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BTeV C0 IR Quadrupole Magnet Niobium Barrier Material (Reactor Grade I) Specification

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Abstract:

This note contains the specification of the Niobium barrier material for the BTeV C0 IR Quadrupole Magnets.

This specification was part of a package consisting of: Inner and Outer Cable Manufacturing Specification (5500-ES-371014), Inner Strand Specification (5500-ES-371009), Outer Strand Specification (5500-ES-371010), Niobium Titanium Alloy Bars and Rods Specification (5500-ES-371015), and Niobium Barrier Material (Reactor Grade I) Specification (5500-ES-371016). All specifications were completed by the end of January 2004, a few days before the BTeV project was cancelled. The cable required for the BTeV C0 IR Quadrupole Magnets was identical to the cable used in the LHC IR Quadrupole Magnet, whose specifications were a mix of original and re-used SSC specifications, with some complications due to this mixed status. The specifications for the conductor to be used in the BTeV IR quadrupoles were originated by modifying the specifications for the LHC IR quadrupoles aiming at a complete and smaller set of documents without redundancy and contradictions, and with updated requirements for quality control. A major modification was introduced in the procurement strategy by procuring the cable (instead of strands and cabling separately) in order to have the vendor fully responsible for all characteristics of the final cable including its mechanical stability (a test was added to specify this characteristic).

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BTeV C0 IR Quadrupole Magnet Niobium Barrier Material (Reactor Grade I) Specification

1.0 SCOPE

This specification establishes the minimum requirements for unalloyed, reactor grade, annealed Niobium Sheet. This material will be used in the manufacture of superconducting wire for use in the inner and outer cable for the BTeV C0 IR magnets at Fermilab.

1.1 Definitions

Lot: A lot is defined as all material of a single size, process and casting, heat treated in a single charge in a batch-type furnace.

2.0 APPLICABLE DOCUMENTS

2.1 Applicability

The following documents of the issue in effect on date of invitation for bids or request for bids or request for proposal, form a part of the specification to the extent specified herein.

2.1.1 Government Documents

a) NBS Handbook 91; Experimental Statistics

2.1.2 Non-Government Documents

a) ASTM B-393; Standard Specification for Niobium and Niobium Alloy Strip, Sheet, Foil and Plate.

b) ASTM E-112; Standard methods for determining the average grain size.

c) ASTM E-8; Methods of tension testing of metallic materials.

d) ASTM E-1024; Chemical Analysis of Metals and Metal Bearing Ores by Flame Atomic Absorption Spectrophotometry.

2.2 Source of Documents

Any difficulty in obtaining the applicable documents should be referred to the Fermilab Subcontract Administrator.

2.3 Precedence

In the event of conflict between the requirements of this specification and the above applicable documents, this specification shall take precedence. Any such conflict shall be brought to the attention of the Fermilab Subcontract Administrator.

3.0 REQUIREMENTS

The niobium sheet is to be produced to ASTM B-393 (Reactor Grade I) with additional and overriding requirements as specified herein.

3.1 Chemical Requirements

- 3.1.1 The ingot to be converted to sheet shall conform to the requirements for chemical composition given in ASTM B-393:

Niobium (by difference) 99.85% minimum

% by Weight Maximum

Oxygen	.015
Nitrogen	.010
Carbon	.010
Hydrogen	.001
Tantalum	.100
Titanium	.004
Iron	.005
Silicon	.005
Molybdenum	.005
Tungsten	.030
Other metallics (each)	.003

- 3.1.2 In addition, each heat of Niobium sheet (final product) shall conform to the following requirements for dissolved interstitials:

% by Weight Maximum

Oxygen	.020
Nitrogen	.010
Carbon	.010
Hydrogen	.002

3.2 Mechanical Requirements

Yield Strength (0.2% offset) 10,000 psi (125 MPa) minimum
Elongation (1 in. gage length) 25% minimum

3.3 Metallurgical Requirements

Material shall be at least 90% recrystallized and exhibit a grain size of predominantly ASTM #5 (.065 mm), or finer, with no grains larger than ASTM #4 (.090 mm).

3.4 Ingot Hardness

The ingot shall be 59 BHN average with no individual reading greater than 65 BHN.

3.5 Surface Finish

3.5.1 The niobium sheet shall be free of any injurious imperfections of a nature which would interfere in manufacture or performance of final product.

3.5.2 Care shall be taken in the final rolling process and subsequent handling that no particles of foreign material are rolled or imbedded in the surface.

3.5.3 The material should be supplied with an "as etched" surface free of oxide inclusions, cracks, blisters, or laminations.

3.6 Manufacturing Plan

A manufacturing plan shall be established by the vendor, defined by flow chart, diagram, or narrative; and shall be submitted to Fermilab for review and approval. Where proprietary processes are applied, such processes may be protected by a non-disclosure agreement between Fermilab and the manufacturer. After production start, any changes to the approved manufacturing plan must be brought to the attention of the Fermilab Subcontract Administrator. No changes shall be implemented without written authorization from the Fermilab Subcontract Administrator.

3.7 Statistical Process Control

The Vendor shall institute formal Statistical Process Control throughout the manufacturing process. Methods and control limits shall be documented as part of the Vendor's Quality Plan, which includes material traceability and quality.

4.0 QUALITY ASSURANCE

4.1 Quality Assurance Plan

Prior to the contract being signed, the Vendor shall submit to the Fermilab Subcontract Administrator, for his/her approval, a documented Quality Assurance Plan, which fulfills all requirements described in the present specification. The Vendor shall also submit to the Fermilab Subcontract Administrator, for its approval, a detailed description of the test procedures and the model test certificates, which he proposes to use.

4.2 Responsibility

The vendor shall be responsible for the performance of all tests and inspections required prior to submission to the buyer of any of the products for acceptance. The performance of such tests and inspections does not limit the right of the buyer to conduct tests and inspections to verify conformance to all requirements of this specification. Such buyer testing and inspection shall be confined to the scope of requirements defined in this specification or approved variations thereof.

4.3 Magnet Component Database

The vendor shall submit to the Fermilab Subcontract Administrator, for each shipment of material, all documents requested in this specification (including the results of chemical analysis and mechanical tests). A mechanism for electronic transfer between the vendor and Fermilab may be established through contacting the fermilab Subcontract Administrator.

4.4 Tests

The tests required herein are the minimum required and are not intended to supplant any controls, examination, inspections, or tests normally employed by the vendor to assure the quality of the product.

4.4.1 Chemistry

- a. Impurity levels on ingot and sheet.

4.4.2 Mechanical, in accordance with ASTM E-8

- a. Yield strength
- b. Elongation

4.4.3 Grain size, in accordance with ASTM E-112, Section 3.1.1. (Alternative proposals to the Comparison Procedure will be considered).

4.4.4 Ingot Hardness

a. Brinell Hardness Number

4.4.5 Surface finish: The material must pass a visual inspection with the naked eye (1x magnification) or correction to 20-20 vision, at a distance of no more than .254 m and with the aid of a 100 watt light source. Magnifying aids may be used to determine the following causes for rejection:

- a. Pores, indentions or "orange peeling".
- b. Visible grain or "fish scaling".
- c. Scratches deeper than .0254 mm.
- d. Dirt or grease deposits detected by a wipe test with a clean lint-free white cloth using moderate pressure.
- e. Any imperfection mentioned in 3.5.

4.5 Inspection

Fermilab's Technical Representative and Subcontract Administrator reserve the right to witness manufacturing steps, tests and inspections established under the vendor's quality assurance program to demonstrate compliance with the specification.

4.6 Documentation of compliance

Documentation shall be submitted to the Fermilab Subcontract Administrator that proves that all final products and all fabrication and inspection procedures were in compliance with this specification. Fermilab reserves the right to reject any material not conforming to the requirements of this specification

5.0 PREPARATION FOR SHIPMENT

The material shall be interleaved with non-abrasive antitarnish paper prior to rolling to prevent surface damage. The rolls shall be individually wrapped in such a manner to avoid degrading the surface.