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

INVESTIGATION OF READOUT FAILURE IN FQH53 AFTER REMOVAL FROM PROBE C

P0680 Rev A

July 09, 2001

PREPARED	_____	_____
	R. Brumley, Gyroscope RE	Date
APPROVED	_____	_____
	B. Clarke, Gyroscope Verification	Date
APPROVED	_____	_____
	C. Gray, Gyroscope Verification	Date
APPROVED	_____	_____
	D. Ross, Quality Assurance and Safety	Date
APPROVED	_____	_____
	B. Muhlfelder, Technical Manager	Date

REVISION RECORD

Rev	Date	Comments
-	05/25/00	
A	07/09/01	Update cleanliness references to reflect current clean room operational practices. Make note that this is not a procedure that is sensitive to cleanliness and is not expected that the gyroscope will meet science mission gyroscope cleanliness requirements at the completion of the procedure. Add Dale K. Gill to the list of personnel authorized to perform the procedure.

1. SCOPE

This procedure describes part of the investigation into the root cause of the readout failure in gyroscope FQH53 (Gyro #4 during the first Payload Acceptance Test). It covers work which occurs after the removal of the gyroscope from Probe C and any possible additional low temperature tests. Specifically, the following steps are included:

- A low-temperature test of the gyroscope to check for a cryogenic failure of the readout loop if P0681 (Removal of Gyro from SIA) did not confirm that the failure was localized to the gyroscope.
- Removal of gyroscope from its storage container on a clean bench
- Initial inspection prior to opening the housing
- Opening of housing
- Inspection for particulates or other defects in the gyroscope
- Detailed microscopic inspection of joint
- Disconnect readout cable from loop
- Detailed inspection and measurement of all components
- Re-assembly of gyroscope with new readout cable design and retest at low temperature *(Optional)*
- Storage of components

2. REFERENCES

2.1 Plans and Procedures

P0108 Science Mission Quality Plan

P0327 Gravity Probe B Relativity Mission System Safety Program Plan

3. GENERAL REQUIREMENTS

3.1 Environmental Requirements

3.1.1 Cleanliness

This procedure takes place in the Class 10,000 cleanroom in the HEPL building on a certified flow bench. Minimum protective garments for personnel working in the clean rooms shall be the standard Tyvek clean room apparel. All activities taking place within this room must be in accordance with the current practices established by the cleanroom manager.

Note that the purpose of this procedure is to verify the cause of an intermittent connection in the readout loop. It is not expected that at the end of this procedure the gyroscope will

meet science gyroscope cleanliness standards (this would be accomplished by a later cleaning if necessary). Therefore it is only required that the individuals performing this procedure adhere to current GP-B clean room practice so as to not degrade the environment from its current condition for other cleanroom users.

3.1.2 Magnetic Contamination

All work on gyroscope hardware must be performed using non-magnetic tools and in accordance with the GP-B Magnetic Control Plan P0057.

3.2 Test Personnel

3.2.1 Test Director

The test director for this procedure shall be Robert Brumley, or his appointed replacement.

3.2.2 Personnel

The following personnel are qualified to perform this procedure

- Paul Bayer
- Chris Gray
- Bruce Clarke
- David Hipkins
- Dale K. Gill
- Dr. Sasha Buchman
- Dr. Barry Muhlfelder
- Ming Luo

See section 3.4 for details on the requirements for Quality Assurance notification and witnessing of this procedure. Also note that some portions of the procedure require notification of Dr. Barry Muhlfelder.

3.2.3 Minimum Personnel

No activity shall be performed on the science mission probe without at least two people in the room, i.e. at least one person to perform the procedure and one person to observe the procedure.

3.3 Safety

3.3.1 Hardware Safety -- General

Great care should be taken in the handling of the gyroscope and its hardware to avoid damage to them.

3.3.2 Electrostatic Discharge

Grounded wrist straps shall be worn when making connections to the readout cable. Also, it is important to adhere to use the multimeter specified in Section 4 so as to avoid any possibility of damaging the pickup loop.

3.3.3 Personnel Safety

All operations shall take place according to Stanford University safety guidelines. Any person observing a situation which they deem unsafe shall report the fact immediately to the test director. The Quality Assurance representative shall be responsible for monitoring that all activities are performed in a safe manner.

3.4 Quality Assurance

- Stanford QA must be notified at least one hour before beginning this procedure.
- ONR QA must be notified at least one hour before beginning this procedure.
- D. Ross (or her designate) must be present to monitor the completion of this procedure.

This procedure shall be conducted on a formal basis to its latest approved and released version. The QA Program Engineer shall be notified of the start of this procedure. A Quality Assurance representative designated by D. Ross shall review any discrepancy noted during test. Redlines shall be approved by the QA representative. The QA representative will nominally be Russ Leese. Upon completion of this procedure, the QA Program Engineer, D. Ross or R. Leese, shall certify his of her concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating the appropriate approval line at the end of the procedure.

3.5 Red-Line Authority

Authority to red-line (make minor chances during execution) this procedure is given to the qualified personnel listed in section 3.2.2. All redlines must be approved by the QA representative. In addition, approval by the Technical Manager shall be required if, in the judgement of the test director or the QA representative, experiment functionality may be affected.

4. REQUIRED EQUIPMENT

The following equipment is necessary to perform this procedure:

Item	Calibration Required

Keithley 580 Multimeter	Yes
Non-magnetic calipers	Yes
Stereo Inspection Microscope with VCR and still image recording capability	No
Various non-magnetic tools from the gyroscope tool box	No

Note: Other miscellaneous measurement equipment may be used to obtain dimensional measurements if they (1) meet the requirements for tools used on the gyroscope in the GPB Magnetics Control Plan P0057, and (2) are properly calibrated.

5. INITIAL CONDITIONS

Before beginning this procedure, it is necessary to have completed the removal of FQH53 from the probe.

6. OPERATIONS

6.1 Procedure Initialization

Start Date: _____ Start Time: _____

Test Engineer: _____ (print)

QA Representative: _____ (print)

Record Model Numbers, Serial Numbers, and Calibration Dates (if applicable) for the equipment designated in Section 4.

Model	**Serial Number**	**Calibration Date**

Verify that Dr. Barry Muhlfelder has been notified that this procedure is about to begin. _____

6.2 Low-Temperature Test

6.2.1 Consult the "As-Built" version of P0681 in which the gyroscope was removed from the SIA. If the room-temperature resistance measurements taken during this procedure record a loop resistance of greater than 8 kΩ, then it shall be considered proof that the readout anomaly is localized to the gyroscope. However, if the measured resistance is less than this, then the results are inconclusive. In this case conduct a low-temperature checkout of the readout loop. This shall be accomplished using the standard traveler and released procedures that are used to commission the gyroscope (specifically, P0299 verifies the superconductivity of the cable). Record the results below:

Conducted Low Temperature Test (circle one): Yes No

Passed Low Temperature Test (circle one): Yes No

6.2.2 If a low-temperature test was performed, then concurrence from the payload technical manager must be obtained before proceeding with the rest of this procedure:

Technical Manager Approval: _____

6.3 Initial Inspections Prior to Opening Housing

6.3.1 Remove the lid from the gyroscope container and remove the end of the cable. *Do not yet remove the housing from the container.* _____

6.3.2 Using the Keithley 580 Multimeter, measure the resistance of the pickup loop:

R = _____ Ω

_____

6.3.3 Now remove the gyroscope from its container. Again using the Keithley 580 Multimeter, measure the resistance in the loop:

R = _____ Ω

6.3.4 Visually inspect the readout cable. Starting at the entrance to the gyroscope housing, and using a microscope, carefully examine for any defects. Document the state of the cable in notes in the space provided below, and by taking pictures and/or video tape of the microscopic images.

6.3.5 Now focus on the entrance of the readout cable to the housing. Again, record observations using notes, images, and/or video tape.

6.3.6 Open the gyroscope housing. Conduct a standard gyroscope inspection, checking for particulates, coating damage, and quartz damage. Complete the standard inspection form and staple to this procedure.

6.3.7 Now carefully inspect the readout loop under the microscope. Take video tape or images to document the state of the loop. Use special lighting as appropriate to improve the image quality. Be sure to look very closely at the location where the cable is mated to the loop. Make

notes below:

6.3.8 Carefully disassemble the readout connection. Refer to drawing 23185 for the part numbers and correct installation of the various components.

Confirm that all required parts are present, and that it was assembled as designed. Record below any notes or observations which might relate to the cause of the gyro 4 failure which become apparent at this stage.

6.3.9 Do a detailed microscopic inspection of all hardware. Check specifically for burrs or other defects that might interfere with the mating of the cable to the readout loop. Make notes below.

6.3.10 Now conduct a microscopic inspection of the area of the pickup loop which was underneath the readout cable. Specifically, look for places where the coating is scraped or missing, or altered in any way. Make notes below.

6.3.11 Using the released drawings for each part (which can be found in the gyroscope drawing tree 23200-112), conduct a 100% dimensional inspection of all parts using non-magnetic calibrated instruments. Upon completion of the inspection of each part, attach the inspection drawing with completed measurements on it to the back of this procedure, and indicate completion by checking below:

P/N	Description	Checked
25012-101	Pin, Contact, R/O Cable	
25555-101	Ring, Retaining, External, "E"	
25013-101	Spring, Contact Pin	
25014-101	Sleeve, Contact Pin	
25401-102	Washer, Conductor, R/O Cable	
25007-101	Washer, Flat, R/O Cable	
25007-102	Washer, Curved, R/O Cable	
25006-101	Nut, Hex, R/O Cable	

6.3.12 Bag and label all parts. Retain for future examination.

6.4 Second Low-Temperature Test

6.4.1 At the discretion of the Technical Manager, the gyroscope may now be reassembled with a readout cable of the new design, or the existing readout cable may be modified to make it consistent with the new design. This test shall be done using the standard gyroscope acceptance test traveler and procedures (specifically P0299 verifies the superconductivity of the loop). This type of action would be taken to confirm that the material properties of the gyroscope and cable are still consistent with superconductivity (to close out the relevant nodes on the fault tree). If this action is taken, the specifics of the process shall be documented in DR 278 and below.

6.4.2 If low-temperature test was performed, indicate below and its pass/fail status.

Conducted Low Temperature Test (circle one): Yes No

Passed Low Temperature Test (circle one): Yes No

Note: The readout anomaly fault tree shall be updated using the information obtained in this examination, and all appropriate nodes closed out.

7. PROCEDURE COMPLETION

Record completion of this procedure in the traveler, as appropriate.

Record any abnormalities or deviations from this procedure in the D-Log. If the QA representative decides it is appropriate, open a Discrepancy Report to document the event.

This test has been completed according to the procedure contained herein. All redlines used have been integrated into this document.

Test Director: (print)	(sign)
(optional) **Test Engineer:** (print)	(sign)
(optional) **Test Engineer:** (print)	(sign)
QA Representative: (print)	(sign)