SSC-MAG-119
SSC-N-292
0784M
1-13-87

SPECIFICATION FOR NbTi SUPERCONDUCTOR CABLE FOR SSC DIPOLE MAGNETS

The final assembled conductor is a flat (Rutherford) cable. It is composed of either 23 or 30 superconducting wires which are twisted around one another during the cabling operation and then pressed into a keystoned shape. Each wire is a multifilamentary conductor with requirements described in an accompanying specification.

1.0 Mechanical Requirements: The dimensions of the cables are listed in Table I and on the drawing attached as Appendix A.

TABLE I. MECHANICAL REQUIREMENTS ON COMPLETED CABLE

Requirement*	Inner	Outer
Cable mid-thickness	.0574 ± .00025"	.0459 ± .00025"
Cable width	.366 ± .001"	.383 ± .001"
Keystone angle	1.6 ± .1°	1.2 ± .1°
** Cable lay pitch	3.1 ± .2"	2.9 ± .2"
** Cable lay direction	Left	Left
** Strand twist pitch in cable	1.6	1.6

* The dimensions and tolerances listed in Table I shall be verified on the first and last 100 ft. of each cable length. These measurements shall be made using the procedures and apparatus described in Appendix B.

** See Appendix B for a definition of these parameters.

2.0 Electrical Requirements: The electrical requirements for the completed cables are listed in Table II.

TABLE 1. ELECTRICAL REQUIREMENTS ON COMPLETED CABLE

Requirement	Inner Layer	Outer Layer
Minimum Critical Current at 5 T (See Note 1)	12700 A	8700 A
Minimum Critical Current at 7 T	7650	5275 A
Maximum R (295K) (micro-ohms/cm) of finished cable See Note 2.	26.5	26.0
Maximum R (10K) (micro-ohms/cm) of finished cable See Note 2.	.388	0.4

Note 1: The minimum critical current is measured with applied magnetic field perpendicular to wide surface of the cable (measured at 4.222 K and 1×10^{-14} ohm m effective resistivity across the entire cross section.

Note 2: The RRR for finished cable is defined by the values of R_{295} and R_{10} given in Table I. The target values for RRR as given there are greater than 68 for the inner and 65 outer layer cables.

3.0 Seller's Quality Assurance, Inspection, and Test Procedures

3.01 Identification: Every billet of material, piece of strand, and spool of cable - either used in the manufacturing or shipped to the SSC project - shall have a unique serial number.

3.02 Test Witnessing: The SSC project reserves the right to witness manufacturing steps, tests, and inspections established under the seller's quality assurance program, and all other testing performed at the seller's plant and his subcontractors' plants to demonstrate compliance with this specification. Any information of a proprietary nature must be identified in the sellers' bid response. The seller will not be required to disclose this proprietary information, but will be required to show that adequate records and quality controls are maintained in these proprietary steps.

3.03 Samples supplied to the Buyer: The vendor shall deliver to the buyer 15 ft. long samples of cable from one end of every continuous length of cable. Each sample must be adjacent to one used by the vendor to measure the cable mechanical properties. Sample identification must be made to allow comparison of vendor and buyer mechanical measurements. These samples shall be marked with their serial numbers and delivered to the buyer soon after the manufacture of the cable and ahead of the regular cable shipment. The cable samples will be accompanied by results of mechanical measurements made during the cabling operation and by a strand map described below. They will be shipped to the buyer in a condition so they will not be damaged. These samples will be used by the buyer to verify the mechanical and electrical requirements of the cable.

3.04 Cold Welds: The vendor may use cold welds during the manufacture of the cable. No single strand can have two cold welds within a distance of 100 ft., and there will not be any welds in the cable closer than 100 ft. After completion, the cold welds shall be tested to a load equivalent to 80% of the wire tensile strength.

3.05 Tracer Wire: A tracer wire will be used in fabricating the cable. This wire shall be the same as the other superconductor wires used in the fabrication of the cable, but will be coated with Ebanol to allow it to be identified. In this way, any potential defects int he cable can be traced to the serial numbers of individual wires and to the wire billet number.

3.06 Strand Map: The vendor shall supply a strand map giving the serial numbers of the strands used in the cable manufacturing and the locations of any cold welds. The minimum acceptable lengths of cable are 2210 ft. for outer layer cable and 1775 ft. for inner layer cable. A maximum of two lengths may be placed on each spool.

3.07 Cable Condition: The cable surface must be thoroughly clean and free from oil, mechanical particles or residue. Any cleaning solvents to be used must be approved by the Project Office. The cable must be free of roughness, sharp edges or burrs. The cable surface shall be uniform to within 25% of a single wire diameter. This measure refers to a cable laying on a flat surface without tension applied to the cable. There can be no crossovers of strands

in the cable. The cable shall not have excessive twist. The twist is measured by suspending a 30 lb. weight from a 3 ft. length of cable. The maximum twist under these conditions is 90° in the direction of the cable lay and 0° in the direction opposite to the cable lay.

4.0 Shipping Requirements: For transporting, the cable must be spooled with a radius larger than or equal to 14 inches. The spools must be constructed to prevent damage to the cable during spooling and unspooling. The spools shall be boxed or strapped to a pallet to prevent damage in shipment. They should be stacked and shipped with the spool flanges maintained in a vertical orientation in order to prevent the cable from settling on the spool. The cable must be wound so there are no crossovers of the cable windings. A sheet of plastic or paper will be placed between cable layers to prevent penetration of one layer into another. Filler cord shall be used at the edges of the cable layers as required so the cable will lie flat. The cable will be wound onto a spool in the following manner, with the observer looking down onto the spool and with the cable being wound in the horizontal plane:

1. The spool rotation direction for winding the cable onto the spool shall be counterclockwise.
2. The cable top or thick keystone edge will be up (facing the observer looking down).

5.0 Test Requirements

5.01 Dimensions: The cable keystone angle, cable width, and cable thickness shall be measured with a device and following a procedure described in Appendix B.

5.02 Bend Test: A sample from each end of each length of cable shall pass a sharp bend test as described in Appendix D.

5.03 Insulation Damage Test: Any sharp edges on the cable may damage the insulation which will be applied to the cable before coil winding. Samples from each end of each length of cable must pass the insulation perforation test described in Appendix F.

5.04 Electric Field Test:

APPENDIX B

With regard the strand twist pitch in SSC cable, the following convention and procedure is being adopted in order to avoid confusion. The effective strand twist pitch in the cable, T.P. (cabled) = T.P. (strand) $\pm \frac{n}{p}$, where

(1) n is the number of revolutions made by a strand spool while the cabler drum is making one revolution,

(2) p is the cable pitch or lay,

(3) + is used when the spool rotation is in the same direction as the original wire twist,

(4) - is used when the spool rotation is in the opposite direction from the original wire twist.

The cable lay direction is left lay, defined as the same direction as a left-hand screw thread.