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Introduction

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For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



90/551/CD

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Mr Hideki Ii

OF INTEREST TO THE FOLLOWING COMMITTEES:

HORIZONTAL FUNCTION(S):

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TITLE:

Electromechanical properties measurement – Electromechanical test of practical REBCO and BSCCO composite superconductors at liquid nitrogen temperature

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SUPERCONDUCTIVITY –**Part 29: Electromechanical properties measurement –
Electromechanical test of practical REBCO and BSCCO composite
superconductor tapes at liquid nitrogen temperature**

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The text of this International Standard is based on the following documents:

Draft	Report on voting
90/XX/CD	90/537/RVN

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn
- replaced by a revised edition, or
- amended.

INTRODUCTION

Several types of composite superconductors have now been commercialized. The rare-earth-based oxide superconductor (SC) with the chemical formula $\text{RE}_1\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ is used in practical SC tapes, where the rare-earth element RE is Y, Dy, Gd, Eu, Nd, Ho, and Sm or a mixture of them. This type of practical SC tape is usually called a REBCO-coated conductor. A typical architecture consists of a substrate of Hastelloy, Ni-W alloy, or stainless steel, a buffer layer consisting of plural oxides, an SC layer, protection layers of Ag, and electroplated copper layers. The substrate and buffer layers act as templates to facilitate the well-oriented crystal grains of the SC layer. To resist the strong electromagnetic force, the tapes are in some cases externally reinforced by laminating thin foils of stainless steel, copper, or a copper alloy.

Two types of bismuth-based oxide superconductors with the chemical formula $(\text{Bi}, \text{Pb})_2\text{Sr}_2\text{Ca}_{n-1}\text{Cu}_n\text{O}_{2n+4}$ where $n = 2$ or 3 , have been developed as practical SC tapes. In either case, superconducting filaments are embedded in a pure silver matrix. This type of practical SC tape is usually called BSCCO tape. In the Bi-2223 tapes, a silver alloy outer sheath surrounds the matrix to increase mechanical strength. They are made exclusively in a flat tape-shaped form. Tapes are commercially available in which thin metallic sheets of copper alloy, stainless steel, or nickel alloy are soldered on both sides of the SC tapes to improve the stress dependence of critical current and the mechanical properties.

Practical composite superconductors have a high current density and a small cross-sectional area. The major application of composite superconductors is to build electrical power devices and superconducting magnets. While the magnet is being manufactured, complex stresses/strains are applied to its windings, and when it is energized, a large electromagnetic force is applied to the superconducting tapes due to their high current density. It is therefore indispensable to determine the electromechanical properties of the practical SC tapes at cryogenic temperatures.

SUPERCONDUCTIVITY –

Part 29: Electromechanical properties measurement – Electromechanical test of practical REBCO and BSCCO composite superconductor tapes at liquid nitrogen temperature

1 Scope

This part of IEC 61788 details the testing procedure for measuring the critical current (I_c) in practical REBCO and BSCCO composite superconductor tapes under tensile loading to determine the electromechanical properties using a stress-based tensile test method without the use of extensometers at liquid nitrogen temperature. This stress-based test method measures the reversible stress limits for I_c degradation under an applied tensile load.

When REBCO tapes are tested using this procedure, they should have a rectangular cross-section with an area of 0,06 mm² to 5,0 mm² (corresponding to tapes 2,0 mm to 12,5 mm in width and 0,03 mm to 0,4 mm in thickness). When BSCCO tapes are tested, they should have a rectangular cross-section with an area of 0,3 mm² to 2,5 mm² (corresponding to tape-shaped ones 2,0 mm to 5,0 mm in width and 0,15 mm to 0,5 mm in thickness).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-815:2024, *International Electrotechnical Vocabulary (IEV) – Part 815: Superconductivity*

IEC 61788-26, Ed. 1: *Superconductivity - Part 26: Critical current measurement – DC critical current of RE-Ba-Cu-O composite superconductors*

IEC 61788-28, CDV: *Superconductivity – Part 28: Mechanical properties measurement – Tensile test of practical REBCO and BSCCO composite superconductors at cryogenic temperatures*

ISO 376:2011, *Metallic materials – Calibration of force-proving instruments used for the verification of uniaxial testing machines*

ISO 7500-1:2018, *Metallic materials – Calibration and verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Calibration and verification of the force-measuring system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-815 and ISO 6892, as well as the following, apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1 tensile stress R

Tensile force divided by the original cross-sectional area at any moment during the test.

3.2 stress interval ΔR

Stress interval set to measure the behaviour of the critical current (I_c) generated by the tensile stress applied to the superconducting tape specimen using a stress-based tensile test method.

Note 1: This stress interval aligns with the strain interval (approximately 0.05%) typically employed in the strain-based test to evaluate the strain-dependent behaviour of I_c . However, it is not constant; rather, it varies across the deformation region within the material. In the initial elastic region, where material deformation is minimal, the ΔR is deliberately broad. As the applied stress escalates and I_c degradation becomes noticeable in the subsequent plastic region, the stress interval narrows.

Note 2: The specific values of ΔR are contingent on factors like the substrate material, tape structure, and the presence of stabilizer layers in the specimen. Generally, the broad ΔR can span from 50 to 100 MPa, while the narrow ΔR typically ranges from 10 to 20 MPa. It is important to note that the narrow ΔR is approximately 1/5 of the magnitude of the broad ΔR . This variation in stress intervals accommodates the evolving response of the superconducting material to the tensile load.

3.3 transition stress R_T

Stress at the point where ΔR changes from a broad to a narrow range while measuring the I_c under tensile stress (see Figure 2).

Note: This R_T is instrumental in accurately establishing the reversible stress limit for I_c degradation in the specimen. It is commonly associated with the stress level at which I_c degrades to approximately 95% of its initial critical current (I_{c0}). Alternatively, when applicable, the transition stress may be set to 80% of the specimen's yield stress [1].

3.4 critical current I_c

Maximum direct current that can be regarded as flowing practically without resistance.

Current that passes through a specimen of HTS tape at a particular temperature, often at the levels of liquid helium (LHe) or liquid nitrogen (LN₂), while maintaining constant pressure. It is defined by an electric field reference (E_c) corresponding to a specific voltage reference (U_c).

Note: I_c measured at the state before the load or deformation is applied is regarded as the initial I_c , I_{c0} . I_c in the unloaded state is referred to as the residual I_c , I_{cr} .

3.5 reversible stress limit for I_c degradation R_{rev} or R_{ret}

Reversible stress limit determined by the 99% I_{c0} recovery criterion, denoted as R_{rev} (see Figure 2). Stress level immediately before the onset of irreversible I_c degradation when subjecting the HTS wire to tensile stress R . This critical point is characterized by the fact that, following unloading, the measured critical current in the unloaded state (I_{cr}) which is also known as the recovered I_c fails to rebound to a level exceeding 99% of the initial I_{c0} during successive loading and unloading cycles.

Reversible stress limit determined by the 95% I_{c0} retention criterion, denoted as R_{ret} (see Figure 2). If the preceding criterion was derived from the I_c at the unloaded state, this criterion, the reversible stress limit was defined during loading without engaging in unloading cycles. The point at which the measured I_c