INTERNATIONAL STANDARD

ISO 8535-2

Second edition
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Compression-ignition engines — Steel tubes for high-pressure fuel injection pipes —

Part 2: Requirements for composite tubes

Moteurs à allumage par compression — Tubes en acier pour lignes d'injection à haute pression —

Partie 2: Caractéristiques des tubes composites

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 8535-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 7, *Injection equipment and filters for use on road vehicles*.

This second edition cancels and replaces the first edition (ISO 8535-2:1993), which has been technically revised.

ISO 8535 consists of the following parts, under the general title *Compression-ignition 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*

Compression-ignition engines — Steel tubes for high-pressure fuel injection pipes —

Part 2: Requirements for composite tubes

1 Scope

This part of ISO 8535 specifies the dimensions of, and gives requirements for, composite steel tubes for high-pressure fuel injection pipes used on diesel (compression-ignition) engines (Class 2) and for fuel injection pump testing (Class 1).

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, *Metallic materials — Tensile testing*

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.

a) Inside diameter, d

± 0,05 mm for Class 2

± 0,025 mm for Class 1[1)]

b) Outside diameter, D

± 0,06 mm for Classes 1 and 2

1) Tolerance in accordance with ISO 4093.

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

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 fin[a] *d*		Outside diameter fin[b] *D*		
Preferred	**Non-preferred**	4,5	6	7
1,12				
1,25				
1,4				
	1,5			
1,6				
	1,7			
1,8				
	1,9			
2				
	2,12			
2,24				
	2,36			
2,5				
	2,65			
2,8				
	3			
3,15				
	3,35			

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.

[b] Size combinations to be used are those falling within the cross-hatched region.

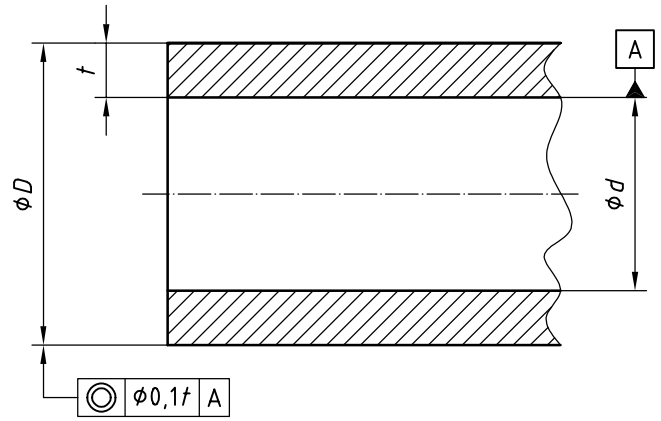


Figure 1 — Tube diameters

4 Material processing

4.1 Steel manufacturing process

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

The composite structure can be produced in various ways:

— a seamless inner (liner) tube is indicated by “CA”;

— a seamed inner tube is indicated by “CB”.

4.2 Surface quality

4.2.1 General

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

4.2.2 Minimum surface quality of 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 depth per tube cross-section, using 50× magnification for examination (see Table 2). This does not apply to tube type CB.

4.2.3 Higher surface quality of bore (Grades O, P, Q and 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). This does not apply to tube type CB.

Table 2 — Bore grades

Code	Permitted imperfections	Magnification ×
S	As in 4.2.2	50
R	No imperfections over 0,08 mm deep are permitted; no more than five imperfections over 0,05 mm deep are permitted	100
Q	A maximum of five imperfections over 0,02 mm to 0,05 mm deep	100
P	A maximum of five imperfections over 0,01 mm to 0,02 mm deep	200
O	No imperfections over 0,01 mm deep are permitted	500

4.3 Surface finish

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

The inside surface of a CA tube shall remain uncoated.

Table 3 — Surface finish

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	
9	As specified, subject to agreement	

[a] Chromating as described in ISO 2080 and ISO 4520.

4.4 Minimum mechanical properties of tube

The tubes shall comply with one of the classes of mechanical properties (Codes 1 to 2) resulting from the steel type and composite structure as listed in Table 4.

Table 4 — Mechanical properties

Code	Tube type	Minimum tensile strength Rm	Minimum upper yield stress ReH	Minimum elongation A5	Maximum hardness	
		N/mm^2	N/mm^2	%	HV 5 [a]	HV1 [b]
1	CB	310	205	30	130	
2	CA	310	205	23	130	170

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

[a] As measured on the tube outside diameter.

[b] As measured on the cross-section of the inner (liner) tube.

4.5 Cleanliness

The bore shall be clean and free from any contamination or coating which would impair the processing and serviceability of the tubes. Any special requirements shall be agreed at the time of enquiry or order between supplier and purchaser.

4.6 Straightness

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

4.7 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 engines and shall be removable with diesel fuel.

5 Testing

5.1 General

Unless otherwise specified, 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 processing during composite construction, structure, dimensions and surface finish.

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, lot size, number of samples and acceptance limit shall be agreed upon between supplier and purchaser in the order.

5.3 Dimension measurements

The tube dimension shall comply with the specifications in Clause 3.

5.4 Mechanical property tests

The tubes shall comply with the specifications given in Table 4. The tests shall be performed in accordance with ISO 6892 and ISO 6507-1.

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

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

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

5.7 Surface quality test

5.7.1 A visual check shall be carried out to ensure that tubes are in accordance with 4.3.

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

5.7.3 If a 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 other treated surfaces shall satisfy tests on these coatings when required. Such tests shall be agreed between supplier and purchaser.

5.8 Inside pressure test

Tubes shall be capable of withstanding appropriate inside pressure agreed upon between supplier and purchaser.

This capability shall be confirmed by a hydraulic test. Other non-destructive testing, such as electronic testing, may be used if agreed upon between supplier and purchaser.

5.9 Retests

If, after testing in accordance with 5.4, the selected tube fails, two other tubes shall be tested 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 the test requirements, the whole lot shall be rejected.

The supplier may resubmit a rejected lot for acceptance 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 continuous production inspections concerning the following tests may be used:

a) dimensions according to 5.3;

b) mechanical properties according to 5.4;

c) cold upsetting according to 5.6;

d) visual inspection according to 5.7.1;

e) metallographic test according to 5.7.3;

f) inside pressure test according to 5.8.

Inclusion of other test items in the certificate may be agreed upon between supplier and purchaser.

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) reference to this part of ISO 8535;

c) tube type, using code letters “CA” or “CB”, in accordance with 4.1 (the first character, C, indicates composite structure);

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)];

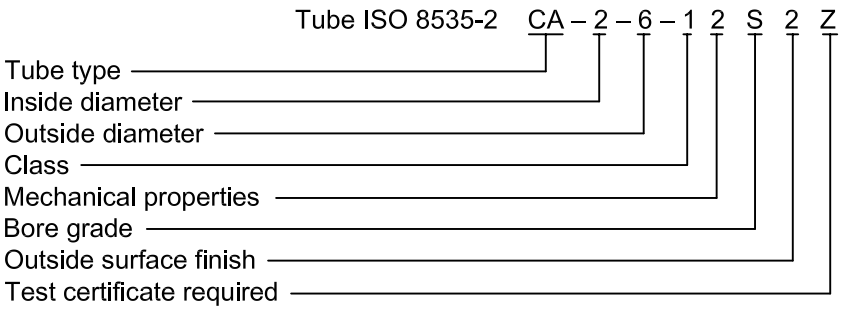
f) the fifth character identifies the mechanical properties of the tube in accordance with Table 4;

g) the sixth character identifies the bore grade of the tube in accordance with Table 2 (this does not apply to tube type CB);

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

i) at the end 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 according to this part of ISO 8535. Additional marking is permissible if agreed upon between supplier and purchaser.

8 Packing

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

Bibliography

[1] ISO 3:1973, *Preferred numbers — Series of preferred numbers*

[2] ISO 2080:1981, *Electroplating and related processes — Vocabulary*

[3] ISO 4093, Diesel engines — *Fuel injection pumps — High-pressure pipes for testing*

[4] ISO 4520:1981, *Chromate conversion coatings on electroplated zinc and cadmium coatings*

[5] ISO 8535-1:1996, *Compression-ignition engines — Steel tubes for high-pressure fuel injection pipes — Part 1: Requirements for seamless cold-drawn single-wall tubes*

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