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

BOTTOM TO TOP PARTICLE CHECKS ON PROBE C EXHAUST LINE

GP-B SCIENCE MISSION PROCEDURE
P0729 Rev -

August 7, 2000

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

1. SCOPE

This procedure will verify the cleanliness of the exhaust manifold with gas flowing from the gyro end of the probe toward the top hat. This procedure is not intended to cleanup particles in the manifold, only survey the manifold's cleanliness at various flow rates.

2. REFERENCES

2.1 Plans and Procedures

P0023 GPB Clean Room Procedures

P0057 GPB Magnetic Control Plan

P0059 Probe Contamination Control Plan

P0108 Science Mission Quality Plan

P0147 Relativity Mission Contamination Control Plan, Master

P0327 Gravity Probe B Relativity Mission System Safety Program Plan

3. GENERAL REQUIREMENTS

3.1 Environmental Requirements

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

3.1.1 Room Cleanliness

The Class 10 clean room where this integration takes place shall be maintained at the cleanliness levels per Federal Stanford 209D. All personnel in the clean room shall wear certified Class 10 cloth garments.

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 parts shall be maintained at level 100 cleanliness per GP-B Contamination Control Plan (P0059). A portable particle counter shall be set up on a table downstream of the local work area, and monitored to ensure that particulate counts are consistent with the 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 all parts of their bodies downstream of the probe, defined by the direction of HEPA airflow.

3.1.3 Magnetic Contamination

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, Science Mission (P0057). Take all necessary precautions to keep tools and handling equipment free of particulate contamination.

Only nonmagnetic materials are allowed to touch the cold end of the probe.

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
- Ken Bower
- Bruce Clarke
- Robert Brumley

See section 3.4 for details on the requirements for Quality Assurance notification and witnessing of this procedure.

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 Probe C and its hardware to avoid damage to them.

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 24 hours before beginning this procedure.

ONR QA must be notified at least 24 hours 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. Additionally, 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

Flight Hardware

- Probe C / SIA Assembly

Non-Flight Hardware

The following GSE hardware is required to complete this procedure

Item	Calibration Required
Digital Camera	NO
Video Camera	NO
Probe C - SIA ICD	NO
Portable Particle Counter	YES

5 Setup and Background Test

5.1 Initial Preparations

Record Start Time and Date: _____

5.1.1 The Probe should be horizontal on the Precision Manipulator at a height of approximately four feet, with the cold end toward the observation window.

5.1.2 Clear off a suitable table and situate it under the cold end of the probe. Make sure that it is clean. If necessary, wipe it down with an appropriate solvent.

5.1.3 Clear adequate space on another table near the Top Hat end of the probe.

5.1.4 Set up a GN2 supply with Regulator. This may be the room supply that is provided by the boiloff of liquid nitrogen from pressure vessels, and is therefore very pure and moisture free. This gas is provided at approximately 40 psi and already has a regulator incorporated. (Alternatively, an ultra-pure supply bottle of pressurized nitrogen may be used). Set the regulator to 5 psi.

5.1.5 Connect the line from the regulator to the input of the flow controller/meter.

5.1.6 Connect the 0.1 micron final filter to the output of the flow controller/meter.

5.1.7 Connect the adapter assembly, including pressure gauge, which interfaces the 0.1 micron filter with a 1/4"non magnetic OD tube that will interface with the teflon tube at the gyroscopes exhaust manifold..

5.2 Measure Cleanliness of the Supply Gas

5.2.1 Fashion a clean bag of approximately one liter volume, and with small openings at opposite ends. These will be later attached, as described below, to the gas source tube and the inlet to the particle counter respectively, The bag serves as a gas conduit maintained at a pressure ≅ 1 ATM. This is important because the pressure in the bag should be just above ambient, but not so high that it interferes with the operation of the particle counter. This ensures that the particle counter which samples at ~ 2800 SCCM senses gas representative of the source. In practice, this requires adjustment of the gas flow to a value typically about 4000 SCCM.

5.2.2 Set up and turn on the particle counter in the vicinity of where this test will take place. Do not attach the particle counter to the hole at the other end of the bag at this time. The particle counter should be operating and integrating particles ≥ 0.5 µm for one minute increments. Confirm that it is reading the expected ambient counts, i.e. < 10 counts/SCFM, consistent with Class 10 cleanroom standards when sampling uncontaminated cleanroom air. Record the data in Table 1 below. The particle counter should typically read ≤ 3 count per SCFM if no particulates are generated upstream in the vicinity of the device. Otherwise check operation and repeat.

Table 1. Ambient Particle Counts per SCFM ≥ 0.5 µm

Sample 1	
Sample 2	
Sample 3	
Sample 4	
Sample 5	
Average	

5.2.3 Now insert the tubing attached to the exit line of the filter directly into the clean bag. Tape the bag with cleanroom tape so that it is well sealed on this exit line. Set the flow controller/meter to approximately 0.15 SCFM (4200 SCCM) by adjusting the flow controller/meter and its input pressure.

5.2.4 Carefully insert the sampling tube of the particle counter, as shown in Figure 2, into the exit hole of the bag and tape in place. Do not seal this opening. Verify that the bag is loosely inflated which ensures that the pressure in the bag is approx. at ambient pressure. If inflated too tightly, decrease the flow or let more gas escape from the bag at/near the attachment point to the sampling tube of the PC and vice versa if the bag does not inflate sufficiently. Record data in Table 2. after 2 min have elapsed. Take five 1 minute samples with the PC.

Data should average ≤ 1 count/SCFM. indicating a source gas of sufficient cleanliness that will be put into the exhaust lines. If this is not true, disconnect, clean and flush the system and repeat this test, recording the data in Table 2A. Otherwise do not enter data into Table 2A

5.2.5 Remove the bag from the particle counter while gas is still flowing. Let purge for ≥ 1 min.

5.2.6 Close bag outlet end slowly, fold and seal it, while shutting slowly off gas supply.

Table 2. Source Gas Cleanliness

1 min Sample Sequence Number	FLOW RATE (SCCM)	INTEGRATED NUMBER OF PARTICLES per SCFM ≥ 0.5 µm
1	4200	
2	4200	
3	4200	
4	4200	
5	4200	
Average	**4200**	

Table 2A. Source Gas Cleanliness

1 min Sample Sequence Number	FLOW RATE (SCCM)	INTEGRATED NUMBER OF PARTICLES per SCFM ≥ 0.5 µm
1		
2		
3		
4		
5		
Average		

Approval of Section 5.

Completed: _____ date: _____

Discrepancies if any:

Approved: _____ __ date: _____
ITD

Approved: _____ date: _____
QA

6. **OPERATIONS**

6.1 Procedure Initialization

6.1 Test Setup

6.1.1 Remove cover or open vat valve at top hat on Probe C on exhaust line to be checked.

6.1.2 Install Teflon tube adapters to the gyroscope side of the exhaust line. This tube should have an ID identical to the tubes used in the science mission. Furthermore, they should be cleaned in a manner identical to the flight parts.

6.1.3 With the gas still flowing connect the gas supply to the teflon tube adapter on the exhaust manifold on the gyroscope side on the exhaust plumbing.

6.1.4 Position the particle detector close to where the gas exits the exhaust line in the line of the gas flow. Gas from the exhaust line should flow toward the intake funnel on the particle detector.

6.2 Exhaust Line Particle Counts

6.2.1 Note the initial gas flow in Table 3 and the number of particles detected.

6.2.2 Take 2 additional 1-minute measurements with the particle detector and record in the appropriate data table.

6.2.3 With the gas still flowing, increase the flow rate at the test director's discretion and record the number of particles in the table.

6.2.4 Take a second set of measurements for this line at the higher flow rate

6.2.5 Take 5 additional 1-minute measurements with the PC and record in the appropriate data table. Flow rates are to be decided by the test director.

6.2.6 With the gas still flowing, disconnect the gas supply to the teflon tube at the exhaust manifold on the gyroscope side of the probe.

Table 3. Gyro Exhaust Line Data

1 min Sample Sequence Number	FLOW RATE (SCCM)	INTEGRATED NUMBER OF PARTICLES per scfm = 0.5 µm
FIRST MEASUREMENT SET (6.2.1 - 6.2.4)		
0		
1		
2		
3		
4		
5		
Average (1-5)		
SECOND MEASUREMENT SET (6.2.4 - 6.2.5)		
0		
1		
2		
3		
4		
5		
Average (1-5)		

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:	_____ (sign) _____ (print)	(date and stamp)
(optional) Test Engineer:	_____ (sign) _____ (print)	(date and stamp)
(optional) Test Engineer:	_____ (sign) _____ (print)	(date and stamp)
QA Representative:	_____ (sign) _____ (print)	(date and stamp)