
**Welding — Micro joining of 2nd
generation high temperature
superconductors —**

**Part 2:
Qualification for welding and testing
personnel**

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

Partie 2: Qualification du personnel en soudage et d'essai



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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).

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).

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.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*.

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.

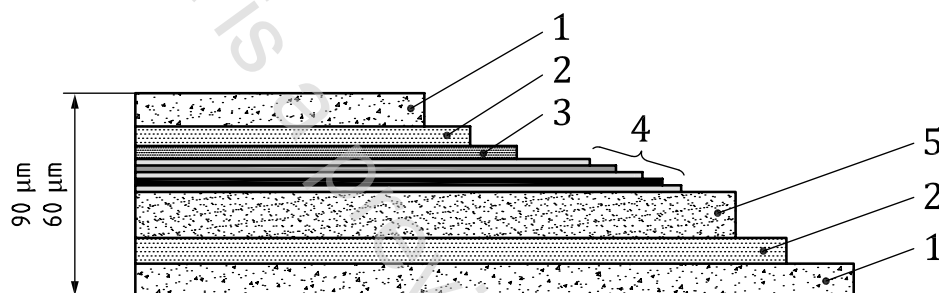
A list of all parts in the ISO 17279 series can be found on the ISO website.

Introduction

The increasing use of 2nd generation high temperature superconductors (2G HTSs) and invention of resistance-free joining on 2G HTSs have created the need for this document 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.

A 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.

A 2G HTS consists of multi-layers and its total thickness is around between 60 μm and 100 μm with or without surrounding copper stabilizer. The superconducting layer made from $\text{ReBa}_2\text{Cu}_3\text{O}_{7-x}$ (ReBCO, abbreviated term of $\text{ReBa}_2\text{Cu}_3\text{O}_{7-x}$) is only between 1 μm and 2 μm thick depending on manufacturer's specifications. Re stands for Rare Earth materials, of which gadolinium, yttrium and samarium are used for 2nd generation high temperature superconducting materials. [Figure 1](#) shows schematic drawing of typical multiple layers with surrounded copper stabilizer, and the constituents and thicknesses of each layer in the 2G HTS. The two layers of No. 1 in [Figure 1](#) does not exist in stabilizer-free 2G HTS.



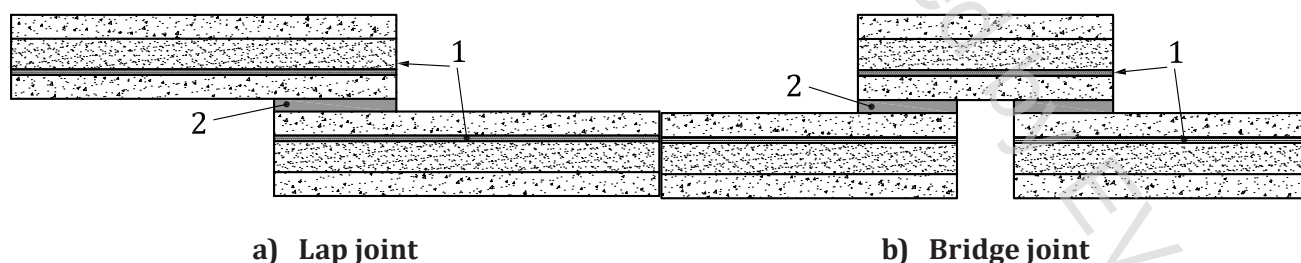
Key

- | | | | |
|---|--|---|--------------------------------------|
| 1 | 20 μm Cu stabilizer | 4 | 5 buffing layers (total 160 nm) |
| 2 | 2 μm Ag overlayer | 5 | 50 μm hastelloy substrate |
| 3 | between 1 μm and 2 μm ReBCO super-conducting layer | | |

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 applied in superconducting industry as shown in [Figure 2](#), which shows high electrical resistance at the joint providing fatal flaw in the superconductor.

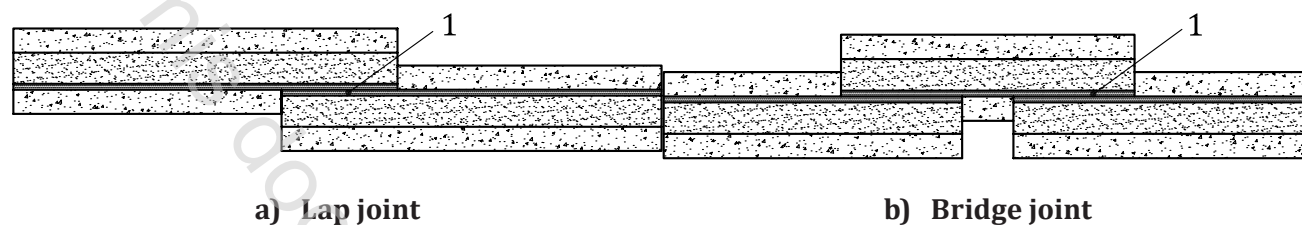


Key

- | | |
|---|-----------------------|
| 1 | superconducting layer |
| 2 | solder |

Figure 2 — Soldering to join 2G HTS

However, this document focuses on the direct autogenous joining of between 1 μm and 2 μm -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 no electrical resistance at the joint.



Key

1 superconducting layer

Figure 3 — Direct autogenous joining of two superconducting layers of 2G HTSs for superconducting joint

Welding — Micro joining of 2nd generation high temperature superconductors —

Part 2: Qualification for welding and testing personnel

1 Scope

This document specifies the qualification requirements for personnel performing micro-joining and oxygenation annealing, and testing the 2G HTS test joints.

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.

ISO 15607:2003, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO 17279-1, *Welding — Micro-joining of 2nd generation high temperature superconductors — Part 1: General requirements for the procedure*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17279-1 apply.

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

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

4 Symbols and abbreviated terms

The abbreviated terms listed in ISO 15607:2003, Table 1, relevant to joining procedure for 2G HTS shall apply.

5 Qualification of personnel performing micro-joining and oxygenation annealing

5.1 General

Manufacturers shall have at their disposal sufficient competent personnel for the 2G HTS micro-joining operations in accordance with specified requirements. The manufacturer shall be responsible for developing the training program, written practice, examination, and practical demonstrations for personnel performing the micro-joining in accordance with this document. These shall establish the capability of the personnel performing the required micro-joining and oxygenation annealing. Qualification records and certificates shall be kept up-to-date. The procedures for micro-joining and oxygenation annealing are presented in ISO 17279-1:2018, 5.4 to 5.6.