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

CALIBRATION OF THE GMA PRESSURE TRANSDUCERS

GP-B ENGINEERING PROCEDURE

P0940 Rev –

29 August, 2002

PREPARED _____ _____
R. Stephenson, GMA Engineer Date

APPROVED _____ _____
D. Meriwether, ECU Engineer Date

APPROVED _____ _____
C. Gray, GMA REE Date

APPROVED _____ _____
D. Ross, Quality Assurance Date

APPROVED _____ _____
R. Brumley, Hardware Manager Date

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REVISION RECORD

REVISION	ECO	PAGES	DATE

A SCOPE

This procedure calibrates the Flight ECU for use with the flight GMA pressure sensors. This will be performed after the GMA has been installed on the space vehicle and connected to the ECU. At this point it will be pressurized to 300 psi. The GMA will first be bled down to about 20 psia using P0942. Then it will be evacuated slowly, and readings taken at different pressures. The readings for the high-pressure transducers (GP1, GP2, and GP3) will be taken during the fill operation (P0886). From these readings, calibration CSTOL scripts will be created for the ECU. This will enable the ECU to read out actual pressures during flight.

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 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

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

Flight GMA

Flight ECU

GMA fill manifold

Gas Delivery System (GDS)

500 psia Mensor gauge, calibrated

3500 psia Mensor gauge, calibrated

Manifold connecting dewar spinup fill and drain valves together (See diagram 1)

Vacuum system (Alcatel pump cart or equivalent)

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 flight ECU using the flight cables

E.6. Optional Non-flight Configurations

N/A

E.7. Verification/ Success Criteria

This procedure takes data for calibration. It is considered successful when Table 1 is completely filled out.
Calibrations will be verified in subsequent operations.

E.8. Constraints and Restrictions

none

F REFERENCE DOCUMENTS

F.1. Drawings

GMA Schematic, Dwg. Number 26273

F.2. Supporting documentation

S0681 "CSTOL Scripts for GMA Testing"

F.3. Additional Procedures

P0886 Gas Delivery System Operations
P0942 GMA Bleed Down Procedure

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 mounted on the Space Vehicle and connected to the flight spinup gas plumbing.
It is also connected to the Flight ECU.
Top Hat Spinup Valves are closed.
Note: This procedure can be rehearsed at Stanford using the ECU FEU while connected to the GAF, if desired. Note necessary changes in a D-log.

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 Start the null script for GMA use, and close/verify closed all the GMA solenoid valves.

3.3 Verify that the dewar fill and drain valves are manifolded together and connected to a vacuum system per Diagram 1.

3.4 Verify that the GMA vent is connected to the vacuum system per Diagram 1.

3.5 Verify that the 500 and 3500 psia Mensor gauges are connected to the GMA via the GMA fill manifold as per Diagram 1 and their lines have been evacuated.

3.6 Verify that pressure at 500 psia Mensor gauge is below 0.05 psia.

3.7 Open GMA fill-and-drain valve MV2. The Mensor now shows the pressure of Zone 4 in the GMA.

3.8 Read the pressure in Zone 4 (on the 500 psia Mensor gauge).

3.9 If the pressure is greater than 30 psia, perform P0942 "GMA Bleed Down Procedure" using existing plumbing. Do not bleed the GMA tanks.

3.10 Verify that pressure in Zone 4 (500 psia Mensor gauge) is below 30 psia.

3.11 Start vacuum system and open manual valves PC2 and PC1.

3.12 Open the GMA off pallet fill-and-drain valves.

3.13 Open manual valves S1, S2, S3, S4, and P1A (see Diagram 1) and evacuate plumbing.

Note: These are NOT the valves at the top hat, but rather GSE valves added for GMA testing only.

3.14 Close PC1.

Quality _____

G.4 GMA Downstream Pressure Transducer Calibration

Started on: _____

Note: Mark off each step of procedure as it is completed.
The second and third runs of this section (steps 14 and 15) are simply back up runs to pick up any points that may have been missed on the first and to correct anomalous points.

4.1 Verify that section G.3 is complete.

4.2 Close PC1 and GMA solenoid valves V1 and V2.

4.3 Open GMA solenoid valves V3, V4, V5, V6, V7, V8, V9, V10, V11, V12, V13, V14, V15, V16, V17, V18, V19, V20, V21, V22, V23, V24, V25, V26, V27, V28, V29, and V30.

4.4 Read the counts at GP4 and GP5.

4.5 If the counts are between 28000 and 32700, record the pressure and counts in the "28000–32700" columns of Table 1.

4.6 Crack open PC1 and evacuate the GMA until either GP4 or GP5 fall below 21000 counts or GP6 falls below 32700 counts.

4.7 Record pressure and counts in appropriate sections of Table 1 ("28000–32700" column or "17000–21000 columns").

4.8 Continue to slowly evacuate the GMA using PC1 as a throttle stopping and recording counts as they are available to fill out the last three pairs of columns in Table 1 for all sensors except GP1, GP2, and GP3.

4.9 Once the last 3 pairs of columns are complete, open PC1 and evacuate the GMA until the 500 psia Mensor gauge reads below 0.01 psia.

4.10 Record the counts in the "<200" column of the table for the first 11 sensors.

4.11 Close PC1.

4.12 Open GMA solenoid valves V1 and V2.

4.13 Wait 1 minute and close GMA solenoid valves V1 and V2.

Quality _____

4.14 (Optional) Repeat steps 4.2 through 4.12 and record data in Table 2.

Quality _____

4.15 (Optional) Repeat steps 4.2 through 4.12 and record data in Table 3.

Quality _____

4.16 Close fill-and-drain valve MV2 on the GMA.

4.17 Close fill-and-drain valves on the dewar spinup lines.

4.18 Use the ECU to close all GMA solenoid valves.

4.19 Close manual valves PC2, S1, S2, S3, S4, and P1A (see Diagram 1).

4.20 Shut down the vacuum system.

4.21 Low pressure calibration of the ECU is now complete:

Test Director: _____

Quality: _____

G.5 GMA High Range Transducer Calibrations

Started on: _____

Note: Mark off each step of procedure as it is completed.
This section to be completed during a fill operation of the GMA supply tanks, P0886.
Note: The GMA fill is the only opportunity to read these data. Be cautious not to fill too quickly and miss a data point.

5.1 Hardware is set up to run P0886 section G.6 "GMA Pressure Vessel Fill". All constraints and safety notices called out there must be followed.

5.2 Verify that GMA solenoid valves V1 and V2 are open so pressure can be monitored at GP2 and GP3.

5.3 Before pressurizing, monitor GMA pressure sensors GP1, GP2, and GP3 and record pressure and counts in the "<200" column if counts are below 200. Record the pressure from the 3500 psia Mensor gauge, located on the GDS.

5.4 As the tanks are filled, monitor GP1, GP2, and GP3 and record the pressures and counts in each of the 4 ranges to complete Table 1.

5.5 High pressure calibration of the ECU is now complete:

Test Director: _____

Quality: _____

G.6 Diagrams

Diagram 1: Supply Gas Setup

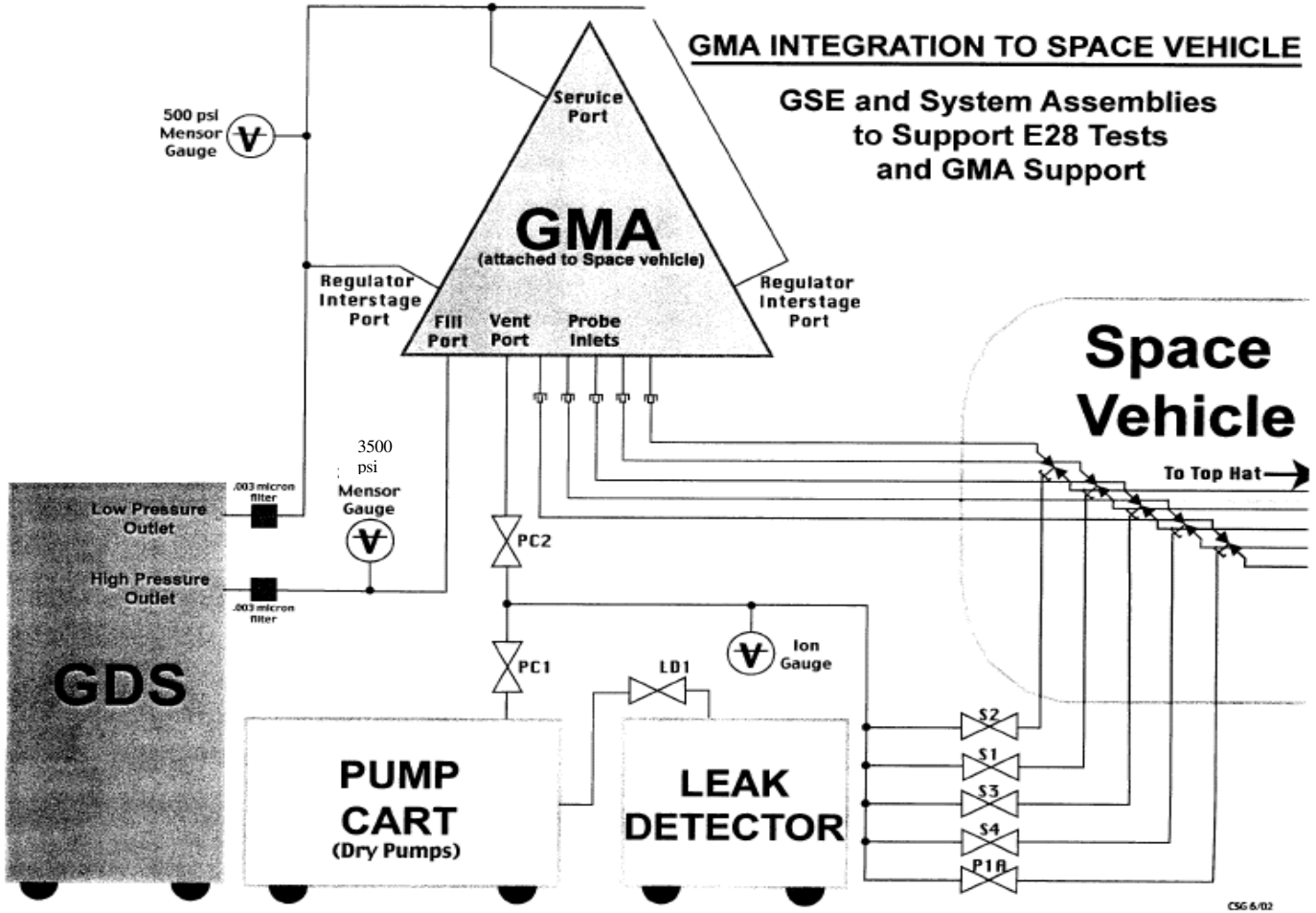
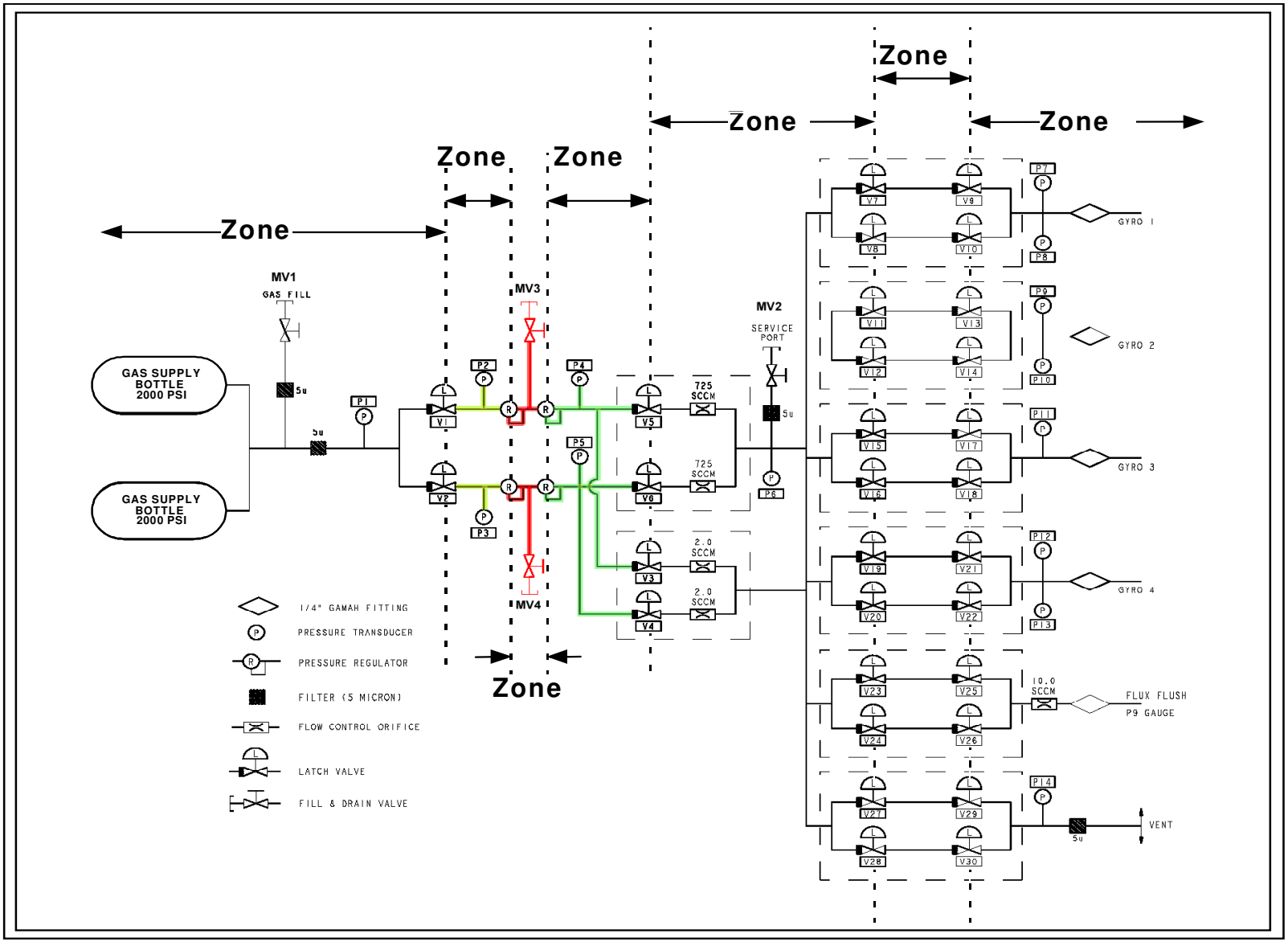


Diagram 2: GMA Schematic



G.8 Tables

Table 1: Pressure and Counts Data, First Run

	Target counts	<200		5000-8000		17000-21000		28000-32700	
	Expected Max psia	Pressure	Counts	Pressure	Counts	Pressure	Counts	Pressure	Counts
GP4	33	0							
GP5	33	0							
GP6	17	0							
GP13	11	0							
GP7	5	0							
GP9	5	0							
GP11	5	0							
GP12	5	0							
GP8	4	0							
GP10	4	0							
GP14	4	0							
GP2	3030								
GP1	3333								
GP3	3333								

Table 2: Pressure and Counts Data, Second Run

	Target counts	<200		5000-8000		17000-21000		28000-32700	
	Expected Max psia	Pressure	Counts	Pressure	Counts	Pressure	Counts	Pressure	Counts
GP4	33	0							
GP5	33	0							
GP6	17	0							
GP13	11	0							
GP7	5	0							
GP9	5	0							
GP11	5	0							
GP12	5	0							
GP8	4	0							
GP10	4	0							
GP14	4	0							
GP2	3030								
GP1	3333								
GP3	3333								

Table 3: Pressure and Counts Data, Third Run

	Target counts	<200		5000-8000		17000-21000		28000-32700	
	Expected Max psia	Pressure	Counts	Pressure	Counts	Pressure	Counts	Pressure	Counts
GP4	33	0							
GP5	33	0							
GP6	17	0							
GP13	11	0							
GP7	5	0							
GP9	5	0							
GP11	5	0							
GP12	5	0							
GP8	4	0							
GP10	4	0							
GP14	4	0							
GP2	3030								
GP1	3333								
GP3	3333								

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