GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Install Fill Line Burst Disk on SMD

P0795A
ECO# 1311

December 5th, 2001

Revised by:

_____Date_____
Ned Calder
Cryogenic Test

Checked by:

_____Date_____
Dave Murray
Cryogenic Test

Approvals:

_____Date_____
Dorrene Ross
Quality Assurance

_____Date_____
Rob Brumley
Payload Technical Manager

_____Date_____
Mike Taber
Payload Test Director

REVISION RECORD

REVISION	ECO	PAGES	DATE
A	1311	Added minor Redlines Added changes to reflect to location of SMD at Lockheed Facilities Added QA inspection points Added step to verify purity of Helium Gas	11/5/01

Table of Contents

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
PTD	Payload Test Director
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
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 describes the steps necessary to Install the Fill Line Burst Disk to the SMD support Ring using a Helicoflex seal, Belleville washers and nuts.

B. SAFETY

B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware. Examples include: positioning Dewar in tilt stand; integrating probe with airlock; positioning airlock on Dewar; removing airlock from Dewar; removing probe from Dewar; and positioning support equipment such as pressurized gas cylinders and supply dewars.

A number of undesired events may be associated with these operations. For example, personnel or equipment can be struck when hardware is being moved (e.g. by forklift or crane load). Personnel are subject to entrapment while positioning hardware, such as hands or feet caught between objects as hardware is moved into place. Suspended hardware may be dropped. Personnel can be caught between objects such as forklifts and walls or loads and building support columns.

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

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

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

The high bay, LM Building 205, has an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. Additional temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions. Emergency vent line deflectors are installed over the four burst disks on the SMD vacuum shell.

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

The following additional requirements apply to all personnel involved directly in cryogenic operations. Gloves that are impervious to liquid helium and liquid nitrogen are to be worn whenever the possibility of

splashing or impingement of high-velocity cryogens exists or when handling equipment that has been cooled to cryogenic temperatures. Protective clothing and full-face shields are to be worn whenever the possibility of splashing cryogens exists.

B.2.3. Other Hazards

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

B.3. **Mishap Notification**

B.3.1. Injury

In case of any injury obtain medical treatment 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 PTD 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 PTD 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 PTD 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 Test Director is the designated signer for the "witnessed by" sign-off located at the end of each procedure. The person in charge of the operation (Test Director or Test Engineer) is to sign the "completed 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.

D.3.1.

Test Director	***Test Engineer***
Mike Taber	Tom Welsh
Dave Murray	Dave Hipkins
Ned Calder	Bruce Clark
	Ned Calder

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

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

E.2. **Lifting Operation Requirements**

There are no lifting operations in this procedure

E.3. **Hardware Requirements**

E.3.1. Hardware needed

BURST DISK	58334150-101	1 EACH
HELICOFLEX SEAL	5833392-101	1 EACH
NUT	MS-21043-3	6 EACH
BELLEVILLE WASHER	B0375-020S	6 EACH

E.4. **Tools required**

1. 3/8 open end wrench
2. alcohol
3. Q tips
4. Torque wrench
5. ½ inch rubber stopper

F. **CONFIGURATION REQUIREMENTS**

F.1. **Main Tank**

Liquid in the Main Tank may be at any level and either subatmospheric or at normal boiling point.

F.2. **Guard Tank**

The Guard-Tank may contain liquid, or be depleted. Whenever it is depleted its pressure must be independently regulated to maintain it at a positive value relative to the atmosphere and continuously monitored. Monitoring is accomplished by placing the relative pressure, as read at the Guard Tank Vent Valve Assembly (GTV-G), on the DAS alarm list. The pressure is kept positive by maintaining liquid in the tank or supplying a source of He gas for independent regulation.

F.3. **Well**

The Well may be evacuated or full of liquid helium.

F.4. **SMD Vacuum Shell**

The Vacuum Shell pressure must be less than 1×10^{-4} torr. Document No. P0213, contains the procedure for connecting to and pumping on the SMD vacuum shell.

F.5. **SMD orientation**

F.5.1. The SMD may be either vertical or horizontal as long as access to the Fill Line Burst Disk is maintained.

F.6. **Alarm System**

F.6.1. The DAS alarm system must be enabled and contain the following alarm set-points:

F.6.2. Station 200 temperature (CN 01) set at $T \leq 6.5$ K.

F.6.3. Top of lead bag temperature set (CN 28) at $T \leq 6.0$ K.

F.6.4. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 0.3$ torr.

F.6.5. The Facility Main Alarm System must be armed.

F.7. **GSE and Non-flight Hardware**

F.7.1. FCG must be connected to it's read out in the gas Module.

F.7.2. A turbo pump and a leak detector will be required to connect to FCG.

F.8. **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.

a) The SMD is installed in its transportation and test fixture.

b) A relief valve is installed in place of the SMD fill-line burst disk.

c) A foreign object and debris shield covers the upper cone of the SMD.

d) The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be; off, actively pumping the pumping line up to a closed SV-14, or actively pumping the vacuum shell.

e) The Fill Cap Assembly must be installed at SV-13

G. REFERENCE DOCUMENTS

G.1. Drawings

Drawing No.	***Title***
LMMS-5833230	*Support Ring Components Assembly*
LAC Spec 3600	*Torque Specifications*

G.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*
SU/GP-B P059	*GP-B Contamination Control Plan*
EM SYS229	Accident/Mishap/Incident Notification Process

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

H. OPERATIONS

H.1. Verify Appropriate QA Notification

- Verify SU QA notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Verify ONR representative notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Perform Pre operations checklist

  QA Witness:_____

H.2. Verify Purity of All Sources of Helium Gas

H.2.1. Record serial number on helium bottle/s.

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

H.2.2. Verify helium bottle/s have been tested for purity and record Op. Number.
Op. Number:_____
Record Step Number:_____

QA Witness:_____

H.3. **Verify Configuration Requirements**

H.3.1. Ensure cabling connected between FCG sensor and FCG read out.

H.3.2. Verify DAS alarm system enabled and record set points.

1. ***Station 200 temperature*** – verify CN [01] on DAS alarm list and set to alarm at $T \leq 6.5$ K.
   Record set point. _____K
2. ***Top of lead bag temperature*** – verify CN [28] on DAS alarm list and set to alarm at $T \leq 6.0$ K.
   Record set point. _____K
3. ***Relative Guard Tank Pressure*** – verify CN [46] on DAS alarm list and set to alarm at $\Delta P \geq 0.3$ torr.
   Record set point. _____torr

H.3.3.

H.3.4. Record liquid helium levels:

H.3.5. Main Tank LLS: _____%

H.3.6. Guard Tank LLS: _____%

H.3.7. QA Witness:_____

H.4. **Establish Initial Condition of SMD**

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

a. ***Closed***: RAV-1, RAV-2, RAV-5, RAV-7

H.4.2. Verify that SMD external valves are in the following positions.

a. ***Closed***: SV-13, and FCV.

QA Witness:_____

H.5. **Set Up to Purge Fill Line.**

H.5.1. Connect pumping line between Access #1 of Gas Module (GM) and Fill Cap valve (FCV) of Fill Cap Assembly. (FCA)

H.5.2. Set APR-1 to ≈1 psig.

H.5.3. Close/ verify closed AV-1, AV-2, AV-9, AV-10 and EV-12.

H.5.4. Turn on AP-1.

H.5.5. Open AV-8 and AV-3.

H.5.6. Open FCV.

H.5.7. When AG-2 is<25 mtorr close AV-8 and AV-3.

H.5.8. Stop AP-1.

H.5.9. Open AV-9 and AV-1.

H.5.10. Open SV-13.

H.5.11. Record FCG: _____torr Pressure in Fill Line should be above 800 torr.

QA Witness:_____

H.6. **Remove Fill Line Relief valve assembly**

H.6.1. Using 3/8 inch wrench remove the 6 nuts holding the Relief valve assy. In place.

H.6.2. Remove washers and Relief valve.

H.6.3. Plug orifice with rubber ½ inch stopper.

H.6.4. Kit all parts to storage locker.

QA Witness:_____

H.7. **Install Fill Line Burst Disk**

H.7.1. Clean Helicoflex seal (5833392-101) with alcohol and Q tips.

H.7.2. Inspect Helicoflex seal for contamination and scratches using 10x magnification.

H.7.3. Clean flange surface of Support Ring (5833230-101)

H.7.4. Clean flange surface of Burst Disk. (5833415-101)

H.7.5.

H.7.6. Inspect Both surfaces with 10x magnification. Comments:

H.7.7.
.

H.7.8. Install Helicoflex seal into groove on Support Ring.

H.7.9. Attach Burst Disk using 6 each Belleville washers (B0375-020S) and 6 each nuts (MS 21043).

H.7.10. Torque to 35-45 in/lbs. QA
Date:
Time:

H.7.11. Tool ID #: _____ Calibration due date: _____
.

H.7.12. Close FCV and AV-9.

QA Witness:_____

H.8. **Set Up UTS/Leak Detector**

H.8.1. Remove pumping line from FCV.

H.8.2. Install pumping line from UTS to FCV.

H.8.3. Close/verify closed TV-3,RGA-V and TV-5.

H.8.4. Power up Converter and Vane pump CB's.

H.8.5. Put override/protect switch into override.

H.8.6. Push reset button and open TV-2.

H.8.7. Slowly open TV-4 until TG-4 is <1 torr.

H.8.8. Verify SV-13 open.

H.8.9. Open FCV.

H.8.10. When TG-4 is < 1 torr turn on Turbo pump and open TV-1.

H.8.11. Turn on Leak detector and calibrate. Record Calibrated Leak

H.8.12. Record Indicated leak:_____

H.8.13. Date: :_____
Time: :_____

H.8.14. Connect leak detector to TV-3.

H.8.15. Leak check all plumbing between leak detector and TV-3.

H.8.16. Background: :_____
Leak rate:_____

H.8.17. Move override/ protect switch to protect.

H.8.18. Slowly open TV-3 and close TV-2.

H.8.19. Leak check all plumbing between UTS and FCA. Also spray around Burst Disk seal

H.8.20. Background: _____ Leak: _____.

H.8.21. Install bag over burst disk taped securely to Support Ring.

H.8.22. Purge bag with gaseous helium for 3 minutes.

H.8.23. QA record background: _____ Leak: _____

H.8.24. Date: _____ Time: _____ .

H.8.25. Verify no leak greater than 1X10-7 .

H.8.26. Close SV-13

QA Witness:_____

H.9. **Final Closure of Fill Line**

H.9.1. Power off turbo pump.

H.9.2. Power down Converter and vane pump CB's.

H.9.3. Open TV-5 until FCG shows 760 torr.

H.9.4. Close TV-5.

H.9.5. Close FCV.

H.9.6. Monitor FCG for 30 minutes.

H.9.7. Any loss of pressure > than ½ torr is cause for concern.

H.9.8. Remove pumping line from FCV and cap.

H.9.9. Remove pumping line from leak detector and cap both connections.

QA Witness:_____

H.10. **Perform Post Operations Checklist**

QA Witness:_____

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

Appendix 1 Pre Operations Checklist

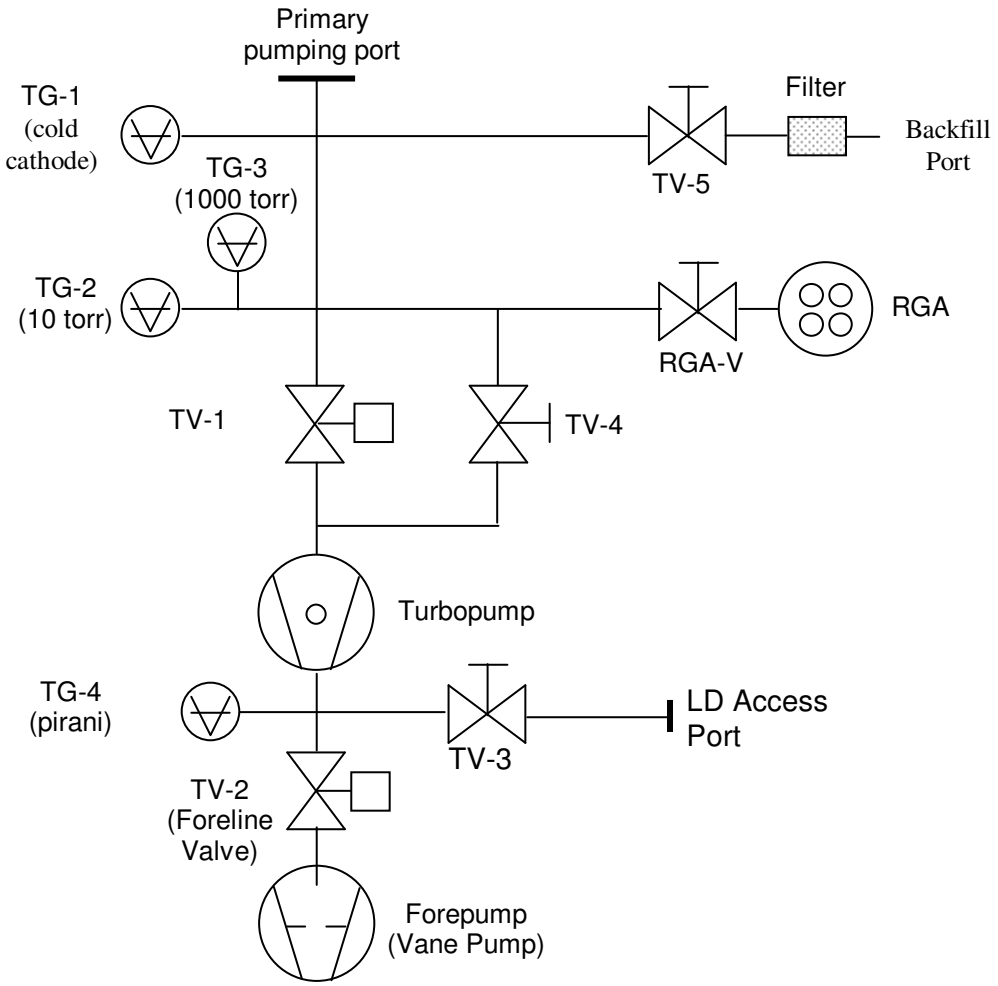
DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.		
	2. Verify all critical items in the test are identified and discussed with the test team.		
	3. Verify all required materials and tools are available in the test area.		
	4. Verify all hazardous 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**	Close EV-17 (if open) and open EV-9. Crack open SV-9 to allow MT to vent. Adjust SV-9 as necessary to restore temperature(s) below alarm limits. Open EV-6 and EV-18 if higher flow rate is needed.
Burst disk rupture (MT/GT)	**Any time**	Evacuate room
Main Tank or Guard Tank liquid level falls below alarm limit	**Any time**	Configure Dewar and Fill as appropriate


Primary
pumping port
TG-1
(cold
cathode)
TG-3
(1000 torr)
TG-2
(10 torr)
Filter
TV-5
Backfill
Port
RGA-V
RGA
TV-1
TV-4
Turbopump
TG-4
(pirani)
TV-3
LD Access
Port
TV-2
(Foreline
Valve)
Forepump
(Vane Pump)