

SPECIFICATION NO. NSCL 6-SDA-17-121687

DECEMBER 16, 1987

16° AND 22.5° BEAMLINER DIPOLE MAGNET STEEL ASSEMBLIES

NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY  
MICHIGAN STATE UNIVERSITY  
East Lansing, Michigan 48824-1321

## 1.0 GENERAL

### 1.1) Use

This specification is to be applied to manufacture of the 16 and 22.5 degree superconducting dipole steel assemblies for the National Superconducting Cyclotron Laboratory at Michigan State University (MSU-NSCL).

### 1.2) Scope of Vendor

The Vendor shall furnish all labor and materials for fabrication, inspection, testing, packaging, and shipping the magnet assemblies specified herein and as specified in the accompanying drawings which are part of these specifications, including necessary handling equipment, special tooling, jigs, test facilities, inspection test reports, and any other item necessary to complete the specified end product in accord with all requirements of this specification.

### 1.3) Access

The Purchaser's designated representatives shall be allowed access to the production and test areas of the vendor's facility at all reasonable times during the progress of the work called for by the specification.

### 1.4) Reports

Progress reports shall be submitted by the Vendor to the Purchaser's representative at four-week intervals starting four weeks after receipt of order. These reports shall list anticipated starting and finishing dates of material procurements and of each major step of the magnet fabrication process (forging, machining, assembly, testing, shipping, etc.). Progress reports shall continue until all assemblies have been shipped. In addition each magnet assembly shall have included its inspection report.

### 1.5) Acceptance

Acceptance will be based on final inspection reports provided by the vendor prior to shipment and possibly by a final inspection by the Purchaser in the Vendor's plant. The Vendor will provide all equipment necessary to demonstrate that the assemblies meet all dimensional tolerances in the specifications and certified records to show that the assemblies are fabricated from materials meeting required specifications.

## 1.6) Definitions

A complete 16<sup>0</sup> Magnet Assembly shall consist of the quantity of parts as listed with drawing numbers below:

(2)	6-SDA-17-1-E	Top and Bottom Slab
(2)	6-SDA-17-2-E	Magnet Side
(2)	6-SDA-17-3-E	Pole Tip
(10)	6-SDA-17-4-A	Pole Tip Spacer
(2)	6-SDA-17-5-B	Front Tie Rod
(2)	6-SDA-17-6-B	Back Tie Rod
(8)	6-SDA-17-7	3/4-10 UNC-2 Hex Nut (no drawing)
(8)	6-SDA-17-8-A	Screw Plug

A complete 22.5<sup>0</sup> Magnet Assembly shall consist of the quantity of parts as listed with drawing numbers below:

(2)	6-SDA-20-1-E	Top and Bottom Slab
(2)	6-SDA-20-2-E	Magnet Side
(2)	6-SDA-20-3-E	Pole Tip
(10)	6-SDA-20-4	Pole Tip Spacer, Dwg. 6-SDA-17-4-A
(4)	6-SDA-20-5-B	Tie Rod
(8)	6-SDA-20-6	3/4-10 UNC-2 Hex Nut (no drawing)
(8)	6-SDA-20-7	Screw Plug, Dwg. 6-SDA-17-8-A

## 2.0 MATERIALS

- 2.1 Materials for Pole Tips (6-SDA-17-3-E and 6-SDA-20-3-E) of magnet steel assemblies shall be AISI 1006 or lower carbon content, with chemical composition as shown in Table 1.
- 2.2 Materials for Top and Bottom Slabs (6-SDA-17-1-E and 6-SDA-20-1-E) of magnet steel assemblies shall be AISI 1010 or lower carbon content, with chemical composition as shown in Table 1.
- 2.3 Materials for Magnet Sides (6-SDA-17-2-E and 6-SDA-20-2-E) of magnet steel assemblies shall be AISI 1010 or lower carbon content, with chemical composition as shown in Table 1.
- 2.4 Materials for Pole Tip Spacers (6-SDA-17-4-A) of magnet steel assemblies shall be ASTM A167, type 304 with chemical composition as shown in Table 1.
- 2.5 Materials for Tie Rods (6-SDA-17-5-B, 6-SDA-17-6-B and 6-SDA-20-5-B) of magnet steel assemblies shall be AISI 1020, or lower carbon content with chemical composition as shown in Table 1.

- 2.6 Materials for Screw Plugs (6-SDA-17-8-A) of magnet steel assemblies shall be AISI 1020, or lower carbon content with chemical composition as shown in Table 1.
- 2.7 Welding Wire material shall be AWS A5.4 Type 308 with weld deposit chemical composition as shown in Table 1.
- 2.8 Hex Nuts shall meet or exceed requirements of ASTM A563, Grade A.
- 2.9 All low carbon steel may be of the same grade as long as the specification for the Pole Tips (Article 2.1) is satisfied.

TABLE 1.  
Material Chemical Compositions ( wt.% )

<u>Material</u>	<u>C</u>	<u>Si</u>	<u>Mn</u>	<u>P</u>	<u>S</u>	<u>Ni</u>	<u>Cr</u>	<u>N</u>
AISI 1006	.08 max	.10 max	.40 max	.025 max	.025 max	-	-	-
AISI 1010	.13 max	.10 max	.60 max	.035 max	.045 max	-	-	-
AISI 1020	.23 max	.10 max	1.00 max	.035 max	.045 max	-	-	-
ASTM A167 Type 304	.08 max	.75 max	2.00 max	.045 max	.030 max	8/10.5	18/20	.10 max
AWS A5.4 Type 308	.08 max	.30/.65	1.0/2.5	.030 max	.030 max	9/11	19.5/22	-

### 3.0 FORGING and HEAT TREATMENT

- 3.1 All magnet parts listed below shall be forged with a forging factor of at least 3:

6-SDA-17-1-E	Top and Bottom Slab
6-SDA-17-2-E	Magnet Side
6-SDA-17-3-E	Pole Tip
6-SDA-20-1-E	Top and Bottom Slab
6-SDA-20-2-E	Magnet Side
6-SDA-20-3-E	Pole Tip

- 3.2 After steel production and rough machining, magnet steels shall be fully annealed under the following conditions:

Annealing Temperature	930 - 1000 °C
Holding Time @ Annealing Temperature	8 Hrs. Min.
Maximum Cooling Rate	27 °C/Hr to 540 °C

The Vendor may propose a different annealing schedule if he feels that such a schedule would achieve superior magnetic performance for his material, but MSU-NSCL approval is required.

#### 4.0 MACHINING

- 4.1 All parts must conform to detail and assembly drawings approved for fabrication by MSU-NSCL.
- 4.2 All screw threads shall be of Class 2 fit and comply with ANSI B1.1.
- 4.3 All hole depth dimensions to drill point unless otherwise stated.
- 4.4 All drill points 118° included angle (standard angle).
- 4.5 Implied tolerance of +.010 in. (.025 cm.), -0. on all hole diameters unless tolerance is specifically stated at the hole dimension.
- 4.6 Implied tolerance of  $\pm .05$  in. (.13 cm.) on all hole depths and depth of full thread on tapped holes unless toleranced otherwise at the depth dimension. When hole depth in centimeters is not given, use conversion of 2.54 cm./in. and round to 2 decimal places.

#### 5.0 INSPECTION

- 5.1 Check chemical analysis to be performed on magnet steels with results provided by the vendor in inspection report. Purchaser shall be notified of results immediately upon completion of analysis.
- 5.2 All parts shall be visually inspected to be free of injurious defects or foreign materials.
- 5.3 Forged Magnet Steels to be ultrasonically inspected according to ASTM A435. Purchaser shall be notified of results immediately upon completion of inspection.

- 5.3.1 There shall be no voids or inclusions of volume greater than  $.001 \text{ in.}^3$  ( $.016 \text{ cm.}^3$ ) within 3.00 in. (7.62 cm.) of one rough machine gage surface, which shall ultimately be made into the gap boundary surface of a pole tip (Surface -A-, Dwg. 6-SDA-17-3-E and 6-SDA-20-3-E)
- 5.3.2 There shall be no voids or inclusions of volume greater than  $.002 \text{ in.}^3$  ( $.032 \text{ cm.}^3$ ) found anywhere throughout magnet steels.
- 5.4 Each part shall be dimensionally inspected to conform to drawings.
- 5.5 A likeness of pole tips common to an assembly may vary within tolerances for an individual pole tip.

## 6.0 ASSEMBLY

- 6.1 Extra care shall be taken to insure the smooth, flat face of pole tips is not damaged during welding of spacer blocks, further than .5 in. (1.27 cm.) away from weld fillet.
- 6.2 Pole tip spacer locations shall be within a  $\pm .050$  in. (.127 cm.) tolerance window of the ideal position, as demonstrated in Figure 1.
- 6.3 Pole tips must be centered over each other as closely as possible in final, welded position, with a maximum difference of .010 in. (.025 cm.) in alignment of boundary surfaces as measured perpendicular to pole tip surface as demonstrated in Figure 2. Vendor welding procedure must be approved by NSCL prior to pole tip assembly.
- 6.4 Each magnet shall be completely assembled for visual and dimensional inspection with all magnet pieces of each assembly being match-marked to show piece orientation and common assembly number. No match marks are allowed on internal pole tip surfaces. All match marks must be visible when magnet is assembled. Magnet shall be disassembled for shipment.

## 7.0 PACKING FOR SHIPPING

- 7.1 Each piece shall be clean, fingerprint neutralized with RUST VETO 266, and coated to prevent corrosion with RUST VETO 342. Other equivalent compounds may be used if deemed acceptable by MSU-NSCL (RUST VETO is a product of E. F. Houghton Co., Philadelphia, Pa., USA).
- 7.2 Packaging for shipment must be adequate to prevent damage while in transit. Extra care must be taken to insure the smooth, flat face of pole tips is not damaged during cleaning, coating, packing, and shipping.

NO.	REVISION	DATE	BY

POLE TIP

POLE TIP SPACER

EXAMPLE SHOWN IS  
22.5° MAGNET, REF.  
DWG. 6-SDA-20-E.

IDEAL POSITION :  
.50 + 10.569 = 11.069 in.  
1.27 + 26.845 = 28.115 cm.

.05 (.127) → ←  
.05 (.127) → ←  
IDEAL POSITION = .180 (.457) → ←

PART NO.	PART NAME - DESCRIPTION	MATERIAL - NOTE
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UNLESS OTHERWISE SPECIFIED:

- DIMENSIONS ARE IN INCHES
- BREAK ALL SHARP EDGES .02 MAX.
- REMOVE ALL BURRS
- 30° CHAMFER ENDS ALL SCREW THREADS
- GEOMETRIC TOLERANCES AND DIMENSIONS CONFORM TO ANSI Y14.5M-1982

ANGLE TOLERANCES  
- ON 90° ANGLES = ± 0° 6'  
- ALL OTHERS = ±

MACHINE SURFACE FINISH ✓  
PER ANSI B46.1 - 1978

ALL FILLETS AND RADII R

DECIMAL DIMENSION TOLERANCES

SIZE	± TOL.
0 TO .125	.003
OVER .125 TO .50	.005
OVER .50 TO 3	.007
OVER 3 TO 10	.010
OVER 10 TO 30	.015
OVER 30 TO 60	.020
OVER 60	.030

DRAWN BY

DATE

SCALE

FIGURE 1

DRAWING NUMBER

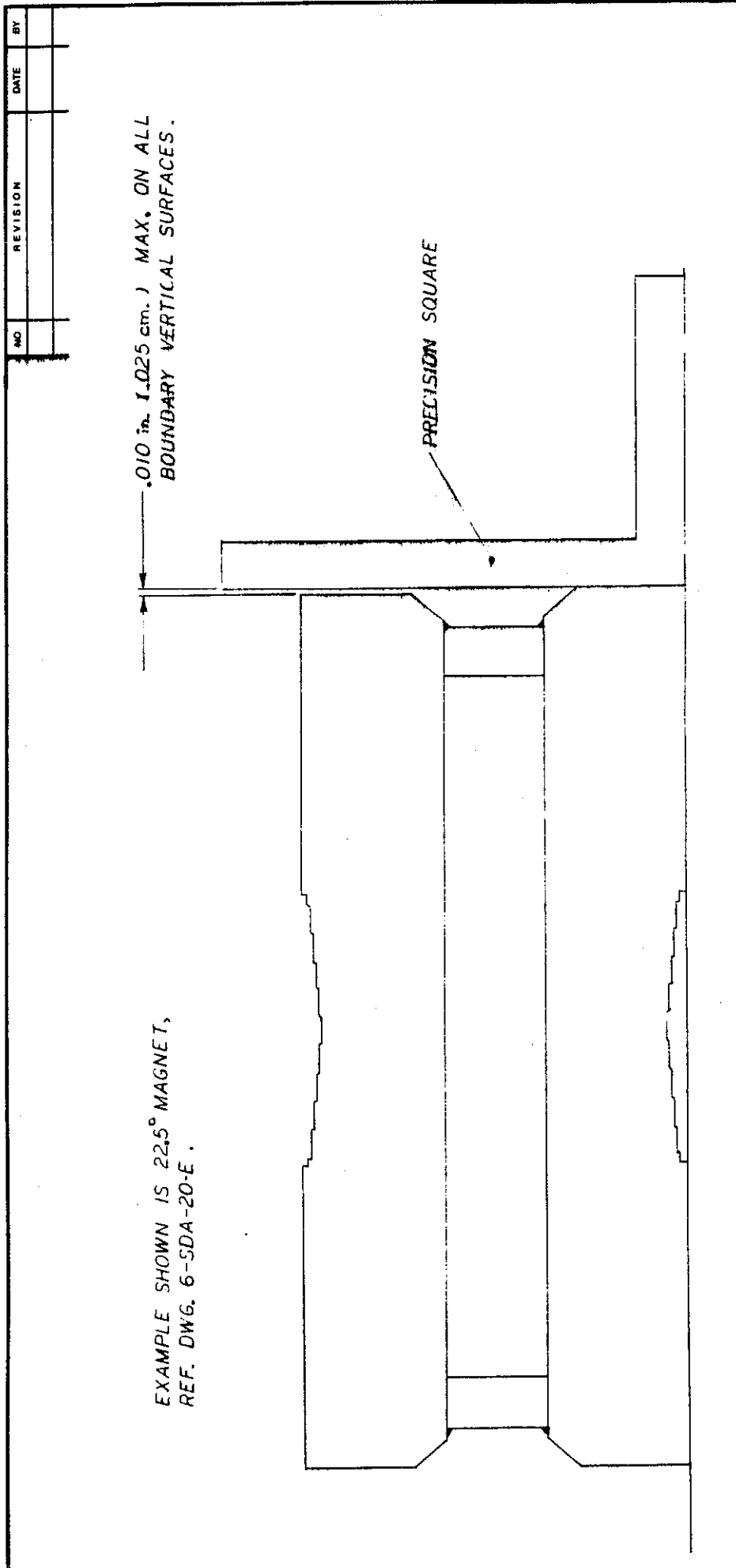
NSCL 6-SDA-17

SHEET

OF

REVISION

BRUNING 40-22 60401



EXAMPLE SHOWN IS 22.5° MAGNET,  
REF. DWG. 6-SDA-20-E.

NO.	REVISION	DATE	BY

PART NO.	PART NAME - DESCRIPTION	MATERIAL	NOTE
	NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY MICHIGAN STATE UNIVERSITY, EAST LANSING, MICHIGAN		
UNLESS OTHERWISE SPECIFIED	DECIMAL DIMENSION TOLERANCES	DRAWN BY	DATE
FRACTIONS	± .010		
ALL ANGLES	± .125		
OTHERS	± .005		
MACHINE SURFACE FINISH	OVER .125 TO .50		
PER ANSI B46.1 - 1978	OVER .50 TO 1.00		
ALL FILLETS AND RADIUS	OVER 1.00 TO 5.00		
	OVER 5.00 TO 30.00		
	OVER 30.00 TO 100.00		
	OVER 100.00		
			SCALE
			FIGURE 2
			DRAWING NUMBER
			NSCL 6-SDA-17
			SHEET
			OF