SU/GP-B P0325 Rev –

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

INTEGRATION OF CAGING ASSEMBLIES INTO QB / PROBE

GP-B SCIENCE MISSION PROCEDURE

10 May, 1999

PREPARED	D. Bardas, Integration Manager	Date
PREPARED	J. Stamets, Integration Engineer	Date
APPROVED	J. Mester, Caging Manager	Date
APPROVED	R. Brumley, Gyro Manager	Date
APPROVED	D. Bardas, Integration Manager	Date
APPROVED	B. Taller, Quality Assurance	Date
APPROVED	S. Buchman, Hardware Manager	Date

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1 SCOPE

This document provides procedures for integrating the caging assemblies into the SIA and probe for Science Mission. This procedure assumes

- the SIA and Probe-C are integrated together, and are on the Precision Manipulator, oriented horizontally with the cold end toward the observation window (P0177), with the Probe Vacuum Can off;
- the Caging Assemblies have been acceptance tested and are ready for installation;
- the Varian Turbo 960 Leak Detector (LD) is in the Class 10 Cleanroom, and has been prepped (rough pumped and calibrated);
- the Caging Control Unit (CCU) is in the Class 10 Cleanroom, and calibrated
- a gaseous helium supply bottle with spray line is in the Class 10 Cleanroom;
- a gaseous nitrogen supply bottle is in the Class 10 Cleanroom;

The following operations are contained in this procedure:

- Check flow through probe caging lines
- Shaping of each jumper line needed from each caging unit to the Spider interface line
- Joining and testing of each jumper line with its respective caging unit
- Evacuate and leak check each caging unit/jumper line assembly
- Pressure test each caging unit/jumper line assembly for functionality
- Soldering of each caging unit to the LMMS interface at the spider
- Vacuum and pressure testing each unit before installation into its respective gyro
- Installation of each caging unit into its respective gyroscope
- Caging Assembly electrical test to verify that caging rod properly engages the rotor.

1.1 Acronyms

The following acronyms are used in this document

- QB Quartz Block
- SIAScience Instrument Assembly
- ITD Integration and Test Director
- Pr-C Probe-C, the Science Mission probe
- LD Leak Detector
- CCU Caging Control Unit

2 REFERENCES

1.2 Stanford Procedures

- P0059 GPB Contamination Control Plan
- P0057 Stanford Magnetic Control Plan
- P0419 Operations Manual for the Precision Manipulator

2.2 Drawings

- 23170 Science Instrument Assembly Kit
- 23171 Science Instrument Assembly
- 1C34121 QBA Mounting Kit
- 1C34103 Probe / SIA Interface

- 1C34355 Pr-C to SU External Interfaces

3 GENERAL REQUIREMENTS

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

3.1 Environmental Requirements

This procedure will be conducted in the Stanford Class 10 Cleanroom in the HEPL facility.

3.1.1. Cleanliness

The Class 10 clean room where this integration takes place shall be maintained at the cleanliness levels per GPB Contamination Control Plan P0059. Certified Class 10 cloth garments shall be worn in the Class 10 clean room.

3.1.2 Particulate Contamination

All parts and tools shall be cleaned at least to the cleanliness levels of the rooms where they are used for assembly or testing. In addition, all flight parts shall be maintained at level 100 cleanliness per GP-B Contamination Control Plan (P0059). Take all necessary precautions to keep tools and handling equipment free of particulate contamination.

To the maximum extent possible, personnel shall keep their bodies and garments downstream of the SIA, relative to the HEPA wall.

3.1.3. Magnetic Contamination

All parts and tools shall be screened per Procedure P0057. All parts and tools shall be cleaned using methods consistent with achieving Mil Spec Level 100 cleanliness. In addition, all parts shall be maintained at level 100 cleanliness per GP-B Magnetic Control Plan, P0057. Take all necessary precautions to keep tools and handling equipment free of particulate contamination. Tools to be cleaned with Ethyl Alcohol prior to use, or when contaminated.

To the maximum extent possible, personnel shall keep parts of their bodies downstream of the SIA, relative to the HEPA wall.

3.1.4. Electrostatic Discharge Control

To prevent electrostatic charge buildup on the QB/T the particle ionizer shall always be upstream of the QB/T relative to the fan wall and the PM and the QB/PM shall be grounded. Use of Grounded wrist cuffs is not required since the items being handled are not ESD sensitive.

3.2 Integration and Test Personnel

3.2.1 Integration and Test Director

The Integration and Test Director (ITD) shall be Dr. Doron Bardas 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.

3.2.2 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 expected to be D. Bardas, C. Gray, J. Stamets, and R. Brumley.

3.3 Safety

3.3.1 General

Personnel working in the Class 10 Cleanroom must be cognizant of the base of the Precision Manipulator, and take special care to avoid tripping or bumping into it.

3.3.2 Hardware Safety

Extreme care must be taken to avoid accidentally bumping or scratching the QB/Telescope.

3.3.3 Maximum Number of People in Cleanroom

Under normal operating conditions, there shall be no more than 5 people in the Class 10 Cleanroom. This is to avoid violating legal make up air requirements, and to provide an efficient workspace. Exceptions must be for short periods only, and approved by the ITD.

3.4 Quality Assurance

Integration 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 B. Taller 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, B. Taller or his designate, will certify his 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.

3.5 Red-line Authority

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

3.5.2 Procedure Computerization Special Requirements

Because of cleanliness requirements in the Class 10 room, and to conveniently record data directly into the procedure thus generating the "as-built" document, the procedure will be handled in a paperless fashion until completed. A Laptop computer containing an electronic version of this procedure will be operated by the ITD or QA Representative and data shall be recorded by typing directly into the electronic file.

3.5.3 Following completion of the procedure, a hard copy of the "as-built" procedure shall be printed ***and signed off by all the designated parties***. It shall then be filed, including an electronic copy into the data base.

The electronic editing of this document shall be as follows:

- Data will be inserted into the document using normal font, i.e. non-bold, non-italic
- "Signatures" shall be designated by **BLACK CAPITAL BOLD LETTERS**.
- "Redlines" shall be in ***RED BOLD ITALICS*** to make them distinguishable both on the Laptop screen and on the hard copy printout.

- If available, digital pictures shall be inserted into the document where appropriate.

4. REQUIRED EQUIPMENT

The following equipment shall be in the Class 10 cleanroom.

Ground Support Equipment

- Precision Manipulator (PM)
- Varian Turbo Auto-test 960 Leak Detector or equivalent, with Liquid Nitrogen supply
- Caging Control Unit with Plumbing
- Vacuum Compression Ring (VCR) Connectors
- Gamah Connectors
- Gaseous Helium Supply Bottle
- Gaseous High Purity Nitrogen Supply Bottle with Pressure Regulator
- GSE Plumbing Assembly for Caging
- Ultra torch

Tools and Miscellaneous

- High Voltage Digital Multimeter : Keithly MegOhm Meter Cal date _______
- Pure Ethyl Alcohol
- 1/4" Nut driver, BeCu
- Beaker of alcohol
- De-ionized water spray bottle
- Miscellaneous BeCu tools such as pliers

5. INITIAL SETUP

Record Start Date and Time ____________________

- Set up the room as in Figure 1 below.

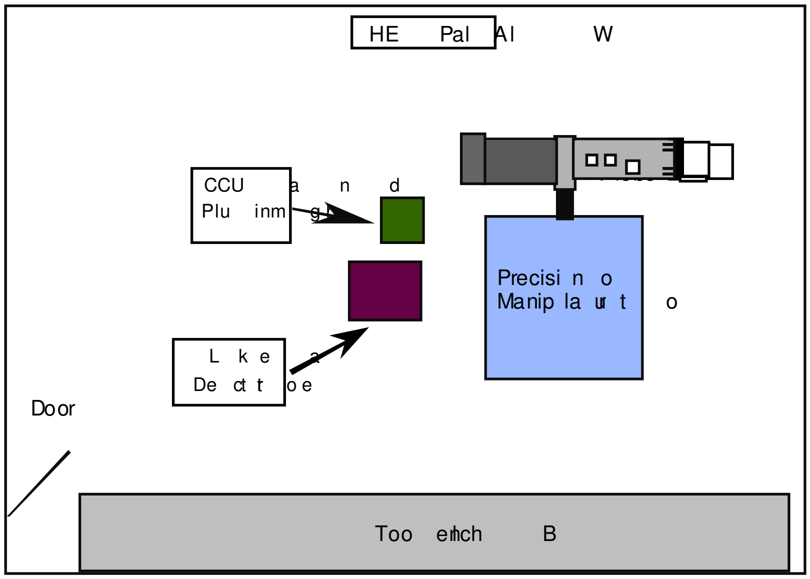

Figure 1 Class 10 Room Setup

- Rotate the probe in the Precision Manipulator so that the – X axis is pointing up, for installation of caging assemblies for gyros 1 and 2, and with –Y up for gyros 3 and 4.

5 CHECK FLOW THROUGH PROBE CAGING LINES

Record Start Date and Time __________________

- Connect the Caging Ground Support Plumbing as shown in diagram below to the Leak Detector, Caging Control Unit (CCU) and Probe Caging Line.

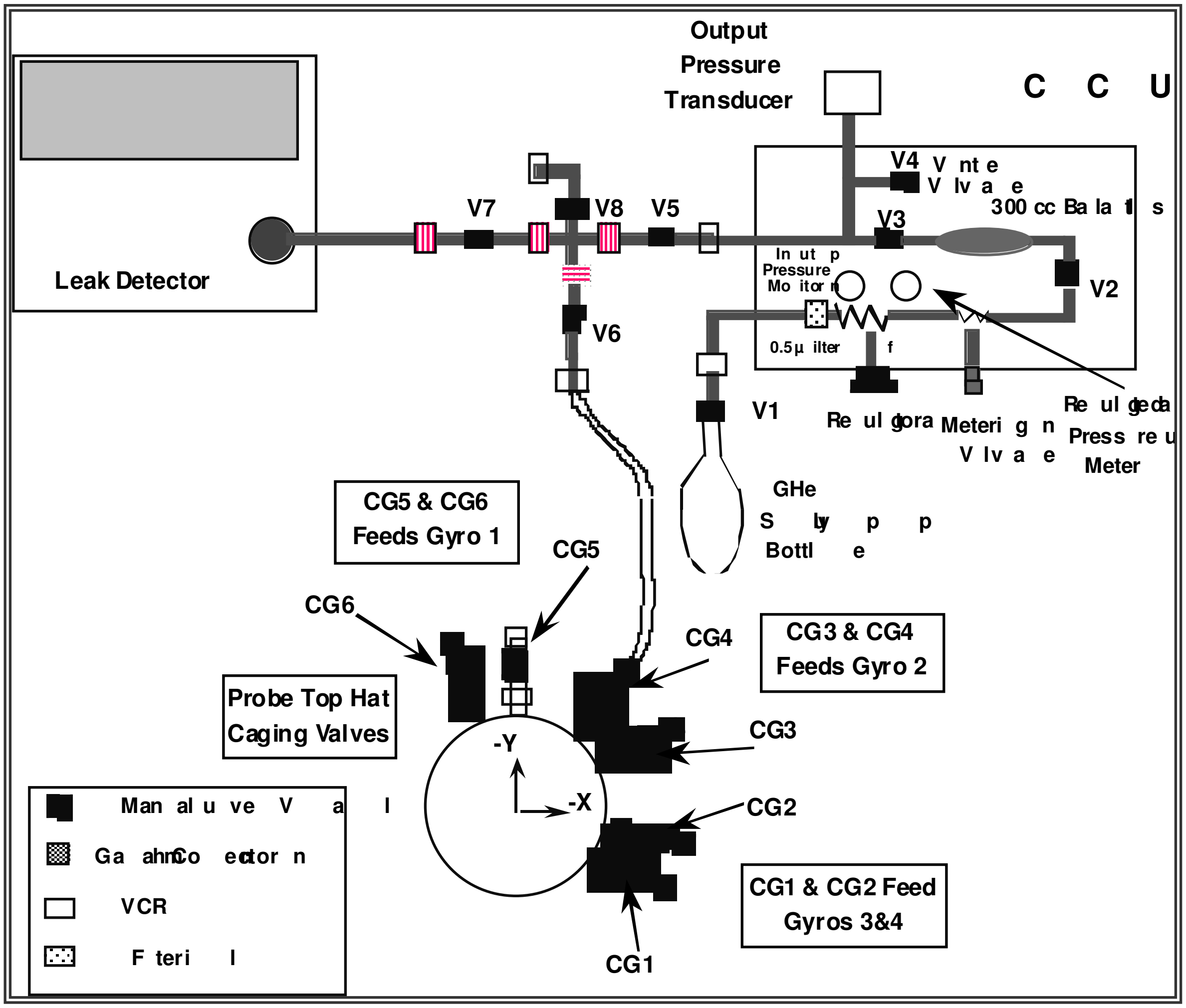

Figure 2. GSE Plumbing Schematic for Caging*

**** Note CG5 and CG6 are temporarily replaced with a line, Valve (with VCR) fitting situated along the probe neck strongback and feeding directly into the capillary tube to the Caging line for Gyro 1 situated on the Spider at the cold end of the probe.***

5.1 Identify Cold End Caging Lines; Verify Line Open

5.1.1 By applying GN_2 pressure to the warm end (temporary) valve CG5/CG6 identify the Gyro 1 caging line at the spider by determining which one forms bubbles in a beaker of ethanol.

5.1.2 Ensure that this cold end line is formed as close as possible to the shape shown in the LMMS ICD 1C34103 Probe / SIA Interface.

5.1.3 Repeat for CG3/CG4 (Gyro 2 caging line) and CG1/CG2 (gyro 3 & 4) caging lines.

5.1.4 In the latter two cases verify that there is flow for each of the CGs at the Top Hat, i.e. cap one of the CGs while applying the GN_2 to the other and verifying flow at the cold end.

5.1.5 Verify that in the case of gyros 3 & 4 at the cold end, flow is approximately uniform through both branches.

5.1.6 Record data in Table 1 below.

Table 1 (Pressure applied is 20 psid)

Set up	Flow (bubbles per min)	ICD verified
CG5/CG6 (temp line); should feed Gyro 1		
CG3; should feed gyro 2		
CG4; should feed gyro 2		
CG1; should feed gyro 3 & 4		
CG2; should feed gyro 3 & 4		

5.2 Section 5 Completed:

Completed: ________________________________ date: ________________
Integration Engineer

Completed: ________________________________ date: ________________
Integration Engineer

Discrepancies if any:

Disposition./.sign-off: __________________________Date:________________
ITD

Concurrence: ______________________________Date:________________

QA Designated Representative

6 SHAPING OF THE CAGING JUMPER LINES

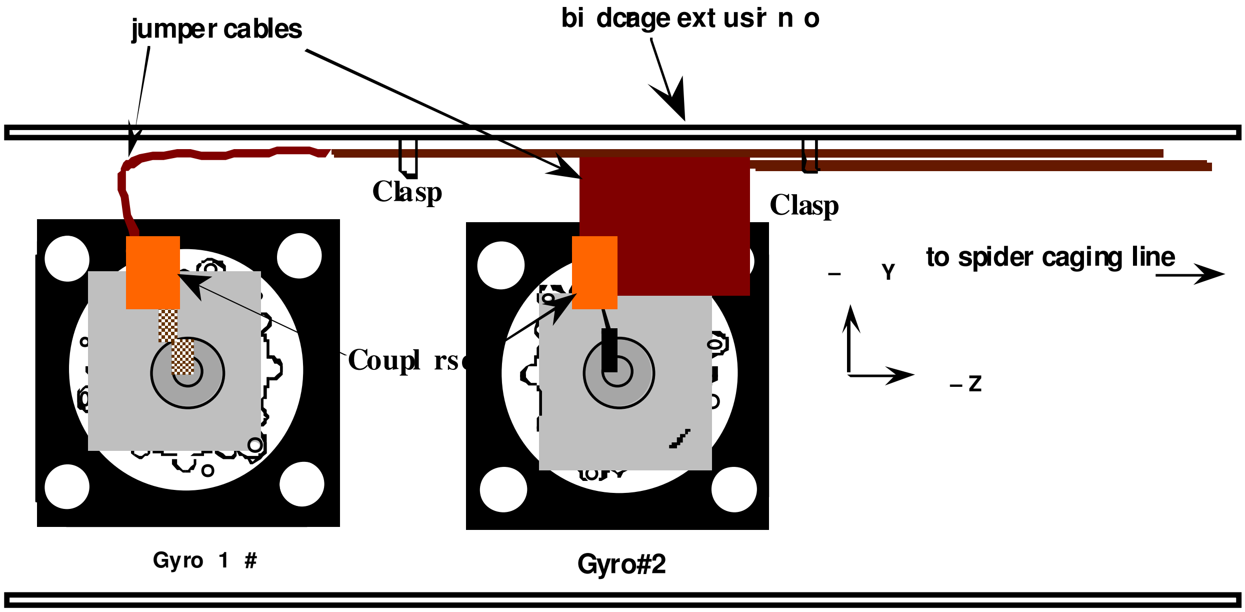

Figure 3. Caging and Caging Jumper routing for Gyros 1 and 2

6.1 Forming the Shape of Jumper for Each Gyro

6.1.1 Install the clasps along the extrusions as appropriate for each jumper line. Note that each clasp has two snaps. Sometimes only one is used, while both are used when two lines are traveling together.

6.1.2 Install two rails and their clasps in the extrusion E1, the extrusion with the suspension lines for Gyros 1 and 2.

6.1.3 Using these clasps as a guide (taking care not to damage them) for the actual caging jumper lines as shown in Figure 3. The distance out from the center of the retainer is not very critical as there is sufficient flexibility in the line for adjustment later, after soldering and final installation.

6.1.4 The actual caging units are not in place at this time, however, one can estimate sufficiently by judging position of the couplers relative to the three pronged support piece which is in place holding the Delrin dummy caging fingers. Each coupler joins at an angle of approx. 30 degrees with respect to the nearest arm of this support.

6.1.5 The line from Gyro 2 travels lower than that from gyro 1. However this foes not effect the order in which the final assemblies are installed.

6.1.6 Form the lines to the approximate location of the LMMS interfaces on the Spider. Again these are not critical as final adjustments can be made due to the soft nature of the capillary tube.

6.1.7 For gyros 3 and 4 there are clasps along the outside of the extrusions (and if necessary on the spider). Go to approximately the location of the LMMS interfaces at the spider.

6.2 Section 6 Completed:

Completed: ______________________________________ date: ___________________
Integration Engineer

Completed: ______________________________________ date: ___________________
Integration Engineer

Discrepancies if any:

Disposition./.sign-off: ______________________________Date:___________________
ITD

Concurrence: _____________________________________Date:___________________
QA Designated Representative

7 SOLDERING / TESTING JUMPERS TO THE CAGING UNITS

7.1 Soldering to the Caging Unit

Note that, except for the section of jumper line near the LMMS interface, the rest of each jumper is lies approximately in a single plane.

7.1.1 Soldering is done on the Laminar flow bench in the Class 1000 room.

7.1.2 Soldering is done with the caging unit line (with its ferrule) co-axial with the caging unit.

7.1.3 Using a suitable fixture such as a gyro retention assembly, orient the jumper line so that when the capillary line that is part of the caging unit is later bent over at 90 degrees forming an angle of approximately 30 degrees with the relevant arm of the caging retainer tri-strut, *the jumper line will lie in a plane parallel to the gyro retainer, i.e. perpendicular to the axis of the caging unit.*

7.1.4 Solder each unique jumper line to the caging unit for a particular gyro.

7.1.5 Now bend each of the caging line stubs exiting the caging units using a 0.25 dia. rod so that the jumper is in a plane perpendicular to the caging unit, as described in 6.1.4 above.

7.1.6 Leak check the caging unit / jumper line combination to ensure integrity of the solder connection.

7.1.7 Pressure test each completed unit in according to Table 2. below

Leak tight to < 1 x 10^8: Gyro 1 _____, Gyro 2 _____, Gyro 3 _____, Gyro 4 _____

Table 2. Tests of Gyro / Jumper Assembly

	Gyro 1		**Gyro 2**		**Gyro 3**		**Gyro 4**	
Pressure (psid)	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**
20								
40								
60								
80								
100								
120								
140								
160								
180								
drop to 0 instantly								
180 instantly								
drop to 0								

instantly								

7.2 Section 7 Completed:

NOTE THAT ALL UNITS LEAK CHECKED AND FUNCTIONED PROPERLY _____

Completed: ___________________________________ date: __________________
Integration Engineer

Completed: ___________________________________ date: __________________
Integration Engineer

Discrepancies if any:

Disposition./.sign-off: ____________________________Date:__________________
ITD

Concurrence: __________________________________Date:__________________
QA Designated Representative

8 INSTALLING AND TESTING THE CAGING UNITS

8.1 Order of installation; Soldering to LMMS Interface

8.1.1 The order of installation is to be gyros 4, 3, 2, 1 unless modifies by the ITD

8.1.2 If the topology of the jumper lines for gyros 3 and 4 is such that the order of these two must be reversed, it is permissible to do so.

8.1.3 While holding or securing the caging unit just above its gyro location, leaving enough room to remove the dummy Delrin gyro protector, solder the aft joint at the LMMS interface.

8.1.4 For gyros 3 and 4 extra flexibility can be easily obtained by removing the screw that secures the LMMS lines to the caging bridge unit.

8.1.5 For gyros 1 and 2 there should be enough flexibility without removing the bridge constraint.

8.1.6 After soldering the connection at the LMMS interface, leak test the entire system by attaching the leak detector to the appropriate Top Hat Connector. For Gyros 3 and 4, after soldering the first unit, it will be necessary to cap the parallel line at the LMMS splitter using Tygon caps similar to those that are presently on the lines.

3.1.7 Note that leak checking verifies that the joint is tight BUT NOT that unit is not clogged.

3.1.8 Pressure test the complete system and fill in Table 3 below for each gyro respectively. Also record the leak tests results above the table.

8.2 Remove Dummy Delrin Caging Unit

3.2.1 Remove the dummy Delrin caging unit from the gyro in question, lifting it out straight up for the first 0.5 inch or so and being careful not to wedge against the gyro recess.

3.2.2 Take care to not damage the cables with the struts of the caging retainer. Gently part those cables in the way and slightly rotate the caging retainer.

8.3 Install Caging Unit into Gyro

3.3.1 Carefully hold the caging unit and lower it into the Gyro retainer part way

8.3.2 Ensure that the caging unit itself is held securely and vertical; the flexibility of the jumper lines allows this to be the case. *Do not snap the jumper line into its clasps yet, just guide it approximately to its final routing locations.*

8.3.3 With the caging unit centered lower it carefully into the gyro. Note that the hole in the gyro for the caging rod is significantly larger than the rod dia. so that the engagement that is to be felt is that of the front of the caging main body into the ~ 0.75 dia. x 0.125 deep counter-bore in the gyro.

8.3.4 Once the unit is in and the caging retainer is secured on the three screws of the gyro retainer, verify that the height of the caging retainer above the gyro retainer surface is as expected. This can be estimated by use of a small straight edge ruler.

8.3.5 Install the nuts on the three screws of the Gyro retainer and tighten them each a little at a time, until they are fully bottomed out.

8.4 Leak Tests Results:

Leak tight to < 1 x 10^8: Gyro 1 _____, Gyro 2 _____, Gyro 3 _____, Gyro 4 _____

Table 3. Tests of Gyro / Jumper Assembly

	Gyro 1		**Gyro 2**		**Gyro 3**		**Gyro 4**	
Pressure (psid)	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**
20								
40								
60								
80								
100								
120								
140								
160								
180								
drop to 0 instantly								
180 instantly								
drop to 0 instantly								

8.5 Section 8 Completed:

NOTE THAT ALL UNITS LEAK CHECKED AND FUNCTIONED PROPERLY ____

Completed: ____________________________________ date: ___________________
Integration Engineer

Completed: ____________________________________ date: ___________________
Integration Engineer

Discrepancies if any:

Disposition./.sign-off: _____________________________Date:___________________
ITD

Concurrence: ___________________________________Date:___________________

QA Designated Representative

9 FINAL VERIFICATION OF CAGING

9.1 Caging Rod Pressure Test

9.1.1 Connect the digital MegOhm multi-meter leads to 1) jumper line, and 2) gyro grounding line as shown in Figure 5 below. Set the ohmmeter gauge to the 100 MΩ range.

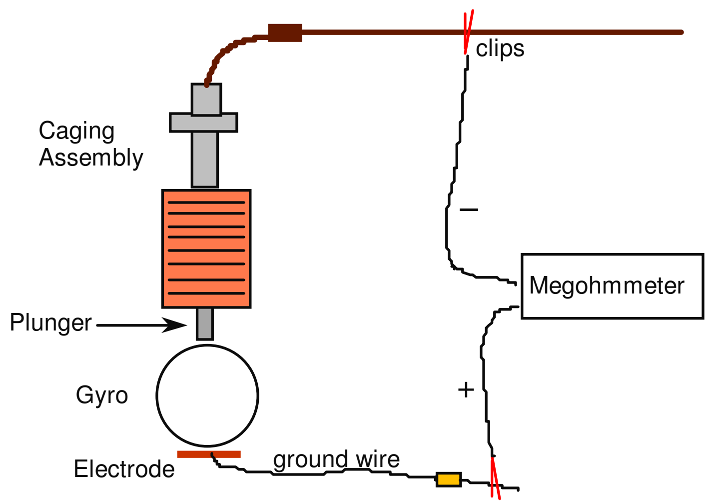

Figure 5. Megohm-meter Setup

9.1.2 Pressurize each caging system. Watch the pressure output gauge rise slowly at approximately 1 psid/sec. Do not exceed 185 psid.

9.1.3 Watching the ohmmeter for a reading of 100 MΩ. This indicates contact between the caging rod and the gyro rotor. When contact is established record the pressure.

9.1.4 Complete taking readings for each gyro as shown in Table 4 below.

9.2 Pressure which Each Caging unit Makes and Breaks Contact with Rotor

Table 4. Final Testing of installed caging units (increase pressure slowly)

	Gyro 1		Gyro 2		Gyro 3		Gyro 4	
Pressure (psid)	**Resistance**	**Time for Circuit to Open or Close**	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**	**Rod Extension**	**Extend / Retract time (secs)**
10								
20								
30								
40								
50								
60								
80								
100								
130								
160								
drop to 0 instantly								
up to 160 instantly								
130								
100								
80								
60								
50								
40								
30								
20								
10								

9.3 Section 9 Completed:

NOTE THAT ALL UNITS FUNCTIONED PROPERLY ___________

Completed: ___________________________________ date: __________________
Integration Engineer

Completed: ___________________________________ date: __________________
Integration Engineer

Discrepancies if any:

Disposition./.sign-off: ____________________________Date:__________________
ITD

Concurrence: __________________________________Date:__________________
QA Designated Representative

10 PROCEDURE COMPLETION

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

Integration Engineer ______________________________ Date _______________

Integration Engineer ______________________________ Date _______________

ITD ______________________________ Date _______________

The information obtained under this assembly and test procedure is as represented and the documentation is complete and correct:

QA Representative _________________________________ Date ______________

QA Program Engineer______________________________ Date ______________

Copy discrepancies to D-Log and open Discrepancy Reports when required.

11 DATA BASE ENTRY

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

1) Name, number and revision of this procedure

2) Date of successful completion of procedure.

3) Part numbers and serial numbers of Caging Units and their components