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

DISCONNECT GSE FROM GMA/SPACE VEHICLE

P0951 Rev –

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A SCOPE

This procedure removes Ground Support Equipment (GSE) from the Gas Management Assembly (GMA) and its associated off-pallet Fill and Drain (F&D) Valves. This GSE was primarily connected during P0945 (GMA to Space Vehicle Plumbing Hookup) and was used for a variety of functions.

The following hardware may be removed by this procedure as desired:
F&D Manifold (connected to off pallet F&D Valves)
Vent Manifold (connected to GMA Vent port)
Fill Manifolds (connected to GMA MV1, MV2, MV3, and MV4)

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 contained gas pressures may be a large fraction of the rated vessel pressures and therefore present a modest safety concern. Close operations around the GMA pallet (including all wrench work) shall be monitored by the Test Director.

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 Gas Delivery System (GDS) has multiple gas pressure vessels. Under normal operations, 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 40 psia maximum pressure to which they may be exposed and therefore do not present a realistic safety concern.

The vacuum/purge manifold lines connected to the GMA and Fill and Drain (F&D) Valves will not be exposed to high pressures and therefore do not present a realistic safety concern. (Purge operations typically run at around 5-20 psig.)

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, plumbing lines, and GDS 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 B159 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 LMMS Class 100,000 practices) shall be worn whenever handling flight hardware. Eyes-only face and full-foot coverings, coveralls, and clean gloves (“head to toe” – consistent with Class 100 practices) shall also be worn whenever working with flight wetted surfaces. All fluid connections shall be visually inspected by the operator making the connection to be visibly clean under laboratory ambient lighting (typically 100-125 foot candles in highbay laboratories).

Care should be taken to preserve the clean state of removed GSE. If desired by the Test Director, test operator, QA, or GMA RE, any manifolds or parts shall be tagged for additional cleaning (appropriate to use) before future uses.

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 Manifold – the GSE hardware connected to the Fill and Drain ports of the GMA

- Fill and Drain (or F&D) Valves – the five “off pallet” flight Fill and Drain valves mounted on the conical section of the Space Vehicle
- Fill and Drain (or F&D) Manifold – the GSE hardware connected to the F&D Valves
- Lower Lines – the five flight lines connecting the F&D valves to the GMA
- GMA Transition Bracket – the flight bracket affixed to the GMA which holds the connection between the GMA and the Lower Lines
- Top Hat Valves – the five flight valves mounted near the Top Hat of the Space Vehicle which control the flow between the GMA and the Probe

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

B.6 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 (GDS V-24, GDS V-25, OM-Vent, OM-Purge, and OM-Vent, 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 (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 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, RE, or QA believe it necessary, a discrepancy report may be issued for MRB review.

For general actions to be taken as a consequence of accidents or mishaps, refer to P0879.

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 physically mounted to Space Vehicle (per LMMS INT-334)
- HEPA downflow hood installed over critical work area
- ECU Flight Equivalent, Flight ECU, or Manual Latch Valve Control Box and related operational equipment (computers, cables, meters, etc.)
  (Note: The procedures will always call for an 'ECU command' to open GMA valves but it can be replaced by similar functions from any of the above equivalents.)
- "gma_null_setup.prc" script (or flight equivalent)
- Interface cables from ECU to GMA
- GDS (Gas Delivery System), with design manual, ATP, and any additional certifying documentation.
- Hand held particle counter (sensitive to 0.5 microns or better)
  Calibration Date: _____ S/N: _____ Model #: _____
- Clean room bags and tape
- 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
  #1) Make/model _____ S/N _____ Certificate expiration _____

#2) Make/model _____ S/N _____ Certificate expiration _____

#3) Make/model _____ S/N _____ Certificate expiration _____

- Moog aluminum conical seal gaskets, for flight, as required (=>9)
- F&D valve caps (9, labeled uniquely and stored cleanly), removed from GMA/Space Vehicle in P0945

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 and electrically grounded on the Space Vehicle.
- The GMA tanks (zone I) are pressurized 200>2100 psia.
- The GMA is in “lock-up” mode (all solenoid valves closed, zones II-IV ~300 psia, zone V ~20 or ~300 psia, zones VI-VII ~20 psia).
- The GMA outlets are connected to the Space Vehicle lower lines (P0945 complete).
- 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.
- The GMA is connected to an ECU.

E.6 Optional Non-flight Configurations

N/A

E.7 Verification/ Success Criteria

All flight Fill and Drain Valves and caps are properly installed and torqued 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

- GMA Installation Dwg. Number 8A00982

F.2 Supporting documentation

GDS design manual, Operations procedure (P0886), and ATP (P0917)

F.3 Additional Procedures

ECU operations as applicable.

G OPERATIONS

Note: Sections G.1, G.2, and G.3 shall be performed first. Any combination of sections G.4, G.5, and G.6 may then be performed in any order. Section G.7 shall be performed last.

G.1 Verify Appropriate QA Notification

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

G.2 Verify Work Environment

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 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.2.5 Samples @ GMA transition bracket : #1 ___ #2 ___ #3 ___ #4___ #5 ___.

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

G.2.7 Set up hand held particle counter near the lowest point of the GMA (near MV2). Take five one-minute samples. Average number of 0.5 micron or greater particles should be less than 5 per cubic foot.

G.2.8 Samples @ MV-2 : #1 ___ #2 ___ #3 ___ #4___ #5 ___.

G.2.9 Sample size: _____ Average particles per cubic foot: ____.

G.2.10 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 _____

G.3 Setup of GDS and ECU

Started on: _____
Note: this section may require venting small quantities of Helium (<10L) into the environment. This is not hazardous to personnel, but may pose a problem for Helium sensitive equipment in the same room. Notify the appropriate facility personnel if Helium venting is anticipated before starting this section. Notification _____.

G.3.1 GDS RE to certify that GDS meets all ATP (SU P0917) requirements _____.

G.3.2 Verify that GDS pressure relief systems are installed and all associated cutoff valves are open (RV-1 cutoff, RV-3 cutoff, V-21, and V-23).

G.3.3 Verify GDS supply cylinders have sufficient Helium to complete required operations. (One cylinder >300 psig should be sufficient for this operation.) When any cylinder is supplying Helium to flight wetted surfaces, do not allow the cylinder to drop below 250 psig. For other uses (i.e. GSE purging, leak check spraying), do not allow the cylinder to drop below 100 psig.

G.3.4 Verify that all GDS valves (except those noted in G.3.2) and Helium supply valves are closed and all unused GDS ports are sealed.

G.3.5 Verify that the GDS is at a positive pressure of Helium or vacuum (not air).

G.3.6 Record PT-2_____ PT-3 _____ VT-1_____

G.3.7 Evacuate GDS if desired.

G.3.8 Use the GDS internal functions to supply pressure to the Fill Manifolds (downstream of V-24 and V-25) to slightly over ambient (~20 psia).

G.3.9 Verify that the ECU is available to read out GMA sensors.

G.3.10 Use ECU to read all pressures/counts from GMA and log in pressure sensor log (at end of section H).

Section G.3 complete. QA _____

G.4 Disconnect F&D Manifold from off pallet F&D Valves

Started on: _____

G.4.1 Verify that all GMA valves are closed. (Use ECU to “close all valves” if necessary.)

G.4.2 Close/verify closed and torque F&DS2, F&DS1, F&DS3, F&DS4, and F&DP1A (40 +/- 5 in.lbs.) 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 _____

G.4.3 Close/verify closed F&D Manifold manual valves OM-Purge, OM-Leak, OMG-2, OMG-1, OMG-3, OMG-4, OM-P1A.

G.4.4 Disconnect F&D Manifold from five F&D Valves (log cycles for F&D valve caps as required).

G.4.5 Remove F&D Manifold from Space Vehicle. Carefully cover outlets and bag as necessary to preserve cleanliness for future use before removing from downflow hood.

G.4.6 Install five conical seals and five caps to F&D valves. Visually inspect each side of connection and confirm that used conical seals have been removed. Torque (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 _____

G.4.7 Disassemble/power down associated GSE as desired.

G.4.8 Shut down ECU if desired.

Section G.4 complete. QA _____

G.5 Disconnect Vent Manifold from GMA

Started on: _____

G.5.1 Verify that all GMA valves are closed. (Use ECU to “close all valves” if necessary.)

G.5.2 Vent the Vent Manifold to air (open/close OM-Vent as required.)

G.5.3 Disconnect Vent Manifold from GMA Vent port. Use care to not strain the GMA vent line.

G.5.4 Remove Vent Manifold from Space Vehicle. Carefully cover outlets and bag as necessary to preserve cleanliness for future use before removing from downflow hood.

G.5.5 Cap GMA vent port with a clean VCR cap (not for flight). Use care to not strain the GMA vent line.

G.5.6 Disassemble/power down associated GSE as desired.

G.5.7 Shut down ECU if desired.

Section G.5 complete. QA _____

G.6 Disconnect Fill Manifold from GMA

Started on: _____

Note: this section will require venting small quantities of Helium (<10L) into the environment. This is not hazardous to personnel, but may pose a problem for Helium sensitive equipment in the same room. Notify the appropriate facility personnel when Helium venting is anticipated before starting this section. Notification _____.

G.6.1 Close/verify closed and torque MV1, MV2, MV3, and MV4 (40 +/- 5 in.lbs.) and log as required.

Wrench used _____
MV1 torque QA _____
MV2 torque QA _____
MV3 torque QA _____
MV4 torque QA _____

G.6.2 Disconnect Fill Manifold from four GMA F&D Valves (log cycles for F&D valve caps as required).

G.6.3 Remove Fill Manifold from GMA and Space Vehicle. Carefully cover outlets and bag as necessary to preserve cleanliness for future use before removing from downflow hood. Close GDS V-24 and V-25 as desired.

G.6.4 Install four conical seals and four caps to GMA F&D valves. Visually inspect each side of connection and confirm that used conical seals have been removed. Torque (120 +/-10 in.lbs.) and log as required.

Wrench used _____
MV1 cap torque QA _____
MV2 cap torque QA _____
MV3 cap torque QA _____
MV4 cap torque QA _____

G.6.5 Disassemble/power down associated GSE as desired.

G.6.6 Shut down ECU if desired.

Section G.6 complete. QA _____

G.7 Completion

Started on: _____

G.7.1 Verify that Top Hat Valves (S1, S2, S3, S4, and P1A) are closed.

G.7.2 Use ECU to read all pressures/counts from GMA and log in pressure sensor log (at end of section H).

G.7.3 Shut down ECU if desired.

G.7.4 Disconnect/shut down remaining GSE as desired.

G.7.5 Visually inspect exterior surface of flight hardware and remove contamination as required to meet “visibly clean” status.

Section G.7 complete. QA _____

G.8 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 to Space Vehicle

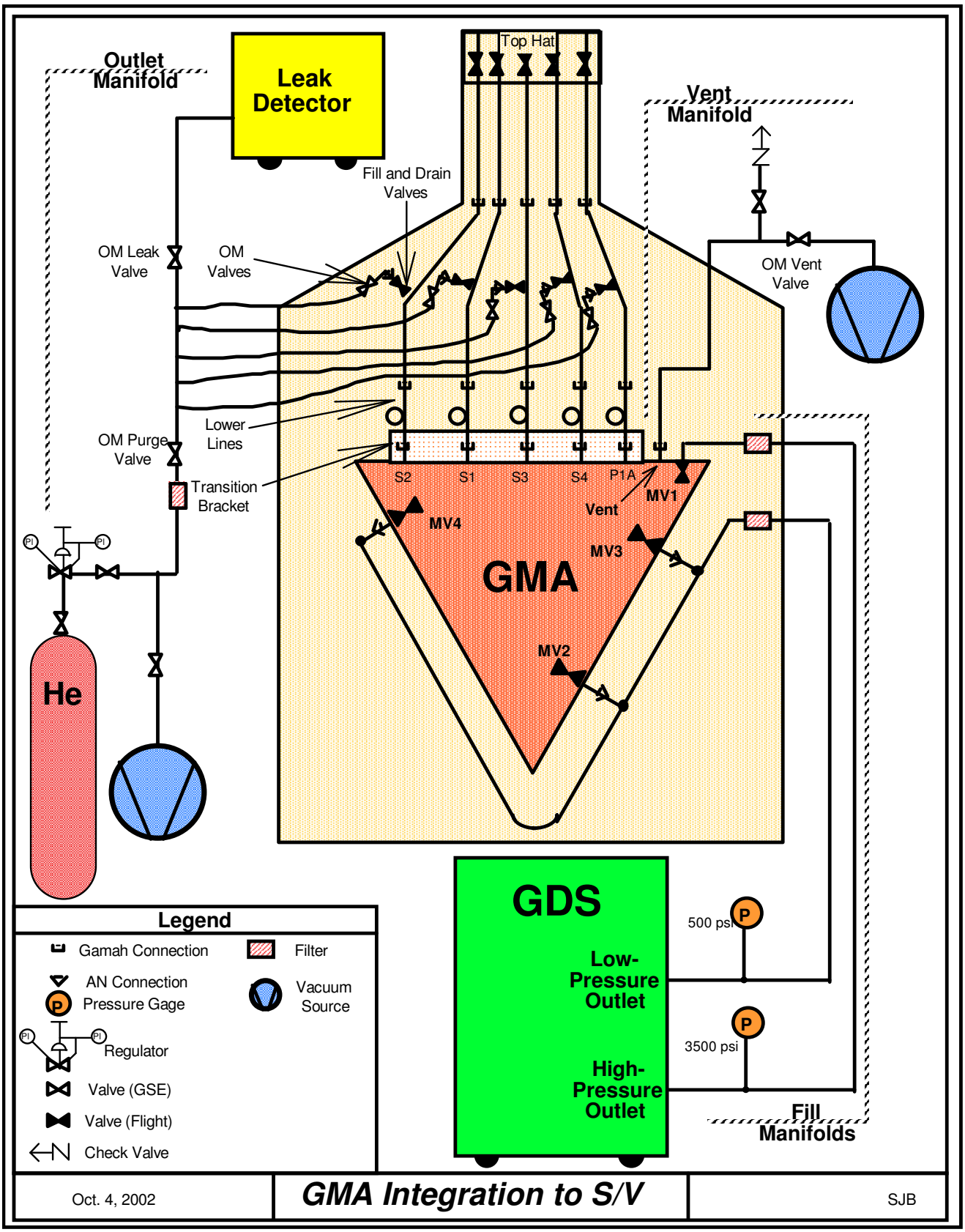
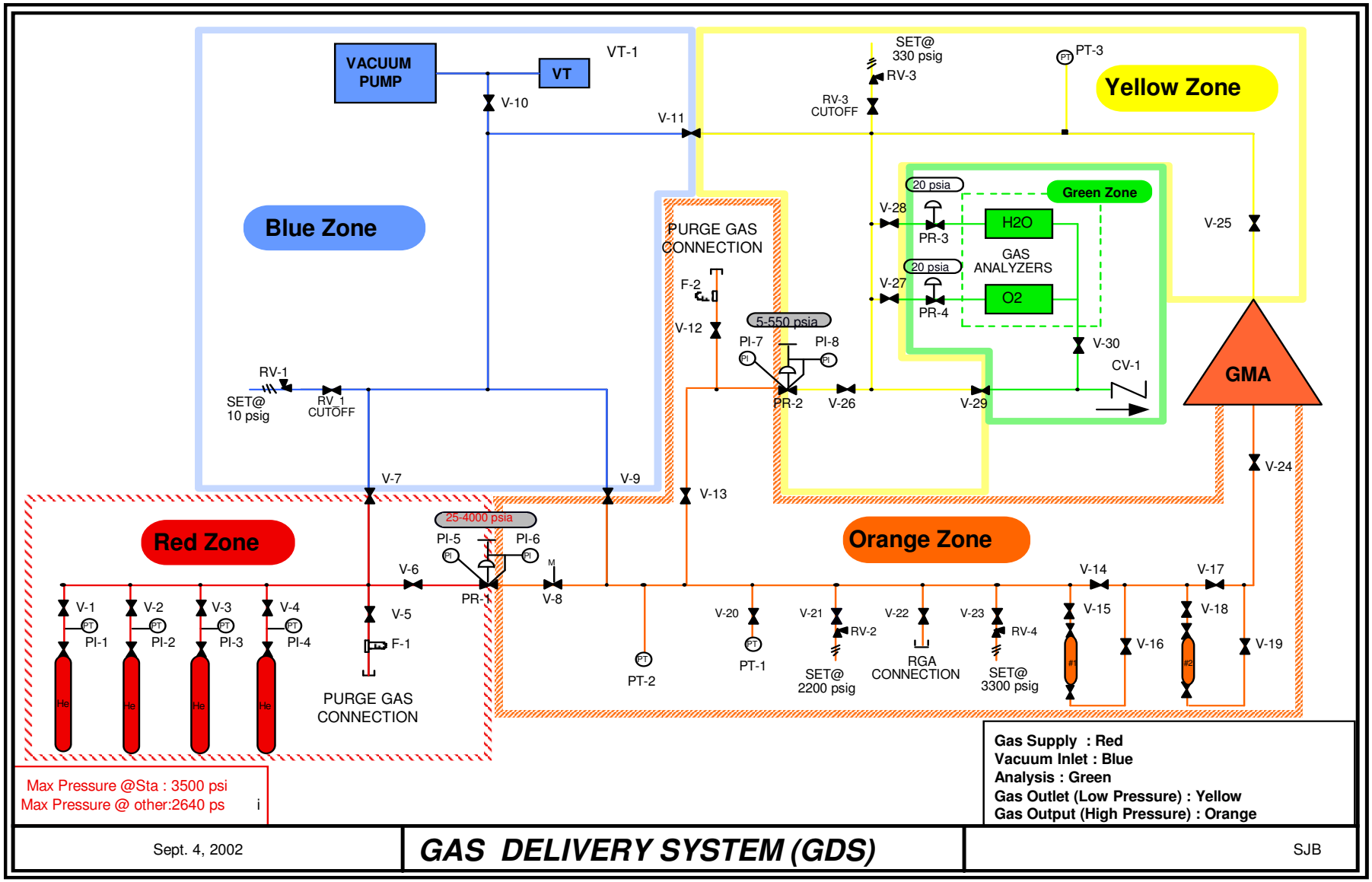
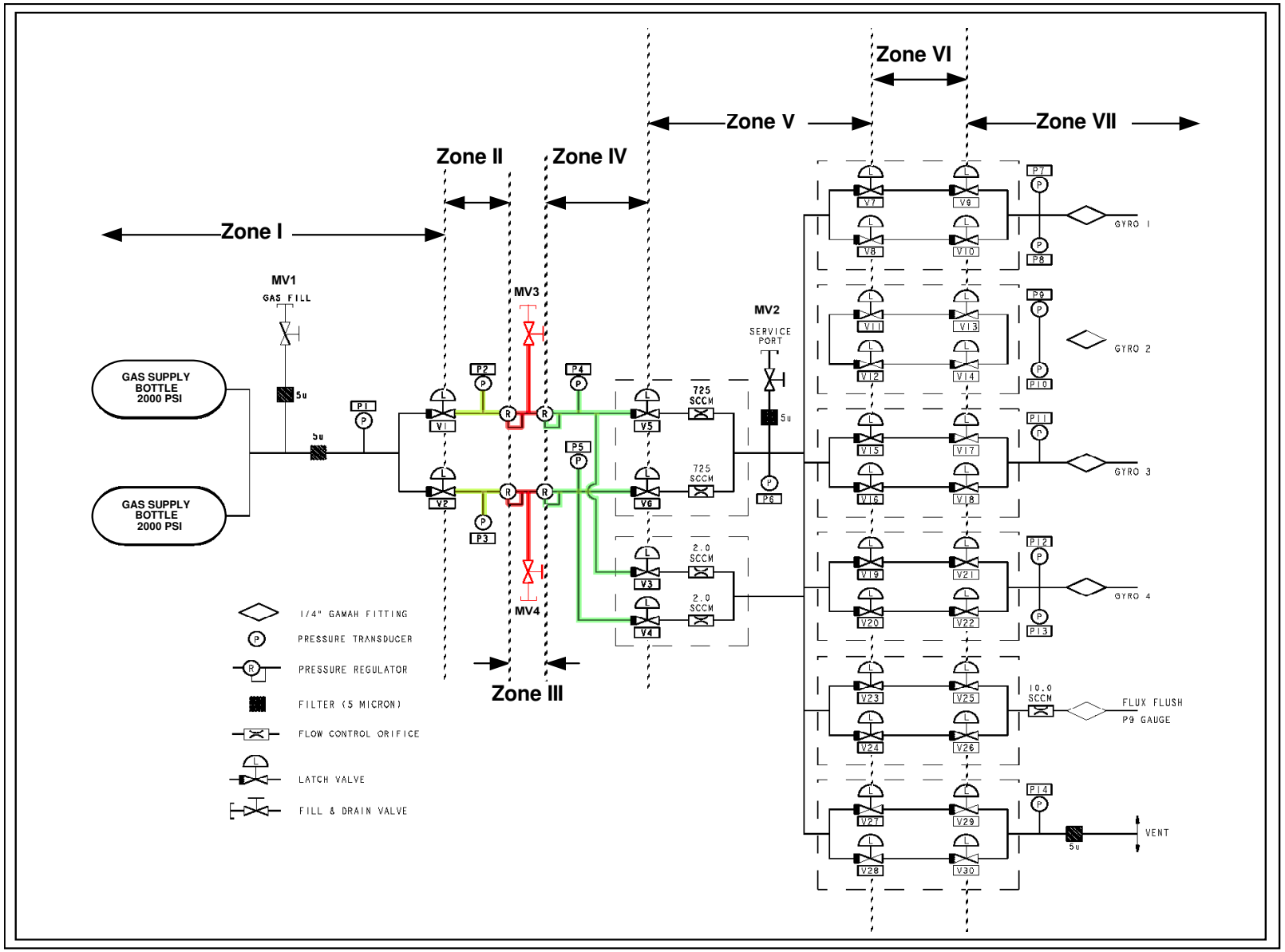


Figure 2 – GDS Schematic



H.2 Figure 3 – GMA Schematic



H.3 Table 1 – Pressure Sensor Log

		GMA Sensors Counts														Manifold Mensors		GDS		
Sect: Step	Time	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	500 psia	3500 psia	PT1 psig	PT2 psig	PT3 psig