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GRAVITY PROBE B, RELATIVITY GYROSCOPE EXPERIMENT
STANFORD, CALIFORNIA 94305-4085

GDS OPERATING PROCEDURE AT VAFB

To be performed at Vandenberg Air Force Base
To be performed in Building 1610

THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

P0960 Rev B

5 February, 2004

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APPROVED	D. Ross, Quality Assurance	Date
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REVISION HISTORY

Rev	Date	Comments
-	03/06/03	
A	07/23/03	Section G.2 edited to include replacing BIP Helium cylinders. Lines G.2.3 to G.2.30 added. (ECO #1432)
B	01/06/04	Minor changes made in several operations sections to conform with d-log notations made in prior as-runs. (Primarily incorporation of running torque values, flexibility in some time-consuming evacuation processes, and accommodations for GSE set-up changes required by varying space vehicle configurations.) Change to fill operation to accommodate “topping off”. (ECO #1466)

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List of Abbreviations and Acronyms

AP	Air Products	LM	Lockheed Martin
AVA	Access Valve Assembly	lpm	Liters per Minute
BIP	Built in Purifier	MEOP	Maximum Expected Operating Pressure
CCW	Counter clockwise	psi	pounds per square inch
CW	Clockwise	psia	pounds per square inch absolute
ECU	Electronic Control Unit	psig	pounds per square inch gauge
ESD	Electro Static Discharge	ONR	Office of Naval Research
F&D	Fill and Drain	QA	Quality Assurance
GDS	Gas Delivery System	scfm	Standard Cubic Feet per Minute
GMA	Gas Management Assembly	SU	Stanford University
GP-B	Gravity Probe B	VAFB	Vandenberg Air Force Base
He	Helium		

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 procedure defines how to operate the GDS for use with flight and flight-like GMA. It will cover the setting of pressures, valve operations for filling external systems and gas sample checks. The minimum static GMA tank pressure shall be 300 psia and a maximum static pressure of 2000 psia.

Each section of this procedure can be run independently but must be preceded by the completion of section **G.2**. Each section can be run multiple times depending on requirements.

All precautions will be made to insure that the GDS and GMA gas paths stay as clean as possible. Upon completion of this operation, the GMA will be "locked up" with all valves closed and ready to go to launch state. The hazardous operation contained in this procedure is the handling of medium pressure Helium gas to service the GMA. This procedure is a revision of P0886, which was used at LM and SU. The revision incorporates requirements for VAFB.

B SAFETY

General

The GDS has multiple gas pressure vessels. Under normal operations, the GDS requires no safety measures or equipment beyond those required for the use of a supply gas cylinder. Personnel Protective Equipment (PPE) will be worn during hazardous operations as required by location. The GDS is a medium-pressure gas delivery system - supply bottle pressure is a maximum 2640 psig. When any of the system is pressurized and connected to the vacuum system and/or leak detector, be cautious not to vent higher pressure through the pumping portions of either system. Only allow higher pressure to vent through approved ports (such as CV-1) and make sure that these are open at time of venting. The table below defines the pressure limits for each zone of the GDS.

GDS Operating Pressure Limitations (psig)

Zone	System MEOP	Rated MEOP	Relief Pressure	Proof Pressure
Red	2640	3500	3775	3960
Orange	2000	3000	2200/3300	3000
Yellow	300	650	330	450
Green	300	1000	330	450
Blue	<10	150	<10	N/A

Note: Observe caution with pressure units, psia and psig. (psia = psig+ 14.7)

Mishap Notification

Injury

In case of any injury or illness requiring medical treatment - Dial 911

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.

Contingency Response

Responses to contingencies/emergency (e.g., power failure) are listed in Section **G.13**.

C QUALITY ASSURANCE

QA Notification

This operation will be conducted on a formal basis to approved and released procedures. **The QA program office and NASA program and NASA Safety representative 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.

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 TD or QA Representative, experiment functionality may be affected. Within hazardous portions of this procedure, all steps shall be worked in sequence. Out-of-sequence work or redlines shall be approved by NASA Safety prior to their performance.

DISCREPANCIES

Discrepancies will be recorded in a D-log or as a DR per Quality Plan P0108.

D TEST PERSONNEL

Personnel Responsibilities

The Test Director shall be Ken Bower or an alternate that he shall designate. The person performing the operations (Test Director or Test Engineer) has overall responsibility for the implementation of this procedure and shall sign off the completed procedure and relevant sections within it

Personnel Qualifications

The Test Director must have a detailed understanding of all procedures and experience in all of the GMA operations. The Test Director shall designate a Test Engineer as required.

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
NASA Safety Rep	1	SFAO or ANALEX

E REQUIREMENTS

Electrostatic Discharge Requirements

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

Lifting Operation Requirements

N/A

Hardware/Software Requirements

- GDS
- Flight ECU
- Research Grade (certified 99.9999%) Helium Supply: four bottles (minimum fill: two>2200psig, two>1000psig) on the GDS cart and one (>1000psig) for purge gas supply.
- GMA physically mounted to Space Vehicle (per LMMS INT-334)
- Outlet Manifold Hardware to connect Space Vehicle Fill and Drain valves to purge gas system
- Fill Manifold Hardware to connect GMA to GDS
- Vent Manifold Hardware to connect vacuum source to the GMA vent port.
- Mensor High Resolution Pressure Transducers attached to manifold
  500 psia digital pressure sensor
  Calibration Date: _____ S/N: _____ Model #: _____
  3500psia digital pressure sensor
  Calibration Date: _____S/N: _____ Model #: _____
- Leak detector, Alcatel (or alternate), internally calibrated
- Hand held particle counter (sensitive to 0.50 microns or better)
  Calibration Date: _____ S/N: _____ Model #: _____
- Torque Wrench
  Calibration Date: _____ S/N: _____ Model #: _____
- Clean room bags and tape
- Alcatel Dry Pump / Turbo Pump Cart (or equivalent)
- Flight Conical Seals: part #C33934-004

Instrument Pretest Requirements

All GMA instrumentation used in taking data shall be “in calibration” at time of test.

Configuration Requirements

- GMA is physically mounted and electrically grounded on the Space Vehicle.
- GDS has passed the Acceptance Test (P0917) and ‘Initial Gas Purity Tests’ (99.9995% He) (P0917 section G.7)
- The GMA Fill & Drain Valves are closed and capped.
- The GMA outlet ports are connected to the Space Vehicle Lower Supply lines.
- The Space Vehicle is oriented such that the GMA and Fill & Drain Valves are accessible by personnel and capable of being enclosed within a downflow hood.
- If the optional portions of Section G.5 are to be completed then the outlet manifold shall be installed per **figure 1**.

Optional Non-flight Configurations

N/A

Verification/ Success Criteria

Individual quantities should be able to be within tolerances set out in individual procedure sections.

Constraints and Restrictions

N/A

F REFERENCE DOCUMENTS

Drawings

Drawing No.	Title
STN-103-ASM	GDS Drawing – Advanced Micropolish Inc (AMI)
26278	GDS Schematic, GP-B Dwg.
26273	GMA Schematic, GP-B Dwg

Supporting Documentation

Document No.	Title
SU/GP-B P0108	Quality Plan
SU/GP-B P059	GP-B Contamination Control Plan
LM/P479945	Missile System Prelaunch Safety Package
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

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
Various	ECU operations as applicable

G OPERATIONS

Verify Appropriate QA Notification

QA Notified: _____ (Date & Time)

NASA Program and Safety Representative Notified: _____ (Date & Time)

Setup of GDS

Started on: _____

Complete Pre-Test Checklist (Section **G.11**)

Verify pressure relief systems are installed and all associated cutoff valves (V-21, V-23, RV-1 and RV-3) are open.

Verify GDS supply cylinders have sufficient Helium to complete required operations. (Minimum of two full Air Products (AP) BIP's 2640 psig cylinders are required to fill the GMA to 2000psia) Optionally, to replace any supply bottle(s) complete steps **G.2.4** to **G.2.30** else go to step **G.2.31**.

As available, record pressures of supply cylinders here:

#1: _____ #2: _____ #3: _____ #4: _____

Verify that all GDS valves (except those noted in **G.2.2**) and He supply valves are closed and all GDS ports are sealed.

Verify GDS outriggers are extended and the cart is stable.

Warning:
Hazardous operations are about to begin, these operations involve working with medium-pressure helium. Use standard practices for handling of medium-pressure gas. (500 to 3000 psi per EWR 127-1)

All personnel involved in hazardous task are certified, equipped, briefed, and ready to proceed. Test Director or Safety_____

Request the area operation light be changed to Amber

Establish a 10 foot diameter controlled area.

Request a PA announcement that a hazardous task is about to begin.

Ensure all nonessential personnel are clear of controlled area.

If there is any trapped residual pressure (PI-1, PI-2, PI-3 and/or PI-4 > 150 psig) than vent pressure through CV-1 by doing the following: Open appropriate GDS supply valve (V-1, V-2, V-3 and/or V-4). Set PR-1 and PR-2 (CW to open) to minimum flows. Open valves V-6, V-8, V-13 and V-26. Crack open valve V-29 (CCW to open) and slowly release pressure to a nominal 10 psig. Close valves V-1, V-2, V-3, V-4, V-6, V-8, V-13, V-26 and V-29.

Note: Remove supply cylinders and replace one bottle at a time. Cylinder replacement can be completed in any order. Only use Air Products BIP Helium cylinders with gas purity certification.

Remove cylinder top cage hardware as required then disconnect bottle at CGA 680 fitting.

Remove cylinder restraint then remove cylinder from GDS cart.

Transfer cap from new cylinder to old cylinder.

Install replacement cylinder on GDS cart and attach cylinder restraint.

Visually verify no excessive particles on connection surfaces then connect to the GDS using CGA 680 fitting.

Replace additional bottles as required by repeating steps **G.2.12** to **G.2.16**.

Install top cage hardware as required. Note cylinder(s) replaced.

#1 _____ #2 _____ #3_____ #4 _____

Start GDS vacuum pump, open GDS valves V-7 and V-10, and start evacuation. If desired, evacuation may be performed in sections and iteratively.

Individually, open GDS supply valves (V-1, V-2, V-3 and/or V-4) that correspond to the supply cylinders that were replaced. Open valves slowly to avoid overloading vacuum pump.

Verify the GDS is under vacuum (< 5x10^-3 torr @ VT-1).

Close GDS valves V-1, V-2, V-3, V-4, V-7 and V-10. Turn off GDS vacuum pump if desired.

Open the supply valves on the cylinders that were replaced then close all cylinder supply valves.

Vent pressure through CV-1 by doing the following: Set PR-1 and PR-2 (CW to open) to minimum flows. Open GDS valves V-1, V-2, V-3 and/or V-4 as required. Open GDS valves V-6, V-8, V-13 and V-26. Crack open valve V-29 (CCW to open) and slowly release pressure then close valve V-29.

NOTE:

THIS HAZARDOUS OPERATION IS NOW COMPLETE.

Request PA announcement that hazardous operations are now complete.

Ensure area warning light is returned to green.

Disband controlled area.

Start GDS vacuum pump, open GDS valves V-7 and V-10 and start evacuation. If desired, evacuation may be performed in sections and iteratively.

Verify the GDS is under vacuum (< 5x10^-3 torr @ VT-1).

Close valves V-7 and V-10 then turn off GDS vacuum pump if desired.

NOTE:

A gas purity sample may now be completed (see Section **G.4**) at the discretion of the test director.

Verify that all GDS valves (except those noted in **G2.2**) and He supply valves are closed and all GDS ports are sealed. Open the GDS sample bottle valves. The sample bottle valves remain open at all times unless stated otherwise.

Verify that the GDS is at a positive pressure of Helium or under vacuum. Record PT-2_____ PT-3 _____

Verify the flight ECU is connected to the GMA and start ECU.

Start Null Script software to control the GMA solenoid valves. The GMA valves will then be in “launch”, “sleep”, or “unchanged” configuration, determined by the Test Director. Record configuration here: _____ (If “unchanged” Is the configuration chosen, attach a configuration description). Make note of all problems in a Discrepancy Log.

Record starting pressure of He supply bottles. (Prior measurements may be recorded here. Open bottles if necessary, then close one at a time.):

#1 _____ #2 _____ #3_____ #4 _____

Note: The following steps must be completed only if hazardous operations are planned immediately following this section. (G.4, G.5, or G.6)

All personnel involved in hazardous task are certified, equipped, briefed, and ready to proceed. Test Director or Safety_____

Request the area operation light be changed to Amber

Establish a 10 foot diameter controlled area.

Request a PA announcement that a hazardous task is about to begin.

Ensure all nonessential personnel are clear of controlled area.

Particle and Leak Check of GDS Manifold to GMA

Started on**: _____**

Note:
Mark off each step of this section as it is completed. Complete section G.2 before starting this section. This is a low pressure, non-hazardous operation.

Position the downflow hood over GMA.

Set up hand held particle counter near the outlet of GMA MV1. Take five one-minute samples. Average number of 0.5 micron or greater particles should be less than 5 per cubic foot.

Samples @ MV1 Valve: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

Sample size: _____ Average particles per cubic foot: ____

Set up hand held particle counter near the outlet of GMA MV2. Take five one-minute samples. Average number of 0.5 micron or greater particles should be less than 5 per cubic foot.

Samples @ MV2: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

Sample size: _____ Average particles per cubic foot: ____

If any of the above particle count averages exceed 5, attempt to readjust the downflow hood arrangement and repeat the measurements as necessary. At the discretion of the Test Director with QA representative concurrence, the average count tolerance may be increased to a maximum of 100, provided that the counts of other measurable particle sizes do not exceed the standards of class 100 air (0.2 micron<750, 0.3 micron<300, 5.0 micron=0).

QA _____

Open one He supply bottle (bottle #_____), the corresponding GDS supply valve (V-1, V-2, V-3 or V-4) and V-6. **(Fig. 2)**

Open GDS valves V-13, V-14, V-17, and V-24. Set GDS pressure regulator PR-1 to a low-pressure (<150 psig) then open valve V-8. Uncap high-pressure outlet on GDS. Adjust PR-1 to set flow between 5-10 lpm (about 0.25 scfm).

Connect high-pressure manifold hardware to GDS high-pressure outlet. **(Fig. 1)**

Close GDS valve V-24 and open valve V-25. Set GDS pressure regulator PR-2 to a low-pressure (<150 psig) then open valve V-26. Uncap low-pressure outlet on GDS. Adjust PR-2 to set flow between 5-10 lpm (about 0.25 scfm).

Connect low-pressure manifold hardware to GDS low-pressure outlet.

Close GDS valve V-25.

Open valve V-24. Fashion a clean room bag into an air trap with small openings at either end.

Affix the clean room bag to the high-pressure outlet of the manifold. The He gas should slightly inflate the air trap.

Insert particle counter inlet loosely into other end of bag.

Allow gas to flow for at least 1 minutes to purge line.

Take five one-minute samples. Average number of 0.5 micron or greater particles shall be less than 10 per cubic foot. Samples @ MV1) : #1 __ #2 __ #3 __ #4__ #5 __

Remove particle counter and gas trap but do not shut off the gas flow.

Initial here to verify test pass for the high-pressure outlet _____.

Open GDS valve V-25 and repeat steps **G.3.7** to **G3.12** for the low-pressure outlets.

Samples - @ MV2): #1 __ #2 __ #3 __ #4__ #5 __ ; @MV3 :#1 __ #2 __ #3 __ #4__ #5 __ ; @ MV4 : #1 __ #2 __ #3 __ #4__ #5 __

Option: If there is insufficient flow, close valve V-24 during low-pressure outlet particle check.

Initial here to verify test pass for the three low-pressure outlets _____.

Uncap GMA valves MV1, MV2, MV3 and MV4 then bag, tag and store caps as flight hardware. Connect low and high-pressure fill manifolds to GMA per **Fig. 1**. Use a conical seal in each connection (part #C33934-004). Verify that positive flow is maintained during mating. (Open valve V-24 if required).

Connections torqued to 120 ± 10 in-lbs and recorded in valve cycle log sheet. If running torque is greater than "finger loose" (~5 in-lbs), then measure and add running torque.

TORQUE @: MV1_____, MV2_____, MV3 _____, MV4_____

QUALITY_____

Vent pressure through CV-1 by doing the following: Close GDS supply valve (V-1, V-2, V-3 or V-4) or the supply bottle valve(s). Set PR-1 and PR-2 (CW to open) to minimum flows. Crack open valve V-29 (CCW to open) and slowly release pressure to a nominal 10 psig. Close valve V-29.

Connect leak detector to the GDS RGA connection. Ensure the leak detector has been tuned and calibrated. Calibration Date _____ Calibration Value _____

Start leak detector. Open GDS valves V-9, V-10 and V-11. Wait for the GDS pump to evacuate the GDS (<5x10^-3 torr @ VT-1). (If desired, evacuation may be performed in sections and iteratively.) Close GDS valves V-8, V-10, V-13 and V-26 then open GDS valve V-22. Verify that all GDS pressure sensors read 0 psia once leak detector goes into test mode. Record background leak rate _____.

Using a small flow from the leak test supply bottle, spray helium around the GDS to GMA manifold hardware. Watch for leak rate spikes that would indicate leaks.

Fix any leaks that are found and repeat step **G.3.28** as necessary. Record any discrepancies in a discrepancy log.

Close GDS valves V-9, V-11, V-14, V-15, V-16, V-17, V-22, V-23, V-24 and V-25. Shut down and /or disconnect leak detector if desired.

Record the completion of leak test on line **1** of Section **G.9**. QUALITY_____

GMA Gas Fill Preparations (Gas Purity Test)

Started on: _____

Note: Mark off each step of this section as it is completed.
Warning:
Hazardous operations are about to begin, these operations involve working with medium-pressure helium. Use standard practices for handling of medium-pressure gas. (500 to 3000 psi per EWR 127-1).

Verify section G.2 is complete (including steps 36-40, required for initiating a hazardous operation).

Open GDS valves V-8, V-13, V-14, V-15, V-16, V-17, V-21, V-23, V-24, V-25 and V-26.

Verify that GDS pressure sensors PT-2 and PT-3 all are <10 psig. Start GDS vacuum pump, open valves V-9, V-10 and V-11 and evacuate GDS. If desired, evacuation may be performed in sections and iteratively.

Verify that GDS and supply manifold are under vacuum (< 5x10^-3 torr @ VT-1) before pressurizing.

Close GDS valves V-8, V-9, V-10, V-11, V-13 and V-26.

Open one He supply bottle (bottle #_____), the corresponding GDS supply valve (V-1, V-2, V-3 or V-4) and V-6.

Set regulator PR-1 to ≥700 psig but ≤ 2000 psia. Crack open valve V-8 to allow the pressure to rise slowly.

Close the valves on a GDS sample bottle.

Close the helium supply bottle and/or the corresponding GDS valve (V-1, V-2, V-3 or V-4).

Vent pressure through CV-1 by doing the following: Open GDS valve V-13. Set PR-1 and PR-2 (CW to open) to minimum flows. Open valve V-26. Crack open valve V-29 (CCW to open) and slowly release pressure then close valve V-29.

Close GDS valves V-8, V-13, V-14, V-15, V-16, V-17, V-24, V-25 and V-26 then lock GDS valves V-15 and V-16. Remove filled GDS sample bottle, cap the ends of the bottle and ports. Send sample to vendor for analysis. (If gas sample does not require vendor analysis, do not remove.) Turn off GDS vacuum pump if desired.

Section G.4. Complete **QUALITY**_____

NOTE:
THIS HAZARDOUS OPERATION IS NOW COMPLETE.

Request PA announcement that hazardous operations are now complete.

Ensure area warning light is returned to green.

Disband controlled area.

Note:
If any configuration of the GDS manifold has been opened to atmosphere or Helium Supply bottles have been changed, sample results must be verified by a qualified gas analysis vendor before proceeding. Helium gas composite shall be 99.9995% or better.

GMA Regulator Lock-Up

Started on: _____

Note:
Mark off each step of this section as it is completed. If a step is N/A draw a line through it.

Note:
If appropriate GSE is available, measurements taken with GSE sensors may be substituted for flight sensors referenced in this section. If such substitution is made, record the designation of the substituted sensor(s) in the body of the procedure (no d-log is required).

Warning:
Hazardous operations are about to begin, these operations involve working with medium-pressure helium. Use standard practices for handling of medium-pressure gas. (500 to 3000 psi per EWR 127-1).

Verify section G.2 is complete (including steps 36-40, required for initiating a hazardous operation), the ECU is ready and the GMA valves are in a launch configuration or all closed (except V27 and V29 if vent manifold is installed).

Measure GMA system pressures and record values in Section **G.10.**

Verify all GDS valves and regulators are closed, except the relief cutoff valves (V-21, V-23, RV-1 and RV-3, see **Figure #2)**.

Position the downflow hood over GMA.

Set up hand held particle counter near the outlet of the GMA Vent Port. Take five one-minute samples. Average number of 0.5 micron or greater particles should be less than 5 per cubic foot.

Samples @ Vent Port : #1 ___ #2 ___ #3 ___ #4___ #5 ___.

Sample size: _____ Average particles per cubic foot: ____

Set up hand held particle counter near the mounting point of the outlet manifold (on the S/V tilt ring). Take five one-minute samples. Average number of 0.5 micron or greater particles should be less than 5 per cubic foot.

Samples @ tilt ring: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

Sample size: _____ Average particles per cubic foot: ____

If any of the above particle count averages exceed 5, attempt to readjust the downflow hood arrangement and repeat the measurements as necessary. At the discretion of the Test Director with QA representative concurrence, the average count tolerance may be increased to a maximum of 100, provided that the counts of other measurable particle sizes do not exceed the standards of class100 air (0.2 micron<750, 0.3 micron<300, 5.0 micron=0).

QA _____

Connect the vacuum source and vent manifold to the GMA non-propulsive vent port (or AVA outlet, if installed). Evacuate vent manifold (< 5x10-3 torr) then close OM Vent valves **(Figure #1)**.

If GMA Zones II, III, IV and V **(Figure #3)** are all at a vacuum (< 5x10^-3 torr) then go to step **G.5.18**.

If GMA Zones II, III, IV or V is > 50 psig then the pressure must be vented by doing the following: Enter ECU command to open GMA valves V3, V4, V5, V6, V27 and V29. Open OM Vent Valves 2 and 3 then vent until GMA pressure is <50 psig. Close OM Vent Valve 2. Otherwise continue to next step.

Turn on vacuum source and then open valve OM Vent valve 1 to evacuate vent manifold.

Close OM Vent Valve 1. Turn off vacuum source if desired.

Enter ECU command to close GMA valves V3, V4, V5, V6, V27 and V29.

Record all GMA pressure sensors and enter values in Section **G.10.**

If GMA sensor GP1 indicates < 270 psia then go to step **G.5.27.**

If GMA sensor GP1 indicates 300 psia ($\pm$ 30) then go to step **G.5.36.**

If GMA sensor GP1 indicates $\geq$ 330 psia then continue.

Enter ECU command to open GMA valves V1, V2, V3, V4, V5, V6, V27 and V29; then enter ECU command to close GMA valves V1 and V2.

Open OM Vent1 and/or OM Vent 2 and slowly bleed gas until desired pressure is obtained at GP2 and GP3 then close OM Vent Valve 1 and/or OM Vent 2. If pressure drops below 270 psia, repeat steps G5.14 to G5.23

Enter ECU command to close GMA valves V3, V4, V5, V6, V27 and V29.

Record all GMA pressure sensors and enter values in Section **G.10.**

Go to step **G.5.37.**

If the GDS is at a positive pressure (> 20 psig) then it must be vented through CV-1 by doing the following: Verify GDS valve V-6 is closed. Open GDS valves V-8, V-13 and V-26. Set PR-1 and PR-2 (CW to open) to minimum flows. Crack open valve V-29 (CCW to open) and slowly release pressure. Close GDS valve V-29.

Start GDS vacuum pump, open GDS valves V-9, V-10 and V-11 and evacuate GDS. If desired, evacuation may be performed in sections and iteratively.

Open GDS valves V-24 and V-25.

Verify the GDS and supply manifold are under vacuum (< 5x10^-3 torr @VT-1).

Close GDS valves V-8, V-9, V-10, V-11, V-13 and V-25.

Open one He supply bottle (bottle #_____), the corresponding GDS supply valve (V-1, V-2, V-3 or V-4) and V-6. Set regulator PR-1 to 300 psia (285 psig). Crack open valve V-8 and allow the pressure to rise slowly.

Slowly open GMA valves MV1 (record in valve cycle log sheet) and enter ECU command to open GMA valves V1 and V2. There might be some settling time required (15 minutes) before verification of the final pressure.

Enter ECU command to close GMA valves V1 and V2.

Close GMA valve MV1 (Torqued to 40 ± 5 in-lbs. over running torque and recorded in valve cycle log sheet) and GDS valve V-24.

Running torque: _____ TORQUE: _____ QUALITY: _____

Record all GMA pressure sensors and enter values in Section **G.10.**

On lines **2** and **3** of Section **G.9** record completion of gas fill and final pressures

If the GDS is at a positive pressure (> 20 psig) then it must be vented through CV-1 by doing the following: Verify GDS valve V-6 is closed. Open GDS valves V-8, V-13 and V-26. Set PR-1 and PR-2 (CW to open) to minimum flows. Crack open GDS valve V-29 (CCW to open) and slowly release pressure. Close GDS valve V-29.

Start GDS vacuum pump, open GDS valves V-9, V-10, V-11, V-25 and V-26 (if not already open) and evacuate. If desired, evacuation may be performed in sections and iteratively.

Verify the GDS and supply manifold are under vacuum (< 5x10^-3 torr @ VT-1).

Close GDS valves V-8, V-9, V-10, V-11 and V-26.

Open one He supply bottle (bottle #_____), the corresponding GDS supply valve (V-1, V-2, V-3 or V-4) and V-6. Open GDS valve V-6 and set regulator PR-1 to 500 psig and crack open valve V-8 to allow the pressure to rise slowly.

Set regulator PR-2 to 50 psig (± 10) and crack open valve V-26 and allow the pressure to rise slowly to 50 psig.

Slowly open GMA valves MV3 and MV4 (record each in valve cycle log sheet).

Increase PR-2 setting to 285 psig (300 psia) (± 30) but limit increase to ≤100 psi/minute. Verify final pressure with the Mensor.

Close GMA valves MV3 and MV4 (Torqued to 40 ± 5 in-lbs. over running torque and recorded in valve cycle log sheet).

Running torque: _____ TORQUE: _____ QUALITY: _____

On lines **4** and **5** of Section **G.9** record completion of gas fill and final pressures. Record all GMA pressure sensors and enter values in Section **G.10.**

Vent pressure through CV-1 by doing the following: Close GDS valve V-6. Set PR-1 and PR-2 (CW to open) to minimum flows. Crack open valve V-29 (CCW to open) and slowly release pressure. Close GDS valve V-29.

Open GDS valves V-9, V-10 and V-11 and evacuate GDS. If desired, evacuation may be performed in sections and iteratively.

Verify the GDS and supply manifold are under vacuum (< 5x10^-3 torr @ VT-1) before pressurizing.

Close GDS valves V-8, V-9, V-10, V-11 and V-26.

Open GDS valve V-6 and set regulator PR-1 to 500 psig and crack open valve V-8 to allow the pressure to rise slowly.

Set regulator PR-2 to 50 psig and crack open valve V-26 and allow the pressure to rise slowly to 50 psig.

Open GMA valve MV2 (record in valve cycle log sheet).

Enter ECU command to open GMA valves V3, V4, V5 and V6.

Increase PR-2 setting to 285 psig (300 psia) (± 30) but limit increase to <100 psi/minute. Verify final pressure with the Mensor.

Enter ECU command to close GMA valves V3, V4, V5, V6 and close the GMA valve MV2 (Torqued to 40 ±5 in-lbs and recorded in valve cycle log sheet).

Running torque: _____ TORQUE: _____ QUALITY: _____

On lines **12** to **14** of Section **G.9** record completion of gas fill and final pressures.
QUALITY_____

Record all GMA pressure sensors and enter values in Section **G.10.**

Vent pressure through CV-1 by doing the following: Close GDS valve V-6. Set PR-1 and PR-2 (CW to open) to minimum flows. Crack open valve V-29 (CCW to open) and slowly release pressure. Close GDS valve V-29.

NOTE

THE HAZARDOUS OPERATION OF THIS SECTION IS NOW COMPLETE.

Request PA announcement that hazardous operations are now complete.

Ensure area warning light is returned to green.

Disband controlled area.

Note:

The following procedures (G.5.62 to G.5.68) are optional depending if GMA Zone V requires evacuation.

Enter ECU command to open GMA valves V27 and V29.

Slowly open OM Vent 2 and/or OM Vent1 to release the pressure in Zone V. Close OM Vent 2 and /or OM Vent1.

Turn on Alcatel Turbo Pump and then open valve OM Vent 1.

Verify the GMA Zone V is under vacuum (read GMA sensor GP6).

Enter ECU command to close GMA valves V27 and V29 and close OM Vent 1.

On line **14** of Section **G.9** record completion of gas fill and final pressures.

Record all GMA pressure sensors and enter values in Section **G.10.**

Note:

The following procedures (G.5.69 to G.5.100) are optional depending if GMA Zone VI requires evacuation

Verify Top Hat Valves on Space Vehicle are closed**.**

Prepare an assembly as shown in Figure 1 (including vacuum and Helium sources) for the Outlet Manifold.

Prepare an assembly as shown in Figure 1 (including Leak Check device) for the Outlet Manifold leak check port.

Assemble the lines prepared above with the Outlet Manifold and manifold valves and secure in position near the F&D valves.

Establish a flow from the helium supply through the Outlet Manifold sufficient for particle counting.

Fashion a clean room bag into an air trap with small openings at either end.

Affix the clean room bag to the outlets of the Outlet Manifold. Gas should slightly inflate the air trap.

Insert particle counter inlet loosely into other end of bag.

Allow gas to flow for at least 1 minute to purge line.

Take five one-minute samples. Average number of 0.5 micron or greater particles should be less than 10 per cubic foot.

Samples @ Outlet Manifold: #1 ___ #2 ___ #3 ___ #4___ #5 ___

Remove particle counter and gas trap and do not shut off the gas flow.

Initial here to verify particle test pass for the Outlet Manifold _____

Verify F&D Valves (F&DS2, F&DS1, F&DS3, F&DS4, and F&DP1A) are closed (40 +/-5 in.lbs.).

Wrench used_____

F&DS2 running torque: _____ torque QA _____

F&DS1 running torque: _____ torque QA _____

F&DS3 running torque: _____ torque QA _____

F&DS4 running torque: _____ torque QA _____

F&DP1A running torque: _____ torque QA _____

Remove, identify, and secure (clean bag, label, and store) caps from F&DS2, F&DS1, F&DS3, F&DS4, and F&DP1A as flight hardware and log as necessary.

Connect Outlet Manifold to F&D Valves using conical seals (part #C33934-004). Verify that positive flow is maintained during mating. (Adjust flow as required.)

Torque AN fittings on F&D Manifold (120 +/-10 in.lbs.) and log as required.

Wrench used_____

F&DS2 cap torque QA _____

F&DS1 cap torque QA _____

F&DS3 cap torque QA _____

F&DS4 cap torque QA _____

F&DP1A cap torque QA _____

Provide strain relief to the F&D Manifold and associated lines by installing supporting bracketing, clamps, or ties as desired. Use care to route and secure plumbing lines to minimize hazard to personnel and equipment.

Shut off Helium supply and evacuate Outlet Manifold and lines with Vacuum source and/or Leak Detector (start leak detector).

Using a small flow from a supplemental external Helium supply, spray helium around the Outlet Manifold hardware. Watch for leak rate spikes that would indicate leaks.

Fix any leaks that are found and repeat step G.5.88 as necessary.

Initial here to verify test pass for the Outlet Manifold hookup and leak check _____.

Use Helium supply and vacuum source to evacuate and purge F&D Manifold and lines as desired. (# of cycles TBD by Test Director – typically 3 evacuation/purge cycles and 1 overnight evacuation.)

Close OM-Purge and start vacuum source connected to Outlet Manifold.

Open F&D valves S1, S2, S3, S4, P1A and log as required. Open OM valves 1, 2, 3, 4 and P1A.

Enter ECU command to close GMA valves V7, V8, V11, V12, V15, V16, V19, V20, V23, and V24.

Enter ECU command to open GMA valves V9, V10, V13, V14, V17, V18, V21, V22, V25, and V26.

Evacuate GMA outlets.

Verify the GMA is under vacuum (< 5x10^-3 torr @ vacuum source)

Enter ECU command to close GMA valves V9, V10, V13, V14, V17, V18, V19, V20, V25 and V26.

On lines **6 to 11** of Section **G.9** record completion of gas fill and final pressures.

Record all GMA pressure sensors and enter values in Section **G.10**.

Note:

The following procedures (G.5.101 to G.5.109) are optional depending if GMA Zones V, VI and VII require backfilling. Verify Outlet manifold is connected. If not, complete steps G.5.69 to G.5.90.

Close OM valves 1, 2, 3, 4 and P1A.

Enter ECU command to open GMA valves V7, V8, V11, V12, V15, V16, V19, V20, V23 and V24.

Open GDS valve V-6 and set regulator PR-1 to 100 psig and crack open valve V-8 to allow the pressure to rise slowly.

Set regulator PR-2 to 20 psig (+ 5/-0) and open GDS valves V-26 and V-25.

Slowly open GMA valve MV2 (record in valve cycle log sheet).

Enter ECU command to close GMA valves V7, V8, V9, V10, V11, V12, V13, V14, V15, V16, V17, V18, V19, V20, V21, V22, V23, V24, V25 and V26.

Close GMA valve MV2 (Torqued to 40 ± 5 in-lbs and recorded in valve cycle log sheet).

Running torque: _____ TORQUE: _____ QUALITY: _____

On lines 6 to 11 and 14 of Section **G.9** record completion of gas fill and final pressures.

Record all GMA pressure sensors and enter values in Section **G.10**.

QUALITY_____

GMA Pressure Vessel Fill

Started on: _____

Note: Mark off each step of this section as it is completed.
Warning:
Hazardous operations are about to begin, these operations involve working with medium-pressure helium. Use standard practices for handling of medium-pressure gas. (500 to 3000 psi per EWR 127-1).

Verify section G.2 is complete (including steps 36-40, required for initiating a hazardous operation), the ECU is ready and the GMA valves are in a “launch” configuration or “all closed”.

Verify that GDS valves V-14, V-18, V-19, V-21, V-23 and V-24 are open.

Open one He supply bottle (bottle #_____), the corresponding GDS supply valve (V-1, V-2, V-3 or V-4) and V-6.

If the GDS is at a positive pressure (> 20 psig) then it must be vented through CV-1 by doing the following: Open GDS valves V-8 and V-26. Set PR-1 and PR-2 (CW to open) to minimum flows. Crack open valve V-29 (CCW to open) and slowly release pressure. Close GDS valve and V-29.

Open GDS valves V-9, V-10 and V-11. Evacuate GDS and supply manifold. If desired, evacuation may be performed in sections and iteratively.

Verify that GDS and supply manifold are under vacuum (< 5x10^-3 torr @ VT-1) before pressurizing.

Close GDS valve V-9, V-10, V-11 and V-21.

Note: If the GMA tank pressures are known to not equal 285 psig (± 30), the Test Director shall designate a different starting pressure. _____

Set regulator PR-1 to 285 psig (± 30) (or the different pressure noted above) and crack open valve V-8 to allow the pressure to rise slowly.

Slowly open GMA valve MV1 (record in valve cycle log sheet).

Caution: If the GMA bottle temperature increases more than 10° C, stop fill process and wait for the temperature to decrease below the 10° delta.

Increase pressure at PR-1 up to a nominal expected 2200 psig but limit increase to <100 psi/minute (Actual fill pressure to be determined by Test Director _____). There might be some settling time required (about 15 minutes) before verification of the final pressure. Verify final pressure with the Mensor.

Close GMA valve MV1 (Torqued to 40 ± 5 in-lbs and recorded in valve cycle log sheet).

Running torque: _____ TORQUE: _____ QUALITY: _____

If the fill operation is a "topping off" operation, go to step **G.6.18**. Otherwise vent pressure through GDS CV-1 by doing the following: Close GDS valve V-6. Set PR-1 and PR-2 (CW to open) to minimum flows. Open valves V-29. Crack open valve V-26 (CCW to open) and slowly release pressure. Close GDS valves V-8, V-26 and V-29.

Open valves V-9, V-10, and V-11 and evacuate GDS. If desired, evacuation may be performed in sections and iteratively.

Verify the GDS and supply manifold are under vacuum (< 5x10^-3 torr @ VT-1) before pressurizing.

Close GDS valves V-8, V-9, V-10, V-11, V-13, V-14 and V-26. Turn off GDS vacuum pump if desired. Wait period – Approval from Test Director required before continuing _____.

Slowly open GMA valve MV1 if closed (record in valve cycle log sheet if applicable) and back fill GDS sample bottle to equilibrium (approximately 1880 psia, actual final pressure to be determined by Test Director _____). Verify pressure with the 3500 psia Mensor. If pressure is greater than desired final pressure, carefully vent surplus pressure through the following sequence of GDS valves as required: V-14, V-13, PR-2 (set to <50 psig), V-26, V-29, and CV-1. Record final pressure _____.

Close GMA valve MV1 (Torqued to 40 ± 5 in-lbs and recorded in valve cycle log sheet) and GDS sample bottle valves.

Running torque: _____ TORQUE: _____ QUALITY: _____

Vent pressure through CV-1 by doing the following: Set PR-1 and PR-2 (CW to open) to minimum flows. Open valves V-13, V-14, V-17 and V-29. Crack open valve V-26 (CCW to open) and slowly release pressure. Close GDS valves V-26 and V-29.

Close and lock GDS valves V-18 and V-19.

NOTE

THE HAZARDOUS OPERATION FOR THIS SECTION IS NOW COMPLETE.

Request PA announcement that hazardous operations are now complete.

Ensure area warning light is returned to green.

Disband controlled area.

Remove sample bottle, cap the ends of the bottle and ports. Send to vendor for analysis. (If gas sample does not require vendor analysis, do not remove.)

On line **15** of Section **G.9** record completion of gas fill and final pressure.

QUALITY_____

Disconnect GDS

Started on**: _____**

Note:
Mark off each step of this section as it is completed.
This is a low pressure, non-hazardous operation.

Verify all GMA valves MV1, MV2, MV3 and MV4 are closed and torqued (Torqued to 40 ± 5 in-lbs and recorded in valve cycle log sheet).

MV1 running torque: _____ torque:_____

MV2 running torque: _____ torque:_____

MV3 running torque: _____ torque:_____

MV4 running torque: _____ torque:_____

QUALITY_____

Verify GDS valves V-6, V-13, V-14, V-17, V-21, V-23, V-24, V-25 and V-26 are open. All other GDS valves are closed.

Record the final pressure of the He supply bottles:

#1 _____ #2 _____ #3_____ #4 _____

Set regulator PR-1 and PR-2 to a low-pressure (<150 psig) then open valve V-8 to set flow between 5-10 lpm (about 0.25 scfm, enough to be felt on a bare palm).

Disconnect fill manifolds from GMA.

Cap and seal all GMA fill and drain valve ports. Use a flight conical seal in each port. (part #C33934-004). (Caps torqued to 120 ± 10 in-lbs and recorded in valve cycle log sheet)

MV1 cap running torque: _____ torque:_____

MV2 cap running torque: _____ torque:_____

MV3 cap running torque: _____ torque:_____

MV4 cap running torque: _____ torque:_____

QUALITY_____

Disconnect fill manifold from GDS as desired.

Verify that all GDS purge gas connections are capped and all relief/check valves are enabled.

Close GDS valves V-24, V-25 and V-26.

Close He supply bottle(s).

Set regulator PR-1 and PR-2 to minimum flows.

Vent GDS to 5 psig (±2 psig): Open GDS valve V-26 and crack open valve V-29 (CCW to open) and slowly release pressure to 5 psig. Close GDS valve V-29.

Close all GDS valves.

Removed any Ground Support Hardware (GSE) hardware as required.

Sign off on line 16 of Section G.9 to verify that the GDS is safe and back-filled with Helium to 5 psig

Complete Post Test Checklist. (Section **G.12**)

Diagrams

Note: Figure 1 should be altered to correctly represent variations in specific GSE setups. GSE changes may be made with Test Director approval provided that EWR-127 standards are maintained.

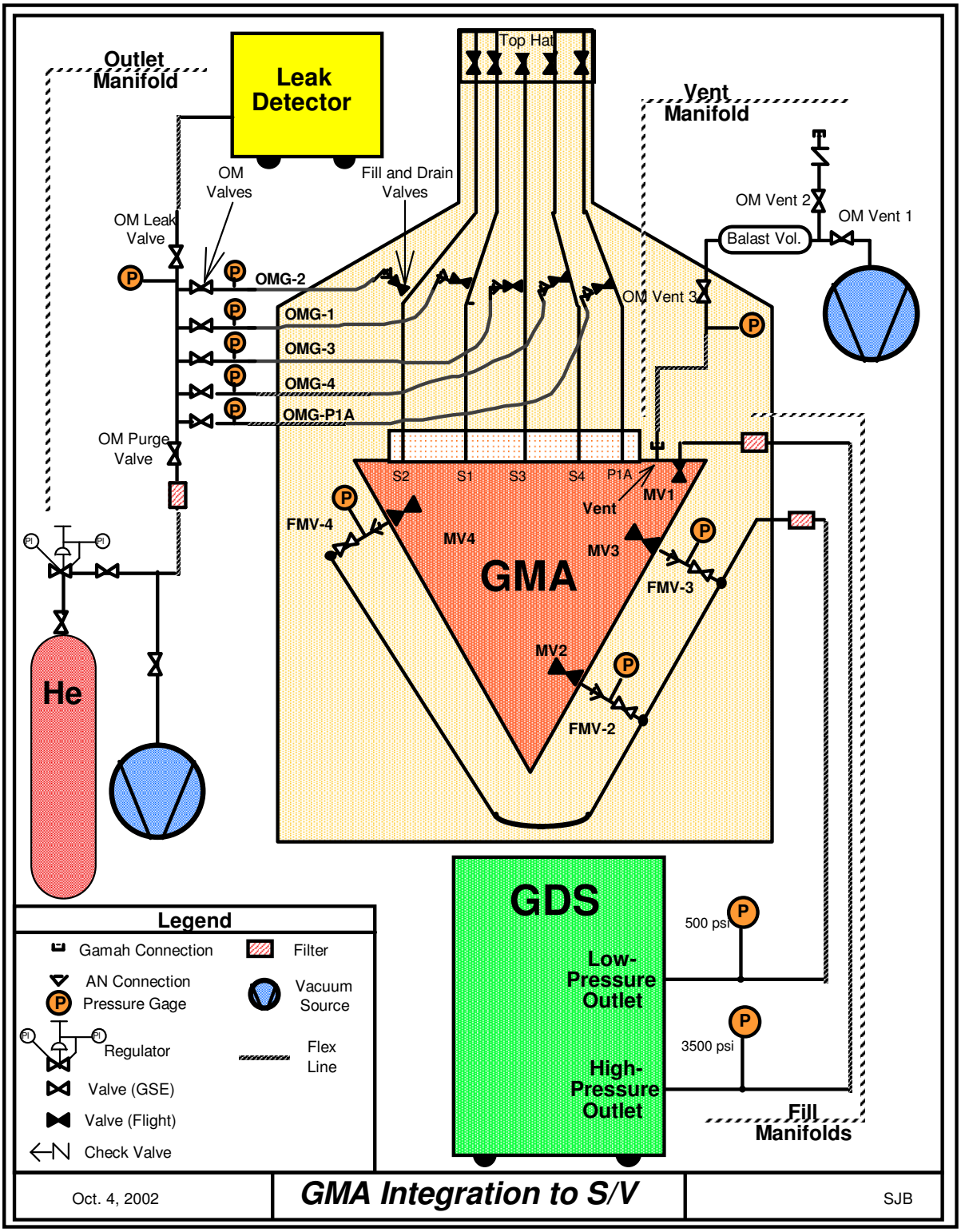


Figure 1

G.8. Diagrams

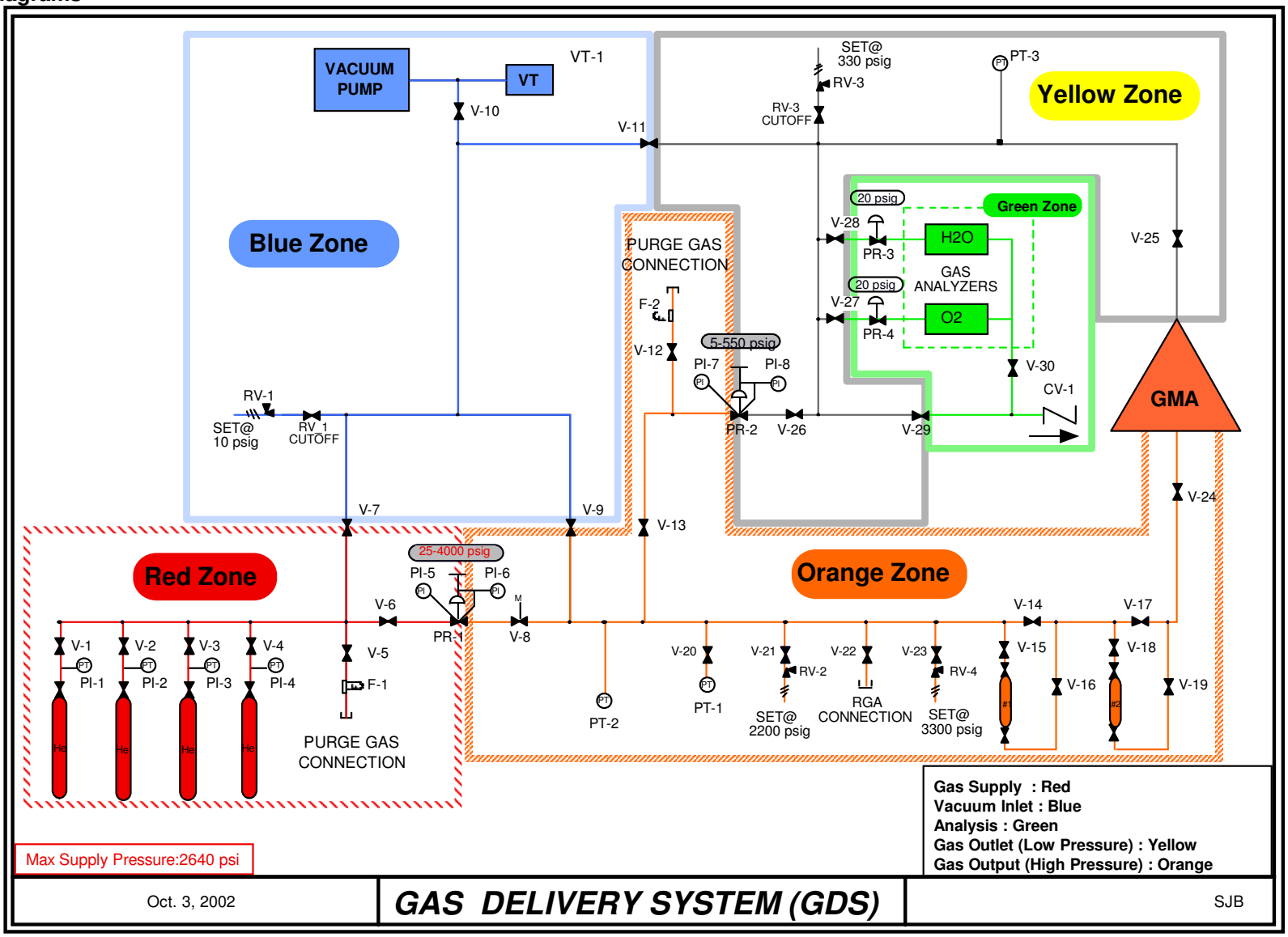
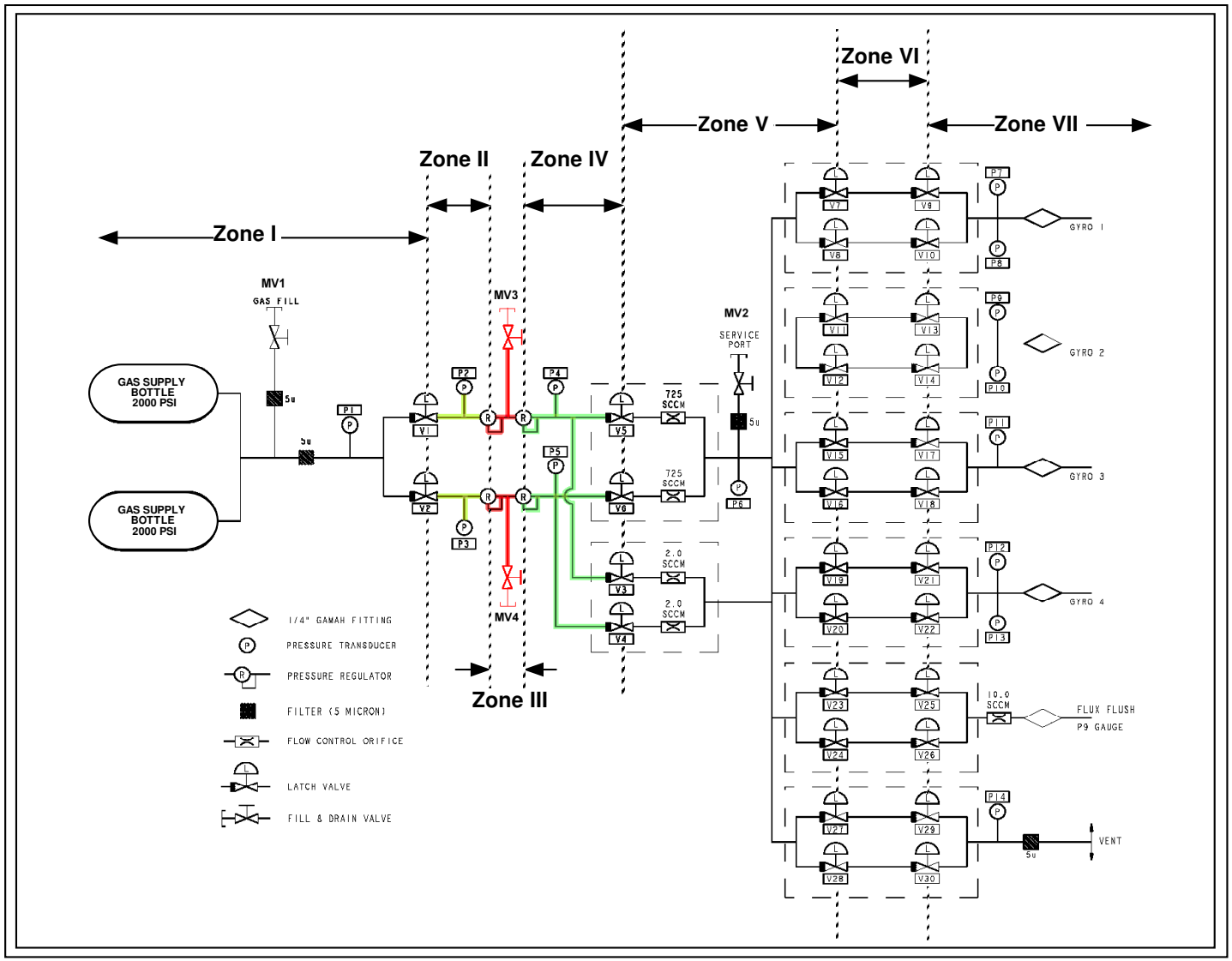


Figure 2

G.8. Diagrams



GMA Schematic
Figure 3

Procedure Completion Table

No.	Section	Task	Details	Final Pressure	Completed		QA Approval	Comments
					Date	Initial		
1	G.3	GDS leak test passed	Better than 1x10^-8 sccs external leak rate					
2	G.5	GDS fill of GMA between V1 and R1 (Zone II)	Pressure @300 psia (-0/+50psi)					
3	G.5	GDS fill of GMA between V2 and R2 (Zone II)	Pressure @300 psia (-0/+50psi)					
4	G.5	GDS fill of GMA between R1 regulators (Zone III)	Pressure @300 psia (-0/+30psi)					
5	G.5	GDS fill of GMA between R2 regulators (Zone III)	Pressure @300 psia (-0/+30psi)					
6	G.5	GDS fill of GMA between V7/V8 and S1	Pressure @0 psia					
7	G.5	GDS fill of GMA between V11/V12 and S2	Pressure @0 psia					
8	G.5	GDS fill of GMA between V15/V16 and S3	Pressure @0 psia					
9	G.5	GDS fill of GMA between V19/V20 and S4	Pressure @0 psia					
10	G.5	GDS fill of GMA between V23/V24 and Probe	Pressure @0 psia					
11	G.5	GDS fill of GMA between V27/V28 and Vent	Pressure @0 psia					
12	G.5	GDS fill of GMA between R1 andV3/V5(Zone IV)	Pressure @300 psia (-0/+30psi)					
13	G.5	GDS fill of GMA between R2 andV4/V6(Zone IV)	Pressure @300 psia (-0/+30psi)					
14	G.5	GDS fill of GMA between V3 to V6 andV9/V10, V13/ V14..etc (Zone V)	Pressure @300 psia (-0/+30psi)					
15	G.6	GDS fill of GMA between gas supply bottles and V1/V2 (Zone I)	Pressure @1880 or designated _____ psia (-0/ +100psi)					
16	G.7	GDS backfilled with Helium	To 5 psig (-0/+5psi)					

Pressure Sensor Log Table

			GMA Sensors Counts														Manifold Mensors		GDS (psig)	
Sect: Step	Date	Time	GP1	GP2	GP3	GP4	GP5	GP6	GP7	GP8	GP9	GP10	GP11	GP12	GP13	GP14	500 psia	3500 psia	PT2	PT3

Pre-Test 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 know 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. During a hazardous operation, the test will only be stopped when it is safe to do so.		
	8. Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly. During a hazardous operation, the test will only be stopped when it is safe to do so.		
	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. Verify/Perform an Engineering and Safety high-bay walk down. Ensure all discrepancies are corrected prior to start of operations.		
	11. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: _____		

Post Test 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 not required to be performed are properly identified.		
	5. If applicable sign-off test completion.		
	Team Lead Signature: _____		

Contingency/Emergency Responses

In the event of an emergency requiring shutdown and/or evacuation which does allow time for steps to be taken without endangering personnel, the following general steps should be taken, in order of priority (operator to determine sequence):

- Isolate the flight hardware wetted surfaces (fluid flow paths) from the exterior environment by closing GSE valves (GDS V-24, GDS V-25, OM Vents, OM Purge, and OM Leak, or similar, as applicable to the state of assembly.)
- Use ECU to close all GMA solenoid valves.
- Record state of GMA and related flight volumes as known (valves open/closed, current pressures, ECU status, etc.).
- Shut down GSE as desired (leak detectors, vacuum sources, ECU control systems, GDS, etc.).

In the event of a power failure, the Test Director shall implement similar steps as applicable (see above emergency shutdown steps).

In the event that these steps have been taken (in part or whole), when it safe for personnel to return to the equipment:

- The Test Director shall perform an evaluation of the current state of the hardware.
- With concurrence of the GMA Responsible Engineer and QA, the Test Director shall issue a d-log detailing the steps required to return the flight equipment to its prior state and to establish which step the procedure shall continue from. The test director may issue partial instructions (i.e. start up GSE) for the purpose of better evaluation of the flight hardware status.
- If the Test Director, Responsible Engineer, or QA believe it necessary, a discrepancy report may be issued for MRB review.

H Procedure Sign Off

The results obtained in the performance of this procedure are acceptable:

_____ date: _____
Test Director/GMA Engineer

Discrepancies if any:

Approved: _____ date: _____
C. Gray, GMA Responsible Engineer

Approved: _____ date: _____
QA Representative

Approved: _____ date: _____
D. Ross, QA