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Critical current measurement - Measurement of critical current and its uniformity along the length of second generation high temperature superconducting long tapes

临界电流测量 第二代高温超导长带临界电流及其沿长度方向均匀性测量

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Foreword

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1.Structure and Drafting Rules of Standardization Documents" drafted. Please note that some content of this document may be patented. The issuing agency of this document assumes no responsibility for identifying patents. This document is proposed by the Chinese Academy of Sciences. This document is under the jurisdiction of the National Superconductivity Standardization Technical Committee (SAC/TC265). This document is drafted by: Shanghai Shangchuang Superconducting Technology Co., Ltd., Shanghai Superconducting Technology Co., Ltd., Suzhou New Materials Research Institute Co., Ltd., Shanghai Cable Research Institute Co., Ltd., China Shipbuilding Industry Corporation No. 712 Research Institute, Institute of Electrical Engineering, Chinese Academy of Sciences, Institute of Physics, Chinese Academy of Sciences, Western Superconducting Materials Technology Co., Ltd., Institute of Plasma Physics, Chinese Academy of Sciences, China Electric Power Scientific Research Institute Co., Ltd., Tsinghua University, North China Electric Power University, Electric Power Research Institute of Guangdong Power Grid Co., Ltd., Shanghai University, Shanghai Jiaotong University. The main drafters of this document. Cai Chuanbing, Zhang Yongjun, Zhao Yue, Zhu Jiamin, Xiong Xuming, Li Jie, Zong Xihua, Zheng Jun, Zhang Guomin, Liu Zhiyong, Li Minjuan, Yan Guo, Liu Huajun, Qiu Ming, Gu Chen, Wang Yinshun, Cheng Junsheng, Chen Sikan, Hu Nannan, Wang Yushan.

In the 30 years since the discovery of Y-Ba-Cu-O (YBCO) in 1987, RE-Ba-Cu-O (REBCO, RE. rare earth element) superconductors Significant progress has been made in the practical application of strips, and the length of strip preparation has reached hundreds of meters or even kilometers. In order to distinguish the bismuth series represented by Bi-2223 The first-generation high-temperature superconducting tape, commonly referred to as REBCO superconducting tape, is the second-generation high-temperature superconducting (2G-HTS) tape, also known as coated conductor tape. body. At this stage, 2G-HTS tape has been commercialized. 2G-HTS tape has the advantages of low loss and high current-carrying density, but compared with conventional conductors or low-temperature superconducting materials, due to REBCO superconductor is a ceramic

material with fragile mechanical properties and is easily damaged, and local defects will affect the performance of the entire strip. The critical current is one of the important technical indicators to characterize the superconducting properties of 2G-HTS tapes. The traditional low temperature superconducting wire uses four leads The measurement method is to take short samples at the head and tail ends of the wire for measurement, and for the 2G-HTS long strip, the results cannot represent the whole wire. performance. Therefore, the continuous measurement of the critical current and its uniformity for the 2G-HTS long strip is very necessary. At present, there are many kinds of continuous measurement methods for the critical current of 2G-HTS long strip, such as transmission method and induction method (which can be subdivided into many kinds) Wait. The measurement methods used by different manufacturers are different, and the inconsistency of measurement standards is not conducive to the large-scale application of 2G-HTS strips. therefore, It is necessary and significant to establish a standard measurement method to standardize the measurement of critical current and its uniformity along its length. Accordingly, this document specifies the measuring device, measuring method and result calculation. The implementation of this document will effectively promote 2G-HTS Industrial development of strips. Critical current measurement of second-generation high-temperature superconducting long ribbons Critical current and its uniformity measurement along its length IMPORTANT. The application of this document may involve certain hazardous materials and operations. but not all security issues related to this all make recommendations. It is the user's responsibility to formulate appropriate safety and protection measures before using this document, and to clarify its restricted scope of application.

1 Scope

China's national method for measuring the critical current and its uniformity along the length of second generation high temperature superconducting tape. Second generation tape is a coated conductor: a thin layer of rare earth barium copper oxide deposited on a flexible metal substrate through a stack of buffer layers, in a process that must maintain crystallographic alignment along hundreds of metres. The critical current is the current above which the tape stops superconducting, and for a long tape the number that matters is not the average but the minimum. A magnet or a cable made from the tape is limited by its weakest point, because that is where the transition begins and where the whole conductor will quench. So the measurement has to be continuous along the length rather than made on samples, and uniformity is the property being bought - which is what distinguishes this standard from an ordinary critical current measurement.

This document describes a method for measuring the DC critical current of second-generation high-temperature superconducting (2G-HTS) long strips with a single length of not less than 10m and its distribution along its length (see Chapter 4). This document is suitable for measuring width 2mm~15mm, thickness 0.1mm~0.5mm, critical current less than 500A, n-value greater than 5, Copper and copper alloy packaging tapes

with an overcurrent capability at liquid nitrogen temperature at least

1.5 times their nominal critical current. This document does not apply to the measurement of 2G-HTS tapes coated with insulating layers. Note

1.This method can be used to measure strips with a critical current exceeding 500A, but the DC constant current source needs to be able to provide a sufficiently high current, and more caution is required The protective circuit is designed to prevent the strip from being damaged during the measurement. Note

2.The measurement conditions of this method are a standard atmospheric pressure and a self-field, and the measurement part is completely immersed in a liquid nitrogen bath and is in a stable state. having measured When the atmospheric pressure deviates or there is a magnetic field during the process, the measurement results can be corrected as needed. Note

3.Other specific limitations and auxiliary measurement methods are given in Appendix A and Appendix B.

2 Normative references

The contents of the following documents constitute essential provisions of this document through normative references in the text. Among them, dated citations documents, only the version corresponding to that date applies to this document; for undated references, the latest edition (including all amendments) applies to this document.

GB/T 2900.100-2017 Electrical term superconductivity

3 Terms and Definitions

The terms and definitions defined in GB/T 2900.100-2017 and the following terms and definitions apply to this document.

3.1 critical current criticalcurrent IC In superconductors, the maximum direct current that can be considered to flow almost unimpeded. NOTE. Ic is a function of magnetic field strength, temperature and strain. [Source: GB/T 2900.100-2017, 815-12-01]

3.2 Ic criterion Iccriterion The criterion of critical current Ic is determined according to electric field strength E or resistivity rho.

Note. The commonly used electric field criterion is E=10μV/m or E=100μV/m, and the resistivity criterion is rho=10-14Omega·m, or rho=10-13Omega·m. [Source: GB/T 2900.100-2017, 815-12-02]