# Science Gyroscope Test Readiness Review

Date & Time: November 12, 1997, 9:00 AM to noon
Location: GP-B conference room

Purpose:
To ensure that the test article hardware, test facility, ground support personnel, and test procedures are ready for testing, data acquisition, reduction, evaluation, and control.

Scope:
The Science Gyroscope Test Readiness Review (TRR) will encompass all Science Gyroscope (SG) flight hardware. The Science Gyroscope flight hardware includes the completed Science Gyroscope assemblies and their components, including: rotors, housings, and support hardware and cabling.

Agenda:
- Requirements Traceability Status
- Procedure Status
- Test Personnel Status
- Test Resources Status
- Test Support Software Status

Review Team:

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| John Turneaure | Hardware Manager |
| Yueming Xiao | Manager, Gyroscope Commissioning |
| Sasha Buchman | Manager, Gyroscope Development |
| George "Mac" Keiser | Lapping and Polishing Manager |
| Barry Muhlfelder | Manager, SQUID Development |
| Ben Taller | Quality Assurance |
| Jeremy Kasdin | Chief Systems Engineer |
| Ken Hooper | Review Leader |
| Ed Ingraham | ONR (ex officio) |

Objectives:
- Confirm that in-place test plans and procedures meet verification requirements and specifications.
- Confirm that sufficient and detailed resources (of the right type) are allocated to the test effort.
- Examine detailed test procedures for completeness and safety during test operations. Note who is in charge of the test operations and test article and who is in charge of the facilities.
- Determine the critical test personnel who are authorized to perform test.
- Confirm that test support software is adequate, pertinent, and verified (validated for intended use).
- Confirm that all interfaces with the test article, test equipment, and facilities, especially power, data, instrumentation, etc., are adequate, safe, and in accordance with the test procedure. Ensure the customer, witnessing agents, test personnel, quality assurance, and support personnel understand the objective of the test and the parameters that are critical for successful operation.
- Confirm that the documentation has proper traceability.
- Confirm that test equipment has been appropriately calibrated.

Exit Criteria:

The following items identify the categories of items to be checked; the individual checks are enumerated in the attached checklists:

- Do the test procedures verify all applicable requirements?
- Have the test procedures been "dry-runned"? Do they indicate satisfactory operation?
- Have test personnel received training in test operations procedures?
- Are resources available to adequately support the planned tests as well as contingencies, including failed hardware replacement?
- Has the test support software been demonstrated to handle test configuration assignments, and data acquisition, reduction, evaluation, control, and archiving?

**Attachments:**

A. Gyroscope Manufacturing Flow Diagrams
B. Requirements Verification Matrix
C. Document Status Checklist
D. Test Personnel Status Checklist
E. Test Resources Checklists and Test Support Software Checklist
F. Completion Certificate

# A. Gyroscope Manufacturing Flow

### Rotor Polishing

- P0074 Lapping Procedure for Quartz Rotors
- P0075 Polishing Procedure for Quartz Rotors
- P0076 Rotor Diameter Measurement Procedure
- P0077 Rotor Sphericity Measurement Procedure

### Rotor Coating

- P0025 Rotor Coating Wet Bench Operating Procedure
- P0079 Rotor Coating Procedure
  - P0062 Procedure for Sulfuric Acid Boil to Remove Organic Contaminants from Fused Quartz
- P0056A Automated Betascope Rotor Uniformity Measurements
- P0080 Cryogenic Magnetic Screening Procedure

### Housing Fabrication and Coating

### Hardware, Cables, and Sensors Fabrication

- P0087 Suspension and Grounding Wire Assembly
- P0120 Heater Assembling, Chip Resistor
- P0304 Procedure for Stripping the Aluminum Cladding from the Fiber Optic Cable
- P0086 UV and Optical Readout Hardware and Cable Assy
- P0202 Procedure for Cable Assembly, Ground
- P0306 Procedure for Assembling Ultra Violet Fiber Optic Cable Assembly
- P0085 Gyroscope Hardware Assembly

### Gyroscope Integration

- P0296 Pre-Commissioning Test Inspections of SM Gyroscopes
  - P0369 Procedure for Resistance Testing of Gyroscope Coatings to Rotor
  - P0370 Procedure for Installing Readout Cable to Gyroscope
  - P0313 Pre-Commissioning Visual Inspection of SM Gyroscope
  - P0297 Functionality Test of Thermometry & Heater for SM Gyroscopes (optional)

### Gyroscope Commissioning (P0281)

# Housing Fabrication and Coating

## Housing Fabrication

P0002 R/O Surface Polishing and Etching Procedure

P0003 Inspection of Stanford Housing Blanks

- P0014 General Inspection of Housings,
- P0016 Fast Cleaning Procedure for the Inspection of Quartz Housings,
- P0021 Housing Dimensions Check

P0004 Inspection by Stanford after Cavitron Operations

- P0018 Inspection of Protective Coatings of R/O Surface (K-10, Al-Ti),
- P0017 A Removal of K-10 Epoxy Resin,
- P0014 General Inspection of Housings,
- P0021 Housing Dimensions Check,

P0005 Etching and Reinspection by Stanford after Cavitron Operations

- P0015 Procedure for Etching of Quartz Housing to Relieve Strain Around Drilled Holes, P0016, P0014, P0021

P0006 Procedure to Clean Housings Prior to Al/Ti Deposition

P0007 Tumble Lapping of Cavity

P0008 Inspection by Stanford of Tumble Lapped Housing

- P0015, P0016, P0014

P0009 Cavity Sphericity and Depth Measurement of Tumble Lapped Housing by Stanford

P0010 Removal of Al/Ti Coating and Inspection of R/O Surface

P0011 Coating of R/O Surface with K-10 Epoxy by Stanford

P0012 Inspection by Stanford of Finished Quartz Housing

- P0018, P0017, P0016, P0014, P0021

P0013 Etching and Reinspection by Stanford of Finished Quartz Housing

- P0015, P0016, P0014, P0021

## Housing Coating

P0114 Deposition of Niobium Loop Layer on Development Quartz Housings

P0105 Gravity Probe B Gyro Housing Lithography Process 4/93

P0044 Quartz Housing Coating Procedure

# Gyroscope Commissioning Test Flow (P0281)

## P0272 Room Temperature SM Gyroscope Commissioning Tests

- P0111 Room Temperature Gyro Installation and Removal — GCP-Op6
- P0203 UV Charge Control Commissioning for SM Gyro (optional) — FGT#3 Tables 1-3
- P0279 Magnetic Screening of the Gyroscope in the Large Scale Magnetics Testing Facility — FGT#1, stripchart, Magnetic Screening Test Report
- P0299 Gyro Levitation with the DDC Suspension System — FGT#3, Traveler
- P0298 Additional Information on Gyroscope Geometry (optional) — FGT#2
- P0307 Confirmation of No Charging During Levitation — FGT#2
- P0321 Room Temperature Gyro Spin-up and Spin-down — FGT#2, file, lab notebook

P0277 Installation of Support Hardware in the Gyroscope Commissioning Probe

## P0275 Low Temperature SM Gyroscope Commissioning Tests

- P0204 Installation of SM Gyroscopes in the Low Temperature Commissioning Probe — P-Doc, GCP-Op1 & 2
  - P0300 Gowning Procedure for the Gyroscope Commissioning Probe Clean Room
- P0273 Gyroscope Commissioning Probe Insertion — P-Doc
- P0308 Post Insertion Electrical Checklist — GCP-Op3 & 4
- P0297 Functionality Test of Thermometry & Heater for SM Gyroscopes (optional) — FGT#1
- P0203 UV Charge Control Commissioning for SM Gyro (optional) — FGT#3, Table 1-3
- P0274 Verification of DC Coupling of SM Gyroscopes — FGT#5
- P0299 Gyro Levitation with the DDC Suspension System — Traveler, FGT#4
- P0298 Additional Information on Gyroscope Geometry (optional) — FGT#3
- P0307 Confirmation of No Charging During Levitation — FGT#3
- P0276 Flux Flushing in Commissioning Probe — FGT#6 & 3
- P0311 Performance Testing (optional) — FGT#3
  - P0310 Low Temperature Gyro Spinup Procedure
- P0314 Fast Spin Test in the Gyroscope Commissioning Probe — FGT#4, 3

P0278 Post Commissioning Handling and Storage — Traveler
- P0300 Gowning Procedure for the Gyroscope Commissioning Probe Clean Room

# B. Science Gyroscopes (Science Payload Specification [PLSE-12, F277277] 3.7.1.5) Verification Matrix

| Section | Title | Text | Method | Comments | REE, ECD | Plan |
|---|---|---|---|---|---|---|
| 3.7.1.3.2.5 | Magnetic Control of Materials | All SIA parts shall be screened in accordance with the Magnetics Control Plan P0057. | I, T | Design Verification:<br>Magnetic Screening of all meterials used in SIA and probe assembly.<br>P0276 Procedure for Flux Flushing the Gyroscope in the Gyroscope Commissioning Probe<br><br>Flight Unit Acceptance:<br>Magnetic testing during Science Payload assembly and Science Payload Test<br>P0080 Cryogenic Magnetic Screening Procedure | J Lockhart | ✓ |
| 3.7.1.5 | Science Gyroscopes | | | | | |

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| 3.7.1.5.1 | Prime Item Definition | Gyro Spherical Science Gyroscope (one of four)<br>Housing Fused quartz Housing to support a single Gyro<br>Support Hardware and Cabling:<br>1) Electrode hardware - for electrostatic suspension and capacitive position readout of the rotor.<br>2) UV Charge Control Hardware - for photoelectric control of the rotor charge.<br>3) Readout Hardware - for pickup and detection of the London moment signal associated with the Gyro rotor spin axis.<br>4) Thermal Control Hardware - for sensing and increasing (as needed) the Gyro Assembly temperature.<br><br>Each Gyro assembly consists of an assembly including a Gyro and a fused quartz Housing. The Gyro shall be a fused quartz or monocrystalline Silicon sphere with a Niobium coating which becomes superconducting at the cryogenic operation temperature. The Housing contains support hardware necessary to sense the Gyro position within the cavity, levitate it, and spin it up and read out its axis of spin using the London moment of the spinning superconducting Gyro.<br>Gyro systems including their SQUID readouts are used to provide a reference fixed to local inertial space.<br>The Drag Free Gyro system is used to provide a translational reference fixed to local inertial space (a drag-free sensor). Gyro systems shall be compatible with serving as the drag-free sensor. | | | | |
| 3.7.1.5.1.1 | Prime Item Diagram | | | | | |
| 3.7.1.5.2 | Characteristics | | | | | |
| 3.7.1.5.2.1 | Operational Performance | | | | | |
| 3.7.1.5.2.1.1 | Trapped Flux | The assembled gyroscopes shall be compatible with the trapped magnetic flux requirement of Section 1.5 of T003.<br><br>*T003 spec: <= 1.0e-10 T (13.0e-6 G) average rotor trapped field.* | A, T | Procedures verified in GTU-1, GTU-2, and Science Payload Integrated testing (acceptance test). Actual trapped flux verified on orbit.<br>P0276 Procedure for Flux Flushing the Gyroscope in the Gyroscope Commissioning Probe during LTC (P0275) - results recorded in FGT#6, #3 §III | S Buchman | ✓ |

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| 3.7.1.5.2.1.2 | Spin Speed | The set of Gyros as installed in the SIA shall be capable of achieving final spin speeds for all four Gyros in the range specified in Section 4.1 of T003 under the constraints of Sections 3.2.1.7 and 3.7.8.7.1.2.<br>The maximum gyroscope temperature during spinup (measured at the housing) must be less than or equal to 6.4 K.<br>The spinup gas must exert a force of less than or equal to 0.05 N on the Gyroscope Rotor.<br><br>*The current specification is 100 to 180 Hz spin speeds.*<br><br>*Spinup gas is baselined as Helium-3, with a nominal flow rate <= 2.1 mg/s at a temperature <= 8 K, and a total supply volume of 1400 l STP. The spinup time constant should be less than 60 min.* | A, T | Analysis (TBS)<br><br>P0314 Procedure for the Fast Spin Test in the Gyroscope Commissioning Probe - results recorded in FGT#4, #3 §IV | S Buchman | |
| 3.7.1.5.2.1.2.1 | Deteted | Deleted at PCB #301 | | | | |
| 3.7.1.5.2.1.2.2 | Deteted | Deleted at PCB #301 | | | | |
| 3.7.1.5.2.1.3 | Deteted | Deleted at PCB #301 | | | | |
| 3.7.1.5.2.1.4 | Spin-Down Rate | The one-g spin-down rate shall be less than or equal to (df/dt)/f = 2.0e-3 per hour in the spin speed range 0.3 Hz to 3 Hz. | T | P0314 Procedure for the Fast Spin Test - results recorded in FGT#3 §IV | Y Xiao | ✓ |
| 3.7.1.5.2.1.5 | Spin Alignment with Respect to Telescope Axis | | | | | |
| 3.7.1.5.2.1.5.1 | Initial Alignment | The geometry of the gas spin-up system shall be compatible with the initial alignment required in Section 4.3 of T003 assuming a rolling spacecraft.<br><br>*T003 spec: within 1 degree of the desired final direction.* | A | S0291 Initial Gyroscope Alignment | M Keiser ECD 1/15/97 | ✓ |
| 3.7.1.5.2.1.5.2 | Final Alignment | The rotor shape for spin speeds in the range specified in Section 4.1 of T003 shall be compatible with final spin alignment given in Section 5.2 of T003 assuming a 10% modulation of the 0.1 g suspension preload at roll frequency in less than 50 hour. Lower levels of suspension preload may be used for the final fine adjustment.<br><br>*T003 spec: within 10 arcsec of the initial apparent line of sight to the Guide Star.* | A | S0256 Gyroscope Spin Axis Alignment Algorithm for the Gravity Probe B Spacecraft<br><br>(P0311 measures ground alignment capability) | B Bencze | ✓ |

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| 3.7.1.5.2.1.6 | Readout Loop/Readout Cable Assembly | | | | | |
| 3.7.1.5.2.1.6.1 | Decay Time | The decay of the signal produced by magnetic flux injected into the superconducting input circuit shall be less than 1% in a 10 min period, under the condition that the R/O loop is connected to the input of a dc SQUID through the readout cable. The dc SQUID supporting this test shall have an input inductance and coupling equal to the requirements for the flight dc SQUID. | T | P0274 Procedure for Verification of DC Coupling of SM Gyroscopes - results recorded in FGT#5, #3 §III | B Muhlfelder | ✓ |
| 3.7.1.5.2.2 | Physical Characteristics | | | | | |
| 3.7.1.5.2.2.1 | Gyroscope Rotor | | | | | |
| 3.7.1.5.2.2.1.1 | Substrate | | | | | |
| 3.7.1.5.2.2.1.1.1 | Material | The rotor substrate material shall be as specified in Section 1.2 of T003.<br><br>*T003 spec: fused quartz or single-crystal silicon.* | I | Visual inspection and vendor acceptance data<br>Quartz rotor: Vendor provided certificate of compliance - copy is in hardware folder<br>Si rotor: Purchase order is available in hardware folder, coupons of material are available<br>S287 Homogeneity and Composition of GP-B Rotors | M Keiser ECD 12/15/97 | ✓ |
| 3.7.1.5.2.2.1.1.2 | Homogeneity | The density homogeneity d(rho)/(rho) across any diameter shall be less than or equal to 1.0e-5 | I, A | Fused Quartz will be verified by inspection of vendor and U. of Aberdeen data - copy in hardware folder.<br><br>Single-crystal Silicon will be verified by analysis.<br>S287 Homogeneity and Composition of GP-B Rotors | M Keiser ECD 12/15/97 | ✓ |
| 3.7.1.5.2.2.1.1.3 | Diameter | The diameter of the substrate shall be within +/- 500 nm (+/- 20 microinch) of the diameter of the reference sphere 93H57 at 22 degree C +/- 4 degree C.<br><br>*Diameter of 93H57 was measured several times, here and other places, with varying results. Its diameter is 1.495881 inch +/- 0.000045 inch.* | T | P0076 Rotor Diameter Measurement Procedure - results recorded in hardware folders | M Keiser | ✓ |
| 3.7.1.5.2.2.1.1.4 | Asphericity of substrate | The substrate shall have a measured peak-to-valley asphericity less than or equal to the following:<br><br>For the l=2 (oblateness) term, 30 nm (1.2 microinch)<br>For odd harmonics l = 3 to 15, 23 nm (0.9 microinch)<br>For even harmonics l = 4 to 16, 23 nm (0.9 microinch) | T | P0077 Rotor Sphericity Measurement Procedure - results recorded in files on PC connected to Talyrond machines | M Keiser | ✓ |

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| 3.7.1.5.2.2.1.2 | Coating | | | | | |
| 3.7.1.5.2.2.1.2.1 | Coating Material | The coating material shall be niobium. | I | P0079 Rotor Coating Procedure<br>All rotors were sputtered using same target: Target certification is in hardware folder; Log book for sputtering system records when each rotor was sputtered and which target was used. | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.1.2.2 | Coating Uniformity | Coating uniformity shall be Less than or equal to 50 nm (p-v). | T | P0056 Automated Betascope Rotor Uniformity Measurements - results recorded in files on PC connected to Betascope | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.1.2.3 | Superconducting Transition Temperature | The superconducting transition temperature shall be greater than or equal to 8 K. | S | Similarity to test sample data - in hardware folder. | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.1.2.4 | Electron Field Emission | The electron field emission current shall be less than or equal to 2 pA at 3.0e7 V/m. | S | P0307 Confirmation of No Charging of the Gyroscope During Levitation | Y Xiao | ✓ |
| 3.7.1.5.2.2.1.2.5 | Thermal Emissivity | The thermal emissivity shall be greater than or equal to 0.01. | S | Qualification test by similarity to test samples using approved procedures.<br>Similarity to "calorimetry tests performed long ago". Rob has provided paper presented at the 21st Int'l Conf. on Low Temp. Physics (LT21 in Proceedings) with a cover letter relating it to the flight rotors. | R Brumley | |
| 3.7.1.5.2.2.1.2.6 | UV 254 nanometer Photoemissivity of Rotor | The photo emission coefficient shall be greater than or equal to 1.0e-6 electrons/photon for 254 nm photons. | T | P0203 UV Charge Control Commissioning Procedures for SM Gyroscopes - results recorded in tables in P0203 | B Clark | ✓ |
| 3.7.1.5.2.2.1.3 | Mass Unbalance | Gyro: The coated rotor mass unbalance shall meet the requirement in Section 1.3.2 of T003.<br><br>*T003 spec: <= 50 nm.* | A, T | Analysis S0288 GP-B Rotor Mass Unbalance<br><br>Acceptance Test<br>P0056 Automated Betascope Rotor Uniformity Measurements - results recorded in files on PC connected to Betascope | D Gill ECD 12/15/97 | ✓ |

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| 3.7.1.5.2.2.1.4 | Rotor Shape | The coated rotor shall meet the rotor shape requirements of T003 (System Design and Performance Requirements) Section 1.4. | A, T, S | Analysis S0289 GP-B Rotor Shape<br><br>Qualification Test<br>P0056 Automated Betascope Rotor Uniformity Measurements (on each flight rotor) - results recorded in files on PC connected to Betascope<br>P0077 Rotor Sphericity Measurement Procedure (on uncoated flight rotors) - results recorded in files on PC connected to Talyrond<br><br>Similarity to anodized rotor test (non-flight rotor was anodized to measure sphericity in P0077) data TBS (3 rotors were measured, of which data for 2 are available from Mac) | M Keiser ECD 1/15/98 | ✓ |
| 3.7.1.5.2.2.2 | Gyroscope Housing | | | | | |
| 3.7.1.5.2.2.2.1 | Substrate | | | | | |
| 3.7.1.5.2.2.2.1.1 | Material | The housing substrate shall be made from the material specified in Section 1a.1 of T003.<br><br>*T003 spec: fused quartz.* | I | P0014 General Inspection of Housings (within P0008 Inspection by Stanford of Tumble Lapped Housing and P0013 Etching and Reinspection by Stanford of Finished Quartz Housing) | S Buchman | ✓ |
| 3.7.1.5.2.2.2.1.2 | Cavity Diameter | The cavity diameter shall be 38.070 mm (1.4988 inch) with the accuracy given in Section 1a.2 of T003.<br><br>*T003 spec: + 0.003/ -0.000 mm (+0.0001/ -0.0000 inch).* | I | Acceptance data package from vendor (Speedring) in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.2.1.3 | Cavity Asphericity | The internal spherical surface of the cavity shall meet the asphericity requirement of Section 1a.2 of T003.<br><br>*T003 spec: <= 250 nm (p-v).* | I | Acceptance data package from vendor (Speedring) in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.2.1.4 | Cavity Centering to Parting Plane | The center of the cavity shall coincide with the parting plane within 2.5 micrometer . | I | Acceptance data package from vendor (Speedring) in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.2.1.5 | Electrodes Position Accuracy | The positions of the six electrodes shall meet the requirement of Section 1a.3.3 of T003.<br><br>*T003 spec: <= 15 arcmin from their targets.* | I | Acceptance data package from vendor (Speedring) in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.2.1.6 | Electrodes Area Variation | The area variations of the six electrodes shall meet the requirement in Section 1a.3.2 of T003.<br><br>*T003 spec: <= 2% p-v).* | I | Acceptance data package from vendor (Speedring) in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.2.2 | Electrode Coatings | | | | | |

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| 3.7.1.5.2.2.2.2.1 | Uniformity | The electrode coating uniformity shall meet the requirements of Section 1a.3.1 of T003.<br><br>*T003 spec: <= 0.25 micrometer (p-v) axial variation and <= 1.25 micrometer (p-v) radial variation.* | S | Qualification<br><br>Similarity to test item measurement package in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.2.2.2 | Electron Field Emission | The electron field emission current shall be less than or equal to 2 pA at 3.0e7 V/m . | S | P0307 Confirmation of No Charging of the Gyroscope During Levitation - results recorded in FGT#2, #3 §II | Y Xiao | ✓ |
| 3.7.1.5.2.2.2.2.3 | Electrical Resistivity | The electrode coating resistivity shall be less than or equal to 25 microohm-m at 2.5 K. | S | Qualification<br>Similarity to test item (TBS - to be written) | S Buchman | |
| 3.7.1.5.2.2.2.3 | Support Land Coatings | The support land coatings shall insure that rotors and electrodes do not come in contact. | T | acceptance test<br>land and electrode heights determined by P0009 Cavity Sphericity and Depth Measurement of Tumble Lapped Housing by Stanford - results recorded on polar chart in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.2.4 | Caging Land Coatings | The caging land coatings shall insure rotor positioning while caged. | A | Analysis (TBS - to be written) | S Buchman | |
| 3.7.1.5.2.2.2.5 | Spinup Land Coating | The spinup land coatings shall insure functional leakage rate during spinup. | I, T | acceptance inspection<br>P0014 General Inspection of Housings<br><br>P0314 Procedure for the Fast Spin Test in the Gyroscope Commissioning Probe appears to measure leakage rate (FGT#3 section IV) | S Buchman | ✓ |
| 3.7.1.5.2.2.2.6 | Cavity Grounding Coating | A cavity grounding coating shall be provided for all surfaces less than 125 micrometer (5 milliinch) from the rotor surface with the exception of: suspension and charge management electrodes, and the isolating areas round these electrodes (Up to 50 missing areas not exceeding 5 mill are allowed in the grounding coating.). | I | acceptance inspection<br>P0014 General Inspection of Housings<br><br>P0305 Procedure for Gyroscope High Voltage to Ground Plane Breakdown - results recorded in table in P0305 | S Buchman | ✓ |
| 3.7.1.5.2.2.2.7 | Readout Loops | | | | | |
| 3.7.1.5.2.2.2.7.1 | Geometry | The readout loop shall be located on the parting plane of the readout housing half and consist of 4 turns. | I | acceptance inspection<br>P0014 General Inspection of Housings | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.2.7.2 | Materials and Composition | The readout loop shall be made from niobium. | I | acceptance inspection<br>Material all came from one lot.<br>Certification of the target is not necessarily available (from '88-89).<br>Deposition equipment log book records the target used and housing material was applied to. | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.2.7.3 | Thickness | The readout loop thickness shall be 400 nm +/- 100 nm. | S | qualification test of coupon samples<br>P0114 Deposition of Niobium Loop Layer on Development Quartz Housings - results recorded in attachment to P0114 hardcopy kept by Mae | B Muhlfelder | ✓ |

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| 3.7.1.5.2.2.2.7.4 | Superconducting Transition Temperature | The readout loop shall have a superconducting transition temperature greater than or equal to 8 K . | S | ~~acceptance~~ qualification test of coupon samples P0114 Deposition of Niobium Loop Layer on Development Quartz Housings- results recorded in attachment to P0114 hardcopy kept by Mae | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.2.7.5 | Centering to Cavity | The readout loop shall be centered on the gyro housing cavity within 10 micrometer. | I | acceptance test P0105 Gravity Probe B Gyro Housing Lithography Process 4/93 - results recorded in data sheet in P0105 | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.2.7.6 | In-Plane Asymmetry | The in-plane asymmetric loop area of the pickup loop shall be less than or equal to 0.6% of the total pickup loop area. This includes both geometric and diamagnetic contributions to the asymmetry. | I, A | acceptance inspection (to confirm that correct mask was used) P0105 Gravity Probe B Gyro Housing Lithography Process 4/93<br><br>S0290 In-Plane Assymetry of Pick-Up Loops (to include other contributions) | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.2.7.7 | Inductance | The readout loop inductance shall be less than or equal to 2 microhenry. | S | qualification test Similarity to test article - results recorded in TBS | B Muhlfelder | |
| 3.7.1.5.2.2.2.7.8 | Diameter | Inside diameter of inner turn >= 19.81 mm (0.780 inch). Outside diameter of outer turn <= 20.68 mm (0.814 inch).<br><br>*The minimum ID is to control the rate of magnetic flux change due to trapped flux.*<br>*The maximum OD is to control the coupling to external magnetic fields.* | I | acceptance inspection (to confirm that correct mask was used)<br><br>P0105 Gravity Probe B Gyro Housing Lithography Process 4/93 | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.2.8 | Readout Cable | | | | | |
| 3.7.1.5.2.2.2.8.1 | Inductance | The readout cable shall have an inductance of less than 0.1 microhenry, and the inductance shall be stable to 5 parts in 1.0e5 per year. | S, A | qualification test similarity to test article to be tested - results will go in hardware folder<br><br>Analysis (TBS) for stability | B Muhlfelder | |
| 3.7.1.5.2.2.2.8.2 | Out of Plane Asymmetry | Asymmetric loop area perpendicular to the plane of the pickup loop times the cosine of the angle between the spin axis and out of plane asymmetry shall be less than 5.0e-5 of the loop area.<br><br>*With the current design, this amounts to an area of less than 2* $mm^2$. | I, A | Inspection of completed gyro assy.<br><br>Analysis (TBS) | B Muhlfelder | |
| 3.7.1.5.2.2.2.8.3 | Transition Temperature | The readout cable shall have a superconducting transition temperature of greater than 8.5 K. | S | qualification test Similarity to material coupon test to be performed (by J Mester) | B Muhlfelder | ✓ |

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| 3.7.1.5.2.2.2.8.4 | Flux Coupling from Applied External Field | The flux coupling from an applied external field shall be less than or equal to 1.0e-7 flux-quanta/pT (flux is referred to flux in SQUID loop). The applied external field is the free magnetic field applied to the shield of the readout cable. | A | ~~qualification tests~~ Analysis TBS | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.3 | Gyroscope Assembly | | | | | |
| 3.7.1.5.2.2.3.1 | Rotor Gap to Electrodes | When the rotor is centered, the gap between the rotor and electrodes shall be as required in Section 1.6.1 of T003.<br><br>*T003 spec: 31 micrometer +/- 3 micrometer.* | I | P0009 Cavity Sphericity and Depth Measurement of Tumble Lapped Housing by Stanford - results recorded in files on PC connected to Talyrond and on polar chart in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.3.2 | Rotor Gap to Support Lands | When the rotor is centered, the gap between the rotor and the support lands shall be as required in Section 1.6.2 of T003 with a tolerance of +/- 3.7 micrometer.<br><br>*T003 spec: 19 micrometer.* | I | P0009 Cavity Sphericity and Depth Measurement of Tumble Lapped Housing by Stanford - results recorded in files on PC connected to Talyrond and on polar chart in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.3.3 | Rotor Gap to Caging Lands | When the rotor is centered, the gap between the rotor and the caging lands shall be 19 micrometer +/- 3.7 micrometer. | I | P0009 Cavity Sphericity and Depth Measurement of Tumble Lapped Housing by Stanford - results recorded in files on PC connected to Talyrond and on polar chart in hardware folder | S Buchman | ✓ |
| 3.7.1.5.2.2.4 | Charge Control | | | | | |
| 3.7.1.5.2.2.4.1 | Photo Emissivity from UV Electrode | The photoemission from the UV electrode shall be greater than or equal to 5.0e-7 electron/photon. | T | P0203 during RTC (P0272) and LTC (P0275) - results recorded in files on data acquisition system | B Clark | ✓ |
| 3.7.1.5.2.2.5 | Gyro Instrumentation Characteristics | | | | | |
| 3.7.1.5.2.2.5.1 | Germanium Resistance Thermometer Characteristics | The GRTs shall have a nominal resistance of 1500 ohm at 4.2 K and be calibrated over the temperature range 1.4 K to 100 K with an accuracy of 5 mK over the temperature range from 1.4 K to 10 K traceable to the International Temperature Scale of 1990 per MIL STD 45662A. | I | Incoming acceptance inspection of manufacturer data sheet in Flight Hardware Storage area | M Taber | ✓ |
| 3.7.1.5.2.2.5.2 | Heater Characteristics | | | | | |
| 3.7.1.5.2.2.5.2.1 | Resistance | The resistance shall be 1320 ohm +/- 100 ohm at 4.2 K. | T | P120 Heater Assembling, Chip Resistor | B Muhlfelder | ✓ |
| 3.7.1.5.2.2.5.2.2 | Dipole Moment due to Current | The current induced magnetic dipole moment shall be less than 2.0e-9 A-$m^2$/mA (2.0e-6 emu/mA). | S | Similarity to qual. article - test data in J Mester's "Miscellaneous" folder | B Muhlfelder | ✓ |

# C. Science Gyroscope Requirements Verification Documents Checklist

## Gyroscope Fabrication

| Document | Revision Date | Author | Title | Written | In Database | Approval Status |
|---|---|---|---|---|---|---|
| *P0001* | *4/16/90* | *P Bayer* | *Standard Cleaning Procedure for Housings* | ✓ | ✓ | *Approved* |
| *P0003* | *3/1/89* | *S Buchman* | *Inspection of Stanford Housing Blanks* | ✓ | ✓ | *Approved* |
| *P0004* | *3/1/89* | *S Buchman* | *Inspection by Stanford after Cavitron Operations* | ✓ | ✓ | *Approved* |
| *P0005* | *3/1/89* | *S Buchman* | *Etching and Reinspection by Stanford after Cavitron Operations* | ✓ | ✓ | *Approved* |
| *P0006B* | *9/1/93* | *B Muhlfelder* | *Procedure to Clean Housings Prior to Al/Ti Deposition* | ✓ | ✓ | *Approved* |
| P0008 | 3/1/89 | S Buchman | Inspection by Stanford of Tumble Lapped Housing | ✓ | ✓ | Approved |
| *P0010* | *1/1/92* | *S Buchman* | *Removal of Al/Ti Coating and Inspection ofR/O Surface* | ✓ | ✓ | *Approved* |
| *P0012* | *3/89* | *S Buchman* | *Inspection by Stanford of Finished Quartz Housing* | ✓ | ✓ | *Approved* |
| P0014 | 2/89 | D Gill | General Inspection of Housings | ✓ | ✓ | Approved |
| *P0016* | *2/1/89* | *S Buchman* | *Fast Cleaning Procedure for the Inspection of Quartz Housings* | ✓ | ✓ | *Approved* |
| *P0020* | *4/1/89* | *S Buchman* | *Housing Numbering* | ✓ | ✓ | *Approved* |
| *P0021* | *4/1/89* | *S Buchman* | *Housing Dimensions Check* | ✓ | ✓ | *Approved* |
| *P0022* | *4/1/89* | *P Bayer* | *Packing and Shipping* | ✓ | ✓ | *Approved* |
| *P0025* | *3/23/93* | *D Gill* | *Rotor Coating Wet Bench Operating Procedure* | ✓ | ✓ | *Approved* |
| *P0044* | *9/1/89* | *P Zhou* | *Quartz Housing Coating Procedure* | ✓ | ✓ | *Approved* |
| P0056A | 12/29/94 | D Gill | Automated Betascope Rotor Uniformity Measurements | ✓ | ✓ | Approved |
| *P0062* | *2/1/92* | *D Gill* | *Procedure for Sulfuric Acid Boil to Remove Organic Contaminants from Fused Quartz* | ✓ | ✓ | *Approved* |
| *P0074* | *1/1/93* | *M Keiser* | *Lapping Procedure for Quartz Rotors* | ✓ | ✓ | *Preliminary* |
| *P0075* | *1/1/93* | *M Keiser* | *Polishing Procedure for Quartz Rotors* | ✓ | ✓ | *Preliminary* |
| P0076 | 1/1/93 | M Keiser | Rotor Diameter Measurement Procedure | ✓ | ✓ | Preliminary ECD imminent |
| P0077 | 12/22/94 | M Keiser | Rotor Sphericity Measurement Procedure | ✓ | ✓ | Preliminary |
| *P0078* | *08/01/92* | *M Keiser* | *Rotor Handling Procedures* | ✓ | ✓ | *Preliminary* |
| P0079 | *08/01/92* | D Gill | Rotor Coating Procedure | ✓ | ✓ | *Preliminary* |
| P0080 | 08/01/92 | J Lockhart | Cryogenic Magnetic Screening Procedure | | | |
| *P0085* | *10/1/92* | *P Bayer* | *Gyroscope Hardware Assembly* | ✓ | ✓ | *Approved* |
| *P0086* | *10/1/92* | *P Bayer* | *UV and Optical Readout Hardware and Cable Assy* | ✓ | ✓ | *Approved* |
| *P0087* | *10/1/92* | *C Gray* | *Suspension and Grounding Wire Assembly* | ✓ | ✓ | *Approved* |
| P0105 | 5/21/97 | R Shile | Gravity Probe B Gyro Housing Lithography Process 4/93 | ✓ | ✓ | *Approved* |

| | | | | | | |
|---|---|---|---|---|---|---|
| P0114 | 9/1/94 | D Gill | Deposition of Niobium Loop Layer on Development Quartz Housings | ✓ | ✓ | *Approved* |
| P0120 | 11/2/94 | M Luo | Heater Assembling, Chip Resistor | ✓ | ✓ | Draft |
| *P0197* | *2/28/97* | *C Gray* | *KJL Coating Facility Gyro Housing Coating Procedure for Manual Operation* | ✓ | *no soft copy* | *Approved* |
| *P0202* | *7/21/97* | *C Gray* | *Procedure for Cable Assembly, Ground* | ✓ | ✓ | *Approved* |
| *P0304* | *6/26/97* | *C Gray* | *Procedure for Stripping the Aluminum Vcladding from the Fiber Optic Cable* | ✓ | ✓ | *Approved* |
| *P0306* | *7/21/97* | *C Gray* | *Procedure for Assembling Ultra Violet Fiber Optic Cable Assembly* | ✓ | ✓ | *Approved* |

**Gyroscope Integration & Commissioning**

| Document | Revision Date | Author | Title | Written | In Database | Approval Status |
|---|---|---|---|---|---|---|
| P0111 | 7/10/97 | C Gray | Room Temperature Gyro Installation and Removal Procedure | ✓ | ✓ | Approved |
| P0203 | 6/9/97 | B Clarke | UV Charge Control Commissioning Procedure for SM Gyroscopes | ✓ | ✓ | Approved |
| P0204 | 6/16/97 | D Hipkins | Procedure for Installation of SM Gyroscopes in the Low Temperature Commissioning Probe | ✓ | ✓ | Approved |
| P0272 | 7/10/97 | D Hipkins | Room Temperature SM Gyroscope Commissioning Tests | ✓ | ✓ | Approved |
| P0273 | 7/10/97 | D Hipkins | Gyroscope Commissioning Probe Installation Procedure | ✓ | ✓ | Approved |
| P0274 | 7/16/97 | D Hipkins | Procedure for Verification of DC Coupling of SM Gyroscopes | ✓ | ✓ | Approved |
| P0275 | 7/16/97 | D Hipkins | Low Temperature SM Gyroscope Commissioning Tests | ✓ | ✓ | Approved |
| P0276 | 7/16/97 | D Hipkins | Procedure for Flux Flushing the Gyroscope in the Gyroscope Commissioning Probe | ✓ | ✓ | Approved |
| P0277 | 7/ 14/97 | D Hipkins | Installation of the Gyroscope Support Hardware for the Gyroscope Commissioning Probe | ✓ | ✓ | Approved |
| P0278 | 7/22/97 | D Hipkins | Procedure for Post Commission Handling and Storage of SM Gyroscopes | ✓ | ✓ | Approved |
| P0279 | 7/11/97 | D Hipkins | Magnetic Screening of the SM Gyroscope in the Large Scale Magnetics Testing Facility | ✓ | ✓ | Approved |
| P0281 | 6/15/97 | D Hipkins | Procedure for Commissioning Gyroscopes for the Science Mission Probe (incl. Gyroscope Acceptance Traveller and FGT#2..6) | ✓ | ✓ | Approved |
| P0296 | | D Hipkins | Pre-Commissioning Test Inspections of SM Gyroscopes | ✓ | ✓ | Approved |
| P0297-2 | 7/22/97 | D Hipkins | Functionality Test of Thermometry and Heater for SM Gyroscopes (Optional) | ✓ | ✓ | Approved |
| P0298 | 7/18/97 | D Hipkins | Procedure for Verifying Rotor Freedom of Movement (TBR) | ✓ | ✓ | Approved |

| | | | | | | |
|---|---|---|---|---|---|---|
| P0299 | 7/16/97 | D Hipkins | Procedure for Gyroscope Levitation With the DDC Suspension System | ✓ | ✓ | Approved |
| P0300 | 7/10/97 | D Hipkins | Gowning Procedure for the Gyroscope Commissioning Probe Clean Room | ✓ | ✓ | Approved |
| P0307 | 7/14/97 | Y Xiao | Confirmation of No Charging of the Gyroscope During Levitation | ✓ | ✓ | Approved |
| P0308 | 7/14/97 | D Hipkins | Post Insertion Electrical Checklist (incl. GCP-Op3 & 4) | ✓ | ✓ | Approved |
| P0310 | 8/10/97 | Y Xiao | Low Temperature Gyro Spinup Procedure | ✓ | ✓ | Approved |
| P0311 | 7/17/97 | D Hipkins | Performance Testing Procedure (Optional) | ✓ | ✓ | Approved |
| P0313 | 12/1/97 | D Hipkins | Pre-Commissioning Visual Inspection of SM Gyroscope | ✓ | ✓ | Approved |
| P0314 | 7/1/97 | D Hipkins | Procedure for the Fast Spin Test in the Gyroscope Commissioning Probe | ✓ | ✓ | Approved |
| P0321 | 7/15/97 | C Gray | Room Temperature Gyroscope Spin-Up & Spin-Down Procedure | ✓ | ✓ | Approved |
| P0369 | 11/21/97 | C Gray | Procedure for Resistance Testing of Gyroscope Coatings to Rotor | ✓ | ✓ | Approved |
| P0370 | 11/21/97 | C Gray | Procedure for Installing Readout Cable to Gyroscope | ✓ | ✓ | Approved |

**Additional Documents**

| Document | Date | Author | Title | Written | In Database | Approval Status |
|---|---|---|---|---|---|---|
| P0057 A | 9/29/94 | J Lockhart | GP-B Magnetic Control Plan - Science Mission | ✓ | | Approved |
| P0305 | 7/21/97 | C Gray | Procedure for Gyroscope High Voltage to Ground Plane Breakdown | ✓ | ✓ | Approved |
| P0381 | 1/8/98 | W Bencze | 70 Khz Digital D.C. Suspension System Checkout and Release Procedure | ✓ | | Approved |
| 23200-112 B | 10/1/96 | F Berkowitz | DRAWING TREE, GYRO ASSY, SM | ✓ | ✓ | Approved |
| 23185-101..104 | 11/8/96 | E Romero | GYRO/PROOF MASS ASSEMBLY | ✓ | ✓ | Approved |
| S0256 | 9/25/97 | B Bencze | Gyroscope Spin Axis Alignment Algorithm for the Gravity Probe B Spacecraft | ✓ | | |
| S0287 | ECD 12/15/97 | M Keiser | Homogeneity and Composition of GP-B Rotors | | | |
| S0288 | ECD 12/15/97 | D Gill | GP-B Rotor Mass Unbalance | | | |
| S0289 | ECD 1/15/98 | A Silbergleit | In-Plane Asymmetry of Pick-Up Loops | | | |
| S0290 | ECD 1/15/98 | A Silbergleit | GP-B Rotor Shape | | | |
| S0291 | ECD 1/15/98 | M Keiser | Initial Gyroscope Alignment | | | |
| | 8/96 | R Brumley | Measurements of the Thermal Emissivity of a Superconducting Niobium Film (in Proceedings of the 21st International Conference on Low Temperature Physics | ✓ | N/A | N/A |

Note: Status data comes from Stanford Database; entries in *italics* do not directly verify requirements, but are part of the mfg. & test process.

# D. Science Gyroscope Test Personnel Status Checklist

**Test Conductors / Inspectors for the Gyroscope Commissioning Facilities** (including the Gyroscope Suspension Systems)

| Name | Received Training in Test Operations |
|---|---|
| Barry Muhlfelder | |
| Bruce Clark | |
| Chris Gray | |
| David Hipkins | |
| Paul Bayer | |
| Ping Zhou | |
| Rob Brumley | |
| Sasha Buchman | |
| Yueming Xiao | |
| Yoshimi Oshima | |

Note: all Science Gyro commissioning test personnel are both conductors and inspectors.

**Qualified Test Directors for Gyroscope Commissioning**

| Name |
|---|
| Sasha Buchman |
| Yueming Xiao |

**Critical test procedures for gyroscope commissioning and the test directors associated with them.**

| # | Title | Test directors |
|---|---|---|
| P0085 | Gyroscope Hardware Assembly | Paul Bayer, Chris Gray |
| P0278 | Procedure for Post Commission Handling and Storage of SM Gyroscopes | Bruce Clark, Chris Gray, Dave Hipkins |
| P0296 | Pre-Commissioning Test Inspections of SM Gyroscopes | Paul Bayer, Chris Gray |
| P0299 | Procedure for Gyroscope Levitation With the DDC Suspension System | Rob Brumley, Sasha Buchman, Bruce Clark, Chris Gray, Dave Hipkins, Yueming Xiao |
| P0314 | Procedure for the Fast Spin Test in the Gyroscope Commissioning Probe | Rob Brumley, Sasha Buchman, Dave Hipkins, Yueming Xiao |

# E. Science Gyroscope Test Resources Checklists

**Test Instruments**

(Instruments that are used for verifying of requirement, calibration required)

| Item Description | Run Number in the database | Calibration Date | Available |
|---|---|---|---|
| Vacuum gauges (for GCP) | 46 | 7/17/98 | Yes |
| DVM (aka Keithley DVM and dc Voltmeter) | ? | CG | |
| Keithley 6512 or 617 Programmable Electrometer | 48 | 8/13/98 | Yes |
| JeLite UV source w/ power supply | replaced by STU, Bruce | | |
| Resonance Ltd. Cs-Te photodiode | Bruce | | |
| Baritron gauge | 35-38 | 7/25/98 x 4 | Yes |
| Talyrond 73 | 49, 50 | 10/7/98 x 2 | |
| Mass Flow Power Supply 246/B? | 39, 40 | 7/25/98 x 2 | |
| Mass Flow Controller? | 41, 42, 44 | 7/25/98 x 3 | |
| Mass Flow Sensor | 45 | 6/21/98 | |
| Class 10 Clean Room areas | 47 | 1/31/97 | |
| Power Supply/Display 246? | 43 | 7/25/98 | |

**Instruments that do not require standard calibration**

| **Item description** | **Reason why calibration is not required** |
|---|---|
| BTI dc Current Source, Model CCS | Only relative measure used to verify requirements |
| High Voltage power supply | Not verifying requirement |
| Vacuum gauges (for RT #3) | Not verifying requirement |
| Vacuum gauges (for RT #4) | Not verifying requirement |
| DDC Suspension Systems | Not a standard equipment. Stanford Calibration procedure: P0381 |
| Germanium Thermometer Readout | GRTs comes with calibration table. This values are constant. |
| Capacitance meter | Not verifying requirement |
| Capacitance bridge | Not verifying requirement |
| Quantum Design dc SQUID Controller (aka “SQUID control electronics” and “dc SQUID readout”) | Only relative measure used to verify requirements |
| Keithly 485 Autoranging Picoammeter | Not verifying requirement |
| HP E3620A 2-25 V Dual Channel DC Power Supply | DVM is used. |
| Alcatel Leak Detector | Not verifying requirement |
| Chart recorder | Not verifying requirement |
| Betascope TC2000 with Rotor Manipulator | Betascope is re-standardized every few days on a regular basis.<br>Calibration is done by D. Gill by comparison to calibrated coating standards. Dale has a note discribing how standards were created. |

| | |
|---|---|
| 93H57 and 87R7 standard spheres | These spheres are the master for measuring Spheres diameter. Only relative measure used to verify requirements. |

**Facilities**

| Item Description |
|---|
| Large Scale Magnetics Facility |
| Low temperature commissioning probe clean room (includes Gyroscope Commissioning Probe (GCP) and trapped flux magnetic readout system (3 axis Helmholtz coils)) |
| R.T. #3 & #4 room temperature test facilities (aka "high vacuum chamber", "vacuum can" and "High vacuum test facility conforming to Stanford / NASA guidelines") |
| Data acquisition system (combination of PC & Lab View software) |
| Exhaust pumping station |
| fiber optic switch |
| Overhead crane with load cell and associated digital readout |
| 55-pin cable extension for instrumentation readout |
| Gyroscope storage container (aka "Stainless steel pot") |
| Strawberry Tree ADC breakout box |
| SpinUp, Exhaust nozzles assembled on titanium support plate |
| Lexan support Tee |

**Supplies**

| Item Description |
|---|
| Non-magnetic screwdriver |
| Twelve point 5/16 wrench |
| Traveler notebook for each Gyro |
| Lab books |
| Floppy disks |
| #8-32 nylon nuts |
| Lexan spacers |
| 8" copper gaskets |
| Bellville washers |
| 2 1/2 inches titanium bolts with #8-32 thread |
| Anti-static "Poly" bags |
| Cubic 10 (class 10) Clean room garments |
| TyVek (class 100) Clean room garments |
| Latex gloves, rinsed using DI water (aka "Cleanroom approved gloves") |
| freon |
| DI water |
| liquid helium |
| helium gas |

**Gyro Commissioning Test Support Software**

| Test Description | Environment | Application | Filenames |
|---|---|---|---|
| UV Charge Transfer | DOS | Strawberry Tree WORKBENCH PC V2.1.0 | AUTOUV |
| | DOS | Strawberry Tree WORKBENCH PC V2.1.0 | TESTCC |
| | DOS | Strawberry Tree WORKBENCH PC V2.1.0 | UVCOMM |
| | DOS | Strawberry Tree WORKBENCH PC V2.1.0 | UVSTRIP |
| Trapped Flux Measurement | DOS | (executable) | MAIN3 |
| Spin Speed Readout and Analysis | DOS | (executable) | FFT |
| | DOS | (executable) | FFT32 |
| | UNIX | (batch) | GETDATA |

| | | | |
|---|---|---|---|
| | Windows 3.1 | Matlab Version 4.2c.1 | GYRODATA |
| | Windows 3.1 | Matlab Version 4.2c.1 | SPINANAL |
| | DOS | (executable) | AFILE |
| NLFF System Readout | Windows 3.1 | Labview for Windows Version 3.1.1 | NLFF3 |
| DDC Suspension System software | Windows 3.1 or 95 | version 107 | DDC |

## Gravity Probe B Relativity Mission

## Science Gyroscope Assembly

## Test Readiness Review

## Completion Certificate

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**Prepared by: Ken Hooper** **Date**
**Systems Engineer**

---

**Approved by: Jeremy Kasdin** **Date**
**Chief Systems Engineer**

---

**Approved by: Yueming Xiao** **Date**
**Manager, Gyroscope Commissioning**

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**Approved by: George "Mac" Keiser** **Date**
**Lapping and Polishing Manager**

---

**Approved by: Barry Muhlfelder** **Date**
**Manager, SQUID Development**

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**Approved by: Sasha Buchman** **Date**
**Manager, Gyroscope Development**

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**Approved by: B. Taller** **Date**
**Quality Assurance**

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**Approved by: J. Turneaure** **Date**
**Hardware Manager**

## Science Gyroscope Test Readiness Review - Actions Items

Those is **bold** need to be completed before the TRR can be certified as completed - the others must be completed before the acceptance review.

| # | Action | Assignee | ECD | Status |
|---|---|---|---|---|
| **1** | **Complete procedure and sign off of P0296, and P0085** | **S Buchman** | **11/26/97** | **done** |
| **2** | **Release P0044 Quartz Housing Coating Procedure** | **S Buchman** | **11/26/97** | **done** |
| **3** | **Change all "Manufacture" to "Fabrication" in TRR package** | **K Hooper** | **11/26/97** | **done 11/17/97** |
| **11** | **Change P0314 to explicitly call for measuring spin speed during step X. & clarify that this is not optional.** | **D Hipkins†** | **11/26/97** | **deleted** |
| **15** | **Approve P0001 to P0014 (cover sheet & signatures)** | **S Buchman** | **11/26/97*** | **done** |
| **16** | **Review entire procedure list for status & get approval on all procedures used for gyro manufacture & test** | **S Buchman** | **11/26/97*** | **done** |
| **18** | **Provide list of qualified test directors & procedures requiring director approval** | **S Buchman** | **11/26/97** | **done 11/26/97** |
| **19** | **Fill out instrument serial numbers & calibration dates for listed items** | **S Buchman** | **11/26/97** | **done** |
| **20** | **Put test support software under configuration control (get copy to Mae)** | **S Buchman** | **11/26/97*** | **done** |
| 7 | PCB to remove "shalls" from 3.7.1.5.1 and other descriptive paragraphs that do not contain performance requirements. Also PCB other marks ups. | K Hooper | 12/3/97 | done 12/3/97 |
| 9 | PCB 3.7.1.5.2.1.2.1 and 3.7.1.5.2.1.2.2 to remove temperature from requirement & incorporate into Spin Speed requirement as a constraint. | S Buchman, K Hooper | 12/3/97 | done 12/3/97 |
| 10 | PCB to delete 3.7.1.5.2.1.3 | K Hooper, J Turneaure | 12/3/97 | done 12/3/97 |
| 14 | PCB 3.7.1.5.2.2.2.6 to make it correct | S Buchman | 12/3/97 | done 12/3/97 |
| 4 | Complete ECOs for procedures as needed | B Taller | 1/28/98 | done |
| 5 | Review drawings for P0057A and issue change notice to remove where not appropriate. Also review P0057A and modify so screening is done as appropriate. (Add trapped flux meas. adequate in lieu of testing whole assemblies.) | B Taller, S Buchman, J Lockhart | 1/28/98 | done |
| 6 | Modify cleanliness procedure to verify drawings & procedures | M Keiser | 1/28/98 | done |
| 8 | Verify T003 for Spin Speed can be verified by analysis | S Buchman | 1/28/98 | done |
| 12 | Review 3.7.1.5.2.2.1.2.6 to make sure $10^{-6}$ is correct | S Buchman | 1/28/98 | done |
| 13 | To verify 3.7.1.5.2.2, Rob to document paper with cover letter stating its relation to flight rotors | R Brumley† | 1/28/98 | done |
| 17 | Review build paper and make sure all procedures called out are listed & approved | S Buchman | 1/28/98 | done |

* For Action Items 15, 16 and 20, only the procedures, instruments, and software used for Gyro Commissioning need be completed before the TRR can be certified as completed.

† S Buchman will coordinate the actions assigned to D Hipkins and R Brumley.