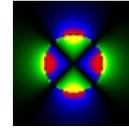


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Magnet Division Procedure

Procedure: SMD-AGS-3002

Revision: B



Superconducting  
Magnet Division

### AGS Snake Magnet Coil Curing & Wrapping

- Prepared by: [Signature on File](#) \_\_\_\_\_
- Cognizant Engineer: [Signature on File](#) \_\_\_\_\_
- Production Technician: [Signature on File](#) \_\_\_\_\_
- Production Section Head: [Signature on File](#) \_\_\_\_\_
- Cognizant Electrical Engineer: [Signature on File](#) \_\_\_\_\_
- Q. A. Approval: [Signature on File](#) \_\_\_\_\_
- ES&H Review: [Signature on File](#) \_\_\_\_\_

### Revision History

Rev A: Initial Release  
Rev. B: Changes per ECN #MG1278

1 Scope:

This procedure describes the final fabrication of inner and outer helical coil assemblies for the AGS Snake magnet. The operations include coil curing, overwrapping, overwrap curing, and size checking in preparation for machining. Also included are all appropriate inspections and testing.

2 Applicable Documents:

RHIC-MAG-Q-1000	Procedure for Control of Measurement Test Equipment
RHIC-MAG-Q-1004	Discrepancy Reporting Procedure
RHIC-MAG-R-7227	Electrical Resistance Measurements
RHIC-MAG-R-7228	Coil Inductance & Q Measurements
RHIC-MAG-R-7242	Hypot Testing
RHIC-MAG-R-8853	Hypot Testing – Helical Coil Insulation Assembly
BNL Dwg. 22010004	Inner & Outer Coil Winding & Curing Assy.
BNL Dwg. 22010002	Inner & Outer Coil Wrapping & Curing Assy.
BNL Dwg. 22010017	Inner Coil Machining Assy.
BNL Dwg. 22010018	Outer Coil Machining Assy.
OPM 8.1.1.16	Operation of Corrector Coil Overwrap Machine
OPM 8.1.1.33	Operation of the Beam Tube Curing Oven

3. Requirements:

3.1 Material & Equipment

Black Felt Tip Pen	BNL Stock No. S-23757
Nitrile Gloves	BNL Stock No. K-62664 (large)
Nitrile Gloves	BNL Stock No. K-62662 (medium)
Tie Wrap	BNL Stock No. A-59829
Insulated Gloves	BNL stock No. K-63028
Brush	BNL Stock No. I-56400
Non-conductive Black Marker	BNL Stock No. S-23757
Paper Container	BNL Stock No. I-80300
Coil Overwrap Machine	
Curing Oven	
Dial Indicator	
Hand Grinder	
Heat Gun	
Orangewood Sticks	
Oven	
Overwrap Template	
Scale	

Squeegee  
Teflon-lined Steel Band Clamps  
Tension Gauge  
Test Rack ETS-001  
Vented Hood  
Vibration Table  
Web Straps

3.2 Safety Precautions:

3.2.1 Operators shall wear:

- Insulated gloves when handling heated coil assembly or soldering operation.
- Nitrile gloves while handling epoxies.
- Nitrile gloves while handling acetone or ethanol.

**NOTE**

**Nitrile gloves only give marginal protection to most solvents used and should only be considered as protection from incidental contact/exposure. If the glove is contaminated, it should be removed and a new glove put on.**

3.2.2 Operators shall wear safety glasses with side shields or goggles while using the over-wrap machine or epoxy.

3.2.3 Some of these electrical test procedures have specific safety requirements. The technicians performing these specific tests shall rigorously follow all the safety requirements listed as well as those prescribed by the BNL ES&H standard.

3.2.4 The operator shall be instructed by the cognizant Technical Supervisor in the safe operation of the Coil Overwrap Machine.

3.2.5 The technicians shall be instructed by their cognizant technical supervisor in the operation of the required test equipment and these electrical testing procedures. They shall be familiar with the latest revision of the applicable documents referenced in section 2. In addition, some of these tests require the technician to have special training. A list of qualified personnel shall be maintained with the training coordinator.

3.2.6 Hypot testing poses a Class “C” electrocution hazard. At least two properly trained technicians must be present to perform this testing. When testing, a trained technician shall be stationed at any point the item under test is accessible to unauthorized people, and barriers shall be set up. Signs shall be posted reading “DANGER HIGH VOLTAGE” and warning lights shall be turned on.

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- 3.2.7 Entanglement with rotating machinery/moving parts can occur if loose fitting clothing or hanging jewelry is worn or if long hair is not tied up.
- 3.2.8 Do not use machines if a test of interlocks was not performed within the last six months and the dated Interlock Test Form is not posted near machines.
- 3.2.9 Specific steps of this procedure contain electrical and mechanical assembly operations that impact the environment. Prior to performing these steps, personnel shall complete the applicable facility specific environmental training.
  - 3.2.9.1 Epoxy Usage Form (Appendix 2) shall be filled out at the end of the workday, recording the weight of all epoxies/agents used. The form shall remain posted in a jacket on the side of the machine until removed by the ESH Coordinator.
  - 3.2.9.2 The ESH Coordinator shall report to the Laboratories Environmental Services Division epoxy usage based on Appendix 2 for Title V compliance (once the information on the information form has been reported to ESD, Appendix 2 may be discarded).
  - 3.2.10 Ensure ventilation is aligned to the machine in use (Curing Oven or Overwrap Machine). Exhaust dampers shall be open for only the machine in use (Curing Oven – 3, Overwrap Machine – 2), and adjoining machine closed.
- 4 Procedure:
  - 4.1 Prep for Coil Curing
    - 4.1.1 Inspect coil assembly for any damage to wires or Kapton insulation. Remove as many band clamps as necessary to inspect all press plates, insuring that wires are properly captured underneath and not pinched. Clean assembly if required.
    - 4.1.2 Attach curing hubs on each end of the tube assembly.
    - 4.1.3 Coil up the lead wires, temporarily insert into hub, and secure with tie wraps.
    - 4.1.4 Measure height of coil layers relative to tube surface. Take sufficient measurements to calculate an average height for all blocks. Discuss results with cognizant engineer to arrive at a suitable final height common for all press plates that will compress the coils adequately.
    - 4.1.5 Modify thickness of temporary curing shims, if required. Shims are to be placed on tube OD between conductor slots and will prevent curing clamps from forcing press plates and coil windings too deep into tube slot. Shims have been made to a thickness

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of .060 inches, but might need modification based on final coil winding depth determined above. There are 15 sets of shims required. Each set contains twelve shims (each 120° coil curing shoe must rest on at least three shims at each longitudinal location).

- 4.1.6 Attach the first set of shims to the tube OD at the longitudinal center, placing shims between conductor slots in a circumferential pattern that will allow each coil curing shoe to be supported by at least three shims.
- 4.1.7 Continuing outward to both ends of the coil, attach subsequent sets of shims spaced about 6 inches apart. Last set must be 44.25 inches from the center set (measured center to center) to provide support for the shoes at the end.
- 4.1.8 Remove all band clamps.
- 4.1.9 Install coil curing shoes loosely over press plates. Gradually apply clamps over curing shoes while removing Kevlar ties from under the shoes.
- 4.1.10 Install band clamps over curing shoes along entire length of coil. The clamps should have about one inch of space between them. Torque all clamps to seat ID of shoe against shims applied to coil using driver with clutch. Torque should be uniform.
- 4.2 Electrical Testing
  - 4.2.1 Perform electrical testing per Appendix 1.
- 4.3 Coil Curing
  - 4.3.1 Install coil in curing oven.

#### **CAUTION**

**Ensure Proper Ventilation for Oven. Oven dampers (3) OPEN and Winding Machine Dampers (2) inserted. Fan runs until coil is at room temperature.**

- 4.3.2 Set oven temperature to 175° C (347° F), start rotation motor.
- 4.3.3 Allow temperature to come up to cure temperature. Check clamp torque to maintain pressure of shoes against shims.
- 4.3.4 Allow coil to remain at cure temperature for a minimum of 2 ½ hours.
- 4.3.5 When the cure is completed, and the coil has cooled to approximately ambient temperature, remove clamps and curing shoes. Remove shims from tube surface.

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4.4 Electrical Tests

**NOTE**

**Allow coil to cool thoroughly (e.g. overnight) before electrical testing is done.**

4.4.1 Perform electrical testing per Appendix 1. Notify cognizant electrical engineer if coil readings vary from pre-cure values.

4.4.2 Dress leads and V-tap wires.

4.5 Epoxy Fill Of Press Plate And Coil Wire Voids

**NOTE**

**Ensure adequate ventilation while performing all epoxy operations. See ES&H Coordinator/FS Representative for determination.**

4.5.1 Install vibration table under center of coil. Secure coil to table with two web straps. Suspend each end of coil with web straps to remove excessive weight from vibration table.

4.5.2 Install heat guns in both ends of coil tube and warm up the ends.

**NOTE**

**Do not allow coil ends to warm to over 250 F. It is important to monitor heat during this operation.**

4.5.3 Mix batch of 2850 FT epoxy.

**NOTE**

**Pot life is approximately 60 minutes at room temperature, and less at elevated temperatures.**

**NOTE**

**Record in Appendix 2 weights of all epoxy/agents used.**

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- 4.5.4 With coil ends warm, fill the voids in the coil ends and press plates with 2850FT epoxy. Syringes can be used to fill voids.

**NOTE**

**Syringes shall be disposed of per the Regulated Medical Waste Management SBMS Subject area (<https://sbms.bnl.gov/standard/0p/0p01d011.htm>).**

- 4.5.5 Turn on vibration table and re-fill areas with epoxy as required.

**NOTE**

**The epoxy fill will have to be done in sections. Check that the epoxy has set before rotating to another section.**

- 4.5.6 After the last section has set, turn off vibration table and heat guns.

- 4.5.7 Remove coil from vibration table.

- 4.5.8 Inspect coil ends, note remaining voids. These are to be filled with 2850FT (blue).

**NOTE**

**Perform all epoxy operations in front of vented hood.**

- 4.5.9 Mix batch of 2850FT (blue) epoxy.

**NOTE**

**Record in Appendix 2 weights of all epoxy/agents used.**

- 4.5.10 Install heat gun in tube end(s) where voids were found. Warm up the coil tube end(s).

**NOTE**

**Do not allow coil ends to warm to over 250 F. It is important to monitor heat during this operation.**

- 4.5.11 Fill any remaining voids in the press plates or in the lead wire channels. Wrap coil end with Tedlar film and tape. Clamps can be used as a hold-down.

- 4.5.12 Turn off heat and allow epoxy to cure.

- 4.5.13 Remove Tedlar tape and inspect.

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- 4.6 Tedlar Wrap
  - 4.6.1 Tedlar is wrapped dry and is used as a potential release layer in case repair of the coil is required at some future time. The Tedlar is also used to exclude epoxy from the vent holes.
  - 4.6.2 Remove curing hubs; install winding hubs in coil assembly.
  - 4.6.3 Install Teflon disc on hub at lead end of coil, routing leads through holes. Coil up leads and secure with tie wrap.
  - 4.6.4 Install second Teflon disc on non-lead end.
  - 4.6.5 Install coil tube assembly onto the overwrap machine.
  - 4.6.6 Seal lead exit holes in Teflon disc with tape.
  - 4.6.7 Wrap bands of masking tape around outside of the coil leads to secure leads from damage during coil rotation. Rotate coil and observe.
  - 4.6.8 Secure leads to hubs to prevent damage during wrapping.
  - 4.6.9 Secure Tedlar film (P/N 12011229) to the non-lead end (NLE) of the coil with tape.
  - 4.6.10 By hand, wrap one pass of Tedlar film over press plates using 75% overlap. Remove band clamps one-by-one at center helix press plates as Tedlar approaches.
  - 4.6.11 Cut the Tedlar film at the lead end (LE) while securing with tape to keep the end from loosening prior to next layer of overwrap.
- 4.7 S-Glass Wrap (B-Stage epoxy impregnated)
  - 4.7.1 Install S-Glass spool on overwrap machine.
  - 4.7.2 Measuring tension with gauge, set tension to 25 ~ 30lbs.
  - 4.7.3 Position overwrap machine carriage to starting position at non-lead end. Set pitch to 18 turns/in, machine pitch setting #4.
  - 4.7.4 Secure the S-Glass yarn at the non-lead end with a knot around the coil. Start S-Glass 0.25 inches from Teflon disc.

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- 4.7.5 Start machine and wrap coil with two layers of S-Glass yarn, reversing the carriage motion when the S-Glass reaches the Teflon lead end disc.
- 4.7.6 Stop machine when S-Glass returns to the starting point at the non-lead end.
- 4.7.7 Wrap an additional two turns and cut and tie off the S-Glass yarn. Wrap Kapton tape 360° around coil over knots to secure.
- 4.8 Fiberglass Wrap
  - 4.8.1 Install 1” wide fiberglass tape on overwrap machine.
  - 4.8.2 Adjust overwrap machine tension to 5 lbs. Set machine pitch to setting #8. Make sure machine will produce a butt wrap or slight gap (no overlap).

**NOTE**

**Inner coils require approximately 10,200 yards. Outer coils require approximately 12,475 yards.**

- 4.8.3 Turn Exhaust Hood on.

**CAUTION**

**Ensure Proper Ventilation. Oven dampers (3) CLOSED and Overwrap Machine Dampers (2) pulled out. Contact ES&H Coordinator/FS representative with any questions.**

- 4.8.4 Mix equal amounts by weight (1:1 ratio): Epoxy 815 adhesive ( Dwg. no. 12010047) and Epoxy curing agent (BNL Dwg. no. 12010065).

**NOTE**

**Inner coils require approximately 64 pints of mixed epoxy. Outer coils require approximately 72 pints of mixed epoxy.**

**NOTE**

**Record in Appendix 2 weights of all epoxy/agents used.**

**NOTE**

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**Epoxy pot life is about 2 hours at room temperature.**

- 4.8.5 Starting at the LE of the tube, attach end of fiberglass cloth to the tube using tape.
- 4.8.6 Start the machine and wrap cloth from the LE to NLE. Apply cloth with a butt wrap or very slight gap; do not overlap. Using a brush, apply wet epoxy over the cloth behind the wrapping head as wrapping progresses.
- 4.8.7 Stop overwrap machine when the NLE is reached.
- 4.8.8 Adjust machine settings and perform wrapping from NLE back to LE in same manner. Press fiberglass cloth into epoxy using squeegee as necessary.
- 4.8.9 Repeat steps 4.8.6 through 4.8.8 to build up layers of fiberglass and epoxy to a diameter about .125 above the final coil assembly diameter shown on drawing 22010002. Use a template to gage size.
- 4.8.10 Allow coil to remain rotating for a minimum of 16 hours to allow the epoxy to set.

#### **NOTE**

**Ensure overwrap hood doors are fully closed and fan is running while epoxy sets.**

- 4.9 Overwrap Curing
  - 4.9.1 Remove winding hubs and attach curing hubs on each end of the tube assembly. Secure leads to prevent damage during rotation.
  - 4.9.2 Install coil in curing oven.

#### **CAUTION**

**Ensure Proper Ventilation for Oven. Oven dampers (3) OPEN and Winding Machine Dampers (2) inserted. Fan runs until coil is at room temperature.**

- 4.9.3 Set oven temperature to 121° C (250° F), start rotation motor.
- 4.9.4 Allow temperature to come up to cure temperature and remain there for a minimum of 2 ½ hours. Coil will be rotating entire time.

#### **NOTE**

**Ensure Overwrap hood doors are fully closed and fan is running while epoxy sets.**

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- 4.9.5 When cure is complete, and the coil has cooled to approximately ambient temperature, remove the coil from curing oven.
- 4.9.6 Remove tie wraps from leads and remove Teflon discs.
- 4.9.7 Remove epoxy “flash” from coil ends with knife.
- 4.9.8 Inspect wire leads for damage and ensure wire labels are intact.
- 4.10 Electrical Tests

**NOTE**

**Allow coil to cool thoroughly (e.g. overnight) before electrical testing is done.**

- 4.10.1 Perform electrical testing per appendix 1. Notify cognizant electrical engineer if coil readings vary from pre-cure values.
- 4.11 OD Measurement and Final Check
  - 4.11.1 Coil up lead wires for protection and secure with tie wraps.
  - 4.11.2 Install coil assembly in coil overwrap machine.
  - 4.11.3 Zero the dial indicator on ends of aluminum coil tube.
  - 4.11.4 Rotate coil by hand, pass dial indicator over coil end press plates and verify minimum diameter is large enough to proceed with coil machining.

**NOTE**

**Minimum height from aluminum coil tube is .210”**

- 4.11.5 Remove excess epoxy around lead wires.
- 4.11.6 Inspect lead wires; verify no damage has occurred. Ensure wire labels are intact.
- 4.12 Electrical Tests
  - 4.12.1 Perform electrical testing per Appendix 1.
  - 4.12.2 Loop leads and secure with tie wraps.

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4.12.3 Cover lead wires with plastic bag and tape.

4.12.4 Tag coil with part number, including dash number, and applicable revision letter.

5 Quality Assurance Provisions

5.1 The Quality Assurance provisions of this procedure require that the technician be responsible for performing all assembly operations in compliance with the procedural instructions contained herein and the recording of the results on the production traveler.

5.2 The technician is responsible for notifying the technical supervisor and/or the cognizant engineer of any discrepancies occurring during the performance of this procedure. All discrepancies shall be identified and reported in accordance with RHIC-MAG-Q-1004.

5.3 Measuring and test equipment used for this procedure shall contain a valid calibration label in accordance with RHIC-MAG-Q-1000.

6 Preparation for delivery:

N/A

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## **Appendix 1 - Electrical Testing**

### **NOTE**

**Pay particular attention to safety requirements included in individual electrical test procedures.**

- Measure coil temperature and the RLQ for each coil block. Perform test in accordance with RHIC-MAG-R-7227 & RHIC-MAG-R-7228.

### **NOTE**

**If Coil has previously been cold tested, contact Cognizant Electrical Engineer before proceeding.**

- Measure the leakage current of each coil block in accordance with RHIC- MAG-R-7242. Hypot voltage is 1000 V (see caution note above). Max acceptable leakage is 50  $\mu$ A.
- Perform electrical test (leakage current) of quench protection heaters to ground and to coils. Max acceptable leakage is 50 $\mu$ A.
- Cognizant Electrical Engineer to review test data and sign-off "OK to proceed".

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**Appendix 2**  
**EPOXY USAGE FORM**

*(Fill in Month and weight in grams of items used)*

<b>MONTH:</b>							
Date	Shell Epon Resin 815C	Shell Epi-Cure 3140 Curing Agent	E&C 2850 FT Epoxy	E&C 24 LV Catalyst w/FT Epoxy	E&C 2850 MT Epoxy	E&C 24 LV Catalyst W/MT Epoxy	Additional Solvents*
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
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**\*If solvents were added, list below**