SLOVENSKI STANDARD
SIST EN 1964-2:2002

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Premiļ ne plinske jeklenke - Specifikacije za zasnovo in izdelavo ponovno polnljivih jeklenk iz celega iz jekla z vodno prostornino med 0,5 in vkljuļ no 150 litri - 2. del: Jeklenke iz celega iz jekla z Rm > 1100 MPa

Transportable gas cylinders - Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres - Part 2: Cylinders made of seamless steel with an Rm value of 1100 MPa and above

Ortsbewegliche Gasflachen - Gestaltung und Konstruktion von nahtlosen wiederbefüllbaren ortsbeweglichen Gasflaschen aus Stahl mit einem Fassungsraum von 0,5 Liter bis einschließlich 150 Liter - Teil 2: Nahtlose Flaschen aus Stahl mit einem Rm-Wert von 1100 MPa und darüber

Bouteilles a gaz transportables - Spécifications pour la conception et la fabrication de bouteilles a gaz rechargeables et transportables, en acier sans soudure, de capacité en eau comprise entre 0,5 litre et 150 litres inclus - Partie 2: bouteilles en acier sans soudure d'une valeur Rm égale ou supérieure a 1100 MPa

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Transportable gas cylinders - Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres - Part 2: Cylinders made of seamless steel with an R_m value of 1100 MPa and above

Bouteilles à gaz transportables - Spécifications pour la conception et la fabrication de bouteilles à gaz rechargeables et transportables, en acier sans soudure, de capacité en eau comprise entre 0,5 litre et 150 litres inclus - Partie 2: bouteilles en acier sans soudure d'une valeur R_m égale ou supérieure à 1100 MPa

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This European Standard was approved by CEN on 11 August 2001.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 23 "Transportable gas cylinders", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2002, and conflicting national standards shall be withdrawn at the latest by March 2002.

This European Standard has been submitted for reference into the RID and/or the technical annexes of the ADR. Therefore in this context the standards listed in the normative references and covering basic requirements of the RID/ADR not addressed within the present standard are normative only when the standards themselves are referred to in the RID and/or in the technical annexes of the ADR.

This standard is one of a series of three standards concerning refillable seamless steel gas cylinders of water capacities from 0,5 litre up to and including 150 litres for compressed, liquefied and dissolved gases:

Part 1: Cylinders made of seamless steel with an R_m value of less than 1 100 MPa

Part 2: Cylinders made of seamless steel with an R_m value of 1 100 MPa and above

Part 3: Cylinders made of seamless stainless steel with an R_m value of less than 1 100 Mpa

The annexes A, B and C are normative. Annex D is informative.

This standard includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The purpose of this standard is to provide a specification for the design, manufacture, inspection and approval of refillable, transportable seamless steel gas cylinders.

The specifications given are based on knowledge of, and experience with, materials, design requirements, manufacturing processes and control during manufacture, of cylinders in common use in the countries of the CEN members.

1 Scope

This European Standard sets out minimum requirements for the material, design, construction and workmanship, manufacturing processes and tests at manufacture of refillable transportable seamless steel gas cylinders of water capacities from 0,5 litres up to and including 150 litres for compressed, liquefied and dissolved gases.

This standard is applicable to cylinders with a value of R_m max. ≥ 1 100 MPa. It does not cover cylinders with diameters > 140 mm where either R_m max. > 1 300 MPa or the design wall thickness > 12 mm. It also does not cover cylinders with diameters ≤ 140 mm where either R_m max ≥ 1 400 MPa or the design wall thickness ≥ 6 mm, because beyond these limits additional requirements could possibly apply.

NOTE 1 For compatibility with the intended gas service and operational conditions, of grades and strength ranges of steels used for cylinder manufacture, see 4.1.4.

NOTE 2 This standard is also suitable for the manufacture of cylinders of water capacity less than 0,5 litre.

2 Normative References

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 473, *Non destructive testing - Qualification and certification of NDT personnel — General principles*

EN 10028-1, *Flat products made of steels for pressure purposes — Part 1: General requirements*

EN 1089-1: 1996, *Transportable gas cylinders — Gas cylinder identification (excluding LPG) — Part 1: Stampmarking*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test (at ambient temperature)*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1:1999)*

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method*

EN 10052, *Vocabulary of heat treatment terms for ferrous products*

EN ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T) (ISO 6508-1:1999)*

EN ISO 11114-1:1997, *Transportable gas cylinder - Compatibility of cylinder and valve materials with gas contents — Part 1: Metallic materials (ISO 11114-1:1997)*

EURONORM 6-55, *Bend test for steel*

3 Terms, definitions and symbols

For the purposes of this European Standard the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1
yield stress
value corresponding to the lower yield stress R_{eL} or, for steels that do not exhibit defined yield, the 0,2 % proof stress $R_{p0,2}$

3.1.2
quenching
hardening heat treatment in which a cylinder, which has been heated to a uniform temperature above the upper critical point (Ac_3, as defined in EN 10052) of the steel, is cooled rapidly in a suitable medium

3.1.3
tempering
softening heat treatment which follows quenching, in which the cylinder is heated to a uniform temperature below the critical point (Ac_1, as defined in EN 10052) of the steel

3.1.4
batch
a quantity of up to 200 cylinders, plus cylinders for destructive testing, of the same nominal diameter, thickness, length and design made from the same steel and subjected to the same heat treatment for the same duration of time

3.1.5
burst pressure
highest pressure reached in a cylinder during a burst test

3.1.6
test pressure
required pressure applied during a pressure test

3.1.7
design stress factor (*F*)
the ratio of equivalent wall stress at test pressure (p_h) to guaranteed minimum yield stress (R_e)

3.1.8
competent body
organization responsible for checking the conformity of cylinders to this standard

NOTE Within the framework of the application of the regulations pertaining to the transport of dangerous goods, this organization may be, depending on the selected conformity assessment module, either a notified body or an approved body, or an entity within the manufacturer's organization.

3.2 Symbols

a Calculated minimum thickness, in millimetres, of the cylindrical shell

a′ Guaranteed minimum thickness, in millimetres, of the cylindrical shell (see Figure 1)

a_1	Required minimum thickness, in millimetres, of a concave base at the knuckle (see Figure 2)
a_2	Required minimum thickness, in millimetres, at the centre of a concave base (see Figure 2)
A	Percentage elongation
b	Required minimum thickness, in millimetres, at the centre of a convex base (see Figure 1)
d	Dimension, in millimetres, of acceptable burst profile (see Figures 10 and 11)
D	Outside diameter of the cylinder, in millimetres (see Figure 1)
D_f	Diameter of former, in millimetres (see Figure 6)
F	Design stress factor (see 3.1.7)
h	Outside height (concave base end), in millimetres (see Figure 2)
H	Outside height of domed part (convex head or base end), in millimetres (see Figure 1)
l_o	surface length of artificial flaw, in millimetres (see 7.7.2 and 7.8.2)
L	Nominal cylinder length, in millimetres (see Figure 3)
L_o	Original gauge length, in millimetres, according to EN 10 002-1 (see Figure 4)
p_b	Measured burst pressure, in bar[1], above atmospheric pressure in the hydraulic burst test
p_f	Measured failure pressure, in bar[1], above atmospheric pressure in the flawed cylinder burst test
p_h	Hydraulic test pressure, in bar[1], above atmospheric pressure
p_s	Design working pressure, in bar[1], above atmospheric pressure (calculated as equal to 2/3 p_h)
p_w	Working pressure, in bar[1], above atmospheric pressure
p_y	Observed yield pressure, in bar[1] , above atmospheric pressure
r	Inside knuckle radius, in millimetres (Figure 1 and 2)
r_c	Flaw root radius, in millimetres (see 7.7.2 and 7.8.2)
R_e	Minimum guaranteed value of yield stress (see 3.1.1), in megapascals
R_{ea}	Value of the actual yield stress, in megapascals, determined by the tensile test (see 7.1.2.1)
R_g	Minimum guaranteed value of tensile strength, in megapascals
R_m	Actual value of tensile strength, in megapascals determined by the tensile test (see 7.1.2.1)
R_m max.	Maximum actual value of the tensile strength, in megapascals
R_m min.	Minimum actual value of the tensile strength, in megapascals
S_o	Original cross-sectional area of tensile test piece, in square millimetres, according to EN 10 002-1

[1] 1 bar = 10^5 Pa = 0,1 MPa

t	Actual thickness of the test specimen, in millimetres (see Figure 6)
V	Water capacity of cylinder, in litres
w	Width, in millimetres, of tensile test piece (see Figure 5)
δ	Depth of artificial flaw, in millimetres (see 7.7.2 and 7.8.2)
ρ_c	Runout radius of flaw, in millimetres (see 7.7.2 and 7.8.2)

4 Materials and heat treatment

4.1 General provisions

4.1.1 Steels for the manufacture of gas cylinders shall meet the requirements of this standard.

4.1.2 The steel used for the fabrication of gas cylinders shall have acceptable non-ageing properties and shall not be rimming quality. In cases where examination of this non-ageing property is required, the criteria by which it is to be specified shall be agreed between the parties.

4.1.3 The cylinder manufacturer shall establish means to identify the cylinders with the cast of steel from which they are made.

4.1.4 High strength steels in this standard are not normally compatible with corrosive or embrittling gases. (See EN ISO 11114-1: 1997). They may however be used with such gases provided that their compatibility is proven by a recognized method.

4.2 Controls on chemical composition

4.2.1 The chemical composition of all steels shall be specified and recorded, including:

— maximum sulphur and phosphorus content;

— carbon, manganese and silicon content;

— nickel, chromium, molybdenum and all other alloying elements intentionally added.

The content of carbon, manganese, silicon and where appropriate, nickel, chromium and molybdenum shall be given, with tolerances, such that the differences between the maximum and minimum values (maximum range) of the cast do not exceed the values shown in Table 1.

Table 1 — Chemical composition tolerances

Element	Maximum content in %	Maximum permissible range in %
Carbon	< 0,30 % ≥ 0,30 %	0,03 % 0,04 %
Manganese	All values	0,20 %
Silicon	All values	0,15 %
Chromium	< 1,20 % ≥ 1,20 %	0,2 % 0,3 %
Nickel	All values	0,30 %
Molybdenum	< 0,50 % ≥ 0,50 %	0,10 % 0,15 %

NOTE The maximum permissible range for each element is not required to be centred on its nominal content. As an example, for a steel with nominal carbon content of 0,10 %, the following three maximum permissible ranges are equally acceptable:

+ 0,00 %, - 0,03 %

+ 0,03 %, - 0,00 %

+ 0,01 %, - 0,02 %

The combined content of the following elements: V, Nb, Ti, B, Zr, shall not exceed 0,15 %.

The actual content of all deliberately added elements shall conform to the above specification and be reported.

4.2.2 Sulphur and phosphorus in the cast analysis of material used for the manufacture of gas cylinders shall not exceed the values shown in Table 2.

Table 2 — Sulphur and phosphorus limits

Element	Content
Sulphur	0,010 %
Phosphorus	0,015 %
Sulphur + phosphorus	0,020 %

4.2.3 The cylinder manufacturer shall obtain and provide certificates of cast analyses of the steels supplied for the manufacture of gas cylinders.

Should check analyses be required, they shall be carried out either on specimens taken during manufacture from material in the form as supplied by the steel maker to the cylinder manufacturer, or from finished cylinders. In any check analysis, the maximum permissible deviation from the limits specified for cast analyses shall conform to the values specified in EN 10028-1.

NOTE EN 10028-1 is a general standard which cross references the actual permissible deviations given in other parts of EN 10028.

4.3 Heat treatment

4.3.1 The cylinder manufacturer shall provide a certificate stating the heat treatment process applied to the finished cylinders.

4.3.2 Quenching in media other than mineral oil is permissible provided that the method produces cylinders free of cracks. If the rate of cooling in the medium is greater than 80 % of that in water at 20 °C without additives, every production cylinder shall be subjected to a non-destructive test to prove freedom from cracks. (See 6.4.)

4.3.3 The tempering process shall achieve the required mechanical properties. The actual temperature to which a type of steel is subjected for a given tensile strength shall not deviate by more than 30 °C from the temperature specified by the cylinder manufacturer for the cylinder type.

5 Design

5.1 General provisions

5.1.1 The calculation of the wall thickness of the pressure-containing parts shall be related to the yield stress (R_e) of the material.

5.1.2 Cylinders may be designed with one or two openings along the central cylinder axis only.

5.1.3 For calculation purposes, the value of the yield stress (R_e) is limited to a maximum of 0,90 R_g.

5.1.4 The internal pressure upon which the calculation of wall thickness is based shall be the hydraulic test pressure (p_h).

5.2 Limiting design stress

The maximum of the tensile strength is limited by the ability of the steel to pass the requirements of A.1 (prototype tests) and A.2 (batch tests). The maximum range of tensile strength shall be 120 MPa (i.e. R_m max. – R_m min. ≤ 120 MPa).

However, the actual value of the tensile strength as determined in 7.1.2.1 shall not exceed 1 300 MPa for cylinders with outside diameter > 140 mm, and 1 400 MPa for cylinders with outside diameter ≤ 140 mm.

5.3 Calculation of cylindrical wall thickness

The guaranteed minimum thickness of the cylindrical shell (*a*') shall be not less than the thickness calculated using equations (1) and (2), and in addition condition (3) shall be satisfied:

$$a = \frac{D}{2}\left[1 - \sqrt{\frac{10.F.R_e - \sqrt{3}.p_h}{10.F.R_e}}\right] \quad (1)$$

Where the value of F is the lesser of $\frac{0,65}{(R_e / R_g)}$ or 0,77

R_e/R_g shall not exceed 0,90.

The wall thickness shall also satisfy the formula

$$a \geq \frac{D}{250} + 1\text{mm} \quad (2)$$

with an absolute minimum of a = 1,5 mm.

The burst ratio

$$p_b/p_h \geq 1,6 \quad (3)$$

shall be satisfied by test.

NOTE If the result of these requirements is a guaranteed thickness of the cylindrical shell (a') ≥ 12 mm for diameter D > 140 mm, or a guaranteed thickness of the cylindrical shell (a') ≥ 6 mm for diameter D ≤ 140 mm, then such a design would be outside the scope of this standard.

5.4 Calculation of convex ends (heads and base ends)

5.4.1 The shapes shown in Figure 1 are typical of convex heads and base ends. Shape A is a base end formed from tubing and from plates, shapes C and D are base ends formed during the piercing of a billet, and shape B is a head.

5.4.2 When convex base ends are used, the following minimum values are recommended:

r = 0,075·D

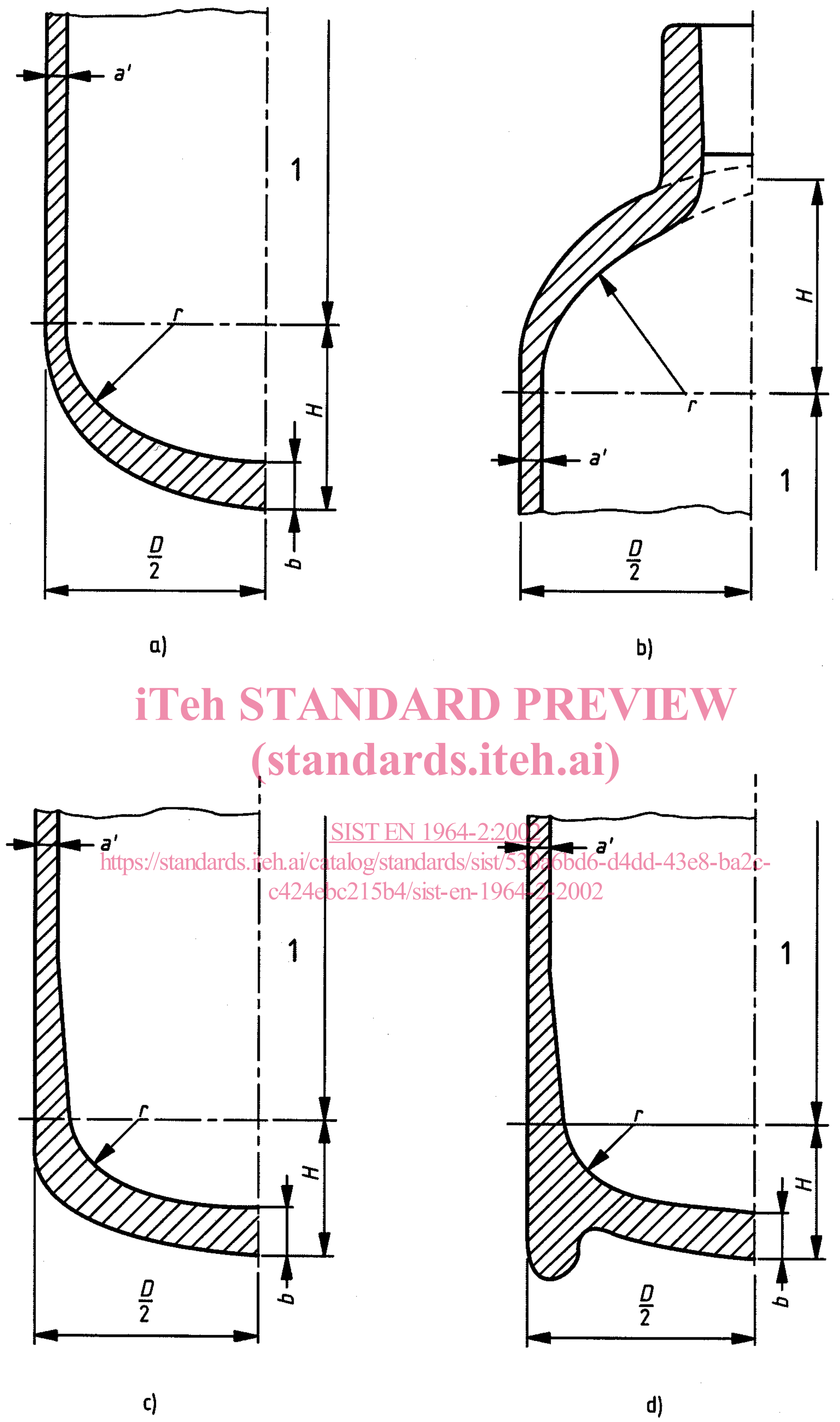
b = 1,5a for 0,40 > H/D ≥ 0,20

b = a for H/D ≥ 0,40

In order to obtain a satisfactory stress distribution in the region where the end joins the shell, any thickening of the end that may be required shall be gradual from the point of juncture. For the application of this rule, the point of juncture between the shell and the end is defined by the horizontal line indicating dimension H in Figure 1.

Shape B shall not be excluded from this requirement.

The cylinder manufacturer shall prove by the pressure cycling prototype test as required in A.1 that the design is satisfactory.



Key

1 Cylindrical part

Figure 1 — Typical convex ends

5.5 Calculation of concave base ends

When concave base ends (see Figure 2) are used, the following minimum values are recommended:

$a_1 = 2\,a$;

$a_2 = 2\,a$;

$h = 0,12\,D$;

$r = 0,075\,D$.

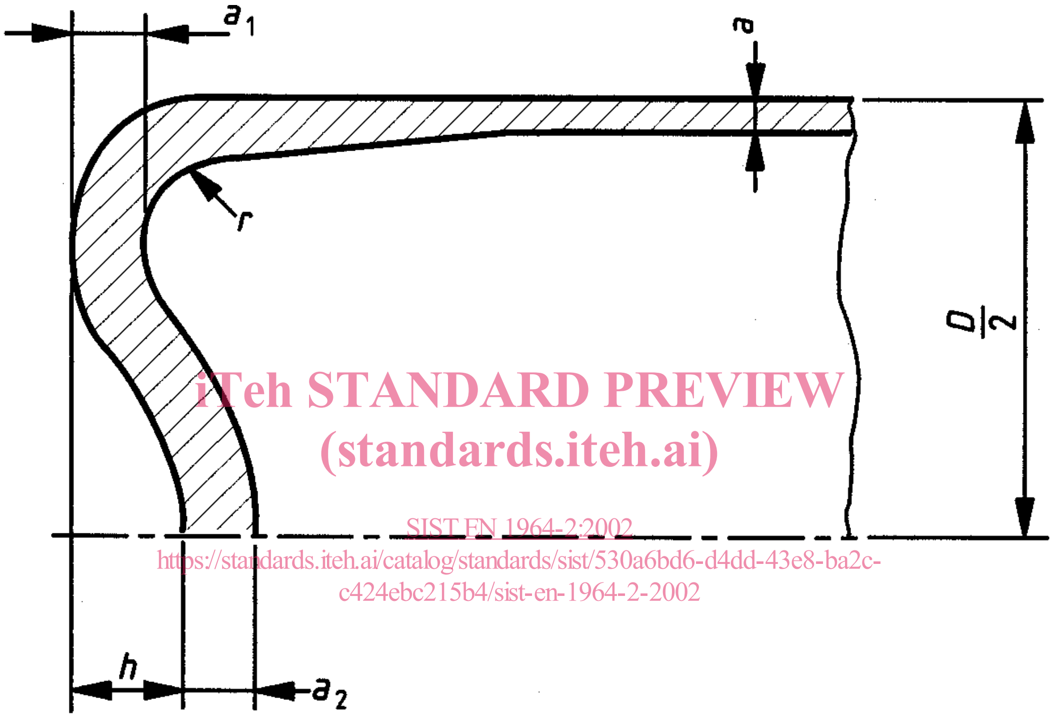


Figure 2 — Concave base ends

In order to obtain a satisfactory stress distribution, the thickness of the cylinder shall increase progressively in the transition area region between the cylindrical part and the base, and the wall shall be free from defects.

The cylinder manufacturer shall prove by the pressure cycling prototype test as required in A.1 that the design is satisfactory.

5.6 Neck design

5.6.1 The external diameter and thickness of the formed neck end of the cylinder shall be adequate for the torque applied in fitting the valve to the cylinder. The torque may vary according to the diameter of thread, the form of thread, and the sealant used in the fitting of the valve.

NOTE For recommended valving torques see EN ISO 13341.

5.6.2 The thickness of the wall in the cylinder neck shall be sufficient to prevent permanent expansion of the neck during initial and subsequent fitting of the valve into the cylinder. Where the cylinder is specifically designed to