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

National foreword

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

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



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Foreword

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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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The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain, and powertrain fluids*.

This fourth edition cancels and replaces the third edition (ISO 13296:2012), which has been technically revised by making normative reference to ISO 4288 for the measurement of surface texture.

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

1 Scope

This document specifies dimensions and requirements for high-pressure fuel injection pipe assemblies and assembled pipe sets for both integral and fabricated 60° female cones used on diesel (compression-ignition) engines.

NOTE Dimensions of integral and fabricated 60° female cone connectors are specified in ISO 2974.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 2974:2011, *Diesel engines — 60° female cones for high-pressure fuel injection components*

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 8535-1:2011, *Diesel engines — Steel tubes for high-pressure fuel injection pipes — Part 1: Requirements for seamless cold-drawn single-wall tubes*

ISO 8535-2:2003, *Compression-ignition engines — Steel tubes for high-pressure fuel injection pipes — Part 2: Requirements for composite tubes*

ISO 12345, *Diesel engines — Cleanliness assessment of fuel injection equipment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7876-4 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

4 Dimensions and tolerances

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

- a) an indication of compliance with this document, i.e. ISO 13296;
- b) the outside diameter and inside diameter of the pipe and an indication of compliance with ISO 8535-1 or ISO 8535-2;
- c) the thread and the hexagon size of the connector nuts according to [Table 2](#) or [Table 4](#);
- d) the type of connection ends as specified in [7.2](#);
- e) a graphic representation of the centre-line of the pipe with the connection ends and each bend intersection labelled as a point, with each point listed in a table with Cartesian coordinates x , y and

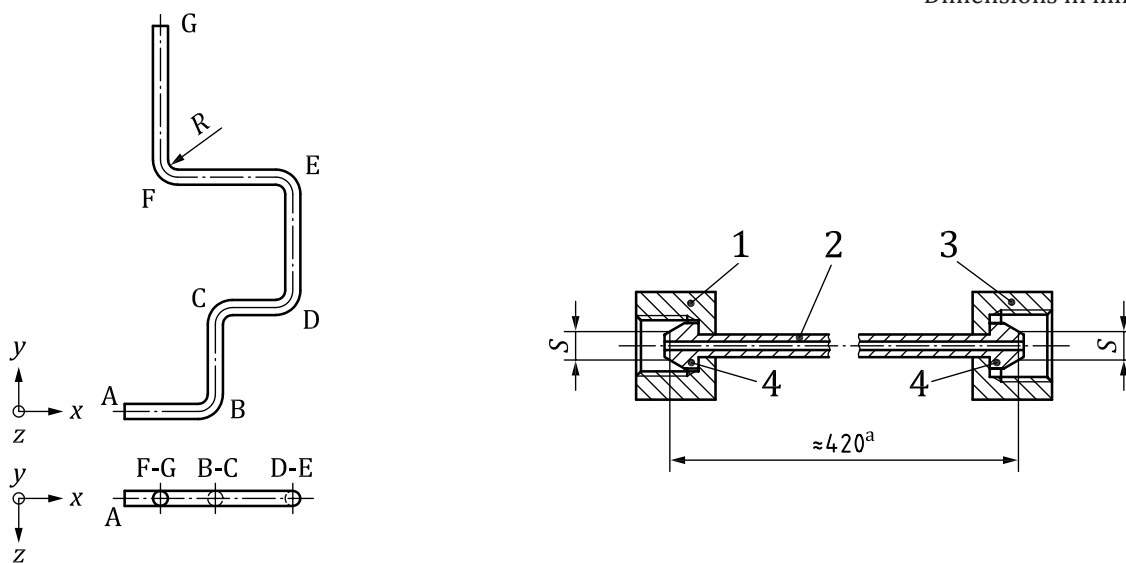
z with the orthogonal distance from the axis and the bend radius (the beginning and end points are given as the “S” dimension for the defined configuration);

NOTE The coordinates are used to specify the theoretical exact centre-line of the pipe. See the example given in [Figure 1](#).

- f) the developed length of the pipe as an approximated value;
- g) the material and surface finish requirements of the pipe and connector nuts according to ISO 8535-1 or ISO 8535-2.

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

Dimensions in millimetres



Point	x	y	z	Radius
A	0	0	0	0
B	65	0	0	15
C	65	100	0	15
D	140	100	0	15
E	140	150	0	15
F	40	150	0	15
G	40	185	0	0

Key

- 1 connector nut: thread M12; hexagon across flats 17
- 2 pipe: tube outside diameter 6 mm
- 3 connector nut: thread M14; hexagon across flats 19
- 4 pipe connection ends: both of Type C
- a Developed length.

Figure 1 — Example of a requirement and configuration drawing

5 Cleanliness

The bore of a high-pressure fuel injection pipe assembly shall be clean, and this shall be assessed in accordance with ISO 12345. Unless otherwise agreed between supplier and customer, cleanliness of pipe assemblies shall be designated using the Fuel Injection Equipment Cleanliness Code (FIECC), as defined in ISO 12345.

6 Minimum bend radii

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

7 Pipe end connections

7.1 General

The relationships of connection ends to the connector nut and with the dimensions G and S are shown in [Table 1](#) for the integral 60° female cone and in [Table 3](#) for the fabricated 60° female cone.

The design of the shoulders of the connection end and of the related connector nut shall be agreed between supplier and customer.

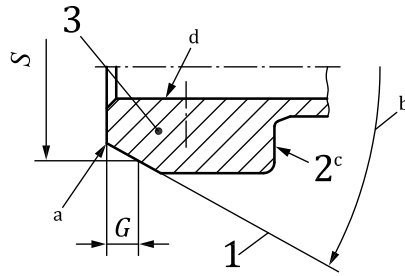
NOTE The dimensional characteristics of integral 60° female cones and of fabricated 60° female cones for high-pressure fuel injection components are specified in ISO 2974.

7.2 Types of connection ends

[Figure 2](#) and [Figure 3](#) show two fundamentally different designs of connection ends for high-pressure fuel injection pipe assemblies:

- Type C, with conical sealing face;
- Type S, with spherical sealing face.

Details of a Type C connection end are shown in [Figure 2](#) while those of a Type S connection end are shown in [Figure 3](#).



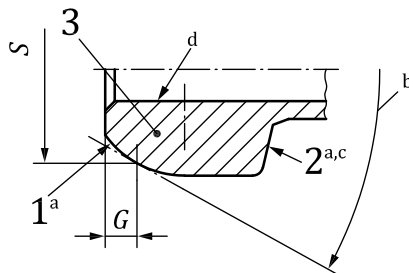
Key

- 1 connection-end sealing face (conical)
- 2 shoulder of connection end^c
- 3 connection end of pipe
- a Rounding of the leading edge of the sealing face is necessary for the straight connection-end sealing face.
- b $58^\circ \pm 1^\circ$ included angle for Type C connection-end sealing face.
- c Design of the shoulder is not specified (see 7.1).
- d The connection-end bore entrance configuration is shown in Figure 6.

NOTE For dimensions *G* and *S*, see Table 1.

Figure 2 — Connection end Type C (conical)

Details of a Type S connection end are shown in Figure 3.



Key

- 1 connection-end sealing face (spherical)
- 2 shoulder of connection end^c
- 3 connection end of pipe
- a Spherical shape of the connection-end sealing face and of the shoulder in order to allow an inclined position of the pipe connection end to the matching female cone.
- b Spherical connection end to fit into the 60° female cone specified in ISO 2974.
- c Spherical shoulder in order to achieve a constant transmission of the axial force to the circumference of the shoulder and the connection-end sealing surface. Details of the shoulder design are not specified (see 7.1).
- d The connection-end bore entrance configuration is shown in Figure 6.

NOTE For dimensions *G* and *S*, see Table 1.

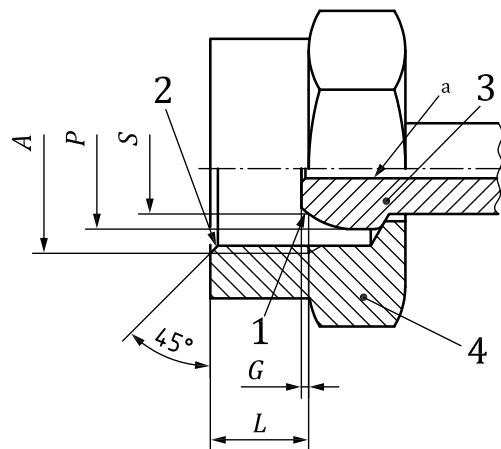
Figure 3 — Connection end Type S (spherical)

7.3 Pipe end assembly for integral 60° female cones

Figure 4 shows the basic requirements and relationships of a connection end assembled to the related connector nut (valid for both Type C and Type S connection ends).

For dimensions, see [Table 1](#).

NOTE The dimensions of [Table 1](#) correspond to the values specified in ISO 2974:2013, Table 1.



Key

- 1 connection-end sealing face (conical or spherical)
- 2 chamfer to root of thread
- 3 connection end of pipe (according to [Figures 2](#) or [3](#))
- 4 connector nut (according to [Table 2](#))
- a The connection-end bore entrance configuration shall be so chosen that, after final assembly, the pipe inside diameter is not reduced (see [7.5](#)).

Figure 4 — Pipe end assembly for integral 60° female cones (schematically)

Table 1 — Dimensions of pipe end connections for integral 60° female cones

Dimensions in millimetres

Tube outside diameter	Thread ^a A	Reference diameter S	P ±0,5	G ±0,3	L max.
4,5	M10 × 1,25 M12 × 1,5	5	7	0,5	7
6	M12 × 1,5 M14 × 1,5	6,5	8,0 to 9,5	0,5 or 1,0	8
6,35	M12 × 1,5 M14 × 1,5 M16 × 1,5	6,5	8,0 to 9,5	0,5 or 1,0	8
7	M14 × 1,5 M16 × 1,5	6,5	8,5 to 10,5	0,5	8
8	M14 × 1,5	7,5	10,5 to 12	0,6	8
	M16 × 1,5	8,5	10,5 to 12	0,6	8
	M16 × 1,5 M18 × 1,5 M22 × 1,5	8,5	11 to 12	0,9	11
	M16 × 1,5	8,5	12	0,9	8

^a Tolerance classes of threads: 6H for connector nuts.

Table 1 (continued)

Tube outside diameter	Thread ^a A	Reference diameter S	P ±0,5	G ±0,3	L max.
10	M16 × 1,5	8,5	13,5	0,9	8
	M20 × 1,5	10,5	13,5	0,9	12,5
	M22 × 1,5				
	M24 × 1,5				
12	M22 × 1,5	12,5	15,5	1,8	15,5
	M26 × 1,5				

^a Tolerance classes of threads: 6H for connector nuts.

The preferred hexagon sizes for the connector nuts are given in [Table 2](#).

Table 2 — Connector-nut wrench size for integral 60° female cones

Dimensions in millimetres

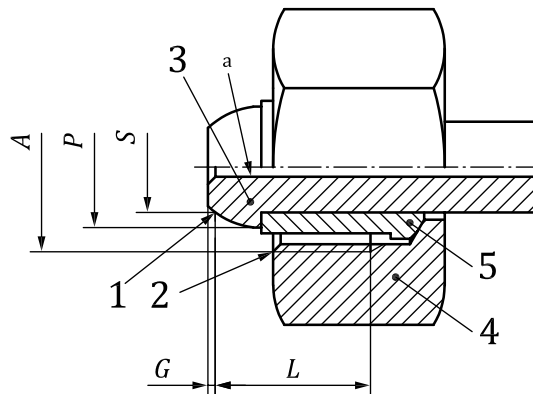
Tube outside diameter	Thread	Wrench size
4,5	M10 × 1,25	14
	M12 × 1,5	17
6	M12 × 1,5	17
	M14 × 1,5	19
6,35	M12 × 1,5	17
	M14 × 1,5	19
	M16 × 1,5	24
7	M14 × 1,5	19
	M16 × 1,5	24
8	M14 × 1,5	19
	M16 × 1,5	24
	M18 × 1,5	24
	M22 × 1,5	32
9	M16 × 1,5	24
10	M16 × 1,5	24
	M20 × 1,5	30
	M22 × 1,5	32
	M24 × 1,5	36
12	M22 × 1,5	32
	M26 × 1,5	36

7.4 Pipe end assembly for fabricated 60° female cones

[Figure 5](#) shows the basic requirements and relationships of a pipe connection end assembled to the related connector nut (valid for both Type C and Type S connection ends).

For dimensions, see [Table 3](#). For connector-nut wrench sizes, see [Table 4](#).

NOTE The dimensions in [Table 3](#) correspond to the values specified in ISO 2974:2013, Table 2.



Key

- 1 connection-end sealing face (conical or spherical)
- 2 chamfer to root of thread
- 3 connection end of pipe (according to [Figure 2](#) or [Figure 3](#))
- 4 connector nut (according to [Table 4](#))
- 5 loading sleeve
- a The connection-end bore entrance configuration shall be so chosen that, after final assembly, the pipe inside diameter is not reduced (see [7.5](#)).

Figure 5 — Pipe end assembly for fabricated 60° female cones (schematically)

Table 3 — Dimensions of pipe end connections for fabricated 60° female cones

Dimensions in millimetres

Tube outside diameter	Thread <i>A</i>	Reference diameter <i>S</i>	<i>P</i> ±0,5	<i>G</i> ±0,3	<i>L</i> min.
6	M14 × 1	6,15	8 to 9	0,5	15
	M15 × 1	6,5	8 to 9,5	0,5	13
	M16 × 1,5 ^a	6,5	8 to 9,5	0,5	17
6,35	M14 × 1	6,15	8 to 9	0,5	15
	M15 × 1	6,5	8 to 9,5	0,5	13
	M16 × 1,5 ^a	6,5	8 to 9,5	0,5	17
8	M18 × 1,5	7,5	10,5 to 12	0,6	18
8	M19 × 1,5	8,23	11 to 13	0,6	18

^a Preferred.

Table 4 — Connector-nut wrench size for fabricated 60° cones

Dimensions in millimetres

Tube outside diameter	Thread	Wrench size
6	M14 × 1	17
	M15 × 1	19
	M16 × 1,5 ^a	19

^a Preferred.

^b Wrench size achieved by using a stepped nut with the hexagon located away from the thread.

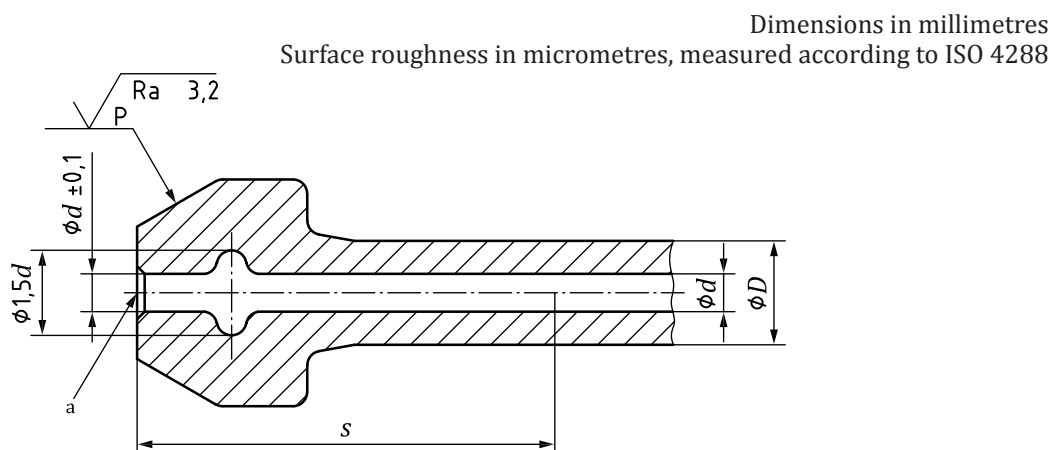
Table 4 (continued)

Tube outside diameter	Thread	Wrench size
6,35	M14 × 1	17
	M15 × 1	19
	M16 × 1,5 ^a	19
8	M18 × 1,5	19 ^b
9	M19 × 1,5	19 ^b

^a Preferred.
^b Wrench size achieved by using a stepped nut with the hexagon located away from the thread.

7.5 Bore entrance configuration

The 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 6](#). After manufacture, the connection ends of the pipe shall comply with the dimensional characteristics given in [Figure 6](#). 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.



Key

- D nominal outside diameter of the pipe
- d nominal inside diameter of the pipe
- $d \pm 0,1$ distortion of inside diameter at length s , excluding inside bulge
- $1,5d$ maximum inside diameter at the inside bulge
- s length over which internal distortion is permitted = $3D_{\max}$
- ^a In this area, the transition from the tube bore to the tube end face shall be achieved by uniformly widening the inside diameter, giving it a rounded run-out. No sharp edges are permitted.

Figure 6 — Tube connection end and bore entrance configuration

8 Assembly clamps

Pipe assemblies may be formed in such a manner that they are attached to the engine and/or held to one another by means of an assembly clamp. Clamp placement should be such that it will prevent damage to the pipe assemblies from engine-induced vibration.

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 given in ISO 8535-1:2011, Table 3 or ISO 8535-2:2003, Table 3.

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 the supplier and the customer. 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.

12 Tightening torque and sealing performance

The tightening torque used to connect the connection ends of the high-pressure fuel injection pipe assemblies to a pump, a rail and injectors shall be determined carefully so that no fuel leakage from the sealing faces, rotational movement of the mating components, or unfavourable deformation of the sealing faces, threads or pipe connection ends will occur.

The tightening torque appropriate for the connection ends will depend on the combination of size and material of the tube, size and material of the 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 supplier and the customer.

The sealing performance shall be tested by fitting the pipe assembly to 60° female cone connectors and by applying the lower limit of the determined tightening torque. For the test, the maximum fuel pressure encountered in actual operation shall be used.

13 Packaging and identification

Pipe assemblies and assembled pipe sets shall be identified as agreed upon between the supplier and the customer. 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 pressure in terms of fatigue strength is determined by the supplier through durability tests under pulsating internal pressure. Apart from the relationship of the internal diameter to the wall thickness, fatigue strength depends mainly upon the following:

- a) the depth of the imperfections in the internal surface;
- b) the tensile strength of the material;
- 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 include 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 and polished section vertical to the tubing. Composite tubes or pipe assemblies with a seamless inner bore usually have a lower inner surface imperfection depth and therefore feature 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. However, higher tensile strength has a negative effect on the material's deformation capability, thus making bending of the pipes more difficult.

After-treatment on single-wall tubes or pipe assemblies by applying a very high internal pressure 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 the supplier and the customer. It shall be specified with an adequate safety margin above the operating pressure.

Bibliography

- [1] ISO 4093, *Diesel engines — Fuel injection pumps — High-pressure pipes for testing*
- [2] ISO 7876-4, *Fuel injection equipment — Vocabulary — Part 4: High-pressure pipes and end-connections*

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