

---

---

**Welding — Micro joining of second  
generation high temperature  
superconductors —**

**Part 3:  
Test methods for joints**

*Soudage — Micro-assemblage des supraconducteurs à haute  
température de deuxième génération —*

*Partie 3: Méthode d'essai des assemblages*

**Document Preview**

ISO 17279-3:2021

<https://standards.iteh.ai/catalog/standards/iso/67a9a027-6081-4640-b3fb-d0672ecb480f/iso-17279-3-2021>



**iTeh Standards**  
**(<https://standards.iteh.ai>)**  
**Document Preview**

[ISO 17279-3:2021](https://standards.iteh.ai/catalog/standards/iso/67a9a027-6081-4640-b3fb-d0672ecb480f/iso-17279-3-2021)

<https://standards.iteh.ai/catalog/standards/iso/67a9a027-6081-4640-b3fb-d0672ecb480f/iso-17279-3-2021>



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2021

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

Page

<b>Foreword</b> .....	<b>v</b>
<b>Introduction</b> .....	<b>vi</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Test methods for joint</b> .....	<b>1</b>
4.1 General.....	1
4.2 Visual testing.....	2
4.2.1 General.....	2
4.2.2 Qualification of test personnel.....	2
4.2.3 Test equipment.....	2
4.2.4 Surface condition and preparation.....	2
4.2.5 Testing.....	2
4.2.6 Acceptance criteria.....	2
4.2.7 Test report.....	3
4.3 Four-point-probe testing.....	3
4.3.1 General.....	3
4.3.2 Qualification of test personnel.....	3
4.3.3 Test equipment.....	3
4.3.4 Surface condition and preparation.....	3
4.3.5 Testing.....	3
4.3.6 Acceptance criteria.....	9
4.3.7 Test report.....	9
4.4 Field-decay testing.....	9
4.4.1 General.....	9
4.4.2 Qualification of test personnel.....	9
4.4.3 Test equipment.....	9
4.4.4 Surface condition and preparation.....	9
4.4.5 Testing.....	9
4.4.6 Acceptance criteria.....	12
4.4.7 Test report.....	12
4.5 In-field testing.....	12
4.5.1 General.....	12
4.5.2 Qualification of test personnel.....	12
4.5.3 Test equipment.....	12
4.5.4 Surface condition and preparation.....	12
4.5.5 Testing.....	12
4.5.6 Acceptance criteria.....	15
4.5.7 Test report.....	15
4.6 Tensile testing.....	15
4.6.1 General.....	15
4.6.2 Qualification of test personnel.....	15
4.6.3 Test equipment.....	15
4.6.4 Surface condition and preparation.....	15
4.6.5 Testing.....	15
4.6.6 Acceptance criteria.....	16
4.6.7 Test report.....	16
4.7 Bend testing.....	16
4.7.1 General.....	16
4.7.2 Qualification of test personnel.....	16
4.7.3 Test equipment.....	16
4.7.4 Surface condition and preparation.....	16
4.7.5 Testing.....	16

4.7.6	Acceptance criteria .....	17
4.7.7	Test report .....	17
4.8	Critical magnetic field testing .....	17
4.8.1	General .....	17
4.8.2	Qualification of test personnel .....	17
4.8.3	Test equipment .....	17
4.8.4	Surface condition and preparation .....	17
4.8.5	Testing .....	18
4.8.6	Acceptance criteria .....	18
4.8.7	Test report .....	18
4.9	Critical current density distribution testing .....	18
4.9.1	General .....	18
4.9.2	Qualification of test personnel .....	18
4.9.3	Test equipment .....	19
4.9.4	Surface condition and preparation .....	19
4.9.5	Testing .....	19
4.9.6	Acceptance criteria .....	19
4.9.7	Test report .....	19
4.10	Microscopic and X-ray diffraction testing .....	19
4.10.1	General .....	19
4.10.2	Qualification of test personnel .....	19
4.10.3	Test equipment .....	19
4.10.4	Surface condition and preparation .....	19
4.10.5	Testing .....	20
4.10.6	Acceptance criteria .....	20
4.10.7	Reporting .....	20
<b>Annex A (informative) Report of visual testing results .....</b>		<b>21</b>
<b>Annex B (informative) Report of four-point-probe testing results .....</b>		<b>23</b>
<b>Annex C (informative) Report of field-decay testing results .....</b>		<b>26</b>
<b>Annex D (informative) Report of in-field testing results .....</b>		<b>29</b>
<b>Annex E (informative) Report of tensile testing results .....</b>		<b>33</b>
<b>Annex F (informative) Report of bend testing results .....</b>		<b>36</b>
<b>Annex G (informative) Report of critical magnetic field testing results .....</b>		<b>39</b>
<b>Annex H (informative) Report of critical current density distribution testing results .....</b>		<b>41</b>
<b>Annex I (informative) Report of microscopic and X-ray diffraction testing results .....</b>		<b>43</b>
<b>Bibliography .....</b>		<b>45</b>

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 17279 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: <https://committee.iso.org/sites/tc44/home/interpretation.html>.

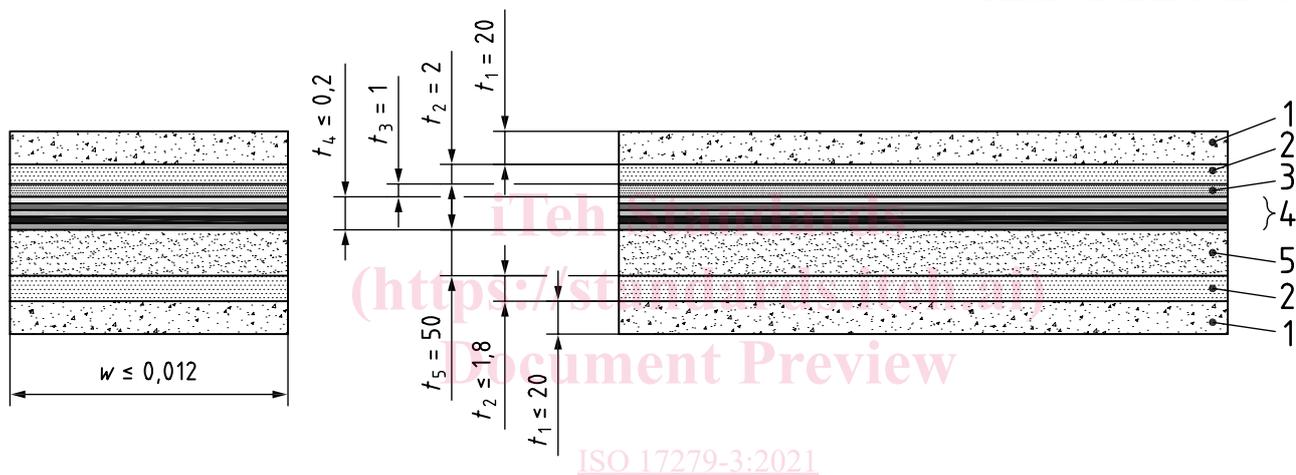
## Introduction

The increasing use of second-generation high temperature superconductors (2G HTSs) and invention of resistance-free joining on 2G HTSs have created the need for the ISO 17279 series in order to ensure that joining is carried out in the most effective way and that appropriate control is exercised over all aspects of the operation. ISO standards for micro-joining and joint evaluation procedure are accordingly essential to get the best and uniform quality of 2G HTS joint.

Superconductor is a material that conducts electricity without resistance and has diamagnetism below critical temperature ( $T_c$ ), critical magnetic field ( $B_c$ ) and critical current density ( $J_c$ ). Once set in motion, electrical current flows forever in a closed loop of superconducting material under diamagnetism.

2G HTS constitutes of multi-layers and total thickness is around 60  $\mu\text{m}$  to 90  $\mu\text{m}$  and the superconducting layer made from  $\text{REBa}_2\text{Cu}_3\text{O}_{7-x}$  is only 1  $\mu\text{m}$  to 3  $\mu\text{m}$  thick depending on manufacturer's specifications. [Figure 1](#) shows schematic drawing of typical multiple layers, and the constituents and thicknesses of each layer in the 2G HTS.

Dimensions in micro-meters



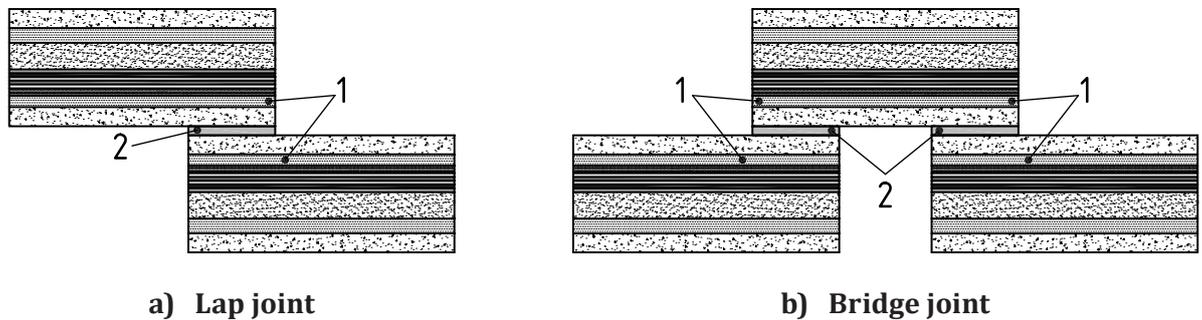
Key <https://standards.iteh.ai/catalog/standards/iso/67a9a027-6081-4640-b3fb-d0672ecb480f/iso-17279-3-2021>

1	Cu stabilizer	$t_1$	thickness of layer 1
2	Ag overlayer	$t_2$	thickness of layer 2
3	REBCO-superconducting layer	$t_3$	thickness of layer 3
4	buffer stack	$t_4$	thickness of layer 4
5	hastelloy®C-276 substrate	$t_5$	thickness of layer 5

NOTE Not to scale.

**Figure 1 — Typical 2G HTS multi-layers, and the constituents and thicknesses of each layer**

Currently soldering, brazing or any filler is applying in superconducting industry as shown in [Figure 2](#), which shows high electrical resistance at the joint providing fatal flaw in the superconductor.

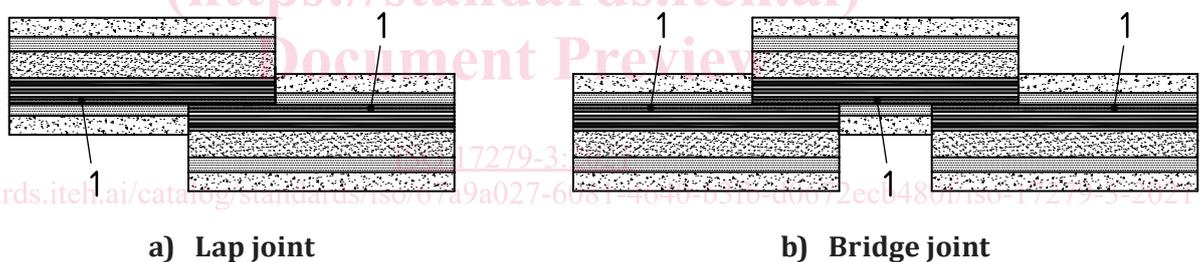


**Key**

- 1 REBCO-superconducting layer
- 2 solder

**Figure 2 — Soldering to join 2G HTS**

However, the ISO 17279 series focuses on the direct autogenous joining of 1  $\mu\text{m}$  to 3  $\mu\text{m}$  thick superconducting layers of 2G HTSs as shown in [Figure 3](#) without filler metals and recovery of superconducting properties by oxygenation annealing process, which shows almost none electrical resistance at the joint.



**Key**

- 1 REBCO-superconducting layer

**Figure 3 — Direct autogenous joining of 1  $\mu\text{m}$  to 3  $\mu\text{m}$  thick superconducting layers of 2G HTSs for superconducting joint**

ISO 17279-1 specifies requirements for the qualification of 2G HTS joining procedure. 2G HTS joints should be capable of performing required electric, magnetic and mechanical properties and free from serious imperfections in production and in service. To achieve that goal, it is necessary to provide controls during design and fabrication.

ISO 17279-2 specifies requirements for the qualification of personnel performing welding and testing.