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

INTERNAL LEAKAGE CHECK OF THE FLIGHT GMA

GP-B ENGINEERING PROCEDURE

P0931 Rev A

13 September, 2002

PREPARED _____ _____
R. Stephenson, GMA Engineer — Date

APPROVED _____ _____
C. Gray, GMA REE — Date

APPROVED _____ _____
D. Ross, Quality Assurance — Date

APPROVED _____ _____
R. Brumley, Hardware Manager — Date

REVISION RECORD

REVISION	ECO	PAGES	DATE
A	1384	Added Table and pressure sensor check after step 3.5 Made provisions for the GMA being connected to the GAF, Space vehicle, or free standing. Changed order of some steps to match the "wait" steps in the CSTOL script. Moved GDS connection. This means that the GDS is only connected if necessary. Removed "Put valves into flight configuration" from end of procedure.	9/13/02

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A SCOPE

This procedure checks the internal through leak rate of the solenoid valves on the flight Gas Management Assembly. A leak detector is connected downstream, and the solenoids are pressurized to a 20 psi differential and the steady state leak rate measured. This mimics exactly the leak test performed by Moog.

B SAFETY

The GMA is a gas pressure vessel. Under normal operations, the GMA requires no safety measures or equipment beyond those required for the use of a supply gas cylinder. When any of the systems are pressurized and connected to a vacuum system, be cautious not to vent high pressure through the pumping portions of the system. Only allow high pressure to vent through approved ports and make sure that these are open at time of venting. Note that the GMA is an extremely high value piece of space flight equipment. The GMA tanks are also fracture critical items, so care must be taken not to damage them in any way.

C QUALITY ASSURANCE

C.1 QA Notification

This test 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 Engineer 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 Chris Gray or an alternate that he shall designate. The Engineer has overall responsibility for the implementation of this procedure and shall sign off the completed procedure and relevant sections within it.

E REQUIREMENTS

E.1. Electrostatic Discharge Requirements

N/A

E.2. Lifting Operation Requirements

N/A

E.3. Hardware/Software Requirements

ECU Flight Equivalent Unit (FEU)

Appropriate software for controlling GMA on the spacecraft, this includes a null script which enables command-line control of the GMA.

Flight Gas Management Assembly (GMA)

Gas Delivery System (GDS)

GMA Fill Manifold

GMA Spin up Outlet Manifold.

Vacuum leak detector

Alcatel pump cart (or equivalent dry pumping system)

Clean manual valve

Plumbing lines, cleaned consistently with Class 100 practices

VCR gender changers, elbows, etc. as required, cleaned consistently with Class 100 practices

Class 100 down flow hood, if required

Hand held particle counter, if required

E.4. Instrument Pretest Requirements

All test equipment used in taking data shall be "in calibration" at time of test.

E.5. Configuration Requirements

GMA work will be performed under Class 100 flow hood or in clean room.

E.6. Optional Non-flight Configurations

N/A

E.7. Verification/ Success Criteria

Procedure must measure a leak rate for every GMA solenoid valve (ie. Table 2 is completely filled out).

E.8. Constraints and Restrictions

Normal clean room practices apply under down flow hood and in clean room.

F REFERENCE DOCUMENTS

F.1. Drawings

GMA Schematic, Dwg. Number 26273

F.2. Supporting documentation

S0699 "GMA Leakage Test CSTOL"
S0681 "CSTOL Scripts for GMA Testing"

F.3. Additional Procedures

P0886 "GDS Operations"
P0923 "Connecting and Disconnecting the GMA and the GAF"
P0942 "Bleed Down of the GMA High Pressure"

G OPERATIONS

G.1. Verify Appropriate QA Notification

QA Notified_____ ONR Notified_____

G.2. Verify Configuration Requirements

Verify GMA is situated in a Class 1000 or better clean room or under a Class 100 or better flow hood. If GMA is under flow hood, verify the environment with a hand held particle counter. Counts under the hood must average better than 5 per 0.1 liter measured of size 0.5 micron or greater.

Quality _____

G.3 Setting Up the GMA

Started on: _____

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

WARNING
HELIUM USED IN THE GRAVITY PROBE-B PROGRAM REPRESENTS A HAZARDOUS MATERIAL FOR THE PERSONNEL INVOLVED IN TESTING AND CRYOGENIC SYSTEM OPERATIONS. EXTREME CARE SHOULD BE USED WHEN WORKING AROUND OR WITH HELIUM.

3.1 Connect the ECU FEU to the GMA and start up the ECU and appropriate software.

Record script used here: _____ **Note: Do not cycle any GMA solenoid valves at this time**.

3.2 Use the ECU to read GMA pressure sensors GP1, GP2, GP3, GP4, GP5, and GP6.

3.3 Record their values here:

Table 1, GMA pressures, PSIA:

	GP1	GP2	GP3	GP4	GP5	GP6
Expected	>200	>200	>200	<30	<30	<30
Pressure						

3.4 If GP4, GP5, and GP6 are above 30 psia, bleed the pressure out. Use procedure P0942, if appropriate. Bleed until GP4, GP5, and GP6 pressure is at about 20 psia and record final pressures here:

Table 1A, GMA pressures, PSIA:

	GP1	GP2	GP3	GP4	GP5	GP6
Expected	>200	>200	>200	~20	~20	~20
Pressure						

3.5 If GP1 reads below 200 psia, connect the GDS and the GMA fill manifold to the GMA, if necessary, and use the GDS to fill the tanks to about 250 psia using P0886 for both processes.

3.6 If GMA is installed on the space vehicle, verify that GSE is connected per diagram 2 (Note: the GDS may not be necessary). For this purpose, OMG1, OMG2, OMG3 etc. manual valves (see diagram 1) will be understood as S1, S2, S3 etc. (see diagram 2).

3.7 If the GMA is connected to the GAF, verify that plumbing is connected according to Diagram 4.

3.8 If the GMA is not connected to either, perform the following operations:

3.8.1 Verify that the spin up outlet manifold (including OMP1A and OMVent) is connected to the GMA. If it is not, connect it using procedure P0923.

3.8.2 Connect the pump cart to OMVent per diagram 4, using P0923, if necessary.

3.8.3 Plumb the P1A line together with the spin up manifold, and connect to the and leak detector per diagram 3 using a manual valve designated DP1.

3.9 Verify all outlet manifold manual valves are closed.

3.10 Open DP1 (and FF1 if connected to GAF, see drawing 4) or PC1, if appropriate, and use leak detector to evacuate this plumbing.

3.11 Open outlet manifold manual valves OMG1, OMG2, OMG3, OMG4, and OMP1A and evacuate this area with the leak detector.

3.12 Use the ECU to verify that V1 and V2 are closed.

3.13 Open GMA solenoid valves V3 through V30.

3.14 Use the leak detector to evacuate the downstream portion of the GMA.

3.15 Calibrate the leak detector and record here: date _____ value _____

3.16 Use ECU to close GMA solenoid valves V3, V4, V5, and V6. Wait for the background leak rate to come down to a reasonable level. Record background leak rate here: _____

3.17 Close DP1. GMA now ready for leakage test.

Quality _____

G.4 GMA Internal Leakage Test.

Started on: _____

Note: Mark off each step of procedure as it is completed.
All GMA solenoid valves will be opened with the ECU
Automatic vent on the leak detector should be disabled for this entire section
PC2 is equivalent to OMvent when GMA is connected to the space vehicle.

4.1 Verify that GMA is in the same configuration as in the end of section G.3 (solenoid valves V1 through V6 closed, and V7 through V30 open, outlet manifold valves OMG1, OMG2, OMG3, OMG4, and OMP1A open and under vacuum).

4.2 Use the ECU to open GMA solenoid valves V3 and V5.

4.3 Open manual valve DP1. Start leak detector.

4.4 Wait ten minutes or until a stable leak rate is reached.

4.5 Record leak rate from V1 in Table 2.

4.6 Open solenoid valves V4 and V6.

4.7 Close solenoid valves V3 and V5.

4.8 Wait ten minutes or until a stable leak rate is reached.

4.9 Record leak rate from V2 in Table 2.

4.10 Close solenoid valves V4 and V6.

4.11 Open solenoid valve V1.

4.12 Wait ten minutes or until a stable leak rate is reached.

4.13 Record leak rate from V3 and V5 in Table 2.

4.14 Close GMA solenoid valve V1.

4.15 Verify automatic vent is disabled and stop leak detector.

4.16 Open solenoid valves V3 and V5 and start leak detector to evacuate.

4.17 After leak detector goes into test mode, wait one minute.

4.18 Close solenoid valves V3 and V5.

4.19 Wait for a sufficiently low background leak rate. Record background here _____.

4.20 Open solenoid valve V2.

4.21 Wait ten minutes or until a stable leak rate is reached.

4.22 Record leak rate from V4 and V6 in Table 2.

4.23 Close solenoid valves V7, V8, and V10-V30 (note: leave V9 open).

4.24 Close Outlet manifold manual valves OMG2, OMG3, OMG4, and OMP1A.

4.25 Open solenoid valves V1, V2, V3, V4, V5, and V6.

4.26 Wait ten minutes or until a stable leak rate is reached.

4.27 Record leak rate from V7 in Table 2.

4.28 Close solenoid valve V9 and open solenoid valve V10.

4.29 Wait ten minutes or until a stable leak rate is reached.

4.30 Record leak rate from V8 in Table 2.

4.31 Close solenoid valve V10 and open solenoid valve V7.

4.32 Wait ten minutes or until a stable leak rate is reached.

4.33 Record leak rate from V9 in Table 2.

4.34 Close solenoid valve V7

4.35 Verify automatic vent is disabled and stop leak detector.

4.36 Open V9.

4.37 Start leak detector to evacuate.

4.38 Wait one minute after leak detector goes into test mode and close V9.

4.39 Wait for a sufficiently low background leak rate. Record background here _____.

4.40 Open solenoid valve V8.

4.41 Wait ten minutes or until a stable leak rate is reached.

4.42 Record leak rate from V10 in Table 2.

4.43 Close solenoid valve V8.

4.44 Close Outlet Manifold Manual Valve OMG1.

4.45 Open Outlet Manifold Manual Valve OMG2.

4.46 Open V13.

4.47 Wait ten minutes or until a stable leak rate is reached.

4.48 Record leak rate from V11 in Table 2.

4.49 Close V13 and open V14.

4.50 Wait ten minutes or until a stable leak rate is reached.

4.51 Record leak rate from V12 in Table 2.

4.52 Close V14 open V11.

4.53 Wait ten minutes or until a stable leak rate is reached.

4.54 Record leak rate from V13 in Table 2.

4.55 Close solenoid valve V11

4.56 Verify automatic vent is disabled and stop leak detector.

4.57 Open V13.

4.58 Start leak detector to evacuate.

4.59 Wait one minute after leak detector goes into test mode and close V13.

4.60 Wait for a sufficiently low background leak rate. Record background here _____.

4.61 Open solenoid valve V12.

4.62 Wait ten minutes or until a stable leak rate is reached.

4.63 Record leak rate from V14 in Table 2.

4.64 Close V12.

4.65 Close OMG2 and open OMG3.

4.66 Open V17.

4.67 Wait ten minutes or until a stable leak rate is reached.

4.68 Record leak rate from V15 in Table 2.

4.69 Close V17 and open V18.

4.70 Wait ten minutes or until a stable leak rate is reached.

4.71 Record leak rate from V16 in Table 2.

4.72 Close V18 and open V15.

4.73 Wait ten minutes or until a stable leak rate is reached.

4.74 Record leak rate from V17 in Table 2.

4.75 Close solenoid valve V15.

4.76 Verify automatic vent is disabled and stop leak detector.

4.77 Open V17.

4.78 Start leak detector to evacuate.

4.79 Wait one minute after leak detector goes into test mode and close V17.

4.80 Wait for a sufficiently low background leak rate. Record background here _____.

4.81 Open solenoid valve V16.

4.82 Wait ten minutes or until a stable leak rate is reached.

4.83 Record leak rate from V18 in Table 2.

4.84 Close V16.

4.85 Close OMG3 and open OMG4.

4.86 Open V21

4.87 Wait ten minutes or until a stable leak rate is reached.

4.88 Record leak rate from V19 in Table 2.

4.89 Close V21 and open V22.

4.90 Wait ten minutes or until a stable leak rate is reached.

4.91 Record leak rate from V20 in Table 2.

4.92 Close V22 and open V19.

4.93 Wait ten minutes or until a stable leak rate is reached.

4.94 Record leak rate from V21 in Table 2.

4.95 Close solenoid valve V19.

4.96 Verify automatic vent is disabled and stop leak detector.

4.97 Open V21.

4.98 Start leak detector to evacuate.

4.99 Wait one minute after leak detector goes into test mode and close V21.

4.100 Wait for a sufficiently low background leak rate. Record background here _____.

4.101 Open solenoid valve V20.

4.102 Wait ten minutes or until a stable leak rate is reached.

4.103 Record leak rate from V22 in Table 2.

4.104 Close V20.

4.105 Close OMG4 and open OMP1A.

4.106 Open V25

4.107 Wait ten minutes or until a stable leak rate is reached.

4.108 Record leak rate from V23 in Table 2.

4.109 Close V25 and open V26.

4.110 Wait ten minutes or until a stable leak rate is reached.

4.111 Record leak rate from V24 in Table 2.

4.112 Close V26 and open V23.

4.113 Wait ten minutes or until a stable leak rate is reached.

4.114 Record leak rate from V25 in Table 2.

4.115 Close solenoid valve V23.

4.116 Verify automatic vent is disabled and stop leak detector.

4.117 Open V25.

4.118 Start leak detector to evacuate.

4.119 Wait one minute after leak detector goes into test mode and close V25.

4.120 Wait for a sufficiently low background leak rate. Record background here _____.

4.121 Open solenoid valve V24.

4.122 Wait ten minutes or until a stable leak rate is reached.

4.123 Record leak rate from V26 in Table 2.

4.124 Close V24.

4.125 Close OMP1A and DP1 and disconnect leak detector.

4.126 Connect leak detector to BV1.

4.127 Open BV1 and start leak detector to evacuate plumbing.

4.128 After leak detector goes into test mode, verify automatic vent is disabled and stop leak detector.

4.129 Open OMvent and start leak detector.

4.130 Open V29.

4.131 Wait ten minutes or until a stable leak rate is reached.

4.132 Record leak rate from V27 in Table 2.

4.133 Close V29 and open V30.

4.134 Wait ten minutes or until a stable leak rate is reached.

4.135 Record leak rate from V28 in Table 2.

4.136 Close V30 and open V27.

4.137 Wait ten minutes or until a stable leak rate is reached.

4.138 Record leak rate from V29 in Table 2.

4.139 Close solenoid valve V27.

4.140 Verify automatic vent is disabled and stop leak detector.

4.141 Open V29.

4.142 Start leak detector to evacuate.

4.143 Wait one minute after leak detector goes into test mode and close V29.

4.144 Wait for a sufficiently low background leak rate. Record background here _____.

4.145 Open solenoid valve V28.

4.146 Wait ten minutes or until a stable leak rate is reached.

4.147 Record leak rate from V30 in Table 2.

4.148 Close OMvent and BV1.

4.149 Stop the leak detector without venting.

Quality _____

G.5 GMA Final Configuration

Started on: _____

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

5.1 Verify Table 2 is completely filled out.

5.2 Read GP1 using the ECU and record final pressure here: _____

5.3 If desired, the tank pressure may be bled out using P0942.

5.4 Verify all outlet manifold manual valves are closed.

5.5 Use the ECU to close all solenoid valves.

5.6 The GMA is now safely filled to about 20 psia downstream.

5.7 Shut down the leak detector and remove any unneeded GSE.

Quality _____

G.6 Tables

Table 2, Solenoid valve leak rates

Solenoid Valve	Leak rate SCCS	Test Engineer initial	Quality Stamp	Solenoid Valve	Leak rate SCCS	Test Engineer initial	Quality Stamp
V1*				V17			
V2*				V18			
V3 + V5				V19			
V4 +V6				V20			
V7				V21			
V8				V22			
V9				V23			
V10				V24			
V11				V25			
V12				V26			
V13				V27			
V14				V28			
V15				V29			
V16				V30			
*200+ psi differential							

G.7 Diagrams

Diagram 1, GMA Schematic

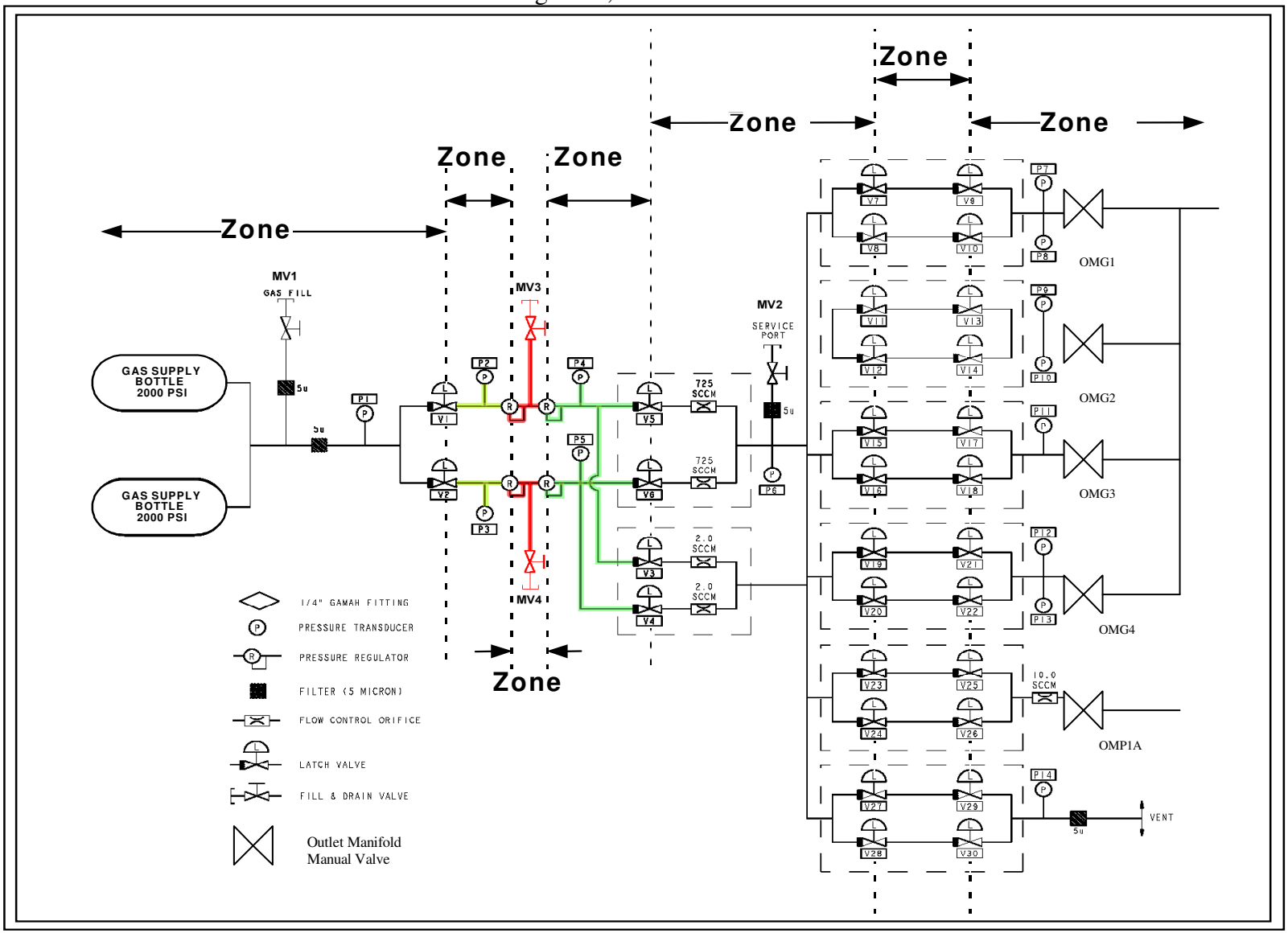


Diagram 2, GMA and Space Vehicle

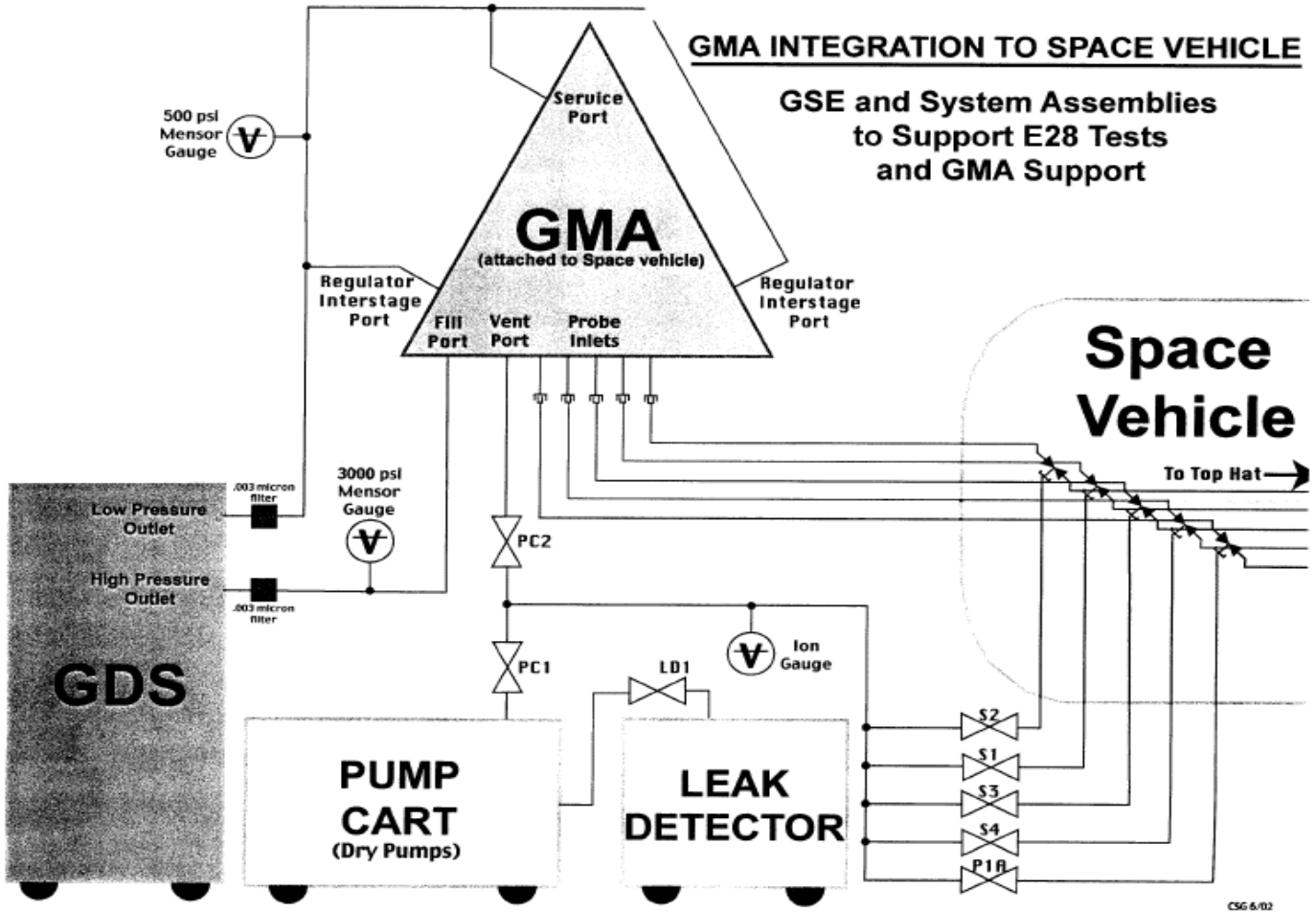
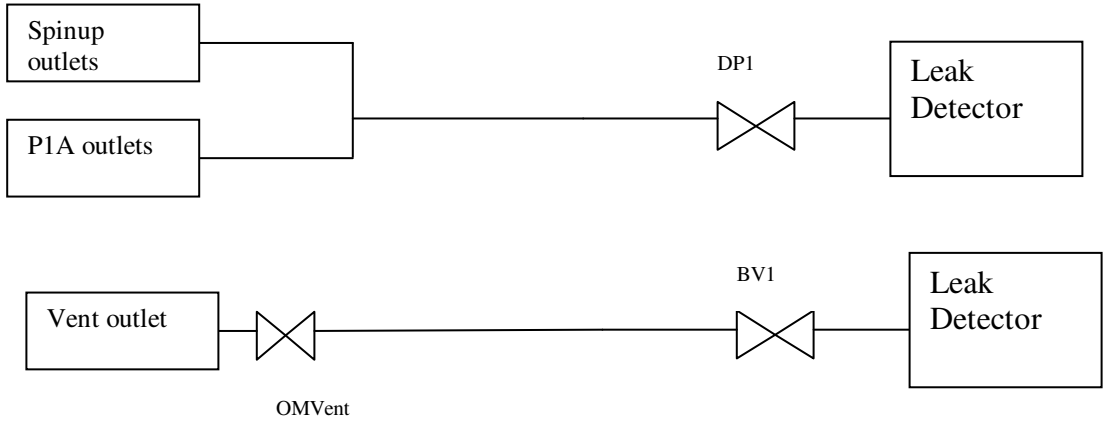


Diagram 3, Vacuum system Plumbing



GMA Interfaced with Gyro Acceptance Facility

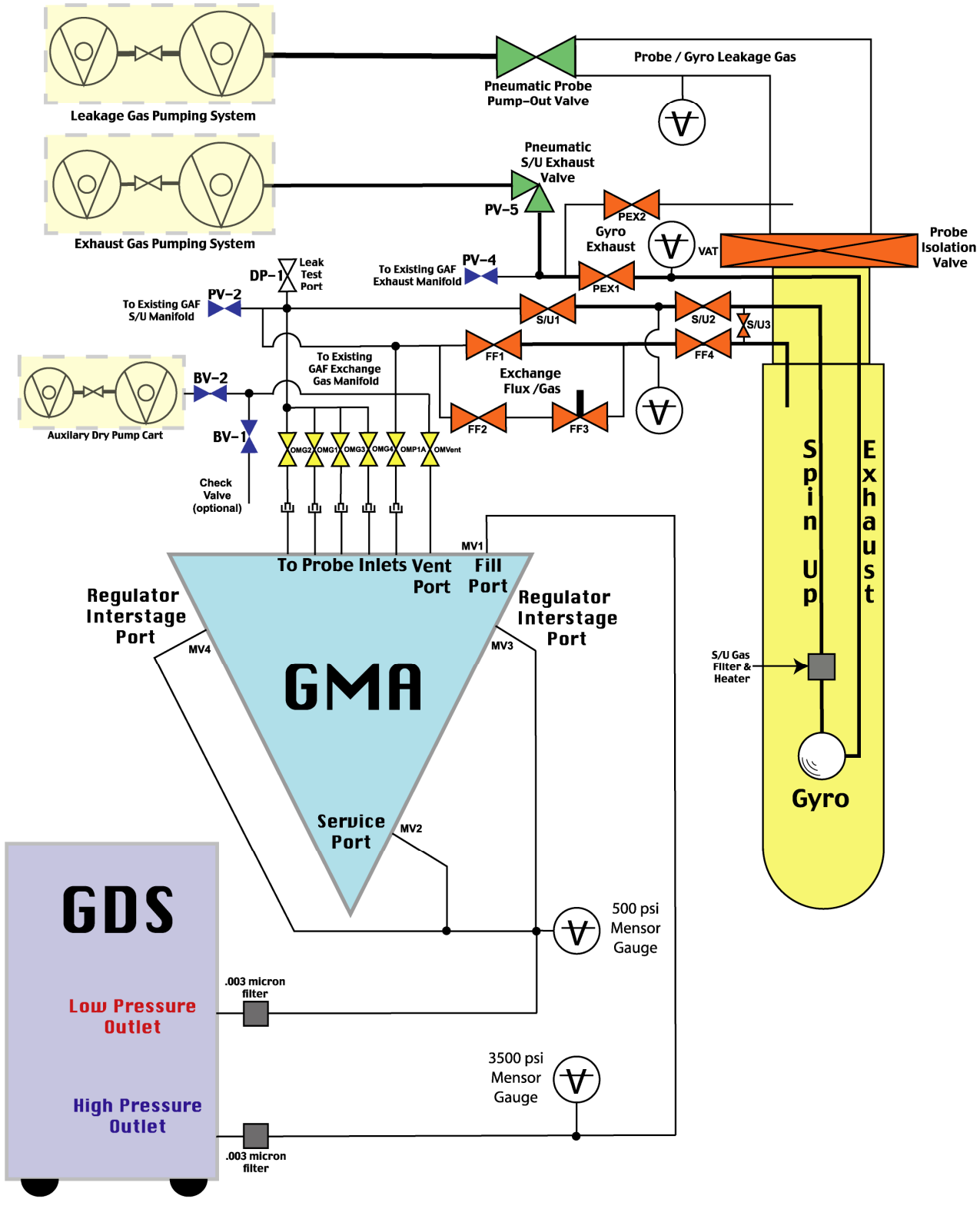


Diagram 4, GMA and GAF Schematic

G.8 PRE-TEST CHECKLIST

DATE	PROCEDURE #	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 PRE-STAGED AND AVAILABLE IN THE TEST AREA.		
		4. VERIFY ALL HAZARDOUS MATERIALS INVOLVED IN THE TEST ARE IDENTIFIED TO THE TEST TEAM.		
		5. IF HELIUM IS TO BE USED VERIFY THAT A BLUE "HELIUM" TAG IS AROUND THE NECK OF THE HELIUM CYLINDER.		
		6. VERIFY ALL HAZARDOUS STEPS TO BE PERFORMED ARE IDENTIFIED TO THE TEST TEAM.		
		7. VERIFY EACH TEAM MEMBER KNOWS THEIR INDIVIDUAL RESPONSIBILITIES.		
		8. 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. **NOTE**: **DURING A HAZARDOUS OPERATION THE TEST WILL ONLY BE STOPPED WHEN IT IS SAFE TO DO SO**.		
		9. CONFIRM THAT EACH TEST TEAM MEMBER CLEARLY UNDERSTANDS THAT HE/SHE HAS THE AUTHORITY TO STOP THE TEST IF THERE IS ANY ANOMALY OR SUSPECTED ANOMALY **NOTE: DURING A HAZARDOUS OPERATION THE TEST WILL ONLY BE STOPPED WHEN IT IS SAFE TO DO SO**		
		10. NOTIFY MANAGEMENT OF ALL DISCREPANCY REPORTS OR D-LOG ITEMS IDENTIFIED DURING THE PROCEDURE. IN THE EVENT AN INCIDENT OCCURS DURING PROCEDURE PERFORMANCE, MANAGEMENT WILL BE NOTIFIED IMMEDIATELY.		
		11. CONFIRM THAT EACH TEST TEAM MEMBER UNDERSTANDS THAT THERE WILL BE A POST-TEST TEAM MEETING.		
		TEAM LEAD SIGNATURE:		

G.9 POST-TEST CHECKLIST

DATE	PROCEDURE #	CHECKLIST ITEM	COMPLETED	REMARKS
		1- VERIFY ALL STEPS IN THE PROCEDURE WERE SUCCESSFULLY COMPLETED.		
		2- VERIFY ALL MINOR/MAJOR DISCREPANCIES DISCOVERED DURING TESTING ARE PROPERLY DOCUMENTED.		
		3- ENSURE MANAGEMENT HAS BEEN NOTIFIED OF ALL MINOR/MAJOR DISCREPANCIES.		
		4- ENSURE THAT ALL STEPS THAT WERE NOT REQUIRED TO BE PERFORMED ARE PROPERLY IDENTIFIED.		
		5- IF APPLICABLE SIGN-OFF TEST COMPLETION.		
		TEAM LEAD SIGNATURE		

H PROCEDURE SIGN OFF

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

_____ date: _____
Test Director

Discrepancies if any:

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

Approved: _____ date: _____
QA Representative

Approved: _____ date: _____
D. Ross, QA