BS EN 4560:2015

BSI Standards Publication

Aerospace series — Pipe coupling 37°, spherical up to 21 000 kPa — Inch series — Technical specification

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National foreword

This British Standard is the UK implementation of EN 4560:2015. It supersedes BS EN 4560:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/69, Aerospace hydraulic systems, fluids and components.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Aerospace series - Pipe coupling 37°, spherical up to 21 000 kPa - Inch series - Technical specification

Série aérospatiale - Système de raccordement sphérique 37°, jusqu'à 21 000 kPa - Série inch - Spécification technique

Luft- und Raumfahrt - Rohrverschraubung 37° mit Kugelbuchse, bis 21 000 kPa - Inch-Reihe - Technische Lieferbedingungen

This European Standard was approved by CEN on 10 January 2015.

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CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Contents

European foreword

This document (EN 4560:2015) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this European Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2016, and conflicting national standards shall be withdrawn at the latest by January 2016.

This document supersedes EN 4560:2003.

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1 Scope

This European Standard specifies the required characteristics, inspection and test methods, quality assurance and procurement requirements for inch series, pipe coupling, 37°, spherical, for temperature ranges from type II to type V according to ISO 6771 and nominal pressure up to 21 000 kPa.

In addition to the requirements of this technical specification, the coupling assemblies shall be qualified in accordance with equipment or component specification requirements.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

prEN 2951, *Metallic materials — Test method — Micrographic determination of content of non-metallic inclusions* [1)]

EN 9133, *Aerospace series — Quality management systems — Qualification procedure for aerospace standard parts*

EN 10204, *Metallic products — Types of inspection documents*

EN ISO 1302, *Geometrical Product Specification (GPS) — Indication of surface texture in technical product documentation (ISO 1302)*

ISO 2685, *Aircraft — Environmental test procedure for airborne equipment — Resistance to fire in designated fire zones*

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 6771, *Aerospace — Fluid systems and components — Pressure and temperature classifications*

ISO 6772, *Aerospace — Fluid systems — Impulse testing of hydraulic hose, tubing and fitting assemblies*

ISO 7137, *Aircraft — Environmental conditions and test procedures for airborne equipment*

ISO 8625-1, *Aerospace — Fluid systems — Vocabulary — Part 1: General terms and definitions related to pressure*

TR 2674, *Aerospace series — Design and construction of pipelines for fluids in liquid or gaseous condition — Rigid lines, installation* [2)]

MIL-L-23699, *Lubricating Oil, Aircraft Turbine Engine, Synthetic Base, NATO Code Number O-156* [3)]

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1) Available on ASD-STAN website (http://www.asd-stan.org/).

2) Published as ASD-STAN Technical Report at the date of publication of this European Standard (http://www.asd-stan.org/).

3) Published by : Department of Defense (DoD), the Pentagon, Washington, D.C. 20301, US (http://www.defenselink.mil/).

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Pressure

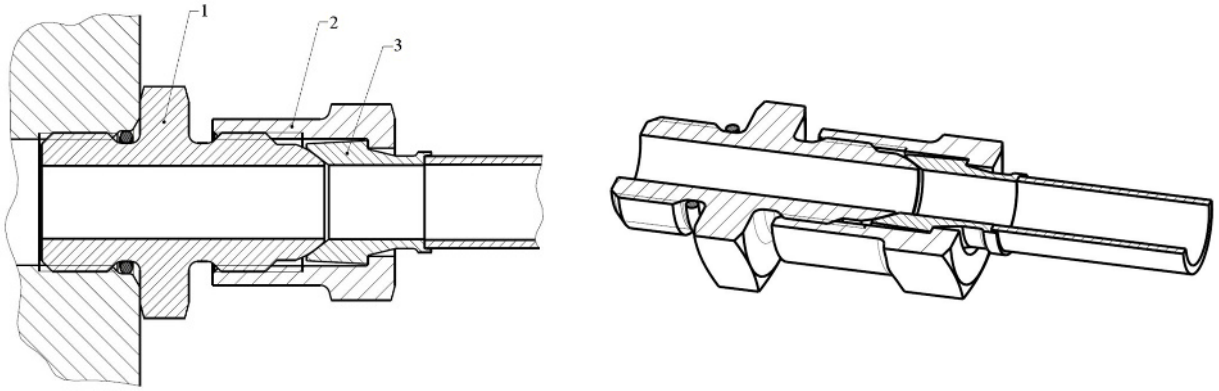
nominal pressure, proof pressure, impulse pressure, burst pressure according to Table 1 below.

Table 1

Dimensional code	Nominal diameter	Wall thickness 0,71 mm				Wall thickness 0,89 mm			
		Nominal pressure	Proof pressure	Impulse pressure	Burst pressure	Nominal pressure	Proof pressure	Impulse pressure	Burst pressure
	mm	bars	bars	bars	bars	bars	bars	bars	bars
03	4,76	210	420	210	840	210	420	210	840
04	6,35								
05	7,92		360		720				
06	9,52	160	270		540		360		720
08	12,70	105	210	105	420	160	270		540
10	15,87		180		360	105	210	105	420
12	19,05		140		280		180		360
16	25,40	40	105	40	210		140		280

3.2 Coupling and assembling

3.2.1
coupling assembly
assembled nut, ferrule and pipe mating with e.g. nipple, union, elbow, see Figure 1



Key

1 Straight union
2 Nut
3 Ferrule

Figure 1 — Example of coupling assembly

3.2.2
dimensional code
corresponds to the nominal diameter given in 16^{th} of inches within two digits

3.2.3
snug
moment when positive resistance to rotation is observed during assembling

3.3 Surface defects

3.3.1
surface irregularity
nonconformity with general surface appearance, possible defect

3.3.2
crack
clean (crystalline) fracture passing through or across the grain boundaries that possibly follows inclusions of foreign elements. Cracks are normally caused by overstressing the metal during forging or other forming operations, or during heat treatment. Where parts are subject to significant reheating, cracks are usually discoloured by scale

3.3.3
fold
doubling over of metal, which can occur during the forging operation. Folds can occur at or near the intersection of diameter changes and are especially prevalent with non-circular necks, shoulders and heads.

3.3.4
lap
fold-like machining defect

3.3.5
seam
(1) usually a surface opening or crack resulting from a defect obtained during casting or forging
(2) extraneous material, stringer in the material, which is not homogeneous with base metal

3.3.6
pit
void or hole in the surface as caused, for example, by corrosion

3.4 Quality assurance

3.4.1
production batch
definite quantity of some commodity or service produced at one time under conditions that are presumed uniform

3.4.2
delivery batch
batch consisting of couplings with the same identity block which may come from different production batches

3.4.3
acceptance quality limit
AQL
when a continuing series of lots is considered, a quality level which for the purposes of sampling inspection is the limit of a satisfactory process average

3.4.4
qualification
testing required to demonstrate successful performance of the coupling assembly in simulated service (overload, destructive and fatigue tests)

3.4.5
major defect
defect other than critical, that is likely to result in a failure or to reduce materially the usability of the considered product for its intended purpose

3.4.6
minor defect
defect that is not likely to reduce materially the usability of the considered product for its intended purpose, or that is a departure from established specification having little bearing on the effective use or operation of this product

4 Requirements, inspection and test methods

See Table 2 and Table 3.

Qualification tests given from 4.12 to 4.15 shall only be made when required. Complementary qualification tests may be determined in direct relation with the application (e.g. vibration test, thermal shock test).

The coupling shown on the figures of this European Standard are for information only. The test specimens shall be assembled with the part to test (e.g. elbow fitting instead of straight fitting).

Non removable coupling (e.g. welded elbow, welded reducer) shall be tested on sample pipes in combination with removable (threaded) couplings.

4.1 Test conditions and preparation of specimens for qualification

4.1.1 Test fluids

Unless otherwise specified, tests shall be carried out using e.g. oil compatible with the test temperature range. Water may be used, whenever practical, for proof, burst, stress corrosion and re-use capability testing.

4.1.2 Specimen preparation

Shaped parts shall be machined with the grain flow of the bar or plate in the direction of the fluid. Installations on the coupling shall be in accordance with TR 2674. The coupling shall not be lubricated prior the first assembling. For the next assembling they shall be lubricated with engine oil (e.g. according to MIL-L-23699) at the interface between the nut and the ferrule.

Prior to testing, and unless otherwise specified, all couplings with dimensional code up to 12 shall be assembled using either of the following methods. For couplings with dimensional code greater than 12 the assembling shall be made by using the torque tightening method:

— torque tightening method:

  A torque value comprised between the minimum and the maximum given in Table 4 shall be applied to the nut per TR 2674.

— angle tightening method:

  The following sequence shall be applied:

  1) tighten the nut with a wrench to snug;

  2) turn the nut an additional 60° [see Figure 2 a)];

3) loosen the nut; (for new parts assembling only);

4) retighten the nut with a wrench to snug;

5) turn the nut an additional 30° [see Figure 2 b)]. Figure 2 c) gives also a checking method by using and returning an open end wrench with a 15° offset.

The torque tightening method used for the test and value applied shall be recorded.

4.1.3 Pipe assembly

The method of joining the pipe to the coupling (brazing, welding, mechanical attachment, etc.) shall not be detrimental to the properties, strength or geometry of the pipe assembly. The joint shall be in accordance with the design instructions and shall be inspected by direct measurement, X-ray or other non-destructive methods.

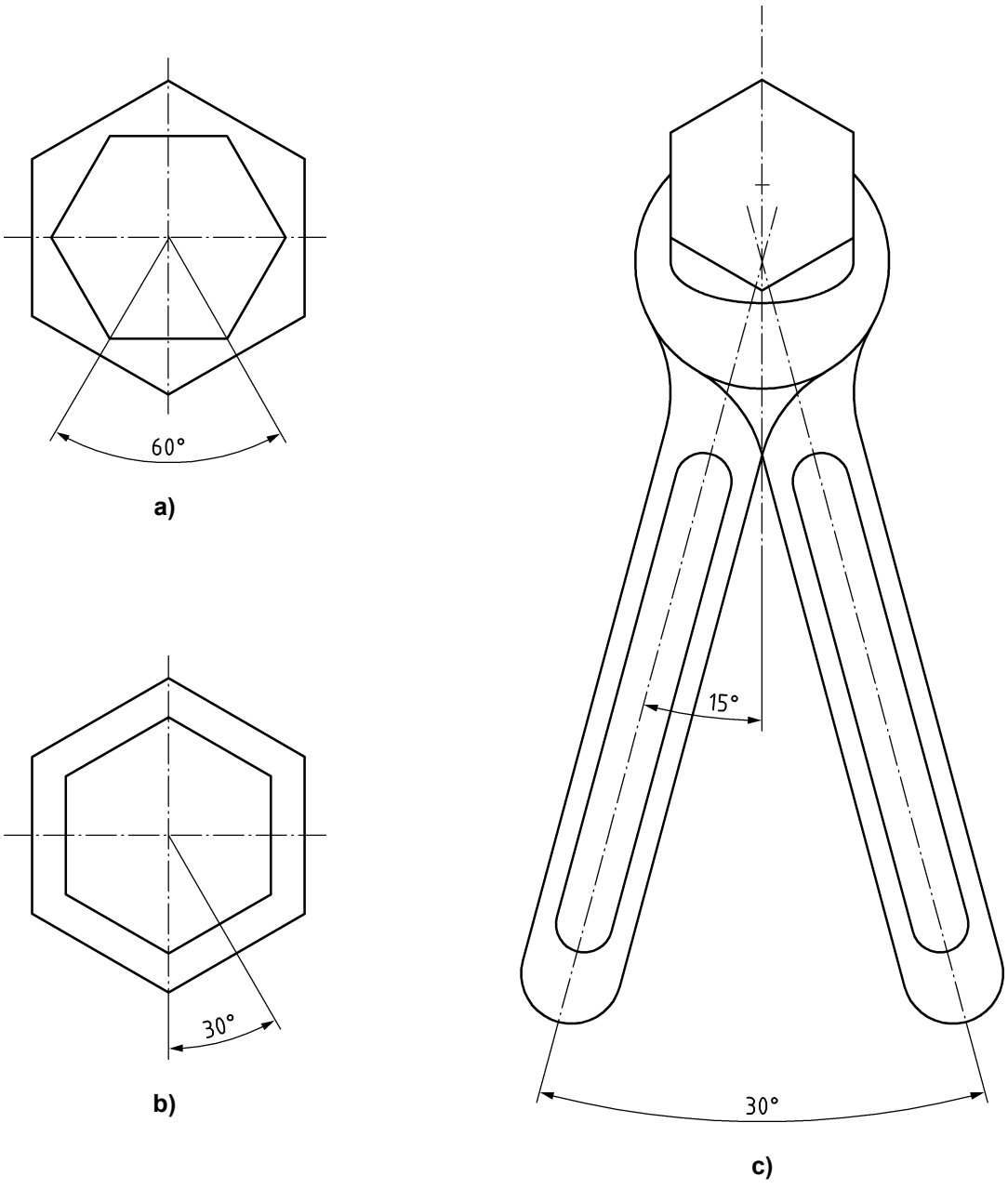


Figure 2 — Configuration for angle tightening method

Table 2 — Requirements, inspection and test methods *(1 of 3)*

<table>
<tr><th>Clause</th><th>Characteristic</th><th>Requirement</th><th>Inspection and test method</th><th>Q [a]</th><th>A [b]</th></tr>
<tr><td>4.2 [b]</td><td>Materials</td><td>Metallic materials shall meet the acceptance criteria given in prEN 2951.
Conformity with the product standards</td><td>Metallic materials shall be tested in accordance with prEN 2951.
Certificate of compliance to EN 10204 issued by the semi-finished product manufacturer</td><td>X
100 %</td><td>X
100 %</td></tr>
<tr><td>4.3 [b]</td><td>Dimensions</td><td>Conformity with the product standards</td><td>Suitable measuring instruments</td><td>X
100 %</td><td>X
20 %</td></tr>
<tr><td>4.4 [b]</td><td>Product identification</td><td>Marking according to product standards. It shall be legible and shall not adversely affect the material or the functioning of the products.</td><td>Visual examination</td><td>X
100 %</td><td>X
100 %</td></tr>
<tr><td>4.5 [b]</td><td>Surface roughness</td><td>Conformity with the product standards Interpreted in accordance with EN ISO 1302.</td><td>Suitable measuring instruments or visual-tactile samples</td><td>X
100 %</td><td>X
200 %</td></tr>
<tr><td>4.6 [b]</td><td>Surface coating or treatment</td><td>Conformity with the product standards</td><td>Visual examination</td><td>X
100 %</td><td>X
50 %</td></tr>
<tr><td>4.7 [b]</td><td>Surface defects</td><td>Parts shall be free from surface defects indicated in 3.3 liable to have an adverse effect on their characteristics and endurance.</td><td>Visual inspection using suitable methods</td><td>X
100 %</td><td>X
100 %</td></tr>
<tr><td></td><td>Threads</td><td>The external threads of couplings should be rolled and, if machined, shall have a maximal value of 1,6 µm for R_a in accordance with EN ISO 1302.
Laps, cracks, surface irregularities and seams (see 3.3) are not acceptable on any part of the pressure thread flank, in the thread root or on the non-pressure thread flank.
Laps and seams, depths of which are within the limits of table, are acceptable on the crest and the non-pressure thread flank above the pitch diameter.
<table>
<tr><th>Dimensional code</th><th>Depth
mm</th></tr>
<tr><td>03</td><td>0,15</td></tr>
<tr><td>04</td><td>0,18</td></tr>
<tr><td>05</td><td>0,18</td></tr>
<tr><td>06</td><td>0,2</td></tr>
<tr><td>08</td><td>0,23</td></tr>
<tr><td>10 to 16</td><td>0,25</td></tr>
</table>
Threads may be cut or rolled.</td><td>Visual examination</td><td>X
100 %</td><td>X
100 %</td></tr>
<tr><td></td><td></td><td>The grain flow in rolled threads shall be continuous and follow the general thread contour with the maximum density at the thread root.</td><td>Thread flanks in rolled threads shall be examined by micro-examination. Specimens shall be taken from the finished part by sectioning on a longitudinal plane across the threaded area. The specimens shall be polished and etched to reveal the surface defects.</td><td>X
2
specimens</td><td></td></tr>
</table>

Table 2 — Requirements, inspection and test methods *(2 of 3)*

Clause	Characteristic	Requirement	Inspection and test method	Q [a]	A [b]
4.8	**Proof pressure**	The coupling assembly shall withstand and shall not show any evidence of permanent deformation or other malfunction that would affect assembly or disassembly without any relative pressure when using the specified torque values.	The coupling assembly shall be connected to a pressure source at a pressure equal to proof pressure for at least five minutes at ambient temperature with one end free to move.	X	
4.9	**Gaseous pressure**	There shall be no visible formation of bubble.	The coupling assembly shall be solvent cleaned and air dried prior to testing. It shall be assembled and tightened to the torque value specified in Table 4. It shall be immersed in water bath at ambient temperature. It shall then be pressurised with air or nitrogen to (500 ± 50) kPa with 0,5 % to 1 % of wetting agent (make up by volume) for at least five minutes, at ambient temperature.	X	
4.10	**Burst pressure**	The coupling assembly shall withstand this test without leakage. Pipe expansion is permissible. The coupling assemblies need not meet any disassembly or assemblies requirements after this test.	The coupling assembly shall be connected to a pressure source at a pressure equal to burst pressure for at least five minutes, when tested at ambient temperature with one end free to move.	X	
4.11	**Re-use capability**	The coupling assembly shall withstand 8 repeated assemblies, without any of the following defects: — leakage at any of the proof or gaseous pressure tests; — nut deformation; — excessive galling or damage to any surfaces of the coupling assembly which prevents the specified tightening torque from being applied smoothly; — inability to tighten the coupling by hand. The following value shall also be recorded: — stress level in pipe while torquing and after assembling; — axial distance between the nut and the corresponding threaded part after each assembling; — hole dimensions of each coupling assembly part after each disassembling.	The coupling assembly shall be tested according to Figure 3 with one end torqued to the maximum and the other to the minimum value of the tightening torque with no additional lubricant permitted for the first tightening. Each coupling assembly shall then be disassembled, and the sealing face rotated 60° to 90°; the coupling assembly shall then be lubricated with the test fluid on threads only and retorqued to the original value to a minimum of × 8. After the first, the 4th and the final tightening operation, the coupling shall be subjected to the gaseous pressure test according to 4.9. After the last one, coupling shall be subjected to proof pressure test according to 4.8.	X	
4.12	**Impulse**	The coupling assembly shall withstand 200 000 impulse pressure cycles without leakage. The temperature type and pressure class in accordance with ISO 6771 and Table 1 used for this test shall be recorded and be compliant with temperature and pressure range of the application.	The coupling assembly shall be tested according to Figure 3 with one end torqued to the maximum and the other to the minimum value of the tightening torque. The coupling assembly shall be impulse tested at the impulse pressure specified in Table 1 and at the temperatures in the sequence specified in ISO 6772.	X	

Table 2 — Requirements, inspection and test methods *(3 of 3)*

Clause	Characteristic	Requirement	Inspection and test method	Q [a]	A [b]
4.13	**Stress corrosion resistance** (welded joining only)	The coupling assembly shall withstand salt spray exposure without any leakage neither during the salt spray test nor during the burst pressure test.	The coupling assembly shall be installed in a test apparatus (see Figure 4) which imposes a bending stress level equal to (85 ± 5) % of $R_{p0,2}$ of the pipe material at the seal interface. Internal pressure equal to the nominal pressure shall be applied without removing the bending stress. The coupling assembly shall then be subjected to the salt spray test in accordance with ISO 7137. After exposure, the coupling assembly shall be subjected to the burst pressure test according to 4.10.	X	
4.14	**Tensile strength** (welded joining only)	The coupling assembly shall withstand a tensile load ≥ the burst pressure x the cross sectional area of the pipe. It shall be demonstrated that the coupling assembly is at least as strong as the associated pipe.	The coupling assembly shall be mounted as shown on Figure 3 in a tensile test machine with no internal fluid or pressure. The tensile load shall be applied at a constant speed at a rate of (4 ± 2,5) mm/min until rupture of the associated pipe.	X	
4.15	**Resistance to fire**	The coupling assembly shall be fire-proof for 15 min without leakage.	In accordance with ISO 2685.	X	

[a] Q: Qualification, A: Acceptance.

[b] Applicable to parts prior to assembly.

Table 3 — Specimens for qualification of coupling assemblies

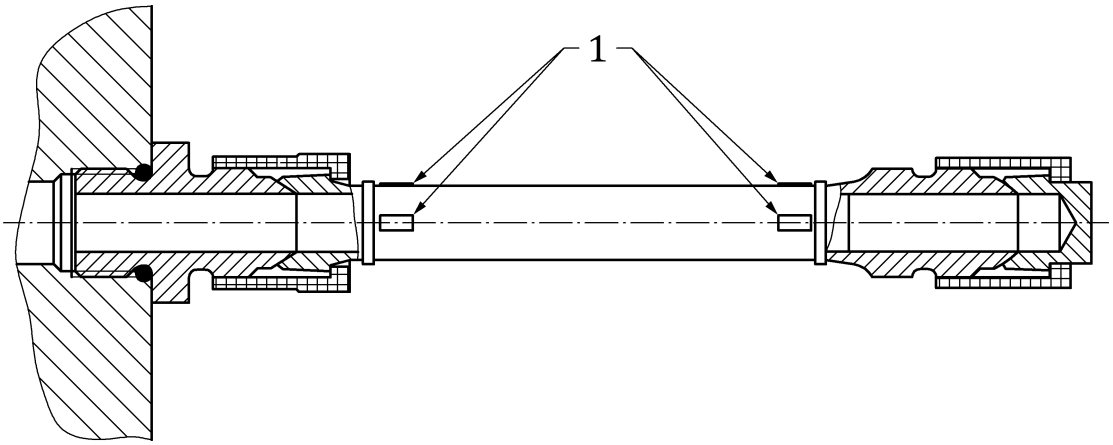
Test	Clause	Quantity	Specimen number	Sizes
Proof pressure	4.8	All coupling assemblies prior to the following tests		All
Gaseous pressure	4.9	2	1 and 2	
Burst pressure	4.1		3 and 4 [a]	
Re-use capability	4.11		5 and 6	
Impulse resistance	4.12		8 and 9 [b]	
Stress corrosion resistance	4.13		10 and 11	
Tensile strength	4.14		12 and 13	
Resistance to fire	4.15		14 and 15	

[a] Same specimens may be tested as those used for the gaseous pressure test (see 4.9).

[b] Same specimens may be tested as those used for the re-use capability test (see 4.11).

Table 4 — Torque values for couplings

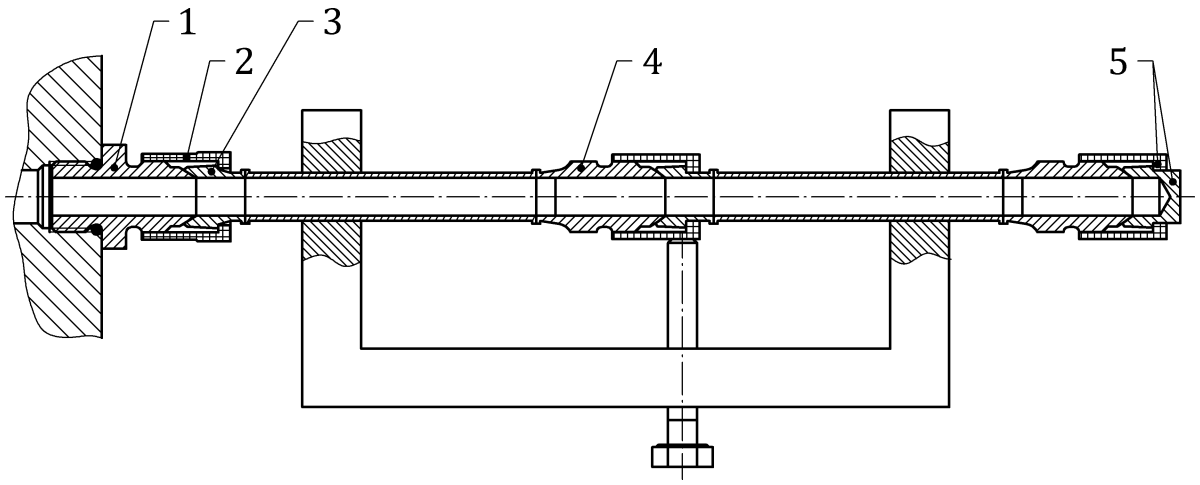
Dimensional code	Nominal diameter	Torque Nm	
	mm	max.	min.
03	4,763	11,3	10,2
04	6,350	17	15,3
05	7,924	23	20
06	9,525	35	30
08	12,700	60	50
10	15,875	85	75
12	19,050	125	100
16	25,400	175	150



Key

1 Strain gauges

Figure 3 — Configuration of coupling assemblies for re-use capability, impulse and tensile strength tests



Key

1 Straight union
2 Nut
3 Ferrule
4 Straight nipple
5 Cap assembly

Figure 4 — Configuration of coupling assemblies for stress corrosion resistance test

5 Quality assurance

5.1 Product qualification

The manufacturer shall obtain qualification in accordance with this European Standard and EN 9133.

5.2 Quality control records

The manufacturer shall maintain a record of inspection applied to each production batch for a minimum of five years. Records of chemical composition analysis, mechanical property tests showing conformance with the applicable material specification and metallurgical tests shall be made available to the purchaser (user) of each delivery batch of coupling parts upon request.

Each delivery batch shall be traceable to its production batch.

5.3 Acceptance conditions

The acceptance of a delivery batch shall be in accordance with 4.2 to 4.7.

Non-destructive tests for inspection of threads, finish, dimensions, marking, surface defects shall be conducted on a sampling basis in accordance with ISO 2859-1.

5.3.1 Classification of defects

Defects are classified in Table 5 according to the effect they have on safety and usability. Definition of classes shall be in accordance with ISO 2859-1.

5.3.2 Level of inspection

The following acceptance quality limits (AQL) shall apply to the defect classifications shown in Table 5.

Failure class Major: AQL 1,5

Failure class Minor: AQL 4,0

All defects not identified in Table 5 shall be inspected in accordance with the "minor defect" classification, AQL 4,0.

5.4 Rejection

Parts subjected to non-destructive tests and failing to conform to the requirements of these tests shall be rejected.

Parts identified as having major defects during acceptance test require a rejection of all parts as above. Parts identified as having minor defects require the definition of a procedure by the quality assurance department of the purchaser (user).

5.5 Purchaser's (user's) quality control

The purchaser (user) may, on receiving of a delivery batch, proceed to inspect it by using the methods specified in 4.2 to 4.7, in full or in part, to ensure that the items conform to the required quality level, and to determine whether the delivery batch is acceptable.

This inspection may be carried out in the purchaser's (user's) factory, or by special agreement with the manufacturer, in the manufacturer's factory.

Table 5 — Acceptance criteria *(1 of 2)*

Male sealing end			Tee, elbow		
Class of defect	**AQL**		**Class of defect**	**AQL**	
		Nonconformity on:			Nonconformity on:
Major	1,5	— thread length, size and form; — distance from spherical end to hexagon; — surface finish; — bore diameter; — seal diameter and distance from the spherical end; — coaxiality of all diameters;	Major	1,5	— wall thickness; — external radii;
Minor	4,0	— hexagon dimension; — radii, chamfer.	Minor	4,0	— distance from sealing end to welding end axis; — marking.

Table 5 — Acceptance criteria *(2 of 2)*

Port end			**Ferrule, cap**		
Class of defect	**AQL**		**Class of defect**	**AQL**	
		Nonconformity on:			Nonconformity on:
Major	1,5	— thread length, size and form; — groove dimension; — coaxiality of all diameters.	Major	1,5	— surface finish; — bore diameter; — overall diameter; — coaxiality of all diameter; — distance from sealing end to nut setting face; — seal diameter and angle; — circular run-out of bearing surfaces for the tube to outside diameter;
Minor	4,0	— hexagon dimension; — locking wire holes dimensions and location.	Minor	4,0	— radii, chamfer; — wall thickness (for cap).
Welding end			**Nut**		
Class of defect	**AQL**		**Class of defect**	**AQL**	
		Nonconformity on:			Nonconformity on:
Major	1,5	— minimum distance from welding plan to external conical location; — bore diameters; — overall length; — coaxiality of all diameters; — surface treatment or coating; — radii, chamfer;	Major	1,5	— coaxiality of all diameters to pitch diameter; — thread length, size and form; — bore diameter; — overall dimensions; — internal radius; — surface treatment or coating;
Minor	4,0	— surface finish.	Minor	4,0	— hexagon dimension; — marking; — locking wire holes diameter and location.
Preparation for delivery					
Class of defect	**AQL**				
		Nonconformity on:			
Major	1,5	— any component (component missing, damaged, or otherwise defective);			
Minor	4,0	— marking (missing, incorrect, incomplete, illegible, of improper size, location, sequence or method of application); — number per package unit (more or less than stipulated); — gross or net weight (exceeds the requirement).			

6 Preparation for delivery

6.1 Cleaning

Before packaging, all parts shall be free from grease, oil, dirt or other foreign matter. No preservative compound shall be applied.

6.2 Preservation and packaging

Prior to packaging, couplings or their assembled components shall be protected by capping all threaded ends and tube attachment ends with caps or plugs to avoid the introduction of foreign matter. Appropriate choice of plastic material, thread tolerances and design of caps/plugs shall prohibit contamination and damage to the part during transportation or storage.

Unless otherwise agreed, the parts shall be packed on cardboard flats tightly enclosed by a transparent bag (skin package) to ensure protection from damage. Each flat shall be pre-printed or a label affixed for identification. As an alternative, each part may be individually packaged in polyethylene bags or net and then unit packaged.

Unless otherwise agreed, nuts, nipples and ferrules of one type and size shall be unit packaged in the quantity per unit as specified in Table 6. Each unit package shall be identified with the following information:

— manufacturer identity;

— description block of the parts;

— density block of the parts;

— quantity per package unit.

Table 6 — Quantity per unit

Dimensional code	Quantity
03 to 08	100
10 to 16	25

Annex A
(informative)

Standard evolution form

MODIFICATION	REASON AND VALIDATION
Subclause 3.1 Before: No table, pressures defined by ISO 8625-1. After: Table 1 defining nominal, proof, impulse and burst pressures according to diameter and tube thickness.	Pressure defined in ISO 8625-1 cannot be applied to that coupling. Nominal pressures have been calculated according to mechanical characteristics of the tube
Before: Clause 4 Table 1 (*continued*) **(§ 4.8, § 4.10, § 4.12)** Proof pressure = 2x nominal pressure Burst pressure = 4x nominal pressure Impulse pressure > ISO 6772 **(§ 4.11)** 25 repeated assemblies Gaseous pressure test after each fifth and the final tightening operation After: Clause 4 Table 1 becomes Table 2 (*continued*) **(§ 4.8, § 4.10, § 4.12)** For proof, burst and impulse pressure: reference to Table 1 page 5 **(§ 4.11)** 8 repeated assemblies Gaseous pressure test after the first, the fourth, and the final tightening operation	Ratio between proof or burst pressure and nominal pressure is not 2 and 4 anymore. These pressures have been calculated and integrated in Table 1. 25 repeated assemblies is a very strict requirement. Generally, common requirement for re-use test is 8 repeated assemblies
Before: Clause 4 Table 1 (*concluded*) (**§ 4.13**) … without any of the following defects: indications of cracking or pitting …. Indications of inter- or tansgranular corrosive attack … After: Clause 4 Table 1 becomes Table 2 (*continued*) (**§ 4.13**) … without any leakage neither during the salt spray test nor during the burst pressure test.	The aim of a coupling is to insure its sealing function, in the worst environmental conditions and particularly in a salt spray atmosphere. Requirement of 'no leakage' must be the main requirement for this test.
Before: Clause 4 Table 2 Specimen number for re-use test: 5 to 7 After: Clause 4 Table 2 becomes Table 3 Specimen number for re-use test: 5 and 6	A number of 2 specimens for re-use test is required as for the other tests

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