
**Gas cylinders — Classification of
imperfections arising during the
manufacture of seamless steel and
aluminium alloy gas cylinders**

*Bouteilles à gaz — Classification des imperfections de fabrication des
bouteilles à gaz en acier et en alliage d'aluminium sans soudures*

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Published in Switzerland

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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*.

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Introduction

Based on a resolution taken by ISO/TC 58/SC 3 at its 54th meeting in Sydney, a particular working group, WG 34, was created with the following tasks:

- a) consider the issue of the manufacturing defects and imperfections at the time of manufacture in International Standards for seamless steel and aluminium alloy cylinders;
- b) develop requirements that are verifiable, measurable, and practicable;
- c) put forward proposals for how to include such requirements in SC 3 International Standards, no later than the next revision of the International Standards, e.g. as an annex in the design standards or within the main body of the text.

SC 3 asked that WG 34 take the current defect annexes of ISO 9809-1, ISO 9809-2, and ISO 9809-3 for seamless steel and ISO 7866 for seamless aluminium alloy cylinders as a starting point.

In order to address the SC 3 resolution, it was further decided to create this Technical Report.

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Gas cylinders — Classification of imperfections arising during the manufacture of seamless steel and aluminium alloy gas cylinders

1 Scope

This Technical Report specifies the procedure on how to evaluate and treat the most commonly found manufacturing imperfections on seamless steel and aluminium alloy gas cylinders at visual inspection at the stage of product acceptance.

[Annex A](#) contains a template for the relevant cylinder design International Standards (i.e. ISO 9809-1, ISO 9809-2, and ISO 9809-3 for seamless steel and ISO 7866 for seamless aluminium alloy cylinders). It further contains information on how to implement the provisions into other cylinder design standards.

2 Explanatory introduction and provisions for the implementation into the cylinder design standards

It is intended that the provisions laid out in this Technical Report should be followed by ISO/TC 58/SC 3 working groups dealing with the design standards for seamless steel (ISO 9809-1, ISO 9809-2, and ISO 9809-3) and aluminium alloy gas cylinders (ISO 7866) at the next revision of these International Standards.

The tables in [Annex A](#) are based on the current "Defect Annexes" of ISO 9809-1, ISO 9809-2, and ISO 9809-3 for seamless steel cylinders and ISO 7866 for seamless aluminium alloy cylinders. Those imperfections applicable for the ISO 9809 series are contained in [Tables A.1](#) and [A.2](#), and those applicable for ISO 7866 are contained in [Tables A.3](#) and [A.4](#).

They are written in such a way that they can also be incorporated in other design standards as a normative annex.

The provisions of this Technical Report should also serve as a basis for a future annex to each of the other relevant design standards (other than ISO 9809-1, ISO 9809-2, ISO 9809-3, and ISO 7866) for seamless cylinders and tubes.

If incorporated in other design standards the content of the columns "Type of imperfection", "Description", and "Note" in [Tables A.1](#), [A.2](#), [A.3](#), and [A.4](#) (which were established by WG 34) should remain unchanged.

The tables should be reviewed by the other relevant ISO/TC 58/SC 3 working groups, in particular, the column "Decision at the time of inspections and follow-up actions" and the three imperfection levels. Where necessary, these conditions can be adapted to reflect the conditions appropriate to their product.

If the individual working groups intend to adopt other typical manufacturing imperfections specific to their product, they can do so, provided the structure of the tables and the remaining provisions are followed.

Annex A (normative)

Description and evaluation of manufacturing imperfections of seamless gas cylinders

A.1 Introduction

Several types of imperfections can occur during the manufacture of seamless gas cylinders.

Such imperfections can be due to material defects, the manufacturing process, handling, and other circumstances during the manufacturing process.

The aim of this Annex is to identify the manufacturing imperfections most commonly found on finished cylinders and to provide requirements for the visual inspection at the stage of product acceptance.

NOTE 1 This Annex does not address customer specifications, e.g. cylinder aesthetics, special surface preparations, etc.

NOTE 2 Cylinder sampling method(s) and the quantity sampled for inspection, after cylinders with imperfections have been found, are not covered by this Annex and are prescribed in the main body of the design standard.

NOTE 3 Manufacturing imperfections can be identified and evaluated at any stage of the manufacturing process.

A.2 General

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A.2.1 The visual inspection shall be conducted in good lighting on a product that is clean, dry, and suitable enough for proper inspection of all surfaces. The visual inspection shall be conducted by eye, and internal inspections can be augmented by a scope, dental mirror, or other suitable device. Where magnification is used, the final assessment of the imperfection shall be evaluated as if no magnification had been used.

In thicker parts of the cylinder, the acceptable absolute value of the size of the imperfection can be proportionately increased to the thickness, provided that it does not adversely affect the safe performance or integrity of the cylinder.

Where needed, the severity of a detected imperfection can be further evaluated by the use of other devices or methods.

NOTE If unclear, the cylinder surfaces should be re-cleaned before submitting the cylinder for inspection.

A.2.2 If appropriate, small imperfections, as permitted by [Tables A.1](#) and [A.3](#), can be removed by local dressing, grinding, machining, or other suitable methods. Great care shall be taken to avoid introducing new defects or imperfections.

After such a repair, the cylinders shall be re-examined, and if the wall thickness is reduced, it shall be rechecked and be at least at minimum guaranteed wall thickness.

A.3 Manufacturing imperfections and the procedure for their evaluation

The most commonly found safety- and performance-related manufacturing imperfections and their descriptions are listed in [Table A.1](#) for seamless steel cylinders and [Table A.3](#) for seamless aluminium

alloy cylinders. In addition, the manufacturing imperfections and their descriptions for features which are not safety- or performance-related (cosmetic) are listed in [Tables A.2](#) and [A.4](#).

Limits for the repair or rejection of cylinders manufactured to this Technical Report are included in [Tables A.1](#) and [A.3](#).

The acceptance or rejection conditions for gas cylinders are categorized into three levels, in accordance with [A.4](#).

The process that shall be followed at the final visual inspection is given in [Figure A.1](#).

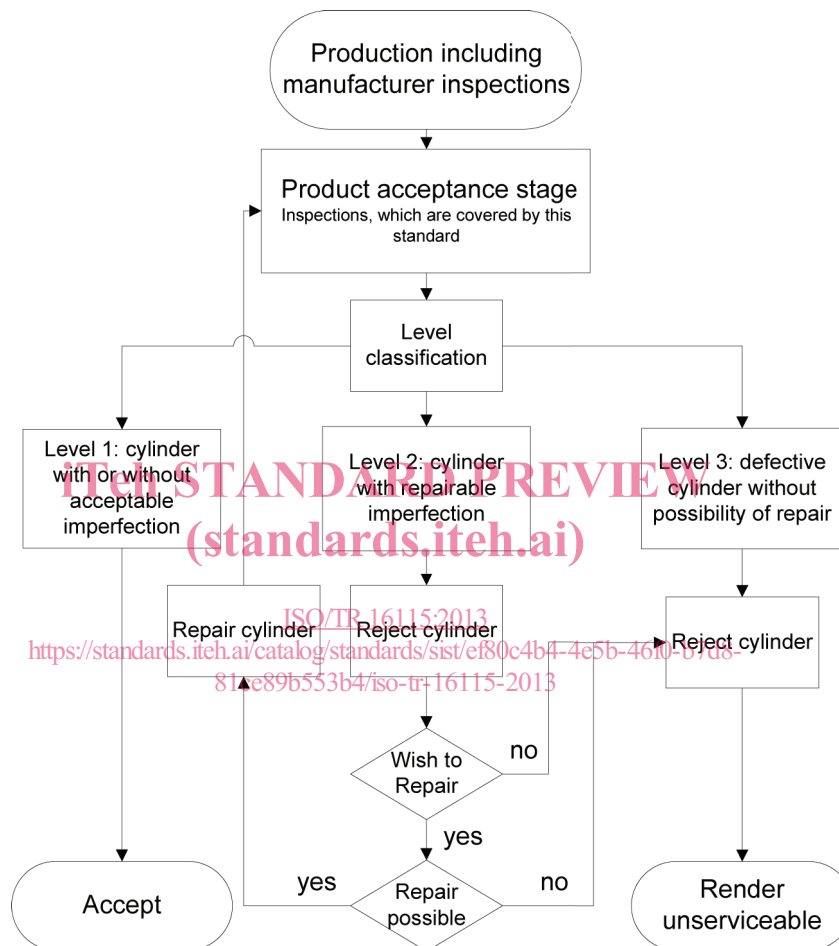


Figure A.1 — Flow-diagram for the final visual inspection of gas cylinders at the time of product acceptance

A.4 Acceptance and rejection conditions

The following categorize the levels of imperfections and provide instructions depending on the severity of the imperfection and regarding the disposition of the cylinders.

Level 1 imperfection

Conforming condition of a cylinder that has no adverse effects on the safe performance or integrity of the cylinder. Cylinders with Level 1 imperfections are acceptable and do not require repair.

Level 2 imperfection

Non-conforming condition of a cylinder with features more severe than Level 1 imperfections. Cylinders with Level 2 imperfections shall be rejected. If it is decided that a rejected cylinder with Level 2

imperfections is to be repaired, it shall be repaired in accordance with [A.2.2](#) and be re-inspected. Otherwise, the cylinders are to be treated as cylinders with Level 3 imperfections.

Level 3 imperfection

Non-conforming condition of a cylinder with features more severe than Level 2 imperfections. Cylinders with Level 3 imperfections shall be rejected. Rejected cylinders with Level 3 imperfections shall not be repaired and shall be rendered unserviceable.

The cylinders presented to the inspector for inspection at the time of product acceptance should have been found acceptable and should be free of imperfections to Levels 2 and 3 by the manufacturer.

A.5 Definitions

A.5.1 repair

action to return a rejected cylinder to a Level 1 condition

A.5.2 reject

cylinder that has been set aside (Level 2 or Level 3) and not allowed to go into service

A.5.3 rendered unserviceable

cylinder that has been treated in such a way as to render it impossible for use

NOTE Examples for acceptable methods to render cylinders unserviceable can be found in ISO 6406. Any actions on cylinders rendered unserviceable are outside the scope of this Technical Report.

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Table A.1 — Safety- and performance-related manufacturing imperfections and their evaluation for seamless steel cylinders

Pos	Type of imperfection	Description	Decision at the time of inspections and follow-up actions			Note
			Level 1 imperfection Acceptable	Level 2 imperfection Reject and repair if possible (for repairs, see A.2.2)	Level 3 imperfection Reject and render unserviceable	
1 S	Bulge	A visible swelling of the wall (see Figure A.2).			All cylinders with such imperfection.	The cause of such failure shall be identified.
2 S	Dent (Flat)	A visible depression in the wall that has neither penetrated nor removed metal and is greater in depth than 0,5 % of the external-cylinder diameter (see Figure A.3). (See also excessive grinding or machining.)	When the depth of the dent is less than 1 % of the external-cylinder diameter and when the diameter ¹⁾ of the dent is greater than 30 times its depth.		When the depth of the dent exceeds 1 % of the external-cylinder diameter or when the diameter ¹⁾ of the dent is less than 30 × its depth.	In all cases, the wall thickness shall be verified at the imperfection area and shall not be less than the guaranteed minimum wall thickness. 1) If the dent is not circular, the largest dimension shall be taken as diameter.
3 S	Dent containing cut or gouge	A depression in the wall (see item 2 S) which contains a cut or gouge (See item 4 S). (See Figure A.4.)			All cylinders with such imperfections.	
4 S	Cut, gouge, groove, metallic, or scale impression	An impression in the wall where metal has been removed, displaced, or redistributed with a depth of greater than 3 % of the guaranteed minimum wall thickness (see Figure A.5).	When the depth does not exceed 5 % of the guaranteed minimum wall thickness and there are no sharp notches longer than 10 times the guaranteed minimum wall thickness.	External surface imperfection in excess of Level 1. They can be dressed provided that the remaining wall thickness below defect is greater than the guaranteed minimum wall thickness.	Internal surface imperfection in excess of Level 1. External surface imperfection in excess of Level 1 which has not been repaired or cannot be repaired.	
5 S	Excessive grinding or machining	A local reduction of wall thickness by grinding or machining or other mechanical metal removal process.			When the wall thickness is reduced to below the guaranteed minimum wall thickness.	When it results in the formation of a dent or grinding mark, treat it as “dent” (item 2 S) or “cut” (item 3 S).