Large Hadron Collider
Magnet Division Procedure

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Title: LHC D1 Cold Mass Assembly & Pressure Leak Check

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REVISION RECORD

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A	11/16/00		Initial Release	
B	8/21/01		Changes per ECR MG2051	

1 Scope:

This specification describes the procedure for LHC D1 Dipole Cold Mass Assembly including pressure leak testing before and after assembly. Included is phase separator installation and installation of most of the plumbing outside the cold mass.

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-MAG-Q-1000	Control of Measurement Test Equipment
RHIC-MAG-Q-1004	Discrepancy Reporting Procedure
RHIC-CR-E-4703-0041	RHIC Leak Checking Specification

BNL Drawings:

14010018	D1 Cold Mass/Pressure Leak Test Assembly.
14010265	D1 Phase Separator Assembly

3 Requirements:

Assembly work shall be done in accordance with the drawings and parts lists, and the installation and welding sequence described below.

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
LHC Cold Mass Lifting Beam	25-1782.02-5

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 trained in the use of the appropriate lifting device by the Cognizant Engineer or Technical Supervisor.

3.2.4 Technicians performing Pressure Testing shall be trained and certified 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.

3.3 Procedure

3.3.1 Pre-Assembly Cold Mass Pressure Leak Test Procedure

3.3.1.1 At the non-lead end, cap-off the 4.5K helium transfer line “c”.

3.3.1.2 At the lead end, install wire blank-off canister over pipe stub “I” (instrumentation).

3.3.1.3 At the lead end, install wire blank-off canister fitted with pressure inlet over pipe stub "m/c" (main power leads).

NOTE

Heat exchanger lines remain open to tank vacuum for helium pressure leak test.

3.3.1.4 Connect the pressure hose adapter to the "m/c" line at the lead end. Mount the porthole cover onto the tank end cover plate.

3.3.1.5 Winch the Cold Mass into the vessel per Appendix 1.

3.3.1.6 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.

3.3.1.7 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.

3.3.1.8 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.

3.3.1.9 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.

3.3.1.10 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.

3.3.1.11 Calibrate the leak detector.

3.3.1.12 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

3.3.1.13 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.

3.3.1.14 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.

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

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

3.3.1.17 Move Cold Mass to assembly station.

3.3.2 Ultem Support Post Installation

3.3.2.1 While the D1 cold mass is suspended above three level pedestals, first install the cold mass blanket around the magnet shell. Secure it temporarily with masking tape.

3.3.2.2 Apply molybdenum disulfide lubricant MIL-M-7866 to the underside of the LE & NLE cradles. Attach the three upper support post sections and the associated hardware onto the underside of the cold mass cradles with a couple of screws each. Note that the center post assembly is fixed while the two outer posts offer axial sliding capabilities.

3.3.2.3 Lower the cold mass onto the three level pedestals. Then install the remaining fasteners and torque them to specification.

3.3.3 Phase Separator Installation

3.3.3.1 Attach the two mounting brackets to the phase separator tank. Hand-tighten the clamp screws.

3.3.3.2 Using a die table, raise the phase separator into position underneath the cold mass. Position the two mounting brackets and align the 2 inch diameter helium vent line with the mating stub on the top face of the end volume. Secure the assembly into

place temporarily while being careful not to damage the blanket.

NOTE

Always purge inside of lines with argon gas during welding

3.3.3.3 Mark the position of the phase separator brackets on the blanket. Then remove the phase separator and brackets. Make appropriate slits in the blanket to accommodate the support brackets. Then weld the brackets to the cold mass shell as indicated.

3.3.3.4 Fully tighten the four bracket screws. Make sure that the front support bracket engages the four restraint tabs on top of the phase separator tank.

3.3.3.5 Weld the 2 inch diameter helium vent line with the mating heat exchanger stub on the top face of the end volume.

3.3.3.6 Perform steps 3.3.3.1 – 3.3.3.5 for the phase separator at the other end of the cold mass.

3.3.4 Installation of Helium Vent Lines (Xb, Xbt) and Heat Shield Return Line (e2)

NOTE:

Always purge inside of lines with argon gas during welding

3.3.4.1 Clamp the short helium vent line assembly (Xb) to the pipe stub on the left side of the lead end phase separator tank. Mount Xb locating fixture (aluminum template) to lead end volume with two 3/4-10 UNC bolts. Capture the outgoing end of Xb line in fixture. When the correct position is achieved, weld it into place as indicated.

3.3.4.2 On a long workbench, lay alongside each other the long helium vent transfer line assembly (Xbt) and the heat shield return line assembly (e2). The e2 line will be positioned below the Xbt line. From each end, slide the G-10 sliding supports onto both pipe assemblies.

3.3.4.3 Have handy the mounting hardware for anchoring these pipes to the center cradle and for attaching the brackets to the end cradles. Included are the Ultem insulating washers that are part of the center fixed anchoring system. Transport the pair of lines together with brackets attached, to the cold mass and loosely assemble the center supports. At least three technicians are required for this task since the lines are quite long and have flexible sections. Slide the G-10 sliding brackets into position and bolt them to the end cradles as required. Then fully torque the center anchors as

indicated.

3.3.4.4 Weld the Xbt line (including bellows) to the stub on the right side of the phase separator tank at the non-lead end.

3.3.4.5 At the lead end, use the appropriate locating fixture (aluminum template) to precisely set the position of the Xbt line and e2 line. Then weld the lead end bracket to the back side of the lead end plate.

3.3.5 1.9 K Helium Transfer Line (Cyt) Installation

3.3.5.1 Detach cold mass blanket and clear it from area where this line will be installed

3.3.5.2 Make sure that this ½ inch diameter tube has all five support bushings slid over it and in their approximate position. Then align the tube axially and tape it into position on the cold mass shell. The Cyt tube will go over the cradle blankets but must run underneath the cold mass blanket.

NOTE:

Always purge inside of lines with argon gas during welding

3.3.5.3 If necessary, trim to specifications the ½ inch diameter tube stub emerging from the top face of the non-lead end volume. Then weld the flexible U-turn connection to the Cyt line while it rests against the OD of the non-lead end volume.

3.3.5.4 Position and weld the fixed support bushing at the center of the cold mass but do not yet weld the tube directly to the bushing.

3.3.5.5 Position and weld the four sliding support bushings to the cold mass. The circumferential position of the sliding bushing on the lead end volume is most important so utilize the proper aluminum template to set its position precisely before welding the sliding support bushing at the lead end.

3.3.5.6 Set the axial position of the Cyt tube and weld the tube to the fixed center bushing as indicated.

3.3.5.7 Rewrap the cold mass blanket over the shell and ultrasonically weld the seam closed.

3.3.6 Installation of the 4.5 K Helium Supply Line (c) and Beam Screen Line (c')

NOTE:

Always purge inside of lines with argon gas during welding

3.3.6.1 On a long workbench, lay alongside each other the 4.5 K helium supply line and the 5/8 inch diameter beam screen line. From each end, slide the G-10 sliding supports onto both tube assemblies.

3.3.6.2 Have handy the mounting hardware for anchoring these pipes to the center cradle and for attaching the brackets to the end cradles. Included are the Ultem insulating washers that are part of the center fixed anchoring system. Transport the pair of lines together with brackets attached to the cold mass and loosely assemble the center supports. At least three technicians are required for this task since the lines are quite long and have flexible sections. Slide the G-10 sliding brackets into position and bolt them to the end cradles as required. Then fully torque the center anchors as indicated.

3.3.6.3 At the face of the non-lead end volume, trim the 1 inch angled tube stub to the appropriate length. Check the flex hose for slack which must be no less than ¾ in. Then weld the flexible connection to the 4.5 K helium supply line.

3.3.6.4 At the lead end, use the appropriate locating fixture (template) to set the position of the c and c' lines. Then weld the lead end bracket to the back side of the lead end plate.

3.3.7 Inspect Welds

3.3.7.1 Call for a certified weld inspector to inspect and sign off on all welds.

3.3.8 Passive Heater Installation (Both Ends)

3.3.8.1 Install passive heater assembly to 3/8" diameter U-tube on phase separator as indicated. The terminal board and strap both point outward.

CAUTION

Temperature sensors are extremely fragile. Handle them very carefully.

3.3.8.2 Record serial numbers of temperature sensors in traveler.

3.3.8.3 Route NLE temperature sensor lead wires along Xbt line. Route LE temperature sensor lead wires along Xb line.

3.3.8.4 Identify lead wires as LE-L, LE-R, NLE-L, NLE-R to identify sensor location. Left/Right convention to be used is: Standing at lead end looking towards non-lead end.

3.3.8.5 Secure temperature sensor lead wire harnesses to RUSH lines with kevlar lacing cord every 18". Epoxy knots with Scotchweld 2216 gray epoxy. Lead wires should extend 10 ft. beyond LE end volume. Coil leads at LE and secure safely.

3.3.9 Transport the cold mass to the pressure leak test facility. When resting it in place, be certain to provide underside support that offers adequate clearance for the phase separators.

3.3.10 Heat Exchanger/Phase Separator Pressure Testing

3.3.10.1 Using blank conflat flanges, cap the phase separator vent and transfer lines (Xb and Xbt).

3.3.10.2 Cap the 1.9k helium transfer line (cyt) at the lead end with a ½ in. stainless steel "Swagelok" fitting.

3.3.10.3 Connect the pressure hose to the ½ in. diameter 1.9k helium line at the lead end (cy line) using a reinforced rubber pressure hose. Secure with two hose clamps in tandem.

NOTE

The "I" stub, m/c line, heat shield return line (e2), and beam screen line, remain open to tank volume for the heat exchanger pressure test

3.3.10.4 Mount the porthole cover onto the tank end cover plate. The bolts may be left hand tight for the 75 psia nitrogen test.

3.3.10.5 Winch the Cold Mass into the vessel per Appendix 1.

3.3.10.6 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 tank.

3.3.10.7 Reach into the tank and extract the non-connected end of the pressure line. Connect

this end to the sealing adapter on the tank end cover plate.

3.3.10.8 Mount the cover plate onto the end of the vacuum tank with four bolts. These bolts need only be hand tight for the 75 psia nitrogen test.

NOTE

The vacuum tank will not be evacuated for this test.

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

3.3.10.10 Pressurize the heat exchanger/phase separator circuit to 75 psia while the cold mass is in the blue tank. Maintain this pressure for ten minutes. Then relieve the pressure completely.

3.3.10.11 Disconnect the pressure line and remove the tank end cover plate at the lead end. Remove the hose connection from the "cy" line, the swagelok cap from the "cyt" line, and the conflat cover flanges from the Xb and Xbt lines.

3.3.11 Final Cold Mass Pressure Leak Test Procedure

3.3.11.1 At the lead end, install wire blank-off canisters over pipe stubs "I" (instrumentation) and "m/c" (main power leads) on the end volume.

NOTE

Heat exchanger and phase separator lines (Cyt, Xb, Xbt), the beam screen line, and the heat shield return line (e2), remain open to tank vacuum for helium pressure leak test.

3.3.11.2 Connect the pressure hose adapter to the conflat flange on the 4.5K helium transfer line "c" at the lead end. Mount the porthole cover with sealing "O" ring onto the tank end cover plate.

3.3.11.3 Winch the Cold Mass into the vessel per Appendix 1.

3.3.11.4 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.

3.3.11.5 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.

3.3.11.6 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.

3.3.11.7 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.

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

3.3.11.9 Calibrate the leak detector.

3.3.11.10 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

3.3.11.11 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.

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

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

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

3.3.12 Vacuum Leak Test of Heat Exchanger Circuit

3.3.12.1 Cap three and pump on one of the four lines: The ½ inch diameter lines cy and cyt, as well as vent line Xb and vent transfer line Xbt.

3.3.12.2 Vacuum leak check the heat exchanger/phase separator circuit, including all external

piping. Spray helium on all external welds or bag all external welds with helium. The leak rate must not exceed $2x10^{-10}$ std cc He/sec per RHIC-CR-E-4703-0041.

3.3.12.3 After successful completion of testing, sign and date a "PASSED LEAK CHECK" decal and apply to the cold mass.

3.3.13 Electrical Testing - Passive Heater Temperature Sensor

CAUTION

To avoid possible damage to the sensor, do not exceed 1 Volt and do not exceed 100mA current while testing

3.3.13.1 Perform a "4 wire" resistance check of each temperature sensor. Record results in traveler and compare to LakeShore room temperature resistance reading supplied with sensor. Resistance to be within ±5Ω of this value.

3.3.13.2 Perform continuity check between I^+ & V^+ leads of each sensor. Repeat for I^- & V^- leads.

4 Quality Assurance Provisions:

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

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

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

5 Preparation for Delivery:

N/A

Appendix 1 - 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.