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Large Hadron Collider
Magnet Division Specification

Proc. No.: LHC-MAG-R-1029

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Title: LHC D1 Yoke Assembly & Collaring

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ES&H Review: Signature on File

REVISION RECORD

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1 Scope:

This procedure describes the methods used to collar LHC 8cm Dipoles D1: to weigh and stack the yoke laminations, to compress the coils within the iron yoke, and to make the necessary electrical measurements.

2 Applicable Documents:

RHIC-MAG-R-7228 RHIC Inductance and Q Measurement
RHIC-MAG-R-7242 RHIC Hypot Testing
RHIC-MAG-R-7243 RHIC Low Precision Resistance Insulation Test
RHIC-MAG-R-7261 RHIC Dipole Beam Tube Assembly Hypot Testing
RHIC-MAG-R-7318 RHIC Impulse Testing
RHIC-MAG-R-7320 RHIC Electrical Resistance Measurement for Collared Individual Coils and Connected Coil Sets
RHIC-MAG-R-7226 RHIC Dipole/Quadrupole Coil Length Measurement
RHIC-MAG-Q-1004 Discrepancy Reporting Procedure
SMD-OPM-8.1.1.38 Operation of Full-Length Collaring Press
Dwg. No. 14010194 D1 Dipole Yoke Collaring Assembly

3 Requirements:

3.1 Material/Equipment:

25-1797.01-5 LHC Yoke Lifting Angle Assembly

3.2 Safety Precautions:

3.2.1 Operators shall be qualified by their cognizant technical supervisor in the safe operation of the collaring press in accordance with SMD-OPM-8.1.1.38.

3.2.2 Due to the use of hydraulic fluid under high pressure, all technicians must use safety glasses during the collaring operations. The assembly area near the collaring press must have restricted access while the press is in operation.

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LHC-MAG-R-1029D

Page 2 of 17

- 3.2.3 The technicians shall be qualified by their cognizant technical supervisor in the operation of the required electrical test equipment and the 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.
- 3.2.4 Some of the 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.
- 3.2.5 Hypot and impulse testing pose 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 All lifting and handling operations requiring overhead crane operations shall be performed by holders of valid Safety Awareness Certificates. They shall also be trained in the use of the appropriate lifting devices by the Cognizant Engineer or Technical Supervisor.
- 3.3 Procedure:
 - 3.3.1 Record the cold mass I.D., the two coil serial numbers, and their respective locations in the traveler.
 - 3.3.2 Weigh Crates and Inspect Yoke Laminations
 - 3.3.2.1 Load empty crate onto scale and zero the scale.
 - 3.3.2.2 Carefully inspect each individual lamination assembly for loose shear pins. Set aside any lamination assembly that has loose pins.
 - 3.3.2.3 Transfer 236 laminations into crate on scale and record weight and material heat number in traveler.
 - 3.3.2.4 Repeat for a total of (6) large and (2) small crates w/special (lead end) lams.
 - 3.3.3 Run Programs
 - 3.3.3.1 Enter crate weights and enter coil data into the Lamination Weights Program. The

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LHC-MAG-R-1029D

Page 3 of 17

program will determine incremental stack length and placement for each crate.

3.3.4 Stack Lower Yoke Half

3.3.4.1 Mark rails with stack lengths.

3.3.4.2 Drill and tap laminations for use at L.E. and N.L.E. (the strip heater mounting boards will be secured to these laminations). Remove all chips before stacking.

3.3.4.3 Stack lamination pairs of the lower yoke (alternating left and right positioning) onto the lower contact tooling.

3.3.4.4 At lead end of cold mass, locate (22) pairs of lead end laminations, (box SPC/Lower/L.E.).

3.3.4.5 Position laminations according to incremental stack length determined by lamination program.

3.3.4.6 Proceeding from the Lead End and working towards the Non-Lead End, stack and “fluff” laminations to incremental stack length.

3.3.5 Prepare Lower Coil

NOTE 1

Cut standard, lead end, and non-lead insulators as required per the assembly drawing. Note that all modified standard insulators go at the non-lead end.

NOTE 2

Insulators shall installed such that the orientation of the part number, which distinguishes front from rear, alternates down the length of the magnet.

NOTE 3

- **D1 models use modified middle insulators (14010192) to accept the larger beam tube**

3.3.5.1 Place lower coil in the prep table stands. Position coil with the midplane down.

3.3.5.2 Install .002" x 3.0" Kapton adhesive tape to coil O.D. at each quadrant. Trim to flush with coil pole turn.

3.3.5.3 Apply one layer of .002" Kapton tape to the ends of the coil in the area of the pole to achieve the same build up in this area as in the area covered by the Kapton in 3.3.5.2.

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LHC-MAG-R-1029D

Page 4 of 17

3.3.5.4 Clamp quench protection resistor heater holders to each end of the prep table.

3.3.5.5 Clean and inspect the coil O.D. Vacuum if necessary. Wipe with a tack rag.

NOTE

The quench protection resistor is a stainless steel ribbon that is sandwiched between two layers of Kapton tape. The stainless steel ribbon is plated with copper for 24.5 inches and is un-plated for 5 inches. This pattern is repeated along the entire roll.

3.3.5.6 Secure the end of the quench protection resistor to the lead end holder with masking tape.

3.3.5.7 Roll out quench protection resistor along the entire length of one side of the coil. Center the quench protection resistor plated areas evenly over each coil end. Tape quench protection resistor to the non-lead end holder and cut from roll.

3.3.5.8 Repeat for the other side.

3.3.5.9 Position the quench protection resistor along the centerpost area with a gap of .020 inch. Secure the quench protection resistor to the coil O.D along the centerpost using .0005 in x .5 in. Kapton tape every 12 inches.

NOTE

Be sure the Kapton tape is not wrinkled and that the quench protection resistor does not extend into the centerpost area.

3.3.5.10 Apply two layers of kapton tape to the ends of the coil in the area of the pole to achieve the same radial build up in this area as in the area covered by the quench protection resistors.

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LHC-MAG-R-1029D

Page 5 of 17

- 3.3.5.11 Install the stainless steel saddles to each coil end saddle with a 6-32 x 1/2 inch pan head screw. If necessary, drill and re-tap threaded holes in end saddles using care not to drill too deep.
- 3.3.5.12 Starting at the lead end, install the lead end coil insulator (with one corner of the pole rounded against the pole led) over coil using care not to tear or wrinkle the quench protection resistor. Bank against the pole spacer.
- 3.3.5.13 Install the remaining straight section insulators using NOMEX shims to evenly space the insulators with a .030-.050 inch gap. Check for proper fit of midplane cap.
- 3.3.5.14 Cut the last straight section insulator to fit. Be sure to have the threaded hole in modified insulator to be used.
- 3.3.5.15 Measure the length of straight section insulators on the coil and note length. Transfer this measurement to the yoke laminations, starting from the first straight section yoke lamination at the lead end to the no-lead end and mark yoke. Place (2) non-lead end insulators (centerpost removed) between this mark and the last yoke lamination. Scribe the outside of the insulator and cut off excess.
- 3.3.5.16 Install the modified non-lead insulator and the full size non-lead insulator at the non-lead end. The modified insulator is placed against the straight section insulators. Align keys and secure to coil midplane using .0005 in x 1/2 in. kapton tape. Do not install the lead end insulators.
- 3.3.5.17 Secure each coil insulator to the coil using Velcro straps.
- 3.3.5.18 Rotate the coil so the midplane is facing up.
- 3.3.5.19 Fasten a RX630 coil shim support onto each insulator with a stainless FH screw.

NOTE

These coil shims and screws will be replaced with spec. parts after the coil is in the yoke half.

- 3.3.5.20 Prior to installing lower coil, verify that there is no debris in lower collar assembly, (lower coil is the shorter OAL). Vacuum and tack rag if necessary.
- 3.3.5.21 Record yoke lamination heat & lot numbers in traveler.
- 3.3.6 Install Lower Coil

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LHC-MAG-R-1029D

Page 6 of 17

- 3.3.6.1 Ramp box should be aligned to the end of the lead end pole spacer.
- 3.3.6.2 Using 120100007-1 lifting beam with steel cables, pick up second standard insulator from the lower yoke plus seven (7) others that align with cables on the beam. Lift and install lower coil into the yoke half.
- 3.3.6.3 Install lead end insulators, with mill step located at mid-plane.

NOTE

Verify that the ramp box is flush with lead end pole spacer, and that first and last standard insulators are banked hard against coil end poles.

- 3.3.6.4 Recheck that insulator gaps are .030 - .050 inch.
- 3.3.6.5 Stop – critical inspection to follow.
- 3.3.7 Inspect
- 3.3.7.1 Verify that all straight section insulators (D1=14010192) are installed correctly and no 12010063 NLE insulators are in straight section region.

CAUTION

The D1 dipole has a larger beam tube and therefore, requires thinner coil shim supports (.010 thick nominally). Using standard coil shim supports (meant for D3) in D1 will cause severe damage to the magnet assembly during collaring.

- 3.3.7.2 Prepare the lead end G-10 shims.

NOTE

Both the left and right shim are notched .005 in. for 1/2 inch at one end to allow for the NOMEX pole cap ears (the side with the notch is to face the pole). The shim placed against the lead is notched .008 in. for 1/2 inch as per drawing. The .008 inch notch faces the coil.

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LHC-MAG-R-1029D

Page 7 of 17

- 3.3.7.3 Remove the RX630 coil shim supports and stainless FH screws. Install G-10 coil shims and fasten a coil shim support (12010066) onto each insulator with an ultem FH screw. Install notched shim at lead end at proper orientation. Install the lead end NOMEX pole cap and remaining G-10.

NOTE 1

Install notched coil shim at the LE on pole lead side with notch toward LE and notched area facing cable.

NOTE 2

- **The shims should have approximately a 1/32” gap between them.**
- **The last shim on both sides at NLE should be trimmed to fit.**
- **Shims are secured in place (2-3 PLS ea) using 12010181-02 adhesive Kapton (.0005” thick). No more than 1” of tape on ID and OD of coil is allowed at each tape location. No wrinkles allowed.**

- 3.3.7.4 Verify that there is no debris in lower coil assembly. Vacuum and tack rag, if necessary.

- 3.3.8 Install Beam Tube

- 3.3.8.1 Record serial number of beam tube in traveler. The serial number is marked or engraved onto the tube by the supplier.

- 3.3.8.2 Move insulated beam tube to lower collar assembly.

- 3.3.8.3 Check once again that all lower coil insulators and coil shims are in place, and that the proper coil shim supports are installed and all 10-32 ultem screws are secured.

NOTE

D1 uses the larger beam tube diameter.

- 3.3.8.4 Install beam tube into lower coil, making sure that the beam tube bumpers are oriented properly and that the beam tube is properly positioned longitudinally within the coil.

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LHC-MAG-R-1029D

Page 8 of 17

Beam tube shall be orientated so that the tie wrap is located at the non-lead end.

- 3.3.9 Upper Coil Preparation
 - 3.3.9.1 Verify Cleanliness
 - 3.3.9.2 Verify upper coil and lower coils have been paired together per engineer's instructions.
 - 3.3.9.3 Place upper coil in the prep table stands. Position coil with the midplane down.
 - 3.3.9.4 Install .002" x 3.0" Kapton adhesive tape to coil O.D. at each quadrant. Trim to flush with coil pole turn.
 - 3.3.9.5 Apply one layer of .002" Kapton tape to the ends of the coil in the area of the pole to achieve the same build up in this area as in the area covered by the Kapton in 3.3.9.4.
 - 3.3.9.6 Clamp quench protection resistor heater holders to each end of the prep table.
 - 3.3.9.7 Clean and inspect the coil O.D. Vacuum if necessary. Wipe with a tack rag.

NOTE

The quench protection resistor is a stainless steel ribbon that is sandwiched between two layers of Kapton tape. The stainless steel ribbon is plated with copper for 24.5 inches and is un-plated for 5 inches. This pattern is repeated along the entire roll.

- 3.3.9.8 Secure the end of the quench protection resistor to the lead end holder with masking tape.
- 3.3.9.9 Roll out quench protection resistor along the entire length of one side of the coil. Center the quench protection resistor plated areas evenly over each coil end. Tape quench protection resistor to the non-lead end holder and cut from roll.
- 3.3.9.10 Repeat for the other side.

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LHC-MAG-R-1029D

Page 9 of 17

- 3.3.9.11 Position the quench protection resistor along the centerpost area with a gap of .020 inch. Secure the quench protection resistor to the coil O.D along the centerpost using .0005 in x .5 in. Kapton tape every 12 inches.

NOTE

Be sure the Kapton tape is not wrinkled and that the quench protection resistor does not extend into the centerpost area.

- 3.3.9.12 Apply two layers of kapton tape to the ends of the coil in the area of the pole to achieve the same radial build up in this area as in the area covered by the quench protection resistors.
- 3.3.9.13 Install the stainless steel saddles to each coil end saddle with a 6-32 x 1/2 inch pan head screw. If necessary, drill and re-tap threaded holes in end saddles using care not to drill too deep.
- 3.3.9.14 Starting at the lead end, install the lead end coil insulator (with one corner of the pole rounded against the pole led) over coil using care not to tear or wrinkle the quench protection resistor. Bank against the pole spacer.
- 3.3.9.15 Install the remaining straight section insulators using NOMEX shims to evenly space the insulators with a .030-.050 inch gap. Check for proper fit of midplane cap.
- 3.3.9.16 Cut the last straight section insulator to fit. Be sure to have the threaded hole in modified insulator to be used.
- 3.3.9.17 Secure each coil insulator to the coil using Velcro straps.
- 3.3.9.18 Rotate the coil so the midplane is facing up.
- 3.3.9.19 Prepare the lead end G-10 shims.

NOTE

Both the left and right shim are notched .005 in. for 1/2 inch at one end to allow for the NOMEX pole cap ears (the side with the notch is to face the pole). The shim placed against the lead is notched .008 in. for 1/2 inch as per drawing. The .008 inch notch faces the coil.

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LHC-MAG-R-1029D

Page 10 of 17

- 3.3.9.20 Install notched G-10 shims at the lead end on pole lead side with .008 notch facing cable and the .005 notch to face the pole spacer. Install lead end NOMEX pole cap.
- 3.3.9.21 Working from LE toward NLE, install remaining shims.
- 3.3.9.22 Check entire coil once again to make certain that all coil shims are positioned and secured properly.

NOTES

- **The shims should have approximately a 1/32” gap between them.**
- **The last shim on both sides at NLE should be trimmed to fit.**
- **Shims are secured in place (2-3 PLS ea) using 12010181-02 adhesive Kapton (.0005” thick). No more than 1” of tape on ID and OD of coil is allowed at each tape location. No wrinkles allowed.**

3.3.10 Install Insulators And Shim Supports

- 3.3.10.1 Fasten a coil shim support (12010066) onto each insulator with an ULTEM screw. Make sure pole spacer is nested tightly to coil and insulator is banked firmly against pole spacer.

NOTE

Do not remove Velcro straps

3.3.10.2 Insure coil is debris free.

3.3.11 Install Upper Clamp Halves

- 3.3.11.1 Install upper halves of clamps at (11) locations and rotate coil (180) degrees, (mid-plane is facing down). Reinstall anti roll pins and remove Velcro straps.

3.3.11.2 Completed upper coil assembly will be positioned to paired lower coil located at the collaring press.

3.3.11.3 Inspect insulator installation. All insulators must be secured with screws and coil shim supports.

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LHC-MAG-R-1029D

Page 11 of 17

When attaching lifting tongs use caution not to damage mid-plane.

- 3.3.11.4 Attach lifting fixture to upper coil.
- 3.3.11.5 Check the Kapton tape on the lifting tong blades, if damaged replace the tape.
- 3.3.11.6 Attach first lifting tong to the 2nd standard insulator at the LE, (1" from NLE of insulator).
- 3.3.11.7 Attach (7) remaining clamping tongs 1" from NLE of the 10th, 18th, 26th, 34th, 42nd, 50th and 58th insulators.
- 3.3.11.8 Lower lifting beam over the upper coil assembly and attach cables to the eight lifting tongs.
- 3.3.11.9 Remove rollover halves so coil can be removed.
- 3.3.12 Install Upper Coil
- 3.3.12.1 Install upper coil half onto lower coil half and beam tube.

NOTE

The upper coil shall be aligned with the lower coil at lead end pole spacer within .030".

- 3.3.12.2 Install lead end insulators.
- 3.3.12.3 Install non-lead end insulator.
- 3.3.12.4 Modify (2) LE insulators, (1) standard insulator, & (1) NLE insulator. Install per drawing.
- 3.3.12.5 Assemble upper yoke half.

NOTE 1

When installing upper lead end lamination hold lead end insulators tight against ramp box.

NOTE 2

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LHC-MAG-R-1029D

Page 12 of 17

Verify that first and last center insulators are banked hard against coil end polespacers.

- 3.3.12.6 Stack the lamination pairs of the upper yoke half according to lamination crate positioning program to match bottom yoke halves. Check for loose shear pins while stacking laminations. Set aside any yoke assemblies with loose shear pins.
- 3.3.12.7 Install modified laminations for temperature sensors in the middle of the upper yoke stack. See drawing for location.
- 3.3.12.8 Position collaring keys on bed of collaring press insertion table.
- 3.3.13 Locate Stop Blocks
- 3.3.13.1 Locate LVDT'S blocks at (16) locations.

NOTE

Reference identification markings on LVDT blocks and mounting surface for proper location.

- 3.3.13.2 Install (2) collaring stop blocks (12010006 – AF, SHT2-2) at each end of the press.
- 3.3.13.3 Check for debris and install shims at each corner of the press as noted below:

- S.E. **.005”**
- N.E. **.019”**
- N.W. **.019”**
- S.W. **No Shims**

Install shims under stop blocks.

- 3.3.14 Loading Cold Mass
- 3.3.14.1 Load magnet assembly into the press. Check for proper positioning per OPM.
- 3.3.15 Pre-Collaring Electrical Tests:

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LHC-MAG-R-1029D

Page 13 of 17

CAUTION

Be sure the "Hypot", yoke, and beam tube is grounded at all times. Failure to observe this caution may result in electrocution.

3.3.15.1 Perform a coil-to-coil hypot check at 3 kV, following RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 μ a.

3.3.15.2 Electrically connect all the main coil leads together.

3.3.15.3 Perform a Hypot check between the main coils and the yoke at 5 kV, attaching the grounded lead of the Hypot tester to the yoke, quench protection resistors, and beam tube following RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 μ a.

3.3.15.4 Attach computer printouts of pre-assembly electrical test data to the traveler.

3.3.16 Preparation for Electrical Testing During Collaring

3.3.16.1 With the coils connected in series, connect a Digital Volt Meter (DVM) across each coil and measure resistance and record in the traveler.

NOTE

DVM's are to remain in place during coil collaring. Changes in excess of 63% of the initial reading must be brought to the attention of the Cognizant Engineer.

3.3.17 Check Lead End Laminations

3.3.17.1 Align lead end laminations with standard laminations using straight edge.

3.3.18 Activate Systems And Begin Collaring.

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LHC-MAG-R-1029D

Page 14 of 17

- 3.3.18.1 Press and hold second hand button, then press “begin collaring process” button. Ram cylinder pressure should rise to 250 PSI. (when pressure is reached continue collar button will flash).
- 3.3.18.2 On AMTEX computer – move mouse to acquire data and click left mouse button – press control.
- 3.3.18.3 After data is acquired press and hold second hand button and press continue collar button (pressure will go up in 200 PSI intervals). After each pressure bump, “continue collar” button will flash before continuing, acquire data on AMTEX monitor must be pressed before continuing.
- 3.3.18.4 Verify that LVDT’S are within .004” from side to side.
- 3.3.18.5 Continue collar process until a key-way opening of .300” is achieved, if key-way of .300” is reached before 3116 PSI or not reached by a maximum pressure of 4350 PSI, contact supervisor.
- 3.3.19 Key Insertion

CAUTION 1

Do not place hands or foreign objects near keyways.

CAUTION 2

Eye protection shall be worn when tapping keys.

- 3.3.19.1 Activate the “control lockout” key switch. This prevent accidental operation.
- 3.3.19.2 Manually insert keys into key-ways. Be sure that beveled edge of key faces center of cold mass. Keys should protrude past cold mass approximately 1/4” at each end and not protrude radially beyond yoke OD. If keys do not stay seated see supervisor for instructions.

NOTE

Light tapping under pressure is acceptable to seat keys.

- 3.3.19.3 Prior to removing system pressure stop concurrent electrical test data collection and record data in the traveler.
- 3.3.19.4 Press end collaring.

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LHC-MAG-R-1029D

Page 15 of 17

3.3.19.5 Unlock the “control lockout” on press.

NOTE

Before removing keyed assembly, mark top portion of LE LAM to identify up direction, (for coil traceability), magnet serial number and part number w/rev using a permanent type marker.

3.3.19.6 Verify all stop blocks are removed after press is opened.

3.3.20 Final Inspection and Preparation

3.3.20.1 Inspect cold mass.

- Verify azimuthal coil match is within .001”.
- Coils positioned properly.
- No saddle damage.
- Leads are positioned properly.

3.3.20.2 Unload Press

3.3.21 Post-Collaring Electrical Tests

3.3.21.1 Measure coil temperature. Measure voltage drops across coil at 1 amp DC, following RHIC-MAG-R-7320. Complete the measurements of inductance and quality factor (Q) following RHIC-MAG-R-7228.

3.3.21.2 Perform an ohmmeter check of the resistance between the two coils, following RHIC-MAG-R-7243. Verify that the resistance is at least 20 megohms.

CAUTION

Be sure the "Hypot", yoke, and beam tube is grounded at all times. Failure to observe this caution may result in electrocution.

3.3.21.3 Perform a coil-to-coil hypot check at 3 kV, following RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 μ a.

3.3.21.4 Electrically connect the main coil leads together.

3.3.21.5 Perform a hypot check between the main coils and the yoke at 5 kV, attaching the

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LHC-MAG-R-1029D

Page 16 of 17

grounded lead of the Hypot tester to the yoke, quench protection resistors, and beam tube following RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 μ a.

CAUTION

Be sure the "Impulse Tester", yoke, and beam tube is grounded at all times. Failure to observe this caution may result in electrocution.

- 3.3.21.6 Perform an impulse test of the individual coils at 2 KV, following RHIC-MAG-R-7318.
- 3.3.21.7 Reconnect the coils in series as per RHIC-MAG-R-7320.
- 3.3.21.8 Perform an impulse test of the series connected coils at 2 KV, following RHIC-MAG-R-7318.
- 3.3.21.9 Measure coil temperature. Measure voltage drops across each coil at 1 amp DC, following RHIC-MAG-R-7320. Complete the measurements of inductance and quality factor (Q) following RHIC-MAG-R-7228.
- 3.3.21.10 Attach computer printouts of post assembly electrical test data to the traveler.
- 3.3.22 Attach Sling
- 3.3.23 Attach lifting beam with ice tongs 25-1797.01-5 to cold mass.
- 3.3.24 Lift cold mass and place on padded 2 x 4's.
- 3.3.25 Disconnect lifting beam and ice tongs.
- 3.3.26 Manually roll cold mass 90 degrees clockwise, view looking at lead end.
- 3.3.27 Move cold mass to next work station.

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LHC-MAG-R-1029D

Page 17 of 17

4 Quality Assurance Provisions

4.1 The Quality Assurance provisions of this procedure require that the technician shall 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.

4.2 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.

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

5 Preparation for Delivery:

N/A