INTERNATIONAL STANDARD

ISO 8535-1

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

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

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

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

Reference number
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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 fifth edition cancels and replaces the fourth edition (ISO 8535-1:2006), 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.

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*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room 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 customer.

Tolerances on inside and outside diameters shall be as follows:

a) Inside diameter, d

$d \leq 4$ mm: $\pm$ 0,05 mm for class 2
$\pm$ 0,025 mm for class 1[1)]

$d > 4$ mm: $\pm$ 0,10 mm.

NOTE Classes 1 and 2 are explained in Clause 1.

1) These tolerances are in accordance with ISO 4093.

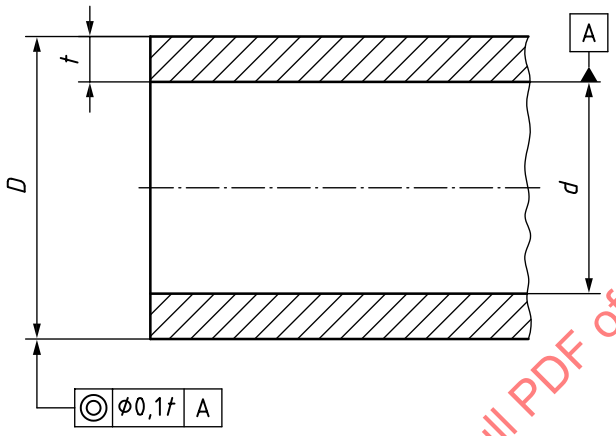
b) Outside diameter, D

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

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

for classes 1 and 2.

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



Concentricity of the tube outside diameter

3.2 Length

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

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 customer, 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.

Recommended inside and outside diameters (in millimetres)

Inside diameter [a] (d)		Outside diameter (D)													
		4		5											
	Preferred		4,5		6	6,35	7	8	9	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				Size combinations to be used appear in shaded cells											
	2,24														
2,36															
	2,5														
2,65															
	2,8														
	3														
	3,15														
3,35															
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4,25															
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	7,1														
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	8														
8,5															
	9														
9,5															
	10														
10,6															
	11,2														
11,8															
	12,5														

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

[a] Based on ISO 3.

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 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 × 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).

Bore grades

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

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 µm minimum and an additional colourless chromating [a].	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 µm minimum and an additional yellow chromating [a].	
(4, 5, 6, 7, 8)	(Reserved for further application.)	—
9	As specified subject to agreement.	—

[a] 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 4) as listed in Table 4.

Mechanical properties

Code	Minimum tensile strength R_m N/mm^2	Minimum proof strength $R_{p0,2}$ N/mm^2	Minimum elongation A_5 %	Maximum hardness HV
1	310	205	30	115
2	360	220	23	150
3	490	355	22	194
4	600	430	15	280
NOTE The mechanical properties apply when the tube is tested in accordance with ISO 6507-1 and ISO 6892-1.				

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 customer, 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 customer. Any temporary coating used shall not be injurious to the injection and combustion systems of the engine and shall be removable with diesel fuel.

5 Testing

5.1 General

Unless otherwise agreed between supplier and customer, tests shall be carried out in accordance with 5.2 to 5.8.

5.2 Scope of tests

Tubes shall be tested by lots of the same dimensions, steel type, heat treatment and surface finish. Tubes from each heat of steel shall be tested irrespective of lot.

For the test in 5.4, a test inspector shall select one tube from each lot, and for the test in 5.6 three tubes. The tests in 5.3, 5.7.1 and 5.8 shall be performed on all selected tubes.

For the test in 5.7.3, the lot size, the number of samples and the acceptance limit shall be agreed upon between supplier and customer.

5.3 Dimension tests

The tube dimensions shall comply with the dimensions and tolerances indicated in Clause 3.

5.4 Mechanical-property tests

The tubes shall comply with the specifications given in Table 4. The tests shall be made in accordance with ISO 6507-1 and ISO 6892-1. Tensile strength, proof strength, elongation and hardness shall be measured.

5.5 Bending test

The tube shall withstand cold bending through 180° over a rod of the same diameter as the tube outside diameter, without showing other than outside superficial cracks.

5.6 Cold upsetting of tubes

This test shall be carried out on tubes of outside diameter 15 mm and below.

A length of tube twice the outside diameter ($2D$) shall be capable of being compressed to a length D without showing cracks of depths exceeding 0,13 mm.

The test shall be made between two plane and parallel plates in a suitable fixture.

5.7 Surface quality test

5.7.1 A visual check shall be made to ensure that tubes satisfy the requirements in 4.3.1.

5.7.2 If mutually agreed between supplier and customer, the visual inspection may be replaced by a non-destructive test procedure.

5.7.3 If proof of a specified defect depth in the bore is required, an inspection by attributes, with an agreed AQL (acceptable quality level) shall be set when ordering; the test shall be made on metallographic cross-sections of the tube with the minimum magnification specified in Table 2.

5.7.4 Surface coatings on tubes with plated or otherwise treated surfaces shall satisfy tests on these coatings when required. Such tests shall be agreed between supplier and customer.

5.8 Inside pressure test

Tubes shall be capable of withstanding appropriate inside pressure, which shall be agreed between supplier and customer (see Annex A), without permanent internal deformation or burst. This ability shall be confirmed by a hydraulic test. Other, non-destructive, tests, such as electronic testing, may be used if agreed between supplier and customer.

5.9 Retesting

If, after testing in accordance with 5.4, the selected tube fails, two other tubes shall be taken from the same lot to repeat the test. The same procedure shall apply to the test in 5.6. Each of the tubes taken shall meet the test requirements. If any tube fails to meet the test requirements, the whole lot is considered as rejected.

The supplier may submit a rejected lot for acceptance again in an improved condition, e.g. by repeating the heat treatment.

If, in this case, the test results of 5.4 and 5.6 do not fulfil the requirements, the whole lot shall be rejected.

5.10 Test certificate

A test certificate, if required [see 6 i)], shall be issued for each shipment, confirming that the tubes supplied meet the specifications of this part of ISO 8535. For proof, the records of the continuous production inspections concerning the following tests may be used:

a) dimensions in accordance with 5.3;

b) mechanical properties in accordance with 5.4;

c) bending test in accordance with 5.5;

d) cold upsetting in accordance with 5.6;

e) visual inspection in accordance with 5.7.1;

f) metallographic test in accordance with 5.7.3;

g) inside pressure test in accordance with 5.8.

Other test certificates may be agreed upon between supplier and customer.

6 Designation

A steel tube that meets the requirements of this part of ISO 8535 shall be designated as follows, in the order given:

a) the word “Tube”;

b) a reference to this part of ISO 8535;

c) tube type: a seamless cold-drawn single-wall steel tube is indicated by the letter “S”;

d) size: the second and third characters identify the nominal inside and outside diameters, respectively, of the tube, in millimetres;

e) class: the fourth character determines the bore tolerance [see 3.1 a)];

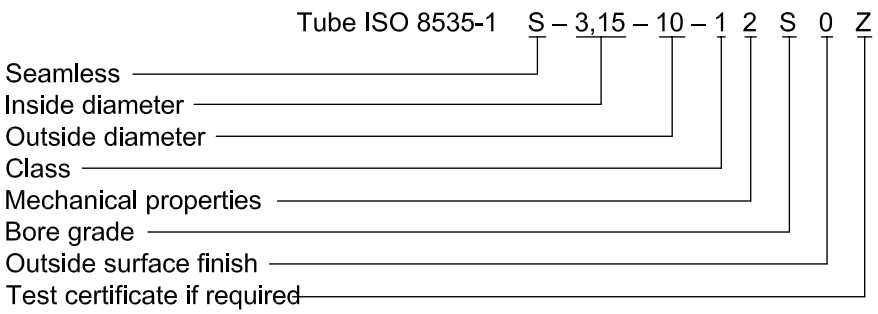
f) the fifth character identifies the mechanical properties of the tube in accordance with Table 4;

g) the sixth character identifies the bore grade of the tube in accordance with Table 2;

h) the seventh character identifies the treatment of the outside surface of the tube (see Table 3);

i) at the end the of the designation, the letter “Z” may be added to indicate that a certificate from the tube manufacturer is required for confirmation of compliance with this part of ISO 8535 and additional delivery requirements, if any (see ISO 404).

EXAMPLE A tube conforming to this part of ISO 8535 shall be designated as shown:



7 Identification and marking

Tubes shall be identified by use of labels with the designation in accordance with Clause 6. Additional marking is permissible if agreed between supplier and customer.

8 Packing

Unless otherwise agreed upon between supplier and customer, the tubes shall be delivered in secure bundles, with tubes sealed at both ends.