GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Reduce Liquid Level in Main Tank- Liquid at NBP

This document contains the use of hazardous materials

P0595B
ECO 1349

January 25, 2002

Revised by:

_____Date_____
Ned Calder
Cryogenic Test

Checked by:

_____Date_____
Dave Murray
Cryogenic Test

Approvals:

_____Date_____
Dorrene Ross
Quality Assurance

_____Date_____
Harv Moskowitz
LMMS Safety

_____Date_____
Rob Brumley
Payload Technical Manager

_____Date_____
Mike Taber
Payload Test Director

REVISION RECORD

REVISION	ECO	PAGES	DATE
A	1094	Section A revised scope to reflect contents more accurately. Section B – Divided into two sections, addressing safety issues (new Section B) and test personnel (new Section D). Reorganized safety paragraphs into: hazards, mitigation, injuries. Content of both new sections essentially unchanged. Added Quality Assurance Section (new Section C) Section C, D, and E – Consolidated all requirements into new Section E entitled Requirements. Added Configuration requirements to include minimum GT and Well liquid levels, GSE/SMD interface requirements, alarm setup requirements, vacuum requirements, and non-flight hardware requirements. Section G.1 Added section to verify notification of QA. Section G.2 – Added steps to verify configuration requirements and alarm setup. Added GT to level alarm list (setpoint = 10%) Section G.3 – Added section to verify Gas Module in Standard Configuration. Section G.4 – Added section to verify initial configuration of SMD valves. Eliminated potential for pressurizing Well with external source of gas. Added caution at end of procedure to monitor Guard Tank pressure and set DAS alarm to 0.3 torr differential.	7-18-00
B	1349	Updated Scope Updated Figures Modified sections B.2.2. and B.3.1 to reflect location of SV in all Lockheed Martin buildings Updated monitored channels and data to reflect installation of the flight ECU Add minor redlines Removed references to filling the well Removed requirement for continously pumping on the vacuum shell	1/25/02

		Added Hazardous Materials comment to title Page. Added QA inspection points Added step to verify purity of helium gas Added sections B.2.3 "Other Hazards", B.3.2 "Hardware Mishap", B.3.3 "Contingency Response". Updated Qualified Personnel List Removed option with Well not evacuated Added Appendix Contingency Responses Added pre/post checklist tables	

Table of Contents

A. SCOPE 1
B. SAFETY 1
B.1. Potential Hazards 1
B.2. Mitigation of Hazards 1
B.3. Mishap Notification 2
C. QUALITY ASSURANCE 2
C.1. QA Notification 2
C.2. Red-line Authority 2
C.3. Discrepancies 2
D. TEST PERSONNEL 3
D.1. Personnel Responsibilities 3
D.2. Personnel Qualifications 3
D.3. Qualified Personnel 3
E. REQUIREMENTS 4
E.1. Electrostatic Discharge Requirements 4
E.2. Lifting Operation Requirements 4
E.3. Hardware/Software Requirements 4
E.4. Instrument Pretest Requirements 5
E.5. Configuration Requirements 6
E.6. Optional Non-flight Configurations 7
F. REFERENCE DOCUMENTS 8
F.1. Drawings 8
F.2. Supporting documentation 8
F.3. Additional Procedures 8
G. OPERATIONS 1
G.1. Pre Operations Verifications 1
G.2. Verify Configuration Requirements 1
G.3. Establish GSE Valve Configuration and Record Pressures 3
G.4. Establish Initial Condition of SMD 3
G.5. Set Up Data Acquisition 5
G.6. Reduce Main Tank Liquid Level 5
G.7. Establish Final Configuration 7

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 reduce the NBP liquid helium level in the Main Tank of the Science Mission Dewar. The steps include:

Turn on Main Tank heater

Reduce liquid level

Turn off Main Tank heater

The Well is evacuated. The Guard Tank may be depleted or contain liquid. When the Guard Tank contains liquid it must be connected to the Gas Module.

B. SAFETY

B.1. Potential Hazards

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

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

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

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

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

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

Only authorized and trained LM and SU personnel are allowed In the LM facilities without escort. All personnel working at a height 30 inches or

more off the floor are required to have an LM approved "Emergency Escape Breathing Apparatus" (EEBA), 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 Test Director or his designate and shall be approved by the QA Representative. Additionally, approval by the Payload Technical Manager shall be required, if in the judgement of the Test Director or QA Representative, experiment functionality may be affected.

C.3. Discrepancies

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

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.

Test Director	*Test Engineer*
Mike Taber	Tom Welsh
Dave Murray	Ned Calder
Ned Calder	Dave Frank
	Jim Maddocks

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

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

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

E.3.2. Ground Support Equipment

The Ground Support Equipment includes the Gas, the Electrical Module, and the Vacuum Module. The Gas Module (Figure 1) 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 and Electrical Modules.

E.3.3. Computers and Software:

The Data Acquisition System (DAS) is 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: NA

E.3.5. Additional Hardware: NA

E.3.6. Tools: NA

E.3.7. Expendables

Description	*Quantity*	*Mfr./Part No.*

Ethanol	AR	N/A
99.999% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Dow Corning High Vacuum or Apiezon N

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*	*User 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	

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
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, Granville-Phillips 360	VG-1, VG-2 VG-5	96021521	No	-

E.5. Configuration Requirements

E.5.1. Main Tank
Liquid in the Main Tank must be at its normal boiling point (NBP)

E.5.2. Guard Tank
The Guard Tank may contain liquid or be depleted.

E.5.3. Well
The Well must be evacuated.

E.5.4. SMD Vacuum Shell
The Vacuum Shell pressure must be less than 5x 10-5 torr. Document No. P0213, *Connect Vacuum Module to SMD*, contains the procedure for connecting to and pumping on the SMD vacuum shell.

E.5.5. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
    a. Top of lead bag temperature set (CN 28 and CN 29) at $T \leq 6.0$ K.
    b. Relative Guard Tank Pressure (CN 46) set at $P \geq 0.3$ torr.

E.5.6. GSE and Non-flight Hardware

1. The flight burst disk is installed at the SMD Fill Line.
2. The ion-pump magnet is 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 Fill Cap Assembly must be installed at SV-13 (See Figure 3)
5. Dewar Adapter heaters on SMD must be installed and operational.

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 SMV may be installed in its transportation and test fixture.
2. A foreign object and debris shield covers the upper cone of the SMD.

3. The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be off, actively pumping the pumping line up to a closed SV-6, or actively pumping the vacuum shell.
4. The thruster vent port is flanged to a shut-off valve.

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

F.3. Additional Procedures

Document No.	***Title***
SU/GP-B P0674	*Connect Main Tank Vent Line to Gas Module – Main Tank at NBP*
SU/GP-B P0676	*Connect Guard Tank Vent Line to Gas Module*
SU/GP-B P0879	Accident/Incident/Mishap Notification Process
SU/GP-B P0213	*Connect Vacuum Module to SMD*
SU/GP-B P0875	*GP-B Maintenance and Testing at all Facilities*

Operation Number:_____

Time Initiated:_____

Date 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 and section E.3.6.
- Verify that persons actually performing this procedure have initialed their names in Sec. D.3 and the name of the Test Director is circled.
- Complete pre-operations review.

QA Witness:_____

G.2. Verify Purity of All Sources of Helium Supply

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

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

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

QA Witness:_____

G.3. Verify Configuration Requirements

G.3.1. Verify Dewar Top Plate heaters are operational.

G.3.2. Verify Main Tank Vent Bayonet heaters are operational.

G.3.3. Verify liquid in Main Tank at NBP (4.2<T<4.3) and record temperature at bottom of tank CN [09] _____K.

G.3.4. Verify ion-pump magnet installed.

G.3.5. Verify Vacuum Shell Pressure < 5 x 10^{-5} torr.

1. Turn on Vac-ion pump and record time of day _____
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) _____ torr. If pressure is above $5x10^{-5}$ torr, turn off Vac-ion pump and perform procedure P0213 to connect Vacuum Module and pump out SMD vacuum shell.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
5. When data cycle is complete, turn off Vac-ion pump.

Verify DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – verify CN [29] on DAS alarm list and set to alarm at $T \leq 6.0$ K.
   Record set point. _____K
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

G.3.7. Verify liquid-level alarms enabled and record set points.

1. ***Main Tank*** – ensure liquid-level alarm set ≥ 20%.
   Record set point. _____%
2. ***Guard Tank*** – ensure liquid-level alarm set ≥ 10%, if there is liquid in the Guard Tank.
   Record set point. _____%

G.3.8. Ensure GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.3.9. Verify Main Tank vent line connected to Gas Module. If not perform procedure P0674, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP*, to connect Main Tank vent.

G.3.10. Record liquid helium levels:

1. ***Main Tank*** _____%
2. ***Guard Tank*** – If liquid in GT, verify level ≥ 15%. If necessary, perform procedure P0211, *Internal Main Tank to Guard Tank Transfer*, to raise level or regulate Guard Tank pressure per procedure P0881. _____%

   Record Opt #:_____

QA Witness:_____

G.4. **Establish GSE Valve Configuration and Record Pressures**

G.4.1. Set GSE valves as indicated in following Table. Record configuration in left-hand column, then place or ensure corresponding valve states as indicated.

Configure Initial Valve States		
	Open	***Close***
1. Main Tank vent	EV-9	EV-17
2. Guard Tank vent		
o With liquid – place in common manifold mode:	EV-16, EV-13, GTV-V	EV-20, EV-23
o Depleted and pressure regulated at EV-23	EV-16, EV-23, GTV-V	EV-13, EV-20
o Depleted and pressure regulated at GTV-Va	GTV-Va	EV-13, EV-16, EV-20, EV-23, GTV-V
3. Remaining EV valves	EV-7a/b	EV-4, EV-21/22, EV-14, EV-5, EV-8, EV-12, EV-10, EV-6, EV-18
4. AV valves		All

G.4.2. If Guard Tank depleted:

1. Verify source of 99.999% pure helium gas available at APR-2.
2. Verify Guard Tank Properly pressurized
   - o Guard Tank Vent Line Connected
     a. Ensure EV-23 open and APR-2 set to 2 psig
   - o Guard Tank Vent Line Disconnected
     b. Verify EV-23 closed
     c. Verify GTV-Va open
     d. Verify line connected between GTV-Va and APR-2V
     e. Verify APR-2V open and APR-2 set to 2psig

QA Witness:_____

G.5. **Establish Initial Condition of SMD**

G.5.1. Using the RAV log book verify that the dewar's internal valves are in the following positions. If not, investigate to ensure previous RAV operations properly recorded. If necessary, note resolution in D-log.

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

G.5.2. Verify that SMD external valves are in the following positions.

1. ***Open***: SV-9.
2. ***Closed***: SV-13, STV and FCV.

G.5.3. Record appropriate Guard Tank pressure:

1. GT with liquid (EG-1a): _____ torr,
2. GT depleted (GTV-G) _____ torr (relative to atm).

G.5.4. Record Main Tank pressure (EG-3) _____ torr.

QA Witness:_____

G.6. **Set Up Data Acquisition**

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

G.6.1. Set the main Tank liquid level sampling interval to 1 minute.

G.6.2. Input comment to DAS “Start reduction of Main Tank liquid level”.

QA Witness:_____

G.7. **Reduce Main Tank Liquid Level**

G.7.1. Specify desired final helium level in Main Tank: _____%

Note: Heaters H09D and H08D are designed for 1.3 A and 52 VDC (40 ohms) per the SMD CDR [Ref. 4]. Heater power supplies should be operated in the voltage limited mode.

The set points for H09D of 50 VDC and 1.3 A results in 62.5 W of heat being deposited in the Main Tank, with the power supply in the voltage limited mode. At 4.2 K (latent heat = 20.6 J/g, density = .125 g/cc) use this requires 27.5 hrs to boil off the entire 2400 liters of Helium, or 2.75 hours to reduce the liquid level by 10%.

The boiloff rate should be limited to approximately 100 liters per hour to avoid exceeding the vent-line heat exchanger capacity. This is equivalent to approximately 70 W of total power from both heaters combined. The set points for H08D are chosen to maintain a combined heater power < 70 W.

G.7.2. Turn on Main Tank Heater H09D:

1. Set power supply current limit to 1.3 amp.
2. Set voltage of heater H09D to 50 Vdc and record:
   a. Time of Day: _____
   b. V: _____ Vdc and I: _____ a

G.7.3. Turn on Main Tank vent-line heat exchanger in Gas Module.

G.7.4. Open EV-6 and EV-18 to reduce back pressure on Main Tank.

G.7.5. **(Option)** Turn on Main Tank Heater H08D

1. Set power supply current limit to 0.5 amp.
2. Set voltage of heater H08D to ≤ 14 Vdc and record:
   a. Time of Day: _____
   b. V: _____ Vdc and I: _____ A

G.7.6. Record data in attached Data Sheet every 10 minutes.

CAUTION
Monitor and maintain positive Guard Tank pressure. If the Guard Tank pressure drops below atmospheric perform the following option (G.7.7).

G.7.7. **(Option)** Add heat to Guard Tank to maintain positive pressure:

1. Close/verify closed EV-13.
2. Turn on power supply for Guard-Tank heater (H-3D or H-4D)
3. Set power supply current limit to 0.07 amps.
4. Set voltage limit to 50 VDC and record:
   V _____Vdc and I _____A.
5. Adjust heater voltage as necessary to maintain Guard Tank pressure (GTV-G). in the range 15 torr < ΔP < 30 torr.
6. Monitor and maintain positive Guard Tank pressure throughout the pump-down. Record data on attached data sheets.

G.7.8. When Main Tank liquid level sensor reads desired level record:

1. Time of day:_____
2. Main Tank bottom temperature CN [09] _____ K
3. Lead Bag CN[28] _____ K

G.7.9. Close EV-6 and EV-18

G.7.10. T
urn off power supply to Main Tank heater(s).

G.7.11. T
urn off power supply to Guard Tank heater(s).

G.7.12. T
urn off Main Tank vent-line heat exchanger (EH-1).

QA Witness:_____

G.8. **Establish Final Configuration**

G.8.1. Input comment to DAS “End of Main Tank liquid level reduction”.

G.8.2. Set the DAS data cycle to 15 minutes.

G.8.3. Ensure that power to Vac-Ion pump is off.

G.8.4. Ensure that Main Tank vent-line heat exchanger (EH-1) is off.

G.8.5. Ensure Main Tank heaters are powered off (H-8D and H-9D).

G.8.6. Ensure Guard Tank heaters are powered off (H-3D, H-4D)

G.8.7. Verify GSE valves set as indicated in following Table. Record configuration in left-hand column, then ensure corresponding valve states are as indicated.

Configure Final Valve States		
	Open	***Close***
Main Tank vent	EV-9	EV-17
Guard Tank vent		
o With liquid – place in common manifold mode:	EV-16, EV-13, GTV-V	EV-20, EV-23
o Depleted and pressure regulated at EV-23	EV-16, EV-23, GTV-V	EV-13, EV-20
o Depleted and pressure regulated at GTV-Va	GTV-Va	EV-13, EV-16, EV-20, EV-23, GTV-V
Remaining EV valves	EV-7a/b	EV-4, EV-21/22, EV-14, EV-5, EV-8, EV-12, EV-10, EV-6, EV-18
AV valves		All

G.8.8.

Ensure DAS alarm enabled and record set points if changed

- Thermal conditions substantially unchanged, alarm set points for the lead bag are unchanged and set to alarm.
- Thermal conditions substantially changed, temperature alarm points reset as follows:

  a. Top of Lead set Point bag CN [29] _____ K (≤ 6.0 K)

  b. Top of Lead Bag set point CN [28] _____ K (≤ 6.0 K)

G.8.9. Ensure liquid level sensor alarms enabled on Main Tank and Guard Tank and record set points if changed.

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

CAUTION
The Guard Tank may tend to subcool following the completion of this procedure. Establish continuous monitoring of the Guard Tank pressure by placing it on the DAS alarm list. Maintain positive pressure in the Guard Tank by regulating pressure as necessary.

G.8.10. Ensure Guard Tank pressure on DAS alarm list and set to alarm at > 0.3 torr differential.

G.8.11. If Guard Tank liquid level <15%, verify Guard Tank properly pressurized

- Guard Tank Vent Line Connected
  a. Ensure EV-23 open and APR-2 set to 2 psig
- Guard Tank Vent Line Disconnected
  b. Verify EV-23 closed
  c. Verify GTV-Va open
  d. Verify line connected between GTV-Va and APR-2V
  e. Verify APR-2V open and APR-2 set to 2psig

G.8.12. Continue to monitor and record data on data sheet for 30 minutes to ensure that system stabilizes.

G.8.13. Verify Completetion of Post Operations checklist

QA Witness:_____

H. **PROCEDURE SIGN OFF**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

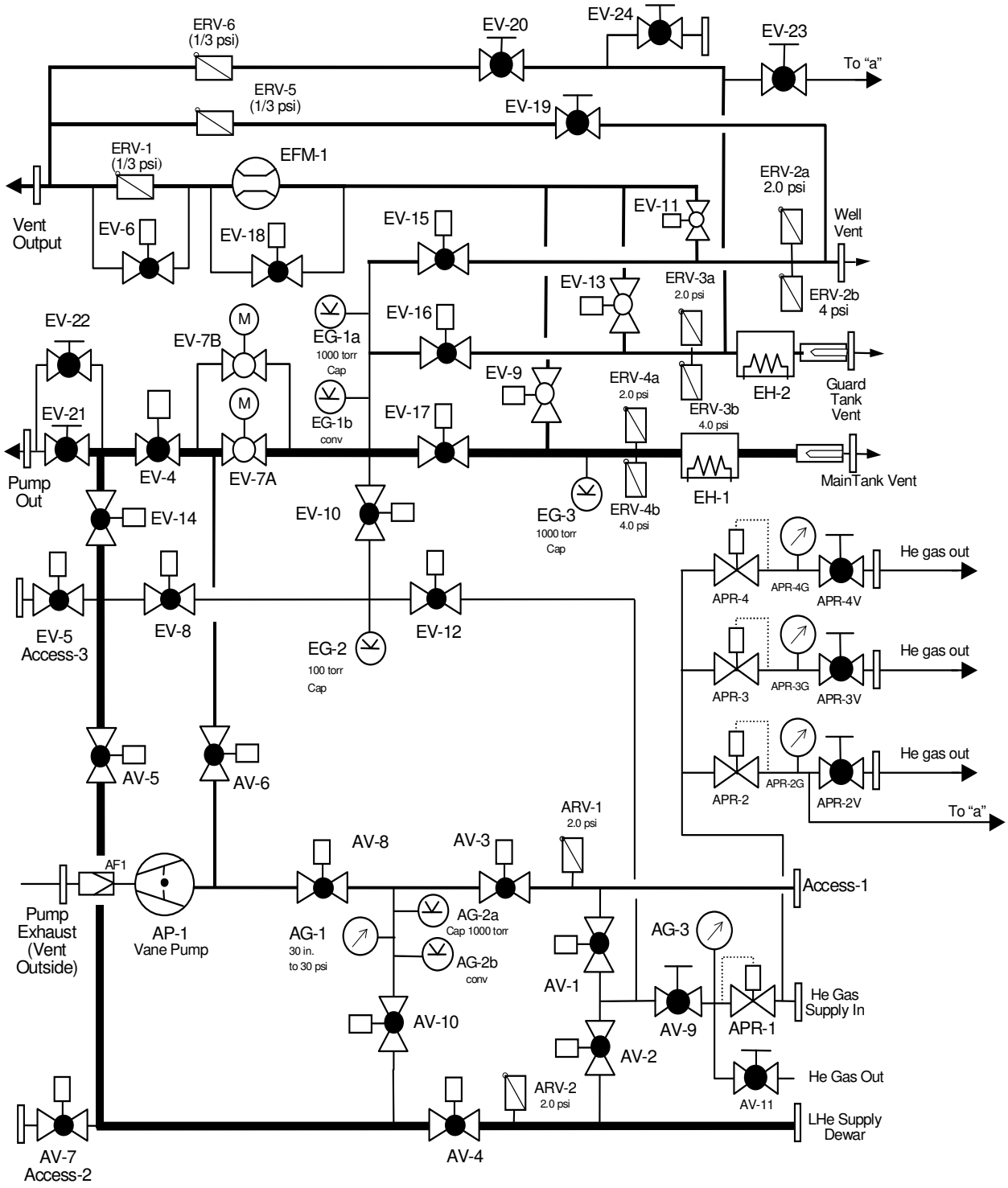
Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

Data Sheet 1

									SMD External Temp. Control		
Date Time	M.T. bottom T-9D [9] (K)	Lead bag top T-20D [28] (K)	HX-1 T-03D [5] (K)	G.T. bottom T-15D [24] (K)	M.T. Pressure EG-3 [114] (torr)	G.T. Pressure EG-1 [112] (torr)	Main Tank Liquid level LL-1D [101] (%)	Main Tank Flow rate PFM-1 [110] LL/hr	M.T. Vent Bayonet /O-ring (^{o}C/ ^{o}C)	Valve SV-9 /Top Plate (^{o}C/ ^{o}C)	SV-9 Knob/ Dewar Adapter (^{o}C/ ^{o}C)

									SMD External Temp. Control		
Date Time	M.T. bottom T-9D [9] (K)	Lead bag top T-20D [28] (K)	HX-1 T-03D [5] (K)	G.T. bottom T-15D [24] (K)	M.T. Pressure EG-3 [114] (torr)	G.T. Pressure EG-1 [112] (torr)	Main Tank Liquid level LL-1D [101] (%)	Main Tank Flow rate PFM-1 [110] LL/hr	M.T. Vent Bayonet /O-ring (^{o}C/ ^{o}C)	Valve SV-9 /Top Plate (^{o}C/ ^{o}C)	SV-9 Knob/ Dewar Adapter (^{o}C/ ^{o}C)


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
EV-9
ERV-4a
2.0 psi
EH-2
Guard
Tank
Vent
EV-21
M
EG-1b
conv
EV-17
ERV-3b
4.0 psi
Pump
Out
EV-4
EV-7A
MainTank Vent
EH-1
EV-14
EV-10
EG-3
1000 torr
Cap
ERV-4b
4.0 psi
He gas out
APR-4
APR-4G
APR-4V
EV-5
Access-3
EV-8
EG-2
100 torr
Cap
EV-12
He gas out
APR-3
APR-3G
APR-3V
He gas out
APR-2
APR-2G
APR-2V
To "a"
AV-5
AV-6
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
AV-1
AV-10
AV-9
APR-1
He Gas
Supply In
AV-2
He Gas Out
ARV-2
2.0 psi
AV-11
LHe Supply
Dewar
AV-7
Access-2
AV-4

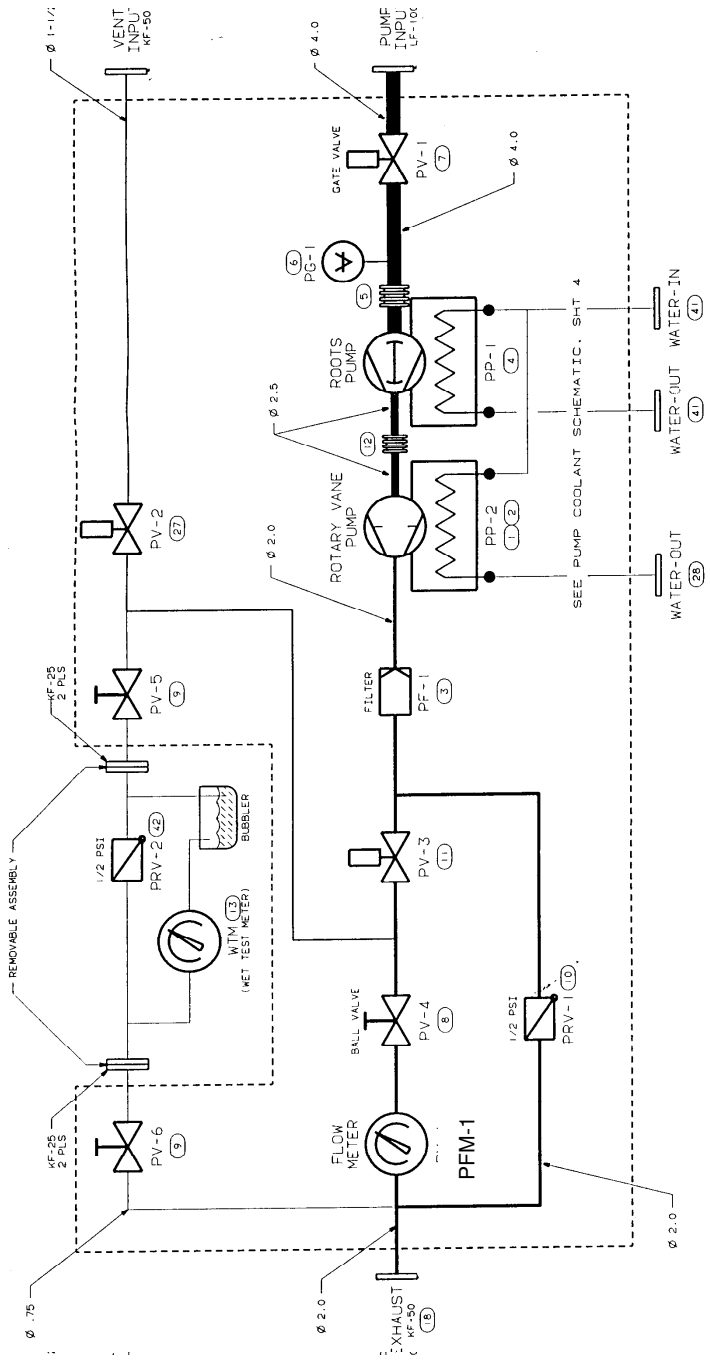


Figure 2. Schematic of Pump Module plumbing.

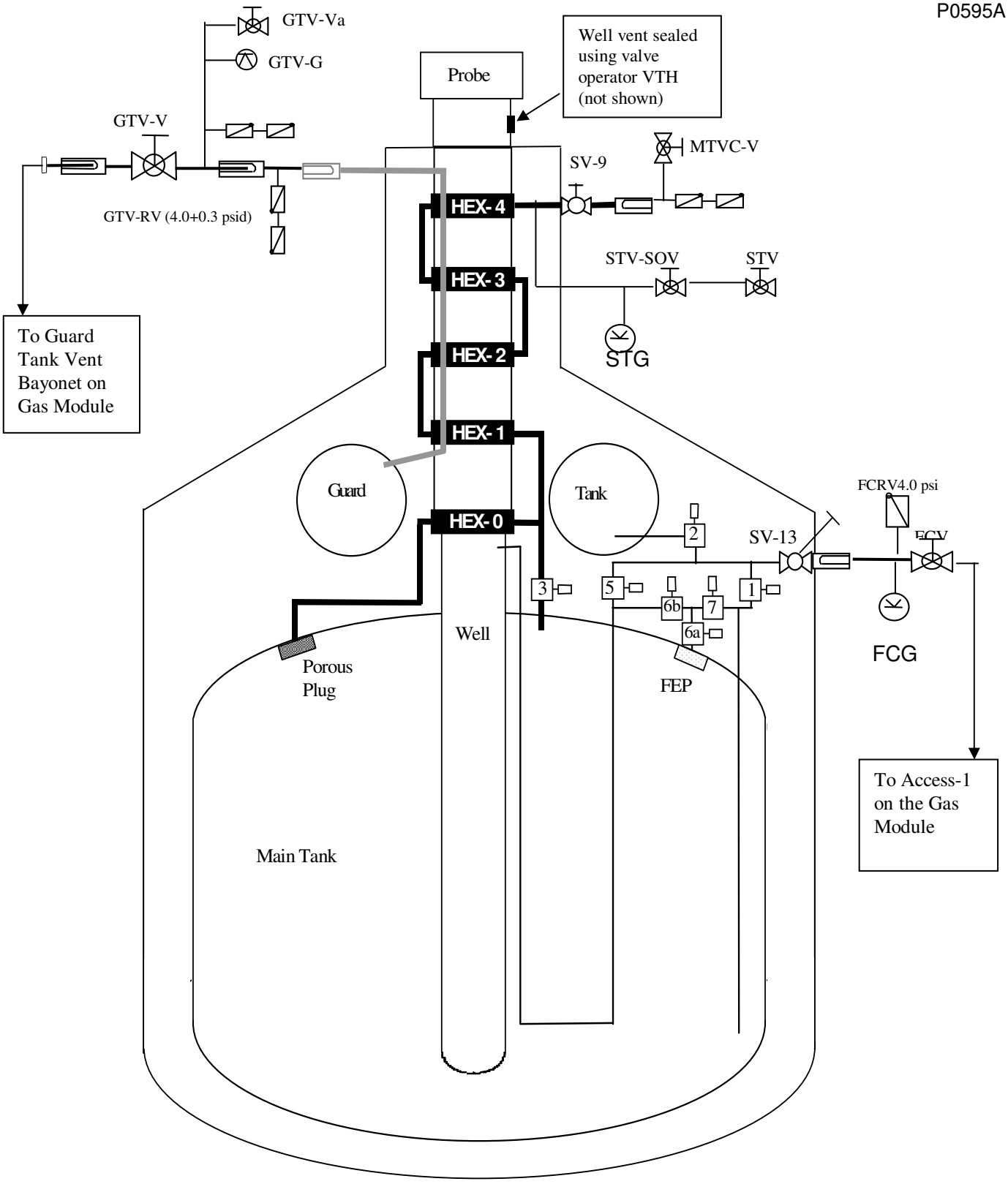


Figure 3 Schematic representation of SMD showing interfaces with Gas module.

Appendix 1

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

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

Appendix 3– Contingency Responses

	Condition	Circumstance	Response
1	Power Failure	If before section G.7 If after section G.7	Terminate Procedure Wait for power restoration
2	Burst disk rupture (MT/GT)	Any time	Evacuate room