

**GRAVITY PROBE B
PROCEDURE FOR
PAYLOAD VERIFICATION
P0516 Rev A
GYRO SLOW SPIN TEST**

10/23/2000

Prepared by: *C. Gray*

Approvals:

Program Responsibility	Signature	Date
<i>C. Gray Gyro Verification</i>		
<i>R. Brumley Gyroscope RE</i>		
<i>B. Clarke Gyroscope Verification</i>		
<i>M. Taber Payload Test Director</i>		
<i>D. Ross GP-B Quality Assurance</i>		
<i>B. Muhlfelder Hardware Test Leader</i>		

NOTES:

Level of QA required during performance of this procedure:
Stanford QA Representative
Government QA Representative

All redlines must be approved by QA

Revision Record:

Rev	Rev Date	ECO #	Summary Description
-	8/24/99	N/A	
A	10/23/00	1218	Redline changes from the last payload test have been incorporated. A contingency for unexpected rotor delevitation has been explicitly called out.

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A Scope

This procedure covers the spin-up of gyroscopes at room temperature in Probe C. It is only intended for very low-frequency spins.

B Requirements Verification

B.1 Requirements Cross Reference: none

B.2 Expected Data for verification per requirement: none

C Configuration Requirements

Probe C is installed into the dewar and being pumped out by the Leakage Gas Management pumping system. The gyroscope is levitated.

D Hardware Required

D.1 Flight hardware required

Description	No. Req'd
Probe C in Flight Dewar	1

D.2 Commercial test equipment

Manufacturer	Model	Serial Number	Calibr. Exp. Date
N/A			

D.3 Mechanical/Electrical Special test equipment

Description	Part No.	Rev. no.	Serial No.	Certification Date
Optical readout systems				
DDC Suspension system				
FFT Data system				
Probe C leakage gas management system				
Gyro spinup gas management system				

D.4 Tools

Description	No. Req'd
N/A	

D.5 Expendables

Description	Quantity
N/A	

E Software Required

N/A

F Procedures Required

N/A

G Equipment Pretest Requirements

N/A

H Personnel Requirements

The following personnel have received extensive training in the testing of GP-B gyroscopes and are qualified to perform this procedure.

- David Hipkins
- Bruce Clarke
- Chris Gray
- Robert Brumley
- Dr. Sasha Buchman
- Dr. William Bencze

I Safety Requirements

I.1 General

It is important to be cognizant at all times of the position of the probe. Be extremely careful not to accidentally bump into the probe. If any connector does not connect smoothly and securely, do not try to force it. Instead, remove the connector and inspect it to find the reason for the difficulty. Great care must be taken at all times during the performance of this procedure.

I.2 Electrostatic Discharge

Grounded wrist straps are to be worn at all times when mating or demating to an electrical connector on Probe C.

I.3 Personnel Safety

All operations shall take place according to Stanford University safety guidelines. Any person observing a situation that 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.

I.4 Electrical mating and demating of flight hardware connectors

I.4.1 Connection and disconnection shall be performed only when the equipment involved is in a powered-down state unless the procedure specifically states otherwise.

I.4.2 Connector savers are to be used unless otherwise specified.

I.4.3 Connectors shall be inspected for contamination and for bent, damaged, or

recessed pins prior to mating.

I.4.4 Grounded wrist straps are to be worn prior to removal of connector caps or covers and during mating/demating operations.

I.4.5 ESD-protective caps or covers are to be immediately installed after demating of connectors.

J General Instructions

J.1 Redline Authority

Redlines can be initiated by any of the qualified operators listed in section H and must be approved by QA.

J.2 Discrepancies

Any nonconformance or test anomaly should be reported by a Discrepancy Report. Refer to the Quality Plan, P0108, for guidance. Do not alter or break test configuration if a test failure occurs; notify quality assurance.

J.3 Test Exit Authority

Only the following persons have the authority to exit/terminate this test or perform a retest:

Rob Brumley, Chris Gray, David Hipkins, Bruce Clarke, Sasha Buchman, William Bencze, and QA personnel.

J.4 Gyroscope Delevitation

If a gyroscope delevitates during the completion of this procedure, all work shall cease and the test configuration shall not be broken. Work may only continue under the guidance of the MRB. A Discrepancy Report shall be immediately opened recording the details of what happened. The immediate concern of the investigation should be to determine whether the GSE was at fault in the delevitation and how this GSE should be re-tested on non-flight gyroscopes prior to attempting levitation on a flight gyroscope.

The delevitation of a gyroscope does not necessarily mean that the gyroscope fails the test altogether. The voltages necessary for ground levitation cause an extreme over-test, and it is expected that arcs due to field emission may occur from time to time. However, if a gyroscope does delevitate it will be necessary to conduct a certain amount of penalty testing. The exact nature of this penalty testing will depend on the details of the gyroscope delevitation, and therefore can not be indicated here (it will be under the control of the MRB). However, the following shall be used as a guideline for a standard set of penalty testing:

- Relevitation according to P0481
- Exploration of the housing (exact ranges may vary according the judgement of the MRB).
- New spindown test of the gyroscope (exact positions used and time spans used are at the discretion of the MRB).

K References and Applicable Documents

Op. Order No. _____

Date Initiated _____

Time Initiated _____

L OPERATIONS

The following sections detail how to spin the different gyroscopes. Complete only the sections indicated as relevant to the gyro being spun. Mark which sections are to be completed as part of this procedure.

- Section L1-L5 for Gyro #1
- Section L6-L10 for Gyro #2
- Section L11-L15 for Gyro #3
- Section L16-L20 for Gyro #4

L.1 Pre Spin-Up Checklist Gyro 1

Start Date: _____

Start Time: _____

Gyroscope #: _____

L.1.1 Verify the gyroscope is levitated and in the desired position

Record Position [X Y Z]: _____

L.1.2 Verify that the gyroscope is not charged >70 volts

L.1.3 Verify that there is no oscillation in the position greater than 40 micro-inches.

L.1.4 Verify that the gyroscope has been levitated for at least one hour

L.1.5 Leakage Gas Pumping System is operating and the system Pressure < 5 x 10⁻⁵ torr

L.1.6 Spinup Exhaust Pumping System is operating and pressure is <5 x 10⁻³ torr (this is used to evacuate the spinup manifold)

L.1.7 Confirm manifold between the Probe C Gyro inlets (S1, S2, S3, or S4) and the Gyro Spinup management manifold (GSV-7) is connected, under vacuum, and has been certified according to P0567. Record Op. Log number:

L.1.8 Confirm the helium spinup gas supply is Grade 6 He and has Conformance Certification available.

L.2 Spinup Manifold Evacuation for Gyro 1

Note: Refer to figure 1 for pumping system schematic.

- L.2.1 Check that **SEP-1/SEP-2** pumps are operating and the pressure is $< 5 \times 10^{-3}$ torr. If the pumps are not running pressing the momentary switches on the right side of the schematic can start them. Place the system in Interlock Defeat mode and verify yellow LED is blinking.
- L.2.2 Open auxiliary valves **AXV-8, AXV-5,** and the gas supply valve **GSV-7.** This will evacuate the spinup manifold up to the flow controller **GSV-4.** Confirm the Probe spinup valve is open. If it is not, gently open the Probe spinup inlet valve, **S1.** Close valves **AXV-8, AXV-5,** and **GSV-7.**
- L.2.3 Turn off interlock defeat. The system is now ready to initiate Bypass flow.

L.3 Initiate Bypass flow for Gyro 1

- L.3.1 Check to ensure the Spinup gas supply bottle has > 250 psi. Open **V5** and **V6** at the helium supply bottle.
- L.3.2 Open **GSV-1** and **GSV-2** (100 sccm flow controller).
- L.3.3 Open **GSV-6**
- L.3.4 Set GSV-4 mode switch to "auto" and rotate the 10-turn pot clockwise on **GSV-2** until the desired flow is displayed on **GSG-4.** *Note: The numbers on the 10-turn pot dial will correspond with the output of the flow controller.* Start recording spin information in Table 1.

L.4 Gyroscope Spinup for Gyro 1

- L.4.1 Start a FFT file on the Sun 386i. Record File name: _____
Record any additional useful information concerning the spin speed readout in the lines below (e.g. type of readout used, if the SQUIDs are being used, what range and gain are they on, etc.).

- L.4.2 When you are ready to start spinning the Gyroscope, open **GSV-7**.
- L.4.3 Confirm GSV-6 closed while GSV-7 was opened.
- L.4.4 Flow gas into the Spinup manifold. Monitor spin speed on the Sun 386i. Continue to record spin information in Table 1.
- L.4.5 To stop spinup (either because the target spin speed has been reached, or to assess how the spinup is proceeding) open **GSV-6** to reinitiate a bypass flow.
- L.4.6 Steps L.4.1 – L.4.4 should be repeated as necessary to spin the gyroscope. Initially, use only a few sccm for a few seconds to get a feel for the spinup. This may be gradually increased as necessary. If it is uncertain whether or not the gyroscope is spinning after several attempts, stop the process and assess the situation.

Table 1-Gyro 1 Spinup

Time	Flow Rate (sccm)	Length of Flow	Gyro Spin Speed	Comments

L.5 Post-Spinup Procedure for Gyro 1

- L.5.1 Turn the 10-turn pot counter clockwise until gas is no longer flowing. Display reads 000. Set the **GSV-4** switch to "off".
- L.5.2 Close **GSV-1** and **GSV-2** to stop the flow of gas.
Close **GSV-6**
Open **AXV-8** and **AXV-5**
Turn on Interlock Defeat and Open **GSV-7**
- L.5.3 Let the **SEP** pumps evacuate the manifold from the flow controller to the Gyroscope. This will evacuate some of the remaining He left in the spinup manifold.
- L.5.4 (Optional) Gently close **S1** on the Probe spinup inlet. Check if done: _____
- L.5.5 Close **GSV-7**, **AXV-5** and **AXV-8**
- L.5.6 Confirm that all the valves are closed and that the interlock switch is still "enabled."
- L.5.7 If **S1** was not closed in L.5.4, wait until gyroscope has been delevitated (end of the spinup test) and then close **S1**.

L.6 Pre Spin-Up Checklist Gyro 2

Start Date: _____

Start Time: _____

Gyroscope #: _____

L.6.1 Verify the gyroscope is levitated and in the desired position

Record Position [X Y Z]: _____

L.6.2 Verify that the gyroscope is not charged >70 volts _____

L.6.3 Verify that there is no oscillation in the position greater than 40 micro-inches. _____

L.6.4 Verify that the gyroscope has been levitated for at least one hour _____

L.6.5 Leakage Gas Pumping System is operating and the system Pressure < 5×10^{-5} torr _____

L.6.6 Spinup Exhaust Pumping System is operating and pressure is < 5×10^{-3} torr (this is used to evacuate the spinup manifold) _____

L.6.7 Confirm manifold between the Probe C Gyro inlets (S1, S2, S3, or S4) and the Gyro Spinup management manifold (GSV-7) is connected, under vacuum, and has been certified according to P0567. Record Op. Log number: _____

L.6.8 Confirm the helium spinup gas supply is Grade 6 He and has Conformance Certification available. _____

L.7 Spinup Manifold Evacuation for Gyro 2

Note: Refer to figure 1 for pumping system schematic.

- L.7.1 Check that **SEP-1/SEP-2** pumps are operating and the pressure is $< 5 \times 10^{-3}$ torr. If the pumps are not running pressing the momentary switches on the right side of the schematic can start them. Place the system in Interlock Defeat mode and verify yellow LED is blinking.
- L.7.2 Open auxiliary valves **AXV-8, AXV-5,** and the gas supply valve **GSV-7.** This will evacuate the spinup manifold up to the flow controller **GSV-4.** Confirm the Probe spinup valve is open. If it is not, gently open the Probe spinup inlet valve, **S2.** Close valves **AXV-8, AXV-5,** and **GSV-7.**
- L.7.3 Turn off interlock defeat. The system is now ready to initiate Bypass flow.

L.8 Initiate Bypass flow for Gyro 2

- L.8.1 Check to ensure the Spinup gas supply bottle has > 250 psi. Open **V5** and **V6** at the helium supply bottle.
- L.8.2 Open **GSV-1** and **GSV-2** (100 sccm flow controller).
- L.8.3 Open **GSV-6**
- L.8.4 Set GSV-4 mode switch to "auto" and rotate the 10-turn pot clockwise on **GSV-2** until the desired flow is displayed on **GSG-4.** *Note: The numbers on the 10-turn pot dial will correspond with the output of the flow controller.* Start recording spin information in Table 2.

L.9 Gyroscope Spinup for Gyro 2

- L.9.1 Start a FFT file on the Sun 386i. Record File name: _____
Record any additional useful information concerning the spin speed readout in the lines below (e.g. type of readout used, if the SQUIDs are being used, what range and gain are they on, etc.).

- L.9.2 When you are ready to start spinning the Gyroscope, open **GSV-7**.
- L.9.3 Confirm GSV-6 closed while GSV-7 was opened.
- L.9.4 Flow gas into the Spinup manifold. Monitor spin speed on the Sun 386i. Continue to record spin information in Table 2.
- L.9.5 To stop spinup (either because the target spin speed has been reached, or to assess how the spinup is proceeding) open **GSV-6** to reinitiate a bypass flow.
- L.9.6 Steps L.9.1 – L.9.4 should be repeated as necessary to spin the gyroscope. Initially, use only a few sccm for a few seconds to get a feel for the spinup. This may be gradually increased as necessary. If it is uncertain whether or not the gyroscope is spinning after several attempts, stop the process and assess the situation.

Table 2-Gyro 2 Spinup

Time	Flow Rate (sccm)	Length of Flow	Gyro Spin Speed	Comments

L.10 Post-Spinup Procedure for Gyro 2

- L.10.1 Turn the 10-turn pot counter clockwise until gas is no longer flowing. Display reads 000. Set the **GSV-4** switch to "off".
- L.10.2 Close **GSV-1** and **GSV-2** to stop the flow of gas.
Close **GSV-6**
Open **AXV-8** and **AXV-5**
Turn on Interlock Defeat and Open **GSV-7**
- L.10.3 Let the **SEP** pumps evacuate the manifold from the flow controller to the Gyroscope. This will evacuate some of the remaining He left in the spinup manifold.
- L.10.4 (Optional) Gently close **S2** on the Probe spinup inlet. Check if done: _____
- L.10.5 Close **GSV-7**, **AXV-5** and **AXV-8**
- L.10.6 Confirm that all the valves are closed and that the interlock switch is still "enabled."
- L.10.7 If **S2** was not closed in L.10.4, wait until gyroscope has been delevitated (end of the spinup test) and then close **S2**.

L.11 Pre Spin-Up Checklist Gyro 3

Start Date: _____

Start Time: _____

Gyroscope #: _____

L.11.1 Verify the gyroscope is levitated and in the desired position

Record Position [X Y Z]: _____

L.11.2 Verify that the gyroscope is not charged >70 volts _____

L.11.3 Verify that there is no oscillation in the position greater than 40 micro-inches. _____

L.11.4 Verify that the gyroscope has been levitated for at least one hour _____

L.11.5 Leakage Gas Pumping System is operating and the system Pressure < 5 x 10⁻⁵ torr _____

L.11.6 Spinup Exhaust Pumping System is operating and pressure is <5 x 10⁻³ torr (this is used to evacuate the spinup manifold) _____

L.11.7 Confirm manifold between the Probe C Gyro inlets (S1, S2, S3, or S4) and the Gyro Spinup management manifold (GSV-7) is connected, under vacuum, and has been certified according to P0567. Record Op. Log number: _____

L.11.8 Confirm the helium spinup gas supply is Grade 6 He and has Conformance Certification available. _____

L.12 Spinup Manifold Evacuation for Gyro 3

Note: Refer to figure 1 for pumping system schematic.

- L.12.1 Check that **SEP-1/SEP-2** pumps are operating and the pressure is $< 5 \times 10^{-3}$ torr. If the pumps are not running pressing the momentary switches on the right side of the schematic can start them. Place the system in Interlock Defeat mode and verify yellow LED is blinking.
- L.12.2 Open auxiliary valves **AXV-8, AXV-5**, and the gas supply valve **GSV-7**. This will evacuate the spinup manifold up to the flow controller **GSV-4**. Confirm the Probe spinup valve is open. If it is not, gently open the Probe spinup inlet valve, **S3**. Close valves **AXV-8, AXV-5**, and **GSV-7**.
- L.12.3 Turn off interlock defeat. The system is now ready to initiate Bypass flow.

L.13 Initiate Bypass flow for Gyro 3

- L.13.1 Check to ensure the Spinup gas supply bottle has > 250 psi. Open **V5** and **V6** at the helium supply bottle.
- L.13.2 Open **GSV-1** and **GSV-2** (100 sccm flow controller).
- L.13.3 Open **GSV-6**
- L.13.4 Set GSV-4 mode switch to "auto" and rotate the 10-turn pot clockwise on **GSV-2** until the desired flow is displayed on **GSG-4**. *Note: The numbers on the 10-turn pot dial will correspond with the output of the flow controller.* Start recording spin information in Table 3.

L.14 Gyroscope Spinup for Gyro 3

- L.14.1 Start a FFT file on the Sun 386i. Record File name: _____
Record any additional useful information concerning the spin speed readout in the lines below (e.g. type of readout used, if the SQUIDs are being used, what range and gain are they on, etc.).

- L.14.2 When you are ready to start spinning the Gyroscope, open **GSV-7**.
- L.14.3 Confirm GSV-6 closed while GSV-7 was opened.
- L.14.4 Flow gas into the Spinup manifold. Monitor spin speed on the Sun 386i. Continue to record spin information in Table 3.
- L.14.5 To stop spinup (either because the target spin speed has been reached, or to assess how the spinup is proceeding) open **GSV-6** to reinitiate a bypass flow.
- L.14.6 Steps L.14.1 – L.14.4 should be repeated as necessary to spin the gyroscope. Initially, use only a few sccm for a few seconds to get a feel for the spinup. This may be gradually increased as necessary. If it is uncertain whether or not the gyroscope is spinning after several attempts, stop the process and assess the situation.

L.15 Post-Spinup Procedure for Gyro 3

- L.15.1 Turn the 10-turn pot counter clockwise until gas is no longer flowing. Display reads 000. Set the **GSV-4** switch to "off".
- L.15.2 Close **GSV-1** and **GSV-2** to stop the flow of gas.
Close **GSV-6**
Open **AXV-8** and **AXV-5**
Turn on Interlock Defeat and Open **GSV-7**
- L.15.3 Let the **SEP** pumps evacuate the manifold from the flow controller to the Gyroscope. This will evacuate some of the remaining He left in the spinup manifold.
- L.15.4 (Optional) Gently close **S3** on the Probe spinup inlet. Check if done: _____
- L.15.5 Close **GSV-7**, **AXV-5** and **AXV-8**
- L.15.6 Confirm that all the valves are closed and that the interlock switch is still "enabled."
- L.15.7 If **S3** was not closed in L.15.4, wait until gyroscope has been delevitated (end of the spinup test) and then close **S3**.

L.16 Pre Spin-Up Checklist Gyro 4

Start Date: _____

Start Time: _____

Gyroscope #: _____

L.16.1 Verify the gyroscope is levitated and in the desired position

Record Position [X Y Z]: _____

L.16.2 Verify that the gyroscope is not charged >70 volts _____

L.16.3 Verify that there is no oscillation in the position greater than 40 micro-inches. _____

L.16.4 Verify that the gyroscope has been levitated for at least one hour _____

L.16.5 Leakage Gas Pumping System is operating and the system Pressure < 5×10^{-5} torr _____

L.16.6 Spinup Exhaust Pumping System is operating and pressure is < 5×10^{-3} torr (this is used to evacuate the spinup manifold) _____

L.16.7 Confirm manifold between the Probe C Gyro inlets (S1, S2, S3, or S4) and the Gyro Spinup management manifold (GSV-7) is connected, under vacuum, and has been certified according to P0567. Record Op. Log number: _____

L.16.8 Confirm the helium spinup gas supply is Grade 6 He and has Conformance Certification available. _____

L.17 Spinup Manifold Evacuation for Gyro 4

Note: Refer to figure 1 for pumping system schematic.

- L.17.1 Check that **SEP-1/SEP-2** pumps are operating and the pressure is $< 5 \times 10^{-3}$ torr. If the pumps are not running pressing the momentary switches on the right side of the schematic can start them. Place the system in Interlock Defeat mode and verify yellow LED is blinking.
- L.17.2 Open auxiliary valves **AXV-8, AXV-5**, and the gas supply valve **GSV-7**. This will evacuate the spinup manifold up to the flow controller **GSV-4**. Confirm the Probe spinup valve is open. If it is not, gently open the Probe spinup inlet valve, **S4**. Close valves **AXV-8, AXV-5**, and **GSV-7**.
- L.17.3 Turn off interlock defeat. The system is now ready to initiate Bypass flow.

L.18 Initiate Bypass flow for Gyro 4

- L.18.1 Check to ensure the Spinup gas supply bottle has > 250 psi. Open **V5** and **V6** at the helium supply bottle.
- L.18.2 Open **GSV-1** and **GSV-2** (100 sccm flow controller).
- L.18.3 Open **GSV-6**
- L.18.4 Set GSV-4 mode switch to "auto" and rotate the 10-turn pot clockwise on **GSV-2** until the desired flow is displayed on **GSG-4**. *Note: The numbers on the 10-turn pot dial will correspond with the output of the flow controller.* Start recording spin information in Table 4.

L.19 Gyroscope Spinup for Gyro 4

- L.19.1 Start a FFT file on the Sun 386i. Record File name: _____
Record any additional useful information concerning the spin speed readout in the lines below (e.g. type of readout used, if the SQUIDs are being used, what range and gain are they on, etc.).

- L.19.2 When you are ready to start spinning the Gyroscope, open **GSV-7**.
- L.19.3 Confirm GSV-6 closed while GSV-7 was opened.
- L.19.4 Flow gas into the Spinup manifold. Monitor spin speed on the Sun 386i. Continue to record spin information in Table 4.
- L.19.5 To stop spinup (either because the target spin speed has been reached, or to assess how the spinup is proceeding) open **GSV-6** to reinitiate a bypass flow.
- L.19.6 Steps L.19.1 – L.19.4 should be repeated as necessary to spin the gyroscope. Initially, use only a few sccm for a few seconds to get a feel for the spinup. This may be gradually increased as necessary. If it is uncertain whether or not the gyroscope is spinning after several attempts, stop the process and assess the situation.

L.20 Post-Spinup Procedure for Gyro 4

- L.20.1 Turn the 10-turn pot counter clockwise until gas is no longer flowing. Display reads 000. Set the **GSV-4** switch to "off".
- L.20.2 Close **GSV-1** and **GSV-2** to stop the flow of gas.
Close **GSV-6**
Open **AXV-8** and **AXV-5**
Turn on Interlock Defeat and Open **GSV-7**
- L.20.3 Let the **SEP** pumps evacuate the manifold from the flow controller to the Gyroscope. This will evacuate some of the remaining He left in the spinup manifold.
- L.20.4 (Optional) Gently close **S4** on the Probe spinup inlet. Check if done: _____
- L.20.5 Close **GSV-7**, **AXV-5** and **AXV-8**
- L.20.6 Confirm that all the valves are closed and that the interlock switch is still "enabled."
- L.20.7 If **S4** was not closed in L.20.4, wait until gyroscope has been delevitated (end of the spinup test) and then close **S4**.

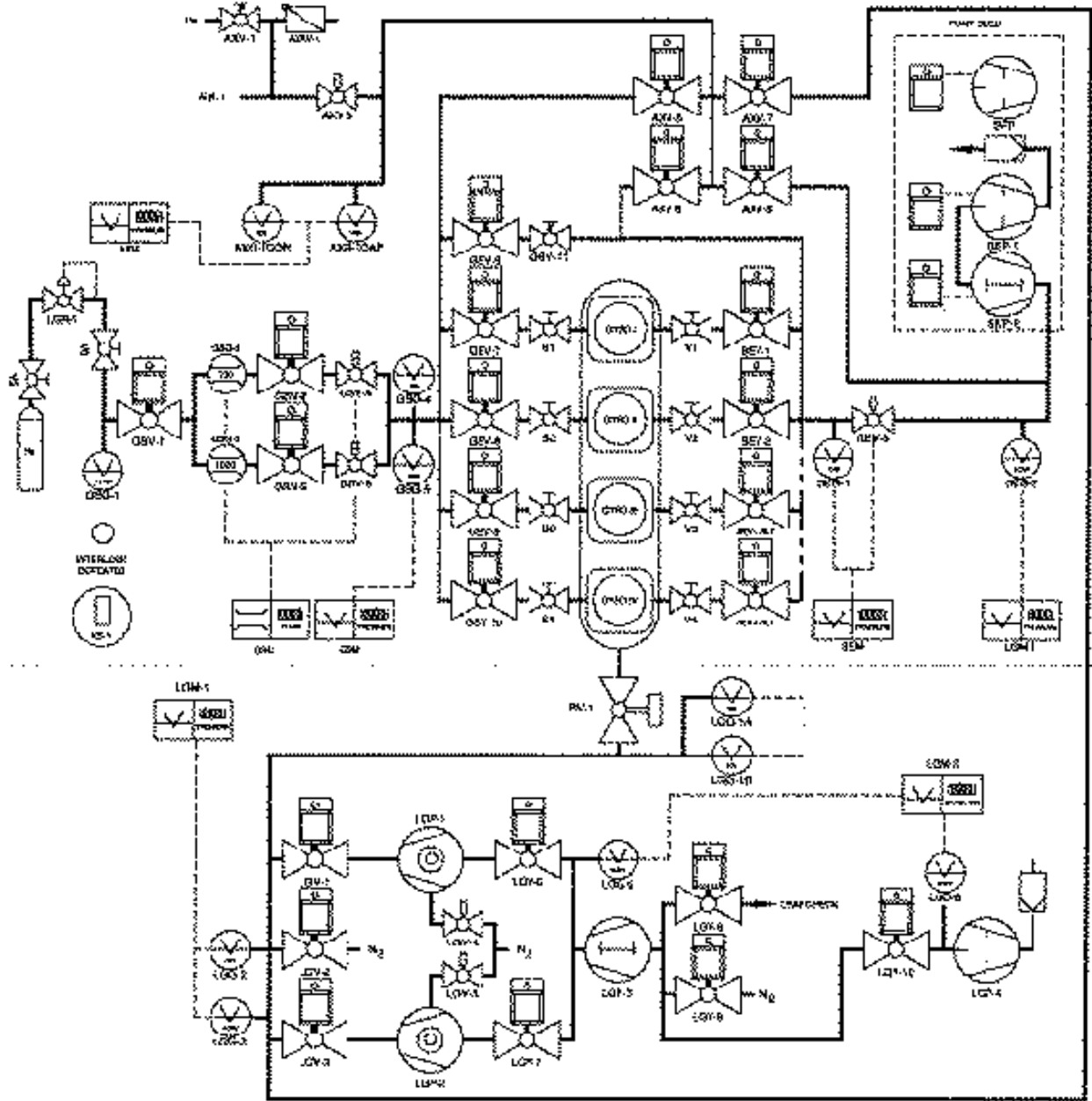


Figure 1: Gyro Gas Management System

Date/time: _____
Operator's initials: _____
QA: _____

L.21 DATA SUMMARY (OPTIONAL):

- L.21.1 Gyro #1 dF/dT _____
- L.21.2 Data file name and directory path: _____
- L.21.3 Gyro #2 dF/dT _____
- L.21.4 Data file name and directory path: _____
- L.21.5 Gyro #3 dF/dT _____
- L.21.6 Data file name and directory path: _____
- L.21.7 Gyro #4 dF/dT _____
- L.21.8 Data file name and directory path: _____

L.21.9 Location of data analysis (lab book, matlab file, EM, etc.):

L.22 Spinup Valve Cycles Log

Note: Torque valves to 60 inch-lb.

- S1** _____
- S2** _____
- S3** _____
- S4** _____

Test completed.

Completed by: _____
Witnessed by: _____
Date: _____