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W.W. HANSEN EXPERIMENTAL PHYSICS LABORATORY
GRAVITY PROBE B, RELATIVITY GYROSCOPE EXPERIMENT
STANFORD, CALIFORNIA 94305-4085

GMA PREPARATION FOR E28 TESTING

P0970 Rev –

2 January, 2003

PREPARED _____ _____
K. Bower, GMA Engineer Date

APPROVED _____ _____
C. Gray, GMA REE Date

APPROVED _____ _____
Harv Moskowitz, LMSSC Safety Engineer Date

APPROVED _____ _____
D. Ross, Quality Assurance Date

APPROVED _____ _____
R. Brumley, Hardware Manager Date

TABLE OF CONTENTS

A SCOPE

This procedure defines how to install several pieces of Gas Management Assembly (GMA) Ground Support Equipment (GSE) for the purpose of E28 Space Vehicle Testing. Additionally, some hardware will also be installed for the purpose of GMA Latch Valve Internal Leakage evaluation. Some of the required GSE will already be installed if this procedure is performed after Space Vehicle (S/V) Thermo-vac testing but before S/V Spin Balancing.

This GSE has three distinct elements which can be installed in any order. The Outlet Manifold allows for GSE control (isolation, evacuation, and limited fill) and pressure monitoring of the five GMA outlets (S1, S2, S3, S4, and P1A). The Vent Manifold allows for GSE control (isolation, evacuation, and fill) of the GMA Vent outlet. The Fill Manifold allows for GSE control (isolation, evacuation, and fill) of the four GMA inlets (MV1, MV2, MV3, and MV4).

Disconnection is also contained within this procedure. It is intended that additional operations will be performed on the GMA throughout this procedure (i.e. GMA functional testing. GMA latch valve leakage testing, “rate of rise” pressure monitoring, etc.). It is preferred that each section of this procedure be completed in its entirety and that all “inserted” operations be performed between the sections within this procedure. Additionally, inserted operations shall either restore the identical starting configuration or shall report its ending configuration in necessary detail. If the latter is the case, then the Test Director shall initiate a D-log (or “blue line”) to align this procedure with the change in configuration as required.

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. The Fill Manifold line connected to MV1 is intended to carry medium high pressures of up to 2200 psia, but it’s use is not called for in this operation and is not anticipated during any intersecting operations. All of the GSE used in this procedure have pressure ratings considerably higher than the maximum expected operating pressures.

The Gas Delivery System (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. The GDS is a high-pressure gas delivery system. When any of the system is pressurized and connected to the vacuum system and/or leak detector, be cautious not to vent high pressure through the pumping portions of either system. Only allow high pressure to vent through approved ports (such as leak detector vent or CV-1) and make sure that these are open at time of venting. The GDS is capable of locking out all critical valves as desired. 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	2000/2300	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)

Further information concerning the GDS can be found in the GDS schematic (on front panel), the GDS design manual (accompanying GDS), the GDS Operations Procedure (P0886), and the GDS Acceptance Test Procedure (P0917).

The pressurized manifold lines and hookups between the GDS and the GMA have a minimum rated MEOP of 2000 psig (3100 flex lines, 5100 rigid line, 3000 filters, 2000/7500 gauges, 8000 fittings) which is many times greater than the 300 psia maximum pressure to which they may be exposed and therefore do not present a realistic safety concern.

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.

Some of the GSE used in this procedure is large and mobile and normal efforts should be used to ensure that equipment does not roll or fall during an earthquake, especially when connected to flight equipment. The GDS is equipped with wheel brakes, floor jacks, and tie down points. It is recommended that the floor jacks be engaged whenever the GDS is not being moved. Avoid positioning the GDS closer than six feet from the Space Vehicle, about ten feet would be ideal (plumbing lines longer than twelve feet are discouraged)..

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
- Fill Manifold – the two part manifold connecting the GDS (or similar GSE) to the on-pallet F&D Valves

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.
- Outlet Manifold Hardware to connect to Space Vehicle F&D Valves.
- Vent Manifold Hardware to connect to GMA vent port.
- Fill Manifold Hardware to connect to GMA F&D Valves.
- 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 Carts (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

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 (or connected to reusable GSE from Thermo-vac testing).
- The off-pallet F&D Valves are capped (or connected to reusable GSE from Thermo-vac testing).
- 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 (may vary from section to section).

E.6 Optional Non-flight Configurations

N/A

E.7 Verification/ Success Criteria

All connections shall be leak tight and properly torqued (when closed) as set out in individual procedure sections.

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

General Note: The three manifolds may be installed and/or removed in any sequence. Individual sections note their restrictions of sequence.

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 Outlet Manifold

Note: This section shall be completed prior to section G.3.
Started on: _____

G.2.1 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.2.2 Samples @ F&D Valves : #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 Setup of GMA and Space Vehicle for Outlet Manifold work

Started on: _____
Note: This section shall be completed prior to section G.4. Section G.2 shall be completed prior to this section.

G.3.1 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.3.2 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.3.3 Install mounting clamps on tilt ring (adjust in future as desired).

Section G.3 complete. QA _____
Customer _____

G.4 Install Outlet Manifold

Started on: _____
Note: Refer to cleanliness standards in section B.4. Section G.3 shall be completed prior to this section.

G.4.1 Install GSE as shown in Figure 1 to build Outlet Manifold. Utilize existing hardware remaining from prior operations as desired. Log F&D valve cap cycles as required.

G.4.2 Leak check Outlet Manifold.

G.4.3 Evacuate (<1 torr), purge (with Helium), and evacuate Outlet Manifold to remove air residue.

G.4.4 With Outlet Manifold under vacuum, open the five off-pallet F&D valves and log as required.

G.4.5 With Outlet Manifold under vacuum (<1 torr), close and secure all GSE valves in the Outlet Manifold.

Section G.4 complete. QA _____
Customer _____

G.5 Verify Work Environment for Vent Manifold

Note: This section shall be completed prior to section G.6.
Started on: _____

G.5.1 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.5.2 Samples @ Vent Port : #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.5.3 Sample size: _____ Average particles per cubic foot: ____

G.5.4 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.5.5 Samples @ tilt ring: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.5.6 Sample size: _____ Average particles per cubic foot: ____

G.5.7 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.5 complete. QA _____

Customer _____

G.6 Setup of GMA and Space Vehicle for Vent Manifold work

Started on: _____
Note: This section shall be completed prior to section G.7. Section G.5 shall be completed prior to this section.

G.6.1 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.6.2 Install mounting clamps on tilt ring (adjust in future as desired).

Section G.6 complete. QA _____

Customer _____

G.7 Install Vent Manifold

Started on: _____
Note: Refer to cleanliness standards in section B.4. Section G.6 shall be completed prior to this section.

G.7.1 Install GSE as shown in Figure 1 to build Vent Manifold. Utilize existing hardware remaining from prior operations as desired.

G.7.2 Leak check Vent Manifold.

G.7.3 Evacuate (<1 torr), purge (with Helium), and evacuate Vent Manifold to remove air residue.

G.7.4 With Vent Manifold under vacuum (<1 torr), close and secure all GSE valves in the Vent Manifold.

Section G.7 complete. QA _____

Customer _____

G.8 Verify Work Environment for Fill Manifold

Note: This section shall be completed prior to section G.9.
Started on: _____

G.8.1 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.

G.8.2 Samples @ MV1 Valve: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.8.3 Sample size: _____ Average particles per cubic foot: ____

G.8.4 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.

G.8.5 Samples @ MV2: #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.8.6 Sample size: _____ Average particles per cubic foot: ____

G.8.7 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.8 complete. QA _____

Customer _____

G.9 Setup of GMA and Space Vehicle for Fill Manifold work

Started on: _____
Note: This section shall be completed prior to section G.10. Section G.8 shall be completed prior to this section.

G.9.1 Verify that all on-pallet F&D valves are closed (40+/-5 in.lbs.)

Wrench used_____

MV1 torque QA _____

MV2 torque QA _____

MV3 torque QA _____

G.9.2 Verify that GMA V1 and V2 are closed (use ECU to close them, or verify last state from prior operations).

method used/verification source_____

Section G.9 complete. QA _____

Customer _____

G.10 Install Fill Manifold

Started on: _____

Note: Refer to cleanliness standards in section B.4. Section G.9 shall be completed prior to this section.

G.10.1 Install GSE as shown in Figure 1 to build Fill Manifold. Utilize existing hardware remaining from prior operations as desired. Log F&D valve cap cycles as required.

G.10.2 Leak check Fill Manifold.

G.10.3 Evacuate (<1 torr), purge (with Helium), and evacuate Fill Manifold to remove air residue.

G.10.4 With Fill Manifold under vacuum (<1 torr), close and secure all GSE valves in the Fill Manifold.

G.10.5 Open MV2, MV3, and MV4 if desired and log as required (do not open MV1).

Section G.10 complete. QA _____

Customer _____

G.11 Remove Outlet Manifold

Started on: _____

G.11.1 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.11.2 Remove any Outlet Manifold GSE as desired.

G.11.3 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.11 complete. QA _____

Customer _____

G.12 Remove Vent Manifold

Started on: _____

G.12.1 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.12.2 Remove any Outlet Manifold GSE as desired.

G.12.3 Cap/Close GMA vent outlet.

Section G.12 complete. QA _____

Customer _____

G.13 Remove Fill Manifold

Started on: _____

G.13.1 Verify that all GMA F&D valves are closed (40+/-5 in.lbs.)

Wrench used_____

MV1 torque QA _____

MV2 torque QA _____

MV3 torque QA _____

MV4 torque QA _____

G.13.2 Remove any Fill Manifold GSE as desired.

G.13.3 Install flight caps and conical seals (120+/-10 in.lbs.) on GMA F&D valves and log as required.

Wrench used_____

MV1 cap torque QA _____

MV2 cap torque QA _____

MV3 cap torque QA _____

MV4 cap torque QA _____

Section G.13 complete. QA _____

Customer _____

G.14 Completion

Started on: _____
Note: This section may be performed multiple times between other sections if desired. If so, note each occurrence in the Sign off section.

G.14.1 If possible and desired, use ECU null script function to put GMA in "sleep" mode (all valves closed, zone I=II, zones III-VII ~20 psia).

G.14.2 If possible, use ECU to read all pressures/counts from GMA and log in pressure sensor log (at end of section H).

G.14.3 Shut down ECU if desired.

G.14.4 Disconnect remaining GSE as desired.

G.14.5 Visually inspect exterior surface of flight hardware and remove contamination if required.

Section G.14 complete. QA _____

Customer _____

G.15 Procedure Sign Off

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

_____ date: _____
Test Director/GMA Engineer

Discrepancies if any:

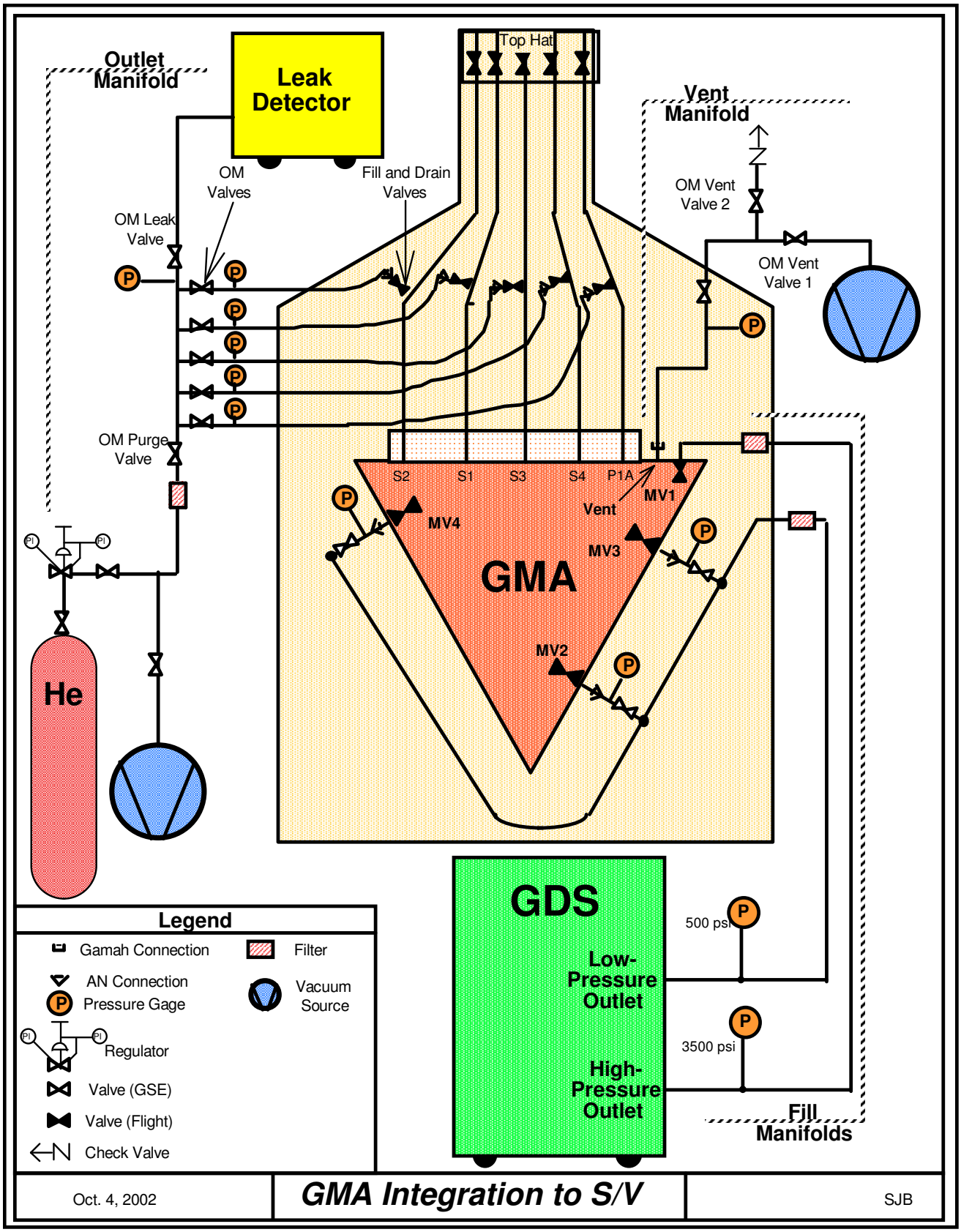
Approved: _____ date: _____
C. Gray, GMA REE

Approved: _____ date: _____
QA Representative

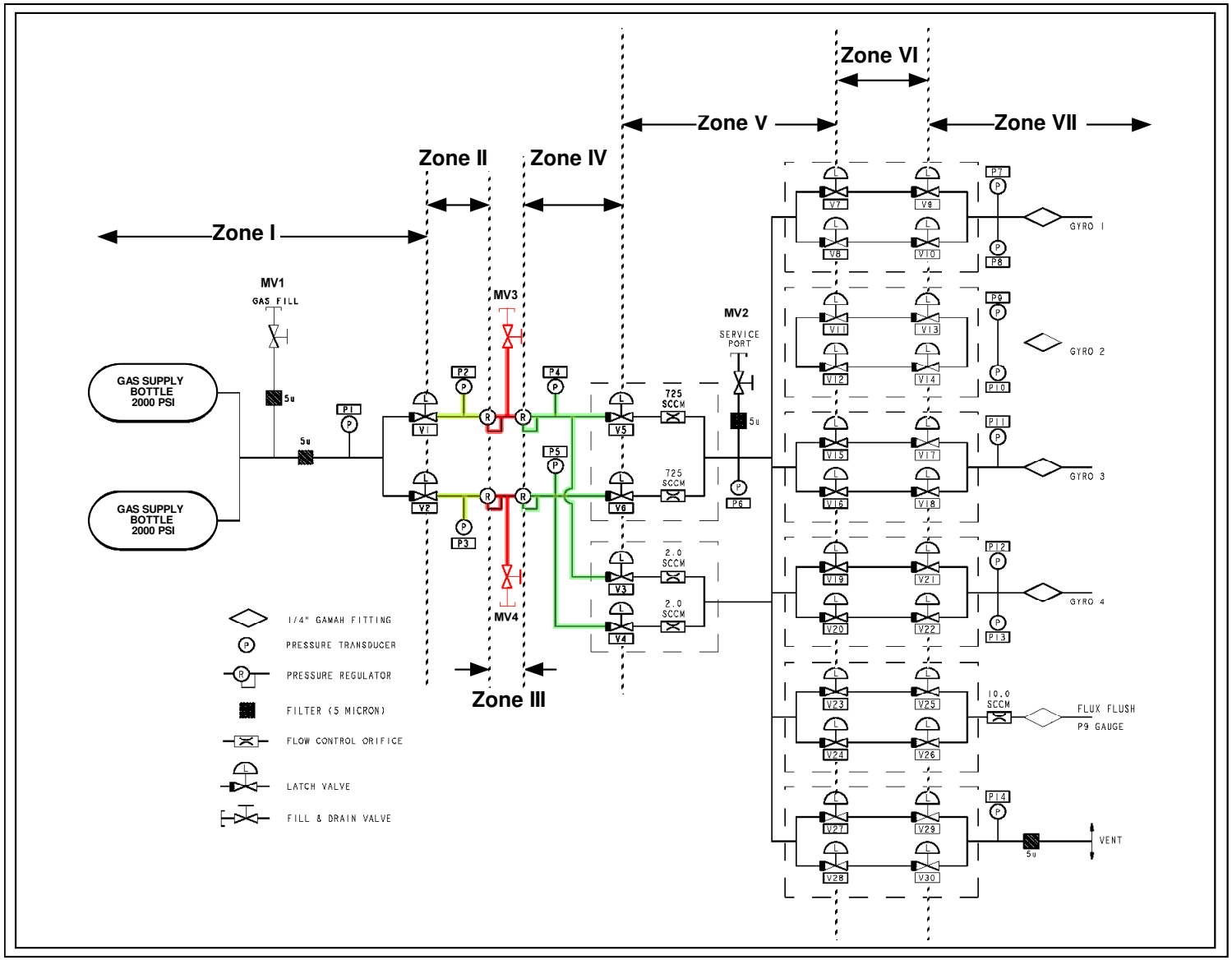
Approved: _____ date: _____
D. Ross, QA

H ILLUSTRATIONS AND TABLES

H.1 Figure 1 – GMA E28 Schematic



H.2 Figure 2 – GMA Schematic



H.3 Table 1 – Pressure Sensor Log

	GMA Sensors Counts														
Sect: Step	**Time**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**