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**Diesel engines — Steel tubes for high-  
pressure fuel injection pipes —**

Part 1:

**Requirements for seamless cold-drawn  
single-wall tubes**

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*Moteurs diesels — Tubes en acier pour lignes d'injection de  
combustible à haute pression —*

*Partie 1: Exigences pour les tubes monopari sans soudure étirés  
à froid*

ISO 8535-1:2006

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 8535-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 7, *Injection equipment and filters for use on road vehicles*.

This fourth edition cancels and replaces the third edition (ISO 8535-1:1996), which has been technically revised.

ISO 8535 consists of the following parts, under the general title *Diesel engines — Steel tubes for high-pressure fuel injection pipes*:

— *Part 1: Requirements for seamless cold-drawn single-wall tubes*

— *Part 2: Requirements for composite tubes*

NOTE The first part of the general title “*Diesel engines*” is used for Part 1 only; for Part 2 “*Compression-ignition engines*” is still used but will be replaced at the next revision.

Annex A is for information only.

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# Diesel engines — Steel tubes for high-pressure fuel injection pipes —

## Part 1: Requirements for seamless cold-drawn single-wall tubes

### 1 Scope

This part of ISO 8535 specifies dimensions and requirements for seamless cold-drawn single-wall steel tubes for high-pressure fuel injection pipes used on diesel (compression-ignition) engines (class 2) and for fuel injection pump testing (class 1).

It applies to diesel (compression-ignition) engines.

### 2 Normative references

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

- ISO 404, *Steel and steel products — General technical delivery requirements*  
<https://standards.iteh.ai/catalog/standards/sist/esa1802d-abaf-412a-bd9a-1ae80a9ed2a1/iso-8535-1-2006>
- ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*
- ISO 6892, *Metallic materials — Tensile testing at ambient temperature*
- ISO 12345, *Diesel engines — Cleanliness assessment of fuel injection equipment*

### 3 Dimensions and tolerances

#### 3.1 Diameters

Recommended inside and outside diameters are given in Table 1. Other sizes may be used by agreement between supplier and purchaser.

Tolerances on inside and outside diameters shall be as follows:<sup>1)</sup>

a) Inside diameter,  $d$ :

- $d \leq 4\text{mm}$ :  $\pm 0,05\text{ mm}$  for class 2;  
 $\pm 0,025\text{ mm}$  for class 1;
- $d > 4\text{mm}$ :  $\pm 0,10\text{ mm}$  for class 2.

NOTE Classes 1 and 2 are explained in Clause 1.

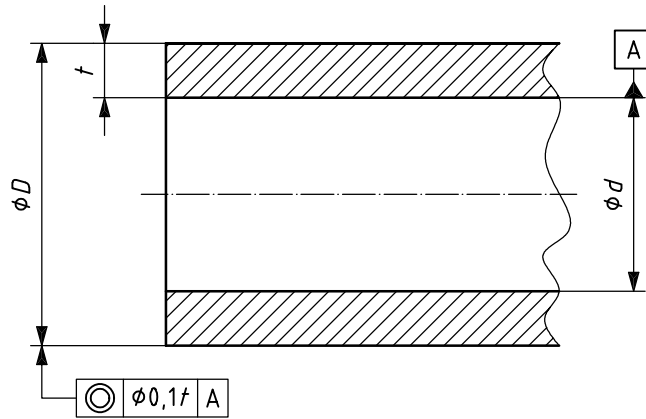
1) These tolerances are in accordance with ISO 4093.

b) Outside diameter,  $D$ , for classes 1 and 2:

$D < 8$  mm:  $\pm 0,06$  mm;

$D \geq 8$  mm:  $\pm 0,10$  mm.

c) Concentricity of the tube outside diameter relative to the inside diameter shall be proportional to the wall thickness, as shown in Figure 1.



**Key**

- $D$  outside diameter
- $d$  inside diameter
- $t$  wall thickness

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**Figure 1 — Concentricity of the tube outside diameter**

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**3.2 Length**

Length and tolerances on length shall be by agreement between supplier and purchaser.

Table 1 — Recommended inside and outside diameters

Dimensions in millimetres

Inside diameter <sup>a</sup> <i>d</i>		Outside diameter <i>D</i>											
		4	4,5	5	6	7	8	10	12	15	19	24	30
Preferred			4,5		6	7	8	10	12	15	19	24	30
1													
	1,12												
	1,25												
	1,4												
1,5													
	1,6												
1,7													
	1,8												
1,9													
	2												
2,12													
	2,24												
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	8												
8,5													
	9												
9,5													
	10												
10,6													
	11,2												
11,8													
	12,5												

Size combinations to be used appear between heavy lines

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NOTE The diameter sizes have been established with the ratio of outside to inside diameter within the range of 2 to 4.

<sup>a</sup> Based on ISO 3.

## 4 Material processing

### 4.1 Steel manufacturing process

The tubes shall be manufactured from unalloyed quality steel or an equivalent quality steel produced by a steel making process that ensures a very homogeneous structure.

If requested by the purchaser, the supplier shall state the method of manufacture and the deoxidation process used.

### 4.2 Manufacturing of tubes

The final reduction(s) of the tube shall be followed by heat treatment to achieve the specified mechanical properties.

### 4.3 Surface quality

#### 4.3.1 General

The outside and inside surfaces of finished tubes shall be free from scale, rust, grooves, laps, laminations, deep pits or other injurious defects.

#### 4.3.2 Minimum quality inside surface (bore grade S)

The inside of the tubes of bore grade S shall be finished to ensure a smooth bore of accurate size with no more than five imperfections (fissures, crevices, etc.) over 0,08 mm to 0,13 mm maximum deep, per tube cross-section, using  $\times 50$  magnification for examination (see Table 2).

#### 4.3.3 Higher quality inside surface (bore grades O, P, Q, R)

If closer control over the depth of imperfections is required, bore grades O, P, Q or R, assessed under the magnification indicated (see Table 2) may be specified in the tube designation (see Clause 6).

Table 2 — Bore grades

Code	Permitted imperfections	Magnification
S	As in 4.3.2	$\times 50$
R	A maximum of five imperfections over 0,05 mm to 0,08 mm maximum deep	$\times 100$
Q	A maximum of five imperfections over 0,02 mm to 0,05 mm maximum deep	$\times 100$
P	A maximum of five imperfections over 0,01 mm to 0,02 mm maximum deep	$\times 200$
O	All imperfections equal to or less than 0,01 mm deep	$\times 500$

### 4.4 Surface finish

The outside surface of the tube may be coated on delivery by metal plating or galvanizing, or may be submitted to a chemical surface treatment (see Table 3).

The inside surface of the tube shall remain uncoated.



Table 3 — Surface finish on delivery

Code	Outside surface condition	Application remarks
0	Not specified (at manufacturer's choice).	May have additional finish at manufacturer's choice.
1	Outside surface as-processed, without any additional finish. Tubes annealed or normalized in a controlled atmosphere may be discoloured, but shall be free from loose scale.	Condition preferred for further surface processing.
2	Zinc electroplated with a coating layer thickness of 8 $\mu\text{m}$ minimum and an additional colourless chromating <sup>a</sup> .	When minimum corrosion-resistance is required. Not recommended for use with light alcohol-based fuels such as methanol.
3	Zinc electroplated with a coating layer thickness of 8 $\mu\text{m}$ minimum and an additional yellow chromating <sup>a</sup> .	
(4,5,6,7,8)	(Reserved for further application).	
9	As specified subject to agreement.	

<sup>a</sup> Chromating as described in ISO 2080 and ISO 4520.

#### 4.5 Minimum mechanical properties of tubes

The tubes shall comply with one of the classes of mechanical properties (codes 1 to 3) as listed in Table 4.

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Table 4 — Mechanical properties

Code	Minimum tensile strength $R_m$ N/mm <sup>2</sup>	Minimum upper yield stress $R_{eH}$ N/mm <sup>2</sup>	Minimum elongation $A_5$ %	Maximum hardness $HV$
1	310	205	30	115
2	360	220	23	150
3	490	355	22	194

NOTE The mechanical properties apply when the tube is tested in accordance with ISO 6507-1 and ISO 6892.

#### 4.6 Cleanliness

The bore shall be clean and free from any contamination or coating which would impair the processing and serviceability of the tubes. When specifying a cleanliness requirement for the inside of the tubes, ISO 12345 shall be used.

#### 4.7 Straightness

Unless otherwise agreed between supplier and purchaser, the tubes shall be straight within a maximum error of 1 in 400 with no localized deformation.

#### 4.8 Corrosion-resistance

The outside and inside surfaces shall be protected against corrosion for transportation and storage in closed areas. A permanent coating may be used on the outside surface when agreed between supplier and purchaser. Any temporary coating used shall not be injurious to the injection and combustion systems of engine and shall be removable with diesel fuel.