BS ISO 21172-1:2015

BSI Standards Publication

Gas cylinders — Welded steel pressure drums up to 3 000 litres capacity for the transport of gases — Design and construction

Part 1: Capacities up to 1 000 litres

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National foreword

This British Standard is the UK implementation of ISO 21172-1:2015.

The UK participation in its preparation was entrusted to Technical Committee PVE/3/3, Gas containers - Transportable gas containers - Cylinder design, construction and testing at the time of manufacture.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Gas cylinders — Welded steel pressure drums up to 3 000 litres capacity for the transport of gases — Design and construction —

Part 1: Capacities up to 1 000 litres

Bouteilles à gaz — Fûts soudés de capacité inférieure ou égale à 3000 litres destinés au transport des gazes —

Partie 1: Capacité jusqu'à 1000 litres

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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).

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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 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

ISO 21172 consists of the following parts, under the general title *Gas cylinders — Welded steel pressure drums up to 3000 l capacity for the transport of gases — Design and construction*:

— *Part 1: Capacities up to 1 000 litres*

Capacities up to 3 000 litres will form the subjects of future Part 2.

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Introduction

The purpose of this part of ISO 21172 is to provide a specification for the design, manufacture, inspection, and approval of welded steel gas pressure drums.

The specifications given are based on knowledge of and experience with, materials, design requirements, manufacturing processes, and control during manufacture of steel drums in common use in the countries of the participating members. Pressure drums is intended to be designed, manufactured, and closed so that during normal conditions of transport including the effects of handling, temperature, vibration, humidity, or pressure, there will be no release of dangerous goods that would endanger public safety.

This part of ISO 21172 is intended to be used under a variety of national and international regulatory regimes. Where there is any conflict between this International Standard and any applicable regulation, the regulation always takes precedence.

This part of ISO 21172 has been written so that it is suitable to be referenced in the UN Model Regulations.

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Gas cylinders — Welded steel pressure drums up to 3 000 litres capacity for the transport of gases — Design and construction —

Part 1: Capacities up to 1 000 litres

1 Scope

This part of ISO 21172 specifies the minimum requirements for the material, design, fabrication, construction and workmanship, inspection, and testing at manufacture of refillable welded steel gas pressure drums, hereafter referred to as drums, of volumes 150 l to 1 000 l and up to 300 bar test pressure for compressed and liquefied gases. Only cylindrical and spherical containers are covered.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 148, *Steel — Charpy impact test (V-notch)*

ISO 1106-1, *Recommended practice for radiographic examination of fusion welded joints — Part 1: Fusion welded butt joints in steel plates up to 50 mm thick*

ISO 2063, *Thermal spraying — Metallic and other inorganic coatings — Zinc, aluminium and their alloys*

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test*

ISO 4978, *Flat rolled steel products for welded gas cylinders*

ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 7438, *Metallic materials — Bend test*

ISO 9328-1, *Steel flat products for pressure purposes — Technical delivery conditions — Part 1: General requirements*

ISO 9328-2, *Steel flat products for pressure purposes — Technical delivery conditions — Part 2: Non-alloy and alloy steels with specified elevated temperature properties*

ISO 9328-3, *Steel flat products for pressure purposes — Technical delivery conditions — Part 3: Weldable fine grain steels, normalized*

ISO 9328-4, *Steel flat products for pressure purposes — Technical delivery conditions — Part 4: Nickel-alloy steels with specified low temperature properties*

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ISO 9328-5, *Steel flat products for pressure purposes — Technical delivery conditions — Part 5: Weldable fine grain steels, thermomechanically rolled*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10920, *Gas cylinders — 25E taper thread for connection of valves to gas cylinders — Specification*

ISO 11114-1, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials*

ISO 11114-2, *Gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 2: Non-metallic materials*

ISO 11114-4, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement*

ISO 11116-1, *Gas cylinders — 17E taper thread for connection of valves to gas cylinders — Part 1: Specifications*

ISO 13769, *Gas cylinders — Stamp marking*

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

ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

ISO 15614-1, *Steel welding procedure qualifications*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17638, *Non-destructive testing of welds — Magnetic particle testing*

EN 462-3, *Non-destructive testing — Image quality of radiographs — Image quality classes for ferrous metals*

ASTM A285/ASTM A285M-03 (2007), *Standard specification for pressure vessel plates, carbon steel, low and intermediate tensile strength*

3 Terms and definitions

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

3.1
yield strength
stress value corresponding to the lower yield strength, R_{eL} or, for steels that do not exhibit a defined yield point, the 0,2 % proof strength, $R_{p0,2}$ for carbon steels; and 1 % proof strength for austenitic stainless steels, $R_{p1,0}$

3.2
normalizing
heat treatment given to the steel by heating to an uniform temperature above the upper critical point (AC_3) of the steel and then cooled in a controlled atmosphere or still air

3.3
stress relieving
heat treatment given to reduce the residual stresses of the steel

3.4
batch
quantity of finished drums of a specific type made to the same design, size, and material specifications; using the same welding procedures and heat-treated under the same conditions of temperature and duration

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3.5
test pressure
pressure applied to the drum after completion of all fabrication

3.6
finished drum
drum which is fully assembled and appropriately stamp marked, but without any external coatings

3.7
rolling bands
circumferential rings attached to the drum to protect it from external damage

3.8
hot pressure welding (forged)
solid state joining of two metallic parts by the application of heat and pressure

4 Inspection and testing

Evaluation of conformity should be performed in accordance with the regulations recognized by the country(ies) where the drums are intended to be used.

To ensure that the drums conforms to the requirements of ISO 21172-1, they shall be subject to inspection and testing in accordance with Clause 16 by an inspection body (hereafter referred to as "the inspector") authorized by the applicable regulation.

Equipment used for measurement, testing, and examination during production shall be maintained and calibrated within a documented quality management system.

5 Materials

5.1 General provisions

5.1.1 Materials for the pressure envelope

Materials for the pressure envelope shall conform to ISO 4978 or ISO 9328-1 to ISO 9328-4 for carbon steels and ISO 9328-5 for austenitic stainless steels and austeno-ferritics steels.

For drums made using hot pressure welded heads according to Annex D, the materials shall conform to ASTM specification A285/285M, Grade A and have a minimum tensile strength of 310 MPa.

5.1.2 The materials used for the drum

The materials used for the drum, including welded zones, shall be compatible with the intended gas service and meet the applicable requirements of ISO 11114-1, ISO 11114-2, and ISO 11114-4.

Components (e.g. bolts and studs) in contact with the gas shall meet the applicable requirements of ISO 11114-1, ISO 11114-2, and ISO 11114-4.

5.1.3 All parts welded to the drum

All parts welded to the drum shall be made of material that is compatible with respect to weldability and strength (e.g. from ISO 9327).

5.1.4 Welding consumables

The welding consumables shall be such that they are capable of giving consistent welds with the material properties at least equal to that specified for the parent material in the finished drum.

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5.1.5 Conformance

The manufacturer shall obtain and provide certificates to verify conformance to the material specifications for the steel used for the construction of pressure retaining parts of the drum. If the minimum values of the yield strength of the material guaranteed by the steel manufacturer for austenitic stainless steels are greater than the minimum specified in the material standard, then this higher figure can be used in the design calculations, up to a maximum enhancement of 15 %. It shall be ensured that the heat treatment (if any) will not affect this minimum guaranteed value.

For all pressure bearing parts of the drum, the manufacturer shall ensure the traceability of the steel casts that they have been manufactured from.

5.2 Heat treatment

Completed drums made of carbon steels shall be stress relieved or normalized. Stress relieving parameters shall be in accordance with the material specification listed in 5.1.

The manufacturer shall record that the drums have been heat treated after completion of all welding and shall record the temperature and duration of the heat treatment applied.

Localized heat treatment is not permitted.

6 Design

6.1 Design stress

At the test pressure, the design stresses

a) f_c (maximum allowable stress for the cylindrical section of a drum),

b) f_e (maximum allowable stress for the dished ends of a drum,

c) f_p (maximum allowable stress for the pad material of a drum), and

d) f_s (maximum allowable stress for the spherical section of a drum).

It shall not exceed 0,77 Y, where Y is the minimum guaranteed value of yield strength of the material in the relevant part of the finished drum).

6.2 Design temperature

The minimum design reference temperature shall be equal to or less than –20 °C, and the maximum equal to or more than +65 °C.

When deciding the test temperature, the actual drum wall thickness shall be taken into account (see ISO 21028-2 which explains the reason).

6.3 Calculation of thickness

6.3.1 Cylindrical wall

The minimum cylindrical section wall thickness, a_1, shall be not be less than the maximum value of thickness calculated using Formula (1), Formula (2), and Formula (3) [or Formula (4), if applicable].

$$a_{1(1)} = \frac{p_h \times D_0}{20 f_c + p_h} \tag{1}$$

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$$a_{1(2)} = K \frac{p_h \times D_0}{20T + p_h} \tag{2}$$

where

p_h is the test pressure;

D_0 is the maximum outside diameter of the drum;

f_c is the maximum allowable stress for the cylindrical section of a drum;

K is the shape factor of the dished ends;

T is the minimum value of tensile strength guaranteed by the drum manufacturer.

The value of K is given in 6.3.3.2 and the minimum thickness of the cylindrical shell is given by Formula (3):

$$a_2 = \frac{D_0}{250} + 2 \tag{3}$$

where

D_0 is the maximum outside diameter of the drum.

where a_2 is the minimum thickness of cylindrical shell or dished end based on handling criterion for highly toxic gases whose $LC_{50\ is}$ less than 200 ppmV is given by Formula (4):

$$a_2 = \frac{D_0}{250} + 4 \tag{4}$$

where

D_0 is the maximum outside diameter of the drum.

6.3.2 Spherical shell

The minimum thickness of a wall of spherical section shall not be less than the maximum value of thickness calculated using Formula (5) and (6).

$$s_{1(1)} = \frac{p_h \times D_0}{40 f_s + P_h} \tag{5}$$

where

p_h is the test pressure;

D_0 is the maximum outside diameter of the drum;

f_s is the maximum allowable stress for the spherical section of a drum.

$$s_{1(2)} = 2{,}25 \frac{P_h \times D_0}{40T + P_h} \tag{6}$$

where

p_h is the test pressure;

D_0 is the maximum outside diameter of the drum;

T is the minimum value of tensile strength guaranteed by the drum manufacturer.

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6.3.3 Dished ends

6.3.3.1 Types of dished end

For a drum with concave ends, the minimum thickness, b_1, of the wall of a torispherical end or ellipsoidal dished end shall be not less than:

$$b_1 = K \cdot a_1 \tag{7}$$

where

K is the shape factor of the dished ends; the value of K (see Figure 1) varies with the shape of the ends. The value of K shall not be taken as less than 1,0;

a_1 is the minimum cylindrical section wall thickness calculated in 6.3.1.

If a drum is made of two dished ends, the thickness of the straight cylindrical part shall be not less than a_1 as calculated according to 6.3.1. If a drum is made of two hemispherical ends, their thickness shall be calculated according to 6.3.2.

6.3.3.2 Shape factor

The shape factor K is determined and taken from Figure 1, using the appropriate values of H_e/D_0 and b_1/D_0.

where:

H_e is the equivalent height of a dished end for determining the shape factor;

H_0 is the external height of the domed part of the end;

D_0 is the maximum outside diameter of the drum.

The value for H_e is determined using Formula (7) and Formula (8). See Annex B for a calculated example.

For an ellipsoidal end:

$$H_e = H_0 \tag{8}$$

For a torispherical end:

$$He = \text{the minimum value of either } H_0, or\ \frac{(D_0)^2}{4R_0} \text{ or } \sqrt{\frac{D_0 r_0}{2}} \tag{9}$$

where

H_e is the equivalent height of a dished end for determining the shape factor;

H_0 is the external height of the domed part of the end;

D_0 is the maximum outside diameter of the drum;

R_0 is the external radius of the crown of a torispherical dished end;

r_0 is the external radius of the knuckle of a torispherical dished end.

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The external height of the domed end for a torispherical end shall be calculated as:

$$H_0 = R_0 - \sqrt{\left(R_0 - \frac{D_0}{2}\right)\left(R_0 + \frac{D_0}{2} - 2r_0\right)} \tag{10}$$

where

H_0 is the external height of the domed part of the end;

R_0 is the external radius of the crown of a torispherical dished end;

D_0 is the maximum outside diameter of the drum;

r_0 is the external radius of the knuckle of a torispherical dished end.

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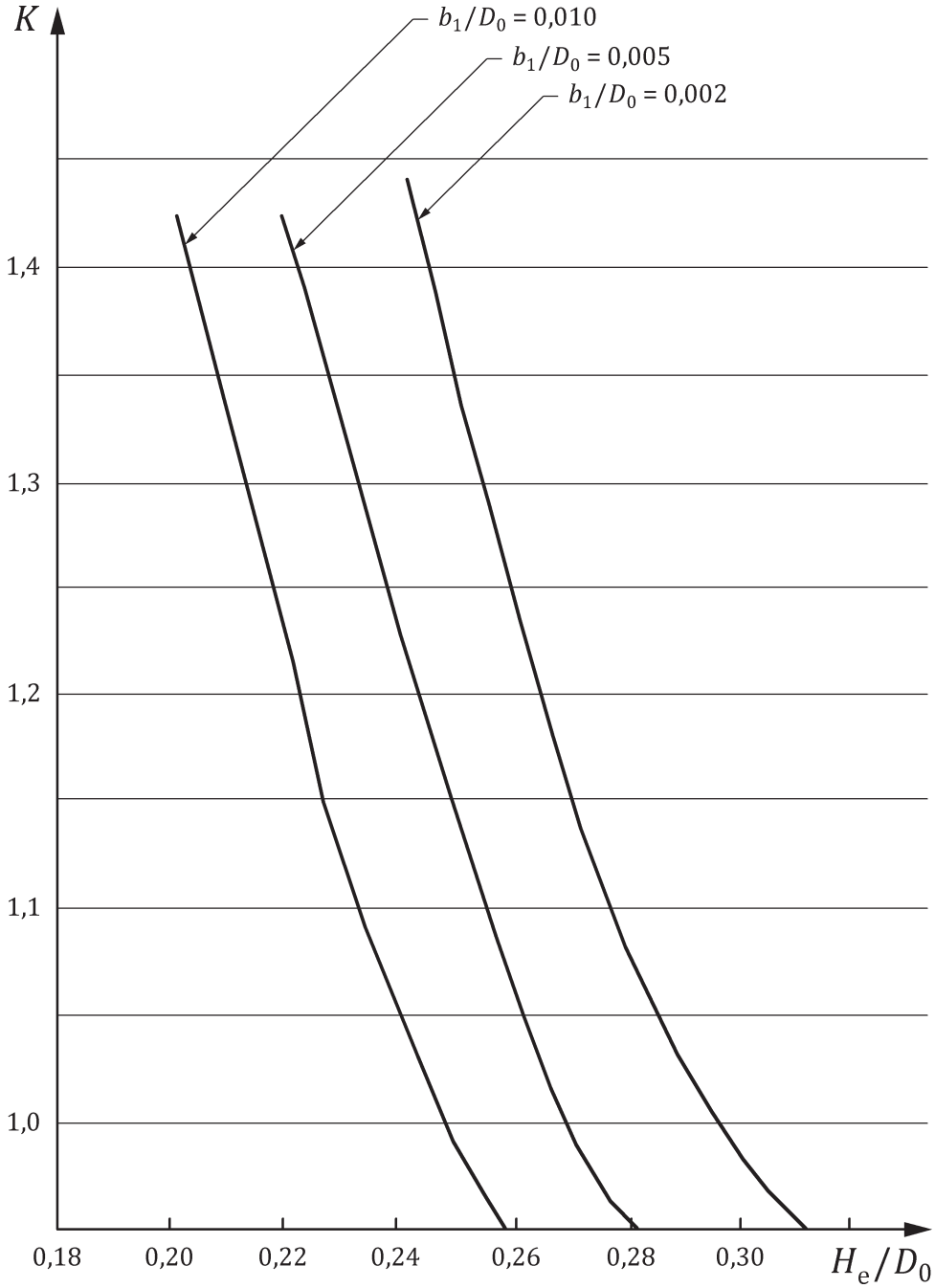

Figure 1 — Shape factor (*K*)

6.3.3.3 Limitations of shape

For a torispherical end, R_0, shall not be greater than D_0, and r_0 shall not be less than $0{,}1D_0$ nor less than four times the thickness of the dished end as manufactured.

For an ellipsoidal end, the ratio $\frac{H_e}{D_0}$ shall be not less than 0,192.

In all cases, S_f shall not be less than $0{,}3\sqrt{D_0 t_e}$

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