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Specification for Ultra Low Carbon Magnet Steel

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SPEC. SNS Ring Systems-0013

Specification for Ultra Low Carbon Magnet Steel

1.0 SCOPE

This Specification describes requirements for a heavy gauge ultra low carbon steel to be used in the construction of the magnet cores being built for the Spallation Neutron Source project at the Oak Ridge National Laboratory .

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this Specification to the extent specified herein. Unless otherwise specified, the issue date or revision level shall be that in effect on the date of the Request for Quote. Exceptions must be approved in writing by BNL.

Number	Title
ASTM A6	Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use.
ASTM A370	Test Methods and Definitions for Mechanical Testing of Steel Products.
ASTM A596	Test Methods for Direct- Current Magnetic Properties of Materials using Ring Test Procedures and the Ballistic Methods.
ASTM A435	Methods for Determination of Carbon, Sulfur, Nitrogen, Oxygen and Hydrogen in Steel and Iron, Nickel and Cobalt Alloys.
ASTM E415	Test Method for Optional Emission Vacuum Spectrometric Analysis of Carbon and Low- Alloy Steel.
ASTM E1010	Specification for Straight Beam Ultrasonic Examination of Steel Plates

3.0 REQUIREMENTS

An important requirement of the magnets is very uniform magnetic field in the magnet gap from magnet to magnet. To obtain this uniformity it is vital that the magnet steel has uniform chemistry and that it is free from defects. The melt practice shall be directed to yield the maximum uniformity with the minimum defects. When heats of the same nominal chemical composition are consecutively cast at one time, the heat number assigned to the cast product need not to be changed until all of the steel in the cast product is from the following heat. However, when consecutively cast heats have different nominal chemical composition ranges, the manufacturer shall remove the transition material by an established procedure.

3.1 Chemical Composition

The chemical composition of the steel shall be in accordance with the following table:

C	≤ 0.005	**Si**	≤ 0.01	**Mn**	≤ 0.10
P	≤ 0.01	**S**	≤ 0.003	**Cu**	≤ 0.03
Cr	≤ 0.03	**Mo**	≤ 0.005	**Al**	≤ 0.05
N	≤ 0.005	**Fe**	Balance		

3.2 Magnetic Properties

The magnetic properties of the steel shall be in accordance with the following table:

Magnetizing	B_1	B_2	B_3	B_5	B_{25}	B_{125}	B_{250}
Force (A/m)	80	160	240	400	2000	10000	20000
Magnetic Flux	≥ 0.8	≥ 1.3	≥ 1.4	≥ 1.5	≥ 1.65	≥ 1.85	≥ 2.0

Coercive force H_e (A/m) at 1.5 Tesla shall be ≤ 65

Where B_1, B_2, B_3, . . ., B_{250} represent the magnetic flux density at a magnetizing force of 1 oersted, 2 oersted, 3oersted, . . ., 250 oersted respectively.

3.3 Tensile Strength

Tensile properties of the steel plate shall be in accordance with the following table:

Sample Location	Yield Point	Tensile Strength	Elongation
½thickness	≥98 N/mm	≥226 N/mm^2	≥24 %

3.4 Annealing

After flame cutting each part shall be annealed. The annealing cycle will be to heat the part to 1700°F ± 500°F, hold for 1 hour per inch of thickness, furnace cool to 600°F, and then air cool.

3.5 Heat Identification

As the various parts are flame cut from the rolled plate, each plate shall be marked to indicate the heat from which the plate was rolled. The reference mark should be on top surface of the plate as rolled.

QUALITY ASSURANCE PROVISIONS

4.1 General

Articles furnished in compliance with this Specification shall be produced under the controls established herein and as required by the applicable contract. Additional Quality Assurance requirements are in accordance with BNL Quality Assurance (QA)-101, Sections 1, 2, 3 (including 3.1 and 3.1.2), 4.1, 4.3, 4.10, 4.10.1, 4.10.4, 4.16, 4.20, 4.21 and 4.23.

Responsibility for Inspections and Tests

Unless otherwise specified in the contract or purchase order, the Seller shall be responsible for the performance of all inspections and tests specified herein and in referenced specifications. BNL reserves the right to re-perform any of the inspections and/or tests set forth in this or referenced specifications where deemed necessary to assure that supplies and services conform to prescribed requirements. BNL shall be advised two weeks in advance when tests are to be conducted so that representatives may be designated to witness or supervise the tests when so desired. When investigation of a failure or non-conformance indicates that like defects exist or could exist in the items already accepted, the seller shall so advise BNL, designate the necessary corrections and incorporate them after approval by BNL.

4.3 Acceptance Tests

Acceptance tests shall be performed to verify that articles supplied under the contract meet the standards established in Section 3. Acceptance or approval of material during the course of manufacture shall not be construed as a guarantee of its acceptance in the finished product. All articles shall have satisfactorily passed the applicable acceptance tests prior to delivery.

4.3. Chemical Analysis

An analysis of each heat shall be made by the manufacturer to determine the properties of the steel. This analysis shall be made from test sample preferably taken during the pouring of the heat. The heat analysis shall be reported to the BNL representative and shall conform to the heat analysis requirements of this specification.

Magnetic Properties

A magnetic test specimen shall be taken from each heat supplied from a location corresponding to ½ the plate thickness. The test specimen shall be machined into a cylinder with a 12 cm outside diameter x .25 cm wall x 2.0 cm long. The specimen shall be heat treated after machining in accordance with section 3.4 herein. Magnetic flux density shall be determined in accordance with the direct current magnetization test procedure described in ASTM A 596. Results of this test shall meet or exceed the requirements set forth in section 3.2 herein.

Ultrasonic Inspection

Each part shall be ultrasonically inspected per ASTM A435-82. If defects are visible after rolling and flame cutting or are detected during ultrasonic inspection, the part shall be rejected. If in the view of the manufacturer rework can reclaim the part, this shall be approved by the BNL before any work is done.

Tensile Strength Measurement

One tensile specimen shall be taken from each heat. The specimen shall be taken such that the test section corresponds to the location at 1/2 the full plate thickness. General requirements for mechanical tests shall be in accordance with ASTM A 370. The material shall conform to section 3.3 herein.