

BS 7993:2011



BSI Standards Publication

Twin ferrule connectors and associated tubing for 316 stainless steel systems – Specification and test methods

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 July 2011. It was prepared by Panel MCE/18/-/4, *Connectors and associated components*, under the authority of Technical Committee MCE/18, *Fluid power systems and components*. A list of organizations represented on these committees can be obtained on request to their secretary.

Information about this document

Product certification/inspection/testing. Users of this British Standard are advised to consider the desirability of third-party certification/inspection/witness of testing of product conformity with this British Standard. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Users of this standard are also advised to consider the desirability of requesting conformity to BS EN ISO/IEC 17025 and BS EN 45011.

Assessed capability. Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage. Attention is particularly drawn to the danger of bursts, fine jets (which can penetrate the skin), energy release of expanding gases and the use of accumulators.

WARNING. Where tests are performed, the maximum working pressure connector (MWPC) or maximum working pressure tube (MWPT) should not exceed the manufacturer's maximum pressure rating.

WARNING. Do not bleed off air under pressure by undoing connector nuts, as they might separate and cause injury.

The practice(s) of intermixing and/or interchanging are not condoned or recommended within the remit of this British Standard. However, it is recognized that, in practice, system interfaces, modification requirements etc., can make these practices necessary, and for this purpose, this British Standard requires suitable instructions to be made available to the user (see Clause 11).

Use of this document

This British Standard is intended for use by manufacturers of connectors and designers of systems that use connector assemblies.

BSI permits the reproduction of BS 7993:2011, Table A.3. This reproduction is only permitted where it is necessary for the user to work/record findings on the table during each application of the standard.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this standard are drafted in accordance with *The BSI guide to standardization – Section 2: Rules for the structure, drafting and presentation of British Standards*, subclause **11.3.1**, which states, “Requirements should be expressed using wording such as: ‘When tested as described in Annex A, the product shall ...’”. This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Twin ferrule connectors provide metal-to-metal seal connections, non-elastomeric seals for leak-free connections to annealed stainless steel tubes. They are for use in applications where operating conditions do not allow elastomeric seals.

Twin ferrule connectors are used to connect tube-to-tube and tube-to-system components, the latter through standardized ports such as pipe threads. This British Standard provides external envelope and tube-end-to-port dimensions that facilitate designing systems that use twin ferrule connectors. It also provides material specifications and minimum performance requirements to ensure the integrity and consistency expected from this type of connector.

This British Standard does not provide detailed descriptions of the contours of connector components. Individual manufacturers determine the fine details of their connector components, and they are continually improving their designs. The nature of these metal-to-metal seals requires consistently compatible components.

The twin ferrule tube connector is designed to have a maximum allowable working pressure that is higher than that of any tubing, as shown in Tables 1 to 22 of this British Standard.

In the case of an all tube-ended connector, such as a union tee, the properly selected tube is the limiting factor in the system. A connector may, however, combine a twin ferrule connector end with another end of different form, such as male or female pipe thread. Pressure ratings for other ends are determined in accordance with applicable standards and may, in fact, be lower than the rating for the twin ferrule tube connector end. The raw material from which the connector is manufactured, either bar stock or a forging may also affect those ratings. As a result, the rating for such other forms is generally the limiting factor for the rating of the entire connector.

1 Scope

This British Standard specifies the characteristics of, and performance requirements for, the tube connector (compression) end(s) of twin ferrule connectors made of 316 stainless steel. It also specifies requirements for 316 stainless steel tubes.

The twin ferrule connectors in this standard are suitable for use with annealed stainless steel tubes with outside diameters from 2 mm to 38 mm and $\frac{1}{16}$ in to 2 in.

This British Standard is applicable to twin ferrule connectors that are intended for the connection of plain end tubes to other tubes and to ports in accordance with BS EN ISO 6149-1, BS EN ISO 1179 and BS EN ISO 9974-1, and other ports agreed between the purchaser and manufacturer. It provides external envelope, tube-end-to-tube-end and tube-end-to-port dimensions that facilitate designing systems that use twin ferrule connectors.

NOTE These twin ferrule connectors can also be used with other austenitic stainless steel tubes, typically 304, 316L, 321, etc.

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.

ANSI B1.20.1, *Pipe threads, general purpose (inch)*

ASME/ANSI B1.1, *Unified inch screw threads (UN and UNR thread form)*

ASME B31.3, *Process piping* ¹⁾

ASTM A182/A182M, *Standard specification for forged or rolled alloy and stainless steel pipe flanges, forged fittings, and valves and parts for high-temperature service*

ASTM A213/A213M-10, *Standard specification for seamless ferritic and austenitic alloy-steel boiler, superheater, and heat-exchanger tubes*

ASTM A249-10, *Standard specification for welded austenitic steel boiler, superheater, heat exchanger, and condenser tubes*

ASTM A262 *Standard practices for detecting susceptibility to intergranular attack in austenitic stainless steels*

ASTM A269-10, *Standard specification for seamless and welded austenitic stainless steel tubing for general service*

ASTM A276, *Standard specification for stainless steel bars and shapes*

ASTM A351/A351M-10, *Standard specification for castings, austenitic, for pressure-containing parts*

ASTM A479, *Standard specification for stainless steel bars and shapes for use in boilers and other pressure vessels*

ASTM A632-4(2009), *Standard specification for seamless and welded austenitic stainless steel tubing (small-diameter) for general service*

ASTM E18, *Standard test methods for Rockwell hardness of metallic materials*

ASTM E140, *Standard hardness conversion tables for metals (relationship among Brinell hardness, Vickers hardness, Rockwell hardness, Rockwell superficial hardness, Knoop hardness, and Scleroscope hardness)*

BS 1580, *Unified screwed threads*

BS 3643, *ISO metric screw threads*

BS 2000-2 (ISO 2977), *Method of test for petroleum and its products – Part 2: Petroleum products and hydrocarbon solvents – Determination of aniline point and mixed aniline point*

BS 2000-15 (ISO 3016), *Methods of test for petroleum and its products – Part 15: Petroleum products – Determination of pour point*

BS 2000-71.2 (ISO 3105), *Method of test for petroleum and its products – Part 71: Kinematic viscosity – Section 2: Specifications and operating instructions for glass capillary kinematic viscometers*

BS EN 837-1, *Pressure gauges – Part 1: Bourdon tube pressure gauges – Dimensions, metrology, requirements and testing*

BS EN ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads – Part 1: Dimensions, tolerances and designation*

¹⁾ This standard also gives an informative reference to ASME B31.3:2008.

BS EN ISO 1179, *Connections for general use and fluid power – Ports and stud ends with ISO 228-1 threads with elastomeric or metal-to-metal sealing*

BS EN ISO 2719 (BS 2000-34), *Determination of flash point – Pensky-Martens closed cup method*

BS EN ISO 6149-1, *Connections for hydraulic fluid power and general use – Ports and stud ends with ISO 261 metric threads and O-ring sealing – Ports with truncated housing for O-ring seal*

BS EN ISO 9227:2006, *Corrosion tests in artificial atmospheres – Salt spray tests*

BS EN ISO 9974-1, *Connections for general use and fluid power – Ports and stud ends with ISO 261 threads with elastomeric or metal-to-metal sealing – Threaded ports*

BS ISO 261, *ISO general purpose metric screw threads – General plan*

BS ISO 5598, *Fluid power systems and components – Vocabulary*

BS ISO 19921, *Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Test methods*

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads – Part 1: Dimensions, tolerances and designation*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in ISO 5598 and the following apply.

3.1 certification of conformity

action by a third party, demonstrating that adequate confidence is provided that a duly identified product, process or service is in conformity with a specific standard or other normative document

3.2 connector

leak-proof device to connect tubes to one another, or to equipment

3.3 face-to-centre dimension

distance from the face of an outlet to the centre axis of an angularly disposed outlet

3.4 face-to-face dimension

distance between the two parallel faces of axially aligned outlets of a fitting

3.5 fire resistance

ability of a connector to fulfil for a stated period of time the required stability, integrity, thermal insulation and/or expected duty specified in a standard fire resistance test

3.6 interchanging

using one manufacturer's assembled nut and ferrule system with another manufacturer's body

NOTE This practice usually arises where there is a similarity of key body elements among certain manufacturers.

3.7 intermixing

random mixing of components, particularly nuts and ferrules including materials and dimensions, which might or might not be compatible

3.8 maximum working pressure connector (MWPC)

maximum permissible working pressure at which a connector is rated

NOTE See Tables 23 to 26.

3.9 maximum working pressure tube (MWPT)

maximum permissible working pressure at which a tube is rated against a stated bending allowance and stated factor of safety

NOTE See Tables 23 to 26.

3.10 proof pressure

pressure, applied after assembly, in excess of maximum working pressure, which causes no damage or subsequent malfunction

3.11 test assembly

assembly of tube and connectors intended for use in tests

NOTE Test assemblies are shown in Figures A.1, A.2 and A.3.

3.12 test connector

twin ferrule connector under test

3.13 test manifold block

part of the test rig possessing port arrangements to accept test connector assemblies

4 Design

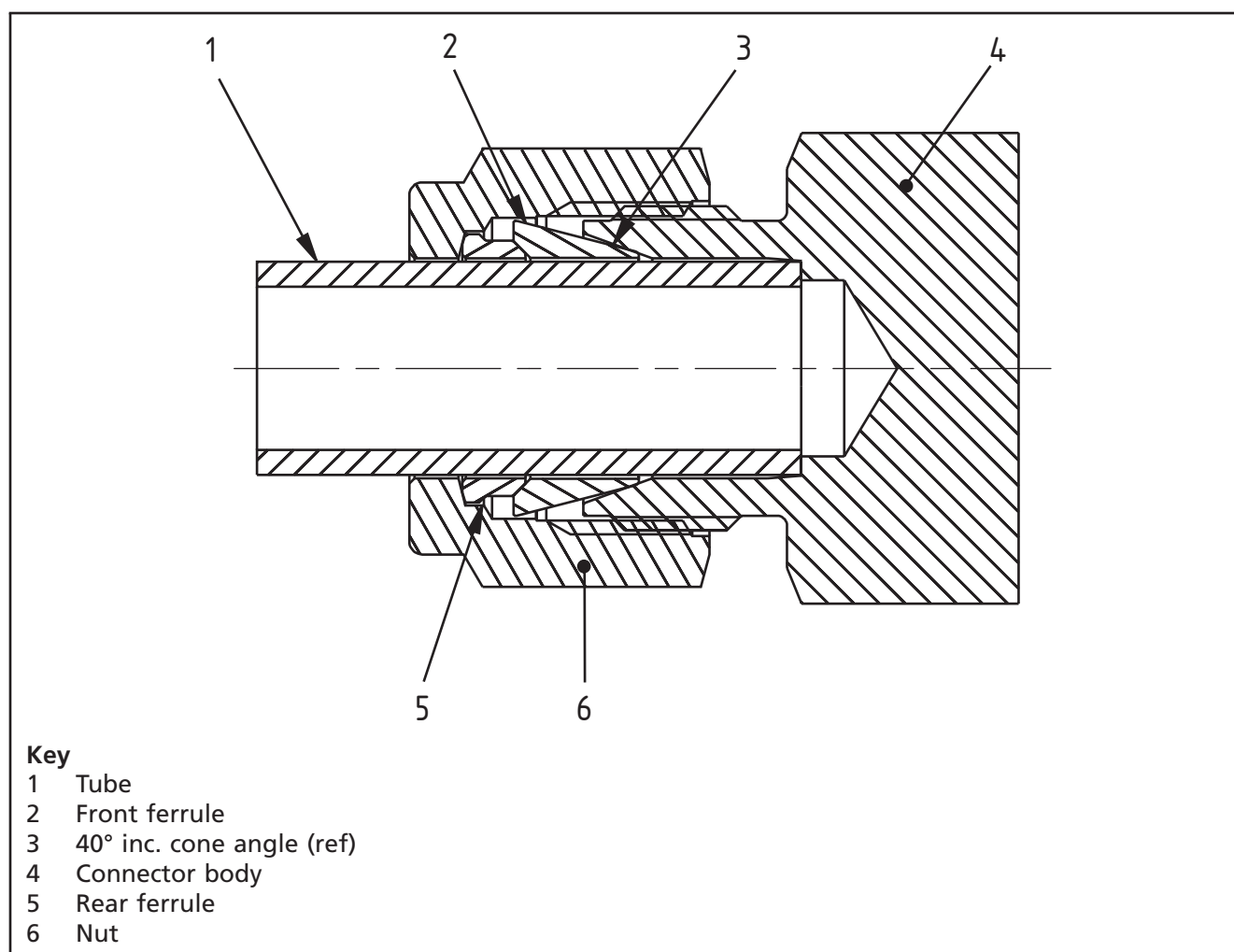
NOTE 1 Twin ferrule connectors are separable and are mechanically attached to squarely cut, deburred plain-end tubes. The components of the connector comprise a body, two ferrules and a threaded nut. The front ferrule provides the primary seal through radial compression around the outer diameter of the tube and axial interface with the connector body. The rear ferrule acts as the primary mechanical holding device for gripping the tube, and the nut screws onto the body to hold the assembly together.

NOTE 2 This clause provides a description of the contours and dimensions of the bodies and their principal nominal included angle of 40° (see Figure 1), whilst the ferrule and mating nut design is left to the manufacturers to determine the fine details of these components. They are thus unrestricted to allow continual improvement of their designs.

NOTE 3 Figure 1 shows the cross-section and component parts of a typical twin ferrule connector.

NOTE 4 By convention, NPT threaded components are not marked. Non-NPT threaded products should carry markings on the bodies only. The thread form of stud ends should be marked on the bodies and optionally with the tube size on any nuts.

Figure 1 Cross-section of a typical twin ferrule connector



4.1 Connectors

Twin ferrule connectors shall be in accordance with the appropriate figure and table as follows:

NOTE The designated tube size numbers for metric and imperial tube outside diameters are shown in Table 1 and Table 2 respectively.

- metric tube ends shall be in accordance with Figure 2 and Table 1;
- fractional tube ends shall be in accordance with Figure 3 and Table 2;
- compression end nuts shall be in accordance with Figure 4, and Table 3 or Table 4;
- union connectors shall be in accordance with Figure 5, and Table 5 or Table 6;
- male bulkhead connectors shall be in accordance with Figure 6, and Table 7 or Table 8;
- equal elbows shall be in accordance with Figure 7, and Table 9 or Table 10;
- equal tees shall be in accordance with Figure 8, and Table 11 or Table 12;
- equal crosses shall be in accordance with Figure 9, and Table 13 or Table 14;
- male stud connectors (NPT) shall be in accordance with Figure 10, and Table 15 or Table 16;
- male stud connectors (BSPT) shall be in accordance with Figure 11, and Table 17 or Table 18;
- male stud connectors (BSPP) shall be in accordance with Figure 12, and Table 19 or Table 20;
- bulkhead connectors shall be in accordance with Figure 13, and Table 21 or Table 22.

4.2 Dimensions of finished parts

NOTE In Tables 1 to 22, C is a face-to-face dimension and N is a face-to-centre dimension. All the specified dimensions apply to finished parts, including any plating or other treatments. The values of dimensions C, D and L are given for the finger-tight position.

Dimensions shall be subject to a general tolerance of $\pm 1/16$ in (1.6 mm) where not otherwise specified. Dimension C shall be subject to an abutment length tolerance of $\pm 1/6$ in (0.4 mm).

4.3 Dimensions of across-flats

The across-flats dimensions for nuts of the connectors shall be in accordance with the values specified in Table 1 and Table 2.

NOTE Where across-flats dimensions are quoted, imperial sizes may be replaced by the nearest metric equivalent and vice versa.

4.4 Passage tolerances

Where internal body passages are machined from opposite ends, the offset at the meeting point shall not exceed 0.4 mm. No cross-sectional area at a junction of passages shall be less than that of the smallest passage.

4.5 Angular tolerances

Angular tolerances on axes of ends of elbows, tees and crosses shall be $\pm 1.5^\circ$ for all connectors.

4.6 Contour details

Details of non-critical contours shall be chosen by the manufacturer. However, abrupt reduction of sections shall be avoided and junctions of small external sections and adjoining sections that are relatively heavy shall be blended by means of ample fillets where possible.

Figure 2 Cross-section of a metric tube end

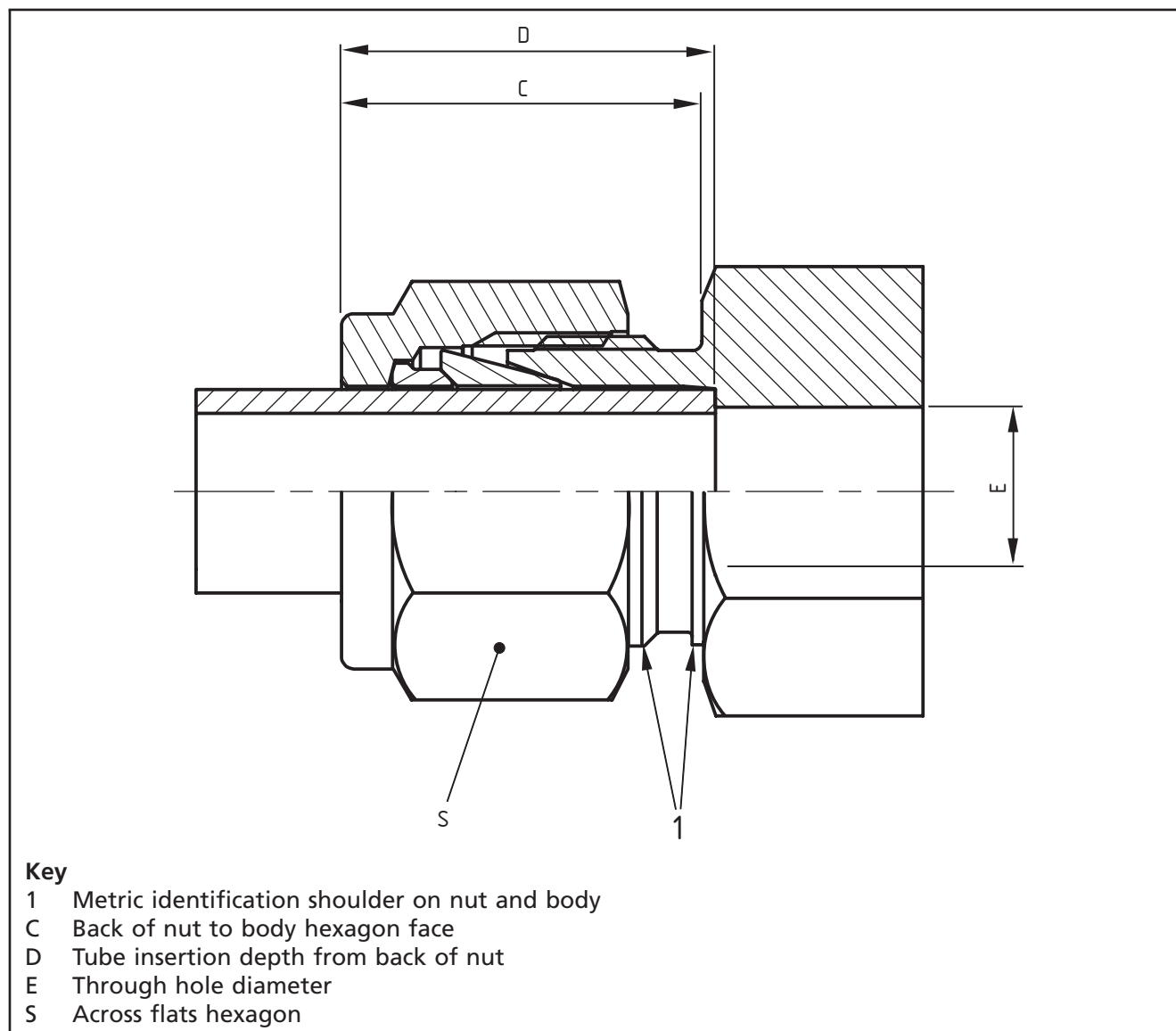


Table 1 Requirements for tube ends for tubes with metric outside diameter sizes

Designated tube size number ^{A)}	Tube O.D. ^{B)}	Requirements					
		Straight thread for nut end of tube fitting ^{C)}	C ^{D)}	S	S	E	D ^{D)}
	mm	in/mm	mm	mm	in	mm	mm
M2	2	5/16 in x 20 UN	15.3	12.0	1/2	1.7	12.9
M3	3	5/16 in x 20 UN	15.3	12.0	1/2	2.4	12.9
M4	4	3/8 in x 20 UN	16.1	12.0	1/2	2.4	13.7
M6	6	7/16 in x 20 UN	17.7	14.0	9/16	4.8	15.3
M8	8	1/2 in x 20 UN	18.6	16.0	5/8	6.4	16.2
M10	10	5/8 in x 20 UN	19.5	19.0	11/16	7.9	17.2
M12	12	3/4 in x 20 UN	22.0	22.0	7/8	9.5	22.8
M14	14	7/8 in x 20 UN	22.0	25.0	1	11.1	24.4
M15	15	7/8 in x 20 UN	22.0	25.0	1	11.9	24.4
M16	16	7/8 in x 20 UN	22.0	25.0	1	12.7	24.4
M18	18	1 in x 20 UN	22.0	30.0	1 1/8	15.1	24.4
M20	20	1 1/8 in x 20 UN	22.0	32.0	1 1/4	15.9	26.0
M22	22	1 1/8 in x 20 UN	22.0	32.0	1 1/4	18.3	26.0
M25	25	1 5/16 in x 20 UN	26.5	38.0	1 1/2	21.8	31.3
M28	28	M37 x 1.5 mm	36.6	46.0	1 7/8	21.8	36.6
M30	30	M40 x 1.5 mm	39.2	50.0	2 1/4	26.2	39.6
M32	32	M42 x 1.5 mm	41.6	50.0	2 1/4	28.6	42.0
M38	38	M50 x 1.5 mm	47.9	60.0	2 3/4	33.7	49.4

NOTE All tolerances are ± 1.6 mm ($1/16$ in) unless otherwise stated.

A) See 6.9.

B) Tolerances for the tube outside diameter shall be in accordance with ASTM A269.

C) UN = Unified thread conforming to BS 1580; M = metric thread conforming to BS 3643.

D) Average value.

Figure 3 Cross-section of a fractional tube end

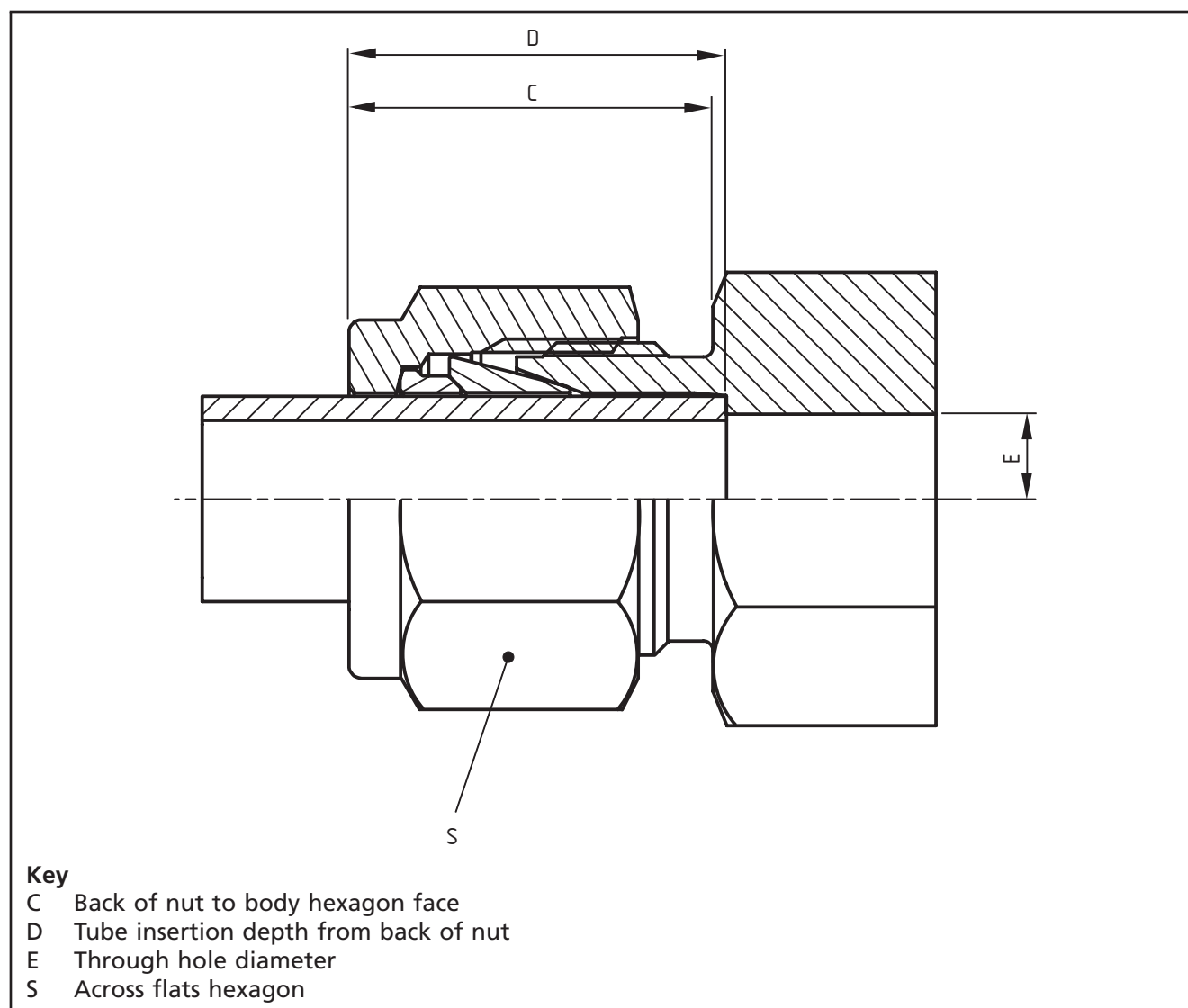


Table 2 Requirements for tube ends for tubes with imperial outside diameter sizes

Designated tube size number ^{A)}	Tube O.D. ^{B)}	Requirements					
		Straight thread for nut end of tube fitting ^{C)}	C ^{D)} ±1/64 in	S	S	E	D ^{D)}
	in	in	in	in	mm	in	in
1	1/16	No. 10 x 32 UN	0.43	5/16	8	0.052	0.34
2	1/8	5/16 in x 20 UN	0.60	7/16	12	0.093	0.50
3	3/16	3/8 in x 20 UN	0.64	1/2	12	0.125	0.54
4	1/4	7/16 in x 20 UN	0.70	9/16	14	0.187	0.60
5	5/16	1/2 in x 20 UN	0.73	5/8	16	0.250	0.64
6	3/8	9/16 in x 20 UN	0.76	11/16	19	0.281	0.67
8	1/2	3/4 in x 20 UN	0.87	7/8	22	0.406	0.90
10	5/8	7/8 in x 20 UN	0.87	1	25	0.500	0.96
12	3/4	1 in x 20 UN	0.87	1 1/8	30	0.625	0.96
14	7/8	1 1/8 in x 20 UN	0.87	1 1/4	32	0.750	1.03
16	1	1 5/16 in x 20 UN	1.05	1 1/2	38	0.875	1.24
20	1 1/4	1 5/8 in x 20 UN	1.52	1 7/8	46	1.090	1.61
24	1 1/2	1 5/16 in x 20 UN	1.77	2 1/4	60	1.340	1.96
32	2	2 5/8 in x 20 UN	2.47	3	76	1.810	2.65

NOTE All tolerances are ±1.6 mm (1/16 in) unless otherwise stated.

A) See 6.9.

B) Tolerances for the tube outside diameter shall be in accordance with ASTM A269.

C) UN = Unified thread conforming to BS 1580.

D) Average value.

Figure 4 Compression end nut

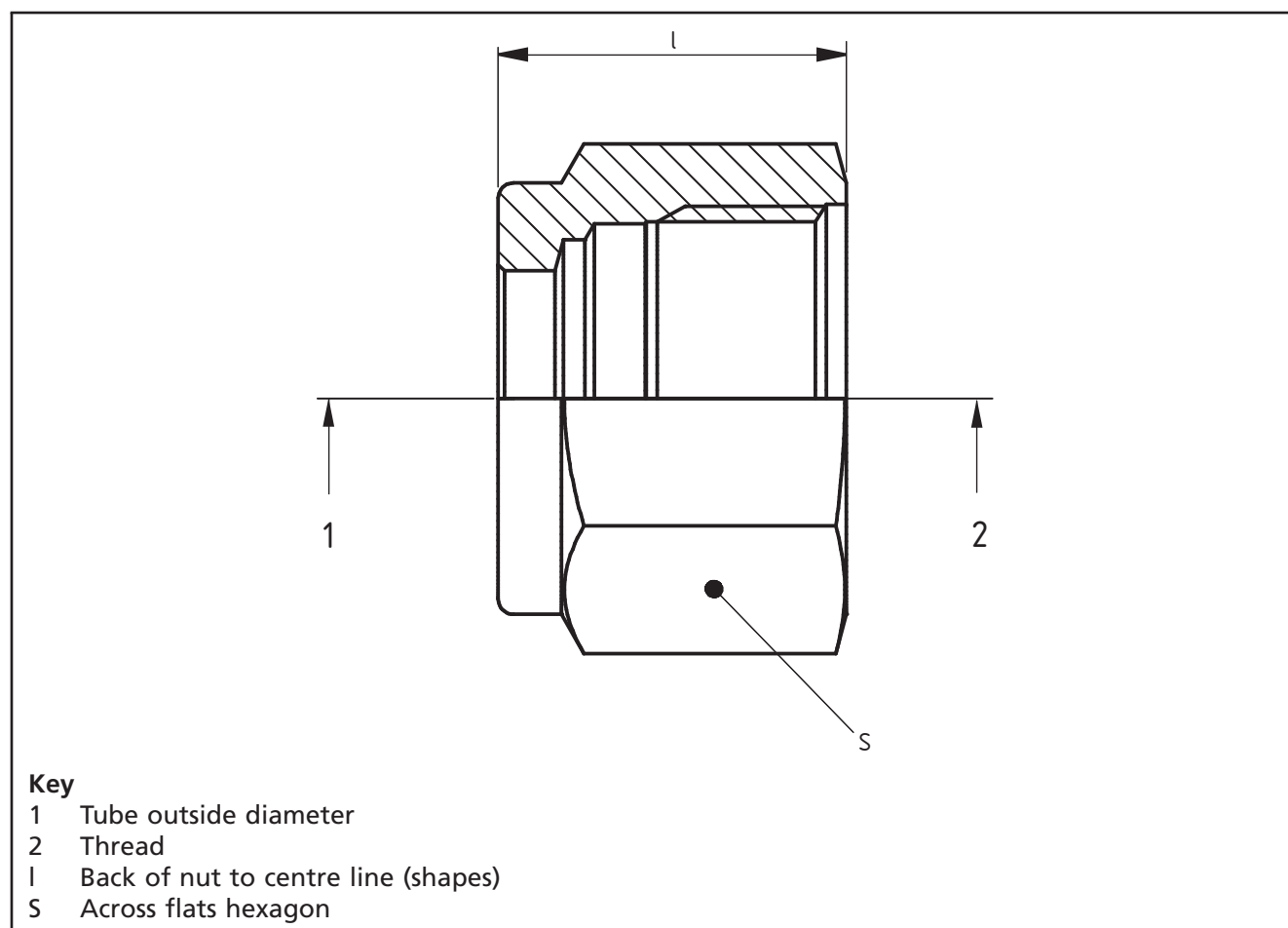


Table 3 Requirements for compression end nuts for tubes with metric outside diameter sizes

Tube O.D. ^{A)} mm	Requirements			
	Straight thread ^{B)} in/mm	l mm	S mm	S in
2	$\frac{5}{16}$ in × 20 UN	11.9	12.0	$\frac{7}{16}$
3	$\frac{5}{16}$ in × 20 UN	11.9	12.0	$\frac{7}{16}$
4	$\frac{3}{8}$ in × 20 UN	11.9	12.0	$\frac{1}{2}$
6	$\frac{7}{16}$ in × 20 UN	12.7	14.0	$\frac{9}{16}$
8	$\frac{1}{2}$ in × 20 UN	13.5	16.0	$\frac{5}{8}$
10	$\frac{5}{8}$ in × 20 UN	15.1	19.0	$\frac{3}{4}$
12	$\frac{3}{4}$ in × 20 UN	17.5	22.0	$\frac{7}{8}$
14	$\frac{7}{8}$ in × 20 UN	17.5	25.0	$\frac{15}{16}$
15	$\frac{7}{8}$ in × 20 UN	17.5	25.0	$\frac{15}{16}$
16	$\frac{7}{8}$ in × 20 UN	17.5	25.0	1
18	1 in × 20 UN	17.5	30.0	$1\frac{3}{16}$
20	$1\frac{1}{8}$ in × 20 UN	17.5	32.0	$1\frac{1}{4}$
22	$1\frac{1}{8}$ in × 20 UN	17.5	32.0	$1\frac{1}{4}$
25	$1\frac{5}{16}$ in × 20 UN	20.6	38.0	$1\frac{1}{2}$
28	M37 × 1.5 mm	30.6	46.0	$1\frac{7}{8}$
30	M40 × 1.5 mm	32.7	50.0	2
32	M42 × 1.5 mm	34.4	50.0	2
38	M50 × 1.5 mm	40.6	60.0	$2\frac{3}{8}$

NOTE All tolerances are ± 1.6 mm ($\frac{1}{16}$ in) unless otherwise stated.

^{A)} Tolerances for the tube outside diameter shall be in accordance with ASTM A269.

^{B)} UN = Unified thread conforming to BS 1580; M = metric thread conforming to BS 3643.

Table 4 Requirements for compression end nuts for tubes with imperial outside diameter sizes

Tube O.D. ^{A)}	Requirements			
	Straight thread ^{B)}	l	S	S
In	in	in	in	mm
$\frac{1}{16}$	No. 10 × 32 UN	0.310	$\frac{5}{16}$	8.0
$\frac{1}{8}$	$\frac{5}{16} \times 20$ UN	0.470	$\frac{7}{16}$	12.0
$\frac{3}{16}$	$\frac{3}{8} \times 20$ UN	0.470	$\frac{1}{2}$	12.0
$\frac{1}{4}$	$\frac{7}{16} \times 20$ UN	0.500	$\frac{9}{16}$	14.0
$\frac{5}{16}$	$\frac{1}{2} \times 20$ UN	0.530	$\frac{5}{8}$	16.0
$\frac{3}{8}$	$\frac{9}{16} \times 20$ UN	0.560	$\frac{11}{16}$	19.0
$\frac{1}{2}$	$\frac{3}{4} \times 20$ UN	0.690	$\frac{7}{8}$	22.0
$\frac{5}{8}$	$\frac{7}{8} \times 20$ UN	0.690	1	25.0
$\frac{3}{4}$	1 × 20 UN	0.690	$1\frac{1}{8}$	30.0
$\frac{7}{8}$	$1\frac{1}{8} \times 20$ UN	0.690	$1\frac{1}{4}$	32.0
1	$1\frac{5}{16} \times 20$ UN	0.810	$1\frac{1}{2}$	38.0
$1\frac{1}{4}$	$1\frac{5}{8} \times 20$ UN	1.250	$1\frac{7}{8}$	46.0
$1\frac{1}{2}$	$1\frac{15}{16} \times 20$ UN	1.500	$2\frac{1}{4}$	57.0
2	$2\frac{5}{8} \times 20$ UN	2.062	3	76.0

NOTE All tolerances are ± 1.6 mm ($\frac{1}{16}$ in) unless otherwise stated.

^{A)} Tolerances for the tube outside diameter shall be in accordance with ASTM A269.

^{B)} UN = Unified thread conforming to BS 1580.

Figure 5 Union connector

