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Magnet Division Procedure

Procedure: SMD-AGS-3004

Revision: A

AGS Snake Magnet Containment Assembly

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Revision History

Rev. A.

1 Scope:

This procedure describes the steps necessary for weighing and stacking the yoke, installing the half shells, and performing pre-cold test wiring, prior to warm measurements and magnetic cold testing of the AGS Snake magnet. 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. 22010522	Yoke Assembly
BNL Dwg. 22010224	Warm-Up Heater Strip Assembly
BNL Dwg. 22010521	Containment Assembly
BNL Dwg 25-1921.01-4 B	Vertical Cold Mass Support

3 Requirements:

3.1 Material & Equipment

Black Felt Tip Pen	BNL Stock No. S-23757
Tie Wrap	BNL Stock No. A-59829
Insulated Gloves	BNL stock No. K-63028

High Efficiency Particulate Air (HEPA) filter equipped vacuum cleaner.
Dial Indicator

3.2 Safety Precautions:

3.2.1 Operators shall wear:

- Insulated gloves when handling machined epoxy/fiberglass overwrapped coil assembly to prevent skin irritation.
- Nitrile or Latex gloves while handling acetone or ethanol.

NOTE

Latex 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 performing machining operations.

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 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.

3.2.5 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 where 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.

3.2.6 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.

4 Procedure:

4.1 Yoke Stacking

4.1.1 Using the up-ending/lifting/stacking tool (25-1905.01-5) inserted from the non-lead end, bring coil assembly to a horizontal position on suitable rest blocks.

4.1.2 Remove the up-ending/lifting/stacking tool (25-1905.01-5) from the coil assembly and re-install from the lead end.

4.1.3 Lift coil assembly from horizontal to vertical position, lead end now facing down. Locate assembly at stacking station. Anchor stacking tooling in station.

4.1.4 Segregate center steel lamination types –01 and –02. Weigh steel and stainless laminations necessary to form one yoke. Create center lamination groups (35 groups of nominally 40 laminations each) and end lamination groups (2 groups of nominally 23 laminations each). Segregate stainless steel lamination halves in pairs.

4.1.5 Stack lead end group of laminations over coil assy and rest on inside surface of lead end plate. Engage lamination slots in stacking tool to align laminations rotationally.

4.1.6 Place two stainless steel lamination halves (one pair) on top of end group. Refer to drawing 22010522 for correct orientation of laminations at this particular location.

CAUTION

Orientation of laminations is critical. Slots between stainless steel lamination halves must align with shell holes later on or magnet will not be cooled adequately.

4.1.7 Stack a center group of laminations over coil assy, lifting a convenient number of laminations that can be handled. After the center group of 40 laminations is stacked, another pair of stainless steel lamination halves must be installed. Direction of stainless laminations must be in accordance with drawing for internal cooling slot to be oriented properly. Engage external lamination alignment slots in stacking tool to align laminations.

CAUTION

Stack height and orientation of laminations are critical. Slots between stainless lamination halves must align rotationally and longitudinally with shell holes later on or magnet will not be cooled adequately.

4.1.8 Check height of stack before each placement of stainless lamination halves to be sure the lamination slots will align with shell holes later. Use gage marks scribed on stacking fixture alignment bars to determine proper positions for stainless laminations. Add/remove center lamination(s) to/from group as required to bring height to proper position as stacking progresses. Record weights of any added or removed laminations.

4.1.9 Continue stacking center lamination groups and interstitial stainless lamination halves as in steps 4.1.7 and 4.1.8 until 35 center groups and their respective stainless lamination pairs have been stacked. Orientation of internal cooling slot between stainless lamination pairs will be mirror image from previous pair.

4.1.10 Stack non-lead end group of laminations over coil assy.

4.1.11 Check for proper stacking via notch pattern on outside of yoke.

4.1.12 Check for proper overall yoke length using gage and adjust number of laminations in end group if necessary.

4.1.13 Record total yoke weight taking into account any added or removed laminations.

4.1.14 Install non-lead end plate in proper orientation and engage in stacking tool to obtain proper alignment. Recheck overall length over outside faces of end plates.

4.2 Yoke Warm-Up Heaters

4.2.1 Attach .040 thick copper bars (P/N 22010228) to longitudinal yoke slots using .002 thick adhesive transfer tape. Twelve of the 16 slots will get copper bars installed in them. The slots on either side of the top (0°) and bottom (180°) of the yoke do not get copper bars.

4.2.2 Install adhesive Kapton (P/N 12010181-22) over each copper bar.

4.2.3 Using transfer tape, attach pre-fabricated & insulated dual heater strip (P/N 22010224) to Kapton on copper bar. Verify proper overhang of Kapton on heaters (past yoke) per drawing.

4.2.4 Install second piece of adhesive Kapton over dual heater strip.

4.2.5 Using transfer tape, attach flat spring over Kapton.

4.3 Weld Back-Up Strips

4.3.1 Place back-up strips into yoke slots located at 90° & 270°. Center the strips lengthwise with respect to end plates. Temporarily clamp in place.

4.3.2 Weld back-up strips to yoke first and then to both end plates in accordance with Dwg. 22010521, working from center of yoke towards ends.

4.3.3 Disengage temporary alignment bars on tooling by unfastening at top and rotating back from yoke.

4.4 Half Shell Installation And Welding

4.4.1 Place lower shell into position. Align lower shell holes with respect to slots in special SST laminations. Temporarily hold shell in place from non-lead end and block it at the lead end. Plug weld slots must be completely over the end plate surface (ideally centered on it) to allow subsequent welding to be done correctly.

NOTE

Do NOT proceed if shell holes cannot be properly aligned to yoke slots and to end plates, and notify cognizant engineer.

4.4.2 Place upper shell into position, and align upper shell to lower to produce equal root weld gaps on each side. Assess weld gap; inform weld supervisor that root gap is ready for inspection and sign-off if proper gap exists. Notify cognizant engineer if proper gap between shells for root weld pass cannot be obtained.

4.4.3 Band shell halves together around yoke to facilitate lifting and supporting containment assembly in horizontal position.

4.4.4 Prepare support tooling to be used for longitudinal shell welding. Install support feet on tooling.

4.4.5 Lift containment assembly and install on horizontal tooling. The support feet will contact the end plate notches through holes provided in the shell at each end. Remove the up-ending/lifting/stacking tool from the containment assembly.

4.4.6 Verify proper seating of end plate notches on tooling feet at both ends. Check with feeler gages. Proper contact indicates twist-free assembly.

NOTE

Notify cognizant engineer if the twist-free state is not indicated above.

4.4.7 Re-check overall length of assembly to outside faces of end plates, compare to drawing requirement, and correct if necessary.

4.4.8 Perform electrical testing prior to shell welding per Appendix 1.

4.4.9 Plug-weld shells to end plates. Fillet weld shells to LE end plate at shell ID inside end volume. Weld must not interfere with blocks for warm-up heaters.

4.4.10 Weld half shells together to within 5.5 inches of end of shell (~3.0 inches from end of yoke). Utilize two welders that must keep in-step with each other down the length to prevent unequal cooling stresses and possible shell shifting or yoke twisting.

4.4.11 Perform electrical testing on after shell welding per Appendix 1.

4.5 Pre-Cold Test Wiring

4.5.1 Locate containment assy on rollers to allow rotation during wiring operations.

4.5.2 On non-lead end plate, install a complete set of bottom terminal blocks for the yoke warm-up heaters using .250-20 NC screws. (These screws are installed temporarily and will be removed when top blocks are put in place)

4.5.3 Fold ends of heater strips to make 90° angles to the left and right as shown on drawing 22010572. The bends must be correctly placed so that the copper ferrules fit into the recesses in the block.

4.5.4 Solder interconnecting wires between ferrules as indicated in electrical schematic 12019042 and on drawing 22010572.

4.5.5 Temporarily remove .250-20 NC screws, install top block, and re-install screws. Check that heater ends are correctly clamped between blocks, and wires and ferrules are in recesses provided.

4.5.6 Repeat steps 4.5.2 through 4.5.5 for the warm-up heater strips at the lead end plate.

4.5.7 Install terminal board assy (P/N 22010561) on lead end plate using stand-offs.

4.5.8 Secure warm-up heater interconnecting wires to terminal board using lacing cord through holes provided.

4.5.9 Dress inner and outer coil leads to the terminals on the board; refer to schematic 12019042 and notations on terminal board for proper placement.

4.5.10 Solder inner and outer coil leads in place. Add jumpers to complete coil series circuit as indicated.

4.5.11 Perform electrical continuity test to check for proper wiring of coil leads per Appendix 2.

4.5.12 Dress quench protection strip heater leads to the terminals on the board, referring to schematic and notations on board for proper placement. Quench heater leads are wired so that two separate series circuits exist.

4.5.13 Solder quench heater leads in place. Add jumpers to complete two series circuits as indicated.

4.5.14 Perform electrical continuity test to check for proper wiring of each quench heater circuit per Appendix 3.

4.5.15 Add voltage tap leads to terminals of inner coil "in lead", outer coil "out lead", and to "inner/outer crossover" between coils. Wire is special low conduction "Nichrome 60", P/N 22010636-XX. Use red wire for inner coil connection, black for outer coil, and white for crossover connection. Add three redundant v-tap leads using separate solder connections located within .25 inches of the first taps.

4.5.16 Attach the other end of the six v-tap leads to the six v-tap resistors (200 Ω) per schematic and drawing.

4.5.17 Install the cold bore tube assembly (Note: assembly has been prefabricated with solenoid and corrector windings).

4.5.18 Install alignment tool by removing four lead end-plate screws and positioning alignment tool then using the 4 removed screws to hold the tool in place.

4.5.19 Engage locating pin in tool into the cuff on the cold bore assembly (this sets the rotation and axial position of the cold bore assembly).

4.5.20 Weld lead end spacer segments in place.

4.5.21 Weld NLE spacer in place (note: weld to endplate only, not to bore tube).

4.5.22 Remove alignment tool.

4.5.23 Reinstall 4 end-plate bolts.

4.5.24 Connect the "in lead" and the "shunt lead" of the solenoid winding to the "main coil out" terminal marked on the board, in accordance with schematic 12019042 . Connect "out lead" of the solenoid to the separate crimp terminal provided.

4.5.25 Connect the corrector leads to the turret terminals located near the top of the terminal board.

4.5.26 Install the two Cernox cold mass temperature sensors (P/N CX-1070-ET-4B) on the lead end plate at the 10:00 o'clock and 2:00 o'clock locations. Exercise extra caution around the fragile leads.

4.5.27 Connect the temperature sensor leads to the four turret terminals provided for each sensor.

4.5.28 In order to perform quench propagation studies on this magnet, two quench-initiating spot heaters and twelve quench propagation v-taps have been added to blocks 5 & 10 of the outer coil. Connect the four spot heater wires and twelve v-tap wires to the appropriate terminals located at the bottom of the board.

4.5.29 Similarly connect the solenoid spot heaters and v-taps (qty 2 & 6, respectively) to the turret terminals provided.

4.5.30 Connect the corrector spot heaters and v-taps (qty 4 & 12, respectively) to the turret terminals provided.

4.5.31 Dress all wires on terminal board in preparation for tying down. Introduce adequate thermal contraction service loops as required between instrumentation mounting points and first tie down points.

4.5.32 Tie all wires down to board using Kevlar lacing cord. Spacing between tie points should not exceed 2 inches.

4.5.33 Perform electrical testing per Appendix 4.

4.6 Uprighting and Vertical Support

4.6.1 Install vertical cold mass support, P/N 25-1921.01-4 onto magnet lead out. Torque nuts onto studs at 13 ft-lb (1000 lb). Weld side gussets to shell edges using (4) 4" x .25 fillet welds as shown on tooling assembly drawing (note that welds will be cut for tool removal after cold test).

4.6.2 Insert temporary 3 ½" square steel support bars between vertical support plate and magnet end plate and clamp into position.

4.6.3 Install (2) shackles through holes in shells at magnet non-lead end. Pass slings around shells and through shackles.

4.6.4 Lift magnet off of support stand using main crane hook (30 ton) at lead end and auxiliary (5 ton) hook at non-lead end.

4.6.5 Upright magnet by lifting at main (30 ton) crane hook. When vertical, disengage the 5 ton hook and remove slings.

4.6.6 Install magnet into wiring stand, resting it temporarily on the (2) 3 ½" square support bars.

4.6.7 Install the tophat to the vertical cold mass support.

CAUTION

The following step requires lifting heavy objects at elevated heights. Care must be exercised to follow proper lifting procedures and to clear the immediate area below the work space so that no injuries occur.

4.6.8 Lift magnet and top hat assembly. Remove temporary support bars and lower top hat back onto the wiring stand.

5 Quality Assurance Provisions

5.1.1 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.

5.1.2 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.

5.1.3 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

Appendix 1 – Pre & Post Shell Welding Electrical Tests

NOTE 1

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

NOTE 3

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

1. Coil Blocks:

20 Individual Coil Blocks to be tested

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

- Connect all items not under test & iron to each other and to ground. Perform 1 kV Hypot between coil block and ground per RHIC-MAG-R-7242. If Coil has previously been cold tested, contact Cognizant Electrical Engineer before proceeding. Max acceptable leakage is 50 μA.

2. Spot Heaters (Quench Propagation):

6 Heaters to be tested

- Connect all items not under test & iron to each other and to ground. Perform 500 volt Hypot of each spot heater to ground. Max acceptable leakage is 50μA.

- Perform Resistance check of each spot heater.

3. Quench Heaters:

[2 per Coil Block, 10 Blocks /Coil, 2 Coils /Cold Mass – Total of 40 to be tested here]

- Connect all items not under test & iron to each other and to ground. Perform 1 Kv Hypot of each quench protection heater to ground. Max acceptable leakage is 50μA.

- Perform Resistance check of each quench heater.

4. **Warm-Up Heaters:**

[2 per slot, 6 slots per CM side, 2 sides per assembly – Total of 24 to be tested here]

- Connect all items not under test & iron to each other and to ground. Perform 2.5 Kv Hypot of each Warm-Up Heater to ground. Max acceptable leakage is 50μA.

5. Voltage Drops:

[3 Inner /3 Outer Taps]

- Perform Continuity Checks of Each V-Tap Lead

Appendix 2 – Coil Lead Dressing Electrical Tests

NOTE 1

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

NOTE 3

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

1. Coil Blocks:

2 Coil Circuits (Inner & Outer) to be tested here

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

- Connect all items not under test & iron to each other and to ground. Perform 1 kV Hypot between coil circuit and ground per RHIC-MAG-R-7242. If Coil has previously been cold tested, contact Cognizant Electrical Engineer before proceeding. Max acceptable leakage is 50 μA.

2. Voltage Taps:

[3 Inner /3 Outer Taps]

- Perform Continuity Checks of Each V-Tap Lead

Appendix 3 – Quench Heater Lead Dressing

NOTE 1

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

NOTE 3

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

1. **Quench Heaters:**

[2 Series Circuits to be tested here]

- Connect all items not under test & iron to each other and to ground. Perform 1 Kv Hypot of each quench protection heater circuit to ground. Max acceptable leakage is 50μA.

- Perform Resistance check of each quench heater circuit.

Appendix 4 – Final Electrical Check of Containment Assembly

NOTE 1

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

NOTE 3

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

1. Coil Blocks:

Coil Circuits now include 1 Cable magnet + 2 corrector coils

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

- Connect all items not under test & iron to each other and to ground. Perform 1 kV Hypot between each coil circuit and ground per RHIC-MAG-R-7242. If Coil has previously been cold tested, contact Cognizant Electrical Engineer before proceeding. Max acceptable leakage is 50 μA.

2. Quench Heaters:

[2 Series Circuits to be tested here]

- Connect all items not under test & iron to each other and to ground. Perform 1 Kv Hypot of each quench protection heater circuit to ground. Max acceptable leakage is 50μA.

- Perform Resistance check of each quench heater circuit.

3. Warm-Up Heaters:

[2 Series Circuits to be tested here]

- Connect all items not under test & iron to each other and to ground. Perform 2.5 Kv Hypot of each Warm-Up Heater Circuit to ground. Max acceptable leakage is 50μA.

Appendix 4 – Final Electrical Check of Containment Assembly (Cont'd)

4. Voltage Taps:

[12 taps Total]

- Perform Continuity Checks of Each V-Tap Lead

5. Quench Propagation Study Circuits:

- Perform Continuity Checks of Snake Coil (Outer Coil Blocks 5, 10) Propagation Study Circuits:
  - 2 Spot Heaters
  - 12 V-Taps

- Perform Continuity Checks of Solenoid Coil Propagation Study Circuits:
  - 2 Spot Heaters
  - 6 V-Taps

- Perform Continuity Checks of Corrector Coil Propagation Study Circuits:
  - 4 Spot Heaters
  - 12 V-Taps

6. **CERNOX Temperature Sensors:**

- Perform electrical check of each sensor.