Simulating High-Magnetic-Field and High-Stress Conditions of Superconducting REBCO Coils

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Exploring the limits of material properties in high-temperature superconducting tapes is crucial for designing next-generation high-field magnet systems. *This research delves into the challenges posed by the combined severe field and force conditions on REBCO (Rare Earth Barium Copper Oxide) tapes that will be experienced in the 40-tesla all-superconducting magnet. REBCO tapes experience large screening currents that tilt the coil tapes. This tilt weakens the tapes against axial forces, the limits of which must be verified*.

The experimental approach, conducted at the National High Magnetic Field Laboratory (MagLab), measured the performance of a superconducting REBCO test coil in combined extreme magnetic field and force conditions experienced in a high-field magnet. By leveraging the unique facilities and expertise at the MagLab, the engineers developed a specialized test setup within an existing 12T superconducting magnet to subject test coils to cyclic compressive loads and high radial magnetic fields, simulating the worst-case conditions encountered by these REBCO tapes.

Two significant findings emerged: first, coils can withstand cyclic pressures of up to 80MPa while experiencing tape tilting deformations of up to a 10° angle, and second, coils subjected to hoop compression beyond strains of -0.4% can buckle. *These findings not only advance the understanding of REBCO tape material limits but also have broader understanding of their use in the next-generation high-field magnets*. *By testing the boundaries of technology in this area, these tests pave the way for developing more efficient and powerful superconducting magnets with applications ranging from medical imaging to energy storage, fusion, and beyond*.

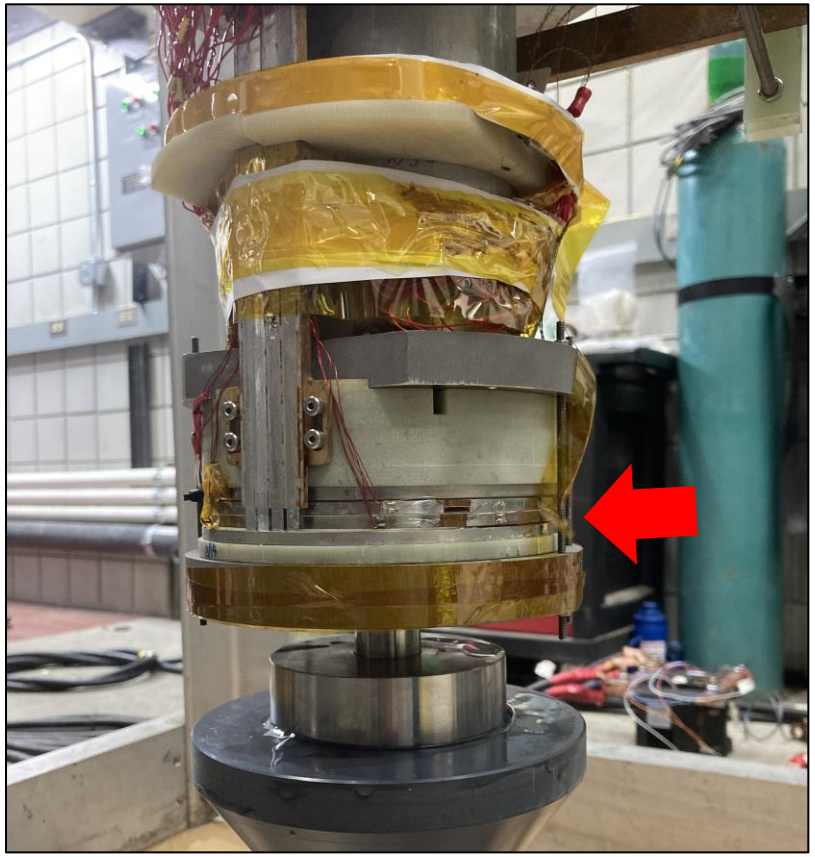

Figure 1 (top): REBCO test coil (red arrow) attached to the load frame that is inserted to test facility at right.

Figure 2 (right): The MagLab's unique facility simulates combined high-magnetic-field and high-stress conditions.

Facilities and instrumentation used: Magnet Science & Technology group, 12 T Oxford split magnet.

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