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Gravity Probe B Relativity Mission

Science Mission Dewar Ground Support Equipment Inspection Report

S0822, Rev. A

April 21, 2003

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ITAR Assessment Performed

Tom Langenstein — 4-23-03

ITAR Control Req'd? ☐ Yes ☒ No

Purpose:

This document verifies many of the requirements in PLSE-12 #3.8 *SMD GROUND SERVICING EQUIPMENT* by SU QA inspection by Russ Leese and by providing successful "as-run" procedures to verify functionality of the Ground Support Equipment (GSE). The GSE has been used to service the Science Mission Dewar since its operation at Stanford University. The timing of this inspection effort is set to ensure functionality and compliance with the launch site at VAFB.

Introduction:

The Science Mission Dewar (SMD) contains gaseous or liquid Helium cryogen at temperatures near zero degrees Kelvin. The GSE provides the capability to refill and vent the SMD of its Helium. In addition the GSE provides instrumentation that monitors the health of the SMD and to activate valves. Finally, the GSE must comply with the payload safety requirements that mirror the range safety requirements at VAFB. Table 1 contains a list of Dewar Servicing GSE and the locations they will be used at the launch site.

TABLE 1 – Science Mission Dewar GSE used at VAFB

Dewar Servicing Equipment	Locations Used (Number of each)				Envelope (in) (L x W x H)	Approx. Weight (lb)	Power	Gases Required
	1610	MST	EEB	836				
Large toolbox	1	1			44 x 29 x 50	300 (est.)	N/A	N/A
Small toolbox	1				27 x 18 x 41	Varies	N/A	N/A
Large storage box	1				79 x 47 x 97	Varies	N/A	N/A
Pumping line storage box	1				102 x 43 x 33	Varies	N/A	N/A
Helium cylinder (T or K) on cart		1			10 dia. x 59	146	N/A	N/A
6-pack Helium cylinders	2				29 x 20 x 74	1200	N/A	N/A
Liquid nitrogen cylinders	2	1			20 dia x 58	210/490	N/A	N/A
500-liter supply dewars	3	2			42 dia. x 75	562/710	N/A	LHe
1000-liter supply dewars	2				54 dia. x 77	900/1195	N/A	LHe
Vacuum Module	1	1			32 x 50 x 36	684	CGSE-PDU	80 psig air
Gas Module	1	1			32 x 48 x 60	1178	CGSE-PDU	80 psig air
Electrical Module	1	1			36 x 50 x 72	1000	CGSE-PDU	N/A
Data Acquisition System	1		1		35 x 24 x 80	400	CGSE-PDU (2x 110V 20 A) (EEB = R14)	N/A
Leak Detector	1	1			34 x 22 x 46	354	CGSE-PDU	LN_2
Temperature Monitor & Alarm	1				20 x 24 x 10	50	120 V 10 A or battery (1610 = R9)	N/A

Dewar Servicing Equipment	Locations Used (Number of each)				Envelope (in) (L x W x H)	Approx. Weight (lb)	Power	Gases Required
	1610	MST	EEB	836				
Pump Module	1				32 x 48 x 60	1000	120/208 V 3Ø Y 60 A[3] CGSE-PDU (1610 = R10)	80 psig air
Backup Pump Module	1[8]				32 x 48 x 60	1000	120/208V 3Ø Y 60A[8] (1610 = R10)	80 psig air
Utility Turbopump System	1	1			40 x 25 x 71	483	CGSE-PDU	80 psig air
Power Distribution Unit (CGSE-PDU)	1	1			25 x 25 x 66	383	120/208 V 3Ø Y 60 A[4] (1610 = R11, MST = R18)	N/A
Heater Control Unit	1		1		36 x 24 x 44	446	CGSE-PDU	N/A
Chiller Unit[5]	1				33 x 27 x 35	460	208 V3Ø Δ 20 A[6] (1610 = R12)	N/A

Acronyms and Abbreviations

ECU – Experiment Control Unit
GP-B – Gravity Probe B
GSE – Ground Support Equipment
EGSE – Electrical Ground Support Equipment
LM – Lockheed Martin (by various current and old names)
STP – Standard Temperature and Pressure
SMD – Science Mission Dewar
RAV – Remotely Activated Valve
PDU – Power Distribution Unit
TM&A – Temperature Monitor & Alarm

Verification Requirements Compliance Matrix

PLSE-12 Requirements

Para	Title	Requirement	Method	Compliance Data	Compliant
3.8.	SMD GROUND SERVICING EQUIPMENT	Section Header	N/A	.	**N/A**
3.8.1	Facilities Compatibility	The applicable SMD GSE shall be compatible with the facility requirements at the following facilities: Western Range B1610 and SLC-2W Launch Tower, Lockheed buildings B205 high bay, B181 vibration facility, B156 (Spin Balance, T-V), B159 (Acoustic Chamber), and Stanford HEPL FIST Area.	D	The SMD GSE is compatible with the Western Range B1610 and SLC 2W as verified by the LSSP Rev. B and the VAFB approved GSE floor plan. The SMD GSE demonstrated compatibility with B205 high bay, B156 (Spin Balance, T-V), B159 (Acoustic Chamber), and Stanford HEPL FIST Area by completing the series of test and integration activities at relevant to each facility as verified by SU QA Insp. #28 Russ Leese. The SMD GSE compatibility cannot be demonstrated with B181, because the SMD will not be tested or serviced in B181.	√ SU GP-B INSP 28 4/23/03

Para	Title	Requirement	Method	Compliance Data	Compliant
3.8.1.1	Explosion Proofing	Electrical GSE shall be consistent with 3.3.6.7.2.4.	I	The SMD EGSE is labeled and built with manual kill switches and therefore complies with PLSE-12 #3.3.6.7.2.4. The SMD EGSE is not intended for use in hazardous locations. If located in a hazardous area, it will be powered down, using manual kill switches, during hazardous operations (i.e., potential or actual presence of fuel) per approved procedures. This approach has been approved by VAFB Range Safety, and complies with PLSE-12 #3.3.6.7.2.4. LM Safety Engineer Harv Moskowitz verifies compliance, which is documented in S0601.	√ AQM 4/24/2003
3.8.1.2	Electrical Interface	GSE electrical equipment shall be compatible with a 208 V, 3 phase, or with a 120 VAC, single phase, voltage source. Current requirements shall be coordinated with facilities, as required.	I	The SMD GSE is compatible with 208 V, 3-phase, or 120 VAC, single-phase voltage source as verified by SU QA Insp. #28 Russ Leese.	√ SU GP-B INSP 28 4/23/03
3.8.3.1	Vacuum Space Evacuation	The GSE shall include a Vacuum Module, with a rated turbo pump speed >= 400 l/s, capable of achieving a blank-off pressure <= 10-6 torr, for the function of evacuating the SMD vacuum space.	I, T	SU QA Insp. #28 Russ Leese verifies the SMD GSE Vacuum Module turbo pump speed is rated at 530 l/s He and is capable of achieving a blank-off pressure < 5E-9 mbar (3.75E-08 torr). P0786A "Certify Vacuum Module After Transport" requires the blank-off pressure as measured by VG-1 to <5.0E-6, and was verified at 4.99E-6 on 2/14/02.	√ SU GP-B INSP 28 4/23/03
3.8.3.2	Well Evacuation	The GSE shall be capable of evacuating the Dewar well.	I, T	SU QA Insp. #28 Russ Leese verifies that the GSE is capable of evacuating the Dewar well. P0613C test procedure evacuates the Dewar Well, successfully ran on 12/20/02 evacuated to 3.0E-4 torr as measured by PW-2.	√ SU GP-B INSP 28 4/23/03
3.8.3.3	Guard Tank Evacuation	The GSE shall be capable of evacuating the guard tank to a pressure of 10 millitorr.	I, T	SU QA Insp. #28 Russ Leese verifies that the GSE is capable of evacuating the Guard Tank. P0916 test procedure ran on 10/05/02 evacuated the Guard Tank to 8E-2 milli-torr.	√ SU GP-B INSP 28 4/23/03
3.8.4	Gaseous Helium Purge	The GSE shall be capable of purging the lines and vessels with gaseous helium prior to transfer and backfill operations.	I, T	SU QA Insp. #28 Russ Leese verifies that the GSE is capable of purging the lines and with gaseous helium prior to transfer and backfill operations. P0881A test procedure purges the lines and vessels in section G.5, successfully ran on 02/28/02.	√ SU GP-B INSP 28 4/23/03
3.8.5.1	Venting of Helium Gas	The GSE shall be capable of venting 60,000 l/hr STP, with backpressure < 50 torr.	I, T	SU QA Insp. #28 Russ Leese verifies that the GSE is capable of venting Helium Gas. The SMD boil off rate is measured by the GSE in liquid liters/hr and not gaseous STP l/hr. A reading in excess of 100 liquid liters/hr corresponds to an external flow rate of 60,500 standard liters/hour. P0595B ran on 03/08/03 verifies that the venting rate is capable of 107.6 l/hr liquid He, with a backpressure of 13 torr-a (773 torr-g).	√ SU GP-B INSP 28 4/23/03

Para	Title	Requirement	Method	Compliance Data	Compliant
3.8.5.2	Warming of Exhaust Gas	The GSE shall be capable of warming 60,000 l/hr STP of vent gas from its initial temperature (approximately 5 to 45 K) to 283 K prior to its reaching the facility vent lines.	I, T	SU QA Insp. #28 Russ Leese verifies that the GSE is capable of warming exhaust gas. The SMD boil off rate is measured by the GSE in liquid liters/hr and not gaseous STP l/hr. A reading in excess of 100 liquid liters/hr corresponds to an external flow rate of 60,500 standard liters/hour. Gas.P0595B ran on 03/08/03 verifies that the venting rate is capable of 107.6 l/hr liquid HeP0648E ran on 01/06/03 verifies that the venting rate the vented Helium was warmed to 283/282 K near 80.3 l/hr liquid He flow rate.	√ SU GP-B INSP 28 4/23/03
3.8.6	Leak Detection	The GSE shall be capable of providing leak detection to a level of <= 10-10 scc/s He.	I, T	SU QA Insp. #28 Russ Leese verifies that the GSE is capable of providing leak detection <= 10-10 sccs He. P0786A "Certify Vacuum Module After Transport" ran on 2/14/02 verifies that the GSE Leak Detector was successfully calibrated to 5.9E-8 sccs and measured the expected background leak rate of > 1.0E-7 sccs.	√ SU GP-B INSP 28 4/23/03
3.8.7.1	Remotely Actuated Valves Electronics	The GSE shall provide power supplies and electronics for all Remotely Actuated Valves (ground and flight).	I, T	SU QA Insp. #28 Russ Leese verifies that the SMD EGSE is capable of providing power and electronics for all the RAVs through the four controller units built in to a patch panel that allows for RAV multiple power configurations. PLSE-12 #3.7.5.9.4 "Remotely Actuated Valves" verified the functionality of the valves in the Dewar AR, GPB-100155A, 26 Feb 97. P0648E ran on 01/06/03 verifies that the patch panel, while configured and to open/close RAV 1 & 2, provided power and control electronics.	√ SU GP-B INSP 28 4/23/03
3.8.7.2	Dewar Instrumentation	The GSE shall provide power supplies and signal conditioning for all SMD instrumentation (ground and flight).	I, T	SU QA Insp. #28 Russ Leese verifies that the SMD EGSE - primarily the PDU - provides power for all SMD instrumentation. P0773 "Certification of Electric Module, Gas Module and Data Acquisition System" verifies the GSE provides signal conditioning for all SMD ground instrumentation. P0774 "SMD "Functional Test (Abbreviated)" verifies the GSE provides signal conditioning for all SMD Flight instrumentation.	√ SU GP-B INSP 28 4/23/03
3.8.7.3	Pressure Sensor Readouts	The GSE shall provide power supplies and electronics for all Dewar and GSE pressure sensor readouts.	I, T	SU QA Insp. #28 Russ Leese verifies that the SMD EGSE - primarily the PDU - provides power for all SMD pressure sensor readouts. P0774 "SMD "Functional Test (Abbreviated)" verifies the GSE provides signal conditioning for all SMD Flight instrumentation. Engineering test by Dave Murray provides the pressure sensor readouts by the GSE electronics.	√ SU GP-B INSP 28 4/23/03
3.8.8	Data Acquisition and Processing	The GSE shall provide the capability to condition, collect, reduce, and store all SMD (except accelerometers) and GSE generated data, and display desired data.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE is capable of conditioning, collecting, reducing, and storing all SMD and GSE generated data, and displaying the desired data.	√ SU GP-B INSP 28 4/23/03

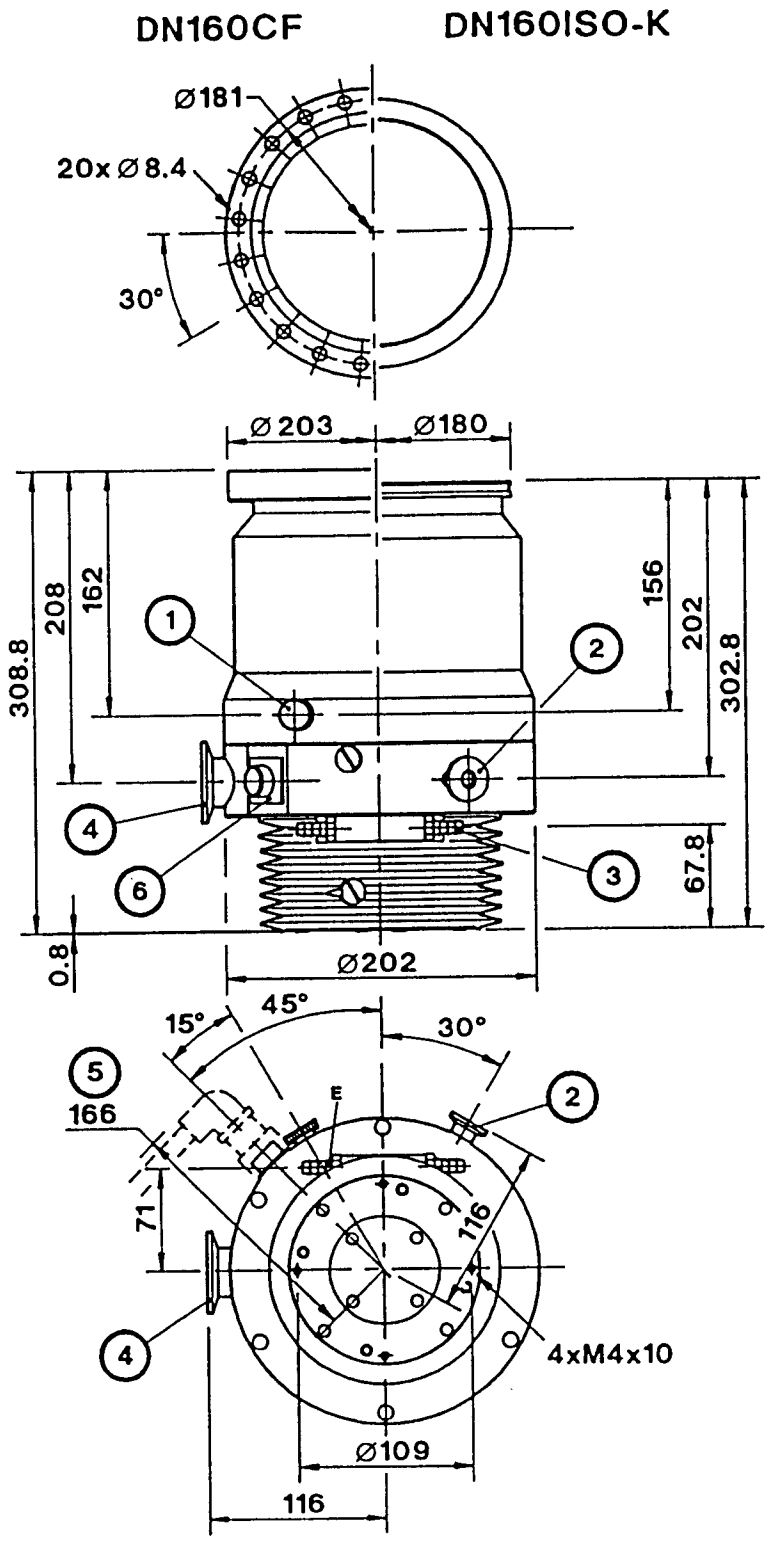
Para	Title	Requirement	Method	Compliance Data	Compliant
3.8.10.1	Modularity	The GSE shall be of modular construction for ease of handling, servicing, transporting, and floor configuration flexibility.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE is modular in construction, noting that the SMD GSE was successfully transported to multiple LM testing facilities from SU FIST Ops.	√ GP-B SP 28 4/23/03
3.8.10.2	Dimensions	The dimensions of the modules shall be compatible with the space allocated on the launch tower.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE modules are compatible with the space allocated on the launch tower. February 2003 PMR documents that the floor layout for the MST is capable of supporting the SMD GSE. Changes in the floor layout will be document in the LSSP.	√ SU GP-B INSP 28 4/23/03
3.8.10.3	Weight	The weight of the modules shall be within the floor loading capability of the launch tower.	T	SU QU Insp. #28 measure the weight of all the Dewar GSE using B/159 scale 6/15/02. The results are documented in the LSSP and in Table 1 of this Science Document, S0822. Modules outside of the floor loading capability (75 lbs/ft^2) will be place on pallets by VAFB to distribute load within the capability.	√ SU GP-B INSP 28 4/23/03
3.8.10.4	Lifting and Handling Structures Factors of Safety	Lifting and handling structures shall be proof tested to 2 times the maximum expected operating load, and designed with an ultimate safety factor of 5.	T	Lower level verification for the SMD GSE: Dewar VRCD (Dewar AR, GPB-100155A, 26 Feb 97) All SMD GSE is mounted on wheels or casters and does require handling structures for movement. All SMD GSE at VAFB will be lifted by a "cookie sheet" type lifting device for getting the Cryo GSE on the MST in accordance with the LSSP requirement GPB-64 PAD Handling.	√ SU GP-B INSP 28 4/23/03
3.8.10.5	Pressure System Structures Factors of Safety	GSE pressure systems structures shall be proof tested to 1.5 times the maximum expected operating pressure, and designed with an ultimate safety factor of 4.	T	The SMD pressure systems operate at subatmospheric or near atmospheric pressures. The UTS uses an Air-Pac T-20ST Thomas Compressor at 80 psig, which is rated for 125 psig and has a relief valve set for 140 psig. The design is compliant with industry standards for pressure vessels. The Helium supply tanks are DOT certified. All proof testing is by vendor testing.	√ GP-B 28 4/23/03
3.8.11	Cleanliness Requirements	The GSE interior lines shall be cleaned to Zone VI of Section 3.3.1.2.6.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE is compliant to P0059 "Probe Contamination Control Plan," which specifies the Zone VI requirements. In addition SU Dewar operation procedures call out visual inspections and cleaning procedures in compliance to the contamination control plan.	√ SU GP-B INSP 28 4/23/03
3.8.12	Grounding Requirements	All external surfaces of GSE shall be at common ground potential at all times.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE external surfaces are at a common ground potential at all times.	√ SU GP-B INSP 28 4/23/03
3.8.13.1	Electrical Switches	External switches shall have protective covers as required by 3.3.6.7.2.2.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE has either protective covers or other manual safety locks for all critical switches.	√ SU GP-B INSP 28 4/23/03

Para	Title	Requirement	Method	Compliance Data	Compliant
3.8.13.2	Alarms for Purge Pressure	If a purge system is utilized on any GSE, an alarm audible to 200 ft shall be provided when the purge gas pressure drops below its minimum allowable pressure. A visual alarm shall be visible to 50 ft when viewing within 60 deg of normal to the front panel.	D	This requirement states that "if" a purge system is utilized, and inspection by SU QA Insp. #28 Russ Leese verified that the purge system is not utilized in the current baseline configuration. The alarm is installed, but not connected to the sensor systems.	√ SU GP-B INSP 28 4/23/03
3.8.13.3	Anchors	The modules shall be anchored to be seismically safe while on the launch tower.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE has latches and straps to anchor the GSE while on the launch tower.	√ SU GP-B INSP 28 4/23/03
3.8.13.4.1	Plumbing Connectors	GSE Plumbing Connectors shall be clearly labeled with regard to mating with Dewar plumbing.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE plumbing connectors are clearly labeled with regard to mating with the Dewar plumbing.	√ SU GP-B INSP 28 4/23/03
3.8.13.4.2	Electrical Connectors	GSE Electrical Connectors shall be clearly labeled and color-coded.	I	SU QA Insp. #28 Russ Leese verifies that the SMD GSE electrical connectors are clearly labeled, and were color coded prior to the flight cables installation.	√ SU GP-B INSP 28 4/23/03

Conclusion: GSE Supports the SMD Servicing Requirements

The GSE used for servicing and maintenance of the science mission Dewar is verified by inspection, test, and demonstration to comply with the PLSE-12 requirements and is compatible with the launch site facilities.

APPENDIX TABLE OF CONTENTS



1. Vent-valve
2. Purge-port
3. Cooling-water connectors
4. Backing-port
5. Allowance for right-angle cable connector
6. Electrical supply connector

Figure 5 - EXT501 Turbomolecular Pump dimensions

Parameter	Pump Units	EXT501/ ISO160	EXT501/ 160CF	EXT501E/ ISO160	EXT501C/ ISO160
Mass	kg	18	19.5	15.5	15.5
Inlet-flange		DN160ISO-K	DN160CF	DN160ISO-K	DN160ISO-K
Outlet-flange		DN40NW	DN40NW	DN40NW	DN40NW
Vent-port		1/8 inch BSP	1/8 inch BSP	1/8 inch BSP	1/8 inch BSP
Purge-flange		DN10NW	DN10NW	DN10NW	DN10NW
Pumping speed N_2	$l.s^{-1}$	500	500	450	450
He	$l.s^{-1}$	530	530	360	360
H_2	$l.s^{-1}$	490	490	200	200
Compression ratio N_2		$> 1 \times 10^9$	$> 1 \times 10^9$	5×10^6	5×10^6
He		2×10^4	2×10^4	600	600
H_2		1000	1000	80	80
Ultimate pressure *	mbar	$< 5 \times 10^{-9}$	$< 5 \times 10^{-9}$	$< 5 \times 10^{-8}$	$< 5 \times 10^{-8}$
Minimum backing pump displacement	m^3h^{-1}	10	10	15	25
Recommended backing pump †		E2M12	E2M12	E2M18	E2M28
Maximum continuous inlet pressure (water-cooling at 15 °C) ‡	mbar	1.4×10^{-2}	1.4×10^{-2}	6×10^{-1}	6×10^{-1}
Maximum continuous inlet pressure (air-cooling at 35 °C) ‡	mbar	2×10^{-3}	2×10^{-3}	8×10^{-2}	8×10^{-2}
Operating attitude		Vertical (upright or inverted)	Vertical (upright or inverted)	Any	Any
Nominal rotational speed	$r.min^{-1}$	36000	36000	36000	36000
Standby rotational speed	$r.min^{-1}$	25200	25200	25200	25200
Starting time to 90% speed					
EXC120/120E	sec	405	405	255	255
EXC300	sec	200	200	130	130
Cooling method		Water/forced-air	Water/forced-air	Water/forced-air	Water/forced-air
Ambient air temperature (forced-air cooling)	°C	0 - 35	0 - 35	0 - 35	0 - 35
Minimum cooling-water flow rate (at 15 °C)	$l.h^{-1}$	30	30	30	30
Water temperature	°C	10 - 20	10 - 20	10 - 20	10 - 20
Maximum water pressure	psi	72.5	72.5	72.5	72.5
(gauge)	mbar	5	5	5	5
Noise level (at 1 metre)	dBA	< 50	< 50	< 50	< 50
Recommended controller		EXC300	EXC300	EXC300	EXC300
EXC300 maximum VA input (including heater band)	VA	480	480	480	480
EXC300 normal power	VA	60	60	60	60
Other compatible controller		EXC120/E	EXC120/E	EXC120/E	EXC120/E
EXC120/E maximum VA input (including heater band)	VA	250	250	250	250
EXC120/E normal power	VA	60	60	60	60
Quiescent power consumption	W	25	25	25	25

* Ultimate pressure 48 hours after bakeout with 2-stage rotary vane backing-pump

‡ Maximum inlet pressure is achieved with the EXC300 Controller. Above this pressure, rotational speed drops below nominal

† A larger backing-pump may be required for maximum throughput. The recommended backing pump for the EXT501C assumes a continuous purge gas flow of 25 sccm..

Table 2 - Technical data (continued)

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Gravity Probe B Relativity Mission

PROBE C CONTAMINATION CONTROL PLAN

P0059 Rev. / C

June 19, 1994

George M. Keiser 5-5-98
Prepared by: George "Mac" Keiser — Date
Chief Scientist

Robert Schultz 5-6-98
Approved by: Bob Schultz
Systems Engineer

B. Taller 5/19/95
Approved by: B. Taller — Date
Quality Assurance

John P. Turneaure 5/21/98
Approved by: J. Turneaure — Date
Hardware Manager

P0059, Rev.# C
June 19, 1994

Probe C Contamination Control Plan

The gyroscopes which will be flown in the Science Mission experiment are particularly sensitive to contamination. Nonmetallic particles may interact with the electric fields used to support the gyroscope and cause frictional drag on the gyroscope. Metallic particles may exchange charge at the electrode and rotor surfaces, bouncing back and fourth, and exchange angular momentum between the rotor and the housing. At a larger size scale, particles may prevent free rotation, and it has long been suspected that particles may play a role in the infrequent arcing that occurs between the electrodes and the rotor. The GP-B gyroscopes are also particularly vulnerable to contamination from regions outside the housing. Not only is it impossible to completely seal the gyroscope because of the gas spin-up system, but vibration during launch and the weightless environment allow the potential for the generation and redistribution of particles.

Another important aspect of Gravity Probe B is the light which reaches the telescope. Contamination either from particles or condensable nonvolatile residues or particles reduce that amount of light which reaches the telescope. In addition, particles may scatter stray light which would increase the background light level and decrease the sensitivity of the telescope pointing system. The most crucial parts of the telescope are the roof prisms which are used to divide the light from the reference star and determine the center of the star image. A 25 micron diameter particle could render the roof prism useless, while other contamination could change the apparent direction of the star. Although a small but constant bias in the apparent direction would not affect the outcome of the experiment, a bias which varied at the roll frequency could seriously affect the outcome of the experiment.

Another important consideration in the cleanliness of the probe is the possibility of magnetic particles on the interior or exterior of the probe. When the probe is inserted into the liquid helium dewar which contains the lead bag,

DEFINITIONS

Level: Level refers to the cleanliness level of a surface as specified in MIL-STD-1246. This document specifies the maximum number of particles of a given size per square foot of surface area which can remain on a surface after cleaning. In this contamination control plan, the cleanliness level of the surface is typically specified as better than level 100. For this level the maximum allowable number of particles per square foot greater than a given size is

Size	Number
100 microns	1
50	11
25	78
15	265

Class: Class refers to the number of particles greater than a given size per cubic foot in a clean room as specified by FED-STD-209. In a class 100 clean room the maximum number of particles per cubic foot greater than a given size is

Size	Number
0.5 microns	100
0.3	300
0.2	750

There is not necessarily any relationship between level 100 and class 100.

Verification: Verification refers to the process utilized to determine if a hardware surface or a cleanroom environment meets the required specification. The procedures for measuring the cleanliness of surfaces are given in MIL-STD-1246 and follow ASTM guidelines. Methods of verifying room air cleanliness are given in FED-STD-209.

Verification of a surface cleanliness level involves counting the number of particles greater than a given size range to determine whether the surface meets the required cleanliness level. However, in many instances it would be valuable to know not only whether the surface or clean room meets the required specification, but also to know by how much the surface exceeds the required specification. In these instances, it would be valuable to count the particles to the smallest size range technically possible. In these cases, verification of the cleanliness levels should be made to the highest level technically possible.

Particulate Fallout: Particulate fallout in a clean room will cause surface cleanliness levels to degrade with time. The particulate fallout rate depends on many factors including the activity in the room, location of the part in the room, and how parts are handled within the clean room. However, a rough guide to the particulate fallout rate is given in Figure 1. Note that in a class 100 environment, a level 100 surface will degrade to a level 150 in approximately 10 days. In a class 10 environment, a level 100 surface will degrade to a level 150 in approximately 100 days. In Figure 1, it is assumed that the reference environment is maintained regardless of the level of activity. A more accurate measure of the particulate fallout rate may be made by placing witness samples close to a part in a clean room.

ESTIMATED PARTICULATE FALLOUT VS TIME FOR FED-STD-209 B CLASS ENVIRONMENTS

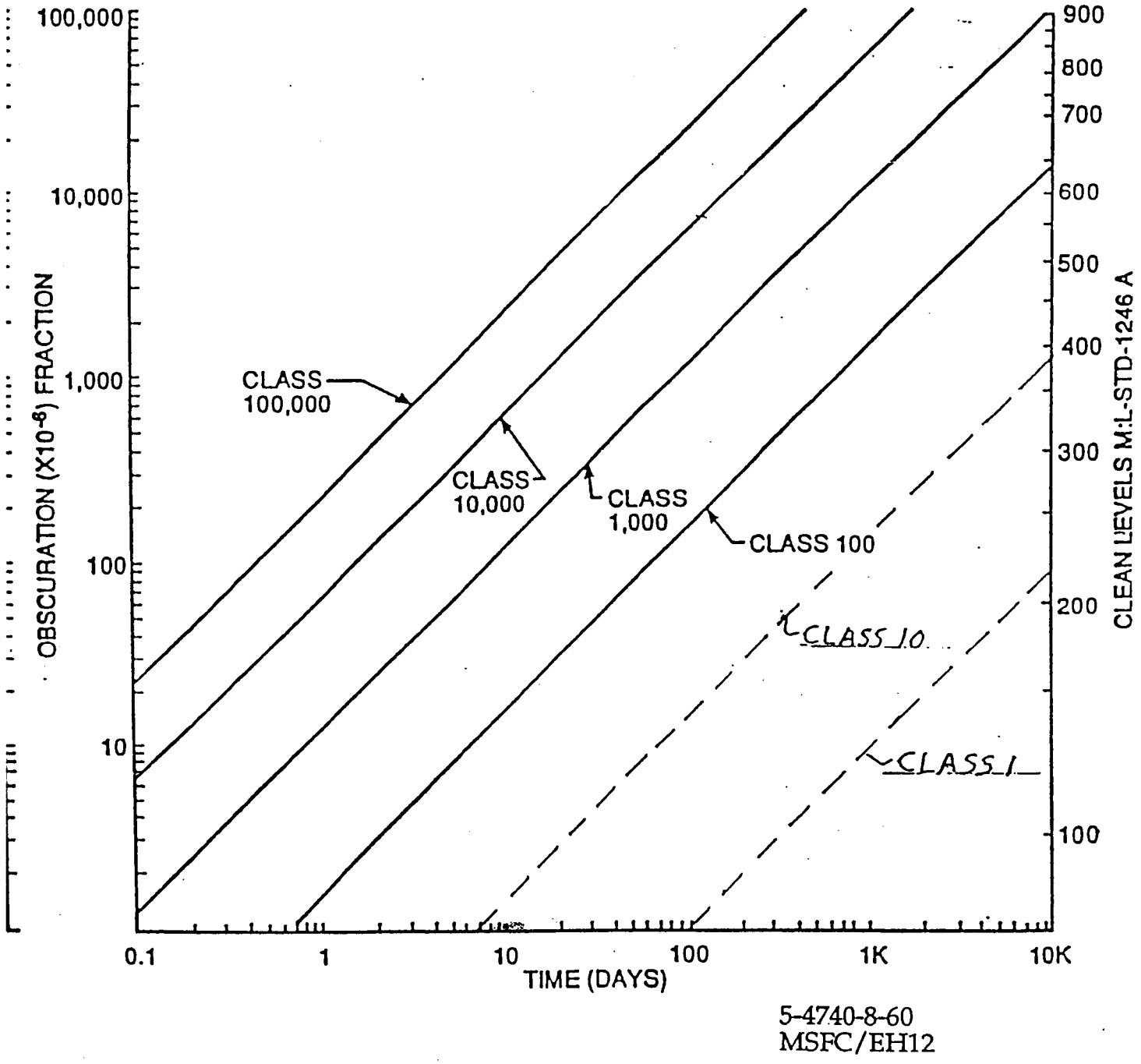


Figure 1 - This chart gives the particulate fallout rate vs. time for various class clean rooms. The dashe lines for class 10 and class 1 are estimated rates extrapolated from the other curves (J. Sakols, LMSC). Since the particulate fallout rate depends on many factors, including the activity in the room and the loaction in the room, these curves should be taken as estimates.

Zone: I - Interior of Gyroscope

Reason for Cleanliness Requirement: Frictional Drag, Precession Torques, Electrical Breakdown

Required Cleanliness Levels: Consideration of the torques acting on the gyroscopes due to dielectric and metallic particles has led to the following goals for the cleanliness levels within the gyroscope housing:

Size Range	Maximum Number
>3 micron	0
1-3 micron	0
0.3-1micron	1
0.1-0.3 micron	10
0.03-0.1 micron	100

Although it will be very difficult to verify these cleanliness levels by direct inspection, these goals should be used to determine procedures for cleaning and handling the gyroscope, cleanliness requirements for other areas of the probe, and procedures for handling the probe once the gyroscopes have been installed.

Verification: Verification of the cleanliness levels within the gyroscope will be done by measuring the spin-down rate of the gyroscope. The gyroscope spin-down rate is a sensitive indicator of any contamination within the gyroscope. A spin-down rate of less than 0.1 milliHertz/hour at spin speeds less than 5 Hz indicates a adequate level of cleanliness.

Special Procedures: Standard housing cleaning and installation procedures should be followed.

Design Considerations:

Environment: After cleaning and assembly the gyroscopes shall be protected from particulate fallout. They shall be installed and removed from test probes in Class 10 or better environment. Where possible, witness samples shall be placed near the gyroscopes during assembly and testing.

Zone: II - Spin-up Gas Inlet Line after Filter and Spin-up Exhaust Line

Reason for Cleanliness Requirement: Communicates directly with Zone I and Spin-up Gas Flows through the Gyroscope.
Required Cleanliness Levels: All parts shall be cleaned to level 100 or better per MIL-STD-1246 using the reference procedure listed below.

Reference Cleaning Procedure: The reference cleaning procedures for the spin-up inlet and exhaust lines and the final spin-up inlet filter are listed below:

Spin-up Inlet

1. Vapor Degrease
2. Ultrasonic
3. Flush with Freon
4. Interior of tubes flushed with Quadrex
5. Certified to highest level technically possible
6. Bag and seal entire tube in bags certified to level 100 or better. Bags remain sealed until assembly.
7. Install in Probe
8. Recertify
9. Bag exposed ends in bagging certified to level 100 or better

Spin-up exhaust line and heat exchanger

1. Vapor degrease
2. Acid clean
3. Ultrasonic
4. Freon Flush
5. Flush with quadrex

(Heat exchangers braze weld. Repeat steps 3-5)

6. Follow steps 4-8 of inlet line procdeure

Inlet Filter

1. Follow steps 1-5 for filter element.
2. Repeat steps 1-5 for sub-assembly.
3. Follow steps 6-8 of inlet line as applicable.

Verification: Verification of the cleanliness levels shall be done to the highest level technically possible, using the ASTM procedures, before and after assembly into the probe. Results of these verification tests shall be delivered with the probe as provided by LMSC.

Special Procedures: During evacuation and venting of the probe, procedures shall be used to ensure that any particles are pumped away from gyroscope side of the inlet filter. If a gyroscope is installed, evacuation and venting of the probe shall be done in such a way that a minimum amount of gas (and particulates) is pumped through the gyroscope. In addition, any evacuation or venting of the

probe shall be done in at a sufficiently slow rate that the flow of gas remains in the laminar flow regime. Guidelines for evacuation are that (1) Evacuation and Venting of the probe shall be done at a rate of less than 10 Torr/minute and (2) that the flow be limited at a point as close as possible to the vacuum pump.

Design Requirements: The ground support equipment shall be designed so that the above special procedures may be implemented.
The final filter must be a 0.5 micron or smaller absolute filter.
Materials used in this zone of the probe must have a level of condensable nonvolatile residues such that the obscuation of light entering the telescope shall not exceed 5%.
Environment: After cleaning, the spin-up inlet and exhaust lines, as provided by LMSC, shall be bagged in a Class 100 or better area. These bags shall only be removed in a Class 100 or better clean room, and the inlet and exhaust lines shall be protected from particulate fallout.

Zone: III - Bore of the Quartz Block

Reason for Cleanliness Requirement: Communicates directly with Zone I

Required Cleanliness Levels: All parts shall be cleaned with methods consistent with level 100 or better. A reference cleaning procedure is listed below. Departures from the reference cleaning procedure may be made depending on the part, but any change in the cleaning procedure shall produce better cleanliness levels than the reference cleaning procedure.

Verification: Verification of the cleanliness levels within zone III shall be done by verifying that the reference procedure listed below cleans surfaces adequately. It is important that this verification be repeated (particularly before a crucial integration of the gyroscopes into the probe) to insure that the procedure still produces adequate cleanliness levels.

Special Procedures: Record cleaning procedures and verification test results in hardware file folders

Design Requirements : Materials used in this zone of the probe must have a level of condensable nonvolatile residues such that the obscuation of light entering the telescope shall not exceed 5%.

Reference Procedure: The following reference procedure shall be used for cleaning parts in this zone:

1. Spray with deionized water to loosen dirt particles
2. Place parts in beaker with hot water and 1% solution, by volume, of Microdetergent and use ultrasonic cleaner for about 10 minutes.
3. Rinse in dump rinser for about 2 cycles.
4. Wash in tray with hot water and 1% Microdetergent and use Z-foam cloths for rubbing the parts.
5. Rinse parts with DI water ($\geq$ 2 Mohm-cm resistivity) hand sprayer.
6. Use Water-pick for parts with hard to reach places.
7. Rinse again with DI water hand sprayer.
8. Rinse again in dump rinser for at least two cycles.
9. Place part in beaker with methanol and place beaker in water inside ultrasonic cleaner.
10. Blow dry with dry, filtered nitrogen
11. Place in clean container (similarly cleaned) and seal container.
12. Take to Quadrex and place inside still in its container.

13. Once door is closed to Quadrex, open container and clean both container and part with Shearstress flow of filtered Freon.
14. Run drying cycle. While still in closed Quadrex machine, place part back in container and seal.
15. Remove container and bag or double bag (as appropriate) immediately for transport to final destination.

Environment: After cleaning, the parts to be used in Zone III shall be protected from particulate fallout. Installation of these parts shall be done in a Class 10 or better environment. Unless the parts are recleaned, they shall not be removed from the clean room unless they are bagged or encapsulated in a sealed vessel like the probe.

Zone: IV - Birdcage Area - Interior of Probe Below the Quartz Block Mounting Flange.

Reason for Cleanliness Requirement: Communicates Directly with Zone III

Required Cleanliness Levels: All parts shall be cleaned to level 100. Verification of the cleanliness level will be done to the highest level technically possible. After cleaning, parts shall be bagged in level 100 or better.

Verification: Verification of the Cleanliness Levels within this zone may be done either by measuring the cleanliness levels on each of the parts or by qualifying the procedure used to clean the parts.

Special Procedures: Evacuation of the probe shall be done at a maximum rate of 10 Torr/minute to avoid redistribution of particles due to gas flow. The flow of gas during the initial evacuation shall be throttled as close to the vacuum pump as possible.

Venting of the probe shall be done with dry, filtered (0.5 micron or better) nitrogen at a maximum rate of 10 Torr/minute.

Design Requirements : Particular attention shall be paid to the use of fasteners, adhesives, and the smoothness of the surfaces. Fasteners must be compatible with cleanliness level 100 and the expected vibration levels. Adhesives are a potential source of particles, and the rough surfaces can generate particles during the assembly process.

The design of the probe must allow for the recleaning and reverification of this zone after assembly of the probe to the best extent possible. Areas that cannot be recleaned and reverified must be brought to the attention of the cleanliness committee

Materials used in this zone of the probe must have a level of condensible nonvolatile residues such that the obscuation of light entering the telescope shall not exceed 5%.

Environment: After cleaning, the parts to be used in this zone shall protected from particulate fallout. They shall be bagged and only opened in class 100 or better clean rooms.

Zone: V - Interior of Probe Above Quartz Block Mounting Flange.

Reason for Cleanliness Requirement: Communicates Directly with Zone IV

Required Cleanliness Levels: All parts shall be cleaned and verified to level 100 or better. Since this region of the probe is relatively inaccessible after assembly and many regions would be difficult to reclean, special care must be taken to insure that this region does not become contaminated

Verification: Verification of the cleanliness levels of the parts used in this area before assembly may be done either by measuring the cleanliness levels of each part or by qualifying the procedure used to clean the parts.

Special Procedures: See special procedures of Zone IV.

Design Requirements: Particular attention shall be paid to the use of fasteners, adhesives, and the smoothness of the surfaces. Fasteners must be compatible with cleanliness level 100 and the expected vibration levels. Adhesives are a potential source of particles, and the rough surfaces can generate particles during the assembly process.

Environment: After cleaning, parts to be used in this area shall be protected from particle fallout. They shall be stored in bags verified to level 100 or better.

After assembly of the probe, it is unlikely that this region of the probe can easily be recleaned. Therefore, it is important that this area of the probe be protected from particulate fallout. In order to achieve better than class 100 air flow over the hardware, activity interrupting the laminar flow will be limited only to those procedures for which there is no alternative.

Zone: VI - Ground Support Equipment Vacuum System

Reason for Cleanliness Requirement: Communicates Directly with Zones II and V

Required Cleanliness Levels: All parts of the ground support vacuum equipment shall be cleaned using standard cleaning methods for vacuum equipment.

Special Procedures: Venting and evacuation procedures shall be designed to prevent particles from flowing into the probe, prevent motion of particles due to turbulent gas flow, and to ensure that condensation of water does not occur on critical parts.

Design Considerations: Special design consideration shall be given the prevention of oil backstreaming in the vacuum system.

Environment:

February 20, 1998

Mac,
As per the auditor's request, I have made a approval sheet for P0059

1. Please check for approval signature-do you need any others to sign?
2. The date on the document is dated June 19, 1994. I have a note on my copy that it was revised October 30, 1996, so it raises a question in my mind as to the correct dates. If this is a third revision, we would need to get copies of prior versions to Rev. 3 for paper trace purposes.

If any changes to approval sheet should be made, please let me know and I will take care of it.
Thanks
Mae

2/27/98 Second request sent to Mac

3/4/98 Added Bert Schultz - signature
Per J.T
Put it through as first issue
P0059 Rev. — (Consulted w/ Ed L.)
Distributed 4 Copies for Signature

3/30/98 Gave original w/ Mac signature to Sue (Bob Schultz assistant) to review & sign. EJI

4/10/98 Bert T signed Copy, recirculated to John T for Signature. This will be "original".

Zone: VII - Exterior of Probe

Reason for Cleanliness Requirement: Communicates Directly with other zones when probe is open. In addition any magnetic particles on the exterior of the probe may increase the magnetic field within the lead bag when the probe is inserted into the dewar

Required Cleanliness Levels: Exterior of the probe shall initially be cleaned and certified for level 200. The entire probe shall be bagged before it is removed from the clean room.

The design of the probe must allow recleaning and recertification of the exterior of the probe to level 200

Special Procedures:

Design Considerations:

Environment:

6.0. 2026
3/8/03

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: ECO # 1349

_____Date 3/21/02
for: Dorrene Ross
Quality Assurance

_____Date_____
Harv Moskowitz
LMMS Safety

_____Date_____
Rob Brumley
Payload Technical Manager

_____Date_____
Mike Taber
Payload Test Director

EWV-9

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 Added Hazardous Materials comment to title Page. Added QA inspection points	1/25/02

		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

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	~~9/2/03~~ 9/9/04
2	DAS	Power Supply, H-P 6627A	-	3452A01956	Yes	~~9/9/03~~ 9/9/04
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A245539	No	9/10/03

No.	Location	Description	User Name	Serial No.	Cal Required	Status Cal due date
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	8/12/04
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	8/23/03
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	10/8/04
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	8/23/04
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, Helse	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: 2026
Time Initiated: 1350
Date Initiated: 3/8/03

G. OPERATIONS

G.1. Pre Operations Verifications

☒ Verify SU QA notified.
Record: Individual notified Jerry C.
Date/time 3/8/03 1350.

☒ Verify NASA representative notified.
Record: Individual notified Ed Ingraham
Date/time 3/8/03 1350.

☐ 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: SU GP-B INSP 28 3/14/03

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

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

1. 535354 2. 09284 3. 27456 6
4. 691605 5 575375 6. 16734

Verify helium bottle/s have been tested for purity and record Op. Number.
Op. Number: 2019
Record Step Number: X

QA Witness: SU GP-B INSP 28 3/14/03

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] 4.189 K.

✓ G.3.4. Verify ion-pump magnet installed.

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

1. Turn on Vac-Ion pump and record time of day 1450
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) 2.2×10^{-6} torr. If pressure is above 5×10^{-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] 175 on DAS alarm list and set to alarm at T ≤ 6.0 K.
   Record set point. 5.0 K
2. ***Top of lead bag temperature*** – verify CN [28] 178 on DAS alarm list and set to alarm at T ≤ 6.0 K.
   Record set point. 5.0 K
3. ***Relative Guard Tank Pressure*** – verify CN [46] on DAS alarm list and set to alarm at ΔP ≥ 0.3 torr.
   Record set point. 12.0 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. 20 %
2. ***Guard Tank*** – ensure liquid-level alarm set ≥ 10%, if there is liquid in the Guard Tank.
   Record set point. N/A %

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*** 89.6 %
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 #:_____ N/A %

QA Witness: SU GP-B INSP 28 3/11/05

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		
☐ With liquid – place in common manifold mode:	EV-16, EV-13, GTV-V	EV-20, EV-23
☐ Depleted and pressure regulated at EV-23	EV-16, EV-23, GTV-V	EV-13, EV-20
☑ 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. ~~1.~~ Verify source of 99.999% pure helium gas available at APR-2.
2. 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 (6-pack)
     e. Verify ~~APR-2V~~ open and ~~APR-2~~ set to ~~2~~ 4 psig

QA Witness: SU GP-B INSP 28 5/14/03

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) 163 torr (relative to atm).

G.5.4. Record Main Tank pressure (EG-3) 775 torr.

QA Witness: SU GP-B INSP 28 3/19/03

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: SU GP-B INSP 28 3/4/03

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

G.7.1. Specify desired final helium level in Main Tank: 75 %

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: 1524
   b. V: 50 Vdc and I: 1.2 a

Heat Heater up

H08D @ .1 amp
H09D @ .1 amp
40.2 Vdc 50
40.2 Vdc 50

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. 20V
2. Set voltage of heater H08D to ≤ 14 Vdc and record:
   a. Time of Day: 1525
   b. V: 20 Vdc and I: 0.44 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.

PSA3 PSA4 ↓ 5V ↓ 5V See Data sheet

Within ±30 ⊕15 of Nominal Pressure value

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

1. Time of day: 1909 — 75.8
2. Main Tank bottom temperature CN [09] 4.247 K
3. Lead Bag CN[28] 4.317 K

SKIP G.7.9. Close EV-6 and EV-18 Time 1915

G.7.10. Turn off power supply to Main Tank heater(s). Time 1909

G.7.11. Turn off power supply to Guard Tank heater(s). Time 1921

G.7.12. Turn off Main Tank vent-line heat exchanger (EH-1). Time 1922

QA Witness: SU GP-B INSP 28 5/14/02

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		
❑ With liquid – place in common manifold mode:	EV-16, EV-13, GTV-V	EV-20, EV-23
❑ Depleted and pressure regulated at EV-23	EV-16, EV-23, GTV-V	EV-13, EV-20
❑ 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 Same
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: SU GP-B INSP 28 3/14/03

H. **PROCEDURE SIGN OFF**

Completed by: D. O. Murray

Witnessed by: M. A. Taber

Date: 3/8/03

Time: 1926

Quality Manager SU GP-B INSP 28 **Date** 3/14/03

Payload Test Director M. A. Taber **Date** 3/8/03

Data Sheet 1

MT HEX	I ave	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	SMD External Temp. Control: M.T. Vent Bayonet /O-ring (°C/°C)	SMD External Temp. Control: Valve SV-9 /Top Plate (°C/°C)	SMD External Temp. Control: SV-9 Knob/ Dewar Adapter (°C/°C)	MT Heater	GT Heater
		1750						162	81.1	88.9	See Supplemental sheet				
12.3	10	1800	4.209	4.314	—	19.71	770	~~772~~	80.6	93.6	CN49			50/35	50/50
12.9	9	1805				19.73		162	80.3	94.9				50/4	4
13.2	10	1815	4.211	4.319	—	19.79	771	162	79.7	99.7				"	"
13.6	10	1820			—				79.3	101.9				"	"
14.0	10	1833			—	19.78			78.4	104.5				"	"
14.05	18	1840			~	19.78			77.9	106.2				"	
14.5	14	1845	4.215	4.322	—	19.69	772	162	77.5	106.6				50/40	50/40
14.4	10	1855					773	162	76.9	107.5	35.6			"	"
		1900	4.217	4.323		19.77	773	162	76.4	107.6	35.6				
14.4	10	1904								102.6				50/0	50/5
12.5	16	1906												30/0	
11.8	17	1908												0/0	
6.1	16	1915									18.5				

+ Set point is 10°C

[illegible]

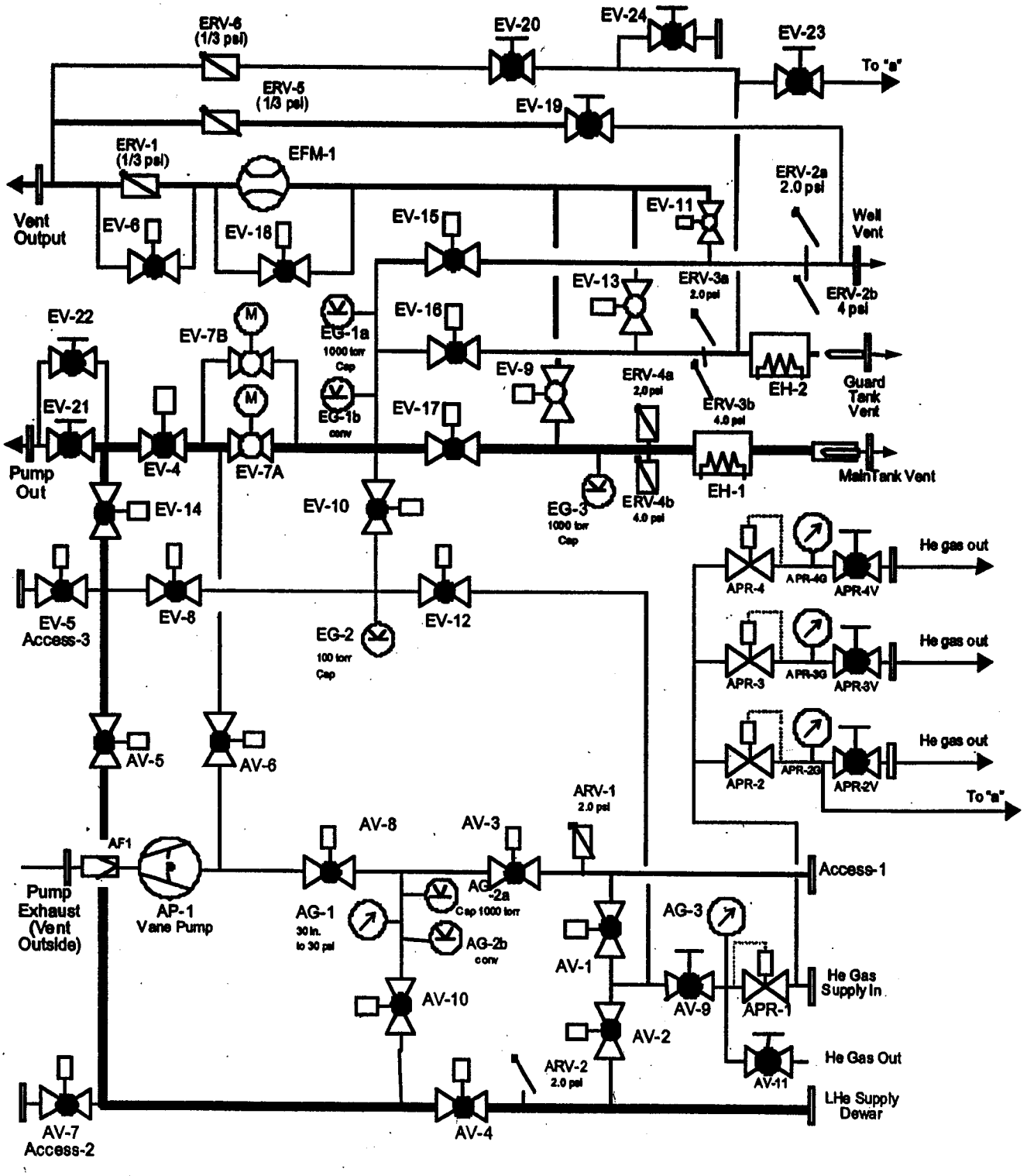
046

MT HEX Ø	MT HEX 1	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	SMD External Temp. Control: M.T. Vent Bayonet /O-ring (°C/°C)	SMD External Temp. Control: Valve SV-9 /Top Plate (°C/°C)	SMD External Temp. Control: SV-9 Knob/ Dewar Adapter (°C/°C)	MT HTRS 105 / 107 VDC	GT HTRS 150 / 150 VDC
		3/5/03													
		1530	4.191	4.565	—	23.65	765	~~751~~	89.7	35	See sup. sheet			50/20	50/0
	5→15 osc	1535													
9	7C	1545	4.193	4.488	—	22.18	767	475	89.1	74				"	"
10.0	5C	1600	4.194	4.433	—	20.30	769	585	88.5	79.2				50/40	50/40
12.1	6	1615	4.195	4.400	—	19.30	771	760	87.4	97.4				50/40	50/30
13.3	(3)	1625					772	88.9	86.7	(103.5)	Reduce Flow →			50/20	50/50
13.0	6	1630	4.194	4.371	—	19.05	771	100.6	86.3	102.7				"	"
		1640							85.5	95.5				50/30	"
2.3	9	1645	4.194	4.343	—	19.42	770	148	85.3	94.2				"	"
		1700	4.198	4.331		19.64	770	166	84.2	94.9				"	"
11.5	-23	1710							83.5					50/15	
11.3	7	1715	4.204	4.318		19.72	770	165	83.3	92.4				"	"
12.0	10	1725							82.5	83.5				50/30	"
11.5	9	1730	4.207	4.311	—	19.74	769	164	82.2	83.8				"	"
11.3	-3	1740							81.8	87.5				50/30	"
12.3	(*)	1745	4.207	4.311		19.71	770	163	81.4	88.6				50/35	"

Big [illegible] power out

Control 4.3 Set out = 10% [illegible] 19:00 DAM 18:37

(*) Prop open HEX MT Control Box for cooling components


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
EG-1a
1000 torr
Cap
EV-16
EV-21
EG-1b
conv
EV-9
ERV-4a
2.0 psi
EH-2
Guard
Tank
Vent
ERV-3b
4.0 psi
EV-17
Pump
Out
EV-4
EV-7A
EV-14
EV-10
EG-3
1000 torr
Cap
ERV-4b
4.0 psi
EH-1
Main Tank Vent
He gas out
APR-4
APR-4G
APR-4V
EV-5
Access-3
EV-8
EV-12
EG-2
100 torr
Cap
APR-3
APR-3G
APR-3V
AV-5
AV-6
APR-2
APR-2G
APR-2V
To "a"
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
ARV-2
2.0 psi
He Gas Out
AV-11
AV-7
Access-2
AV-4
LHe Supply
Dewar

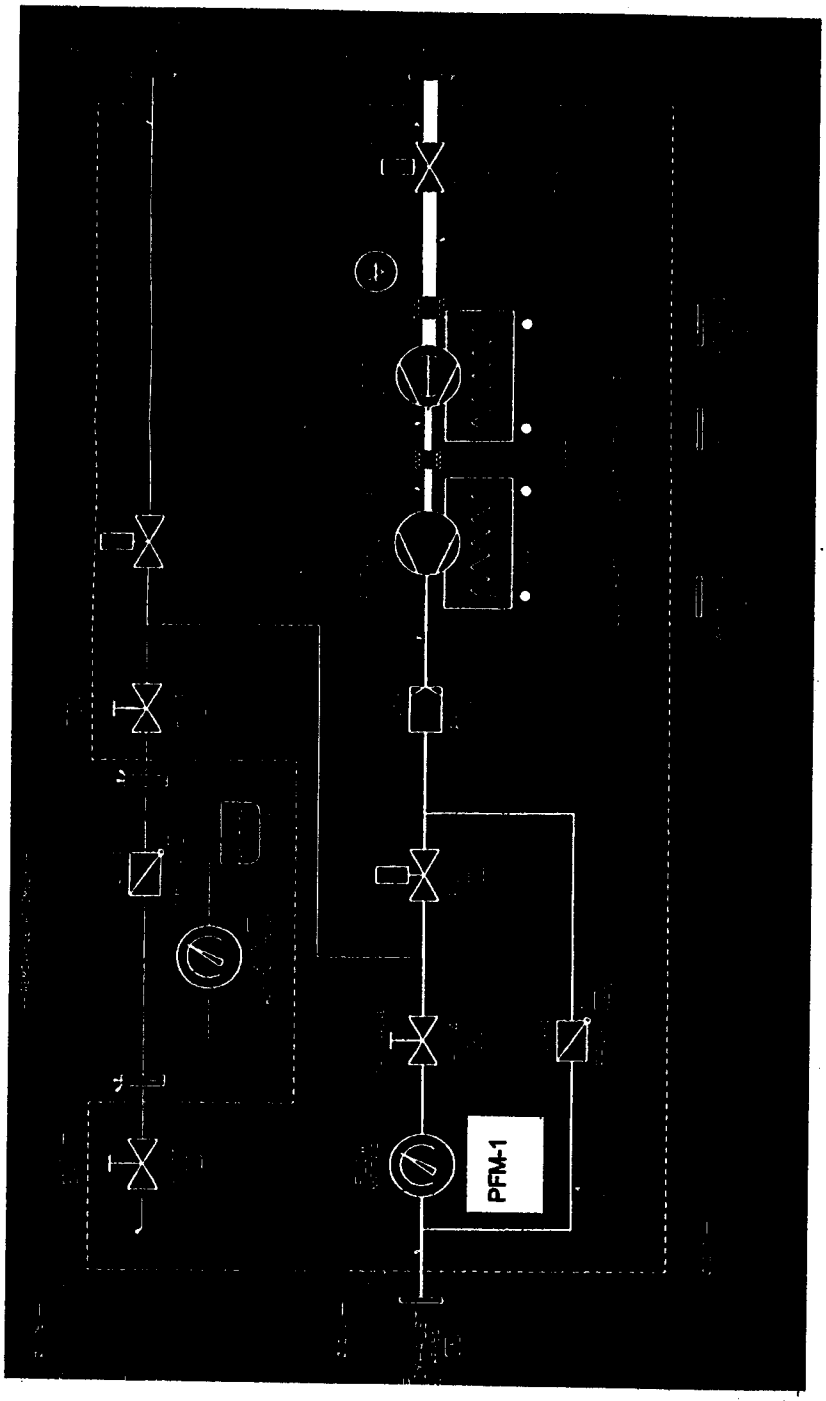


Figure 2. Schematic of Pump Module plumbing.

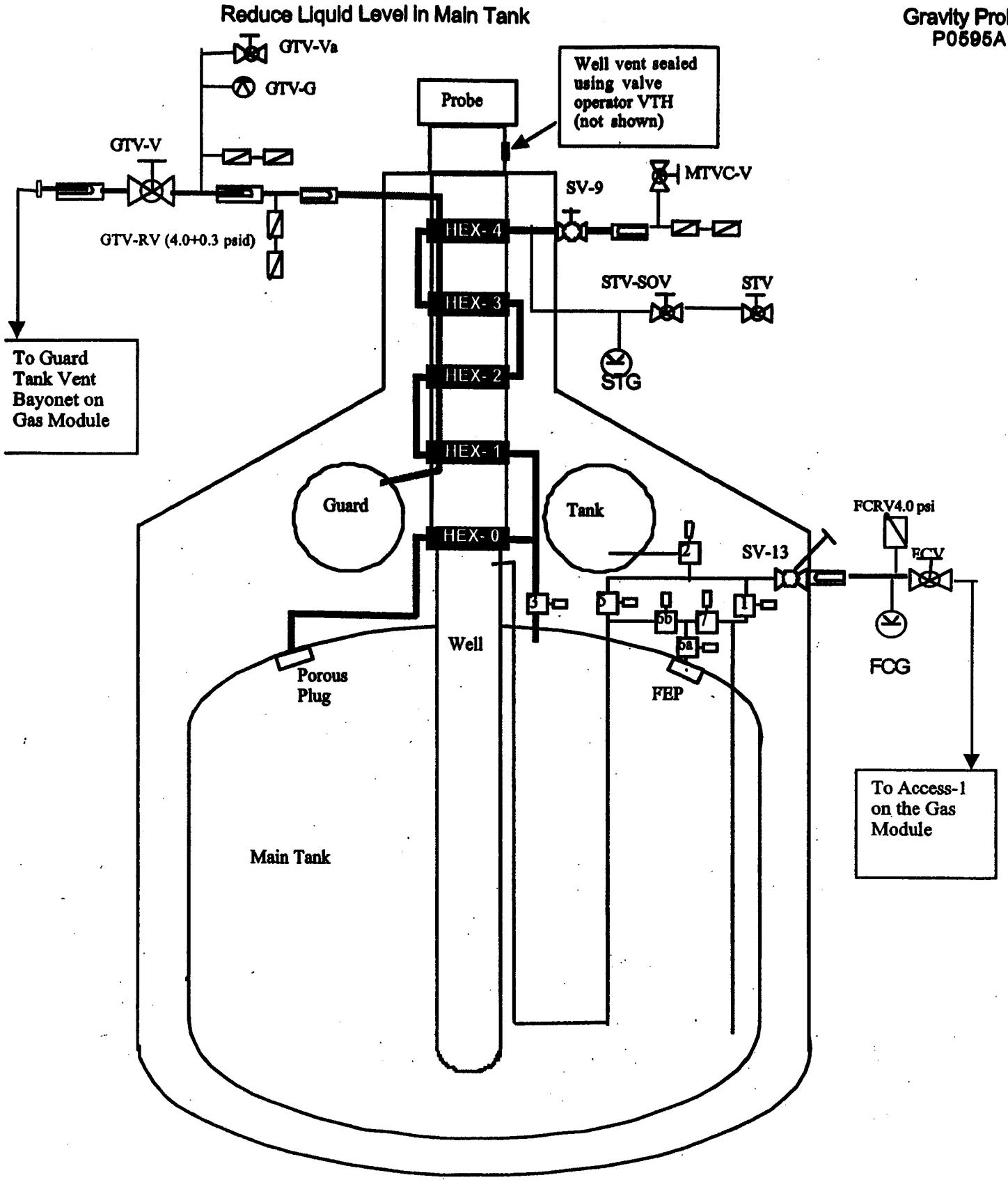


Figure 3 Schematic representation of SMD showing interfaces with Gas module.

Appendix 1

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.	3/8/02	
	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.	3/8/02	
	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	Terminate Procedure
		If after section G.7	Wait for power restoration
2	Burst disk rupture (MT/GT)	Any time	Evacuate room

MANUAL P.S. (above column 2) — 12/— (above column 4)

3/8/03	1 MTV IB Cntr/OT	2 Bayo Nut Cntr/OT	3 Valve Stem Cntr/NA	4 Top Plate Cntr/OT	5 GTV Bayo Cntr/OT	6 MTV OB Cntr/OT	Ext GTVA Cntr/OT	1 CT/OV setpnt	2 CT/OV setpnt	3 CT/OV setpnt	4 CT/OV setpnt	5 CT/OV setpnt	6 CT/OV setpnt	Comments
1500	19/21	60/13	[crossed out]	14/14	NA	17/14	NA	20/30	*	20/—	20/35	NA	20/39	Zero Power
Current (at Nominal)	1.5	0.4	0.4	0.9		1.6 max	—							
Peak	28/23	27	24	[crossed out]		[crossed out]	—	31/33						
				Low TOP was 29			—							
1513	20/22	—/27	24/—	27/25	—	21/29	—							
15__														
1533	20/22	—/32	17/—	27/33	—	19/31	—							
		TO .2A												
1545	19/22	—/30	16/—	25/32	—	20/31								
1600	19/24	—/31	18/—	23/30	—	20/33								
1615	19/30	—/31	19/—	22/29	—	20/34								
	O.Temp ONLY	TO .1A												
1630	21/22	—/30	20/—	21/29	—	20/34								
1645	20/21	—/32	20/—	20/29	—	20/35								
1715	20/22	—/33	20/—	21/29	—	20/35								
		TO .1A												
1—														
1800	20/22	—/33	20/—	20/29	—	20/35								
		TO .0A TO 0.0amp												
1855	20/22	—/32	20/—	20/29	—	20/29								

* TC 2AL Bayonut Control; UNIT IS IN ERROR RUN IN MANUAL MODE

OP # 1984

GRAVITY PROBE B PROCEDURE FOR SCIENCE MISSION DEWAR

Repump Well with Probe Installed

THIS PROCEDURE CONTAINS HAZARDOUS OPERATIONS

P0613D
ECO 1395

December 3, 2002

Revised by

_____Date_____
Ned Calder
Cryogenic Test

Checked by

_____Date_____
Dave Murray
Cryogenic Test

Approvals: ECO # 1395

SU GP-B INSP 28

_____Date 12/18/02
Dorrene Ross
Quality Assurance

_____Date_____
Harv Moskowitz
LMMS Safety

_____Date_____
Barry Muhlfelder
Payload Technical Manager

_____Date_____
Mike Taber
Payload Test Director

ENV-7

X

REVISION RECORD

REV	ECO	PAGES	DATE
A	1159	Change title to *Repump Well with Probe Installed.* Section A – Updated scope to accurately reflect content. 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, 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.7 – added section to verify DAS and Main Facility alarms enabled.	7-14-00
B	1239	Change to reflect change in normal operating status of Well vent valve VTH. VTH is normally closed with 2 to 5 torr helium gas captured between VTH and VW-3. Include steps for installation and removal of Well Vent Manifold at VTH (see Figure 3).	1-3-01
C	1353	Update to reflect operation at LM rather than SU; Update per P0875; Replaced references to CN [1] (STA 200 temperature) with references to CN [29] (top of lead bag temperature, redundant to CN [28]); Added pre- and post-operation checklists (Appendices 1, 2); Added contingency responses (Appendix 3).	
D	1395	Incorporate Minor Redlines Update to reflect installation of flight plumbing	11/11/02

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 document provides the necessary steps to pump on the Well with the UTS. The steps include:

Install the Well Vent Manifold (Figure 1)

Connect pumping line between UTS and Well at VW-3

Pump up to closed VW-2

Leak check pumping line

Open VW-2 and pump on Well

Close VW-2, perform leak-back test of closure,

Remove the Well Vent Manifold (optional)

The procedure may also be used to install or remove the Well Vent Manifold at VW-2, by skipping the appropriate sections.

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 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 requirements apply to personnel involved 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 Hardware 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 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	Tom Welsh
Dave Murray	
Ned Calder	

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

Proper ESD protection is required when working around the SV.

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

Description
Varian Leak Detector Model # 960 Cal Due Date: 10/2/03

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 Electrical Module (Table 1).

E.3.3. Computers and Software:

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
Utility Turbo System (UTS)

E.3.5. Additional Hardware

Description
Stainless steel flex line to connect UTS to Well at VW-3
Well vent manifold

E.3.6. Tools

Description
Torque Wrench, Cal Due Date: 1/7/03 S/N 13683-175

E.3.7. Expendables

Description	*Quantity*	*Mfr./Part No.*
Alcohol	AR	N/A
99.99% 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	10/10/03
2	DAS	Power Supply, H-P 6627A	-	3452A01956	Yes	10/10/03
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A245539	No	-
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	01/29/03
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	8/22/03
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	10/8/04
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	8/22/03
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	-

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
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 may be either subatmospheric or at NBP.

E.5.2. Guard Tank

The Guard Tank may contain liquid or be depleted.

E.5.3. Well

The Well should be nominally evacuated. (This procedure is intended for repumping and not for initial evacuation.)

E.5.4. SMD Vacuum Shell

There is no requirement on the vacuum shell pressure.

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 175) at $T \leq 6.0$ K.
   b. Top of lead bag temperature set (CN 178) at $T \leq 6.0$ K.
   c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 30$ torr.
2. The Watch Dog alarm must be armed.

E.5.6. 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).

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. The ion-pump magnet is installed.

3. The Main Tank vent line may be connected to the Gas Module or disconnected with a vent cap installed.
4. The Guard Tank vent line may be connected to the Gas Module or disconnected with a vent cap installed.
5. The Vacuum shell pump out port at SV-14 may be connected to the Vacuum Module (P/N 5833816) via a 2-in valve operator and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be off, actively pumping the pumping line up to a closed SV-14, or actively pumping the vacuum shell.
6. The thruster vent port is flanged to a shut-off valve.
7. The Fill Cap Assembly is installed at SV-13 (See Figure 1)

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

F.3. Additional Procedures

Document No.	*Title*
SU/GP-B P0140	*Prepare Probe C for Testing*

Operation Number: 984
Date Initiated: 12/18/02
Time Initiated: 1352

G. OPERATIONS

G.1. Verify Preparations

G.1.1. Verify SU QA notified.
Record: Individual notified R. Geete,
Date/time 12/18/02 0830.

G.1.2. Verify NASA representative notified.
Record: Individual notified G. Ingalls,
Date/time 12/18/02 0830.

G.1.3. Verify that persons actually performing this procedure have initialed their names in Sec. D.3 and the name of the Test Director is circled.

G.1.4. Verify completion of pre-operations checklist

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G.2. Verify Configuration Requirements

G.2.1. Ensure Watch Dog Timer enabled.

G.2.2. Verify DAS alarm system enabled and record set points.

1. ***Top of lead bag temperature*** – verify CN [175] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. 5.5 K
2. ***Top of lead bag temperature*** – verify CN [178] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point. 5.5 K
3. ***Relative Guard Tank Pressure*** – verify CN [46] on DAS alarm list and set to alarm at ΔP ≥ 10 torr. Record set point. 30 torr

G.2.3. Verify liquid-level alarms set, as appropriate, and record set points.

1. ***Main Tank*** – verify liquid-level alarm set ≥20%. Record set point. 20 %
2. ***Guard Tank*** – If appropriate, verify liquid level alarm set ≥ 20% (if liquid in GT). Record set point. NA %

G.2.4. Verify VTH open and handle restrainer installed.

NA G.2.5. Ensure VW-1 open

G.2.6. Ensure VW-2 Closed

G.2.7. Install/verify installed Well Vent Manifold:

- ☒ Manifold removed:
  1. Install manifold at VW-2 per configuration in Figure 1.
  2. Connect PW-2 to Convectron readout controller.
- ☐ Manifold currently installed and configured per Figure 1.

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G.3. Connect Pumping Line and Leak Check Up to VW-1

G.3.1. Turn on and verify calibration of leak detector. Record

1. Calibrated leak value 6.0×10^{-8} sccs; cal exp. Date: 10/2/03
2. Measured leak value 6.0×10^{-8} sccs

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G.3.2. Connect leak detector to the UTS at access port (LD).

G.3.3. Open/verify open VW-3

G.3.4. Connect UTS primary pumping port to Well manifold assembly at VW-3 and start the UTS pumping up to closed VW-2 as follows:

1. Close/verify closed TV-1, -2, -3, -4, -5 and RGA-V.
2. Place valve interlock switch in "over-ride" position.
3. Turn on vane pump and converter (Note: converter switch provides power to turbopump controller and the vacuum-gauge display.)
4. Push the red "reset" button to activate the interlock over-ride circuit. (the neon indicator light will come on).
5. Turn "foreline" switch on, to open TV-2, and verify that the switch is illuminated.
6. Push the "Sensor" button on the vacuum gauge display to read the foreline pressure (TG-4). (This is the pirani gauge. The "Pir" annunciator will appear in upper left corner of the display.)
7. Slowly open TV-4.
8. When foreline pressure (TG-4) < 1 torr, push "Start" button on turbo controller.
9. When the "Normalbetrieb" light illuminates on turbo controller, indicating turbopump is up to speed, open gate valve TV-1 and close TV-4.
10. Switch the valve interlock switch to the "protected" position.
11. Push the "Sensor" button on the vacuum gauge readout so that the "Hi-Vac" annunciator shows, and push the "Emis" button to turn on the cold cathode gauge (TG-1).
12. Record the pumping line pressure (TG-1) 7.3×10^{-4} torr.

~~G.3.5.~~ Close TV-2 and open TV-3.

~~G.3.6.~~ Leak check all joints between VW-2 and Leak Detector.

> **Note:**
>
> No leaks greater than 1 x 10^{-7} sccs are allowed.

1. Record background 7.2×10^{-8} sccs.
2. Record Leak Rate 6.6×10^{-9} sccs.
3. Record TG-1 4.14×10^{-5} torr.

~~G.3.7.~~ When finished with leak check, open TV-2 and close TV-3.

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VW-3 VW-2 Section Complete Quality 12/18/01

Close ~~TV-3~~, open ~~TV-2~~, RECORD PW-2 START 0.4 mtorr and 34.5 ~~torr~~

G.4. Pump On Well

* → ☐ Skip this section, only using procedure for purposes of installing or removing Well Vent Manifold.

☒ Perform this section to pump on Well.

> **Note:**
>
> Step G.4.1 provides the option of filling the cold trap on the UTS with LN2. This is done primarily to achieve a lower base pressure and, only as a secondary concern, to prevent back-streaming of any fore pump oil into the Well.

G.4.1. **Option:** Add LN_2 to UTS cold trap.

~~G.4.2.~~ Close VW-3.

~~G.4.3.~~ Record PW-2: 0.7×10^{-3} torr

~~G.4.4.~~ Open VW-2.

~~G.4.5.~~ Record PW-2: 1.0×10^{-3} torr.

G.4.6. Record VW-2 operation in Well Valves Log Book

* Open VW-3 to pump out on to VW-1

G.4.7. Proceed as follows

☑ PW-2 < 1 torr

1. Open VW-3, now pumping on Well with turbo.
2. Record Date/Time 12/18/02 / 1555.

☐ PW-2 > 1 torr

1. Close TV-1 and stop turbo pump
2. When turbo is fully stopped, open TV-4 and VW-3. Now pumping on Well with forepump.
3. When TG-4 < 1 torr, turn on turbo.
4. When "normalbetrieb" light comes on open TV-1 and close TV-4. Now pumping on Well with turbo.
5. Record Date/Time _____/_____.

SKIP

LEAK CHECK PER P0957 OP# 1981

G.4.8. Remove Leak Detector from UTS as follows:

1. Verify UTS interlock switch in "protected" position.
2. Verify TV-3 closed and TV-2 open.
3. While monitoring the pressure on the cold cathode gauge (TG-1), vent and disconnect the leak detector
4. Disconnect Leak Detector from UTS and cap TV-3.

G.4.9. Start Data collection in Table 2.

Table 2

Date/Time	TG-1 (torr)	TG-4 (torr)	PW-2 (torr)	Comments
12/18/02 1600	3.3×10^{-5}		0.5×10^{-3}	
12/19/02 0930	2.2×10^{-6}		0.3×10^{-3}	
12/19/02 1500	1.8×10^{-4}	2.0×10^{-4}	0.3×10^{-3}	

G.4.10. **(Option)** Set Up RGA

SKIP N/A

1. When TG-1 is < 1 x10^{-5} torr slowly open RGA-V.
2. Set up RGA software (Transpector Ware)
3. Record Transpector Ware File Name _____.
4. When data collection is complete, shutdown RGA and close RGA-V.

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G.5. Terminate Well Pump Down

G.5.1. Record Time 1500 and Date 12/19/02 7:15

G.5.2. Record pressures:

1. PW-2 0.3x10^{-3} torr, .3 - 3
2. TG-1 1.8x10^{-6} torr, 1.3 x10^{-6}
3. TG-4 2x10^{-4} torr. 0

CAUTION:
In the following operation, it is important to ensure that VW-2 is properly closed.

G.5.3. Close VW-2 and torque to 72-84 in-lbs (6-7 ft-lbs) TORQUE = 48 IN-LBS
48 4
12/19/02

Quality _____

G.5.4. Record VW-2 operation in Well Valves Log Book

G.5.5. Close TV-1 and shut off TG-1.

G.5.6. Install a purged Helium source, set to approximately 1 psig, at TV-5.

G.5.7. Open TV-5 until ~100 torr is read on PW-2. Note:The real pressure is about 6.5 torr. The sensitivity of a Convectron to He is enhanced above 1 torr.)

G.5.8. Close TV-5.

G.5.9. Perform Leak Back Test of VW-2 Closure

1. Close VW-3
2. Record PW-2: 139 torr
3. Slowly open TV-4 to evacuate UTS plumbing
4. Close TV-4 when TG-2 < 25 mtorr
5. Monitor TG-2 and PW-2 for 30 minutes to verify successful closure of VW-2 and VW-3.

Time	743	753	803	813		
TG-2 (torr)	.016	.016	.016	.016		
PW-2 (torr)	136	132	132	132		

Note:

A pressure drop < 10 torr at PW-2 during the last 20 minutes indicates successful closure of VW-2.

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G.6. (Option) Close out procedure leaving Well Vent Manifold Installed at VW-2

G.6.1. Ensure losed TV-4, following successful closure of VW-2, capturing 6-7 torr helium gas between VW-2 and VW-3.

G.6.2. ,Remove UTS as follows:

1. Turn turbo pump off.
2. Close foreline valve (TV-2) and turn off vane pump.
3. Open TV-5 and backfill to 760 torr, as read at TG-3.
4. Remove pumping line from VW-3 and UTS.
5. Cap port at VW-3.

Section Complete Quality _____

G.7. (Option) Close out procedure by removing Well Vent Manifold from VTH

G.7.1. Open VW-3

G.7.2. Open/Verify open TV-4 until TG-2 reads ~0.00 torr

G.7.3. Close TV-4

G.7.4. Remove Helium source from TV-5

G.7.5. Open TV-5 until 760 torr (air) is read on TG-3.

G.7.6. Close TV-5.

G.7.7. Close VW-3.

G.7.8. Monitor ~~PW-2~~ for 30 minutes to verify successful closure of VW-2

Time	823	833	843	853	903	
~~PW-2~~ (torr)	757	751	752	752	752	

Note: a pressure drop < 1 torr at PW-2 during the last 20 minutes indicates successful closure of VW-2.

G.7.9. Following successful closure of VW-2, remove UTS as follows:

1. Turn turbo pump off.
2. Close foreline valve (TV-2) and turn off vane pump.
3. Remove pumping line from VW-3 and UTS.

G.7.10. Remove Well Vent Manifold from VW-2

G.7.11. Cap port at VW-2

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Section Complete Quality _____ 12/20/02

G.8. Establish Final Configuration

G.8.1. Ensure DAS alarm enabled and record set points if changed

☑ Thermal conditions substantially unchanged, alarm set points for lead bag unchanged

☐ Thermal conditions substantially changed, temperature alarm points reset as follows:

a. Top of Lead Bag set point [CN 175] 5.5 K (≤ 6.0 K)

b. Top of Lead Bag set point [CN 178] NA K (≤ 6.0 K)

G.8.2. Ensure liquid level sensor alarms enabled, as appropriate, and record set points if changed.

1. Main Tank Level Set Point 20 %
2. Guard Tank Level Set Point NA %

G.8.3. Ensure Guard Tank pressure on DAS alarm list and set to alarm at ~~10~~ 30 torr differential.

G.8.4. Ensure Watch Dog Timer is armed.

G.8.5. Perform Post-Operations Checklist (Appendix 2)

Section Complete Quality SU GP-B INSP 28 12/20/02

Completed by: M. A. Taber

Witnessed by: SU GP-B INSP 28

Date: 12/20/02

Time: 1350

Quality Manager SU GP-B INSP 28 **Date** 12/20/02

Payload Test Director M. A. Taber **Date** 12/20/02

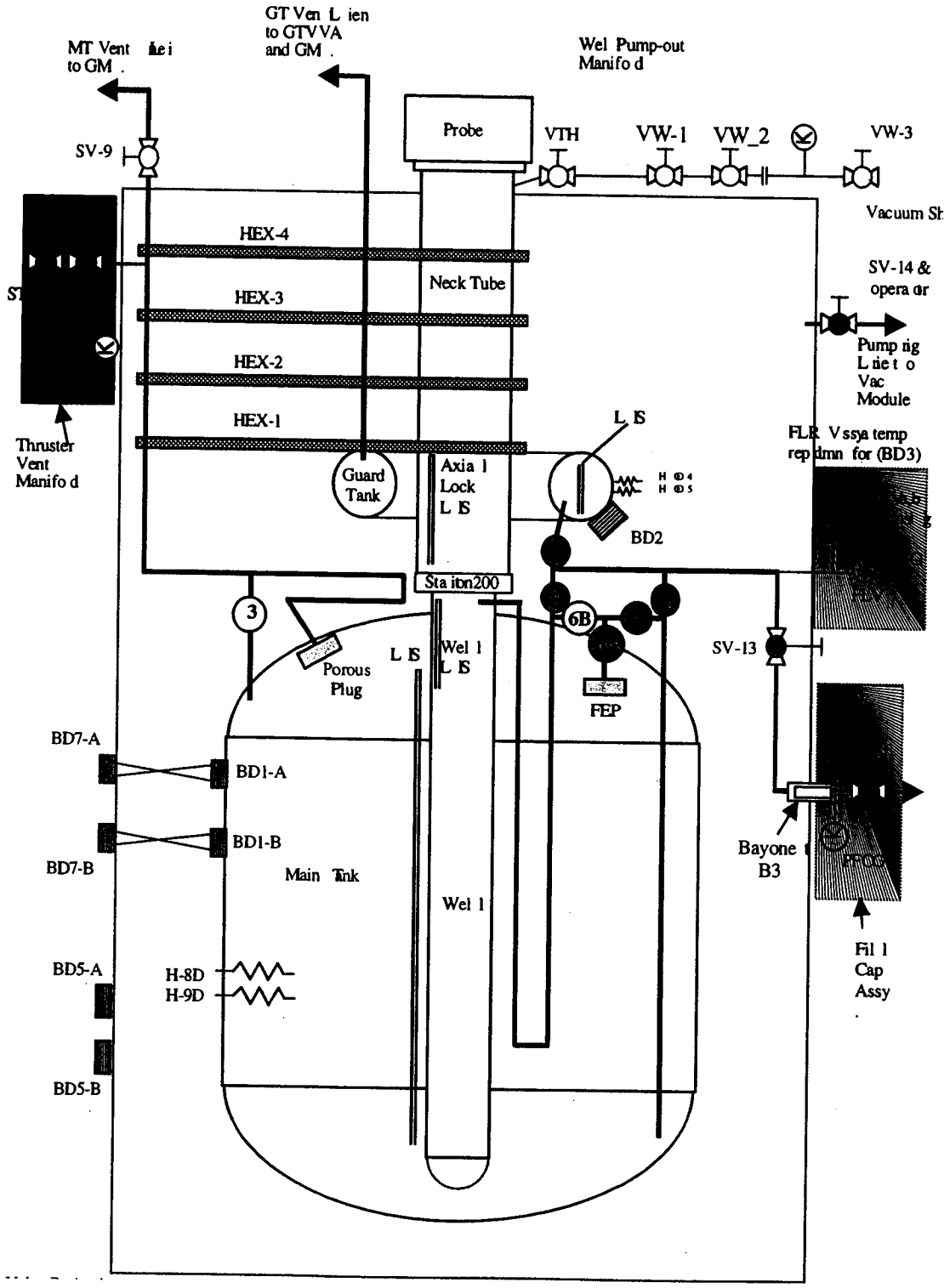

Figure 1. Schematic of Science Mission Dewar plumbing.

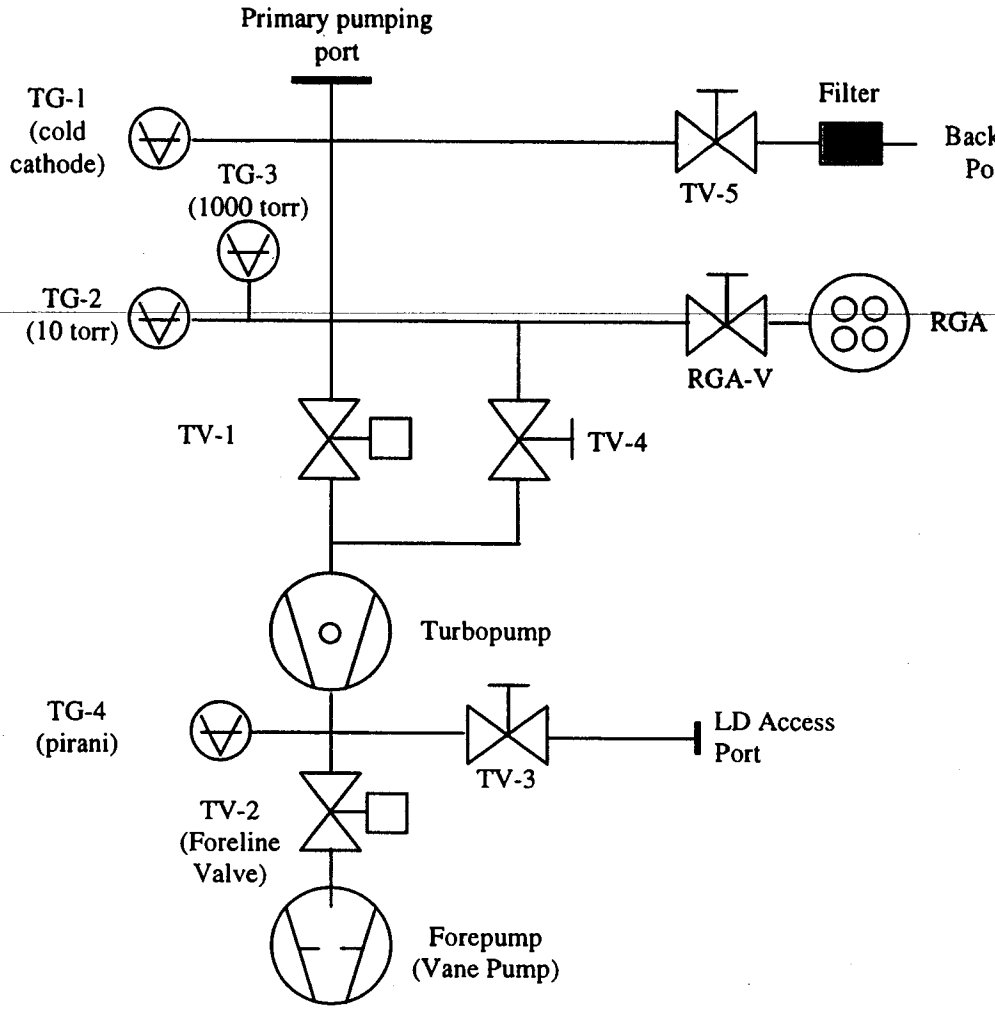

Figure 2. Schematic diagram of Utility Pumping System (UTS)

Figure 3. Well manifold assembly

Appendix 1

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
12/12/02	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
12/20/02	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	Sections G.1, G.2	Wait for power resumption and continue with procedure.
		G.3 – G.4	**Close VW-3 (if open) and all open valves on the UTS. Wait for power restoration.** Note: TV-1 and TV-2 will automatically close upon loss of power. They will not reopen nor will the turbo restart when the power is restored. **After power restoration,** restart procedure at the beginning of G.3. If the leak check has already been completed, it need not be repeated.
		After G.4	**Wait for power restoration** and continue with procedure.
2	Failure of leak-back test	At G.5.8	1) Verify that VTH is fully seated. 2) If the pressure drop was <30 mtorr, wait another 20 minutes to see if the trend continues. 3) If the pressure drop exceeded 30 mtorr or the trend continues, slowly open TV-4 to evacuate the pumping line. When TG-2 reads < 1 torr, open TV-1 and close TV-4. Turn on TG-1 and when it reads < 0.1 mtorr, reopen VTH. When the pressure at TG-1 returns to the value recorded in G.5.2, repeat the procedure starting at G.5.

3	Failure of leak-back test	At G.7.3	1) Verify that VTH is fully seated. 2) Wait another 20 minutes to see if the trend continues. 3) If the trend continues, place the interlock in the override position and stop turbopump. Very slowly open TV-4 to evacuate the pumping line. When TG-2 reads < 1 torr, restart turbopump, open TV-1, and close TV-4. Turn on TG-1 and when it reads < 0.1 mtorr, take interlock out of override and reopen VTH. When the pressure at TG-1 returns to the value recorded in G.5.2, repeat the procedure starting at G.5.
4	Burst disk rupture (MT/GT)	Any time	Evacuate room

OP# 1989

GRAVITY PROBE B PROCEDURE FOR SCIENCE MISSION DEWAR

NBP MAIN TANK FILL – GUARD TANK INITIALLY DEPLETED AND CONNECTED TO GAS MODULE

THIS PROCEDURE CONTAINS HAZARDOUS OPERATIONS

P0648E
ECO 1352
January 28, 2002

Revised by:

_____Date_____
Mike Taber
Cryogenic Test

Checked by:

_____Date_____
Harv Moskowitz
LM Safety

Approvals:

Raymond W. Cranch Date 1/31/02
for: Dorrene Ross
Quality Assurance

_____Date_____
Dave Murray
Cryogenic Test

_____Date_____
Robert Brumley
Payload Technical Manager

REVISION RECORD

REVISION	ECO	PAGES	DATE
A	1158	Changed title to reflect content 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. G.4. – Added section to verify SMD in standard configuration. Added warnings to monitor temperatures at Station 200 and the top of the lead bag continuously while the Main Tank vent is closed. Section G.18 – changed to require Manifolding of Guard Tank vent with Main Tank vent, following completion of procedure. Added caution at end of procedure to monitor Guard Tank pressure and set DAS alarm to 0.3 torr differential.	
B	1253	Changed to allow use in more cases than just following an SMD upright procedure (P0633). Changed title to reflect this change. Changed scope to include any fill operation in which the GT is initially depleted and pressure regulated. Changed section G.8 to allow MT pressure to be built in one of two ways: (1) by turning on the MT heater (2) by allowing the pressure to build passively as is done with P0633.	3/27/01
C	1292	Changed DAS setup to include switch the fast scan mode at beginning of procedure and return to normal scan mode at end of procedure. Updated list of qualified personnel and added other minor updates	8/8/01
D	1308	Remove operations dealing with Well not evacuated, add QA inspect points, add additional valve configuration callouts. Remove option for Guard Tank not connected to Gas Module. (For latter case, Guard Tank not connected to Gas Module, see P00877). Added Hazardous Materials comment to title Page. Added step to verify purity of helium gas Modified Sections B2.2 and B3.1 to reflect new location of SMD dewar in Lockheed Martin building 205 Added Appendix Contingency Responses Added pre/post checklist tables	9/1/01
E	1352	Added option for RAV-2 operation by spacecraft command if ECU is connected to J802; Added requirement to use cryogenic safety gear during stinger installation or removal; Added installation of vent line from VF-3 to facility vent; Replaced references to CN [1] (STA 200 temperature) with references to CN [29] (top of lead bag temperature, redundant to CN [28])	

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
APR-x	Pressure regulator x of Gas Module
AV-x	Valve x of Gas Module auxiliary section
CG-x	Gauge x of portable helium pressurization source
CPR-x	Pressure regulator x of portable helium pressurization source
CV-x	Valve x of portable helium pressurization source
CN [xx]	Data acquisition channel number
DAS	Data Acquisition System
ECU	Experiment Control Unit
EFM	Exhaust gas Flow Meter
EG-x	Gauge x of Gas Module exhaust section
EH-x	Vent line heat exchanger in Gas Module
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
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
LHV-x	Liquid Helium Supply Dewar valves
LLS	Liquid level sensor
LM	Lockheed Martin 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
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 perform an external fill of the SMD Main Tank with normal boiling point liquid helium with the Guard Tank initially depleted of liquid helium. (For Guard Tank initially with liquid helium, see P0442.) The Guard Tank and Main Tank are connected to the Gas Module via their vent lines. (For Guard Tank vent not connected to Gas Module, see P0877) The Well is evacuated and the Well pump-out manifold may be installed.

The steps include:

1. Fill Guard Tank to 15% from Main Tank
2. Pre-cool SMD internal fill line from Guard Tank
3. Pre-cool external transfer line from storage dewar
4. Fill Guard Tank
5. Switch from Guard Tank fill to Main Tank fill
6. Terminate transfer

Heating the Main Tank to raise its pressure when the level is low should be done judiciously to avoid overheating the ullage gas, hence raising the temperature at Station 200 and the top of the lead bag to unacceptable levels (> 6 K). If fill operation is to be performed as part of P0633, *Upright SMD Rotate from Horizontal to Vertical Orientation,* the pressure has already been built passively while still horizontal. If not, EV-9 may be closed well in advance of performing the actual fill operation (e.g., overnight) as the pressure may take some time to build this way. Note, however, that leaving EV-9 closed for extended periods of time while the SMD is vertical may also cause the temperatures at Station 200 and the top of the lead bag to rise to unacceptable levels. It should also be noted that since the installation of the flight fill line burst disk, the temperature at the top of the main tank rises fairly rapidly when RAV-1 is opened for the internal transfer. This phenomenon should be taken into account in the planning and execution of this procedure.

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

The following additional requirements apply to all personnel involved directly in cryogenic operations. Gloves that are impervious to liquid helium and liquid nitrogen are to be worn whenever the possibility of splashing or impingement of high-velocity cryogens exists or when handling equipment that has been cooled to cryogenic temperatures. Protective clothing and full-face shields are to be worn whenever the possibility of splashing cryogens exists.

B.2.3. Other Hazards

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

B.3. Mishap Notification

B.3.1. Injury

In case of any injury obtain medical treatment by immediately calling 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

Contingency responses to possible equipment troubles or irregularities (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.

C.3.1. 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.

C.3.2. 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 Test Director and approved by the QA representative.

C.3.3. 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. However, during the startup of the transfer (Sec. G.14), there are to be a minimum of two qualified persons (Sec. D.3) in attendance. 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.

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	Dave Hipkins
Ned Calder	Bruce Clarke
	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(see the *Electrical Module Manual* for details), 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 uses hardware located in the Gas Module (Figure 1), the Pump Module (Figure 2) and the Electrical Module (Table 1). However, the Pump Module may be omitted if a stand-alone gas meter (a substitute for PFM-1) is connected at the Gas Module Vent Output. The primary helium vent and all vane pump exhausts must be connected to an outside vent.

E.3.3. Computers and Software:

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. Spacecraft Support:

If connector J802 is connected to the Experiment Control Unit (ECU), operation of RAV-2 must be commanded through the spacecraft instead of the RAV controller in the Electrical Module.

E.3.5. Additional Test Equipment

Description	*Manufacturer*	*Model*
AMI Level Sensor Readout for LHSD	AMI	110

E.3.6. Additional Hardware

Description	*Manufacturer*	*Model*
Filter Line assembly	LM	5833827
Liquid He Transfer Line	LM	5833804
Liquid He Stinger	LM	5833803
GHe supply fittings to LHSD	N/A	N/A
500 or 1000 Liter Liquid Helium Supply Dewar	**Cryofab**	**CMSH-500, -1000**
Protective face shield or googles	N/A	N/A
Cryo gloves	N/A	N/A
Impermeable apron	N/A	N/A

E.3.7. Tools

Description
Torque Wrench, 1-1/4-in socket, 60 in-lb
1-1/4 adjustable wrench

E.3.8. Expendables

Description	*Quantity*	*Mfr./Part No.*
Ethyl alcohol	AR	N/A
99.999% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Dow Corning High Vacuum or Apiezon N
Tie wraps – large size	AR	N/A
Liquid helium	AR	N/A

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. Serial numbers are to be updated as appropriate.

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	A1, A2, A3, A4	3452A01975	Yes	10/10/03
2	DAS	Power Supply, H-P 6627A	B1, B2, B3, B4	3452A01956	Yes	10/10/03
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A24553 9	No	-
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	01/29/03
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	LLS Main Tank	96-409-11	No	-

No.	Location	Description	User Name	Serial No.	Cal Required	Status Cal due date
		American Magnetics, Inc. 136				
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	5/22/03
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	10/8/04
19	EM	Vac Ion Pump power supply Varian 929-0910, Minivac	SIP	5004N	No	8/22/03
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	EH-1	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	EH-2	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), 4.2 K. The SMD is vertical with the +z axis up. The actuator control valve for EV-9 switches the state that EV-9 defaults to, should a power failure occur. It should be placed in the "NBP." position, for this procedure, ensuring that EV-9 remains open in the event of power failure.

E.5.2. Guard Tank

The Guard Tank is depleted and regulated to a pressure > 0.3 torr above atmosphere. Care must be taken at all times to keep its pressure above atmospheric.

E.5.3. Well

The Well is evacuated and the Well pump-out at VTH may be in one of the following configurations: 1) VTH closed with the VTH operator removed; 2) the Well manifold connected to a closed VTH; or 3) the Well manifold connected to an open VTH while the Well is being pumped through the manifold per procedure P0613 "Repump Well with Probe Installed".

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure should be less than 1×10^{-4} torr. However, if this procedure is being used in conjunction with up-righting the dewar (P0633) and the Main Tank liquid level is very low (< 30%), priority should be given to filling the Main Tank. The fill operation, by cooling the vapor cooled shields, will result in a vacuum shell pressure less than the required 1 x 10-4 torr, and pumping on the vacuum shell can be deferred to a later date. Document No. P0213 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) at $T \leq 6.0$ K.
   b. Top of lead bag temperature set (CN 29) at $T \leq 6.0$ K.
   c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 0.3$ torr.
2. The Watch Dog alarm must be armed.

E.5.6. GSE and Non-flight Hardware

1. A relief valve or flight-like burst disk may be installed in place of the SMD fill-line burst disk.
2. The ion-pump magnet must be 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). J801 and J802 (of the SMD) may be connected either to the ECU or to the Electrical Module.
4. The Main Tank vent line must be connected to the Gas Module with a vacuum insulated line, use procedure P0674, *Connect Main Tank Vent Line to Gas Module – Main Tank at NBP* if this is not the case.

5. The Guard Tank vent line is connected to the Gas Module.
6. The thruster vent port may be opened to a Endevco pressure transducer, STG.
7. The Fill Cap Assembly must be installed at SV-13 (Figure 3)
8. Top Plate heaters must be installed on SMD and be operational.

E.6. Optional Non-flight Configurations

The following non-flight modifications of the basic SMD and optional GSE configurations are incidental to the performance of this procedure. Any combination represents an acceptable configuration.

1. The SMD is installed in: the SMD transportation and test fixture or the space vehicle assembly fixture; or the space vehicle tilt dolly.
2. A foreign object and debris shield may cover the upper cone of the SMD. If it is not present, any object that could cause damage to the payload, if dropped, must be tethered.
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-14, or actively pumping the vacuum shell

E.7. Verification/ Success Criteria

N/A

E.8. Payload Constraints and Restrictions

N/A

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*
EM SYS229	*Accident/Mishap/Incident Notification Process*
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*

F.3. Additional Procedures

Document No.	*Title*
SU/GP-B P0213	*Connect Vacuum Module/ Pump on SMD Vacuum Shell*
SU/GP-B P0674	*Connect Main Tank Vent Line to Gas Module – Main Tank at NBP*

Operation Number: 1989
Date Initiated: 01/04/03
Time Initiated: 1000

G. Operations

G.1. Verify Preparations

G.1.1. Verify SU QA notified.
Record: Individual notified R. LEESE,
Date/time 1/4/03 / 1000.

G.1.2. Verify NASA representative notified.
Record: Individual notified E. INGRAHAM,
Date/time 1/4/03 / 1000.

G.1.3. If SMD connector J802 is connected to the ECU, verify that the Spacecraft is prepared to command RAV-2 when requested.
N/A

G.1.4. Record calibration due dates in Table 1 (Sec. E.4).

G.1.5. Verify that persons actually performing this procedure have initialed their names in Sec. D.3 and the name of the Test Director is circled.

G.1.6. Verify Pre-ops meeting with operations group has been conducted. (Checklist is in Appendix 1.)

G.1.7. Verify Purity of All Sources of Helium Gas

Record serial number on helium bottle/s.

1. _____ 2. _____ 3. _____ NONE VISIBLE
4. _____ 5. _____ 6. _____

G.1.8. Verify helium bottle/s have been tested for purity and record Op. Number. Op. Number: 1971

Date/time 01/04/03 / 1010.

Quality SU GP-B INSP 28 1/4/03

G.2. Verify Configuration Requirements

CAUTION
The Main Tank vent path is closed at EV-9 during the initial stages of this procedure to allow pressure for the transfer to build. During this period of closure the temperature at the top of the lead bag is appropriately alarmed and continuously monitored to detect trends prior to alarm. Corrective action for over temperature is given in Appendix 3.

G.2.1. Verify that the SMD is vertical. This procedure may be performed only in the vertical orientation.

G.2.2. Ensure DAS Watch Dog Alarm enabled.

G.2.3. Ensure that Top Plate heaters on SMD are operational.

G.2.4. Verify GSE cabling connected between SMD and Electrical Module and between SMD and Data Acquisition System.

G.2.5. Record MT pressure (EG-3 and/ or STG) 808 torr ✓ torr.

Note: if allowing pressure to build passively (see G.8.2) , Main Tank pressure must be greater than 15 torr above atmospheric before proceeding with initial Guard Tank fill.

G.2.6. 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. Complete P0674 through paragraph G.6.6 step 1 only (i.e., open SV-9 but **do not** reestablish Main Tank venting by opening EV-9).

G.2.7. Close /Verify closed EV-9 Date/Time 1/4/03 13:04

G.2.8. Verify DAS alarm system enabled and record set points.

1. Main Tank level ("A" or "B"): Record set point 42.9 %
2. Guard Tank Level ("A" or "B"): Record set point 0 %
3. Top of lead bag temperature – verify [CN 28] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point 5.5 K
4. Top of lead bag temperature – verify [CN 29] on DAS alarm list and set to alarm at T ≤ 6.0 K. Record set point N/A K
5. Relative Guard Tank Pressure – verify [CN 46] on DAS alarm list and set to alarm at ΔP ≥ 0.3 torr. Record set point 30 torr

G.2.9. Ensure Main Tank liquid-level alarm enabled.

G.2.10. Ensure Main Tank liquid-level alarm set ≥ 20%: Record. 20 %

Not Yet G.2.11. Verify Fill Cap Assembly installed at SV-13.

G.2.12. Ensure ion-pump magnet installed.

G.2.13. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day 1306
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) 6.95^{-6} torr. If pressure is above 1×10^{-4} torr, perform procedure P0213, *Connect of Vacuum Module / Pump on SMD Vacuum Shell,* to connect Vacuum Module and pump out SMD vacuum shell.

Note: If performing this procedure as part of up-righting the SMD and the Main Tank level is < 30%, fill the MT first after up-righting and then pump on the 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.

G.2.14. Verify liquid in Main Tank is at NBP (4.2<T<4.3) and record temperature at bottom of tank CN [9] 4.3454 K.

G.2.15. Verify Actuator Control for EV-9 set to "NBP" position.

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G.3. Verify Valve Configuration and Record Initial Conditions

G.3.1. Verify valve states as indicated in following Table. Record configuration in left-hand column, then verify corresponding valve states.

Verify Initial Valve States		
	Verify Open	**Verify Closed**
1. Main Tank vent Connected to GM		EV-9, EV-17
Guard Tank vent Connected to GM; depleted of LHe and pressure regulated at EV-23 (verify source of He gas at APR-2)	EV-16, EV-23 NA GTV-V, APR-2 GTV-Vb	EV-13, EV-20, EV-24 GTV-Va EV-23
2. Remaining EV valves	EV-7a/b	EV-4, EV-5, EV-6, EV-8, EV-10, EV-11, EV-12, EV-14, EV-15, EV-18, EV-19, EV-21/22
3. AV valves		All
4. Dewar Valves	GTV-V, SV-9	GTV-Va, V-12 (or STVa and STVb), SV-13, FCV

G.3.2. Record initial temperatures

1. Top of Lead Bag CN [28] 4.490 K.
2. Top of Lead Bag CN [29] 4.491 K.
3. Temperature at bottom of Main Tank CN [9] 4.2789 K.

G.3.3. Record pressures.

1. Guard Tank (GTV-G) CN [46]: 67.6 torr (relative to atm.).
2. Main Tank (STG) CN [49]: 479.8 torr. (Endevco on Thruster Vent Manifold)

G.3.4. Record liquid level in Main Tank 42.9 %.

G.3.5. Record Fill Cap Assembly pressure and verify that it reads >760 torr. If not, enter in D-log and consult Payload Test Director.

Fill Cap Assembly (PFCG): NA torr. NOT installed

G.3.6. Record status of Well pump-out:

- ☐ VTH closed and Well manifold not installed.
- ☐ Well manifold installed, record valve positions and pressure:

VTH ____ VW-3 ____, PW-1 ____ torr.

VW-3 closed

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Section G.3 complete. Quality ____ 1/4/03

G.4. Verify SMD In Standard Configuration

G.4.1. 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.4.2. Verify SV-9 open.

G.4.3. Verify SV-13, and FCV closed. N/A

G.4.4. Valve configuration:

	Open	Closed
EV valves	EV-7a/-b, EV-16, EV-23	All other EV-23
AV valves	APR-2	All other
Dewar valves	GTV-V, SV-9 GTV-Va	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-3, RAV-6B	All other
VF valves	N/A	N/A

Note: The regulator valves APR-1 and APR-2 are included in the open column when appropriate to indicate that they are actively involved in supplying gas at a regulated pressure. APR-1 feeds AV-9 and APR-2 feeds EV-23, the latter for GT pressurization.

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Section G.4 complete. Quality ____ 1/4/03

G.5. Set Up Data Acquisition System

Note: refer to DAS operating instructions for information on configurations and mechanics of keyboard/mouse operation.

G.5.1. Verify DAS set to configuration 4M. 446

G.5.2. Set DAS to fast scan mode using [other menus], [data config], [fast scan]

G.5.3. Record directory and data file name 301070.pcd

G.5.4. Start "Special Data Cycle" by using [Other Menus] + [Special Data Col] + [Use Pre-Selected], and from menu select "1 = Main Tank fill with Guard Tank empty", + [Init. Collectn] + [Enter] (=use default file). Use 0.1 minute cycle time.

175
24
96
44
105
42

G.5.5. Record directory and special data file name 6301070.

G.5.6. Set Main Tank and Guard Tank Liquid Level Sensor sampling intervals to 1 min.

G.5.7. Ensure printer is displaying special Data Cycle data.

G.6. Check Initial Pressure in Fill Line

- Ensure SV-13 closed. Install Filter

G.6.1. Install a pumping line between valve FCV on the Fill Cap Assembly and the Access Port #1 of the Auxiliary gas section.

G.6.2. Turn on pump AP-1.

G.6.3. Open AV-8 and AV-3.

G.6.4. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.6.5. Close AV-8 and FCV.

G.6.6. Once the pressure in the Fill Cap Assembly has stabilized, record Fill Cap Assembly pressure (PFCG): 2.2 torr.

G.6.7. Open valve SV-13 to bring Fill Cap Assembly up to SMD Fill line pressure and record

Fill line pressure (PFCG): 2.2 torr.

Section G.6 complete. Quality SU GP-B INSP 28 1/4/03

G.7. Raise Pressure in Fill Line to Main Tank Pressure

CAUTION:

Opening RAV-1 in the following steps may cause heating of the top of the Main Tank. Be prepared to proceed to the opening of RAV-2 to start the transfer without undue delay. The rate of temperature rise at the top of the lead bag (CN [28], CN [29]) should be monitored by the test director. If the temperature limit at the top of the lead bag is reached, be prepared to undertake Contingency Response #2 In Appendix 3.

G.7.1. Discontinue normal data cycles by using [D.C. off]

G.7.2. Verify that the Special Data Cycle is rolling over at 0.1 minute intervals.

G.7.3. Open RAV-1 using:

1. Ensure all RAV controller selection switches in OFF position.
2. Turn on RAV power supply and adjust current limit to 1.85 amps.
3. Adjust power supply to 28 VDC.
4. Power up controller #1.
5. Position selection switch for controller #1 to RAV-1.
6. Record initial status lights(4) on: Open: ❑ ❑ Closed: ☑ ☑ No lights
7. Activate controller #1 to open RAV-1 and record:
   a. Run time: 21.6 seconds.
   b. Current draw: 1.63 amps.
   c. Time of day: 13:38.
8. Record final status lights(4) on: ☑ ☑ Closed: ❑ ❑
9. When convenient, record operation in RAV log book.

G.7.4. Verify that the Fill Cap Assembly pressure (PFCG) rises to Main Tank pressure

1. Record Main Tank pressure (EG-3) 21.812 torr
2. Record Fill line pressure (PFCG): 748 torr.

G.7.5. Close SV-13 and torque to 60 in-lbs ± 5 in-lbs.

G.8. Prepare for Internal Transfer to Guard Tank

G.8.1. Prepare RAV-2 for activation

❑ J802 connected to Electrical Module:

1. Ensure selection switch for controller #2 in OFF position.
2. Power up controller #2.
3. Position selection switch for controller #2 to RAV-2.
4. Record status lights(4) on: Open: ❑ ❑ Closed: ❑ ❑

❑ J802 connected to the ECU:

5. Verify that operations personnel are prepared to operate RAV-2 on request.

G.8.2. Turn on Main Tank heater power supply, (H-8D or H-9D) as follows.

❑ Pressure in Main Tank to be raised by adding heat.

1. Verify liquid level of Main tank is > 40 % and the temperature at the top of the lead bag (CN[28]) is stable, if not, use the alternate process below; build pressure passively
2. Adjust current limit to 1.25 amps.
3. Starting the voltage at zero volts, incrementally increase the voltage to a maximum of 15 volts. Record heater settings and other data in the table at G.9.6

❑ Pressure in Main Tank is to be raised "passively".

4. Adjust current limit to 0.5 amps.
5. Adjust voltage output to zero volts.
6. If necessary, incrementally raise the heater voltage in one-volt steps. Record heater settings and other data in the table at G.9.7.

G.8.3. Verify Main Tank pressure (STG) > 15 torr above atmospheric pressure and record STG: 812 torr diff.

G.8.4. Valve configuration:

	Open	Closed
EV valves	EV-7a/-b, EV-16, EV-23	All other EV-23
AV valves	AV-3, APR-2	All other
Dewar valves	GTV-V, SV-9 GTV-Vc	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-1, RAV-3, RAV-6B	All other
VF valves	N/A	N/A

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Section G.8 complete. Quality 1/4/03

G.9. Initiate Transfer to Guard Tank

CAUTION
Pay close attention to the top of the lead bag temperatures as opening RAV-2 may further increase the rate of rise. Prepare to open EV-9 briefly (see contingency 2 of Appendix 3) if this happens.

G.9.1. Input comment to DAS "Start Internal transfer to Guard Tank".

G.9.2. Establish Guard Tank vent path.

1. Close EV-23 GTV-Va

2. Open EV-13 and record time 134.1

G.9.3. When Guard Tank pressure as read at (CN [46]) ≤ 7.1 torr diff, :

1. Record Guard Tank pressure (GTV-G), CN [46] 7.1 torr diff.
2. Immediately open RAV 2 (next step).

☐ J802 connected to Electrical Module:

3. Activate controlier #2 to open RAV-2 and record:
   a. Run time: 22.1 seconds
   b. Current draw: 1.75 amp
   c. Time of day: 1347

INITIAL: I CLOSE LIGHT

4. Record final status lights(4) on: Open: ☑ ☑ Closed: ☐ ☐
5. When convenient, record operation in RAV log book.

☐ J802 connected to the ECU:

6. Request operations personnel to open RAV-2 and record time of day: _____.
7. Record valve status indication from operations personnel when the information is available: _____
8. When convenient, record operation in RAV log book.

G.9.4. When RAV-2 operation is completed, immediately open EV-6 and EV-18.

G.9.5. Confirm transfer by noting Guard Tank vent gas flow and, ultimately, an increase in the Guard Tank liquid level.

G.9.6. Adjust Main Tank heater voltage, as necessary, to maintain a reasonable transfer rate.

CAUTION

Use of the Main Tank heater will heat the MT ullage as well as the liquid and should be done sparingly when the Main Tank level is < 40%.

G.9.7. Record data in the following table.

Time	MT Pressure EG-3 (torr)	GT Pressure GTV-G (torr)	GT Temp CN [24]	MT Heater Voltage (V)	MT LLS (%)	GT LLS (%)	Comments
13:46	808	.2065	4,228	0	42.7	3.4	
14:00	801	.04883	4,243	0	42.3	8.4	
14:21	796	.0714	4,238	5	41.7	16.4	

~~G.9.8.~~ When the Guard Tank liquid level reaches 15%:

~~1.~~ Turn off Main Tank heater

2. Terminate transfer (perform following section).

	Open	Closed
EV valves	~~EV-6, EV-7a/-b, EV-13, EV-16, EV-18~~	~~All other~~
AV valves	~~AV-3~~	~~All other~~
Dewar valves	~~GTV-V, SV-9~~	~~GTV-Va, ST-Va/Vb, SV-13, FCV~~
RAV valves	~~RAV-1, RAV-2, RAV-3, RAV-6B~~	~~All other~~
VF valves	N/A	~~N/A~~

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Section G.9 complete. Quality 1/4/03

G.10. Terminate Transfer to Guard Tank

G.10.1. Close RAV-1 as follows:

~~1.~~ Verify controller #1 powered up and selection switch set to RAV-1.

~~1.~~ Controller #1 powered up and set to RAV-1.

2. Controller #1 not powered up — perform the following steps:
   a. Ensure selection switch for controller #1 in off position
   b. Power up controller #1.
   c. Position selection switch for controller #1 to RAV-1.

~~2.~~ Record initial status lights(4) on: Open: ❑ ❑ Closed: ❑ ❑ No lights

3. Activate controller #1 to close RAV-1 and record:
   a. Run time: 21.0 seconds
   b. Current draw: 1.72 amp
   c. Time of day: 14:45

~~4.~~ Record final status lights(4) on: ❑ ❑ Closed: ☑ ❑

~~5.~~ Turn selection switch for controller #1 to OFF.

6. Power off controller #1.

7. When convenient, record operation in RAV log book.

G.10.2. Configure Guard Tank vent valves as follows

1. Close EV-6, and EV-18.

~~2.~~ Close EV-13.

3. Open EV-20.

G.10.3. Open EV-9 and record time 14:47

G.10.4. Enter comment to DAS "Open EV-9 - end internal GT transfer."

G.10.5. Once conditions have stabilized, record:

1. Guard Tank Pressure (GTV-G): 1154 torr (relative to atm.).
2. Main Tank pressure (EG-3): 788 torr.
3. Flow rate EFM-1 _____ ~~slpm~~.

16.22 SCCM

G.10.6. Record liquid levels:

1. Main Tank level ("A" or "B"): 30.9 %
2. Guard Tank Level ("A" or "B"): 30.6 %

G.11. Install Stinger in LHSD

CAUTION

The following operations involve steps that pose cryogenic safety hazard. To prevent injury, the person performing the stinging operation must wear protective gloves, face shield, and apron.

Note: Use appropriate extension for the LHSD being used and clean and inspect all O-rings and mating surfaces.

G.11.1. Reduce LHSD pressure to < 1.0 psig by opening low-pressure relief. LHV-2.

G.11.2. Open valve VF-1 (Liquid withdrawal valve) on the stinger.

G.11.3. Slowly insert stinger into LHSD while purging. Position stinger withdrawal end approx. 1-in. above bottom of LHSD and tighten quick disconnect.

G.11.4. Close valve VF-1 just as cold gas is expelled from stinger.

G.11.5. Close the primary (low-pressure) relief valve, LHV-2, on the LHSD.

G.11.6. Increase LHSD ullage pressure builder to 8 to 10 psig by performing the following steps:

1. Attach a GHe hose to the VENT outlet (LHV-1) of the LHSD while purging the hose and the VENT outlet.
2. Adjust pressure regulator to obtain 8 to 10 psig in LHSD.

G.11.7. Record LHSD data:

Date / time: 1/4/03 / 1507
Liquid level 74 %
LHSD serial number: 237

G.11.8. LHSD valve positions:

Open: LHV-1; Closed: all other

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Section G.11 complete. Quality 1/4/03

G.12. Install Fill Line Assembly

Note: Two transfer lines are available for use. One has an integrated filter and connects directly to bayonet B3 at the dewar. The other has a separate filter that is first installed at bayonet B3 (the latter case is shown in Fig. 5), after which the fill line is connected to the filter.

G.12.1. Record fill line used:

- ☑ Fill line with integrated filter
- ☐ Fill line and separate filter

G.12.2. Backfill Pumping line and Fill Cap Assembly as follows:

1. Ensure AV-8 closed.
2. Open AV-1
3. Open AV-9 until pressure reaches 0 psig at AG-1, then close AV-9.
4. Close AV-1.

G.12.3. Remove the pumping line from the fill cap assembly.

G.12.4. Remove fill cap assembly from bayonet B2.

G.12.5. Install Filter Line Assembly (P/N 5833827) to Dewar Fill Bayonet B3 if used.

G.12.6. Install Fill Line Assembly as follows:

1. Mate the Fill Line (P/N 5833804) with the LHSD Stinger at VF-1.
2. Mate VF-2 end of transfer line with Filter Line Assembly or B3 as appropriate.
3. Ensure VF-2 and relief valve stems pointed upwards.
4. Ensure VF-3 closed.
5. Connect a low-impedance facility vent line to the KF fitting at VF-3.

G.12.7. Valve configuration:

	Open	Closed
EV valves	EV-7a/-b, EV-9, EV-16, EV-20	All other
AV valves	AV-3, APR-1	All other
Dewar valves	GTV-V, SV-9	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-2, RAV-3, RAV-6B	All other
VF/VH valves	LHV-1	VF-1, VF-2, VF-3, LHV-2, LHV-3

Section G.12 complete. Quality SU GP INSP 28 1/9/03

G.13. Condition Transfer Line/Filter/Stinger Assembly

G.13.1. Configure Pumping Line as follows:

1. Connect 1.5-in diameter flexible pumping line mated to Access-1 of Gas Module to VF-3.

G.13.2. Evacuate Transfer Line:

1. Open valve VF-2.
2. Open/verify open AV-3.
3. Open AV-8.
4. Close AV-8 when pressure reaches less than 50 mtorr as read on gauge AG-2.

G.13.3. Backfill Transfer Line:

1. Open AV-1.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.
3. Close AV-1.

G.13.4. Evacuate Transfer Line (second time):

1. Open AV-8.
2. Close AV-8 when pressure reaches less than 50 mtorr as read on gauge AG-2.

G.13.5. Backfill Transfer Line (second time):

1. Open AV-1.
2. Open AV-9 until pressure reaches 0.5 psig as read on gauge AG-1 and then Close AV-9.
3. Close AV-1

G.13.6. Valve configuration

	Open	Closed
EV valves	EV-7a/-b, EV-9, EV-16, EV-20	All other
AV valves	AV-3, APR-1	All other
Dewar valves	GTV-V, SV-9	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-2, RAV-3, RAV-6B	All other
VF/LH valves	VF-2, LHV-1	VF-1, VF-3, LHV-2, LHV-3

Section G.13 complete. Quality SU GP-B INSP 28 1/4/03

G.14. Start Guard Tank Transfer

Note: This section starts the transfer by precooling the SMD internal Fill Line by pushing liquid up from the Guard Tank.

CAUTION
Transfer startup is a critical operation. All potentially interfering operations must be suspended. A qualified test director/engineer must be assigned to monitor temperatures at the top of the lead bag during pre-cool and initial startup of transfer.

G.14.1. Turn on Main and Guard Tank vent line heat exchangers (EH-1, EH-2).

G.14.2. Ensure VF-3 closed

G.14.3. Open/verify open VF-2.

G.14.4. Open SV-13.

G.14.5. Ensure Guard Tank pressure is grater than atmospheric pressure and :

Record Guard Tank pressure CN[46] (GTV-G): 0.27 torr diff.

G.14.6. Verify EV-17 closed.

G.14.7. Verify EV-9 open.

G.14.8. Close EV-20.

G.14.9. Turn on power supply for Guard Tank heater (H-3D or H-4D).

1. Set power supply current limit to 0.07 amps.
2. Set power supply voltage to 50 volts.

G.14.10. Record voltage 50 vdc, and current .06 amps.

G.14.11. Open VF-3: starting precool of fill line.

G.14.12. When Fill Valve (SV-13) temperature T-24D [CN 42] is <73 K:

1. Power off Guard Tank heaters.

2. Close SV-13.
3. **Immediately** open VF-1 to start pre-cooling of transfer line.

G.14.13. Configure Guard Tank venting

1. Close EV-9.
2. Open EV-13.

G.14.14. When the facility vent line connected to VF-3 indicates adequate cooling of the transfer line, initiate transfer to Guard Tank as follows:

1. Close VF-2 and immediately.
2. Open SV-13.
3. Record time of day 1545.

G.14.15. Open EV-6 and EV-18.

G.14.16. When Guard Tank pressure (EG-1a) drops to less than 3 torr above the Main Tank pressure (EG-3), then,

1. Open EV-9.

G.14.17. Verify start of transfer by observing an increasing flow rate at PFM-1 and record PFM-1 81 Liquid liters/hr.

G.14.18. Input comment to DAS "Starting external fill of GT".

G.14.19. Record all fill data on the attached data sheets every 15 minutes.

G.14.20. Adjust LHSD pressure:

1. Close pressurization valve, LHV-1, at the LHSD.
2. Adjust the gas supply pressure regulator, APR-3, to the desired pressure (as high as possible without exceeding 10 psig at the LHSD).
3. Reopen pressurization valve at LHSD.

G.14.21. Close VF-3 when it thaws out.

G.14.22. When Guard Tank is filled to desired level:

1. Record Guard Tank level (circle unit used "A" or "B") 35 %
2. If J802 is connected to the ECU, verify that operations personnel are prepared to operate RAV-2 on request.
3. Switch to Main Tank fill: perform following section.

G.14.23. Valve configuration:

	Open	Closed
EV valves	EV-6, EV-7a/-b, EV-9, EV-13, EV-16, EV-18	All other
AV valves	AV-3, APR-1	All other
Dewar valves	GTV-V, SV-9, SV-13	GTV-Va, ST-Va/Vb, FCV
RAV valves	RAV-2, RAV-3, RAV-8B	All other
VF valves	VF-1, VF-8	VF-2

Section G.14 complete. Quality GP-B INSP 28 1/4/03

G.15. Switch from Guard Tank to Main Tank Fill

G.15.1. Open RAV-1 (MT fill valve) by performing the following steps:

1. Ensure selection switch for controller #1 is in OFF position.
2. Power up controller #1.
3. Position selection switch for controller #1 to RAV-1.
4. Record initial switch status: Open: ☐ ☐ Closed: ☐ ☐
5. Activate controller #1 to open RAV-1 and record:
   a. Run time: 21.8 seconds
   b. Current draw: 1.71 amps
   c. Time of day: 16:12 .
6. Record initial status lights(4) on: ☐ ☐ Closed: ☐ ☐
7. When convenient, record operation in RAV log book.

G.15.2. Open/verify open EV-6 and EV-18.

G.15.3. Close RAV-2 (GT fill valve) by performing the following steps:

- ☐ J802 connected to Electrical Module:
  1. Setup controller #2 :
  - ☐ Controller #2 is powered up and set to RAV-2 go to step 2.
  - ☐ Controller #2 is not powered up do the following steps:
    a. Ensure selection switch for controller #2 is in OFF position.
    b. Power up controller #2.
    c. Position selection switch for controller #1 to RAV-2.
  2. Record initial status lights(4) on: ☐ ☐ Closed: ☐ ☐
  3. Activate controller #2 to close RAV-2 and record:
     a. Run time: 21.2 seconds
     b. Current draw: 1.75 amps
     c. Time of day: 16.13.
  4. When convenient, record operation in RAV log book. left closed

- ☐ J802 connected to the ECU:
  5. Request operations personnel to close RAV-2 and record time of day: _____.
  6. Record valve status indication from operations personnel when the information is available: _____
  7. When convenient, record operation in RAV log book.

G.15.4. Input comment to DAS "Switch from GT to MT fill".

G.15.5. Valve configuration:

	Open	Closed
EV valves	EV-6, EV-7a/-b, EV-9, EV-13, EV-16, EV-18	All other
AV valves	AV-3, APR-1	All other
Dewar valves	GTV-V, SV-9, SV-13	GTV-Va, ST-Va/Vb, FCV
RAV valves	RAV-1, RAV-3, RAV-6B	All other
VF valves	VF-1	VF-2, VF-3

Section G.15 complete. Quality SU GP-B INSP 28 1/4/03

G.16. Monitor Main Tank Fill

G.16.1. Continue recording data in Data Sheets.

G.16.2. Maintain LHSD ullage pressure between 6 and 10 psig.

G.16.3. **Note:** A full Dewar or empty LHSD is indicated by a rapid and consistent increase in the flow rate.

G.16.4. Verify the transfer is complete, LHSD empty, when the LHSD level is zero and a rapid and consistent increase in the flow rate is observed.

G.16.5. Proceed **IMMEDIATELY** to the next section.

G.17. Terminate Transfer

CAUTION

The Guard Tank may tend to subcool following the completion of this procedure. Maintain positive pressure in the Guard Tank by ensuring the Guard Tank and Main Tank are venting in common.

G.17.1. Stop the flow of liquid helium

1. Close VF-1.
2. Close SV-13 and torque to 60 ± 5 in-lbs and immediately open VF-2.
3. Close EV-6 and EV-18.

G.17.2. Establish Guard Tank vent configuration.

1. Verify GTV-V open.

2. Verify EV-9, EV-13 and EV-16 open.

3. Record CN [46] (GTV-G) 15.65 torr (relative to atm.)

G.17.3. Remove the pumping line at valve VF-3.

G.17.4. Remove the Transfer/ Filter Lines from the Dewar fill bayonet B3 and;

G.17.5. **Immediately** install the Fill Cap Assembly with FCV closed.

G.17.6. Valve configuration:

	Open	Closed
EV valves	EV-7a/-b, EV-9, EV-13, EV-16	All other
AV valves	AV-3, APR-1	All other
Dewar valves	GTV-V, SV-9	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-1, RAV-3, RAV-6B	All other
VF valves	N/A	N/A

Section G.17 complete. Quality SU JP.B 1/4/03

G.18. Remove Stinger from LHSD

CAUTION
The following operations involve steps that pose cryogenic safety hazard. To prevent injury, the person handling the stinger must wear protective gloves, face shield, and apron.

G.18.1. Shut off the GHe supply used to pressurize the LHSD.

G.18.2. Close LHV-1 (VENT outlet valve of the LHSD), and disconnect the pressurization line.

G.18.3. Crack open LHV-1 and LHV-2, the primary (low-pressure) relief valve, to allow the LHSD to depressurize.

G.18.4. When the primary relief valve at LHV-2 stops venting, completely open LHV-1 and carefully remove the stinger from the LHSD.

G.18.5. Close LHV-1 (the VENT outlet valve).

G.18.6. Ensure that LHV-2, the primary (low-pressure) relief valve, is fully open

Section G.18 complete. Quality SU JP.B 1/4/03

G.19. Condition Dewar Fill Line

G.19.1. Connect a pumping line between the Fill Cap Assembly at valve FCV and the Auxiliary Gas Section access port no. 1.

G.19.2. Ensure valves AV-1 and AV-9 closed.

G.19.3. Ensure AP-1 on.

G.19.4. Open AV-8 and AV-3.

G.19.5. Open valve FCV and evacuate Fill Cap Assembly to <25 mtorr measured at AG-2B.

G.19.6. Close FCV.

G.19.7. Open SV-13.

G.19.8. Close RAV-1

(Note: At this time, relief of fill line is through Fill Cap Assembly)

1. Verify that RAV controller #1 is already on and that controller #1 selection switch is already set to RAV-1. if not perform the following steps:

☑ Controller #1 powered up and set to RAV-1.

☐ Controller #1 not powered up — perform the following steps:

a. Ensure selection switch for controller #1 in off position

b. Power up controller #1.

c. Position selection switch for controller #1 to RAV-1.

2. Record initial status lights(4) on: Open: ❑ ❑ Closed: ❑ ❑ No light

3. Activate controller #1 to close RAV-1 and record:

a. Run time: 21.1 seconds

b. Current draw: 1.63 amp

c. Time of day: 20:23

4. Record final status lights(4) on: Open: ❑ ❑ Closed: ❑ ❑

5. When convenient, record operation in RAV log book.

G.19.9. Turn OFF all RAV controllers as follows:

1. Turn all RAV selection switches to OFF.

2. Power off all controllers.

3. Turn off RAV power supply.

G.19.10. Open FCV and evacuate the Dewar fill line to < 25 mtorr as measured

at AG-2b.

G.19.11. Close SV-13 and torque to 60 +/- 5 in-lbs.

G.19.12. Close FCV

G.19.13. Close AV-8.

G.19.14. Open AV-1.

G.19.15. Open AV-9 until pressure reaches 1.5 psig on AG-1, then close AV-9.

G.19.16. Close AV-1.

G.19.17. Monitor the pressure in the Fill Cap Assembly for 15 minutes to be sure it maintains vacuum and record:

Initial PFCG pressure: 1.8 torr Date/Time: 1/4/03 / 2047

Final PFCG pressure: 1.9 torr Date/Time: 1/4/03 / 2101

Note: If PFCG drops by more than 2.0 torr in 30 minutes, open FCV and AV-8 and pump until AG-2b is less than 25 mtorr then repeat steps G.18.13 through G.18.17.

Section G.19 complete. Quality SU GP-B INSP 28 1/4/03

G.20. Record Configuration of Dewar and GSE

G.20.1. Verify valve states are as indicated in following Table

	Open	Closed
EV valves	EV-7a/-b, EV-9, EV-13, EV-16	All other
AV valves	AV-8, APR-1	All other
Dewar valves	GTV-V, SV-9	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-3, RAV-8B	All other
VF valves	N/A	N/A

G.20.2. Record the final liquid levels as appropriate:

1. Main Tank level ("A" or "B"): 65.6 %
2. Guard Tank Level ("A" or "B"): 35.8 %

G.20.3. Record Main Tank pressure (EG-3): 787 torr:

G.20.4. Turn off Main and Guard Tank vent-line heat exchangers (EH-1, EH-2).

G.20.5. Ensure all RAV operations recorded in log book.

Section G.20 complete. Quality_____ 11/4/05

G.21. Place Data Acquisition System in Standard Configuration

Note: refer to DAS operating instructions for information on configurations and mechanics of keyboard/mouse operation.

G.21.1. Input comment to DAS "Completed External NBP fill of Main Tank".

G.21.2. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.21.3. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day _____ Newton

2. Use DAS [Monitor Data] for CN 99.

3. When value is steady, record pressure (IP) 6.28^{-6} torr.

4. Exit [Monitor Data] and collect data with [Set Data Interval] to 15 min.

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

G.21.4. Set DAS to normal scan mode using [other menus], [data config], [normal scan]

G.21.5. Set Main Tank liquid level sampling interval to 10 minutes.

G.21.6. Set Guard Tank liquid level sampling interval to 10 minutes.

G.21.7. Ensure that Vac-ion pump is off.

G.21.8. Ensure DAS alarm enabled and record set points if changed

3. Thermal conditions substantially unchanged, alarm set points for Station 200 and lead bag are unchanged and set to alarm.

4. Thermal conditions substantially changed, temperature alarm points reset as follows:

a. Top of Lead Bag set point [CN 175/28] 5.0 K (≤ 6.0 K)

b. Top of Lead Bag set point [CN 178/29] 5.0 K (≤ 6.0 K)

G.21.9. Ensure liquid level sensor alarms enabled on Main Tank and Guard Tank and record set points if changed.

1. Main Tank Level Set Point 20 %

2. Guard Tank Level Set Point 10 %

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.

G.21.10. Ensure Guard Tank pressure on DAS alarm list and set to alarm at 0.3 torr diff.

G.21.11. Ensure Facility Main Alarm System enabled.

G.21.12. Ensure DAS watchdog timer and alarm enabled.

Section G.20 complete. SU GP-B INSP 28 1/4/03

G.22. Perform Final Closure of SV-13 and Conditioning the Dewar Fill Cap Assembly

G.22.1. Once SV-13 has warmed sufficiently to try final closure perform the following steps.

Note: The time required may be a few hours.

G.22.2. Verify that the Fill Cap Assembly is still evacuated and record:

Date: 1/6/03 Time of day 1105

PFCG pressure: 19.9 torr

G.22.3. Retorque SV-13 to 60 ± 5 in-lbs.

G.22.4. Open FCV.

G.22.5. VERIFY AP-1 ON Open/Verify open AV-3.

G.22.6. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.22.7. Close AV-8.

G.22.8. Ensure EV-12 closed.

G.22.9. Open AV-1.

G.22.10. Open AV-9 until pressure reaches 1.5 psig as read on gauge AG-1 and then close AV-9.

G.22.11. Close FCV.

G.22.12. Close AV-1 and record:

1. Time of day: 1110
2. Initial PFCG pressure: 844.7

G.22.13. Open AV-8 and evacuate to < 25 mtorr as measured at AG-2b.

G.22.14. Close AV-8.

G.22.15. Verify closure of SV-13 and FCV by verifying the pressure in the Fill Cap Assembly (PFCG) does not drop by more than 1.0 torr over 30 minutes.. After 30 minutes record:

1. Time of day: 1140
2. Final PFCG pressure: 844.6

Note: If PFCG drops by more than 1.0 torr in 30 minutes, repeat steps G.21.2 through G.21.14.

G.22.16. Open AV-1.

G.22.17. Open AV-9 until pressure reaches 0 psig as read on gauge AG-1 and close AV-9.

G.22.18. Close AV-1.

G.22.19. Close AV-3.

G.22.20. Turn off pump AP-1

G.22.21. (Optional) Remove pumping line from Fill Cap Assembly.

G.22.22. (Optional) Install KF-25 blank-off cap on valve FCV.

G.22.23. Valve configuration:

	Open	Closed
EV valves	EV-7a/-b, EV-9, EV-13, EV-16	All other
AV valves	None	All other
Dewar valves	GTV-V, SV-9	GTV-Va, ST-Va/Vb, SV-13, FCV
RAV valves	RAV-3, RAV-6B	All other
VF valves	N/A	N/A

G.22.24. Perform Post-Operations Checklist (Appendix 2)

Section G.22 complete. Quality SU GP-B INSP 28 1/6/03

H. Procedure Completion

Completed by: _____

Witnessed by: _____

Date: 1/16/03

Time: 1145

Quality Manager _____ **Date** 1/16/03

Payload Test Director _____ **Date** 3/14/03

Data Sheet 1

Date/Time 1/4/03	LHSD Level (%)	LHSD press (psig)	Main Tank pressure EG-3 (Torr)	Guard Tank pressure EG-1a (Torr)	LHe Flow PFM-1 [B] (l/hr)	Main Tank Liquid He Level (%)	Guard Tank Liquid He Level (%)	
16:15	70.2	8	770	775	36.40	40.7	39.1	
1630	67	7.6	773	774	53.0	42.2	38.7	
1645	63	8.3	774	775	56.6	43.6	38.6	
1700	59	8.6	774	776	58.5	45.2	38.4	
1715	54	8.8	775	775	60.3	46.7	38.4	
1730	50	9.2	775	776	62.3	48.5	38.2	
1745	45	9.4	776	777	64.6	50.1	38.1	
1800	41	9.5	777	777	66.9	51.7	37.9	
1815	36	9.5	777	774	71.03	53.5	37.8	
1830	30	10	778	774	70.45	55	37.4	
1900	22.5	10	779	774	77.11	58.2	37.0	
1930	14	10	779	774	7049	62	36.7	
20:00	2	10	780	774	80.30	65.3	36.1	

Data Sheet 2

reads 10C too high } ↓ GT / MT Bayo

Date Time 1/4/03	Lead bag top T-20D [28] (K)	Lead bag top T-21D [29] (K)	G.T. bottom T-15D [24] (K)	HX-4 T-08D[8] (K)	M.T. bottom T-09D [9] (K)	Vac-Ion Pump (torr)	Gas Mod HX GT/MT (°C/°C)	MT Vent Bayonet/ Baynt Nut (°C/°C)	SV-9 Valve/ Top Plate (°C/°C)	~~Top~~ Plate Cyl(2) (°C/°C)
1615	4.921	4.921	4.245	—	4.2592	2.15^{-7}	51/6	25/20	19/30	25/25
1630	4.830	4.831	4.230	—	4.264	4.28^{-7}	38/9	25/18	19/30	25/25
1645	4.776	4.776	4.229	—	4.265	9.89^{-7}	8/9	24/20	20/30	24/24
1700	4.730	4.730	4.230	—	4.265	5.57^{-7}	10/9	24/20	20/30	25/25
1715	4.682	4.683	4.230	—	4.266	5.21^{-7}	19/10	25/20	20/30	25/25
1730	4.628	4.629	4.230	—	4.267	3.37^{-7}	11/10	25/19	20/30	25/25
1745	4.576	4.577	4.230	—	4.268	2.67^{-7}	14/10	25/20	20/30	24/25
1800	4.522	4.523	4.231	—	4.270	2.32^{-7}	15/10	25/20	20/30	24/25
1815	4.490	4.491	4.231	—	4.2714	2.05^{-7}	17/10	23/20	20/30	25/25
1830	4.444	4.446	4.231	—	4.2718	1.90^{-7}	8/10	25/20	20/30	25/25
1900	4.374	4.376	4.233	—	4.2742	1.78^{-7}	13/10	25/20	20/30	25/25
1930	4.331	4.333	4.234	—	4.2757	1.6^{-7}	16/10	25/20	20/30	25/25
20:00	4.315	4.317	4.235	—	4.2777	1.47^{-7}	10/9	25/20	20/30	25/25

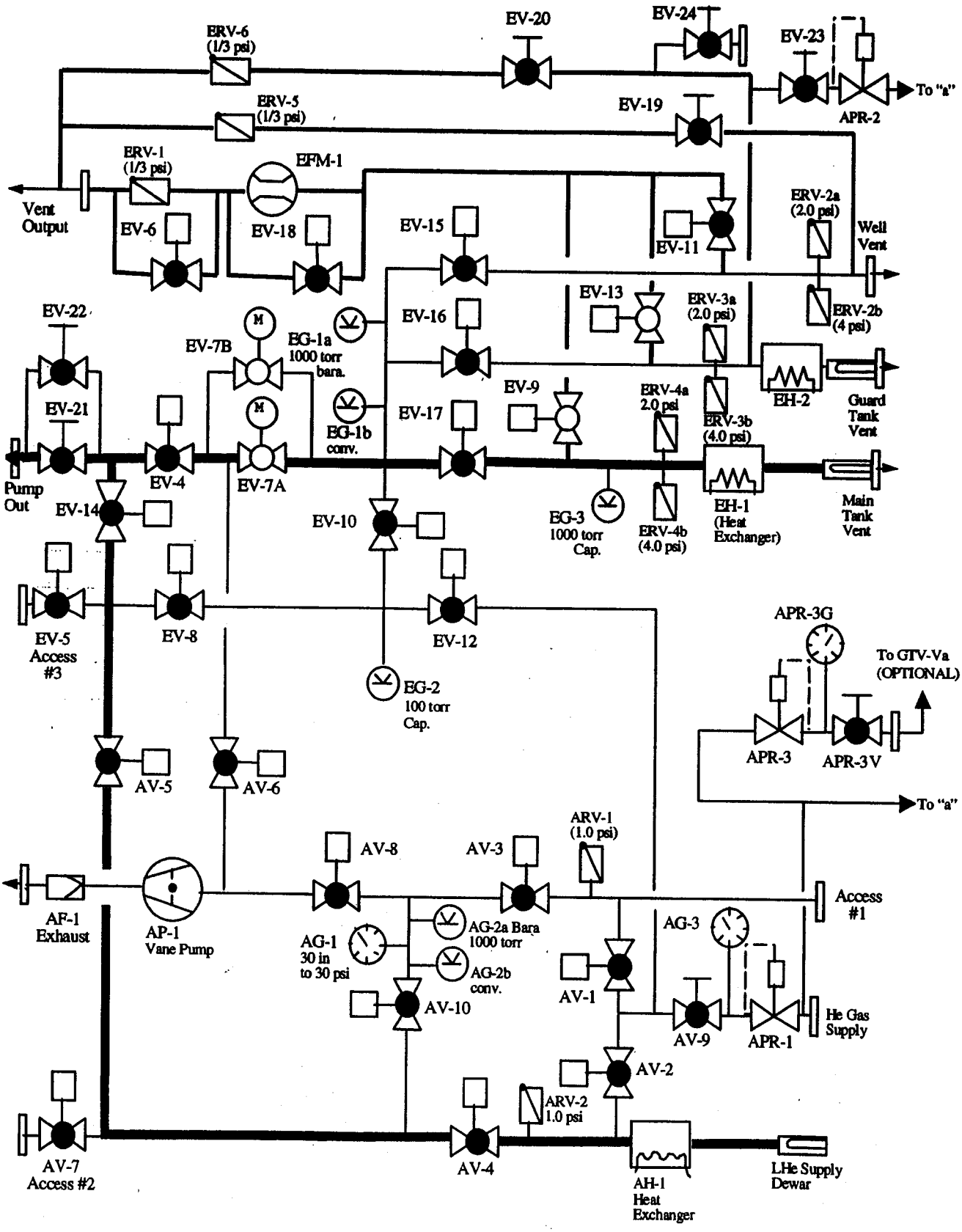


Figure 1. Schematic of Gas Module Plumbing.

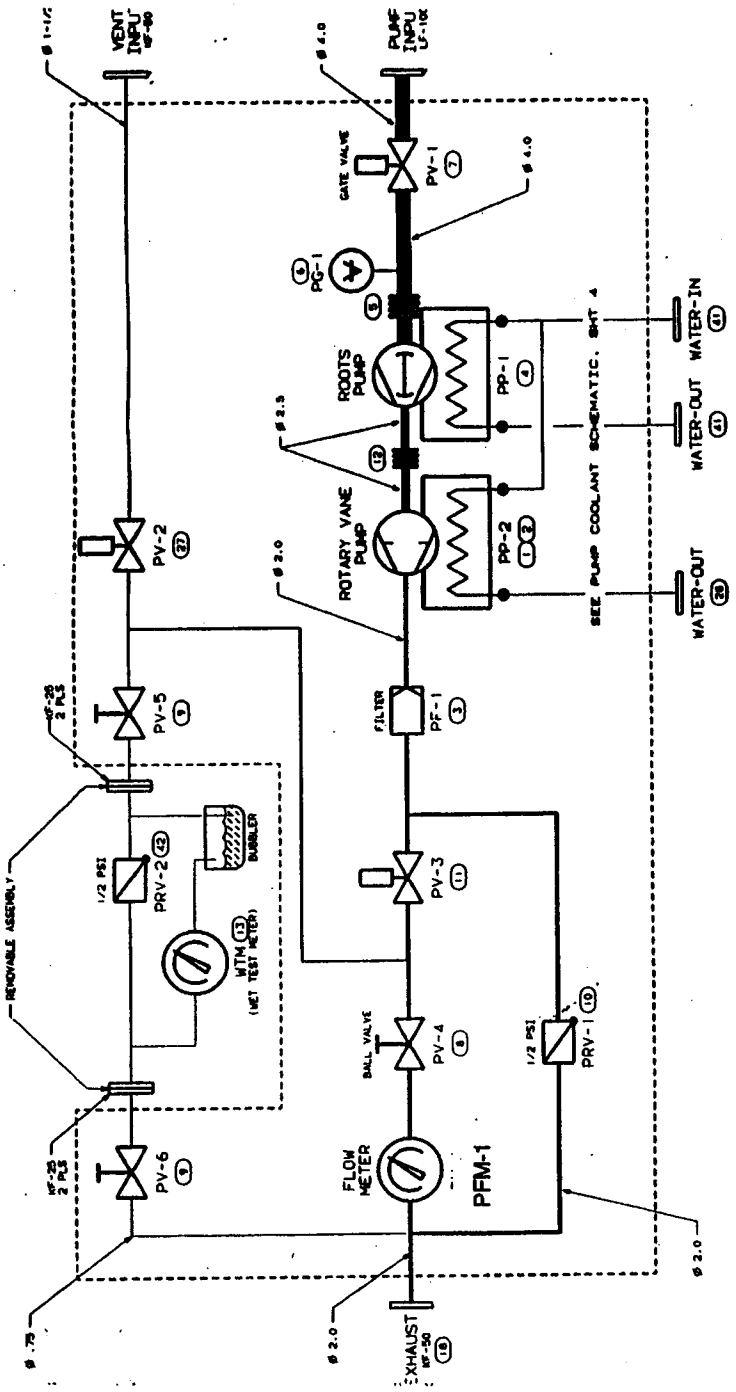


Figure 2. Schematic of Pump Module plumbing.

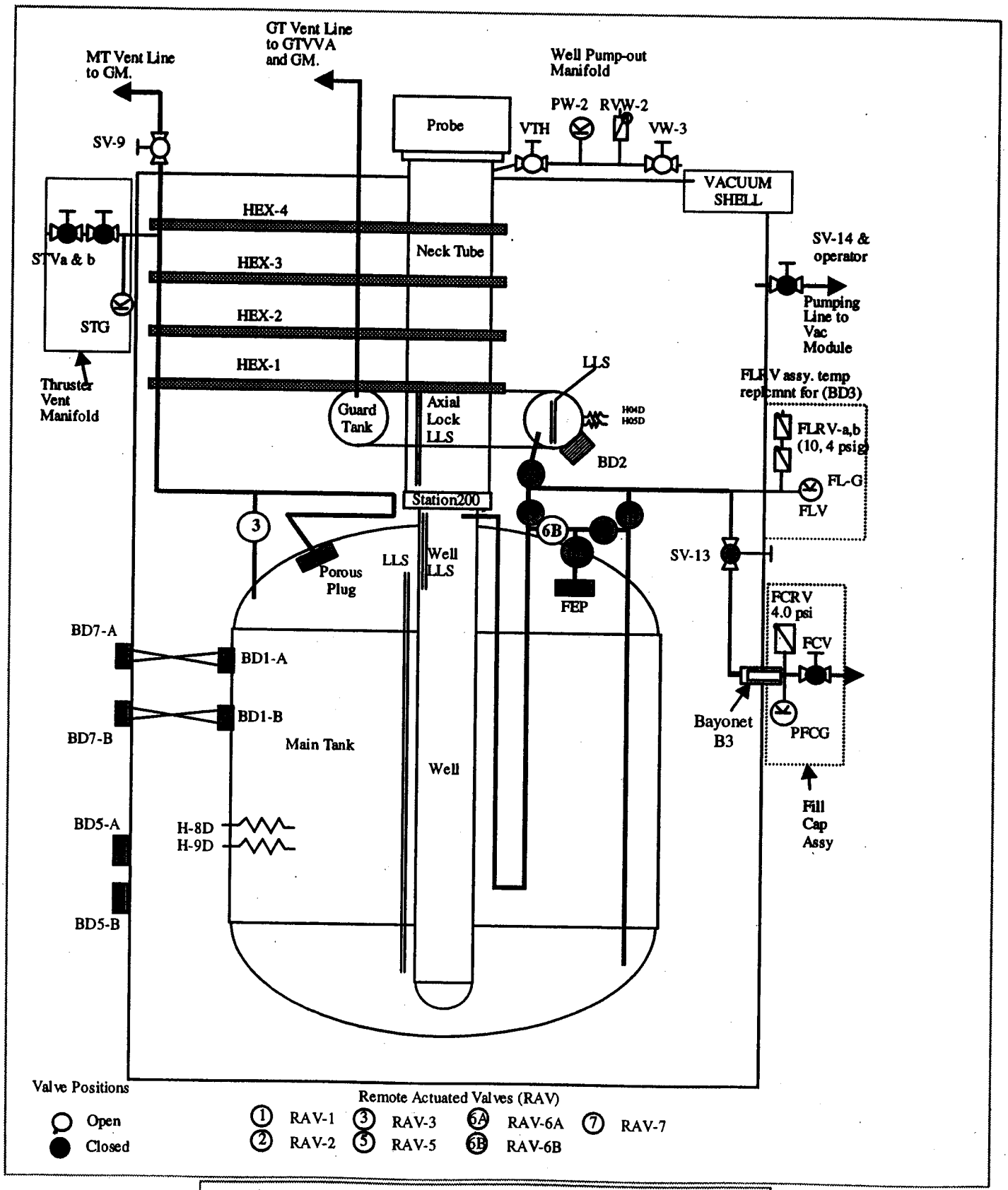


Figure 3. Schematic of Science Mission Dewar plumbing

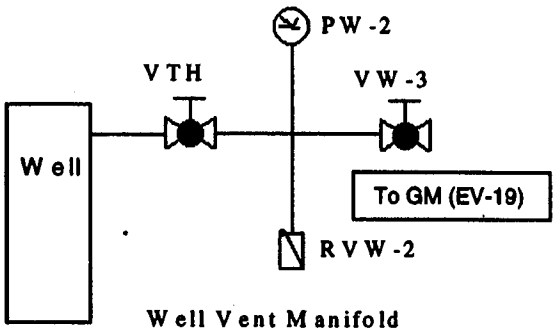


Figure 4 Well vent manifold.

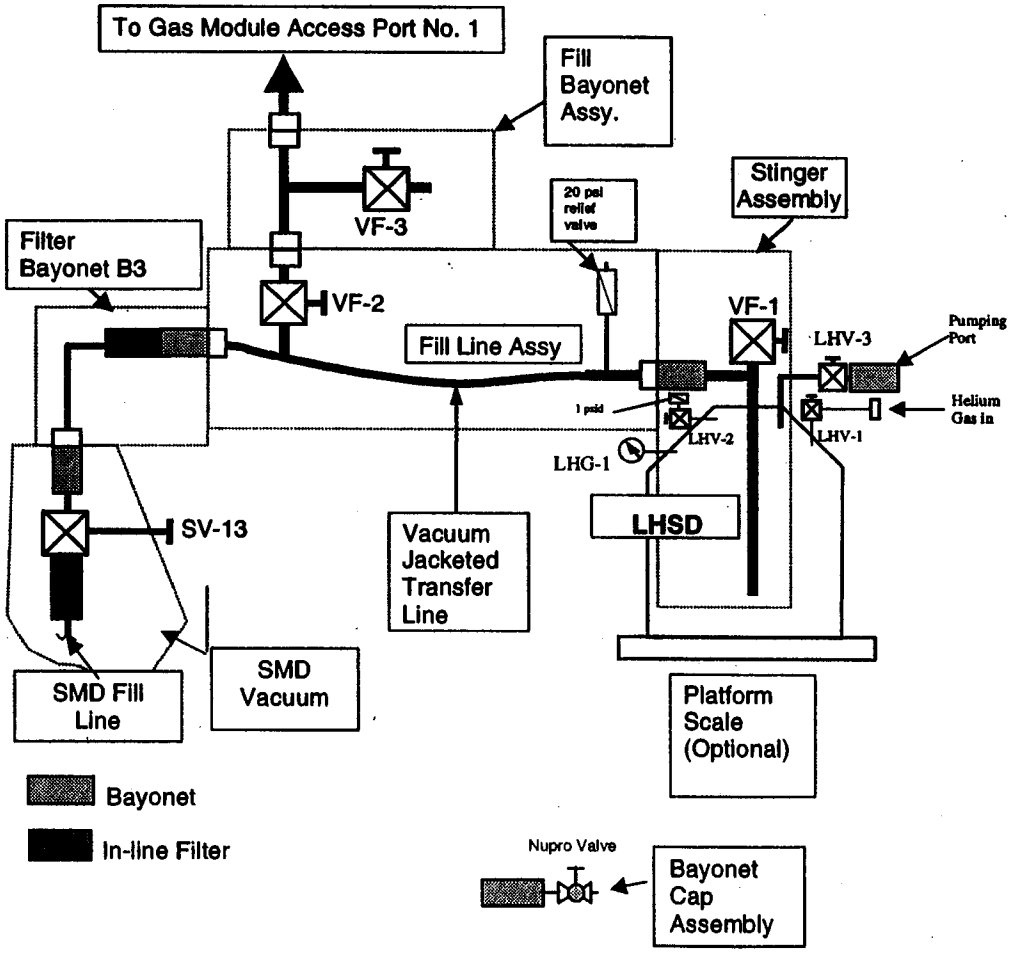


Figure 5. Schematic of liquid helium transfer plumbing

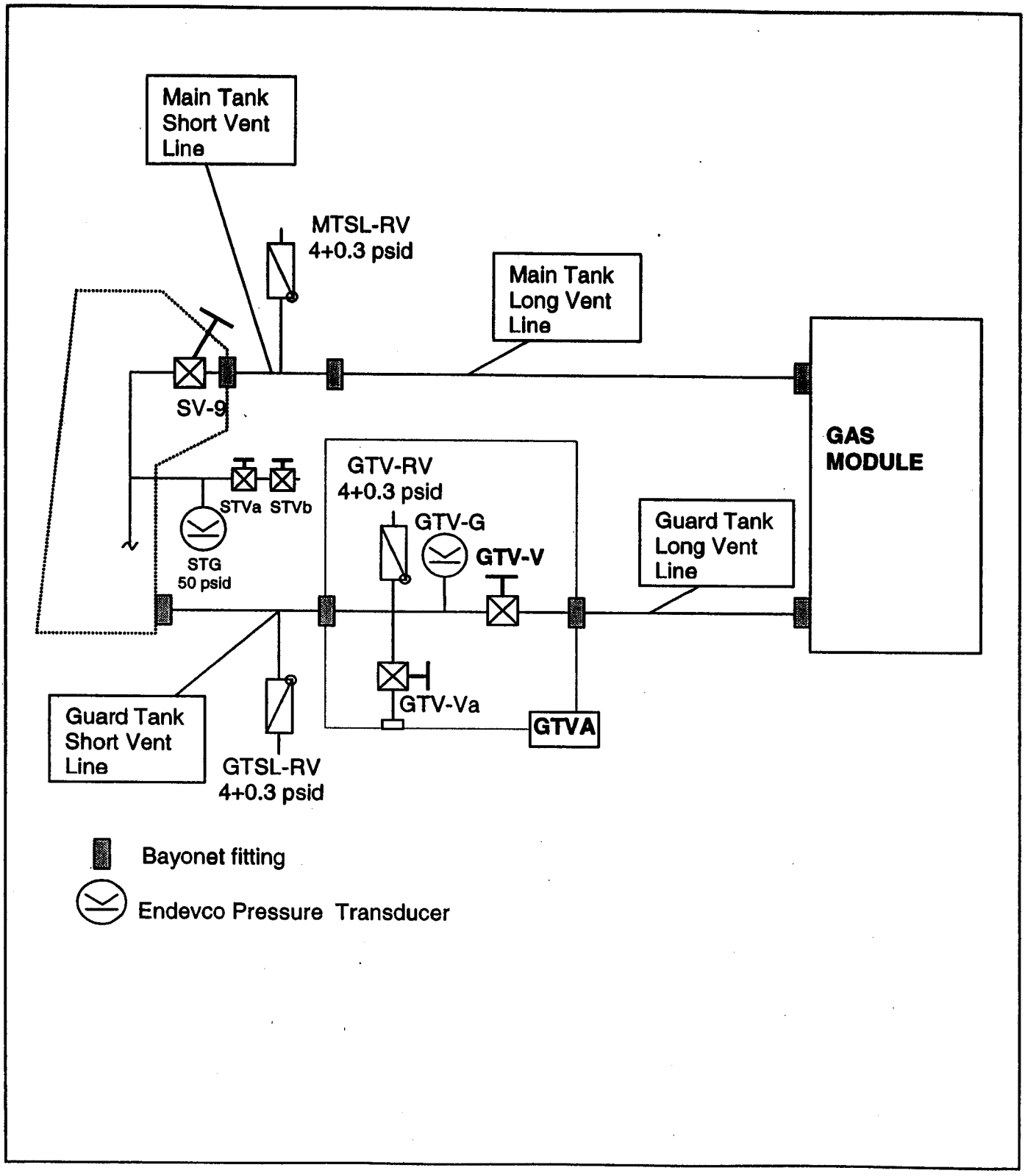


Figure 6. Main Tank and Guard Tank venting to Gas Module with Guard Tank Vent Assembly (GTVA) in place. (MT&GT_toGM_dwg.doc)

Appendix 1

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
1/16/03	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
1/6/03	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	Before. G.12 (start of transfer)	**Wait for power restoration:** Re-establish valve configuration, and resume procedure
		Section G.12 through G.16	**Go to Safemode:** Close VF-1, SV-13, if open; Immediately open VF-2; Open EV-20; Close VF-3, when possible.
		After G.16	**Wait for power restoration:** Re-establish valve configuration , and resume procedure
		Any time	**Wait for power restoration** **Note:** the DAS computer will continue to function for several hours, however no data will be collected DAS computer still operating: Reset GM valving per the last configuration in procedure and resume procedure DAS computer not operating: Reboot computer and launch DRP_SMD and select auto startup option Reset GM valving per the last configuration in procedure and resume procedure
2	Temperature limits (CN 28) exceeded	MAIN TANK IS NOT VENTING	**ALLOW MAIN TANK TO VENT** **If SV-9 is closed:** Close EV-17 (if open) and verify EV-9 open, 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. **If SV-9 open and EV-9 closed:** Open EV-9 for short periods (~15 sec) and allow increased flow from Main tank; in addition, Open EV-6 and EV-18 if higher flow rate is needed. **If SV-9 and EV-9 open** Open EV-6 and EV-18 for higher flow If problem persists see item 3

STANFORD UNIVERSITY

SU/GP-B P0786a

Operations No. 1865

GRAVITY PROBE-B PAYLOAD TESTING PROCEDURE

CERTIFY VACUUM MODULE AFTER TRANSPORT

P0786a

ECO 1297

August 10, 2001

Originator

J. Maddocks

Approvals:

_____ Date _____

Jim Maddocks

Test Director

_____ Date _____

Mike Taber

Payload Test Director

_____ Date _____

Tom Welsh

Test Engineer

ECO 1297

_____ Date _____

Robert Brumley

Payload Technical Manager

Dorrene Ross Date 8/11/01

Dorrene Ross

GP-B Quality Engineer

BOOK ENV-1

REVISION RECORD

REVISION	ECO	PAGES	DATE
A	1297	Added minor redlines Changed expected values of pressure in Section G.1.11 Changed numbering format and updated Sections A through F.	8/10/99

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
APR-x	Pressure regulator x of Gas Module
AV-x	Valve x of Gas Module auxiliary section
CG-x	Gauge x of portable helium pressurization source
CPR-x	Pressure regulator x of portable helium pressurization source
CV-x	Valve x of portable helium pressurization source
CN [xx]	Data acquisition channel number
DAS	Data Acquisition System
EFM	Exhaust gas Flow Meter
EG-x	Gauge x of Gas Module exhaust section
EH-x	Vent line heat exchanger in Gas Module
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
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
LHV-x	Liquid Helium Supply Dewar valves
LLS	Liquid level sensor
LM	Lockheed Martin 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 start up the Vacuum Module after transportation, and check all gauges, pneumatic valves, and pumps for proper operation.

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

There are no cryogenic operations in this procedure.

B.2.3. Injuries

In case of any injury obtain medical treatment as follows
LMMS **Call 117**; Stanford University **Call 9-911**

C. QUALITY ASSURANCE

C.1. QA Notification

The ONR 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 to be dealt with in one of three ways.

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. Red-lines to procedures are included in this category.
2. If the discrepancy is minor, but affects procedure functionality, it shall be recorded in the D-log. Resolution shall be in consultation with the PTD and QA representative.
3. All critical and major discrepancies shall be documented in Discrepancy Reports.

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.

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	Tom Welsh
Dave Murray	Chris Gray
Jim Maddocks	Bruce Clarke
Dave Frank	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

None required

E.3.3. Additional Test Equipment

Item	Description	Manufacturer
1	Helium leak detector	Varian

E.3.4. Additional Hardware

None required

E.3.5. Tools

None required

E.3.6. Expendables

Description	Quantity	Mfr./Part No.
Liquid nitrogen	AR	N/A
99.99% pure helium gas	AR	N/A

E.4. Instrument Pretest Requirements

N/A

E.5. Configuration Requirements

N/A

E.6. Optional Non-flight Configurations

N/A

E.7. Verification/Success Criteria

N/A

E.8. Payload Constraints and Restrictions

N/A

E.9. Configuration Requirements

N/A

F. REFERENCE DOCUMENTS

F.1. Drawings

Drawing No.	*Title*
LMMS-5833394	*Instrumentation Installation*

F.2. Supporting documentation

Document No.	*Title*
SU/GP-B P0108	*Quality Plan*

F.3. Additional Procedures

Document No.	*Title*
SU/GP-B P0778	*Disconnect Electrical GSE from Payload*

Operation Number: 1865
Date Initiated: 2/13/02
Time Initiated: 0910

G. OPERATIONS

G.1. Establish Initial Condition of Vacuum Module

G.1.1. Visually inspect module. Record damage: NONE

G.1.2. Ensure all access ports are capped.

1. Primary pump-out port
2. Utility pump-out port (at VV-10)
3. Access port 1
4. Leak Detector port

G.1.3. Ensure over-ride switch is in off position (switch down).

G.1.4. Ensure all manual valves VV-3, VV-5, VV-7, and VV-10 are closed.

Note: It is necessary to remove the right-hand panel to access VV-5.

G.1.5. Connect pressurized air for pneumatic valve operation.

N/A G.1.6. Connect exhaust hose to pump exhaust.

G.1.7. Plug in and turn on Vacuum Module.

G.1.8. Record status of pneumatic valves per indicator lights.

Valve	*Light on (Open)*	*Light off (Closed)*	*Expected Status*
VV-1		✓	Closed
VV-2		✓	Closed
VV-4		✓	Closed
VV-6		✓	Closed

G.1.9. Turn on pressure gauges VG-2, VG-3, VG-4, and VG-5.

Caution
Do Not turn on ionization gauge VG-1 as the pressure in this section of the Vacuum Module is approximately 1 torr.

G.1.10. Verify that Vacuum Module was shut down according to procedure P0778, *Disconnect Electrical GSE from Payload.*

Record Operation Number _____ and date _____.

Note: if Vacuum Module not shut down according to P0778 the expected values in the following step may not be obtained.

G.1.11. Record pressures and compare to expected values. If pressures are significantly higher than expected, a leak may be indicated. In any case, continue with the remainder of the procedure.

	Actual Reading	*Expected Reading*
VG-2	~~708~~ 388 torr	< 200 torr
VG-3	~~749~~ 713 torr	< 10 torr
VG-4	749 torr	< 10 torr
VG-5	3.12 torr	< 10 torr

G.1.12. Turn override switch on (switch up) and push reset button.

G.1.13. Verify closure of VV-4 and normal operation of rotary vane pump (VP-2) as follows:

1. Record pressure VG-2 386 torr.
2. Record pressure VG-5 3.12 torr.
3. Turn on vane pump. Verify proper rotation – NO - SWAPPED RED & BLACK WIRES ON RELAY FOR VANE PUMP (ROTATION OK)
4. Record condition of Indicator light "VP-2" ✓ on ____ off.
5. When pressure at VG-2 < 25 mtorr, record VG-2: 10 m torr.
6. Verify decrease in pressure VG-2 (to verify pump operating).
7. Record pressure VG-5 3.13 torr.
8. Verify pressure at VG-5 unchanged (to verify VV-4 closed).
9. When satisfied vane pump is operating normally (VG-2 < 25 mtorr) and VV-4 closed (VG-5 unchanged), proceed to next step.

G.1.14. Verify closure of VV-1 and VV-6 and normal operation of VV-4 as follows:

1. Record pressure VG-5 3.13 torr.
2. Record pressure VG-3 713 torr.
3. Open VV-4.
4. Record condition of Indicator light "VV-4" ✓ on (open) ____ off (closed).
5. When pressure at VG-5 < 25 mtorr, record VG-5: 24 m torr.

6. Verify decrease in pressure VG-5 (to verify VV-4 open).
7. Record pressure VG-3 713 torr.
8. Verify pressure at VG-3 unchanged (to verify VV-1 and VV-6 closed).
9. When satisfied VV-4 opened normally, close VV-4.
10. Record condition of Indicator light "VV-4"
    ____ on (open) ____ off (closed).
11. When satisfied VV-4 operates normally proceed to next step.

G.1.15. Verify normal operation of VV-2.

1. Record pressure VG-5 35 mtorr.
2. Open VV-2.
3. Record condition of Indicator light "VV-2"
    ____ on (open) ____ off (closed).
4. When pressure VG-5 stabilizes, record VG-5 315 mtorr.
5. Verify increase in pressure VG-5 (to verify VV-2 opened)
6. When satisfied VV-2 opened normally, close VV-2.
7. Record condition of Indicator light "VV-2"
    ____ on (open) ____ off (closed).
8. When satisfied VV-2 operates normally proceed to next step.

G.1.16. Verify normal operation of VV-1.

1. Open VV-4.
2. When VG-5 < 25 mtorr, Record pressure VG-5 24 mtorr.
3. Close VV-4
4. Open VV-1.
5. Record condition of Indicator light "VV-1"
    ____ on (open) ____ off (closed).
6. When pressure at VG-5 stabilizes, record VG-5: 419 torr.
7. Verify increase in pressure VG-5 (to verify VV-1 opened).
8. When satisfied VV-1 opened normally, close VV-1.
9. Record condition of Indicator light "VV-1"
    ____ on (open) ____ off (closed).
10. When satisfied VV-1 operates normally proceed to next step.

G.1.17. Verify normal operation of VV-6.

1. Record pressures:
2. VG-3 368 torr.
3. VG-4 370 torr.
4. Open VV-4 and VV-6.
5. Record condition of Indicator light "VV-6"
   ✓ on (open) ____ off (closed).
6. Slowly open valve VV-3 to evacuate the high-vacuum pumping manifold up to the capped-off pump inlet.
7. When pressure at VG-3 stabilizes, record VG-3: 20 torr.
8. When pressure at VG-4 stabilizes, record VG-4: 13 torr.
9. Verify decrease in pressures VG-3 and VG-4 (to verify VV-6 opened).
10. When satisfied VV-6 opened normally, close VV-6.
11. Record condition of Indicator light "VV-6."
    ____ on (open) ✓ off (closed).
12. When satisfied VV-6 operates normally, close VV-3 and proceed to next step.

G.1.18. Verify normal operation of turbo pump.

1. Verify open/open VV-4.
2. Verify Vacuum Module over-ride switch is on (up position).
3. Open VV-2.
4. When pressure at VG-5 < 50 mtorr, Record VG-5 47 M torr.
5. Open VV-6.
6. Slowly open VV-3 and evacuate to ensure pressure at VG-3 < 1 torr. Record VG-3 960 M torr.
7. Open gate valve VV-1 (switch up).
8. Turn on Turbo pump.
9. Verify that turbo comes up to normal operating speed.
10. Turn on ionization gauge VG-1 when the pressure at VG-5 is < 1.0 x 10-3 torr.
11. Continue evacuation up to capped-off pump-out port until the pressure at VG-1 is < 5.0 x 10-6 torr then record:
    a. Time of day: 1700
    b. VG-1 pressure: 4.99×10^{-6} torr.
12. When satisfied that turbo is operating normally, proceed to next step.

G.2. Leak Test Vacuum Module

G.2.1. Calibrate leak detector

1. Standard leak value 5.9×10^{-8} sccs He
2. Leak detector reading 5.8×10^{-8} sccs He

G.2.2. Connect the leak detector to the leak check access port of the vacuum module.

G.2.3. Leak test the system up to closed valve VV-7.

G.2.4. Turn the leak detector's vent disable switch to the disabled position.

G.2.5. Slowly open leak detector access valve VV-7. Monitor the system pressure as read on gauge VG-1 as this valve is opened.

G.2.6. While monitoring VG-1 to ensure it does not rise above 1 x 10-5 torr, close valve VV-4.

G.2.7. Leak test all internal pumping lines and connections.

PUMPED OUT OVERNIGHT CONTINUED ON 2/14/02

G.2.8. Record Leak detector readings:

1. Initial background: 2.0×10^{-7} sccs He
2. Final reading: 1.4×10^{-7} sccs He

G.2.9. Verify no leaks > 1.0×10^{-7} sccs are present.

G.2.10. Open valve VV-4.

G.2.11. Close valve VV-7.

G.2.12. Turn off the ionization gauge (VG-1).

G.2.13. Close VV-2, VV-3, and VV-6.

G.2.14. Turn the leak detector's vent disable switch to the off position.

G.2.15. Record pressure VG-2 4.5×10^{-3} torr.

G.2.16. While monitoring the pressure at gauge VG-2 to ensure that valve VV-7 is closed, vent the leak detector to air.

Record pressure VG-2 4.6×10^{-3} torr

G.2.17. Disconnect the leak detector from the vacuum module's leak check access port.

G.3. Place System in Final Configuration

G.3.1. Ensure VV-7 closed.

G.3.2. Close gate valve VV-1.

G.3.3. Turn off the turbo pump as follows:

1. Turn ~~on~~ OFF Vacuum module over-ride switch (down).
2. Power off turbo pump and verify that VV-4 closes (indicator light goes off).
3. Open manual valve VV-5 slowly to decelerate the turbo pump.

4. When turbo deceleration is complete, close VV-5.
5. Switch Vacuum Module override to on (up) and verify that VV-4 opens by observing a decrease in pressure VG-5.

G.3.4. Purge and install gaseous helium supply line to leak detector port of Vacuum Module.

G.3.5. Close VV-4.

G.3.6. Open VV-1.

G.3.7. Backfill Vacuum Module with gaseous helium to 770 +/- 5 torr as read on gauge VG-4 by slowly opening valve VV-7.

G.3.8. Once VG-4 is greater then 770 torr, close VV-7 and record the following:

1. VG-4 pressure: 815 torr
2. Time of day: 0955 2/14/02

G.3.9. Disconnect helium pressurization line from leak detector port.

G.3.10. Cap leak detector access port at valve VV-7.

G.3.11. Close gate valve VV-1.

G.3.12. Verify closed VV-4.

G.3.13. Turn system override switch off (down).

G.3.14. **(Option)** Shut down pump VP-2.

H. PROCEDURE COMPLETION

Completed by: [signature]

Witnessed by: [signature] SU GP-B INSP 28

Date: 2/14/02

Time: 0956

SU GP-B INSP 28

Quality Manager _____ **Date** 2/14/02

Payload Test Director M. C. Taber **Date** 3/4/02

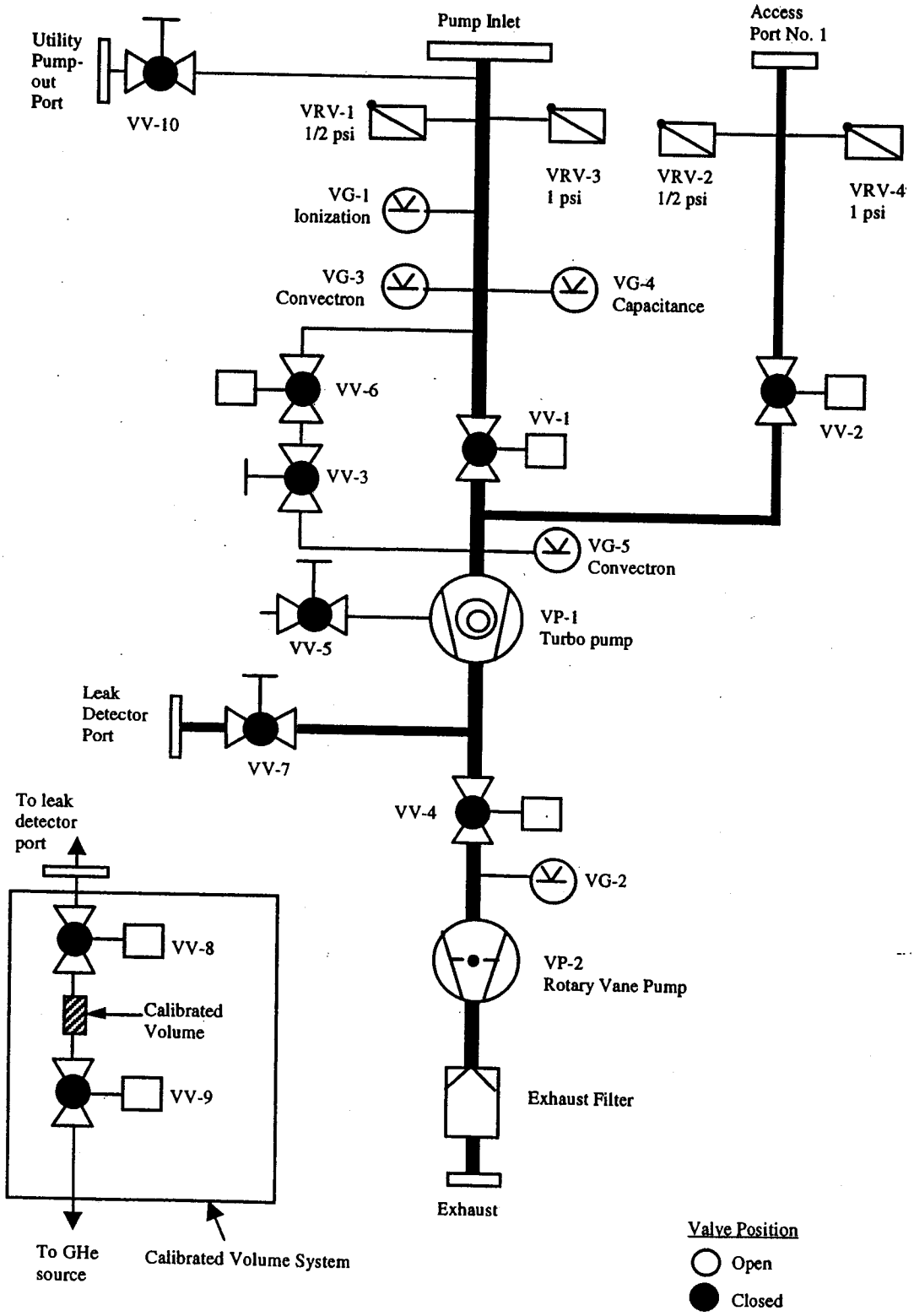


Figure 1. Schematic representation of Vacuum Module plumbing.

GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

OP#1879

Verify Helium Cylinder Content/Connect Helium Supply Line

THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

ECO# 1335

P0881A

January 23, 2002

Prepared by:

_____Date_____
Ned Calder
Cryogenic Test

Checked by:

_____Date_____
Dave Murray
Cryogenic Test

Approvals:

_____Date 1/24/02
FOR Dorrene Ross
Quality Assurance

_____Date_____
Harv Moskowitz
LM Safety

_____Date_____
Rob Brumley
Payload Technical Manager

_____Date_____
Mike Taber
Test Director

ENV-1

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	MT	Main Tank
AMI	American Magnetics Inc.	MTVC	Main Tank Vent Cap
ATC	Advanced Technology Center	MTVC-G	Main Tank Vent Cap pressure gauge
Aux	Auxiliary	MTVC-RV	Main Tank Vent Cap relief valve
AV-x	Valve x of Gas Module auxiliary section	MTVC-V	Main Tank Vent Cap valve
Bot	Bottom	NBP	Normal boiling point
CN [xx]	Data acquisition channel number	ONR	Office of Naval Research
DAS	Data Acquisition System	PFCG	Fill Cap assembly pressure Gauge
EFM	Exhaust gas Flow Meter	PFM	Pump equipment Flow Meter
EG-x	Gauge x of Gas Module exhaust section	PG-x	Gauge x of Pump equipment
EM	Electrical Module	PM	Pump Module
ERV-x	Relief valve of Gas Module exhaust section	psi	pounds per square inch
EV-x	Valve number x of Gas Module exhaust section	psig	pounds per square inch gauge
FCV	Fill Cap Valve	PTD	Payload Test Director
FIST	Full Integrated System Test	PV-x	Valve x of the Pump equipment
GHe	Gaseous Helium	QA	Quality Assurance
GM	Gas Module	RAV-x	Remote Actuated Valve-x
GP-B	Gravity Probe-B	RGA	Residual Gas Analyzer
GSE	Ground Support Equipment	SMD	Science Mission Dewar
GT	Guard Tank	STV	SMD Thruster vent Valve
GTVC	Guard Tank Vent Cap	SU	Stanford University
GTVC-G	Guard Tank Vent Cap pressure gauge	SV-x	SMD Valve number x
GTVC-RV	Guard Tank Vent Cap relief valve	TG-x	Gauge x of Utility Turbo System
GTVC-V	Guard Tank Vent Cap valve	TV-x	Valve x of Utility Turbo System
GTV-G	Guard Tank vent pressure gauge	UTS	Utility Turbo System
GTV-RV	Guard Tank vent relief valve	Vac	Vacuum
GTV-V	Guard Tank vent valve	VCP-x	Vent cap pressure gauge
HX-x	Vent line heat exchanger in Gas Module	VCRV-x	Vent cap relief valve
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)	VCV-x	Vent cap valve
LHe	Liquid Helium	VDC	Volts Direct Current
LHSD	Liquid Helium Supply Dewar	VF-x	Liquid helium Fill line valve
Liq	Liquid	VG-x	Gauge x of Vacuum Module
LL	Liquid level	VM	Vacuum Module
LLS	Liquid level sensor	VV-x	Valve x of Vacuum Module
LMMS	Lockheed Martin Missiles and Space	VW-x	Valve x of Dewar Adapter
LMSC	Lockheed Missiles and Space Co.		

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	Tom Welsh
Dave Murray	Ned Calder
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: N/A Cal Due Date:

NOT USED

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

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: 1879
Date Initiated: 2/28/02
Time Initiated: 1330

G. OPERATIONS

G.1. Pre-Operations Verifications

☑ Verify SU QA notified.
Record: Individual notified R. LEESE,
Date/time 2/28/02 1380.

☒ Verify NASA representative notified.
Record: Individual notified E. INGRAHAM,
Date/time 2/28/02 1330.

☑ 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).

SU GP-B INSP 28
QA Witness: 2/28/02

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.

SU GP-B INSP 28
QA Witness: 2/28/02

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

1. 30138 2. ~~3.~~
4. ~~5~~ 6.

(30138 - OTHERS IN SIX PACK NOT VISIBLE)

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.

	6. Open EV-23 and allow to purge. 7. Close APR-2V
☐ 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. 5. Adjust APR-2 to 1-2 psi. 7. Record pressure used 1.5 psig 8. 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

Completed by: _____

Witnessed by: _____ SU GP-B INSP 28

Date: 2/28/02

Time: 1357

QA Witness: SU GP-B INSP 28 2/28/02

SU GP-B INSP 28

Quality Manager _____ **Date** 2/28/02

Payload Test Director M. G. Tabry **Date** 3/4/02

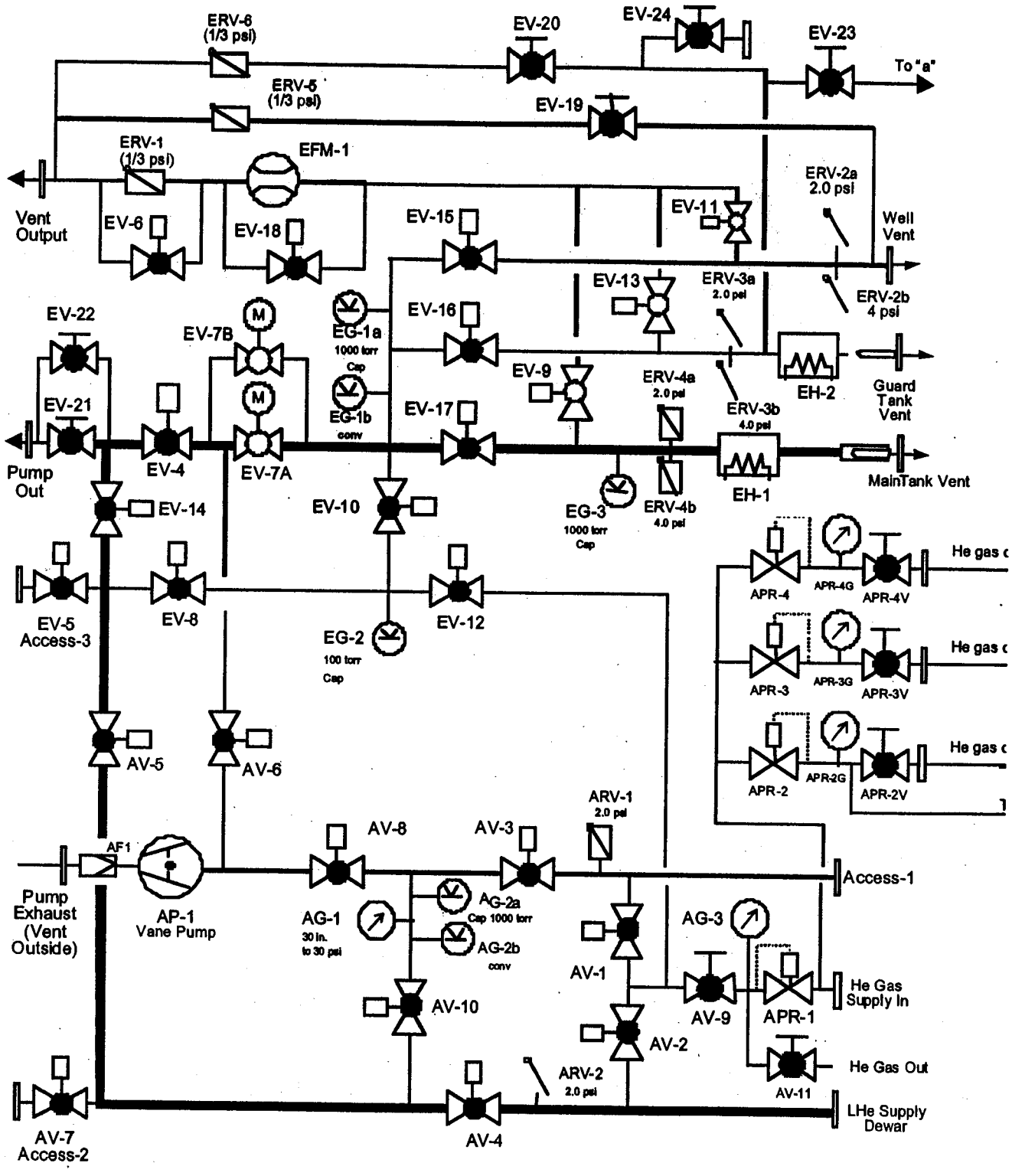
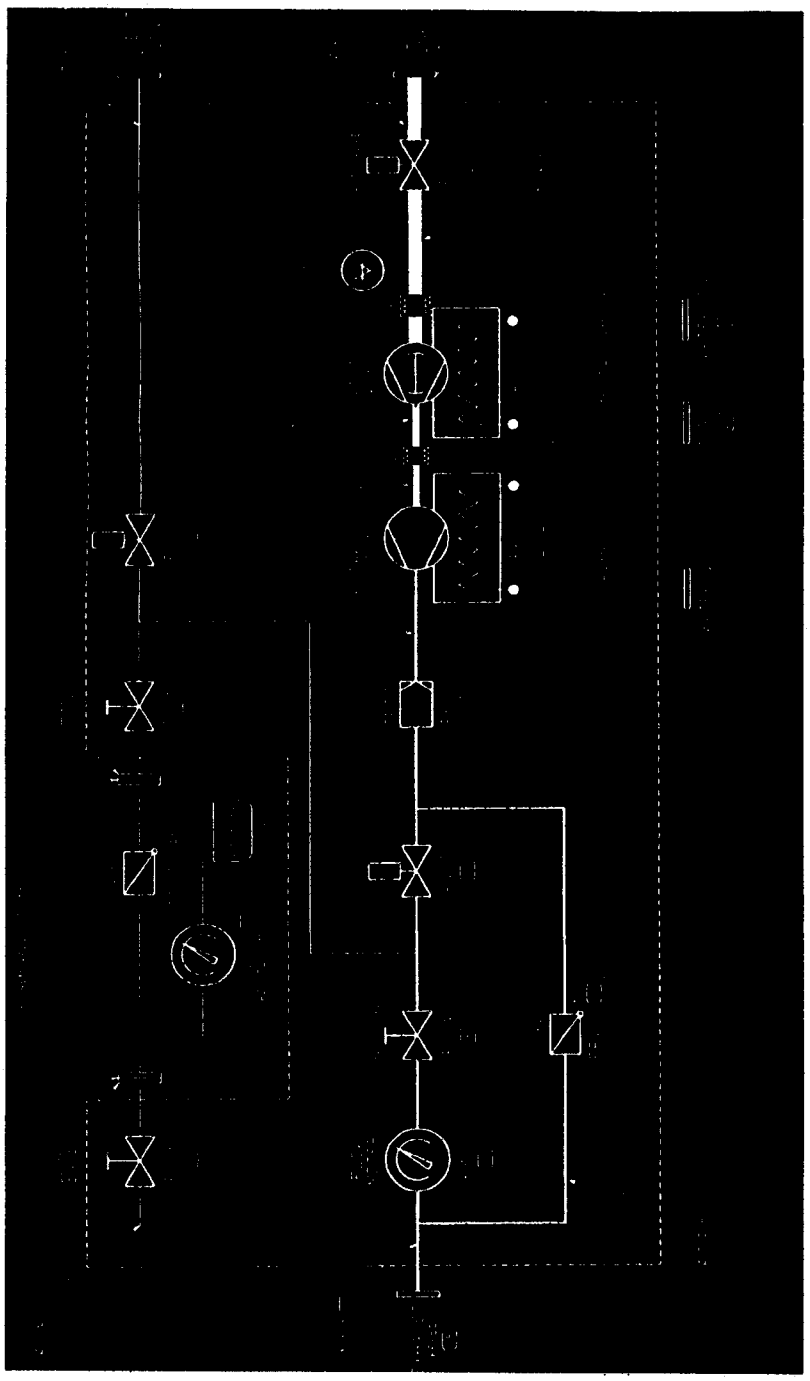


Figure 1 Gas Module

Figure 2-Schematic diagram of the Pump Module



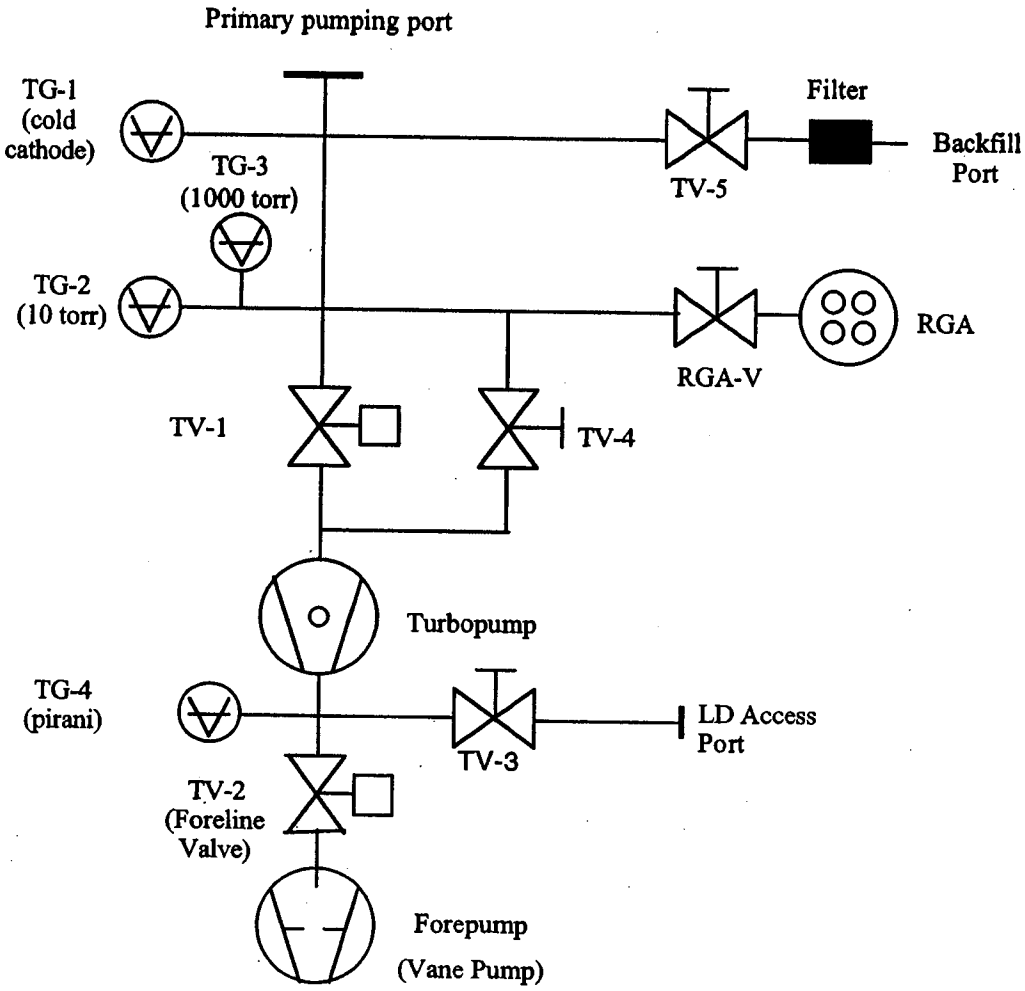


Figure 3. Schematic diagram of Utility Pumping System (UTS)

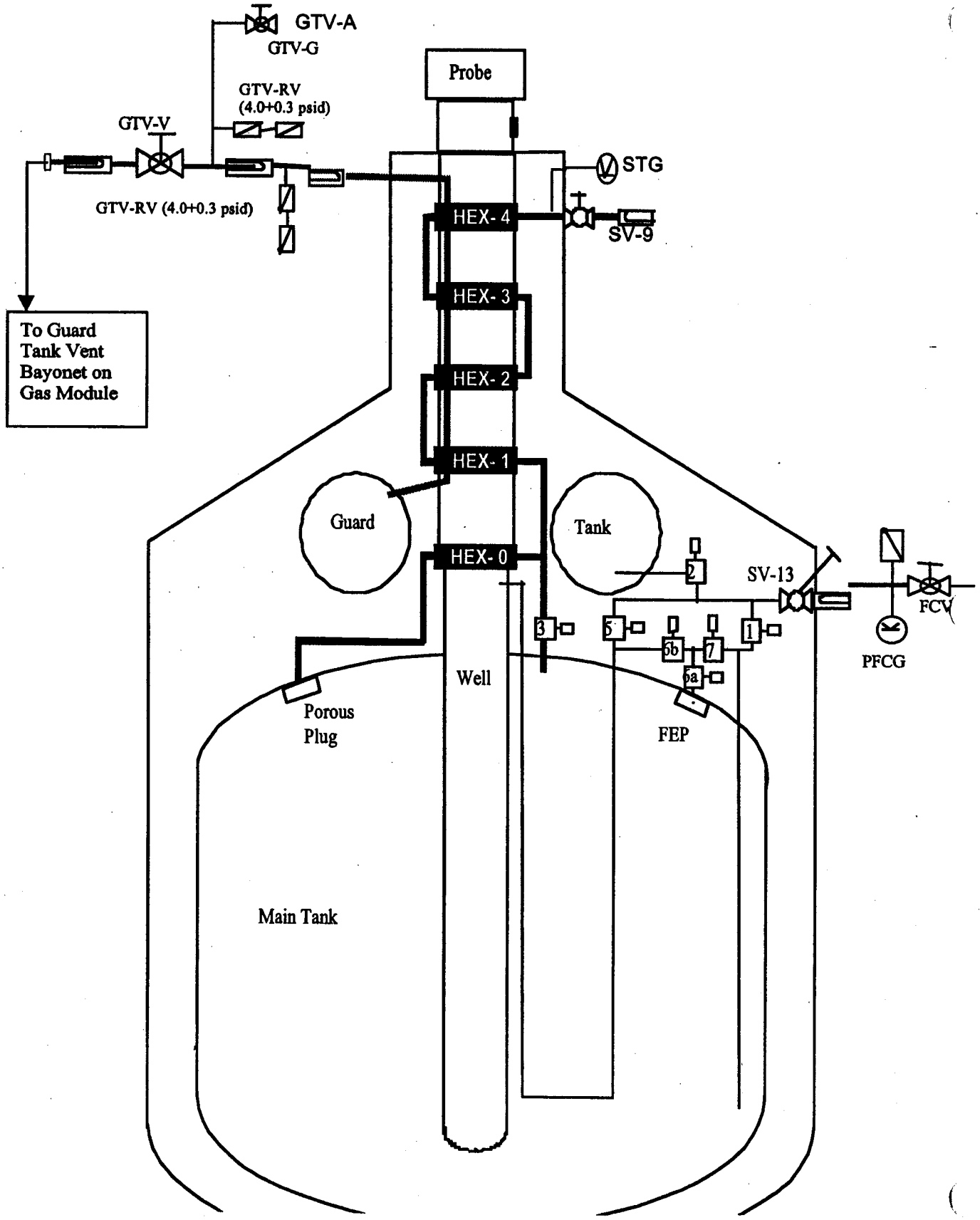
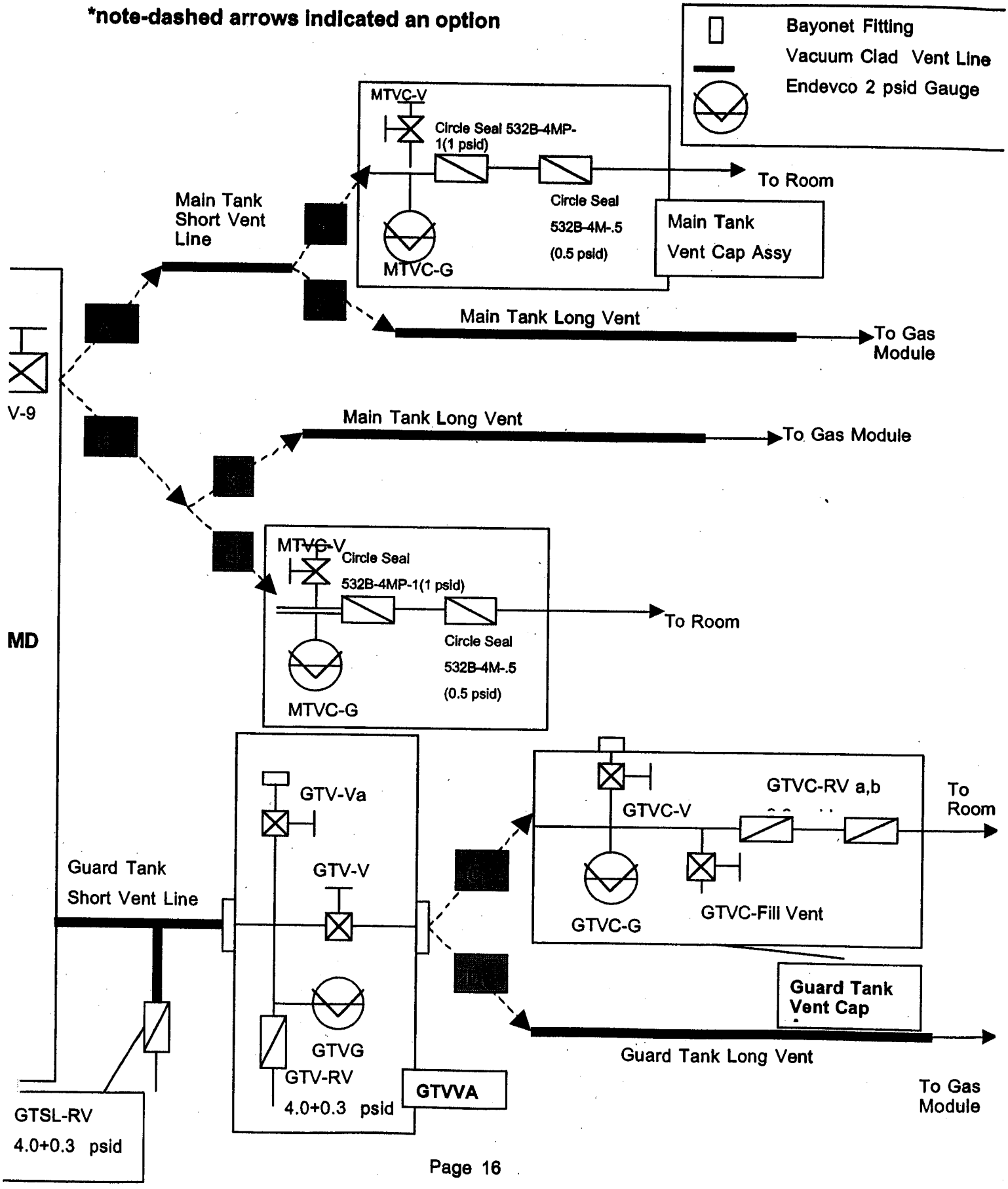


Figure 4. Schematic of Science Mission Dewar plumbing.

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
2/28/02	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
2/28/02	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

1-5
Sep 6-8

GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

1958

INSTALLATION OF
FEE GUARD TANK VENT LINE
AND LEAK CHECK WITH SV VERTICAL

(POST ACOUSTIC LEAK CHECK)

P0916 Rev-

May 16, 2002

Prepared by:

D.O. Murray Date 5-22-02

Dave Murray

Cryogenic Test

Checked by:

Date 5/22/02

Mike Taber

Payload Test Director

Approvals:

Dorrene Ross Date 5/23/02

Dorrene Ross

Quality Assurance

Dorrene Ross Date 5/23/02

Harv Moskowitz for H. Moskowitz per voice message

Payload Safety

Date 5/24/02

Robert Brumley

Payload Technical Manager

BOOK GNV-5

X

REVISION RECORD

REVISION	ECO	PAGES	DATE
Original	-	All	May 16, 2002

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
APR-x	Pressure regulator x of Gas Module
AV-x	Valve x of Gas Module auxiliary section
CG-x	Gauge x of portable helium pressurization source
CPR-x	Pressure regulator x of portable helium pressurization
CV-x	Valve x of portable helium pressurization source
CN [xx]	Data acquisition channel number
DAS	Data Acquisition System
EFM	Exhaust gas Flow Meter
EG-x	Gauge x of Gas Module exhaust section
EH-x	Vent line heat exchanger in Gas Module
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
FEE	Forward Equipment Enclosure
FIST	Full Integrated System Test
FGTVL	FEE Guard Tank Vent Line
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
GTV-Va	Guard Tank Vent auxiliary valve
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
LHV-x	Liquid Helium Supply Dewar valves
LLS	Liquid level sensor
LM	Lockheed Martin 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
FCG	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
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 to effect the removal and replacement of the Guard Tank Short Vent Line with the FEE Guard Tank Vent Line. This process assumes liquid helium in the Guard Tank and the SV in a vertical orientation. The steps for installing the FEE Guard Tank Vent Line are given in a LM Operations Order No. INT-251 and will be carried out by LM personnel.

B. Safety

B.1. Potential Hazards

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

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 proximity to the SV without escort. All personnel working at a height 30 inches or more off the floor are required to have a 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 by immediately calling 117

B.3.2. Hardware Mishap

In case of an accident, incident, or mishap, notification is to proceed per the procedures outlined SU P0879 and as referenced therein to Lockheed Martin Engineering Memorandum EM SYS229.

B.3.3. Contingency Response

Contingency responses to possible equipment troubles or irregularities (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, QA 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 judgment 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.

C.3.1. 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.

C.3.2. 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 Test Director and approved by the QA representative.

C.3.3. 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. However, during the startup of the transfer (Sec. G.14), there are to be a minimum of two qualified persons (Sec. D.3) in attendance. 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	Tom Welsh
~~Dave Murray~~ DC	Ned Calder

Ned Calder

E. Requirements

E.1. Electrostatic Discharge Requirements

All work on the SV requires the use of grounding wrist straps attached to grounding points on the SV per LM requirement.

E.2. Lifting Operation Requirements

There are no lifting operations in this procedure

E.3. Hardware/Software Requirements

E.3.1. Commercial Test Equipment

Leak Detector

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(see the Electrical Module Manual for details), 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 uses hardware located in the Gas Module (Figure 1), the Pump Module and the Electrical Module (Table 1). However, the Pump Module may be omitted if a stand-alone gas meter (a substitute for PFM-1) is connected at the Gas Module Vent Output. The primary helium vent and all vane pump exhausts must be connected to an outside vent.

E.3.3. Computers and Software:

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	Manufacturer	Model
AMI Level Sensor Readout for LHSD	AMI	110

E.3.5. Additional Hardware

Description	Manufacturer	Model
SMD Vent Bayonet O-rings	Parker	2-027
SMD Bayonet fit check tool	SU	N/A
Apiezon	MI Products Ltd	Model N
No. 5 rubber stopper with .5 psid relief valve	N/A	N/A

E.3.6. Tools

Description	Serial No.	Cal Due
Strap wrench 2-in.	N/A	N/A

E.3.7. Expendables

Description	Quantity	Mfr./Part No.
Ethyl alcohol	AR	N/A
99.99% pure gaseous helium	AR	N/A
Tie wraps – large size	AR	N/A

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. Serial numbers are to be updated as appropriate.

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	A1, A2, A3, A4	3452A01975	Yes	10/10/03
2	DAS	Power Supply, H-P 6627A	B1, B2, B3, B4	3452A01956	Yes	10/10/03
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A245539	No	-
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	11/29/03
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	8/22/03

No.	Location	Description	User Name	Serial No.	Cal Required	Status Cal due date
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	10/8/04
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	8/22/02
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, Helse	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	EH-1	C-19950	No	-
24	GM	Guard Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	EH-2	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	Leak Detector	Standard leak internal to leak detector	N/A	-	N/A	Yes

E.5. Configuration Requirements

E.5.1. Main Tank

Liquid in the Main Tank must be at its normal boiling point (NBP), 4.2 K. The SMD is vertical with the +Z axis up. The actuator control valve for EV-9 controls the state to which EV-9 defaults should a power failure occur. For this procedure it must be in the "NBP." Position, ensuring that EV-9 remains open in the event of power failure.

E.5.2. Guard Tank

The Guard Tank is filled with liquid helium to a level greater than 20%.

E.5.3. Well

The Well is evacuated and the Well pump-out at VTH may be in one of the following configurations:

1) closed with the VTH operator removed;
2) have the Well manifold connected to a closed VTH; or
3) have an open VTH with a pumpout valve, VW-3, and convectron, PW-2, making up the Well manifold.

E.5.4. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 1×10^{-4} torr.

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) at $T \leq 6.5$ K.
   b. Top of lead bag temperature set (CN 29) at $T \leq 6.5$ K.
   c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 0.3$ torr.
2. The watchdog alarm must be armed.

E.5.6. GSE and Non-flight Hardware

1. A relief valve or flight-like burst disk may be installed in place of the SMD fill-line burst disk.
2. The ion-pump magnet must be 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 Main Tank is venting to the room via the Main Tank vent cap assembly.
5. The Guard Tank is pressurized at the GTVA via the GTV-Va valve and then to the GM helium source at APR-2V.
6. The thruster vent port must be plumbed to an Endevco pressure transducer, STG.
7. The Fill Cap Assembly must be installed at SV-13 (Figure 3)
8. Top Plate heaters must be installed on SMD and be operational.

E.6. Optional Non-flight Configurations

The following non-flight modifications of the basic SMD and optional GSE configurations are incidental to the performance of this procedure. Any combination represents an acceptable configuration.

1. The SV is installed in: the SMD transportation and test fixture or in the space vehicle assembly fixture; or the space vehicle tilt dolly.
2. A foreign object and debris shield may cover the upper cone of the SMD. If it is not present, any object that could cause damage to the payload, if dropped, must be tethered.
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 valve operator and pumping line, with the valve in either the closed position or in the open position. The Vacuum Module pump may be off, actively pumping the pumping line up to a closed SV-14, or actively pumping the vacuum shell
4. If the Vacuum shell operator is not installed, then the vacuum shell valve is closed and capped off.

E.7. Verification/ Success Criteria

N/A

E.8. Payload Constraints and Restrictions

N/A

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
EM SYS229	Accident/Mishap/Incident Notification Process
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
SU/GP-B P0879	GP-B Accident/Incident/Mishap Notification Process

F.3. Additional Procedures

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

Operation Number: 1458
Date Initiated: 10/2/02
Time Initiated: 0900

G. Operations

G.1. Perform Preparatory Operations

G.1.1. Verify SU QA notified.

Record: Individual notified R Leese,

Date/time 10/2/02 600.

G.1.2. Verify NASA representative notified.

Record: Individual notified Ed Ingram

G.1.3. Verify LM SV Operations representative (Frank Mendoza, Norm Bennett) notified of approximate time for RAV-2 operations.

Record: Individual notified ~~Ed~~ 830 meeting

Date/time 10/2/02 830

G.1.4. Record calibration due dates in Table 1 (Sec. E.4).

G.1.5. Verify that persons actually performing this procedure have initialed their names in Sec. D.3 and the name of the Test Director is circled.

G.1.6. Verify Pre-ops meeting with operations group has been conducted.

G.1.7. Verify Purity of All Sources of Helium Gas

Record serial number on helium bottle/s.

1. 30138 2. — 3. —
4. NA 5 — 6. —

G.1.8. Verify helium bottle/s have been tested for purity and record Op. Number. Op. Number: 1925

Date/time 10/2/02 911

SU GP-B INSP 28

Quality _____
10/2/02

G.2. **Connect GTV to GM**

G.2.1. Connect GTVA to GM using procedure "Connect Guard Tank Vent to Gas Module, P0676, Record Op number 1959. **Note:** Stop the procedure at the completion of para. G.6.11, **the point at which the UTS is pumping up to a closed GTV-V and with the Guard Tank pressurized at GTV-Va from the helium 6-pack.**

G.2.2. Record: Date/Time 10/2/02 @ 1400

G.3. Verify Configuration Requirements

G.3.1. Ensure DAS Watch Dog Alarm enabled.

G.3.2. Ensure that Top Plate heaters on SMD are operational.

G.3.3. Verify GSE cabling, excluding P801 and P802 flight cables, are connected between SMD, Electrical Module, Gas Module and Data Acquisition System.

G.3.4. Record MT pressure (STG) 6.54 torr.

G.3.5. Verify DAS and liquid level alarms enabled and record set points.

1) Main Tank level ("A" or "B"): Record set point 20 %
2. Top of lead bag temperature/a – verify [CN 28] on DAS alarm list and set to alarm at T ≤ 6.5 K. Record set point 5.2 K
3. Top of lead bag temperature/b – verify [CN 29] on DAS alarm list and set to alarm at T ≤ 6.5 K. Record set point 5.2 K
4. Relative Guard Tank Pressure – verify [CN46] on DAS alarm list and set to alarm at ΔP ≥ 0.3 torr. Record set point 2 torr
5. Relative Main Tank Pressure – verify [CN49] on DAS alarm list and set to alarm at ΔP ≥ 4.0 torr. Record set point 5 to

G.3.6. Verify orientation of SMD/SV: is vertical with +Z up.

G.3.7. Verify Main Tank is venting to the room via the Main Tank Vent Cap Assembly (MTVCA) relief valve.

G.3.8. Verify Guard Tank is venting via the GTV-RV of GTVA.

G.3.9. Verify connected/connect the DAS Endevco read out to GTV-G (2 psid) on the GTVA and verify read out and DAS receive appropriate indicated values.

G.3.10. Ensure ion-pump magnet and signal cable installed.

G.3.11. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day ~1330
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) 3.42^{-7} torr. If pressure is above $1x10^{-4}$ torr, perform procedure P0213, *Connect of Vacuum Module / Pump on SMD Vacuum Shell*, to connect Vacuum Module and pump out SMD vacuum shell.

   ☐ Pressure is $<5x10^{-5}$ torr, continue at step 4.

   ☐ Pressure is $>5x10^{-5}$ torr, turn of vac-ion pump and perform P0213, record date/time _____.

4. Exit [Monitor Data] and collect data with [Set Data Interval] to 10 min.

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

G.3.12. Verify Actuator Control for EV-9 set to "NBP" position.

G.3.13. Record: Date/Time 10/2/02

Quality SU GP-B INSP 28

G.4. Verify Gas-Module Configuration and Record Initial Conditions

G.4.1. Verify valve states as indicated in following Table.

Verify Initial Valve States		
	Verify Open/Active	Verify Closed
Main Tank vent Not Connected to GM, venting to room	SV-9, MTVC-RV	MTVC-Va
Guard Tank vent Connected to GM at "Guard Tank Vent" and pumped by the UTS up to GTV-V	TV-1, TV-2, EV-5, EV-14, EV-4, EV-7A/B, **EV-16**	
Venting	**GTV-RV**	GTV-V, GTV-Va
Remaining EV valves		All other EVs
AV valves	APR2, APR2-V	All other AVs

G.4.2. Record initial temperatures

1. Top of Lead Bag CN [~~28~~ 40] 4.375 K.
2. Top of Lead Bag CN [~~29~~ 41] 4.372 K.
3. Temperature at bottom of Main Tank CN 09] 4.2569 K.

G.4.3. Record pressures.

1. Guard Tank (GTV-G) CN[46]:____ torr (relative to atm.)
2. Main Tank (STG) CN[49]:____ torr. (Endevco on Thruster Vent Manifold)

G.4.4. Record liquid level in Main Tank 90.7 %.

G.4.5. Record liquid level in Guard Tank 31.6 %.

G.4.6. Verify Main Tank liquid level is above 35%.

G.4.7. Verify Guard Tank liquid level is above 20%.

G.4.8. Record status of Well pump-out:

☑ VTH closed and Well manifold not installed.

☐ Well manifold installed, record valve positions and pressure:

VTH ____, VW-3 ____, PW-1 ____ torr.

Quality SU GP-B INSP 28 10/2/02

G.5. **Set Up Data Acquisition System**

Note: Refer to DAS operating instructions for information on configurations and mechanics of keyboard/mouse operation.

G.5.1. Verify DAS set to configuration ~~4Y~~. 4aa

G.5.2. Set DAS to fast scan mode using [other menus], [data config], [fast scan] and [Remove MultScan]

G.5.3. Record directory and data file name 209270.pcd

G.5.4. Start "Special Data Cycle" by using [Other Menus] + [Special Data Col].

G.5.5. Enter CNs: ~~28~~ 46, 24, ~~64~~ 62, 46 (GTV-G) and 49 (ST-G, Thruster Vent) and ~~114~~ 2 (EG-1a).

G.5.6. [Init. Collectn]

G.5.7. [Enter] use default file name.

G.5.8. Record directory and special data file name 210020.spc.

G.5.9. Ensure printer is displaying special Data Cycle data.

G.5.10. Connect/verify connected power supply ~~A1~~ A3 and ~~A2~~ A4 to Guard Tank heaters H03D and H-04D. on umbilical

G.5.11. Turn on power supply A and set outputs A1 and A2 to 0.08 amp current limit.

G.5.12. N/A Verify heater power to H03D and H04D are recorded and plotted at DAS.

Proceed to G.10

G.5.13. Record heater settings in Table G.5

Table G.5 Guard Tank Heater

Date/Time	H03D CN64	H04D CN66	GT Temp CN24	Lead Bag CN28	
	Watt	Watt	K	K	

Quality ✓

G.6. **Prepare FEE Guard Tank Vent Line (FGTVL)**

G.6.1. Record the bayonet female fit check gap measurements made in LM operations order No. INT-251 for the inboard FEE Guard Tank Vent Line.

1. Maximum gap _____
2. Minimum gap _____

G.6.2. Record the bayonet male fit check gap measurements made in LM operations order No. INT-251 for the outboard end of the FEE Guard Tank Vent Line.

1. Maximum gap _____
2. Minimum gap _____

G.6.3. At a convenient time enter the above values in the Bayonet Usage Book.

G.6.4. Prepare a new bayonet O-ring (Parker Viton 2-027) with a thin layer of Apiezon N vacuum grease.
Record: Lot No. _____ , Expiration date _____ .

G.6.5. Install the O-ring into the outlet bayonet O-ring groove of the FGTVL.

G.6.6. Valve configuration: Same as G4.1

Quality_____

G.7. **Remove GT Short Vent Line**

G.7.1. Prepare a No. 5 rubber stopper with a 1 psid relief valve (1/8-in NPT size)

CAUTION

In the following steps the Guard Tank pressure must be prevented from going subatmospheric which could result in air contamination and plugging of the internal Guard Tank vent. Corrective action is to increase the flow rate by raising the Guard Tank heater voltages.

G.7.2. Remove GTSVL from SMD GT vent port (B2) and **immediately** install No. 5 stopper/relief valve.

G.7.3. Verify Guard Tank is venting via stopper/RV combination.

G.7.4. Remove O-ring from SMD bayonet and clean O-ring groove with clean room wipes and ethyl/isopropyl alcohol.

G.7.5. Remove stopper assembly and:

Immediately insert the male bayonet gauge fit check and using feeler gauges measure gap and record:

Maximum gap _____ Minimum gap _____

G.7.6. Remove tool and reinstall stopper.

G.7.7. Prepare a new bayonet O-ring (Viton 2-027) with a thin layer of Apiezon N vacuum grease.
Record: Lot No. _____ , Expiration date _____ .

G.7.8. Install the O-ring into the SMD Guard Tank vent bayonet O-ring.

G.7.9. Remove the Guard Tank Vent Assembly (with GTLVL attached) from the GTSVL and install onto the bayonet outlet for FGTVL. Keep helium purge hose on closed GTV-Va and signal cable on GTV-G.

G.7.10. Valve configuration:

Verify Initial Valve States		
	Verify Open/Active	Verify Closed
Main Tank vent Not Connected to GM, venting to room	SV-9, MTVC-RV	MTVC-Va
Guard Tank vent Connected to GM at "Guard Tank Vent" and pumped by the UTS up to GTV-V	TV-1, TV-2, EV-5, EV-14, EV-4, EV-7A/B, EV-16	
Venting	**B2-RV**	GTV-V, GTV-Va
Remaining EV valves		All other EVs
AV valves	APR2, APR2-V	All other AVs

G.7.11. Record: Date/Time _____

Quality_____

G.8. **Install FGTVL**

CAUTION

In the following steps the Guard Tank pressure must be prevented from going subatmospheric which could result in air contamination and plugging of the internal Guard Tank venting. Corrective action is to increase the flow rate by raising the Guard Tank heater voltages.

CAUTION

Watch the special data collection output to warn of excessive lead bag temperatures. Corrective action is to increase Guard Tank flow by increasing Guard Tank heater voltages.

G.8.1. Perform LM operations order No. INT 251 "Install Guard Tank Vent Line ..." up to the point of removing B2 rubber stopper.

G.8.2. Verify helium flow from stopper/relief valve.

NOTE

In the following step ensure helium gas flow out of Guard Tank B2 and out of GTVA (open GTV-Va for purging) as FGTVL is assembled to dewar B2.

G.8.3. Continue with the LM operation.

G.8.4. When the operation is completed verify FGTVL has been purged by Guard Tank outflow and the valve GTV-V and GTV-Va are closed with vent path supplied by GTV-RV.

G.8.5. Record:

Date/Time _____

Quality_____

G.9. **Preparing Equipment for Leak Detection**

G.9.1. Verify SV is vertical, Main Tank is venting to room via SV-9 and Main Tank Vent Cap Assembly relief valve, MTVC-RV

G.9.2. Ensure 'pump exhaust' of Gas Module is vented to outside of facility.

G.9.3. Close verify/closed RGA-V.

G.9.4. Install Neon Standard Leak at GTV-Va opening GTV-Va to allow purging of NSL flex hose before making plumbing connection.

G.9.5. Record Neon Standard Leak and calculate leak value:

1. Record original leak value 1.5×10^{-6} sccs Ne.
2. Record original leak calibration date 3/14/95
3. Record rate of change in leak value .8 %/year.
4. Calculate present leak value 1.416^{-6} sccs Ne.

G.9.6. Leave GTV-Va open.

G.9.7. Verify the configuration of the Vacuum Module, Gas Module, UTS, RGA, Neon Standard Leak and SMD is as shown in Figures 1b with valve configuration as given below.

G.9.8. Valve configuration:

	Open/Active	Closed
Main Tank vent Not Connected to GM	SV-9, MTVC-RV	
Guard Tank vent Connected to GM at "Guard Tank Vent" and pumped by the UTS up to GTV-V	TV-1, TV-2, EV-5, EV-14, EV-4, EV-7A/B, EV-16	
Venting	GTV-RV	GTV-V, GTV-Va
Remaining EV valves		All other EV valves
Neon leak valves	GTV-Va	RGA-SOV, RGA-LV, NSL-V
GSE RAVs	RAV-3	All other RAVs
SV RAVs	RAV-6B	RAV-2

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G.10. **Remove Liquid Helium from Guard Tank**

G.10.1. Begin recording data in Table G.10.

G.10.2. Input comment to DAS "Begin Guard Tank boil-off".

G.10.3. Verify heater power to H03D and H04D are recorded and plotted by DAS.

G.10.4. When Guard Tank temperature [CN24] reaches 35 +/-5 K, power off heaters.

Table G.10 Guard Tank boil-off Data

Date/Time	H03D	H04D	GT Temp CN24	Lead Bag CN28	GT LLS	
	Watt	watt	K	K	%	
10/2/02 14:19	0	50V ~3W	4.371	4.377	31.5	
10/2/02 14:24	50V .06A ~3W	50V .06A ~3W	4.372		30.7	
10/2/02 17:00	50V .06A ~3W	50V .06A ~3W	4.252	4.367	3.2	
10/2/02 17:17	0	0	4.249	4.365	1.6	Closed GTVA
10/3/02 702	10V, .072A	0	4.975			Warm up GT
10/3/02 725	30V,		4.381 ↔	5.423	—	
10/3/02 730	30V, .036A	30V, .036A	4.382 ↔	5.534	—	
10/3/02 739	40V, .048A	40V, .048A	5.874	4.380	—	

G.10.5. Record:

Date/Time 10/2/02 1720

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* Close GTVVA; Pressurize GT with He 6pack

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Perform G.9

G.11. **Pump Guard Tank with AP-1**

G.11.1. Put Gas Module control panel into INTLK DEFEAT.

G.11.2. Turn on/verify on AP-1.

G.11.3. Close EV-5.

G.11.4. Verify RGA-LV closed.

G.11.5. Open RGA-SOV slowly.

G.11.6. Open RGA-V slowly.

G.11.7. Open AV-6: AP-1 now pumping up to closed GTV-V.

G.11.8. Open GTV-V gradually, keeping pressure at EG-1a to less than 20 torr.

G.11.9. Enter comment to DAS: "Begin pumping Guard Tank".

G.11.10. Valve configuration:

	Open/Active	Closed
Main Tank vent Not Connected to GM	SV-9, MTVC-RV	
Guard Tank vent Connected to GM at "Guard Tank Vent" and pumped by the AP-1	AV-6, EV-14, EV-4, EV-7A/B, EV-16, GTV-V	
Remaining EV valves		All other EV valves
RGA & Neon leak valves	TV-1, TV-2, RGA-SOV, RGA-V, GTV-Va	RGA-LV, NSL-V
GSE RAVs	RAV-3	All other RAVs
SV RAVs	RAV-6B	RAV-2

NOTE:

The UTS turbo is now pumping up to RGA-LV, EV-21, -22, EV-4, EV-8 and AV-5.

AP-1 is pumping Guard Tank through a partially open GTV-V

G.11.11. Record:

Date/Time 10/3/02 11:20

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G.12. **Configure for Neon Leak Detection**

G.12.1. Enter comment to DAS " Start neon leak at 50 torr".

G.12.2. Power-on RGA.

G.12.3. Verify RGA-SOV is open.

G.12.4. Adjust RGA-LV to maintain TG-1 between 1E-5 to 8E-5 torr.

G.12.5. Set up RGA in leak detect mode for mass 20.

G.12.6. Start data recording in Table 1.

G.12.7. Bag/verify bagged, connections at GTVA/GTLVL, FGTVL/GTVA and FGTVL/B2 bayonet.

G.12.8. Install/verify installed regulator on Neon supply Bottle.

G.12.9. When GTV-G is approximately 50 torr proceed with the following steps

G.12.10. Valve configuration:

	Open/Active	Closed
Main Tank vent Not Connected to GM	SV-9, MTVC-RV	
Guard Tank vent Connected to GM at "Guard Tank Vent" and pumped by the UTS	AV-6, EV-14, EV-4, EV-7A/B, EV-16, GTV-V	
Remaining EV valves		All other EV valves
RGA & Neon leak valves	TV-1, TV-2, RGA-V, RGA-SOV, RGA-LV, GTV-Va,	NSL-V
GSE RAVs	RAV-3	All other RAVs
SV RAVs	RAV-6B	RAV-2

Quality_____

G.13. Leak Check at 50 Torr

G.13.1. ~~Leak Check GTVA/GTLVL~~ Bayonet at 50 Torr: ~~Date/Time~~ _____

1. Record data in Table 1.
2. Open/verify open RGA-SOV.
3. Adjust RGA-LV to maintain T...1 to 5 +/- 1x10^{-5} torr.
4. Verify RGA is in leak check mode for mass 20.
5. Record steady state data in Table 1 and below:
   Record TG-1 _____ ~~torr~~, I_{RGA} _____ amp.
6. Introduce neon gas into bagged GTV bayonet for 2 mins.
7. Record steady state data in Table 1 and below:
   Record TG-1 _____ torr, I_{RGA} _____ amp.
8. Comments: _____

N/A PER P0800 OP# 1955 STEP G.3.1.3. 10/3/02

G.13.2. Leak Check FGTVL/GTVA bayonet at 50 Torr

Date/Time

1. Open/verify open RGA-SOV.
2. Adjust RGA-LV to maintain TG-1 to 5 +/- 1x10^{-5} torr.
3. Verify RGA is in leak check mode for mass 20.
4. Record steady state data in Table 2 and below:
   Record TG-1 _____ torr, I_{RGA} _____ amp.
5. Introduce neon gas into bagged FGTVL/GTVA bayonet for 2 mins.
6. Record reading _____ amps.
7. Comments: _____

~~G.13.3. Leak Check FGTVL/B2 bayonet at 50 Torr~~

Date/Time _____

1. Adjust RGA-LV to maintain TG-1 to 5 +/- 1x10^{-5} torr.
2. Introduce neon gas into bagged FGTVL/B2 bayonet for 2 mins.
3. Record steady state data in Table 2 and below:
   Record TG-1 _____ torr, I_{RGA} _____ amp.
4. Comments: _____
5. Enter comment to DAS "End 50 Torr Leak Test".

N/A PER P0800, OP# 1955 G.3.1.3. 10/3/02

Quality_____

G.14. Pumping Guard Tank to Vacuum and Leak Check

G.14.1. When EG-1a is between 1 and 10 torr, and GTV-V is fully open:

1. Power off RGA and TG-1.
2. Close RGA-LV and RGA-SOV.
3. Close AV-6.

G.14.2. Open EV-5: now pumping Guard Tank with UTS turbo.

G.14.3. When TG-3 < 1 torr power on TG-1.

G.14.4. Power on TG-1.

G.14.5. Record: TG-1 3×10^{-3} torr, VG-4 3×10^{-2} torrDate/Time 10/3/02 1310

G.14.6. When TG-1 is less than 8E-5 proceed.

G.14.7. Record TG-1 8×10^{-5} torr. Date/Time 10/3/02 @ 1423

G.14.8. Power on RGA and place in leak check mode for mass 20.

Calibrate RGA at Low Pressure

Note: The neon standard leak has a value of 1.416×10^{-6} sccs Ne, ref. G5.8. 9.5

UNABLE TO LEAK CHECK WITH NEON DUE TO HIGH BACKGROUND AFTER PURGING NSL-V

MONITOR N_2 & O_2 ON RGA WHILE PURGING BAG WITH NEON GAS. NO DROP IN N_2 OR O_2 ⇒ NO GROSS LEAKS

G.14.9. Open NSL-V.

G.14.10. Record steady state data in Table 1 and below:
Record TG-1 _____ torr, I_{RGA} _____ amp.

G.14.11. Close NSL-V

G.14.12. Record steady state data in Table 1 and below:
Record TG-1 _____ torr, I_{RGA} _____ amp.

G.14.13. Open NSL-V.

G.14.14. Record steady state data in Table 1 and below:
Record TG-1 _____ torr, I_{RGA} _____ amp.

G.14.15. Close NSL-V

G.14.16. Record steady state data in Table 1 and below:
Record TG-1 _____ torr, I_{RGA} _____ amp.

G.14.17. When time allows calculate RGA sensitivity, 1.5×10^{-6} sccs/change in amps, _____sccs/amp.

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G.15. Leak Check at low pressure

NOTE:

Maximum Leak rate shall be less than $1X10^{-6}$ sccs Neon

G.15.1. Leak Check GTVA/GTLVL Bayonet Date/Time _____

1. Open/verify open RGA-SOV.
2. Adjust RGA-LV to maintain TG-1 on same value as used for low pressure calibration above.
3. Verify RGA is in leak check mode for mass 20.
4. Record steady state data in Table 1 and below:
   Record TG-1 _____ torr, I_{RGA} _____ amp.
5. Introduce neon gas into bagged GTV bayonet for 2 mins.
6. Record steady state data in Table 1 and below:
   Record TG-1 _____ torr, I_{RGA} _____ amp.
7. Calculate leak rate using RGA sensitivity determined above
   _____sccs Ne.
8. Calculate leak rate: _____ sccs Ne
9. Verify leak rate is less than $1x10^{-6}$ sccs Ne.
10. Comments: _____

N/A per P0800 OP# 1955 G.3.1.3. 10/2/02 SU GP-B INSP 28

G.15.2. Leak Check FGTVL/GTVA bayonet Date/Time _____.

1. Verify RGA is in leak check mode for mass 20.
2. Record steady state data in Table 2 and below:
   Record TG-1 _____ torr, I_{RGA} _____ amp.
3. Introduce neon gas into bagged FGTVL/GTVA bayonet for 2 mins.
4. Record reading _____ amps.
5. Calculate leak rate: _____ sccs Ne
6. Verify leak rate is less than $1x10^{-6}$ sccs Ne.
7. Comments: _____

G.15.3. Leak Check FGTVL/B2 bayonet

Date/Time _____.

1. Adjust RGA-LV to maintain TG-1 on same value as used for low pressure calibration above.
2. Introduce neon gas into bagged FGTVL/B2 bayonet for 2 mins.
3. Record steady state data in Table 1 and below:
   Record TG-1 _____ torr, I_{RGA} _____ amp.
4. Calculate leak rate: _____ sccs Ne
5. Verify leak rate is less than $1x10^{-6}$ sccs Ne.
6. ~~Comments:~~ _____

N/A
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G.15.4. Enter comment to DAS "End low pressure Ne Leak Test".

~~G.15.5. Spray Ne around the GTLVL/HEX bayonet and adjacent GM joints up to EV-13 and EV-16.~~

G.15.6. Record steady state data in Table 1 and below:
Record TG-1 _____ torr, I_{RGA} _____ amp.

G.15.7. Turn off RGA.

G.15.8. Close/verify closed RGA-LV.

G.15.9. Close/verify closed RGA-SOV, RGA-V.

G.15.10. Close GTV-Va.

G.15.11. Valve configuration:

	Open/Active	Closed
Main Tank vent Not Connected to GM	SV-9, MTVC-RV	
Guard Tank vent Connected to GM at "Guard Tank Vent" and pumped by the UTS	TV-1, TV-2, EV-5, EV-14, EV-4, EV-7A/B, EV-16, GTV-V	
Remaining EV valves		All other EV valves
RGA & Neon leak valves		GTV-Va, NSL-V, RGA-SOV, RGA-LV, RGA-V
GSE RAVs	RAV-3	All other RAVs
SV RAVs	RAV-6B	RAV-2

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Quality _____
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G.16. **Helium Leak Check**

G.16.1. Put RGA in spectrum mode to monitor He, H_2O, O_2, N_2 and CO_2

G.16.2. Continue pumping with UTS until the leak detector shows a background of less than $1X10^{-5}$ sccs He.

G.16.3. Maintain data entries in Table 1.

G.16.4. Remove leak detector from UTS, cap the pumping port, put leak detector in test mode and record:
Std leak size 5.9x10-8 sccs
Std leak signal 6.0x10-8 sccs
Std leak S/N EBAL5056
Std leak call due date 1/23/03

G.16.5. Verify agreement to within 5% of full scale.

G.16.6. Connect leak detector to TV-3.

G.16.7. Leak check all plumbing up to closed TV-3.

G.16.8. Perform periodic leak detector hookups to determine the leak detector background using:

1. Activate leak detector using leak detector instructions
2. Close TV-2 open TV-3.
3. Record background in Table 1.

G.16.9. When background is less than $2X10^{-5}$ proceed.

G.16.10. Record leak detector background 8.8x10-7 sccs He

G.16.11. Leak Check GTVA/GTLVL Bayonet

Date/Time —

1. Verify leak detector backing UTS turbo pump.
2. Record steady state data in Table 1 and below:
   Record TG-1 8.8x10-7 torr, He background 8.8-7 sccs He
3. Introduce helium gas into bagged GTVA bayonet for 2 mins.
4. Record steady state data in Table 1 and below:
   Record TG-1 _____ torr, He leak rate _____ sccs He
5. Verify helium leak rate is less than $1x10^{-6}$ sccs.
   Comments: _____

G.16.12. Leak Check FGTVL/GTVA bayonet Date/Time 10/4/02 1500

1. Verify leak detector backing UTS turbo pump.
2. Record steady state data in Table 1 and below:
   Record TG-1 8×10^{-7} torr, He background 8.8^{-7} sccs He
3. Introduce helium gas into bagged FGTVL/GTVA bayonet for 2 mins.
4. Record steady state data in Table 1 and below:
   Record TG-1 $8X10^{-7}$ torr, He leak rate $8.2X10^{-7}$ sccs He 10/4/02
5. Verify helium leak rate is less than $2x10^{-6}$ sccs.
   Comments: _____

G.16.13. Leak Check FGTVL/B2 bayonet Date/Time —.

1. Verify leak detector backing UTS turbo pump.
2. Record steady state data in Table 1 and below:
   Record TG-1 _____ torr, He background _____ sccs He
3. Introduce helium gas into bagged FGTVL/B2 bayonet for 2 mins.
4. Record steady state data in Table 1 and below:
   Record TG-1 _____ torr, He leak rate _____ sccs He
5. Verify helium leak rate is less than $2x10^{-6}$ sccs
   Comments: _____

G.16.14. Enter comment to DAS "End helium leak test".

G.16.15. Spray He around the GTLVL/HEX bayonet and adjacent GM joints up to EV-13 and EV-16.

G.16.16. Verify helium leak rate is less than $2x10^{-6}$ sccs.

G.16.17. Remove leak detector from UTS, cap the pumping port, put leak detector in test mode and record:
   Std leak size 5.4×10^{-8} sccs
   Std leak signal 5.8×10^{-8} sccs

G.16.18. Verify agreement to within 5% of full scale.

G.16.19. Shut down leak detector

G.16.20. Power down RGA and close RGA-V, Date/Time N/A.

SKIP

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G.17. **Re-pressurize Guard Tank with Helium Gas from Main Tank**

Date/Time 10/5/02 / 1300

G.17.1. Record: EG1b 700 torr.

G.17.2. Close EV-5, EV-14, and EV-4.

G.17.3. Close TV-1 and shut down UTS.

G.17.4. Valve configuration:

	Open/Active	Closed
Main Tank vent Not Connected to GM	SV-9, MTVC-RV	
Guard Tank vent Locked up to GM manifold	EV-16, GTV-V	
Remaining EV valves	EV-7A/B	All other EV valves
RGA & Neon leak valves		GTV-Va, NSL-V, RGA-SOV, RGA-LV, RGA-V
GSE RAVs	RAV-3	All other RAVs
SV RAVs	RAV-6B	RAV-2

Quality_____

G.18. **Prepare Fill Line**

G.18.1. Verify installed/install 1-in. pumping line from Access-1 of Gas Module to FCV of FCA.

G.18.2. Turn on pump AP-1.

G.18.3. Open AV-8 and AV-3.

G.18.4. Open valve FCV and evacuate to 20 mtorr as measured at AG-2.

G.18.5. Close AV-8.

G.18.6. Open AV-1 and adjust AV-9 to give 1 psig at AG-1.

G.18.7. Close AV-1

G.18.8. Open AV-8 and evacuate to 20 mtorr. as measured at AG-2.

G.18.9. Close AV-8 and FCV.

G.18.10. Once the pressure in the Fill Cap Assembly has stabilized, record Fill Cap Assembly pressure (FCG): 4.3 torr.

G.18.11. Open valve SV-13 to bring Fill Cap Assembly up to SMD Fill line pressure and record
Fill line pressure (FCG): 4.3 torr.

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Quality_____
10/5/02

G.19. **Open RAV-1**

G.19.1. Enter comment to DAS "Start repress of GT". Date/Time 10/5/02 1302

G.19.2. Verify all selector switches are off.

G.19.3. Power up RAV power supply to 28 volt at ~~1.9 a.~~ 1.75

G.19.4. Power up RAV controller No. 1.

G.19.5. Position selection switch to RAV-1.

G.19.6. Record initial switch status: Open: ❑ ❑ Closed: ❑ ❑

G.19.7. Activate controller No. 1 and record:

1. run time: 21.7 seconds
2. current draw: 1.63 amp
3. time of day: 1303 hrs

G.19.8. Record final switch status: Open: ❑ ❑ Closed: ❑ ❑

G.19.9. Record operation in RAV log book.

G.19.10. Record FCG 858 torr

G.19.11. Record ~~EG-1a~~ STG 98.26 torr

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G.20. **Open RAV-2**

G.20.1. Verify closed FCV.

G.20.2. Request LM personnel install arming plug for RAV-2

G.20.3. Request LM SV Operations open RAV-2.

G.20.4. Record FCG 852 torr

G.20.5. Record EG-1a 700 torr

G.20.6. Verify RAV-2 is open by near coincident with SV open command of rise of Guard Tank pressure to the Main Tank pressure (FCG).

G.20.7. Record FCG 503 torr

G.20.8. Record EG-1a 43 torr

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G.21. **Close RAV-2**

G.21.1. Request LM SV Operations close RAV-2.

G.21.2. Request LM personnel remove arming plug for RAV-2

G.21.3. Verify by pressure rise in FCG that RAV-2 is closed.

G.21.4. Record:

1. FCG 325 torr
2. EG-1a 948 torr

G.21.5. Verify ~~APR-2~~ is adjusted to ~~~5 psig~~ He regulator

G.21.6. Open ~~EV-23~~ GTV-Va to regulate pressure to Guard Tank, purge connections

G.21.7. ~~Adjust APR-2 g~~radually to ~2 psig, watching CN28 for temperature excedance.

G.21.8. Valve configuration:

	Open/Active	Closed
Main Tank vent Not Connected to GM	SV-9, MTVC-RV	
Guard Tank vent Pressurized by APR-2	EV-16, EV-23, APR-2, GTV-V, GTV-RV	GTV-Va
Remaining EV valves	EV-7A/B	All other EV valves
Fill line		FCG, SV-13, AV-1, AV-9
GSE RAVs	RAV-1, RAV-3	All other RAVs
SV RAVs	RAV-6B	RAV-2

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G.22. **Close RAV-1 and Pump Fill Line**

G.22.1. Verify FCV and all AVs closed.

G.22.2. Open AV-3 and AV-8.

G.22.3. Open FCV.

G.22.4. When FCG < 20 mtorr, close FCV.

G.22.5. Open SV-13, record FCG 807.

G.22.6. Close RAV-1.

1. Record initial switch status: Open: ☐ ☐ Closed: ☐ ☐ N/C
2. Activate controller No. 1 and record:
   a. run time: 21.3 seconds
   b. current draw: 1.63 amp
   c. time of day: 1319

Immediately:

3. Verify SV-13 open
4. Record FCG 853 torr
5. Open FCV: now pumping fill line with AP-1.
6. Record final switch status: Open: ☐ ☐ Closed: ☑ ☐
7. Record operation in RAV log book.
8. Position selection switch to off.
9. Power down RAV controller No. 1.
10. Power off RAV power supply.

G.22.7. Record FCG 4.5 torr, EG-1a 870 torr.

G.22.8. Record: Date/Time 10/5/02 1322

Power off GT Heaters

Quality SU GP-B INSP 28 10/5/02

G.23. Pump Fill Line

1. When AG-2b < 20 mtorr,
2. Record AG-2b 13.1 mtorr.
3. Close SV-13, torquing to 60 in-lb.
4. Close AV-8.

G.23.2. Backfill with helium gas via AV-1 and AV-9 to 1.5 psig as indicated by AG-1

G.23.3. Close FCV.

G.23.4. Close AV-1.

G.23.5. Open AV-8: pump line to vacuum.

G.23.6. When AG-2b < 20 mtorr

1. Close AV-8
2. Close AV-3.

G.23.7. Record FCG pressure for 30 minutes:

G.23.8. Date:	10/5/02				
G.23.9. Time	~~1324~~ 1325	1342 ~~1385~~	1349	1355	
G.23.10. FCG (torr)	840.9	840.9	840.8	840.8	

G.23.11. Verify no leakage at SV-13 into fill line.

SU GP-B INSP 28

Quality 10/5 for

G.24. Final Configuration

G.24.1. Valve configuration:

	Open/Active	Closed
Main Tank vent Not Connected to GM	SV-9, MTVG-RV	
Guard Tank vent Pressurized by APR-2	EV-16, EV-23, APR-2, GTV-V	GTV-Va EV-16
Remaining EV valves	EV-7A/B	All other EV valves
Fill line		FCV, SV-18, AV-1, AV-9
GSE RAVs	RAV-3	All other RAVs
SV RAVs	RAV-6B	RAV-2

G.24.2. Input comment to DAS "GT leak check completed".

G.24.3. Stop DAS Special Data Cycle.

G.24.4. Remove pumping line between Access 1 and FCV.

Section G.25 complete. Quality SU GP-B INSP 28 10/5 tcr

G.25. Configuration of Dewar and GSE

G.25.1. Record the Main Tank liquid level (LL-1D or LL-2D): 88 %

G.25.2. Record the following pressures:

1. Main Tank pressure (EG-3): NA torr STG 64,26
2. Guard Tank pressure (EG-1a/GTVG): 118.8 torr

Quality SU GP-B INSP 28 10/5 tcr

G.26. Setting up Data Acquisition

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

G.26.1. Set DAS to configuration choice 4Y. 4 cc

G.26.2. Stop Special Data Cycle by using [Other Menus] + [Special Data Col] + [Stop Data Col].

G.26.3. Record Vacuum Shell Pressure.

1. Turn on Vac-ion pump and record time of day 1402
2. Use DAS [Monitor Data] for CN 99.
3. When value is steady, record pressure (IP) 4.0^{-6} torr.
4. Exit [Monitor Data] and collect data with [Set Data Interval] to 15 min.
5. When data cycle is complete, turn off Vac-ion pump.

G.26.4. Set DAS data cycle interval to 15 minutes.

G.26.5. Set Main Tank Liquid Level sampling interval to 10 minutes.

G.26.6. Confirm that the liquid level sensors are set at a sampling rate of 10 minutes or turned off.

G.26.7. Confirm that Vac-ion pump is off.

G.26.8. Enable/verify enabled the alarms on the Main Tank and Well Liquid Level Sensors.

G.26.9. Verify enabled the DAS alarm and record the set points:

a) CN 40, Level 5.2
b) CN 41, Level 5.2
c) CN 46, Level 30
d) Main Tank Level: 20 %
e) Guard Tank Level: 20 %

G.26.10. Ensure DAS watchdog timer and alarm enabled.

Quality SU GP-B INSP 28 10/5/02

H. **Procedure Completion**

Completed by:
Witnessed by: M. G. Tabry
Date: 10/5/02
Time: 1400
Quality Manager: SU GP-B INSP 28 **Date** 10/5/02
Payload Test Director: M. G. Tabry **Date** 10/5/02

Table 1 Neon leak Data

Date/Time	Neon	EG-1a	TG-1	EG-1a	FCG		Comments
10/03/02	Amp	Torr	torr	torr	Torr-diff		(G.15)
							Low Press Leak Check (~~G.15~~)
							~~RGA Filename:~~
		BKGND 4.3×10^{-10} AMP					~~SM0_1M.004~~
							G.14.10
							G.14.12
							G.14.14
							~~G.14.16~~
TIME	N_2	O_2					PURGE BAG w/NEON
1535	1.5×10^{-7} torr	4.8×10^{-8} torr					↓
1537	1.5×10^{-7}	4.8×10^{-8}					
1539	2.0×10^{-7}	4.8×10^{-8}					

Figure 1a. Schematic of Gas Module Plumbing at Start of FEE Guard Tank Vent Line Install

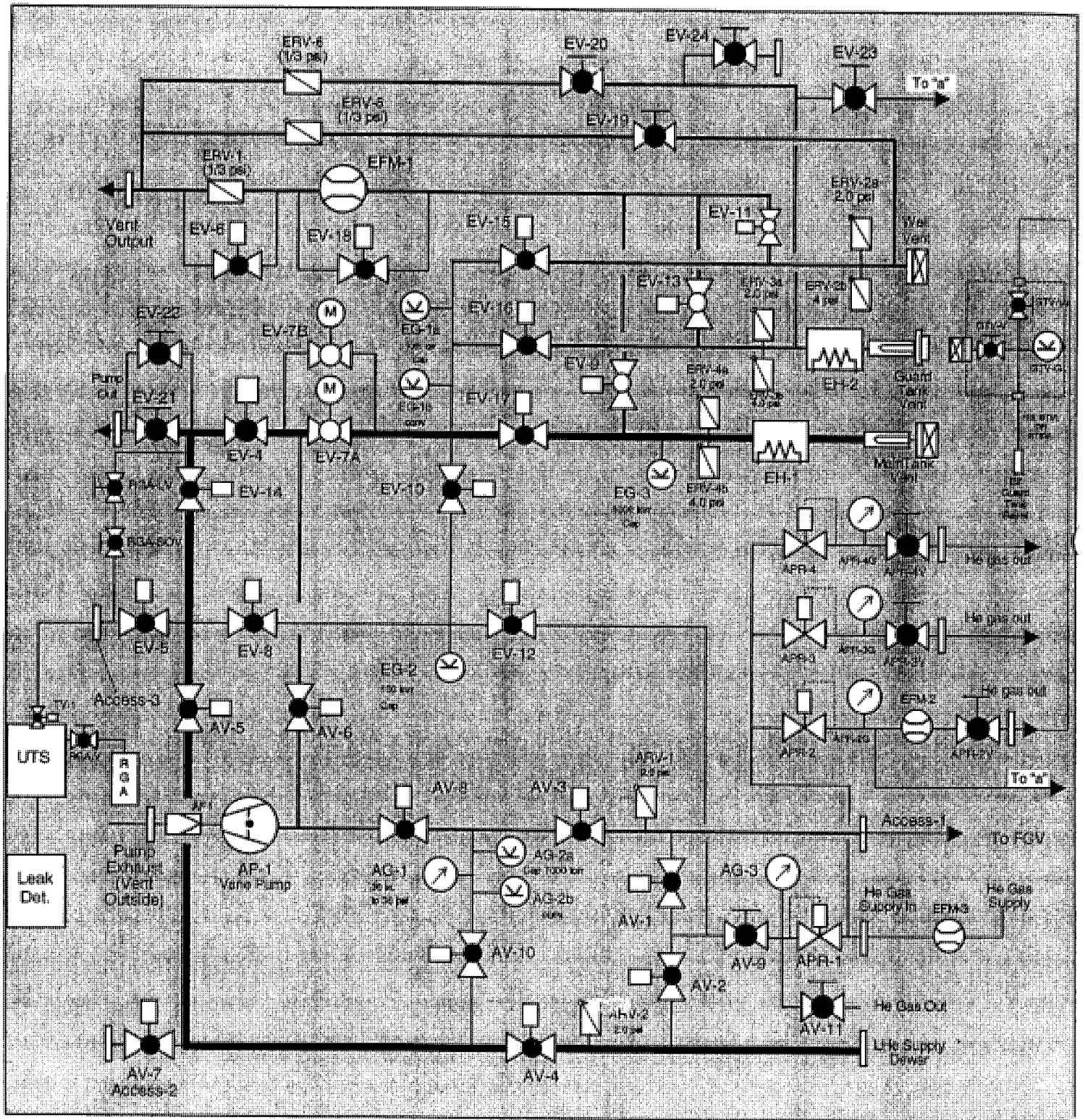


Figure 1b. Schematic of Gas Module Plumbing for Neon Leak Detection of Guard Tank Vent

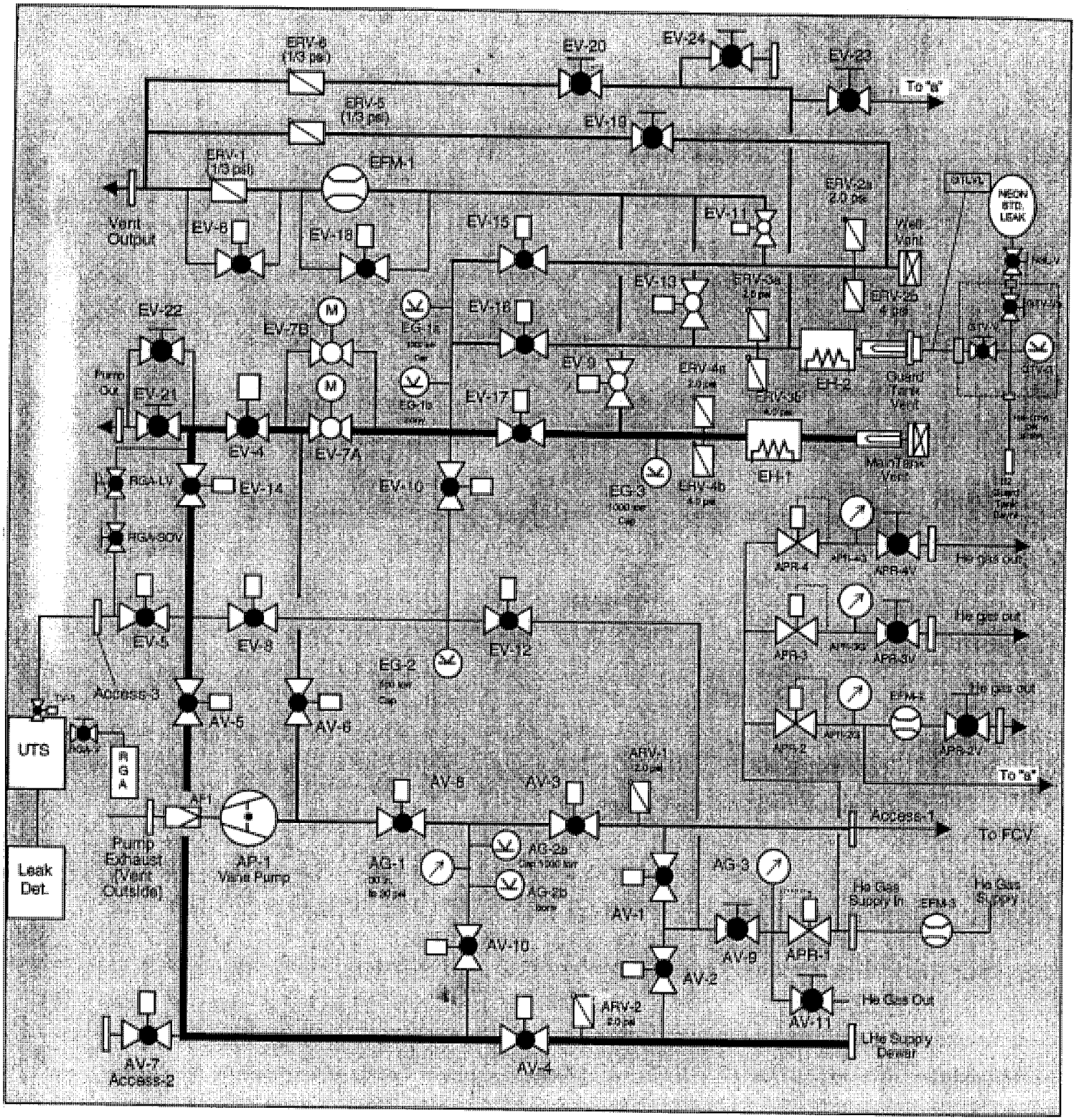


Figure 2 Gas Module and Vent lines connected to SMD

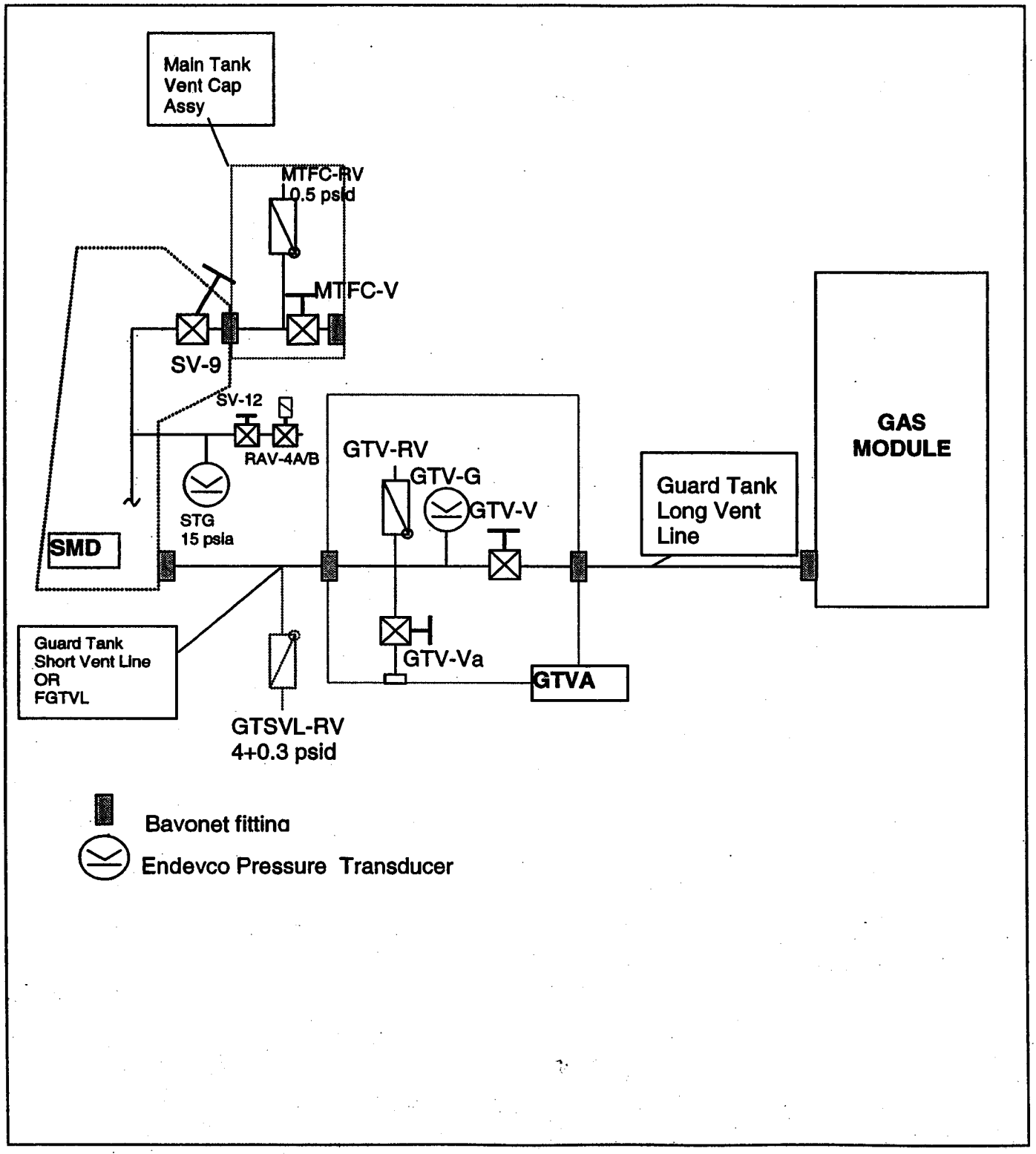


Figure 2 Utility Pump System with RGA for Neon leak detection

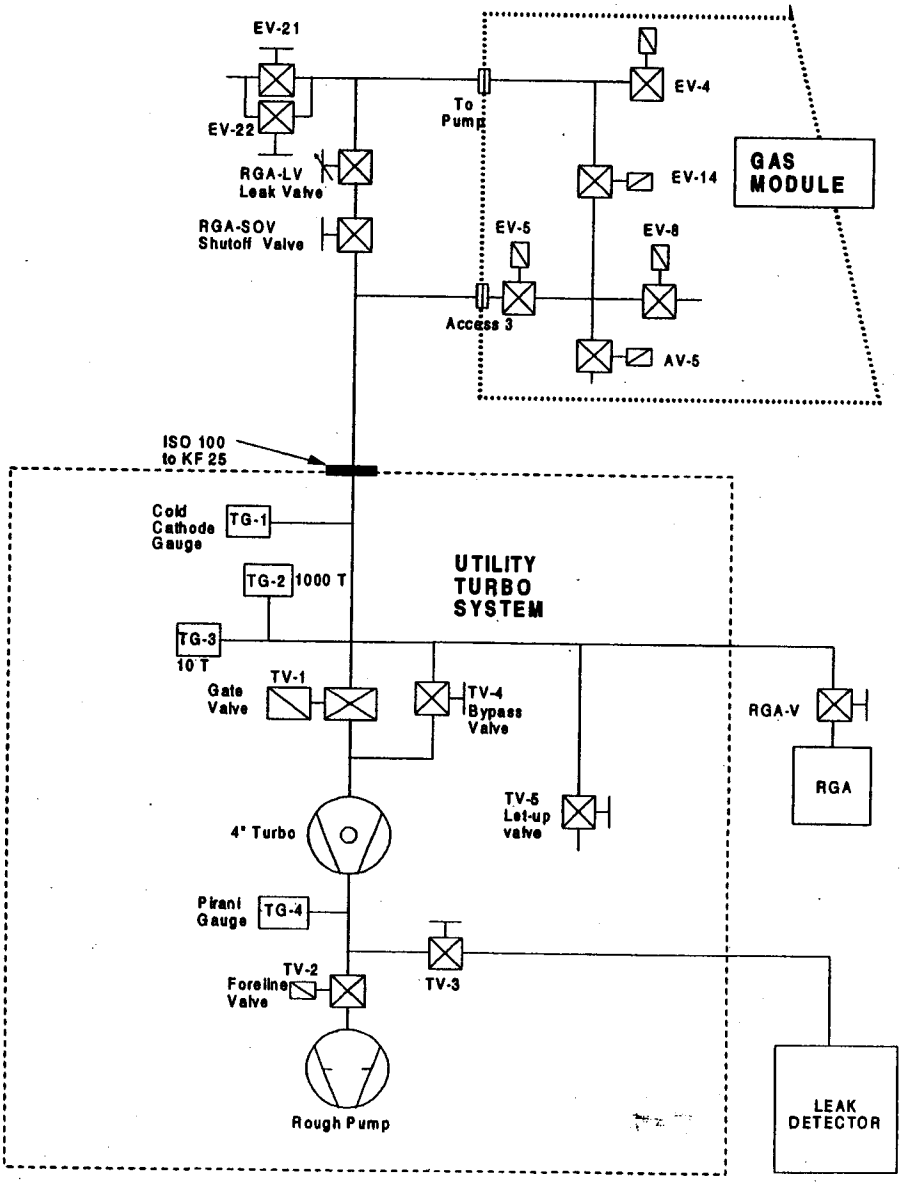
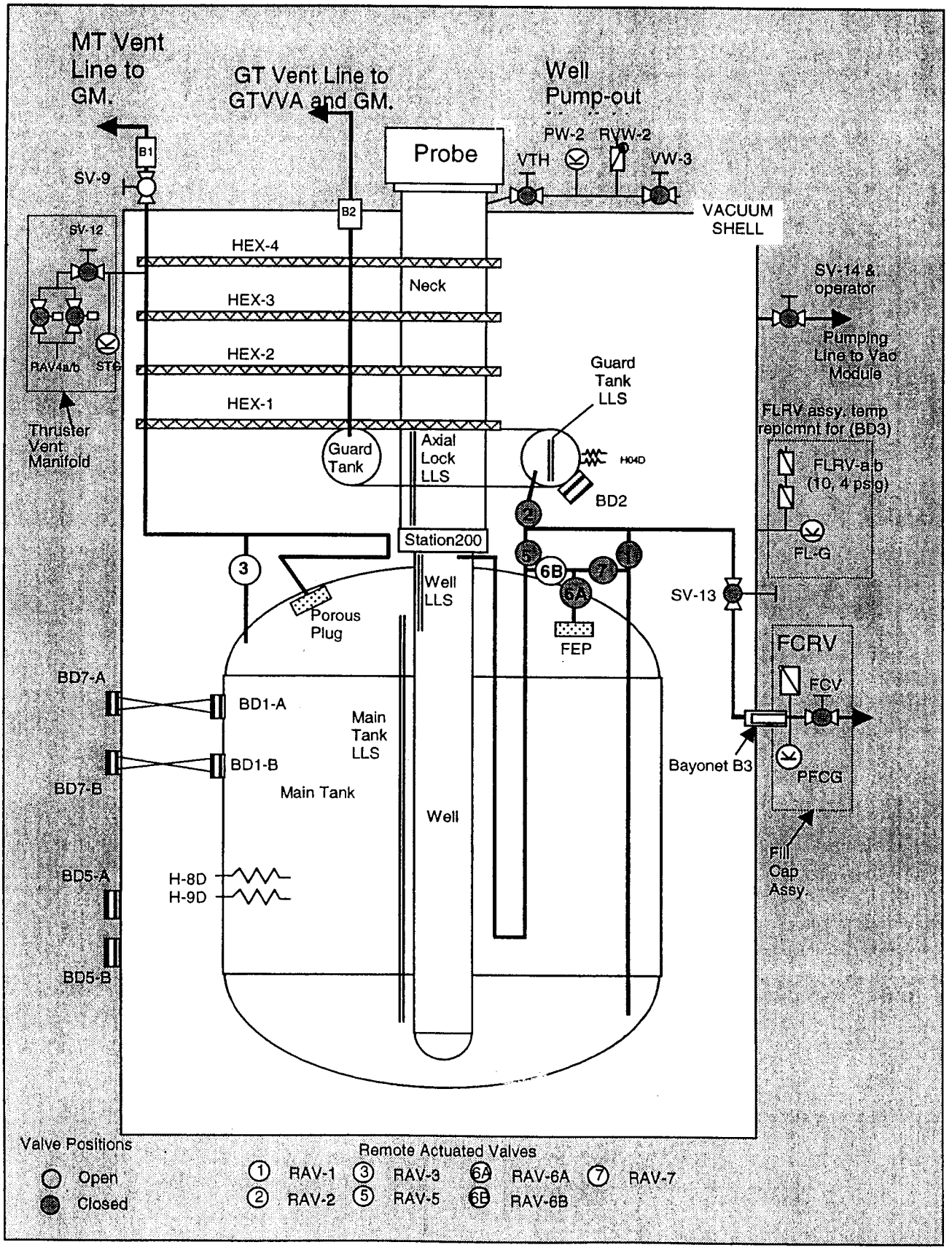


Figure 3. Schematic of Science Mission Dewar plumbing



I. Appendices

I.1. Appendix 1 Pre-Test Check List

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
7/12/02	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:		

I.2. Appendix 2 Post-Test Check List

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
10/5/02	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:		

I.3. Appendix 3– Contingency Responses

	Condition	Circumstance	Response
1	Power Failure		
		Any time	Wait for power restoration Note: the DAS computer will continue to function for several hours, however no data will be collected DAS computer still operating: Reset GM valving per the last configuration in procedure and resume procedure DAS computer not operating: Reboot computer and launch DRP_SMD and select auto startup option Reset GM valving per the last configuration in procedure and resume procedure
2	Temperature limits (CN 28 or 29) exceeded	ANY TIME	Lower inflow of helium gas to Guard Tank OR, INCREASE MAIN TANK VENTING Open MTVC-V momentarily or if problem persists see 3 below
3		ANY TIME	PROMOTE INCREASE IN MAIN TANK VENTING Power up heater at H08D or H0-9D and starting at 15 vdc input increase power until increased flow has cooled the problem area
4	Burst disk rupture (MT/GT)	ANY TIME	Evacuate room

STANFORD UNIVERSITY

SU/GP-B P0773 Rev -

Operations No. 1577

GRAVITY PROBE-B

PAYLOAD TESTING

PROCEDURE

CERTIFICATION OF ELECTRICAL MODULE, GAS MODULE AND DATA ACQUISITION SYSTEM

P0773

December 11, 2000

Originator
D. Murray

Approvals:

M. A. Taber Date 12/15/00
Mike Taber
Test Director

D. A. Murray Date 12-15-0
Dave Murray
Test Director

Barry Muhlfelder Date 12/18/00
Barry Muhlfelder
Payload Technical Manager

Dorrene Ross Date 12-15-00
Dorrene Ross
GP-B Quality Engineer

REVISION	ECO No.	PAGES	DATE
Original	-	All	December 11, 2000

ABBREVIATIONS

xxP	Kit number xx of P type kits (ref. SU GP-B P0141)
ALSP	Airlock Support Plate
ALSPV	Airlock Support Plate Valve
ATC	Advanced Technology Center (at LMSS)
AVxx	Gas Module Auxiliary valve number xx
BPS	Bellville Pre-load System
CNT	Composite Neck Tube of Probe
DAS	Data Acquisition System
EM	Electrical Module
ESD	Electrostatic Discharge
EVxx	Gas Module Exhaust Valve number xx
AWG	American Wire Gauge
Cryoperm	Trade name for cryogenic magnetic shielding
CT	Cooling Tube
CTE	Cryogenic Test Engineer
DAS	Data Acquisition System
DEV-xx	Dewar Exhaust Valve number xx
DR	Discrepancy Report
DVM	Digital Volt Meter
EEBA	Emergency Evacuation Breathing Apparatus
EG-xx	Gas Module Exhaust Gauge number xx
ESD	Electrostatic Discharge
EVRx	Gas Module Relief Valve number x
FIST	Final Integrated System Test
GM	Gas Module
GHe	Gaseous Helium
GP-B	Gravity Probe-B program (also, Relativity Mission)
GRT	Germanium Resistance Thermometer
GSE	Ground Support Equipment
GTU-2	Ground Test Unit number 2
HEPA	High Efficiency Particulate Air
LGS	Leakage Gas System
LLS	Liquid Level Sensor
LMSS	Lockheed Martin Space Systems
LN_2	Liquid Nitrogen
mG	milli Gauss
MHZ	Megahertz
NPB	Normal Boiling Point
ONR	Office of Naval Research
Ozsi	Ounces per square inch
PPS	Programmable Power Supply
PWx	Well Pressure gauge x
QD	Quick Disconnect - O-ring seal under cap
RCM	Rotating Coil Magnetometer
RGA	Residual Gas Analyzer
RSE	Responsible Safety Engineer
RQE	Responsible Quality Engineer
sccs	Standard cubic centimeters per second
SMD	Science Mission Dewar (of GP-B , Relativity Mission program)
SU	Stanford University
TAO	Thermal Acoustic Oscillation
TGxx	UTS Gauge xx
TM xx	Task Module number xx.
TVxx	UTS Valve xx
VMA	Valve of Mini-Airlock
UTS	Utility Turbo pumping Station
VFV	Vatterfly Valve
VSx	Valve number x on Shutter
VW-1	Valve on Dewar Adapter connecting Well to outside

Table of Contents

A SCOPE

This procedure describes the steps to interconnect the components of and certify the operation of the Payload GSE. This GSE interfaces with the Science Mission Dewar instrumentation and plumbing. The GSE are Electrical Module (EM), Gas Module (GM) and Data Acquisition System (DAS).

B REFERENCE DOCUMENTS

B.1 Procedures

Procedure No.	Title
None	

B.2 Drawings

LMSC Drawing No.	Title
None	

B.3 Figures

None

B.4 Supporting documentation

a) GP-B Magnetic Control Plan, LMSS-5835031

b) SMD Safety Compliance Assessment, LMSS GPB-100153C

c) SM Dewar FMECA, LMSS GPB-100333

d) FIST Emergency Procedures SU/GP-B P0141

e) SMD Final Assembly, LMSS 5833500

C SAFETY

C.1 In case of any injuries obtain medical treatment at:

Stanford University **Call 9-911** or, at LMSS, **Call 117**

C.2 Safety

The GP-B (FIST) Safety Plan, LMSS GPB-100153C, discusses safety design, operating and maintenance requirements which the LMSS program office has adhered to. These requirements should be reviewed for applicability at any facility outside of LMSS (e.g. Stanford University) where FIST hardware is operated.

C.3 Hazards Analysis

The GP-B (FIST) Preliminary Hazards Analysis, LMSS GPB-100333, discusses hazards inherent in LMSS-developed FIST hardware in greater detail.

D CONTAMINATION CONTROL

D.1 Particulate Contamination

The control of particulate contamination of the probe is described in "GP-B Contamination Control Plan", SU/GP-B P059. Specific cases that require special methods are treated individual in this procedure.

E PERSONNEL

The personnel certified to set up and perform this procedure are:

Dave Murray	Stanford University
Mike Taber	Stanford University
Jim Maddocks	Stanford University
Tom Welsh	Lockheed

F QUALITY ASSURANCE

Payload integration shall be conducted on a formal basis to approved and released procedures. The QA program office and ONR office shall be notified 24 hours prior to the start of this procedure. A Quality Assurance Representative, designated by D. Ross shall be present during the procedure and shall review any discrepancies noted and approve their disposition. Upon completion of this procedure, the QA Program Engineer, D. Ross or her designate will certify 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.

A Quality Assurance Representative, designated by D. Ross shall be present during the procedure and shall review any discrepancies noted and approve their disposition

a) All discrepancies shall be recorded in a D-log

b) Any discrepance resulting in a nonconformance or test anomaly shall be reported by a Discrepancy Report. Refer to the Quality Plan, P0108, for guidance. Do not alter or break test configuration if a test failure occurs; notify quality assurance.

F.1 Redline Authority

The persons authorized to create and sign-off on redline modifications of the procedure as it is performed are the test directors, M. Taber and D. Murray. The redlines shall be reviewed and approved by the RQE and ,as appropriate, the RSE during or after the performance of the redline.

G CONFIGURATION REQUIREMENTS

a) Payload **not** connected to GSE (EM, GM, DAS)

H HARDWARE REQUIRED

a) Gas, Electrical and DAS modules
b) Helium Gas Supply System
c) Compressed air at 80-120 psig

I CALIBRATIONS REQUIRED

None

Operations Number 1577
Date Initiated 1/29/01
Time Initiated 1417

J OPERATIONS

1 System Set Up

1.1 Verify the power switch on the DAS, GM and EM units is off.

1.2 Connect the DAS, GM and EM with appropriate cables per Fig. 1.

1.3 ☐ Pump Module is to be installed, install cables per Fig. 1.

☒ Pump Module is not installed, ignore the PM connections.

1.4 Connect each unit to AC outlets (2 req'd for DAS).

1.5 Power on DAS (refer to Fig. 3):

1.5.1 Turn on power to DAS

1.5.2 Power on HP Scanner and Extender and DVM.

1.5.3 Power on power supplies A and B.

1.6 Power on EM (refer to Fig. 4):

1.6.1 Turn on power to EM

1.6.2 Power on all instruments on left side panel including power supplies.

1.6.3 Open right side back panel and activate 5v dc power supply which operates Valve Control panel.

1.6.4 Verify Control panel is operating.

1.7 Configure Gas Module (Refer to Fig 4):

RGA-SOV EV-25 1/29/01 SU GP-B INSP 31

1.7.1 Verify all manual valves: EV-19, EV-20, EV-21, EV-22, EV-23 and EV-9 are closed.

1.7.2 Verify blank-off flanges have been installed on ports: Access-1, -2, -3 and -4; the " Vent Exit", "Well Vent", "Guard Tank Vent", "Main Tank Vent" and "LHe Supply Dewar".

1.7.3 Verify "To Pump" port down stream of EV-21/EV-22 has a blank-off flange installed.

1.7.4 Verify the "Purge Gas" valve is in the "OFF" position.

1.7.5 Verify the "Actuator Control for EV-9" is in the "NBP" position.

1.7.6 Connect one of the following:

☐ house air at pressure > 80 psig OR,

☐ nitrogen bottle regulated to > 80 psig

to the "Purge and Valve Actuator" port.

1.7.7 Verify the "Helium Out" port is capped off.

NOTE:

In the following step do not activate the circuit breakers for the two GT and MT heat exchangers.

1.7.8 Activate the two GM, "MAIN" and "PUMP", main circuit breakers.

1.7.9 Connect a compressed helium bottle to the "Helium In" port.

1.7.10 Adjust helium bottle regulator to 20 psig, adjust APR-1 to give approximate 2 psig at AG-3.

1.7.11 Close AV-3 & AV-2 Open AV-11 and AV-9. SU GP-B INSP 31 1/29/01

1.7.12 Crack open "Helium Out" port cap and adjust helium supply to purge through AV-11 for approximately 1 minute and then tighten "Helium Out" port Cap and close AV-11.

1.7.13 Close AV-9.

skip 1.7.14 Vent the "Pump Exhaust" to the outside of building using 1-in (or larger) diameter flexible hose.

skip 1/30/01 1030

OK 1/30/01 1438

2 Check of Gas Module

NOTE:

The Gas module was shipped with rough vacuum in all lines up to the blank-off flanges.

2.1 Enter in Table 1 the last data recorded in the "Prepare to Ship SMD GSE". Need Table added to procedure

2.2 Begin data recording in Table 1. See below

2.3 Evaluate general condition of pre- and post-ship pressures: pressure increase of ≈ .25 torr 1/29/01 SU GP-B INSP 31

Time	EG-1	AG-2	EG-3
1135	1.75	1.77	0.0-0

~~8~~ Check AV Section of Gas Module

3.1 Record: Time/date 1135 / 1/30/01

~~3.2~~ Verify all AV valves are closed.

3.3 Record pressure: AG-2a/-2b 1.77 torr

3.4 Open AV-3 and record: AG-2a/-2b 2.83 torr

3.5 Open AV-1 and record: AG-2a/-2b ~~14.0~~ torr 13.4

3.6 Open AV-2 and record: AG-2a/-2b 6.15 torr

3.7 Open AV-10 and record: Note: Do not open AV-5 this plumbing will be checked in the EV-section AG-2a/-2b 4.57 torr

3.8 Open AV-4 and record: AG-2a/-2b 4.6 torr

3.9 Open AV-7 and record: AG-2a/-2b 4.62 torr

~~3.10 Open AV-5 and record:~~ AG-2a/-2b 3.63 torr

~~3.11 Close AV-8 and record:~~ 8 5 f-f AG-2a/-2b 2.94 torr

3.11a Open AV-8 and record

3.12 Turn on roughing pump, AP-1. AG-2a/-2b TBD torr

3.13 When pressure equilibrium is reached record: AG-2a/-2b 10 M torr

3.14 Close AV-8.

3.15 Perform leak up test for > 15 minutes.

Time:	1143	1145	____	____	1200
Pressure(torr):	22.9 mtorr	54.2 mtorr	____	____	148 mtorr

3.16 Adjust AV-9 and pressurize system to atmospheric, AG-1 to 1 psig.

3.17 Close all AV ~~vales leaving AV system at atmospheric helium.~~ valves

SU GP-B INSP 31 2/1/01

SU GP-B INSP 31 2/1/01

SU GP-B INSP 31 2/1/01

4 Leak Check EV section of Gas Module

4.1 Activate and calibrate leak detector:

Background 4.0×10^{-7} sccs He JM 2/1/01 SU GP-B INSP 31 2/1/01

Std leak measured 5.6×10^{-8} sccs He

Std leak value 5.6×10^{-8} sccs He

4.2 Connect leak detector to Access-3.

4.3 Activate leak detector up to EV-5 and leak check up to EV-5 connection; enter results in Table 2.b

4.4 Open/verify open EV-21, -19, -20, -10, -6 and EV-7a/-7b.

4.5 Open in sequence: EV-14, -4, -10, -15, -16, -17, -9, -13, -11.

4.6 Verify pressure: JM 2/1/01

Replace with Jobel 3A JM 2/1/01

4.6.1 ☐ EV-2b is < 1 torr, skip the next subsection.

4.6.2 ☐ EV-2b is > 1 torr, perform the following: SU GP-B INSP 31 2/1/01

a) Verify AP-1 on

b) Open AV-6. JM 2/1/01

c) Close AV-6 when EV-2b is < .2 torr

4.7 Open EV-5: leak detector is now pumping all of GM EV section.

4.8 Record data in Table 2.b

4.9 Leak detect in selected areas of GM and record in Table 2.b

4.10 Record any significant leaks here: no significant leaks detected

4.11 Pressurize EV section of GM to atmospheric helium

4.11.a Close EV-5

JM 2/1/01 SU GP-B INSP 31 2/1/01

4.11.1 Open EV-12.

4.11.2 Adjust AV-9 until EG-1a equilibrates between 760 to 790 torr.

4.11.3 Close AV -9 and EV-12.

4.11.4 Close EV-6, -18, -19, -20.

SU GP-B INSP 31 2/1/01

4.11.5 Close all other EV valves except EV-7a, -7b.

4.11.6 Shut down the leak detector and stow.

JM 2/1/01 4.11.7 shut-off AP-1

Table 3.A

SU GP-R INSP 31

		EG-1 (torr)	EG-2 (torr)	EG-3 (torr)
Record	EG-3	0.0		
Record	EG-2	—		
Record	EG-1	1.5		
open	EV-7 & 6	1.5	—	0.0
	EV-10	90.0	101.13	0.0
	EV-4	159	off scale	0.0
	EV-14	158	off scale	0.0
	EV-22	128	off scale	0.0
close	EV-22			
open	EV-15	115	off scale	0.0
	EV-11	70.1	78.9	0.0
	EV-18	67.8	78.6	0.0
	EV-6	67.6	76.1	0.0
close	EV-15			
open	EV-17	42.2	47.6	39.9
	EV-16	31.1	35.2	28.8
	EV-15	41.2	47.0	39.3
Open	EV-9, 13	41.6	47.0	39.3
open	EV-12	47.7	53.78	45.4
open	EV-19	47.5	53.61	45.2
open	EV-20	47.3	53.4	45.1

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

SU GP-B INSP 31 2/1/01

SU GP-B INSP 31 2/1/01

Table 2 Leak Detector results for Gas Module

Time/ Date	Leak Detection area	Backgnd sccm He	Reading sccm He	Comment
2/1/01 0842	(Sec. 4.3) up to EV-5	4.0×10^{-7}	3.8×10^{-7}	no leaks
1032	All EV section	2×10^{-5}	2×10^{-5}	no ~~significant~~ leaks detected

4.12 Set Up Gas Meter

4.12.1 Remove blank off from "Vent Exit" and plumb this port to Gas Meter.

4.12.2 Connect the electrical output leads of the Gas Meter to the Veeder Root input cable of the EM.

4.12.3 Vent the Gas Meter exit to the outside of the building using 2-in. diameter flexible hose.

4.13 This completes the GM and EM to GM checkout.

5 DAS Checkout with EM and PM (if in use)

SKIP PMG not used in Body 159

5.1 Connect the SMD simulator to the EM and DAS using the five GSE cables per Fig. 2.

5.2 If not running, boot up the DAS PC and launch "DRP_SMD" from start menu: use the A = autostart option and follow the DAS operating instructions to initialize data collection configuration number 1, "All channels".

5.3 Perform a data collection with [Get Data] of Main Menu.

5.4 Compare the printed output with that taken during last shutdown of Operations log number ___ .

5.5 Recognizing that the Gas Module pressure and Pump Module pressure readings may be slightly different (or for PM may be missing),verify no differences in temperatures (>.01 K) or pressures are indicated.

2-1-01 SU GP-B INSP 31

2/1/01 SU GP-B INSP 31

6 DAS/EM RAV Checkout

6.1 Open Simulated RAV-1:

- 6.1.1 Connect the test RAV to the DAS simulator at SRAV1.
- 6.1.2 Verify all RAV selector switches are off.
- 6.1.3 Power on RAV power supply to 2.0 amp and 28 volts.
- 6.1.4 Power on RAV drive units Nos. 1, 2, 3, and 4.
- 6.1.5 Turn RAV selector switch No. 1 to RAV-1.
- 6.1.6 Record micro switch lights: Open: ☒ ☐ Closed: ☐ ☐
- 6.1.7 Activate Drive Unit #1 to open and record:
  - a) Run time: 29 / 21.3 sec.
  - b) Current draw: 1.42 / 1.73
  - c) Time of day: 1634 / 1642
- 6.1.8 Record micro switch lights: Open: ☒ ☒ Closed: ☐ ☐

6.2 Close Simulated RAV-1:

- 6.2.1 Activate dive unit #1 to open and record:
  - a) Run time: 21.8 sec.
  - b) Current draw: 1.72 a.
  - c) Time of day: 1644.
- 6.2.2 Record micro switch lights: Open: ☒ ☒ Closed: ☐ ☐
- 6.2.3 Turn selector switch No. 1 to "OFF"
- 6.2.4 Turn drive unit #1 off.

15mD
Pinout to Breakout Bat "
(.2 Amp)
motor Sound not by lights
Repeat
DD
2/1/01 SU GP-B INSP 31

SU GP-B INSP 31 2/1/01

1/31/01

6.3 Open Simulated RAV-2:

6.3.1 Connect the test RAV to the DAS simulator at SRAV2. Pinouts for Sm D Rev

6.3.2 Turn RAV selector switch No. 2 to RAV-2.

6.3.3 Record micro switch lights: Open: ☒ ☒ Closed: ☐ ☐

6.3.4 Activate Drive Unit #2 to open and record:

a) Run time: 21.2 sec.

b) Current draw: 1.67 a.

c) Time of day: 1655.

6.3.5 Record micro switch lights: Open: ☐ ☐ Closed: ☐ ☒

2/1/01 Open

6.4 Close Simulated RAV-2:

SU GP-B INSP 31

6.4.1 Activate drive unit No. 2 to open and record:

a) Run time: 21.5 sec.

b) Current draw: 1.66 a.

c) Time of day: 1656.

6.4.2 Record micro switch lights: Open: ☒ ☒ Closed: ☐ ☐

6.4.3 Turn selector switch No. 2 to "OFF"

6.4.4 Leave drive unit #2 on.

6.5 Open Simulated RAV-6B:

6.5.1 Connect the test RAV to the DAS simulator at SRAV6B.

6.5.2 Turn RAV selector switch No. 2 to RAV-6B.

6.5.3 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.5.4 Activate Drive Unit #2 to open and record:

a) Run time:_____ sec.

b) Current draw: _____ a.

c) Time of day: _____ .

6.5.5 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.6 Close Simulated RAV-6B:

6.6.1 Activate drive unit No. 2 to open and record:

a) Run time:_____ sec.

b) Current draw: _____ a.

c) Time of day: _____ .

6.6.2 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.6.3 Turn selector switch No. 2 to "OFF"

6.6.4 Turn drive unit #2 off.

SU GP-B INSP 31

6.7 Open Simulated RAV-3:

6.7.1 Connect the test RAV to the DAS simulator at SRAV3.

6.7.2 Turn RAV selector switch No. 2 to RAV-3.

6.7.3 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.7.4 Activate Drive Unit #3 to open and record:

a) Run time:_____ sec.

b) Current draw: _____ a.

c) Time of day: _____ .

6.7.5 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.8 Close Simulated RAV-3:

6.8.1 Activate drive unit No. 3 to open and record:

a) Run time:_____ sec.

b) Current draw: _____ a.

c) Time of day: _____ .

6.8.2 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.8.3 Turn selector switch No. 3 to "OFF"

6.8.4 Leave drive unit #3 on.

SU GP-B INSP 31

To be recorded at S.O. 2/1/01

6.9 Open Simulated RAV-5:

6.9.1 Connect the test RAV to the DAS simulator at SRAV5.

6.9.2 Turn RAV selector switch No. 3 to RAV-5.

6.9.3 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.9.4 Activate Drive Unit #3 to open and record:

a) Run time:_____ sec.

b) Current draw: _____ a.

c) Time of day: _____ .

6.9.5 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.10 Close Simulated RAV-5:

6.10.1 Activate drive unit No. 3 to open and record:

a) Run time:_____ sec.

b) Current draw: _____ a.

c) Time of day: _____ .

6.10.2 Record micro switch lights: Open: ❑ ❑ Closed: ❑ ❑

6.10.3 Turn selector switch No. 3 to "OFF"

6.10.4 Turn drive unit #3 off.

SU GP-B INSP 31 2/1/01

SU GP-B INSP 31 2/1/01

Close

6.11 Open Simulated RAV-7:

6.11.1 Connect the test RAV to the DAS simulator at SRAV7, Front End Box

6.11.2 Turn RAV selector switch No. 4 to RAV-7.

6.11.3 Record micro switch lights: Open: ☒ ☒ Closed: ☐ ☐

6.11.4 Activate Drive Unit #4 to open and record:

a) Run time: 21.2 sec.

b) Current draw: 1.69 a.

c) Time of day: 1704.

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6.11.5 Record micro switch lights: Open: ☐ ☐ Closed: ☐ ☒

Open

6.12 Close Simulated RAV-7:

6.12.1 Activate drive unit No. 4 to open and record:

a) Run time: 21.2 sec.

b) Current draw: 1.68 a.

c) Time of day: 1704.

6.12.2 Record micro switch lights: Open: ☒ ☒ Closed: ☐ ☐

6.12.3 Turn selector switch No. 4 to "OFF"

6.12.4 Turn drive unit #4 off.

6.12.5 Verify all drive units are off.

6.12.6 Verify all selector switches are "OFF"

6.12.7 Turn off RAV power supply.

6.12.8 Disconnect the test RAV from the DAS simulator at SRAV7.

26-3a-46

7 Procedure completed

Completed By: ____________

Witnessed By: ____________

RQE: ____________

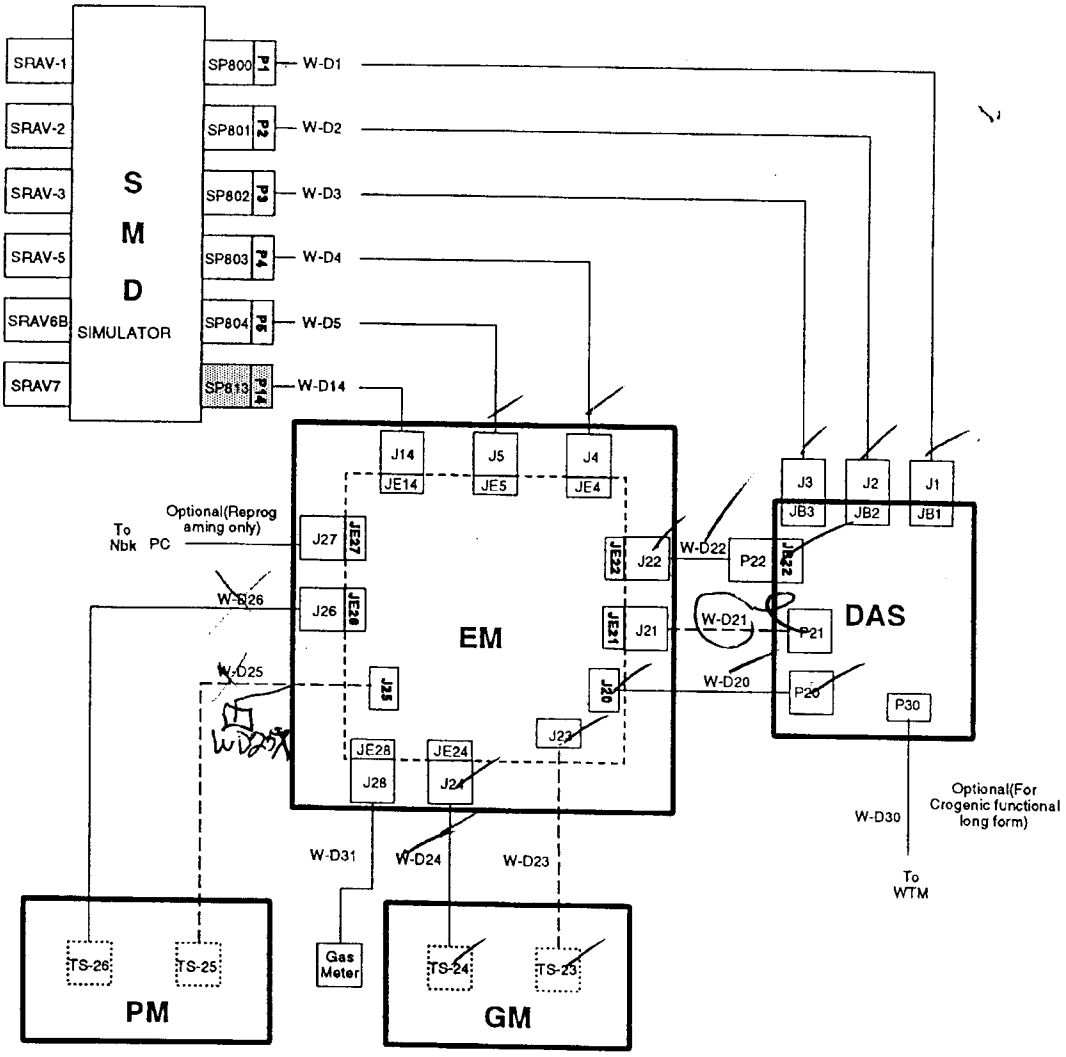
Date: 2/1/01

Time: 1600

Payload Test Director ____________ Date 2/1/01

Quality Manager ____________ SU GP-B INSP 31 Date 2/1/01

Figure 1 SMD Ground Support Equipment Cable Layout



1. W-D20: IEEE 488
2. W-D21, D23 & D25: GE/Fanuc serial line in daisy chain with terminator
3. W-D22, 24 & 26: analog signals
4. Cable lengths: W-D1 THROUGH -D5 and W-D14 ARE 60 feet; EM to DAS 20 feet; EM to GM, 50 feet; EM to PM, 50 feet.

Figure 2 DAS Console Layout

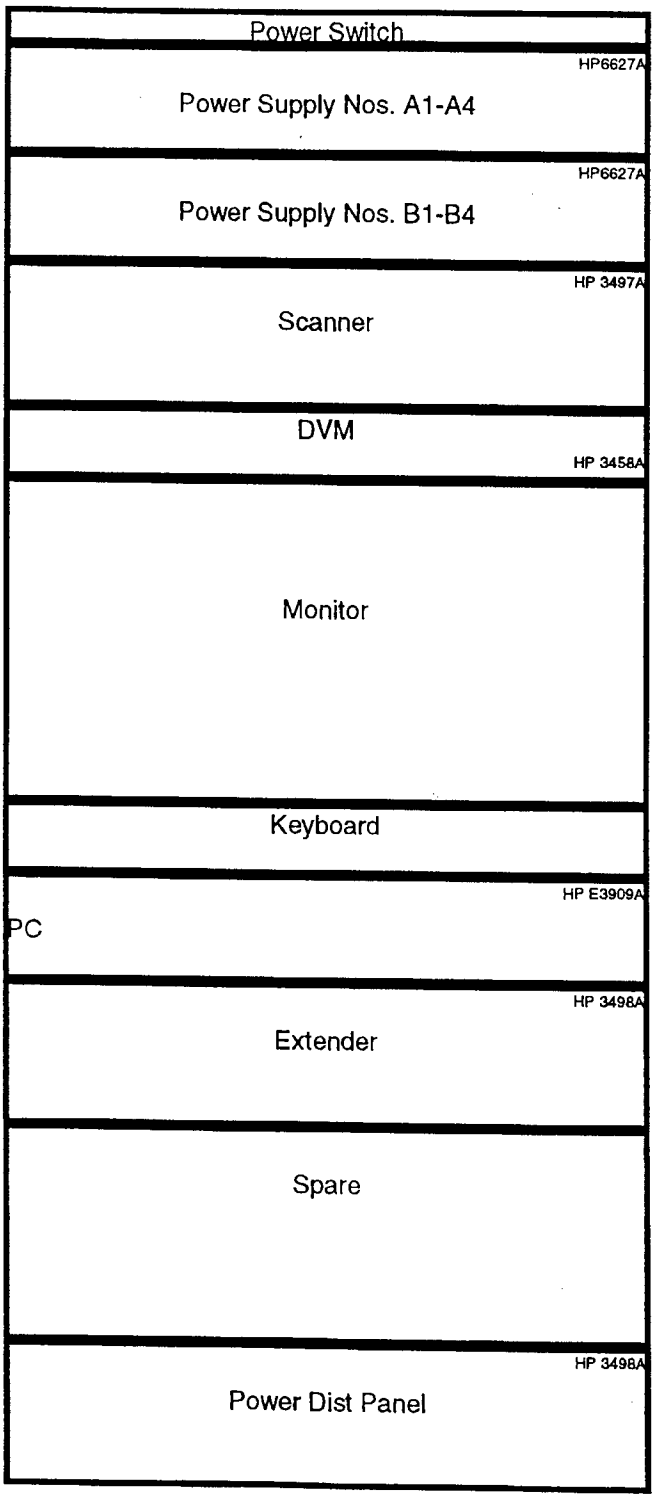


Figure 3 Electrical Module Layout

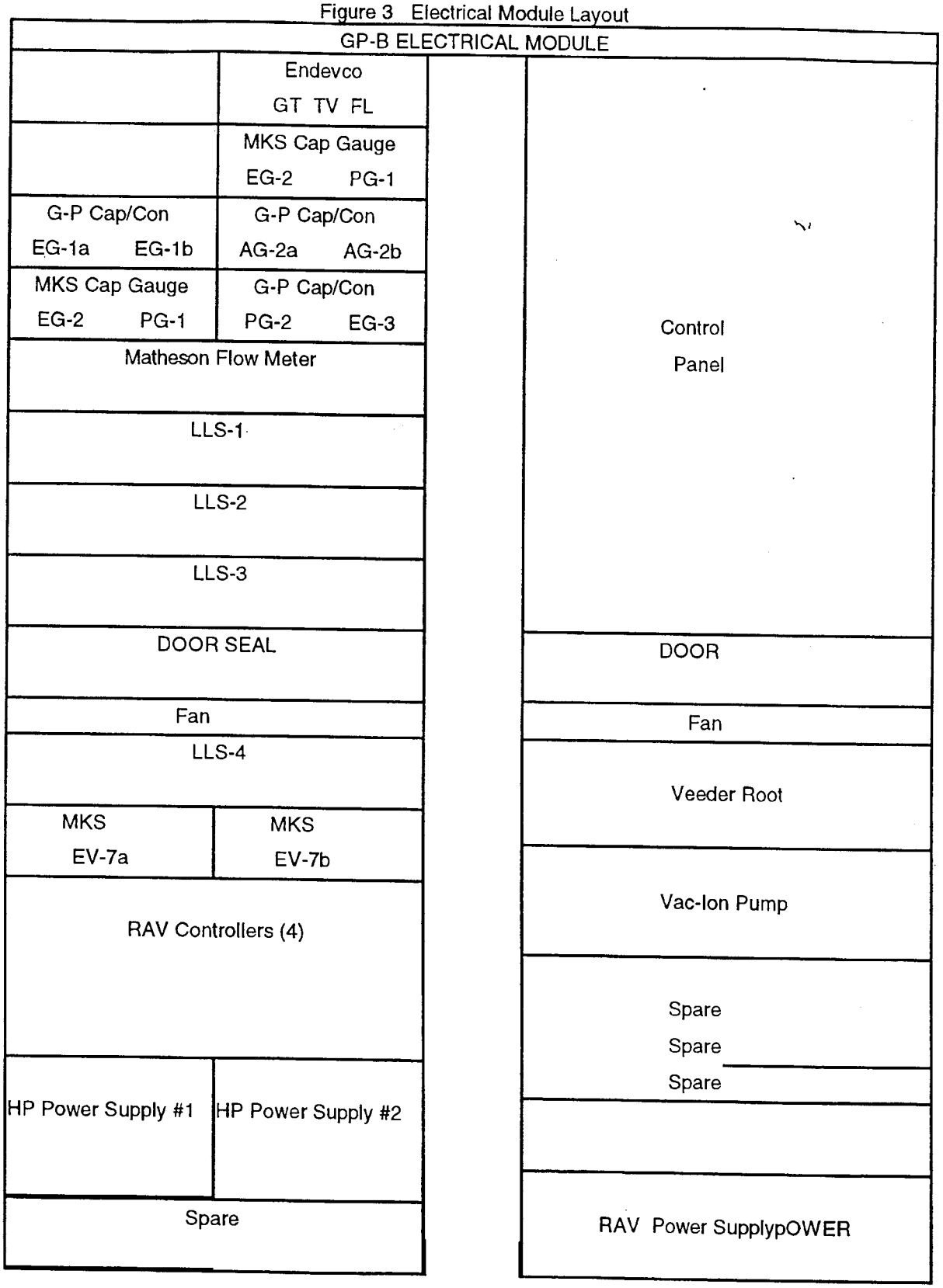
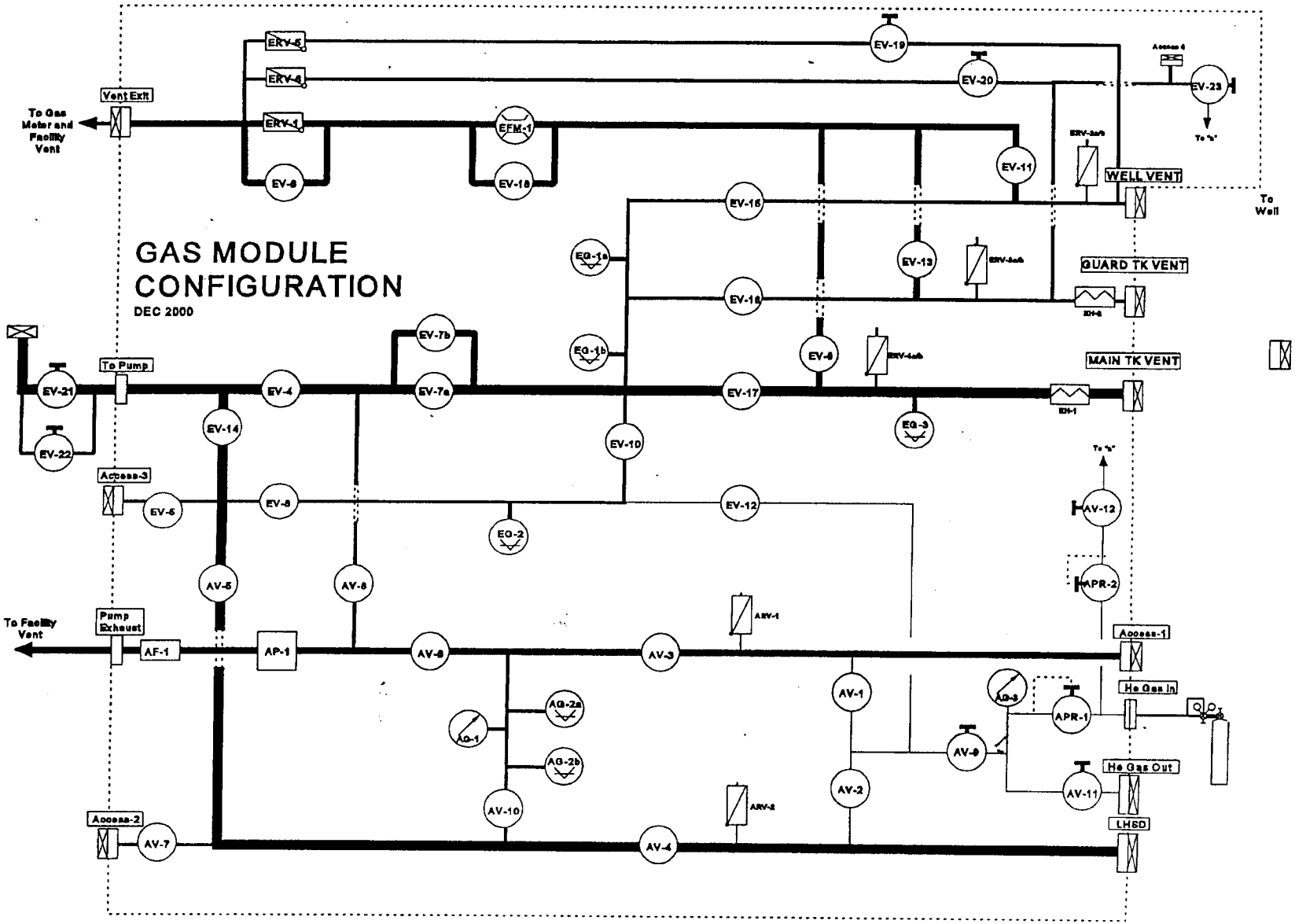


Figure 4 Gas Module Plumbing Schematic



Part of PO #3 00, #1577

P800 to DAS via W-D01

Device ID	Wire funct.	GSE Cable 63P: P800 / P1	W-D01	J1	Cn No.	DAS CN	Temp / Ohms / volts
	-	-	Shd	1			
	V+	6	+	2	000	40	
T22D	V-	12	-	3			4.575
Top Lead	-	-	Shd	4			
Bag /a	I+	1	+	5	010	50	1598.3
(GRT)	I-	5	-	6			
	Shield	-	Shd	7			
	V+	28	+	8	001	41	4.297
T23D	V-	29	-	9			
Top Lead	Shield	-	Shd	10			1601
Bag /b	I+	19	+	11	011	51	
(GRT)	I-	20	-	12			
	Shield	-	Shd	13			
	V+	16	+	14	009	9	
T09D	V-	23	-	15			1593
Main Tank	Shield	-	Shd	16			
Bot.	I+	9	+	17	019	19	.1848
(SDT)	I-	15	-	18			
	Shield	-	Shd	19			
	V+	7	+	20	004	24	1626.2
T15D	V-	8	-	21			
Guard Tank/a	Shield	-	Shd	22			.84107
	I+	2	+	23	014	34	
(SDT)	I-	3	-	24			
	Shield	-	Shd	25			
	V+	11	+	26	002	42	160.9
T24D	V-	18	-	27			
Fill Valve V13	Shield	-	Shd	28			.84419
	I+	4	+	29	012	52	
(SDT)	I-	10	-	30			

Polarity switched

1/29/01

P800 to DAS via W-D01

Device ID	Wire funct.	GSE Cable 63P: P800 / P1	W-D01	J1	No.	Device
	Shield	-	Shd	31		
	Phase 1	30	+	32		
	Phase 2	31	-	33		
	Shield	-	Shd	34		
	Phase3	32	+	35		
	Phase 4	33	-	36		
RAV-1	Shield	-	Shd	37		RAV #
Tank Fill	Motor VCC	24	+	38		Elect.
	N/C	-	-	39		
	Shield	-	Shd	40		
	Com MS O1/C1	41	+	41		
	Open1-MS	40	-	42		
	Shield	-	Shd	43		
	Close1-MS	42	+	44		
	Open 2-MS	48	-	45		
	Shield	-	Shd	46		
	Close 2-MS	49	+	47		
	Com MS O2/C2	50	-	48		

S/B 24+34

iS 5835xxx Rev -

O.K. Murphy Rev 1

P801 to DAS via W-D02 (Internal to DAS)

Device ID	Wire funct.	CSE Cable P801 / P2	W-D02	J2	Ch No.	Das CN	Temp Resis
T01D	-	-	Shd	1			
	V+	16	+	2	001	1	4.086
	V-	23	-	3			
	-	-	Shd	4			1606.9
	I+	9	+	5	011	11	
(GRT)	I-	15	-	6			
T02D	Shield	-	Shd	7			
	V+	7	+	8	002	2	4.556
	V-	8	-	9			
	Shield	-	Shd	10			1609.1
	I+	2	+	11	012	12	
(GRT)	I-	3	-	12			
T03D	Shield	-	Shd	13			
	V+	21	+	14	005	5	161.2
	V-	22	-	15			
	Shield	-	Shd	16			.8411
	I+	13	+	17	015	15	
(SDT)	I-	14	-	18			
T06D	Shield	-	Shd	19			
	V+	11	+	20	006	6	161.2
	V-	18	-	21			
	Shield	-	Shd	22			.814
	I+	4	+	23	016	16	
(SDT)	I-	10	-	24			
T07D	Shield	-	Shd	25			
	V+	35	+	26	007	7	159.9
	V-	36	-	27			1582
	Shield	-	Shd	28			
	I+	26	+	29	017	17	.849
(SDT)	I-	27	-	30			
T08D	Shield	-	Shd	31			
	V+	34	+	32	008	8	1593
	V-	43	-	33			
	Shield	-	Shd	34			.849
	I+	17	+	35	018	18	
(SDT)	I-	25	-	36			
T04D	Shield	-	Shd	37			
	V+	6	+	38	003	3	139.5
	V-	12	-	39			
	Shield	-	Shd	40			.847
	I+	1	+	41	013	13	
(SDT)	I-	5	-	42			
T05D	Shield	-	Shd	43			
	V+	28	+	44	004	7	165
	V-	29	-	45			
	Shield	-	Shd	46			.826
	I+	19	+	47	014	14	
(SDT)	I-	20	-	48			

P801 to DAS via W-D02 (Internal to DAS)

Device ID	Wire funct.	CSE Cable P801 / P2	W-D01	J2	Ch No.	Das CN	TEMP Resis / volts
T16D	Shield	-	Shd	49			
	V+	53	+	50	005	25	157.1
	V-	54	-	51			~~1049~~
	Shield	-	Shd	52			~~1340~~
	I+	46	+	53	015	35	.0853
(SDT)	I-	47	-	54			
T10D	Shield	-	Shd	55			
	V+	62	+	56	000	20	4.455
	V-	63	-	57			
	Shield	-	Shd	58			1606
	I+	56	+	59	010	30	
(GRT)	I-	57	-	60			
T11D	Shield	-	Shd	61			
	V+	65	+	62	001	21	4.660
	V-	66	-	63			
	Shield	-	Shd	64			1605.9
	I+	55	+	65	011	31	
(GRT)	I-	61	-	66			
T12AD	Shield	-	Shd	67			
	V+	60	+	68	002	22	4.643
	V-	64	-	69			
	Shield	-	Shd	70			1606.6
	I+	58	+	71	012	32	
(GRT)	I-	59	-	72			
T12BD	Shield	-	Shd	73			
	V+	51	+	74	003	23	4.652
	V-	52	-	75			
	Shield	-	Shd	76			1605.4
	I+	44	+	77	013	33	
(GRT)	I-	45	-	78			
T18D	Shield	-	Shd	79			
	V+	39	+	80	006	26	3.896
	V-	30	-	81			
	Shield	-	Shd	82			1606.4
	I+	37	+	83	016	36	
(GRT)	I-	38	-	84			
T19D	Shield	-	Shd	85			
	V+	40	+	86	007	27	4.043
	V-	41	-	87			
	Shield	-	Shd	88			1606.1
	I+	31	+	89	017	37	
(GPT)	I-	32	-	90			

JTS 6T/9
WAS 6T/6

P801 to DAS via W-D02 (Internal to DAS)

0 Page 3 of 3

Device ID	Wire funct.	GSE Cable P801 / P2	W-D01	J2	Ch No.	Das CN	R-STS (2)
			Shd	91			
R-1	R+	24	R	92	005	85	1613
R-2	R+	33	R	93	006	86	1613
			Shd	94			
R-3	R+	42	R	95	007	87	1613
R-4	R+	50	R	96	008	88	1613
			Shd	97			
R-5	R+	49	R	98	009	89	1613
R-6	R+	48	R	99	010	90	1613
			N/C	100			

Ro R⁻ 3V

P802 to DAS via W-D03 Internal to DAS

Device ID	Wire funct.	GSE Cable P802 / P3	W-D03	J3	Ch No.	DAS Ch. No.
H01D xfer/a	Shd	-				
	V+	16			000	60
	V-	23				
	Shd	-				
	I-	15				
					001	61
	I+	8				
H02D xfer/b	Shd	-				
	V+	7			002	62
	V-	8				
	Shd	-				
	I-	3				
					003	63
	I+	2				
H05AD	Shd	-				
	V+	21			008	68
	V-	22				
	Shd	-				
	I-	14				
					009	69
	I+	13				
H05BD	Shd	-				
	V+	6			010	70
	V-	12				
	Shd	-				
	I-	5				
					011	71
	I+	1				

Power Rays

,605mW 1608Ω

,605mW 1608

,605mW 1608

,605mW 1609

Device ID	Wire funct.	GSE Cable P802 / P3	W-D03	J3	Ch No.	DAS Ch. No.
H10D	Shd	-				
	V+	28			016	76
	V-	29				
	Shd	-				
	I-	20				
					017	77
	I+	19				
H10D	Shd	-				
	V+	17			018	78
	V-	18				
	Shd	-				
	I-	10				
					019	79
	I+	4				
H13AD	Shd	35				
	V+	-			000	80
	V-	36				
	Shd	-				
	I-	27				
					001	81
	I+	26				
H13BD	Shd					
	V+	34			002	82
	V-	43				
	Shd	-				
	I-	25				
					003	83
	I+	17				
LPU	Shd	-				
	V+	02			017	97
	V-	63				
	Shd	-				
	I+	56				
	I-	57				

,607mW 1612Ω

,607mW 1610Ω

1.497V

P802 to DAS via W-D03 and to EM via WE22

		GSE Cable			
Device ID	Wire funct.	P802 / P3	W-D03	J3	Device ID
	Shd	-	Shd	55	
	Phase 1	30	+	56	
	Phase 2	31	-	57	
	Shd	-	Shd	58	
	Phase3	32	+	59	
	Phase 4	33	-	60	
	Shd	-	Shd	61	
RAV-2 (Grd Tk F)	Motor VCC	24	+	62	RAV-2 Elect. (Grd Tk F)
	N/C	-	-	63	
	Shd	-	Shd	64	
	Com MS O1/C1	41	+	65	
	Open1-MS	40	-	66	
	Shd	-	Shd	67	
	Close1-MS	42	+	68	
	Open 2-MS	48	-	69	
	Shd	-	Shd	70	
	Close 2-MS	49	+	71	
	Com MS O2/C2	50	-	72	
	Shd	-	Shd	73	
	Phase 1	51	+	74	
	Phase 2	52	-	75	
RAV-6B (Well Isolation	Shd	-	Shd	76	
	Phase3	53	+	77	
	Phase 4	54	-	78	
	Shd	-	Shd	79	
	Motor VCC	44	+	80	RAV-6B Elect. (Well Isolation)
	N/C	-	-	81	
	Shd	-	Shd	82	
	Com MS O1/C1	38	+	83	
	Open1-MS	37	-	84	
	Shd	-	Shd	85	
	Close1-MS	39	+	86	
	Open 2-MS	45	-	87	
	Shd	-	Shd	88	
	Close 2-MS	46	+	89	
	Com MS O2/C2	47	-	90	

SKIP
Not

SKIP
This unit is not used in Bldg 156
Acquat. + ext. will be cert. upon return S.U.

P802 to DAS via W-D03 Internal to DAS

		GSE Cable					
Device ID	Wire funct.	P802 / P3	W-D03	J3	Cn No.	DAS Ch. No.	Resistance (Ω)
R-0	Shd	-	Shd	91			NC
	R-	58	+	92			
R-7	R+	59	-	93	011	91	1817 Ω
R-8	Shd	-	Shd	94			1817
	R+	60	+	95	012	92	
R-9	R+	61	-	96	013	93	1817
R-10	Shd	-	Shd	94		96 ~~94~~	1820
	R+	64	+	97	014		
R-11	R+	65	-	98	015	94 ~~96~~	1817
R-12	Shd	-	Shd	94		95 ~~96~~	1820
	R+	66	+	99	016		
				100			

11
12

SKIP

58 12
66 11

P803 to EM

L 933XXX Rev -

Device ID	Wire funct.	GSE Cable P803 / P4	GSE Cable W-D04	GSE Cable J4	Instr Cable Conn 15 pin D or Bendix MS3476L-14-18S	Instr Cable Wire funct	Instrument	Vdc / ohms
H08D Tank (Xfer /a)	-	-	Shd	1	-	-		
	V+	16	+	2	-	V+	Power Supply No. 1	1.105V
	V-	23	-	3	-	V-		335Ω
	-	-	Shd	4	-	-		
	I+	9	+	5	-	I+ (Xfer /a)		
	I-	15	-	6	-	I- IEEE488		
H09D Tank (Xfer /b)	-	-	Shd	7	-	-		P.S. N.C. To IEEE 11/2/01 Never S.V.
	V+	7	+	8	-	V+	Power Supply No. 2	
	V-	8	-	9	-	V-		
	-	-	Shd	10	-	-		
	I+	2	+	11	-	I+ (Xfer /b)		
	I-	3	-	12	-	I- IEEE488		
LL-1D Tank b LLS	-	-	Shd	13	-	-		I = 74.8 50Ω = 55.6" 100Ω = 51.4 ∞V = 60.5 15-16V
	V+	21	+	14	8	V+	LLS-1 Tank prim	
	V-	22	-	15	6	V-		
	-	-	Shd	16	-	-		
	I+	13	+	17	1	I+		
	I-	14	-	18	7	I-		
LL-2D Tank a LLS	-	-	Shd	19	-	-		I = 74.9 50Ω ⇒ 55.6" 100Ω ⇒ 51H ∞V ⇒ 60.5
	V+	6	+	20	8	V+	LLE-2 Tank sec	
	V-	12	-	21	6	V-		
	-	-	Shd	22	-	-		
	I+	1	+	23	1	I+		
	I-	5	-	24	7	I-		
LL-4D Well a LLS	-	-	Shd	25	-	-		Sensor Electronics is faulty. Sample switch inoperative. Add sign.
	V+	28	+	26	8	V+	LLE-4 Well second	
	V-	29	-	27	6	V-		
	-	-	Shd	28	-	-		
	I+	19	+	29	1	I+		
	I-	20	-	30	7	I-		
RAV-3 (PP Bypass)	-	-	Shd	31	Shd	-		
	Phase 1	30	+	32	A	Phase 1	RAV-3 Electronics (PP Bypass)	
	Phase 2	31	-	33	B	Phase 2		
	-	-	Shd	34	-	-		
	Phase 3	32	+	35	C	Phase 3		
	Phase 4	33	-	36	D	Phase 4		
	-	-	Shd	37	-	-		
	Motor VCC	24	+	38	E	Motor VCC		
	N/C	-	-	39	-	N/C		
	-	-	Shd	40		-		
	Com MS O1/C1	41	+	41	F	MS O1/C1		
	Open1-MS	40	-	42	L	Open1-MS		
	-	-	Shd	43	-	-		
	Close1-MS	42	+	44	N	Close1-MS		
	Open 2-MS	48	-	45	P	Open 2-MS		
	-	-	Shd	46	-	-		
	Close 2-MS	49	+	47	R	Close 2-MS		
	Com MS O2/C2	50	-	48	U	MS O2/C2		

Device ID	Wire funct.	GSE Cable P803 / P4	GSE Cable W-D04	GSE Cable J4	Instr Cable Conn 15 pin D or Bendix MS3476L-14-18S	Instr Cable Wire funct	Instrument
	-	-	Shd	49	Shd	-	
	Phase 1	59	+	50	A	Phase 1	
	Phase 2	60	-	51	B	Phase 2	
	-	-	Shd	52	-	-	
	Phase 3	64	+	53	C	Phase 3	
	Phase 4	65	-	54	D	Phase 4	
	-	-	Shd	55	-	-	
	Motor VCC	66	+	56	E	Motor VCC	
RAV-5 (Well F Ext)	N/C	-	-	57	-	N/C	RAV-5 Electro
	-	-	Shd	58		-	
	Com MS O1/C1	57	+	59	F	MS O1/C1	
	Open1-MS	55	-	60	L	Open1-MS	(Well F
	-	-	Shd	61	-	-	
	Close1-MS	62	+	62	N	Close1-MS	
	Open 2-MS	56	-	63	P	Open 2-MS	
	-	-	Shd	64	-	-	
	Close 2-MS	61	+	65	R	Close 2-MS	
	Com MS O2/C2	63	-	66	U	MS O2/C2	
	-	-	Shd	67	Shd	-	
	Phase 1	51	+	68	A	Phase 1	
	Phase 2	52	-	69	B	Phase 2	
	-	-	Shd	70	-	-	
	Phase 3	53	+	71	C	Phase 3	
	Phase 4	54	-	72	D	Phase 4	
	-	-	Shd	73	-	-	
RAV-7 (Tk/W F)	Motor VCC	44	+	74	E	Motor VCC	RAV-7 Electro
	N/C	-	-	75	-	N/C	
	-	-	Shd	76		-	
	Com MS O1/C1	38	+	77	F	MS O1/C1	(Tk/W I
	Open1-MS	37	-	78	L	Open1-MS	
	-	-	Shd	79	-	-	
	Close1-MS	39	+	80	N	Close1-MS	
	Open 2-MS	45	-	81	P	Open 2-MS	
	-	-	Shd	82	-	-	
	Close 2-MS	46	+	83	R	Close 2-MS	
	Com MS O2/C2	47	-	84	U	MS O2/C2	

TO BE respec at

1/30/01

P804 to EM (and to DAS via W-D22)

		GSE Cable					
Device ID	Wire funct.	P804 / P5	W-D05	J5	Ch No.	DAS CN	Temp (K) / Resis (Ω)
T20D (TLB/c)	-	-	Shd	1			1600 Ω *
	V+	35	+	2	008	28	
	V-	36	-	3			
	-		Shd	4			
	I+	26	+	5	018	38	
(GRT)	I-	27	-	6			
T21D (TLB/d)	Shield	-	Shd	7			1605 **
	V+	16	+	8	009	29	
	V-	23	-	9			
	Shield	-	Shd	10			
	I+	9	+	11	019	39	
(GRT)	I-	15	-	12			

* Resistor #1

** Resistor #2

01/30/01

P804 to EM (and to DAS via W-D22)

Device ID	Wire funct.	Cable: P804 / P5	Cable: W-D05	Cable: J5	MUX No.	Ch No.	DAS CN	Pow(W) / Res(Ω)
H03D (GT/a)					4	004	64	.613mW / 1610
	Shield	-	Shd	13				
	I-	3	-	15				
					4	005	65	
	I+	2	+	14				
H04D (GT/b)					2			
						006	66	~~.613~~ .605mW / 1612 Ω
	Shield	-	Shd	16				
	I-	8	-	18				
					4	007	67	
	I+	7	+	17				
H06D (FEP/a)					4	012	72	.605mW / 1612
	Shield	-	Shd	19				
	I-	14	-	21				
					4	013	73	
	I+	13	+	20				
H07D (FEP/b)					4	014	74	.605mW / 1611
	Shield	-	Shd	22				
	I-	22	-	24				
					4	015	75	
	I+	21	+	23				

5Ω R≤7D

01/30/01

P804 to EM (and to DAS via W-D22)

		GSE Cable			inst Cable		
Device ID	Wire funct.	P804 / P5	W-D05	J5	Conn 15 pin D or Bendix MS3476L-14-18S	Wire funct	Instrument
LL-3D W ell LLS/ 1b	-	-	Shd	25	-	-	LLE-1 Well prim
	V+	28		26	8	V+	
	V-	29		27	6	V-	
	-	-		28	-	-	
	I+	19		29	1	I+	
	I-	20		30	7	I-	
LL-5D GT LLSA 1b	-	-		31	-	-	LLE-1 GT prim
	V+	6		32	8	V+	
	V-	12		33	6	V-	
	-	-		34	-	-	
	I+	1		35	1	I+	
	I-	5		36	7	I-	
LL-6D GT LLSA 1a	-	-		37	-	-	LLE-2 GT second
	V+	11		38	8	V+	
	V-	18		39	6	V-	
	-	-		40	-	-	
	I+	4		41	1	I+	
	I-	10		42	7	I-	
RAV-6A (FEP)	-	-	Shd	43	Shd	-	RAV-6A Electronics (FEP)
	Phase 1	51	+	44	A	Phase 1	
	Phase 2	52	-	45	B	Phase 2	
	-	-	Shd	46	-	-	
	Phase 3	53	+	47	C	Phase 3	
	Phase 4	54	-	48	D	Phase 4	
	-	-	Shd	49	-	-	
	Motor VCC	44	+	50	E	Motor VCC	
	N/C	-	-	51	-	N/C	
	-	-	Shd	52		-	
	MS O1/C1	38	+	53	F	MS O1/C1	
	Open1-MS	37	-	54	L	Open1-MS	
	-	-	Shd	55	-	-	
	Close1-MS	39	+	56	N	Close1-MS	
	Open 2-MS	45	-	57	P	Open 2-MS	
	-	-	Shd	58	-	-	
	Close 2-MS	46	+	59	R	Close 2-MS	
	MS O2/C2	47	-	60	U	MS O2/C2	

$L_o = 40$
50 r ⇒ 31.8"
100 r ⇒ 36.1"
∞ r ⇒ 41.0"

$L_o = 7.7$ std
100 – 0"
50 – 9.6"
∞ – 27

$L_o = 7.7$
100r → 0.0
50 → 72.8

To be respecd at 5.0

SMD Flight Payload Test No. 2

1 Feb 2001 14:13:09

1	.008343	2	1733.590486	3	.088026	4	.365777	5	.230594
6	-.086024	7	-.010252	8	.137504	9	4.568109	10	0.000000
16	0.000000	17	0.000000	18	0.000000	19	0.000000	2099999.000000	
21	1838.327450	22	OUTPUT ERROR 105						
26	37433.626100	27	1365.267993	28	OUTPUT ERROR 105				
36	0.000000	37	0.000000	38	0.000000	39	0.000000	4099999.000000	
41	99999.000000	42	.534898	43	.101092	44	-.021694	45	1.048913
46	-4.751032	47	8.630147	48	9999.999999	49	4.507140	50	0.000000
61	0.000000	62	0.000000	63	0.000000	64	.914930	65	0.000000
81	0.000000	82	0.000000	83	0.000000	84	7.697623	85	514.115025
86	9999.999999	87	9999.999999	88	9999.999999	89	9999.999999	90	9999.999999
91	534.834750	92	569.119725	93	558.380447	94	580.610404	95	9999.999999
96	9999.999999	97	0.000000	98	-2.662956	99	-2.315055	100	0.000000
101	100.000000	102	0.000000	103	0.000000	104	0.000000	105	0.000000
106	0.000000	107	0.000000	108	0.000000	109	99999.000000	110	0.000000
111	99999.000000	112	887.000000	113	0.000000	114	862.000000	115	837.000000
116	0.000000	117	99999.000000	118	99999.000000	119	.004900	120	99999.000000
121	0.000000	122	0.000000	123	0.000000	124	0.000000	125	769.000000
126	0.000000	127	0.000000	128	2.000000	129	0.000000	130	0.000000
141	0.000000	142	0.000000	143	122.000000	144	0.000000	145	0.000000
146	0.000000	147	0.000000	148	0.000000	149	443.636364	150	0.000000

14:13:09 1 Feb 2001

Config4m: SMD only at SU using DRP_SMD for: Start press. MT for Transport Ops

Dewar Temperatures - Kelvin

Sta 200 Dewar /a	T01D [01] -999.100	Guard Tank /a	T15D [24] -999.200
Hex-1 Dewar	T03D [05] -999.100	Hex-2 Dewar	T06D [06] -999.100
Hex-3 Dewar	T07D [07] -999.100	Hex-4 Dewar	T08D [08] -999.100
Main Tank Top /a	T10D [20] -999.200	P Plug dwnstm /a	T12AD [22] -999.100
Flow Meter /a	T18D [26] -999.200	Bot Tank;corr.-.05	T09D [09] -999.2500
Top Lead Bag /a	T20D [28] -999.100	Top Lead Bag /b	T21D [29] -999.200
Top Pb Bag /c	T22D [40] -999.200	Top Pb Bag /d	T23D [41] -999.200
VCS-1 Bottom	T05D [04] -999.100	VCS-1 Middle	T04D [03] -999.100

Pressures - Torr

EG-3 Analog value 1000T[47]	859.71	EG-1a Exh Gas Pr-cap T[112]	887.00
EG-1b Exh Gas Pr-con T[111]	9.90E+09	GTVVA Endevco T [46]	-5.24E+01
Vac Mod press Stabil1 T[98]	4.60E-09	Ion Pump Vac Shell T [99]	-9.99E+02
Atmospheric Press T [84]	7.70E+02	Thruster V Endvc-50 T [49]	4051.37
EG-3 Main Tnk Pr-cap T[114]	862.00	PW-2 Well convec T[117]	9.90E+09
Press Cont Valve VDC [45]	3.249		0.000

Lquid Level - %

LLS Main Tank%/aLL-1D [101]	-.1	LLS GuardTank%/aLL-5D [102]	0.0

Flow Rates - slpm

Mth 7/00 Cal=*1.0slpm [44]	-.14	PFM1(110) L1/hr=-9.99&slpm=	-9.99

Main Tank Heater (W & a)

Htr Main T Ex/a H08D W[105]	0.00E+00	Htr Guard Tank /a H03D [64]	0.00E+00

Data Averages

22:33:18 110 0.0000 +0.00000 44 -.4890 -.01083 No. S=6

STANFORD UNIVERSITY

SU/GP-B P0774 Rev -

Operations No. 1584

GRAVITY PROBE-B
PAYLOAD TESTING
PROCEDURE
SMD FUNCTIONAL TEST (ABBREVIATED)

P0774

January , 2001

Originator
D. Murray

Approvals:

M. A. Taber Date 2-1-01
Mike Taber
Test Director

D. C. Murray Date 2-1-01
Dave Murray
Test Director

Barry Muhlfelder Date 2/1/01
Barry Muhlfelder
Payload Technical Manager

Dorrene Ross Date 2/1/01
Dorrene Ross
GP-B Quality Engineer

REVISION	ECO No.	PAGES	DATE
Original	-	All	January 31, 2001

ABBREVIATIONS

xxP	Kit number xx of P type kits (ref. SU GP-B P0141)
ALSP	Airlock Support Plate
ALSPV	Airlock Support Plate Valve
ATC	Advanced Technology Center (at LMSS)
AVxx	Gas Module Auxiliary valve number xx
BPS	Bellville Pre-load System
CNT	Composite Neck Tube of Probe
DAS	Data Acquisition System
EM	Electrical Module
ESD	Electrostatic Discharge
EVxx	Gas Module Exhaust Valve number xx
AWG	American Wire Gauge
Cryoperm	Trade name for cryogenic magnetic shielding
CT	Cooling Tube
CTE	Cryogenic Test Engineer
DAS	Data Acquisition System
DEV-xx	Dewar Exhaust Valve number xx
DR	Discrepancy Report
DVM	Digital Volt Meter
EEBA	Emergency Evacuation Breathing Apparatus
EG-xx	Gas Module Exhaust Gauge number xx
ESD	Electrostatic Discharge
EVRx	Gas Module Relief Valve number x
FIST	Final Integrated System Test
GM	Gas Module
GHe	Gaseous Helium
GP-B	Gravity Probe-B program (also, Relativity Mission)
GRT	Germanium Resistance Thermometer
GSE	Ground Support Equipment
GTU-2	Ground Test Unit number 2
HEPA	High Efficiency Particulate Air
LGS	Leakage Gas System
LLS	Liquid Level Sensor
LMSS	Lockheed Martin Space Systems
LN_2	Liquid Nitrogen
mG	milli Gauss
MHZ	Megahertz
NPB	Normal Boiling Point
ONR	Office of Naval Research
Ozsi	Ounces per square inch
PM	Pump Module
PPS	Programmable Power Supply
PWx	Well Pressure gauge x
QD	Quick Disconnect - O-ring seal under cap
RCM	Rotating Coil Magnetometer
RGA	Residual Gas Analyzer
RSE	Responsible Safety Engineer
RQE	Responsible Quality Engineer
sccs	Standard cubic centimeters per second
SMD	Science Mission Dewar (of GP-B , Relativity Mission program)
SU	Stanford University
TAO	Thermal Acoustic Oscillation
TGxx	UTS Gauge xx
TM xx	Task Module number xx.
TVxx	UTS Valve xx
VM	Vacuum Module
VMA	Valve of Mini-Airlock
UTS	Utility Turbo pumping Station
VIP	Vacuum Ion Pump
VFV	Vatterfly Valve
VSx	Valve number x on Shutter
VW-1	Valve on Dewar Adapter connecting Well to outside
VSx	Valve number x on Shutter
VW-1	Valve on Dewar Adapter of Well

Table of Contents

SMD FUNCTIONAL TEST (ABBREVIATED)

A SCOPE

This procedure describes the steps to effect a functional (thermal proof) test of the GP-B Payload, or GP-B SMD alone, after any major transportation or period in which the health and status of the SMD have not been continuously monitored.

B REFERENCE DOCUMENTS

B.1 Procedures

Procedure No.	Title
None	

B.2 Drawings

LMSC Drawing No.	Title
None	

B.3 Figures

None

B.4 Supporting documentation

a) GP-B Magnetic Control Plan, LMSS-5835031

b) SMD Safety Compliance Assessment, LMSS GPB-100153C

c) SM Dewar FMECA, LMSS GPB-100333

d) FIST Emergency Procedures SU/GP-B P0141

e) SMD Final Assembly, LMSS 5833500

C SAFETY

C.1 In case of any injuries obtain medical treatment at:

Stanford University **Call 9-911** or, at LMSS, **Call 117**

C.2 Safety

The GP-B (FIST) Safety Plan, LMSS GPB-100153C, discusses safety design, operating and maintenance requirements which the LMSS program office has adhered to. These requirements should be reviewed for applicability at any facility outside of LMSS (e.g. Stanford University) where FIST hardware is operated.

C.3 Hazards Analysis

The GP-B (FIST) Preliminary Hazards Analysis, LMSS GPB-100333, discusses hazards inherent in LMSS-developed FIST hardware in greater detail.

D CONTAMINATION CONTROL

D.1 Particulate Contamination

The control of particulate contamination of the probe is described in "GP-B Contamination Control Plan", SU/GP-B P0059. Specific cases that require special methods are treated individual in this procedure.

E PERSONNEL

The personnel certified to set up and perform this procedure are:

Dave Murray	Stanford University
Mike Taber	Stanford University
Jim Maddocks	Stanford University
Tom Welsh	Lockheed

F QUALITY ASSURANCE

Payload integration shall be conducted on a formal basis to approved and released procedures. The QA program office and ONR office shall be notified 24 hours prior to the start of this procedure. A Quality Assurance Representative, designated by D. Ross shall be present during the procedure and shall review any discrepancies noted and approve their disposition. Upon completion of this procedure, the QA Program Engineer, D. Ross or her designate will certify 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.

A Quality Assurance Representative, designated by D. Ross shall be present during the procedure and shall review any discrepancies noted and approve their disposition

a) All discrepancies shall be recorded in a D-log

b) Any discrepance resulting in a nonconformance or test anomaly shall be reported by a Discrepancy Report. Refer to the Quality Plan, P0108, for guidance. Do not alter or break test configuration if a test failure occurs; notify quality assurance.

F.1 Redline Authority

The persons authorized to create and sign-off on redline modifications of the procedure as it is performed are the test directors, M. Taber and D. Murray. The redlines shall be reviewed and approved by the RQE and ,as appropriate, the RSE during or after the performance of the redline.

G CONFIGURATION REQUIREMENTS

a) Payload electrically disconnected from GSE (EM, GM, DAS) and **not** connected by plumbing.

H HARDWARE REQUIRED

a) Gas, Electrical and DAS modules
b) Plumbing module is optional
c) Helium Gas Supply System
d) Compressed air at 80-120 psig
e) SMD/Probe/Payload

I CALIBRATIONS REQUIRED

None

Operations Number 1584
Date Initiated 2/1/01
Time Initiated 1700

J OPERATIONS

1 Verify Payload Ready to Test

SU GP-B INSP 31 2/1/01

1.1 Verify P0773 kcm ~~P0788~~, "Certification of Electrical Module, Gas Module and Data Acquisition System" has been completed since the last transportation of the Payload and GSE.

1.2 Verify "Connect Electrical GSE to Payload", ~~P0774~~ P0791 kcm 2/1/01, has been performed since the last transportation of the Payload and/or cryogenic GSE.

2/1/01 SU GP-B INSP 31

2 Prepare DAS to Collect Data

NOTE

Refer to Figure 1 for cable/module configuration.

SU GP-B INSP 31 2/1/01

2.1 Put the DAS in the "All Channel" No. 1 configuration. (SMD)

2.2 Verify the data scan is producing appropriate output for all channels.

2.3 Set up plotter to plot all temperature output of the SMD over a time scale of ~6 hours.

2.4 Adjust DAS data cycles to 5 to ~~10~~ 15 minutes. kcm 1/2/01

SU GP-B INSP 31 2/1/01

3 Verify SMD Performance

3.1 Verify more than two hours of data have been recorded and plotted.

3.2 Verify all channels are plotting within limits of plotter.

3.3 Verify no channel has noisy/erratic behavior: if not then annotate below and disposition in D-log:

All Channels are O.K.

~~8~~.4 Attach data print out including the page of status data and a copy of the plot results to this procedure.

4 Procedure Complete

Completed By: D. O'Mara

Witnessed By: Jim Hollander

RQE: Dorene Rus

Date: 2/2/01

Time: 1030 hrs

Payload Test Director Jim A. Tony Date 2/14/01

Quality Manager Dorene Rus SU GP-B INSP 31 Date 2/2/01

DOM 2/2/01

SU GP-B INSP 31 2/2/01

He. Heater verification

Had Using [Monitor Data] do the following

a) Set output to hard copy printer

b) Set 1.0volt on Power Supply A and plug into one of the heaters of Table 1

Cycle through appropriate CN of Table 1 with

Table 1

CN	Name	Volts(V)	Resistance
60	H01D	.477	23.3
62	H02D	.471	48.3
64	H03D	.978	836
66	H04D	.975	832
68	H5AD	.903	937
70	H5BD	.902	926
76	H10D	.738	1638
78	H11D	.800	1636
105	H08D	1.02	44.35
107	H09D		

C:\WPDOC\Proctransport\Disconnect\P0774_AFunct.wpd

c) Unplug Power while cycling

d) Repeat for each heater of Table 1

e) Power off all power supplies

NOTE: H06D, H07D, H13AD & H13BD are not used. Also see attached Data printouts

Presently using: Config4m: SMD only at SU using DRP_SMD
This configuration has 34 data ID's

CONFIGURATION DATA FOR EXPERIMENT for: SMD Flight Payload Test No. 2

/ 1/	2 /	3 /	4	/ 5 /	6 /	7 /	8 /	9/	10/	
'TYP	/TAB#	/REF/	RESIS /	A	B	C	D	E	F	DESCRIPTOR
1 3	11	0	0	0	-3.E-6					
						2004	10922	22	4	Sta 200 Dewar /a T01D {01}
3 3	13	0	0	0	0	2002	20922	22	4	VCS-1 Middle T04D [03]
4 3	14	0	0	0	0	2002	20922	22	4	VCS-1 Bottom T05D [04]
5 3	15	0	0	0	0	2002	20922	22	4	Hex-1 Dewar T03D [05]
6 3	16	0	0	0	0	2002	20922	22	4	Hex-2 Dewar T06D [06]
7 3	17	0	0	0	0	2002	20922	22	4	Hex-3 Dewar T07D [07]
8 3	18	0	0	0	0	2002	20922	22	4	Hex-4 Dewar T08D [08]
9 3	19	0	-.05	5	0	2002	20922	23	4	Bot Tank;corr.-.05T09D [09]
20 3	20	0	0	0	-3.E-6					
						2005	10922	22	4	Main Tank Top /a T10D {20}
22 3	22	0	0	0	-3.E-6					
						2002	10922	22	4	P Plug dwnstm /a T12AD {22}
24 3	24	0	0	0	0	2002	20922	22	4	Guard Tank /a T15D [24]
26 3	26	0	0	0	-3.E-6					
						2002	10922	22	4	Flow Meter /a T18D {26}
28 3	28	0	0	0	-3.E-6					
						2002	10922	22	4	Top Lead Bag /a T20D {28}
29 3	29	0	0	0	-3.E-6					
						2002	10922	22	4	Top Lead Bag /b T21D {29}
40 3	30	0	0	0	-3.E-6					
						2002	10922	22	4	Top Pb Bag /c T22D {40}
41 3	31	0	0	0	-3.E-6					
						2002	10922	22	4	Top Pb Bag /d T23D {41}
8	-1	11	200	4	0	2002	30922	21	4	Mth 7/00 Cal=*1.0slpm [44]
8	4	10	-.025	0	0	2002	30922	24	4	TG-1 UTS cold Cath. T [45]
46 8	0	11	10.34	-3.3	-9992002		30922	21	4	GTVVA Endevco T [46]
47 8	-1	11	100	0	0	2005	30922	21	4	EG-3 Analog value 1000T[47]
49 8	0	11	258.5	-188.7	-9992004		30922	21	4	Thruster V Endvc-50 T [49]
64 7	0	65	1000.1	0	0	2002	30922	24	4	Htr Guard Tank /a H03D [64]
65 1	0	0	5.0001	0	0	2002	30922	24	4	Htr I Grd Tank /a H03D [65]
84 8	0	11	100	0	0	2002	30922	21	4	Atmospheric Press T [84]
98 8	0	9	0	0	0	2002	30922	24	4	Vac Mod press Stabil1 T[98]
99 8	-1004		6.7E-8	0	0	2002	30922	24	4	Ion Pump Vac Shell T [99]
101 8	0	11	1	0	0	0025	50013	20	4	LLS Main Tank%/aLL-1D [101]
102 8	0	11	1	0	0	0025	50014	20	4	LLS GuardTank%/aLL-5D [102]
105 7	0	106	1	0	0	4026	50025	24	4	Htr Main T Ex/a H08D W[105]
106 1	0	129	1	0	0	4027	50025	24	4	Htr Main T Cr/a H08D a[106]
109 8	0	11	1	0	0	0000	60000	20	4	Flow Liq l*60 PFM1 l [109]
110 8	109	24	0	0	0	0000	00000	21	4	PFM1(110) Ll/hr= 0.0&slpm=
111 8	0	11	1	0	0	0023	50010	24	4	EG-1b Exh Gas Pr-con T[111]
112 8	0	11	1	0	0	0024	50010	21	4	EG-1a Exh Gas Pr-cap T[112]
114 8	0	11	1	0	0	0024	50012	21	4	EG-3 Main Tnk Pr-cap T[114]
117 8	0	11	1	0	0	0022	50011	24	4	PW-2 Well convec T[117]

Where TYP is the type of calculation: (0-12)
NO USECURRENT PRTABS T/CRESITORT/C>PRTT/C>T/CHTR VLTSPECIALTHERMIS RESDVM SDTa PRTa
GRTa HTRLWRPPS I&VHtr-cur RGA Htr2ld DUMMY
Where TAB# is lookup table No.
Where REF is the Reference channel ID, e.g., current for power, OR Sdt matrix id special calc ID (for Typ=8), latter can use Id.4,5 and 6
where RESIS is the resistance assoc. with this ID,e.g., PRT Ro,,etc., OR
also first coeficient for Spec calc
also temp offset cor. for Type 3,4 & 5 Absolut TC and PRTs
Where A is second coef. for Special calc, or heater resis (Type=7), also =0 no c

```
alculation
done
Where B is third coef. for special calc
Where C=uvww gives the IDs for the instrument and scanner commands
  u:is index of 1st scanner command, v the 2nd
  u=1, 1 plc; u=2, 10 plc; u=3, 120 plc; u=4, 600 plc
   NOTE: For type=5, IEEE488, u=return word turncate value
  ww:1-19->DMM; 20-29->Gran-Ph press; 30-39->GRT ac bridge
Where D = tssii, scan control number with:
          t= type of scan, 1=GRT,2=SDT,3=VDC,4=ohms,5=IEEE488
          ss= scanner address
          ii= instrument address
Where E is the  print output format control
Where F is the  Experiment Number (Expno), =0 for this channel inoperative (sele
cted by Pn(
*))

Derived variables are the following:
    No derived variables (ID>190) in data stream
SHORT ID =  0
Maximum No. ID's for data storage=  34
 Comment written to file: COMMENT|||2 Feb 2001 09:08:32  |-| 0101310.PCD
                          Program File P010124.PG   has been read

    Y-AXES DATA FOR PLOT NO. 1
PLOT SERIES-ID  NO. IS  0

NUMBER 1 Y-AXIS; SCALE LIMITS ARE (Lin):  4 TO 6 CH. NO.  1   9   20   24   28
NUMBER 2 Y-AXIS; SCALE LIMITS ARE (Lin):  0 TO 100 CH. NO.  5   6   7   8   24
 MBER 3 Y-AXIS; SCALE LIMITS ARE (Lin):  0 TO 100 CH. NO.  101   84   102
  MBER 4 Y-AXIS; SCALE LIMITS ARE (Lin):  0 TO 20 CH. NO. -1044  -1110   105
NUMBER 5 Y-AXIS; SCALE LIMITS ARE (Lin):  0 TO 1000 CH. NO.  99   98   42   49
 114   46
 2.11847908375E+11


WHAT IS DATE/TIME CORRESPONDING TO TIME AXIS ORIGIN
                      Program File P010202.PG has been written
!! NO !! -   Comment written to file: COMMENT|||2 Feb 2001 09:14:02  |-| 0101180
.PCD
New D.C. is = 15  minutes - starting at  09:45:00 present time: 09:29:01
          SMD Flight Payload Test No. 2
 2 Feb 2001  09:29:03
```

1	1343.693416	2	1733.590486	3	1.106308	4	1.105688	5	1.111438
6	1.034785	7	.900928	8	.767673	9	1.616121	10	0.000000
16	0.000000	17	0.000000	18	0.000000	19	0.000000	20	1643.333676
21	1838.327450	22	1786.093123	23	1830.472797	24	1.109587	25	0.000000
26	1174.400319	27	1365.267993	28	1201.277810	29	1541.646382	30	0.000000
36	0.000000	37	0.000000	38	0.000000	39	0.000000	40	1709.129093
41	1508.726326	42	.534898	43	.101092	44	-.018683	45	-.063834
46	14.539718	47	8.412552	48	9999.999999	49	1.171570	50	0.000000
61	0.000000	62	0.000000	63	0.000000	64	.000002	65	-0.000000
81	0.000000	82	0.000000	83	0.000000	84	7.734111	85	514.115025
86	9999.999999	87	9999.999999	88	9999.999999	89	9999.999999	90	9999.999999
1	534.834750	92	569.119725	93	558.380447	94	580.610404	95	9999.999999
96	9999.999999	97	0.000000	98	7.050564	99	.000001	100	0.000000
101	100.000000	102	0.000000	103	0.000000	104	0.000000	105	0.000000
106	0.000000	107	0.000000	108	0.000000	10999999.000000	110	0.000000	
11199999.000000		112	873.000000	113	0.000000	114	840.000000	115	837.000000

```
116     0.00000011799999.00000011899999.000000119      .00490012099999.000000
121     0.000000122     0.000000123     0.000000124     0.000000125  769.000000
126     0.000000127     0.000000128     2.000000129     0.000000130    0.000000
141     0.000000142     0.000000143   122.000000144     0.000000145    0.000000
  5     0.000000147     0.000000148     0.000000149   443.636364150    0.000000
```

09:29:03 2 Feb 2001
Config4m: SMD only at SU using DRP_SMD for: Tilt P/L from Horiz to Vert

Dewar Temperatures - Kelvin

Sta 200 Dewar /a	T01D {01}	4.449	Guard Tank /a	T15D [24]	28.852
Hex-1 Dewar	T03D [05]	28.053	Hex-2 Dewar	T06D [06]	69.582
Hex-3 Dewar	T07D [07]	135.446	Hex-4 Dewar	T08D [08]	195.038
Main Tank Top /a	T10D {20}	4.406	P Plug dwnstm /a	T12AD {22}	4.410
Flow Meter /a	T18D {26}	4.532	Bot Tank;corr.=.05	T09D [09]	4.3829
Top Lead Bag /a	T20D {28}	4.435	Top Lead Bag /b	T21D {29}	4.416
Top Pb Bag /c	T22D {40}	4.431	Top Pb Bag /d	T23D {41}	4.416
VCS-1 Bottom	T05D [04]	30.428	VCS-1 Middle	T04D [03]	30.198

Pressures - Torr

EG-3 Analog value 1000T[47]	837.96	EG-1a Exh Gas Pr-cap T[112]	873.00
EG-1b Exh Gas Pr-con T[111]	9.90E+09	GTVVA Endevco T [46]	1.47E+02
Vac Mod press Stabil1 T[98]	1.12E-04	Ion Pump Vac Shell T [99]	4.32E-12
Atmospheric Press T [84]	7.73E+02	Thruster V Endvc-50 T [49]	878.64
EG-3 Main Tnk Pr-cap T[114]	840.00	PW-2 Well convec T[117]	9.90E+09
Press Cont Valve VDC [45]	2.136		0.000

Lquid Level - %

LLS Main Tank%/aLL-1D [101]	100.0	LLS GuardTank%/aLL-5D [102]	0.0

Flow Rates - slpm

Mth 7/00 Cal=*1.0slpm [44]	.46	PFM1(110) L1/hr= 0.0&slpm=	0.00

Main Tank Heater (W & a)

Htr Main T Ex/a H08D W[105]	0.00E+00	Htr Guard Tank /a H03D [64]	0.00E+00

01180.PCD /650388 END DATA C. NO. 154253 AT 09:30:09 NEXT DATA CYCLE 09:45:00
09:30:11 Data file is getting large; 714281 bts; setup new, use {Files Menu}

```
PRINTER IS  26
 60  +4.772542E-01  +9.764602E-03  08:40:31    R= +2.3326E+01 4.07E-03
 60  +4.772543E-01  +9.764610E-03  08:40:36    R= +2.3326E+01 4.04E-03
PRINTER IS  26
    ******** DATA ID =  60 ********* Htr Main Tk Int/a H01D [60] **********
 60  +4.772581E-01  +9.764735E-03  08:41:06    R= +0.0000E+00 0.00E+00
    ******** DATA ID =  62 ********* Htr Main Tk Int/b H02D [62] **********
 62  +4.714606E-01  +9.762997E-03  08:41:29    R= +0.0000E+00 0.00E+00
    ******** DATA ID =  62 ********* Htr Main Tk Int/b H02D [62] **********
 62  -1.110187E-06  +0.000000E+00  08:41:45    R= +0.0000E+00 0.00E+00
    ******** DATA ID =  64 ********* Htr Guard Tank /a H03D [64] **********
 64  +9.783570E-01  +1.144544E-03  08:42:06    R= +0.0000E+00 0.00E+00
 64  +9.783682E-01  +1.144580E-03  08:42:15    R= +8.3629E+02 0.00E+00
 64  +2.297405E-01  +2.687635E-04  08:42:20    R= +1.9638E+02 3.10E-04
 64  +2.506413E-06  +0.000000E+00  08:42:25    R= +0.0000E+00 3.71E-04
 64  +2.731668E-06  +0.000000E+00  08:42:30    R= +0.0000E+00 3.67E-04
    ******** DATA ID =  66 ********* Htr Guard Tank /b H04D [66] **********
 66  +9.782688E-01  +1.149733E-03  08:43:04    R= +0.0000E+00 0.00E+00
 66  +9.782502E-01  +1.149660E-03  08:43:13    R= +8.3240E+02 0.00E+00
 66  +9.782439E-01  +1.149656E-03  08:43:18    R= +8.3239E+02 1.40E-09
 66  +2.763847E-06  +0.000000E+00  08:43:23    R= +0.0000E+00 4.43E-04
 66  +2.781725E-06  +0.000000E+00  08:43:28    R= +0.0000E+00 4.79E-04
    ******** DATA ID =  68 ********* Htr Flow Meter/a H05AD [68] **********
 68  +9.026925E-01  +9.735328E-04  08:44:05    R= +0.0000E+00 0.00E+00
 68  +9.026919E-01  +9.734834E-04  08:44:14    R= +8.3705E+02 0.00E+00
 68  +9.026990E-01  +9.735079E-04  08:44:19    R= +8.3704E+02 8.66E-09
 68  -7.580021E-07  +8.175041E-10  08:44:24    R= +7.0283E-04 3.75E-04
 68  -6.900680E-07  +0.000000E+00  08:44:29    R= +0.0000E+00 4.06E-04
    ******** DATA ID =  70 ********* Htr Flow Meter/b H05BD [70] **********
 70  -4.165436E-07  +0.000000E+00  08:44:49    R= +0.0000E+00 0.00E+00
 70  -5.506242E-07  +0.000000E+00  08:44:58    R= +0.0000E+00 0.00E+00
    ******** DATA ID =  70 ********* Htr Flow Meter/b H05BD [70] **********
 70  -4.540862E-07  +0.000000E+00  08:45:13    R= +0.0000E+00 0.00E+00
    ******** DATA ID =  76 ********* Htr Flow Cntrl/a  H10D [76] **********
 76  +7.377286E-01  +3.325034E-04  08:46:05    R= +0.0000E+00 0.00E+00
 76  +7.377424E-01  +3.322498E-04  08:46:14    R= +1.6381E+03 0.00E+00
 76  +7.377394E-01  +3.322827E-04  08:46:19    R= +1.6379E+03 1.17E-08
 76  -1.137003E-06  +5.120975E-10  08:46:24    R= +2.5245E-03 1.28E-04
 76  -4.626673E-06  +0.000000E+00  08:46:29    R= +0.0000E+00 1.38E-04
    ******** DATA ID =  78 ********* Htr Flow Cntrl/b  H11D [78] **********
 78  +8.001359E-01  +3.916141E-04  08:46:51    R= +0.0000E+00 0.00E+00
 78  +8.001324E-01  +3.914036E-04  08:46:59    R= +1.6357E+03 0.00E+00
 78  +3.217933E-06  +1.574105E-09  08:47:04    R= +6.5784E-03 1.38E-04
 78  +2.690550E-06  +0.000000E+00  08:47:09    R= +0.0000E+00 1.36E-04
    ******** DATA ID =  105 ********* Htr Main T Ex/a H08D W[105] **********
105  +1.020000E+00  +2.346000E-02  08:48:28    R= +0.0000E+00 0.00E+00
105  +1.020000E+00  +2.346000E-02  08:48:35    R= +4.4348E+01 0.00E+00
105  +1.020000E+00  +2.346000E-02  08:48:40    R= +4.4348E+01 0.00E+00
105  +0.000000E+00  +0.000000E+00  08:48:51    R= +0.0000E+00 9.03E-03
105  +0.000000E+00  +0.000000E+00  08:49:05    R= +0.0000E+00 9.78E-03

     [illegible].462600[illegible]  +[illegible].0934[illegible]E-03  09:47:[illegible]7 DELTA  [illegible] 7.838E-08 9.04E-09
    ******** DATA ID =  70 ********* Htr Flow Meter/b H05BD [70] **********
 70  +9.024911E-01  +9.859024E-04  09:47:25    R= +0.0000E+00 0.00E+00
 70  +9.024941E-01  +9.859760E-04  09:47:34    R= +8.2606E+02 0.00E+00
 70  +9.024896E-01  +9.860229E-04  09:47:39    R= +8.2606E+02 1.60E-08
 70  -7.812427E-07  +8.527578E-10  09:47:44    R= +7.1573E-04 3.80E-04
 70  -5.450040E-07  +0.000000E+00  09:47:49    R= +0.0000E+00 4.11E-04
```

R = .471 / 62 .00976

Rerun see below

STANFORD UNIVERSITY

SU/GP-B P0774 Rev -

Operations No. 1599

GRAVITY PROBE-B
PAYLOAD TESTING
PROCEDURE
SMD FUNCTIONAL TEST (ABBREVIATED)

P0774

January , 2001

Originator
D. Murray

Approvals:

M.A. Taber Date 2-1-01
Mike Taber
Test Director

D.C. Murray Date 2-1-01
Dave Murray
Test Director

Barry Muhlfelder Date 2/1/01
Barry Muhlfelder
Payload Technical Manager

Dorrene Ross Date 2/1/01
Dorrene Ross
GP-B Quality Engineer

REVISION	ECO No.	PAGES	DATE
Original	-	All	January 31, 2001

ABBREVIATIONS

xxP	Kit number xx of P type kits (ref. SU GP-B P0141)
ALSP	Airlock Support Plate
ALSPV	Airlock Support Plate Valve
ATC	Advanced Technology Center (at LMSS)
AVxx	Gas Module Auxiliary valve number xx
BPS	Bellville Pre-load System
CNT	Composite Neck Tube of Probe
DAS	Data Acquisition System
EM	Electrical Module
ESD	Electrostatic Discharge
EVxx	Gas Module Exhaust Valve number xx
AWG	American Wire Gauge
Cryoperm	Trade name for cryogenic magnetic shielding
CT	Cooling Tube
CTE	Cryogenic Test Engineer
DAS	Data Acquisition System
DEV-xx	Dewar Exhaust Valve number xx
DR	Discrepancy Report
DVM	Digital Volt Meter
EEBA	Emergency Evacuation Breathing Apparatus
EG-xx	Gas Module Exhaust Gauge number xx
ESD	Electrostatic Discharge
EVRx	Gas Module Relief Valve number x
FIST	Final Integrated System Test
GM	Gas Module
GHe	Gaseous Helium
GP-B	Gravity Probe-B program (also, Relativity Mission)
GRT	Germanium Resistance Thermometer
GSE	Ground Support Equipment
GTU-2	Ground Test Unit number 2
HEPA	High Efficiency Particulate Air
LGS	Leakage Gas System
LLS	Liquid Level Sensor
LMSS	Lockheed Martin Space Systems
LN_2	Liquid Nitrogen
mG	milli Gauss
MHZ	Megahertz
NPB	Normal Boiling Point
ONR	Office of Naval Research
Ozsi	Ounces per square inch
PM	Pump Module
PPS	Programmable Power Supply
PWx	Well Pressure gauge x
QD	Quick Disconnect - O-ring seal under cap
RCM	Rotating Coil Magnetometer
RGA	Residual Gas Analyzer
RSE	Responsible Safety Engineer
RQE	Responsible Quality Engineer
sccs	Standard cubic centimeters per second
SMD	Science Mission Dewar (of GP-B , Relativity Mission program)
SU	Stanford University
TAO	Thermal Acoustic Oscillation
TGxx	UTS Gauge xx
TM xx	Task Module number xx.
TVxx	UTS Valve xx
VM	Vacuum Module
VMA	Valve of Mini-Airlock
UTS	Utility Turbo pumping Station
VIP	Vacuum Ion Pump
VFV	Vatterfly Valve
VSx	Valve number x on Shutter
VW-1	Valve on Dewar Adapter connecting Well to outside
VSx	Valve number x on Shutter
VW-1	Valve on Dewar Adapter of Well

Table of Contents

SMD FUNCTIONAL TEST (ABBREVIATED)

A SCOPE

This procedure describes the steps to effect a functional (thermal proof) test of the GP-B Payload, or GP-B SMD alone, after any major transportation or period in which the health and status of the SMD have not been continuously monitored.

B REFERENCE DOCUMENTS

B.1 Procedures

Procedure No.	Title
None	

B.2 Drawings

LMSC Drawing No.	Title
None	

B.3 Figures

None

B.4 Supporting documentation

a) GP-B Magnetic Control Plan, LMSS-5835031

b) SMD Safety Compliance Assessment, LMSS GPB-100153C

c) SM Dewar FMECA, LMSS GPB-100333

d) FIST Emergency Procedures SU/GP-B P0141

e) SMD Final Assembly, LMSS 5833500

C SAFETY

C.1 In case of any injuries obtain medical treatment at:

Stanford University **Call 9-911** or, at LMSS, **Call 117**

C.2 Safety

The GP-B (FIST) Safety Plan, LMSS GPB-100153C, discusses safety design, operating and maintenance requirements which the LMSS program office has adhered to. These requirements should be reviewed for applicability at any facility outside of LMSS (e.g. Stanford University) where FIST hardware is operated.

C.3 Hazards Analysis

The GP-B (FIST) Preliminary Hazards Analysis, LMSS GPB-100333, discusses hazards inherent in LMSS-developed FIST hardware in greater detail.

D CONTAMINATION CONTROL

D.1 Particulate Contamination

The control of particulate contamination of the probe is described in "GP-B Contamination Control Plan", SU/GP-B P0059. Specific cases that require special methods are treated individual in this procedure.

E PERSONNEL

The personnel certified to set up and perform this procedure are:

Dave Murray	Stanford University
Mike Taber	Stanford University
Jim Maddocks	Stanford University
Tom Welsh	Lockheed

F QUALITY ASSURANCE

Payload integration shall be conducted on a formal basis to approved and released procedures. The QA program office and ONR office shall be notified 24 hours prior to the start of this procedure. A Quality Assurance Representative, designated by D. Ross shall be present during the procedure and shall review any discrepancies noted and approve their disposition. Upon completion of this procedure, the QA Program Engineer, D. Ross or her designate will certify 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.

A Quality Assurance Representative, designated by D. Ross shall be present during the procedure and shall review any discrepancies noted and approve their disposition

a) All discrepancies shall be recorded in a D-log

b) Any discrepance resulting in a nonconformance or test anomaly shall be reported by a Discrepancy Report. Refer to the Quality Plan, P0108, for guidance. Do not alter or break test configuration if a test failure occurs; notify quality assurance.

F.1 Redline Authority

The persons authorized to create and sign-off on redline modifications of the procedure as it is performed are the test directors, M. Taber and D. Murray. The redlines shall be reviewed and approved by the RQE and ,as appropriate, the RSE during or after the performance of the redline.

G CONFIGURATION REQUIREMENTS

a) Payload electrically disconnected from GSE (EM, GM, DAS) and **not** connected by plumbing.

H HARDWARE REQUIRED

a) Gas, Electrical and DAS modules
b) Plumbing module is optional
c) Helium Gas Supply System
d) Compressed air at 80-120 psig
e) SMD/Probe/Payload

I CALIBRATIONS REQUIRED

None

Operations Number 1599
Date Initiated 2/27/01
Time Initiated 0830

J OPERATIONS

1 Verify Payload Ready to Test

✓ 1.1 Verify P0788, "Certification of Electrical Module, Gas Module and Data Acquisition System" has been completed since the last transportation of the Payload and GSE.

✓ 1.2 Verify "Connect Electrical GSE to Payload", P0774, has been performed since the last transportation of the Payload and/or cryogenic GSE.

2 Prepare DAS to Collect Data

NOTE

Refer to Figure 1 for cable/module configuration.

✓ 2.1 Put the DAS in the "All Channel" No. 1 configuration.

✓ 2.2 Verify the data scan is producing appropriate output for all channels.

✓ 2.3 Set up plotter to plot all temperature output of the SMD over a time scale of ~6 hours.

✓ 2.4 Adjust DAS data cycles to 5 to 10 minutes. Plot # 590/502

3 Verify SMD Performance

✓ 3.1 Verify more than two hours of data have been recorded and plotted. Ref. All6hours.prd 2/27/01

✓ 3.2 Verify all channels are plotting within limits of plotter.

✓ 3.3 Verify no channel has noisy/erratic behavior: if not then annotate below and disposition in D-log:

_____

_____

_____

SMD FUNCTIONAL TEST (ABBREVIATED)

3.4 Attach data print out including the page of status data and a copy of the plot results to this procedure.

3.5 Using Table 1 record heater data reading [Heaters DATA].

4 **Procedure Complete**

SU GP-B INSP 31
2/27/01

Completed By: N.C. Mann

Witnessed By: _____

RQE: Donna Paz

Date: 2/27/01

Time: 1400

Payload Test Director M.A. Toth Date 2/27/01

Quality Manager Donna Paz SU GP-B INSP 31 Date 2/27/01

Table 1

Ch. No.	HEATER CHECK OUT DATA Description	Date/Time 2/27/01 Raw Data* (vdc)	Reduced Data (W/a)	Resistance (ohm)
60	Htr Main Tank Int. /a H01D	.41781	.0097798	23.33
61	Htr Current Main Tank Int. /a H01D	.102	.0205	—
62	Htr Main Tank Int. /b H02D	.4732	.009796	22.77
63	Htr Current Main Tank Int. /b H02D	.10371	.02074	—
64	Htr Guard Tank /a H03D	.9959	.001179	841.5
65	Htr Current Guard Tank /a H03D	.005917	.001183	—
66	Htr Guard Tank /b H04D	.97835	.0011425	837.7
67	Htr Current Guard Tank /b H04D	.005839	.001168	—
68	Htr Flow Meter /a H05AD	.903419	.0009752	837.1
69	Htr Current Flow Meter /a H05AD	.005397	.0010794	—
70	Htr Flow Meter /b H05BD	.96353	.0010794	828.1
71	Htr Current Flow Meter /b H05BD	.005456	.0010911	—
72	Omit H06D (FEP)	—		
73	Omit H06D	—		
74	Omit H07D	—		
75	Omit H07D	—		
76	Htr Flow Cntrl /a H10D	.73941	.0003341	1636.3
77	Htr Current Flow Cntrl /a H10D	.0004519	.0004519	—
78	Htr Flow Cntrl /b H11D	.8019	.0003932	1635-1
79	Htr Current Flow Cntrl /b H11D	.0004904	.0004904	—
80	Omit H13AD (Porous Plug)	—		
81	Omit H13AD	—		
82	Omit H13BD	—		
83	Omit H13BD	—		
105	Htr Main Tank Ext/ a H08D	1.005	.0231	43.70
106	Htr Current Main Tank Ext/ a H08D	.023	.023	—
107	Htr Main Tank Ext/ b H09D	1.005	.0251	40.2
108	Htr Current Main Tank Ext/ b H09D	.025	.025	—

* 1 Volt excitation

SMD Flight Payload Test No. 2

27 Feb 2001 11:35:09

1	1412.048282	2	1776.215855	3	1.562742	4	1.553858	5	1.583518
6	1.108531	7	1.006551	8	.883625	9	1.619555	10	0.000000
16	0.000000	17	0.000000	18	0.000000	19	0.000000	20	1718.187576
.	1886.183369	22	1867.552130	23	1879.814244	24	1.611459	25	1.611308
26	1285.187810	27	1388.155126	28	1262.030011	29	1606.833371	30	0.000000
36	0.000000	37	0.000000	38	0.000000	39	0.000000	40	1793.059949
41	1575.528838	42	.536080	43	.457771	44	-.008118	45	3.706504
46	.684845	47	0.000000	48	9999.999999	49	5.775238	50	0.000000
56	0.000000	57	0.000000	58	0.000000	59	0.000000	60	.000002
61	0.000000	62	-.000001	63	0.000000	64	.996012	65	.005918
66	.000003	67	0.000000	68	-.000001	69	0.000000	70	0.000000
71	0.000000	72	.000001	73	0.000000	74	.000002	75	0.000000
76	-.000001	77	0.000000	78	.801909	79	.000490	80	0.000000
81	-0.000000	82	0.000000	83	0.000000	84	7.619322	85	0.000000
96	0.000000	97	.000004	98	.489319	99	-.000027100		0.000000
101	89.300000	102	48.200000	103	0.000000	104	0.000000	105	1.005000
106	.023000	107	1.080000	108	.025000	10999999	.000000	110	0.000000
11199999	.000000	112	722.000000	113	0.000000	114	0.000000	115	0.000000
116	1.150000	11799999	.000000	11899999	.000000	119	0.000000	120	0.000000
126	0.000000	127	0.000000	128	0.000000	129	43.695652	130	43.200000

11:32:02 27 Feb 2001

SMD Full Data SET

Config_4: SMD operation at Stanford using DRP_SMD for: SMD Functional (abr.)

Dewar Temperatures

Sta 200 Dewar /a	T01D	{01}	4.344	Sta 200 Dewar /b	T02D	{02}	4.346
VCS-1 Middle	T04D	[03]	5.867	VCS-1 Bottom	T05D	[04]	6.072
Hex-1 Dewar	T03D	[05]	5.321	Hex-2 Dewar	T06D	[06]	29.300
Hex-3 Dewar	T07D	[07]	84.567	Hex-4 Dewar	T08D	[08]	143.484
Bot Tank;corr.-.05	T09D	[09]	4.2847				0.000
Main Tank Top /a	T10D	{20}	4.317	Main Tank Top /b	T11D	{21}	4.318
P Plug dwnstm /a	T12AD	{22}	4.320	P Plug dwnstm /b	T12BD	{23}	4.322
Guard Tank /a	T15D	[24]	4.492	Guard Tank /b	T16D	[25]	4.574
Flow Meter /a	T18D	{26}	4.337	Flow Meter /b	T19D	{27}	4.335
Top Lead Bag /a	T20D	{28}	4.331	Top Lead Bag /b	T21D	{29}	4.333
Top Pb Bag /c	T22D	{40}	4.333	Top Pb Bag /d	T23D	{41}	4.329
Fill Valve V13	T24D	[42]	293.116	PG-1 Pump Mod	10 T	(43)	3.75E-01

Flow Rates - slpm

Mth Cal=1.0-2.55	slpm	[44]	-4.17	TG-1 UTS cold Cath.	T	[45]	1.60E-05

Pressures Analog - Torr

GTVA Endevco 50 psid	T	[46]	2.18E+02	EG-3 Analog value 1000	T	[47]	0.00
WTM Thermistor K		[48]	11.10	Thruster V Endvc-50	T	[49]	5.17E+01
Atmospheric Press	T	[84]	761.93	Liq Pt Dt(@~50 ma)V12D		[97]	3.60E-06
Vac Mod press Stabil1	T	[98]	3.09E-11	Ion Pump Vac Shell	T	[99]	0.00E+00

Heaters - watt/amps

Htr Main Tk Int/a	H01D	[60]	0.00E+00	Htr I Mn Tk Int/a	H01D	[61]	3.90E-08
Htr Main Tk Int/b	H02D	[62]	0.00E+00	Htr I Mn Tk Int/b	H02D	[63]	1.79E-08
Htr Guard Tank /a	H03D	[64]	1.18E-03	Htr I Grd Tank /a	H03D	[65]	1.18E-03
Htr Guard Tank /b	H04D	[66]	0.00E+00	Htr I Grd Tank /b	H04D	[67]	1.79E-08
Htr Flow Meter/a	H05AD	[68]	0.00E+00	Htr I Fw Meter/a	H05AD	[69]	2.65E-08
Htr Flow Meter/b	H05BD	[70]	0.00E+00	Htr I Fw Meter/b	H05BD	[71]	6.29E-08
Htr FEP /a	H06D	[72]	0.00E+00	Htr I FEP /a	H06D	[73]	5.33E-08
Htr FEP /b	H07D	[74]	0.00E+00	Htr I FEP /b	H07D	[75]	7.51E-08
Htr Flow Cntrl/a	H10D	[76]	0.00E+00	Htr I Fw Cntrl/a	H10D	[77]	1.95E-07
Htr Flow Cntrl/b	H11D	[78]	3.93E-04	Htr I Fw Cntrl/b	H11D	[79]	4.90E-04
Htr P Plug Ds/a	H13AD	[80]	0.00E+00	Htr I P Pg Ds/a	H13AD	[81]	-1.25E-08
Htr P Plug Ds/b	H13BD	[82]	0.00E+00	Htr I P Pg Ds/b	H13BD	[83]	5.72E-08

Htr Main T Ex/a H08D W[105]	2.31E-02	Htr Main T Cr/a H08D a[106]	2.30E-02
Htr Main T Ex/b H09D W[107]	2.70E-02	Htr Main T Cr/b H09D a[108]	2.50E-02
H08D resistance ohm [129]	9.99E+01	H09D resistance ohm [130]	9.99E+01

Liquid Level Sensors - %

LLS Main Tank%/aLL-1D [101]	89.3	LLS GuardTank%/aLL-5D [102]	48.2
LLS Ax Lock % LL-7D [103]	-.1	LLS Well % LL-3/4D [104]	-.1

Pressures - Torr

EG-1b Exh Gas Pr-con T[111]	9.90E+09	EG-1a Exh Gas Pr-cap T[112]	722.00
EG-3 Main Tnk Pr-cap T[114]	0.00	AG-2a Aux Gas Pr-cap T[115]	0.00
AG-2b Aux Gas Pr-con T[116]	1.15E+00	PW-2 Well convec T[117]	9.90E+09
P9 Probe P convec T[118]	9.90E+09	Pump press PG-2 conv T[119]	0.00E+00

Wet Test Meter Flow

WTM Flow liters [120]	0.0	WTM Flow rate slpm [121]	0.00E+00
WTM calc heat rate mW [122]	0.00E+00	WTM temperature K [123]	0.00
WTM Mass LOSS rt mg/s [124]	0.00E+00		0.000

Flow Rates - slpm

Mth Cal=1.0-2.55 slpm [44]	-4.17	PFM1(110) Ll/hr= 0.0&slpm=	0.00

Data Averages

11:03:31 24 4.4925 -.00045 9 4.2848 -.00057 No. S=2

New D.C. is = 10 minutes - starting at 11:50:00 present time: 11:46:02

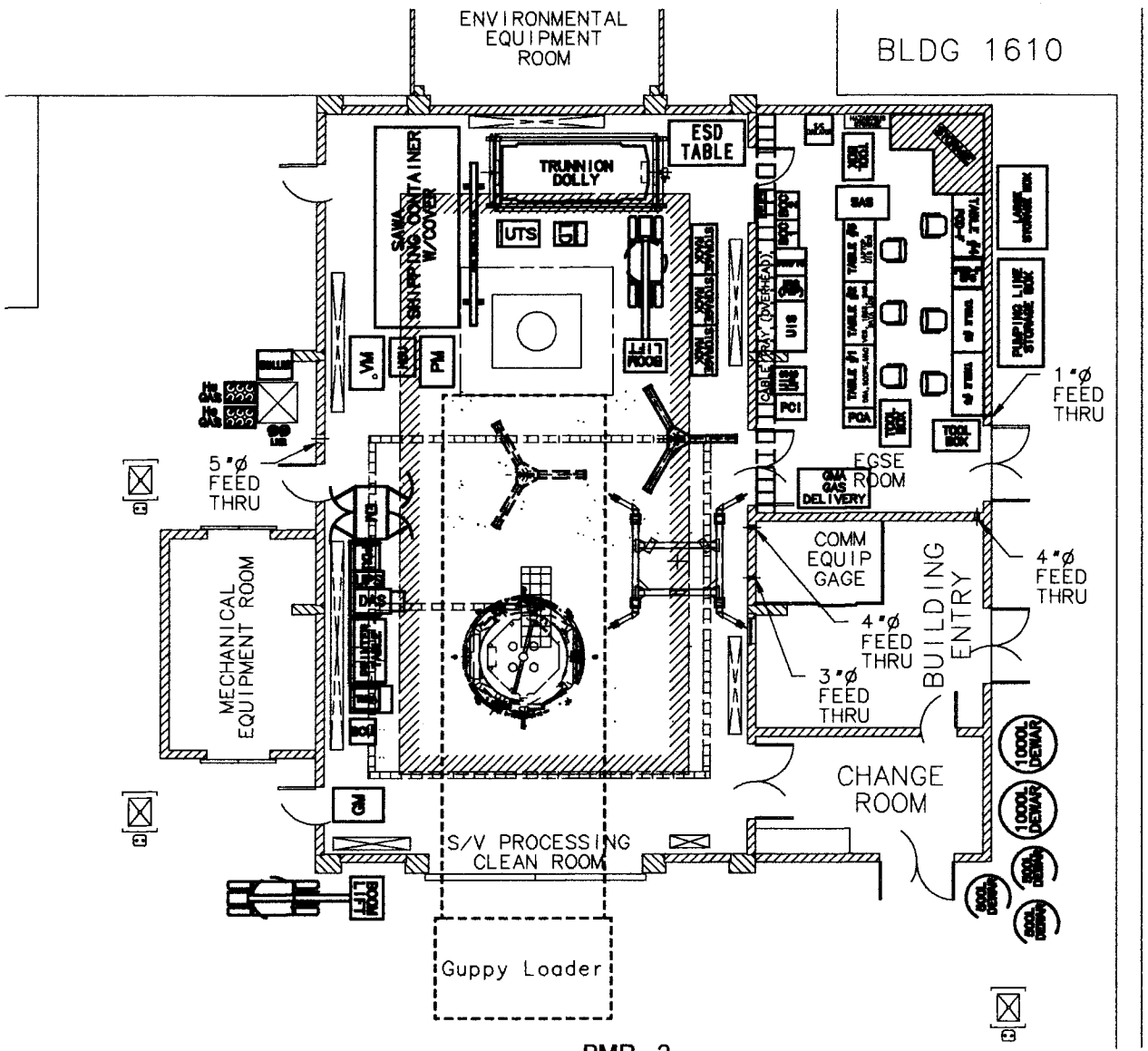
GP-B Equipment Layouts At VAFB Facilities

Russell Katz

Teamwork & Innovation
RELATIVITY MISSION
SPACE VEHICLE

VAFB B/1610 Operation Layouts
S/V Arrival

STANFORD
LOCKHEED MARTIN
LMSSC/P480709
19 February 2003



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SPACE VEHICLE

VAFB B/1610 Operation Layouts
S/V Offloading

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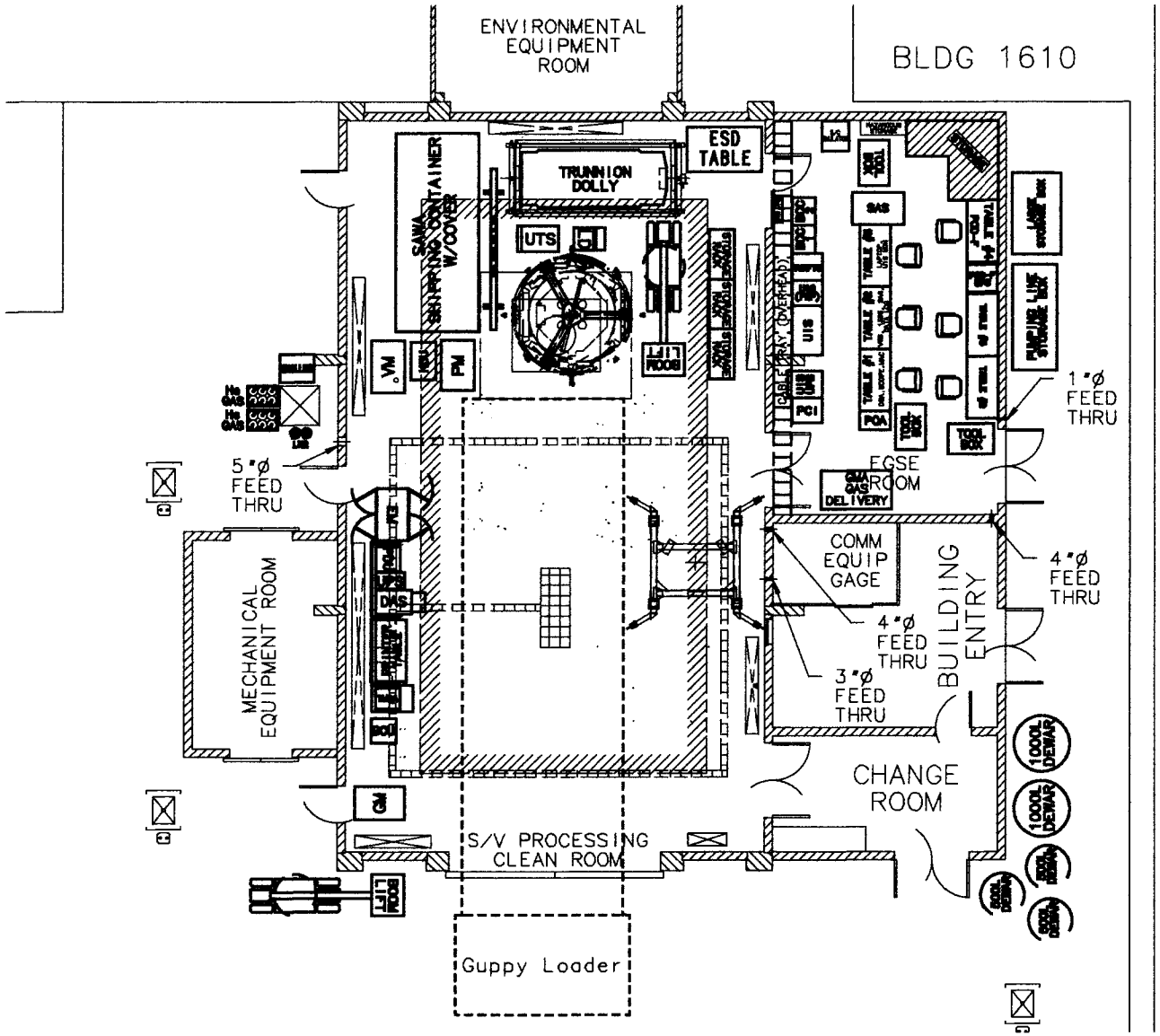

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VAFB B/1610 Operation Layouts
S/V Mount On Assy Stand

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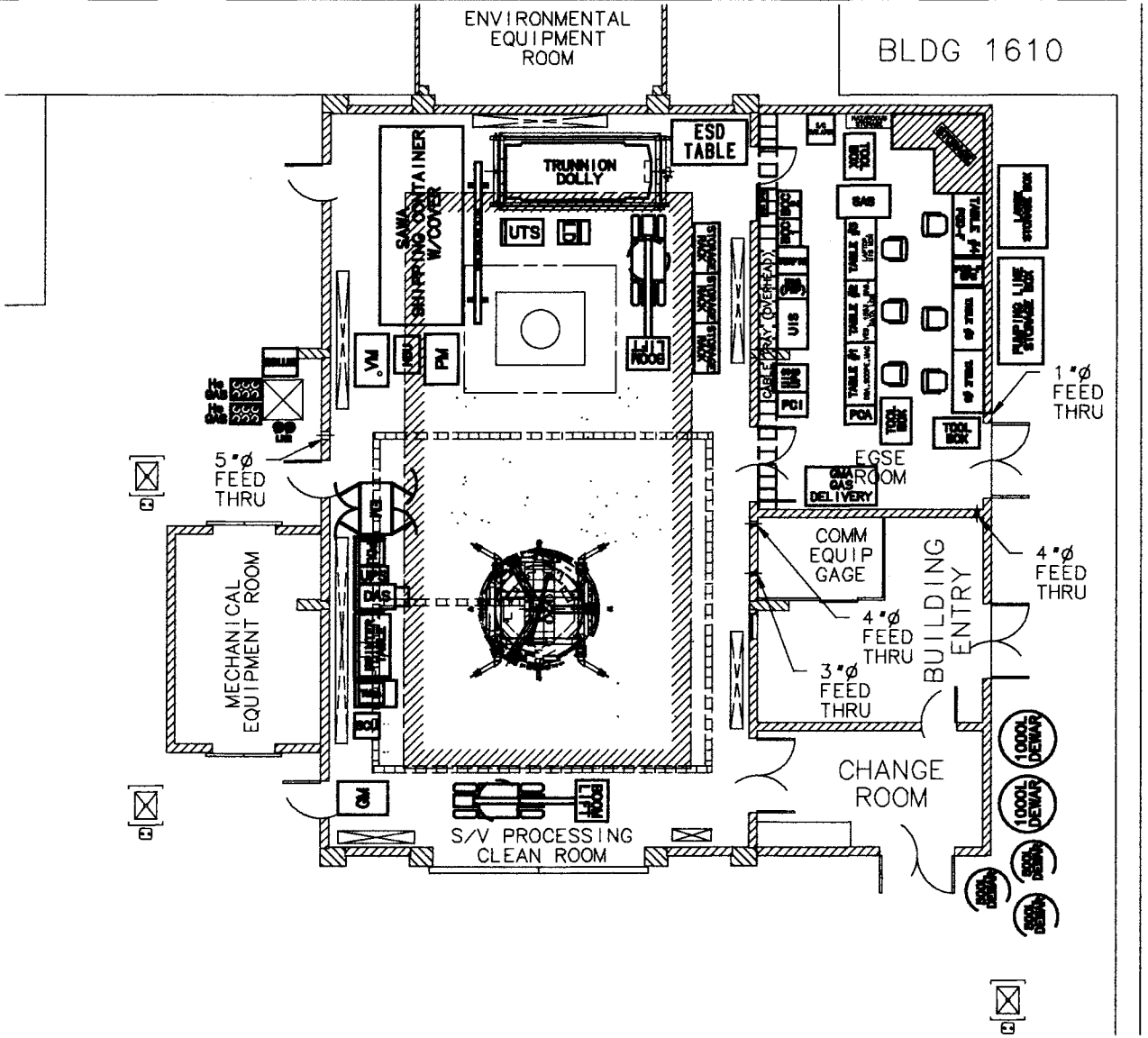

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VAFB B/1610 Operation Layouts
S/V Tilt Ring Removal

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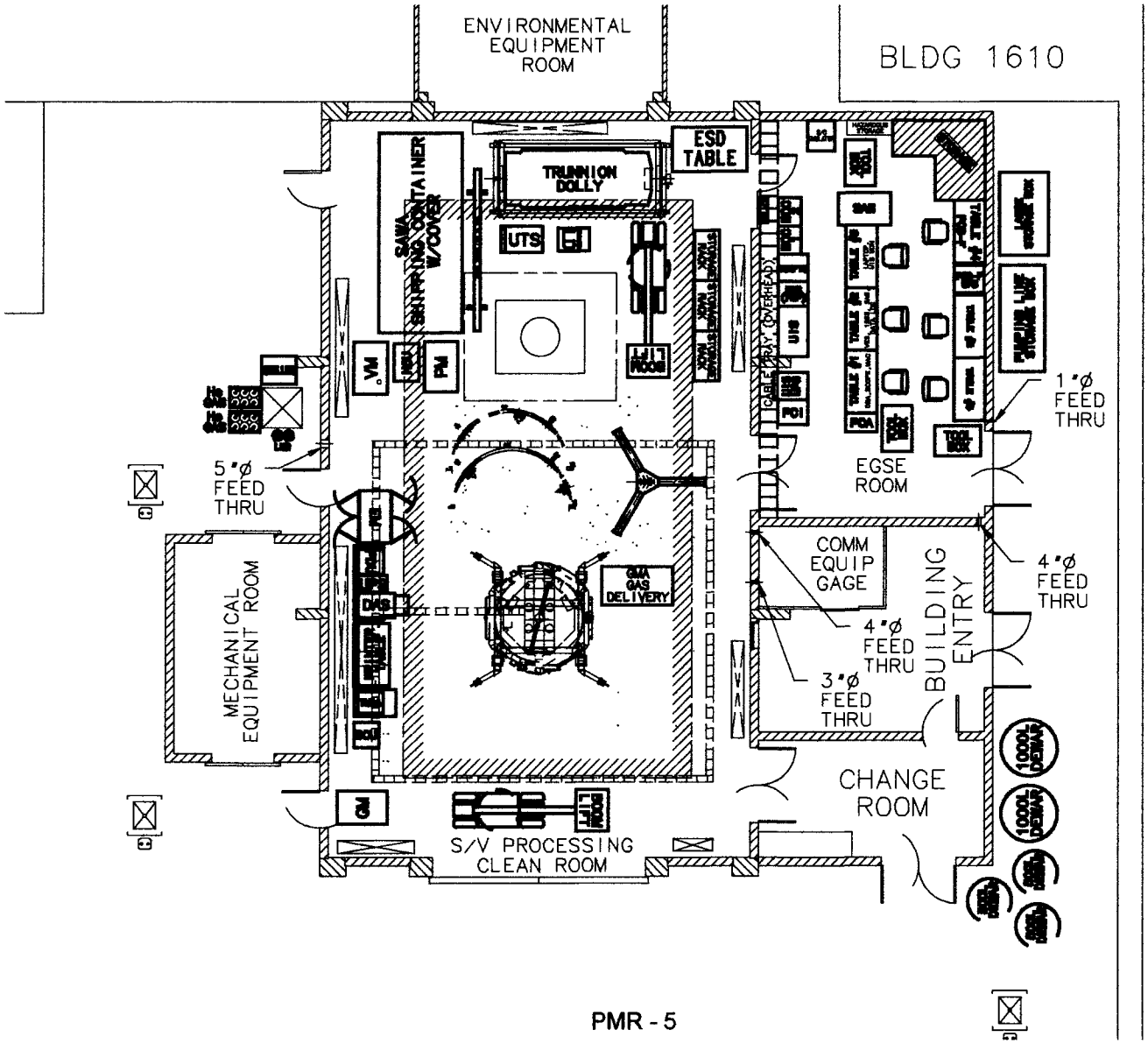

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VAFB B/1610 Operation Layouts S/V and Dewar Servicing

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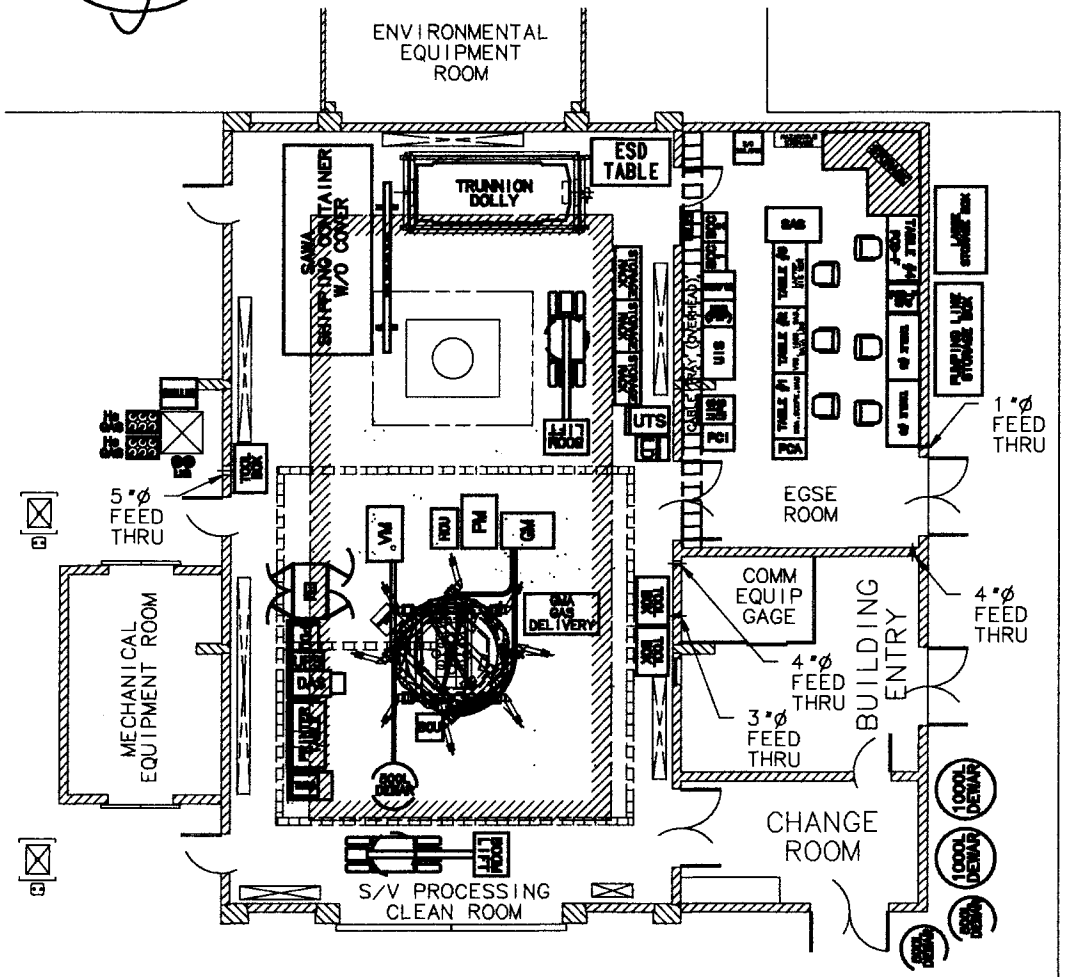

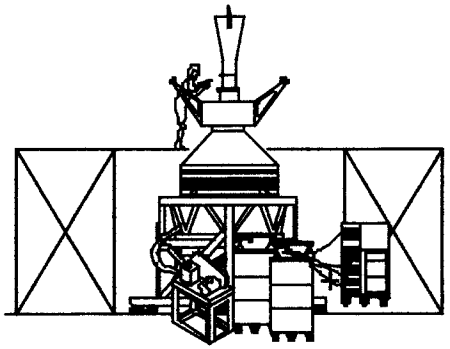

Additional Ops/Details

- Connect SV EGSE, He vent lines, & Dewar GSE
- Install & Charge Batteries
- Post ship functional
- Complete work on Forward Equipment Enclosure (FEE)
- FEE pyro initiator installation & safing
- Final install FEE shields & blankets
- Gas Management Assembly (GMA) servicing
- Final SV cleaning & closure of any open action items

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VAFB B/1610 Operation Layouts
S/A Installation and Final Testing

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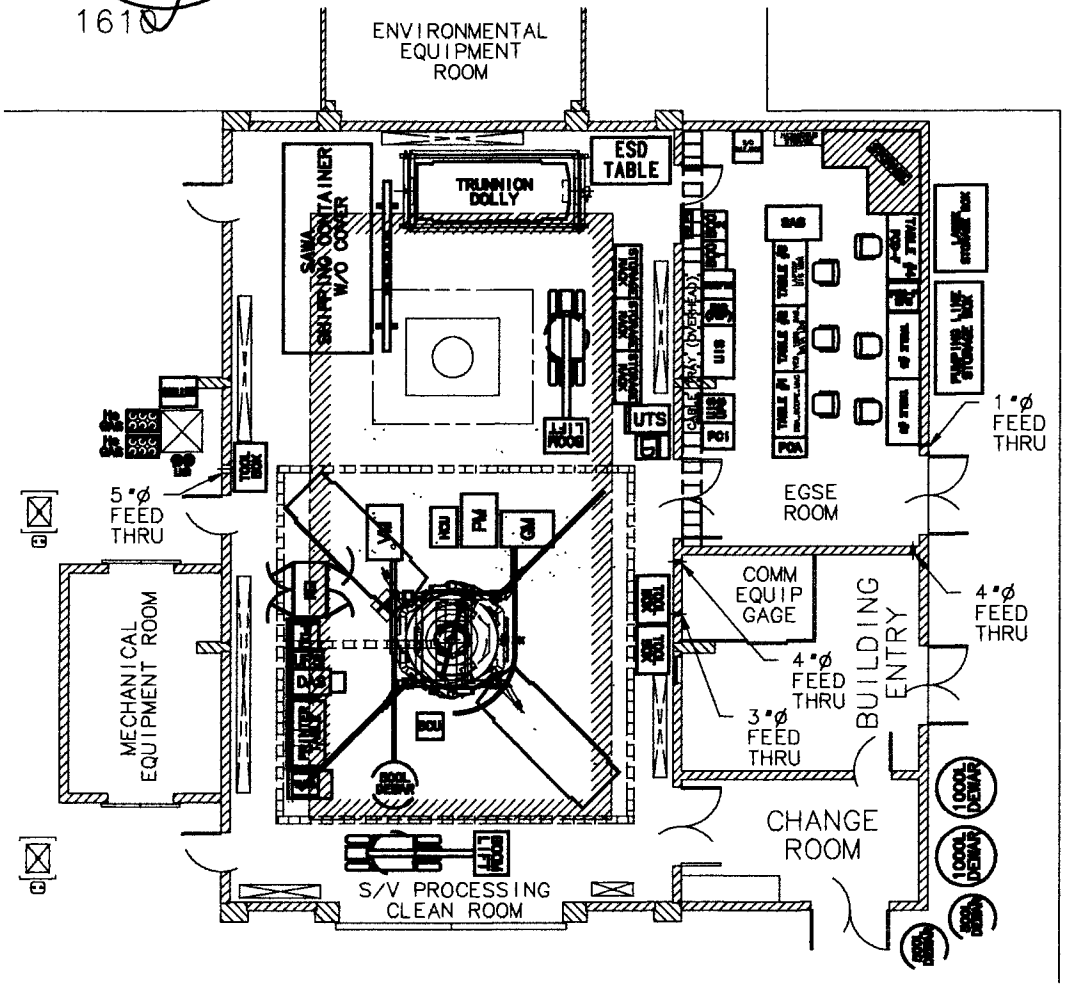

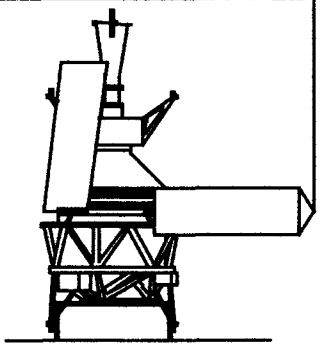

Additional Ops/Details

- Install panel lifting fixture
- Install panel in deployed position
- Electrical & mechanical mate
- Stow & preload panel
- First Motion test
- Deploy panel
- S/A Aliveness test & visual inspect solar cells
- Final stow, preload & inspection of cells in preload area
- Repeat for panels 2 - 4

NOTE: Umbilical plug must remain installed when computer is powered on or S/A deploy countdown will start

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VAFB B/1610 Operation Layouts
PAF and Canister Segments Arrival

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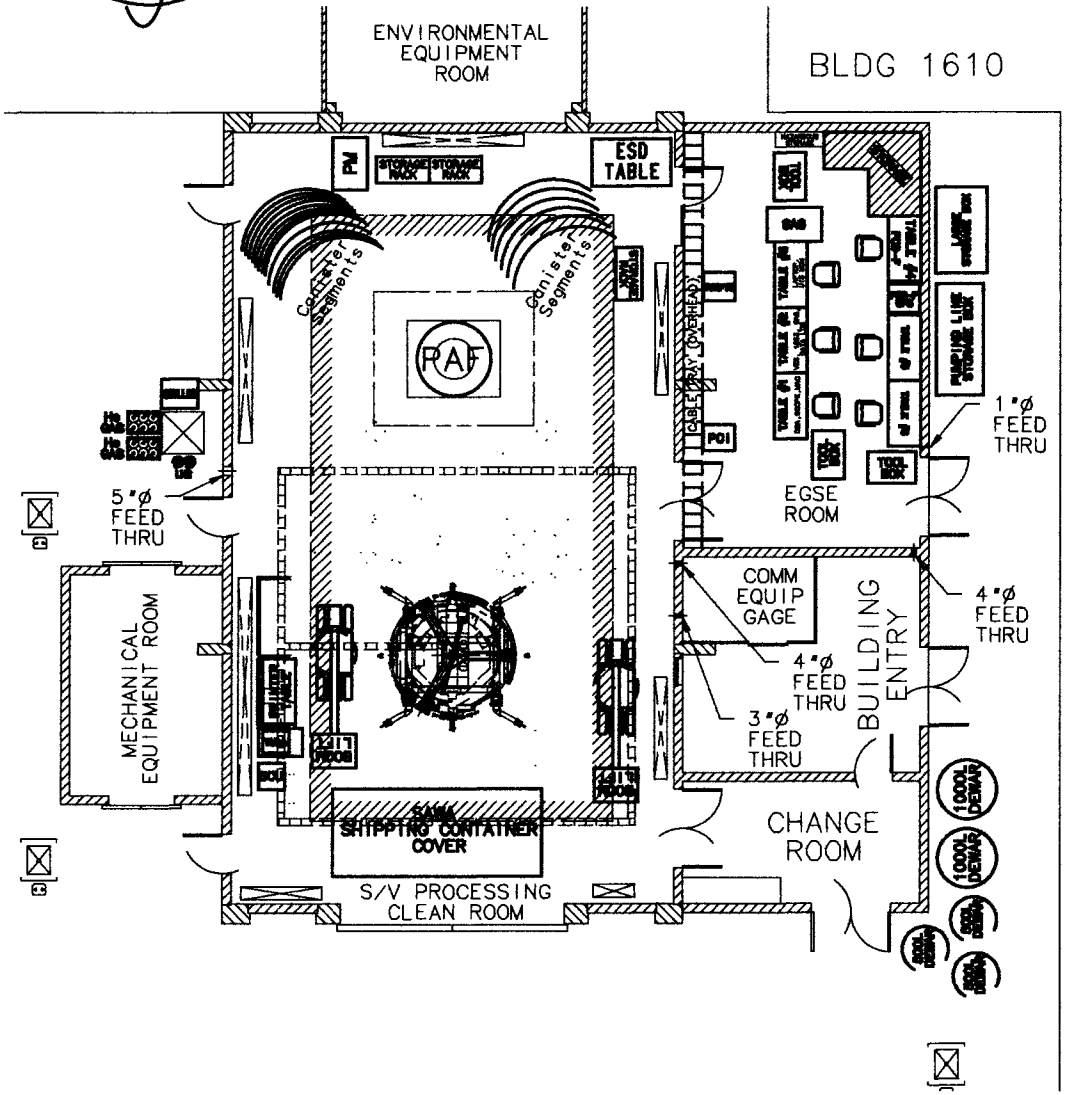
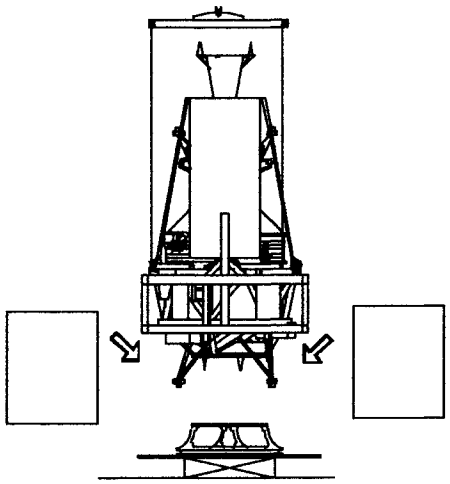
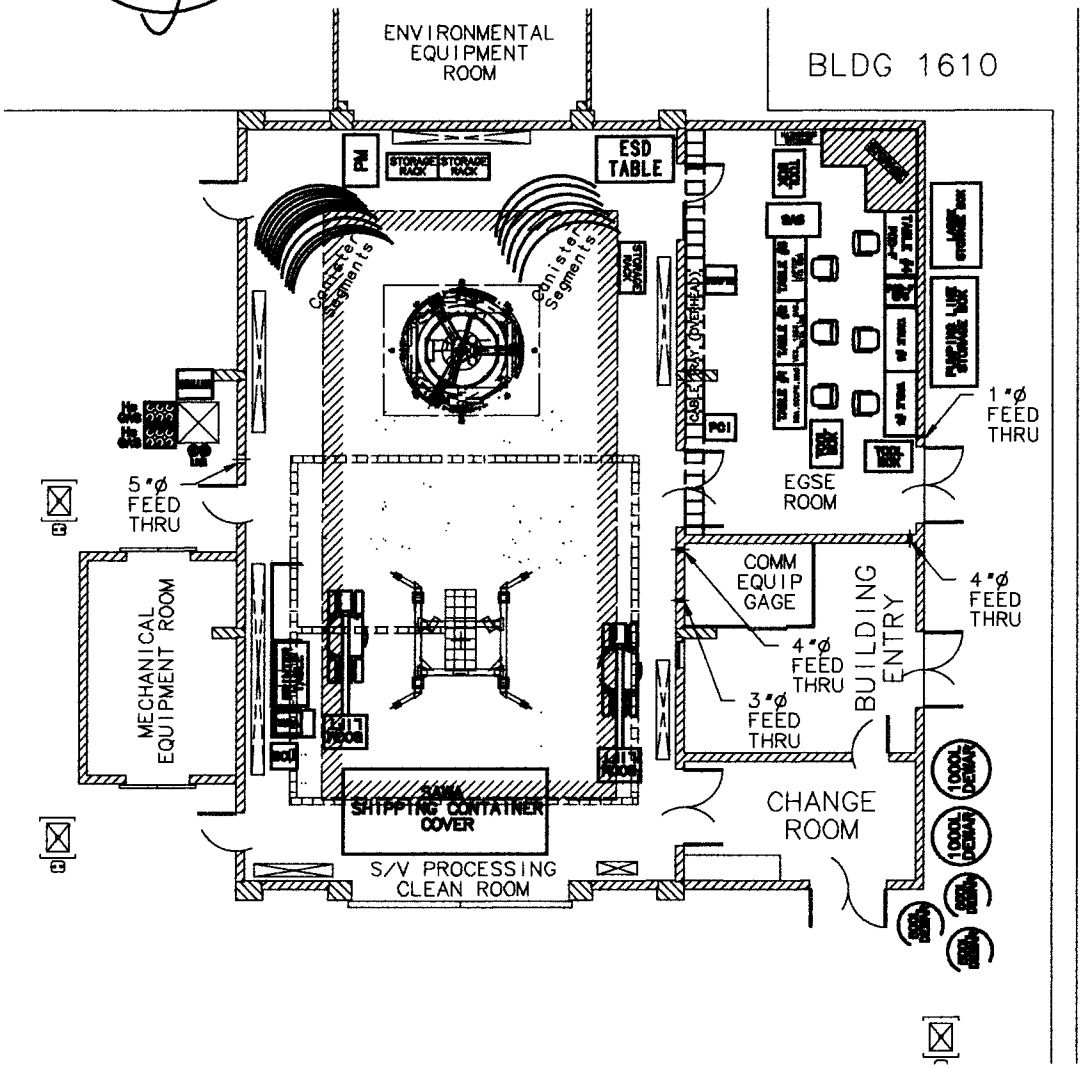


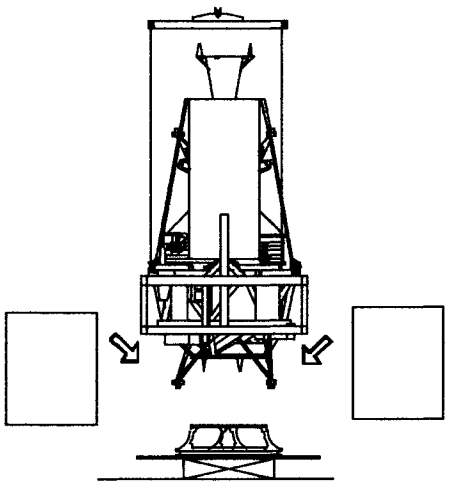


Additional Ops/Details

- Discharge batteries
- Remove and store S/A Dolly
- Mount PAF to spin table
- Disconnect EGSE & Dewar GSE
- Install Tilt Ring onto SV

VAFB B/1610 Operation Layouts
S/V Bag and Install on PAF





Additional Ops/Details

- Attach Vertical Lift Sling/Strongback
- Lift & weigh SV
- Install onto PAF
- Remove Tilt Ring

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VAFB B/1610 Operation Layouts
Install Canister Around S/V

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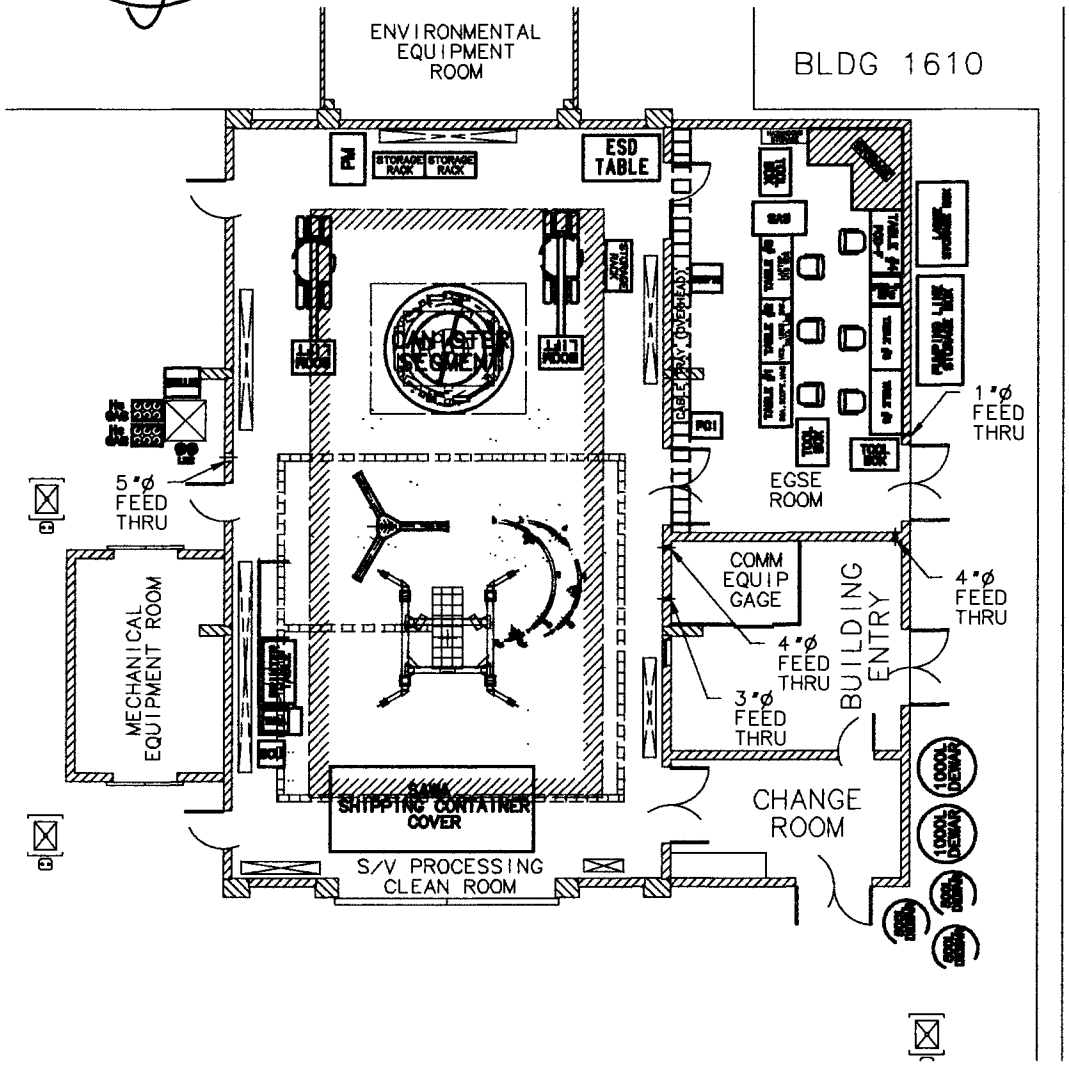

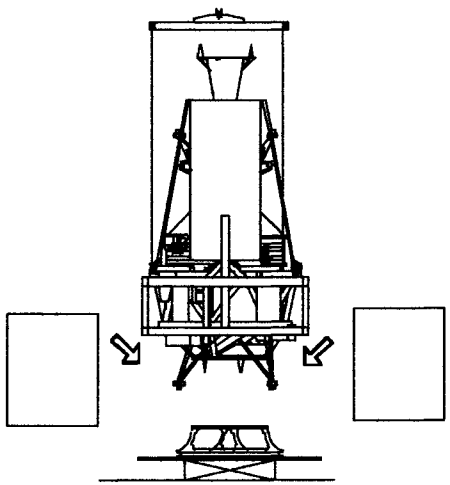

Additional Ops/Details

- Bag & purge SV
- Erect transportation can around SV

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VAFB B/1610 Operation Layouts
Install S/V In Can On Transporter

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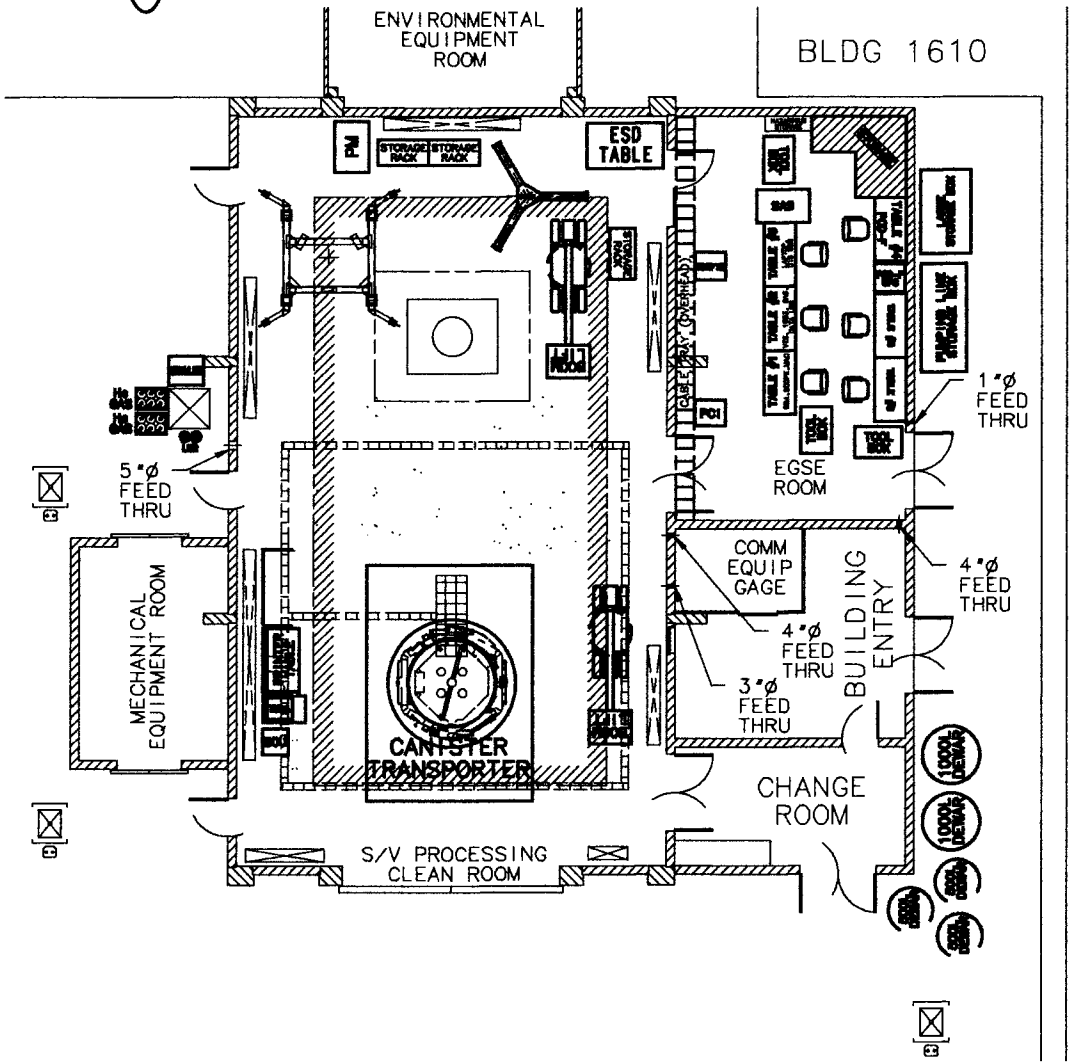
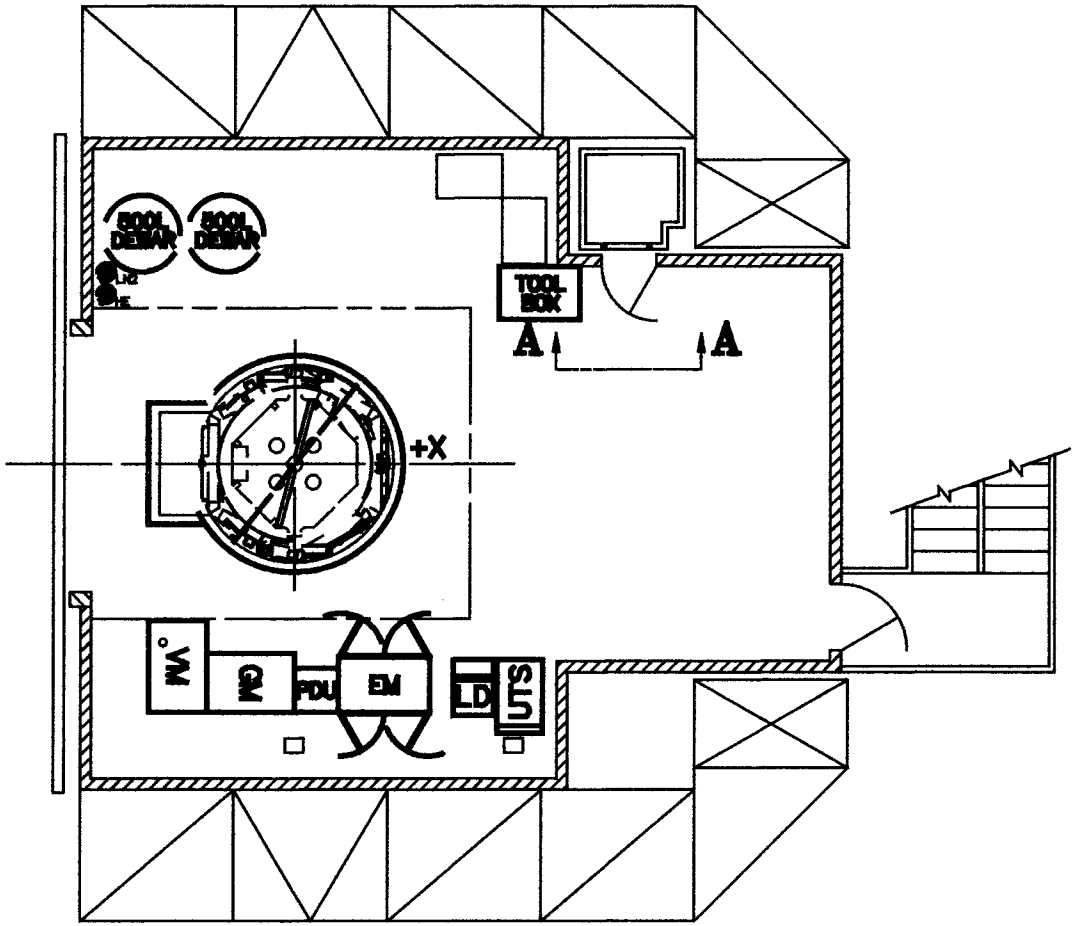
19 February 2003



Additional Ops/Details

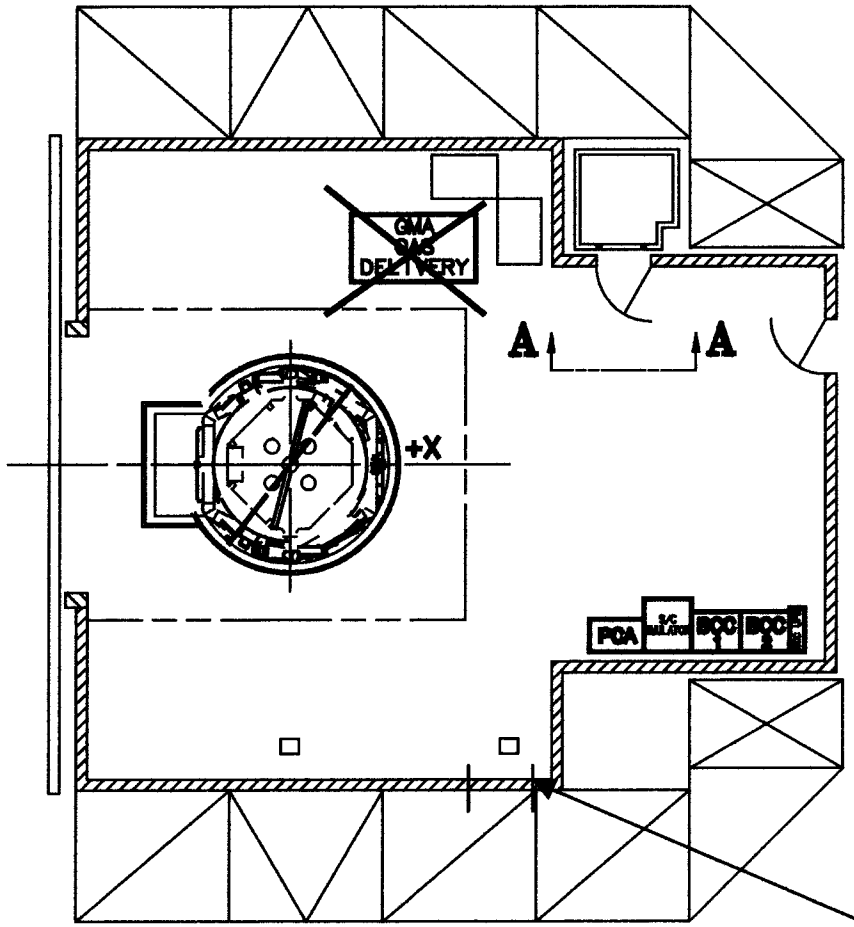
- Transport to MST

GP-B GSE on MST Level 5



SLC-2 W
GP-B EQUIPMENT LAYOUT
MST LEVEL 5

GP-B GSE on MST Level 4

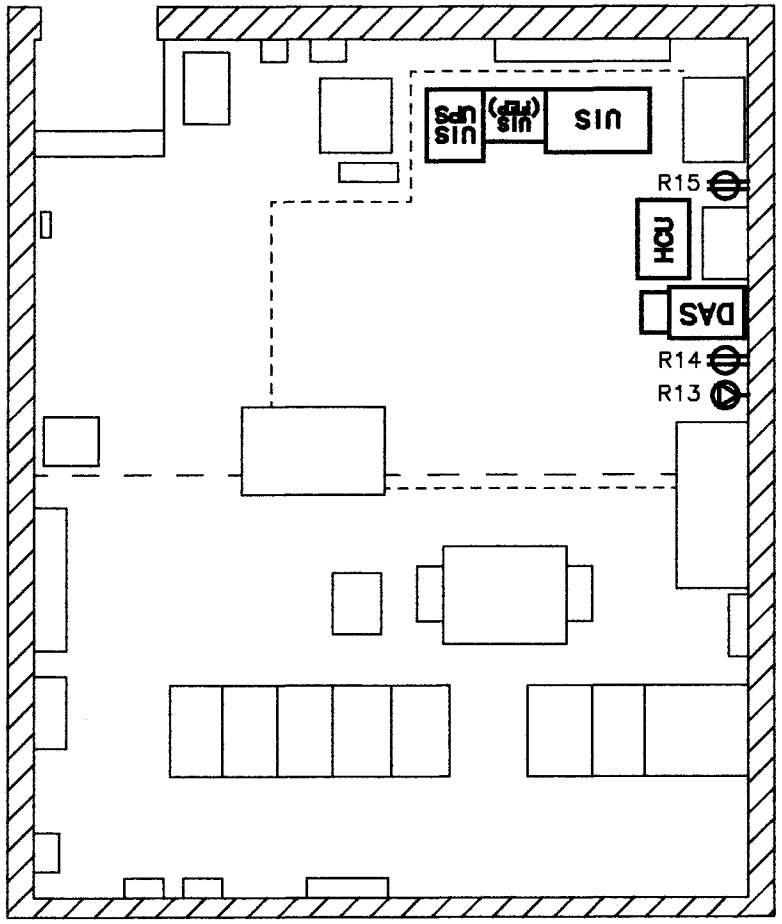


SLC-2 W
GP-B EQUIPMENT LAYOUT
MST LEVEL 4

Summary

- **Current layouts coordinated and accepted by Boeing/NASA KSC**
- **Items not used in B/1610 stored in B/836**
  - S/V Tilt Dolly
  - One time use or contingency lifting hardware
- **Items not used on MST stored in B/1610 or B/836**
  - Immediate need items stored in B/1610 for possible destack
  - Contingency items stored in B/836

GP-B GSE in EEB



EEB
GP-B EQUIPMENT LAYOUT/
ELECTRICAL REQUIREMENTS