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**Safety and performance criteria for
seamless gas cylinders**

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*Critères de performance et de sécurité pour les bouteilles à gaz sans
soudures*

[ISO/TR 13763:1994](#)

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Contents

	Page
1 Scope.....	1
2 Safety and performance criteria	1
3 Definitions and symbols	2
4 Materials of construction	4
5 Design.....	5
6 Inspection and testing.....	6

Annexes

A Material tests.....	15
B Mechanical tests	23
C Pressure tests.....	27
D Design and manufacturing tests	32
E Product tests.....	37
F Bibliography.....	39

Tables

1 Summary of prototype, periodic prototype batch and individual cylinder tests.	7
2 Details of material and cylinder tests	10

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 ISO/TR 13763:1994

Figures

1 "F" factors for quenched and tempered steels	6
A.1 Location of samples.....	16
A.2 Orientation of specimens.....	17
A.3 Location of sample from cylinders made from steel tube	17
A.4 Location of test rings	18
A.5 Application of stress	18
A.6 Correction factor Z	19
B.1 Location of test piece.....	25

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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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 13763, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 3, *Cylinder design*.

Introduction

Current International Standards for the design, inspection and testing of gas cylinders are based on good contemporary practice and experience in several ISO member countries. Revisions to these standards should take into account developments in gas cylinder technology so that cylinders may employ different metallic materials, design criteria and methods of test appropriate to the higher stresses and the environmental conditions they may encounter in service.

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Safety and performance criteria for seamless gas cylinders

1 Scope

This document offers guidance towards the preparation of future gas cylinder standards, revisions to existing gas cylinder standards, and identifies aspects of design criteria and tests which are recognized as providing information relevant to the safety and performance in service of seamless gas cylinders of water capacities between 0,5 l and 150 l. These principles shall also be applied, where possible, to cylinders with water capacities outside of the limits stated.

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Where applicable guidance is given on recommended procedures and limiting requirements.

2 Safety and performance criteria

During their life, cylinders can be subjected to rough handling, varying temperatures and corrosive environments.

Under these circumstances it is important to make available products which are able to withstand the most arduous service conditions envisaged.

It is essential that the gas cylinder will:

- a) withstand severe impact;
- b) in the event of accidental rupture, fail in a ductile manner;
- c) withstand successive pressurizations and depressurizations;
- d) withstand the extremes of normal environmental conditions;
- e) withstand pressure up to the test pressure;

- f) remain gas-tight;
- g) be compatible with the gas it contains.

Tables 1 and 2 list factors which ensure compliance with the above criteria, tests for each factor, and acceptable quantitative values where applicable.

3 Definitions and symbols

The following definitions and symbols apply to this specification:

3.1 application safety factor: The ratio of the test pressure to the maximum developed pressure.

3.2 burst safety factor: The ratio of the minimum bursting pressure to the test pressure.

3.3 total safety factor: The product of the application safety factor and the burst safety factor (i.e. the ratio of the minimum bursting pressure to the maximum developed pressure).

3.4 yield factor (design safety factor): The ratio of the pressure at the onset of plastic deformation to the test pressure.

3.5 design stress factor (F) (variable): The ratio of equivalent wall stress at test pressure to guaranteed minimum yield stress R_e .

$$\text{Where generally } F = \frac{0,65}{Re/Rg}$$

$$\begin{aligned} \text{Except that } F &\leq 0,85 \\ Re/Rg &\leq 0,90 \end{aligned}$$

and the burst ratio $P_b/P_h \geq 1,6$ shall be satisfied by test.

3.6 yield strength: The resistance of a material to plastic deformation.

3.7 tensile strength: The resistance of a material to rupture.

3.8 hardness: Resistance to indentation.

3.9 hardenability: The ability of a material to harden throughout its mass.

3.10 toughness: The ability of a material to resist crack propagation.

- 3.11 ductility:** The ability of the material to deform in a plastic manner.
- 3.12 ductile fracture:** Fracture with apparent plastic deformation.
- 3.13 brittle fracture:** Fracture without apparent plastic deformation.
- 3.14 resistance to impact:** The ability to withstand impact without rupture.
- 3.15 impact transition temperature:** The temperature at which the fracture mode changes from ductile to brittle.
- 3.16 permanent gas:** A gas whose critical temperature is lower than $-10\text{ }^{\circ}\text{C}$.
- 3.17 liquefiable gas:** A gas whose critical temperature is above $-10\text{ }^{\circ}\text{C}$.
- 3.18 fatigue failure:** Failure caused by cyclic stressing.
- 3.19 new design:** A cylinder is considered to be of a new design compared with an existing approved design when:

- a) it is manufactured in a different factory;
- b) it is manufactured by a different process;
- c) it is manufactured from a material of different nominal chemical composition;
- d) it is given a different heat treatment;
- e) the base profile and base thickness have changed relative to the cylinder diameter and calculated minimum wall thickness;
- f) the guaranteed minimum yield stress has changed by more than 50 N/mm^2 ;
- g) the length of the cylinder has increased by more than 50 %;
- NOTE - Cylinders with an L/D ratio less than 3 shall not be used as reference cylinders for any new design with an L/D ratio greater than 3.
- h) the diameter has changed by more than 5 %;
- j) an increase in hydraulic test pressure requires a change in design wall thickness.

NOTE - Where a cylinder is to be used at a lower pressure duty than that for which design approval has been given, it shall not be deemed to be of a new design.

3.20 Symbols

a	Calculated minimum thickness, in millimetres, of the cylindrical shell.
A	Percentage elongation.
b	Calculated minimum thickness, in millimetres, of the dished end.
C	Shape factor.
D	Outside diameter of the cylinder, in millimetres.
F	Design stress factor (variable) see 3.5.
h	Height, in millimetres, of the cylindrical part of the dished end.
H	Outside height, in millimetres, of the domed part of the dished end.
J	Stress reduction factor.
L	Length, in millimetres, of the cylinder.
L_0	Original gauge length, in millimetres, according to ISO 6892.
n	Ratio of diameter of bend test former to the thickness of the test piece.
P_b	Maximum pressure, in bars, attained during the burst test.
P_c	Charged pressure at 15 °C, in bar.
P_d	Maximum developed pressure in service at reference pressure, in bar.
P_h	Test pressure in bars, above atmospheric pressure.
r	Inside knuckle radius, in millimetres, of the dished end.
R	Inside dishing radius, in millimetres, of the dished end.
R_e	Minimum value of yield stress (apparent), in newtons per square millimetre, guaranteed by the cylinder manufacturer for the finished cylinder.

NOTE - The term yield stress means the upper yield stress R_{eH} , or (for materials that do not exhibit a defined yield) the 0,2 % proof stress (non-proportioned elongation) $R_{p0,2}$.

R_g	Minimum value of tensile strength, in newtons per square millimetre, guaranteed by the cylinder manufacturer for the finished cylinder.
R_m	Actual value of tensile strength, in newtons per square millimetre, determined by the tensile test.
S_0	Original cross-sectional area, in square millimetres, of tensile test piece according to ISO 6892.

4 Materials of construction

Materials used for the construction of gas cylinders shall be manufactured by processes that guarantee acceptable material cleanliness. They shall be suitable for manufacture into cylinders by the chosen process and provide the properties required, where necessary by heat treatment, to prevent failure in service. The materials shall not degrade by natural ageing.

5 Design

5.1 Design parameters

Design stress is the equivalent wall stress at test pressure (P_h). Design stress is rated as a fraction of guaranteed minimum yield (or 0,2 % proof) stress of the material of construction. ISO cylinder design and construction specifications shall use a design stress equal to a design stress factor F x guaranteed minimum yield stress R_e of the material of construction. Values for F are given in figure 1 for a range of materials.

5.2 Developed pressure in service

The maximum developed pressure in service shall be the pressure developed in the cylinder at the National reference temperature. Cylinders intended for worldwide usage shall be designed using a reference temperature of 65 °C at which the maximum developed pressure in service shall not exceed the test pressure.

NOTE - The reference temperature adopted nationally shall be determined by the National Authority.

5.3 Test pressure

The test pressure is used to calculate the minimum cylinder wall thickness and to prove the cylinder. For calculation purposes it shall be 1,5 x the settled filling pressure at 15 °C for permanent gases.

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5.4 Burst pressure

The burst pressure is the pressure at which the cylinder fails under pressure.

It shall be not less than the calculated value $P_b \geq 1,6 P_h$.

5.5 Design formula

The cylinder wall thickness design formula shall be:

$$a = \frac{D}{2} \left(1 - \frac{\sqrt{10 F R_e - \sqrt{3} P_h}}{10 F R_e} \right)$$

except that the wall thickness shall also satisfy the formula

$$a > \frac{D}{250} + 1 \text{ mm for steel cylinders,}$$

or

$$a > \frac{D}{100} + 1 \text{ mm for aluminium cylinders}$$

with an absolute minimum of $a = 1,5 \text{ mm}$.

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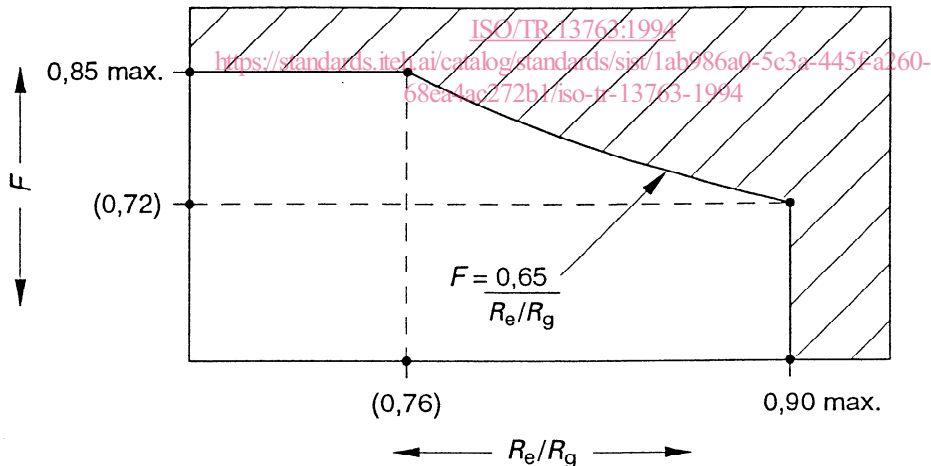


Figure 1 - "F" factors for quenched and tempered steels

6 Inspection and testing

The number, type and frequency of tests are intended to show that the cylinder is free from harmful defects that may cause failure, and to ensure consistency and conformity to its design.

Tables 1 and 2 detail the tests and the annexes provide information on the procedures to be undertaken with some of the lesser known tests.

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Table 1 - Summary of prototype, periodic prototype batch and individual cylinder tests

Stage of tests	Nature of tests	ISO/TR 13763:1994	Type "Super H and 'N'" cylinders	Type "M" cylinders	Type "S" and "N" cylinders	Aluminium 6351 cylinders	Table 2 refs.	
Prototype - initial test on new design	Design approval	https://standards.iteh.ai/catalog/standards/sist/13763-1994/iso-tr-13763-1994	Check that design calculations and drawings are in accordance with the design specifications and appropriate regulations.				3	
	Material	Chemical analysis	Check cast (heat) analysis with Mill's certificate and product analysis for deviation.				1	
	Finished cylinder material	Micro/macro		Carry out metallurgical examination with considering conditions of heat treatment.			Check given size of billet.	1
		Corrosion		Confirm compatibility with cylinder corrosive content			-	8
		Tensile		Check yield stress, tensile strength, elongation and if required reduction of area.			Check hardness.	5 and 6
		Impact		Check impact values in longitudinal and transverse directions as practicable.			-	7
		Impact transition		Check new material and/or heat treatment to establish whether the transition point meets the requirements			-	7
	Cylinder	Bend/flattening		Check ductility and confirm defect-free.			-	6
		Design check		Check physical dimension, such as wall thickness, base thickness, end form, threads, diameter and circularity, length and straightness etc.				3
		Defects inspection		Check surface defects, such as cracks, folds, laminations, seams, gouges, bulges, etc., by visual inspection or other suitable means.				2
Heat treatment			Verify and record heat treatment temperature(s) and quenching conditions.			Check temperature and duration of heat treatment	1	
Hardness			Check hardness and its distribution on the cylinder.				5	
	Hydraulic volumetric expansion		Carry out hydraulic volumetric expansion test and check the total expansion and permanent expansion. This may be carried out at the same time as the burst test.				5	
	Hydraulic burst		Check yield and burst pressures, nature of fracture and if necessary, shape of fracture. The volumetric expansion characteristics may also be measured during this test.				5	

Table 1 - Summary of prototype, periodic prototype batch and individual cylinder tests (continued)

Stage of tests	Nature of tests	Type "Super H" and "H" cylinders	Type "M" cylinders	Type "S" and "N" cylinders	Aluminium 6351 cylinders	Table 2 refs.	
Periodic prototype	Hydraulic proof pressure	As an alternative to the hydraulic proof pressure test the hydraulic proof pressure test may be carried out.		Type "S" and "N" cylinders		5	
		Pressure cycle fatigue	Confirm that the cylinder can withstand the specified number of cycles of pressurization.			9	
	Special	Stress corrosion	Confirm compatibility with environmental conditions.	Not required to carry out	Carry out stress corrosion test.		
Batch	Bonfire	ISO/TR 13763-1	Carry out only when required. (It is better to carry out when unapproved safety devices are fitted).			8	
		Hydro-pneumatic dards	Check nature of test results. 260-6824ac272b1/iso-tr-13763-1994			7	
	Ballistic		Carry out only at request.	Not required to carry out.	Carry out if requested	8	
		Fracture toughness	Required for cylinders made from new materials and/or heat treatment	Not required to carry out	Charpy impact at ambient if requested	7	
	Cylinder	Pressure cycle fatigue	Carry out at specified times during protection		-	9	
		Material	Chemical analysis	Check deviation between cast (heat) and product analysis if required.		1	
	Batch size	Batch size	200 + 2 test cylinders	200 + 2 test cylinders except when cylinders are heat treated in a continuous furnace and following production of 20 000 cylinders, and subject to the inspection authority being satisfied with quality control procedures, the batch may be increased to 500 + 2 cylinders.			-
			Tensile	Carry out on one cylinder from each batch to determine yield stress, tensile strength, elongation and if required reduction of area.	Each heat test batch	5 and 6	
		Impact	Carry out on one cylinder from each batch at a temperature of -50 °C.		7		
		Bend/flattening	Carry out either a bend or flattening test on one cylinder from each batch.		6		
End thickness		Sample checks on cut sections from each end of a test container.		3			

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Table 1 – Summary of prototype, batch and individual cylinder tests (concluded)

Stage of tests	https://standards.iteh.ai/catalog/standards/siv/1ab786a0-5c3a-4458fa266-68ea4ac272b1/iso-tr-13763-1994 Type "Super H" and "H" cylinders		Type "M" cylinders	Type "S" and "N" cylinders	Aluminium 6351 cylinders	Table 2 refs.	
Cylinder	Heat treatment	Verify heat treatment records on each batch.					1
	Burst	Carry out on one cylinder from each batch.					
	Shape	Sample check on formed shape.					
Individual cylinder	Dimension etc.	Check of cylindrical wall by ultrasonic, radiation or mechanical means.				Sample checks shall be made on the ends	3
	Threads	Full check by calibrated gauge					3
	Dimensional	Check on diameter, circularity, straightness, permanent markings, etc.					3
Defects	Surface and internal defects	Full check by visual inspection and other suitable means.					2
Hardness measurement		Full check by suitable means	Sample check only when controlled continuous heat treatment is employed				5
Hydraulic		When a hardness check has been carried out on each cylinder then each cylinder shall be subjected to a hydraulic proof pressure test. When a hardness check has not been carried out on each cylinder then each cylinder shall be subjected to a hydraulic volumetric expansion test.					5
Leakage		The manufacturer shall apply such tests as will demonstrate to the satisfaction of the inspecting authority that the cylinders do not leak					