GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Internal Main Tank to Well Transfer

December 10,1998

Prepared by

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REVISION RECORD

REVISION	ECO	PAGES	DATE
A	732	Revision incorporates the Guard Tank locked-up mode and option to keep the Guard Tank pressurized with the Gas Module (G.2 and G8). Modification for condition with LHe in aGuard Tank (G.5 and G.6).	1/27/98
B	769	Revision incorporates the new Guard Tank vent path through EV-20 (by-pass mode) and elimination of the Guard Tank locked-up mode and elimination of option to keeping Guard Tank pressurized with Gas Module. (G.2.2, G.2.3, G.5.1.5, inserted new G.6.7, G.6.8, G. 8, figure 1).	3/6/98
C	806	Change procedure such that Guard Tank vent is manifolded to Main Tank vent for all cases. Simplifies procedure. (G.3.5, added G.3.6, G.5.2, deleted G.5.6, added Guard Tank And Axial-Lok level to Table, deleted G.6.5, Combined G.6.7 and G.6.8, removed G.6.9, and G.8. Note that paragraph numbers refer to those in revision B.	6/23/98
D	893	Modified operation of Vac-ion pump (G.1.4.1, delete G.4.1, G.5.3.e, G.5.4). Added recording of alarm set points G.7.7. Increase heater voltage (G.3.8).	12/10/98

Table of Contents

List of Abbreviations and Acronyms

ATC	Advanced Technology Center
Aux	Auxiliary
AV-x	Valve x of the Auxiliary gas section of the Gas Module
AG-x	Gauge x of the Auxiliary gas section of the Gas Module
Bot	Bottom
DAS	Data Acquisition System
EFM	Exhaust gas Flow Meter
EM	Electrical Module
EV-x	Exhaust gas valve of Gas Module number x
EG-x	Gauge x of Exhaust gas section of Gas Module
FIST	Full Integrated System Test
FCG	Fill Cap assembly pressure Gauge
GHe	Gaseous Helium
GM	Gas Module
GP-B	Gravity Probe-B
GSE	Ground Support Equipment
KF25	Quick connect o-ring vacuum flange (25 mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
Liq	Liquid
LMMS	Lockheed Martin Missiles and Space
LMSC	Lockheed Missiles and Space Company
PFM	Pump equipment Flow Meter
PM	Pump Module
psi	pounds per square inch
psig	pounds per square inch gauge
PV-X	Valve x of the Pump equipment
PG-x	Gauge x of Pump equipment
RAV-x	Remote Actuated Valve x
RGA	Residual Gas Analyzer
SMD	Science Mission Dewar
SU	Stanford University
SV-x	SMD Valve number x
TV-x	Valve x of Utility Turbo System
TG-x	Gauge x of Utility Turbo System
UTS	Utility Turbo System
Vac	Vacuum
VDC	Volts Direct Current
VF-x	Valve x of liquid helium Fill line
VM	Vacuum Module
VV-x	Valve x of Vacuum Module
VG-x	Gauge x of Vacuum Module
VW-x	Valve x of Dewar Adapter
STV	SMD Thruster vent Valve
FCV	Fill Cap Valve

A. SCOPE

This procedures describes the steps necessary to transfer normal boiling point liquid helium from the main tank into the well of the Science Mission Dewar.

B. GENERAL REQUIREMENTS

B.1. Electrostatic Discharge

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

B.2. Safety

B.2.1. General

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware (e.g. positioning of Dewar in tilt stand; integration of probe into airlock; integration of airlock/probe onto Dewar; removal of airlock from Dewar; removal of probe from Dewar); and during positioning of support equipment (e.g. pressurized gas cylinders; supply dewars).

Undesired events associated with these operations include: (1) Personnel or other objects are struck (e.g. by forklift or crane load) when hardware is being moved . (2) Personnel are subject to entrapment while positioning hardware when their hands or feet are caught between objects as hardware is moved into place. (3) Suspended hardware is dropped. (4) Personnel who are present during hardware movements (e.g. by forklift; crane) are caught between objects (e.g. forklifts and walls; loads and building support columns).

B.3. Lifting Operations

There are no lifting operations in this procedure

B.4. Injuries

In case of any injuries adhere to the following:

B.4.1. Obtain medical treatment:

LMMS **Call 117;** Stanford University **Call 9-911**

B.5. Safety Requirements

The SMD Safety Compliance Assessment, document GPB-100153C discusses the safety design, operating requirements and the hazard analysis of the SMD. The FIST Emergency Procedures, document SU/GP-B P0141 discusses emergency procedures. These documents should be reviewed for applicability at any facility where the hardware is operated.

B.6. **Test Personnel**

B.6.1. Personnel Qualifications:
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-offs located at the end of each procedure/task module. The person in charge of the operation (Test Director or Test Engineer) is to sign the “completed by” sign-off.

B.6.2. Qualification of Personnel:
The Test Director must have a detailed understanding of all procedures and facility operations and experience in all of the SMD operations and is the only personnel that has authority to approve redlines.
The 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.
The personnel who qualify for the above categories are:

Test Director:	Mike Taber
	Dave Murray
Test Engineer:	Tom Welsh
	David Frank

C. **CONFIGURATION REQUIREMENTS**

C.1. **General System Configuration Requirements and Test Conditions.**

C.1.1. Note that the following modifications or non-flight arrangement of the basic SMD configuration have been made:

1. The SMD is installed in its transportation and test fixture.
2. A relief valve is installed in place off the fill line burst disk.
3. Emergency vent line deflectors are installed over the four burst disk ports and an oxygen collection pan is installed on the floor below these.
4. A foreign object and debris shield covering the upper cone of the SMD is installed.
5. The ion pump magnet is installed.
6. The Airlock Support Plate may be installed on the SMD.
7. Dewar Adapter or Probe is mounted to the Well of the SMD.
8. The GSE cabling is connected between SMD and Electrical Module (P/N 5833812) and Data Acquisition System (P/N 5833811).
9. The Guard Tank vent is connected to the Gas Module (P/N 5833813) with a vacuum insulated line.
10. The Main Tank vent is connected to the Gas Module with a vacuum insulated line (P/N 5833806).
11. The Well is connected to the Gas Module via a pumping line attached to the Dewar Adapter interface flange at the Airlock Support Plate.
12. The Vacuum shell pump out port at SV-6 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve operator and pumping line.
13. The thruster vent port is flanged to a shut-off valve.

D. HARDWARE/SOFTWARE REQUIRED

D.1. Special Test Equipment

No special test equipment is required for this operation.

D.2. Tools

No tools are required for this operation.

D.3. Expendables

No expendables are required for this operation.

D.4. Commercial test equipment

No commercial test equipment is required for this operation.

D.5. Computers and software:

No special computers and software are required in addition to the Data Acquisition System.

E. EQUIPMENT PRETEST REQUIREMENTS

Verify Dewar Adapter heaters are operational.

The GSE instruments used to perform this procedure are listed in the following table together with their serial numbers were available. The instruments which are required to have current calibrations are so indicated in the Cal Required column. Instruments that do not require calibration are 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.

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	-

No.	Location	Description	User Name	Serial No.	Cal Required	Status Cal due date
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	-

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

Operation Number: _____.

Date Initiated: _____.

Time Initiated: _____.

G. **OPERATIONS**

G.1. **Initial Configuration of SMD**

G.1.1. Verify proper sealing of the Well. Record the closure (i.e. cover plate, holecutter, Probe etc...):

_____

G.1.2. Verify Dewar Adapter heaters are operational and record:

a) HP power supply: V: _____ Vdc, I: _____ a

b) Top Plate temperature: _____ ^{o}C

G.1.3. Record liquid helium levels:

a) Main Tank level (LL-1D or LL-2D): _____ %

b) Well level (LL-3LD or LL-4LD):_____%

c) Guard Tank Level (LL-5D or LL-6D): _____%

d) Axial Lock level (LL-7D or LL-8D): _____%

G.1.4. Record Pressures:

G.1.4.1. Record Vac-ion pressure:

a. Turn on Vac-ion pump and record time of day : _____

b. Use DAS “Monitor Data” for CN 99.

c. When value is at equilibrium record pressure (IP): _____ torr

d. Exit “Monitor Data” and collect data using “Set Data Interval” to 2.5 minutes.

e. When data cycle is complete, **turn off** Vac-ion pump.

G.1.4.2. Record Well pressure:

(PW-1):_____ oz / in^2

G.1.4.3. Record Vacuum Module Pressure (if connected):

(VG-1):_____ torr

G.1.5. Valve Configuration:

EVs open: EV-9, -13, -15, -19.

G.2. **Configuring Gas Module**

G.2.1. Open/verify open EV-9 ~~and EV-16~~.

~~G.2.2. Verify Is Guard Tank *is not in* in a bypass Mode .~~

~~G.2.2.1. θ Yes θ No~~

G.2.3. Perform **one** of the following:

~~θ **(Only if Guard Tank in bypass mode):**~~

~~G.2.3.1. Verify open EV-20.~~

~~G.2.3.2. Verify closed EV-13.~~

~~θ **(Only if Guard Tank is not in bypass mode):**~~

G.2.4. Record the Well pressure at Gas Module manifold EG-1a: _____torr.

G.2.5. *Close/*verify closed EV-20.

G.2.6. *Open/*verify open EV-13.

G.2.7. Verify open:

a) EV-19

Note: Well effluent is venting by pass mode via EV-19 and ERV-5.

b) open EV-11 to manifold Well venting with GT and MT.

G.2.8. Close/verify closed all other EV valves.

G.3. **Preparing to Transfer**

G.3.1. Verify Ev-16 closed and EV-15 open.

G.3.2. Record the tank pressure EG-3: _____torr.

G.3.3. Record the GT pressure (CN46) _____ torr diferential.

G.3.4. Record the tank pressure desired for performing transfer: _____ torr.

Note: a value 15 torr greater than EG-3 and at a minimum 770 torr.

G.3.5. Record the desired final Axial Lock level: _____ %.

~~G.3.6. Close/verify closed Main and Guard Tank vent valves EV-9, EV-13, and EV-20 and record time: _____ .~~

~~G.3.7. Open EV-17 to manifold Main and Guard Tank vent lines.~~

G.3.8. Turn on Main Tank Heater (H-8D or H-9D) power supply and adjust current limit to 1.25 amps.

~~G.3.9.~~ Set heater to 0.0 volts. ~~(0 VDC for Main Tank level > **50%** or 25 VDC for < **50%**) and record:~~

~~V: _____ vdc and I: _____ a~~

G.3.10. Valve configuration: Evs open: EV9, -11, -13, -15, -19

G.4. **Setting up Data Acquisition**

G.4.1. Initiate Special Data with cycle time of 0.5 minutes.

G.4.2. Set Axial Lock sampling interval to 1 minute.

G.4.3. Set the Main Tank sampling interval to 1 minute.

G.4.4. **If** Well level is below 100%, set well sampling interval to 1 minute.

G.4.5. Input comment to DAS "Start Internal X-fer to Well".

G.5. **Initiating the Transfer**

G.5.1. Close EV-9 and record time _____.

G.5.2. ~~When EG-3 reaches the desired initial pressure of Para G.3.3,~~ Opening RAV-7:

G.5.2.1. **Verify all** RAV selection switches are in the OFF position.

G.5.2.2. Turn on RAV power supply and adjust current limit to 1.8 amps.

G.5.2.3. Adjust power supply to 28 VDC.

G.5.2.4. Power up RAV controller No. 4.

G.5.2.5. Position selection switch #4 to RAV-7.

G.5.2.6. Record initial switch status: Open: θ θ Closed: θ θ

G.5.2.7. Activate controller No. 4 and record:

a) run time: _____ seconds

b) current draw: _____ amp

c) time of day: _____

d) Record final switch status: Open: θ θ Closed: θ θ

G.5.2.8. Record operation in RAV log book.

CAUTION:

Prepare to open EV-9 if T28>6.3

~~G.5.3. Perform **one** of the following to vent the Well:~~

~~θ **(Only if NOT performing Well operations and Well is connected to Gas Module):**~~

G.5.4. Venting Well to atmosphere:

G.5.4.1. Verify closed EV-9 and EV-20.

G.5.4.2. Open EV-6.

G.5.4.3. Once the flowrate at EFM-1 has stabilized, open EV-18.

G.5.4.4. Valve configuration:

EVs open: EV-11, -13, -15, EV-6, -18, -19.

G.5.5. Record pressures:

a) Time of Day: _____

b) EG-3: Main _____ torr

c) EG-1a: Well _____ torr

d) GTVVA: Guard(CN46) _____ torr

G.5.6. Adjust Tank heater voltage to maintain desired transfer pressure of Para. G.3.3 and record in the following table.

NOTE: Do not exceed 35 volts.

Time	Heater Voltage (V)	Pressure EG-3 (Torr)	Pressure EG-1a (Torr)	Main Tank LLS (%)	Well LLS (%)	Axial-Lok LLS (%)	Flowrate-B PFM-1 (Ll/hr)	Guard Tank Temp [24] (K)

G.6. **Stopping the flow of liquid helium**

G.6.1. When the Axial Lock level reaches the value chosen in Para G.3.4 close RAV-7:

G.6.1.1. Record initial switch status: Open: θ θ Closed: θ θ

G.6.1.2. Activate controller No. 4 and record:

a) run time: _____ seconds

b) current draw: _____ amp

c) time of day: _____

G.6.1.3. Record final switch status: Open: θ θ Closed: θ θ

G.6.1.4. Turn RAV selection switch to OFF.

G.6.1.5. Power off controller No. 4.

G.6.1.6. Turn off RAV power supply.

G.6.1.7. Record operation in RAV log book.

G.6.2. Turn off power to the Main Tank heater.

G.6.3. Close relief bypass valves EV-6 and EV-18 if open.

G.6.4. Perform **one** of the following for the Well Vent:

~~θ **(Only if NOT performing Well operations and Well is connected to Gas Module):**~~

G.6.5. Verify open EV-19

G.6.6. Close EV-11.

~~θ **(Only if performing Well operations and Well is connected to Gas Module):**~~

~~G.6.6.1. Record Well vent path if EV-19 is closed for the Well operations: _____.~~

~~θ **(Only if Well Cover Plate is installed for Probe insertion and Well is NOT connected to Gas Module):**~~

~~G.6.6.2. Close VWC.~~

G.6.7. Record pressures:

a) Main Tank pressure (EG-3): _____ torr

b) Guard Tank Pressure (CN46): _____ torr *differential*

b) Well Pressure (EG-1a): _____ torr

G.6.8. Establish venting of the Main and Guard Tanks:

G.6.8.1. Close EV-17.

G.6.8.2. Open Main Tank vent valve EV-9.

G.6.8.3. Open EV-18.

~~G.6.8.4. Perform **one** of the following for the Guard Tank Vent:~~

~~θ (Only if Guard Tank **is not to be** in a bypass Mode):~~

~~a. Open EV-13.~~

~~b. Close/Verify closed EV-20.~~

~~θ (Only if Guard Tank vent **is to be** in a bypass Mode):~~

~~c. Open EV-20.~~

~~d. Close/verify closed EV-13.~~

G.6.8.5. Wait 1 minute and close EV-18.

G.6.9. Once flowrate EFM-1 has stabilized, record EFM-1: _____.

G.6.10. Once conditions have stabilized, record final transfer conditions:

a) Main Tank level (LL-1D or LL-2D): _____ %

b) Well level (LL-3LD or LL-4LD): _____ %

c) Guard Tank Level (LL-5D or LL-6D): _____ %

d) Axial Lock level (LL-7D or LL-8D): _____ %

G.6.11. Record Well pressures:

~~a) Well (PW-1): _____ oz / in^2~~

b) Main Tank (EG-3): _____ torr

c) Guard Tank (GTVVG; CN46): ____torr diff.

a) Well (EG-1a): _____ torr

G.7. **Configuring the DAS and liquid level sensor sampling interval**

G.7.1. Input comment to DAS “End of Internal X-fer to Well”.

G.7.2. Set the DAS data cycle to 15 minutes.

G.7.3. Terminate Special Data collection.

G.7.4. Set all the liquid level sampling intervals to 10 minutes.

G.7.5. **Confirm** that the liquid level sensors are set at a sampling rate of 10 minutes.

G.7.6. **Confirm** that power to Vac-Ion pump is off.

G.7.7. Enable/verify enabled the alarms on the Main Tank and Well Liquid Level Sensors.

G.7.8. Verify enabled the DAS alarm and record set points:

a) CN ____, Level _____ d) Main Tank Level: _____ %

b) CN ____, Level _____ e) Well Level: _____ %

c) CN ____, Level _____

G.7.9. Enable/verify enabled the Main Alarm System.

G.8. **Verify Final Configurations**

G.8.1. Verify open: EV-9 and EV-1*5*.

~~G.8.2. Perform **one** of the following for the Guard Tank vent:~~

~~θ **(Only if Guard Tank is not in a bypass Mode):**~~

G.8.3. Verify open EV-13 and EV-20 closed.

~~θ **(Only if Guard Tank vent is in a bypass Mode):**~~

~~G.8.3.1. Verify open EV-20.~~

~~G.8.4. Perform **one** of the following for the Well vent:~~

~~θ **(Only if not performing Well operations):**~~

~~G.8.4.1. Verify open EV-19 and EV-11.~~

~~θ **(Only if Well Cover is installed and NOT connected to Gas Module):**~~

~~G.8.4.2. Verify closed VWC.~~

~~G.8.5. Verify all other EV valves closed.~~

G.8.6. Verify EV-19 open.

G.8.7. Valve configuration:

EVs open: EV-9, -13, -19, -15.

G.8.8. Record Main Tank liquid usage:

a) Start level: _____ %, Finish level : _____ %.

b) Amount transferred: _____ liters (use 1 % = 24 l)

Witnessed by : _____.

Completed by : _____.

Date: _____.

Time: _____.

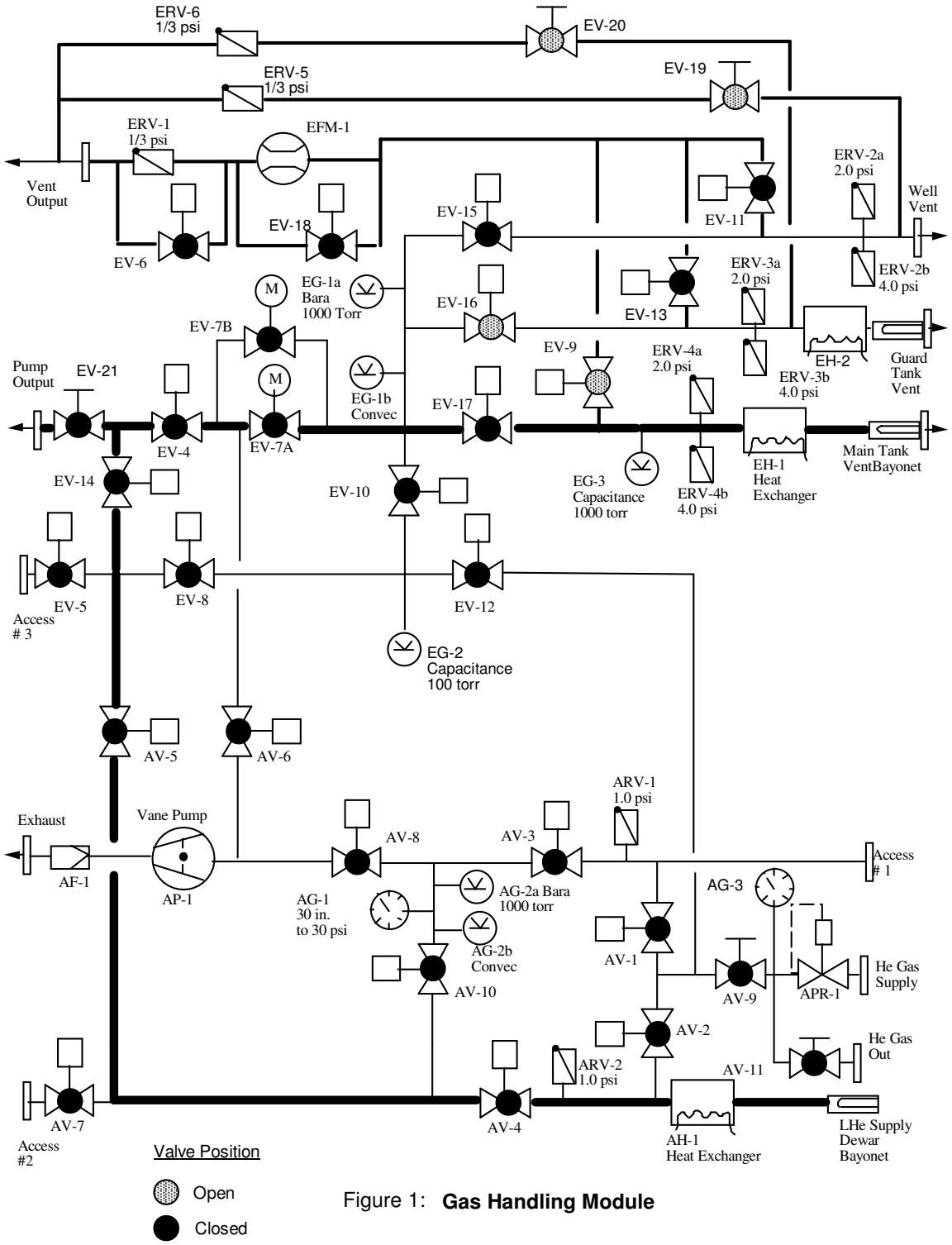

Figure 1: **Gas Handling Module**