaters on for ~.5 hour after end of reduction, then turn off heaters and monitor Guard Tank bayonet for condensation

Section Complete QA Witness:_____

## G.7. **Remove Thrust Nullifier and Install GTVVA**

G.7.1. Continue to monitor Guard Tank with Thrust Nullifier installed until liquid level reaches 20%

G.7.2. Prepare GTVVA

1. Lightly grease o-ring (Parker 2-027) with Apiezon N
2. Open GTV-Va/b and GTV-V
3. Zero GTV-G and record offset
    a. Record GTV-G serial number:_____
    b. Connect GTV-G to endevco readout
    c. Record Unit/Channel numbers:_____/_____
    d. Set auto zero function to ‘On”
    e. Record offset on DAS CN46:_____

G.7.3. Ensure available number 5 rubber stopper with 1psig relief valve

G.7.4. Raise Guard Tank pressure

1. Turn on Guard Tank heaters H03D
2. Set current limit to .08A
3. Adjust voltage to raise Guard Tank pressure to ~50-100 torr

G.7.5. Remove Thrust Nullifier from SV and immediately install GTVVA

G.7.6. After GTVVA sufficiently purged from Guard Tank boil off, close GTV-Va/b and GTV-V

G.7.7. Turn off Guard Tank heaters

Section Complete QA Witness:_____

G.8. **Prepare to Leak Check GTVVA**

| Note: |
| --- |
| The following sections prepares the Gas Module, Guard Tank Vent Line and the UTS for transition to P0916, “Installation of FEE Guard Tank Vent Line and Leak Check with SV Vertical” |

G.8.1. Ensure all EV and AV valves closed

G.8.2. Connect Guard Tank Vent Line to GTVVA and Gas Module

G.8.3. Configure UTS

1. Connect UTS to EV-5
2. Start UTS pumping with turbo up to a closed EV-5
3. Ensure TV-1 and TV-2 open
4. Ensure TV-3, TV-4 and TV-RGA closed
5. Record TG-1:_____torr

G.8.4. Configure Gas Module

1. Turn on AP-1
2. Open AV-8 and AV-6
3. Open EV-4, EV-7a/b, EV-14 and EV-16
4. When EG-1 <25 mtorr, open EV-5

G.8.5. Transition to procedure P0916, “Installation of FEE Guard Tank Vent Line and Leak Check with SV vertical”

1. Record Opt number:_____
2. The following sections must be skipped G.2, G.4, G.6, G.7, G.

G.8.6. Perform Post-Operations Checklist (Appendix 2)

Section Complete QA Witness:_____

H. **PROCEDURE COMPLETE**

**Completed by:_____**

**Witnessed by:_____**

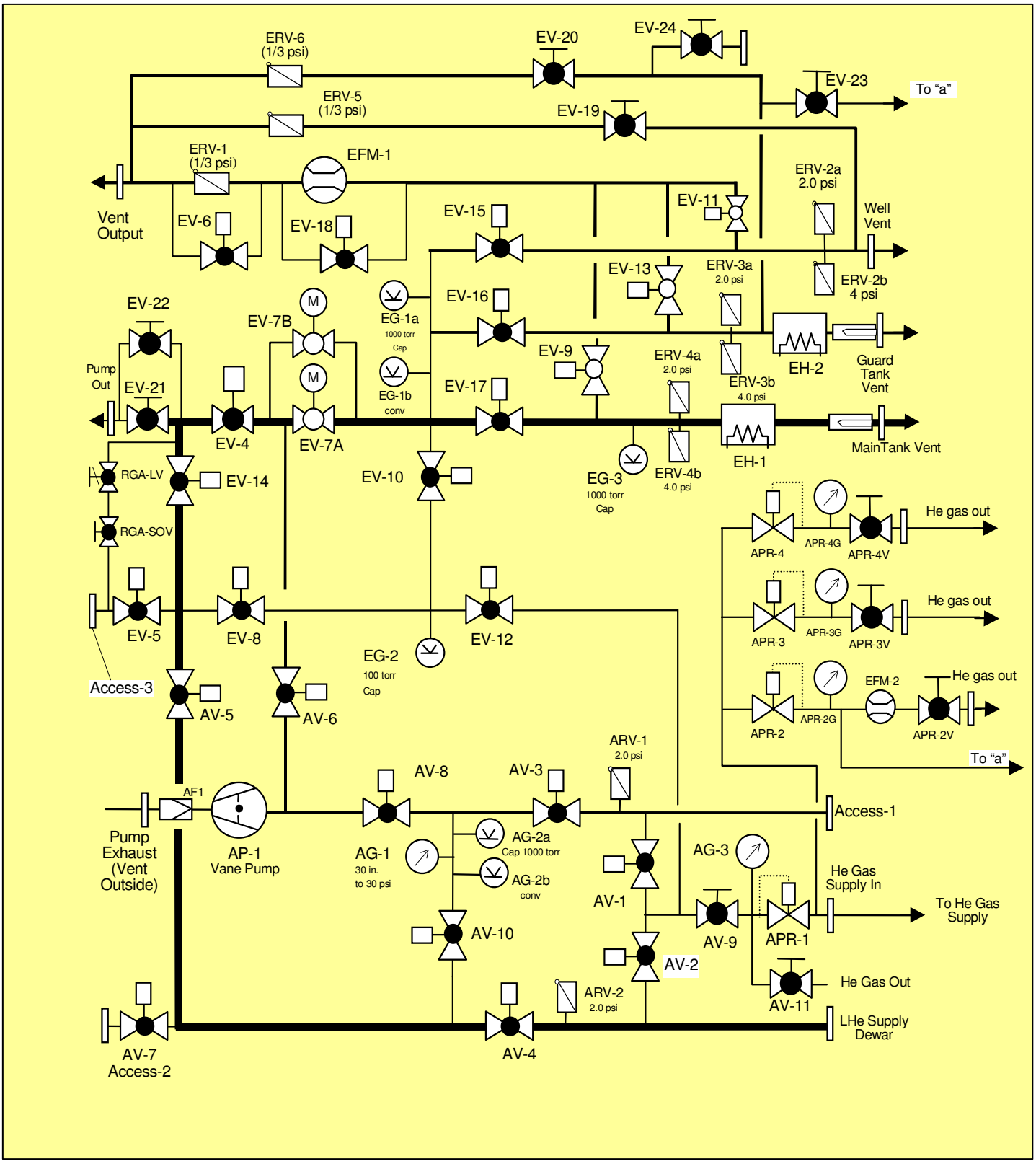
**Date: _____**

**Time:_____**

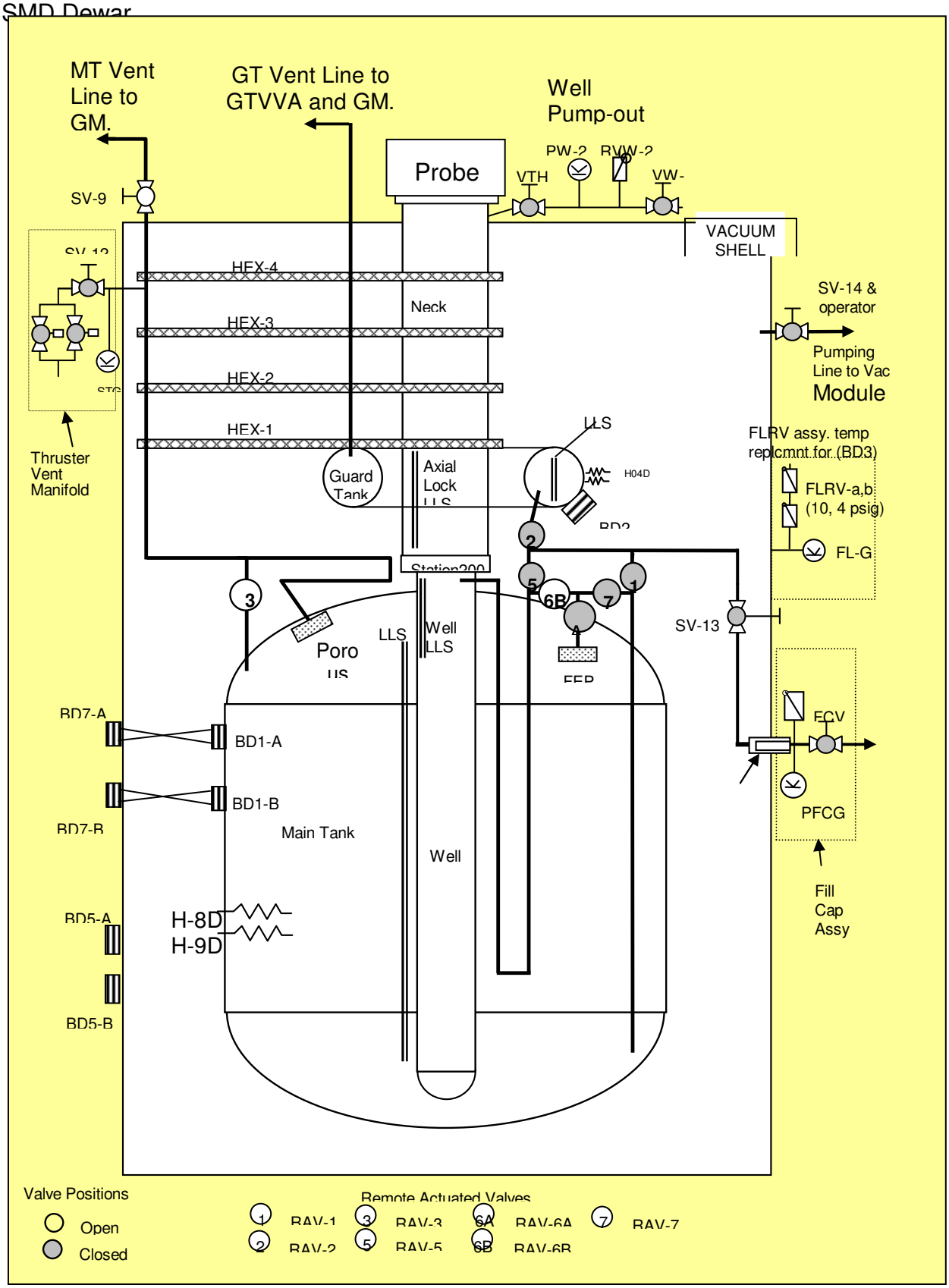
**Quality Manager**_____ **Date**_____

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

**Gas Module**


ERV-6
(1/3 psi)
EV-20
EV-24
EV-23
To "a"
ERV-5
(1/3 psi)
EV-19
ERV-1
(1/3 psi)
EFM-1
ERV-2a
2.0 psi
Vent
Output
EV-6
EV-18
EV-15
EV-11
Well
Vent
EV-13
ERV-3a
2.0 psi
ERV-2b
4 psi
EV-22
EV-7B
M
EG-1a
1000 torr
Cap
EV-16
Pump
Out
EV-21
EG-1b
conv
EV-9
ERV-4a
2.0 psi
EH-2
Guard
Tank
Vent
ERV-3b
4.0 psi
EV-4
EV-7A
EV-17
EH-1
MainTank Vent
RGA-LV
EV-14
EV-10
EG-3
1000 torr
Cap
ERV-4b
4.0 psi
He gas out
APR-4
APR-4G
APR-4V
RGA-SOV
He gas out
APR-3
APR-3G
APR-3V
EV-5
EV-8
EV-12
EG-2
100 torr
Cap
EFM-2
He gas out
Access-3
AV-5
AV-6
APR-2
APR-2G
APR-2V
To "a"
ARV-1
2.0 psi
AV-8
AV-3
AF1
Access-1
Pump
Exhaust
(Vent
Outside)
AP-1
Vane Pump
AG-1
30 in.
to 30 psi
AG-2a
Cap 1000 torr
AG-2b
conv
AG-3
He Gas
Supply In
AV-1
To He Gas
Supply
AV-10
AV-9
APR-1
AV-2
He Gas Out
ARV-2
2.0 psi
AV-11
AV-7
Access-2
AV-4
LHe Supply
Dewar

SMD Dewar


MT Vent Line to GM.
GT Vent Line to GTVVA and GM.
Well Pump-out
Probe
PW-2
RVW-2
VTH
VW-
SV-9
VACUUM SHELL
HEX-4
HEX-3
HEX-2
HEX-1
Neck
SV-14 & operator
Pumping Line to Vac Module
LLS
FLRV assy. temp replcmnt for (BD3)
FLRV-a,b (10, 4 psig)
FL-G
Thruster Vent Manifold
Guard Tank
Axial Lock
H04D
BD2
Station200
3
2
5
6B
7
1
4
SV-13
Poro
LLS
Well LLS
FEP
BD7-A
BD1-A
BD1-B
BD7-B
Main Tank
Well
FCV
PFCG
Fill Cap Assy
BD5-A
H-8D
H-9D
BD5-B
Valve Positions
Open
Closed
Remote Actuated Valves
1 RAV-1
3 RAV-3
6A RAV-6A
7 RAV-7
2 RAV-2
5 RAV-5
6B RAV-6B

## Appendix 1 **Pre Operations Checklist**

| DATE | CHECKLIST ITEM | COMPLETED | REMARKS |
|---|---|---|---|
| | 1. Verify the test procedure being used is the latest revision. | | |
| | 2. Verify all critical items in the test are identified and discussed with the test team. | | |
| | 3. Verify all required materials and tools are available in the test area. | | |
| | 4. Verify all hazardous materials involved in the test are identified to the test team. | | |
| | 5. Verify all hazardous steps to be performed are identified to the test team. | | |
| | 6. Verify each team member knows their individual responsibilities. | | |
| | 7. Confirm that each test team member clearly understands that he/she has the authority to stop the test if an item in the procedure is not clear. | | |
| | 8. Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly. | | |
| | 9. Notify management of all discrepancy reports or d-log items identified during procedure performance. In the event an incident or major discrepancy occurs during procedure performance management will be notified immediately. | | |
| | 10. Confirm that each test team member understands that there will be a post-test team meeting. | | |
| | **Team Lead Signature:** _____ | | |

## Appendix 2 **Post Operations Checklist**

| DATE | CHECKLIST ITEM | COMPLETED | REMARKS |
|---|---|---|---|
| | 1. Verify all steps in the procedure were successfully completed. | | |
| | 2. Verify all anomalies discovered during testing are properly documented. | | |
| | 3. Ensure management has been notified of all major or minor discrepancies. | | |
| | 4. Ensure that all steps that were not required to be performed are properly identified. | | |
| | 5. If applicable sign-off test completion. | | |
| | Team Lead Signature: _____ | | |

## Appendix 3– **Contingency Responses**

| Condition | Circumstance | Response |
|---|---|---|
| Temperature limits (CN 1 or 28) exceeded | Any time | Open EV-9 to Vent Main Tank |
| Burst disk rupture (MT/GT) | Any time | Evacuate room |