GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Reconfigure SMD for ECU Repair

To be performed at Vandenberg Air Force Base building 1610

THIS DOCUMENT DOES NOT CONTAIN HAZARDOUS OPERATIONS

P1055 Rev-

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List of Abbreviations and Acronyms

AG-x	Gauge x of Gas Module auxiliary section
AMI	American Magnetics Inc.
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
FEE	Forward Equipment Enclosure
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.
MOC	Mission Operations Center
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
PAF	Payload Adapter Flange
PFCG	Fill Cap ass'y 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
STG	SMD Thruster vent pressure gauge
SU	Stanford University
SV	Space Vehicle
SV-x	SMD Valve number x
TD	Test Director
TG-x	Gauge x of Utility Turbo System
TV-x	Valve x of Utility Turbo System
UTS	Utility Turbopump 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

LIST OF SPECIFIC HEADING DEFINITIONS

Each type of alert message will precede the procedural step to which it applies

Note:
Used to indicate an operating procedure of such importance that it must be emphasized.

CAUTION:
Used to identify hazards to equipment.

WARNING:
Used to identify hazards to personnel.

A. SCOPE

This master procedure describes the steps necessary to configure the SMD for ECU repair hold period and also the transition into reconditioning the Main Tank. The steps include:

Reconfigure SMD for hold period

- Close SV-12
- Install P802 GSE cable
- Install Vatterfly Valve Covers
- Connect Guard Tank Vent Line
- Configure misc items

Hold Period

- Maintain Guard Tank liquid level above 20%
- Certify Pump Module
- Connect SMD Vacuum Module to SMD Vacuum Shell (optional)
- Reinstall Top Plate heaters

Reconfigure SMD for reconditioning of Main Tank

- Install Main Tank Vent Line
- Prepare for Resumption of pumping
- Perform Main Tank subatmospheric transfer (2x)
- Transition to P1002A

Note that this procedure is classified as non-hazardous. That classification does not necessarily apply, however, to other procedures that are called by this procedure.

B. SAFETY

B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware.

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.

During the performance of this procedure the main tank is at subatmospheric pressure. If the main tank fill or vent line is opened to atmosphere, air will be ingested into a cryogenic region where it will freeze with a high probability of blocking of the line. This could prevent proper venting of the main tank on orbit,

consequent over temperature and over pressurization, and ultimately the rupturing of one of the main tank burst disks.

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

Mitigation of over pressurization hazard is primarily through the use of burst disks or relief valves. A rupture of the main tank burst disk(s) will be obvious due to the plume of cold gas. Emergency vent lines are installed over the burst disks on the SMD vacuum shell to eliminate the possibility of direct plume impingement on personnel. Orderly evacuation shall be performed in the event one or more of these burst disks rupture. An oxygen deficiency monitor (provided by GP-B) that alarms when the oxygen level is reduced to 19.5% will be utilized as an added precaution. Temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions.

Only authorized and trained personnel are allowed in VAFB facilities without escort. All personnel working on platforms at a height 30 inches or more off the floor are required to have an approved air tank (emergency breathing apparatus) within easy reach. Note that tank need not be kept available when working from a ladder. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the room and contact NASA and VAFB safety. The following additional requirements apply to all personnel involved directly in cryogenic operations: Insulated gloves when handling equipment that has been cooled to cryogenic temperatures. A protective apron, gloves impervious to liquid cryogens, impermeable shoes, and full-face shields are to be worn whenever the possibility of splashing or impingement of high velocity cryogens exists.

B.2.3. Other Hazards

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

B.3. **Mishap Notification**

B.3.1. Injury

In case of any injury obtain medical treatment as follows
VAFB Call 911

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 and Stanford University GP-B P0879. Additionally, VAFB NASA Safety and 30th Spacewing Safety will be notified as required.

B.3.3. Contingency Response

Responses to contingencies (e.g., power failure, burst disk failure) are listed in Appendix 3.

C. QUALITY ASSURANCE

C.1. QA Notification

The NASA program and NASA safety representatives 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 TD 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 TD or QA Representative, mission 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.

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.

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 TD and approved by the QA representative.

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, procedures called by this procedure may have additional requirements. 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. Required Personnel

List below those personnel involved with the procedure

The following personnel are essential to the accomplishment of this procedure:

FUNCTIONAL TITLE	NUMBER	AFFILIATION
Test Director/Test Engineer	1	Stanford
GP-B Quality Assurance	1	Stanford

E. REQUIREMENTS

E.1. Electrostatic Discharge Requirements

Any person who comes in contact with the SV must use a grounding wrist strap that has been tested that day. Appropriate attachment points are positioned 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

No commercial test equipment is required for this operation.

E.3.2. Ground Support Equipment

The Ground Support Equipment includes the Gas Module (GM), the Pump Module (PM), the Electrical Module (EM), the Vacuum Module (VM), and the Utility Turbopump System (UTS). 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. The UTS is a smaller version of the Vacuum Module.

This procedure calls for use of hardware located in the Gas Module (Figure 2), the Electrical Module (Table 1), and the UTS (Figure 3).

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

With connector J802 connected to flight electronics, operation of RAV-2 and RAV-6B must be commanded through the spacecraft instead of the RAV controller in the Electrical Module. Spacecraft telemetry and EGSE support will also be needed.

E.3.5. Additional Test Equipment

Description	***Manufacturer***	***Model***
O_2 Monitor and Alarm	Alpha-Omega Instruments	1000

E.3.6. Additional Hardware

No additional hardware is required

E.3.7. Protective Clothing

None required.

E.3.8. Tools

No tools are required for this operation.

E.3.9. Expendables

Description	***Quantity***	***Mfr./Part No.***
Liquid Helium	≥ 500 liters.	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	
2	DAS	Power Supply, H-P 6627A	B1, B2, B3, B4-	3452A01956	Yes	

No.	*Location*	*Description*	*User Name*	*Serial No.*	*Cal Required*	*Status Cal due date*
3	DAS	Data Acquisition/Control Unit H-P 3497A	-	2936A245539	No	-
4	DAS	Digital Multimeter H-P 3458A	-	2823A15047	Yes	
5	EM	Vacuum Gauge Controller Granville-Phillips Model 316	EG-1a, -1b	2827	No	-
6	EM	Vacuum Gauge Controller Granville-Phillips Model 316	AG-2a, -2b	2826	No	-
7	EM	Vacuum Gauge Controller Granville-Phillips Model 316	EG-3	2828	No	-
8	EM	MKS PDR-C-2C	EG-2, FCG	92022108A	No	-
9	EM	Flow meter – Matheson 8170	EFM-1	96186	No	-
10	EM	Flow meter totalizer Matheson 8124	EFM-1	96174	No	-
11	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Main Tank	96-409-11	No	-
12	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Guard Tank	96-409-10	No	-
13	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Well	96-409-9	No	-
14	EM	Liquid Helium Level Controller American Magnetics, Inc. 136	LLS Axial Lock	96-409-12	No	-
15	EM	Pressure Controller – MKS 152F-92	EV-7a, -7b	96203410A	No	-
16	EM	Power Supply HP 6038A	H08D Tank Heater	96023407A	Yes	
17	EM	Power Supply HP 6038A	H09D Tank Heater	3511A-13332	Yes	
18	EM	Power Supply HP 6038A	RAV Power Supply	3329A-12486	Yes	
19	EM	Vac Ion Pump power supply Varian 929-0910, Minivac	SIP	5004N	No	-
20	EM	Flow meter totalizer Veeder-Root	PFM-1	576013-716	No	-
21	GM	Pressure Gauge, Heise	AG-1	CC-122077	No	-
22	GM	Pressure Gauge, Marshall Town	AG-3	N/A	No	-
23	GM	Main Tank Heat Exchanger: a) Thermocouple, b) Current meter, c) Temperature set point controller	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. Space Vehicle

The SV must be mounted vertical (+Z up) in the Assembly Stand with solar panels and FEE skins removed to allow to the vent boss region.

E.5.2. Main Tank

The Main Tank liquid must be subatmosphericwith the liquid level ≥ 95% as obtained by the completion of P1001, *Prepare Main Tank for Launch*. The Main Tank is closed out in flight configuration with SV-9 closed, SV-12 (V12) open, and the flight cap installed on the main tank vent bayonet.

E.5.3. Guard Tank

The Guard Tank is filled with NBP liquid He and must be maintained above a minimum level of 20%. The Guard Tank pressure must not be allowed to drop below atmospheric.

E.5.4. Well

The Well must be evacuated with the UTS connected to the Well pumpout port per P1001, *Prepare the Main Tank for Launch*.

E.5.5. SMD Vacuum Shell

The Vacuum Shell pressure must be less than 5×10^{-5} torr. Procedure P1015, *Connect Vacuum Module to SMD*, contains the steps for connecting to and pumping on the SMD vacuum shell.

E.5.6. Alarm System

1. The DAS alarm system must be enabled and contain the following alarm set-points:
    a. Bottom of main tank temperature (CN 48) set at $T \leq 2.2$ K.
    b.
    c. Relative Guard Tank Pressure (CN 46) set at $\Delta P \geq 10$ torr.
2. The DAS watchdog timer and alarm are enabled.

E.5.7. GSE and Non-flight Hardware

1. GSE cabling must be connected between the SMD and the Electrical Module (P/N 5833812) and between the SMD and the Data Acquisition System (P/N 5833811).
2. The Fill Cap Assembly must be installed at SV-13.
3. The heaters on the SMD top plate, SV-9, and Main Tank vent bayonet are not installed
4. The Utility Turbopump System is connected to the Well, but may be in a valved-off state.

E.6. Optional Non-flight Configurations

1. The ion-pump magnet is installed and ion pump is cabled to its readout.

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*
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*
LM EM SYS229	*Accident/Incident/Mishap Notification Process*
EWR 127-1, 31 March 1995, Eastern and Western Range Safety Requirements	*Hazardous and Safety Critical Procedures*
KHB 1710, rev D	*Kennedy Space Center Safety Practices Handbook*

F.3. Additional Procedures

Document No.	***Title***
SU/GP-B P1005A	*Disconnect Main Tank Vent Line to Gas Module – Main Tank Subatmospheric*
SU/GP-B P1017	*Repump Well with UTS*
SU/GP-B P1018	*Install Vatterfly Valve Covers*
SU/GP-B P1020	*Certify EM, GM, and DAS*
SU/GP-B P1028	*Guard Tank Fill- Main Tank Subatmospheric*
SU/GP-B P1002	*Configure SMD for Transport to SLC-2W*
SU/GP-B P1004	*Connect Main Tank Vent Line to GM- MT Subatmospheric*
SU/GP-B P1036	*SMD Main Tank Subatmospheric Fill from NBP Supply Dewar- GT Precool*
SU/GP-B P1015	*Connect Vacuum Module to SMD Vacuum Shell*
SU/GP-B P1027	*External Guard Tank Fill- Main Tank Subatmospheric (B1610)*

SU/GP-B P1009	*Disconnect Guard Tank Vent Line from Gas Module*
SU/GP-B P1010	*Disconnect Electrical GSE from SMD*
SU/GP-B P1016	*Stop Pumping SMD / Disconnect Vacuum Module*
SU/GP-B P1035	*Reduce Main Tank Liquid Level-MT Subatmospheric*
SU/GP-B P1043	*Pressurize Main Tank to NBP*

Operation Number:_____

Date Initiated:_____

Time Initiated:_____

G. OPERATIONS

G.1. Pre-Operations Verifications

- ❑ Verify SU QA notified.

  Record: Individual notified _____,

  Date/time _____/_____.
- ❑ Verify NASA program representative notified.

  Record: Individual notified _____,

  Date/time _____/_____.
- ❑ Verify performance of pre-operations checklist (Appendix 1).

Section complete _____ QA.

G.2. Phase 1: Reconfigure SMD for Hold Period

G.2.1. Ensure SMD relocated to assembly stand, solar arrays and FEE skins removed

G.2.2. Ensure Well connected to UTS and actively pumping either the Well or up to a closed VW-4

G.2.3. Close SV-12

1. Request LM team perform HPF-044. This procedure removes the staking in addition to cleaning the threads of SV-12
2. Close SV-12 hand tight

G.2.4. Ensure S1-S4 and P1A closed by the GMA Team

1. Record Date/Time:_____
2. Record Operations number and procedure number:_____/_____

G.2.5. Install Guard Tank Vent Line per P1008, “Connect Guard Tank Vent Line to Gas Module”

1. Record operations number:_____

G.2.6. Configure SMD data cables

1. Request LM remove P803 shorting plug and connect cable P803 to bottom of FEE
2. Request LM remove P6 shorting plug and connect P6 to Main Tank Endevco GSE cable

3. Request LM remove P800 umbilical from bottom of FEE and install P800 GSE cable
4. Print out complete data set

G.2.7. Request LM team power on space craft and open RAV-6B

1. Record LM operations number:_____
2. Record date/time:_____

G.2.8. Perform procedure P1020, "Certify Electrical, Gas Module and DAS" to certify P802 GSE cable.

1. Sections not involving the certification of P802 may be skipped
2. Record operations number:_____

G.2.9. While ECU still installed, request LM team to disconnect the flight cable P802 and to connect P802 GSE cable to dewar top plate

G.2.10. Perform Guard Tank fill P1028 "Guard Tank Fill-Main Tank Subatmospheric"

1. Record operations number:_____

G.2.11. After successful completion of step G.2.11, notify LM team they can proceed with ECU removal

G.2.12. Perform procedure P1018, "Install Vatterfly Valve Covers"

1. Record operations number:_____
2. Record Date/Time:_____

Note:
If the Guard Tank goes empty and/or the Main Tank rate of rise is elevated to the point that it may reach the lambda point before restarting Main Tank conditioning, a contingency response is provided in appendix 3.

G.3. **Phase 2: Hold Period**

G.3.1. Perform Guard Tank fills per P1028, "Guard Tank Fill- Main Tank Subatmospheric" as necessary to maintain liquid level above 20%

Note:
The Well should be kept evacuated at all times. It should be pumped with the UTS for a minimum of 4 hours after every GT fill. When the Well is sufficiently evacuated, both VW-3 and VW-4 should be closed. The UTS may be kept running during this period.

G.3.2. Reinstall top plate heaters as necessary and verify proper operation.

G.3.3. Connect Pump Module to Gas Module and certify per procedure P1025, "Certify Pump Module"

1. Record operations number:_____

G.3.4. (Optional) Connect Vacuum Module to Vacuum Shell per procedure P1015, "Connect Vacuum Module to SMD Vacuum Shell"

1. Record operations number:_____

G.4. **Prepare for Resumption of Pumping**

G.4.1. Connect Main Tank Vent Line to GM per procedure P1004, "Connect Main Tank Vent Line to Gas Module-Main Tank Subatmospheric"

1. Record operations number:_____
2. It will be necessary to break the staking on the Main Tank Flight Vent Cap to remove it from the SMD. The threads on the Main Tank bayonet should be cleaned per engineering direction after the cap is removed

G.4.2. Open RAV-3 as follows

1. Ensure all RAV selection switches in OFF position.
2. Turn on RAV power supply and adjust current limit to 1.95 A.
3. Adjust power supply to 28 VDC.
4. Power up RAV controller #3.
5. Position controller #3 RAV selection switch to RAV-3.
6. Record initial switch status: Open: θ θ Closed: θ θ.
7. Activate controller #3 to open RAV-3 and record:
    a. Run time: _____ seconds.
    b. Current draw: _____ amp.
    c. Time of day: _____.
8. Record final switch status: Open: θ θ Closed: θ θ.
9. When convenient, record operation in RAV log book.

G.4.3. Record Initial Conditions

1. Record initial SMD vacuum shell pressure as follows:
    a. Connect Vac Ion Pump and Magnet if not already installed
    b. Turn on Vac-ion pump and record date/time _____/_____
    c. Use DAS [Monitor Data] for CN 99.
    d. When value is steady, record pressure (IP) _____ torr.
    e. Also record results in SMD Vacuum Shell Health Log.
    f. Verify Vacuum Shell Pressure < 5×10^{-5} torr. If not, turn off Vac-ion pump and perform procedure P1015, *Pump SMD Vacuum Space with Vacuum Module*, to pump out SMD vacuum shell. Record Op No. _____.
    g. Exit [Monitor Data] and collect data with [Set Data Interval] to 5 min.
    h. When data cycle is complete, turn off Vac-ion pump.
2. Record initial pressures:

a. Guard Tank relative to atm. (GTV-G): _____ torr.
b. Main Tank manifold (EG-3):_____ torr.
c. Vacuum Module Pressure (VG-1):_____ torr.

3. Record initial temperatures
   a. Main Tank bottom (CN [9]) _____ K.
   b. Guard Tank (CN [24]) _____ K.
   c. Top of lead bag (CN [175]) _____ K.
   d. Top of lead bag (CN [41]) _____ K.

G.4.4. Establish Configuration of Pump Module

1. Verify open PV-2 and PV-4.
2. Verify closed PV-1, PV-3, PV-5, and PV-6.
3. Verify on/turn on water cooling (chiller unit) of pump module.
4. Verify cooling fans are operating.
5. Verify sound enclosure is installed.
6. Turn on rotary vane pump PP-2 and blower PP-1.
7. Open PV-1.
8. Once pressure PG-1 in steady state record (PG-1): _____ torr.
9. Open PV-3.

G.4.5. Set up Data Acquisition System

1. Verify DAS set to configuration 4ae
2. Set the Main Tank liquid-level sampling interval to 10 minutes.

Section complete _____ QA.

G.5. **Resume Pumping on Main Tank**

G.5.1. Verify all AV valves are closed.

G.5.2. Verify all EV valves closed except for EV-13, EV-7A/B.

G.5.3. Ensure EV-21/22 closed.

G.5.4. Verify that “Actuator Control EV-9” on Gas Module is set to “Subatm He.”

G.5.5. Open EV-21.

G.5.6. Open EV-4

G.5.7. Open EV-10 to allow EG-2 to read the Main Tank manifold pressure.

G.5.8. Open EV-17

G.5.9. Open SV-9

1. Clean staking material per engineering direction

G.5.10. Input comment to DAS “Start resumption of Main Tank Pumping”.

G.5.11. If needed, add heat to Guard Tank to maintain positive pressure:

1. Turn on power supply for Guard-Tank heater (H-3D or H-4D)
2. Set power supply current limit to 0.07 amps.
3. Set voltage limit to 20 VDC and record:
   V _____Vdc and I _____A.
4. Adjust heater voltage as necessary to maintain Guard Tank pressure (GTV-G) in the range 5 torr < ΔP < 7 torr.
5. Monitor and maintain positive Guard Tank pressure as needed. Record data on attached data sheets.

G.5.12. When heater power required to maintain positive pressure in the Guard Tank is zero, turn off GT heater supply.

G.5.13. Verify valve configurations

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

Verify Final Valve States		
	Verify Open	***Verify Closed***
Main Tank connected to GM		EV-9
Guard Tank connected to GM – liquid level ≥ 15%	EV-13 GTV-V	EV-20, EV-23, EV-24 GTV-Va, EV-16,
o Well evacuated – Pumping with UTS	TV-1, VW-1, VW–2 VW-3, VW-4	
o Well evacuated – valved off	VW-1, VW-2	VW-3, VW-4, TV-1
Remaining EV valves	EV-4, EV-17, EV-21 EV-7a/b, EV-10	EV-5, EV-6, EV-8, EV-11, EV-12, EV-14, EV-15, EV-18, EV-22
AV valves		All

G.5.14. Set Up Data Acquisition

1. Set Main Tank liquid level sensor to 10 minute sampling interval.
2. Set Guard Tank liquid level sensor to 10 minute sampling interval.
3. Set Data interval to 15 min.

G.5.15. Continue pumping on Main Tank with pump module until main tank temperature is 1.75 K or less.

G.6. **Transfer NBP LHe to Subatmospheric Main Tank-1**

G.6.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [9] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [24] _____ K.
5. Guard Tank pressure (GTV-G) _____ torr.

G.6.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.6.3. Perform procedure P1036, *SMD Main Tank Subatmospheric Fill From NBP Supply Dewar – GT Precool*

G.6.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.6.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (GTV-G) _____ torr.

G.6.6. Continue pumping on Main Tank with pump module until the main tank is temperature is ~1.75K

G.7. **Transfer NBP LHe to Subatmospheric Main Tank-2**

G.7.1. Record initial conditions:

1. Record Date _____ and Time _____.
2. Main Tank bottom temp. CN [9] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [24] _____ K.
5. Guard Tank pressure (GTV-G) _____ torr.

G.7.2. Record liquid helium levels.

1. Main Tank – _____%
2. Guard Tank – _____%

G.7.3. Perform procedure P1036, *SMD Main Tank Subatmospheric Fill From NBP Supply Dewar – GT Precool*

G.7.4. When transfer complete, record:

1. Date _____ and Time_____
2. Op. No. _____
3. Final MT level _____ %.

G.7.5. Record final fill conditions:

1. Time of day _____.
2. Main Tank bottom temp. CN [171] _____ K.
3. Main Tank pressure (EG-2)
    a. Dynamic (EV-4 open)_____ torr.
    b. Static (EV-4 briefly closed) _____ torr.
4. Guard Tank temperature CN [170] _____ K.
5. Guard Tank pressure (GTV-G) _____ torr.

G.7.6. Continue pumping on Main Tank with pump module until the main tank is 94.3 - 95% full indicated (95 - 95.5% full by volume).

G.8. **Switch Pumping to Gas Module (AP-1)**

G.8.1. Record Date/time: _____

G.8.2. Enter comment in the DAS: “Complete conditioning of MT; switch to AP–1”

G.8.3. Turn on AP-1

G.8.4. Open AV-6.

G.8.5. Adjust both EV-7a/b to 0% (these valves do not completely close).

G.8.6. Close EV-4 and EV-21/22.

G.8.7. Close PV-1.

G.8.8. Turn off Pumps PP-1, and PP-2.

G.8.9. (Option)Turn off coolant water in Pump Module.

G.8.10. Continue monitoring Dewar instrumentation to verify that temperatures have stabilized.

G.8.11. Begin P1002A

1. Record Operations Number:_____

Section complete _____ QA

H. **PROCEDURE COMPLETION**

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

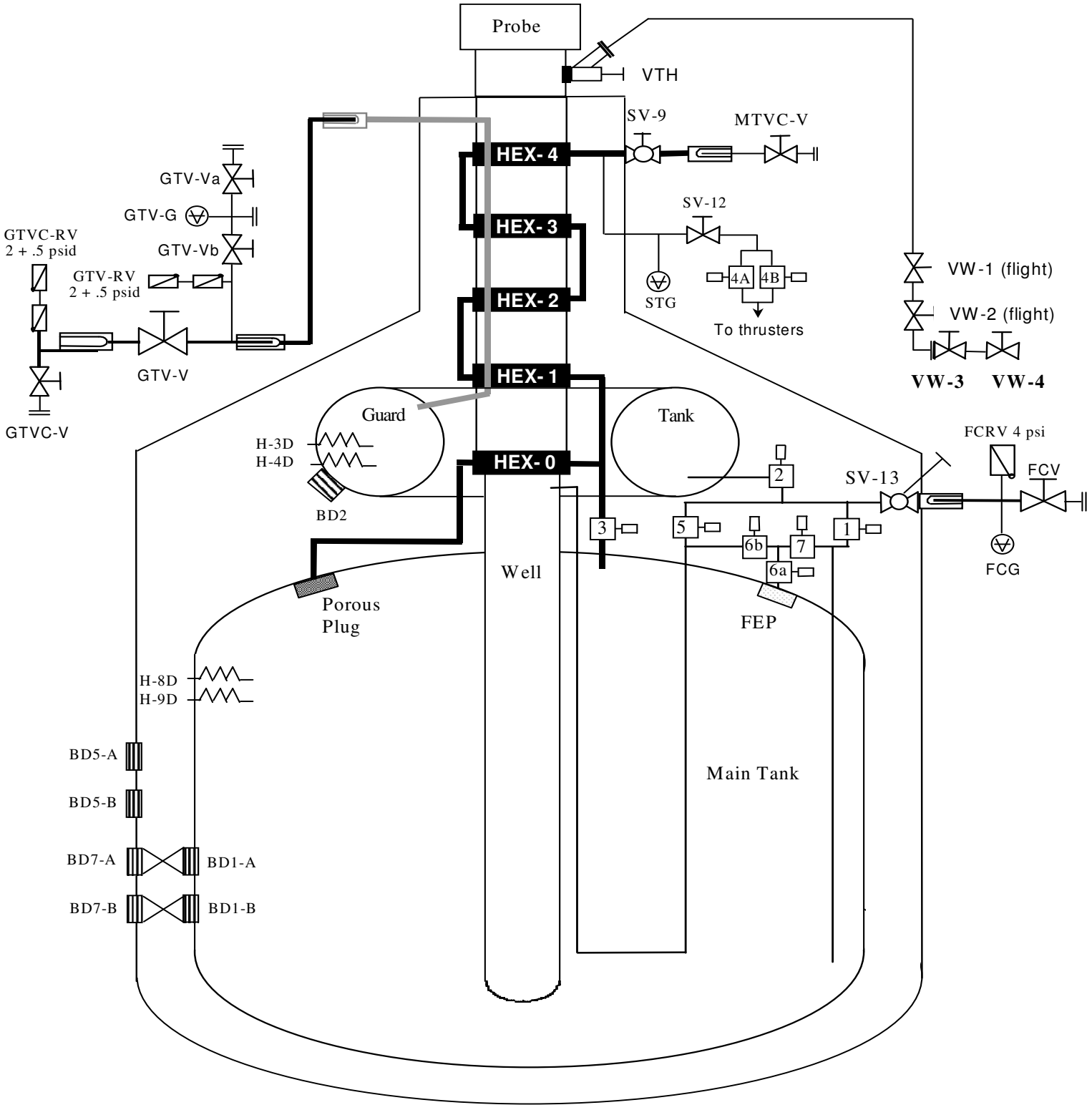


Figure 1 Schematic representation of SMD after completion of this procedure.

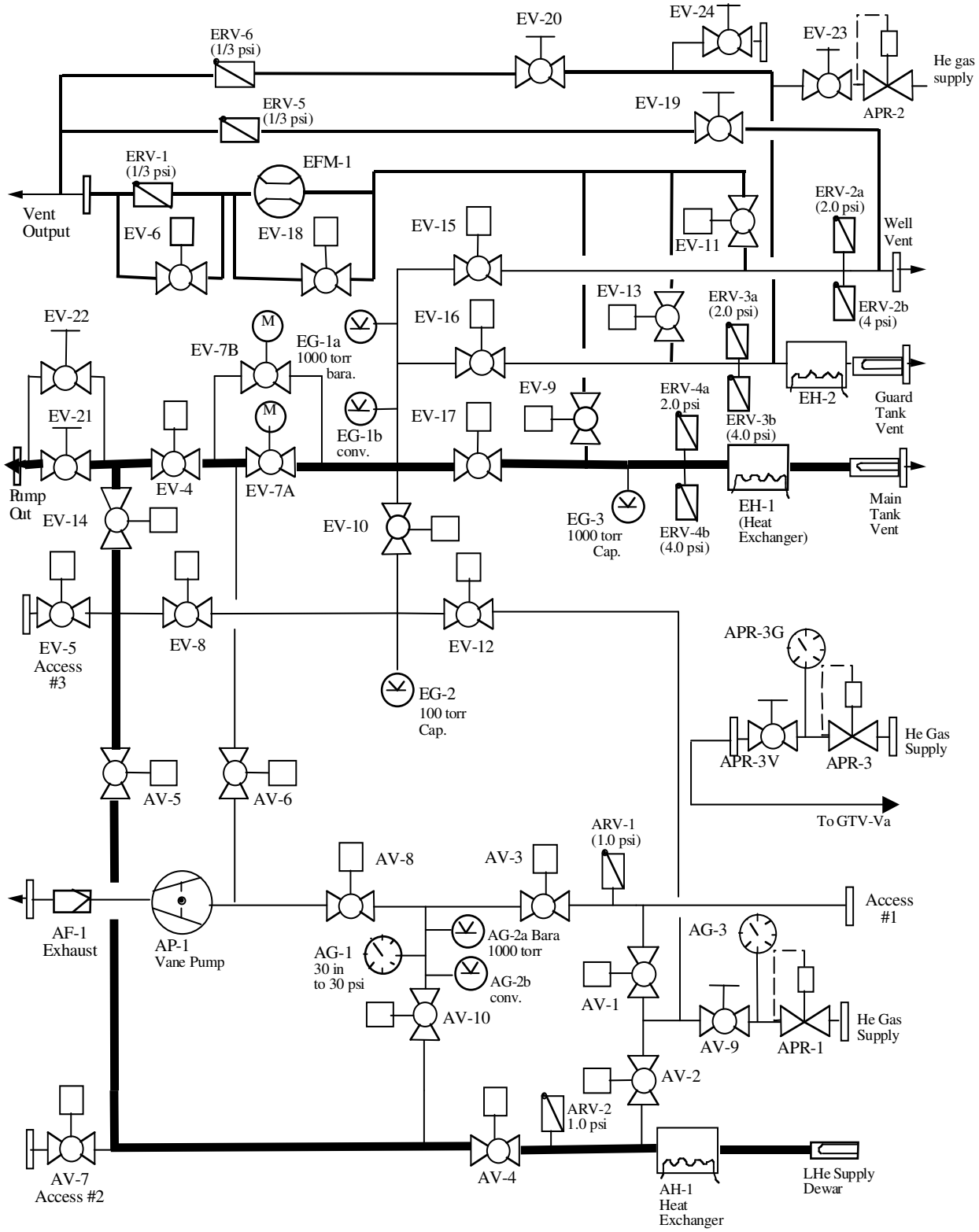


Figure 2. Schematic of Gas Module Plumbing.

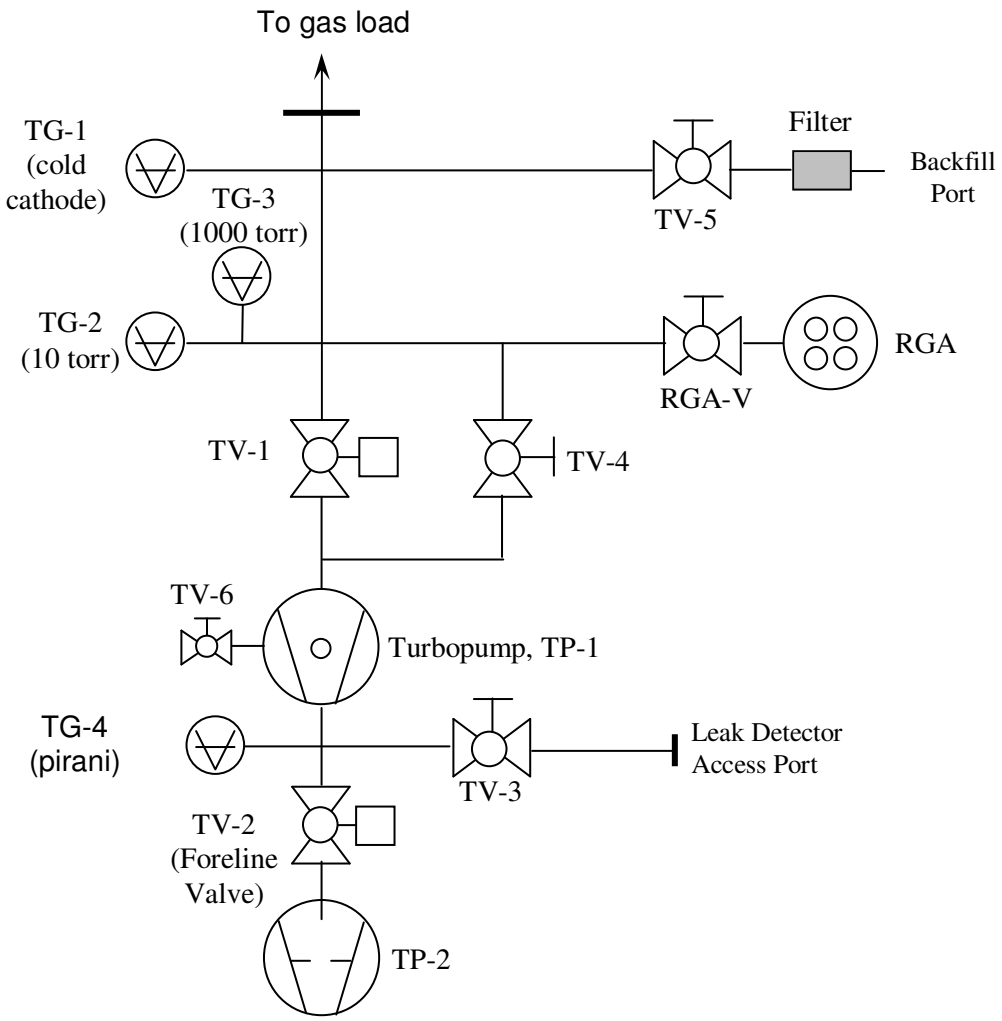
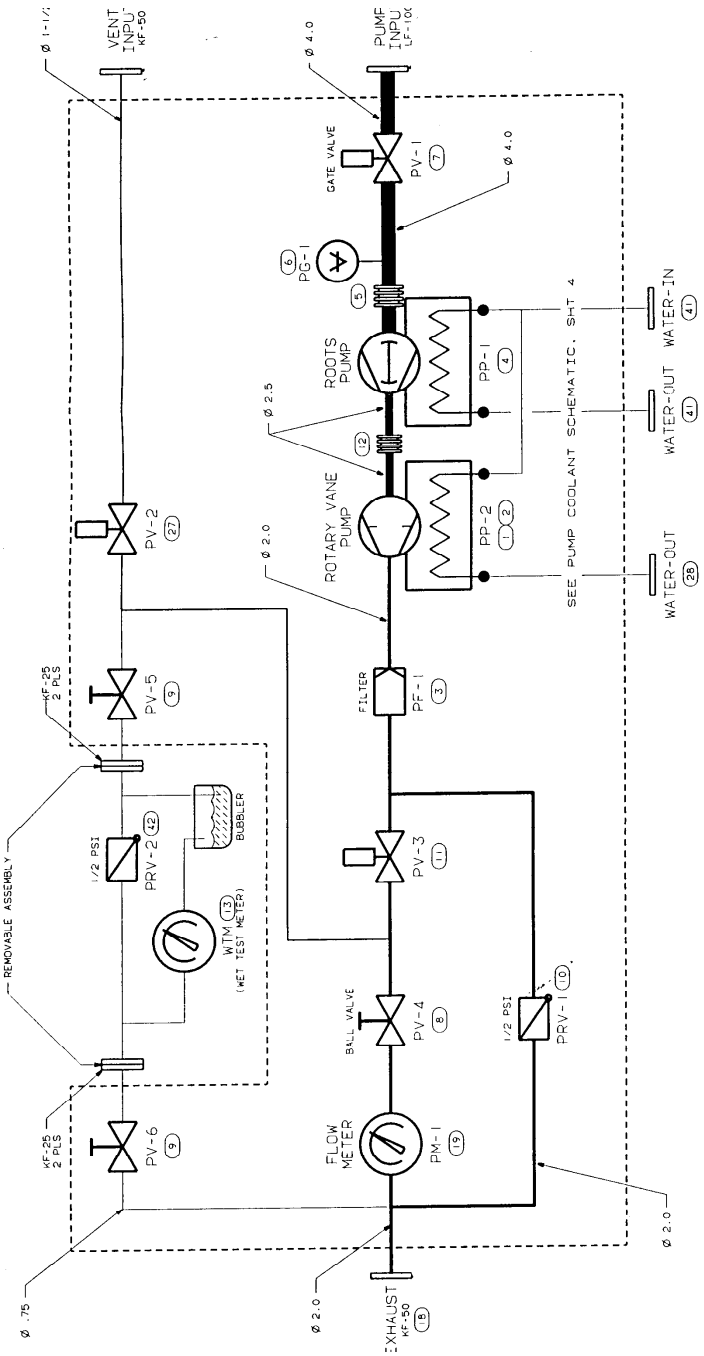


Figure 3. Schematic diagram of Utility Turbopump System (UTS)

I.


VENT INPUT KF-50
PUMP INPUT LF-10
Ø 4.0
GATE VALVE
PV-1 (7)
PG-1 (6)
ROOTS PUMP
PP-1 (4)
WATER-IN (41)
WATER-OUT (41)
Ø 2.5
ROTARY VANE PUMP
PP-2 (1)(2)
SEE PUMP COOLANT SCHEMATIC, SHT 4
WATER-OUT (28)
Ø 2.0
PV-2 (27)
KF-25 2 PLS
PV-5 (9)
FILTER
PF-1 (3)
REMOVABLE ASSEMBLY
BUBBLER
1/2 PSI
PRV-2 (42)
WTM (13) (WET TEST METER)
PV-3 (11)
BALL VALVE
PV-4 (8)
1/2 PSI
PRV-1 (10)
KF-25 2 PLS
PV-6 (9)
FLOW METER
PM-1 (19)
Ø .75
Ø 2.0
EXHAUST KF-50 (8)

APPENDIX 1 – PRE-PROCEDURE CHECKLIST

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.		
	2. Verify all critical items in the test are identified and discussed with the test team.		
	3. Verify all required materials and tools are available in the test area.		
	4. Verify all hazardous materials involved in the test are identified to the test team.		
	5. Verify all hazardous steps to be performed are identified to the test team.		
	6. Verify each team member knows their individual responsibilities.		
	7. CONFIRM THAT EACH TEST TEAM MEMBER CLEARLY UNDERSTANDS THAT HE/SHE HAS THE AUTHORITY TO STOP THE TEST IF AN ITEM IN THE PROCEDURE IS NOT CLEAR.		
	8. Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly.		
	9. NOTIFY MANAGEMENT OF ALL DISCREPANCY REPORTS OR D-LOG ITEMS IDENTIFIED DURING PROCEDURE PERFORMANCE. IN THE EVENT AN INCIDENT OR MAJOR DISCREPANCY OCCURS DURING PROCEDURE PERFORMANCE MANAGEMENT WILL BE NOTIFIED IMMEDIATELY.		
	10. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: _____		

J. APPENDIX 2 – POST-PROCEDURE CHECKLIST

DATE	CHECKLIST ITEM	COMPLETED	REMARKS

	1. Verify all steps in the procedure were successfully completed.		
	2. Verify all anomalies discovered during testing are properly documented.		
	3. Ensure management has been notified of all major or minor discrepancies.		
	4. Ensure that all steps that were not required to be performed are properly identified.		
	5. If applicable sign-off test completion.		
	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: _____		

K. APPENDIX 3– CONTINGENCY RESPONSES

	Condition	Circumstance	Response
1	Power Failure	Before closeout of the main tank, section G.4.1	1) Verify EV-9 and all other EVs and AVs are closed 2) Close / verify closed VW-3 3) Verify that all TVs are closed 4) Upon restoration of utility power, verify AP-1 is now running 5) Open AV-8 and verify that the pressure read by AG-2b is less than 0.1 torr 6) Open in sequence AV-6, EV-10, EV-17 to re-establish pumping on the MT 7) Reopen EV-13 8) Restart UTS per P1017 9) Continue with procedure
		After closeout of the MT per P1005	1) Verify that all TVs are closed 2) Close / verify closed VW-3 3) Upon restoration of utility power, restart UTS per P1017 4) Continue with procedure
2	Burst disk rupture (MT/GT)	Any time	Evacuate room
3	Oxygen depletion alarm	Any time	Evacuate room
4	Empty Guard Tank or elevated rate of rise of Main Tank temperature	Any time	See appendix 4

Appendix 4

K.1. Contingency response to Empty Guard Tank or elevated rate of rise of Main Tank temperature

K.1.1. Ensure Pump Module certified and connected to Gas Module

K.1.2. Ensure Main Tank Vent line connected to Gas Module

1. If not, connect Main Tank vent line to GM per procedure P1004, “Connect Main Tank Vent Line to GM- Main Tank Subatmospheric”

K.1.3. Begin pumping Main Tank with Gas Module

1. Turn on AP-1
2. Verify open EV-16 and EV-13
3. Ensure all other GM valves closed
4. Close EV-16
5. Turn on AP-1
6. Open AV-6 and AV-8
7. Open EV-7A/B and EV-17
8. When EG-1b <100mtorr, open SV-9
9. Enter comment to DAS, “Now pumping Main Tank with AP-1”

K.1.4. Reduce level in Main Tank by performing procedure P1035, “Reduce Liquid Level in Main Tank- Main Tank Subatmospheric”

1. The Main Tank level should be reduced to < 85%
2. Record operations number:_____

K.1.5. Heat Main Tank to NBP per procedure P1043, “Pressurize Main Tank to NBP”

1. Record operations number:_____