STANDARDIZED TESTS FOR SUPERCONDUCTING MATERIALS*

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It has become necessary to define more clearly the properties of commercial winding materials for superconducting magnet coils and to standardize appropriate test methods. Basic physical constants (e.g., critical temperature of the superconductor, or the resistance of the substrate of a compound conductor) are important data which can be determined by means of well-known experimental procedures. However, they are not sufficient to describe fully all of the relevant properties of commercial superconductive materials. More complex performance data are of interest which call for special test methods.

First of all, I shall discuss the concepts of the critical current I_c, the take-off current I_t, and the recovery current I_r. The dependence of these three quantities on the external field H should be determined by short sample tests in unrestricted liquid helium flow. Furthermore, the current source should have such a characteristic that complete test cycles involving I_c, I_t, and I_r can be run without damaging the sample.[1] Besides these three numerical values, complete flux flow diagrams are desirable for describing fully the stability performance of short samples, because different forms of the flux flow characteristics can be observed. "Stability Case A" means a smooth transition from resistanceless superconducting state to a stable flux flow state which is terminated by "take-off" to the normal state. "Stability Case B" designates discontinuous transition from the resistanceless state to a stable flux flow state, and finally, "Stability Case C" stands for abrupt transition from superconducting to normal state without attaining a stable flux flow state.[2]

In addition to these tests with noninductive short samples, tests with inductive samples (conductor lengths from a few hundred to a thousand feet) are of interest. At ORNL such a special test, called "Cusp Coil Test," has been developed.[3] The superconducting material is wound in a split coil with horizontal axis. In the two halves the current flows in opposite directions so that a "cusp field" is produced. This split coil is exposed to a vertical external field of up to 60 kG which is generated by a "conventional" magnet coil with an inside diameter of 32 cm. Critical currents of the test cusp coil are most conveniently measured by raising the cusp coil current with constant external field. The windings of the cusp coil are exposed to a nonaxisymmetrical field which results from the superposition of the external and the self fields. Thus, the magnitude of the resulting field in the various volume elements of the windings varies between the sum and difference of self and external fields. The cusp coil characteristics deviate appreciably from the short sample characteristics of the same winding materials. Furthermore, significant influence of the rate of rise of the external field can be observed. The cusp coil test, which can be done with a not too

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1. W.F. Gauster and J.B. Hendricks, J. Appl. Phys. 39, 2572 (1968).

2. W.F. Gauster and J.B. Hendricks, in Proc. Intermag Conf. 1968 (to be published).

3. W.F. Gauster and D.L. Coffey, J. Appl. Phys. 39, 2647 (1968).

large quantity of superconducting winding material, seems at present to be the most realistic test for the material performance in the actual magnet coil. However, the cusp coil test needs a coil of large working diameter for providing the external field, and this restricts this test method to larger laboratories.

After this discussion of test procedures, we arrive at the following conclusions: In the interest of both manufacturers and users, it is highly desirable to work out clear concepts and definitions concerning the performance of winding materials of superconducting magnet coils. In order to achieve well reproducible test data, standardized test methods should be used. There have been undisputed benefits of the various standardized test procedures now generally employed in almost all fields of engineering. I would suggest the formation of a working group (most fittingly in the frame of the IEEE) with the goal of working out clear definitions of the nomenclature used in connection with the performance of commercial superconducting winding materials and to standardize methods for determining the relevant numerical test data.

SUPERCONDUCTING MAGNETS FOR THE 200 GEV ACCELERATOR EXPERIMENTAL AREAS*

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INTRODUCTION

The experimental areas of the 200 GeV accelerator provide an opportunity to realize a really large payoff from the use of superconducting magnets. Costs might be reduced because of the virtual elimination of the electric power and the systems necessary for delivering and dissipating that power. Further savings, and perhaps better physics, may result from the shortening of beam lines made possible by the higher magnetic fields.

A major part of the cost of an experimental area is associated with the dc magnets used for transporting secondary particle beams, and it is these magnets which are under consideration in this paper. If it is decided to make them superconducting, that decision must be made before large sums of money are committed for furnishing the electrical and cooling systems and other features of the experimental areas associated with conventional magnets. For the first of the three experimental areas planned, the decision must be reached by the fall of 1969. An early decision will furnish an impetus to the development of magnets suitable for that application.

The multitude of problems associated with superconducting magnets can be divided into two groups. The "priority program" comprises those items necessary for reaching a decision at an early date on whether to adopt conventional or superconducting magnets. The "nonpriority program" comprises the remaining items aimed at deriving the maximum benefit from superconducting magnets by continued improvement of the technology.

The priority program must include not merely the magnets but also the entire system associated with large numbers of magnets, and the interaction between that system and the performance of physics experiments.

To be acceptable, the superconducting magnet system must be economical. But, the economics will probably be rather different from a system of conventional magnets. At present it seems that the total capital cost of the superconducting magnet system will be higher than a system of conventional magnets. If initial equipment money is limited, this may mean that the superconducting system must be acquired at a slower rate. But a strong argument could be made for enhanced equipment funds to be traded off against lowered operating costs.

To be acceptable, superconducting magnets must be predictable, realiable, and easy to operate. If each of the 20 to 40 magnets on a beam had the characteristics of a temperamental laboratory device the physicists would find it intolerable. The optical properties must be at least as good as conventional magnets, and this requires careful design, precise conductor placement, and freedom from hysteresis effects. Short focal lengths and large acceptance angles may cause additional problems.

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