Large Hadron Collider
Magnet Division Procedure

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Title: LHC D3 Cold Mass Assembly /Pressure Leak Check

- Prepared by: Signature on File
- Cognizant Engineer: Signature on File
- LHC Project Engineer: Signature on File
- Electrical Engineer: Signature on File
- Production Section Head: Signature on File
- Production Representative: Signature on File
- Q. A. Approval: Signature on File
- ES&H Review: Signature on File

REVISION RECORD

Rev. No.	Date	Subject	Approval
A	7/9/03	Initial Release	
B	10/17/03	Changes per ECN #MG2161	

1 Scope:

This specification describes the procedure of D3 cold mass assembly immediately after E/M assembly. Included are end volume installation, IFS line installation, cradles and Fiducials, and pressure leak check.

2 Applicable Documents:

The following documents, of the issue in effect at the time of release for manufacture, form a part of this procedure to the extent specified herein:

RHIC-CR-E-4703-0041	RHIC Leak Checking Specification
RHIC-MAG-Q-1004	Discrepancy Reporting Procedure
RHIC-MAG-Q-1000	Control of Measurement Test Equipment
RHIC-MAG-R-7242	RHIC Hypot Testing
RHIC-MAG-R-7243	RHIC Resistance Test
RHIC-MAG-R-8792	Removal of Cold Mass Twist
LHC-MAG-R-1038	LHC Twist Check & Fiducial Survey
LHC-MAG-R-1051	Testing of Level and Temperature Sensors

BNL Drawings:

14010488	D3 Cold Mass Assembly

3 Requirements:

All welding shall be performed by welders qualified in accordance with ASME Section IX. The welding parameters shall be set in accordance with those specified during welding process development.

3.1 Material/Equipment

LHC Cold Mass Lifting Beam	25-1782.01-5
LHC Weld Rotator Assembly	25-1784.01-5
Cradle Welding Fixture	25-1785.01-5
Fiducial Inspection Bracket	25-1821.01-5
Cold Mass Lifting Beam	25-1782.02-5
Helium Supply Support Arm Welding Fixture	25-1897.01-4
Electronic Digital Micrometer Depth Gauge	Starrett 735BZ-6RL
Electronic Digital Micrometer Height Gauge	Starrett 752

3.2 Safety Precautions

3.2.1 Operators shall be trained by their cognizant technical supervisor and qualified in the operation of the welding equipment.

3.2.2 No welding shall take place unless all welding screens are in place around the welding station, and all personnel not directly involved with the welding process are outside the screens. Any personnel inside the screens shall wear protective gear to prevent eye injury, and shall be clothed to prevent burns caused by intense ultra-violet light.

3.2.3 All lifting and handling operations requiring overhead crane operations shall be performed by holders of valid Safety Awareness Certificates. They shall also be instructed in the use of the appropriate lifting device by the Cognizant Engineer or Technical Supervisor.

3.2.4 Technicians performing Pressure Testing shall be instructed in the procedures prescribed by the BNL ES&H Standard 1.4.0 /1.4.1 /5.1.0 for operating pressurized gas systems and in the use of nonflammable cryogens by the Cognizant Engineer or Technical Supervisor.

3.2.5 Examine all pressure test equipment before pressure is applied to ensure it is tightly connected.

3.2.6 Suitable precautions shall be taken during pressure testing to eliminate hazards to personnel in the proximity of the test in the event of a rupture.

3.2.7 Safety glasses must be worn during potential eye damaging operations.

3.2.8 All relief devices and gauges used for pressure tests shall meet the requirements of ES&H standard 1.4.1.

4 Procedure

4.1 End Volume Welding

4.1.1 Verify E-M assembly and electrical testing is complete. Tack weld deflector 14010614 over cutout in LE endplate.

4.1.2 Mount the lead end volume on the magnet. Feed all instrumentation wires through the lower left port in the end volume as shown on the assembly drawing. Also feed the undulator bus cable through the bottom port (-01 cold mass units only). Be certain that the service loop remains in the instrumentation harness. Mark the exiting instrumentation harness to match to flange position.

4.1.3 Fix the lead end volume in its proper position per the assembly drawing. Tack weld the end volume in place using six equally spaced fillet welds approximately 1/2" long using filler wire (P/N 12010441-03).

4.1.4 Complete the welding of the end volume by rotary MIG welding using .035" filler wire (P/N 12010441-01).

4.1.5 Repeat steps 4.1.2 through 4.1.4 for the non-lead end volume. NOTE: Before welding, verify that overall length is correct, allowing for weld shrinkage. The undulator bus exits out the lower port of the non-lead end volume on -01 cold mass units only.

4.1.6 Fillet weld the beam tube to end volume flange at both ends. Argon purge the beam tube while welding.

4.1.7 When all welds have cooled, measure and record the cold mass length from LE end volume flange – to – NLE end volume flange.

4.1.8 **ON -02 COLD MASS ONLY:** Permanently weld the cap on the undulator bus stub at the NLE.

4.1.9 Perform electrical testing per Appendix I.

4.2 Cover Patch Installation

4.2.1 Weld cover patches over all shell holes except at the ten designated survey locations (see assembly drawing).

4.3 Cradle Welding

4.3.1 Install the cradles onto the three cradle support assemblies. Measure and record the inclination of each cradle support and calculate the average.

4.3.2 Fit an insulating blanket over each cradle so that the angled legs of the cradle protrude through the mating cut-outs in the blanket.

4.3.3 Using 25-1782.02-5, crane lift the cold mass unit and rest it on the cradle assembly fixture rollers. Use the alignment angle to align the lead end plate with the scribe line on the fixture. Be certain that the shell with survey holes is facing up indicating that the unit is right-side up.

4.3.4 Using the twist bridge, measure and record the inclination at all survey locations (5 points). Calculate the average twist of the cold mass. Verify that the values are within tolerance, ≤ 1 milliradian RMS. If outside this range, consult with the Cognizant Engineer. Should twist removal be required, flame straightening per RHIC-MAG-R-8792 may be required.

4.3.5 Position the axial restraints along side the cradle as shown on the assembly drawing and clamp in place.

4.3.6 Using a spirit level, rotate the cold mass to level it with respect to the cradle supports (preliminary angle adjustment).

4.3.7 Fillet weld the axial restraint blocks to the shell using ER385 filler wire (12010441-03) as shown on the assembly drawing.

NOTE

Power up the inclinometer LED display and allow it to warm up for at least one hour in order for it to stabilize.

4.3.8 Using the inclinometer, rotate the cold mass so that the average twist equals the average cradle support angle (from paragraph 4.3.1) within 0.2 milliradians. Release hydraulic pressure to rollers and lower the cold mass onto the cradles.

4.3.9 Tack weld the cradles to the axial restraint blocks using filler wire (P/N 12010441-03) as shown on the assembly drawing. Monitor the cold mass inclination during welding and add additional weld as required to ensure that each cradle be parallel to within 0.2 milliradians with respect to the plane defined by the average cold mass twist after welding is complete and the welds have cooled.

4.3.10 Wrap each of the three blankets around the cold mass shell and secure the ends temporarily with masking tape.

4.3.11 Check each cradle with .002 feeler stock for full contact with the fixture.

4.3.12 **ON -02 COLD MASS ONLY:** Weld the seven CL/LD transfer line supports to the upper left side of the shell as specified on the engineering drawing. Use the positioning fixture 25-1897.01 to achieve the proper inclination of these supports along the cold mass length.

4.4 Cold Mass Measurements & Line Installations

4.4.1 Measure cold mass straightness and sag per LHC-MAG-R-1038, section 4.1. The Cognizant Engineer shall verify straightness and sag within drawing requirements and sign-off traveler "OK to proceed."

4.4.2 Establish cold mass fiducial locations and install remaining cover discs per LHC-MAG-R-1038, section 4.2.

4.4.3 **ON -02 COLD MASS ONLY**: Permanently install both CL/LD lines and secure them to the supports with the G-10 hangers as specified. Permanently install the CL/LD U-turn connecting the right LC/LD transfer line to the NLE end volume. Leave the hangers at the ends loose. They will be adjusted in a later procedure.

NOTE

The ends of the CL/LD transfer lines will be accurately positioned using a set-up fixture. This fixture will key off both beam tubes after the two cold masses rest on their common cradle.

4.5 Instrumentation Feed-Thru Installation

4.5.1 Select the appropriate IFS assembly based on cold mass dash number (either -01 or -02).

4.5.2 Thread the instrumentation wire bundle thru the IFS assembly and temporarily support the assembly. Include all dummy wires per drawing.

4.5.3 Perform electrical testing per Appendix I.

NOTE

The "Cold Head" refers to the line end which attaches to the Cold Mass

4.5.4 Position the assembly so that the warm head is approximately 70^0 clockwise from vertical.

4.5.5 Position the cold head to approximately 2" from the end volume flange. This will allow some flexibility to move the tube as bends are being made.

4.5.6 Using a 5/8" tubing bender, bend the IFS tube as shown on the assembly drawing.

4.5.7 When all the bends are complete and the warm head is in the proper position, complete the weld of the cold head to the end volume flange.

4.5.8 Perform electrical testing per Appendix I.

4.5.9 Temporarily secure the flex line and warm head to the cold mass.

4.6 Inspect Welds

4.6.1 Call for a certified weld inspector to inspect and sign off on the following welds:

- End Plates (including end of seam welds)
- Cradles
- Cover Discs
- Cold Head Attachment (IFS)
- End Volumes
- Beam Tube ↔ End Volume

4.7 Cold Mass Pressure Leak Test Procedure

4.7.1 At the lead end, install temporary wire blank-off canisters over pipe stubs "m/c" (main power leads).

4.7.2 Roll up the instrumentation wires and carefully push them into the warm head on the instrumentation feed-thru (IFS) assembly.

4.7.3 Install temporary wire can 25-1403.21-3 on the IFS warm head and secure with grade 5 (minimum) hardware.

4.7.4 Temporarily secure the warm head at the lead end of the cold mass with 2 one-inch wide nylon ratchet clamps as shown in Figure 0 so that it will not move during the pressure leak test. Tighten the straps only lightly to keep the can in place. Do not over tighten.

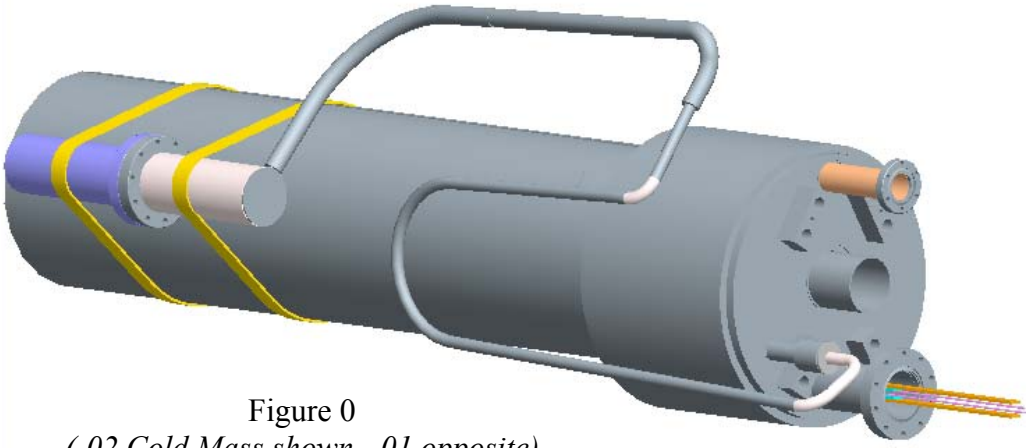

Figure 0
(-02 Cold Mass shown, -01 opposite)

4.7.5 **ON -02 COLD MASS ONLY**: Prepare CL /LD lines for pressure leak check using either method:

- Method 1: Temporarily join the two CL/LD transfer lines at the lead end with a short flexible U-turn. Temporarily cap the conflat flange of the open (outboard) CL/LD transfer line at the NLE.

- Method 2: Temporarily cap the conflat flange at the LE of the inboard (closest to the cold mass) CL /LD line. Temporarily cap the conflat flange of the open (outboard) CL/LD transfer line at the NLE.

4.7.6 **ON -01 COLD MASS ONLY:** At the NLE, temporarily cap the CL /LD stub and install wire canister on the undulator bus stub.

4.7.7 Connect the pressure hose adapter to the conflat flange for the undulator lead bus at the lead end. Note: If Method 2 was used in section 4.7.5, a line must be tee'd into the pressure hose at one end and connected at the other end to the flange at the LE of the outboard CL /LD transfer line.

4.7.8 Mount the porthole cover with sealing "O" ring onto the tank end cover plate.

4.7.9 Winch the Cold Mass into the vessel per Appendix II.

4.7.10 Lift the tank end cover plate, part number 25-1762.29 with the crane up to a position a few inches away from its bolted location on the vacuum vessel.

4.7.11 Reach into the vacuum vessel and extract the non-connected end of the hose weldment. Connect this end to the sealing adapter on the end plate.

4.7.12 Mount the tank end cover plate with its sealing "O" ring onto the end of the vacuum vessel. Install and torque all of the mounting bolts.

4.7.13 Connect the pressure port swage lock fitting to a helium bottle with a flex hose capable of 500 PSI operating pressure through a regulator and gauge.

CAUTION

Move all operating persons away from the end cover plates of the vacuum tank and the connection to the helium bottle.

4.7.14 Connect the vacuum pump line to the cover and start the mechanical pump. At 60 microns (60×10^{-3} Torr) start the turbo pump and valve it into the test loop. Close valve to the mechanical pump and turn off.

4.7.15 Calibrate the leak detector.

4.7.16 Allow to pump down to approximately 10 microns before leak check is started.

NOTE

Pressure tests need to be witnessed by an ES&H Representative

4.7.17 Pressurize the cold mass to 350 psig in the vacuum environment with helium gas and monitor the leak detector for a minimum of 10 minutes.

4.7.18 The maximum acceptable leak rate at 350 psig is 5.0×10^{-9} Std. cc He/Sec. This is equivalent to a leak rate of 2×10^{-10} Std. cc He /Sec. at one Atm. differential.

4.7.19 Bleed the helium pressure from the cold mass into the helium return gas system and vent the vacuum system with nitrogen.

4.7.20 Remove the vacuum tank end cover plate. Disconnect the plumbing & tow the cold mass out of the vacuum tank.

5 Quality Assurance Provisions:

5.1 The Quality Assurance provisions of this procedure require that all assembly and test operations be performed in accordance with the procedural instructions contained herein.

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

5.3 All discrepancies shall be identified and reported in accordance with RHIC-MAG-Q-1004.

6 Preparation for Delivery:

N/A

Appendix I - Electrical tests

1. Connect beam tube, all quench protection resistors & iron to each other and to ground. Connect coils together and perform 5 kV Hypot between coils and ground per RHIC-MAG-R-7242 and RHIC-MAG-R-7243.

NOTE

The leakage current must be less than 50 µa.

2. Connect beam tube, coils & iron to each other and to ground. Perform 2.5kV Hypot between each of two quench protection resistor circuits and ground per RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 µa.

3. Connect beam tube, coils & iron to each other and to ground. Perform 5kV Hypot between each of two quench protection resistor circuits and ground per RHIC-MAG-R-7242. Record the leakage.

4. Connect beam tube, all coils, iron & quench protection resistors to each other and to ground. Perform 2kV Hypot between each warm-up heater circuit and ground per RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 µa.

5. Perform DC resistance tests per RHIC-MAG-R-7320 to measure voltage drops across the entire magnet winding and the voltage drop across each individual coil. Perform measurements using regular and redundant voltage taps individually.

Resistance - Section 1 (lead → midplane):	1.543-1.606
Resistance - Section 2 (lead → lead):	3.109-3.172

6. Perform complete measurements of RL&Q per RHIC-MAG-R-7228. Measured values should be:

R: 3.109-3.172 Ω
L: 27.19-28.30 mH
Q: 3.636-4.444

7. Perform resistance check of Level Probes as noted in LHC-MAG-R-1051.

8. Perform resistance check of Cold Mass Temperature Sensors as noted in LHC-MAG-R-1051.

9. Perform resistance check of Warm-Up heaters. Allowable resistance is 95-105Ω

10. Perform resistance test between normal and redundant voltage tap wire at each point. Resistance to be 320Ω - 480Ω.

11. Perform resistance test on each of two Quench Protection Resistor circuits. Allowable resistance is 2.8-3.4Ω

Appendix II - Cold Mass Insertion into Vacuum Tank

1. Connect the winch chain from the vacuum tank end to the tow rod and pull the trolley frames into the tank. Make any lineup adjustment in the "V" rails.

2. Connect the winch chain from the rail weldment end to the tow rod.

3. Disconnect the winch chain from the tank end. Pull the trolley frames out of the tank and center them on the rail weldment.

NOTE

When preparing the cold mass for insertion into the vacuum tank, take care not to damage the instrumentation wire harness emerging from the "I" stub at the lead end.

4. Using the cold mass lifting beam (part number 25-1782.02-5) lift the cold mass with the overhead crane and place it onto the three trolley frames with the lead end towards the central aisle.

5. Connect the winch chain from the vacuum tank end to the tow rod. Winch the cold mass into the tank until the end of the beam tube at the non-lead end is 1-2 inches away from the bolted and sealed end cover plate of the vacuum tank. Disconnect the winch chain from the tow rod and pull the chain completely out of the tank.

6. Cover the winch chain port by mounting the porthole cover with sealing "O" ring onto the tank end cover plate.