SLOVENSKI STANDARD
oSIST prEN IEC 61788-27:2024

01-februar-2024

Merjenje naklona praktičnih superprevodnih žic - Metoda merjenja naklona kompozitnih superprevodnikov NbTi in Nb3Sn

Twist pitch measurement of practical superconducting wires - Twist pitch measurement method of NbTi and Nb3Sn composite superconductors

Ta slovenski standard je istoveten z: **prEN IEC 61788-27:2023**

ICS:

17.220.20	Merjenje električnih in magnetnih veličin	Measurement of electrical and magnetic quantities
29.050	Superprevodnost in prevodni materiali	Superconductivity and conducting materials

oSIST prEN IEC 61788-27:2024 **en**

90/507/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 61788-27 ED1**	
DATE OF CIRCULATION: **2023-10-20**	CLOSING DATE FOR VOTING: **2024-01-12**
SUPERSEDES DOCUMENTS: **90/498/CD, 90/502/CC**	

IEC TC 90 : SUPERCONDUCTIVITY

SECRETARIAT: Japan	SECRETARY: Mr Jun Fujikami
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC ☐ ENVIRONMENT ☒ QUALITY ASSURANCE ☐ SAFETY

☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any relevant “In Some Countries” clauses to be included should this proposal proceed. Recipients are reminded that the CDV stage is the final stage for submitting ISC clauses. (SEE AC/22/2007 OR NEW GUIDANCE DOC).

TITLE:

Twist pitch measurement of practical superconducting wires - Twist pitch measurement method of NbTi and Nb3Sn composite superconductors

PROPOSED STABILITY DATE: 2031

NOTE FROM TC/SC OFFICERS:

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SUPERCONDUCTIVITY–

Part 27: Twist pitch measurement of practical superconducting wires— Twist pitch measurement of Nb-Ti/Cu and Nb-Sn/Cu composite superconductors

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61788-27 has been prepared by IEC technical committee 90: Superconductivity.

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

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://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.

The National Committees are requested to note that for this document the stability date is 20XX.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

INTRODUCTION

Twisting of multi-filamentary superconductors is an important step in the development of wires with AC losses at an acceptable level for AC applications. The necessary twist pitch depends on wire architecture, critical current density, matrix material, and external factors such as temperature, frequency and applied magnetic field.

Therefore, twist pitch is a very important parameter in the design and application of composite superconducting wires, which often needs to be inspected in the last stage of fabrication. Due to the different architectures of different composite superconductors, appropriate test methods should be adopted for specific architectures.

This standard specifies the untwisting method for measuring the twist pitch of Nb-Ti/Cu and Nb-Sn/Cu composite superconductors [1]. As supplementary methods, the direct measurement method and the image processing method [1] are specified in Annex A and Annex B, respectively.

SUPERCONDUCTIVITY –

Part 27: Twist pitch measurement of practical superconducting wires – Twist pitch measurement method of Nb-Ti/Cu and Nb-Sn/Cu composite superconductors

1 Scope

This International Standard specifies a test method for the twist pitch measurement of Nb-Ti and Nb-Sn/Cu composite superconductors by an untwisting method.

The test method is applicable to Nb-Ti/Cu and Nb-Sn/Cu composite superconducting wires with monolithic structures, which have either a round cross section with a diameter ranging from 0,2 mm to 2 mm or a rectangular cross section that is equivalent in area to the round cross-sectional wires. These wires possess a filament diameter ranging from 6 μm to 200 μm, a twist pitch between 5 mm to 50 mm, and a matrix of copper or copper alloy. This standard uses nitric acid to remove the matrix (copper or copper alloy), so the surface of the composite superconducting wire is allowed to be plated with a material that is dissolvable by nitric acid.

Though uncertainty may increase, the method could apply to Nb-Ti/Cu or Nb-Sn/Cu composite superconducting wires when the parameters of cross-sectional area, filament diameter and/or twist pitch are out of the limit.

The test method described in this standard is expected to apply to other types of composite superconducting wires after some appropriate modifications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their contents constitute 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, *International Electrotechnical Vocabulary* (*IEV*) – *Part 815: Superconductivity*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1

twist

turns made by a filament around a central wire axis

[SOURCE: IEC 60050-815，815-13-46 Modified]

3.2

twist direction

direction of a filament in twist, which can be divided into two types: Z-twist (sometimes referred to as right-hand twist) and S-twist (sometimes referred to as left-hand twist)

NOTE It is called Z-twist when the filament or strand is twisted in a clockwise direction, otherwise it is called S-twist.

3.3

twist pitch

L_p

axial length in which a filament firstly returns to its original relative position in a twisted superconducting wire

[SOURCE: IEC 60050-815，815-13-47 Modified]

3.4

twist angle/untwist angle

θ

angle at which all filaments of a twisted superconducting wire return to parallel original axial positions during the untwisting process

4 Principle

Low temperature superconducting wire is usually composed of tens to even thousands of superconducting filaments embedded in copper and/or copper alloy matrix. After the superconducting wire is twisted, the inner filaments are also regularly twisted with a specific twist pitch. This standard specifies an untwisting method to measure the twist pitch (see Figure 1).

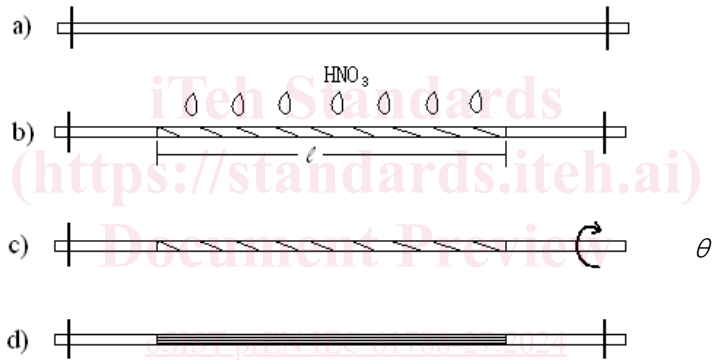

Figure 1–Principle demonstration

The untwisting method can be briefly described as follows:

a) Fix the two ends of the specimen (Figure 1a).

b) Remove the copper or copper alloy matrix in the middle section of the specimen with HNO_3 solution (Figure 1b).

c) Measure the length of the dissolved zone (denoted as l, explanation see 8.4).

d) Rotate one end of the wire to untwist it until the filaments in the dissolved zone are parallel (Figure 1c and d). Record the rotated angle (denoted as θ).

e) Calculate the twist pitch L_p using l and θ (see Eq. (1) and (2)).

The other two normative methods, the direct measurement method and the image processing method, are specified in Annex A and Annex B, which are recommended as equivalent alternatives.

5 Reagents and auxiliary materials

The following reagents shall be prepared for specimen preparation:

— detergent and/or degreaser

— anhydrous ethanol

— nitric acid solution (40% to 65%, mass percentage concentration, recommend)

NOTE Rubber gloves and acid resistant tweezers should be used when handling acid solution.

The following auxiliary materials and tools shall be prepared for specimen preparation:

— 300 to 800 mesh fine sandpaper (apply to Nb-Sn/Cu specimens only)

6 Apparatus and tools

The apparatus and tools required for measurement shall include:

— an auxiliary tool for twist pitch measurement, which has an angle scale with accuracy 5° or better (an example in Annex C)

— fume hood

— slide gauge (accuracy 0,02 mm or better)

— oven or dryer

7 Specimen preparation

7.1 Requirements

It is recommended to use the untwisting method for twist pitches in the range of 5 mm to 50 mm to ensure adequate accuracy for the measurement. The specimen length shall be longer than 6 times of the nominal twist pitch.

The specimen shall be free from torsion and bend.

7.2 Cleaning

Detergent and/or degreaser shall be used to remove oil stains and other contamination from the specimen. Then, the specimen shall be rinsed repeatedly with running water, and finally dehydrated by anhydrous ethanol.

7.3 Drying

After cleaning, the specimen shall be dried completely in an appropriate manner. For example, dried with hot air or placed into an oven (60 ℃ to 70 ℃).

7.4 Removing matrix copper and sanding barrier (apply to Nb-Sn/Cu specimen of external stabilizer type only)

Some Nb-Sn/Cu wires have a Nb or Ta external diffusion barrier that is diffusional nitric acid. When the external copper stabilizer is dissolved, this barrier prevents the inner copper from being corroded by nitric acid, therefore needs to be removed. The following steps are recommended when removing the barrier: These steps are not applied to distributed barrier wires.

a) Removing matrix copper: Immerse the Nb-Sn/Cu specimen in nitric acid solution, and leave the container in a fume hood for about 15 minutes until the copper sheath of the specimen is completely dissolved. Take the specimen out by acid resistant tweezers, rinse it with running water, and then dehydrate it with anhydrous ethanol, and dry it.

NOTE For safety, wearing long sleeves, trousers, and rubber gloves to prevent nitric acid from splashing on the skin.

b) Inspecting barrier surface for barrier seam: If the barrier has a seam, inspect the surface of the barrier which will follow the filament position underneath. If a seam is clearly visible, the specimen needs no further preparation.

c) Sanding barrier: Take a fine sandpaper, evenly sand the measuring section until the internal coppery red is completely exposed.

NOTE Use fume hood during sanding.