

Superconductivity —

Part 3: Critical current measurement — DC critical current of Ag-sheathed Bi-2212 and Bi-2223 oxide superconductors

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National foreword

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Part 3: Critical current measurement -
DC critical current of Ag-sheathed Bi-2212
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Supraconductivité
Partie 3: Mesure du courant critique -
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Supraleitfähigkeit
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von Ag-ummantelten oxidischen Bi-2212
und Bi-2223-Supraleitern
(IEC 61788-3:2000)

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

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Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annexes A and B are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61788-3:2000 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

In 1986 J.G. Bednorz and K.A. Mueller discovered that some Perovskite type Cu-containing oxides show superconductivity at temperatures far above those which metallic superconductors have shown. Since then, extensive R & D work on high-temperature oxide superconductors has been and is being made worldwide, and its application to high-field magnet machines, low-loss power transmission, electronics and many other technologies is in progress [1].¹

Fabrication technology is essential to the application of high-temperature oxide superconductors. Among high-temperature oxide superconductors developed so far, BiSrCaCu oxide (Bi-2212 and Bi-2223) superconductors have been the most successful at being fabricated into wires and tapes of practical length and superconducting properties. These conductors can be wound into a magnet to generate a magnetic field of several tesla [2]. It has also been shown that Bi-2212 and Bi-2223 conductors can substantially raise the limit of magnetic field generation by a superconducting magnet [3].

In summer 1993, VAMAS-TWA16 started working on the test methods of critical currents in Bi-oxide superconductors. In September 1997, the TWA16 worked out a guideline (VAMAS guideline) on the critical current measurement method for Ag-sheathed Bi-2212 and Bi-2223 oxide superconductors. This pre-standardization work of VAMAS was taken as the base for the IEC standard, described in the present document, on the d.c. critical current test method of Ag-sheathed Bi-2212 and Bi-2223 oxide superconductors.

The test method covered in this International Standard is intended to give an appropriate and agreeable technical base to those engineers working in the field of superconductivity technology.

The critical current of composite superconductors like Ag-sheathed Bi-oxide superconductors depends on many variables. These variables need to be considered in both the testing and the application of these materials. Test conditions such as magnetic field, temperature and relative orientation of the specimen and magnetic field are determined by the particular application. The test configuration may be determined by the particular conductor through certain tolerances. The specific critical current criterion may be determined by the particular application. It may be appropriate to measure a number of test specimens if there are irregularities in testing.

¹ The numbers in brackets refer to the bibliography.

SUPERCONDUCTIVITY –

Part 3: Critical current measurement – DC critical current of Ag-sheathed Bi-2212 and Bi-2223 oxide superconductors

1 Scope

This part of IEC 61788 covers a test method for the determination of the d.c. critical current of short and straight Ag- or Ag alloy-sheathed Bi-2212 and Bi-2223 oxide superconductors that have a monolithic structure and a shape of round wire or flat or square tape containing mono- or multicores of oxides.

This method is intended for use with superconductors that have critical currents less than 500 A and n -values larger than 5. The test is carried out with and without applying external magnetic fields. In the test of the tape specimen in magnetic fields, the magnetic fields are parallel or perpendicular to the tape surface. The test specimen is immersed either in a liquid helium bath or a liquid nitrogen bath during testing. Deviations from this test method that are allowed for routine tests and other specific restrictions are given in this standard.

Substantial parts of the test method covered in this standard are in common with, or similar to, those for Nb_3Sn composite superconductors (IEC 61788-2). Special features newly found for oxide superconductors may be classified into two groups. The first group is specific to oxide composite superconductors, including mechanical fragility originating from the presence of weak links, cryogen gas bubble formation, aging degradation, magnetic flux flow and creep, large anisotropy, hysteresis in critical current with magnetic field sweep, etc. The second group is due to the short length of the specimen used in the standard. A critical current measurement on such a specimen may easily pick up different voltage signals due to thermal electromotive force, inductive voltage, thermal noise, current redistribution, specimen motion relative to the holder, etc. Current transfer voltages may be present due to the short distance from a current contact to a voltage tap. Short specimen length may reduce mechanical tolerance against the Lorentz force, for example, by promoting the formation of cryogen gas bubbles within the composite.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61788. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61788 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050-815:2000, *International Electrotechnical Vocabulary (IEV) – Part 815: Superconductivity*

IEC 61788-2:1999, *Superconductivity – Part 2: Critical current measurement – DC critical current of Nb_3Sn composite superconductors*

3 Terminology

For the purpose of this standard, the definitions given in IEC 60050-815 and the following definitions apply.

3.1

critical current (I_c)

current at which a specified electric field strength (electric field) criterion (E_c) or resistivity criterion (ρ_c) is reached in the specimen at a certain value of a static applied magnetic field at a specified temperature either in a liquid helium bath or a liquid nitrogen bath at a constant pressure. For either E_c or ρ_c , there is a corresponding voltage criterion U_c for a specified sample length.

3.2

Bi-2212 and Bi-2223 oxide superconductors are defined in the chemical formulae as follows:

Bi-2212; $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_x$ ($x = \sim 8$),

Bi-2223; $(\text{Bi,Pb})_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_x$ ($x = \sim 10$).

4 Requirements

The critical current of a superconductor shall be measured by applying a direct current (I) to the superconductor specimen and then measuring the voltage (U) generated along a section of the specimen. The current shall be increased from zero and the voltage-current ($U-I$) characteristic generated and recorded.

The target precision of this method is a coefficient of variation (standard deviation divided by the average of the critical current determinations) that is less than 5 % for the measurement at 0 T and near 4,2 K or 77 K.

The use of a common current transfer correction is excluded from this test method. Furthermore, if a current transfer signature is pronounced in the measurement, then the measurement shall be considered invalid.

It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. Specific precautionary statements are given below.

Hazards exist in this type of measurement. Very large direct currents with very low voltages do not necessarily provide a direct personal hazard, but accidental shorting of the current leads with another conductor, such as tools or transfer lines, can release significant amounts of energy and cause arcs or burns. It is imperative to isolate and protect current leads from shorting. Also the energy stored in the superconducting magnets commonly used for the background magnetic field can cause similar large current and/or voltage pulses or deposit a large amount of thermal energy in the cryogenic systems causing rapid boil-off or even explosive conditions. The use of cryogenic liquids is essential to cool the superconductors, which allows the transition into the superconducting state. Direct contact of skin with cold liquid transfer lines, storage dewars or apparatus components can cause immediate freezing, as can direct contact with a spilled cryogen. It is imperative that safety precautions for handling cryogenic liquids be observed.