Brookhaven National Laboratory
Associated Universities, Inc.
STAR Collaboration

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Title: Specification for STAR Solenoid Magnet Main Coil Aluminum Conductor
QA Category: A2

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REVISION RECORD

Rev. No.	Date	Page	Subject	ECN

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Specification for STAR Solenoid Magnet

Main Coil Aluminum Conductor

1.0 GENERAL

1.1 Summary

This specification describes the aluminum conductor used for the Main coils and Space Trim coils of a large solenoid magnet detector system. This detector system is known as the Solenoidal Tracker at RHIC (STAR) and will be installed in the Relativistic Heavy ion Collider which is a particle accelerator being constructed at Brookhaven National Laboratory.

1.2 Scope

This specification outlines the minimum requirements governing the materials, fabrication and testing of the electrical conductor used in the Main coils and Space Trim coils of the STAR detector. The seller shall:

1. Manufacture the aluminum conductor in strict accordance with this specification and all other documents listed.
2. Perform testing on all material to assure compliance with this specification.
3. Deliver the completed conductor to a coil manufacturing facility specified by the buyer.

1.3 Access

Designated representatives of the Buyer shall be allowed access to the production and test areas of the Seller's facilities, and , if applicable, the Seller's subcontractor facilities during the progress of work called for by this specification. The Seller shall assist and facilitate inspection visits of the Buyer.

2.0 DOCUMENTS AND STANDARDS

2.1 The following documents are an integral part of this specification:

2.1.1 Brookhaven National Laboratory drawings MAG113-B-1 and MAG124-A-1.

2.1.2 Published Standards:

ASTM B193 "Standard Test Method for Resistivity of Electrical Conductors."

ASTM B236 "Standard Specification for Aluminum Bar for Electrical Purposes (Bus Bars)."

ASTM B324 "Standard Specification for Aluminum Rectangular and Square Wire for Electrical Purposes."

All standards shall be the latest revision available at the start of the contract.

2.2 Dimensional Units

All dimensions provided in the specifications and drawings are in "U.S. Customary" (English) units. Should the Seller wish to work in S.I. or metric units, he shall submit to the Buyer for approval duplicate drawings containing the units of choice.

2.3 Conflicts

In the event of a conflict between the Drawings and this Technical Specification, the Seller shall immediately notify the Buyer. The Buyer in each instance shall determine which document takes precedence and advise the Seller accordingly. Failure of the Seller to so notify the Buyer in any given instance shall not relieve the Seller of the obligation to comply with the Buyers determination of precedence at no additional cost to the Buyer.

2.4 Revisions

Any and all specification and/or drawing revisions shall be documented and negotiated by both parties. Any cost differential shall be recorded and approved in writing by both parties.

3.0 SUBMISSIONS AND APPROVALS

3.1 Production Schedule

The Seller shall submit to the Buyer a production schedule showing the actual completion date after the formal order is placed. This shall be submitted within 30 days after receipt of the order.

3.2 First Piece Acceptance

The Seller shall submit to the Brookhaven National Laboratory technical representative a test specimen before beginning the production run of the conductor. This specimen shall be at least 20 feet in length and shall contain at least one marked press stop. The Brookhaven technical representative shall, after testing, notify the Seller regarding acceptance or rejection of the test specimen. The production run shall not begin until the test specimen has been accepted.

4.0 CONDUCTOR PARAMETERS

4.1 Material

The aluminum conductor shall be fabricated from either alloy 1060 or 1350 and supplied to the coil vendor in the T-0 temper condition.

4.2 Dimensions

The cross sectional dimensions of the conductor are as follows:

width = 2.120" ± 0.010"
height = 1.870" ± 0.010"
center hole = 0.660" ± 0.010" diameter
corner radius = 0.13"

The conductor cross section is shown in drawing MAG113-B-1.

The conductor shall be fabricated in continuous lengths of between 400 to 500 feet. The minimum acceptable length of useable conductor will be specified at the placement of the order. Material required for testing as outlined in Section 6 will be in addition to the minimum length required and the seller shall produce additional material consistant with the testing requirements. The tolerance on the length of conductor shall be -0/+20 feet. Spooling requirements are as outlined in Section 5.

Additional lengths of conductor may be required for bussing or other purposes and their lengths specified at the time of the order.

4.3 Mechanical Properties

The conductor shall be in the annealed condition as it emerges from the forming process. The mechanical properties of the conductor at that point shall be in accordance with ASTM B 324.

Effect of die bridges: The fusing of the material after it has flowed past the bridges of the forming die shall be sufficiently good that failure of a specimen under a flare test does not occur as a separation due to inadequate bonding. Details of the flare test are given in Appendix I.

4.4 Electrical Properties

The volume conductivity of the conductor shall be in accordance with ASTM B 324: 61.8% IACS or greater, that is, a volume resistivity at 68°F of 1.0984 μΩ-inch or less.

5.0 FABRICATION ENVIRONMENT AND SPOOLING

5.1 Environment

The conductor material shall be fabricated in a clean environment to assure that the material is not exposed to any mechanical or chemical hazards to both the outside surfaces and the interior bore as well. The Seller shall take all steps necessary to protect the conductor material during fabrication, storage and shipment to avoid these hazards.

5.2 Spooling

Each continuous length of conductor material shall be spooled onto a reel having a minimum inside diameter (drum) of 84 inches. The traverse of this reel shall be such that all material from each continuous length shall be spooled on a single layer. Each reel shall contain only one length (piece) of conductor material. The material is to be spooled in a manner that both ends are accessable for "on reel" testing.

5.3 Cleanliness

The conductor material shall be produced with the minimum of lubricants. It is preferred that no lubricants be used if possible. In any event, the conductor shall be throughly cleaned on all inside and outside surfaces prior to shipping. Shipping shall be accomplished in a manner to preserve this cleanliness.

At no time shall any materials containing silicones come in contact with the conductor material.

6.0 Testing and Inspection

6.1 Dimensional

During fabrication of the conductor, the height and width of the conductor shall be continuously monitored and the actual dimensions will be recorded every 25 feet and this information will be reported in the inspection report described in Section 6.6.

6.2 Ball Test

Following the spooling of the material onto a reel, a ball test will be performed. A 0.500 ± 0.005 inch diameter ball will be blown through the conductor bore to test for obstructions. Failure of the ball to pass through a length shall be cause for rejection of that length. The result of this test shall be recorded on the report described in Section 6.6.

6.3 Pressure Test

After the material has been spooled onto a reel, the ends of the bore will be sealed and the bore pressurized to a minimum of 375 psig with helium. After one hour, the entire spool shall be bagged and "sniffed" with a helium leak detector. Leaks detected using the most sensitive scale of the leak detector shall be considered a test failure. The result of this test shall be recorded on the report described in Section 6.6.

6.4 Resistivity Test

The results of this test shall be recorded as described in Section 6.6.

6.5 Flare Test

A short sample from each end of each reel shall be flare tested to determine any adverse effects from die bridges. The description of the flare test is given in Appendix I. Results of the flare test shall be recorded as described in Section 6.6.

6.6 Inspection Report

An inspection report will be prepared for each reel. Three copies will be made with one copy being mailed to the Buyer's Technical Representative, one copy mailed to the Brookhaven National Laboratory Technical Representative and one copy accompanying the reel as it is shipped to the coil winding vendor. The report shall contain:

1. A serial number for the material on the reel. This serial number must be unique and is generated by the Seller.

2. Date of manufacture.

3. A record of the height and width data described in Section 6.1. This data shall be recorded to the nearest 1/1000th of an inch. Additionally, the bore diameter and material length shall be included.

4. A record of performance and passing of the ball test described in Section 6.2.

5. A record of performance and passing of the pressure test described in Section 6.3.

6. Numerical results of the conductivity/resistivity measurements as described in Section 6.4.

7. A record of performance and passing of the flare test as described in Section 6.5.

8. A record of the number of press stops for the particular length.

All test results shall be accompanied with the date they were performed and the name of the person performing the test.

7.0 MATERIAL NOT TO SPECIFICATION

Any material which fails any of the required tests is deemed to be not to specification. Proposals for rework and/or repair of material not to specification shall be submitted to both the coil manufacturer and to the Brookhaven National Laboratory technical representative for resolution.

All rework and/or repair shall be at the expense of the Seller.

8.0 MARKING

Each press stop on a length of conductor shall be clearly marked.

Each reel shall be marked as follows:

Brookhaven National Laboratory
STAR Magnet Conductor
Drawing # MAG113-B-1
Revision Letter
Serial Number
Seller's Name

9.0 PACKING

The Seller is responsible for the proper packing or crating to ensure that damage is not incurred during shipment and shall be in accordance with transportation industry standards, and conductor packaging design shall be approved by the Buyer. In particular, all liquid and/or solid material shall be removed from the bore and the ends sealed. Additionally, the packaging shall be such as to prevent the conductor material from coming into contact with any moisture. The Seller shall be responsible for procuring all permits, etc. necessary for the delivery of all reels of conductor to the coil vendor specified by the Buyer.

APPENDIX I

HOLLOW CONDUCTOR FLARE TEST

Purpose: To flare and stretch the metal in all four walls of the hollow bore to determine the integrity of any longitudinal welds.

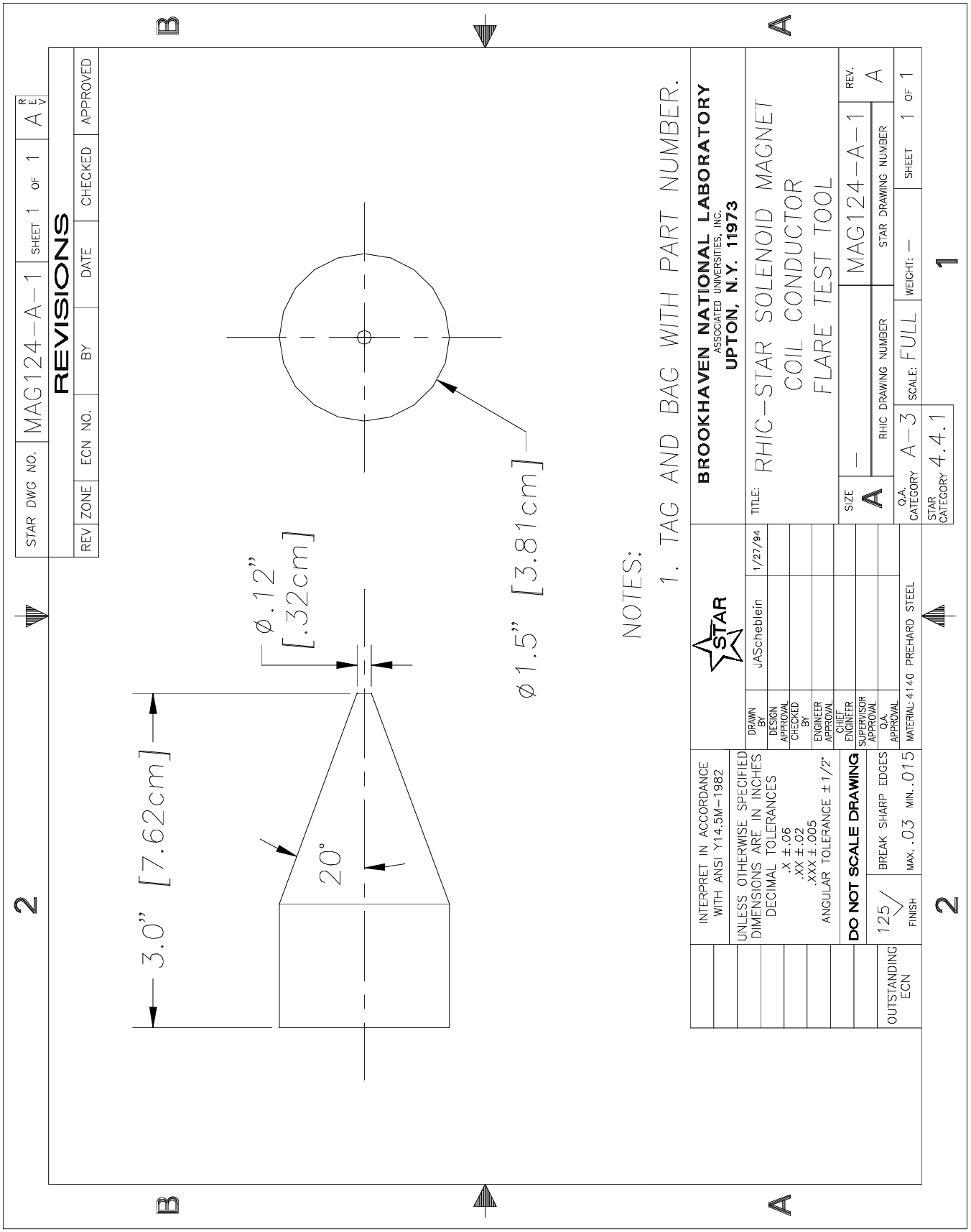
Description: Two flare samples shall be cut, one from each end of the reel and shall be tested as follows by the Seller using a 20 degree flaring tool as per drawing MAG124-A-1.

On each test sample the flaring tool shall be forced into the hollow bore by means of a press.

The flare tool is to expand the internal diameter (ID) of the hole until the ID increased by 50 percent or a separation takes place, whichever occurs first.

If separation occurs before 15 percent increase of ID, and continues to occur with two re-tests and if both ends of the length separate, the complete coil or reel will be rejected.

If separation occurs between 15 percent and 50 percent ID increase, the Seller will analyze the characteristics of the separation. An unacceptable separation is one on which both parted faces show evidence of longitudinal stream line and not the random grainy surface which is characteristic of sound metal.


STAR DWG NO. MAG124-A-1 SHEET 1 OF 1 REV A
REVISIONS
REV ZONE ECN NO. BY DATE CHECKED APPROVED
3.0" [7.62cm]
20°
ø.12" [.32cm]
ø1.5" [3.81cm]
NOTES:
1. TAG AND BAG WITH PART NUMBER.
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N.Y. 11973
TITLE: RHIC-STAR SOLENOID MAGNET COIL CONDUCTOR FLARE TEST TOOL
SIZE A
RHIC DRAWING NUMBER —
STAR DRAWING NUMBER MAG124-A-1
REV. A
Q.A. CATEGORY A-3
STAR CATEGORY 4.4.1
SCALE: FULL
WEIGHT: —
SHEET 1 OF 1
STAR
DRAWN BY JAScheblein 1/27/94
DESIGN APPROVAL
CHECKED BY
ENGINEER APPROVAL
CHIEF ENGINEER
SUPERVISOR APPROVAL
Q.A. APPROVAL
MATERIAL: 4140 PREHARD STEEL
INTERPRET IN ACCORDANCE WITH ANSI Y14.5M-1982
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DECIMAL TOLERANCES
.X ± .06
.XX ± .02
.XXX ± .005
ANGULAR TOLERANCE ± 1/2°
DO NOT SCALE DRAWING
OUTSTANDING ECN
125 FINISH
BREAK SHARP EDGES
MAX. .03 MIN. .015
2
1
A
B