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Large Hadron Collider
Magnet Division Procedure

Proc. No.: LHC-MAG-R-1050

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Title: Preparation for D1 Magnet Acceptance at CERN

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REVISION RECORD

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1 Scope:

This procedure describes the steps to for receiving LHC D1 magnets at CERN. Work required to install the magnet is described separately.

2 Applicable Documents:

14060005	D1 Magnet Assembly, Tested & Shipped
RHIC-MAG-R-7242	Hypot Testing
RHIC-MAG-R-7243	Low Precision Resistance/Continuity/ Insulation Test.
RHIC-MAG-R-7320	Electrical Resistance Measurement for Coils
RHIC-MAG-R-7228	Magnet Coil Inductance and Q Measurements

3 Requirements:

3.1 Material/Equipment:

See section 3.2 and the documents listed in section 2.

3.2 Safety Precautions:

3.2.1 LHC D1 magnet assemblies will be rigged using CERN supplied and approved lifting devices and procedures. Note that these magnets contain chafe points that must be considered prior to lifting. Also note that the magnet's center of gravity is above the cryostat geometric center.

3.2.2 The technicians shall be qualified in the operation of the required electrical test equipment and the electrical testing procedures. They shall be familiar with the latest revisions of the applicable documents referenced in section 2. In addition, some of these tests may require the technician to have special training. 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 appropriate safety personnel at CERN.

3.2.3 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.

4 Procedure

4.1 General Condition

4.1.1 Notify BNL cognizant engineer (CE) that shipping container has arrived at CERN.

4.1.2 Check condition of shipping container as received. Note any obvious gross damage, missing or torn top cover, loose or missing signage, water or corrosion in container, etc. Notify BNL CE and make written report entry if damage has occurred.

4.1.3 Remove the loose parts kit from the container. Verify contents match list below and hold for installation per section 4.5 of this procedure.

Loose Parts Kit

Part Number	Description	Drawing Number	Part-list Item #	Quantity
AN960-C1216	0.750 Flat Washer	14010018	*45*	2
NAS1593-453	Preformed 0-ring	14060006	*26*	3
MS35338-146	0.750 Lock Washer	14010018	*46*	2
MS35338-65	Lock Washer, 0.375	14060006	*24*	24
MS90728-62	0.375-16 x 1.25 Hex Screw	14060006	*21*	24
MS9320-12	Flat Washer, 0.375	14060006	*22*	24
MS51971-8	0.750 Hex Nut	14010018	*47*	2
12010109	Anti-Seize Compound	14060006	*20*	1 oz. tube
12065070	Insulating Baffle Assy.	14060005	*8*	3
12065091	Port Cover	14060006	*9*	3
-	Sensor Carrying Case	-	-	1
MS90728-71	.375-16 X 3.25 Hex Screw	-	-	6
MS9320-12	.375 Washer	-	-	6

4.1.4 The following mechanical restraints are used to secure the magnet assembly to the shipping fixture and should be removed and packaged/secured within the intermodal shipping container to be returned to BNL with the container and shipping fixture:

- Chains and shackles (3 sets)
- Eye bolts, nuts and washers (6 sets)

CAUTION

Heed all safety precautions in Section 3 prior to lifting magnet

NOTE

Do not remove the fixture from the container when unloading the magnet

4.1.5 Remove the magnet from the container and install on tooling suitable for removal of the (3) BNL support post restraints and (2) sets of end shipping restraints. Check the shipping restraints at the ends and at each post location for looseness or damage. Notify CE and make written report entry as required.

NOTE

Make sure that all (7) spherical bearings remain with the magnet and are not still affixed to the shipping fixture. See figure 2 for locations.

4.2 Instrumentation

NOTE

Instruments are used to monitor and record shock and temperature during shipment and must be removed and returned to BNL under separate cover. They shall be packaged in the carrying case supplied with the container and shipped by mail or parcel delivery service as noted below

4.2.1 Remove plastic wrap on each end of the magnet. Discard.

4.2.2 See figure 1. One accelerometer is located on each cold mass end restraint. Unscrew the power cable from each accelerometer, leaving the cable attached to the corresponding battery pack. Tape the loose end to the battery pack to prevent damage during shipment.

NOTE

The battery packs remain attached to the restraints

4.2.3 Remove the two #6 screws that retain each accelerometer to the restraint.

4.2.4 Remove the temperature recorder from each magnet end. They are located on the cold mass end volumes. Use a single edged razor blade to cut through the silicone adhesive under each button. See figure 1.

4.2.5 Record on the data sheet (see Appendix 1) the exact date and time that the accelerometers and temperature sensors are detached from the magnet. Use local time.

4.2.6 Pack the (2) accelerometers, the (2) temperature sensors, and the data sheets in the carrying case supplied in the container toolbox. Using a temporary tag, identify with the magnet serial number and return separately to:

Brookhaven National Laboratory
P.O. Box 5000
Bldg 902A
Upton, NY 11973 USA
Attn: Stephen R. Plate

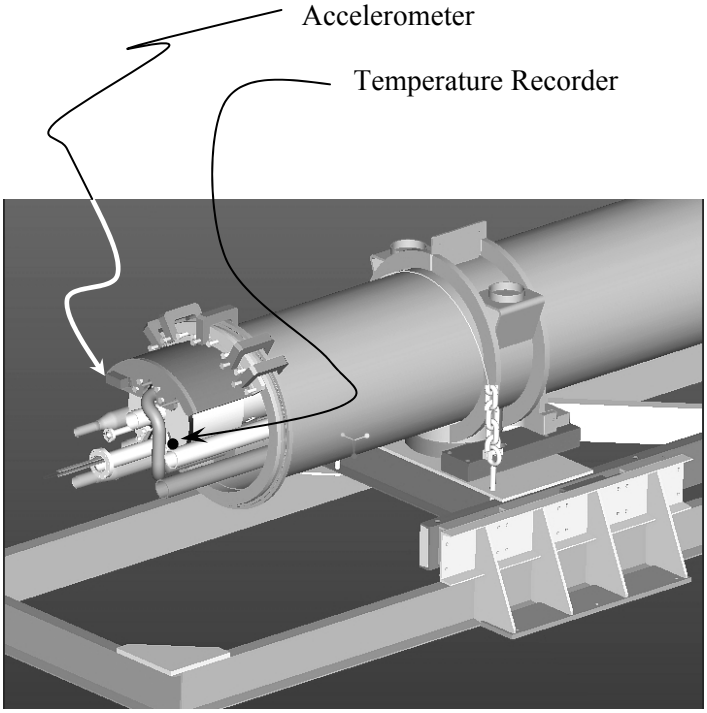
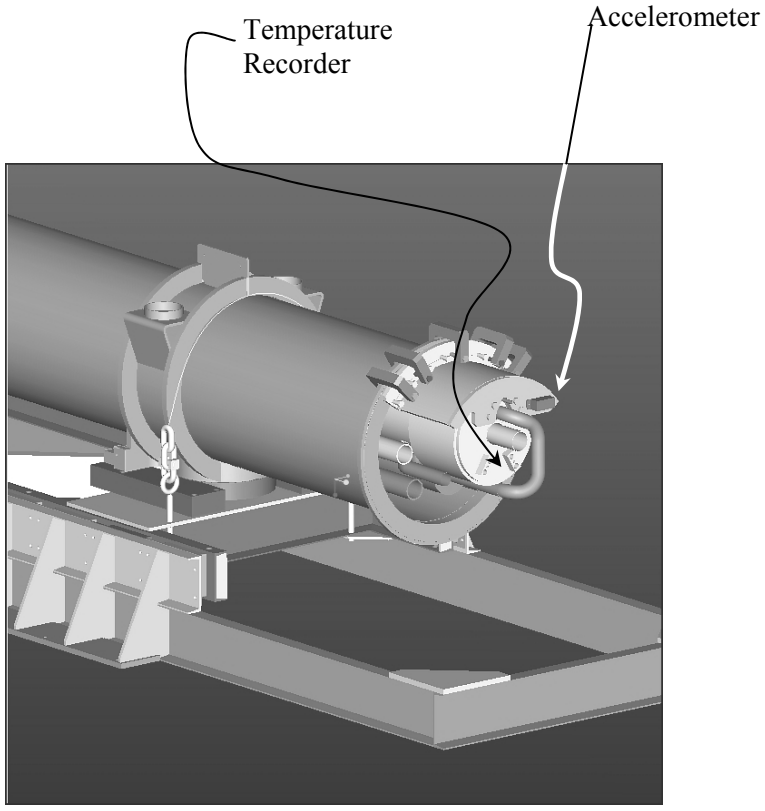


Figure 1



4.2.7 Remove protective caps from the six Taylor-Hobson fiducial sockets located on the top of the cryostat. If necessary, carefully pry them off with a screwdriver.

4.2.8 Remove the desiccant bags from the cryostat. There are two at each end.

4.2.9 See figures 2 & 3. The following components are used to restrain the cold mass to the cryostat during shipment and should be removed from the magnet after the magnet has been removed from the shipping fixture. They should be secured within the intermodal container as noted below for the return shipment of the container to BNL:

NOTE 1

- **Weight of each end restraint is approximately 87 lbs.**
- **To avoid injury, all posts should be removed using jacks**

NOTE 2

The BNL restraints must be returned promptly to allow shipment of the next magnet. See figures below. CERN shall supply equivalent temporary shipping restraints for the magnet during transportation to the tunnel.

Seq	Part	Qty per Magnet	Stowage for Return Shipment
1	Cold Mass Restraint Clamps	LE: 5 NLE: 6	Boxed and secured in container
2	Cold Mass Restraint Assembly (Lead End)	1	Bolted to fixture - See figure 3
3	Cold Mass Restraint-To-End Volume Retention Cap Screws – LE	2	Boxed and secured in container
4	Cold Mass Restraint Assembly (Non-Lead End)	1	Bolted to fixture - See figure 3
5	Cold Mass Restraint-To-End Volume Retention Cap Screws - NLE	2	Boxed and secured in container
6	Post Stiffener Assemblies (remove center post first)	3	Bolted to fixture - See figure 3
7	Post Stiffener–To-Cryostat Retention Cap Screws And Washers (*including tapered shims if used)*	24 Each	Boxed and secured in container
8	Post Stiffener-To-End Cradle Coupling Nuts	2	Boxed and secured in container
9	Post Stiffener-To-Center Cradle Retention Cap Screw & Spacer	1 Each	Boxed and secured in container

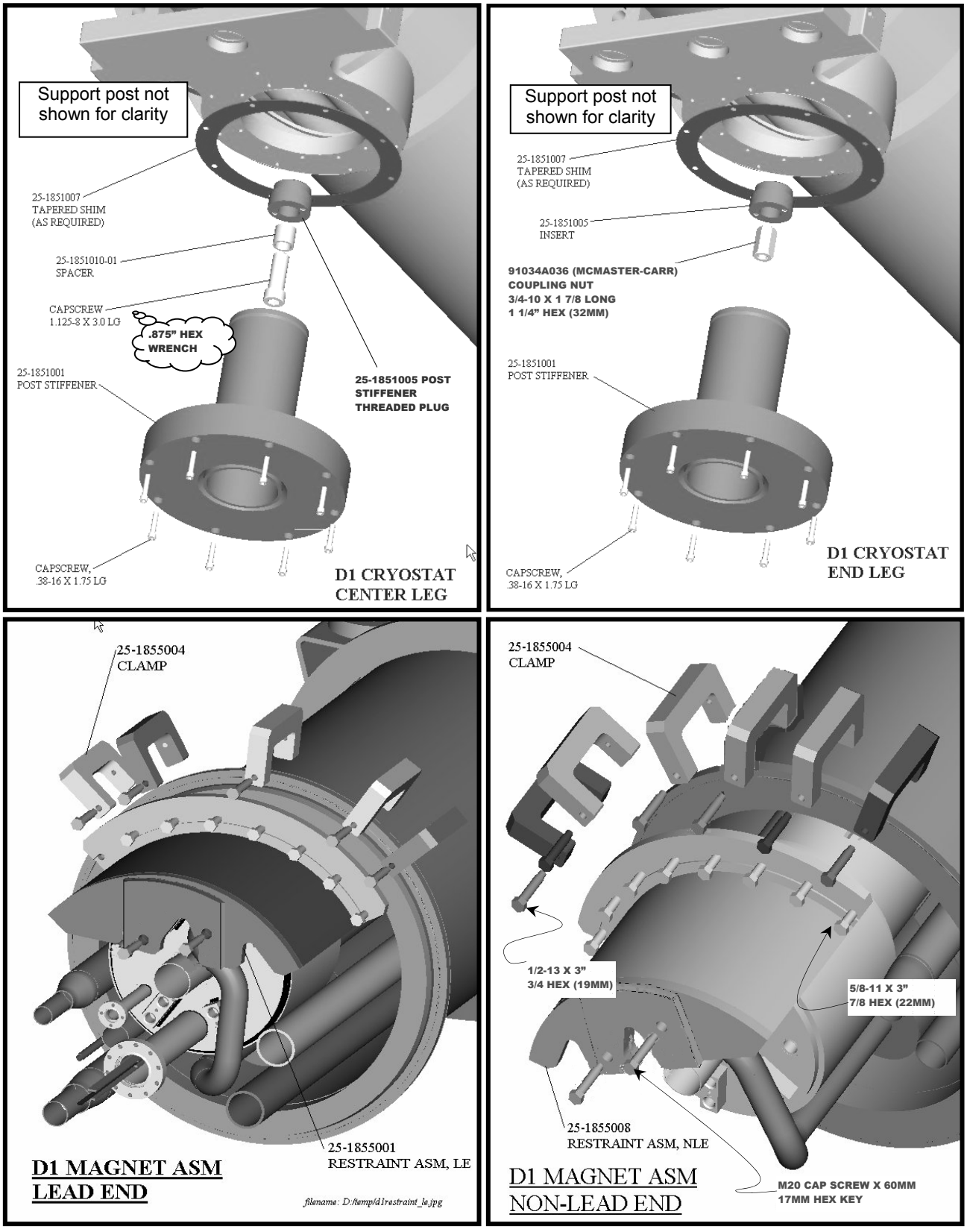
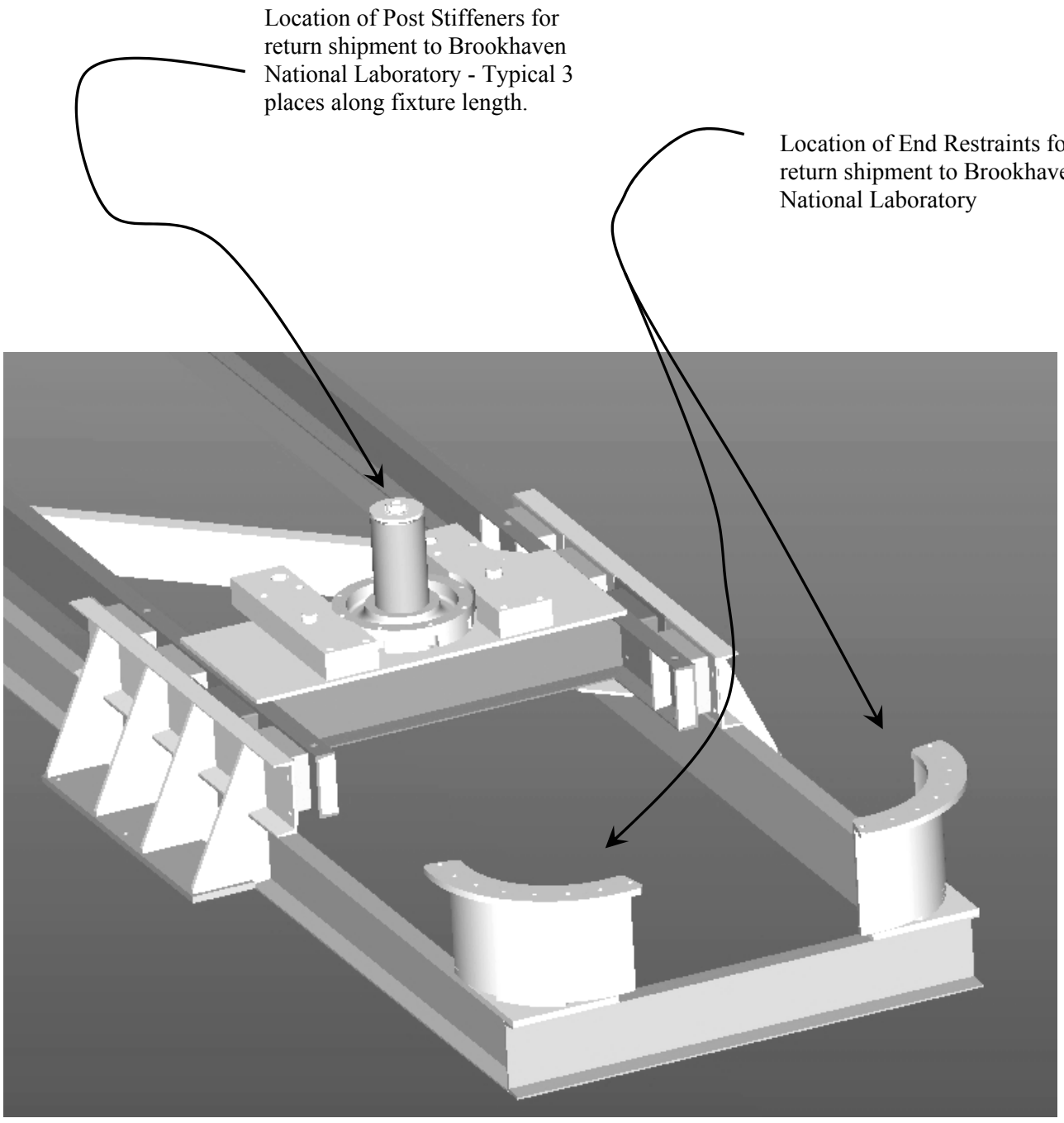


Figure 2

Figure 3



Shipping Fixture - End Closest to Container Door

4.3 Mechanical Checks

4.3.1 Carefully inspect the integrity of the support posts from the inside. There should be no cracks.

4.3.2 Using an optical or laser survey, check cold mass position relative to vacuum vessel fiducials, and compare with data provided by BNL. Position shifts should be ≤ 2mm.

4.3.3 Using an optical or laser survey, check the positions of the pipe ends and compare to data provided. Position shifts should be ≤ 3mm.

4.3.4 Notify BNL CE of any out-of-tolerance discrepancies between "before shipping" and "after shipping" mechanical data.

4.4 Electrical Checks

CAUTION

Equipment Damage

Avoid possible sensor damage. During all Hypot operations in this section, ensure that the leads for the Temperature Sensors and Level Sensors are connected to ground

4.4.1 Connect Beam Tube, Quench Protection Resistors & Iron to each other and to ground. Perform 2.5 kV Hypot between coil and ground per RHIC-MAG-R-7242 and RHIC-MAG-R-7243. The leakage current must be less than 50μA.

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

4.4.3 Perform Quench Protection Resistance test on each connected pair of resistors. The resistance to be 2.8-3.4Ω.

4.4.4 Connect Beam Tube, Coil & Iron to each other and to ground. Perform 2.5kV Hypot between each connected pair of Quench Protection Resistors and ground per RHIC-MAG-R-7242. The leakage current must be less than 50 μA.

4.4.5 Connect Beam Tube, Coil, 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. The leakage current must be less than 50 μA.

4.4.6 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) should be: 1.543-1.606Ω

Resistance - Section 2 (lead → lead) should be: 3.109-3.172Ω

4.4.7 Perform complete RL&Q measurements 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

CAUTION

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

NOTE

Magnet Assembly contains 4 Passive Heater Temperature Sensors. Sensor test results must be compared with manufacturer's values for that serial number. See table.

4.4.8 Perform a "4 wire" resistance check of each Passive Heater Temperature Sensor. Evaluate to limits in table below.

Passive Heater Temperature Sensor Resistances			
Sensor Serial No.	**LakeShore Value(Ω)**	**Allowable Min(Ω)**	**Allowable Max(Ω)**
X15897	67.0	62.0	72.0
X15899	71.2	66.2	76.2
X15902	71.5	66.5	76.5
X15903	71.0	66.0	76.0
X15904	68.5	63.5	73.5
X15906	70.4	65.4	75.4
X15907	68.7	63.7	73.7
X15918	69.5	64.5	74.5
X16042	68.6	63.6	73.6
X16188	68.3	63.3	73.3
X16629	60.5	55.5	65.5
X16630	59.8	54.8	64.8
X16735	69.3	64.3	74.3
X16736	69.3	64.3	74.3
X17138	64.9	59.9	69.9
X17145	65.4	60.4	70.4
X17242	67.5	62.5	72.5
X17259	65.5	60.5	70.5
X17365	75.6	70.6	80.6
X17425	64.7	59.7	69.7

4.4.9 Perform continuity check between I+ & V+ leads of each Passive Heater Temperature Sensor. Repeat for I - & V - leads.

4.4.10 Perform resistance test of each Passive Heater Temperature Sensor & lead wire combination to ground. Resistance to be > 20 mega-ohms

4.4.11 Perform resistance checks of both yoke temperature sensors as noted in table below. Verify readings are within ranges noted in table.

CAUTION

To avoid possible damage to the probe, do not exceed 1 volt and 100mA while testing yoke temperature sensors

Yoke Temperature Sensor Resistance Values		
	Lead Color	**Range (Ω)**
R (U^+ U^- I^+ I^-)		59.81 - 69.81
R (U^- I^-)	Red ↔ Green	5.04 - 7.04
R (U^+ I^+)	Black ↔ Yellow	4.99 - 6.99

4.4.12 Perform resistance test of each yoke temperature sensor & lead wire combination to ground. Resistance to be > 20 mega-ohms.

4.5 Installation of Port Covers and Baffles

4.5.1 At each end post install flat washer (item 45 on 14010018), lock washer (item 46 on 14010018), and 0.750 nut (item 47 on 14010018). Apply a small amount of anti-seize compound (item 20 on 14060006) to the nut threads before installation. After hand tightening, torque the nut to 61 N-M [45 ft.-lb.].

CAUTION

If the guide pin sleeve falls out during removal of the restraints, reinstall so that arrow marked on part points toward the nearest magnet end. An incorrectly installed sleeve will allow thermal shrinkage of the cold mass to over-stress the support posts.

4.5.2 Install the insulating baffle assembly (item 8 on 14060005) in all three ports. (Large diameter insulation to top). At the two ends, the baffle stem must engage the hole in the cradle pin (there is no hole to engage at the center post).

4.5.3 Clean the three port covers. Grease the "O" rings (item 26 on 14060006) with Apiezon "M" high vacuum grease, and place in groove of each port cover (item 9 on 14060006).

4.5.4 Clean the machined “O” ring mating surface on the underside of each cryostat leg casting. Install the three port covers (with "O" rings), each using eight screws (item 21 on 14060006), eight flat washers (item 22 on 14060006), and eight lock washers (item 24 on 14060006), and hand tighten. Torque to 24 N-M [18 ft.-lb.] (diagonally tightening). Perform this three times (lead end, middle, non-lead end).

4.5.5 Reinstall protective plastic wrap over the exposed ends of the magnet to seal out dirt and moisture.

4.6 Additional Work to be Performed by CERN Personnel

NOTE 1

The procedure for interconnecting this magnet with adjacent equipment in the tunnel is covered under a separate MAP to be supplied by Brookhaven National Laboratory.

4.6.1 The following conditions and operations are the responsibility of CERN personnel. Procedures written, approved, and implemented by CERN may be required:

A. The proper storage of the magnet until installation in the tunnel. The guidelines for acceptable temperature and humidity limits for BNL magnets are found in Appendix 2 of this procedure.

B. The blank-off of redundant piping. Each D1 magnet includes redundant piping that allows installation to either side of the IP. Therefore, some piping ends on each assembly will need to be capped dependent on the specific placement chosen in ring. Refer to Interface Specification LHC-MBX-ES-0002 for more detail.

C. The installation and removal of any temporary shipping restraints used for transporting the magnet between the receiving dock and the final destination in the tunnel.

D. The final pressure and leak checks on all interconnecting piping supplied in kits and installed by CERN.

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 be properly calibrated.

5.3 All discrepancies shall be identified and reported to the BNL Cognizant Engineer.

Appendix 1

Brookhaven National Laboratory - U.S. LHC Program

D1 Magnet - Instrumentation Sensor Removal Data Sheet

All times are local (CERN /Geneva)

Magnet Serial Number: _____

1) Temperature Sensor Serial #: _____

Date /time removed from Magnet: _____

2) Temperature Sensor Serial #: _____

Date /time removed from Magnet: _____

3) Accelerometer Serial #: _____

Date /time removed from Magnet: _____

4) Accelerometer Serial #: _____

Date /time removed from Magnet: _____

Return data sheet with sensors to address stated in Brookhaven National Laboratory procedure LHC-MAG-R-1050.

Appendix 2

Storage Requirements For BNL Magnets

1. It is imperative that the magnet coils not be subjected to temperatures at or above 37° C. The thermal mass of the yoke, and the limited protection against thermal radiation afforded by the vacuum vessel, tend to delay rapid heat gain but do not protect against longer term gain. Therefore, the magnet shall not be stored in an environment above 30° C for more than six hours, and the average temperature over any 24 hour period shall be below 30° C. There are no restrictions on minimum temperature.

2. High humidity levels will degrade the interior surface of the vacuum vessel and also cause electrical shorts due to creep path reduction. Moisture trapped between MLI layers will cause increased pump down time. Therefore, the magnet shall not be stored in an environment above 70% relative humidity, nor shall the interior of the vacuum vessel be allowed to exceed this value due to water intrusion or build up of moist air due to thermal cycling.

3. At all times the magnet shall be protected from direct contact with rain, snow, etc. by a protective covering surrounding the magnet that is not in direct contact with its exterior. Independently, the vacuum vessel ends shall remain sealed using plastic shrink wrap or similar method, except during mechanical and electrical inspections and tests, and during occasional monitoring of the humidity and temperature inside.

4. The magnets shall be stored in an area where accidental contact with heavy equipment is minimized, and where they do not pose personnel hazards.