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SPEC. SNS Ring Systems – 0014
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Specification
For
High Energy Beam Transport Dipole Magnets

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SPEC. SNS Ring Systems-0014

SPECIFICATION FOR HEBT Dipole Magnets

1.0 SCOPE

This Specification, in conjunction with associated drawing(s), specifications, and other applicable documents, defines the design requirements, configuration, materials, quality assurance, inspection, testing, workmanship, cleaning, and packaging for two sizes of dipole magnet for the Spallation Neutron Source (SNS) High Energy Beam Transfer (HEBT) line. Magnets supplied under this Specification will be used to guide a high intensity beam of protons.

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 Invitation to Quote. Exceptions must be approved in writing by BNL.

Number	Title
BNL-QA-101	BNL Seller Quality Assurance Requirements
SPEC. SNS-0001	Specification for Radiation Resistant Fiberglass/Epoxy Insulated Magnet Coils
SPEC. SNS-0013	Specification for Ultra Low Carbon Steel

3.0 REQUIREMENTS

3.1 Magnet Parameters

The following parameters are provided for information only:

Designation	Core Aperture Dim. (HxWxL) inches	Field kG	Current Amps	Coil Turns (total magnet)	Weight Lbs.
8D533	3.2 x 20.0 x 209.7	2.5	665	24	31,000
8D414	3.2 x 20.0 x 160.0	2.5	665	24	26,000

3.2 Units

Parameter dimensions for the magnets and the drawing dimensions are in English units (inches and pounds).

3.3 Manufacturing

The magnet steel is to be fabricated in accordance with the accompanying drawings for this purchase order. The steel shall meet the tolerances as defined in the drawings. All dimensions are for the steel in the unrestrained condition. The steel shall meet the requirements of SPEC. SNS-0013 Specification for Ultra Low Carbon Steel. The pinning of the magnet core must provide the accuracy necessary for the magnet to be meet the dimensional requirements after it has been disassembled and reassembled without special jigs or fixtures. All exterior surfaces of the magnet steel and associated ferrous parts shall be properly cleaned and painted with two coats of primer, followed by one coat of BUYER approved machinery enamel. The pole tips and the mating steel surfaces shall not be painted. A suitable surface coating shall be selected by the VENDOR approved by the BUYER to prevent rusting. Stainless steel and nonferrous parts shall not be painted.

The magnet coils are to be fabricated in accordance with the accompanying drawings for this purchase order. The coils shall meet the requirements of SPEC. SNS-0001 Specification for Radiation Resistant Fiberglass/Epoxy Insulated Magnet Coils.

3.4 Water System

Water manifolds shall be provided that allow single point connections to the water supply and return hoses in the SNS tunnel. The cooling water in the SNS tunnel will have 150 psig maximum supply pressure, 95° F maximum inlet temperature, and maximum 130° F outlet temperature. A pressure gradient of 80 psig minimum shall be maintained across the magnet.

The tunnel cooling water hoses will enter the magnet manifolds from below. The water manifolds shall be mounted on the return steel side of the magnets. All water manifold components shall be stainless steel and they shall be electrically grounded to the magnet core. All wetted surfaces in the magnet system shall be Type 304 stainless steel, oxygen free copper, ceramic, or approved hose material. No aluminum or brass is allowed. Each magnet coil will be supplied with water directly from the manifolds (the coils will be cooled in parallel).

The water system fittings shall be Parker Fluid connectors stainless steel FTX type Triple-Lok, 37° flared tube end/male pipe end conforming to SAE 070102 (Parker Hannifin Corp. Columbus, Ohio). The electrical isolation break shall be provided by Synflex^{R} hoses type 3740 with orange non-perforated cover, electrically non-conductive conforming to SAE100R7. Working pressure shall be 1000 to 3000 psi. To reduce the possibility of radiation damage the hoses shall not be routed between the magnet coils near the aperture of the magnet.

3.5 Power Cable Terminations

The dipole magnets will be powered by two 600 MCM cables for each magnet lead (for a total of four cable terminations). The cables will be terminated with part number 54220 cable termination lugs from Thomas & Betts Co, Memphis TN. The magnets shall be provided with terminal blocks or flags for the cable termination lugs. The terminals shall be located on the return steel side of the magnet. The weight of the termination and the cable shall be supported by the core steel of the magnet not the magnet coil leads. Bus of sufficient size and rating shall be used between the coil ends and the termination block. All mating surfaces shall be silver plated as needed to provide a low resistance joint. The terminal support insulation shall be sufficient to allow the magnet assembly to meet the test requirements of section 4.4.3 herein.

3.6 Temperature Monitoring

Thermal protection for the magnet coils shall be provided by thermal switches that open when the surface temperature exceeds a preset value of 170 °F. The thermal switches shall be part number 3156-009-009 silhouette hermetic thermostats from Elmwood Sensors Inc., Pawtucket RI (w/terminals mounted at 90°, solder connections, gold plated terminals, 16mAmps D.C.). There shall be two thermal switches located on the end surfaces of each coil (total four per magnet) and shall be in good thermal contact with the coils. The thermal switches shall be electrically insulated from the copper conductor. The thermal switches shall be wired to a single terminal block that is located on the return steel side of the magnet.

3.7 Marking

Prior to shipping, each magnet shall be identified by an identification plate mounted to the return side core steel. The plate information shall include the magnets assembly drawing number with revision, its serial number, magnetic field, the current, the effective length, the weight of the magnet assembly, and the Vendor's name. In addition each core block is to be marked at the mating surface in accordance with the associated core drawings.

3.8 Repairs

The Buyer will not accept any magnet assembly that has been reworked or repaired in whole or in part unless the rework or repair was authorized in writing by the Buyer.

3.9 Hazardous Materials

Materials that may be defined as hazardous in accordance with Title 29, Code of Federal Regulations, Section 1910.1200 Appendix A and B (attached) shall not be used without written approval from BNL.

4.0 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, 4.5, 4.10, 4.10.1, 4.10.2, 4.16, 4.18, 4.18.3, 4.18.4, 4.20, and 4.21.

4.2 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.

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. The acceptance test data for each delivered coil shall be recorded on a "Coil Data Sheet" (attached). Copies of the Seller certified test results shall be submitted to the Buyer.

4.3.1 Hydrostatic Test

After assembling the magnet the water cooling system shall be filled with water and pressured to 300 psig. The magnet shall be isolated from the pressure source for a period of 1 hour and any pressure changes shall be recorded on the Magnet Traveler Sheet at intervals of 15 minutes. Recorded data shall include the following:

Coil water pressure to the nearest 0.5 psig.
Coil water temperature to within 2 deg F.

The coil shall show no evidence of external leakage or internal pressure drop other than that resulting from any changes in water temperature.

4.3.2 Hydraulic Flow Test

After assembling the magnets, they shall be checked for water flow in gallons per minute at a pressure differential of 85 psi with a water temperature range of 60°F to 80°F. The 8D533 shall provide a water flow of 2.0 GPM minimum and the 8D400 shall provide a water flow of 2.7 GPM minimum. In addition, no magnet shall have a flow rate that is 30% less than the average for the other magnets of the same type.

4.3.3 Ground Insulation

The insulation to ground of the fully assembled magnet shall be tested to withstand 10,000 volts DC for one minute applied between the coil leads and the magnet core. Evidence of insulation breakdown or damage or a leakage current that exceeds 100 micro amps at 10,000 volts DC shall be cause for rejection.

4.3.4 Magnet Resistance

The Ohmic resistance of the assembled magnet shall be measured and recorded to four significant figures, at 70 $\pm$5 °F, by means of a standard commercial Double Kelvin Bridge. Ohmic resistance readings that exceed $\pm$ 10% of the average readings for all the magnets produced or that does not meet the resistance specified by the buyer shall be rejected.

4.3.5 Dimensional Compliance

The Seller shall inspect and verify dimensional compliance of the core and coils to their respective drawing.

4.3.6 Visual Inspection

The Seller shall inspect the magnet assembly for voids, cracks, fissures, missing hardware, or other defects before packing and shipping.

4.3.7 Magnetic Measurement (Optional)

The seller shall do D.C. magnetic measurements to verify the quality of the magnets, to determine the magnetic center of the magnet, and to find the extent of the good field region of the magnet. These measurements are to be done on each magnet produced. This data is to be correlated to the four survey fiducals that are located on the top magnet core steel. The survey information, field measurements, and other pertinent data shall be sent to BNL in a common digital format agreed to by BNL and the vendor. The measurement results are to be approved by BNL staff before the magnet is shipped; preferably before it is taken off the test stand. The approvals shall be given in a timely fashion, within five or fewer working days.

The magnet is to be measured at its two operating currents 510 A and 665 A and two additional test currents 460 A and 730 A. Measurements are to be made from the highest current to the lowest. Before measurement, the magnet is to be cycled three times between power supply idle current and 730A and then run at 730 A for one hour. Except as noted, the random measurement error shall be less than 10% of the required values and the systematic measurement error shall be less than 10% of the required values. The magnet current shall be determined to an accuracy of 0.1 A (either random or systematic). The current measurement shall be traceable to an NBS standard. The random error in the field angle measurement shall be less than 0.25 mrad. The systematic error shall be less than 0.1 mrad. A complete set of measurements is to be done twice for each magnet.

The magnet parameters to be measured, and the required values, are as follows.

1. INTEGRAL DIPOLE FIELD, $\int Bdl$. The integral dipole field is to be within 1 part in 1,000 of the design value when measured at the horizontal and vertical center of the magnet aperture. The magnet-to-magnet rms fractional variation is to be 2 parts in 10,000 or better. The measurements can be made with a straight measuring coil (i.e., the coil does not have to follow the orbit of the particle).

2. FIELD UNIFORMITY. The variation of the integral dipole field across the aperture ("good field region") shall be at most 1 part in 1,000. The dimensions of the good field region are 4.5 cm vertical by 15 cm horizontal, centered on the magnet aperture.

3. HORIZONTAL AND VERTICAL CENTER OF MAGNETIC FIELD. The vertical center of the magnetic field is the midpoint between the poles. The horizontal center is the horizontal center of poles. These centers shall be determined with respect to external fiducials within 1 mm.

4. AXIAL CENTER OF MAGNETIC FIELD. The center shall be determined with respect to the fiducials within 1 mm.

5. ROLL, PITCH, YAW. The roll of the magnet, the difference between the vertical field of the magnet measured magnetically and the level position of the magnet determined mechanically, shall be less than 2 mrad. The pitch and yaw of the magnet shall be less than 1 mrad. Roll, pitch, and yaw measurements shall be given with respect to the fiducials on the magnet.

4.4 Inspection of BNL Furnished Material (if applicable)

When material is furnished by BNL, the Seller's procedures shall include as a minimum the following:

(a) Examination upon receipt to detect damage in transit.
(b) Inspection for completeness and proper type.

(c) Periodic inspection and precautions to assure adequate storage conditions and to guard against damage from handling and deterioration during Storage.
(d) Functional testing as required to determine satisfactory operation.
(e) Identification and protection from improper use or disposition.
(f) Verification of quantity.

The Seller shall report to BNL any BNL furnished material found damaged, malfunctioning or otherwise unsuitable for use. Use of BNL furnished material in no way relieves the Seller of the responsibility to furnish an acceptable product.

5.0 PREPARATION FOR DELIVERY

The Seller is responsible for proper packing or crating of the magnet assemblies. Magnets shall be packaged to protect them from damage during shipping. 1g accelerometers shall be mounted on each magnet assembly to measure in all three planes. Wooden wedges and packing reinforcements may be used provided they do not damage the magnet components.

Water shall be completely drained from each magnet, and the coolant system dried by blowing air through it. When dry, both ends shall be suitably sealed. Flare fittings shall be protected with suitable plastic caps that shall also serve to seal off the water passages.

Coils shall be packed in completely enclosed containers in accordance with the coil specification.

6.0 NOTES

6.1 Seller Suggested Modifications

The Seller is encouraged to bring to the attention of BNL any improvements in design, performance, or reliability that would result form the use of materials, parts, and processes other than those specified. A request for approval of such improvements shall be submitted to BNL for consideration accompanied by complete supporting information. Changes may be made only with the written approval of BNL.

6.2 Seller Subcontracting

The seller may subcontract all or part of the work defined by this Specification. However, the seller is responsible for fulfilling all of the conditions given in the Specification and the requirements of the Terms and Conditions in the Contract/Purchase Order.

6.3 Defects in Items Already Accepted

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.

BROOKHAVEN NATIONAL LABORATORY MAGNET INSPECTION DATA SHEET

Manufacturer: _____ Serial No:

Magnet Assembly Drawing No: _____ Date:_____

Purchase Order No.: _____

4.4.3 Hydrostatic Test By: _____Date:_____[]passed [ ]failed

Interval (min)	Pressure (psig)	Temperature (F)
1		
15		
30		
45		
60		

4.4.4 Flow Test By: _____Date: [ ]passed [ ]failed

Flow (US gpm)		Δ Pressure (psig)		Temperature (°F)	

Upper Coil Serial Number:_____ Coil Traveler Attached [ ]

Lower Coil Serial Number:_____ Coil Traveler Attached [ ]

4.5.1 Magnet Ground Insulation Check By:_____Date:_____[ ]passed [ ]failed

4.5.3 Magnet D.C. Resistance By: _____Date:_____[ ]passed [ ]failed

Leakage Current @ 10 kVDC	micro amps	DC Resistance	Ohms	Temperature (°F)	

4.5.4 Dimensional Compliance Check By:_____Date: _____[ ]passed [ ]failed

Notes:_____

4.5.6 Visual Inspection By:_____ Date: _____[ ]passed [ ]failed

Notes:_____