ICS 17.220, 29.050 SLOVENSKÁ TECHNICKÁ NORMA Október 2024

STN	**Supravodivosť Časť 23: Meranie pomeru zvyškového odporu Pomer zvyškového odporu Nb supravodičov vysokého stupňa čistoty**	**STN EN IEC 61788-23 34 5685**

Superconductivity - Part 23: Residual resistance ratio measurement - Residual resistance ratio of cavity-grade Nb superconductors

Táto norma obsahuje anglickú verziu európskej normy.
This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 09/24

Obsahuje: EN IEC 61788-23:2024, IEC 61788-23:2024

Oznámením tejto normy sa od 26.06.2027 ruší
STN EN IEC 61788-23 (34 5685) z januára 2022

obsahuje farebné strany

139115

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 61788-23

June 2024

ICS 17.220; 29.050

Supersedes EN IEC 61788-23:2021

English Version

Superconductivity - Part 23: Residual resistance ratio measurement - Residual resistance ratio of cavity-grade Nb superconductors (IEC 61788-23:2024)

Supraconductivité - Partie 23: Mesurage du rapport de résistance résiduelle - Rapport de résistance résiduelle des supraconducteurs de Nb à cavités (IEC 61788-23:2024)

Supraleitfähigkeit - Teil 23: Messung des Restwiderstandsverhältnisses - Restwiderstandsverhältnis von hochreinen Nb-Supraleitern für Kavitäten (IEC 61788-23:2024)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN IEC 61788-23:2024 E

EN IEC 61788-23:2024 (E)

European foreword

The text of document 90/515/FDIS, future edition 3 of IEC 61788-23, prepared by IEC/TC 90 "Superconductivity" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61788-23:2024.

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) 2025-03-26
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2027-06-26

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Endorsement notice

The text of the International Standard IEC 61788-23:2024 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 standard indicated:

IEC 61788-4	NOTE	Approved as EN IEC 61788-4
IEC 61788-10	NOTE	Approved as EN 61788-10

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cencenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60050-815	-	International Electrotechnical Vocabulary - Part 815: Superconductivity	-	-

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INTERNATIONAL STANDARD

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IEC 61788-23:2024-05(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 17.220, 29.050

ISBN 978-2-8322-8888-7

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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IEC 61788-23 has been prepared by IEC technical committee 90: Superconductivity. It is an International Standard.

This third edition cancels and replaces the second edition published in 2021. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) The principle is changed to represent the present test method.

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

Draft	Report on voting
90/515/FDIS	90/519/RVD

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.

A list of all parts in the IEC 61788 series, published under the general title *Superconductivity,* can be found on the IEC website.

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, or
- revised.

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INTRODUCTION

High-purity niobium is the chief material used to make superconducting radio-frequency cavities. Similar grades of niobium can be used in the manufacture of superconducting wire. Procurement of raw materials and quality assurance of delivered products often use the residual resistance ratio (RRR) to specify or assess the purity of a metal. RRR is defined for non-superconducting metals as the ratio of electrical resistance measured at room temperature (293 K) to the resistance measured for the same specimen at low temperature (~4,2 K). The low-temperature value is often called the residual resistance. Higher purity is associated with higher values of RRR.

Niobium presents special problems due to its transformation to a superconducting state at ~9 K, so DC electrical resistance is effectively zero below this temperature. The definition above would then yield an infinite value for RRR. This document describes a test method to determine the residual resistance value by using a plot of the resistance to temperature as the test specimen is gradually warmed through the superconducting transition in the absence of an applied magnetic field. This results in a determination of the residual resistance at just above superconducting transition, ~10 K, from which RRR is subsequently determined.

International Standards also exist to determine the RRR of superconducting wires. In contrast to superconducting wires, which are usually a composite of a superconducting material and a non-superconducting material and the RRR value is representative of only the non-superconducting component, here the entire specimen is composed of superconducting niobium. Frequently, niobium is procured as a sheet, bar or rod, and not as a wire. For such forms, test specimens will likely be a few millimetres in the dimensions transverse to electric current flow. This difference is significant when making electrical resistance measurements, since niobium samples will likely be much longer than that for the same length-to-diameter ratio as a wire, and higher electrical current can be required to produce sufficient voltage signals. Guidance for sample dimensions and electrical connections is provided in Annex A. Test apparatus should also take into consideration aspects such as the orientation of a test specimen relative to the liquid helium surface, accessibility through ports on common liquid helium dewars, design of current contacts, and minimization of thermal gradients over long specimen lengths. These aspects distinguish this document from similar wire standards.

Other test methods have been used to determine RRR. Some methods use a measurement at a temperature other than 293 K for the high resistance value. Some methods use extrapolations at 4,2 K in the absence of an applied magnetic field for the low resistance value. Other methods use an applied magnetic field to suppress superconductivity at 4,2 K. A comparison between this document and some other test methods is presented in Annex A. Note that systematic differences of up to 10 % are produced by these other methods, which is larger than the target uncertainty of this document. It is therefore important to apply this document or the appropriate corrections listed in Annex A according to the test method used.

Whenever possible, this test method should be transferred to vendors and collaborators who also perform RRR measurements. To promote consistency, the results of inter-laboratory comparisons are described in Clause C.2.

SUPERCONDUCTIVITY –

Part 23: Residual resistance ratio measurement – Residual resistance ratio of cavity-grade Nb superconductors

1 Scope

This part of IEC 61788 addresses a test method for the determination of the residual resistance ratio (RRR), r_{RRR}, of cavity-grade niobium. This method is intended for high-purity niobium grades with $150 < r_{RRR} < 600$. The test method is valid for specimens with rectangular or round cross-section, cross-sectional area greater than 1 mm^2 but less than 20 mm^2, and a length not less than 10 nor more than 25 times the width or diameter.

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, *International Electrotechnical Vocabulary – Part 815: Superconductivity* (available at: https://www.electropedia.org/)