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Large Hadron Collider
Magnet Division Procedure

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Title: D1 Magnet – Preparation for Shipping

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REVISION RECORD

Rev. No.	Date	Page	Subject	Approval
A	3/18/02		Initial Release	
B	7/25/02		Changes per ECN MG2097	
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D	9/19/02		Changes per ECN MG2109	
E	3/20/03		Changes per ECN MG2127	
F	5/15/03		Changes per ECN MG2142	

1 Scope:

This procedure describes the steps to prepare LHC D1 magnets for shipping. Included is: 1) Final Electrical Checks 2) Final Inspection 3) Preparation of the Shipping Fixture including installation and initializations of shipping sensors 4) Assembly of the magnet onto the shipping fixture and all other preparations required before transport to the customer.

2 Applicable Documents:

14060005	D1 Magnet Assembly, Tested & Shipped
RHIC-MAG-Q-1004	Discrepancy Reporting Procedure
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:

25-1849.01-5	Shipping Fixture

3.2 Safety Precautions:

3.2.1 LHC D1 magnet assemblies will be rigged using the 25-1782.02 lifting beam and slings so no chafing protection is required.

3.2.2 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 Technical Supervisor.

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 revisions 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 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 Final Electrical Checks

CAUTION

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

NOTE

Record all electrical test data in traveler

4.1.1 Connect Beam Tube, Quench Protection Resistors & Iron to each other and to ground. Perform 5 kV Hypot between coil and ground per RHIC-MAG-R-7242 and RHIC-MAG-R-7243. Leakage current shall not exceed 50 μa.

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

4.1.3 Perform Quench Protection Resistance test on each connected pair of resistors. The acceptable range is 2.8Ω-3.4Ω.

4.1.4 Connect Beam Tube, Coil & Iron to each other and to ground. Perform 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.

4.1.5 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.

4.1.6 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

4.1.7 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 Passive Heater Temperature Sensors

NOTE

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

Passive Heater Temperature Sensor Resistances			
Sensor Serial No.	**LakeShore Value(Ω)**	**Allowable Min**	**Allowable Max**
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

4.1.8 Perform a "4 wire" resistance check of each Passive Heater temperature sensor. Evaluate to limits in table 1.

4.1.9 Perform continuity check between I+ & V+ leads of each Passive Heater temperature sensor. Repeat for I - & V - leads.

4.1.10 Perform resistance test of each Passive Heater Temperature sensor & lead wire combination to ground. Resistance to be > 20 mega-ohm.

4.1.11 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 manufacturers voltage & current limits (1 volt, 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

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

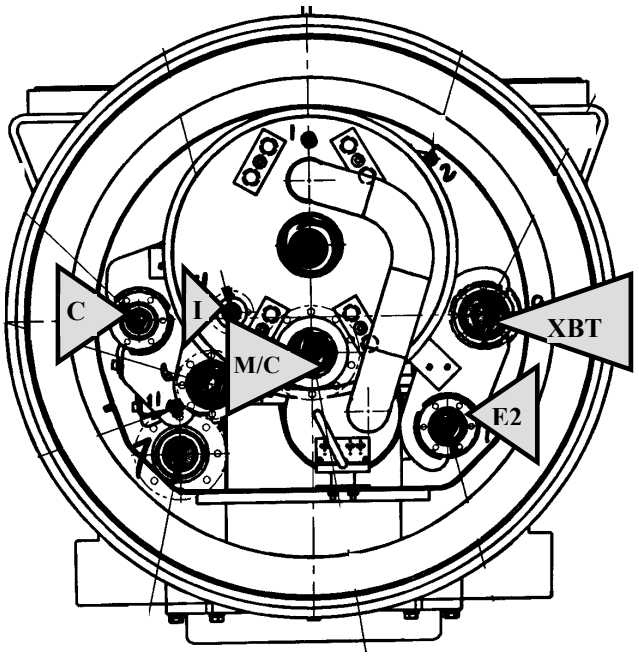
4.1.13 Remove any temporary labels from leads. Add permanent labels according to convention noted below.

Nomenclature of Lead Labeling for D1 (LBX) Magnets

	ITEM DESCRIPTION	NOMENCLATURE
COLD MASS LEADS	Magnet Main Leads	Label leads "A" and "B" in accordance with convention described in Interface Specification LHC-MBX-ES-0002.00
	Yoke Temperature Sensor, left[1]	YTL
	Yoke Temperature Sensor, right	YTR
	Voltage Taps, main[2]	VTM
	Voltage Taps, redundant	VTR
	Quench Heaters, CKT 1	QH1
	Quench Heaters, CKT 2	QH2
	Warm-Up Heater	EH1
	Warm-Up Heater	EH2
CRYOSTAT LEADS	Phase Sep. Liquid Presence (Temp. Sensor)[3,4]	PS1
	Phase Sep. Liquid Presence (Temp. Sensor)	PS2
	Phase Sep. Liquid Presence (Temp. Sensor)	PS3
	Phase Sep. Liquid Presence (Temp. Sensor)	PS4

Notes:
1. Left & Right are defined as viewed from lead end.
2. "main" and "redundant" voltage taps are identical.
3. PS1 & PS2 are the lead end sensors, PS3 & PS4 the non-lead end sensors. PS1/PS3 are on the left side and PS2/PS4 are on the right side. See note 1 for convention.
4. left side of the IP magnets will have PS3 & PS4 connected; right side PS1 & PS2 connected.

4.2 Stowage of LE Leads



NOTE

Left / Right convention used: Standing at LE looking towards NLE - Top of magnet UP.

4.2.1 LH Passive Heater Temperature Sensor Wires: Inspect wires for kinks or damage. Bundle wires into an approximately 6" diameter loop and place between the I & C line. Place the bundle close to the end of the line (farthest from the end volume). Tie the bundle loosely to the I line with a nylon tie.

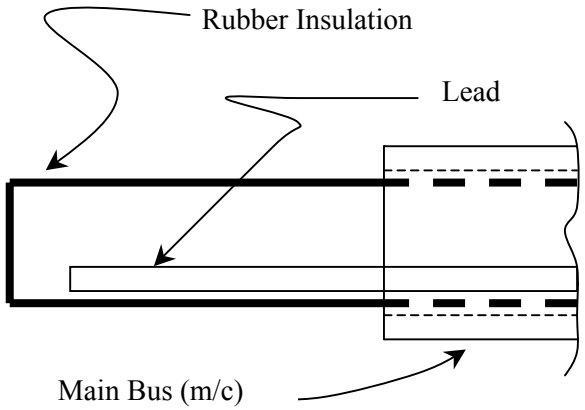
4.2.2 RH Passive Heater Temperature Sensor Wires: Inspect wires for kinks or damage. Bundle wires into an approximately 6" diameter loop and place to the left of the Xbt and E2 lines. Place the bundle close to the end of the line (farthest from the end volume). Tie the bundle loosely to the Xbt line with a nylon tie.

4.2.3 Instrumentation Harness: Inspect wires for kinks or damage. Bundle wires into an approximately 6" diameter loop and place to the left side of line m/c. Tie the bundle loosely to the m/c line with a nylon tie.

4.2.4 Superconductor lead: See sketch below. Use a piece of foam rubber pipe insulation $1^{3/8}$" ID x 1/2" wall thickness. Place pipe over lead and slide into main bus until approximately 4" of the rubber tube is inserted. Tube should be of sufficient length such that the end of the rubber tube extends 1" beyond end of lead. Use a nylon tie around the rubber tube. Tie should be tight enough to prevent movement of the lead.

NOTE

Prior to installation, verify that the rubber tube is sound and does not contain loose pieces of foam which may dislodge and remain in the m/c line.



4.3 Installation of Post Stiffeners

NOTE

See figures 1 & 2 for installation of post stiffeners

4.3.1 Lower the threaded plug at the top of the stiffeners using spanner wrench to ensure top of post stiffener will not contact the bottom of the cradles during installation.

4.3.2 Remove nut from center cradle pin. Install post stiffener using grade 8 bolts (8 ea., 3/8-16 x 1.75"). Apply anti-seize compound to threads (sparingly). Torque bolts to 31 Ft.-Lbs.. For specific posts on certain D1 magnets, tapered circular shims will be required. These will be used to compensate for an out-of-parallel condition of the leg-cryostat centerline. See drawing 25-1851.07-3. When shims are required, insure that the proper shim is used between the post stiffener , lower flange, and the post mounting surface on the cryostat. Verify orientation of

tapered shim with respect to magnet (location of thick part of shim with respect to magnet axis and direction).

4.3.3 Using spanner wrench, screw the threaded plug up to make positive contact with the bottom of the cradle.

4.3.4 On end cradles, install flat washer and coupling nut on cradle center pin. Apply anti-seize compound to threads (sparingly) and torque to 100 ft-lb.

4.3.5 For center cradle, install post stiffener same as above except install a 1-1/8" cap screw in lieu of the coupling nut. Apply anti-seize compound to threads (sparingly) and torque to 150 ft.-lbs.

4.4 Initialization of "Snap Shock" Accelerometers

4.4.1 Verify that previous data has been downloaded from sensors prior to initialization.

4.4.2 Install fresh batteries in each accelerometer and battery pack. Prior to battery installation, verify each contains a full charge (≈ 9 volts).

NOTE

Battery life is significantly reduced when the unit is in communication mode during set-up and initialization. Keep use of communication mode to a minimum after installation of new batteries.

4.4.3 Using software supplied with accelerometers, set recording parameters as noted below:

MODE:	Recording Mode = "Event" Max Event Length = 0.85 Seconds	
TRIGGER:	<u>Acceleration (G's)</u>	<u>Velocity Chg.(F/S)</u>
	X=.25	2.0
	Y=.25	2.0
	Z=.25	2.0
LOGGER:	"Off"	
START & STOP TIMES:	"No Delayed Start" "No Delayed Stop"	
FILTER:	Low Pass Filter = 119 Hz.	

4.4.4 Using software supplied with accelerometers, set preferences & set units as noted below:

Acceleration:	G's	Jerk:	Ft. /Sec.^{3}
Angle:	Degrees	Pressure:	Lb. /In.^{2}
Angular Acceleration:	Deg. /Sec.^{2}	Temperature:	^{0}F
Angular Velocity:	Deg /Sec	Time:	S
Current:	A	Velocity:	Ft. /Sec.
Displacement:	Inches	Voltage:	V
Humidity:	R.H.		

4.4.5 After completing initialization, turn accelerometers off. (see table of operating modes /LED status).

4.5 Initialization of Temperature Data Logger Buttons

NOTE

Verify that previous data has been removed from sensor prior to initializing.

4.5.1 Recording Parameters

GENERAL

Sample Interval = 120 minutes
Logger Delay Start Setting = See note below
Logger Behavior Setting = "Stop when Full"

NOTE

Each logger has a memory of 2000 separate data points. At a sampling rate of once per hour, there is a maximum 83 day recording span. When entering the start setting for the logger, ensure that the required period of data acquisition falls within this span.

ALARMS

High Alarm = 95^0 F
Low Alarm = -22^0 F

4.6 Installation of Temperature Data Logger Buttons

NOTE 1

See figures 3 & 5 for locations

NOTE 2

Verify that loggers have been initialized prior to installation

4.6.1 Mount a data logger button on each end volume restraint using RTV per engineering direction.

4.6.2 Record serial number and location on magnet (LE /NLE) for each temperature logger button.

4.6.3 Record date and time of temperature sensor installation into the traveler.

4.7 Installation of End Restraints

NOTE

See figures 6 & 7 for installation of end restraints

4.7.1 Bolt end restraints to end volume lugs and torque bolts to 125 ft-lbs.

4.7.2 Extend all bolts in outer flange of end restraint to make positive contact with cryostat flange.

4.7.3 Install clamps and torque to 19 ft-lbs.

4.8 Installation of "Snap Shock" Accelerometers

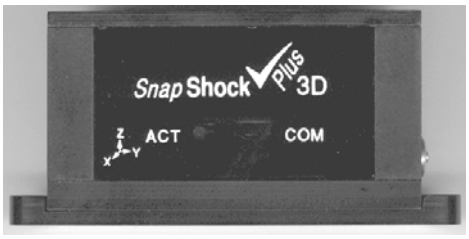
NOTE 1

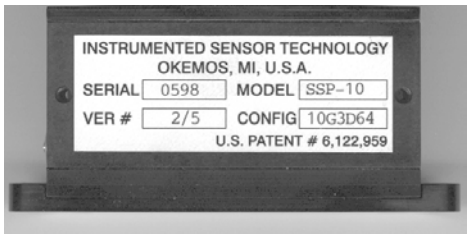
See figures 3 & 5 for locations

NOTE 2

Verify that accelerometers have been initialized prior to installation

4.8.1 Install accelerometers and battery packs on Lead & Non-Lead End Cold Mass Restraints using hardware and existing tapped holes in the restraints. This will result in a horizontal orientation of the sensor. The sensor should be mounted so that the top will face up when the magnet is in the fixture. See figure below. Connect power cable from each battery pack to it's corresponding sensor.





Top **Bottom**

4.8.2 Record serial numbers of accelerometers along with location (LE /NLE) into traveler.

4.9 Final Preparation and Inspections

4.9.1 Verify outside of cryostat vessel is clean and free of dust, dirt and grease.

4.9.2 Inspect painted surfaces for abrasions and scratches. Touch-up as required.

4.9.3 Inspect cryostat for proper identification

- Identification Nameplate filled out completely.
- All appropriate labeling affixed.

4.9.4 Install desiccant bags within cryostat and secure.

4.9.5 Cover six T-H fiducials with a protective cap.

4.10 Installation of Magnet Assembly to Container

NOTE

See figures 3, 4 & 5 for fixture arrangements

4.10.1 Record fixture /container I.D. in traveler.

NOTE

Verify rubber mounts are located properly for fixturing of D1 magnets. There is one mount at each of 6 locations on fixture.

4.10.2 Insert locating pins into appropriate hole in shipping fixture spacers.

4.10.3 Lower magnet assembly onto fixture ensuring that locating pins engage spherical bearings in cryostat legs.

4.10.4 Install eyebolts, shackles, chains and chafe guards.

4.10.5 Tighten eyebolts to provide positive preload between magnet and shipping fixture. Install jam nuts on eyebolts to positively lock adjusting nuts (6 places).

4.11 Preparation of Loose Part Kit

4.11.1 Collect the following magnet parts, labeling each part or package with part number and quantity.

Loose Parts Kit

Part Number	*Description*	**Quantity**	***Drawing Number***	***Part-list Item #***
AN960-C1216	0.750 FLAT WASHER	2	*14010018*	*45*
NAS1593-453	PREFORMED 0-RING	3	*14060006*	*26*
MS35338-146	0.750 LOCK WASHER	2	*14010018*	*46*
MS35338-65	LOCK WASHER, 0.375	24	*14060006*	*24*
MS90728-62	0.375-16 X 1.25 HEX SCREW	24	*14060006*	*21*
MS9320-12	FLAT WASHER, 0.375	24	*14060006*	*22*
MS51971-8	0.750 HEX NUT	2	*14010018*	*47*
12010109	ANTI-SEIZE COMPOUND	1 oz tube	*14060006*	*20*
12065070	INSULATING BAFFLE ASSY.	3	*14060005*	*8*
12065091	PORT COVER	3	*14060006*	*9*
-	SENSOR CARRYING CASE	1	-	-
MS90728-71	.375-16 X 3.25 HEX SCREW	6	-	-
MS9320-12	.375 WASHER	6	-	-

4.11.2 Place the parts into the toolbox located in the inter-modal container. Ensure that the contents are secure and will not move during shipment. Latch the toolbox closed.

4.12 Final Shipping Container Close-Out

4.12.1 Verify all roof bows in place and cover tarp is secured.

4.12.2 Just prior to container closeout, activate accelerometer at each end by pressing and holding mode button located on the side of the sensor. There are 2 LED's that will light as the sensor cycles through its various operating modes. Release the button when the sensor is at the "Activated" mode. In this mode, the ACT LED is "on" and the COM LED is "off".

Operating Mode	ACT LED - Green	COM LED - Red
Off	ON	ON
In Communication	OFF	ON
Activated	ON	OFF

NOTE

The present status of the sensor may be verified by pressing the mode button momentarily and observing the LED's. Do not hold the mode button after the LED's illuminate as the unit will begin cycling through the modes and will then need to be reset.

4.12.3 Record date and time of accelerometer activation into the traveler.

4.12.4 Seal vessel ends with plastic shrink-wrap.

4.12.5 Cognizant Engineer to inspect shipping container and sign-off traveler "OK to close".

4.12.6 Photograph inside of container to document "as shipped" condition.

4.12.7 Secure container doors and latches for shipping. Do not lock.

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.

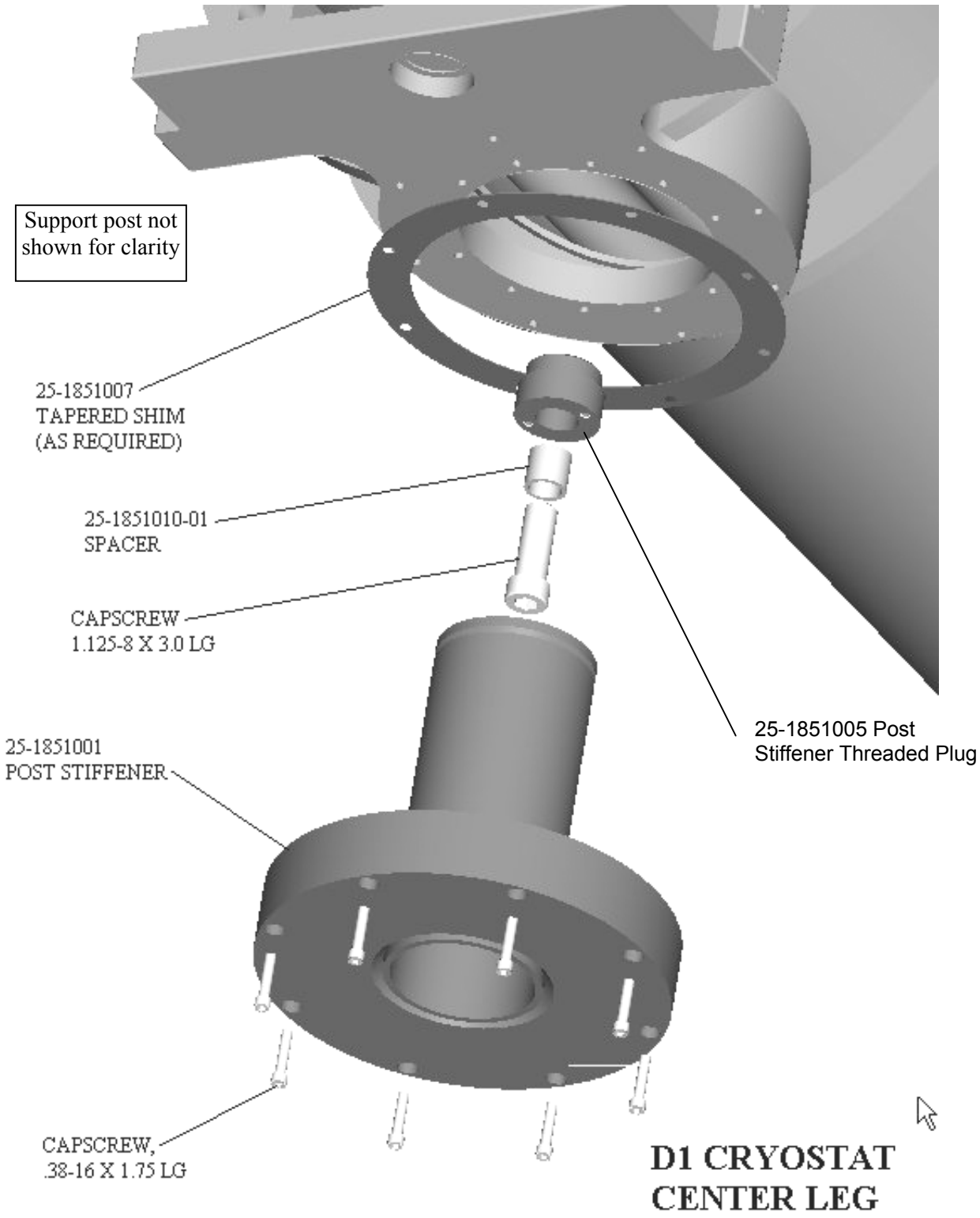


Figure 1
Center Post Stiffener

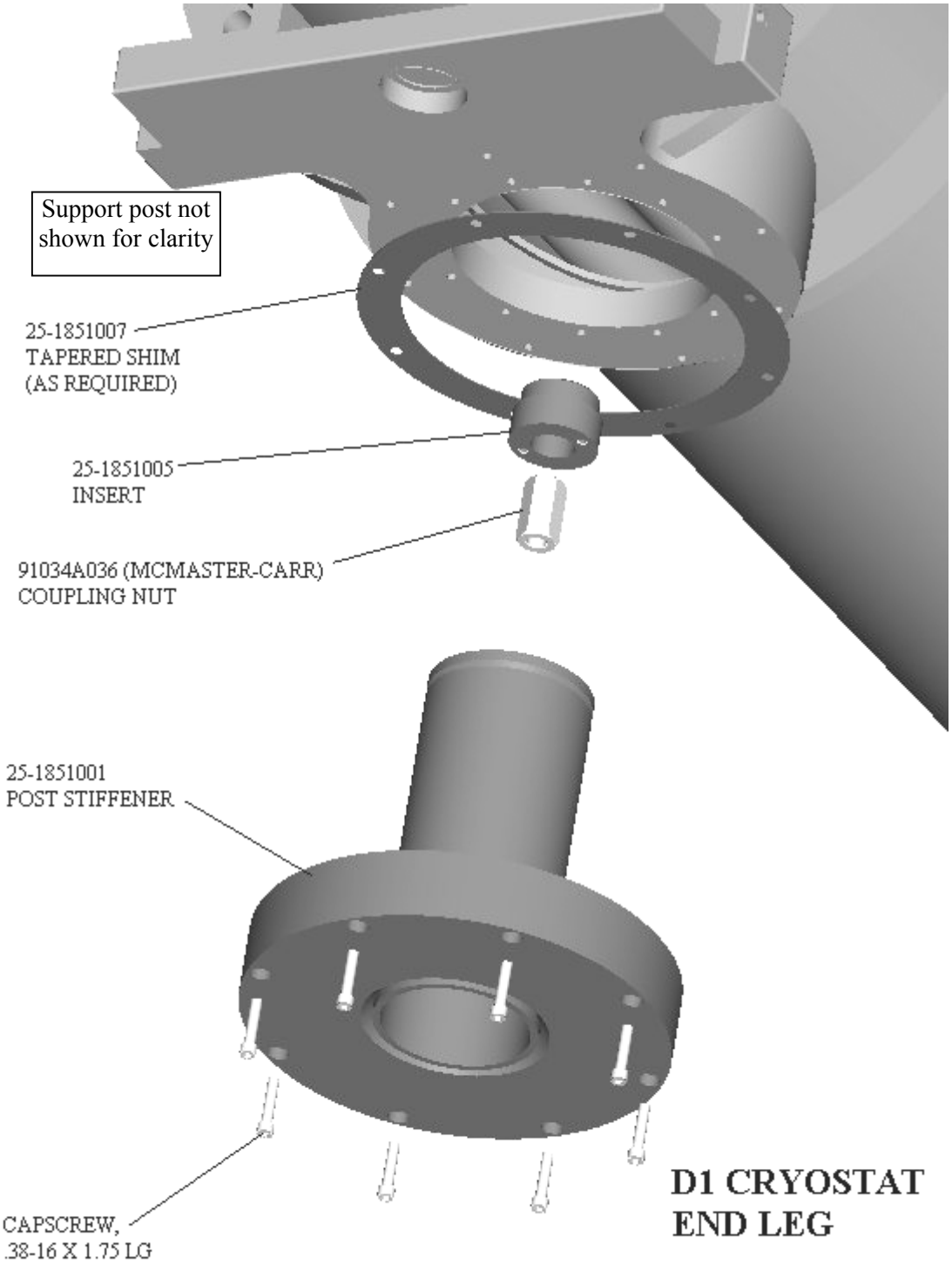


Figure 2
End Post Stiffener

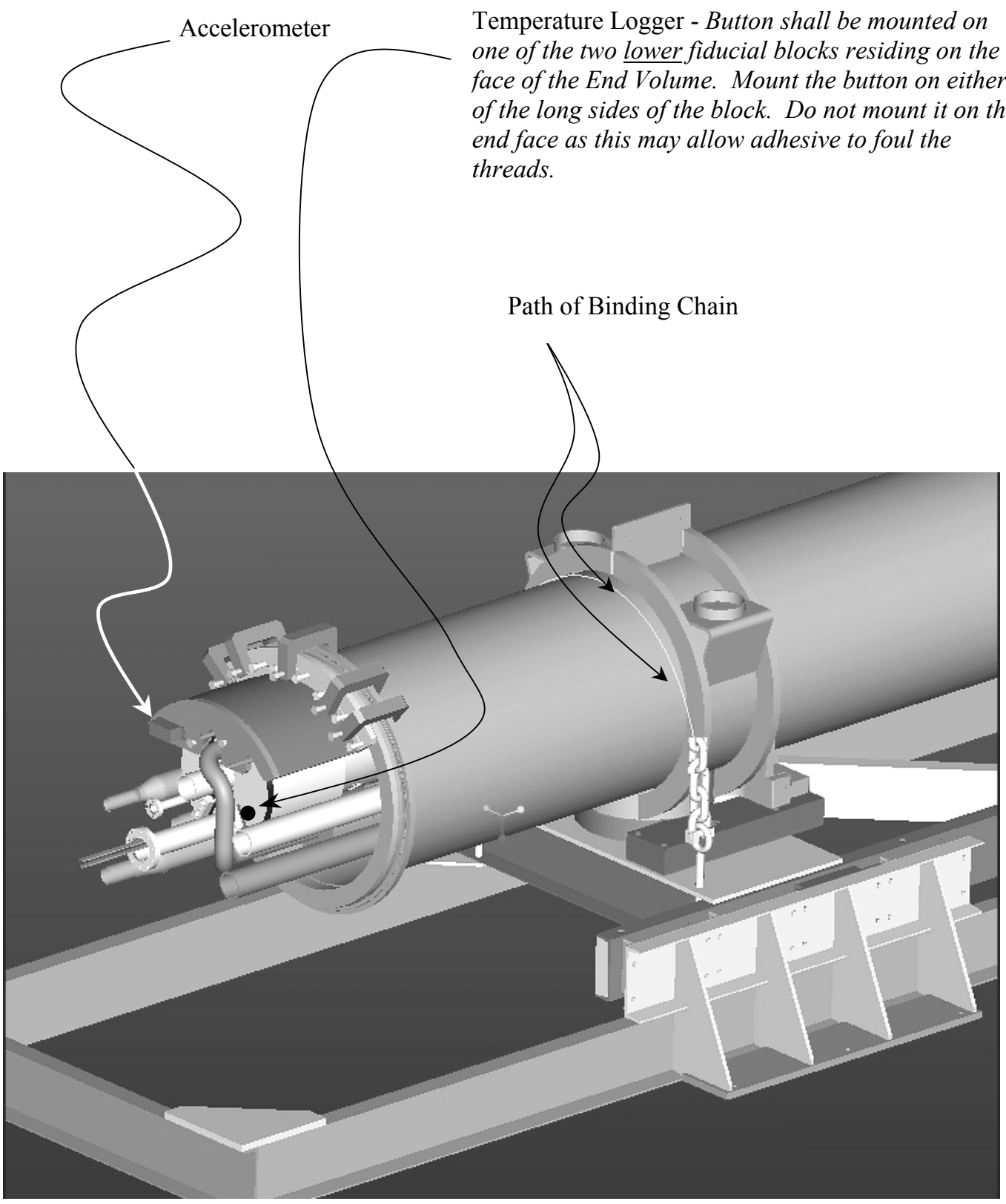


Figure 3
Magnet + Fixture Assembly - Lead End

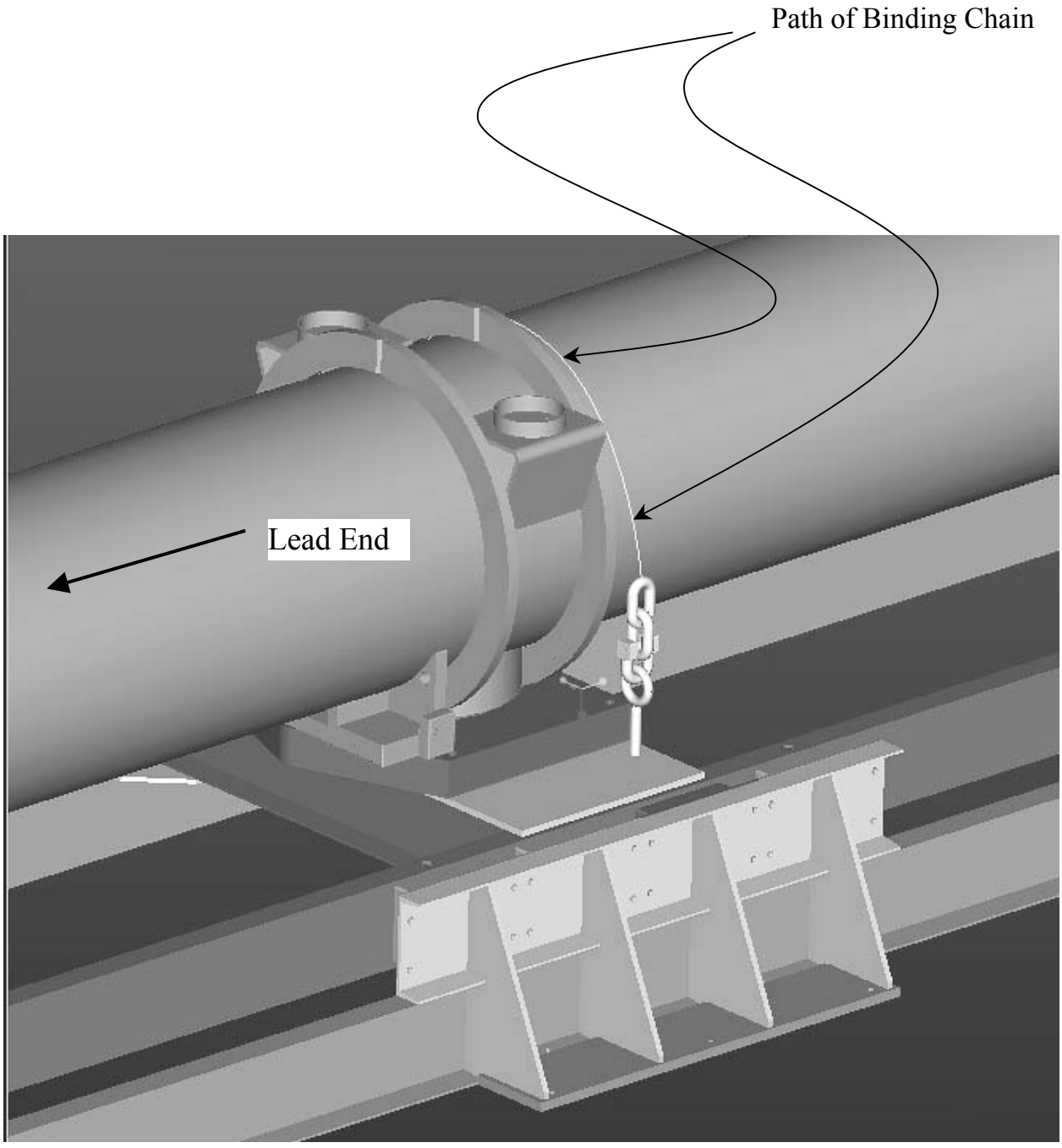


Figure 4
Magnet + Fixture Assembly - Center

Temperature Logger - *Button shall be mounted on one of the two <u>lower</u> fiducial blocks residing on the face of the End Volume. Mount the button on either of the long sides of the block. Do not mount it on the end face as this may allow adhesive to foul the threads.*

Path of Binding Chain

Accelerometer

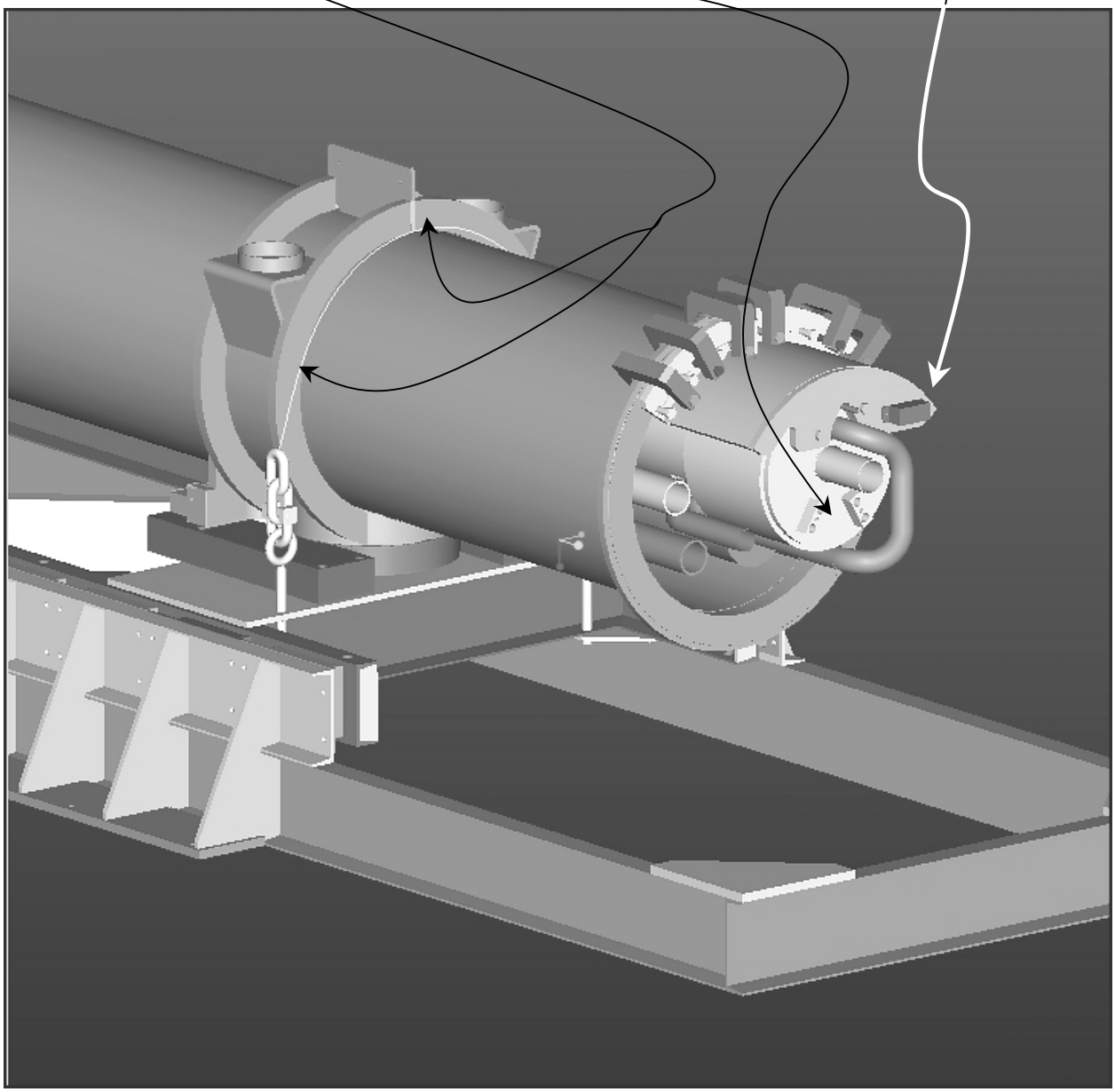


Figure 5
Magnet + Fixture Assembly - Non Lead End

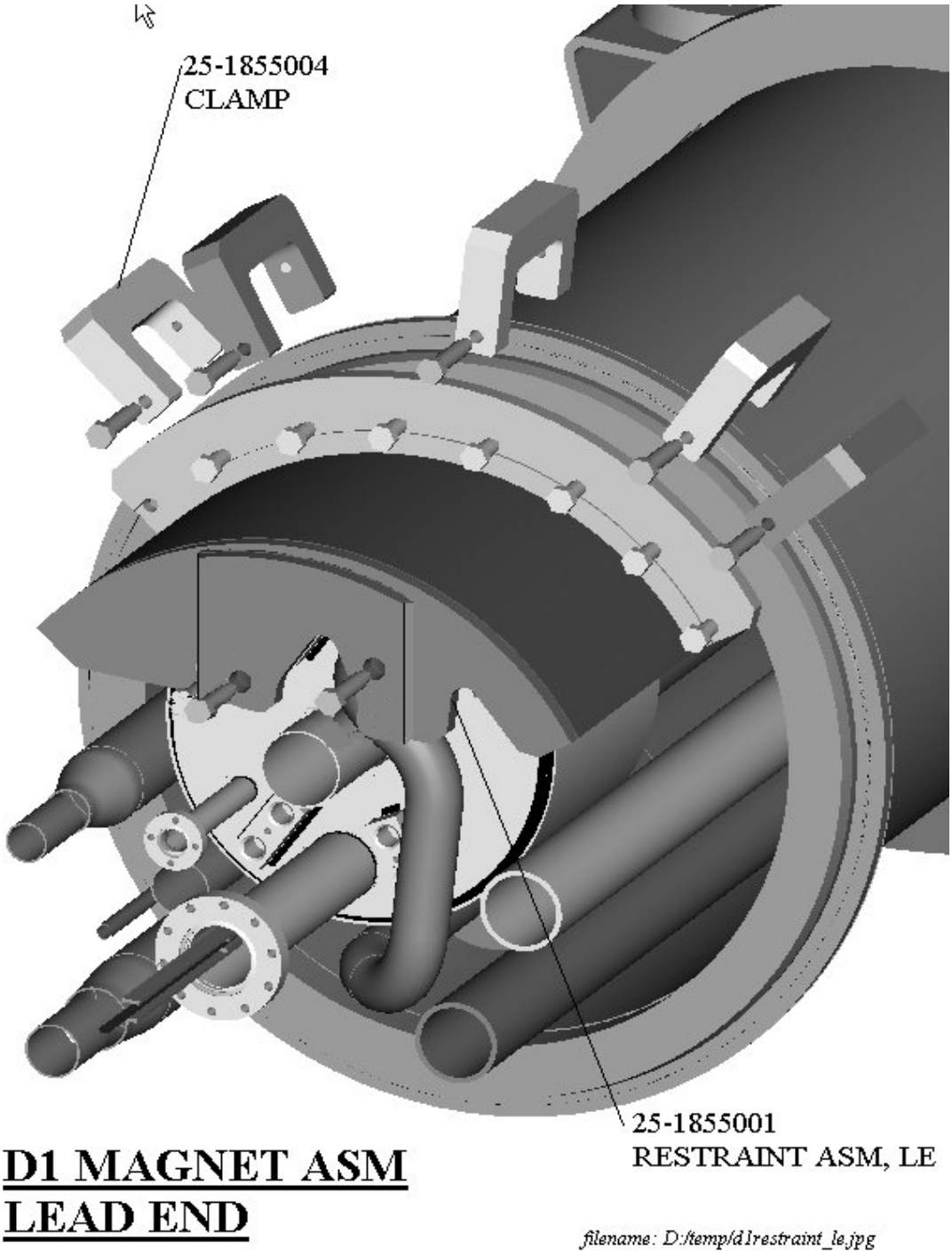


Figure 6
Restraint Assembly - Lead End

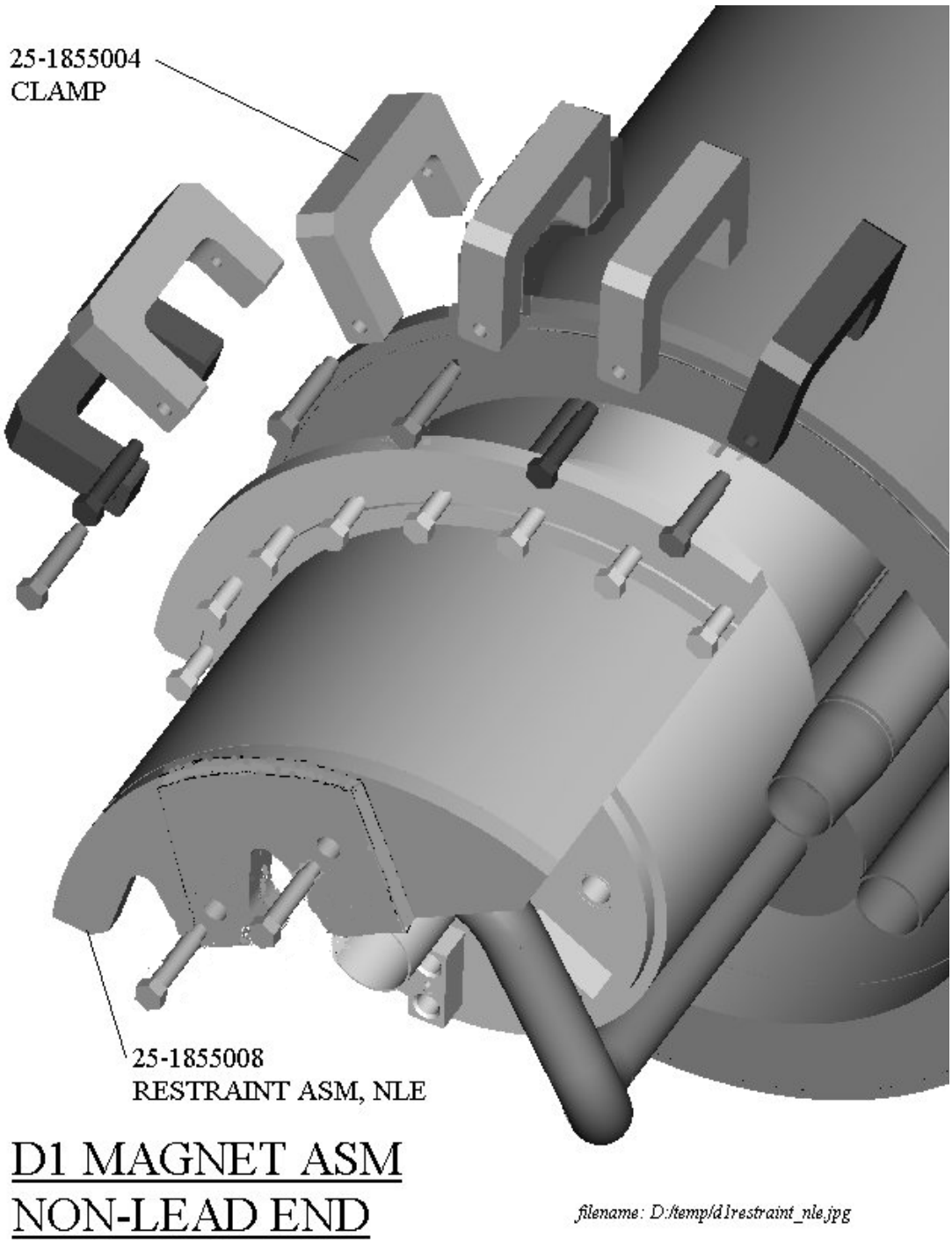


Figure 7
Restraint Assembly - non Lead End