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

TESTING PROBE PRESSURE WITH THE P9 GAUGE

P0984 Rev –

25 March, 2003

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APPROVED	C. Gray, GMA REE	Date
APPROVED	D. Ross, Quality Assurance	Date
APPROVED	R. Brumley, Hardware Manager	Date

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REVISION HISTORY

Rev	Date	Comments
-	3/28/03	

A SCOPE

The purpose of this procedure is to determine the pressure of the science probe using the P9 gauge. This gauge is currently isolated from the probe. In order to open it to the probe, the GMA outlet manifold must be connected to the GMA off pallet fill and drain valves and evacuated. In the interests of time, the installation of the Vent Manifold (sections G.2 and G.3) may be omitted or postponed.

B SAFETY

B.1 Flight equipment:

The GMA is a self-contained gas delivery device and contains volumes under gas pressure. During this procedure, the configuration of the GMA will be such that the primary gas tanks are protected from impact by the GMA pallet and therefore do not present a realistic safety concern.

The GMA and the Space Vehicle are high value space flight hardware and should be handled with great care. The GMA tanks (mounted underneath the GMA pallet) are fracture critical items.

B.2 Ground Support Equipment (GSE)

The manifold lines connected to the various GMA outlets may be exposed to pressures of up to 300 psia and therefore present a minor safety concern. Purge operations typically run at around 5-20 psig, regulator bleed down releases very small volumes of <300 psig gas into large vented volumes. All of the GSE used in this procedure have pressure ratings considerably higher than the maximum expected operating pressures.

During the operation, some lines connecting equipment together will represent minor trip/snag hazards – these hazards shall be minimized by careful routing, securing, and/or marking of such lines. Only qualified personnel under the supervision of the Test Director should work directly with this equipment.

B.3 Heights:

Some functions of this procedure may be completed with the use of ladders, platforms, and/or personnel lifts. The potential for falls from such equipment represents a moderate safety concern. The use of these items shall be consistent with the normal practices of the Space Vehicle and the facility within which it is located and shall be subject to the authority and policies of facility safety personnel.

B.4 Contamination:

Care should be exercised whenever venting any gas system to atmosphere to ensure that the internal volumes of the GMA and GSE plumbing lines are only exposed to appropriate

environments. Improper venting of air into critical wetted areas can result in contamination requiring significant cleanup and verification.
These operations are expected to occur within the B156 highbay, a Class 100,000 clean room, but may occur in any similar environment. Care should be exercised during all connections to flight hardware to prevent contamination of wetted surfaces by particulates. Smocks, bonnets, and gloves (consistent with Class 10,000 practices) shall be worn whenever handling flight hardware. Full hoods, coveralls, bootcovers, and clean gloves (consistent with LMMS Class 1,000 practices) shall also be worn whenever working with flight wetted surfaces. All fluid connections shall be visually inspected by the operator making the connection.

B.5 Terms used:

In some cases, different equipment used in this procedure will have similar names. For clarity, the following are defined generally:

- Fill and Drain (or F&D) Valves – the five off-pallet and four on-pallet flight Fill and Drain valves
- Outlet Manifold – the GSE hardware connected to the off-pallet F&D Valves
- Vent Manifold – the GSE hardware connected to the Vent port of the GMA

Within this procedure, flight valves will generally be designated without hyphens (i.e. GMA V1, F&DS1, MV1) while GSE valves will be designated with hyphens (i.e. OS-1, MV-1, V-1).

B.6 Personnel Threatening Emergencies

In the event of an emergency threatening personnel health or safety, the area shall be evacuated without regard for equipment safety. Post-emergency steps shall be documented by D-log as required.

B.7 Non-Personnel Threatening Emergencies

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 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 (Use care to ensure that equipment remains safe when power is restored.

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 RE 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 from which step the procedure shall continue. 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, RE, or QA believe it necessary, a discrepancy report may be issued for MRB review.

C QUALITY ASSURANCE

C.1 QA Notification

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

C.2 Red-line Authority

Authority to redline (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.

C.3 Discrepancies

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

D TEST PERSONNEL

The Test Director shall be Ken Bower or an alternate that he shall designate. The Test Director has overall responsibility for the implementation of this procedure and shall sign off the completed procedure and relevant sections within it. Additional personnel shall be assigned and supervised by the Test Director.

E REQUIREMENTS

E.1 Electrostatic Discharge Requirements

The Space Vehicle is defined as ESD sensitive. Appropriate ESD protection must be used when handling the space vehicle *or conductive equipment connected to it*.

E.2 Lifting Operation Requirements

N/A

E.3 Hardware/Software Requirements

- GMA on Space Vehicle
- HEPA downflow hood installed over critical work area when applicable to specific sections.
- Research Grade (certified 99.9999%) Helium Supply: one (>1000psig) bottle for purge gas supply (BIP+).
- Outlet Manifold Hardware to connect to Space Vehicle F&D Valves.
- Vent Manifold Hardware to connect to GMA vent port.
- GSE mounting hardware for valves and manifolds as required.
- Leak detector, Alcatel (or alternate), internally calibrated
- Hand held particle counter (sensitive to 0.5 microns or better)
  Calibration Date: _____ S/N: _____ Model #: _____
- Various clean flex lines and fittings as required (Test Director to approve cleanliness of individual elements for specific uses)
- Alcatel Dry Pump / Turbo Pump Cart (or equivalent)
- Torque wrenches as required
  #2) Make/model _____ S/N _____ Certificate expiration _____
  #3) Make/model _____ S/N _____ Certificate expiration _____
  #4) Make/model _____ S/N _____ Certificate expiration _____
- Moog conical seal gaskets, for flight, as required
- CSTOL Script for controlling, calibrating, and reading the P9 gauges, P9VACGONOF

E.4 Instrument Pretest Requirements

All test equipment used to verify test data is required to be “in calibration.”

E.5 Configuration Requirements

- The GMA is physically mounted, plumbed, and electrically grounded on the Space Vehicle (per LMMS INT-334 and SU P0945).
- The GMA Fill & Drain Valves are closed and capped.
- The GMA vent ports are capped.
- The off-pallet F&D Valves are capped.
- 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.

E.6 Optional Non-flight Configurations

N/A

E.7 Verification/ Success Criteria

Probe pressure and P9 gauge temperature will have successfully been determined.

E.8 Constraints and Restrictions

N/A

F REFERENCE DOCUMENTS

F.1 Drawings

- GMA Schematic, GP-B Dwg. Number 26273

F.2 Supporting documentation

N/A

F.3 Additional Procedures

N/A

G OPERATIONS

G.1 Verify Appropriate QA Notification

Note: This section shall be completed prior to all other sections.

QA Notified_____ (Date & Time) ONR Notified_____ (Date & Time)

G.2 Verify Work Environment for Vent Manifold

Started on: _____
Note: This is an optional section that may be skipped, or postponed.

G.2.1 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.

G.2.2 Samples @ Vent Port : #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.2.3 Sample size: _____ Average particles per cubic foot: ____

G.2.4 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.

G.2.5 Samples @ tilt ring: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.2.6 Sample size: _____ Average particles per cubic foot: ____

G.2.7 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).

Section G.2 complete. QA _____

Customer _____

G.3 Installation of Vent Manifold

Started on: _____
Note: This is an optional section that may be skipped, or postponed.

G.3.1 Verify that GMA valves V27, V28, V29, V30 are closed (use ECU to close them, or verify last state from prior operations).

method used/verification source_____

G.3.2 Install GSE as shown in Figure 1 to build Vent Manifold.

G.3.3 Close OM-Vent, and leak check Vent Manifold and GSE plumbing up to that valve.

G.3.4 Open OM-Vent and leak check to as low as level as possible, given that the GMA vent quad latch valves are leaking at ~$5x10^{-5}$ sccs.

G.3.5 Evacuate (<1 torr), purge (with Helium), and evacuate Vent Manifold to remove air residue.

G.3.6 With Vent Manifold under vacuum (<1 torr), close and secure all GSE valves in the Vent Manifold.

Section G.3 complete. QA _____

Customer _____

G.4 Verify Work Environment for Outlet Manifold

Started on: _____
Note: Sections G.2 and G.3 need not be completed before this section.

G.4.1 Set up hand held particle counter near the caps of the Space Vehicle F&D Valves. Take five one-minute samples. Average number of 0.5 micron or greater particles should be less than 5 per cubic foot.

G.4.2 Samples @ F&D Valves : #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.4.3 Sample size: _____ Average particles per cubic foot: ____

G.4.4 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.

G.4.5 Samples @ tilt ring: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.4.6 Sample size: _____ Average particles per cubic foot: ____

G.4.7 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).

Section G.4 complete. QA _____

Customer _____

G.5 Setup of GMA and Space Vehicle for Outlet Manifold work

Started on: _____

Note: Section G.4 must be completed before this section is begun.

G.5.1 Verify that all off-pallet F&D valves are closed (40+/-5 in.lbs.)

Wrench used_____

F&DS2 torque QA _____

F&DS1 torque QA _____

F&DS3 torque QA _____

F&DS4 torque QA _____

F&DP1A torque QA _____

G.5.2 Verify that GMA valves V7 through V26 are closed (use ECU to close them, or verify last state from prior operations).

method used/verification source_____

G.5.3 Install mounting clamps on tilt ring (adjust in future as desired).

Section G.5 complete. QA _____

Customer _____

G.6 Install Outlet Manifold

Started on: _____
Note: Section G.5 must be completed before this section is begun.

G.6.1 Verify that ECU is on and ready for use.

G.6.2 Load CSTOL script for controlling, calibrating, and reading the P9 gauges (P9VACGONOF).

G.6.3 Use ECU to turn on/enable the P9 gauges to allow them time to warm up.

G.6.4 Install GSE as shown in Figure 1 to build Outlet Manifold. Log F&D valve cap cycles as required.

G.6.5 Leak check Outlet Manifold.

G.6.6 Evacuate (<1 torr), purge (with Helium), and evacuate Outlet Manifold to remove air residue.

G.6.7 With Outlet Manifold under vacuum (<1 torr), close and secure all GSE valves in the Outlet Manifold.

Section G.6 complete. QA _____

Customer _____

G.7 Verify Probe Pressure

Started on: _____
Note: Section G.6 must be completed before this section is begun.

G.7.1 Use the ECU to read GMA pressure sensors GP1 through GP14 and record in Table 1.

G.7.2 Use the ECU to record the pressures on both P9 gauges in Table 2. Also record P9 gauge temperature in Table 2 using the thermocouples placed there for use in the Thermo-vac test. If direct readings are unavailable, record the raw count values. These should be given to appropriate personnel for calculation of pressure before this procedure is closed out.

G.7.3 Verify that Outlet manifold is evacuated.

G.7.4 Open OM valves to pump out any residual helium that may be in the lines.

G.7.5 Open the five Off Pallet Fill and Drain valves and log as required.

G.7.6 Use ECU to read GMA pressure sensors and P9 gauges to verify that lower lines have been evacuated. Record these pressures in Tables 1and 2. Also record P9 gauge temperatures.

G.7.7 Close the five Off Pallet Fill and Drain Valves and log cycles as required. Torque to 40 ±5 in-lbs.

Wrench used_____

F&DS2 torque QA _____

F&DS1 torque QA _____

F&DS3 torque QA _____

F&DS4 torque QA _____

F&DP1A torque QA _____

G.7.8 Close the Outlet Manifold valves corresponding to S1-S4. (Leave OM-P1A valve open.)

G.7.9 Record in Table 2 the P9 Gauge temperatures using Thermo-Vac thermocouples.

G.7.10 When temperature is sufficiently stable, open the P1A probe manual inlet valve (top hat valve).

G.7.11 Use ECU to monitor the probe pressure with both P9 Gauges.

G.7.12 When pressure stabilizes record in Table 2. If direct readings are unavailable, record the raw count values. These should be given to appropriate personal for calculation of pressure before this procedure is closed out.

G.7.13 Use ECU to turn off/disable the P9 Gauges.

G.7.14 Close the P1A probe manual inlet valve (top hat valve).

G.7.15 Verify the outlet manifold is being pumped on and that OM-P1A is open, and open the P1A Fill and Drain Valve and log cycle as required.

G.7.16 Evacuate the plumbing line and outlet manifold.

G.7.17 Close the P1A Fill and Drain Valve and log as required. Torque to 40 ±5 in.-lbs.

F&DP1A torque QA _____

G.7.18 Close OM-P1A and shut down vacuum system and any other GSE as necessary.

Section G.7 complete. QA _____

Customer _____

Note: This procedure can be halted here to perform other GMA testing. Sections G.8 and G.9 are used to remove the GSE from the S/V.

G.8 Remove Outlet Manifold

Started on: _____
Note: Sections G.8 and G.9 need not be performed directly after Section G.7. Other tests can be run between sections G.7 and G.8.

G.8.1 Verify that all off-pallet F&D valves are closed (40+/-5 in.lbs.)

Wrench used_____

F&DS2 torque QA _____

F&DS1 torque QA _____

F&DS3 torque QA _____

F&DS4 torque QA _____

F&DP1A torque QA _____

G.8.2 Remove any Outlet Manifold GSE as desired.

G.8.3 Install flight caps and conical seals (120+/-10 in.lbs.) on off Pallet F&D valves and log as required.

Wrench used_____

F&DS2 torque QA _____

F&DS1 torque QA _____

F&DS3 torque QA _____

F&DS4 torque QA _____

F&DP1A torque QA _____

Section G.8 complete. QA _____

Customer _____

G.9 Remove Vent Manifold

Started on: _____
Note: This section must only be performed if Vent Manifold is installed. It may be skipped if not necessary.

G.9.1 Verify that GMA V27, V28, V29, V30 are closed (use ECU to close them, or verify last state from prior operations).

method used/verification source_____

G.9.2 Remove any Outlet Manifold GSE as desired.

G.9.3 Cap/Close GMA vent outlet.

Section G.9 complete. QA _____

Customer _____

H PROCEDURE SIGN OFF

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

_____ date: _____
Test Director/GMA Engineer

Discrepancies if any:

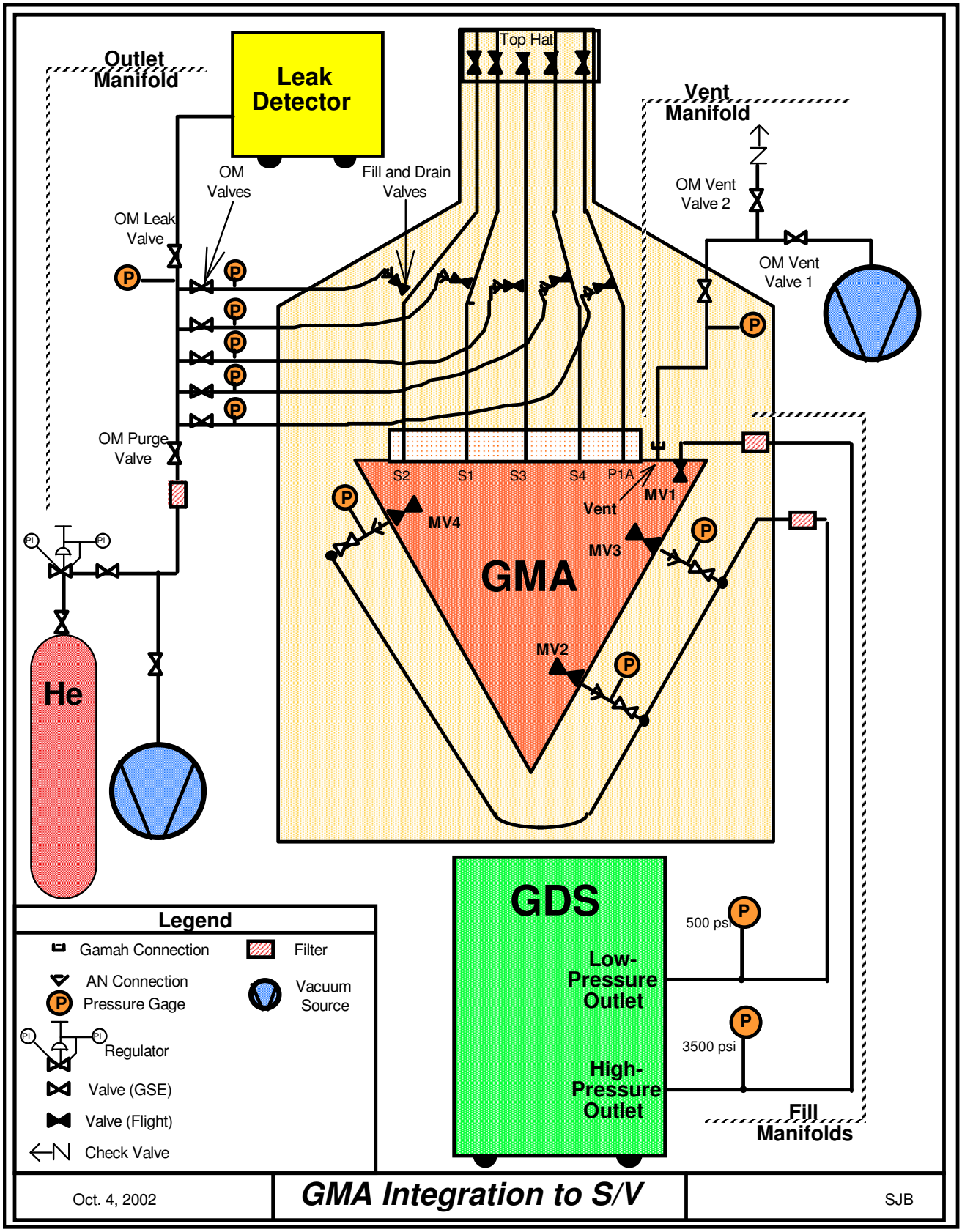
Approved: _____ date: _____
C. Gray, GMA REE

Approved: _____ date: _____
QA Representative

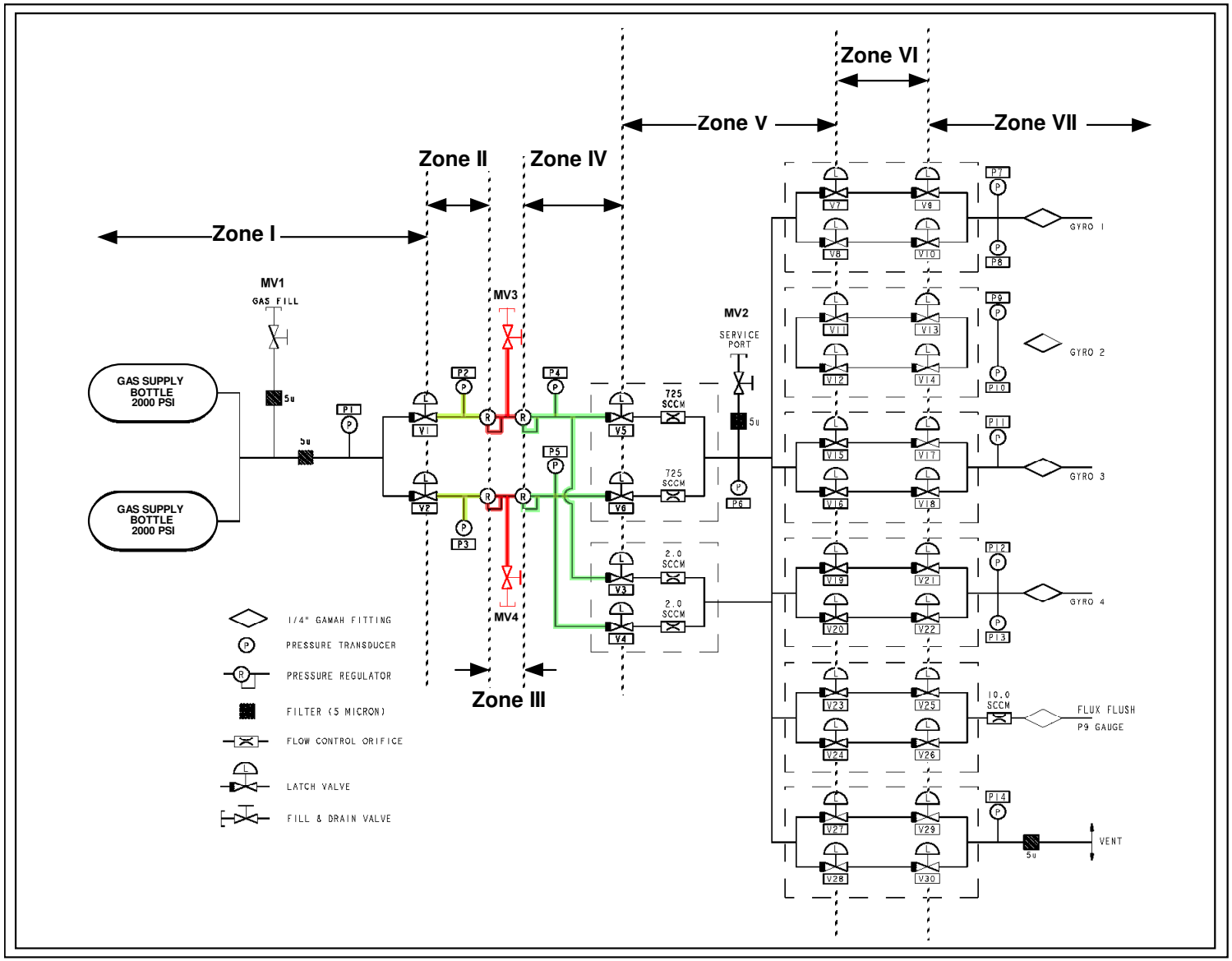
Approved: _____ date: _____
D. Ross, QA

I ILLUSTRATIONS AND TABLES

I.1 Figure 1 – GMA GSE Schematic



I.2 Figure 2 – GMA Schematic



I.3 Table 1 – Pressure Sensor Log

	GMA Sensors Counts														
Sect: Step	**Time**	**GP1**	**GP2**	**GP3**	**GP4**	**GP5**	**GP6**	**GP7**	**GP8**	**GP9**	**GP10**	**GP11**	**GP12**	**GP13**	**GP14**

I.4 Table 2 – Probe Pressure Log

Section: Step	**Time**	**P9 A Temperature**	**P9 B Temperature**	**P9 A Pressure**	**P9 B Pressure**