Materials and Component Testing in Support of the All-Superconducting 32T Magnet

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Introduction

The design and development of an all superconducting high field (32T) magnet requires specialized research and development of materials, design concepts and components to ensure success. The primary research for the design has focused on the advanced High Temperature Superconductor, YBCO, and has been previously reported [1]. Ancillary materials necessary for the construction and operation of the magnet also require electro-mechanical testing for evaluation of their performance at cryogenic temperatures. The list of some of the components tested in Mechanical and Physical Properties Testing Laboratory in 2012 are shown in **Table 1**.

Experimental Results and Discussion

- The bore tube is a precision magnet coil-form with optimized dimensions designed to withstand assembly and operational stresses. Tension tests are conducted at 77 K to measure the stress-strain behavior of the bore-tube assembly and shear strength of the threads that fasten the coil's end plates.
- The magnet's electrical insulation system consist of stainless steel tape (0.025 mm thick) that is dip-coated with sol-gel insulation and then co-wound with the YBCO conductor to provide turn insulation. The tensile properties of the tape are measured to provide necessary data for stress analysis. Cyclic fatigue tests at were conducted at 77 K to confirm the insulation's stress and strain endurance at cryogenic temperatures.
- The performance of the electrical connections from the magnet current leads to the coil terminals is critical. A soldered array of YBCO tapes is used that must perform reliably under thermal and operating stress. Cryogenic electro-mechanical tests are used to qualify prototype terminal performance and fatigue endurance.
- A short (6 layer) prototype coil (**Figure 1**) is compression tested to measure the axial compliance. The compliance data (units kN/mm) are used for magnet pre-stress and operating stress considerations (**Figure 2**).

Table 1: List of 32T magnet components characterized for the 32T SC Magnet design.

Material or Component	Description
Bore Tube	316 Stainless Steel thin walled-tube with fine threads on the ends
Co-wind Tape	316 Stainless Tape substrate for insulation system,4 mm wide x 0.025 mm thick.
Sol-gel insulation	A thin layer of Sol-gel (Alumina impregnated) is used to dip coat ss substrate
SS overband clamps	Magnet coils require overbanding with high strength ss clamps, testing is needed for consideration of assembly prestress conditions.
Terminals	Current leads are connected to the coil with a soldered array of YBCO conductors that are subject to thermal and operating stress.
6- Module Prototype Coil Stack	A Short-Prototype coil is compression tested to measure the axial deflection and coil compliance in consideration of assembly prestress requirements.

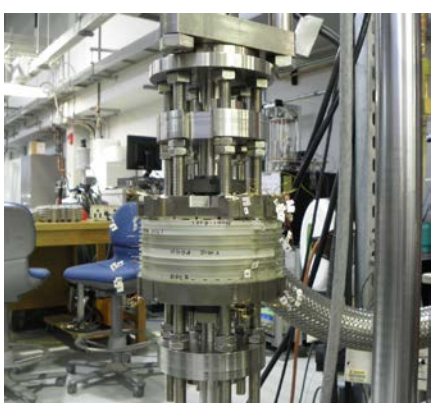

Figure 1: Prototype coil in test machine.

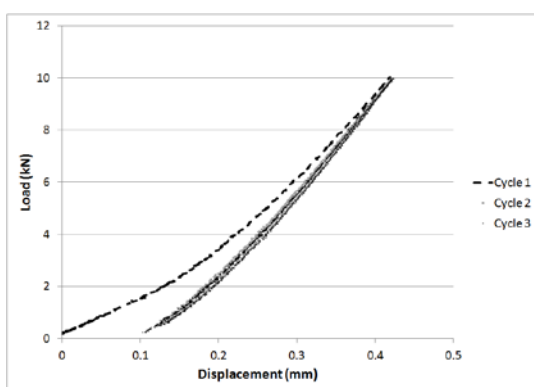

Figure 2: Load vs Displacement for Prototype Coil.

1. The 77 K Stress and Strain Dependance of the Critical Current of YBCO Coated Conductors and Lap Joints, R. P. Walsh, *et al*., IEEE Transactions on Applied Superconductivity, Vol. 22, Issue 1, Feb. 2012.