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Magnet Division Procedure

Superconducting Magnet Division

Specification Number: SMD-MAG-4002

Revision: A

Procedure for the Testing of $Nb_3Sn$ Short Sample Strand

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**Revision History**

Rev A: Initial Release:

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## 1 Scope

This procedure describes the method that is used to measure the electrical properties of $Nb_3Sn$ short sample strand at cryogenic temperatures.

## 2 Applicable Documents

12 T Solenoid Magnet operating manual.

## 3 Requirements

### 3.1 Material /Equipment

12 T Solenoid Magnet
Power Ten Inc. P.S. 1000A
HP 6260B D.C. P.S. 100A/0-10V
HP 6680A D.C. P.S. 875A/0-5V
HP 6002A D.C. P.S. 10A/0-50V
Ultrastab 860 R Current Transducer
4-HP 3457A Multi-meters
4-HP 3458A Multi-meters
WAVETEK-WAVEFORM Generator Model 75A
H.P. 7044B X-Y recorder
1- 3478A Multi-meter H.P.
2- 34401A H.P. Multi-meter
1- Keithley 191 Multi-meter
1- American Magnetics Liquid Helium Meter
1- OMEGA Model 199 Thermocouple Gauge
1- Keithley Null Detector Micro voltmeter
1- Sample current ramp generator and quench detector (BNL built #BP000001007)
1- magnet current ramp generator (BNL built #BP000001006)
1- MI Gaussmeter Model 7305

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3.2 Safety Precautions

3.2.1 Specific steps of this procedure contain Electrical & Mechanical Assembly operations that impact the environment. Prior to performing these steps, personnel shall complete the applicable facility specific environmental training.

3.2.2 Eye protection is recommended to be worn during soldering operations.

3.2.3 Prior to performing these steps, personnel shall complete the applicable facility specific safety training.

3.3 Procedure

3.3.1 *Sample Mounting on Test Barrel*

3.3.2 Wire samples are received on reaction barrels (3” or 6”) after heat treatment.

3.3.3 A test barrel is selected and placed in the Soldering Fixture.

3.3.4 The reaction barrel is attached to the test barrel with the thread pattern matched up.

3.3.5 The $Nb_3Sn$ short sample is manually threaded-off of the reaction barrel and onto the test barrel.

3.3.6 The sample is centered so at least a turn and a half is in the joint region at both ends.

**WARNING:**

**Personal injury can be sustained from hot surfaces.**

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3.3.7 Secure the end of the sample and begin to heat the fixture to $420^0$F.

3.3.7.1 Turn on the air flow mini vacuum, to remove fumes from the flux.

3.3.8 When the fixture has reached the set temperature, apply solder (60/40) to the joint region.

3.3.9 After soldering, wipe the joint area with a wet rag and remove from soldering fixture.

3.3.10 Reverse test holder and place unsoldered end in heating fixture.

3.3.11 Hand-tighten the sample (with gloves) and secure the other end under the clamp.

3.3.12 Repeat the previous steps.

3.3.13 Remove the test holder from the heating fixture. Turn off the fixture, and place the holder in cool-off shelf.

3.3.14 Turn on the fan to cool down the test holder.

3.3.15 After the test holder is room temperature, carefully thread a piece of $Nb_3Sn$ strand (≈ one and a half turn) onto each end of the test barrel until at least a ¼ turn is into the titanium test area. This is to stabilize the region where the sample goes from the soldered joint region to the titanium test section.

3.3.16 Place the test holder in the soldering fixture and heat to $320^0$F.

3.3.16.1 With a hand held soldering gun, solder the joint wire to the test sample.

3.3.16.2 Reverse the test holder in the soldering fixture and solder joint wire at other end of sample.

3.3.17 Turn off the solder fixture. Remove the test holder, and place in cool-down shelf.

**NOTE:**
**Ensure excess solder is captured in a metal tray and is re-cycled or disposed of in an approved manner.**

3.3.2 *Mounting the $Nb_3Sn$ Test Barrel to the Sample Holder(also referred to as Probe)*

3.3.2.1 Select sample holder (H or J).

3.3.2.2 Clean current leads (forks) of test the barrel with Scotch-Brite® and apply a strip of Indium to the current contact side of each fork.

3.3.2.3 Insert into current block observing correct polarity (top of test barrel holder +).

3.3.2.3.1 Sample probe leads A (+) B (-).

3.3.2.4 Hand-tighten the eight screws evenly.

3.3.2.5 Solder voltage tap wires onto the sample according to the wiring diagram.

3.3.2.6 Wrap voltage tap wires in a clockwise direction and secure with masking tape.

3.3.2.7 Perform a room temperature check of the voltages across the sample using a current of 2 amps.

3.3.3 *Inserting Sample Probe in Magnet Cryostat and Filling with Liquid Helium*

3.3.3.1 When the magnet is at room temperature, check the vacuum of the insulating jacket of the magnet cryostat.

3.3.3.1.1 It should be < 50 microns when the cryostat is at room temperature. When the magnet is cold that drops to less than 10 microns.

3.3.3.2 Fill the nitrogen jacket with LN2.

3.3.3.2.1 If the magnet is warm, fill the LN2-jacket two days prior to filling the cryostat with liquid helium. This allows sufficient time to pre-cool the magnet.

3.3.3.3 Insert the test probe and connect current leads from the magnet power supply (MPS) and the sample power supply (SPS) to the appropriate magnet leads and sample leads at the top of the cryostat.

3.3.3.3.1 Pre-cool the test probe in liquid Nitrogen prior to insertion in magnet cryostat.

3.3.3.4 Fill the magnet cryostat with liquid Helium to a desired level (usually 12" above the magnet).

**Caution:**
**Always use proper PPE gloves, goggles and face shield.**

3.3.3.5 When fill is completed, remove Helium transfer line and rope off area with appropriate warning signs.

3.3.3.6 Turn on "Magnet On" warning light and leave area.

3.4 *Energizing the Magnet and Critical Current Testing of $Nb_3Sn$ Sample*

3.4.1 Turn on the breaker for the1000A SPS power supply.

**Caution:**
**Use proper PPE**.

3.4.2 Set the current (0.412A) for the persistent switch heater. This allows the magnet to be energized.

3.4.3 Turn on the 100A MPS and proceed to ramp up the magnet to the desired test field.

3.4.3.1 Refer to the magnet operation manual.

3.4.4 After the magnet is ramping, the current for the persistent switch can be turned off. This prevents additional helium loss.

3.4.5 When nearing the current for the desired field, turn on the persistent switch, set current, turn off switch to lock-in the magnetic field, and then lower MPS current.

**Note:**
**To prevent quenching of the magnet, the maximum field should not exceed 11.5 T**

3.4.6 Turn on 1000A sample SPS.

3.4.7 Make sure the sample voltmeter is reading the correct voltage-tap pair on the sample.

3.4.8 Make sure the quench detector is properly connected.

3.4.9 Load the current version of the data acquisition program in the PC (RamPDots.93).

3.4.10 Ramp the SPS and take V-I data with the data acquisition system.

3.4.11 After the test is complete at the set field (checking different voltage pair sections of sample if necessary), proceed to next the magnet field.

3.4.12 After all desired fields are complete, power down magnet to zero current.

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3.5 *Sample Field Stability Test*

3.5.1 Load "H_Sweep" Program into the PC.

3.5.2 At zero field - power-up sample using 2 power supplies (max. 1500A) until sample quenches or reaches maximum current.

3.5.3 If sample does not quench - activate the quench detector manually to bring current to zero.

3.5.4 With magnet at zero field, set desired constant current in sample (using 2 power supplies if necessary).

3.5.5 With desired constant current in sample - ramp the magnet field to 3 T using a ramp voltage of 1.0 V (5 mT/s).

3.5.6 If sample quenches - repeat steps 3.5.3 to 3.5.5 at a lower constant current.

3.5.6.1 If sample does not quench - repeat steps 3.5.3 to 3.5.5 at a higher constant current.

3.5.7 Continue this process until 2 currents (one when the sample quenches - the other going to 3 T without undergoing any quench).

3.5.8 These 2 currents should be within 50 Amps of each other.

3.5.9 This test is now complete.

3.6 *Shut-down Procedure*

3.6.1 Turn off MPS and SPS power supplies.

3.6.2 Turn off 1000A power supply breaker.

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3.6.3 Disconnect SPS leads from sample leads at the top of the cryostat, and then the remove the sample holder.

3.6.4 Leave the magnet cryostat overnight on Helium Gas Return Line.