

NCSX

**Product Specification
For the
Trim Coils**

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1 SCOPE

The Trim Coils are mounted onto the surface of the NCSX Device and provide error correction for stray fields. There are two types of Trim coils that are addressed in this specification- Trim Coil A (TR-A) and Trim Coil B (TR-B). There are a quantity of twenty four of each type of Trim Coil for a total of 48 Coils. The coils use a pre-insulated solid copper conductor and are vacuum impregnated in a 10 x 12 rectangular build for a total of 120 turns minus one turn lost to transitions. The coils are cryogenically convection cooled within a cryostat to 77K. This specification defines the Trim Coils and the requirements for their fabrication.

2 REQUIREMENTS

2.1 Item Definition

. Figure 2-1 Trim Coils A and B in their installed configuration. For illustration purposes the coils are shown with the supporting hardware not covered by this specification. TR-A are the upper coils with the green brackets and TR-B are the lower coils with the yellow brackets.

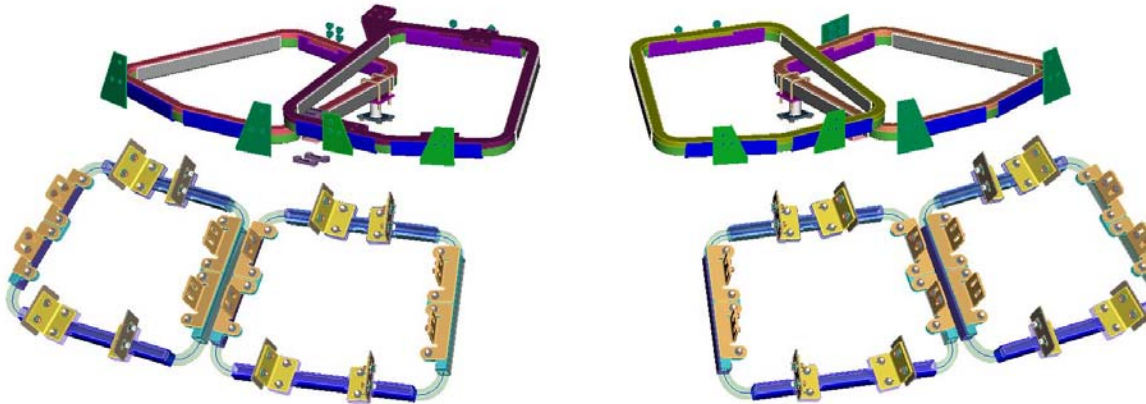


Figure 2-1 Trim Coils A and B

- a. Conductor: The conductor is a continuous length of 2mm square copper pre-insulated with the layer to layer insulation specified in c
- b. Ground Insulation: The ground insulation is .125 inches thick and consists of multiple layers of fiberglass tape surrounding the winding pack.
- c. Layer to Layer Insulation: The layer to layer insulation is pre-applied to the conductor and is supplemented by one .006 inch layer of E glass in the vertical plane between each layer as depicted in SE133-041 and SE133-031. This extra

layer of glass is meant to help wick the epoxy into the coil during the VPI process.

- d. Coil Leads: There are no lead blocks applied to the coil turns as they exit the coil. The coil conductor is to be sleeved with Teflon insulation which extends into the coil body and is firmly fastened to the coil to prevent damage in shipping as depicted in SE133-041 and SE133-031.

2.2 Characteristics

2.2.1 Performance

2.2.1.1 Electrical Requirements

2.2.1.1.1 DC Resistance

The total coil resistance measured at room temperature (20°C) shall be within +/-2% of the calculated resistance given in Table 1:

Table 1- Coil Resistance

Coil Identification	Calculated Coil Resistance Ohms
TR-A	1.35
TR-B	1.20

2.2.1.1.2 Voltage Standoff, Terminal- to-ground

The Assembly shall provide a standoff capability between the electrical circuit (conductor) and ground or any other component of 4.5 kV with a minimum resistance of 1000 MΩ. [Calculated voltage standoff capability is 18.9 kV] The maximum test voltage must be held for 1 full minute during testing to allow reading to stabilize.

2.2.1.1.3 Voltage Standoff, Turn-to-turn

The Trim Coils shall provide a voltage standoff capability between adjacent conductors or leads adequate to withstand a peak terminal-to-terminal voltage of 1.0 kV with a maximum of 10 μA of current leakage.

2.2.2 Physical Characteristics

2.2.2.1 Component Characteristics

2.2.2.1.1 Conductor and Turn to Turn Insulation

The conductor is a continuous length of 2mm square copper pre-insulated with one half lap layer of Kapton and then one half lap layer of “Dayglass” tape. The copper material is UNS C11000 (C110 ETP) with a minimum yield of 9 KSI. The total build of the conductor with insulation is .090 inches +/- .003 inches square. The Conductor can be

purchased from Superior Essex, Fort Wayne, IN in spool quantities up to 1750 lbs with P/N C0005A00612024A. All void areas are to be filled with either E glass or G10 material so that there are no resin rich areas after vacuum epoxy impregnation. Almost one full turn in the top corner of the coil will also require E glass or G10 material for filler as it will be left empty due to the last turn being pulled back as a result of maintaining the lead exit points in spite of the space taken up by transitions.

2.2.2.1.2 Ground Insulation

The ground insulation is applied over the coil turns and is composed of 0.012 inch thick by one inch wide E glass. The E glass is applied in half lap layers to bring the total build of the turn-to-turn insulation to 0.125 inches and the external width and height of the coil to match the dimensions on the referenced drawings. (SE133-041 and SE133-031). The number of layers of the ground wrap insulation shall be determined by measurement and adjusted to achieve a sum total of 10% compression for both the ground wrap and turn to turn glass insulation. The number of layers of E glass used shall be approved by PPPL prior to fabrication.

The completed ground wrapped assembly is to be vacuum impregnated using CTD 101K (see 2.2.2.1.4, below) epoxy. The number of layers of ground insulation is to be optimized so that the compression of the coil in the VPI mold is sufficient to minimize resin rich areas. To eliminate resin rich areas, voids in the corners of the VPI mold are to be eliminated with the use of radiused fillers or a machined radiused surface.

2.2.2.1.3 Leads and Lead Insulation

As the leads exit the coils they are to be insulated with an extra layer of Teflon sleeve material as specified on the drawings (SE133-041 and SE133-031). The Teflon sleeve is to extend a minimum of ½ inch below the surface of the groundwrap. The insulation shall be AMS-DTL-23053/12 PTFE Heat Shrink Tubing available from McMaster Carr or an equivalent approved by PPPL. Sleeve material shall be no less than .012” per layer. Sleeve material shall extend to the end of the conductor. Leads shall be bent up out of the coil and protected and fastened to the coil body for shipment in a manner approved by PPPL. Bending of the leads after the exit the coil is to be minimized.

2.2.2.1.4 Vacuum-Pressure-Impregnation [VPI]

Each finished Trim Coil shall be vacuum pressure impregnated [VPI] using the pre-selected epoxy resin system identified below.

- a. Epoxy Description: CTD-101K: a modified 3-part anhydride cured epoxy system with excellent performance at cryogenic temperatures.
- b. Manufacturer: Composite Technology Development Inc.
1505 Coal Creek Drive
Lafayette, Colorado 80026
Phone: (303) 664-0394

- c. Epoxy Working and Cure Temperatures
- *Mixing Temperature*: 40-60 degrees C
 - *Cure Cycle*: 5 hours @ 110 degrees C
 - *Post Cure*: 16 hours @ 125 degrees C

2.3 Design and Construction

2.3.1 Materials, Processes, and Parts

2.3.1.1 Production Drawings

The Assembly shall be fabricated in accordance with the drawings listed in Section 4.1.

2.3.1.2 Metrology

Inspection reports shall be provided to verify dimensions are within tolerance as specified in coil drawings identified in Section 4.1. Dimensions shall be checked in every corner at the center of each leg of the coil and at a minimum of every 6 inches per side.

2.3.2 Labels

The Assembly shall have a permanent label with the following minimum information – NCSX Trim Coil Assembly, P/N [coil drawing number], the serial number of the item, the manufacturer of the item, and the date of manufacture (month and year). The label shall be located at the location specified in reference drawings (SE133-041 and SE133-031).

2.3.3 Workmanship

During assembly, fabrication, and finishing, particular attention shall be given to freedom from blemishes, defects, burrs, and sharp edges; thoroughness of cleaning; quality of brazing and alignment of parts. Copper conductor shall be stored and processed in an environment free from metallic dust or other contaminants. Materials shall be protected from skin oil, etc., by requiring shop personnel to handle conductors only while wearing clean, lint free, white cotton or latex gloves. Winding operations shall be performed within a clean room.

3 QUALITY ASSURANCE PROVISIONS

3.1 General

The vendor has sole responsibility for inspection and testing of all Trim coil assemblies.

3.2 Verification

3.2.1 Performance Verification

3.2.1.1 Electrical Requirement Verification

The time at test voltage for all electrical verifications shall be a minimum of one minute

3.2.1.1.1 Verification of DC Resistance

The total coil resistance shall be measured at room temperature (20°C) in order to verify compliance with Section 2.2.1.1.1. This test shall be performed:

- Prior to ground wrapping the coil
- After Coil VPI

3.2.1.1.2 Verification of Terminal-to-ground Voltage Standoff

Each Trim coil assembly shall be Megger tested at room temperature (20°C) during acceptance testing to verify compliance with Section 2.2.1.1.2. The coil shall be completely wrapped with a conductive layer (tin foil or a substitute) to create the required ground plane. This test shall be performed prior to and after VPI operations. The test values are identified below:

- Prior to ground wrapping the coil at 1kV
- After Coil VPI at 4.5 kV

3.2.1.1.3 Verification of Turn-to-turn Voltage Standoff

Each Trim coil assembly shall be tested for turn to turn dielectric strength. The vendor shall propose a testing plan for achieving this turn to turn test. Compliance with the values identified in 2.2.1.1.3 is required. In addition the inductance of each coil is to be measured and recorded after VPI. The turn to turn test shall be performed:

- Prior to ground wrapping the coil
- After Coil VPI

3.2.2 Verification of Physical Characteristics

3.2.2.1 Verification of Component Characteristics

3.2.2.1.1 Verification of Conductor

The conductor width is to be verified and recorded before winding begins on each coil.

3.2.2.1.2 Verification of Ground Insulation Parameters

Measurements of insulation build and the number of layers are to be recorded in the winding procedure for each coil to verify compliance with paragraph 2.2.2.1.2

3.2.2.1.3 Geometry

Each completed Trim Coil assembly is to be measured with all drawing dimensions verified and documented. Coil cross-sectional dimensions (height and width) are to be verified at a minimum of 3 evenly spaced places per straight. Inspection reports are to note nominal dimensions and deviations from those dimensions along with allowable tolerances.

3.2.2.1.4 Verification of Lead Insulation

Insulation of leads as specified in paragraph 2.2.2.1.2 shall be verified and documented.

3.2.2.1.5 VPI Parameters

Epoxy temperature and cure time shall be recorded to verify compliance with paragraph 2.2.2.1.2

4 APPENDICES

4.1 Drawings

Drawing Number	Description
SE133-031	Trim Coil -A
SE133-041	Trim Coil -B