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Cryogenic vessels — Toughness requirements for materials at cryogenic temperature —

Part 1:
Temperatures below -80 °C

Récipients cryogéniques — Exigences de ténacité pour les matériaux à température cryogénique —

Partie 1: Températures inférieures à -80 °C

Please see the administrative notes on page ii

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ISO/CEN PARALLEL PROCESSING

This final draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO-lead** mode of collaboration as defined in the Vienna Agreement. The final draft was established on the basis of comments received during a parallel enquiry on the draft.

This final draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel two-month approval vote in ISO and formal vote in CEN.

Positive votes shall not be accompanied by comments.

Negative votes shall be accompanied by the relevant technical reasons.

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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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 220, *Cryogenic vessels*.

This second edition cancels and replaces the first edition (ISO 21028-1:2004), which has been technically revised.

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 are to be addressed. Consideration is 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.

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 a temperature below -80 °C to ensure their suitability for cryogenic vessels.

This part of ISO 21028 is not applicable to unalloyed steels and cast materials.

2 Normative references

There are no normative references in this document.

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 following requirements.

The toughness of the materials used shall be guaranteed by the material producer or cryogenic vessel manufacturer by conducting an impact test on each heat (lot) of the material in accordance with the following requirements.

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

4.2.1 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) Ferritic steels: Minimum impact energy value: 34 J/cm^2.

NOTE 1 34 J/cm^2 corresponds to a 27 J energy for a full-size specimen.

b) Austenitic steels: Minimum impact energy value: 40 J/cm^2.

NOTE 2 40 J/cm^2 corresponds to a 32 J energy for a full-size specimen.

c) Minimum lateral expansion value: 0,38 mm.

4.2.2 The requirements of 4.2.1 apply to parent metal, welds and heat-affected zones at minimum working temperature and for the following steels.

a) Ferritic alloy steel Ni ≤ 9 %

NOTE 1 Product standards specify more stringent requirements in some cases (e.g. ISO 20421-1).

b) Austenitic stainless steels (CrNi, CrNiMo, CrNiMn, etc., see, for example, EN 10028-7)

NOTE 2 The values relate to V-notch impact test pieces as specified in ISO 148-1.

4.2.3 The extent of testing should be as follows.

a) For working temperatures warmer or equal to –196 °C, only the weld should be subjected to the impact test.

b) 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/cm^2 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.

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

— minimum impact energy value should be 48 J/cm^2,

— or minimum impact energy value should be 40 J/cm^2, if, during the welding procedure test, it was demonstrated that there are no significant differences of the impact energy values of –196 °C and the values of the lower temperature,

— 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, ISO 6361-3 and ISO 6361-4).

4.4 Copper or copper alloys

The toughness of copper and copper alloys is inherently high enough at low temperatures to render impact energy unnecessary (see, for example, EN 1652, EN 1653, EN 1981 and 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 148-1. 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

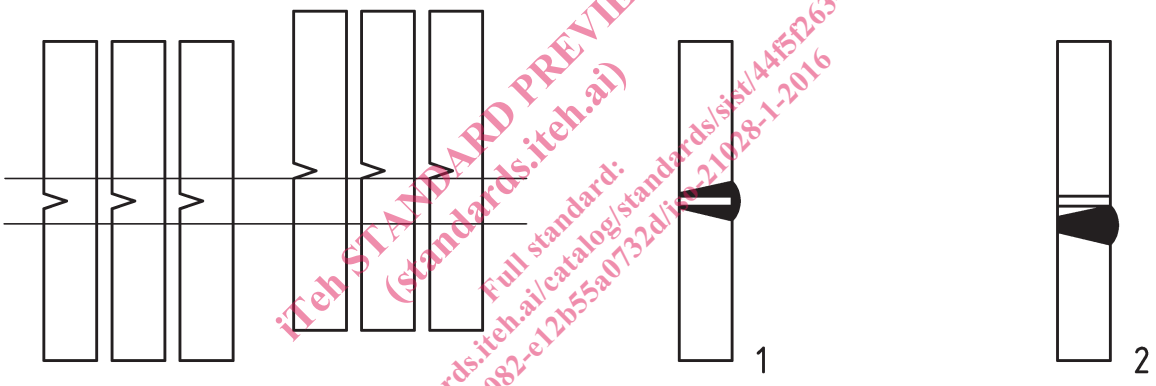
4.5.3.1 For thicknesses $e \leq 10$ mm

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).