

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

# **SPINUP PLUMBING ASSEMBLY PROCEDURE**

## **GP-B SCIENCE MISSION PROCEDURE**

13 May 1998

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## TABLE OF CONTENTS

<b>1. SCOPE</b> .....	<b>4</b>
<b>2. REFERENCES</b> .....	<b>5</b>
2.1 Plans and Procedures .....	5
2.2 Drawings .....	5
<b>3. GENERAL REQUIREMENTS</b> .....	<b>5</b>
3.1 Environmental Requirements.....	5
3.2 Personnel .....	5
3.3 Safety.....	6
3.4. Quality Assurance.....	6
3.5. Red-line Authority .....	6
<b>4. REQUIRED EQUIPMENT</b> .....	<b>7</b>
<b>5 ASSEMBLY AND MEASUREMENT OF TUBING ASSEMBLY, SPINUP     INLET, P/N 22886-201</b> .....	<b>9</b>
5.1 Bond Bellows.....	9
5.2 Bond Spherical Fitting .....	10
5.3 Verify Measurement .....	10
5.3 Clean and Magnetic Test .....	10
<b>6 ASSEMBLY AND MEASUREMENT OF TUBING ASSEMBLY, SPINUP     EXHAUST, P/N 22879-201</b> .....	<b>12</b>
6.1 Bond Tube (Bond 1) .....	12
6.2 Bond Bellows (Bond 2).....	13
6.3 Bond Threaded Fitting (Bond 3) .....	13
6.4 Bond Spherical Fitting .....	13
6.5 Verify Measurement .....	15
6.6 Clean and Magnetic Test .....	15
<b>7 ASSEMBLY OF PLUMBING ASSEMBLY, SPINUP, P/N 23183-201</b> .....	<b>17</b>
7.1 Assemble the Plumbing Assembly, Spinup.....	17
7.2 Fit Check and Fine Adjustments .....	18
7.3 Bond Threaded Nuts .....	18
<b>8 PROCEDURE COMPLETION</b> .....	<b>20</b>
<b>9 DATA BASE ENTRY</b> .....	<b>20</b>

## 1. SCOPE

This document contains procedures for assembly and in-process testing of the Science Mission Spinup Plumbing Assemblies (Figure 1). The procedure takes place at Stanford HEPL on the Flow Bench in the Class 1000 cleanroom. This procedure consists of the following task modules:

- A. Assembly and Measurement of Inlet Tube Assembly, P/N 22886
- B. Assembly and Measurement of Exhaust Tube Assembly, P/N 22879
- C. Assembly and Test of Plumbing Assembly, P/N 23183

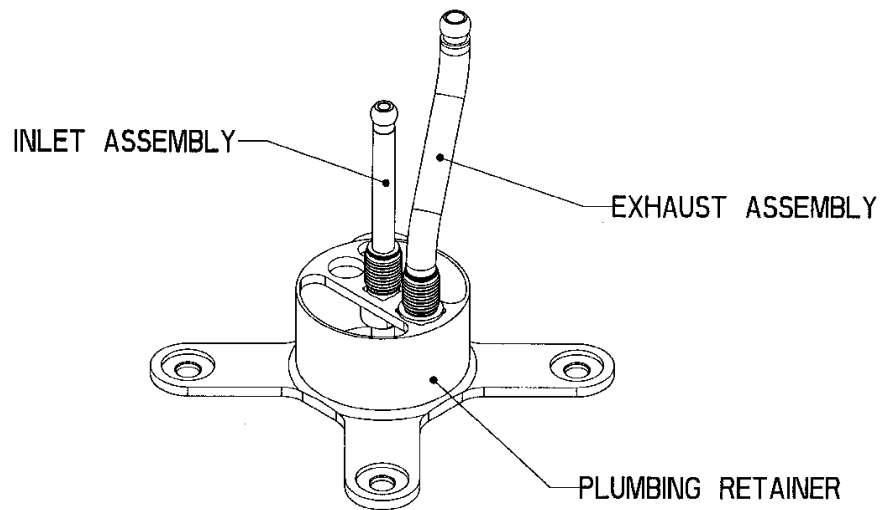


Figure 1. Spinup Plumbing Assembly

## **2. REFERENCES**

### **2.1 Plans and Procedures**

P0059	GPB Contamination Control Plan
P0057	Stanford Magnetic Control Plan
P0054	Vacuum Leak Test Procedure
P0355	Epoxy Bond Procedure 2115

### **2.2 Drawings**

22886A	Tube Assembly, Spinup, Inlet
22879A	Tube Assembly, Spinup, Exhaust
23183A	Plumbing Assembly, Spinup

## **3. GENERAL REQUIREMENTS**

### **3.1 Environmental Requirements**

#### 3.1.1. Cleanliness

Assembly is conducted on a clean room flow bench with laminar flow. This bench shall be maintained at cleanliness level 100 per Federal Standard 209D. Most of the Stanford activity is conducted in the HEPL Class 1000 Cleanroom. Minimum protective garments for personnel working in the clean rooms shall be the standard Tyvek clean room apparel for room classes from 10,000 to 1000.

#### 3.1.2. Particulate Contamination

All parts and tools shall be cleaned using methods consistent with achieving Mil Standard 1246B Level 100 cleanliness. In addition, all parts shall be maintained at level 100 cleanliness per Procedure P0059.

#### 3.1.3. Magnetic Contamination

Parts to be handled are in Zones 1 and 2. All parts shall have been pre-screened per Procedure P0057. Take all necessary precautions to keep tooling and handling free of magnetic contamination. Tools that come in contact with these components must be of beryllium copper, carbide, or other non-magnetic material. Post-magnetic screening shall be done per P0057.

### **3.2 Personnel**

#### 3.2.1 Integration Engineer

The Integration Engineer shall be John Stamets. He has overall responsibility for the implementation of this procedure and shall sign off the completed task modules.

#### 3.2.2 Integration Test Director (ITD)

The Integration and Test Director (ITD) shall be Dr. Doron Bardas. He has overall responsibility for the implementation of this procedure and shall sign off the completed procedure.

### 3.2.3 Other

All engineers and technicians participating in this procedure shall work under the direction of the ITD who shall determine whether the person is qualified to participate in this procedure.

### 3.3 Safety

The responsible engineer shall ensure that all personnel are aware of the specific personnel and hardware safety concerns indicated in the safety requirements, cautions and warnings in this procedure.

### 3.4. Quality Assurance

All assembly and testing shall be conducted on a formal basis to approved and released assembly and test procedures.. A Quality Assurance representative designated by B. Taller shall review any discrepancy noted during assembly or test. Redlines shall be stamped by the QA rep. The QA representative will nominally be A. Nakashima. Upon completion of this procedure, the QA program engineer, B. Taller or P. Unterreiner, will certify his concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating his approval line at the end of the procedure.

### 3.5. Red-line Authority

Authority to red-line (make minor changes during execution ) this procedure is given solely to the Integration Engineer, with approval of the ITD. Approval by the Hardware Manager shall be required, if in the judgment of the ITD or QA program engineer, experiment functionality may be affected.

#### 4. REQUIRED EQUIPMENT

##### Flight Hardware

<b>Hardware</b>	<b>Part Number</b>	<b>Quantity</b>
<b>Plumbing Assembly, Spinup</b>	23183-201	8 (4 flight)
Tube Assembly, Spinup Inlet	22886-201	8 (4 flight)
threaded fitting, inlet	22895-201	1/subassembly
spherical fitting, inlet	23245-101	1/subassembly
tube, inlet	23241-201	1/subassembly
bellows, spinup	22888-101	1/subassembly
adhesive	epoxy, Tra-Bond 2115	
Tube Assembly, Spinup Exhaust	22879-201	8 (4 flight)
threaded fitting, exhaust	22884-201	1/subassembly
spherical fitting, exhaust	23244-101	1/subassembly
tube, exhaust	23184-101	1/subassembly
bellows, spinup	22888-101	1/subassembly
fitting, tube/bellows	23242-201	1/subassembly
fitting, tube/sphere	22885-201	1/subassembly
adhesive	epoxy, Tra-Bond 2115	
Retainer, Plumbing	22883-201	1/subassembly
Nut, Exhaust	22889-201	1/subassembly
Nut, Inlet	22890-201	1/subassembly
adhesive	epoxy, Tra-Bond 2115	

*Note: Serial Numbers and/or Lot Date Code of Flight Hardware are listed in the various tables as the assembly occurs in Sections 5, 6, and 7.*

##### Ground Support Equipment

Exhaust Assembly Bonding Fixture (Delrin)  
 Exhaust Assembly Verification Fixture (Delrin)  
 Inlet Assembly Bonding Fixture (Delrin)  
 Inlet Assembly Verification Fixture (Delrin)  
 Plumbing Retainer Assembly Verification Fixture

##### Tools and Miscellaneous

Tetrafluorethane (TF) Solvent - .05 µm filtered Freon  
 Chemtronics Freez-It 2000 can of Tetrafluorethane 1,1,1,2 (-51 °C)

Chemtronics Ultra-jet Duster can of Tetrafluorethane 1,1,1,2 (-51 °C)  
Bottle of Ethyl alcohol



**5 ASSEMBLY AND MEASUREMENT OF TUBING ASSEMBLY, SPINUP INLET, P/N 22886-201**

This task module takes place on the laminar flow bench in Stanford's Class 1000 cleanroom in the HEPL building. It assumes the Tubing Assembly parts have been cleaned, magnetically screened, and released. The Tubing Assembly, Spinup Inlet, 22886-201, is shown in Figure 2.

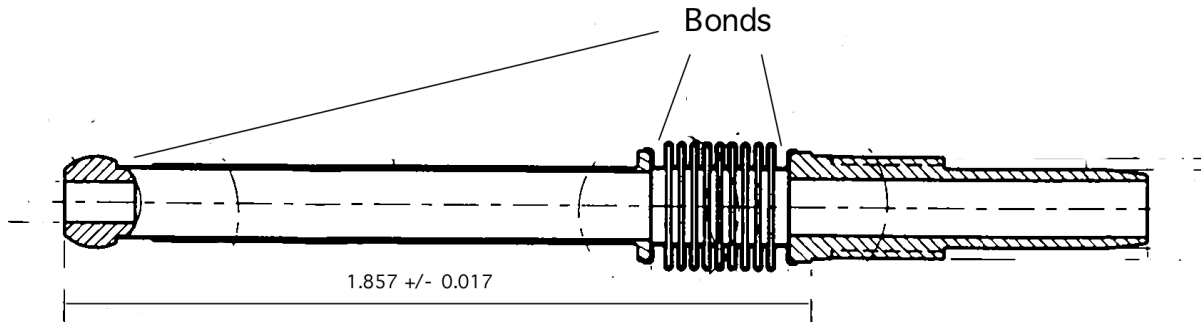


Figure 2. Tubing Assembly, Spinup Inlet

Record Start Date and Time \_\_\_\_\_

**5.1 Bond Bellows**

5.1.1 Place the inlet tube threaded fitting, P/N 22895-201, the bellows, P/N 22888-101, the inlet tube, P/N 23241-201, and the spherical fitting, P/N 23245-101, to be bonded together on the Inlet Assembly Bonding Fixture. Do a fit check and disassemble. Record Lot Date Codes in Table 1.

Inlet Tube Assembly (22886-201)	Tube, Inlet (23241-201) Lot Date Code	Bellows (22888-101) Lot Date Code	Threaded Fitting (22895-201) Lot Date Code	Spherical Fitting (23245-101) Lot Date Code	Tra-Bond 2115 Epoxy Lot # and Expiration Date

Table 1. Lot Date Codes of Tubing Assemblies, Spinup Inlet

5.1.2 In the Inlet Assembly Bonding Fixture, bond the bellows onto the threaded fitting, by applying a minimal amount of TRA-BOND 2115 uniformly over the contact surface, in accordance with procedure P0354.

*NOTE: A minimum uniform bond coating has been demonstrated to have thickness between 0.001 - 0.002 inch.*

- 5.1.3 Bond the bellows onto the inlet tube, in accordance with procedure P0354, by applying a minimal amount of TRA-BOND 2115 uniformly over the contact surface.
- 5.1.4 Let stand in the fixture for curing. Cure in accordance with P0354.
- 5.1.5 Repeat 5.1.1 through 5.1.4 for all of the inlet tube assemblies.

**5.2 Bond Spherical Fitting**

- 5.2.1 In the Inlet Assembly Bonding Fixture, bond the spherical fitting, P/N 23245-101, onto the inlet tube, by applying a minimal amount of TRA-BOND 2115 uniformly over the contact surface, in accordance with procedure P0354. Let cure in the stand in accordance with P0354.
- 5.2.2 Let stand in the fixture for curing. Cure in accordance with P0354.
- 5.2.3 Repeat 5.2.1 and 5.2.2 for all of the inlet tube assemblies.

**5.3 Verify Measurement**

- 5.3.1 After curing, place each Inlet Tube Assembly in the Inlet Assembly Verification Fixture for verifying the distance between the end of the spherical ball and the interface with the Plumbing Retainer (see Figure 2). This distance is required to be 1.857 +/- 0.017 inch.
- 5.3.2 This is a go-no go measurement, and if the measurement tolerance is met, the assembly will fit into the fixture as designed. If the tolerance is exceeded, the assembly will not fit into the fixture properly, and is subject to review by the ITD and QA. Separate and serialize each assembly by applicable bagging and tagging. Record whether the requirement is met in Table 2 below.

Inlet Tube Assembly Serial Number	Meets 1.857+/- 0.017 in. length requirement. (Y/N)
01	
02	
03	
04	
05	
06	
07	
08	

Table 2. Inlet Tube Assembly Interface Length Verification

**5.3 Clean and Magnetic Test**

5.3.1 Clean inlet tubing assemblies, P/N 22886-201, with TF spray in accordance with P0059, bag, and store in cleanroom marked compartment.

5.3.2 Send to Stanford Magnetics Lab for magnetic testing, in accordance with P0057.

Completed: \_\_\_\_\_ date: \_\_\_\_\_

Integration Engineer

Discrepancies if any:

Disposition and signoff: \_\_\_\_\_ date: \_\_\_\_\_

ITD

**6 ASSEMBLY AND MEASUREMENT OF TUBING ASSEMBLY, SPINUP EXHAUST, P/N 22879-201**

This task module takes place on the laminar flow bench in Stanford's Class 1000 cleanroom in the HEPL building. It assumes the Tubing Assembly parts have been cleaned, magnetically screened, and released. The Tubing Assembly, Spinup Exhaust, 22879-201, is shown in Figure 3.

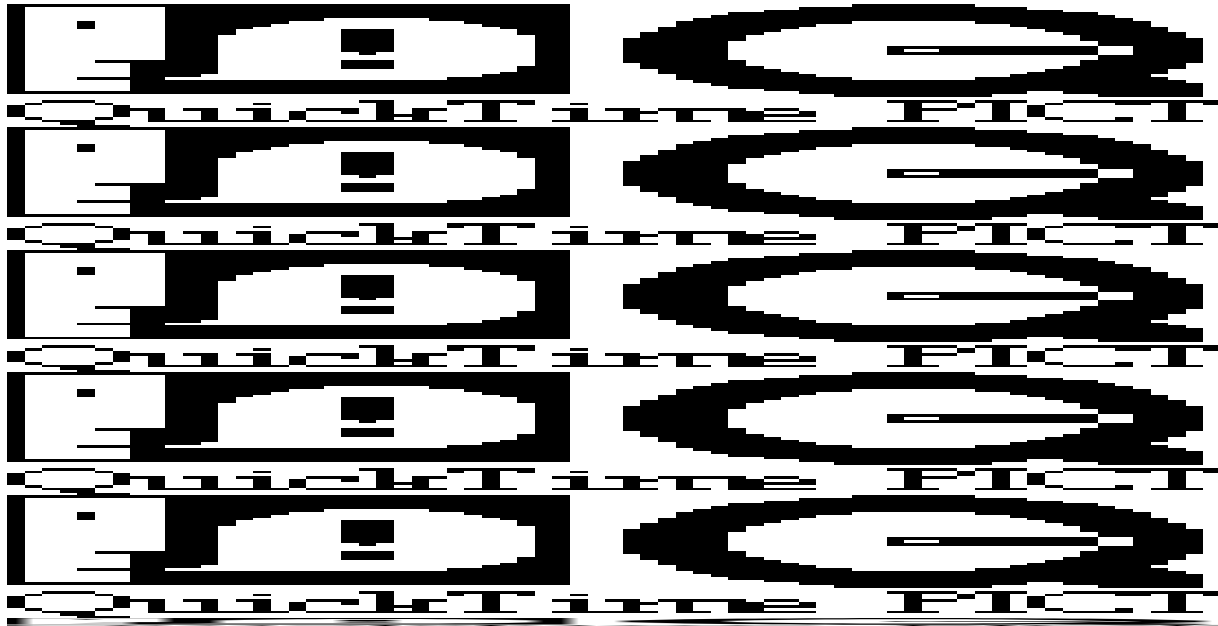


Figure 3. Tubing Assembly, Spinup Exhaust

Record Start Date and Time \_\_\_\_\_

**6.1 Bond Tube (Bond 1)**

6.1.1 Place the exhaust tube threaded fitting, P/N 228884-201, the bellows, P/N 22888-101, the exhaust tube, P/N 23184-101, the fitting, tube/bellows, P/N 23242-201, the fitting. tube/sphere, P/N 22885-201, and the spherical fitting, P/N 23245-101, to be bonded together on the Exhaust Assembly Bonding Fixture.. Do a fit check and disassemble. Record Lot Date Codes in Table 3.

Exhaust Tube Assembly (22879-201)	Tube, Exhaust (23184-101) LDC	Bellows (22888-101) LDC	Fitting, Tube/Bellows (23242-201) LDC	Threaded Fitting (22884-201) LDC	Fitting, Tube/Sphere (22885-201) LDC	Spherical Fitting (23244-101) LDC	Tra-Bond 2115 Epoxy Lot # and Expiration Date

Table 3. Lot Date Codes of Tubing Assemblies, Spinup Exhaust

- 6.1.2 In the Exhaust Assembly Bonding Fixture, bond the fitting tube/bellows, P/N 23242-201 onto the exhaust tube, P/N 23184-101, by applying a minimal amount of TRA-BOND 2115 uniformly over the contact surface, in accordance with procedure P0354.
- 6.1.3 In the Exhaust Assembly Bonding Fixture, bond the fitting, tube/sphere, P/N 22885-201, onto the tube, by applying TRA-BOND 2115 on the contact surface, in accordance with procedure P0354.
- 6.1.4 Let stand in the fixture for curing. Cure in accordance with P0354.
- 6.1.5 Repeat 6.1.2 through 6.1.4 for all of the exhaust tubes.

## **6.2 Bond Bellows (Bond 2)**

- 6.2.1 In the Exhaust Assembly Bonding Fixture, bond the bellows, P/N 22885-101, onto the free end of the fitting tube/bellows, P/N 23242-201, by applying a minimal amount of TRA-BOND 2115 uniformly over the contact surface, in accordance with procedure P0354.
- 6.2.2 Let stand in the fixture for curing. Cure in accordance with P0354.
- 6.2.3 Repeat 6.2.1 and 6.2.2 for all of the exhaust tube assemblies.

## **6.3 Bond Threaded Fitting (Bond 3)**

- 6.3.1 In the Exhaust Assembly Bonding Fixture, bond the the threaded fitting, P/N 22884-201, onto the free end of the bellows, by applying a minimal amount of TRA-BOND 2115 uniformly over the contact surface, in accordance with procedure P0354.
- 6.3.2 Let stand in the fixture for curing. Cure in accordance with P0354.
- 6.3.3 Repeat 6.3.1 through 6.3.3 for all of the exhaust tube assemblies.

*NOTE: The Exhaust Assembly Bonding Fixture is a custom, precision fixture which, when the exhaust tube assembly is placed in the fixture, ensures that the angle made by the exhaust tube relative to the threaded fitting complies with requirements, which is 28 deg +/- 15 arc-min.*

## **6.4 Bond Spherical Fitting**

- 6.4.1 In the Exhaust Assembly Bonding Fixture, bond the spherical fitting, P/N 23244-101, onto the free end of the fitting, tube/sphere, P/N 22885-201, by applying a minimal amount of TRA-BOND 2115 uniformly over the contact surface, in accordance with procedure P0354.

6.4.2 Let stand in the fixture for curing. Cure in accordance with P0354.

6.4.3 Repeat 6.4.1 and 6.4.2 for all of the exhaust tube assemblies.

**6.5 Verify Measurement**

- 6.5.1 After curing, place each Exhaust Tube Assembly in the Exhaust Assembly Verification Fixture for verifying the distance between the end of the spherical ball and the interface with the Plumbing Retainer (see Figure 2). This distance is required to be 2.362 +/- 0.022 inch.
- 6.5.2 This is a go-no go measurement, and if the measurement tolerance is met, the assembly will fit into the fixture as designed. If the tolerance is exceeded, the assembly will not fit into the fixture properly, and is subject to review by the ITD and QA.. Separate and serialize each assembly by applicable bagging and tagging. Record whether the requirement is met in Table 4 below.

Exhaust Tube Assembly Serial Number	Meets 2.362 +/- 0.022 in. length requirement. (Y/N)
01	
02	
03	
04	
05	
06	
07	
08	

Table 4. Exhaust Tube Assembly Interface Length Verification

**6.6 Clean and Magnetic Test**

- 6.6.1 Clean exhaust tubing assemblies with TF spray in accordance with P0059, bag, and store in numbered compartment.
- 6.6.2 Send to Stanford Magnetics Lab for magnetic testing, in accordance with P0057A.

Completed: \_\_\_\_\_ date:  
 Integration Engineer

Discrepancies if any:

Disposition and signoff: \_\_\_\_\_ date: \_\_\_\_\_  
ITD





- 7.1.2 Insert the Spinup Exhaust Tube Assembly (P/N 22879-101) into the large square hole of the Plumbing Retainer (P/N 22883-201) bar from the inside (index plate side) of the retainer, such that the bellows are against the bar. The tube fitting has 4 sides, and there is only one way the tube can go into the retainer such that the spherical ball lines up with the centerline. Secure hand tight with nut (P/N 22889-201) on the other side of bar, using the aluminum wrench custom built for this tube, so that there is no relative motion between the retainer and the installed assembly.
- 7.1.3 Insert the Spinup Inlet Tube Assembly (P/N 22886-101) into the center round hole of the Plumbing Retainer bar from the index plate side of the retainer, such that the bellows are against the bar. Secure hand tight with nut (P/N 22890-201) on other side of bar, using the aluminum wrench custom built for this tube, so that there is no relative motion between the retainer and the installed assembly.

## **7.2 Fit Check and Fine Adjustments**

*NOTE: The Plumbing Retainer Assembly Verification Fixture uses a spare non-commissioned Gyro Housing and spare Index Plate/Spacer, with additional hardware to accurately duplicate the spacing and location due to snouted washers and retention rods, to fit check the Spinup Assembly and do any fine adjustments.*

- 7.2.1 With the fixture on the bench with the IP/S on top, align the Plumbing Assembly relative to the IP/S/G Unit such that the Exhaust Tube hole in the Plumbing Retainer Bar is to the right of the notch in the Gyro Assembly, when looking from the outside of the Plumbing Retainer towards the gyro, with the gyro below the bar.
- 7.2.2 Place the Plumbing Assembly over the bottom of the Index Plate and seat the quartz balls in the proper holes of the housing. The quartz ball on the end of the spinup inlet tube seats in the center hole of the Gyro Assembly, and the quartz ball on the end of the spinup exhaust tube seats in the hole in the Gyro Assembly notch. The balls should drop easily, without sticking, into the holes with the flat ends on the backs of the balls just below flush with respect to each external hole end.
- 7.2.3 When satisfied with the fit, remove the Plumbing Assembly from the fixture and put into the Plumbing Assembly Stand. If the fit does not comply with 7.2.2, record discrepancy and adjust (with ITD present) to fix, if possible.

## **7.3 Bond Threaded Nuts**

- 7.3.1 In the Plumbing Assembly Stand, apply one drop of TRA-BOND 2115 on the contact surface inlet nut, in accordance with procedure P0354.
- 7.3.2 Repeat 7.3.1 for the exhaust nut.

7.3.3 Let stand in the fixture for curing. Cure in accordance with P0354.

7.2.7 Repeat 7.1.2 through 7.3.3 for all of the plumbing assemblies.

Completed: \_\_\_\_\_ date:  
Integration Engineer

Discrepancies if any:

Disposition and signoff: \_\_\_\_\_ date: \_\_\_\_\_  
ITD

## **8 PROCEDURE COMPLETION**

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

Integration Engineer \_\_\_\_\_ Date \_\_\_\_\_

ITD: \_\_\_\_\_ Date \_\_\_\_\_

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

Quality Assurance \_\_\_\_\_ Date \_\_\_\_\_

## **9 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.