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STANFORD, CALIFORNIA 94305-4085

GMA FLOW TEST (15.10.1)

GP-B ENGINEERING PROCEDURE

To be performed at Vandenberg Air Force Base Building 1610

THIS DOCUMENT CONTAINS NON-HAZARDOUS OPERATIONS

P1057 Rev –

2 December, 2003

PREPARED	R. Stephenson, Prepared by	Date
APPROVED	K. Bower, GMA Engineer	Date
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APPROVED	D. Ross, Quality Assurance	Date
APPROVED	R. Brumley, Hardware Manager	Date

REVISION HISTORY

Rev	Date	Comments
-	12/2/03	Similar to P0921 revision A, which was performed at LMMS.

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Acronym List

AVA	Access valve Assembly	NASA	National Aeronautics and Space Administration
CCCA	Command & Control Computer Assembly	OASIS-CC	Operations and Science Instrument Support - Command and Control
CSTOL	Colorado Spacecraft Test and Operations Language	ONR	Office of Naval Research
D-Log	Discrepancy Log	PDU	Power Distribution Unit
DR	Discrepancy Report	POD	Not an acronym, its a cluster of computers
ECU	Experimental Control Unit	psi	pounds per square Inch
EPS	Electrical Power Subsystem	psia	pounds per square inch absolute (=psig+14.7)
ESD	Electro Static Discharge	psig	pounds per square inch gauge
EU	Engineering Unit	QA	Quality Assurance
FEU	Flight Equivalent Unit	RTC	Real-Time Commands
FSW	Flight Software	TD	Test Director
FTP	File Transfer Protocol	SPC	Stored Program Commands
GMA	Gas Management Assembly	SRE	Squid Readout Electronics
GP-B	Gravity Probe B	SU	Stanford University
GSE	Ground Service Equipment	S/V	Space Vehicle
He	Helium	TCP/IP	Transmission Control Protocol over Internet Protocol
ICD	Interface Control Document	Tlm	Telemetry
LM	Lockheed Martin	UPS	Uninteruptable Power System
MOC	Mission Operations Center	VAC	Volts AC
MST	Mobile Service Tower	VSC	Vent Service Cart
MSS	Mission Support Software	VAFB	Vandenberg Air Force Base

Acronym / Abbreviation	Meaning
ECU Monitor Mnemonics	
BE_XXXXX_XXXXXX	Binary Word Monitor
CE_XXXXX_XXXXXX	Current Monitor
DE_XXXXX_XXXXXX	Digital Word Monitor
TE_XXXXX_XXXXXX	Temperature Monitor
TE_XXXXX_X**GT**XXX	GRT TYPE Thermometer
TE_XXXXX_X**PT**XXX	PRT TYPE Thermometer
TE_XXXXX_X**ST**XXX	SDT TYPE Thermometer
TE_XXXXX_XXXXX**D**	Dewer located Thermometer
TE_XXXXX_XXXXX**P**	Probe located Thermometer
TE_XXXXX_XXXXX**Q**	Quartz Block located Thermometer
VE_XXXXX_XXXXXX	Voltage Monitor
AC	Alternate Current
Closed Loop	Hardware Controlled
Command	Software response indicating command sent
Current	Commanded Heater Amperage
DC	Direct Current
Open Loop	Software Controlled
Power	UV Lamp Power Supply readout
Pressure	GMA Pressure Sensor readout
Range	UV Lamp Power Hi Lo Range readout
Signal	UV Lamp Intensity readout
Temperature	Thermometer readout
Voltage	Commanded Heater Voltage

LIST OF SPECIFIC HEADING DEFINITIONS

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

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

A SCOPE

This procedure verifies gas flows from the Flight GMA to the payload at each probe inlet (S1, S2, S3, S4, P1A and Vent Line). Both the low and high-flow functionality of the GMA is verified. The ECU is initialized and it's internal monitors limit checked. ALL GMA monitors are recorded initially and upon change. The Flight GMA Heaters are then turned on and off, the GMA Temperature sensors are monitored and checked, the GMA Pressure sensors are monitored and checked. All GMA valves are configured into the pre-launch configuration, Each possible Gas flow path is then tested, and finally, all GMA valves are again configured into the pre-launch configuration.

B SAFETY

B.1 General

The GMA is a gas pressure system. Under normal operations, the GMA requires no safety measures or equipment beyond those required for the use of a supply gas cylinderThe 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. All of the GSE used in this procedure have pressure ratings considerably higher than the maximum expected operating pressures.

B.2 Mishap Notification

B.2.1 Injury

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

B.2.2 Hardware Mishap

In case of an accident, incident, or mishap, notification is to proceed per the procedures outlined in Lockheed Martin Engineering Memorandum EM SYS229 and Stanford University GP-B P0879. Additionally, VAFB NASA Safety and 30th Space Wing Safety will be notified as required.

B.2.3 Contingency Response

Responses to contingencies/emergency (e.g., power failure) are listed in Section G.7.

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 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 (TD) or his designate and shall be approved by the QA Representative. Additionally, approval by the Payload Technical Manager shall be required, if in the judgement of the TD or QA Representative, experiment functionality may be affected.

C.3 Discrepancies

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

D TEST PERSONNEL

D.1 Personnel Responsibilities

The Test Director shall be Dave Meriwether 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.

D.2 Personnel Qualifications

The following personnel are qualified to perform this procedure using the FIST Ops test set:

Dave Meriwether

Michael Alpers

D.3 Required Personnel

The following personnel are essential to the accomplishment of this procedure:

FUNCTIONAL TITLE	NUMBER	AFFILIATION
Test Director	1	Stanford
GMA Engineer	1	Stanford
GP-B Quality Assurance	1	Stanford
ECU Controller	1	Stanford
LMMS Quality Assurance	1	LMMS

E REQUIREMENTS

E.1 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.

E.2 Lifting Operation Requirements

N/A

E.3 Hardware/Software Requirements

E.3.1 Software Required
MSS (Mission Support Software)
gma_monitor.prc
Oasis (Operating System Software)

E.3.2 Hardware required
GMA on S/V
Impedance Simulation Manifold (ISM)
Outlet Manifold connected to the off pallet fill and drain valves and the ISM
Turbo Pump cart (or VSC)
AVA connected to the GMA Vent
GSE plumbing connected to the AVA and the ISM

E.4 Instrument Pretest Requirements

N/A

E.5 Configuration Requirements

- The GMA is physically mounted, plumbed, and electrically grounded on the Space Vehicle (per LMMS INT-334 and SU P0945).
- Outlet Manifold is connected to the off-pallet F&D Valves (per appropriate Pdoc).
- ECU operations are available and P9 gauge(s) working.
- The GP-B Space Vehicle shall be powered on and in its default (Side A 1553, CCCA, Side A ECU) configuration
- Space vehicle orientation should be such that there is access to the manual valves and vacuum lines needed to be operated or connected to for this operation, nominally horizontal with the -X axis up.
- Pressure gauge shall be attached at fill and drain valve to monitor GMA output pressure.
- GMA has been filled with Helium, and gas cleanliness has been certified.
- All GMA operations require the Dewar HLD to be enabled.

E.6 Optional Non-flight Configurations

N/A

E.7 Verification/ Success Criteria

This sequence of operations involves instigating flows at 2, 10, and 725 sccm into first GSE and later (for 2 sccm only) into the probe. For each flow experiment, the success criteria is that the pressure indicated by GSE pressure gauges in the drain vacuum system reads in its nominal range for the given flow (the nominal ranges will be defined in the test procedure). For flows into the gyro spinup lines and P1 line which are bypassed into a pumping system at the fill and drain valves, the relevant pressure indicator is the pressure gauge on the line. For flows into the GMA vent path, the relevant pressure indicator is the pressure gauge on the pumping system connected to the vent path. For flows into the probe, the relevant pressure gauge is the ionization gauge on the pumping system that is connected to the leakage valve. For steps 10 and 11, which test the ability of the valves to respond to the HLD commands, the requirement is that when the dewar HLD is disabled, the flow of gas stops, as indicated by the relevant pressure going to its zero-flow baseline.

E.8 Constraints and Restrictions

All CARD's applicable to the GMA

E.9 Requirements Verification

E.9.1 Requirements Cross Reference

Moog GMA Functional Test

E.9.2 Expected Data for Verification per requirement

All Limits passed as specified within CSTOL procedure.

F REFERENCE DOCUMENTS

F.1 Drawings

Drawing No.	Title
26273	GMA Schematic, GP-B Dwg

F.2 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
SCIT-01	System Design, Verification, Integration & Test Plans
SCSE 06	Command and Telemetry Handbook, App B sw_cmd 3.2.5
SCSE 16 SECTION 9,	Flight Software Design Specification, External Interface Detailed Design, Version Gh
MSS3.3.3_Report_Excel.xls	GMA Telemetry Monitor List

F.3 Additional Procedures

Document No.	Title
SU/GP-B P0879	Accident/Incident/Mishap Notification Process
SU/GP-B P0875	GP-B Maintenance and Testing at all Facilities
Various	ECU operations as applicable

G OPERATIONS

G.1 Verify Appropriate QA Notification

QA Notified:

_____
(Date & Time)

G.2 General instructions

- Test operators shall read this procedure in its entirety and resolve any apparent ambiguities prior to beginning this test.
- This procedure operates the Flight ECU, GMA, Vatterfly Valves and the Vacuum Gauge systems of the GP-B satellite. Knowledge of these systems, caution in their operation and attention to displayed information must be exercised at all times during these operations or Hardware damage may result.
- This procedure shall be conducted on a formal basis to its latest approved and released Version.
- In order to expedite test operations, unless specifically noted, the sequence in which major sections or subsections are performed may be altered at the discretion of the GMA REE or his representative.
- All GMA Commands will be separated by at least a 1 second wait statement.
- All GMA Commands will be sent twice.

G.3 Verify Configuration Requirements

- Assemble test team and complete Pre-Test Checklist in Section G.6.
- Verify Flight ECU is available and P9 gauge is operational. (If P9 is not operating at startup of P0977, activate P9A and P9B then wait 30 minutes for gauges to stabilize.)
- Record P9 pressure(s): _____
- Verify the Outlet Manifold is connected to the Off-pallet Fill and Drain valves per **Figure 1**.

Section complete. **Quality** _____

G.4 Initialization

Started on: _____

Note: Mark off each step of procedure as it is completed.

G.4.1 Verify that manual valves which lead to S1, S2, S3, S4, and P1A (“Top Hat Valves”)are closed.

G.4.2 Verify that Outlet Manifold is connected to the off pallet Fill and Drain valves.

G.4.3 Verify that the Outlet Manifold is connected to the ISM and a vacuum source.

G.4.4 Ensure that Pod C is in it's default configuration, as specified in Configuration Requirements; section E.1

G.4.5 Bring up the Flight SRE

G.4.6 Bring up the Flight ECU using scfpwrecua

G.4.7 Bring up the Flight Vacuum Gauge using p9abvacg_on

G.4.8 Command On and then Off Side B GMA Heaters.

G.4.9 Command On Side A GMA Heaters.

G.5 Setup and Verify GMA nominal Initialization State

G.5.1 Limit check Internal ECU Monitors

G.5.2 Start gma_monitor.prc

G.5.3 Display and limit check each Flight GMA SDT
GMA_SDT1A, 1B, 2A, 2B, 3A, 3B

G.5.4 Display and limit check each GMA Pressure Sensor
GP1,2,3,4,5,6,7,8,9,10,11,12,13,14

G.5.5 Start gma_setup.prc and initiate the launch configuration

G.6 ECU / GMA Safe Mode Test

Initiate a flow through the A-side GMA and confirm that the HLD for V1 disables gas flow as designed.

G.6.1 Record Pressure Sensors GP2, GP4, GP6, and GP14.

G.6.2 Command Open GMA Valves V29, V1, V5.

G.6.3 Wait for a pressure rise in Pressure Sensors GP2, GP4, GP6, and GP14 and then record value.

G.6.4 Send HLD 431 (Disable ECU_DEWAR_Htrs AsideHt).

G.6.5 Wait until pressure returns to the values as recorded in M.9.1.1 for Pressure Sensors GP2, GP4, GP6, and GP14 and then record value.

G.6.6 Command Closed GMA Valves V5, V1, (wait 60 sec.)V29

Initiate a low-flow through the B-side GMA and confirm that the HLD for V2 disables gas flow as designed. Reset HLD, evacuate the GMA and re-initialize all GMA valves.

G.6.7 Record Pressure Sensors GP3, GP5, GP6, and GP14.

G.6.8 Command Open GMA Valves V30, V2, V4.

G.6.9 Wait for a pressure rise in Pressure Sensors GP3, GP5, GP6, and GP14 and then record value.

G.6.10 Send HLD 472 (Disable ECU_DEWAR_Htrs BSideHt).

G.6.11 Wait until pressure returns to the values as recorded in M.9.2.1 for Pressure Sensors GP3, GP5, GP6, and GP14 and then record value.

G.6.12 Command Closed GMA Valves V4, V2, (wait 60 sec.) V30

Place GMA into Launch Mode

G.6.13 Start gma_launch.prc

G.7 Gas Flow Path Test

G.7.1 Verify “Open” Fill and Drain Valves (Ensure pumping system is operating and manifold is under vacuum)

Gyro 1, Side B, Primary 725 sccm Flow Path

G.7.2 Record Pressure Sensors GP1,3,5,6,7,8

G.7.3 Manually Open GSE valve OMG1

G.7.4 Command Open GMA Valves V2, V6, V9

G.7.5 Wait for a rise in pressure as monitored by the Pressure Sensors GP7,8

G.7.6 Command Closed GMA Valves V6, V2,

G.7.7 Wait for a fall in pressure as monitored by the Pressure Sensors GP7, GP8

Gyro 1, Side A, Primary 725 sccm Flow Path

G.7.8 Command Open V1, V5

G.7.9 Wait for a rise in pressure as monitored by the Pressure Sensors GP7,8

G.7.10 Command Closed GMA Valves V9

G.7.11 Wait for a fall in pressure as monitored by the Pressure Sensors GP7, GP8

G.7.12 Record Pressure Sensors GP1,2,4,6,7,8

Gyro 1, Side A, Redundant 725 sccm Flow Path

G.7.13 Command Open GMA Valves V10

G.7.14 Wait for a rise in pressure as monitored by the Pressure Sensors GP7,8

G.7.15 Command Closed GMA Valves V10

G.7.16 Wait for a fall in pressure as monitored by the Pressure Sensors GP7, GP8

G.7.17 Record Pressure Sensors GP1,2,4,6,7,8

G.7.18 Manually Close GSE valve OMG1

Gyro 2, Side A, Primary 725 sccm Flow Path

G.7.19 Manually “Open” GSE valve OMG2

G.7.20 Command Open GMA Valves V13

G.7.21 Wait for a rise in pressure as monitored by the Pressure Sensors GP9, 10

G.7.22 Command Closed GMA Valves V13

G.7.23 Wait for a fall in pressure as monitored by the Pressure Sensors GP9, GP10

G.7.24 Record Pressure Sensors GP1,2,4,6, 9,10

Gyro 2, Side A, Redundant 725 sccm Flow Path

G.7.25 Command Open GMA Valves V14

G.7.26 Wait for a rise in pressure as monitored by the Pressure Sensors GP9, 10

G.7.27 Command Closed GMA Valves V14

G.7.28 Wait for a fall in pressure as monitored by the Pressure Sensors GP9, GP10

G.7.29 Record Pressure Sensors GP1,2,4,6, 9,10

G.7.30 Manually Close GSE valve OMG2

Gyro 3, Side A, Primary, 725 sccm Flow Path

G.7.31 Manually “Open” GSE valve OMG3
G.7.32 Command Open GMA Valves V17
G.7.33 Wait for a rise in pressure as monitored by the Pressure Sensors GP11
G.7.34 Command Closed GMA Valves V17
G.7.35 Wait for a fall in pressure as monitored by the Pressure Sensors GP11
G.7.36 Record Pressure Sensors GP1,2,4,6,11

Gyro 3, Side A, Redundant 725 sccm Flow Path

G.7.37 Command Open GMA Valves V18
G.7.38 Wait for a rise in pressure as monitored by the Pressure Sensors GP11
G.7.39 Command Closed GMA Valves V18
G.7.40 Wait for a fall in pressure as monitored by the Pressure Sensors GP11
G.7.41 Record Pressure Sensors GP1,2,4,6,11
G.7.42 Manually Close GSE valve OMG3

Gyro 4, Side A, Primary 725 sccm Flow Path

G.7.43 Manually “Open” GSE valve OMG4
G.7.44 Command Open GMA Valves V19
G.7.45 Wait for a rise in pressure as monitored by the Pressure Sensors GP12, 13
G.7.46 Command Closed GMA Valves V19
G.7.47 Wait for a fall in pressure as monitored by the Pressure Sensors GP12, 13
G.7.48 Record Pressure Sensors GP1,2,4,6,12,13

Gyro 4, Side A, Redundant 725 sccm Flow Path

G.7.49 Command Open GMA Valves V20
G.7.50 Wait for a rise in pressure as monitored by the Pressure Sensors GP12, 13
G.7.51 Command Closed GMA Valves V20
G.7.52 Wait for a fall in pressure as monitored by the Pressure Sensors GP12, 13
G.7.53 Record Pressure Sensors GP1,2,4,6,12,13
G.7.54 Manually Close GSE valve OMG4

Vent, Side A, Primary 725 sccm Flow Path

G.7.55 Manually Open GSE valve OMVent, then Command Open GMA Valves V29
G.7.56 Wait for a rise in pressure as monitored by the Pressure Sensors GP14
G.7.57 Command Closed GMA Valves V29
G.7.58 Wait for a fall in pressure as monitored by the Pressure Sensors GP14
G.7.59 Record Pressure Sensors GP1,2,4,6,14

Vent, Side A, Redundant 725 sccm Flow Path

G.7.60 Command Open GMA Valves V30
G.7.61 Wait for a rise in pressure as monitored by the Pressure Sensors GP14
G.7.62 Command Closed GMA Valves V30
G.7.63 Wait for a fall in pressure as monitored by the Pressure Sensors GP14
G.7.64 Record Pressure Sensors GP1,2,4,6,14,
G.7.65 Manually Close GSE valve OMVent

Place GMA into Launch Mode

G.7.66 Start gma_launch.prc

Flush, Side A, Primary 2 sccm Flow Path

G.7.67 Manually Open GSE valve OMP1A
G.7.68 Command open V1, V3, V25
G.7.69 Wait for 30 seconds
G.7.70 Close V25, V3, V1
G.7.71 Command open V2, V4, V26
G.7.72 Wait for 30 seconds
G.7.73 Close V26, V4, V2
G.7.74 Manually Close GSE valve OMP1A
G.7.75 Finish 15.10.1 Type “Go to GMA End” to compete this procedure.

Section complete. **Quality** _____

G.8 Completion

Started on: _____

G.8.1 Go to GMA Set-Up, Start gma_sleep.prc
G.8.2 Command Off the Flight Vacuum Gauge using p9abvacg_off
G.8.3 Command Off Flight ECU using scfoffecua
G.8.4 Command Off the Flight SRE

G.9 Drawings

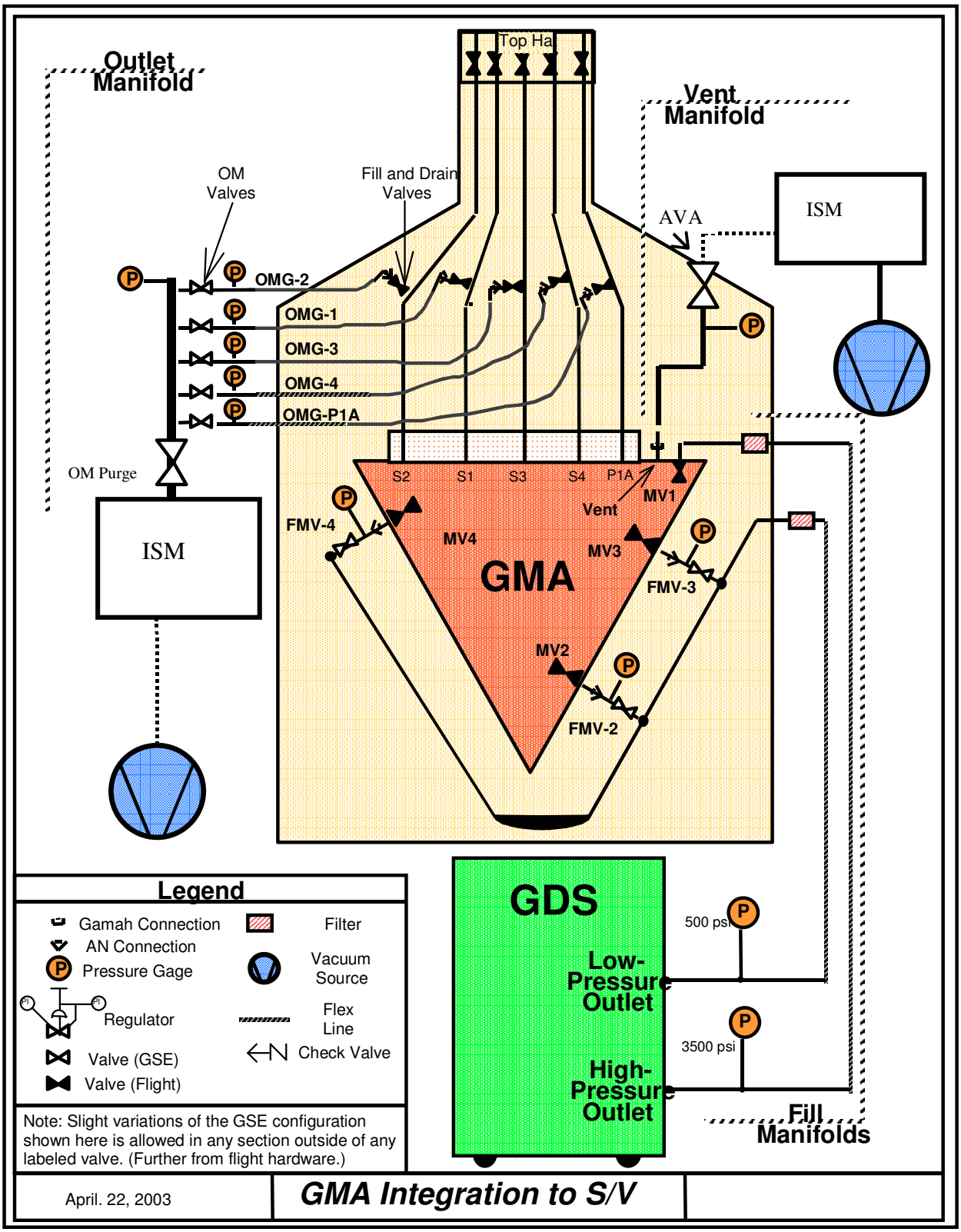
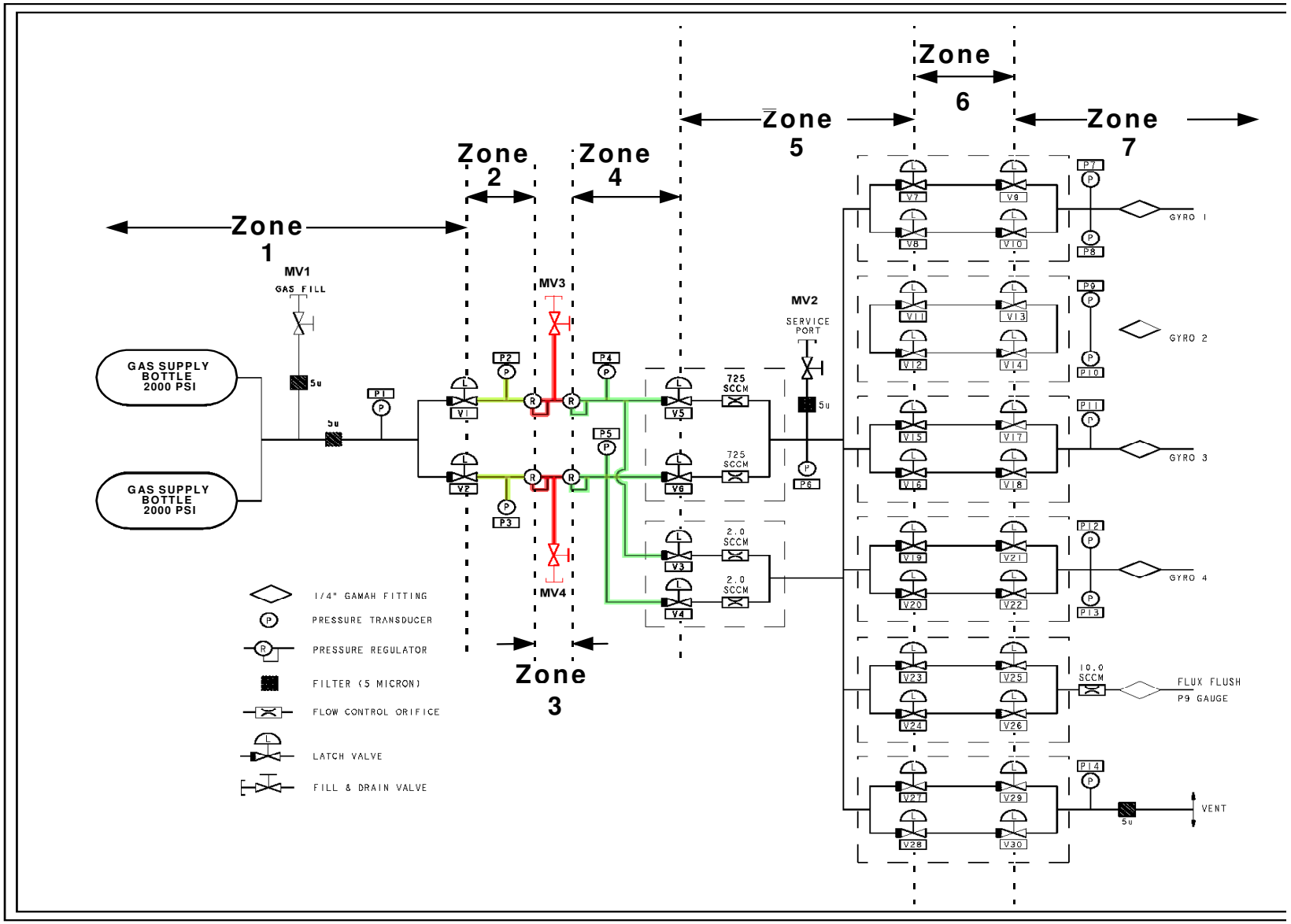


Figure 1



GMA Schematic - Figure 2

G.10 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 each team member is certified for the task being performed and know their individual responsibilities.		
	5. 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.		
	6. Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly.		
	7. 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.		
	8. Verify/Perform an Engineering and Safety high-bay walk down. Ensure all discrepancies are corrected prior to start of operations.		
	9. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: _____		

G.11 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: _____		

G.12 Contingency/Emergency Responses

G.12.1 Emergency Shutdown/ Evacuation

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 (OM Valves, or similar, as applicable to the state of assembly.)
- Record state of all 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, etc.).

G.12.2 Power Failure

In the event of a power failure, the Test Director shall implement similar steps (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.
- 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

Approved: _____ date: _____
QA Representative

Discrepancies if any:

Approved: _____ date: _____
D. Ross, QA