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

DESIGN VERIFICATION AND QUALIFICATION OF NEW POPPET AND BUSHING ON GMA FLIGHT SOLENOID VALVES

GPB ENGINEERING PROCEDURE

P0737 Rev -

2 August, 2000

PREPARED _____ _____
R. Stephenson, GMA Engineer Date

APPROVED _____ _____
L. Sokolsky, Mechanical Engineer Date

APPROVED _____ _____
G. Asher, GMA REE Date

APPROVED _____ _____
D. Ross, Quality Assurance Date

APPROVED	_____	_____
	B. Muhlfelder, Hardware Manager	Date

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1. SCOPE

This procedure describes the qualification of the flight GMA solenoid valves. This also acts as the design verification tests of the new Honeywell poppet design. This test has four main parts. These are random vibration, shock testing, thermal vac testing, and life cycle testing. The vibration will be performed at Bell Technologies in Mountain View, while the pyro shock and thermal vac tests will be performed at Lockheed's facilities. Finally, the leak testing and life cycling will be done by Stanford.

2. TEST INFORMATION

- Proper care should be taken in handling components, and their cleanliness must be preserved.
- Temperature: Room temperature
- Humidity: not critical

2.1 Cleanliness

5.1.1 Normal lab environment when components are double bagged.

5.1.2 Inlet and outlet of valve should be appropriately capped whenever possible.

2.2 ESD precautions

None required.

ONR representative, and QA to be notified prior to beginning this procedure

2.3 Personnel, QA, and Documentation

Personnel Integration and Test Director

The Integration and Test Director (ITD) shall be Larry Sokolsky or an alternate that he shall designate. The ITD has overall responsibility for the implementation of this procedure and shall sign off the completed procedure and relevant sections within it. The GMA REE shall also sign off the completed "As-Built" procedure.

Integration Engineers and other personnel. All engineers and technicians participating in this procedure shall work under the direction of the ITD who shall determine personnel that are qualified to participate in this procedure. Participants in this procedure are to be G. Asher, A. Halevy, L. Sokolsky and R. Stephenson.

The test shall be conducted on a formal basis to approved and released procedures. The QA program office shall be notified of the start of this procedure. A Quality Assurance Representative, designated by D. Ross shall be present during the procedure (if deemed necessary) and shall review any discrepancies noted and approve their disposition. Upon completion of this procedure, the QA Manager, D. Ross or her designate, shall certify their 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. Discrepancies will be recorded in a D-log or as a DR per Quality Plan P0108. If a re-test of any or all of the hardware is necessary, the ITD will determine the appropriate changes in the procedure, with the QA Manager's approval.

2.4 Red-line Authority

Authority to red-line (make minor changes during execution) this procedure is given solely to the ITD or his designate, or the GMA Manager, and shall be approved by QA. Additionally, approval by the Hardware Manager shall be required, if in the judgment of the ITD or QA Representative, experiment functionality may be affected.

5 DOCUMENTS AND EQUIPMENT

3.1 Applicable Documents

Document number	Rev	Description
26211-101	B	Solenoid Valve Assembly
P0686	–	Readjustment and Reassembly of Flight GMA Solenoid Valves
P0488	–	Probe Fastener Staking
MIL-STD-1540C		Space Vehicle Test Requirements

3.2 Test Equipment

Equipment	Model and Serial Number	Calibration
Solenoid Control Box		P0621
Leak Detector		Internally Calibrated
Non flight solenoid valve	A8 (body)	
Leak checking manifold		

4 REASSEMBLY

Started on: _____

5.1 Reassemble spare solenoid with new components according to P0686.

5.2 Check that it functions using the Solenoid control box and a connector saver.

5 LEAK TEST

Started on: _____

5.1 External Leak

5.1.1 Connect the solenoid valve to the leak detector manifold with the inlet side of the valve connected to the helium end of the manifold.

5.1.2 Connect the solenoid valve to the Solenoid Control Box using connector savers.

5.1.3 With the solenoid valve closed, evacuate both sides of the valve with the leak detector.

5.1.4 Spray a small stream of helium around the bottom cap of the valve, the fittings, and the top side of the valve while watching for spikes. The leak rate will gradually climb over a few minutes, but if it jumps suddenly, there is a leak.

5.1.5 Test is failed if a spike is detected or leak rate goes above 10^{-5} sccs.

5.2 Internal Leak

5.2.1 Close the valve on the manifold to isolate the inlet side of the solenoid valve.

5.2.2 Record the background leak rate in Table 1.

5.2.3 Introduce 1 Atm (abs) into the inlet side of the valve.

5.2.4 Measure the Helium leak rate every minute for 10 minutes and record in Table 1.

5.2.5 Test is failed if the leak rate goes above 10^{-6} sccs.

5.3 Staking

5.3.1 After the first leak test only, loosen one screw at a time from the bottom cap (poppet guide) and place a small drop of epoxy under the head of the screw and retighten.

5.3.2 Repeat for the top cap screws.

5.3.3 Repeat for the solenoid fastening screws.

Table 1 Leak Test Results

Date:					
t_0 + (min)	**Leak Rate (sccs)**	**Leak Rate (sccs)**	**Leak Rate (sccs)**	**Leak Rate (sccs)**	**Leak Rate (sccs)**
Background	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
1.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
2.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
3.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
4.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
5.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
6.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
7.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
8.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
9.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$
10.0	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$	$\times 10^{-}$

6 RANDOM VIBRATION TEST

Started on _____

6.1 Z Axis Shake

6.1.1 Bolt solenoid valve fixture to shake table in Z-axis configuration using torque recommended by Bell.

6.1.2 Bond 3 axis accelerometer and redundant accelerometer to fixture.

6.1.3 Run Z-axis fixture trial to qual level (Table 2). Approve resulting spectrum and cross-axis responses. Test Director_____

6.1.4 Bolt solenoid valve to fixture using lock washers.

6.1.5 Vibrate solenoid valve in Z direction to –12 dB qual levels.

6.1.6 Approve resulting spectrum and cross axis responses for flight item (Table 3).

6.1.7 Vibrate solenoid valve in Z direction to 0 dB qual levels (Table 2).

6.1.8 Approve resulting spectrum and cross axis responses for flight item (Table 3).

6.1.9 Remove solenoid valve from fixture

6.1.10 Attach all plots to back of procedure.

6.2 X Axis Shake

6.2.1 Bolt solenoid valve fixture to slip table in X-axis configuration. Torque bolts to levels recommended by Bell.

6.2.2 Bond 3 axis accelerometer and redundant accelerometer to fixture.

6.2.3 Run X-axis fixture trial to qual level (Table 2). Approve resulting spectrum and cross-axis responses. Test Director_____

6.2.4 Bolt solenoid valve to fixture using lock washers.

6.2.5 Vibrate solenoid valve in X direction to –12dB qual levels.

6.2.6 Approve resulting spectrum and cross axis responses for flight item (Table 3).

6.2.7 Vibrate solenoid valve in X direction to 0 dB qual levels (Table 2).

6.2.8 Approve resulting spectrum and cross axis responses for flight item (Table 3).

6.2.9 Remove solenoid valve from fixture

6.2.10 Attach all plots to back of procedure.

6.3 Y Axis Shake

6.3.1 Bolt solenoid valve fixture to slip table in Y-axis configuration. Torque bolts to levels recommended by Bell.

6.3.2 Bond 3 axis accelerometer and redundant accelerometer to fixture.

6.3.3 Run Y-axis fixture trial to qual level (Table 2). Approve resulting spectrum and cross-axis responses. Test Director_____

6.3.4 Bolt solenoid valve to fixture using lock washers.

6.3.5 Vibrate solenoid valve in Y direction to –12dB qual levels.

6.3.6 Approve resulting spectrum and cross axis responses for flight item (Table 3).

6.3.7 Vibrate solenoid valve in Y direction to 0 dB qual levels (Table 2).

6.3.8 Approve resulting spectrum and cross axis responses for flight item (Table 3).

6.3.9 Remove solenoid valve from fixture

6.3.10 Attach all plots to back of procedure.

6.4 Leak Test

6.4.1 Perform Section 5 "Leak Test" again at Stanford.

Table 2 0 dB Random Vibration Spectrum

Frequency (Hz)	PSD (g^2/hz)
20	0.021
150	0.16
600	0.16
2000	0.014
Composite (grms)	**12.2**

Duration: 180 ±5 seconds

Spec: ±3 dB, 20 Hz to 2000 Hz

RMS: ± 10%

Table 3 Approval of Vibration Spectrum for Flight Valves

Direction	Test Director Approval
X	

Y	
Z	

7 SHOCK TEST

Started on _____

7.1 Z Axis Shock

7.1.1 Bolt solenoid valve fixture to shock table in Z-axis configuration using recommended torque.

7.1.2 Bond 3 axis accelerometer and redundant accelerometer to fixture.

7.1.3 Bolt solenoid valve to fixture using lock washers.

7.1.4 Shock solenoid valve in Z direction 3 times to qual levels (Table 4).

7.1.5 Remove solenoid valve from fixture

7.1.6 Attach all plots to back of procedure.

7.2 X Axis Shock

7.2.1 Bolt solenoid valve fixture to shock table in X-axis configuration using recommended torque.

7.2.2 Bond 3 axis accelerometer and redundant accelerometer to fixture.

7.2.3 Bolt solenoid valve to fixture using lock washers.

7.2.4 Shock solenoid valve in X direction 3 times to qual levels (Table 4).

7.2.5 Remove solenoid valve from fixture

7.2.6 Attach all plots to back of procedure.

7.3 Y Axis Shock

7.3.1 Bolt solenoid valve fixture to shock table in Y-axis configuration using recommended torque.

7.3.2 Bond 3 axis accelerometer and redundant accelerometer to fixture.

7.3.3 Bolt solenoid valve to fixture using lock washers.

7.3.4 Shock solenoid valve in Y direction 3 times to qual levels (Table 4).

7.3.5 Remove solenoid valve from fixture

7.3.6 Attach all plots to back of procedure.

7.4 Leak Test

7.4.1 Perform Section 5 “Leak Test” again at Stanford.

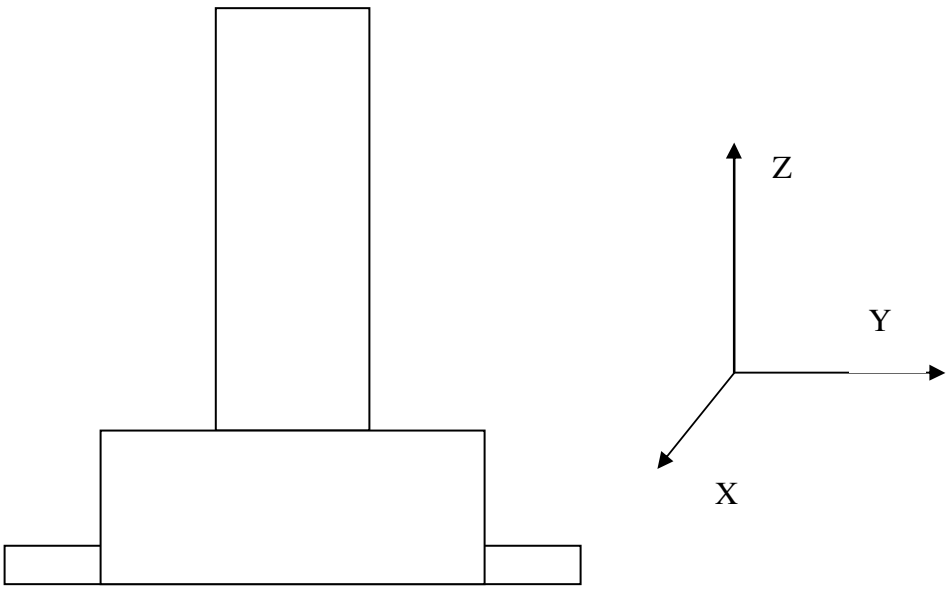
Table 4 Shock Spectrum

Frequency (Hz)	G
100	100
3000	5500
4000	5500
10000	1000

Tolerance is ±6 dB

Figure 1

Solenoid Valve Orientation



8 THERMAL VAC TEST

Started on: _____

8.1 Place valve in the thermally controlled vacuum chamber.

8.2 Attach 2 thermocouples to the valve in convenient locations.

8.3 Connect valve to Solenoid Control Box using a connector saver.

8.4 Cycle the valve open and closed to check function. Leave it closed. Disconnect control box.

8.5 Evacuate chamber to 1 x 10^{-5} Torr.

8.6 Heat up the valve to 56 centigrade at a rate of 3-5 deg c/minute.

8.7 Wait for two hours in that temperature.

8.8 Cool down to –54 centigrade at a rate of 3-5 deg c/minute.

8.9 Wait for two hours in that temperature.

8.10 Bring the valve back to room temperature at a rate of 3-5 deg c/minute.

8.11 Open chamber and connect valve to Solenoid Control Box using a connector saver.

8.12 Cycle the valve open and closed to check function. Leave it closed. Disconnect control box.

8.13 Evacuate chamber to 1 x 10^{-5} Torr.

8.14 Heat up the valve to 56 centigrade at a rate of 3-5 deg c/minute.

8.15 Wait for two hours in that temperature.

8.16 Cool down to –54 centigrade at a rate of 3-5 deg c/minute.

8.17 Wait for two hours in that temperature.

8.18 Repeat steps 5.13 – 5.16 six times for a total of 8 cycles.

8.19 Bring the valve back to room temperature at a rate of 3-5 deg c/minute.

8.20 Open chamber and connect valve to Solenoid Control Box using a connector saver.

8.21 Cycle the valve open and closed to check function. Leave it closed.

8.22 Bring valve back to Stanford and run section 5 “Leak Test” again.

9 LIFE CYCLE TEST

Started on _____

9.1 Perform section 5 leak test.

9.2 Cycle valve open and closed 50 times.

9.3 Perform section 5 leak test.

9.4 Repeat steps 9.1 – 9.3 5 times for a total of 300 cycles.

10 PROCEDURE COMPLETION

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

_____ date: _____
L. Sokolsky, Test Director

Discrepancies if any:

Approved: _____ date: _____
G. Asher, GMA REE

Approved: _____ date: _____
D. Ross, QA

11 DATA BASE ENTRY

The following data shall be entered into the GP-B Data Base:

- Name, number and revision of this procedure
- Date of successful completion of procedure.
- Part numbers and serial numbers of Caging Units and their components