# IN-FIELD $I_c$ of $Nb_3Sn$ WIRES UNDER STRAIN

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## Introduction

High current carrying capabilities and strain tolerance are important properties to achieve in superconductors to be used in successful high field magnet applications. To study the various effects of strain on practical $Nb_3Sn$ conductor and ultimately to characterize conductor that will be used within high-field magnet projects at the NHMFL, a device has been built to measure the critical current of short wire samples at 4.2 K as a function of strain in a large-bore high-field magnet. The device is operated by a stepper-motor and worm gear assembly and is rated for maximum loads up to 2.5 kN. Tensile strains of 1 % can be easily accommodated. The probe is instrumented with vapor-cooled current leads and high temperature superconducting current lead extensions to allow for transport currents up to 1.5 kA. The setup was operated in the NHMFL large bore resistive magnet in fields up to 20 T.

## Experimental

Fig. 1 shows the complete probe and the strain device. The strain device consists of two brass blocks, between which the sample is mounted. One of the blocks is bolted to the bottom flange and the other can move freely operated by a stainless steel spindle and worm gear assembly, which is driven by a stepper motor on the outside of the cryostat. At a thread pitch of 24 $inch^{-1}$ one turn of the stepper motor translates to 0.011 mm linear displacement of the brass block. This ratio provides sufficient resolution for the strain data. In this configuration the whole setup is rated for tensile loads up to 2.5 kN.
The setup allows for characterization of short sample lengths of 130 mm.

## Results and Discussion

Preliminary experiments were conducted on research grade $Nb_3Sn$ wire samples of 0.42 mm diameter. $I_c$ ratios versus strain data for two samples from different sections of a wire batch are shown in Fig. 2 (top). Both samples have peak Ic values of 50 A and 57.3 A at strain values of about 0.30 %, averaged over two strain gauges mounted on each sample. Fig. 2 (bottom) shows the *n*-values as a function of the applied strain. Up to about 0.4 % strain the *n*-values for both samples stay almost constant at around $n = 8$. Above 0.4 % strain the *n*-values drop to $n = 5$ indicating begin of mechanical damage to the samples. Microstructural analysis on sections of the conductor material revealed irregularities in the filament geometry, which contributed to low *n*-values. Further modifications and experiments allowing the use of an extensometer for the strain characterization are in progress.

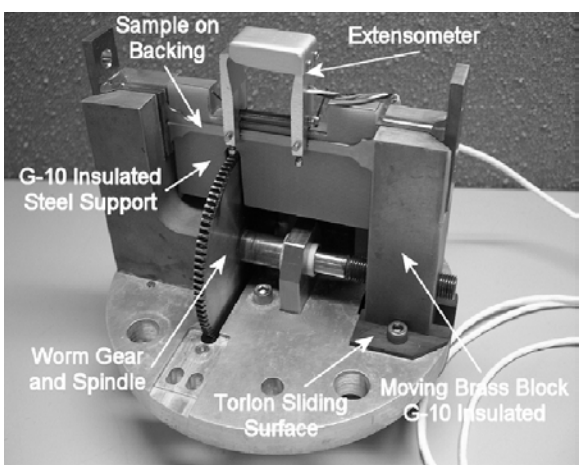


Figure 1. View of the strain device. Below the bottom flange (not visible in the picture) is a guiding rod, which is connected to the moving brass block. It moves in a slide bearing that is bolted to the bottom flange and enforces parallel displacement.

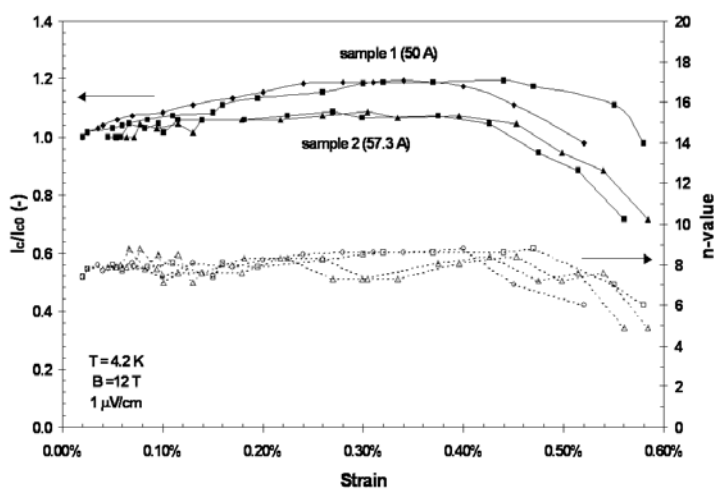


Figure 2. top: Normalized $I_c$ ($\varepsilon = 0$) versus strain at 4.2 K and 12 T background field for two wire samples of different sections from the same batch. The values in brackets represent the maximum currents achieved under strain. Bottom: *n*-values of the samples versus applied strain.

Ref.: U.P. Trociewitz, R.P. Walsh, V.J. Toplosky, B. Trociewitz, H.W. Weijers, J. Miller, "A Device to Evaluate the In-field Transport Properties of Superconductors under Strain", submitted to IEEE Transactions on Applied Superconductivity, 2004.