GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

DISCONNECT GUARD TANK VENT LINE FROM GAS MODULE

THIS DOCUMENT CONTAINS THE USE OF HAZARDOUS MATERIALS

ECO# 1333

January 23, 2002

PO677B

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_____
Sasha Buchman
Program Manager

_____Date_____
Mike Taber
Test Director

REVISION RECORD

REVISION	ECO	PAGES	DATE
A	1338	Added Hazardous Materials comment to title Page. Added QA inspection points Added minor redlines Added step to verify purity of helium gas Modified sections B.2.2. and B.3.1 to reflect new location of SMD in Lockheed Martin building 205 Added sections B.2.3 "Other Hazards", B.3.2 "Hardware Mishap", B.3.3 "Contingency Response". Updated Qualified Personnel List Added EM SYS229 Added Appendix Contingency Responses Added pre/post checklist tables Updated Figures Added Valve tables	9/24/01
B	1333	Updated Scope Updated Figures Modified sections B.2.2. and B.3.1 to reflect location of SMV in all Lockheed Martin buildings Updated monitored channels and data to reflect installation of the flight ECU Add minor redlines	1/23/02

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 provides the necessary steps to disconnect the Guard Tank vent line from the Gas Module and install a Vent Cap. The steps include:

Close off vent line at Guard Tank Vent Valve (GTV-V)

Leak check Guard Tank Vent Cap

Disconnect Guard Tank short vent line

Install vent cap at GTV-V

Leak Check Guard Tank Vent Cap

Open Guard Tank vent valve if not depleted.

The procedure is applicable when the Guard Tank contains liquid, as well as, when it is depleted. The Main Tank vent line may be connected to the Gas Module or disconnected from the Gas Module. The Main Tank liquid may be at normal boiling point or subatmospheric.

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

In LM facilities, there may be 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 LM facilities 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 EMSYS229.

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**

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

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

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

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

E.3.2. Ground Support Equipment

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

E.3.3. Computers and Software:

E.3.4. 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

Description
Helium leak detector S/N or Model #:_____ Cal Due Date:_____

E.3.5. Additional Hardware

Description
Guard Tank Vent Cap – See Figure 2

E.3.6. Tools

No special tools are required.

E.3.7. Expendables

Description	*Quantity*	*Mfr./Part No.*
Ethanol	AR	N/A
99.99% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Aperizon N 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*	*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	EG-3	2828	No	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
		Granville-Phillips Model 316				
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, Granville-Phillips 360	VG-1, VG-2 VG-5	96021521	No	-

E.6. **Configuration Requirements**

E.6.1. Main Tank

Liquid in the Main Tank may be at its normal boiling point (NBP) or subatmospheric. When subatmospheric, the initial configuration of the Gas Module may be such that the bath is being actively pumped or is set up in a non-vented mode.

E.6.2. Guard Tank
The Guard-Tank may contain liquid, or be depleted.

The Guard Tank liquid boils away at a rate of approximately 15% per day. If the vent line is to be disconnected for a period of less than 7 days, the liquid level should be topped off before disconnection (see document no.SU/GP-B-P0211 *Internal Guard Tank Fill – Vent Lines Connected*). Note: to perform an internal fill of the Guard Tank while the vent line is disconnected requires that the Main Tank be at NBP and that the Main Tank vent line also be disconnected with a vent cap installed (see document no. SU/GP-B-P0699, *Internal Guard Tank Fill – Vent Lines Disconnected*). Otherwise, the Guard Tank must be reconnected to the Gas Module, or depleted (see document no. SU/GP-B-P0212, *Guard Tank Depletion*).

When the Guard Tank is depleted, its pressure must be independently regulated from a source of 99.99% pure helium gas and its pressure must be continuously monitored and maintained at a positive value relative to that of the atmosphere. Monitoring is accomplished by placing the relative pressure, as read at the Guard Tank Vent Valve Assembly (GTV-G), on the DAS alarm list.

E.6.3. Well
The Well is evacuated.

E.6.4. Vacuum Shell

The Vacuum Shell pressure must be less than 5*10^-5 torr.

E.6.5. 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 $\Delta P \geq 0.3$ torr.

E.6.6. 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).
2. Guard Tank Vent Cap (Figure 2).

E.7. **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 SMD is installed in its transportation and test fixture.

2. A relief valve is installed in place of the SMD internal fill-line burst disk.
3. A foreign object and debris shield covers the upper cone of the SMD.
4. The ion-pump magnet is installed.
5. The Airlock Support Plate may be installed on the SMD. This plate supports the Airlock that is used to keep air out of the Well during probe installation and removal. It is left in place while the Probe is removed.
6. A Dewar Adapter, Shutter, and Shutter Cover are mounted to the Well of the SMD when the Probe is removed
7. The Main Tank Vent Line may be connected to the Gas Module, or it may be disconnected either at the Bayonet at the end of the short line or the Bayonet at SV-9.
8. When the Well contains liquid, it vents through the Gas Module unless Well operations are being performed (e.g., Probe insertion). Venting through the Gas module is accomplished via a pumping line attached to the Dewar Adapter interface flange at the Airlock Support Plate (Probe not installed), or via a pumping line attached to the Well vent manifold installed at the Well pump-out port (Probe installed).
9. The Vacuum shell pump out port at SV-6 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 with the Vacuum Module actively pumping the vacuum shell.
10. The thruster vent port is flanged to a shut-off valve.
11. The 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
EM SYS229	Accident/Incident/Mishap Notification Process
SU/GP-B P059	*GP-B Contamination Control Plan*
SU/GP-B-P0108	Quality Plan

F.3. Additional Procedures

Document No.	***Title***

SU/GP-B-P0211	*Internal Guard Tank Fill – Vent Lines Connected*
SU/GP-B-P0699	*Internal Guard Tank Fill – Vent Lines Disconnected*
SU/GP-B P0875	*GP-B Maintenance and Testing at all Facilities*
SU/GP-B-P0212	*Guard Tank Depletion*
SU/GP-B P0879	Accident/Incident/Mishap Notification Process

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

G. OPERATIONS

CAUTION

Once the Guard Tank vent line is disconnected, an internal fill of the Guard Tank requires that (1) the Main Tank be at NBP and (2) the Main Tank vent line also be disconnected with a vent cap installed. If either one of these criteria presents a problem, be prepared to regulate the Guard Tank pressure with an external source of 99.99 % pure helium gas, to prevent suck back, if and when it goes dry.

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).
- Verify Guard Tank Vent Line connected to Gas Module- if not terminate procedure

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

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. No.

Operation. Number:_____ Step Number:_____

QA Witness:_____

G.3. **Leak Check Guard Tank Vent Cap.**

1. Attach Leak Detector at GTVC-V
2. Bag the entire assembly.
3. Ensure all other access ports are capped off.
4. Record Leak Detector background rate: _____scc/s
5. Ensure background on the $1*10^{-7}$scc/s range.
6. Spray helium into bagged assembly for two minutes.
7. Record leak rate after two minutes:_____scc/s.
8. Verify that no rise is detected.
9. Close GTVC-V.
10. Disconnect Leak Detector at GTVC-V.

G.3.2.

G.4. **Verify Configuration Requirements**

G.4.1. Verify proper sealing of Well. Record closure (cover plate, Hole cutter, Probe etc.)._____

G.4.2. Ensure DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – ensure CN [28] and CN [29] on DAS alarm list and set to alarm at $T \leq 6.0$ K. Record set point. _____K
2. ***Relative Guard Tank Pressure*** – ensure CN [46] on DAS alarm list and set to alarm at $\Delta P \geq$ 0.3 torr. Record set point. _____torr

G.4.3. Ensure liquid-level alarms set, as appropriate, and record set points.

1. ***Main Tank*** – ensure liquid-level alarm set. Record set point. _____%
2. ***Guard Tank*** – ensure liquid level alarm set (if liquid in GT). Record set point. _____%

G.4.4. Ensure GSE cabling connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811).

Section Complete QA Witness:_____

G.5. **Record Initial Configuration and Conditions**

G.5.1. Record Main Tank Configuration.

- MT.A- Main Tank at NBP – vent line connected to Gas Module:
- MT.B- Main Tank at NBP – vent line disconnected from Gas Module:
- MT.C- Main Tank subatmospheric- vent line disconnected from Gas Module.
- MT.D. Main Tank subatmospheric and being pumped by AP-1-verify that AP-1 is running.

G.5.2. :

G.5.2. Record Guard Tank Configuration

- GT.A-Guard Tank contains liquid and is venting in Bypass mode
- GT.B- Guard Tank is depleted and regulated by APR-3 through GTV-Va.
- GT.C- Guard Tank is depleted and regulated by APR-2 through EV-23.
- GT.D-Guard Tank contains liquid and is venting in common manifold mode.

G.5.3. Verify valves are in the proper configuration as given by the following table.

Configuration	**EV Valve States**		**AV Valve States**		**Other Valves**	
	Open	Closed	Open	Closed	Open	Closed
MT.A/GT.A	EV-9, EV-16, EV-20	All other EV valves	None	All AV valves	SV-9, GTV-V,	MTVC-V, GTV-Va
MT.A/GT.B	EV-9, EV-16, APR-3V	All other EV valves	None	All AV valves	SV-9, GTV-Va	MTVC-V, GTV-V
MT.A/GT.C	EV-9, EV-16, EV-23	All other EV valves	None	All AV valves	SV-9, GTV-V	MTVC-V, GTV-Va
MT.A/GT.D	EV-9, EV-13, EV-16	All other EV valves	None	All AV valves	SV-9, GTV-V	MTVC-V, GTV-Va
MT.B/GT.A	EV-16, EV-20	All other EV valves	None	All AV valves	SV-9, GTV-V,	MTVC-V, GTV-Va
MT.B/GT.B	EV-16, APR-3V	All other EV valves	None	All AV valves	SV-9, GTV-Va	MTVC-V,GTV-V
MT.B/GT.C	EV-16, EV-23	All other EV	None	All AV	SV-9, GTV-V	MTVC-V,

Configuration	EV Valve States		AV Valve States		Other Valves	
	Open	Closed	Open	Closed	Open	Closed
		valves		valves		GTV-Va
MT.B/GT.D	EV-16, EV-13	All other EV valves	None	All AV valves	SV-9, GTV-V	MTVC-V, GTV-Va
MT.C/GT.A	EV-16, EV-20,	All other EV valves	None	All AV valves	SV-9, GTV-V,	MTVC-V, GTV-Va
MT.C/GT.B	EV-16, APR-3V	All other EV valves	None	All AV valves	SV-9, GTV-Va	MTVC-V,GTV-V
MT.C/GT.C	EV-16, EV-23	All other EV valves	None	All AV valves	SV-9, GTV-V	MTVC-V, GTV-Va
MT.C/GT.D	EV-16, EV-13	All other EV valves	None	All AV valves	SV-9, GTV-V	MTVC-V, GTV-Va
MT.D/GT.A	EV-7a/b, EV-17, EV-20	All other EV valves	AV-6,	All AV valves	SV-9, GTV-V,	MTVC-V, GTV-Va
MT.D/GT.B	EV-7a/b, EV-17, APR-3V	All other EV valves	AV-6	All other AV valves	SV-9, GTV-Va	MTVC-V,GTV-V
MT.D/GT.C	EV-7a/b, EV-17, EV-23	All other EV valves	AV-6	All other AV valves	SV-9, GTV-V	MTVC-V, GTV-Va
MT.D/GT.D	EV-7a/b, EV-13,EV-17	All other EV valves	AV-6	All other AV valves	SV-9, GTV-V	MTVC-V, GTV-Va

G.5.4. Record initial liquid helium levels as appropriate.

1. Main Tank (LL-1D or LL-2D) _____%
2. Guard Tank (LL-5D or LL-6D) _____%

G.5.5. Record initial pressures, as appropriate.

1. Main Tank – Subatmospheric (EG-2):_____ torr.
2. Main Tank – NBP (EG-3/STG):_____ torr.
3. Guard Tank – with liquid (EG-1a) _____ torr.
4. Guard Tank – depleted (GTV-G) _____ torr.

G.5.6. Branch to appropriate section of procedure

1. If in configuration GT.A or GT.D proceed to section G.6
2. If in configuration GT.B or GT.C proceed to section G.7

Section Complete QA Witness:_____

G.6. **Disconnect Vent Line – Liquid in Guard Tank**

G.6.1. Close/verify closed EV-13 and EV-20.

G.6.2. Verify Guard Tank pressure positive relative to atmospheric pressure.

Record relative pressure (GTV-G) _____ torr.

G.6.3. Close GTV-V.

G.6.4. Remove long vent line from GTV-V.

G.6.5. Inspect, clean, and lubricate (use Braycote 601 or Apeizon "N") Vent-Cap o-ring.

G.6.6. Install Guard Tank Vent Cap at GTV-V.

G.6.7. Leak Check Guard Tank Vent Cap.

1. Attach Leak Detector at GTVC-V.
2. Bag the entire assembly, including connection to between GTV and Guard Tank Vent Cap assembly.
3. Ensure all other access ports are capped off.
4. Record Leak Detector background rate: _____scc/s
5. Ensure background on the $1*10^{-7}$scc/s range.
6. Spray helium into bagged assembly for two minutes.
7. Record leak rate after two minutes:_____scc/s.
8. Verify that no rise is detected.
9. Close GTVC-V.
10. Disconnect Leak Detector at GTVC-V.

QA Witness:_____

G.6.8. Open GTV-V.

G.6.9. Record Guard Tank pressure (GTV-G, relative to atm.) _____ torr.

G.6.10. **(Option)** Remove Guard Tank vent line from inlet to Gas Module heat exchanger and install blankoff.

- o Guard Tank Vent Line disconnected from Gas Module
- o Guard Tank Vent Line not disconnected from Gas Module

G.6.11. Cover open ends of vent line.

G.6.12. Proceed to Section G.8.

Section Complete QA Witness:_____

G.7. **Disconnect Vent Line – Guard Tank Depleted**

G.7.1. Record method of Guard Tank pressure regulation:

- If in configuration GT.B skip to Section G.7.2.

- If in configuration GT.C; perform the following:
    1. Close EV-23
    2. Crack open GTV-Va and adjust for He gas outflow.
    3. Attach GHe supply line (while purging) from APR-2V to access port at GTV-Va.
    4. Open GTV-Va fully.
    5. Perform Section G.7.2

G.7.2. Ensure Guard Tank pressure positive relative to atmospheric pressure.

Record relative pressure (GTV-G) _____ torr.

G.7.3. Close GTV-V.

G.7.4. Remove long vent line from GTV-V.

G.7.5. Inspect, clean, and lubricate (use Braycote 601 or aperizon "N") Vent-Cap o-ring.

G.7.6. Install Guard Tank Vent Cap at GTV-V.

G.7.7. Leak Check Guard Tank Vent Cap.

1. Attach Leak Detector at GTVC-V
2. Bag the entire assembly, including connection to between GTV and Guard Tank Vent Cap assembly.
3. Ensure all other access ports are capped off.
4. Record Leak Detector background rate: _____scc/s
5. Ensure background on the $1*10^{-7}$scc/s range.
6. Spray helium into bagged assembly for two minutes.
7. Record leak rate after two minutes:_____scc/s.
8. Verify that no rise is detected.
9. Close GTVC-V.
10. Disconnect Leak Detector at GTVC-V.

QA Witness:_____

G.7.8. Open GTVC-V.

G.7.9. Crack open GTV-V, observe flow and purge Vent Cap for one minute.

G.7.10. Close GTVC-V.

G.7.11. Close GTV-V

G.7.12. **(Option)** Remove Guard Tank Vent line from inlet to Gas Module heat exchanger and install blankoff.

- o Guard Tank Vent Line disconnected from Gas Module
- o Guard Tank Vent Line not disconnected from Gas Module

G.7.13. Cover open ends of vent line.

G.7.14. Proceed to Section G.8.

Section Complete QA

Witness:_____

G.8. **Establish Final Configuration**

G.8.1. Close/verify closed EV-13, EV-16, EV-20, EV-23 and EV-24.

G.8.2. Ensure DAS alarm enabled and record set points if changed

- o Thermal conditions substantially unchanged, alarm set point for the lead bag is unchanged
- o Thermal conditions substantially changed, temperature alarm points reset as follows:

a. Top of Lead Bag set point _____ K (≤ 6.0 K)
[CN 28 and CN 29]

G.8.3. Ensure liquid level sensor alarms enabled, as appropriate, and record set points if changed.

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

G.8.4. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr differential.

G.8.5. Verify completion of Post-Operations Checklist. (Appendix 2)

Section Complete QA Witness:_____

H. **PROCEDURE COMPLETION**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

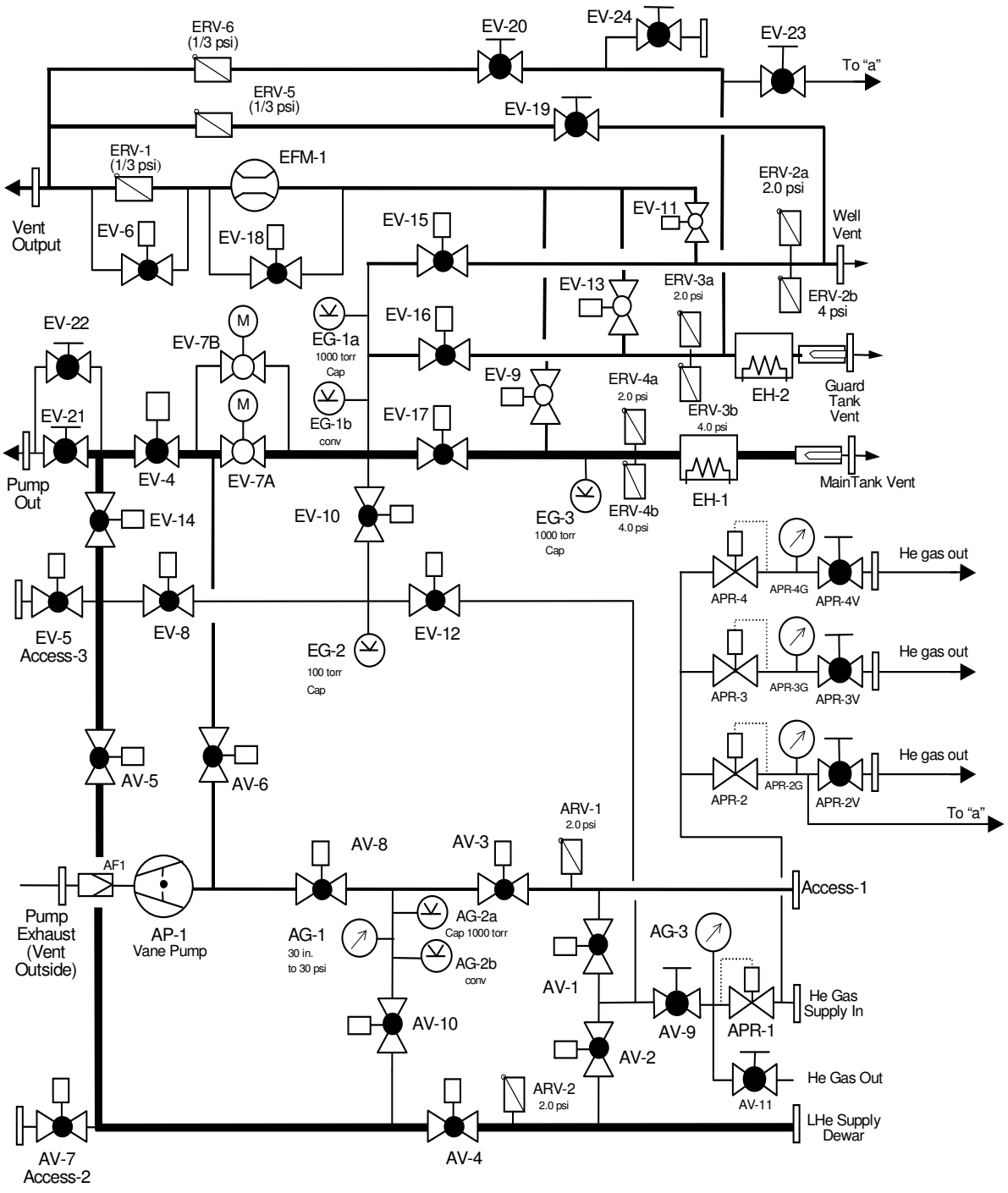
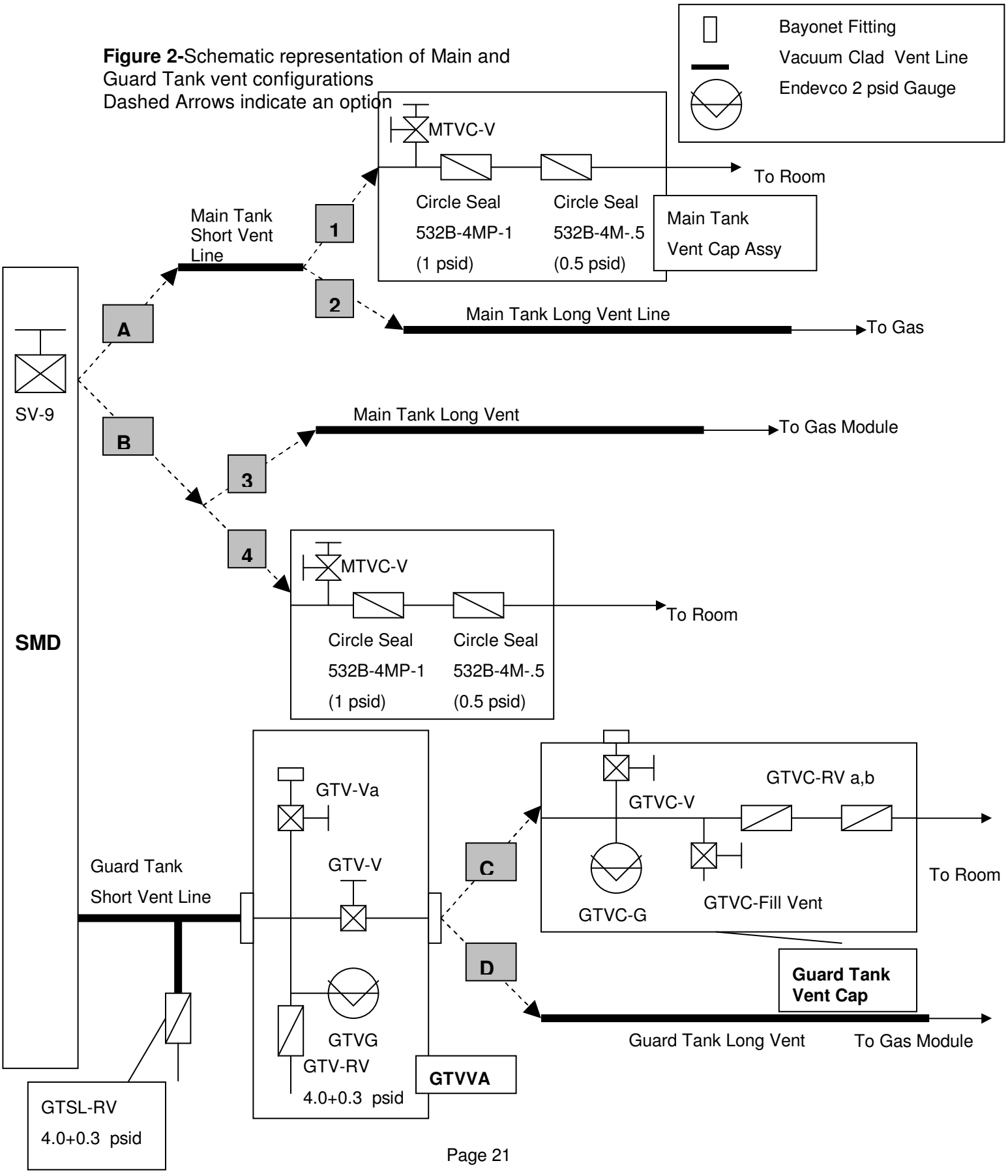

To
Outside
ERV-6
(1/3 psi)
EV-20
EV-24
EV-23
To "a"
ERV-5
(1/3 psi)
EV-19
ERV-1
(1/3 psi)
EFM-1
ERV-2a
2.0 psi
Vent
Output
EV-6
EV-18
EV-15
EV-11
Well
Vent
EV-13
ERV-3a
2.0 psi
ERV-2b
4 psi
EV-22
EV-7B
M
EG-1a
1000 torr
Cap
EV-16
EV-9
ERV-4a
2.0 psi
EH-2
Guard
Tank
Vent
EV-21
M
EG-1b
conv
EV-17
ERV-3b
4.0 psi
Pump
Out
EV-4
EV-7A
EV-10
EG-3
1000 torr
Cap
ERV-4b
4.0 psi
EH-1
MainTank Vent
EV-14
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
AV-5
AV-6
He gas out
APR-2
APR-2G
APR-2V
To "a"
To Outside
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
AV-7
Access-2
AV-4
LHe Supply
Dewar

Figure 2-Schematic representation of Main and Guard Tank vent configurations
Dashed Arrows indicate an option



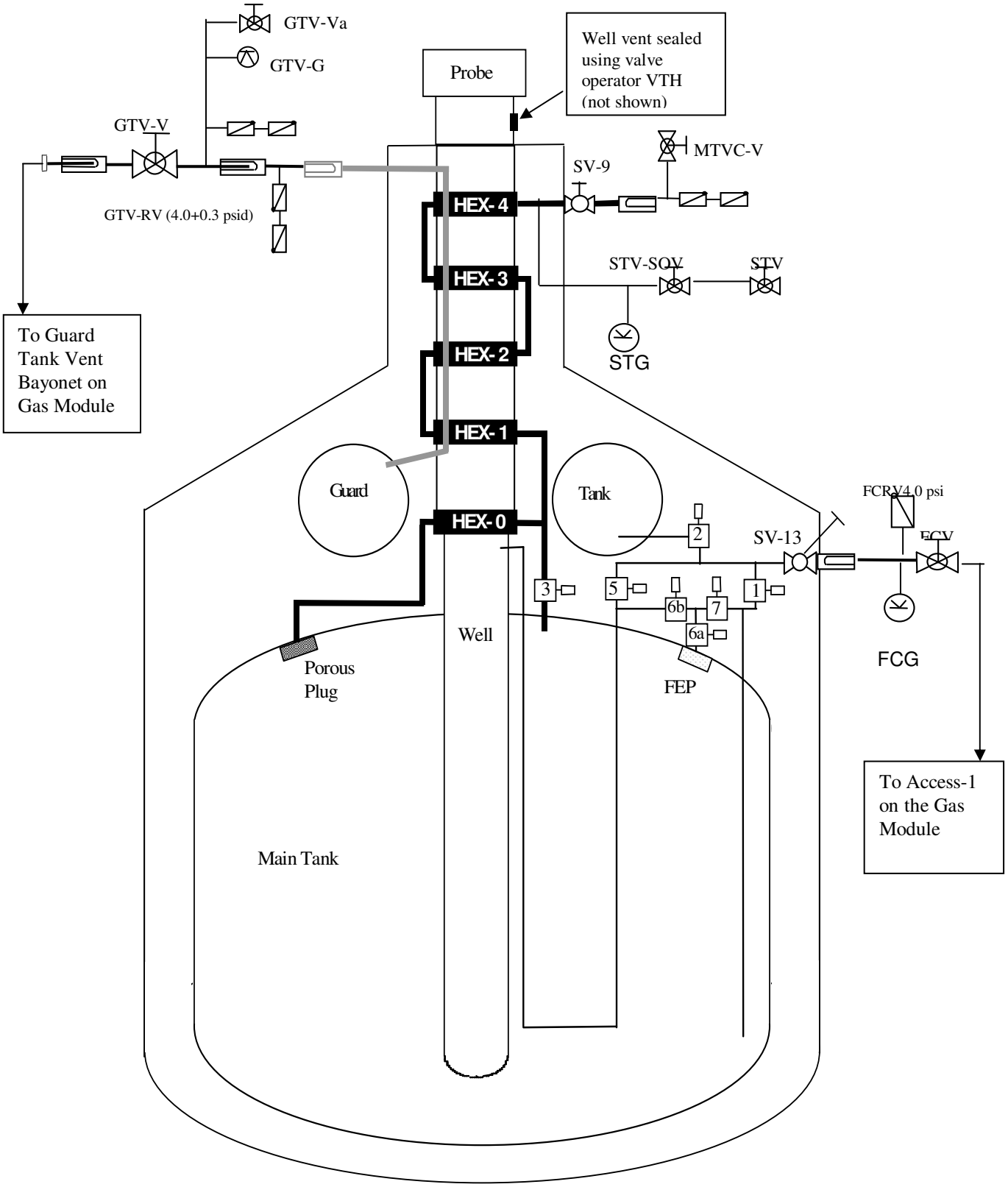
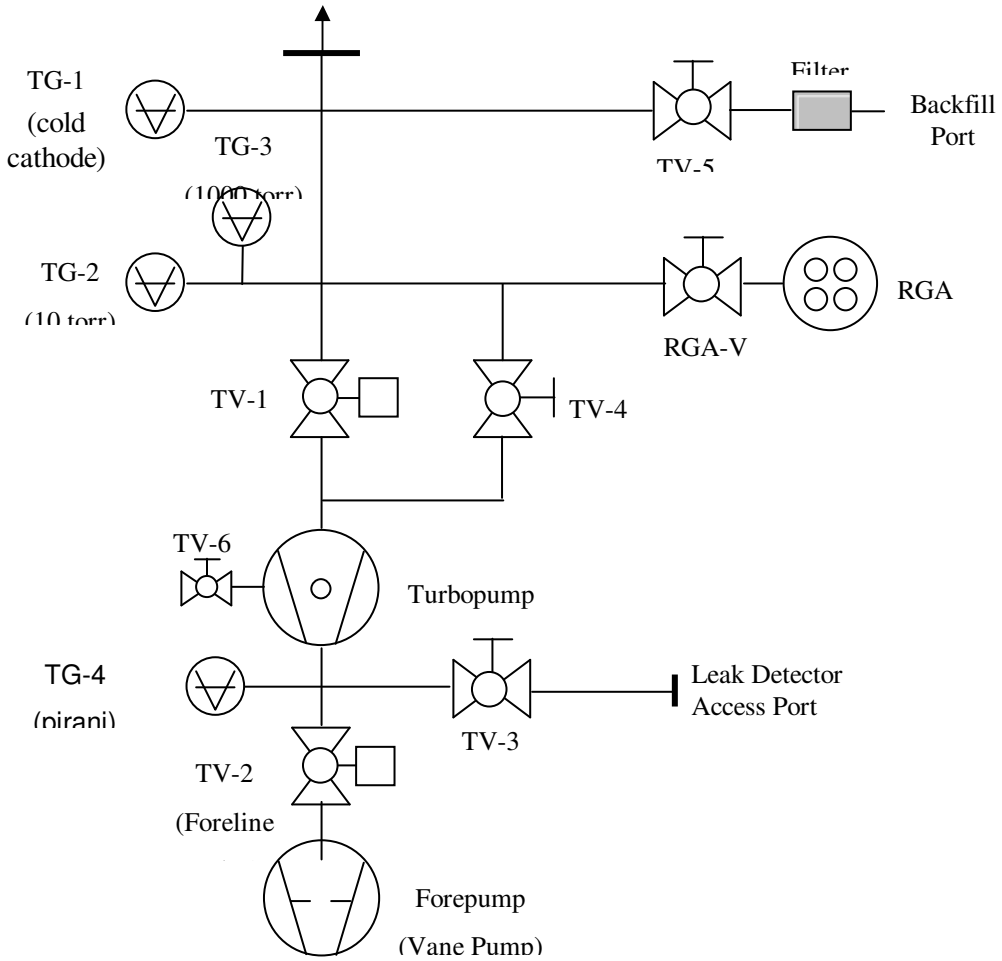


Figure 3 Schematic representation of SMD showing interfaces with Gas module.

Figure 4: Utility Turbo Pumping System



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
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