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

VERIFICATION OF GMA OUTLET FLOW RATES

GP-B ENGINEERING PROCEDURE

P0943 Rev –

20 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

TABLE OF CONTENTS

REVISION RECORD

REVISION	ECO	PAGES	DATE

A SCOPE

This procedure connects the Probe Impedance Simulation Manifold (ISM) to the Gyro Acceptance Facility (GAF) in order to measure the helium flow rates of all flow paths in the flight Gas Management Assembly (GMA). This manifold simulates the flow impedance of the flight probe and has flow meters to measure the helium flow.

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. Note that the GMA is a high value space flight item. Also, the GMA tanks are 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 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 Chris Gray or an alternate that he shall designate. The Director 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

Flight Gas Management Assembly (GMA)

ECU Flight Equivalent Unit (FEU)

GMA outlet manifold

Gyro Acceptance Facility

Impedance Simulation Manifold (ISM)

Gas Delivery System (GDS) (optional)

GMA fill manifold (optional)

Vacuum system (Alcatel pump cart or equivalent)

CSTOL script “gma_null.prc”

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 must be connected to the GAF per P0923

E.6. Optional Non-flight Configurations

N/A

E.7. Verification/ Success Criteria

Flows for every path through a given flow orifice should be consistent with expected values to within 20%.

E.8. Constraints and Restrictions

none

F REFERENCE DOCUMENTS

F.1. Drawings

GMA Schematic, Dwg. Number 26273

F.2. Supporting documentation

none

F.3. Additional Procedures

P0930 GMA Sleep

P0886 Gas Delivery System Operations (optional)

G OPERATIONS

G.1. Verify Appropriate QA Notification

QA Notified_____ ONR Notified_____

G.2. Verify Configuration Requirements

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.

GMA is connected to the GAF.
There is no gyroscope levitated in the GAF, and the GAF is otherwise in a safe mode.
Top Hat Spinup Valves are closed (S/U2, S/U3).
Manual valve "OMVent-2" is installed per D-log to P0923
Sufficient helium must be in the GMA tanks to complete the procedure.
GMA zones downstream of the internal pressure regulators are not pressurized to greater than 30 psia (i.e. GMA regulators have not been "locked up").

Quality _____

G.3 Setup of GMA

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

3.1 Start the ECU and run script "load_gma.prc".

3.2 Connect the ISM Gyroscope port to DP1 on the GAF.

3.3 Verify that ISM flow meters have been powered up for at least 15 minutes and set zero point on flow meters.

3.4 Verify that GAF manual valve FF1 is open.

3.5 Verify that ISM manual valves F1, F2, B1, F5, F3, F4, and B2 are firmly closed.

3.6 Connect vacuum pump to ISM valve E2.

3.7 Start vacuum pump.

3.8 Slowly open ISM manual valves E2, E1, M1, and M2.

3.9 Once pressure stabilizes at the vacuum pump, close ISM manual valve E1 and slowly open ISM manual valve B1.

3.10 Once pressure stabilizes at the vacuum pump, slowly open GAF manual valve DP1.

3.11 Once pressure stabilizes at the vacuum pump, slowly open outlet manifold manual valves OMG1, OMG2, OMG3, OMG4, OMP1A, OMVent, and OMVent2.

Quality _____

G.4 Verification of Flow Rates

Started on: _____

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

4.1 Verify that section G.3 is complete.

4.2 Load CSTOL script "gma_null.prc"

4.3 Use ECU to put GMA solenoid valves into a launch configuration.

4.4 Close ISM manual valve B1 and open ISM manual valve F2.

725 sccm flow path, side A

4.5 Open GMA solenoid valves V1, V5, and V9.

4.6 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro1A.

4.7 Close GMA solenoid valve V9 and open V10.

4.8 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro1B.

4.9 Close GMA solenoid valve V10 and open V13.

4.10 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro2A.

4.11 Close GMA solenoid valve V13 and open V14.

4.12 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro2B.

4.13 Close GMA solenoid valve V14 and open V17.

4.14 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro3A.

4.15 Close GMA solenoid valve V17 and open V18.

4.16 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro3B.

4.17 Close GMA solenoid valve V18 and open V19.

4.18 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro4A.

4.19 Close GMA solenoid valve V19 and open V20.

4.20 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro4B.

4.21 Close GMA solenoid valve V20 and open V25.

4.22 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Flux Flush A (expected <10 sccm)..

4.23 Close GMA solenoid valve V25 and open V26.

4.24 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Flux Flush B (expected <10 sccm).

4.25 Close GMA solenoid valve V26 and open V29.

4.26 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for VentA.

4.27 Close GMA solenoid valve V29 and open V30.

4.28 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for VentB.

4.29 Close V30.

All flow paths nominal.

Test engineer: _____

Quality: _____

725 sccm flow path, side B

4.30 Close GMA solenoid valves V5 and V1.

4.31 Open GMA solenoid valves V2, V6 and V9.

4.32 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro1A.

4.33 Close GMA solenoid valve V9 and open V10.

4.34 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro1B.

4.35 Close GMA solenoid valve V10 and open V13.

4.36 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro2A.

4.37 Close GMA solenoid valve V13 and open V14.

4.38 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro2B.

4.39 Close GMA solenoid valve V14 and open V17.

4.40 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro3A.

4.41 Close GMA solenoid valve V17 and open V18.

4.42 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro3B.

4.43 Close GMA solenoid valve V18 and open V19.

4.44 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro4A.

4.45 Close GMA solenoid valve V19 and open V20.

4.46 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for Gyro4B.

4.47 Close GMA solenoid valve V20 and open V29.

4.48 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for VentA.

4.49 Close GMA solenoid valve V29 and open V30.

4.50 Wait until a stable flow is reached and record flow rate from FM2 in Table 1 for VentB.

4.51 Close V30.

All flow paths nominal.

Test engineer: _____

Quality: _____

2 sccm flow path, side A

4.52 Close GMA solenoid valves V6 and V2.

4.53 Close ISM manual valve F2 and open F1.

4.54 Open GMA solenoid valves V1, V3 and V9.

4.55 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro1A.

4.56 Close GMA solenoid valve V9 and open V10.

4.57 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro1B.

4.58 Close GMA solenoid valve V10 and open V13.

4.59 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro2A.

4.60 Close GMA solenoid valve V13 and open V14.

4.61 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro2B.

4.62 Close GMA solenoid valve V14 and open V17.

4.63 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro3A.

4.64 Close GMA solenoid valve V17 and open V18.

4.65 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro3B.

4.66 Close GMA solenoid valve V18 and open V19.

4.67 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro4A.

4.68 Close GMA solenoid valve V19 and open V20.

4.69 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro4B.

4.70 Close GMA solenoid valve V20 and open V25.

4.71 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Flux Flush A

4.72 Close GMA solenoid valve V25 and open V26.

4.73 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Flux Flush B.

4.74 Close V26.

All flow paths nominal.

Test engineer: _____

Quality: _____

2 sccm flow path, side B

4.75 Close GMA solenoid valves V3 and V1.

4.76 Open GMA solenoid valves V2, V4, and V9.

4.77 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro1A.

4.78 Close GMA solenoid valve V9 and open V10.

4.79 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro1B.

4.80 Close GMA solenoid valve V10 and open V13.

4.81 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro2A.

4.82 Close GMA solenoid valve V13 and open V14.

4.83 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro2B.

4.84 Close GMA solenoid valve V14 and open V17.

4.85 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro3A.

4.86 Close GMA solenoid valve V17 and open V18.

4.87 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro3B.

4.88 Close GMA solenoid valve V18 and open V19.

4.89 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro4A.

4.90 Close GMA solenoid valve V19 and open V20.

4.91 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Gyro4B.

4.92 Close GMA solenoid valve V20 and open V25.

4.93 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Flux Flush A

4.94 Close GMA solenoid valve V25 and open V26.

4.95 Wait until a stable flow is reached and record flow rate from FM1 in Table 1 for Flux Flush B.

4.96 Close V26, V4, and V2.

All flow paths nominal.

Test engineer: _____

Quality: _____

GMA Sleep

4.97 Open ISM manual valve B1.

4.98 Wait for pressure to stabilize at the vacuum pump.

4.99 Close outlet manifold manual valves OMG1, OMG2, OMG3, OMG4, OMP1A, OMVent, and OMVent2.

4.100 Close DP1.

4.101 Close ISM manual valves B1 and E2 and shut down vacuum pump.

4.102 Disconnect any unnecessary GSE.

4.103 Run P0930, “GMA Sleep”.

Quality: _____

G.6 Diagrams

Diagram 1: GMA Schematic

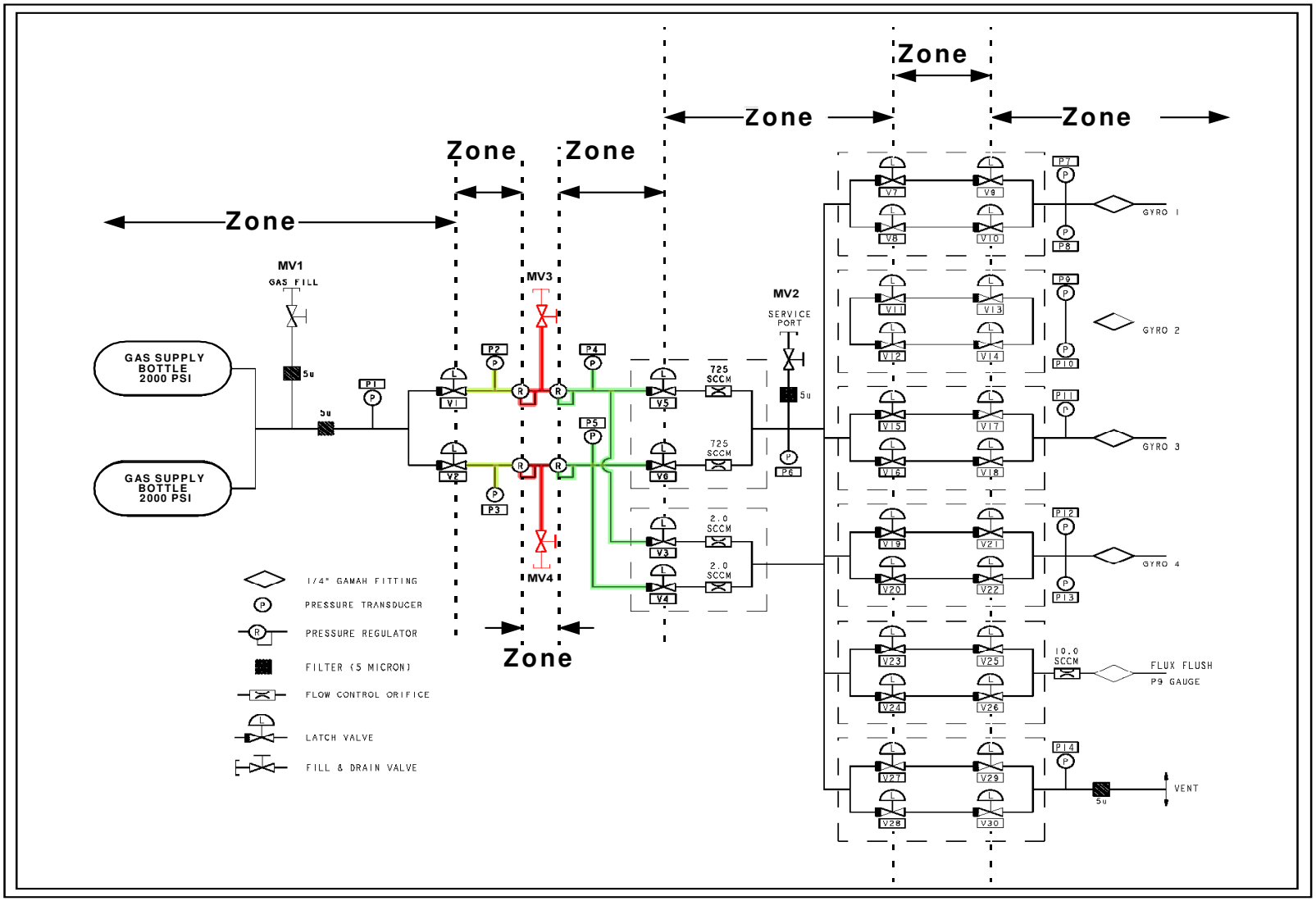
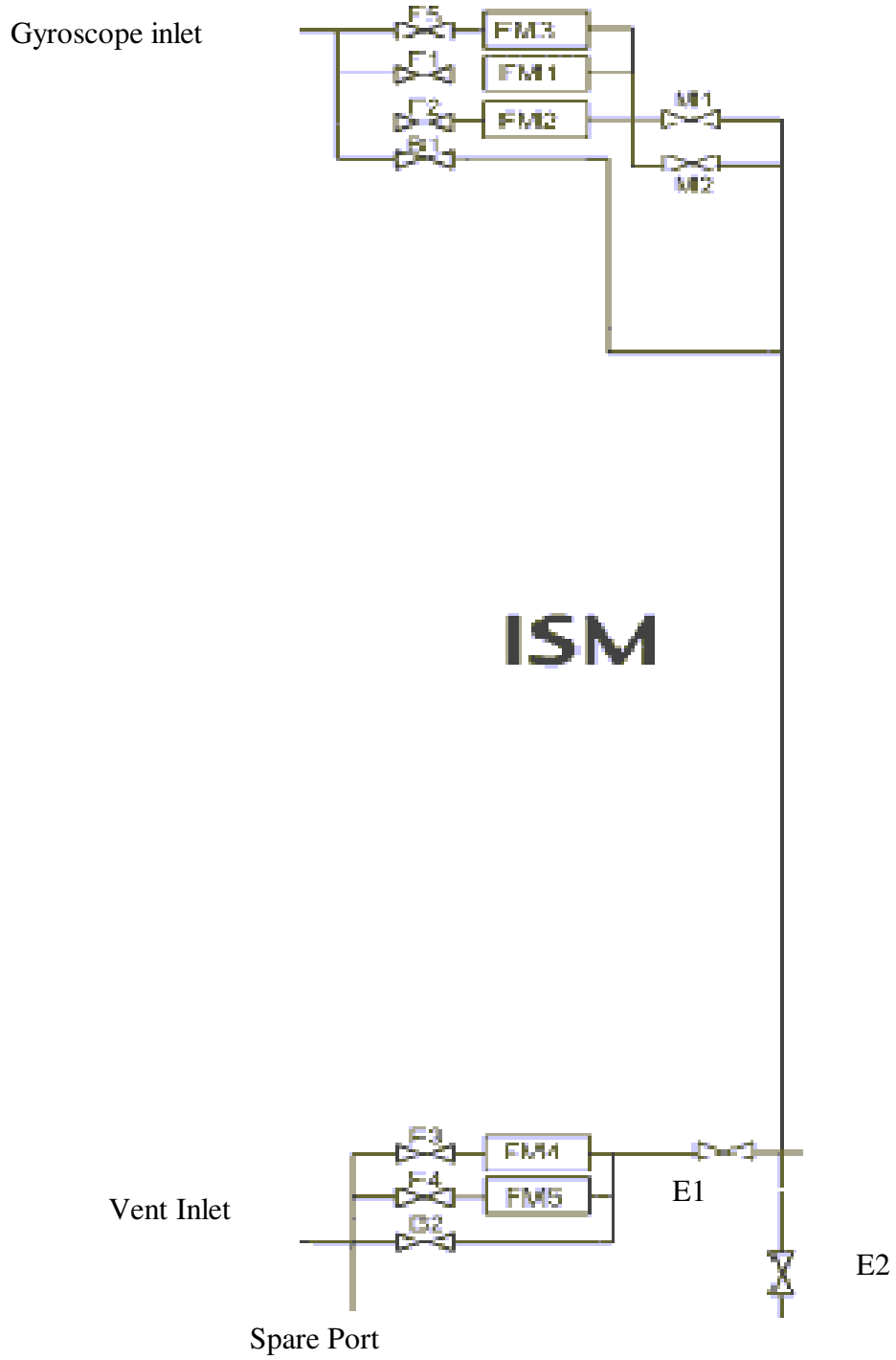


Diagram 2, ISM schematic



GMA Interfaced with Gyro Acceptance Facility

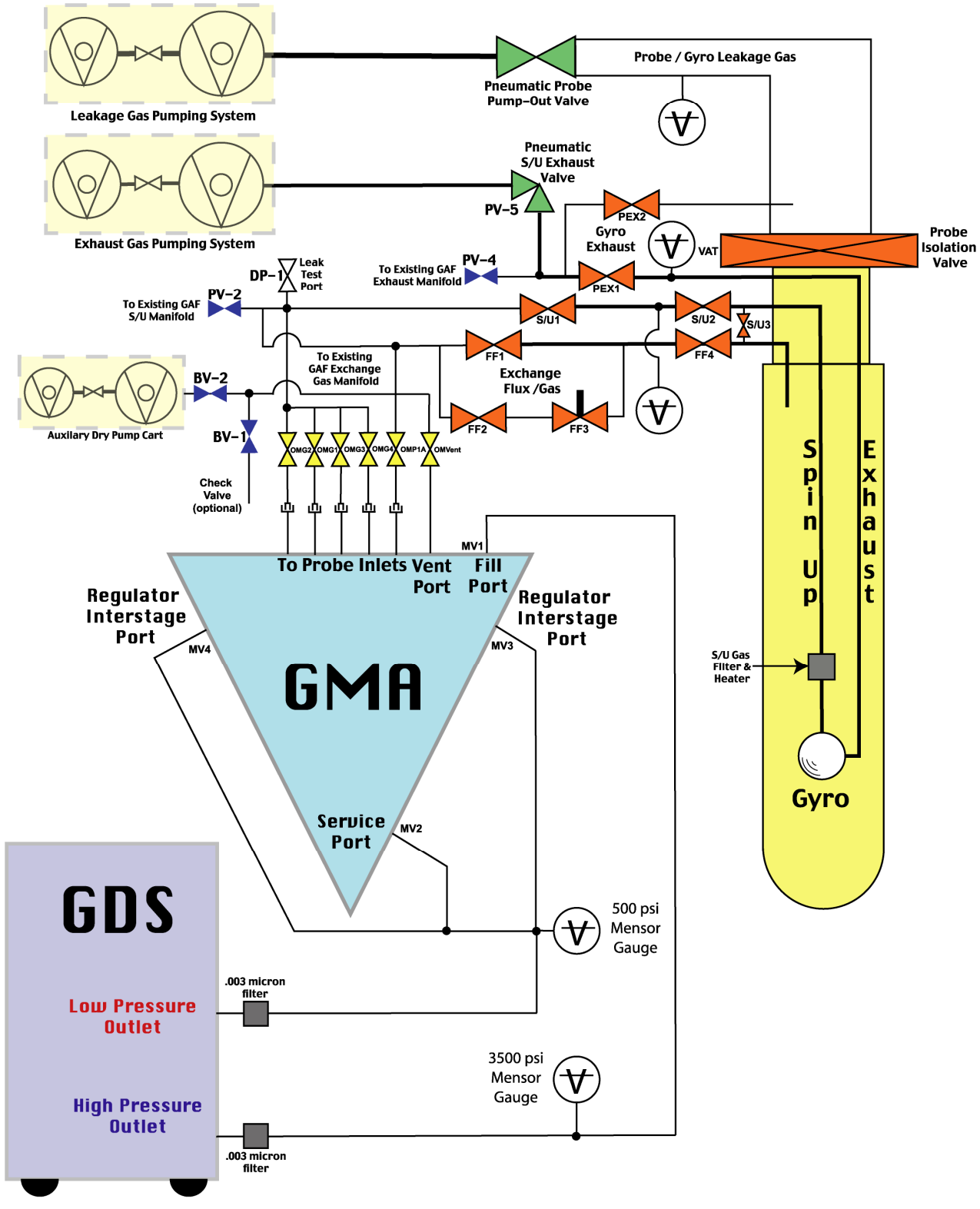


Diagram 3

G.8 Tables

Table 1: GMA flow rates

Gas Path	Regulator Path	Flow Rate	Test Engineer Initial	QA stamp
725 sccm A	Gyro 1A			
725 sccm A	Gyro 1B			
725 sccm A	Gyro 2A			
725 sccm A	Gyro 2B			
725 sccm A	Gyro 3A			
725 sccm A	Gyro 3B			
725 sccm A	Gyro 4A			
725 sccm A	Gyro 4B			
725 sccm A	Flux Flush A			
725 sccm A	Flux Flush B			
725 sccm A	Vent A			
725 sccm A	Vent B			
725 sccm B	Gyro 1A			
725 sccm B	Gyro 1B			
725 sccm B	Gyro 2A			
725 sccm B	Gyro 2B			
725 sccm B	Gyro 3A			
725 sccm B	Gyro 3B			
725 sccm B	Gyro 4A			
725 sccm B	Gyro 4B			
725 sccm B	Vent A			
725 sccm B	Vent B			

2 sccm A	Gyro 1A			
2 sccm A	Gyro 1B			
2 sccm A	Gyro 2A			
2 sccm A	Gyro 2B			
2 sccm A	Gyro 3A			
2 sccm A	Gyro 3B			
2 sccm A	Gyro 4A			
2 sccm A	Gyro 4B			
2 sccm A	Flux Flush A			
2 sccm A	Flux Flush B			
2 sccm B	Gyro 1A			
2 sccm B	Gyro 1B			
2 sccm B	Gyro 2A			
2 sccm B	Gyro 2B			
2 sccm B	Gyro 3A			
2 sccm B	Gyro 3B			
2 sccm B	Gyro 4A			
2 sccm B	Gyro 4B			
2 sccm B	Flux Flush A			
2 sccm B	Flux Flush B			

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