Relativistic Heavy Ion Collider
Magnet Division Procedure

Proc No.: DESY-MAG-M-4009

Issue Date: Nov. 24, 1998

Rev. No.: A

Rev. Date: Nov. 24, 1998

Class: DESY Combined Function Magnets
Title: Nb-Ti Superconducting Cable for HERA Upgrade IR Quadrupole Magnets

- Prepared by: Signature on File
- Cognizant Engineer/Scientist: Signature on File
- Head, Production Engineering Section: Signature on File
- Q. A. Approval: Signature on File
- ES&H Review: Signature on File

REVISION RECORD

Rev. No.	Date	Page	Subject	Approval
A	11/24/98		Initial Release	

1. Scope:

This specification establishes the requirements for the manufacture, inspection, test, identification and delivery of Nb-Ti superconducting, insulated cable for use in DESY Combined Function Magnets. The seven-wire cable is to be fabricated using 0.013 in.(0.33 mm) superconducting wire supplied by BNL. The cable is then electrically insulated with a polyimide polymer wrap and coated with an epoxy adhesive.

The main emphasis of the specification is on adherence to a uniform production method for the conductor.

2. Applicable Documents:

The following documents in effect on the date of invitation to quote 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 invitation to quote.

· DESY-MAG-M-4008	DESY Combined Function Magnet Wire at 0.013 in. (0.33 mm)
· RHIC-MAG-R-7152-C	Splicing Electrical Insulating Film.
· BNL Dwg. 15000001	DESY Combined Function Magnet Wire at 0.013 in. (0.33 mm)
· BNL Dwg. 15000002	DESY Combined Function Magnet Cable Assy.
· BNL Dwg. 15000003	DESY Combined Function Magnet Insulated Cable Assy.
· BNL Dwg. RD12011095	Helical Magnet cable AGO - NO GO A Gauge
· BNL-QA-101	Brookhaven National Laboratory Seller Quality Assurance Requirements
· DuPont-Summary of Information E - 72087	Kapton Polyimide film - General Properties
· DuPont General Procedures Bulletin GS-85-3	Procedures for the Film Properties and Characteristics of Kapton Polyimide Film
· 3M Company	ScotchWeld Epoxy Adhesive 2290

3. Requirements:

3.1 General: Any and all conflicts among the requirements listed in this procedure are to be brought to the attention of the buyer for resolution prior to the commencement of work. Under no circumstances is the seller to take any initiative without this resolution.

3.2 Technical Properties: The wire must be cabled on a high quality, fully controlled cabling machine. The required characteristics of the six around one cable are given in Table I.

Table I. Cable Dimensional and Mechanical Requirements

Requirement	Value	Defined in Para. No.
Number of wires in cable	7	3.2.1
Outside diameter of cable	0.039 +/-0.0003 in. (0.99 +/-0.011 mm)	3.2.1
Cable Lay Pitch	0.375+/-0.04 in. (9.5 +/-1.02 mm)	3.2.2
Cable Lay Direction	Left	3.2.2
Cable Surface Condition	Clean and free from metallic particles and oil. The cable must be free of external roughness, sharp edges, or burrs that could damage the insulating material; no broken wires or crossovers.	3.2.7
Cable Lengths	Maximum Length on spool: 4,000 m. Minimum unit length: 1000m	3.2.5

3.2.1 Cable Dimensions: The conductor is a six-around one cable fabricated using 0.013 inch (0.33 mm) diameter superconducting wire as per BNL Dwg. 15000001. The outside diameter of the cable should be controlled to the value given. This dimension for every cable length produced will be checked at the beginning and end of the cable run using a AGo- No Go@ Gauge similar to the one shown in the BNL Dwg. RD12011095.

3.2.2 The cable lay pitch is to be checked at the start of the cabling run and set to the value specified.

3.2.3 Cable Map: For each length of cable produced, a wire map is to be delivered to BNL. This would record the identification and length of each of the seven wires. An example of a cable map is given in Appendix A. All footage should be referenced to the hub end of the delivered cable.

3.2.4 Cable Lengths: A unit length is defined as the minimum continuous length of conforming cable. Identification of the delivered spool will be specified by BNL. All leaders used for cabling setup and which do not meet the cable requirements must be cut off and discarded.

The following conditions apply to the length of cable delivered:

- The maximum amount of cable on a spool will be 4,000 m; the minimum amount shall be 1,000 m.
- Only fully conforming cable shall be shipped to BNL.
- Cold welds are not permitted.

3.2.5 Cable Annealing: The cable shall be annealed at 250°C for 2 hours in an inert atmosphere. Annealing will performed after cabling and before insulating. The seller shall submit a written procedure for BNL approval.

3.2.6 Cable Surface Condition: The cable as produced will be free of any oil residue, metallic chips, broken wires and crossovers. The cable is to be cleaned if oil residue is present. If wire breakage occurs frequently, cabling should be stopped and the occurrence discussed with BNL before resuming cabling.

3.2.7 Cable Insulation: The cable is to be insulated with a polyimide polymer film. The film is to be wound on the cable in a spiral manner with 40-49% overlap, single wrap. The direction of the wrap shall be in accordance with BNL drawing 15000003. The tensile force on the film during winding shall be 5.0 to 10.0 ounces.

3.2.7.1 Insulation Material: The insulation material shall be a polyimide polymer in the form of a .001 inch thick film with electrical and mechanical properties equal to or better than those listed for Kapton H film in DuPont Bulletin GS-85-3.

3.2.7.2 Splicing of Kapton Tape: If the insulating tape needs to be spliced then the vendor should use the method outlined in RHIC-MAG-R-7152-C. Alternate methods are allowed such that the Kapton film thickness at the splice joint is < 0.003 in. (0.075 mm). Vendor must disclose to BNL the procedure used. No offline repairs shall be permitted without written BNL consent.

3.2.7.3 Taping Map: For each length of cable produced, a taping map is to be supplied to BNL. The map shall record the identification and location of splice joints. An example of a taping map is given in Appendix B. All footage should be reference to the hub end of the delivered cable.

3.2.8 Adhesive Coating: Following insulation, the cable is to be dip-coated with Scotch- Weld™ 2290 Epoxy Adhesive. The coating thickness shall be 0.0015 in. (0.038mm) +0.0005/-0.0000 in. The coating thickness shall be measured at both the beginning and the end of each spool, using the procedure contained in Appendix C. The coating must be completely dry before spooling, to prevent sticking of adjacent turns.

3.2.9 Cable Spooling: The direction of the insulated cable on the delivered spools shall be in accordance with shipping spool diagram depicted on BNL drawing 15000003.

4. Quality Assurance Provisions:

The vendor shall maintain a quality assurance program to ensure that each item offered for acceptance or approval conforms to the requirements herein.

4.1 Requirements of BNL-QA-101

4.1.1 The vendor shall accomplish the following requirements of BNL-QA-101, Brookhaven National Laboratory Seller Quality Assurance Requirements:

Paragraph in BNL-QA-101

3.1.2 MIL-I-45208 system specified
4.3
4.5
4.7 including 4.7.1, except that a cable annealing procedure shall be submitted
4.8
4.9
4.10 including 4.10.1, 4.10.2, 4.10.4, 4.10.5
4.12 see additional requirement in paragraph 4.2

4.16
4.19 except that no changes are permitted
4.23

4.1.2 BNL does not grant the Seller material review authority to accept as-is, items that do not conform to the requirements of this procurement, or to repair items to a still nonconforming condition.

4.1.3 In the event of conflict between this specification and BNL-QA-101, this specification shall take precedence.

4.2 Data Transmittal: The vendor shall complete and submit to BNL the Cable Map and the Taping Map for the spools being shipped. Copies of these along with the cable samples are to be sent to BNL separate from the cable spool shipment.

4.3 Cable Samples: A 3 meter-long cable sample shall be taken from both the hub end and the lead end of every cable spool, and sent to BNL. It must indicate whether the sample is from the hub or the lead end of the cable spool. Envelopes and labels for the cable samples will be provided by BNL.

5. Preparation for Delivery:

5.1 Packing: The insulated cable will be shipped on non-metallic spools so that adequate protection is provided during shipment and handling. The spool shall be -12.0@ O.D., 6.5@ Hub Dia., 1.5@ Dia. hole, 7.0@ width. The completed spool shall be overwrapped with a cotton tape or substantially equal non-metallic material, which will prevent damage to the cable while preventing unwinding of the same.

5.2 Marking/Requirements: Spools and exterior packaging shall be identified on both flanges with the following information in the order shown:

"Superconductor Insulated Cable for DESY Combined Function Magnets"
Specification No. DESY-MAG-M-4009, Rev A
BNL Dwg. No.15000003
BNL P.O. No. _____
Cable Spool No. BNL-15-_____
Length _____ feet
Weight _____ pounds
Date of Manufacture _____
Name of Manufacturer _____

5.3 Cable Identification Numbers: The system for cable identification will be given to the vendor by BNL.

APPENDIX A

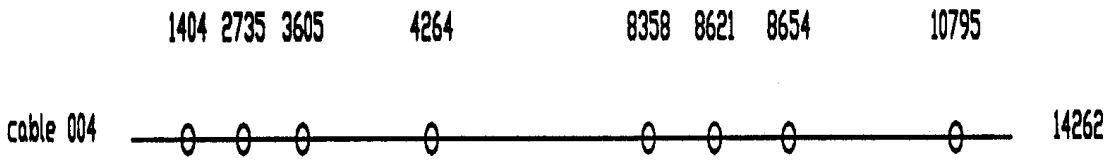
Example of a CABLE MAP

DESY Magnet Cable				
Cable Map # 001			Cable Length = 3,900 m.	
Cable ID	Cabling Vendor	Cable Spool No.	Wire ID	Comments
BNL-15-N-001	N	1	2590E-1A1	
		2	2590E-1A1	
		3	2590E-1A1	
		4	2590E-1A1B	
		5	2590E-1A1B	
		6	2590E-1A1B	
		7	2590E-1A1B	

APPENDIX B

Example of a TAPING MAP

TAPING MAP _ 004



LEGEND

0 - TAPE JOINT

APPENDIX C

Inspection Method No. 4009-1 - Epoxy Coating Thickness Measurement

1. Purpose:

This procedure establishes a standard method for measuring the thickness of the epoxy coating on polyimide insulated superconductor cable.

2. Materials Required:

Kapton tape, 0.5 in. wide
clear plastic tape

3. Equipment Required:

2 inch parallel blocks (2)
0-1 inch tenths micrometer
single edge safety razor blade
scissors

4. Applicable Documents:

None.

5. Procedure:

5.1 Unwind approximately 20 inches from the spool and wrap at this location with a piece of 0.5 inch wide Kapton tape (to prevent unraveling of the insulation). Using sharp scissors, cut the cable adjacent to the tape, leaving the taped end on the spool.

5.2 Straighten the removed segment, and identify the wrap direction of the insulation. Locate the trailing end (last wrapped layer) of the insulation.

5.3 Using a single edge safety razor blade, slit the Kapton insulation at the trailing end for a distance of approximately 0.5 inch.

5.4 Lay the segment on a clean sheet of paper, and gently roll it in the direction opposite that of the insulation wrapping, until the wrap begins to loosen from the cable. Once the insulation has loosened, gently unravel approximately 6 inches, and remove from cable using scissors.

5.5 Using ordinary clear tape, secure each end of the insulation to a separate 2 inch parallel block. The two blocks should be laid side-by-side on the surface plate. Pull the insulation taut by gently separating the parallel blocks, being careful not to stretch it.

5.6 Identify the coated edge and the non-coated edge of the insulation. Note that the coated edge appears more wrinkled in appearance.

5.7 Using a 0 - 1" tenths micrometer (smallest increment equal to .0001 inch), measure and record the thickness of the coated edge and the non-coated edge. Subtract the value obtained for the non-coated edge from the coated edge and record on the data sheet. This is the coating thickness.

5.8 Repeat steps 5.4 through 5.7 twice more for the remaining insulation on the insulated cable segment. This will yield a total of three measurements.

5.9 Calculate and record the arithmetic mean for the three readings obtained from the sample. Verify that the three readings and the mean are within the specified range of .0015 to .0020 inch.

5.10 Using an eye loupe, visually inspect the epoxy coating for evidence of bubbles, voids, or any other condition that may cause doubt about the integrity of the coating.