# Subscale Cable-in-Conduit Conductor Measurements of $T_{CS}(B, I, \varepsilon)$ for the Series-Connected Hybrid Magnets

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## Introduction

Two Series-Connected Hybrid magnets (a combination of resistive and superconducting coils) are planned for construction, one to be located at the NHMFL and one at the Hahn Meitner Institut in Berlin. The most critical development for the magnet systems is the configuration of the cable-in-conduit conductor (cicc) for the superconducting coil. It has been shown that the performance of cicc's can degrade from the transverse pressure produced during electromagnetic cycling. The severity is dependent on their construction

The current sharing temperature of four cicc sub-scale samples are measured to compare how the internal void space (30% or 40%), core cable pattern (6 around 1 or triplet), and cable twist pitch (long or short) impacts the performance. The samples are tested as a function of temperature, magnetic field, and longitudinal strain. In addition the samples are electro-magnetically cycled.

## Experimental

The measurements were performed in the Oxford superconducting split magnet located in the DC field facility at the NHMFL. The magnet cryostat is equipped with a hydraulic actuator for applying tensile loads to the test samples while also exposing the samples to magnetic fields up to 14 T. The cicc samples have a u-bend in the center to form two straight, parallel legs. The ends of the samples are connected to leads that are subsequently connected to one of the DC user facilities power supplies. A vacuum jacket is constructed around the CICC sample to insulate it from the helium bath of the magnet. The conduit is plumbed to a separate pressurization cryostat to deliver temperature and flow regulated supercritical helium.

## Results and Discussion

Figure 1 contains the results of the four cicc samples measured at 10.5 T and 14 kA. Samples A and B are both constructed with a 6/1 cable pattern and only vary in void fraction. A problem with sample B prevented strain from being applied to it however the results are very similar between the two. A comparison between the triplet and 6/1 cable pattern shows improved performance with the triplet. Sample A has good performance at low strain but the $T_{CS}$ shows to plateau out with increased strain. Sample D with the long twist pitch, 30% void, and triplet cable pattern has the highest current sharing temperature.

## Conclusions

From the results of the measurements the construction of the cicc for the hybrid magnet has been determined. The design is proceeding with cicc's consisting of a long twist pitch, 30% void, and a core triplet cable pattern. Subsequent measurement will be conducted on full-size samples for verification.

## Acknowledgements

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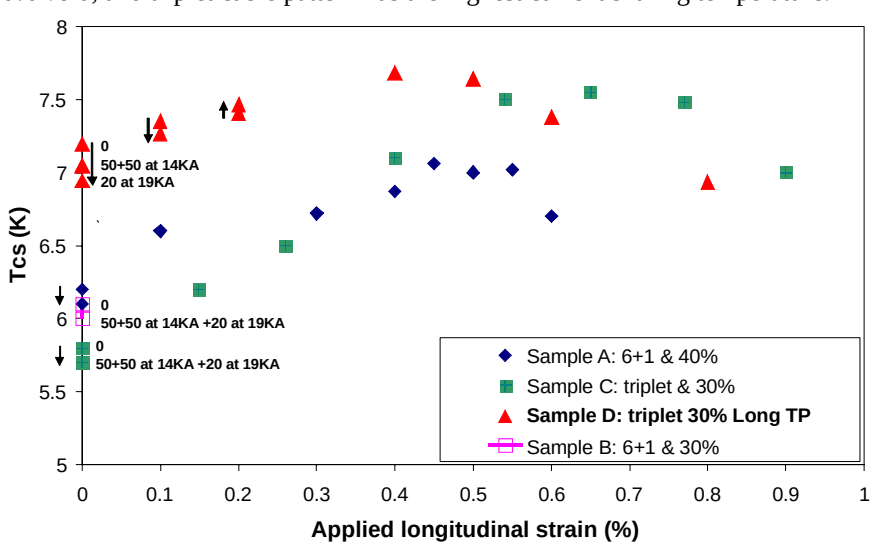


Figure 1. Measurement of $T_{CS}$ vs. Strain of Four CICC Test Samples at 10.5 T and 14 kA