**Experimental investigations on tape-to-tape contact resistance and its impact on current distribution around local *Ic* degradations in CORC® cables**

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RE-Ba2Cu3O7−δ (REBCO, RE = rare earth) coated conductors are a promising conductor for the future of high field magnets, next generation electric machines, and power transmission. Over the years manufacturing improvements have led to a strong, ready to wind conductor capable of maintaining high current densities in magnetic fields exceeding 25 T. However, manufacturing can still produce lengthwise variations in the critical current, *Ic*, sometimes producing significant drops in *Ic*. Conductor operation can exacerbate these flaws and introduce new defects leading to performance degradation. Ensuring conductor robustness and reliability is fundamental in ensuring long term performance of magnets and electric machines. One way to mitigate the impact of these defects is by using superconducting cables instead of single conductors. Superconducting cables enable current sharing, providing alternative current pathways and allowing the current to bypass *Ic* dropouts, minimizing the risk of superconductor burnout.

Conductor on Round Core (CORC®) cables are comprised of multiple layers of helically wound REBCO tapes, resulting in a highly flexible cable. However, this might lead to a high contact resistance, *Rc*, as the contact between tapes is limited to discrete crossovers, which can have a significant impact on current sharing and current distribution in CORC® cables. Special CORC® cables were manufactured to investigate the impact of different winding parameters on *Rc­*. Variations included winding with different lubricants, winding from pre-tinned tapes, and a short heat treatment to melt the solder. *Rc* was measured for both straight samples and samples bent to a 10 cm diameter. A large variation in *Rc* was observed for the straight samples ranging from 1 to over 1000 µΩ·cm2, depending on winding parameters. The control cables, representing a typical CORC® cable, produced the largest *Rc*. Bending the cables to a 10 cm diameter reduced the coefficient of variation by up to 80%. *Rc* was 3 orders of magnitude smaller in the cables wound from tinned tapes. A heat treatment to melt the solder produced only a small reduction in *Rc*. In the control cable the measured *Rc* corresponds to a current transfer length on the order of tens of centimeters compared to a few millimeters in the soldered cable. Microscopy revealed a hooked substrate at the edge of the tapes preventing good contact between tape layers. In the tinned cable, the solder fills in any asperities in the tape surface, creating a much more uniform contact between tapes. Cross sectional images showed only a few regions of good contact in the control cable compared to near perfect contact in the cable wound from tinned tapes.

Special two tape CORC® cables, one tape per layer, were constructed to examine how *Rc* impacts current redistribution around local defects. Three different cables, each containing a 100% *Ic* drop halfway along its length, were measured: Cu cable (wound from regular REBCO tapes), PbSn cable (wound from tinned tapes), and a soldered cable (the PbSn cable following a heat treatment to melt the solder). The ends of each cable were unwound and shunt resistors measured the current into and out of each tape. An array of z-axis Hall sensors, which could be positioned at any location along the length of the cable, monitored changes in the self-field due to current redistribution. A clear shift in Hall polarity occurs at the defect location, with Hall sensors producing a positive voltage upstream of the defect and a negative voltage downstream of the defect. As the current transfers around the defect a normal zone is initiated in the “good” tape. In the Cu and PbSn cables, voltage taps reveal that the normal zone is confined to the “good” tape, while the “bad” tape remains superconducting. The decreased *Rc* in the soldered cable promotes better current sharing, resulting in the normal zone spreading in both tapes. A stable normal zone can persist even at currents above *Ic* and depending on *Rc*, a severe *Ic* drop can cause significant power dissipation, 590 mW at 60 A in the Cu cable.

Similar measurement techniques were employed to investigate the impact of current sharing on cables that permit current transfer around *Ic* drops to cables with insulation between tape layers, disabling current sharing. The onset of current sharing is marked by a change in slope of the Hall sensors which increases in magnitude near the defect. The presence of a single defect can impact current distribution up to 35 cm away. In general no slope change is observed in the insulated cables. However, near one of the defects a small slope change was observed. Cable deconstruction revealed a severe burn that melted insulation and permitted some localized current transfer in that region. The onset of a quench is marked by a jump in the Hall voltages. During a quench, Hall sensors revealed a 4 cm region of active current redistribution near the defect. Cable performance depends both on the number of defects, and the ability to redistribute current around those defects. Increasing the number of defects from 1 to 2 decreases cable *Ic*by 50 A. Adding insulation between the layers, preventing current sharing around a single defect, had nearly the same effect as doubling the number of defects. Additionally, the insulated cables were never driven above *Ic*, yet the temperature near the defect was hot enough to melt the insulation. Whereas the other cables were quench dozens of times with no noticeable degradation. These experiments have demonstrated that *Rc* can have a significant impact on power dissipation and that current sharing is essential for robust cable performance.