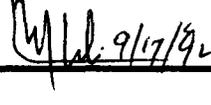


SDC
SOLENOIDAL DETECTOR NOTES

**LOW CARBON (AISI 1010) STEEL
FOR SDC DETECTOR TOROIDS**

October 1, 1992

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SSC LABORATORY Material Specification	DOC. NUMBER SDC-92-332	REV	PAGE 1 of 9
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SPONSORING DEPARTMENT PHYSICS			
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Subject: Low Carbon (AISI 1010) Steel for SDC Detector Toroids			

1.0 Scope

1.1 This specification establishes the requirements for low carbon steel plates used for assembling the SDC Detector Toroids at the Superconducting Super Collider Laboratory.

1.2 This specification covers AISI 1010 low carbon steel or equivalent with controlled permeability.

2.0 Applicable Documents

2.1 Applicability

The following documents form a part of this specification to the extent specified herein.

2.1.1 ASTM Publications:

ASTM A20/A20M Specification for general requirements for Steel plates for pressure vessel.

ASTM A370 Test method and definitions for mechanical testing of steel products.

ASTM A435/A435M Specification for straight-beam ultrasonic examination of steel plates.

ASTM A577/A577M Specification for ultrasonic angle-beam examination of steel plates.

- ASTM A773-80 D.C. magnetic properties of materials using ring and permeameter procedures with D-C electronic hysteresigraphs.
- ASTM E8- Standard testing method of tension testing of metallic materials.
- ASTM E29- Practice for using significant digits in test data to determine conformance with specifications.
- ASTM E112- Standard methods for estimating the average grain size of metals.

2.1.2 Military Standards:

- MIL-STD-163 - Steel mill products, preparation for shipment and storage.

2.1.3 SSCL Documents:

- SSCL QA-1 - SSCL seller quality assurance requirements

2.2 Source of Documents:

Any difficulty in obtaining the applicable documents should be referred to the SDC 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 SSCL subcontract.

3.0 Requirements

3.1 Manufacture

3.1.1 The steel shall be produced by one of the following primary steelmaking processes: open hearth, basic oxygen, or electric furnace. Steel may be made by Killed, semi-killed, capped or rimmed steel practices at the producer's option, provided product meets the chemical, physical, mechanical, and soundness requirements as specified in this specification.

3.1.2 The steel may be cast in ingot or may be strand cast.

3.1.3 The ratio of reduction of thickness from a strand-cast slab to plate shall be a minimum of 3 to 1.

3.2 Chemical Requirements (for both heat & product analysis)

3.2.1 The steel shall conform to the following chemical requirements. The following elements, % by weight maximum, except where range is given.

Carbon	0.08 - 0.13
Manganese	0.3 - 0.6
Silica	0.12 - 0.35
Phosphorus	0.04
Sulfur	0.05

3.2.2 Heat Analysis

An analysis of each heat shall be made by the manufacture to determine the percentages of elements specified. The analysis shall be made from the test sample taken during the pouring of the heat.

3.2.3 Product Analysis

A product analysis may be made by the purchaser from samples representative of the plate/block, heat, and lot. The chemical composition and metallurgical characteristics thus determined shall meet the requirements specified in the body of this document.

3.3 Restricted Unspecified Elements(for both hear & product analysis)

The maximum limits on the following elements are as listed:

Chromium	0.30 %
Nickel	0.40 %
Copper	0.40 %
Molybdenum	0.12 %

The sum of Cu, Ni, Cr, and Mo shall not exceed 1.00 % on heat analysis.

3.4 Mechanical properties

Tensile strength	45-65 Ksi (310-450 MPa)
Yield strength, min.	29 Ksi (200 MPa)
Elongation in 2 in. (50 mm), min, %	38

3.5 Heat treatment

Plates shall be supplied in as-rolled condition. Normalizing or stress relieving is permissible to produce uniform microstructure and mechanical properties provided it does not adversely effects the permeability.

3.6 Metallurgical Structure

Steel shall exhibit the uniform microstructure throughout the cross section of plate. Steel shall conform to the austenitic grain size of Number 6 to 8 range. Steel shall be free of excessive blow holes, seams, segregation, internal fissures, cracks, pipes and non-metallic inclusion to the extent that the integrity of the material is maintained to its final application.

3.7 Grain size

Steel shall conform to the grain size of Number 6 to 8 range as determined by McQuaid-Ehn test.

3.8 Surface soundness

The finished product shall be free from visually detectable cracks, seams, silver, blisters, laps, gouges, and other injurious imperfections visible to the unaided eye, corrected to 20/20 vision.

3.9 Internal soundness

Plates shall be inspected for internal discontinuities such as pipe, rupture, laminations, and surface imperfection using Ultrasonic examination.

3.10 Inclusions

The type, size, and severity level of inclusions shall be subject to agreement between the purchaser (SSCL) and the manufacturer.

3.11 Permeability

Permeability shall be greater than 164 at B=1.8 Tesla as measured in the long direction of a plate. The permeability shall be within +/- 3% of the nominal value for all plates.

Permeability shall be measured as per ASTM A 773-80 specification.

3.12 Maximum Carbon Equivalent for weldability

Plates shall be supplied with maximum carbon equivalent of 0.46 when checked based on heat analysis. The carbon equivalent shall be calculated using the following formula.

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

3.13 Size and Tolerance

3.13.1 Plate size and tolerance are as specified on the applicable drawings

SDD000324A	Long Upper Edge Plate
SDD000325A	Long Upper Center Plate
SDD000326A	Long Bottom Center Plate
SDD000327A	Short Edge Plate
SDD000328A	Short Center Plate
SDD000422	Full Upper Side Plate
SDD000423	One-Third Upper Side Plate
SDD000424	Two-Third Upper Side Plate
SDD000425	Full Bottom Side Plate
SDD000426	One-Third Bottom Side Plate
SDD000427	Two-Third Bottom Side Plate
Sdd000430	Long Bottom Edge Plate

3.13.2 Following Parameters are applicable to all plates.

Flatness	1.5 mm/meter
Crown	2.5 mm over the entire cross section
Parallelism	3 mm max, over the entire cross section
Machining	Center plates within +/- 0.5mm

4.0 Quality Assurance

A quality assurance program will be maintained to insure that each plate offered for acceptance or approval conforms to the requirements herein. A quality assurance plan must be submitted by JINR and its subcontractors to the SDC Project Manager prior to start of fabrication of the prototype blocks.

4.1 The quality assurance plan shall conform to SSCL QA-1 except as noted below.

4.2 In the event of conflict between this specification and QA-1, this specification shall take precedence.

4.3 Responsibility

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

4.4 Inspection and Test

The SSCL's technical representative and subcontract administrator reserve the right to witness manufacturing steps, tests and inspections established under the JINR's quality assurance program to demonstrate compliance with this specification.

4.4.1 Plate Composition

The average elemental composition of each plate shall be established based on representative sampling and shall conform to para 3.2.1 & 3.3 of this specification.

4.4.2 Product Chemical Composition

The average elemental composition of each lot/block shall be established based on representative sampling and shall be conforming to para 3.2.1 & 3.3 of this specification.

4.4.3 Mechanical Testing

4.4.3.1 Test specimens selected for mechanical tests shall be heat treated with the same procedure as the plates.

4.4.3.2 Test samples shall be machined to the form and dimension as per ASTM practice E 8

4.4.3.3 Test results shall conform to the para 3.4 of this specification when tested as per ASTM practice E 8. To determine conformance with the mechanical tests requirements, an observed value or calculated value shall be rounded off in accordance with ASTM practice E 29 to the nearest 500 psi for tensile strength and to the nearest 1% for elongation.

4.4.4 Heat treatment

Type of heat treatment if required, shall be as agreed upon between the manufacturer and SSCL.

4.4.5 Metallurgical Structure

Acceptance criteria for metallurgical structure shall be as agreed upon between manufacturer and SSCL.

4.4.6 Grain Size

Grain size shall be number 6 to 8 range as determined in accordance with ASTM practice E 112

4.4.7 Surface Soundness

Acceptance criteria for surface soundness shall be as agreed upon between manufacturer and purchaser.

- a) Plates furnished under this specification shall be free from injurious defects and shall be a workmanlike finish.
- b) All injurious surface imperfections shall be removed by the manufacturer.
- c) Shallow imperfection shall be ground to sound metal; the ground area shall be well faired and thickness of ground plate shall not reduced below the minimum thickness permitted.
- d) Laminar-type discontinuities 1 in. (24 mm) and less in length visible to the unaided eye on the edges of the plate are acceptable.
- e) All larger discontinuities on the edge shall be explored to determine their depth and extent. Discontinuities shall be considered continuous when located in the same plane within 5% of the plate thickness and separated by a distance less than the length of the smaller of two adjacent discontinuities.
- f) Discontinuities on the cut edges of a plate shall not exceed the limits given in columns 1 & 2 of table A1.14 Of ASTM specification A 20/A 20M.
- g) Larger indications shall be removed by the manufacturer by grinding provided the resultant cavity does not exceed the limits given in columns 3 & 4 of table A1.14.
- h) Repair welding of plates to bring within acceptable limits will required the prior approval of the purchaser.

4.4.8 Interl Soundness**a) Ultrasonic examination:**

- 1. Gross internal discontinuities such as pipe, rupture or laminations shall be examined per ASTM A435/A435M**
 - 2. Internal discontinuities not laminar in nature and surface imperfection shall be examined per ASTM A577/A577M**
- b) Resistance of a steel plate to lamellar tearing shall be examined per ASTM A-770/A-770M**

4.4.9 Inclusions

The acceptance level of inclusions shall be subject to agreement between the purchaser (SSCL) and the manufacturer.

4.4.10 Permeability

Permeability shall conform to para 3.11 of this specification when measured as per ASTM A 773-80

4.4.11 Weldability

Maximum carbon equivalent for weldability shall conform to para 3.12 of this specification.

Weldability tests shall be conducted. The type of test and acceptance criteria shall be as agreed upon between the manufacturer and SSCL.

4.4.12 Size and Tolerance

Size and tolerance shall conform to para 3.13 of this specification.

4.4.13 Approval and Acceptance

All documents for final approval and acceptance must be submitted to the SSCL on the schedule in Annex A. Acceptance may be subject to source inspection. The SSCL reserves the right to reject any materials not conforming to the requirements of this specification.

