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Large Hadron Collider
Magnet Division Procedure

Proc. No.: LHC-MAG-R-1063

Issue Date: May 19, 2005

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Title: Preparation for D3 Magnet Acceptance at CERN

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REVISION RECORD

Rev. No.	Date	Page	Subject	Approval
A	5/19/05		Initial Release	

1 Scope:

This procedure describes the steps for receiving LHC D3 magnets at CERN. Work required to install the magnet is described separately.

2 Applicable Documents:

14060290	D3 Final Assembly
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 D3 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. Magnet assembly only to be rigged by qualified personnel.

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 4.2 & 4.3 of this procedure.

Table 1 - *Loose Parts Kit*

Description	Quantity
Sensor Carrying Case	1
5/8-11 x 3 Hex Head Bolt	4
5/8-11 x 3 ½ Hex Head Bolt	2
5/8-11 x 4 ½ Hex Head Bolt	8
5/8 Bevel Washer	14
5/8 Flat Washer	28
5/8-11 Nut	14
3/8-16 x 2 ¾ Hex Head Bolt	4
3/8 Flat Washer	6
3/8-16 x 3 ½ Hex Head Bolt	2

4.1.4 Remove the tarps covering the ends of the magnet. Fold and place in the loose parts box for return with the container.

4.1.5 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 (6 sets)
- Eye bolts, nuts and washers (12 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

4.1.6 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 (4) spherical bearings remain with the magnet and are not still affixed to the shipping fixture. Reference figure 4. Each end cradle should contain (2) bearings. The center cradle has none.

4.2 Removal of 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 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.

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

4.3 Removal of Shipping Equipment

4.3.1 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.

4.3.2 Remove the desiccant bags from the cryostat. There is one at each end.

4.3.3 Reference Table 2 & figures 1-4. The components shown are used to restrain the cold mass to the cryostat during shipment. They should be removed from the magnet using the sequence noted in Table 2 after the magnet has been removed from the shipping fixture.

WARNING

Reference the removal sequences noted in Table 2. Removal of fasteners in certain sequences will allow a tooling part to fall free. Provide adequate support during removal of these fasteners to avoid serious personal injury or damage to the magnet and fixture.

4.3.4 Secure the removed components within the intermodal container as noted in figure 5 for return shipment of the container to BNL. Hardware required to secure the components is contained in the loose parts kit and is painted red.

NOTE

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

Table 2 – Sequence of Removal

Seq	Part	Qty / Magnet	Stowage for Return Shipment	Part Which Will Become Loose (See WARNING on Previous Page)
1	Cold Mass Restraint Clamp Cap Screws – LE [1"-8 x 6"]	8	Boxed and secured in container	**Cold Mass Restraint Clamp 80 LB / 36 Kg (each)**
2	Cold Mass Restraint Clamps – LE [25-1876.01]	2	Secured to Fixture – See Figure 4	
3	Cold Mass Restraint Cap Screws – LE [5/8" – 11 x 4"]	16	Boxed and secured in container	
4	Cold Mass Restraint Cap Screws – LE [M20 x 2.5 x 120]	4	Boxed and secured in container	**LE Restraint 340 LB / 153Kg NOTE: Lifting eyes provided**
5	Cold Mass Restraint – LE (25-1885.01)	1	Secured to Fixture – See Figure 4	
6.5				
6	Cold Mass Restraint Clamp Cap Screws –NLE [1" – 8 x 6"]	8	Boxed and secured in container	**Cold Mass Restraint Clamp 80 LB / 36Kg (each)**
7	Cold Mass Restraint Clamps – NLE [25-1876.01]	2	Secured to Fixture – See Figure 4	
8	Cold Mass Restraint Cap Screws – NLE [5/8 – 11 x 4"]	16	Boxed and secured in container	
9	Cold Mass Restraint Cap Screws – NLE [M20 X 2.5 X 120]	4	Boxed and secured in container	**NLE Restraint 340 LB / 153Kg NOTE: Lifting eyes provided**
10	Cold Mass Restraint – NLE [25-1893.01]	1	Secured to Fixture – See Figure 4	
14.5				
11	Post Stiffener Center Cap Screw (1 ¼) and washer	3 ea	Boxed and secured in container	
12	Post Stiffener Retention Screws and Washers	24 ea	Boxed and secured in container	**Post Stiffener + Ring 163 LB /73Kg (each)**
13	Post Stiffener [25-1868.01]	3	Secured to Fixture – See Figure 4	
14	Spacer Ring 25-1868.02	3	Secured to Fixture – See Figure 4	

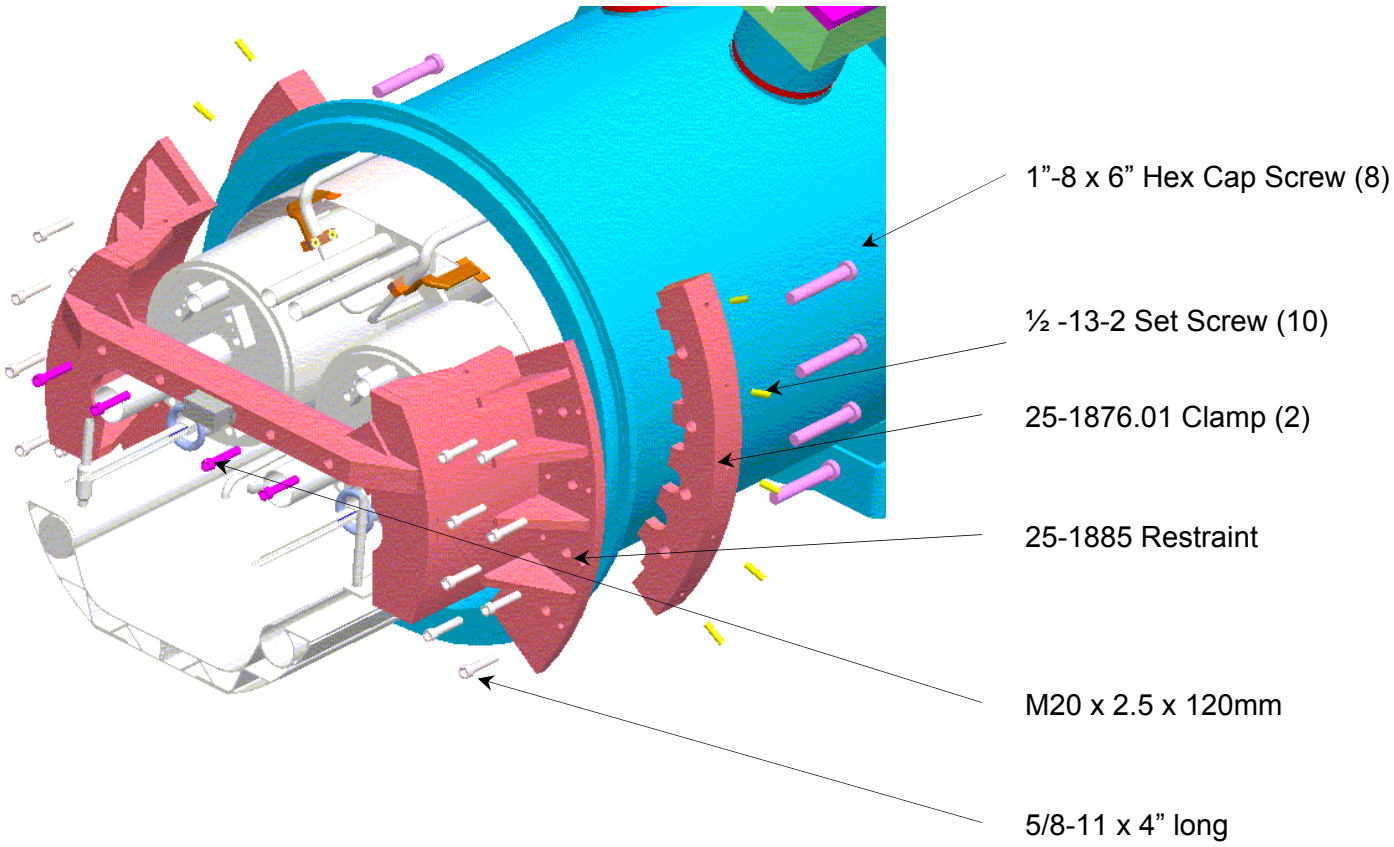


Figure 1

LE

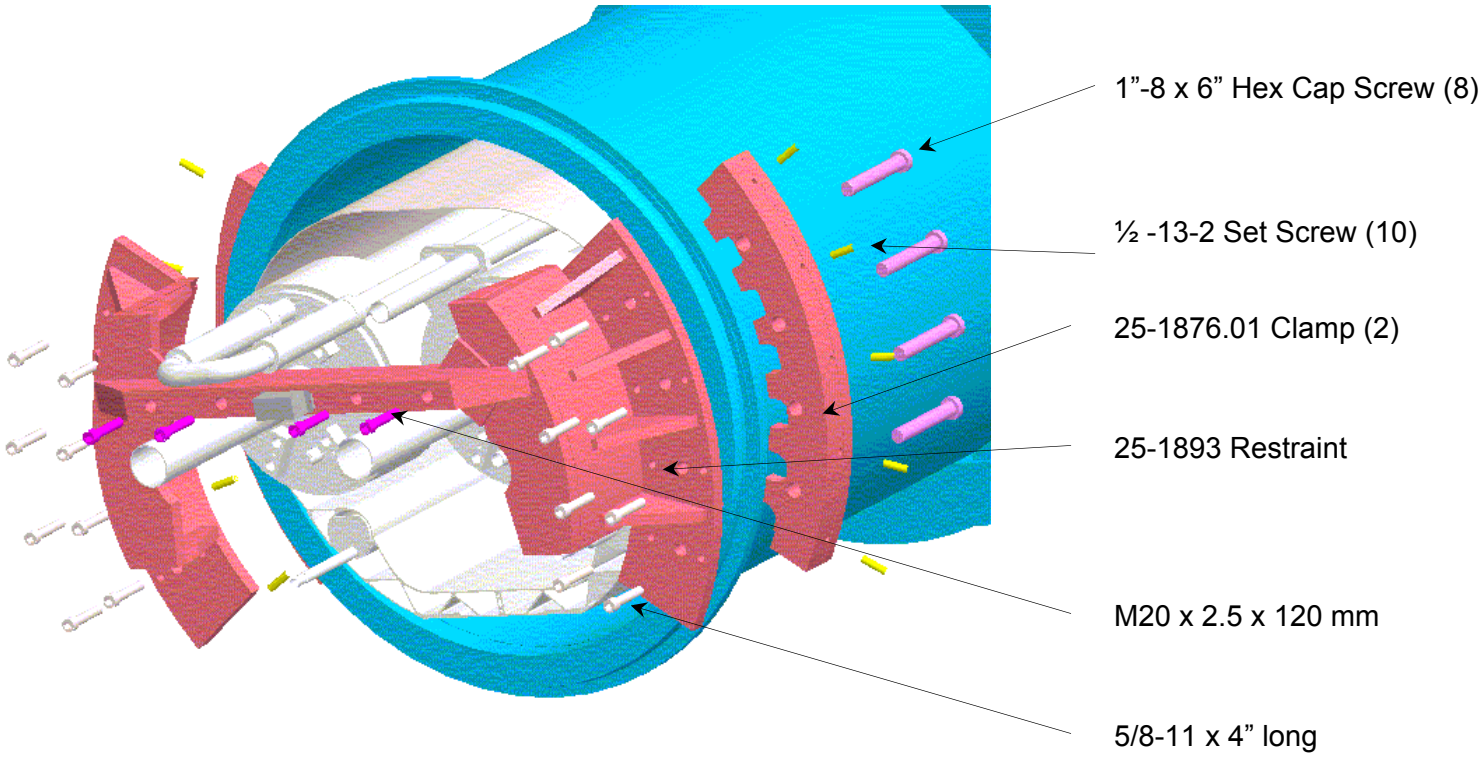


Figure 2
NLE

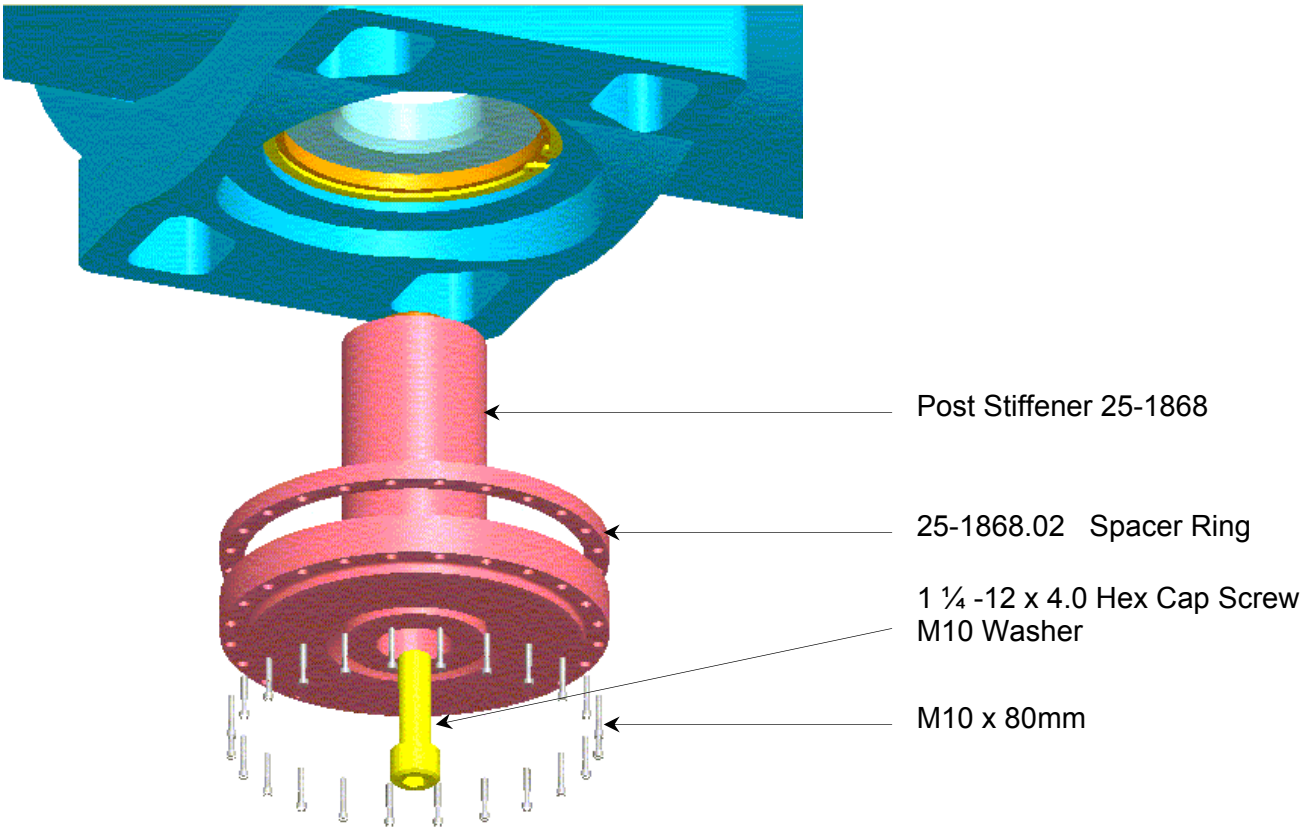


Figure 3

Typical All 3 Posts

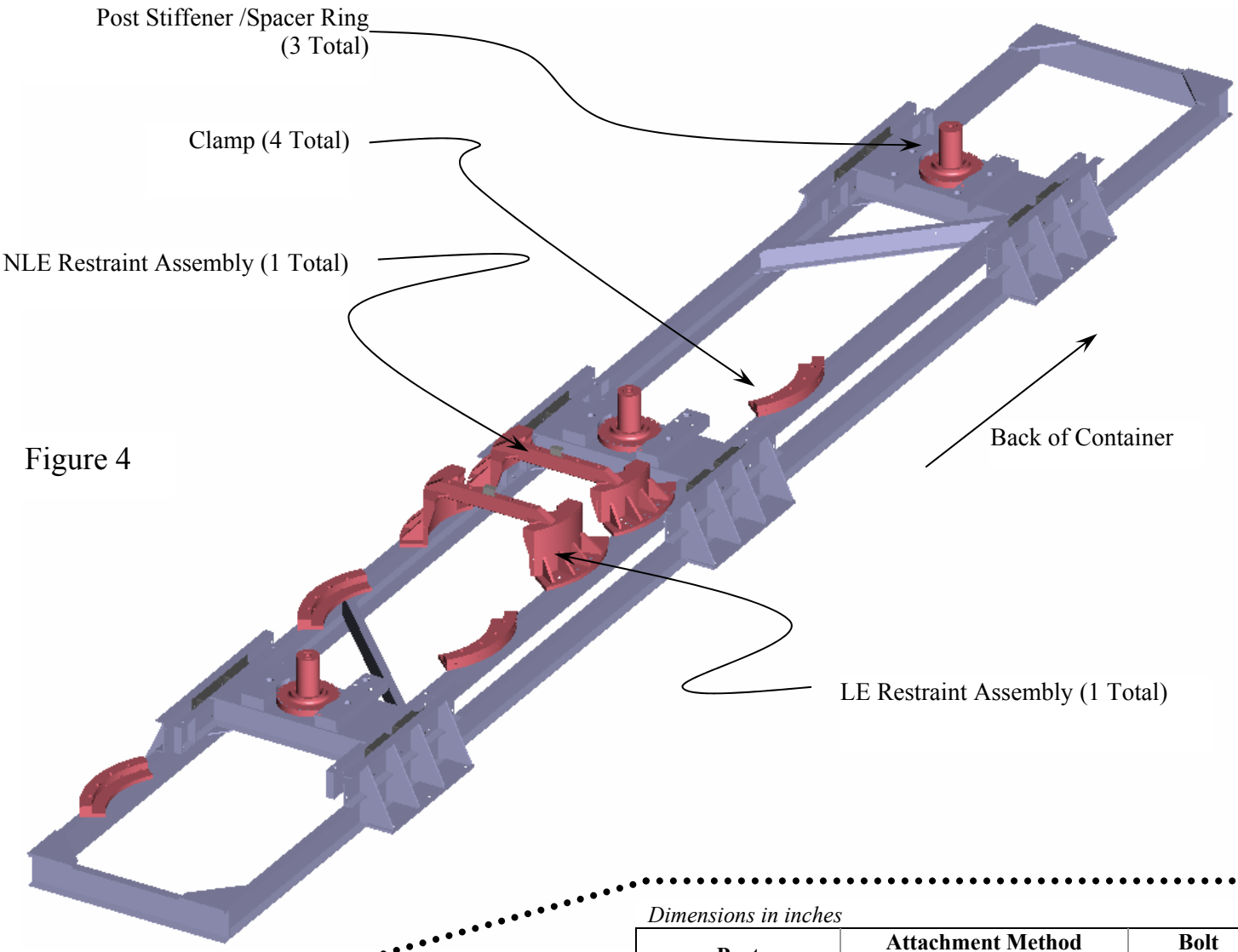
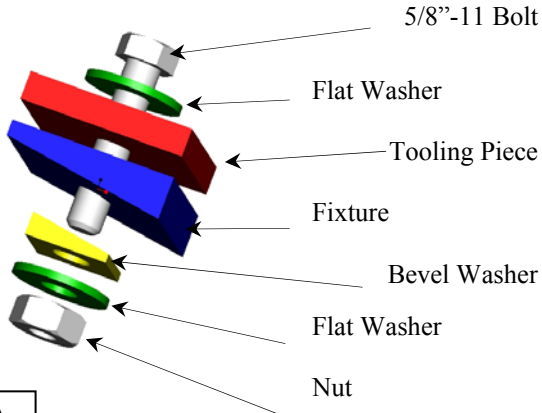


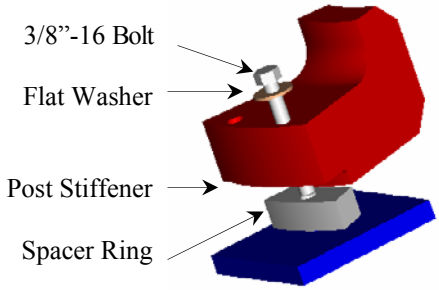
Figure 4

Dimensions in inches

Part	Attachment Method (Each Part)	Bolt Length
NLE Restraint	*2 Places – See Detail A*	3
LE Restraint	*2 Places – See Detail A*	3
Clamp	*2 Places – See Detail A*	4.5
Post Stiffener /Spacer Ring	*3 Places – See Detail B*	3 ½



Detail A



Detail B

4.4 Mechanical Checks

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

4.4.2 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.

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

4.5 Final Electrical Checks

4.5.1 With the two umbilical cables connecting the feed throughs installed, perform electrical checks on each cold mass as noted below.

NOTE

See Table 3 and Table 4 for connector layouts on each cold mass

4.5.2 Connect beam tube, all quench protection resistors & iron to each other and to ground. Connect coils together and perform 2.5 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.

4.5.3 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.

4.5.4 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. Record the leakage.

4.5.5 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.

4.5.6 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):	1.543-1.606
Resistance - Section 2 (lead → lead):	3.109-3.172

4.5.7 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

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

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

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

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

4.5.12 Perform resistance test on each of two Quench Protection Resistor circuits. Allowable resistance is 5.6-6.8 Ω

Table 3
Master Feed-Through Box (Right Hand Magnet)

Description	Connector ID	Feed-through ID
Level Probe – 1	C32-4	LT821 I-
Level Probe - 1	C32-3	LT821 I+
Level Probe - 1	C32-2	LT821 U-
Level Probe - 1	C32-1	LT821 U+
Level Probe - 2	C32-8	LT822 I-
Level Probe - 2	C32-7	LT822 I+
Level Probe - 2	C32-6	LT822 U-
Level Probe - 2	C32-5	LT822 U+
V-Tap Upper 1st	P30-2	EE211
V-Tap Upper 2nd	D31-6	EE212
V-Tap Mid 1st	D31-7	EE231
V-Tap Mid 2nd	D31-8	EE232
V-Tap Lower 1st	D31-9	EE251
V-Tap Lower 2nd	D31-10	EE252
Warm-Up Heater Circuit 1	C31-2	EH821 I-
Warm-Up Heater Circuit 1	C31-1	EH821 I+
Warm-Up Heater Circuit 2	C31-4	EH822 I-
Warm-Up Heater Circuit 2	C31-3	EH822 I+
Yoke Temperature Sensor 1	C30-4	TT821 I-
Yoke Temperature Sensor 1	C30-3	TT821 I+
Yoke Temperature Sensor 1	C30-2	TT821 U-
Yoke Temperature Sensor 1	C30-1	TT821 U+
Yoke Temperature Sensor 2	C30-8	TT822 I-
Yoke Temperature Sensor 2	C30-7	TT822 I+
Yoke Temperature Sensor 2	C30-6	TT822 U-
Yoke Temperature Sensor 2	C30-5	TT822 U+
Description	**Connector ID -** *Master Box*	
Quench Protection Circuit “A”	P31-1	
Quench Protection Circuit “A”	P31-3	
Quench Protection Circuit “B”	P31-4	
Quench Protection Circuit “B”	P31-2	
V-Tap LH Magnet Lower 2nd (EE152)	P30-1	

Note: *Quench Circuit “A” consists of circuits YT311 from each magnet wired in series. Quench Circuit “B” consists of circuits YT312 from each magnet wired in series. The identifiers “A” and “B” are arbitrary and serve merely to designate the separate circuits for testing purposes.*

Table 4
Slave Feed-Through Box (Left Hand Magnet)

Description	Connector ID	Feed-through ID
Level Probe – 1	C32-4	LT821 I-
Level Probe - 1	C32-3	LT821 I+
Level Probe - 1	C32-2	LT821 U-
Level Probe - 1	C32-1	LT821 U+
Level Probe - 2	C32-8	LT822 I-
Level Probe - 2	C32-7	LT822 I+
Level Probe - 2	C32-6	LT822 U-
Level Probe - 2	C32-5	LT822 U+
V-Tap Upper 1st	D31-1	EE111
V-Tap Upper 2nd	D31-2	EE112
V-Tap Mid 1st	D31-3	EE131
V-Tap Mid 2nd	D31-4	EE132
V-Tap Lower 1st	D31-5	EE151
Warm-Up Heater Circuit 1	C31-2	EH821 I-
Warm-Up Heater Circuit 1	C31-1	EH821 I+
Warm-Up Heater Circuit 2	C31-4	EH822 I-
Warm-Up Heater Circuit 2	C31-3	EH822 I+
Yoke Temperature Sensor 1	C30-4	TT821 I-
Yoke Temperature Sensor 1	C30-3	TT821 I+
Yoke Temperature Sensor 1	C30-2	TT821 U-
Yoke Temperature Sensor 1	C30-1	TT821 U+
Yoke Temperature Sensor 2	C30-8	TT822 I-
Yoke Temperature Sensor 2	C30-7	TT822 I+
Yoke Temperature Sensor 2	C30-6	TT822 U-
Yoke Temperature Sensor 2	C30-5	TT822 U+

4.6 Final Steps

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

4.7 Additional Work to be Performed by CERN Personnel

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

C. Loosening of the cold mass restraint straps at the lead and non-lead end post locations (four places). See Figure 5

CAUTION

Failure to loosen these straps may result in support post damage at cool-down to cryogenic temperature

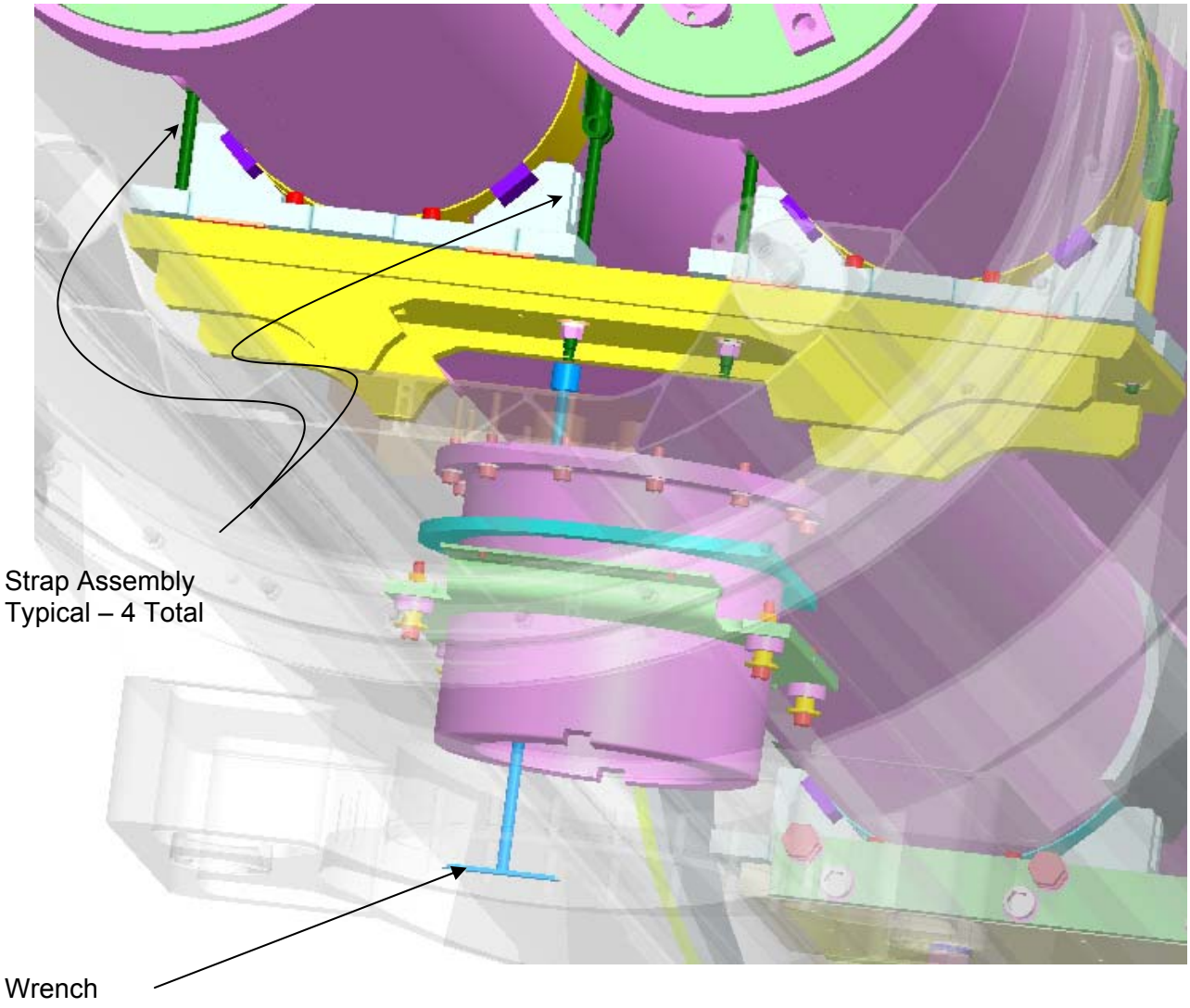


Figure 5
Cradles partially cut-away

2 Straps LE
2 Straps NLE
No straps at center cradle

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

D3 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-1058.

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.