Outline of Test Plan Procedures
for SQUID Package

Document Revision Record

Rev	Date	ECO#	Pages Affected	Description
-	12/6/97	NA	NA	New procedure
A	1/22/98	724	ALL	update Pdoc
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Precautions
SQUID chip is ESD and EOS sensitive. Use the following precautions to guard against ESD/EOS induced SQUID failure.
1. When connecting and disconnecting electrical cables to the probe, the operator shall be grounded to the electronics ground by using a wrist grounding strap and the probe shall also be grounded to the electronics ground.
2. A female Lemo connector shall be mated to the SQUID package Lemo connector unless access to the SQUID Lemo connector is required (as in all performance testing).
3. Room temperature resistance measurements shall be carried out as given in P0153.

Test Plans Included
The following procedures correspond to tests described as qualification/ acceptance tests in the Test Plan Matrix of Readout Components, 2/12/96. This outline addresses those tests which will be performed in the SQUID Package Acceptance Facility.

Test SIA #	Description
	EMI
	Thermal Cycling (4.2K to 300K)
	Thermal Cycling (300 K to 360 K)
3.7.1.7.2.1.3	V/Phi Curve Measurement (Linearity)
3.7.1.7.2.1.15	Magnetic Shielding Factor
3.7.1.7.2.1.3.1	Harmonic Distortion
3.7.1.7.2.1.9	Electrical Isolation
3.7.1.7.2.1.1	Squid Package Noise @ 5.5 mHz @ 4.2 K
3.7.1.7.2.1.4.2	SQUID Bias Temperature Coefficient @ 3 K
3.7.1.7.2.1.4.3	SQUID Scale Factor Temperature Coefficient @ 3 K
3.7.1.7.2.1.12	SQUID Bias Current
3.7.1.7.2.1.2	SQUID Package Noise @ 4.2 K @ 100-200 Hz
3.7.1.7.2.1.5	Flux Jump Specification
3.7.1.7.2.1.7	Input Circuit Decay Time
3.7.1.7.2.1.4.1	SQUID Operation Temperature (2.5-4.2 K)
3.7.1.7.2.1.17	Scale Factor by Flux Slipping
Appendix A.	Probe Insertion and Cooling Procedure
Appendix B.	Probe Extraction and Warmup Procedure
Appendix C.	Sample Test Report

Preparation

Unless otherwise noted, the tests described in the subsequent pages are expected to be carried out after completing the following preparations:

1) The SQUID package is to be installed into the acceptance probe in the clean room.
2) The SQUID input is to be shorted by a Nb strip.
3) The LEMO connector leads shall be checked for continuity before taking probe to the screened room (the measurement to be performed as described in P0153).
4) The SQUID shall not be taken out of the probe except in the clean room.
5) All instruments used to provide direct spec verification must be calibrated.
6) All data collection equipment should be turned on at least 1/2 hour before using so as to minimize the chance of warm up drift of the desired signal.
7) The SQUID package will have passed magnetic screening.
8) Except as noted, no special environments are required.
9) All software is archived in the documentation center.
10) ONR QA has been notified and confirmed notification that SQUID acceptance testing will begin in 48 hours_______(initials of operator).

Instrumentation

1)	BTI model CCS Current Source	S/N 262 490-04
2)	Linear Research GRT Bridge	LR-400-20K/130 S/N 316-1
3)	Fluke 77 Hand Meter	S/N 66970626
4)	HP 54601A Oscilloscope	S/N 3242A02102
5)	HP 8620C Oscillator	S/N 1604A00504
6)	HP 3326A Oscillator	S/N 2519A0025A
7)	HP 1.5GHz Spectrum Analyzer	S/N HP8590A S/N 2722A01668
8)	HP E3620A DC Power Supply	S/N KR51301451
9)	HP LCZ meter	HP4277A S/N 2830I02934
10)	Keithley 580 Micro-ohmmeter	S/N 0624803
11)	Keithley 196 Multimeter	S/N 467886, 0575473
12)	Omega Temperature Controller	CN 3000 S/N01770
13)	PC	HEPL #00433-1
14)	Power Amplifier	HP 6266B S/N 1025A0642
15)	Rev B SQUID Electronics	S/N 0001
16)	SR345 Function Generator	S/N 26562
17)	SR560 Pre-amplifier	S/N 00204
18)	SR770 Network Analyzer	S/N 24185
19)	Strawberry Tree Data Acquisition System	DS-16-8-TC S/N 379 R2-03
20)	Vacuum pump and controller	Stokes model 005-2

Results Recording

The results of acceptance tests obtained using this procedure and the associated data analysis are summarized in individual test reports (See appendix C for an example report). This report also indicates whether each test has passed or failed. The detailed data are recorded in the SM qualification test log book. The results of qualification tests on a single SQUID will be summarized in S0302..

Part I Acceptance Test

1. Electrical Isolation (3.7.1.7.2.1.9)

1.1 Assemble SQUID in the readout clean room.
1.2 Check continuity (as given in P0153) at the 10 pin Lemo connector.
1.3 Record pair resistances and cross resistances. Verify that the readings have not changed more than 15% as compared with the measurement after SQUID carrier assembly.

2. Cool Down SQUID

2.1 See Appendix A for cool down procedure.
2.2 Use Rev B electronics to check tune up and flux lock SQUID. Do next test if the SQUID is functional. Otherwise diagnosis the problem.

3. Thermal Cycling

3.1 Disconnect the probe from the SQUID electronics.
3.2 Connect the probe to the lifting structure. Purge dewar with gas helium to keep pressure positive.
3.3 Lift up the probe slowly (refer to Appendix A).
3.4 Watch the temperature corresponding to the GRT on the bottom of the can. When the temperature reaches 10K remove the probe from the dewar and place in the storage vessel.
3.5 Monitor the temperature of the probe until it reaches 300K.
3.6 Slowly insert the probe back into the dewar (refer to Appendix A).
3.7 Repeat steps 3.3 through 3.6 two more times.
3.8 Connect the SQUID electronics to the probe.
3.9 Check that the SQUID tunes up and flux locks.

4. SQUID Tune up (3.7.1.7.2.1.12)

Requirement: 20-60 μA

4.1 Connect the "amp" and "FLL" outputs of the electronics to the scope.

4.2 Tune up the SQUID. Record the optimal bias, modulation setup and the maximum peak-to-peak waveform voltage. Calculate the bias current and compare with the requirement:

Bias Current = Bias Knob Reading x 10 (μA)

Note: This step requires QA inspection. QA must signoff on test report at this step.

5. V/Φ Calibration

5.1 Apply 3 $\Phi 0$ into the SQUID using the offset. Write down the position of the knob (p1).
5.2 Return offset to the original setup. Flux lock the SQUID. Write down the FLL output (v1).
5.3 Adjust the offset knob to position p1. Write down the FLL output (v2).
5.4 Calculate the ratio:

$$V/\Phi = |(v1-v2)/3|$$

Record the number.

6. SQUID Package Noise @100-200 Hz (3.7.1.7.2.1.2)

Requirement: Less than 15 $\mu\Phi o/\sqrt{Hz}$ (60 marcsec/$\sqrt{Hz}$)

6.1 Adjust offset to make the FLL output close to zero (<10 mV).
6.2 Connect the FLL output to the SR770 spectrum analyzer.
6.3 Pick frequency range from 100 kHz to 1 kHz and get PSD respectively. Write down the value at 10 kHz, 1 kHz, and 100 Hz. Convert them to $\Phi 0/\sqrt{Hz}$ using the result of step 5.4.
6.4 Compare the result at 100 Hz with the requirement.

7. Flux Jump Specification (3.7.1.7.2.1.5)

Requirement: Less than 1 jump (with amplitude greater than 10^{-4} Φo (0.4 arcsec)) in 6 hours.

7.1 Adjust offset to make FLL output close to zero (10 mV).
7.2 Connect the FLL output to the A/D system through a SR560 preamplifier. Set LPF=0.3 Hz, gain=100x, and sampling rate=2 Hz.
7.3 Take data for 12 hours.
7.4 Process the data using program "bkcrunch" Rev -.
7.5 Plot the time domain result. Compare with the requirement.

8. SQUID Package Noise @ 4.2K @ 5.5 mHz (3.7.1.7.2.1.1)

Requirement: Less than 35 $\mu\Phi o/\sqrt{Hz}$ (140 marcsec/$\sqrt{Hz}$)

8.1 Run FFT analysis using "bkcrunch" Rev - on the data obtained from step 6. Linear fit the data to get the noise average @5 mHz.
8.2 Plot the FFT result.
8.3 Compare the result with the requirement.

9. Harmonic Distortion (3.7.1.7.2.1.3.1)
Requirement: Less than 1 part in 10^4 harmonic distortion

9.1 Connect HP3326A to the feedback connector of the SQUID electronics through two 500kΩ resistors. The resistors should be in a balanced configuration with one on each side of the HP3326A supply. Set the frequency to be 200Hz. Quasistatically sweep the amplitude from 0.1V to 10V.
9.2 Use SR770 spectrum analyzer to measure the harmonics of the SQUID FLL output.
9.3 Record the base and the second harmonic spectrum peaks. Plot the harmonic ratio vs. Base frequency.
9.4 Compare the result with the requirement.

10. Input Circuit Decay Time (3.7.1.7.2.1.7)
Requirement: Less than 1% decay in 10 minutes of observation

10.1 Apply current to feedback using the HP E3620A through two 500kΩ resistors (configured as given above).
10.2 Apply 10V (~10Φ0) into the SQUID.
10.3 Use Keithley 196 meter to measure both the input and the FLL output . Record the readings.
10.4 Wait for 10 minutes. Record both readings again. Calculate the input decay rate and compare with the requirement.

Input Decay = {Abs[(Vout2-Vout1)/Vout1]+Abs[(Vin2-Vin1)/Vin1]}/ (Time2-Time1)

11. SQUID Bias Temperature Coefficient @ 3.0 K (3.7.1.7.2.1.4.2)
& SQUID Operation (3.7.1.7.2.1.4.1)
Requirement: Less than 0.01 Φo/K (40 arcsec/K) for bias temp. coef. spec. Flux locked operation for SQUID operation spec.

11.1 Run the SQUID electronics temperature controller for 1 hour to stabilize (to better than 0.2 K) the temperature.
11.2 Connect the probe to the pump. Pump the helium until the temperature falls below 2.3K.
11.3 During pumping, record SQUID FLL output, electronics temperature, and helium bath temperature using the A/D system. Use program "SMPUMP" Rev - with a 1 Hz sampling rate.
11.4 Plot FLL output vs. helium temperature. Calculate the bias temperature coefficient at 3K.
11.5 Compare the result with the requirement.

12. SQUID Bias Current @ 3.0 K (3.7.1.7.2.1.12)
Requirement: 20-60 µA

12.1 Stop the pump when helium temperature reaches 2.3 K.
12.2 Increase the helium temperature by injecting helium gas into the dewar.
12.3 Tune up SQUID when helium temperature reaches 3 K.
12.4 Record the tune up parameters. Calculate the bias current and compare with the requirement:

Bias Current = Bias Knob Reading x 10 (µA)

13. SQUID Scale Factor Temperature Coefficient @ 3.0 K (3.7.1.7.2.1.4.3)
Requirement: Less than 3×10^{-4}/K

13.1 When helium temperature reaches 2.5 K (heat coming down the neck of the dewar causes the temp. rise), apply current to the feedback using the HP E3620A through two 500 kΩ resistors. Measure signal input and the FLL output with Keithley 196 meters.
13.2 Increase input voltage from 0 V to 10 V (~10 Φ0). Record both input (Vin1) and FLL output (Vout1).
13.3 Turn the input down from 10 V to 0 V. Record both input (Vin2) and FLL output (Vout2).
13.4 Repeat 13.2 and 13.3 3 times.
13.5 Calculate the net input and output by subtracting the two adjacent measurements. Divide the net input by the net output:

Input/ Output Ratio = (Vin1-Vin2)/(Vout1-Vout2)

13.6 Calculate the average ratio and the repeatability.
13.7 Repeat step 13.2 to 13.5 when helium temperature reaches 4.2K. Calculate the ratio @4.2K.
13.8 Calculate the scale factor temperature coefficients:

Scale Factor Tempco(average) = (Ratio@4.2K - Ratio@2.5K) / (4.2K - 2.5K)

13.9 Calculate the scale factor tempco for the temperature range from 2.8 K to 3.0 K.

Scale Factor Tempco(spot) = (Ratio@3.0 K - Ratio@2.8 K)/(3.0 K - 2.8 K)

13.10 Compare with requirement.

14. Scale Factor Flux Slipping Measurement (3.7.1.7.2.1.17)
Requirement: Better than 1 part in 10^5 repeatability for 100 Φo applied signal

14.1 Tune up and flux lock SQUID. Adjust offset to make FLL output close to zero (<10 mV). Monitor the FLL output with a Keithley 196 meter. Zero the meter.
14.2 Open the loop. Apply current to feedback using HP E3620A through two 50 kΩ resistors. Monitor the E3620A voltage with the second Keithley 196 meter. Increase the voltage to inject 100 $\Phi 0$ by observing the tune up waveform.
14.3 Close the loop. Adjust the input carefully to make the FLL output close to zero (< 10 mV). Record the voltage readings (Vin1) and the corresponding FLL output (Vout1). Change the voltage of E3620A by approximately 1 mV. Record the new values as Vin2 and Vout2.
14.4 Calculate the exact input voltage which would make the FLL output exactly zero using linear interpolation.
14.5 Open the loop. Decrease the input to zero. Flux lock the loop.
14.6 Adjust the input to make FLL output close to zero (<10 mV). Write down two sets of readings as step 14.7 Calculate the exact input voltage which would make FLL output exact zero.
Repeat 14.2 to 14.7 three times.
14.8 Calculate the maximum difference in the calculated applied voltages for both 0 $\Phi 0$ signal and 100 $\Phi 0$ signal. Pick the largest one as δ_{Max}.
14.9 Calculate the flux slipping error:

$\delta_{Max/}$ Vin1

PROCEDURE COMPLETE

Signoff completion of procedure on Test Report Table 1. Both test operator and QA must signoff.

Part II Qualification Test

These tests are performed on only one carrier.

15. EMI
This experiment will be done in a dip probe in a non-clean environment.

Requirement: minimum rf detection level -50 dBm or better

15.1 Assemble a SM-like SQUID into a SM-like SQUID package.
15.2 Assemble a SM-like gyro housing with a SM-like SC cable and an input filter kit.
15.3 Measure the resistances and capacitances of the SQUID, input filter and gyroscope.
15.4 Connect the output cable with the solid-shielded test probe.
15.5 Seal the cable connector joints with copper tape.
15.6 Wrap the SQUID assembly in Kimberly wipes.
15.7 Insert into the 2” Nb can. Make sure the can is isolated from the cable ground.
15.8 Check continuity from the 9-pin Winchester connector of the probe.

15.9 Insert the probe into the 5”-neck dewar.
15.10 Transfer liquid helium to the dewar.
15.11 Connect the probe with the Rev B electronics. Tune up SQUID and close the FLL. Monitor the FLL output on the scope and measure the noise @1 kHz on the SR770 spectrum analyzer.
15.12 Insert the antenna into the dewar through the venting hole. Secure the position at about 2.5’ deep in the dewar.
15.13 Connect the antenna with the HP8620C oscillator. Turn on the 1 kHz modulation.
15.14 Decrease the attenuation from “-70 dB+10dB” (nominally -60 dB) gradually. Manually sweep frequency from 10 kHz to 2.4 GHz. Write down the FLL response @1 kHz. Gradually decrease the attenuation to “0 dB+10 dB”.
15.15 Turn off the electronics. Warm up the probe. Disassemble the SQUID.
15.16 Analyze the data. Verify that the SQUID response meets the spec.

16. Magnetic Shielding Factor (3.7.1.7.2.1.15)
Requirement: Greater than 1000

A dip probe will be used in a non-clean environment.

16.1 Make a coil with .005” Ph Bronze wire over a Φ1/4” x 1/2” fiber glass tube.
16.2 Connect the coil to a BTI DC current source.
16.3 Use a flux gate to calibrate the field generated by the coil.
16.4 Assembly a SM-like SQUID into a SM-like SQUID package.
16.5 Locate the coil at the interface between the SQUID body and lid. Secure the position.
16.6 Wrap the SQUID assembly in Kimberly wipes.
16.7 Insert into the Φ2”x5” Nb can. Make sure the can is isolated from the cable ground.
16.8 Check electrical continuity of the SQUID at the 9-pin Winchester connector of the probe.
16.9 Insert the probe into the 2.5”-neck dewar.
16.10 Transfer liquid helium to the dewar to 100% full.
16.11 Connect the probe with the Rev B electronics. Tune up SQUID and close the FLL. Monitor the FLL output on the scope.
16.12 Turn on the BTI current source. Increase the current gradually. Record the SQUID FLL output response.
16.13 Turn off the electronics. Warm up the probe. Undo the SQUID Assembly.
16.14 Analyze the data. Verify that the SQUID response meets the spec.

17. Thermal Cycling
Requirement: SQUID survivability

17.1 Test a SQUID to check that it meets the basic tuning up, FLL, and the noise performance requirement.
17.2 Disassemble the SQUID from the package.
17.3 Bake the SQUID carrier in air in an oven at 360K for one week.
17.4 Assembly and retest the SQUID to confirm no change (greater than 10%) in the optimal bias current.

18. V/Φ Curve Measurement:Linearity (#3.7.1.7.2.1.3)
Requirement: Less than 1% deviation from straight line fit for 100 arcsec offset from nominal lock point

Inject a monotonically increasing current for a time duration of approximately 2 minutes and an amplitude corresponding to 3 or 4 flux quanta via the feedback input.
Adjust the amplitude of the 420 kHz modulation signal to a 0.01Φ0 level. The response of the SQUID is obtained from the output of the demodulator.
Acquire data from the demod out using the Strawberry Tree S/N 379 R2-03 data acquisition system. Run program named “Linear.wbw’ Rev -. Sample the output at 1Hz, low pass filter signal at 0.3Hz and acquire 1000 points of data.
Verify the linearity requirement.

Appendix A. Probe Insertion and Cooling Procedure

Three Cases:

A: probe is entirely connected
B: probe can is disconnected, probe body is connected
C: entire probe is disconnected

Case A:
(This assumes the entire probe is inside the bellows and connected:
-to the rubber hose at the top flange
-to the cryodiodes through the banded LEMO cable
-to the GRT through the gray LEMO cable

1. Check level of liquid helium in dewar.
A) Fasten helium level meter cord to receptacle on dewar located underneath gate valve. (plug is keyed to attach only 1 way)
B) Turn on liquid helium meter using the toggle switch.
C) Get a % reading from the meter. Determine if there is sufficient helium remaining to perform all tests. Expect a loss of approximately 10%/day due to standard boil-off. If helium level is too low, the dewar will need to be refilled through a liquid helium transfer.

2. Test cryodiode connection.
A) Press the on/off button on the thermometer in to the "on" position.
B) The temperature should not read "OL"
C) Press the <u>unit select</u> button repeatedly until the display shows room temperature in Kelvin. (about 295-305 Kelvin)
D) Test channels 1 (interior cryodiode) and 2 (exterior)- discount channels 3-8. channels 1 and 2 should read similarly.

3. Test GRT connection.
A) Turn on GRT bridge and check reading. With the setpoint at 0, and the display set to dR or R*x*, the readout should show 4 or 5 ohms.
B) If superfluid temperature control is going to be used, test resistance of internal heater. To do this, test resistance between the center sockets of the labeled "heater HI" and "heater LO" BNC connectors on the GRT/heater junction box in the back of the electronics rack. It should read ~130 ohms.

4. Check to make sure bellows are attached to dewar.
A) Check for sealing gasket between bellows and dewar.
B) Check probe alignment with gate valve. Move dewar to center probe over gate valve before fixing dewar and closing bellows. Also make sure the swing arm that supports the bellows is not affecting the centering.
C) Swing arm out of the way and lower bellows base onto sealing gasket.

5. Back fill bellows with helium.
A) Go to the helium gas tank outside the screenroom, and open the main valve. Making sure that the hose is not connected to anything, open the nipple valve and adjust the metering valve until a noticeable trickle of helium is escaping.
B) Connect the hose to the brass nipple on the manifold (check that the valve is closed). Also make sure that the base of the bellows is not locked to the dewar. You should be able to lift the bellows and see the probe.
C) Open the manifold nipple valve to let the helium gas in to the system. You should see the boil-off meter raise accordingly. Now close the Varian inline valve leading to the boil-off meter.
D) You will soon see the bellows expand as it is filled with helium gas. Lift the bottom of the bellows slightly to let the pressure off.
E) Repeat the process three times. Then re-open the boil-off meter channel and close the nipple valve. This purges the air and water vapor from the bellows before it is exposed to the liquid helium in the dewar.
F) Fix the flexible metal ring over the bottom lip of the bellows to seal them to the gasket and the dewar. Turn off the helium gas and remove the rubber hose.

6. Open the dewar gate valve.
A) Connect the quick flange at the end of the rubber hose connected to the probe to the plumbing system at the T-section closest to the boil-off indicator.
B) Turn the knob extending from the gate valve assembly counterclockwise until valve is fully open.

7. Close Varian inline valve underneath Gate Valve.

A) Turn knob clockwise fully. Boil-off indicator should show venting to atmosphere. You may have to wait a minute or two to see this. If venting is absent, check to see if dewar is venting through rubber hose. **The dewar needs to vent through a single path.**

8. Begin to lower probe.
A) Hold rope below fastener with two hands, about 1.5 feet apart. Use hand nearest the fastener to pull the rope loose, and then slowly provide slack with the other hand. Observe the venting (boil-off) rate. When it reaches 1/2 scale (a ping-pong gauge), fasten the rope and let the probe hang until venting decreases.
B) When boil-off venting calms down, lower probe a little further and repeat.
C) If boil-off becomes too strong, (above the 2/3 mark on the boil-off indicator) raise the probe a little by pulling and fastening the rope.
D) Watch cryodiode readings as you lower the probe. CD 2 should show the most dramatic change, as it is at the bottom of the probe and exposed to maximum vapor cooling. If you notice a large difference between the interior and exterior temperatures, let the probe hang at constant height until Cryodiode 1 cools to within about 75 degrees of Cryodiode 2.
E) When the exterior cryodiode (channel 2) reads about 7 degrees Kelvin, stop lowering. At this point the probe is just above the liquid level.

9. Lowering the probe into the helium bath:
A) Wait for interior and exterior cryodiodes (channels 1 and 2) to come to some agreement (CD 1 will read about 7 degrees higher).
B) Slowly lower probe until crydiode 2 reads approximately 3.89 K. At this point the foot of the probe is below the surface of the bath (the crydiode is offset; the true temperature is about 4.21 K)
C) Watch the interior crydiode temperature. Wait for it to stabilize, then begin lowering probe into the bath. Keep an eye on the boil-off, it will increase at this point. Keep the boiloff below the 3/4 mark at all times, try to keep it near the 1/2 mark to conserve helium.
D) The interior crydiode should cool to read about 3.38 K, (also offset) as the can begins to fill with liquid. At this point the GRT should be displaying an increase in resistance as the inside of the can is cooled rapidly by the liquid. The temperature equivalents for the GRT readings can be found in the calibration sheets in the blue folder. Probe 1 holds GRT 26791, while Probe 2 holds GRT 26792. Use the correct interpolation table for temperature conversion.
E) The GRT reading should settle to about 1600 ohms, which corresponds with about 4.21 Kelvin. At this point the probe is mostly filled with liquid helium.
F) Finish lowering probe, keeping boil-off below 1/2. At some point the probe may get stuck, if alignment was improper. Use rope to gently lift and lower while using the other hand on the top of the bellows to guide the probe. Do not lift the probe far, just enough to guide it in.

10. Disconnect probe from bellows.
A) Locate the yellow-handled Allen head screwdriver with extension. Stand on footstool and look down into bellows to locate hex screws.
B) Loosen hex screws that fasten probe to bellows. This can be done without removing the pulley plate from the bellows.
C) Remove flexible ring holding bellows to dewar, by removing the wingnut and then bending the ring outwards.
D) Check that bellows is free of probe. If it is not, check hex screws, one or more may not have been completely loosened.
E) Lift bellows, making sure they clear the probe. When bellows top is of sufficient height, lift bottom of bellows, and set swing arm to hold them. At this point the two LEMO cables and the venting hose should be still going through the bellows.
F) Turn off GRT and cryodiode readout. Unplug LEMO cables from probe and remove them from the bellows. Open quick flange at top of probe and remove venting hose from bellows. Quickly replace venting hose on probe.

11. Fasten probe to dewar.
A) Get the drawer of hex screws from the toolbox inside screen room. It should contain 6 screws (#10 screws, 3/4" length). Also get the green-handled socket driver with double-stick tape at the end.
B) Line up probe with threaded holes in the dewar flange by turning it. When approximately lined up, use the sticky green driver to place two screws in opposite holes in the top flange. Use yellow hex driver to tighten. (if screws will not thread, try adjusting the probe- the holes may be misaligned or you may be aligned with the wrong holes.)
C) Insert and tighten remaining hex screws.

12. Connect probe to electronics. (note: observe the ESD precautions given at the beginning of this procedure).
A) Reconnect gray LEMO cable to inner socket on probe. Test GRT reading by turning on bridge. It should read about 1600 ohms.
B) Reconnect banded LEMO cable to outer socket on probe. Test crydiodes by turning on crydiode readout and checking channels 1 and 2.
C) Make sure SQUID electronics are turned off before connecting shielded SQUID cable to socket on top flange of probe.

Case B: Can is disconnected.

(This assumes the probe body is connected to the bellows and hanging from the swing arm and the can has been sealed and is ready to be returned to the helium bath. This also assumes that the LEMO cables and venting hose are attached to the probe.)

1. Free space beneath probe.
A) Check that dewar is not below probe. If it is, raise the feet and roll it aside.

2. Check wires.
A) Check to see that there are 5 thin twisted pair of wire hanging down, as well as a SQUID cable with a ground pin attached.
B) Check that all 10 individual wires have pins or sockets.

3. Attach can.
A) Take the probe can in one hand, and use the other to feed the pairs of wires into the tube along the can's side. Slide the wires through until the pins and sockets emerge at the bottom of the can.
B) Line up the tube that now holds the wires with the holes in the radiation baffles, and then tighten the sockets at the bottom of the probe onto the threads at the top of the can.
C) Feed the SQUID cable through the tube at the side of the can.

4. Connect cables to probe can.
A) Gently connect the pins and sockets coming from the can to the pins and sockets from the probe body according to like colors.

white:	heater
blue:	GRT voltage
clear:	GRT current
black:	Cryodiode 1 (internal)
red:	Cryodiode 2 (external)

B) Connect SQUID cable and grounding pin.
C) Turn on GRT bridge and Cryodiode readout to test connections. If there are problems, check connections.
D) Use one or two pieces of Kapton tape to bundle the wires and keep them where they cannot catch on anything.

5. Move dewar back under probe.
A) Roll dewar to underneath probe. You may choose to line up the probe before fixing dewar in place with the feet on the stand. If so-remove the swing arm, as it will keep the probe from hanging straight and will therefore affect the alignment.

If you wish to lower the probe into the helium, follow case A for the procedure.

Case C: Entire Probe is Disconnected.
(This case assumes the probe is fully assembled: The can is connected to the body, and all connections have been made and tested. If the can and body are separate, connect them as in Case B, only do this at the lab bench, as it will make the process easier. Also the bellows should be sitting on the swing arm.)

1. Bring probe into screenroom.
A) Make sure dewar is out of the way.
B) Carry probe into the screen room.
Stand probe up on it's feet in front of the electronics rack.
2. Double check connections.
A) Plug in LEMO cables and turn on readouts to check cryodiodes and GRT reading. (banded on the outside, gray on the inside)
B) Turn off readouts and remove cables.

3. Connect probe to bellows.
A) Check that all 6 hex screws are hanging from the lip of the bellows can.
B) Stand probe on the floor under the bellows.
C) Feed the small (QF25) quick-flange end of the rubber venting hose through the bellows and attach it to the top of the probe.
D) Feed the LEMO cables through the bellows and connect them to the probe.
E) Make sure the top of the bellows is being supported by the rope, and then move the swing arm out of the way and lower the bottom of the bellows over the probe.
F) Lower the top of the bellows with the rope. Use the venting hose and the cables to guide it onto the top flange of the probe.
G) Turn the bellows around the top flange until the screws inside the bellows can line up with the threads in the top flange. Make sure you are lining up with the threaded holes and not the hex screw sockets. Turn one of the screws until it begins to thread. (If it will not,

adjust probe.) Then do the same for the screw opposite the first. Once both are threaded, all the screws may be tightened, as all will be held in alignment.

4. Raise probe.
A) Make sure swing arm is folded against the wall.
B) Use rope to raise probe and bellows. (Let bottom of bellows hang loose).
C) Lift probe all the way (twist slightly to straighten ropes).
D) Lift bottom of bellows up to above swing arm level by hand.
E) Bring out swing arm, tighten wingnut, extend arm to hold probe.
F) Set bellows on arm.

For instructions to cool the probe, follow Case A above.

Appendix B. Probe Extraction and Warm up Procedures

Two cases:

Case A: Probe is secured to the Dewar
Case B: Probe is secured to the bellows

Probe Removal
Case A:

(This assumes the probe is secured to the dewar and connected to the electronics, as after a set of data has been collected. This also assumes that the bellows are disconnected and are sitting on the swing arm above the probe, and that the dewar is venting through the top flange of the probe via the rubber hose leading to the manifold.)

1. Disconnect probe from electronics.
A) Turn off all connected electronics. (GRT bridge, Cryodiode readout, SQUID electronics)
B) Unplug LEMO cables from top flange of probe.
C) Unscrew and remove SQUID cable from probe.

2. Prepare to install bellows.
A) Use yellow handled Allen driver to loosen the six hex screws that fasten the probe to the top flange. Use the green handled sticky socket tool to remove the screws once they are fully loosened. Put the screws in an empty drawer in the toolbox inside the screen room.
B) Disconnect rubber hose from the probe by opening the quick flange. At this point the dewar will be venting to atmosphere through the open quick flange.
C) Quickly feed the hose down through the bellows on the swing arm, and reconnect it to the probe. The boil-off indicator should then show a positive pressure (the ball is floating). You may have to wait a minute to see this. If you do not, check to make sure boil-off is venting through the hose. If it is, check to make sure there is not path open except for the boil-off indicator.
D) Feed the two LEMO cables through the bellows from above and connect them to the sockets on the probe's top flange. The gray cable goes to the inner socket, while the banded (cryodiode) cable goes to the outer socket.

3. Check the electronics.
A) Turn on the Cryodiode readout and wait for it to settle. When set for degrees Kelvin, (K appears in the corner) cryodiode 1 should read about 3.38, while cryodiode 2 should read about 3.89 degrees Kelvin.
B) Turn on the GRT bridge. Set the setpoint to 0 and the display to R*x* or *D*R. It should read about 1600 ohms.

4. Connect the bellows.
A) Lift bellows off of the swing arm.
B) Fold swing arm against the wall.
C) Check and make sure sealing ring is on top of dewar.
D) Lower bellows over probe and on to dewar. Carefully guide inner can of the bellows over the cables and hose until it is resting on the top flange of the probe.
E) Turn bellows to untwist ropes and to line up bellows screws with the threaded holes in the top flange of the probe.
F) Use yellow handled Allen screwdriver to tighten one of the screws. If it does not thread properly, shift bellows slightly until it does. Then repeat for the screw opposite the first one.

G) Tighten all remaining screws, fastening probe to bellows.
H) Connect base of bellows to the dewar lip by opening the flexible metal ring and closing it around the joint, and then fastening it with the wingnut.

5. Prepare purging apparatus.
A) Go outside of screenroom to helium gas tank by the door. Checking that the valve beyond the regulator is set to closed, open the main valve on top of the tank all the way. Observe the pressure on the regulator scale. If pressure is less that 250 psi, consider replacing the tank.
B) Turn main knob in the "decrease" direction (counterclockwise) until no resistance is felt. Then open the valve to the left fully to allow gas to escape through the clear hose. No gas should come out at first- if it does, check to see that the metering (large) knob is turned sufficiently counterclockwise.
C) Turn metering knob slowly clockwise while holding the end of the clear hose. Stop when you can feel the gas escaping.
D) Bring the end of the hose into the screen room, and push it onto the brass fixture on the plumbing system, below the pressure sensor.

6. Begin to purge system with helium gas.
A) Slowly open the valve on the brass fixture, releasing the helium into the manifold.
B) You should see the boiloff level indicator rise as the helium gas enters the system. Adjust the purging rate at both the brass fixture and the metering valve of the regulator until the ball floats 1/3 to 1/2 of the way up.

7. Calculate liquid level.
A) Check reading on liquid helium level indicator. The reading is the percentage of the 18 inch belly that is filled. In addition to this, the dewar has a 15-inch tail that is still filled after the gauge reads zero percent.
B) Multiply the percentage as a decimal (50%=0.5) by 18 and then add the 15 inches for the foot to get the height the probe must be raised to clear the liquid helium entirely. For example, if the dewar was 20% full, the probe would be out of the liquid helium after being lifted (0.2*18 + 15 =) 18.6 inches.

8. Begin to lift probe.
A) Turn on GRT bridge and Cryodiode readout.
B) Begin to pull on the rope to lift the probe. Pull rope very slowly directly downward such that the clamp holds the probe's weight at all times. Watch the boil-off indicator, and raise the probe at such a rate that it maintains positive pressure. (the ball should float at all times)
C) After the probe has been lifted to within 4 inches of the calculated liquid level, the GRT reading will begin to drop. This indicates that helium is draining from the can. Stop raising the probe until the reading stabilizes, then bring it up a little farther and let it stabilize again. Repeat until you see a significant rise in the temperature indicated by Crydiode 1.
D) Cryodiode 1 will begin to rise as the can is finishing draining. Once it reads 4.5 Kelvin, the can will be empty. At this point, the probe can be raised further above the liquid without danger.

9. Warm the probe.
A) Continue to lift slowly, maintaining a positive pressure (at the boil-off indicator). Watch the cryodiodes (1 and 2) carefully.
B) Cryodiode 2 will warm more quickly than cryodiode 1, inside the can. If the temperatures begin to diverge dramatically (more than 30 degrees different) let the probe hang still until the inside of the can warms to within 20 degrees or so of the outside.
C) Continue until probe has been raised to the ceiling.

10. Close the Gate Valve.
A) Turn the gate valve knob clockwise fully until resistance is felt. Then give another half turn to seal the valve.
B) Open the Varian inline valve below the gate valve to allow sealed dewar to vent through the manifold.

11. Finish purging.
A) Turn down the helium purging rate (as monitored by the boil-off indicator) at the regulator such that the ball floats at about at the 1/4 mark.
B) Leave the system purging, checking about every 2-5 minutes. Check cryodiode readings.
C) When both cryodiodes read at least 273 degrees Kelvin, you can stop the purging process.
D) Turn off main valve on top of helium gas cylinder.
E) Close regulator valve.
F) Close valve on brass fixture.
G) Remove clear hose.

12. Inspect probe.

A) When probe temperature approaches room temperature (300K) you can remove the flexible fastening ring and lift the base of the bellows.
B) Lift the bellows above the swing arm, then fold it out around the probe and set the bellows on it.
C) Inspect the connections on the bottom of the probe. Look for loose wires or broken connections.

13. Remove probe can
A) Gently pull apart pin/socket connections at the base of the probe can.
B) Disconnect SQUID grounding pin, and then SQUID cable.
C) Carefully lift the bundle of thin wires through the tube and out of the can.
D) Gently pull the SQUID cable through, feeding the grounding wire into the tube before pulling the connector through.
E) Hold probe can with one hand while loosening the sockets at the top of the can with the other. You will find it easier to separate the probe if you loosen all three simultaneously, rather than sequentially.
F) Remove probe can.

At this point the can is ready to be disassembled inside the cleanroom and fitted with a new SQUID. For reattachment procedures, see the probe cooldown procedure, case B.

Case B:

(This case assumes that the probe is in he liquid, but is still connected to the bellows, rather than being secured to the dewar. One example of this situation would be during a
thermal cycle or a flux-flush.)

Perform the warming and extraction as per Case A, steps 6-11.