GRAVITY PROBE B
PROCEDURE

Prepare Payload Ground Support Equipment for Transport

To be performed in Vandenberg Air Force Base building 1610

The document contains non-hazardous operations

P1024

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Written by

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REVISION RECORD

REVISION	ECO	PAGES	DATE

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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

LIST OF SPECIFIC HEADING DEFINITIONS

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

1. NOTE: Used to indicate an operating procedure of such importance that it must be emphasized
2. CAUTION: Used to identify hazards to equipment
3. WARNING: Used to identify hazards to personnel

A. SCOPE

This document provides the necessary steps and lists to assure the GSE, and it's related tools and equipment are prepared for shipment.

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.

The SMD Safety Compliance Assessment, document GPB-100153C and the Missile System Prelaunch Safety Package discuss the safety design, operating requirements and the hazard analysis of the SMD.

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

In VAFB building 1610, the GP-B cryogenic team provides 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 lines are installed over the four burst disks to direct any flow to an outside area.

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 ladder. In the unlikely event of a large LHe spill all employees have been instructed to evacuate the room and contact NASA 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, non-absorbent shoes and full-face shields with goggles/glasses are to be worn whenever the possibility of splashing cryogens exists.

B.3. Mishap Notification

B.3.1. Injury

In case of any injury or illness requiring emergency medical treatment **DIAL 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 Space Wing Safety will be notified as required..

B.3.3. Contingency Response

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

C. QUALITY ASSURANCE

C.1. QA Notification

The NASA program and the NASA safety 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 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 judgement of the TD 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. Required Personnel

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

D.4. Electrostatic Discharge Requirements

When working on the space vehicle, proper ESD protection is required. ESD wrist-straps will be checked on a calibrated checker prior to use.

D.5. Lifting Operation Requirements

There are no lifting operations in this procedure

D.6. Hardware/Software Requirements

D.6.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

D.6.2. Ground Support Equipment

The Ground Support Equipment includes the Gas Module, the Electrical 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.

This procedure prepares the Gas Module, Pump Module , Vacuum Module, Electrical Module, and UTS (Figure 1) for transportation.

D.6.3. Additional Test Equipment

No additional test equipment is required.

D.6.4. Additional Hardware

Item	Description	Manufacturer	Model
1	Wooden crates	All Pak	Various
2	Wooden Covers	All PAk	Various

D.6.5. Tools

	Description
1	Phillips screw driver
2	Side cutting pliers

D.6.6. Expendables

WARNING

Ethanol is highly flammable and vapor/air mixtures are Explosive.

Exposure hazards include: Inhalation (headache/fatigue),

skin (dryness, eyes (redness/pain/burning)

Description	Quantity	Mfr./Part No.
Ethanol	AR	N/A
99.999% pure gaseous helium	AR	N/A
Vacuum Grease	AR	Dow Corning, or Apiezon
Tie wraps - large size	AR	N/A

D.7. Configuration Requirements

D.7.1. The TM&A must be connected to the SMD in place of the DAS and supporting GSE that is to be packed

D.8. Optional Non-flight Configurations

N/A

E. REFERENCE DOCUMENTS

E.1. Drawings

Drawing No.	*Title*
LMMS-5833394	Instrumentation Installation

E.2. Supporting documentation

Document No.	*Title*
LMMC-5835031	GP-B Magnetic Control Plan
GPB-100153C	SMD Safety Compliance Assessment
LM/P 479945	Missile System Prelaunch Safety Package
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
EWR 127-1	Eastern and Western Range Safety Requirements
KHB 1710.2 rev E	Kennedy Space Center Safety Practices Handbook

E.3. Additional Procedures

Document No.	*Title*
SU/GP-B P0879	Accident/Incident/Mishap Notification Process
SU/GP-B P0875	GP-B Maintenance and Testing at all Facilities

Operation Number:_____
Date Initiated: _____
Time Initiated:_____

F. OPERATIONS

F.1. Pre-Operations Verifications

- Verify SU QA notified.

  Record: Individual notified _____,

  Date/time _____/_____.

- Verify NASA program representative notified.

  Record: Individual notified _____,

- Record calibration due dates in Table 1 (Sections. E.3.4, E.4)
- Persons actually performing this procedure should list their names in Sec D.3.
- Verify completion of the pre-operations checklist (Appendix 1).
- Verify availability and functioning of emergency shower.

QA Witness:_____

F.2. Gas Module(PN 5833813)

F.2.1. Verify that “Disconnect Electrical GSE from SMD” P1010 has been completed. Record Op. Number _____. and Date _____.

F.2.2. Verify Guard Tank pressurization transferred to Auxiliary Helium Pressurization Unit per P1014 Record Operation Number _____ and Date _____.

F.2.3. Verify all manual valves are closed.

F.2.4. Verify removed 4-foot, 4” Pump-Module pumping line, otherwise remove:

1. Remove line from Pump Outlet on GM and cap port.
2. Remove line from Pump Module inlet (under flooring).
3. Cap pumping line and stow in transport locker.

F.2.5. Verify removed “Pump Exhaust” hose and cap port with aluminum foil.

F.2.6. Verify removed helium vent line.

F.2.7. Verify removed line from “Vent Output” port on GM and cap port.

F.2.8. Remove other end of stainless line from plastic piping.

F.2.9. Cap both ends of line and stow in transport locker.

F.2.10. Verify removed/remove any pumping lines connected to Access port 1, Access port 3, and the Well vent port.

F.2.11. Remove/verify removed both Main and Guard Tank vent lines from GM.

F.2.12. Verify all plumbing is capped.

F.2.13. Verify 2 ea Circuit Breakers marked " Main C/B 30 amp" and " Pump C/B 15amps" are powered down.

F.2.14. Verify all electrical connections are removed or stowed onboard GM: WD-23, WD-24, PW-2, GM Genius Block, Power cable208Vac, and 3ph 30A.

F.2.15. Verify removed gaseous helium supply line from "Helium gas inlet".

F.2.16. Verify removed gas line from " Purge and Valve Activation Gas Inlet"

F.2.17. Install all panels on GM. Verify all screws are tight on panels that were previously installed.

F.2.18. Install shipping panels with straps. Ratchet mechanisms should be on top.

F.3. Prepare Vacuum Module (PN 5833816)

F.3.1. Verify Vacuum Module has been pumped out per procedure P1010. Record Operation Number _____ and Date _____.

F.3.2. Verify unit is powered down and 30amp Main power breaker is off.

F.3.3. Disconnect power from wall and stow cable on unit.

F.3.4. Verify all manual valves are closed.

F.3.5. Remove any external plumbing and stow in transport locker.

F.3.6. Verify all vacuum ports are capped.

F.3.7. Remove Nitrogen Pressurization Supply line.

F.3.8. Close/verify closed water in/out valves.

F.3.9. Remove/verify removed water supply lines.

F.3.10. Remove/verify removed pump exhaust line.

F.3.11. Ensure all data connections removed.

F.3.12. Install all panels and verify existing panels are screwed securely to vacuum module.

F.3.13. Install shipping panels and attach with straps ensuring ratchets remain on top of unit.

F.4. Prepare Electrical Module (PN 5833812)

F.4.1. Verify all units in EM are powered down.

F.4.2. Verify 30 amp breaker on side panel is off.

F.4.3. Disconnect power cable from receptacle and stow cable to transport locker.

F.4.4. While verifying all cables are properly marked remove and stow cables. Refer to Cable Table 1.

F.4.5. Remove Endevco read-out box to transport locker.

F.4.6. Check all units inside of EM for security during transport.

F.4.7. Check all cabling inside EM for stress relief during transport.

F.4.8. Secure all panels and doors.

F.4.9. Install packing covers and attach using straps ensuring ratchets are located on top of EM.

F.5. Prepare Data Acquisition System (PN 5833812)

F.5.1. Verify all units are powered down.

F.5.2. Verify breaker at top of unit is off.

F.5.3. Unplug both 110Vac lines and stow.

F.5.4. Verify all units are mounted securely into DAS.

F.5.5. Verify all cabling is marked and remove or stow in DAS. Refer to Cable Table 1.

F.5.6. Disconnect UPS from DAS and stow for shipment.

F.5.7. Close/verify back door closed securely

F.5.8. Pack DAS into it's transport container and secure door.

F.6. Prepare Utility Turbo Pump System

F.6.1. Verify UTS pumps are shut down and the two circuit breakers on the front panel are off.

F.6.2. Verify TV-3, TV-4, TV-5, TV-6, and RGA-V closed.

F.6.3. Verify TV-1 and TV-2 are closed (Gate valve and foreline valve)

F.6.4. Verify pumping ports are capped:

1. Primary pumping port (TV-1).
2. Leak Detector port (at TV-3).

F.6.5. Turn on roughing pump TV-2.

F.6.6. Place interlock switch in "override" position.

F.6.7. Push the reset button to activate the override circuit.

F.6.8. Open TV-2.

F.6.9. Open TV-1.

F.6.10. Pump for approximately .5 hour until pressure at TG-2 < 25 mtorr.

F.6.11. Close TV-2.

F.6.12. Monitor TG-2 for .5 hour to verify the pressure does not rise above 1 torr. (If pressure does rise above 1 torr, check to be sure all manual

valves are fully closed and all pumping port caps are properly installed, then repeat steps G.6.8 through G.6.12.)

F.6.13. Close TV-1.

F.6.14. Turn off roughing pump.

F.6.15. Turn off both circuit breakers on front panel.

F.6.16. Disconnect power cord and stow in bottom of cart.

F.6.17. Remove RGA electronics from RGA sensor and stow in transport container. Verify RGA power supply is stowed with electronics.

F.6.18. Verify all units are secured to pump cart.

F.6.19. Release pressure from compressor tank and close valve.

F.6.20. Install UTS into transport container and secure door.

F.7. Prepare Leak Detector (2ea Varian units)

F.7.1. Verify LD is turned off and all 4 circuit breakers are off.

F.7.2. Disconnect power cord and securely stow on back of unit.

F.7.3. Verify pumping port plug is installed and secure.

F.7.4. Verify cold trap installed.

F.7.5. Verify calibration date on Standard leak: _____ . The calibration date must exceed the duration of the deployment.

F.7.6. Install LD in it's shipping container and secure door.

F.8. Prepare Pump Module

F.8.1. Verify unit's pumps are powered down and both 60amp and 20 amp breakers are off.

F.8.2. Disconnect power from wall and stow cables on unit.

F.8.3. Verify all manual valves are closed.

F.8.4. Remove any external plumbing and stow in transport locker.

F.8.5. Verify all vacuum ports are capped.

F.8.6. Remove Nitrogen Pressurization Supply line.

F.8.7. Close/verify closed water in/out valves.

F.8.8. Remove/verify removed water supply lines.

F.8.9. Install all panels and verify existing panels are screwed securely to vacuum module.

F.8.10. Install shipping panels and attach with straps ensuring ratchets remain on top of unit.

F.9. List of Support Equipment to be Packed.

Verify all equipment is accounted for and stowed in transport containers.

Name	Part Number	Qty
Leak detector adapter	KF-25	1ea
Leak detector adapter	KF-40	1ea
Helium Probe	0981-K0167-301	1ea
Helium Probe extension		1ea
¼ " nylon hose	50'	3ea
Vacuum pump exhaust hose	20'	4ea
Helium exhaust hose	80' and 20'	1ea
RGA electronics/power supply	TSP TH100/911-038-P1	1ea
Stinger	5833803-101	2ea
Endevco read out	Model 136	2ea
Main Tank Vent line (long)	5833805-101	2ea
Main tank Vent line (short)	5833805-102	1ea
Guard Tank Vent line (long)	5833805-101	2ea
Liquid Helium Transfer line	5833804-101	2ea
Liquid Helium Transfer elbow	5833827-101	1ea
Vacuum Shell Pump line 10'	5833808-101	1ea
4" ISO elbow	5833808-76-1610	1ea
4" to 6" adapter	5833808-76-2510	1ea
Nitrogen supply line		2ea
Nitrogen manifold		1ea
		1ea
Fill Line Vacuum Hose		2ea
KF-40 Hoses	Various	
KF-25 Hoses	Various	
GT Regulator		1

G. PROCEDURE COMPLETION

Completed by:_____

Witnessed by:_____

Date: _____

Time:_____

Quality Manager_____**Date**_____

Payload Test Director_____**Date**_____

Cable Table 1.

Cable No.	Dewar/Probe Connection	Connection No	GSE Connection	Connection No.	Ft.	Comments
W-D1	Dewar P800	P1	DAS	J1/JB1	60	TM&A/Cryo-Ops/Test/Accelerometer
W-D2	Dewar P801	P2	DAS	J2/JB2	60	TM&A/Cryo-Ops/Test
W-D3	Dewar P802	P3	DAS	J3/JB3	60	Cryo-Ops/Test
W-D4	Dewar P803	P4	EM	J4/JE4	60	Cryo-Ops/Test
W-D5	Dewar P804	P5	EM	J5/JE5	60	Cryo-Ops/Test
Heater	Dewar Tophat	Tophat Htr	Htr Control	Htr1	10	Cryo-Ops
GT	GTV-VA	GTVV 1	Endevco	End 1	30	TM&A/Cryo-Ops/Test
TV	Thruster Vent	TV 1	Endevco	End 2	30	TM&A/Cryo-Ops/Test
ION	Ion Pump	IP 1	EM Minivac	MV 1	25	Cryo-Ops
W-D24	GM	TS-24	EM	J24/JE24	50	Cryo-Ops
W-D23	GM	TS-23	EM	J23	50	Cryo-Ops
W-D20	DAS	P20	EM	J20	20	Cryo-Ops/Test
W-D21	DAS	P21	EM	J21/JE21	20	Cryo-Ops/Test
W-D22	DAS	P22/JB22	EM	J22/JE22	20	Cryo-Ops/Test
Printer	DAS	Comp/Zip	Printer	Parallel	10	Cryo-Ops/Test
Plotter	DAS	HP3497A	Plotter	Parallel	20	Cryo-Ops/Test
IEEE	DAS	Computer	EM	H08D	20	Cryo-Ops/Test

H.

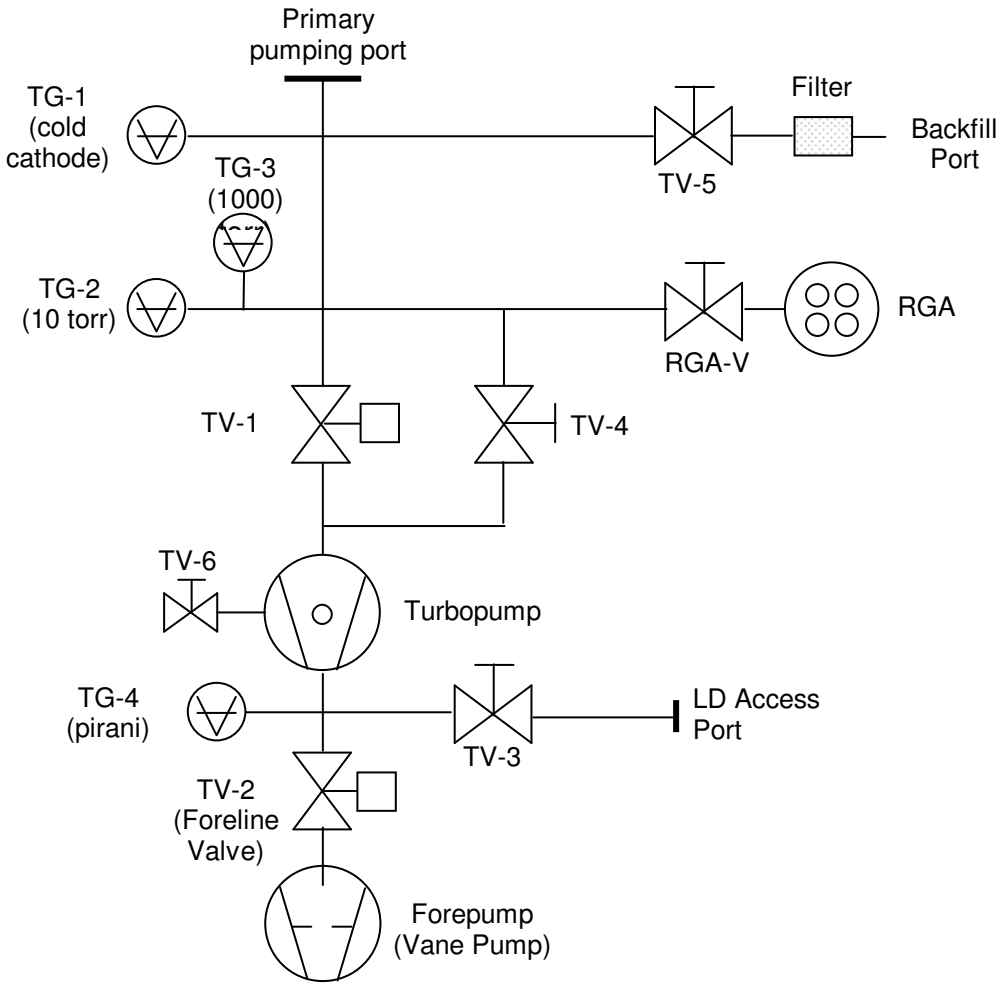

Figure 1. Schematic diagram of Utility Pumping System (UTS)

APPENDIX 1 POST OPERATIONS CHECKLIST

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.		
	2. Verify all critical items in the test are identified and discussed with the test team.		
	3. Verify all required materials and tools are available in the test area.		
	4. Verify all hazardous materials involved in the test are identified to the test team.		
	5. Verify all hazardous steps to be performed are identified to the test team.		
	6. Verify each team member is certified for the task being performed and knows their 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. Perform Engineering/Safety high-bay walk down. Ensure all discrepancies are corrected prior to start of operation.		
	11. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: _____		

I. APPENDIX 2 PRE OPERATIONS CHECKLIST

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

J. APPENDIX 3– CONTINGENCY/EMERGENCY RESPONSES

Condition	Circumstance	Response
Power Failure	Anytime	Wait for power restoration, and resume procedure
Burst disk rupture (MT/GT)	Anytime	Evacuate room
Oxygen monitor alarm	Anytime	Evacuate room
Liquid Nitrogen Spill	Anytime	Clear area until all liquid has evaporated