

Superconductivity —

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

The European Standard EN 61788-3:2006 has the status of a British Standard

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National foreword

This British Standard was published by BSI. It is the UK implementation of EN 61788-3:2006. It is identical with IEC 61788-3:2006. It supersedes BS EN 61788-3:2001 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee L/-/90, Super Conductivity.

A list of organizations represented on L/-/90 can be obtained on request to its secretary.

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Superconductivity
Part 3: Critical current measurement -
DC critical current of Ag- and/or Ag alloy-sheathed
Bi-2212 and Bi-2223 oxide superconductors
(IEC 61788-3:2006)

Supraconductivité

Partie 3: Mesure du courant critique -
Courant critique continu des oxydes
supraconducteurs Bi-2212 et Bi-2223
avec gaine Ag et/ou en alliage d'Ag
(CEI 61788-3:2006)

Supraleitfähigkeit

Teil 3: Messen des kritischen Stromes -
Kritischer Strom (Gleichstrom) von
Ag- und/oder Ag-Legierung ummantelten
oxidischen Bi-2212 und
Bi-2223-Supraleitern
(IEC 61788-3:2006)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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

Foreword

The text of document 90/184/FDIS, future edition 2 of IEC 61788-3, prepared by IEC TC 90, Superconductivity, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61788-3 on 2006-06-01.

This European Standard supersedes EN 61788-3:2001.

Modifications made to EN 61788-3:2001 mostly involve wording and essentially include no technical changes.

Examples of technical changes introduced include the voltage lead diameter being smaller than 0,21 mm and the mode of expression for magnetic field accuracy being $\pm 1\%$ and $\pm 0,02\text{ T}$ instead of 1% . The expression for magnetic field precision has been changed in the same way.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2007-03-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2009-06-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61788-3:2006 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 dc 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- and/or Ag alloy-sheathed Bi-2212 and Bi-2223 oxide superconductors

1 Scope

This part of IEC 61788 covers a test method for the determination of the dc critical current of short and straight Ag- and/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 an applying external magnetic field. For all tests in a magnetic field, the magnetic field is perpendicular to the length of the specimen. In the test of a tape specimen in a magnetic field, the magnetic field is parallel or perpendicular to the wider tape surface (or one surface if square). 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.

2 Normative reference

The following referenced document is indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-815, several of which have been repeated here for convenience, and the following apply.

3.1 critical current

I_c

maximum direct current that can be regarded as flowing without resistance

NOTE I_c is a function of magnetic field strength and temperature.

[IEV 815-03-01]

3.2 critical current criterion

I_c criterion

criterion to determine the critical current, I_c , based on the electric field strength, E or the resistivity, ρ

NOTE 1 $E = 10 \mu\text{V/m}$ or $E = 100 \mu\text{V/m}$ is often used as the electric field strength criterion, and $\rho = 10^{-13} \Omega \cdot \text{m}$ or $\rho = 10^{-14} \Omega \cdot \text{m}$ is often used as the resistivity criterion.

NOTE 2 For short high temperature oxide superconductor specimens, less sensitive criteria than those shown in Note 1 are sometimes used.

[IEV 815-03-02, modified]

3.3

n-value (of a superconductor)

exponent obtained in a specific range of electric field strength or resistivity when the voltage/current U - I curve is approximated by the equation $U \propto I^n$

NOTE In the case for high temperature oxide superconductors, the equation $U \propto I^n$ does not hold in a wide range of U .

[IEV 815-03-10, modified]

3.4

quench

uncontrollable and irreversible transition of a superconductor or a superconducting device from the superconducting state to the normal conducting state

NOTE A term usually applied to superconducting magnets.

[IEV 815-03-11]

3.5

Lorentz force (on fluxons)

force applied to fluxons by a current

NOTE 1 The force per unit volume is given by $\mathbf{J} \times \mathbf{B}$, where $\mathbf{J}$ is a current density, and $\mathbf{B}$ is a magnetic flux density.

NOTE 2 "Lorentz force" is defined in IEC 60050-111-20.

[IEV 815-03-16]

3.6

current transfer (of composite superconductor)

phenomenon that a dc current transfers spatially from filament to filament in a composite superconductor, resulting in a voltage generation along the conductor

NOTE In the I_c measurement, this phenomenon appears typically near the current contacts where the injected current flows along the conductor from periphery to inside until uniform distribution among filaments is accomplished.

3.7

constant sweep rate method

a U - I data acquisition method where a current is swept at a constant rate from zero to a current above I_c while continuously or frequently and periodically acquiring U - I data

3.8

ramp-and-hold method

a U - I data acquisition method where a current is ramped to a number of appropriately distributed points along the U - I curve and held constant at each one of these points while acquiring a number of voltages and current readings

3.9

Bi-2212 and Bi-2223 oxide superconductors

oxide superconductors with layered structure containing CuO_2 sheets and chemical formulae, $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_x$ ($x \approx 8$) and $(\text{Bi,Pb})_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_x$ ($x \approx 10$), respectively