



BSI Standards Publication

Superconductivity

Part 6: Mechanical properties measurement
— Room temperature tensile test of
Cu/Nb-Ti composite superconductors

National foreword

This British Standard is the UK implementation of EN 61788-6:2011. It is identical to IEC 61788-6:2011. It supersedes BS EN 61788-6:2008, which is withdrawn.

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

A list of organizations represented on this committee can be obtained on request to its secretary.

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**Superconductivity -
Part 6: Mechanical properties measurement -
Room temperature tensile test of Cu/Nb-Ti composite superconductors
(IEC 61788-6:2011)**

Supraconductivité -
Partie 6: Mesure des propriétés
mécaniques -
Essai de traction à température ambiante
des supraconducteurs composites de
Cu/Nb-Ti
(CEI 61788-6:2011)

Supraleitfähigkeit -
Teil 6: Messung der mechanischen
Eigenschaften -
Messung der Zugfestigkeit von Cu/Nb-Ti-
Verbundsupraleitern bei Raumtemperatur
(IEC 61788-6:2011)

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Foreword

The text of document 90/267/FDIS, future edition 3 of IEC 61788-6, prepared by IEC TC 90, Superconductivity was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61788-6:2011.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2012-05-15
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2014-08-15

This document supersedes EN 61788-6:2008.

EN 61788-6:2011 includes the following significant technical changes with respect to EN 61788-6:2008:

– specific example of uncertainty estimation related to mechanical tests was supplemented as Annex C.

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Endorsement notice

The text of the International Standard IEC 61788-6:2011 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61788-5	NOTE	Harmonized as EN 61788-5.
ISO 3611:2010	NOTE	Harmonized as EN ISO 3611:2010 (not modified).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are 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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-815	-	International Electrotechnical Vocabulary - Part 815: Superconductivity	-	-
ISO 376	-	Metallic materials - Calibration of force-proving instruments used for the verification of uniaxial testing machines	EN ISO 376	-
ISO 6892-1	-	Metallic materials - Tensile testing - Part 1: Method of test at room temperature	EN ISO 6892-1	-
ISO 7500-1	-	Metallic materials - Verification of static uniaxial testing machines - Part 1: Tension/compression testing machines - Verification and calibration of the force-measuring system	EN ISO 7500-1	-
ISO 9513	-	Metallic materials - Calibration of extensometers used in uniaxial testing	EN ISO 9513	-

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INTRODUCTION

The Cu/Nb-Ti superconductive composite wires currently in use are multifilamentary composite material with a matrix that functions as a stabilizer and supporter, in which ultrafine superconductor filaments are embedded. A Nb-40~55 mass % Ti alloy is used as the superconductive material, while oxygen-free copper and aluminium of high purity are employed as the matrix material. Commercial composite superconductors have a high current density and a small cross-sectional area. The major application of the composite superconductors is to build superconducting magnets. While the magnet is being manufactured, complicated stresses are applied to its windings and, while it is being energized, a large electromagnetic force is applied to the superconducting wires because of its high current density. It is therefore indispensable to determine the mechanical properties of the superconductive wires, of which the windings are made.

SUPERCONDUCTIVITY –

Part 6: Mechanical properties measurement – Room temperature tensile test of Cu/Nb-Ti composite superconductors

1 Scope

This part of IEC 61788 covers a test method detailing the tensile test procedures to be carried out on Cu/Nb-Ti superconductive composite wires at room temperature.

This test is used to measure modulus of elasticity, 0,2 % proof strength of the composite due to yielding of the copper component, and tensile strength.

The value for percentage elongation after fracture and the second type of 0,2 % proof strength due to yielding of the Nb-Ti component serves only as a reference (see Clauses A.1 and A.2).

The sample covered by this test procedure has a round or rectangular cross-section with an area of 0,15 mm² to 2 mm² and a copper to superconductor volume ratio of 1,0 to 8,0 and without the insulating coating.

2 Normative references

The following referenced documents are 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, *International Electrotechnical Vocabulary – Part 815: Superconductivity*

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

ISO 6892-1, *Metallic materials – Tensile testing – Part 1: Method of test at room temperature*

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

ISO 9513, *Metallic materials – Calibration of extensometers used in uniaxial testing*

3 Terms and definitions

For the purposes of this document, the definitions given in IEC 60050-815 and ISO 6892-1, as well as the following, apply.

3.1

tensile stress

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

3.2 tensile strength

R_m
tensile stress corresponding to the maximum testing force

NOTE The symbol σ_{UTS} is commonly used instead of R_m .

3.3 extensometer gauge length

length of the parallel portion of the test piece used for the measurement of elongation by means of an extensometer

3.4 distance between grips

L_g
length between grips that hold a test specimen in position before the test is started

3.5 0,2 % proof strength

$R_{p0,2}$ (see Figure 1)
stress value where the copper component yields by 0,2 %

NOTE 1 The designated stress, $R_{p0,2A}$ or $R_{p0,2B}$ corresponds to point A or B in Figure 1, respectively. This strength is regarded as a representative 0,2 % proof strength of the composite. The second type of 0,2 % proof strength is defined as a 0,2 % proof strength of the composite where the Nb-Ti component yields by 0,2 %, the value of which corresponds to the point C in Figure 1 as described complementarily in Annex A (see Clause A.2).

NOTE 2 The symbol $\sigma_{0,2}$ is commonly used instead of $R_{p0,2}$.

3.6 modulus of elasticity

E
gradient of the straight portion of the stress-strain curve in the elastic deformation region

4 Principle

The test consists of straining a test piece by tensile force, generally to fracture, for the purpose of determining the mechanical properties defined in Clause 3.

5 Apparatus

5.1 Conformity

The test machine and the extensometer shall conform to ISO 7500-1 and ISO 9513, respectively. The calibration shall obey ISO 376. The special requirements of this standard are presented here.

5.2 Testing machine

A tensile machine control system that provides a constant cross-head speed shall be used. Grips shall have a structure and strength appropriate for the test specimen and shall be constructed to provide an effective connection with the tensile machine. The faces of the grips shall be filed or knurled, or otherwise roughened, so that the test specimen will not slip on them during testing. Gripping may be a screw type, or pneumatically or hydraulically actuated.

5.3 Extensometer

The weight of the extensometer shall be 30 g or less, so as not to affect the mechanical properties of the superconductive wire. Care shall also be taken to prevent bending moments from being applied to the test specimen (see Clause A.3).

6 Specimen preparation

6.1 Straightening the specimen

When a test specimen sampled from a bobbin needs to be straightened, a method shall be used that affects the material as little as possible.

6.2 Length of specimen

The total length of the test specimen shall be the inward distance between grips plus both grip lengths. The inward distance between the grips shall be 60 mm or more, as requested for the installation of the extensometer.

6.3 Removing insulation

If the test specimen surface is coated with an insulating material, that coating shall be removed. Either a chemical or mechanical method shall be used, with care taken not to damage the specimen surface (see Clause A.4).

6.4 Determination of cross-sectional area (S_0)

A micrometer or other dimension-measuring apparatus shall be used to obtain the cross-sectional area of the specimen after the insulation coating has been removed. The cross-sectional area of a round wire shall be calculated using the arithmetic mean of the two orthogonal diameters. The cross-sectional area of a rectangular wire shall be obtained from the product of its thickness and width. Corrections to be made for the corners of the cross-sectional area shall be determined through consultation among the parties concerned (see Clause A.5).

7 Testing conditions

7.1 Specimen gripping

The test specimen shall be mounted on the grips of the tensile machine. At this time, the test specimen and tensile loading axis must be on a single straight line. Sand paper may be inserted as a cushioning material to prevent the gripped surfaces of the specimen from slipping and fracturing (see Clause A.6).

7.2 Pre-loading and setting of extensometer

If there is any slack in the specimen when it is mounted, a force not greater than one-tenth of the 0,2 % proof strength of the composite shall be applied to take up the slack before the extensometer is mounted. When mounting the extensometer, care shall be taken to prevent the test specimen from being deformed. The extensometer shall be mounted at the centre between the grips, aligning the measurement direction with the specimen axis direction. After installation, loading shall be zeroed.

7.3 Testing speed

The strain rate shall be 10^{-4} /s to 10^{-3} /s during the test using the extensometer. After removing the extensometer, the strain rate may be increased to a maximum of 10^{-3} /s.