INTERNATIONAL STANDARD

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Diesel engines — High-pressure fuel injection pipe assemblies — General requirements and dimensions

Moteurs diesels — Lignes assemblées d'injection de carburant haute pression — Exigences générales et dimensions

Reference number
ISO 13296:1997(E)

Foreword

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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.

International Standard ISO 13296 was prepared by Technical Committee ISO/TC 22, *Road vehicles,* Subcommittee SC 7, *Injection equipment and filters for use on road vehicles*.

Annexes A and B form an integral part of this International Standard. Annex C is for information only.

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Introduction

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this International Standard may involve the use of a patent concerning an apparatus to measure the inside diameter of the pipe assembly as described in annex B.

ISO takes no position concerning the evidence, validity and scope of this patent right.

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Diesel engines — High-pressure fuel injection pipe assemblies — General requirements and dimensions

1 Scope

This International Standard specifies dimensions and requirements for high-pressure fuel injection pipe assemblies and assembled pipe sets used on a compression-ignition (diesel) engines.

High-pressure pipes for use on test benches are specified in ISO 4093.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2974:1994, *Diesel engines — High-pressure fuel injection pipe end-connections with 60° female cone.*

ISO 7876-4:1994, *Fuel injection equipment — Vocabulary — Part 4: High-pressure pipes and end-connections.*

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.*

ISO 8535-2:1993, *Compression-ignition engines — Steel tubes for high-pressure fuel injection pipes — Part 2: Requirements for composite tubes.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 7876-4 apply.

4 Dimensions and tolerances

The requirement and configuration drawing for a pipe assembly shall include at least the following:

a) indication of compliance with this International Standard;

b) the outside diameter and inside diameter of the pipe and indication of compliance with ISO 8535-1 or ISO 8535-2;

c) a graphic representation of the centreline of the pipe with the connection ends and each bend intersection labeled as a point; each point shall be listed in a table with Cartesian co-ordinates *x*, *y* and *z* with the orthogonal distance from the axis and the bend radii;

NOTE — The co-ordinates are used to establish the theoretical exact centreline of the tube. See the example given in figure 1.

d) the developed length of the pipe as an approximate value;

e) the surface finish requirements of the pipe and connector nuts.

The dimensional tolerance of a pipe assembly shall be stated in terms of the actual outside contour of the tube in relation to the theoretical maximum outside contour and the variance of the actual connection ends from theoretical position as agreed upon between the supplier and customer.

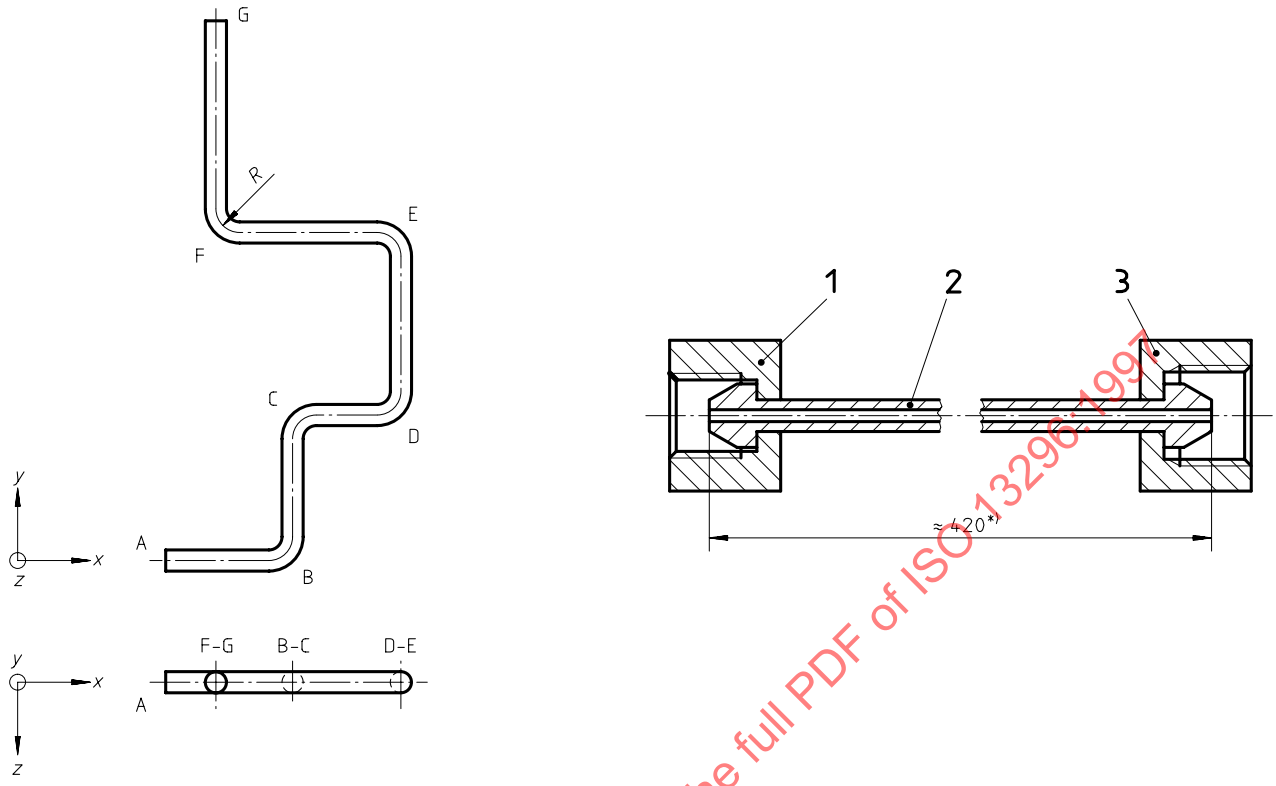
5 Cleanliness

The bore of a high-pressure fuel injection pipe assembly shall be clean and shall be assessed using a method which has been agreed upon by the supplier and customer.

6 Minimum bend radii

The radius of any bend made in fabricating high-pressure pipe assemblies shall be not less than two and one-half times (2,5 ×) the outside diameter of the pipe as measured from the pipe centreline. Bends shall be a sufficient distance from the end-connections so as to allow easy fitting of the pipe assembly for its intended used. Bends shall be of a sufficient distance from one another and from the end-connections so as not to impair fabrication. Bend radii shall be of uniform size in each pipe assembly whenever possible.

Dimensions in millimetres



Key

1 Connector nut M12
2 Pipe
3 Connector nut M14

*) Developed length

Point	*x*	*y*	*z*	Radius
A	0	0	0	0
B	65	0	0	15,75
C	65	100	0	15,75
D	140	100	0	15,75
E	140	150	0	15,75
F	40	150	0	15,75
G	40	150	0	0

Figure 1 — Example of a requirement and configuration drawing

7 End connections

The dimensional characteristics of the high-pressure pipe end-connections with 60° female cone are specified in ISO 2974. The preferred hexagon size for the connector nusts are listed in table 1.

Table 1 — Connector nut hexagon size

Dimensions in millimetres

Tube outside diameter	Thread	Hexagon across flats (preferred)
4,5	M10 × 1,25	14
	M12 × 1,5	17
6	M12 × 1,5	17
	M14 × 1,5	19
8	M16 × 1,5	24
	M18 × 1,5	24
	M22 × 1,5	32
10	M20 × 1,5	30
	M22 × 1,5	32
	M24 × 1,5	36
12	M22 × 1,5	32
	M26 × 1,5	36

The tube-connection end and bore configuration shall be chosen such that, after final assembly, the inside diameter of the tube is not less than that which is shown in figure 2. After manufacture, the connection ends of the pipe shall comply with the dimensional characteristics given in figure 2. This figure also determines any internal distortion limits. If, by agreement between supplier and customer, a chamfer is to be put in the bore, the maximum tolerance of d_1 at the front of the male sealing face may be increased.

8 Assembly clamps

Pipe assemblies may be formed in such a manner as to be held to the engine and/or to one another with a form of assembly clamp. Clamp placement should be such that it will prevent damage from engine-induced vibration. It is recommended that the assembly clamps hold the pipes at a centre-to-centre distance of 1,42 *D*, where *D* is the pipe outside diameter.

9 External coatings

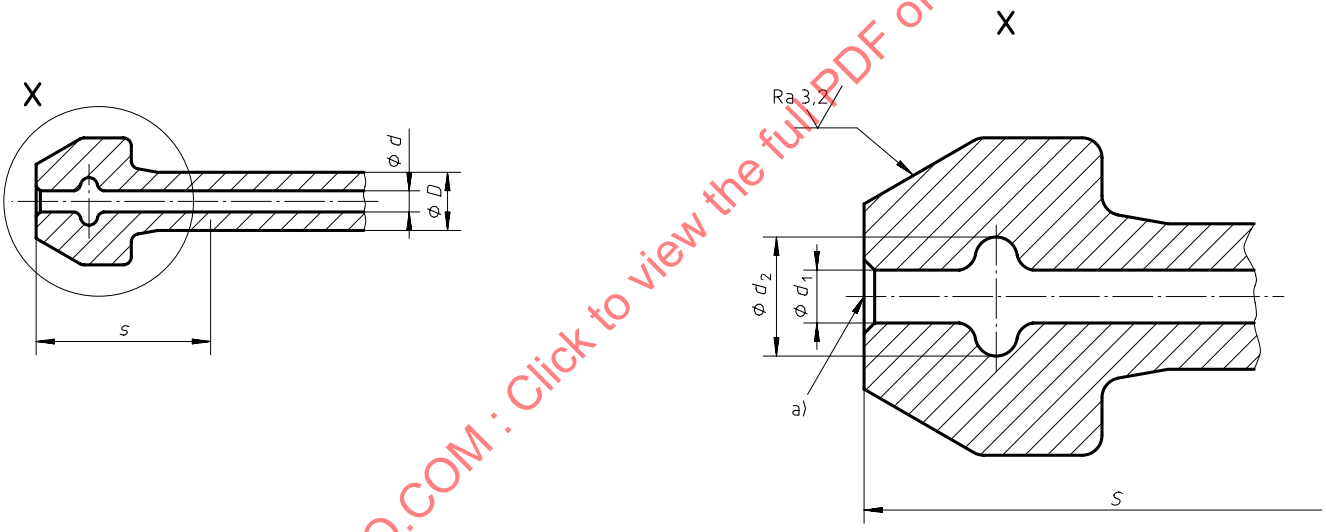
The outside surfaces of high-pressure pipe assemblies, assembled pipe sets, or pipe components may be plated or left in an untreated condition. If an untreated condition is specified a temporary preservative shall be applied to external surfaces. The outside surface specification of metallic components shall be in accordance with the specifications for tubes as given in table 3 of ISO 8535-1:1996 or ISO 8535-2:1993.

10 Operating pressure

The permissible operating pressure shall be specified with an adequate safety margin below the fatigue strength under pulsating internal pressure and shall be agreed upon between customer and supplier. See annex A for additional information.

11 Pipe inside diameter

The pipe inside diameter shall not exhibit any permanent deformation due to bending other than a 3 % maximum reduction in the cross-sectional area of the bore through the length of a bend when compared with an adjacent straight portion. The cross-sectional area reduction is affected by material physical properties, inside/outside diameter ratio, bend radius, and type of fabrication. A method to measure the diameter of the cross-sectional area of the bore of the pipe assembly, in which a ball on a wire is passed through the pipe and the clearance between the ball and the inside wall at each point is determined by pneumatic flow, is given in annex B.



$d_1 = d \pm 0{,}1$

$d_2 = 1{,}5\ d_{max}$

$s = 3D_{max}$

Key

D Nominal outside diameter of the pipe
d Nominal inside diameter of the pipe
d_1 Inside diameter at length s, excluding inside bulge
d_2 Inside diameter at the inside bulge
s Length over which internal distortion is permitted (see d_1)

a) In this area, tube bore transition to tube end face made by uniform widening of inside diameter with rounded run-out. No sharp edges permitted.

Figure 2 — Tube-connection end and bore configuration

12 Tightening torque and resistance of sealing

The tightening torque to connect the connection ends of the high-pressure fuel injection pipe assemblies with the injection pump and injector shall be determined carefully so that no fuel leakage from the sealing face, inadvertent rotational movement of the mating component, or injurious deformation of the sealing face, thread, or pipe connection end will occur.

The adequate tightening torque for the connection ends will vary according to the combination of size and material of the tube, size and material of connector nut, design of the shoulder of the connection end and the connector nut, etc. The required tightening torque shall be determined empirically between the customer and the supplier.

The sealing resistance shall be tested to verify satisfactory sealibility in the following manner: fit the pipe assembly with 60° female cones by applying the lower limit of the determined tightening torque; for the test, the same type of fuel as that to be used for actual operation and the pressure at actual operation shall be used.

13 Packaging and identification

Pipe assemblies and assembled pipe sets shall be identified as agreed upon between customer and supplier. The products shall be packaged in such a manner as to prevent the ingress of debris during transit or storage.

Annex A
(normative)

Operating pressure

The permissible operating pressures are determined by the supplier by long-term tests under pulsating internal pressure on the fatigue strength which, apart from the relationship of the internal diameter to the wall thickness, depends mainly upon

a) the depth of the imperfections in the internal surface,

b) the tensile strength of the material, and

c) the after-treatment of the tubes or pipes.

The fatigue strength under pulsating internal pressure decreases along with the depth of the imperfections in the inner surface. Such imperfections result from manufacturing processes and includes such irregularities as plug lines, draw wrinkles, overlaps, oxidation points and cavities. These cannot be detected by surface-roughness measurements, but only by microscopic investigation of a ground section vertical to the tubing. Composite tubes or pipe assemblies with seamless inner bore usually have a lower inner surface imperfection depth and therefore feature a higher fatigue strength under pulsating internal pressure.

As is to be expected, the higher the material's tensile strength, the higher its fatigue strength under pulsating internal pressure. On the other hand, higher tensile strength has negative effects on the material's deformation capability.

After-treatment of the single wall tubes or pipe assemblies with very high internal pressures up into the plastic deformation range of the inner surface (autofrettage) increases the fatigue strength under pulsating internal pressure.

The desired fatigue strength under pulsating internal pressure shall be agreed upon between customer and supplier. It shall be specified with an adequate safety margin above the operating pressure.

Annex B
(normative)

Pipe inside diameter measurement

B.1 Principle

This annex describes a method of measuring the inside diameter of the pipe assembly, in which a ball on a wire is passed through the pipe and the clearance between the ball and the inner surface at each point is determined by pneumatic flow.

B.2 Measurement conditions

The equipment required for the measurement installation is shown in figure B.1. The bore of the pipe assembly shall be free of any contamination which could influence the flow test and it shall be dry before measuring.

The flow indicated by the measuring device is proportional to the effective cross-section between ball and inner surface of the pipe, if the velocity of sound is reached in the effective cross section. It is therefore necessary to maintain a pressure p_V of at least 300 kPa[1)] above the ambient pressure p_a.

Before measuring, it is necessary to choose the optimum ball diameter by selecting the one with the smallest gap between itself and inner surface of the pipe. The minimum allowed ball diameters are given in table B.1.

Table B.1

Dimensions in millimetres

Pipe inside diameter, d_i	Ball diameter ± 0,001 25	Wire diameter
⩽ 1,8	d_i – 0,2	0,15
> 1,8	d_i – 0,3	

B.3 Calibration

The flow is calibrated by using three calibrating orifices as shown in figure B.1.

1) 100 kPa = 1 bar