

**2010 Advanced Cables and Conductors Peer Review
Project Summary**

Project Title:	Long Length Coated Conductor Characterization
Organization:	Los Alamos National Laboratory
Presenters:	J. Y. Coulter, J. O. Willis
FY 2010 Funding:	\$350 K

Overall Project Purpose and Objectives:

The production of reproducible, engineered, pinning microstructures in YBCO films is critical to coated conductor wire manufacturers who need to be able to control the critical current, I_c , of long wires to close tolerances. Uniform wire with known properties is needed for HTS power applications to meet DOE-OE goals. Long length characterization and development is required to meet this need. To investigate I_c variations on intact, long length, prototype coated conductors, several years ago we started to build systems for position-dependent $I_c(H, \text{field angle})$ measurements. We have developed the capability to nondestructively identify and investigate position dependent variations in superconducting properties on long, practical length coated conductors. Through the CRADAs we provide our collaborators with information that they can use to trace I_c variations to the source. We are expanding present capabilities and developing, designing, and demonstrating the next generation of characterization systems that can be used to provide physical insights, performance information, and quality assurance for coated conductor manufacturers.

2010 Approach and Results:

A modular approach to system development using commercially available components has allowed us to adjust to the continually evolving understanding of superconductivity in HTS conductors. The intellectual property originating within this subtask including the hardware, software, and methods for long length characterization is available to our industry CRADA partners. The technology transfer aspects of this subtask are performed within the respective CRADA subtasks.

Results: This year our general goals were 1) validation of and continued development of the uniformity characterization system and 2) a more general understanding of the in-field I_c variations observed in commercially fabricated superconductors in the 0-1T and 75K temperature region for a range of conductor process types. To meet objective #1, we modified an existing $I_c(75K, H, \text{angle})$ system and developed software which uses the J_c model as described by M. Xu, Phys Rev B 1990 and used to quantify pinning. We call this new measurement the Full Angle I_c because the field dependence is measured at all angles relevant to the microscopic properties of the tape. Using the Full Angle I_c we investigated the range of field dependent behavior exhibited by a wire supplied by American Superconductor and reported upon at Peer Review 2009. The results are assisting AMSC in identifying process variations, which is a CRADA goal. They also validate our uniformity characterization methods, which is a project goal. The results show that the field dependence throughout the 0-90 degree angular range is changing along the wire, indicated by systematic variations in the slope of the field dependence of the α -value. A key result of the characterization is a banding of behavior for future characterization.

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We continued characterization of tapes made by a range of process systems, including samples supplied by STI, MetOx, and long tapes supplied by SuperPower. We continued development of the characterization system in parallel with these measurements. These four commercial tape fabricators each use a different film deposition and substrate combinations. Our hypothesis was that different in-field performance would result from each process, but that there should be similarities. We found that samples from each process, including some use Zirconium to enhance performance on production tape, in fact did possess a unique field dependence determined by the angular dependence of the power law coefficient, $\alpha(\text{angle})$. We have initiated comparative microstructural investigations of the samples mentioned above which are being performed at Los Alamos and by collaborators Argonne National Laboratory. To estimate performance in applications, supporting data continues to be obtained by magnetometry to determine $I_c(H)$ over a wide range of magnetic fields and temperatures.

Control Milestone 2010: Demonstrate feasibility of an electromagnet system to provide variable $H_{||ab}$ capability. (July 1, 2010). We met the milestone in April by 1) testing the magnet system shown at PR2009 and generated 1.2T across a 6mm gap which accommodates the industry standard 4mm tape and is suitable for $H_{||ab}$ plane investigations. This also establishes the feasibility of a full electromagnetic approach to the determination of in-field uniformity and is compatible with $I_c(H=0)$ measurements performed by industry. 2) We also developed a new split coil with a 25mm radial access horizontal bore which is rotatable over the 360 degree range with a 75mm long central field region. A wire of any length may be translated through this magnet. This approaches a SuperPower 10cm long field objective. $\mu_0 H = 0.9T$ has been generated in the magnet system. Further system development is ongoing and two additional systems are under construction.

2011 Plans and Expectations:

We anticipate that we can scale up in-field uniformity characterization to length scales $\sim 1\text{km}$ with our industrial partners. This will increase confidence in performance for applications. Continued development is based on both the expressed and anticipated needs of our CRADA partners. (Plans for measurement and analysis of results for conductors of our CRADA partners will be noted in the CRADA presentations.) There is an industry expressed need for 0-4 tesla and intermediate temperature $\sim 30K$, $I_c(\text{angle})$ characterization. We will attempt to meet this need on practical wire by developing additional high current (350+amps) measurements on short samples using 75-64K characterization as a starting point.

Technology Transfer, Collaboration, Partnerships:

We have collaborations with industrial partners AMSC, SuperPower, STI and MetOx which include characterization and system development. Results will be described in the CRADA presentations.