Relativistic Heavy Ion Collider
Magnet Division Procedure

Proc. No.: RHIC-MAG-M-4344

Issue Date: Jan. 13, 1992

Rev. No.: E

Rev. Date: May 12, 2011

Class: Ancillary Specifications
Title: 1/4 Inch Thick Magnet Steel for RHIC 8cm Dipole and Quadrupole Yoke Laminations

- Prepared by: Signature on File
- Cognizant Engineer/Scientist: Signature on File
- Head, Production Engineering Section: Signature on File
- Cognizant Scientist: Signature on File
- Q. A. Approval: Signature on File
- ES&H Review: Signature on File

REVISION RECORD

Rev. No.	Date	Page	Subject	Approval	QA	ES&H
A	1/13/92		Initial Release.			
B	1/31/92	1-6	Rewritten to Specify			
			Both Coiled Material or			
			Flat Sheets.			
			ECN#MG00054.			
C	7/28/92	Through-	Reference Specification			
		out	as per ECN# MG00160.			
D	3/12/93		Specification Changes as			
			per ECN#378.			
E	5/12/2011		Changes per ECN#2179			

1 Scope:

This specification lists the requirements for 1/4 in. thick extra low carbon magnet steel used for RHIC 8cm production dipole and quadrupole magnet yoke laminations.

2 Applicable Documents:

The following documents, of the issues specified, form a part of this specification to the extent specified herein:

ASTM E8-89b - Standard Test Methods of Tension Testing of Metallic Materials.

ASTM A568-88a - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.

ASTM A596-89 - Standard Test Method for Direct-Current Magnetic Properties of Materials Using the Ballistic Method and Ring Specimens.

ASTM A700-81 - Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment.

ASTM A773-80 - Standard Test Method for DC Magnetic Properties of Materials Using Ring and Permeameter Procedures with DC Electronic Hysteresigraphs.

3 Requirements:

Extra low carbon magnet steel offered by the Seller under this specification shall conform to the requirements of ASTM A568-88a except when stated otherwise in this document. Requirements explicitly specified herein take precedence over those of ASTM A568-88a.

3.1 Chemistry:

3.1.1

Chemical Composition	%
carbon	0.006 max
silicon	0.050 max
aluminum	0.080 max
nitrogen	0.005 max
manganese	0.100 to 0.300

Furthermore, the sum of all alloying ingredients and impurities other than the five elements listed above, shall not exceed 0.2%. The Seller shall provide a list of the additional impurities and quantities that may be expected in a typical heat.

3.2 Mechanical Properties:

3.2.1 Yield Strength:

The tensile yield strength (offset = 0.2%) measured parallel to the material rolling direction shall be 32,000 psi or greater.

3.3 Magnetic Properties:

3.3.1 Coercive Force:

The coercive force (H_c) of the material shall be measured after it is excited by a magnetic force of 100 Oersted. No value of H_c shall differ from the average value of H_c over the entire production run by more than 0.25 Oersted, and no value of H_c shall exceed 1.75 Oersted.

Note: Material with a lower coercive force is desirable provided that all other requirements stated herein remain in accordance with this specification.

3.3.2 Permeability:

The permeability at a magnetizing force of one (1) Oersted shall be greater than 500.

3.3.3 Saturation Magnetization:

A high and very uniform saturation magnetization is necessary. Since variation in saturation magnetization is caused mainly by variations in impurity content, strict impurity limits as stated in paragraph 3.1 are required.

3.4 Physical Characteristics:

The Seller shall supply the steel in the form of slit coils.

3.4.1 Each coil shall possess the following characteristics:

3.4.1.1 Edge Quality: Slit (cut). Mill edges shall not be permitted.

3.4.1.2 Width after slitting shall be 11.25 6 0.03 in.

3.4.1.3 Thickness shall be 0.250 +0.016/-0.000 in.

3.4.1.4 Straightness across slit width (neglecting 0.2 inches in from the slit edges) shall be within 0.010 in.

3.4.1.5 Maximum crown across slit width shall be 0.002 in.

3.4.1.6 Inside diameter shall be between 20 and 24 in.

3.4.1.7 Cross-breaks shall not be permitted.

3.4.1.8 Finish: Pickled. All scaling shall be removed.

3.5 Process Uniformity:

Since the uniformity of magnetic properties of the yoke steel is fundamentally important to the successful operation of the RHIC magnets, there shall be no change in the manufacturing process during the production run. Furthermore, the complete production run with the exception of the first three production magnets' quantity of steel, shall consist of a series of continuous uninterrupted heats.

4 Quality Assurance Provisions:

By making a shipment of magnet steel, the Seller automatically certifies that the steel shipped and all processes applied to the steel comply with this specification and the requirements of the purchase order. The Seller agrees to retain objective evidence, including records, of the inspections and tests performed in the course of manufacturing, testing, inspecting, preserving, packaging, and preparation for shipment of the steel. These records shall be made available to the Buyer's representative for review upon request.

Responsibility for the performance of the following inspections, test, and data requirements rests with the material manufacturer. Finished material shall be subjected to the following inspections and tests.

4.1 Physical Characteristics: Each individual coil shall be inspected for the following physical characteristics:

4.1.1 Coiled Steel:

Edge Quality: paragraph 3.4.1.1
Width after Slitting: paragraph 3.4.1.2
Thickness: paragraph 3.4.1.3
Straightness Across Slit Width: paragraph 3.4.1.4
Maximum Crown Across Slit Width: paragraph 3.4.1.5
Coil Inside Diameter: paragraph 3.4.1.6
Cross-breaks: paragraph 3.4.1.7
Finish: paragraph 3.4.1.8

4.2 Chemical Composition: Tests for material conformity with the requirements of paragraph 3.1 shall be performed by the Seller for each heat.

4.3 Mechanical Properties: Yield strength tests shall be performed by the Seller on a total of nine specimens per heat. Three specimens shall be extracted from the beginning, three from the middle, and three from the end of each heat of the finished product (.25 in. thick material cooled down to room temperature) to determine conformance with paragraph 3.2. Test methods for determination of yield strength shall be as per ASTM E8-89b. The material shall be straightened as required for the machining of tensile specimens.

4.4 Magnetic Properties: Tests for coercive force and permeability (paragraph 3.3) shall be performed by the Seller on ring specimens and shall be in strict conformance with the guidelines described in ASTM A596-89 or ASTM A773-80. Magnetic properties shall be determined based on a total of nine samples per heat (three samples extracted from the beginning, three from the middle, and three from the end of each heat). These samples shall be extracted from the finished product (.25 in. thick material cooled down to room temperature). The material shall be straightened as required for the machining of ring specimens.

4.5 BNL Material Performance Verification: The Seller shall furnish Brookhaven National Laboratory (BNL) with duplicates of each of the tensile specimens acquired as per paragraph 4.3. In addition, after completion of magnetic testing (as per paragraph 4.4), the Seller shall promptly ship either the wound ring specimens obtained in satisfaction of paragraph 4.4 or a set of wound duplicates directly to BNL along with the Seller's test data. These specimens shall be analyzed by BNL in order to verify conformance with this specification. The Seller shall clearly label each specimen so that BNL can determine its origins as well as compare test data acquired from it to the Seller's measurements if necessary. Labeling must also include the wire gauge and number of turns for the primary and secondary coil.

4.6 Non-Conforming Material: Material which does not fully meet the requirements of the purchase order shall not be offered to the Buyer.

4.7 Certificate of Conformance: With each shipment of magnet steel, the Seller shall submit a certificate of conformance. In case of drop shipment, a copy of the certificate shall be submitted to the Buyer at the time of shipment. The certificate shall be signed by an officer of the company, and shall constitute a representation by the Seller that:

A. Materials used are those which have been specified by the Buyer, and that the items delivered were produced from materials for which the Seller has on file reports of chemical or physical analysis, or any other equivalent evidence of conformance of such items to applicable specifications;

B. Processes used in the fabrication of items delivered are in compliance with applicable specifications forming a part of the purchase order, or Buyer approved procedures or specifications;

C. The items as delivered comply with all specifications and other requirements of the purchase order.

4.8 B-H Data: Normal B-H tables with at least twenty data pairs which comprehensively cover the range from 0.5 Oersted to 100 Oersted shall be generated based on measurements of finished material extracted from the middle of each heat.

5 Preparation for Delivery:

5.1 Final Treatment and Packaging:

5.1.1 Before final packaging, all surfaces of the material shall receive a Type A protective coating (thin petroleum oil containing a rust inhibitor) as described in ASTM A700-81.

5.1.2 Each individual coil shall be suitably wrapped, bound, and skidded "eye to the sky" as shown in Fig. 69 of ASTM A700-81 in order to protect it against shipping and environmental damage. Edge protectors must be used under the bands to protect the edges of the coil from being damaged by the bands. The wrapping material shall retard moisture penetration and minimize loss of the protective coating described in 5.1.1.

5.1.3 Each coil shall weigh between 9000 and 10,000 lb.

5.1.4 If transported in open top equipment (such as a flat-bed truck), the coils shall be adequately shrouded to protect them against weather damage. Truck tarpaulins shall be employed in this case unless the wrapping material (stated in Sect. 5.1.2) is certified to be completely waterproof.

5.1.5 For the purpose of crown identification, the thick edge of each coil shall be marked clearly and indelibly.

5.2 Release for Shipment: The Seller shall provide the Buyer with all inspection and test data required in paragraph 4.0 prior to shipment of the material. In no event shall the Seller ship the magnet steel without prior authorization from the Buyer in writing. In the event that material is shipped prior to such authorization, the Seller shall bear all additional costs this action may incur.

5.3 Marking Identification Requirements: Each individual coil shall be identified with the following data, in the order given:

RHIC MAG-M-4344 Rev. _ - 1/4 Inch Thick Magnet
Steel for RHIC 8cm Dipole and Quadrupole Yoke
Laminations
Buyer's P.O. No. _____.
Manufacturer's Name _____.
Heat No. _____.
Coil Serial Number _____.
Sheet Width _____11.25 in._____.
Coil Weight _____.

5.4 Ordering Data: Procurement documents should specify the title, number and date of this specification.