
**Cryogenic vessels — Toughness
requirements for materials at cryogenic
temperature —**

**Part 1:
Temperatures below – 80 °C**

*Réipients cryogéniques — Exigences de ténacité pour les matériaux à
température cryogénique —*

Partie 1: Températures inférieures à – 80 °C



PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

STANDARDSISO.COM : Click to view the full PDF of ISO 21028-1:2004

© ISO 2004

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 ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 21028-1 was prepared by Technical Committee ISO/TC 220, *Cryogenic vessels*.

ISO 21028 consists of the following parts, under the general title *Cryogenic vessels — Toughness requirements for materials at cryogenic temperature*:

- *Part 1: Temperatures below – 80 °C*
- *Part 2: Temperatures between – 80 °C and – 20 °C*

Introduction

The use of materials at low temperatures entails special problems which have to be addressed. Consideration has to be given, in particular, to changes in mechanical characteristics, expansion and contraction phenomena and the thermal conduction of the various materials. Austenitic stainless steel can transform from the austenitic to the martensitic phase when cooled down, leading to dimensional change that needs to be considered during design.

However, the most important property to be considered is material toughness at low temperatures.

This part of ISO 21028 is based on the European Standard EN 1252-1:1998.

STANDARDSISO.COM : Click to view the full PDF of ISO 21028-1:2004

Cryogenic vessels — Toughness requirements for materials at cryogenic temperature —

Part 1: Temperatures below – 80 °C

1 Scope

This part of ISO 21028 specifies the toughness requirements of metallic materials for use at temperatures below – 80 °C to ensure their suitability for cryogenic vessels. It is not applicable to unalloyed steels and cast materials.

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.

ISO 148 (all parts), *Metallic materials — Charpy pendulum impact test*

EN 10028-4:1994, *Flat products made of steels for pressure purposes — Part 4: Nickel alloy steels with specified low temperature properties*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

minimum working temperature

lowest temperature likely to be reached by the vessel or by one of the vessel components during operation

4 Toughness requirements

4.1 General

The toughness of the materials used shall be either guaranteed by the material producer or verified by conducting an impact test on the material in accordance with the requirements given in this clause.

Additionally, impact tests shall be performed on welded vessels as part of welding procedure qualification and production weld tests as specified in the product standard.

4.2 Steels

The materials used for the manufacture of the vessels, the welds and the heat-affected zone shall meet either the minimum impact energy or lateral expansion values.

- a) Minimum impact energy value: 34 J/cm².

NOTE 1 34 J/cm² corresponds to a 27 J energy for a full-size specimen.

- b) Minimum lateral expansion value: 0,38 mm.

These requirements apply to parent metal, welds and heat-affected zones at minimum working temperature and for the following steels.

- Ferritic alloy steel Ni ≤ 9 %

NOTE 2 Product standards could specify more stringent requirements (e.g. ISO 20421-1).

- Austenitic stainless steels CrNi (see, for example, EN 10028-7)

NOTE 3 The values relate to V-notch impact test pieces as specified in ISO 148.

- 1) For working temperatures warmer or equal to – 196 °C, only the weld should be subjected to the impact test.
- 2) For working temperatures colder than – 196 °C, base metal, heat-affected zones and weld metal should be impact tested. It is sufficient to perform the impact test at – 196 °C, but either minimum impact energy value should be 48 J/cm² or the minimum lateral expansion value should be 0,53 mm. For the base material, the value guaranteed in the material test certificate may be used.

4.3 Aluminium or aluminium alloys

The toughness of aluminium and aluminium alloys is inherently high enough at low temperatures to render impact tests unnecessary (see, for example, EN 485-3:1993).

4.4 Copper or copper alloys

The toughness of copper and copper alloys is inherently high enough at low temperatures to render impact tests unnecessary (see, for example, EN 1652, EN 1653, EN 1981, EN 12163).

4.5 Test methods

4.5.1 General

The impact energy and lateral expansion values specified in 4.2 relate to test pieces measuring 10 mm × 10 mm with a V-notch.

For materials of thickness less than 10 mm but greater than or equal to 5 mm, test pieces with a cross-section of 10 × *e*, where *e* is the thickness of the material in millimetres, shall be used. If standard test pieces cannot be obtained from the material, reduced section test pieces, with a width equal to the product thickness, 7,5 mm or 5 mm, may be used as specified in ISO 148. A minimum value as specified in 4.2 shall be met.

Impact testing shall not be carried out on plates of thickness less than 5 mm or on their welds.

4.5.2 Test piece locations for plates

The impact test shall be performed on three test pieces. Each test piece shall be taken transverse to the rolling direction and the notch, and therefore parallel to the direction of rolling and perpendicular to the plate surface.

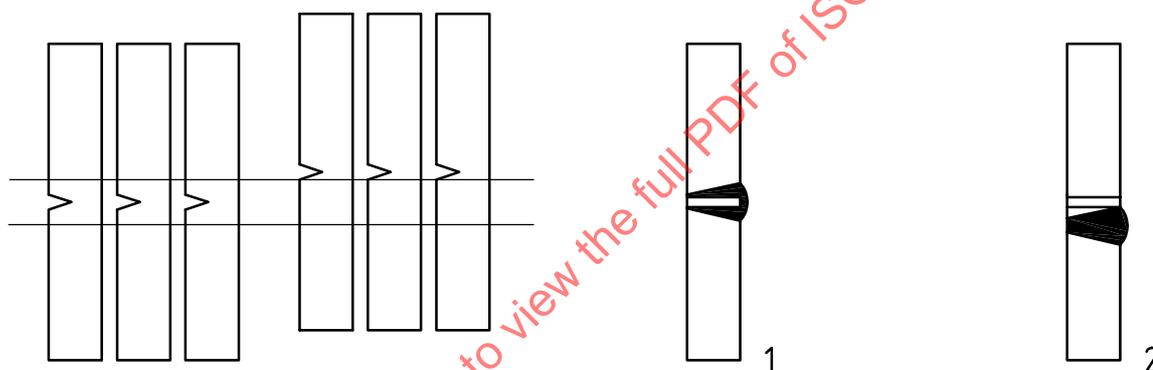
4.5.3 Test piece locations for welds and heat-affected zones

4.5.3.1 For thicknesses $e \leq 10$ mm

The test pieces shall be taken as follows:

- three test pieces from the centre of the weld;
- three test pieces from the heat-affected zone created by the weld, with the notch being completely outside the fused zone but as close as possible to it;

i.e. six test pieces in total (see Figure 1).



Key

- 1 centre of weld
- 2 heat-affected zone

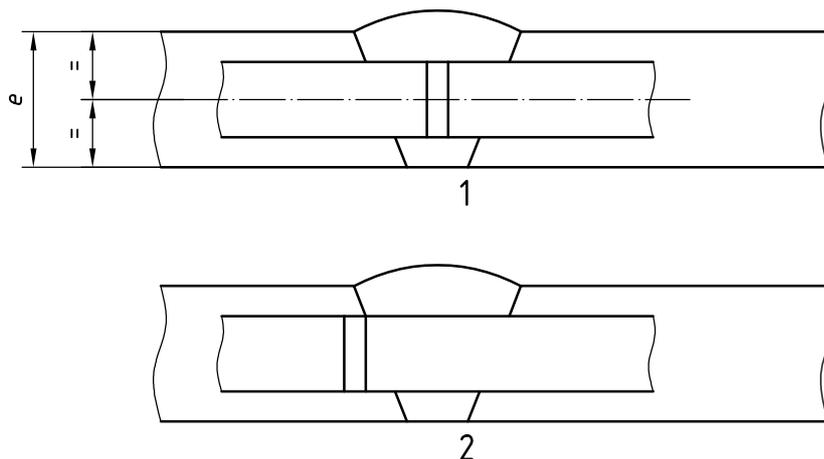
Figure 1 — Test pieces for $e \leq 10$ mm

4.5.3.2 For thicknesses $10 \text{ mm} < e \leq 20$ mm

The test pieces shall be taken as follows:

- three test pieces from the centre of the weld;
- three test pieces from the heat-affected zone;

i.e. six test pieces in all (see Figure 2).



Key

- 1 centre of weld
- 2 heat-affected zone

Figure 2 — Test pieces for $10 \text{ mm} < e \leq 20 \text{ mm}$

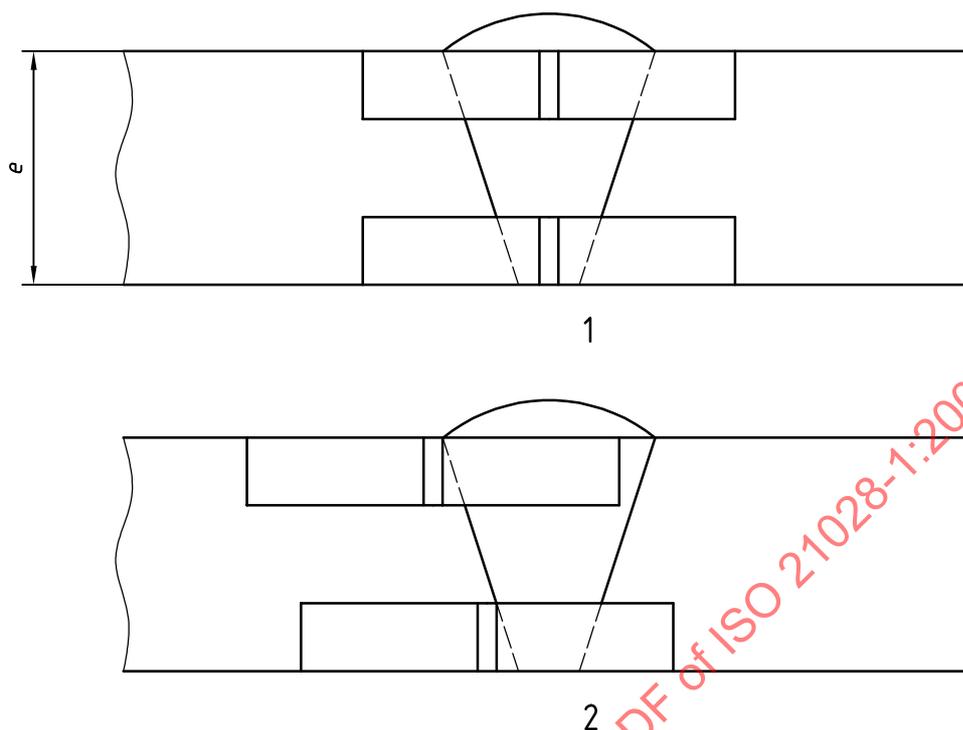
4.5.3.3 For thicknesses $e > 20 \text{ mm}$

Two sets, each consisting of three test pieces, shall be taken at each of the two points indicated in Figure 3 as follows:

- one set from the upper surface;
- the other set from the lower surface;

i.e. 12 test pieces in total (see Figure 3).

STANDARDSISO.COM : Click to view the full PDF of ISO 21028-1:2004

**Key**

- 1 centre of weld
- 2 heat-affected zone

Figure 3 — Test pieces for $e > 20$ mm

4.6 Acceptance criteria**4.6.1 For impact energy**

The minimum impact energy values specified in this part of ISO 21028 and in EN 10028-4 correspond to the average from three test pieces. One individual value may be less than the specified value, but shall not be less than 70 % of the specified value. If the above requirements are not met, a supplementary series of three test pieces shall be taken from the same sample. The following acceptance criteria shall apply to the original results and to the results of the second test series, together, and shall be met simultaneously:

- a) the average of the six tests shall be greater than or equal to the minimum specified value;
- b) a maximum of two of the six individual values may be less than the specified minimum value.

If these conditions are not met, the sample shall be rejected and the rest of the batch shall be subjected to retests.

4.6.2 For lateral expansion

4.6.2.1 Each set of the three specimens tested shall have a lateral expansion opposite the notch of not less than the required value according to 4.2 b).

4.6.2.2 If the value of lateral expansion for one specimen is less than the required value according to 4.2 b), but not less than 2/3 of the required value, a retest of three additional specimens may be made, each of which shall be greater than or equal to the required value. Such a retest shall be permitted only when the average value of the three specimens is greater than or equal to the required value. If the values required are not obtained in the retest, or if the values in the initial test are less than the values required for retest, the material may be reheat-treated. After reheat-treatment, a set of three specimens shall be made, each of which shall be greater than or equal to the required value according to 4.2 b).