MECHANICAL DESIGN FEATURES OF THE MSU K-800 CYCLOTRON SUPERCONDUCTING COIL

D. Lawton, H.G. Blosser, J.M. Moskalik, G.A. Stork
National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824

The winding of the K-800 cyclotron superconducting magnet coil was completed in late 1983. The windings consist of four separate coils (symmetrical large and small coils on each side of the median plane). The coils are wound in vertical layers in a spiral fashion. The large coils are 32 layers with 2329 total turns each (59,000 feet of wire) and the small coils are 32 layers with 1544 turns each (39,000 feet of wire). The spiral winding was achieved by supporting the first turn of a layer by a set of gradually increasing spacers with subsequent turns supported by previous turns. Winding was done on our 10 foot diameter table vertical lathe. The winding apparatus was mounted on the lathe's tool arm which had an automatic vertical feed to match the spiral path of the wire. The superconducting cable has a retangular cross section (with rounded corners) of dimentions .207 inches x .150 inches. Approximately 200 niobium titanium filaments are contained in a .04 inch x .06 inches copper insert that is soldered (50/50 lead tin) in a slot in the side of the copper conductor substrate. The specification calls for the wire to carry 1100 amperes in a 5 tesla magnetic field under a 15,000 PSI tensile load. The turn to turn insulation is provided by .003 in thick polyester strips bounded to the top and bottom of the conductor by pressure sensitive adhesive. The layers are separated by 216 equally spaced vertical G-10 strips of cross section .50 inches x .04 inches. The voids created between the strips become the liquid helium flow channels. The purchased conductor lengths varied from 2000 feet to 16,000 feet. Splices were achieved by separating the insert from the substrate, silver soldering the substrate along a beveled joint, milling a double deepslot and soft soldering the inserts in an overlapping fashion. The splices tested at greater than 90% of their original tensile strength. There are a total of 50 splices in the windings. Winding tension for the superconductor was 3,000 PSI. The major apparatus on the winding line included:

-A hydraulic servo controlled tensioner.

-A steam and detergent cleaning station.

-An ultrasonic transducer station, checking the integrity of the insert to substrate solder joint.

-An insulation application station.

-A dimension check station utilizing electronic proximity devices to monitor conductor dimensions and look for bumps and flaws.

-A "winding arm" to apply vertical and horizontal positioning pressure to the conductor at the winding point.

-An interlock system that monitored several parameters on the line looking for problems.

Each of the coils is covered by 20 layers of 5052-H34 aluminum banding wire of .100 inch x .215 inch cross section wound on at 20,000 PSI tension. A second air brake/spring tensioner was added to the winding line to achieve this. Splices in the banding were accomplished by a cold weld (pressure) technique with full retention of tensile strength.

The bobbin is an all stainless steel weldment (alloy 316 with 12% min. nickel content). With it's outer covers welded on, the bobbin becomes the liquid helium vessal. The helium vessal is covered with 20 layers of superinsulation and then enclosed in a liquid nitrogen temperature aluminum (alloy 1100) thermal radiation shield. The shield is cooled by conduction from six annular reservoirs surrounding each of the three upper and the three lower vertical coil supports. The shield is covered with 30 layers of superinsulation and the entire coil assembly is installed in the steel cryostat (vacuum vessal).

The coil is supported by nine symmetrically located support links (three upper vertical , three lower vertical, three horizontal at the median plane). The link design utilizes titanium and fiberglass to achieve a compact, low heat conducting, high spring constant support system. The main load carrying elements of the link are a titanium (alloy 6Aℓ-4v-ELI) inner tension rod, a fiberglass compression cylinder, a titanium outer tension cylinder, and an alloy steel stud fitted with a strain gage circuit to allow monitoring of the support system loading.

The helium gas coolled electrical leads to the coil were fabricated in-house. Each lead consists of 19 bundled .312 O.D. x .020 wall stainless steel tubes. Each tube contains a cabled (3x7x7) superconducting wire lead (cabled from .010 inch diameter 2:1 superconducting ratio). The helium gas flows over the cabled leads inside of each .312 diameter tube. The lead lengths are approximately 7 feet.

Pressure relief for the helium vessal is provided by a 4 inch nominal aluminum foil rupture disc rated for burst at 30 PSI.

Instrumentation for the coil includes liquid helium level sensors, platinum thermometers inside the coil as well as on the nitrogen cooled shield, voltage taps on the leads and between coils, field sensing coils on the inner bore of the bobbin and the support link strain gages.

Initial tests of the coil are scheduled for the first week of May 1984.