GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Verify Helium Cylinder Content/Connect Helium Supply Line

THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

ECO# 1335

P0881A

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Revision Record

REVISION	ECO	PAGES	DATE
A	1335	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 Add steps for use during transport and with the TM&A	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 describes the steps necessary to verify the purity of any source of helium gas used for GP-B cryogenic operations and to connect it to the Guard Tank or the Gas Module.

A Gow-Mac thermal conductivity meter is used to verify the purity of the helium gas. If this meter is not available, a second option is provided to verify the purity of the helium gas using a helium leak detector.

The hazardous operations in this procedure involve the use of 2500 psi Helium bottles.

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 facility 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 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 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 qualified personnel as determined by the Test Director. The person performing the operations (Test Director or Test Engineer) is to sign the “Completed by” sign-off. Any other qualified person or QA person who can attest to the successful performance of this procedure may sign the “Witnessed by” sign-off. ***The Test Director will perform Pre-Test and Post-Test Briefings in accordance with P0875 “GP-B Maintenance and Testing at all Facilities.” Checklists will be used as directed by P0875***

D.2. Personnel Qualifications

The Test Director must have a detailed understanding of all procedures and facility operations and experience in all of the SMD operations. Test Engineers must have SMD Cryogenic operations experience and an understanding of the operations and procedures used for the cryogenic servicing/maintenance of the Dewar.

D.3. Qualified Personnel

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

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 (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 does not require the use of any of these modules, but may involve connection of the helium gas supply to the Gas Module.

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

Description
GOW MAC Gas Analyzer

Helium leak detector: Calibrated Leak:_____ Cal Due Date:_____

E.3.5. Additional Hardware

Description
Ultra High Purity High Pressure Regulators
1/4' poly hose

E.3.6. Tools: N/A

E.3.7. Expendables

Description	***Quantity***	***Mfr./Part No.***
Ethanol	AR	N/A
99.99% pure gaseous helium	AR	N/A
Snoop liquid leak detector	AR	Swagelok

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	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
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	-
27	NA	Gow-Mac Gas Analyzer			Yes	

E.5. Configuration Requirements

E.5.1. Main Tank

There are no special requirements for the Main Tank

E.5.2. Guard Tank

There are no special requirements for the Guard-Tank.

E.5.3. Well

The Well is always evacuated.

E.5.4. Vacuum Shell

There is no requirement for the vacuum shell pressure.

E.5.5. Alarm System

1. The DAS alarm system may be enabled and contain the following alarm set-points:

    a. Top of lead bag temperature set (CN 28 and CN 29) at T ≤

6.0 K.

b. Relative Guard Tank Pressure (CN 46) set at □P ≥ 0.3 torr.

2. The TM&A may also be enabled during transport operations. The Guard Tank pressure must be alarmed at P ≥ 0.3 torr on the TM&A if in use.

E.5.6. GSE

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 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 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.
6. The thruster vent port is flanged to a shut-off valve.
7. 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
SU/GP-B P0108	Quality Plan
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:_____

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).

QA Witness:_____

G.2. Initial Operations

G.2.1. Verify bottle/s to be tested have label identifying them as pure helium, grade 5.0 or better.

QA Witness:_____

G.2.2. Record serial number on helium bottle/s to be tested.

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

G.2.3. Install and purge a regulator (0-150 psi) on the helium bottle/s to be tested.

G.2.4. Bubble leak check regulator connection with Snoop leak detection solution or equivalent.

G.2.5. Record method of verifying purity of helium bottles.

Note- the preferable method for verifying the purity of any source of helium gas is by use of the Gow-Mac Gas Analyzer. However, if the Gas Analyzer is not available (as to be noted below) a second option is provided using a helium leak detector.

- Gow-Mac Binary Gas Analyzer-Proceed to section G.3
- Bottles have already been tested:

  Record Opt #:_____

  Record Date:_____

  Proceed to section G.5, skipping G.3 and G.4
- Helium Leak Detector-Proceed to section G.4

  Explain reason for not using Gas Analyzer:_____
  _____
  _____

QA Witnesss:_____

G.3. **Verify purity of helium gas with Gow-Mac Binary Gas Analyzer**

G.3.1. Place power mode switch in desired position, 'Bat' or 'Line Charge'

G.3.2. Adjust rotary switch to most sensitive range.

G.3.3. Attach certified 99.999% pure helium supply to meter.

G.3.4. Purge certified 99.999% pure gas through the meter.

G.3.5. Adjust zero control so that the meter reads "0" on the scale.

G.3.6. Attach calibrated mixture (5% air in helium) of gas to the analyzer.

G.3.7. Purge calibrated mixture through the analyzer.

G.3.8. Adjust Calibration Trimmer until the meter indicates gas composition (5% air in helium).

G.3.9. Attach gas to be tested to analyzer.

G.3.10. If using a six pack, verify all six bottles are open for testing.

G.3.11. Allow meter to sample gas for a minimum of 30 seconds.

G.3.12. Verify that the gas being tested is less than 1% air in helium.

G.3.13. Disconnect helium source from gas meter.

G.3.14. Place blue indicator label on bottles tested indicating that their purity has been verified.

G.3.15. Proceed to section G.5

QA Witness:_____

G.4. **Option- Verify purity of helium gas with helium leak detector.**

G.4.1. Turn on leak detector and pump-out test port.

G.4.2. Record calibrated standard leak:_____

G.4.3. Record measured standard leak:_____

G.4.4. Verify measured and standard are within 5% of each other.

G.4.5. Vent test port and attach Varian Super Probe nozzle.

G.4.6. Begin pumping on probe nozzle

G.4.7. Record Background:_____

G.4.8. If using a six pack, verify all six bottles are open.

G.4.9. Flow gas to be verified into probe nozzle.

G.4.10. Verify leak detector goes immediately to gross leak check mode.

G.4.11. Place blue label on bottles tested indicating that their purity has been verified.

QA Witness:_____

G.5. **Connect verified helium source to desired location**

G.5.1. Connect helium source line to regulator.

G.5.2. Use Snoop solution or equivalent to leak check regulator connections.

G.5.3. Purge helium source line for one minute.

G.5.4. Record hardware helium supply line to be attached to and perform connection.

o Guard Tank at GTV-Va	1. Verify that the Guard Tank is at a positive pressure, record CN46 _____ torr or GTVCG on TM&A 2. Set output regulator to 1-2 psi. 3. Record pressure used _____ psi 4. Crack open GTV-Va and verify outflow of helium gas. 5. While purging from both directions, connect the helium source line to GTV-Va 6. Fully open GTV-Va
o He Gas Supply In port on Gas Module and regulate Guard Tank pressure with APR-2 through EV-23	1. Close/Verify closed EV-23. 2. Connect helium source line to helium in port on Gas Module. 4. Adjust APR-2 to 1-2 psi.

	5. Record pressure used _____ psig 4. Verify Guard Tank at positive pressure 5. Open APR-2V 6. Open EV-23 and allow to purge. 7. Close APR-2V
o He Gas Supply In port on Gas Module and regulate Guard Tank pressure at GTV-Va with APR-2 through APR-2V.	1. Verify EV-23 closed. 2. Connect helium source line to helium in port on Gas Module. 3. Open APR-2V and adjust APR-2 to purge plumbing for 30 seconds. 4. Close APR-2V. 6. Adjust APR-2 to 1-2 psi. 7. Record pressure used _____ psig 6. Verify Guard Tank at positive pressure 7. Attach line to APR-2V and allow to purge for one minute. 8. Crack open GTV-Va and verify outflow of helium gas. 9. While purging from both directions connect line to GTV-Va 10. Fully open GTV-Va

QA Witness:_____

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

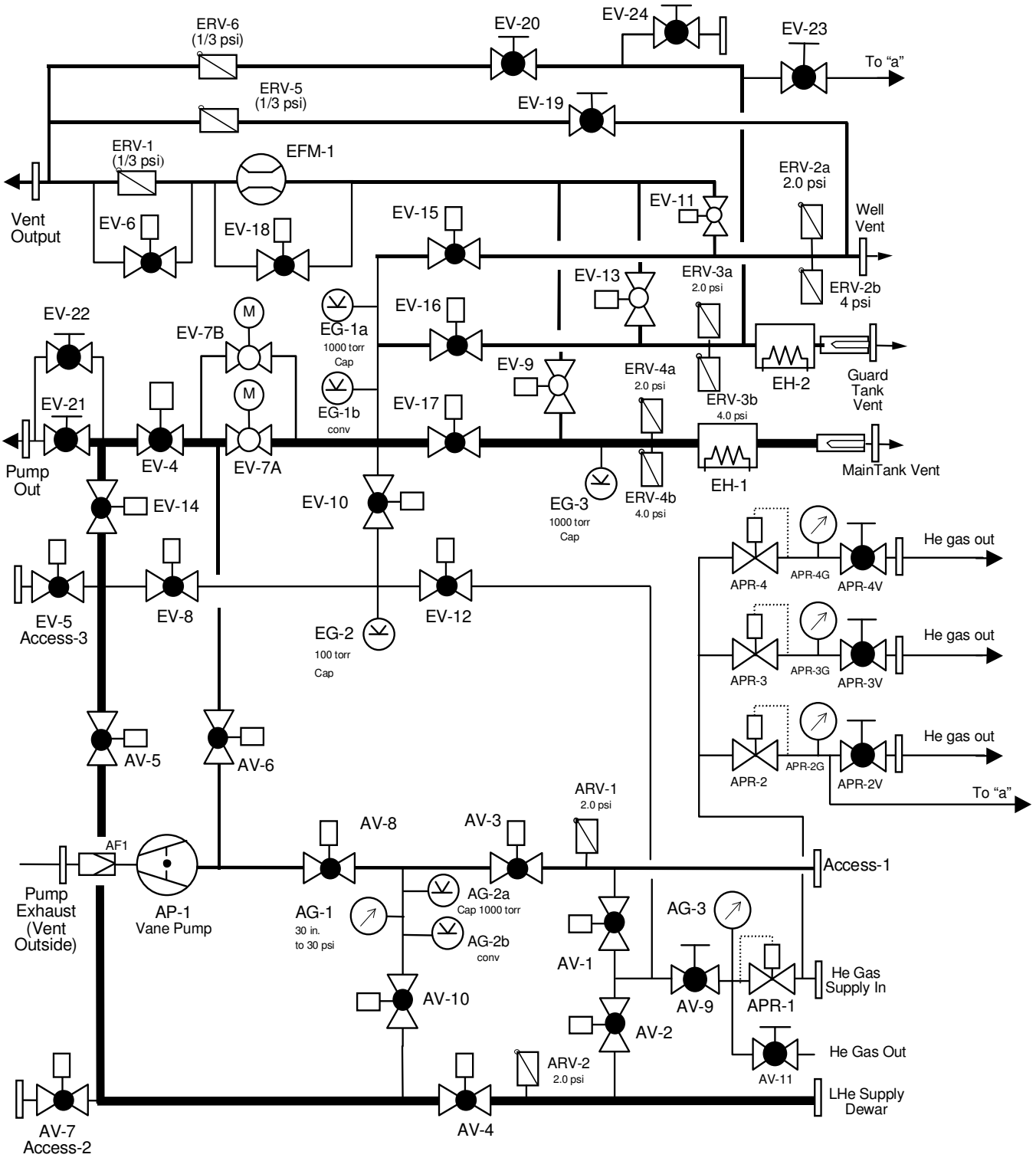
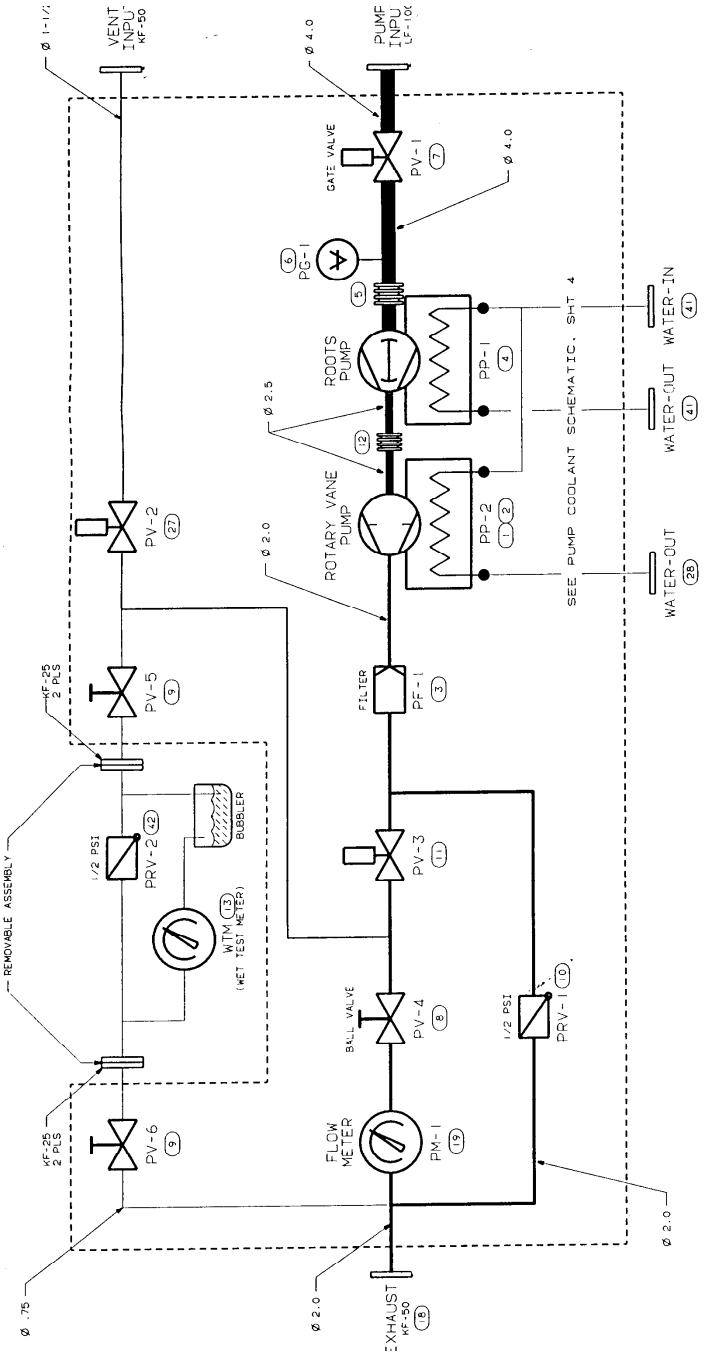


Figure 1 Gas Module

Figure 2-Schematic diagram of the Pump Module



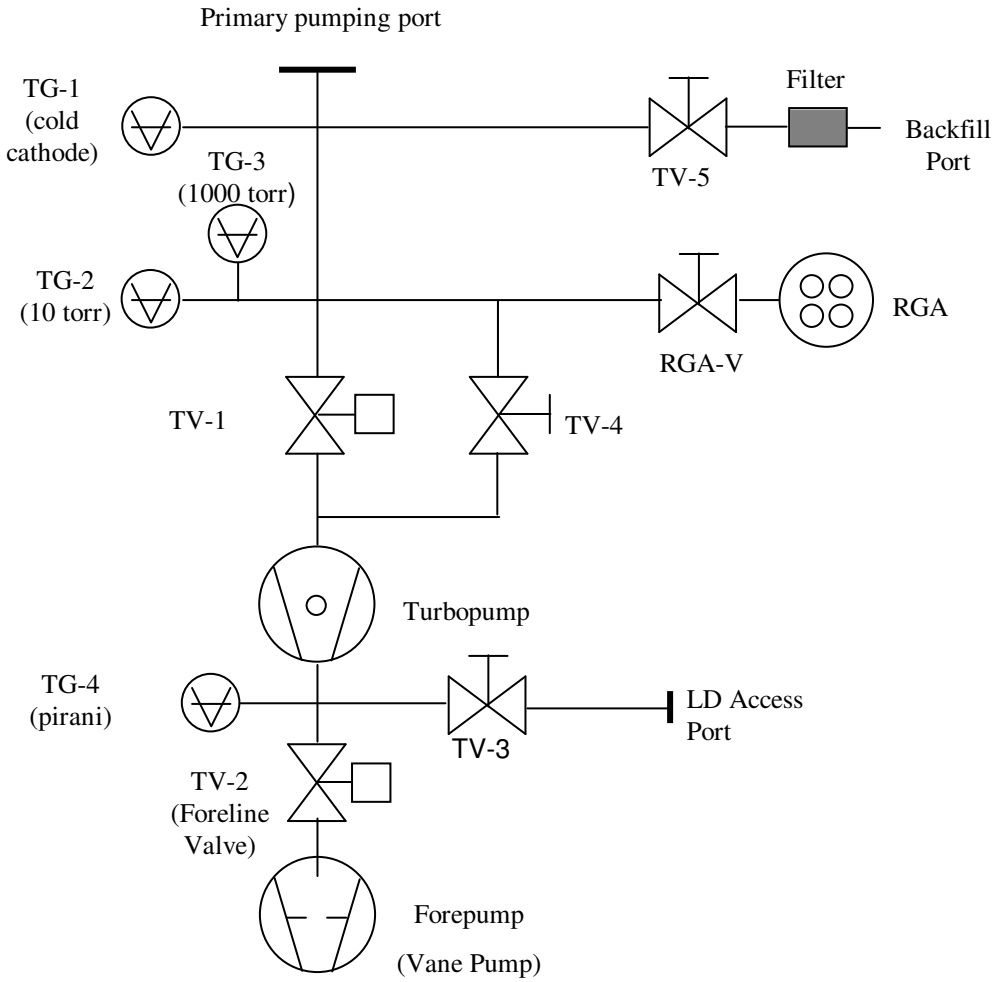


Figure 3. Schematic diagram of Utility Pumping System (UTS)

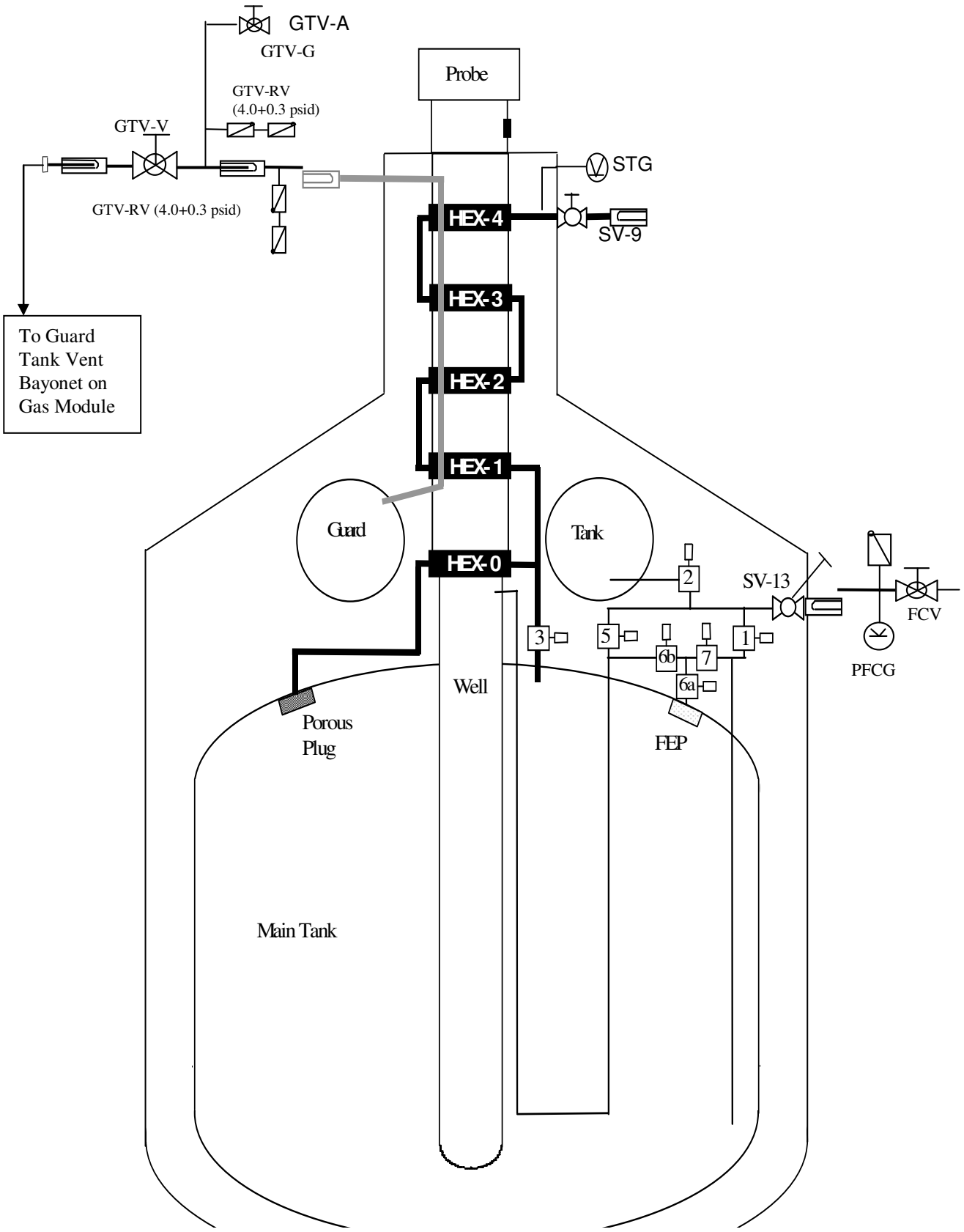
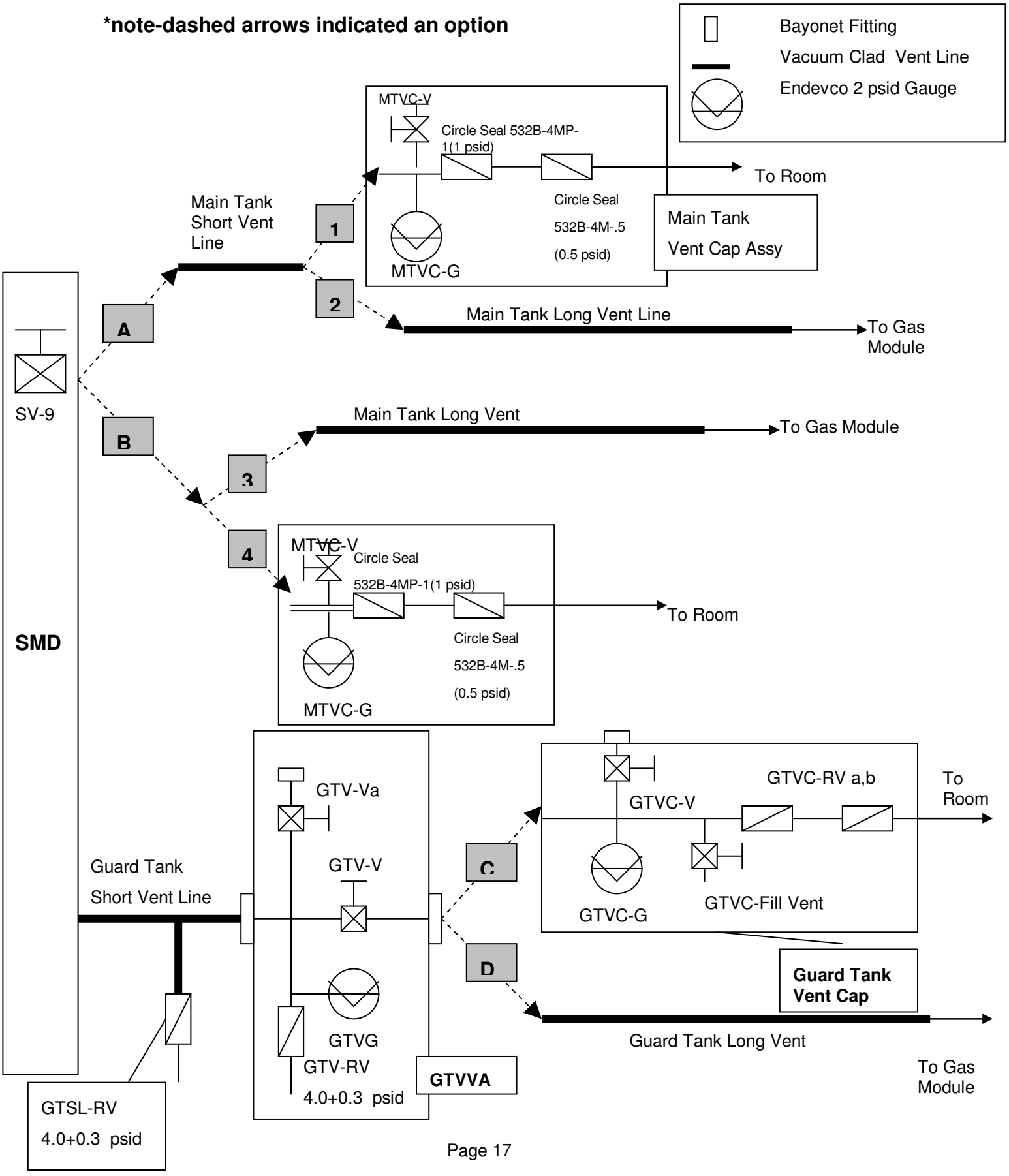


Figure 4. Schematic of Science Mission Dewar plumbing.

Figure 5- Possible Main Tank and Guard Tank Vent Configurations

***note-dashed arrows indicated an option**



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
Power failure	Any time	Suspend any operations requiring power (e.g., use of the leak detector) until power is resumed.
Burst disk rupture (MT/GT)	Any time	Evacuate room. If above floor, don escape breathing apparatus prior to egress.
Main Tank or Guard Tank liquid level falls below alarm limit	Any time	Configure Dewar and Fill as appropriate