

Edition 2.0 2008-01

INTERNATIONAL STANDARD

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

https://standards.iteh.a

<u>1 88-6:2008</u> 0195e-7b2b-4806-8b5e-e263cbd48cfe/iec-61788-6-2008



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2008 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office 3, rue de Varembé CH-1211 Geneva 20 Switzerland Email: inmail@iec.ch Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Catalogue of IEC publications: <u>www.iec.ch/searchpub</u>

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications

• IEC Just Published: <u>www.iec.ch/online_news/jisstpub</u> Stay up to date on all new IEC publications. Just Published details wice a month all new publications released. Available on-line and also by email.

Electropedia: <u>www.electropedia.org</u>

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

• Customer Service Centre: <u>nww.iec.ch/webstore/custserv</u> If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch https://tel.: +41 22 919 02 11 Fax: +41 22 919 03 00

-7b2b-4806-8b5e-e263cbd48cfe/iec-61788-6-2008



Edition 2.0 2008-01

INTERNATIONAL STANDARD

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

https://standards.iteh.a

<u>58-0:2008</u> 5e-7b2b-4806-8b5e-e263cbd48cfe/iec-61788-6-2008

eview

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE

ICS 29.050; 77.040.10

ISBN 2-8318-9529-4

S

CONTENTS

NTRODUCTION 5 Scope 6 Normative references 6 Terms and definitions 6 Principle 7 Apparatus 7 5.1 Conformity 5.2 Testing machine 5.3 Extensometer 5 Specimen preparation 6.1 Straightening the specimen 6.2 Length of specimen 6.3 Removing insulation 6.4 Determination of cross-sectional area (So) 7.1 Specimen gripping 7.2 Pre-loading and setting of extensometer 7.3 Testing speed 7.4 Test. Calculation of results So 8.1 Tensile strength (Rp) 8.2 0.2 % orost strength (Rp) 9.1 0 10.1 Specimen 10.2 Results 10.3 Test conditions 11 Ortest report 10.3 Test conditions 11 Specimen 12.3 Modulus of elasticity (Considerations <th>FOF</th> <th>Reword</th> <th>3</th>	FOF	Reword	3
Scope	INT	RODUCTION	5
Scope (f) Normative references (f) Terms and definitions (f) Principle (f) Apparatus (f) 5.1 Conformity 5.2 Testing machine 5.3 Extensometer Specimen preparation (f) 6.1 Straightening the specimen 6.2 Length of specimen 6.3 Removing insulation 6.4 Determination of cross-sectional area (So) 7.1 Specimen gripping 7.2 Pre-loading and setting of extensometer 7.3 Testing speed 7.4 Test. 7.5 Preside strength (Rip 2a and Rip 2b) 8.1 Tensile strength (Rip 2a and Rip 2b) 8.2 0.2 % proof strength (Rip 2a and Rip 2b) 8.3 Modulus of elasticity (E and E a) 0 Test report 10.1 Specimen 10.2 Results 10.3 Test conditions 11 12 12 Additional information relating to Clauses 1 to 10 13 T			
Normative references (f) Terms and definitions (f) Principle (f) Apparatus (f) 5.1 Conformity 5.2 Testing machine 5.3 Extensometer 5.4 Conformity 5.5 Testing machine 5.3 Extensometer 6.1 Straightening the specimen 6.2 Length of specimen 6.3 Removing insulation 6.4 Determination of cross-sectional area (So) 7.4 Testing conditions 7.5 Pre-loading and setting of extensometer 7.4 Test. 7.5 Pre-loading and setting of extensometer 7.4 Test. 7.4 Test. 6 Calculation of results 7.4 Test. 7.5 Calculation of results 8.1 Tensile strength (Ro) 8.2 0.2 % proof strength (Ro) 8.3 Modulus of elasticity (E and E	1	Scope	6
a Terms and definitions (a) b Principle (a) c Apparatus (a) c Apparatus (a) c Testing machine (a) c Specimen preparation (a) c A moving insulation (a) c A moving insulation of cross-sectional area (Sq) (a) c Testing conditions (a) 7.1 Specimen gripping (a) 7.2 Pre-loading and setting of extensometer (a) 7.3 Testing speed (a) 7.4 Test (a) 3.2 0.2 % proof strength (R_m) (a) 8.1 Tensile strength (R_m) (a) 8.2 0.2 % proof strength (R_m) (a) 9 Uncertainty (a) 10	2	Normative references	6
Principle 7 5 Apparatus 7 5.1 Conformity 7 5.2 Testing machine 7 5.3 Extensometer 6 5 Specimen preparation 8 6.1 Straightening the specimen 8 6.2 Length of specimen 8 6.3 Removing insulation 8 6.4 Determination of cross-sectional area (S_0) 8 7.2 Pre-loading and setting of extensometer 8 7.3 Testing speed 8 7.4 Test 8 6 Calculation of results 8 8 Calculation of results 8 8 Calculation of results 9 9 Uncertainty 10 10 Specimen 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 11 10 12 10 13 11 14 10 <td>3</td> <td>Terms and definitions</td> <td>6</td>	3	Terms and definitions	6
Apparatus 7 5.1 Conformity 5.2 Testing machine 5.3 Extensometer 6 Specimen preparation 6.1 Straightening the specimen 6.2 Length of specimen 6.3 Removing insulation 6.4 Determination of cross-sectional area (Sq) 7 Testing conditions 7.1 Specimen gripping 7.2 Pre-loading and setting of extensometer 7.3 Testing speed 7.4 Test 6 Calculation of results 8.1 Tensile strength (R_p) 8.2 0.2 % proof strength (R_p) 8.3 Modulus of elasticity (Eq and E_q) 9 Uncertainty 10 Test report 10.1 Specimen 10.2 Results 10.3 Test conditions 11 Informative) 12 Additional information relating to Clauses 1 to 10 13 Test conditions 14 An example of the light extensometer 15 Informative)<	4	Principle	7
5.1 Conformity	5	Apparatus	7
5.2 Testing machine 1 5.3 Extensometer 8 5.3 Extensometer 8 5.4 Specimen preparation 8 6.1 Straightening the specimen 8 6.2 Length of specimen 8 6.3 Removing insulation 8 6.4 Determination of cross-sectional area (Sp. 8 7 Testing conditions 8 7.1 Specimen gripping 8 7.2 Pre-loading and setting of extensometer 8 7.3 Testing speed 8 7.4 Test 9 8.1 Tensile strength ($R_{p0,2A}$ and $B_{p0,2B}$) 8 8.3 Modulus of elasticity (Equal Equal Equation (Strength, Concertainty) 10 0 Test report 10 10 10 10.1 Specimen 10 10 10 10.2 Results 11 11 11 11 10.3 Test conditions 12		5.1 Conformity	7
5.3 Extensometer 6 Specimen preparation 6 6.1 Straightening the specimen 6 6.2 Length of specimen 6 6.3 Removing insulation 6 6.4 Determination of cross-sectional area (Sp) 6 7 Testing conditions 6 7.1 Specimen gripping 6 7.2 Pre-loading and setting of extensometer 7 7.3 Testing speed 7 7.4 Test 6 6 Calculation of results 6 8.1 Tensile strength (R_m) 6 8.2 0.2 % proof strength (R_m) 6 8.3 Modulus of elasticity (E_0 and E_d) 7 10 Incertainty 10 11 Specimen 10 10.3 Test conditions 11 10.3 Test conditions 12 11 Informative) Additional information relating to Clauses 1 to 10 13 10.3 Test conditions 14 10.4 Informative) 10		5.2 Testing machine	7
Specimen preparation 8 6.1 Straightening the specimen 8 6.2 Length of specimen 8 6.3 Removing insulation 8 6.4 Determination of cross-sectional area (So) 8 7 Testing conditions 8 7.1 Specimen gripping 8 7.2 Pre-loading and setting of extensometer 8 7.3 Testing speed 8 7.4 Test 8 6.1 Tensile strength (R_m) 8 8.2 0.2 % proof strength (R_m) 9 8.3 Modulus of elasticity (E_0 and E_d) 9 9 Uncertainty 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.3 Test conditions 12 11 Informative) Additional information relating to Clauses 1 to 10 13 10.3 Test conditions 14 10.4 Informative) Additional information relating to Clauses 1 to 10 15 <td< td=""><td></td><td>5.3 Extensometer</td><td></td></td<>		5.3 Extensometer	
6.1 Straightening the specimen 8 6.2 Length of specimen 8 6.3 Removing insulation 8 6.4 Determination of cross-sectional area (S ₀) 8 7 Testing conditions 8 7.1 Specimen gripping 8 7.2 Pre-loading and setting of extensioneter 8 7.3 Testing speed 8 7.4 Test 9 8.1 Tensile strength (R_m) 9 8.2 0.2 % proof strength (R_m) 9 8.3 Modulus of elasticity (E_0 and E_d) 9 9 Uncertainty 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.4 Specimen 10 10.5 Results 10 10.6 Results 10 10.7 Results 10 10.8 (informative) Uncertainty considerations 16 10.1 Specimen 10 12	6	Specimen preparation	8
6.2 Length of specimen 6.3 6.3 Removing insulation 8 6.4 Determination of cross-sectional area (S_0) 8 7 Testing conditions 8 7.1 Specimen gripping 8 7.2 Pre-loading and setting of extensioneter 8 7.3 Testing speed 8 7.4 Test 9 8.1 Tensile strength (R_m) 9 8.2 0.2 % proof strength (R_m) 9 8.3 Modulus of elastroity (E_0 and E_d) 9 9 Uncertainty 10 10 Test conditions 11 10.1 Specimen 11 10.2 Results 11 10.3 Test conditions 11 10.4 (informative) Uncertainty considerations 12 10.3 Test conditions 12 110.3 Test-strain curve and definition of modulus of elasticity and 0,2 % proof 21 12 Grigure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 12 Grigure 4 <td></td> <td>6.1 Straightening the specimen</td> <td>8</td>		6.1 Straightening the specimen	8
6.3 Removing insulation 4 6.4 Determination of cross-sectional area (S_0) 8 7 Testing conditions 8 7.1 Specimen gripping 8 7.2 Pre-loading and setting of extensometer 8 7.3 Testing speed 8 7.4 Test 9 8.1 Tensile strength (R_0) 9 8.2 0.2 % proof strength ($R_{p0,2B}$) 9 8.3 Modulus of elasticity (E_0 and E_d) 10 0 Test report 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.4 Results 10 10.5 Results 10 10.6 Results 10 10.7 Stolional information relating to Clauses 1 to 10 13 Nunnex A (informative) Additional information relating to Clauses 1 to 10 13 Nunnex B (informative) Uncertainty considerations 16 Sibliography 2 2 Sibliography		6.2 Length of specimen	8
6.4 Determination of cross-sectional area (S_0) 8 7 Testing conditions 8 7.1 Specimen gripping. 8 7.2 Pre-loading and setting of extensioneter 8 7.3 Testing speed. 8 7.4 Test. 9 8.1 Tensile strength (R_{n0}) 9 8.2 0.2 % proof strength ($R_{p0,2A}$ and $B_{p0,2B}$) 9 8.3 Modulus of elasticity (E_0 and E_0) 10 0 Test report 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.3 Test conditions 12 Sibliography 21 22 Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 Tengths 12 12 12 Testing strengths 12 12 12		6.3 Removing insulation	8
Testing conditions 8 7.1 Specimen gripping 7.2 Pre-loading and setting of extensometer 7.3 Testing speed 7.4 Test 8 Calculation of results 8.1 Tensile strength ($R_{p0, 2A}$ and $B_{p0, 2B}$) 8.2 0.2 % proof strength ($R_{p0, 2A}$ and $B_{p0, 2B}$) 8.3 Modulus of elasticity (E_{0} and E_{1}) 0 Test report 10.1 Specimen 10.2 Results 10.3 Test conditions 11 10.3 10.3 Test conditions 11 10.3 12 Stibliography 21 21 21 21 22 24 24 35 25 36 26 37 27 37 28 38 29 39 30 30 31 30 32 31 33 33 34 34 <t< td=""><td></td><td>6.4 Determination of cross-sectional area (So)</td><td>8</td></t<>		6.4 Determination of cross-sectional area (So)	8
7.1 Specimen gripping. 8 7.2 Pre-loading and setting of extensometer 8 7.3 Testing speed. 8 7.4 Test. 9 Calculation of results 9 8.1 Tensile strength (R_m) 9 8.2 0.2 % proof strength (R_m) 9 8.3 Modulus of elasticity (E_0 and E_d) 9 9 Uncertainty 10 10 Test report 10 10.1 Specimen 10 10.3 Test conditions 11 10.3 Test conditions 12 Sibliography 21 21 Sibliography 21 21 10 Annex B (informative) Uncertainty considerations 12 11 Sibliography 21 12 Tengths 12 13 An example of the light extensemeter 14 or example of the light extensemeter	7	Testing conditions	8
7.2 Pre-loading and setting of extensioneter 8 7.3 Testing speed 8 7.4 Test. 9 8.1 Tensile strength (R_m) 9 8.2 0.2 % proof strength (R_m) 9 8.3 Modulus of elasticity (E_0 and E_s) 9 9 Uncertainty 10 10 Test report 10 10.1 Specimen 10 10.3 Test conditions 11 10.3 Test conditions 12 Sibliography 21 21 Sibliography 21 12 10 Annex A (informative) and definition of modulus of elasticity and 0,2 % proof 12 Tigure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 Tigure 4 An example of the light extensometer, where P1 and P3 indicate the 12		7.1 Specimen gripping	8
7.3 Testing speed. 8 7.4 Test. 9 Calculation of results 9 8.1 Tensile strength (R_{n}) 9 8.2 0.2 % proof strength ($R_{p0,2A}$ and $B_{p0,2B}$) 9 8.3 Modulus of elasticity (E_0 and E_d) 9 9 Uncertainty 10 10 Test report 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.3 Test conditions 12 Sibliography 21 21 Sibliography 21 21 Test strain curve and definition of modulus of elasticity and 0,2 % proof 12 Test strain curve and definition of modulus of elasticity and 0,2 % proof 13 Test strain curve and definition of modulus of elasticity and 0,2 % proof 14 Test strain curve and definition of modulus of elasticity and 0,2 % proof 15 12 16 12 17 12 18 12 19 14 10 15 <td></td> <td>7.2 Pre-loading and setting of extensioneter</td> <td>8</td>		7.2 Pre-loading and setting of extensioneter	8
7.4 Test 5 3 Calculation of results 5 8.1 Tensile strength (R_m) 5 8.2 0.2 % proof strength ($R_{p0,2A}$ and $B_{p0,2B}$) 5 8.3 Modulus of elasticity (E_0 and E_d) 5 9 Uncertainty 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.3 Test conditions 12 Sunnex A (informative) Additional information relating to Clauses 1 to 10 13 Subliography 21 9 Uncertainty considerations 16 10.3 Test conditions 16 10.4 Informative) Additional information relating to Clauses 1 to 10 13 11 10.3 Test strength (R_p) 21 12 Informative) Incertainty considerations 16 13 Informative) Incertainty considerations 16 14 Informative) Incertainty considerations 16 15 Informative) Incertainty considerations <td></td> <td>7.3 Testing speed</td> <td>8</td>		7.3 Testing speed	8
3 Calculation of results 5 8.1 Tensile strength (R_{p0}) 6 8.2 0,2 % proof strength ($R_{p0,2A}$ and $B_{p0,2B}$) 6 8.3 Modulus of elasticity (E_{0} and E_{d}) 7 9 Uncertainty 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.3 Test conditions 12 11 Subliggraphy 21 21 Sibliography 21 21 Sigure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 21 Sigure 4.1 An example of the light extensometer, where P1 and P2 indicate the		7.4 Test	9
8.1 Tensile strength (R_{p0}) 9 8.2 0.2 % proof strength ($R_{p0,2A}$ and $B_{p0,2B}$) 9 8.3 Modulus of elasticity (E_0 and E_d) 10 0 Test report 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.3 Test conditions 12 Sibliography 21 Sibliography 21 Sigure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 Sigure 4.1 An example of the light extensometer, where P1 and P3 indicate the	3	Calculation of results	9
8.2 0,2 % proof strength ($R_{p0,2A}$ and $R_{p0,2B}$) 2008 300 8.3 Modulus of elasticity (E_0 and E_d) 100 0 Uncertainty 100 10.1 Specimen 100 10.2 Results 100 10.3 Test conditions 100 10.3 Test conditions 100 10.4 Informative) Additional information relating to Clauses 1 to 10 100 10.3 Test conditions 100 100 100 10.3 Test conditions 100 100 100 100 10.4 Informative) Additional information relating to Clauses 1 to 10 100 100 10.5 Sibliography 100 100 100 100 10.4 Annex A (informative) Uncertainty considerations 100 100 100 10.4 Prove A 1 An example of the light extensioneter where P1 and P2 indicate the 100 10.5 Indicate the 100 100 100 10.5 Indicate the 100 100 100 100		8.1 Tensile strength (Rm)	9
Standards include the basic relation (Eq. and Eq.) 50.25-4806-855e-e263cbd48cfe/iec-61788-6 8.3 Modulus of elasticity (Eq. and Eq.) 10. 0 Test report 10. 10.1 Specimen 10. 10.2 Results 10. 10.3 Test conditions 11. 10.3 Test conditions 11. 10.4 Informative) Additional information relating to Clauses 1 to 10. 13. 11 Annex A (informative) Uncertainty considerations 16. 12 Sibliography. 21. 21. 13 Sibliography. 21. 21. 14 An example of the light extensometer, where P1 and P2 indicate the 12.		8.2 0,2 % proof strength ($R_{00,24}$ and $R_{00,2B}$)	9
0 Uncertainty. 10 0 Test report. 10 10.1 Specimen 10 10.2 Results. 10 10.3 Test conditions. 11 10.3 Test conditions. 11 10.4 Next conditions. 11 10.5 Test conditions. 11 10.6 Informative) Additional information relating to Clauses 1 to 10. 13 11 Next conditions. 16 16 12 Sibliography. 16 17 13 Sibliography. 21 21 14 Sibliography. 21 12 15 Sigure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 15 Sigure 4 1 – An example of the light extensioneter, where P1 and P3 indicate the 12		8.3 Modulus of elasticity (E. and E.)	-61788-6-
0 Test report 10 10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 Annex A (informative) Additional information relating to Clauses 1 to 10 13 Annex B (informative) Uncertainty considerations 16 Bibliography 21 Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 Figure 4.1 An example of the light extensioneter, where P1 and P3 indicate the 12	a		10
10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 11 10.3 Test conditions 11 10.3 Test conditions 11 10.4 Additional information relating to Clauses 1 to 10 13 10.5 Additional information relating to Clauses 1 to 10 13 10.6 Additional information relating to Clauses 1 to 10 13 11 Annex B (informative) Uncertainty considerations 16 3ibliography 21 21 Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 Figure A 1 An example of the light extensioneter, where P1 and P3 indicate the 12	10		10
10.1 Specimen 10 10.2 Results 10 10.3 Test conditions 10 11.3 Test conditions 10 11.4 A (informative) Additional information relating to Clauses 1 to 10 13 Annex B (informative) Uncertainty considerations 16 Bibliography 21 Sibliography 21 Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof 12 Figure A 1 An example of the light extensioneter, where P1 and P3 indicate the	10		10
10.2 Results. 10.3 Test conditions 10.3 T		10.1 Specimen	10
10.3 Test colutions 10.3 Test colutions Annex A (informative) Additional information relating to Clauses 1 to 10 13 Annex B (informative) Uncertainty considerations 16 Bibliography 17 Sibliography 21 Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof trengths 12 Figure A 1 An example of the light extensioneter, where P1 and P3 indicate the		10.2 Results.	10
Annex A (informative) Additional information relating to Clauses 1 to 10			
Annex B (informative) Uncertainty considerations	٩nn	ex A (informative) Additional information relating to Clauses 1 to 10	
Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof trengths	Ann	ex B (informative) Uncertainty considerations	18
Bibliography			
Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof strengths	Bibli	iography	21
Figure 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof trengths			
trengths	-igu	re 1 – Stress-strain curve and definition of modulus of elasticity and 0,2 % proof	
igure A.1. An example of the light extensionetor, where P1 and P3 indicate the	stre	ngths	12
	=igu	Ire A.1 – An example of the light extensometer, where R1 and R3 indicate the	
orner radius	corn	ier radius	16
igure A.2 – An example of the extensometer provided with balance weight and	-igu	Ire A.2 – An example of the extensometer provided with balance weight and	47

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SUPERCONDUCTIVITY -

Part 6: Mechanical properties measurement – Room temperature tensile test of Cu/Nb-Ti 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 herd 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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication. 200200048cfc/lec-01788-0-2008
 - 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 to 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 61788-6 has been prepared by IEC technical committee 90: Superconductivity.

This second edition cancels and replaces the first edition published in 2000. It constitutes a technical revision.

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

- the minimum distance between grips was changed from 100 mm to 60 mm;
- accuracy and precision statement were converted to uncertainty statements.

The text of this standard is based on the following documents:

FDIS	Report on voting
90/207/FDIS	90/209/RVD

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

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

A list of all parts of 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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

A bilingual version of this standard may be issued at a later date,

https://standards.iteh.a

5e-7b2b-4806-8b5e-e263cbd48cfe/iec-61788-6-2008

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 -

- 6 -

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 $0,15 \text{ mm}^2$ to 2 mm^2 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 (IEV) – Part 815: Superconductivity

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

ISO 6892, Metallic materials – Tensile testing at ambient 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, 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

Lg

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 $R_{p0,2B}$ corresponde 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 %, of which value 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

https://standards.iteh.avo.tolog

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 strain rate 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 extensioneter 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 crosssectional area of the specimen after the insulation coating has been removed. The crosssectional 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 crosssectional area shall be determined through consultation among the parties concerned (see Clause A.5).

https://standards.iteh

b-4806-8b5e-e263cbd48cfe/iec-61788-6-2008

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 between one-tenth and onethird 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.