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CHAPTER SIX

ELECTRICAL CONSIDERATIONS

6.16 SUPERCONDUCTING WIRE AND CABLE

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NbTi remains the "workhorse" material for most applications today with a higher field alternative, NbTiTa also available. Recent advances[1,2] have shown the viability of Nb_3Sn for some magnet applications as well. The high temperature superconductors Bi-2212, 2223 and YBCO are becoming available as practical materials.

Intrinsic properties of superconductors are discussed in 6.2. They are composition dependent but not strongly processing dependent. However, the most useful engineering property, J_c, depends strongly on the microstructure and processing details. The J_c of NbTi wire which has been optimized is typically 2750 A/mm^2 at 5T, 4.2K. Were the same wire to be annealed at 700-800 °C for a few hours the J_c may drop by an order of magnitude, leaving T_c and B_{c2} basically unchanged. Although J_c is process dependent it is predictable and can be scaled as a function of T_c and H_{c2}. This applies to NbTi and Nb_3Sn once a measurement has been made at a field and/or temperature near the proposed operating point. Eq. 1 gives the scaling rule[3] valid for B>0.7 B_{c2}.

$$J_c(T_o,B) = J_c(T_o,B_o)\frac{B_{c2}(T_o)-B(T_o)}{B_{c2}(T_o)-B_o(T_o)} \quad (1)$$

where T_o is the temperature at which J_c was measured, B_o is the highest magnetic induction at which the J_c is known, $B_{c2}(T_o)$ is the critical induction at T_o and $J_c(T_o,B_o)$ is the critical current density at T_o,B_o. Fig. 1[6] and Table 1 display useful examples of commercially available materials as well as improvement potential.

A scaling rule for Nb_3Sn is also known[4] but in this case the critical values are also strain dependent[5] which needs to be taken strictly into account in practical coil design.

J_c is also radiation dependent, as shown in Fig. 2, with the J_c increasing up to a neutron fluence of about 10^{18} neutrons/cm^2 and then decreasing at higher fluences.

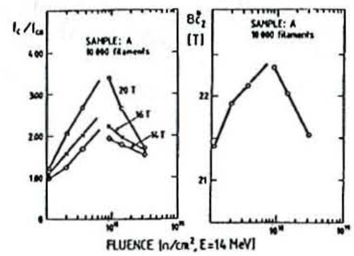

Figure 1. I/I and B_{c2} of a 10000 core bronze processed binary Nb_3Sn wire after neutron irradiation at 25°C.

NbTi is available in the form of multifilimentary composite wire and cable with a wide range of filament sizes, matrix to superconductor ratios and current ratings. For accelerator magnets where conductor magnetization is important (see 7.2.3, 7.2.2), composites with filament sizes as fine as 5 microns are standard with 2.5 micron being available on special order. Cu to superconductor ratios from 1:1 to about 4:1 are easily manufacturable; higher ratios or special matrix materials such as Al for higher radiation transparency are also available on special order. Multikiloamp conductors are routinely available as monolithic conductors or more likely as cables of wires since it is easier to get higher current densities in small wires and cables are more flexible than monolithic conductors.

High current, low heat loss leads are available with high temperature superconductor components (yrrrium barium copper oxide or bismuth strontium calcium copper oxide) in the range of 100 to 10,000 A, at a price of approximately $3/amp. per lead.

References
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