Cryogenics 35 (1995) S99–S100

0011-2275/95/$10.00

V-6: Effects of temperature variation

H. Kirchmayr and L.F. Goodrich*

Technische Universität Wien, Vienna, Austria
*National Institute of Standards and Technology, Boulder, Colorado, USA

Introduction

The critical current (I_c) of a NbTi or Nb_3Sn superconductor specimen depends on its temperature. NbTi or Nb_3Sn specimens are usually immersed in liquid helium, whose temperature is a function of the vapour pressure inside the cryostat. The pressure, and thus the liquid helium temperature, may vary between laboratories due to different altitudes and different cryostats used for the I_c measurement. Thus, it is necessary to study the temperature dependence of the specimen's critical current. This paper presents measurements of I_c as a function of temperature for tests carried out at the Technical University of Vienna (TUW) and the National Institute of Standards and Technology (NIST).

Experimental details

Sample B was used for this study. Mandrels made from G-10CR with two different texture orientations (normal and fill; see papers II-5 and V-4 for definitions) were used for this measurement. The mandrel dimensions are shown in *Table 1*. They have an overall length of 60 mm including a 30 mm tube of stainless steel or G-10CR with 10 turns (3 mm pitch) and a 15 mm wide copper current terminal ring at both ends of the mandrel with five turns. The voltage taps were located over the two innermost windings of the specimen wire coil.

The following conditions apply for measurements at TUW. Critical currents for 10 and 100 μV m^{-1} criteria were determined between $\approx$2.3 and 4.2 K in magnetic fields of 6–12 T. Critical current was defined on the basis of an n-value fit through five to six points at the upper end of a V–I curve. The V–I measurement was done under quasistatic conditions, meaning that the specimen-current ramp rate was approximately zero for each point on the V–I curve. The experimental details cited above (for TUW) were very similar to those at NIST, except that the measurement temperatures were 4.0 and 4.2 K at NIST. The estimated uncertainty of the I_c measurements is less than 1% at 12 T for both laboratories.

Results and discussion

In *Figure 1*, critical currents based on a 10 μV m^{-1} criterion are shown as a function of temperature. It is generally accepted that for most practical superconductors, the temperature dependence of I_c is approximately linear for a small enough range of temperature and magnetic field. *Table 2* summarizes the results of the dI_c/dT measurements using G-10CR mandrels with normal texture. For the highest magnetic field measured, the change in I_c due to a 0.1 K change in liquid helium temperature is estimated to be $\approx$1.28%. This is not expected to be a limiting factor for an interlaboratory comparison of I_c measurements, since it is assumed that the variation in liquid helium temperature is

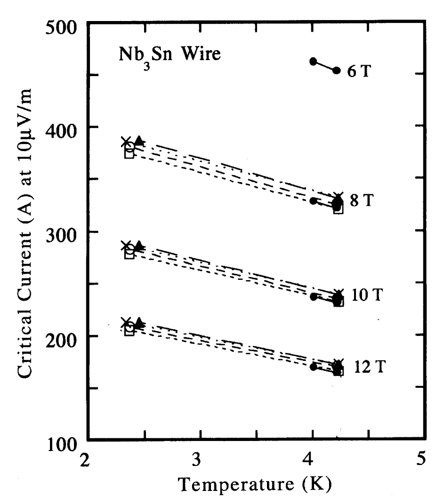

Figure 1 Temperature dependence of I_c for a criterion of 10 μV m^{-1} and G-10CR mandrels with fill and normal directions (○, □, two fill specimens; ●, ▲, X, three normal specimens)

Table 1 Specifications of measurement mandrels

Overall length (mm)	Outer diameter (mm)	Inner diameter (mm)	Spiral groove/pitch
60	25.0	15.0	60° V/3 mm

Table 2 Summarized results on temperature dependence of I_c (G-10CR mandrel, normal direction)

Field (T)	I_c at 4.2 K (A)	dI_c/dT (A K^{-1})	ΔI_c (for ΔT of 0.1 K) (%)[a]	Laboratory
8	332	−31	−0.93	TUW
10	240	−27	−1.13	TUW
12	172	−22	−1.28	TUW
6	453	−43	−0.96	NIST
8	321	−33	−1.02	NIST
10	231	−27	−1.15	NIST
12	164	−24	−1.45	NIST

[a] ΔI_c (%) = $\{dI_c/dT(\text{A K}^{-1})/I_c(\text{A})\} \times 0.1(\text{K}) \times 100(\%)$

usually much smaller than 0.1 K. The difference in the two dI_c/dT determinations from NIST and TUW for a 0.1 K temperature range is less than 0.2%, which is sufficiently low for this study. Some of this difference may be due to a slight curvature in the temperature dependence of I_c.

Figure 1 also shows that the temperature dependence of I_c (dI_c/dT) does not depend on the texture anisotropy of the mandrel composite, although systematic differences in I_c between mandrels are observed.

Conclusions

It is desirable to monitor and report the temperature of liquid helium, since large variations in the vapour pressure in the cryostat may affect the measured critical current. For small temperature changes, however, the variation in liquid helium temperature is not expected to be a significant source of data scatter in interlaboratory comparisons of critical current. For temperature changes of the order of 0.1 K, the temperature dependence is estimated to be between 1.28 and 1.45% at 12 T, which is sufficiently low for this study.