

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

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

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English Version

**Superconductivity - Part 23: Residual resistance ratio  
measurement - Residual resistance ratio of cavity-grade Nb  
superconductors  
(IEC 61788-23:2021)**

Supraconductivité - Partie 23: Mesurage du rapport de  
résistance résiduelle - Rapport de résistance résiduelle des  
supraconducteurs de Nb à cavités  
(IEC 61788-23:2021)

Supraleitfähigkeit - Teil 23: Messung des  
Restwiderstandsverhältnisses - Restwiderstandsverhältnis  
von hochreinen Nb Supraleitern für Kavitäten  
(IEC 61788-23:2021)

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The text of document 90/478/FDIS, future edition 2 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 61788-23:2021.

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) 2022-06-27
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2024-09-27

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IEC 61788-4 NOTE Harmonized as EN IEC 61788-4

IEC 61788-10 NOTE Harmonized 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.cenelec.eu](http://www.cenelec.eu).

<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	--	-

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Superconductivity –**

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

**Supraconductivité –**

**Partie 23: Mesurage du rapport de résistance résiduelle – Rapport de résistance  
résiduelle des supraconducteurs de Nb à cavités**



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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



### **Superconductivity –**

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

### **Supraconductivité –**

### **Partie 23: Mesurage du rapport de résistance résiduelle – Rapport de résistance résiduelle des supraconducteurs de Nb à cavités**

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## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions .....	7
4 Principle.....	8
5 Measurement apparatus .....	9
5.1 Mandrel or base plate.....	9
5.2 Cryostat and support of mandrel or base plate .....	9
6 Specimen preparation.....	10
7 Data acquisition and analysis.....	11
7.1 Data acquisition hardware .....	11
7.2 Resistance ( $R_1$ ) at room temperature.....	11
7.3 Residual resistance ( $R_2$ ) just above the superconducting transition .....	11
7.4 Validation of the residual resistance measurement.....	13
7.5 Residual resistance ratio .....	13
8 Uncertainty of the test method .....	13
9 Test report.....	13
9.1 General.....	13
9.2 Test information .....	13
9.3 Specimen information.....	14
9.4 Test conditions.....	14
9.5 RRR value .....	14
Annex A (informative) Additional information relating to the measurement of RRR.....	15
A.1 Considerations for specimens and apparatus.....	15
A.2 Considerations for specimen mounting orientation .....	16
A.3 Alternative methods for increasing temperature of specimen above superconducting transition temperature .....	16
A.3.1 General .....	16
A.3.2 Heater method .....	16
A.3.3 Controlled methods .....	16
A.4 Other test methods.....	16
A.4.1 General .....	16
A.4.2 Measurement of resistance versus time .....	17
A.4.3 Comparison of ice point and room temperature .....	17
A.4.4 Extrapolation of the resistance to 4,2 K .....	17
A.4.5 Use of magnetic field to suppress superconductivity at 4,2 K.....	18
A.4.6 AC techniques .....	18
Annex B (informative) Uncertainty considerations .....	19
B.1 Overview.....	19
B.2 Definitions.....	19
B.3 Consideration of the uncertainty concept .....	20
B.4 Uncertainty evaluation example for IEC TC 90 standards .....	22
Annex C (informative) Uncertainty evaluation for resistance ratio measurement of Nb superconductors .....	24

C.1	Evaluation of uncertainty .....	24
C.1.1	Room temperature measurement uncertainty .....	24
C.1.2	Cryogenic measurement uncertainty .....	25
C.1.3	Estimation of uncertainty for typical experimental conditions .....	27
C.2	Inter-laboratory comparison summary .....	28
Bibliography	.....	29
Figure 1	– Relationship between temperature and resistance near the superconducting transition .....	8
Figure A.1	– Determination of the value of $R_2$ from a resistance versus time plot.....	17
Figure C.1	– Graphical description of the uncertainty of regression related to the measurement of $R_2$ .....	27
Table B.1	– Output signals from two nominally identical extensometers .....	20
Table B.2	– Mean values of two output signals .....	20
Table B.3	– Experimental standard deviations of two output signals .....	21
Table B.4	– Standard uncertainties of two output signals .....	21
Table B.5	– Coefficients of variation of two output signals.....	21
Table C.1	– Uncertainty of measured parameters .....	27
Table C.2	– RRR values obtained by inter-laboratory comparison using liquid helium .....	28

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## SUPERCONDUCTIVITY –

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

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This second edition cancels and replaces the first edition published in 2018. This edition constitutes a technical revision.

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

- a) The scope of this standard was modified to restrict the range of residual resistance ratio to that encountered by providers of material for superconducting radio-frequency cavities.
- b) The references to technical material were updated and corrected.

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

FDIS	Report on voting
90/478/FDIS	90/482/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.

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## INTRODUCTION

High-purity niobium is the chief material used to make superconducting radio-frequency cavities. Similar grades of niobium may 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 ( $\sim 4,2$  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  $\sim 9$  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,  $\sim 10$  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, tube, 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 may 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.