BS EN ISO 15546:2011

BSI Standards Publication

Petroleum and natural gas industries — Aluminium alloy drill pipe (ISO 15546:2011)

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National foreword

This British Standard is the UK implementation of EN ISO 15546:2011. It supersedes BS EN ISO 15546:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PSE/17/-/7, UK experts in ISO TC 67 Working Groups.

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Foreword

This document (EN ISO 15546:2011) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by March 2012, and conflicting national standards shall be withdrawn at the latest by March 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 15546:2007.

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Endorsement notice

The text of ISO 15546:2011 has been approved by CEN as a EN ISO 15546:2011 without any modification.

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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.

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ISO 15546 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

This third edition cancels and replaces the second edition (ISO 15546:2007), which has been technically revised.

Introduction

Users of this International Standard need to be aware that further or differing requirements could be needed for individual applications. This International Standard is not intended to inhibit a manufacturer from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application, this being particularly applicable where there is innovative or developing technology. Where an alternative is offered, the manufacturer will need to identify any variations from this International Standard and provide details.

This International Standard includes requirements of various nature. These are identified by the use of certain verbal forms:

— “shall” is used to indicate that a provision is mandatory;

— “should” is used to indicate that a provision is not mandatory, but recommended as good practice;

— “may” is used to indicate that a provision is optional.

INTERNATIONAL STANDARD **ISO 15546:2011(E)**

Petroleum and natural gas industries — Aluminium alloy drill pipe

1 Scope

This International Standard specifies the technical delivery conditions, manufacturing process, material requirements, configuration and dimensions, and verification and inspection procedures for aluminium alloy drill pipes with or without attached steel tool joints, for use in drilling and production operations in the petroleum and natural gas industries.

A typical drill pipe configuration is provided, showing main elements and lengths (see Figures 1 to 4). The main dimensions and masses of the grades of drill pipe are given in both SI units and USC units (see Annex A).

This International Standard does not consider performance properties.

NOTE 1 Reference can be made to ISO 10424-2 and ISO 27627 for the detailed requirements for the threading of drill pipe tool joints.

NOTE 2 Reference can be made to ISO 20312 for the performance properties of the drill pipe.

NOTE 3 Reference can be made to ISO 27627 for the “pipe body-tool joint” thread connection gauging.

2 Conformance

In this International Standard, data are expressed in both the International System (SI) of units and the United States Customary (USC) system of units.

Tables for data expressed in SI units are given in the body of this International Standard, whilst those expressed in USC units are given in Annex A. All figures in the body of this International Standard express data in both SI and USC units (the latter given in brackets), with the exception of Figure 11, which is reproduced as Figure A.1 using USC units. In the text, data in SI units are followed by data in USC units in brackets.

For a specific order item, it is intended that only one system of units be used, without combining data expressed in the other system.

Products manufactured to specifications expressed in either of these unit systems shall be considered equivalent and totally interchangeable. Consequently, compliance with the requirements of this International Standard as expressed in one system provides compliance with requirements expressed in the other system.

For data expressed in the SI system, a comma is used as the decimal separator and a space as the thousands separator. For data expressed in the USC system, a dot (on the line) is used as the decimal separator and a space as the thousands separator.

NOTE The procedures used to convert from SI units to USC units are given in Annex E.

3 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 6892 (all parts), *Metallic materials — Tensile testing*

ISO 6506 (all parts), *Metallic materials — Brinell hardness test*

ISO 10893-10, *Non-destructive testing of steel tubes — Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections*

ISO 10424-2*, Petroleum and natural gas industries — Rotary drilling equipment — Part 2: Threading and gauging of rotary shouldered thread connections*

ISO 11130, *Corrosion of metals and alloys — Alternate immersion test in salt solution*

ISO 11960:—[1)], *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ISO 11961, *Petroleum and natural gas industries — Steel drill pipe*

ASTM B594-09, *Standard Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications*

ASTM G1, *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens*

4 Terms, definitions and symbols

4.1 Terms and definitions

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

4.1.1
aluminium alloy drill pipe
aluminium alloy drill pipe body with threaded steel tool joints

4.1.2
aluminium alloy drill pipe body
aluminium alloy pipe formed by extrusion, including any upsets and protector thickening

4.1.3
box
tool joint part that has internal tool joint thread

4.1.4
corrosion
adverse chemical alteration or destruction of a metal by air, moisture or chemicals

4.1.5
defect
imperfection of sufficient magnitude to warrant rejection of the product based on the criteria of this International Standard

1) To be published. (Revision of ISO 11960:2004.)

4.1.6
gauge plane
imaginary plane, perpendicular to the thread axis of rotary shouldered connections, at which the pitch diameter at gauge point is measured

4.1.7
heat
metal melted with one continuous operation of one metal batch

4.1.8
imperfection
discontinuity in the product wall or on the product surface that can be detected by visual inspection or a non-destructive evaluation (NDE) method, as given in ISO 11960:—, Table C.42 or Table E.42

4.1.9
linear imperfection
imperfection which includes, but is not limited to, seams, laps, cracks, plug scores, cuts and gouges

NOTE See API STD 5T1 for terminology on imperfections.

4.1.10
lot
definite quantity of product manufactured under conditions that are considered uniform for the attribute being inspected

4.1.11
manufacturer
firm, company or corporation responsible for marking the product

NOTE Marking by the manufacturer warrants that the product conforms to this International Standard, and it is the manufacturer who is responsible for compliance with all of its applicable provisions.

4.1.12
pin
tool joint part that has external tool joint thread

4.1.13
pipe mill
firm, company or corporation that operates pipe-making facilities

4.1.14
plain pipe
part of aluminium alloy pipe body excluding upsets and protector thickening

4.1.15
room temperature
temperature between 5 °C and 50 °C

NOTE Between 41 °F and 122 °F.

4.1.16
seal gauge plane
imaginary plane, perpendicular to the thread axis of rotary shouldered connections, at which the seal estimated diameter is measured

4.1.17
tool joint
steel tool joint element for aluminium alloy drill pipes consisting of two parts (pin and box)

4.2 Symbols

D_{dp}	pipe body outside diameter
D_e	tool joint elevator bevel diameter
D_f	tool joint bevel diameter
D_{pe}	tool joint bevel diameter
D_{pt}	outside diameter of protector thickening
$D_{pt,min}$	outside diameter of protector thickening with lower limit of tolerance
D_{tj}	tool joint outside diameter
D_u	outside diameter of upset end
D_1	pipe end external bevel diameter
D_2	pipe end outside diameter in the end plane
D_3	pipe thread outside diameter in the end plane
D_4	pipe outside diameter in the seal estimated plane
d_b	tool joint box inside diameter
d_{dp}	pipe body inside diameter
d_p	tool joint pin inside diameter
d_u	inside diameter of the pipe upset
d_1	pipe thread inside diameter in the gauge plane
d_2	tool joint tapered bore diameter in the end plane
d_3	tool joint tapered bore diameter in the seal estimated plane
d_4	tool joint thread inside diameter in the gauge plane
d_5	tool joint thread inside diameter in the end plane
d_6	tool joint internal shoulder bevel diameter
f	hydrostatic pressure test factor
K	conversion coefficient
L_b	tool joint box length
L_{eu}	length of external upset end
L_{iu}	length of internal upset end

L_{pb}	tool joint pin outside diameter length
L_{pe}	pipe length without tool joint (the distance between the pipe ends)
L_{dp}	pipe length with tool joint (the distance between the tool joint box face and the pin shoulder)
L_1	length of external upset end transition zone
L_2	length of internal upset end transition zone
L_3	length of protector thickening transition zone
L_4	distance from tool joint end plane to inside shoulder face
L_5	distance between the pipe body end and the end of the external taper shoulder
M_b	cyclic bending moment
m_1	mass of the specimen before the test
m_2	mass of the specimen after the test
p	standard hydrostatic test pressure
$\sqrt{\text{Ra } x\left[y\right]}$	indicator of surface roughness, where x stands for values in 10^{-6} m and y stands for values in 10^{-6} in
S	surface area of the specimen
T_t	test time
t_{dp}	wall thickness of pipe body
t_u	wall thickness of upset end
V_k	corrosion rate
W_u	section modulus of pipe body upset area
Y_{min}	specified minimum yield strength of the pipe body
$\sqrt{y}$	indicator of surface roughness, where y stands for values in 10^{-6} in
σ	stress level

5 Information to be supplied when placing orders for drill pipe

5.1 Basic information

When placing orders for aluminium alloy drill pipe without threads, with threads but without tool joints, or with tool joints attached, the purchaser shall specify the following on the purchase order:

a) reference to this International Standard (i.e. ISO 15546);

b) quantity;

c) upset type (internal, external, with protector thickening) (see Tables 3 to 6 and Figures 1 to 4);

d) aluminium alloy drill pipe delivery condition (see 6.4 and Clause 15);

e) outside diameter of pipe body (see Tables 3 and 4);

f) wall thickness of pipe body (see Tables 3 and 4);

g) aluminium alloy name (see Table 1);

h) pipe range or special length and tolerance by agreement between purchaser and manufacturer (see 8.2, 8.3.3 and Table 2);

i) delivery date and shipping instruction;

j) inspection by purchaser (see Annex B);

k) variants of the tool joint elevator bevel, if ordered with tool joints or other special connection by agreement between purchaser and manufacturer (see Figure 8);

l) percentage of assembled pipes subject to hydrostatic testing (see 9.3).

5.2 Optional information

The purchaser should also state on the purchase order requirements concerning the following stipulations, which are at the option of the purchaser:

a) pipe coatings (see 8.10);

b) marking requirements (see Clause 12);

c) non-destructive inspection (see 11.2 and 11.3);

d) corrosion rate test for material Group IV (see Table 1);

e) test certificates (see 14.1).

6 Process of manufacturing and delivery condition

6.1 General

Aluminium alloy drill pipe body furnished to this International Standard shall be made by a seamless process.

6.2 Heat treatment

Aluminium alloy drill pipe bodies shall be heat treated by solution heat treatment followed by artificial or natural ageing. The aluminium pipe shall not be subjected to cold working after the final heat treatment process, except for that which is incidental to normal straightening or threading operations.

The temperature and time requirements for the solution and ageing heat treatment cycles shall be determined in accordance with the manufacturer's documented practice. Actual furnace temperatures and transfer timing shall be documented in order to verify that each heat treatment lot meets the manufacturer's documented requirements.

6.3 Traceability

The manufacturer shall establish and follow procedures for maintaining heat and/or lot identity until all required heat and/or lot tests have been performed and conformance with specification requirements has been verified. The procedures shall provide means for tracing tool joint and aluminium alloy drill pipe body to the relevant heat or lot and to the specified chemical, mechanical or other performed test result.

6.4 Delivery condition

Aluminium alloy drill pipes and aluminium alloy drill pipe bodies shall be supplied as:

a) plain end pipe (without threads);

b) threaded pipe (without tool joints);

c) with tool joints attached.

7 Material requirements

7.1 Material groups

Materials for aluminium alloy drill pipe bodies shall comply with the requirements specified in Table 1:

— Group I: aluminium alloy drill pipe body of base strength;

— Group II: aluminium alloy drill pipe body of high strength;

— Group III: aluminium alloy drill pipe body of elevated temperature resistance;

— Group IV: aluminium alloy drill pipe body of enhanced corrosion resistance.

Table 1 — Material requirements for aluminium alloy drill pipe bodies
(see Table A.1 for USC units)

Characteristics[a]	Unit	Material group			
		I	II	III	IV
Alloy name[b]	—	D16T	1953T1	AK4-1T1	1980T1
Minimum yield strength (0,2 % offset method)	MPa	325	480	340	350
Minimum tensile strength	MPa	460	530	410	400
Minimum elongation	%	12	7	8	9
Maximum operational temperature	°C	160	120	220	160
Maximum corrosion rate in 3,5 % sodium chloride solution	g/(m^{2}h)	—	—	—	0,08
It is permitted to use an alternative aluminium alloy, as long as there is purchaser agreement and this alloy conforms to the requirements of one of the four material group categories. Mechanical testing shall be made in accordance with ISO 6892. Maximum operational temperature is a material temperature that results in the minimum room temperature yield strength reduction by no more than 30 % at the exposure time of 500 h. See ISO 20312 for material yield strength reduction at other operating temperatures.					
[a] The mechanical properties of the alloys given in this table are for a test temperature of (20 ± 3) °C. [b] For chemical composition and properties of alloys, see References [9] and [11].					

7.2 Metallographic examination

Each heat treatment lot sample shall undergo metallographic examination. The macrostructure shall be homogeneous, without cracks, pits, laminations, shrinkage cavities, surface tears or sponginess. The microstructure shall not contain porosities or grain boundary eutectic melting resulting from solution heat treatment.

For terminology relating to microstructure examination, see ASTM B917.

7.3 Chemical composition

Chemical analysis shall be undertaken on each heat. The manufacturer shall establish limits for chemical composition and shall confirm to the established limits.

7.4 Steel tool joints

Material requirements for steel tool joints shall conform to ISO 11961.

8 Configuration and dimensions of pipes

8.1 Configuration

The configuration of the aluminium alloy drill pipe shall be in accordance with Figure 1 for pipes with internal upset ends, with Figure 2 for pipes with external upset ends, and with Figures 3 and 4 for pipes with protector thickening.

8.2 Length

Aluminium alloy drill pipe and aluminium alloy drill pipe body length ranges shall comply with the requirements specified in Table 2 and Figure 1.

Table 2 — Aluminium alloy drill pipe and aluminium alloy drill pipe body length (see Figure 1)
(see Table A.2 for USC units)

Dimensions in metres

Pipe delivery condition	Range		
	1	2	3
Aluminium alloy drill pipe, L_{dp}, tolerance ±0,25	6,20	9,10	11,80
Aluminium alloy drill pipe body, L_{pe}, tolerance ±0,25	5,80	8,70	11,40
Other pipe lengths can be ordered by agreement between manufacturer and purchaser.			

8.3 Dimensions of pipes and tool joints

8.3.1 Standard configuration

The configuration and dimensions of the pipe body and upset ends, together with the tolerances, shall be in accordance with the following tables and figures and/or with the purchase agreement:

— for pipes with external upset ends: Table 3 (see also Figure 5);

— for pipes with internal upset ends: Table 4 (see also Figure 6);

— for pipes with protector thickening: Tables 5 and 6 (see also Figure 7).

All dimensions shown without tolerances are related to the basis for design and are not subject to measurement to determine acceptance or rejection of product. Drill pipe dimensions that are not in this International Standard or in the purchase agreement are at the manufacturer's discretion.

8.3.2 Protector thickening dimensions

Aluminium drill pipe of range 1, as well as aluminium drill pipe with outside diameter 63 mm (2.52 in), may not be manufactured with protector thickenings.

Protector thickening shall be located in the middle of the pipe [tolerance $\pm$ 350 mm (13.78 in)].

The length of protector thickening transition zone, L_3, shall depend on the range of aluminium drill pipe, and shall be (1 000 $\pm$ 200) mm [(39.37 $\pm$ 7.87) in] for range 2, and (1 600 $\pm$ 250) mm [(62.99 $\pm$ 9.84) in] for range 3.

8.3.3 Alternative configurations

When specified in the purchase agreement, drill pipe shall be furnished in dimensional configurations not defined in this International Standard. In this case, dimensions, tolerances and markings shall be agreed between the purchaser and manufacturer. The drill pipe body and tool joint shall be modified in accordance with this agreement, but the drill pipe shall otherwise be manufactured in accordance with the requirements of this International Standard.

8.3.4 Tool joint dimensions

The dimensions for the tool joints shall be in accordance with Figure 8 and Table 8.

Rotary shouldered connections shall conform to requirements of ISO 10424-2. Right-hand thread connections shall be considered standard.

Other dimensions and designs of tool joints may be used by agreement between purchaser and manufacturer.

8.3.5 Pipe to tool joint connection dimensions

The thread dimensions of the tool joint (see Figure 9) are given in Table 8.

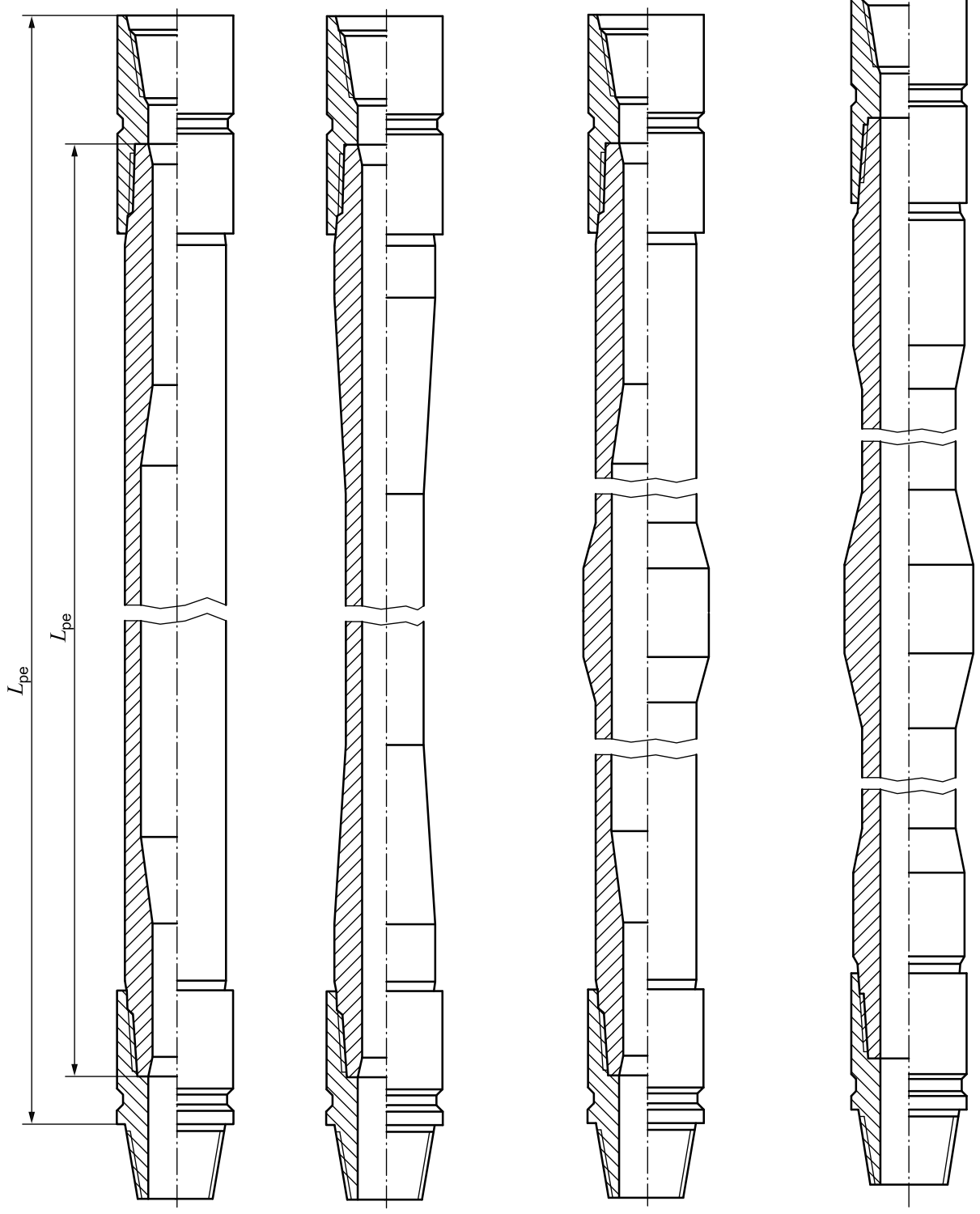
The thread dimensions for pipes (see Figure 10) are given in Table 9.

The dimensions of thread form are given in millimetres in Figure 11 (in inches in Figure A.1) for the tool joints (top of figure) and for the pipe (bottom of figure).

Other types of connections for assembling tool joints with pipe may be used by agreement between purchaser and manufacturer. In this case, the manufacturer shall have documented testing results to verify that this connection complies with the tensile, torque and pressure requirements of ISO 20312.

8.4 Design mass

The calculated mass of the plain pipe per unit length, the mass increase of the upset ends and protector thickening are indicated in Tables 3 to 6. The calculated mass of the tool joints is given in Table 7.



NOTE Symbols are defined in 4.2.

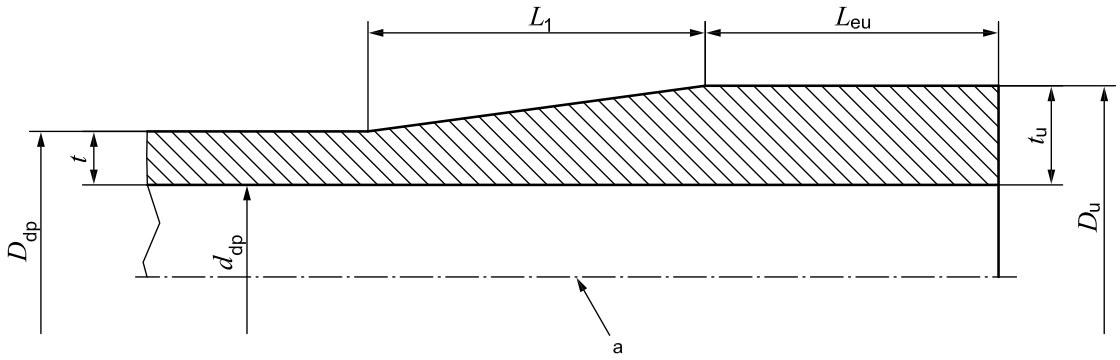
Figure 1 — Aluminium alloy drill pipe with internal upset

(see Table 2)

Figure 2 — Aluminium alloy drill pipe with external upset

Figure 3 — Aluminium alloy drill pipe with internal upset and protector thickening

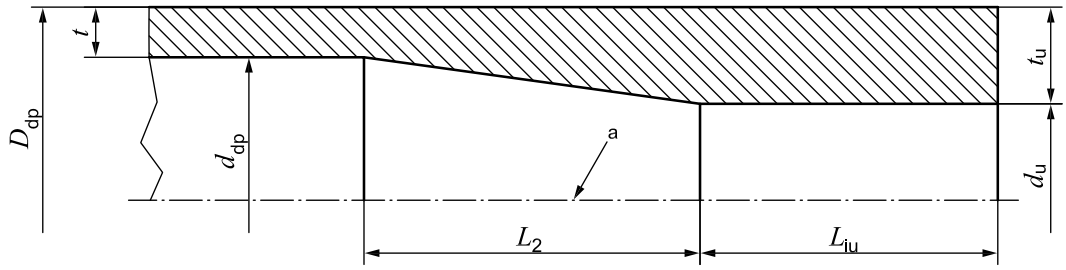
Figure 4 — Aluminium alloy drill pipe with external upset and protector thickening



[a] Drill pipe axis.

NOTE Symbols are defined in 4.2.

Figure 5 — Aluminium alloy drill pipe body end with external upset (see Table 3)

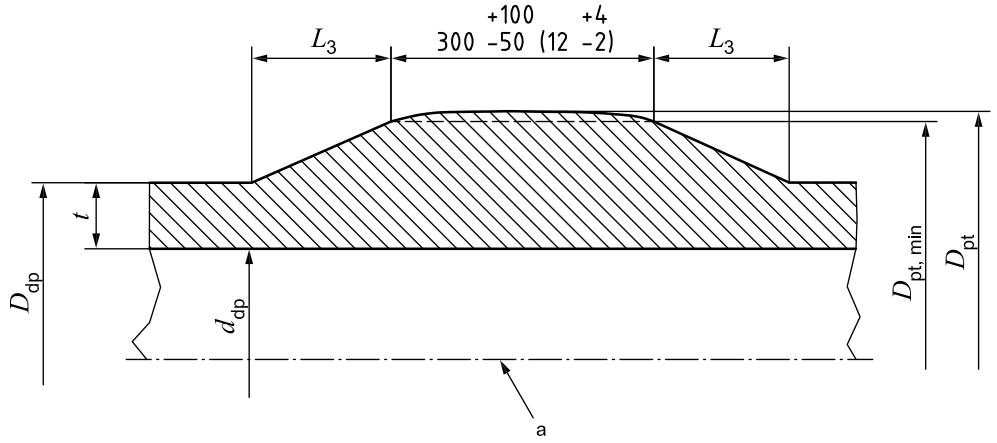


[a] Drill pipe axis.

NOTE Symbols are defined in 4.2.

Figure 6 — Aluminium alloy drill pipe body end with internal upset (see Table 4)

Dimensions in millimetres (inches)



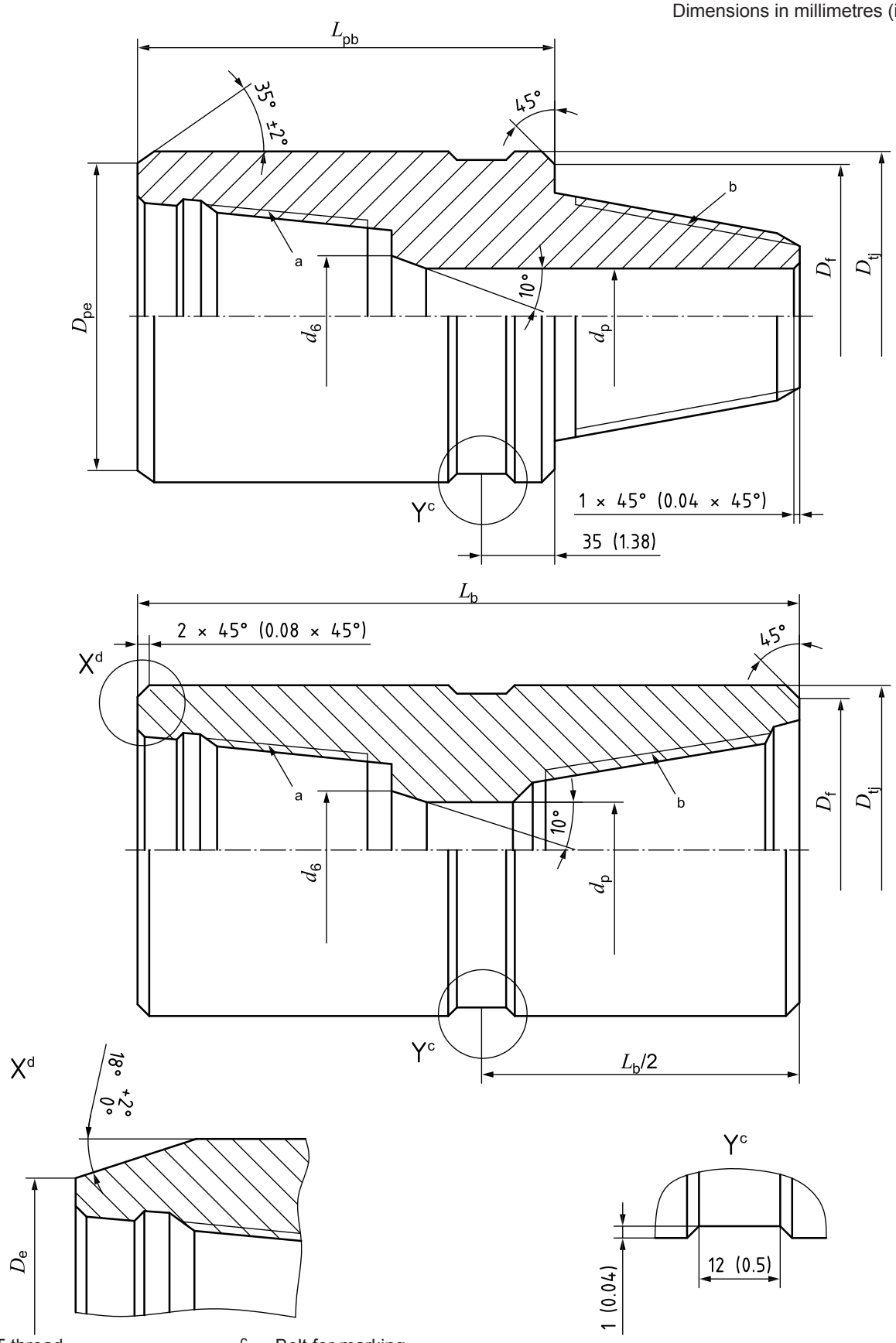
[a] Drill pipe axis.

NOTE 1 The protector thickening's outside surface can be of any shape, within the tolerance of D_{pt}.

NOTE 2 Symbols are defined in 4.2.

Figure 7 — Aluminium alloy drill pipe body protector thickening (see 8.3.2 and Tables 5 and 6)

Dimensions in millimetres (inches)

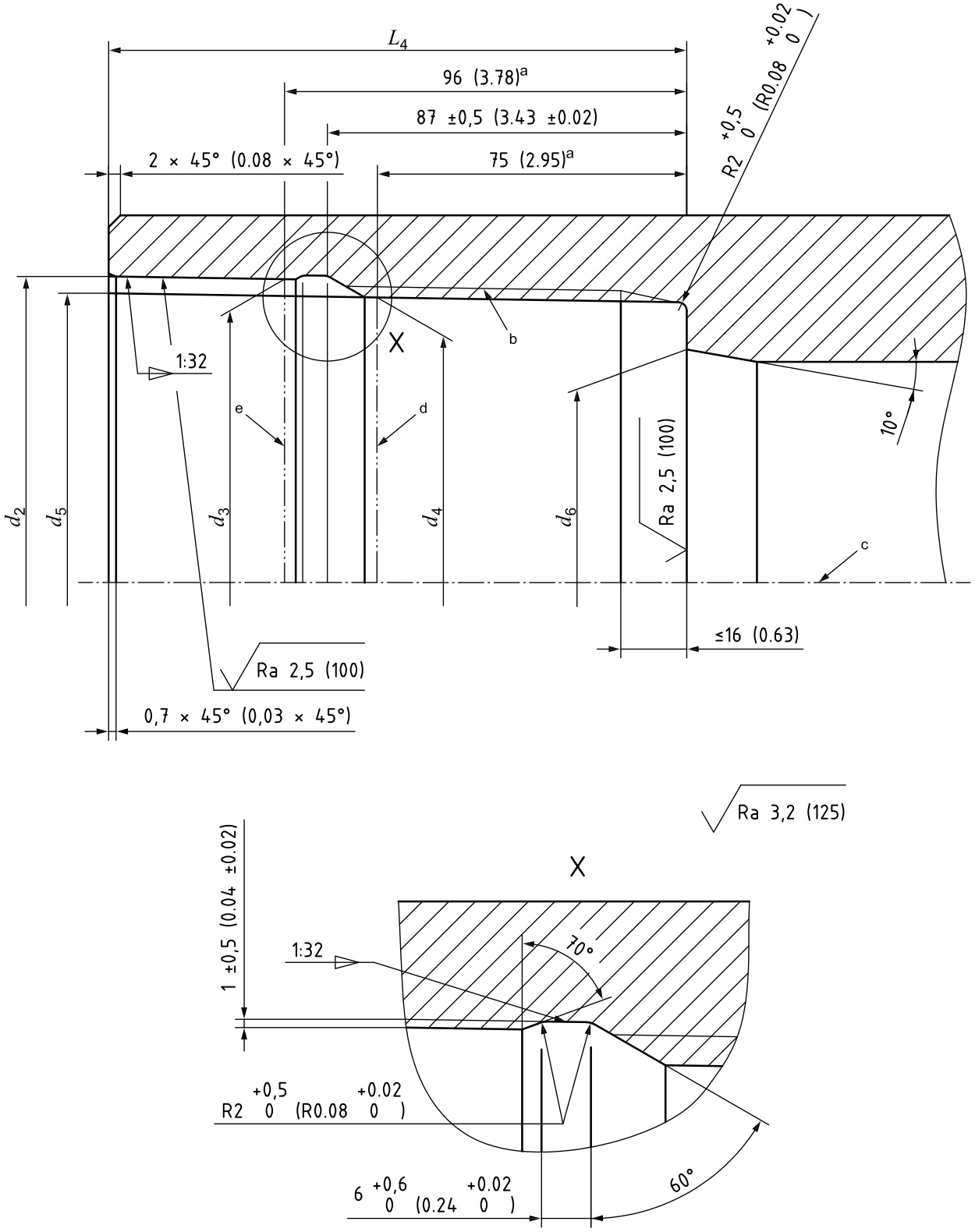


a TT thread.
b Rotary shouldered thread.
c Belt for marking.
d Variants of the elevator shoulders.

NOTE Symbols are defined in 4.2.

Figure 8 — Tool joint for aluminium alloy drill pipe (see Table 7)

Dimensions in millimetres (inches)

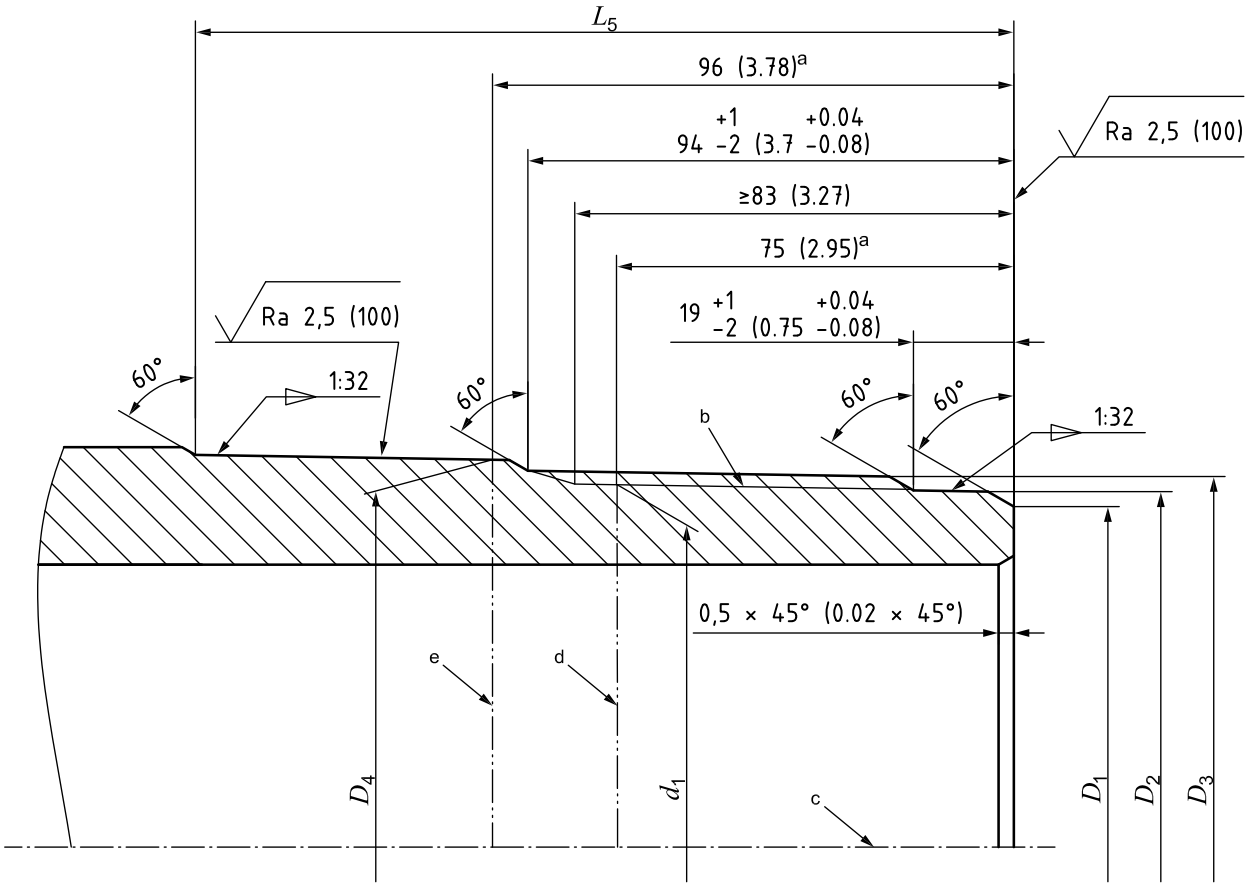


a Reference dimensions.
b TT thread.
c Thread axis.
d Gauge plane.
e Seal estimated plane.

NOTE 1 For shoulder configuration, see Figure 8.
NOTE 2 The thread length with the full profile is at least 83 mm.
NOTE 3 Symbols are defined in 4.2.

Figure 9 — Aluminium alloy drill pipe body-tool joint thread connection (tool joint) (see Tables 7 and 8)

Dimensions in millimetres (inches)



a Reference dimensions.

b TT thread.

c Thread axis.

d Gauge plane.

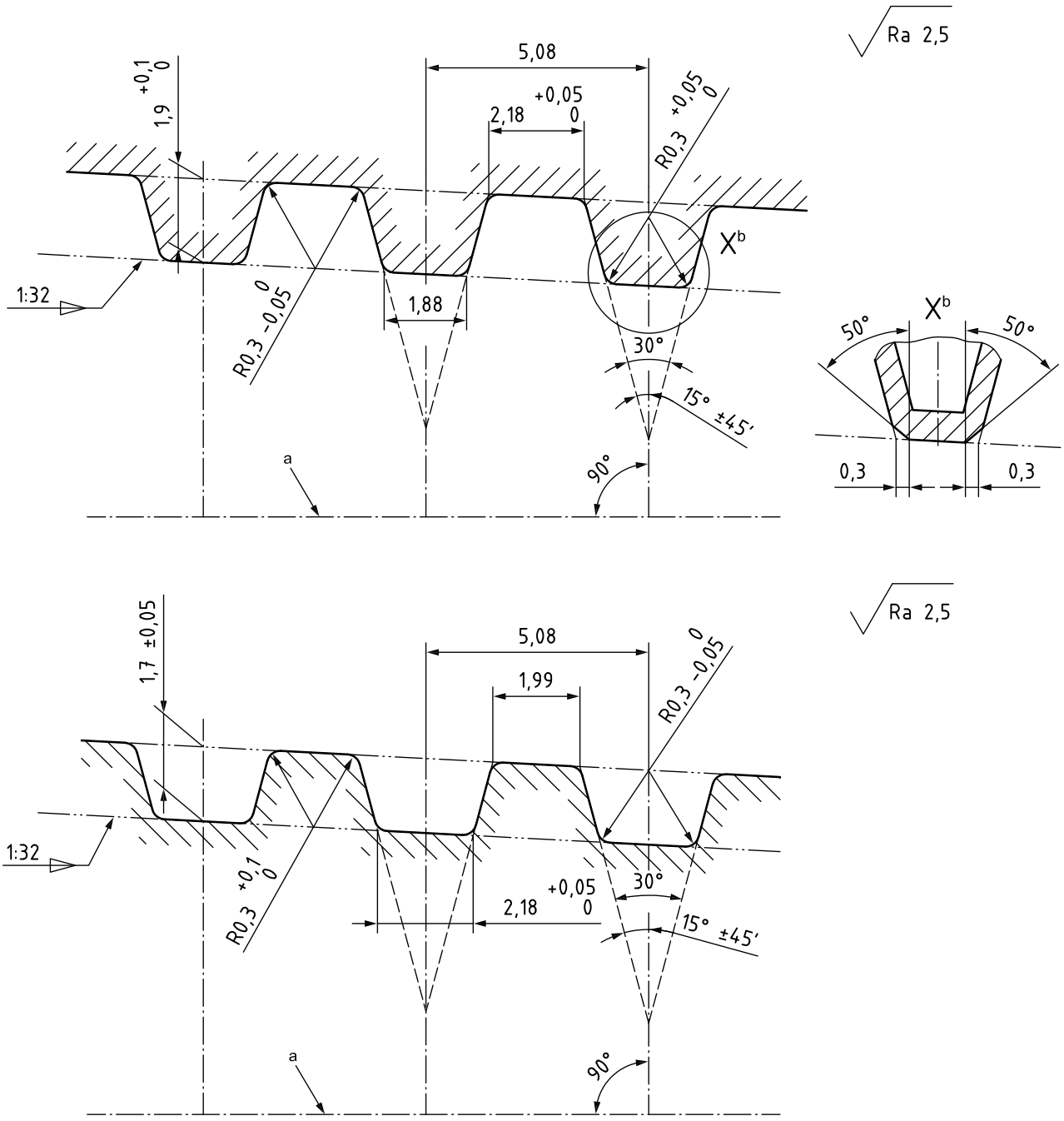
e Seal estimated plane.

NOTE 1 The thread length with the full profile is at least 83 mm.

NOTE 2 Symbols are defined in 4.2.

Figure 10 — Aluminium alloy drill pipe body-tool joint thread connection (drill pipe body) (see Table 9)

Dimensions in millimetres



a Thread axis.

b Variants of the thread crest (fillet or chamfer).

NOTE 1 Upper thread shape relates to tool joint thread, lower thread shape relates to pipe thread.

NOTE 2 Thread pitch (5,08 mm) is measured parallel to the thread axis.

NOTE 3 Bisectrix of the thread angle is perpendicular to the thread axis.

NOTE 4 All tolerances for the thread characteristics, except for the thread depth, are given for designing of the thread-cutting tool.

NOTE 5 Thread run-out can be located on the chamfer between the thread and seal taper shoulder.

NOTE 6 For dimensions in inches, see Figure A.1.

Figure 11 — TT thread shape for aluminium alloy drill pipe bodies and tool joints

Table 3 — Aluminium alloy drill pipes with external upset ends (see Figure 5)

(see Table A.3 for USC units)

Dimensions of pipe body mm			**Approximate calculated mass** kg		**Dimensions of upset ends** mm					
Outside diameter, D_{dp}	**Wall thickness,** t_{dp}	**Inside diameter,** d_{dp} [a]	**1 m of the plain pipe body**	**Upset of both ends (increment)**	**Wall thickness,** t_u	**Outside diameter** D_u		**Upset end length** L_{eu}		**Transition zone length (both ends)** L_1
								Box end	**Pin end**	
Tol. ± 1 %	Tol. ± 10 %				Tol. ± 10 %		Tol.	Tol. $^{+150}_{-100}$	Tol. ± 50	Tol. $^{+300}_{-450}$
90	8	74	5,77	4,00	13,0	100	$^{+2,5}_{-1,0}$	350	350	500
114	10	94	9,15	7,77	19,0	132	$^{+2,5}_{-1,0}$	350	350	500
129	9	111	9,50	21,97	18,0	147	$^{+2,5}_{-1,0}$	1 300	350	500
131	13	105	13,49	22,32	21,5	147	$^{+4}_{0}$	1 300	350	500
133	11	111	11,80	17,10	18,0	147	$^{+3,5}_{-2,0}$	1 300	350	500
140	13	114	14,52	9,72	16,5	147	$^{+3,5}_{-2,0}$	1 300	350	500
147	11	125	13,16	29,26	21,5	168	$^{+3,5}_{-2,0}$	1 300	350	500
151	13	125	15,78	23,69	21,5	168	$^{+3,5}_{-2,0}$	1 300	350	500
155	15	125	18,47	18,02	21,5	168	$^{+3,5}_{-2,0}$	1 300	350	500
164	9	146	12,27	31,69	19,5	185	$^{+3,5}_{-2,0}$	1 300	350	500
168	11	146	15,19	25,51	19,5	185	$^{+3,5}_{-2,0}$	1 300	350	500

[a] Reference dimensions.

While calculating mass, aluminium alloy density shall be taken equal to 2 800 kg/m^3. In case of using other density alloys, compensation factor shall be used.

Table 4 — Aluminium alloy drill pipe with internal upset ends (see Figure 6)

(see Table A.4 for USC units)

Dimensions of pipe body mm			**Approximate calculated mass** kg		**Dimensions of upset ends** mm						
Outside diameter, D_{dp}	**Wall thickness,** t_{dp}	**Inside diameter,** d_{dp} [a]	**1 m of the plain pipe body**	**Upset of both ends (increment)**	**Wall thickness,** t_u	**Inside diameter,** d_u	**Upset end length** L_{iu}			**Transition zone length (both ends)** L_2	
							Box end		**Pin end**		
Tol. ± 1 %	Tol. ± 10 %				Tol. ± 10 %			Tol.	Tol. ± 50	Tol. ± 30	Tol. ± 30
64	8	48	3,94	0,76	13	38	250	± 50	350	50	250
73	9	55	5,07	1,55	16	41	250	± 50	350	50	250
90	9	72	6,41	2,05	16	58	800	± 50	350	50	250
103	9	85	7,44	5,83	16	71	1 000	± 100	350	50	250
114	10	94	9,15	7,34	16	82	1 300	± 100	350	50	300
114	11	92	9,97	6,92	16	82	1 300	± 100	350	50	300
129	9	111	9,50	11,58	17	95	1 300	± 100	350	50	300
129	11	107	11,42	11,07	19	91	1 300	± 100	350	50	300
147	11	125	13,16	10,17	17	113	1 300	± 100	350	50	300
147	13	121	15,32	11,52	20	107	1 300	± 100	350	50	300
147	15	117	17,42	11,07	22	103	1 300	± 100	350	50	300
168	11	146	15,19	17,80	19	130,3	1 300	± 100	350	50	300
168	13	142	17,72	16,26	20,5	127,3	1 300	± 100	350	50	300

[a] Reference dimensions.

While calculating mass, aluminium alloy density shall be taken equal to 2 800 kg/m^3. In case of using other density alloys, compensation factor shall be used.

Table 5 — Protector thickening of aluminium alloy drill pipe with external upset (see Figures 4 and 7)

(see Table A.5 for USC units)

Aluminium alloy drill pipe outside diameter D_{dp} mm	Protector thickening		
	Outside diameter D_{pt} mm	Increase in pipe mass due to protector thickening kg	
		2 range	3 range
	Tol. $^{+3,0}_{-2,8}$		
129	146	9,57	13,99
131	156	17,29	25,27
133	146	13,37	19,53
140	172	20,51	29,98
147	172	10,37	15,15
151	172	28,54	41,72
155	172	22,80	33,32
164	185	19,39	28,34
168	185	15,89	23,23
While calculating mass, aluminium alloy density shall be taken equal to 2 800 kg/m^3. In case of using other density alloys, compensation factor shall be used.			

Table 6 — Protector thickening of aluminium alloy drill pipe with internal upset (see Figures 3 and 7)

(see Table A.6 for USC units)

Aluminium alloy drill pipe outside diameter D_{dp} mm	Protector thickening		
	Outside diameter D_{pt} mm	Increase in pipe mass due to protector thickening kg	
		2 range	3 range
	Tol. $^{+3,0}_{-2,8}$		
73	88	6,90	10,09
90	105	8,36	12,22
103	118	9,48	13,85
114	140	18,88	27,59
129	150	16,75	24,48
147	172	22,80	33,32
168	197	30,26	44,23
While calculating mass, aluminium alloy density shall be taken equal to 2 800 kg/m^3. In case of using other density alloys, compensation factor shall be used.			

Table 7 — Tool joint dimensions (see Figures 8 and 9)

(see Table A.7 for USC units)

Aluminium alloy drill pipes		Tool joint										Thread type	
D_{dp} mm	t_{dp} mm	D_{tj} mm	D_f mm	D_e mm	D_{pe} mm	d_p mm	d_b mm	d_6 mm	L_b mm	L_{pb}[a] mm	Mass kg	Tool joint	Pipe
		Tol. ± 0,8	Tol. ± 0,4	Tol. ± 0,8	Tol. +1	Tol. $^{+0,4}_{-0,8}$	Tol. $^{+0,4}_{-0,8}$	Tol. ± 0,4	Tol. $^{+6}_{-10}$	Tol. $^{+9}_{-10}$			
Aluminium alloy drill pipe with external upset													
90	8	118	114	106	109	68	68	74	275	185	19,5	NC38	TT90
114	10	155	150	139	143	95	95	98	320	210	38,6	NC50	TT122
129	9	172	169	156	160	112	112	114	340	225	46,0	5-1/2FH	TT138
131	13	178	170,5	150	160	105	105	-	320	203	46,0	5-1/2FH	TT138
133	11	172	169	156	160	112	112	114	340	225	46,0	5-1/2FH	TT138
140	13	172	169	156	160	112	112	114	340	225	46,0	5-1/2FH	TT138
147	11	195	188	176	183	124	124	130	365	244	65,2	6-5/8FH	TT158
151	13	195	188	176	183	124	124	130	365	244	65,2	6-5/8FH	TT158
155	15	195	188	176	183	124	124	130	365	244	65,2	6-5/8FH	TT158
164	9	203	196	190	198	124	138	146	365	244	66,5	6-5/8FH	TT172
168	11	203	196	190	198	124	138	146	365	244	66,5	6-5/8FH	TT172
Aluminium alloy drill pipe with internal upset													
64	8	80	76	68	73	34	34	38	240	163	9,5	NC23	TT53
73	9	95	91	79	82	44	44	44	260	170	14,5	NC26	TT63
90	9	108	104	—	100	54	56	60	270	180	16,5	NC31	TT82
90	9	120,6	116	100	102	58	56	60	300	183	25,4	NC38	TT82
103	9	120,6	116	—	113	68	68	71	285	185	21,0	NC38	TT94
103	9	127	116	112	113	68	68	71	285	185	25,0	NC38	TT94
114	10	145	140	121	126	82	82	84	305	195	34,9	NC44	TT104
114	11	152	145	128	128	80	80	83	310	196	41,0	NC46	TT106
129	11	162	154	140	141	95	93	97	320	206	43,5	NC50	TT120
147	11	178	171	156	160	105	108	113	340	225	54,3	5-1/2FH	TT138[b]
147	13	178	171	156	160	105	108	109	340	225	54,3	5-1/2FH	TT138[b]
147	15	178	171	156	160	105	108	109	340	225	54,3	5-1/2FH	TT138[b]
168	11	203	196	178	183	127	127	130	345	245	71,5	6-5/8FH	TT158
168	13	203	196	178	183	127	127	130	345	245	71,5	6-5/8FH	TT158

[a] Reference dimensions.

[b] TT136 thread can be used by agreement between manufacturer and purchaser.

Table 8 — Dimensions of tool joint thread for aluminium alloy drill pipes (see Figure 9)

(see Table A.8 for USC units)

Dimensions in millimetres

Thread type	Tool joint				
	d_2[a]	d_3	d_4[a]	d_5[a]	L_4
		Tol. +0,1			± 0,3
Aluminium alloy drill pipes with external upset ends					
TT90	97,345	96,22	90,32	92,101	132
TT122	129,525	128,15	122,25	124,281	140
TT138	145,495	144,12	138,22	140,251	140
TT158	165,445	164,07	158,17	160,201	140
TT172	179,395	178,02	172,12	174,151	140
Aluminium alloy drill pipes with internal upset ends					
TT53	60,425	59,30	53,40	55,181	132
TT63	70,405	69,28	63,38	65,161	132
TT82	89,369	88,24	82,34	84,121	132
TT94	101,335	100,21	94,31	96,091	132
TT104	111,575	110,20	104,30	106,331	140
TT106	113,565	112,19	106,29	108,321	140
TT120	127,175	125,80	120,25	122,281	140
TT136	143,495	142,12	136,22	138,251	140
TT138	145,495	144,12	138,22	140,251	140
TT158	165,465	164,09	158,19	160,221	140

[a] Reference dimensions.

Table 9 — Thread dimensions of aluminium alloy drill pipes (see Figure 10)

(see Table A.9 for USC units)

Dimensions in millimetres

Thread type	Tool joint					
	d_1[a]	D_1	D_2	D_3[a]	D_4	L_5[a]
		Tol. ± 0,8	Tol. $^{0}_{-0,6}$		Tol. ± 0,05	
Aluminium alloy drill pipes with external upset ends						
TT90	90,60	82	86,5	91,656	96,5	150
TT122	122,60	112	118,5	123,656	128,5	160
TT138	138,60	129	134,5	139,656	144,5	160
TT158	158,60	148	154,5	159,656	164,5	160
TT172	172,60	163	168,5	173,656	178,5	160
Aluminium alloy drill pipes with internal upset ends						
TT53	53,60	45	49,8	54,656	59,5	150
TT63	63,60	55	59,5	64,656	69,5	150
TT82	82,60	73,5	78,5	83,656	88,5	150
TT94	94,60	85,5	90,5	95,656	100,5	150
TT104	104,60	96	100,5	105,656	110,5	160
TT106	106,60	97,5	102,5	107,656	112,5	160
TT120	120,60	111,5	116,5	121,656	126,15	160
TT136	136,60	128	132,5	137,656	142,5	160
TT138	138,60	130	134,5	139,656	144,5	160
TT158	158,60	150	154,5	159,656	164,5	160

[a] Reference dimensions.

8.5 Upset run-out

At any place on the transition zone between the upset end and the pipe body, a transverse groove or bulge is allowed, the height or depth of which shall not increase by more than 2,5 mm (0.098 in) or decrease by more than 5 mm (0.197 in) the outside diameter of the specified size, but the wall thickness shall not be less than the minimum specified wall thickness of the aluminium drill pipe body.

8.6 Straightness

Deviation from straightness or pipe maximum curvature, excluding external upset ends, protector thickening and transition areas, shall not exceed 0,2 % on the length being checked [2 mm/m (0.024 in/ft)].

8.7 Ovality and eccentricity of pipes

The ovality and eccentricity of pipes shall be within the tolerances on outside diameter and wall thickness (see Tables 3 and 4).

8.8 Drift requirements

Each aluminium alloy drill pipe with external upset ends shall be tested all the way across the pipe length with a cylindrical drift mandrel being 3,2 mm (0.079 in) smaller in diameter than the minimum inside diameter, d_{dp}, of the drill pipe, and a length of 10 times the inside diameter.

Each aluminium alloy drill pipe with internal upset ends shall be tested full pipe length with a ball drift mandrel having a minimum diameter of 2 mm (0.126 in) smaller than the minimum inside diameter, d_{dp}, of the aluminium alloy drill pipe, upset end, d_u, or tool joint (d_p and d_b), whichever is the smallest.

NOTE The minimum inside diameter can be calculated by taking aluminium drill pipe body outside diameter, D_{dp}, with maximum negative tolerance, and subtracting from it two wall thicknesses, t_{dp}, with maximum positive tolerance.

The tolerance for drift mandrels shall be −0,25 mm (−0.009 8 in).

8.9 Tool joint alignment

The maximum misalignment between the longitudinal axis of the drill pipe body and the longitudinal axis of the threaded tool joint shall not exceed the following:

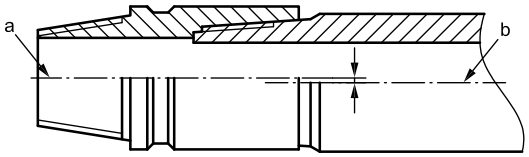
— for parallel misalignment: 4 mm (0.157 in) total indicator reading;

— for angular misalignment: 8 mm/m (0.008 in/in) for aluminium alloy drill pipe outside diameter 114 mm (4.49 in) and larger;

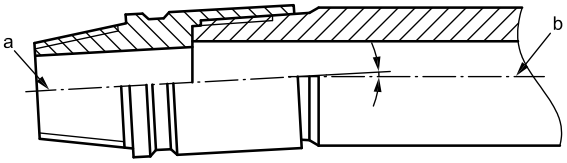
— 10 mm/m (0.010 in/in) for aluminium alloy drill pipe outside diameter smaller than 114 mm (4.49 in).

The axis of the tool joint shall be determined on the surface of the outside diameter, D_{tj}, that is unaffected by markings or hard banding. The axis of the drill pipe body shall be determined over a minimum length of 400 mm (16 in) on the outside surface of the pipe body.

The method of measuring misalignment shall be defined by the manufacturer. Figure 12 illustrates parallel and angular misalignment of the tool joint.



a) Parallel misalignment



b) Angular misalignment

a Tool joint axis.

b Drill pipe body axis.

Figure 12 — Tool joint misalignment

8.10 Internal coating

By agreement between the manufacturer and purchaser, aluminium alloy drill pipe may be given an internal coating.

8.11 Aluminium alloy drill pipe body-tool joint assembly

Aluminium alloy drill pipe body-tool joint assembly may be carried out by any method (either hot or cold) that ensures a proper interference between pipe body and tool joint.

A good contact on the internal and external (tapered) tool joint to aluminium alloy drill pipe body shouldered faces is checked by the go/no-go thickness gauge of 0,03 mm (0.001 2 in).

If hot assembly of screwed-on tool joints is used, the temperature of the aluminium pipe shall not exceed the temperature limitation for the material group given in Table 1.

The manufacturer shall have documented full-scale fatigue testing to verify the design fatigue limits of aluminium alloy drill pipe body-tool joint assembly. The full-scale fatigue testing shall be in accordance with Annex C.

9 Test methods

9.1 General

Each pipe lot shall be inspected and tested at the mill after heat treatment.

9.2 Chemical composition test

Chemical composition shall be determined by any of the procedures commonly used for determining chemical composition, such as emission spectroscopy, X-ray emission, atomic absorption, combustion techniques or wet analytical procedures. The calibration methods used shall be traceable to established standards. In case of conflict, chemical analyses shall be made in accordance with ASTM E1251.

9.3 Mechanical test

9.3.1 A minimum of 5 % of pipes from each lot shall be subjected to mechanical tests (but not less than two pipes). The types of tests shall be established in accordance with Table 1. If any of the test specimens representing a lot of pipes fails to conform to the requirements specified in Table 1, the manufacturer may retest double the number of specimens from this lot. If any of the specimens retested fails to conform to the specified requirements, the entire lot shall be rejected.

Evaluation of the aluminium alloy drill pipe mechanical properties shall be carried out on longitudinal specimens taken from the upset part of the pipe. The macrostructure check shall be made on crosscut macro sections representing two pipes from each lot.

NOTE The mechanical properties are invariably lower for the upset areas than for the pipe body.

9.3.2 Tensile testing shall be carried out in accordance with ISO 6892.

9.3.3 Testing for tool joint hardness shall be carried out at the purchaser's request in accordance with ISO 6506.

9.4 Hydrostatic test

When the manufacturer supplies aluminium alloy drill pipes with made-up tool joints, a hydrostatic test under internal pressure shall be performed. The percentage of assembled pipes subject to hydrostatic testing shall be assigned by purchase order and the agreement between purchaser and the manufacturer.

The manufacturer shall establish the hydrostatic testing method.

Each assembled pipe subject to hydrostatic testing shall be tested to at least the hydrostatic pressure calculated by Equation (1) without leakage. The test conditions shall be held at full pressure for not less than 1 min.

The standard hydrostatic test pressure shall be calculated using Equation (1), rounded to the nearest 0,5 MPa (100 psi) and limited to a maximum of 35,0 MPa (5 100 psi):

$$p = \frac{2 \times f \times Y_{\text{min}} \times t_{\text{dp}}}{D_{\text{dp}}} \tag{1}$$

where

p is the standard hydrostatic test pressure, expressed in megapascals (psi);

f is a hydrostatic pressure test factor, f = 0,5;

Y_{min} is the specified minimum yield strength for the pipe body, expressed in megapascals (psi);

D_{dp} is the specified outside diameter, expressed in millimetres (inches);

t_{dp} is the specified wall thickness, expressed in millimetres (inches).

NOTE Equation (1) for hydrostatic test pressure is applicable to both SI and USC units (in brackets).

Lower test pressures may be allowed only for reasons of the physical limitations of the test equipment. The manufacturer shall have a documented design basis to enable the physical limits of the hydrostatic test equipment to be established. If the calculated test pressure (based on the outside diameter, thickness and grade) is greater than the physical capability of the hydrostatic test equipment, the manufacturer, upon agreement with the purchaser, shall use a test pressure equal to the physical capability of the test equipment. However, the hydrostatic test capability may be less than 20,5 MPa (2 973 psi) only for those products where the calculated test pressure is less than 20,5 MPa (2 973 psi).

Alternative test pressures shall be used when specified on the purchase agreement and when agreed by purchaser and manufacturer.

9.5 Corrosion test

Aluminium alloy drill pipe Group IV corrosion rate shall not exceed the value specified in Table 1, and shall be determined by the weight-loss method. This method is based on the estimation of the material mass loss per unit time per unit area in the test solution. A minimum of 2 % of aluminium alloy drill pipes of each heat shall be subjected to the corrosion rate test, as described in Annex D.

10 Measuring methods

10.1 General

10.1.1 Dimensional measurements shall be carried out on each joint of pipe.

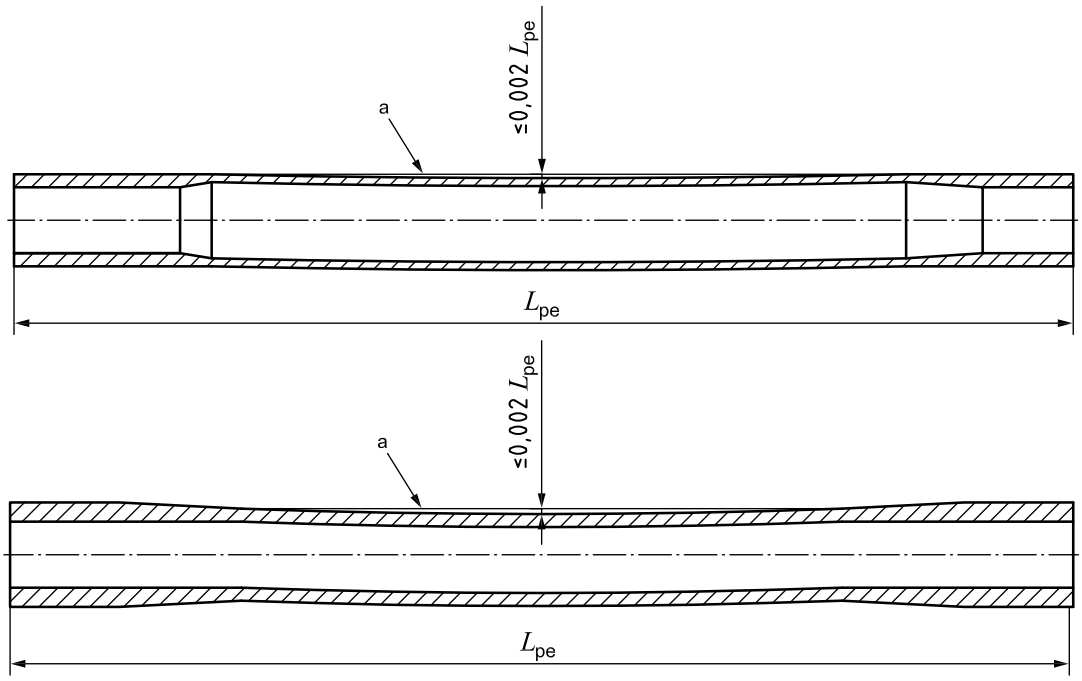
10.1.2 For pipes without tool joints, the outside diameter of the upset ends shall be measured before threading in two perpendicular planes at a distance of 50 mm (2 in) to 100 mm (4 in) from the pipe end and shall be within the tolerances specified in Tables 3 and 4.

10.1.3 Wall thickness shall be checked by a non-destructive testing method along the entire length of the aluminium alloy pipe body. The type of non-destructive method used shall be at the discretion of the manufacturer, but the manufacturer shall demonstrate that the accuracy of the method used is adequate to ensure the wall thickness meets the requirements specified in Tables 3 and 4.

10.1.4 All aluminium drill pipe bodies shall be visually examined. The straightness of questionably bent pipes or crooked extremities shall be verified using a straight-edge or taut string (wire) from one end of plain pipe to its other end, as shown in Figure 13. The straight-edge shall be positioned to highlight the maximum deviation.

Deviation from the straight or chord height shall not exceed the requirements in 8.6.

The pipe straightness shall be measured with an accuracy of ±0,5 mm (±0.02 in).



a Taut string or wire.

NOTE Symbols are defined in 4.2.

Figure 13 — Aluminium drill pipe body straightness measurement

10.2 Calibration and verification of measuring equipment

The accuracy of all measuring instruments used for acceptance/rejection shall be verified at least once every operating shift. Accuracy verification of rules, length measuring tapes and other non-adjustable measuring devices shall be defined as a visual check of markings' legibility and the general wear of fixed reference points. The verification procedure of these working gauges shall be documented. The adjustable and non-adjustable designation utilized by the manufacturer shall be documented.

If measuring equipment whose calibration or verification is required under the provisions of the specification is subjected to unusual or severe conditions such as would make its accuracy questionable, recalibration or reverification shall be performed before further use of the equipment.

11 Inspection

11.1 General

11.1.1 The outside and inside pipe surfaces shall be free of cavities, cracks, laminations, blisters, non-metallic inclusions and corrosion pits. Scratches, grooves, dents and mechanical damage are permitted, provided that their depth remains within the limits of the tolerance for the outside diameter. Local traces of lubricant are also permitted.

11.1.2 The depth of a local imperfection on the outside pipe surface shall be determined by grinding or machining the defective area by a method that ensures visual inspection until the imperfection is completely removed. The depth of the imperfection shall not exceed 10 % of the specified pipe wall thickness.

11.1.3 Local hammering and repair-welding of defects on the outside pipe surface is not allowed.

11.2 Levels of non-destructive inspection

Non-destructive inspection of aluminium drill pipe body shall be by agreement between the manufacturer and purchaser. The three levels of non-destructive inspection are:

— level 1: no non-destructive inspection;

— level 2: non-destructive inspection of the transition zone, only in accordance with ASTM B594-09 Class A;

— level 3: full body ultrasonic inspection in accordance with ISO 10893-10.

11.3 Tool joint non-destructive inspection

Tool joint non-destructive inspection shall be carried out in accordance with the requirements of ISO 11961.

12 Marking

12.1 General

Drill pipe manufactured in conformance with this International Standard shall be marked as in 12.2.

Additional markings may be applied, including those for applicable compatible standards, at the option of the manufacturer or as specified in the purchase agreement. Markings shall not overlap and shall be applied in such a manner as to not damage the drill pipe.

12.2 Sequence of marking

The final marking of the drill pipe shall consist of:

a) marking on the drill pipe body in accordance with 12.3;

b) marking on the tool joint in accordance with 12.4;

c) traceability marking in accordance with 12.5.

12.3 Marking on the drill pipe body

Marking on the drill pipe body shall be made by the drill pipe body manufacturer.

The marking shall be made by a round-bottomed die stamp. The height of the marking shall be 6 mm (0.236 in) to 10 mm (0.394 in) and the depth shall be 0,3 mm (0.012 in) to 0,7 mm (0.028 in).

Pipes shall be die-stamped on the outside surface of the upset end, at a distance not less than 300 mm (12 in) from the pin end. Markings shall be placed longitudinally.

The sequence of marking shall be as follows:

a) manufacturer's name or trade mark;

b) reference to this International Standard (i.e. ISO 15546);

c) material group (see 7.1);

d) size (outside diameter), in millimetres;

e) pipe body wall thickness, in millimetres;

f) serial number of the lot and identification number of the pipe in the lot;

g) month and year of manufacturing in MMYY format.

12.4 Tool joint marking

If not specified otherwise by agreement between purchaser and manufacturer, each tool joint (box and pin) shall be provided with a 10 mm (0.394 in) band for marking (see Figure 8). On the band, the following information shall be die-stamped:

a) manufacturer's name or trade mark;

b) ISO 10424-2;

c) thread type;

d) other marks, following manufacturers' procedures, indicating the acceptance by ultrasonic inspection, magnetic wet particle inspection and quality control;

e) number of heat or lot.

When tool joints are supplied with a left-hand thread, they shall be provided with a hemispherical identification groove of 5 mm (0.197 in) width, spaced 10 mm (0.394 in) from the marking groove.

By agreement between purchaser and the manufacturer, tool joints may be marked at the base of the pin and with grooves or flats, in accordance with ISO 11961. In this case marking on the outside surface band shall be not mandatory.

12.5 Drill pipe traceability marking

This marking (for traceability requirements, see 6.3) shall be die-stamped on the pin 35° taper, as shown in Figure 8, unless otherwise specified in the purchase agreement.

Left-hand threaded pipes shall be marked with the letter “L”.

12.6 Paint stencilling

At the manufacturer's option or upon request of the purchaser, the aluminium alloy drill pipes can be marked in addition to the die-stamping, by paint-stencilling. Paint-stencilling shall be located starting not less than 0.6 m (1.97 ft) from either end of the drill pipe body and shall be made longitudinally by letters and figures of between 35 mm (1.38 in) and 50 mm (1.97 in). The paint used for marking aluminium alloy drill pipe should be of a low chloride type. The sequence of paint-stencilled marking shall be the same as in 12.2.

13 Packaging, transport and storage

Aluminium alloy drill pipes and aluminium alloy drill pipe bodies may be shipped in bundles. The pipes in each bundle shall be of the same diameter, the same wall thickness, the same material group, and the same range length. Aluminium alloy drill pipe should be electrically isolated from the ground during storage.

14 Documents

14.1 Certificate of compliance

The manufacturer shall supply a certificate of compliance stating that aluminium alloy drill pipe itself and all of its components have been manufactured, sampled, tested and inspected in accordance with this International Standard and have been found to meet all the requirements.

14.2 Retention of records

Information for which the retention of records is required for this International Standard is as follows:

a) country of manufacturer;

b) manufacturer's name or trade mark;

c) material group;

d) pipe diameter, wall thickness and length;

e) pipe length (total) and masses;

f) results of any test;

g) delivery completeness (when pipes are supplied with tool joint, the tool joint size and whether threads are left-handed shall be indicated);

h) number of the pipe lot;

i) heat treatment records;

j) tool joint certificates;

k) non-destructive examination system verification.

Such records shall be retained by the manufacturer and shall be made available to the purchaser on request for a period of three years after the date of purchase from the manufacturer.

15 Delivery conditions

Aluminium alloy drill pipes shall be delivered in accordance with the requirements of this specification. For delivery of threaded pipes or pipes with screwed-on tool joints, threads shall be protected with anticorrosive lubricant and provided with thread protectors to protect them from damage during transportation and storage.

Annex A
(normative)

Tables and figures in USC units

Table A.1 — Material requirements for aluminium alloy drill pipe bodies

(see Table 1 for SI units)

Characteristics[a]	Unit	Material group			
		I	II	III	IV
Alloy name[b]	—	D16T	1953T1	AK4-1T1	1980T1
Minimum yield strength (0,2 % offset method)	ksi	47.14	69.62	49.31	50.76
Minimum tensile strength	ksi	66.72	76.87	59.47	58.02
Minimum elongation	%	12	7	8	9
Maximum operational temperature	°F	320	248	428	320
Maximum corrosion rate in 3,5 % sodium chloride solution	oz/(ft^{2}h)	—	—	—	2.62×10^{-5}
It is permitted to use an alternative aluminium alloy, as long as there is purchaser agreement and this alloy conforms to the requirements of one of the four material group categories. Mechanical testing shall be made in accordance with ISO 6892. Maximum operational temperature is a material temperature that results in the minimum room temperature yield strength reduction by no more than 30 % at the exposure time of 500 h. See ISO 20312 for material yield strength reduction at other operating temperatures.					
[a] The mechanical properties of the alloys given in this table are for a test temperature of (68 ± 5) °F. [b] For chemical composition and properties of alloys, see References [9] and [11].					

Table A.2 — Aluminium alloy drill pipe and aluminium alloy drill pipe body length (see Figure 1)

(see Table 2 for SI units)

Dimensions in feet

Pipe delivery condition	Range		
	1	2	3
Aluminium alloy drill pipe, L_{dp}, tolerance ±0.82	20.34	29.86	40.68
Aluminium alloy drill pipe body, L_{pe}, tolerance ±0.82	19.03	28.54	39.37
Other pipe lengths can be ordered by agreement between manufacturer and purchaser.			

Table A.3 — Aluminium alloy drill pipes with external upset ends (see Figure 5)

(see Table 3 for SI units)

Dimensions of pipe body in			**Approximate calculated mass** lb		**Dimensions of upset ends** in					
Outside diameter, D_{dp}	**Wall thickness,** t_{dp}	**Inside diameter,** d_{dp} [a]	**1 m of the plain pipe body**	**Upset of both ends (increment)**	**Wall thickness,** t_u	**Outside diameter** D_u		**Upset end length** L_{eu}		**Transition zone length (both ends)** L_1
								Box end	**Pin end**	
Tol. ± 1 %	Tol. ± 10 %				Tol. ± 10 %		Tol.	Tol. $^{+5.90}_{-3.94}$	Tol. ± 1.97	Tol. $^{+11.81}_{-17.72}$
3.55	0.32	2.92	12.62	8.81	0.51	3.94	$^{+0.08}_{-0.04}$	13.78	13.78	19.69
4.49	0.39	3.70	20.00	17.12	0.75	5.20	$^{+0.08}_{-0.04}$	13.78	13.78	19.69
5.08	0.35	4.37	20.77	48.40	0.71	5.79	$^{+0.08}_{-0.04}$	51.18	13.78	19.69
5.16	0.51	4.14	29.72	49.17	0.85	5.79	$^{+0.16}_{0}$	51.18	13.78	19.69
5.24	0.43	4.37	25.82	37.67	0.71	5.79	$^{+0.14}_{-0.08}$	51.18	13.78	19.69
5.52	0.51	4.49	31.75	21.41	0.65	5.79	$^{+0.14}_{-0.08}$	51.18	13.78	19.69
5.79	0.43	4.93	28.77	64.46	0.85	6.61	$^{+0.14}_{-0.08}$	51.18	13.78	19.69
5.95	0.51	4.93	34.50	52.19	0.85	6.61	$^{+0.14}_{-0.08}$	51.18	13.78	19.69
6.11	0.59	4.93	40.38	39.70	0.85	6.61	$^{+0.14}_{-0.08}$	51.18	13.78	19.69
6.46	0.35	5.75	26.83	69.81	0.77	7.28	$^{+0.14}_{-0.08}$	51.18	13.78	19.69
6.62	0.43	5.75	33.22	56.20	0.77	7.28	$^{+0.14}_{-0.08}$	51.18	13.78	19.69

[a] Reference dimensions.

While calculating mass, aluminium alloy density shall be taken equal to 174.80 lb/ft^3. In case of using other density alloys, compensation factor shall be used.

Table A.4 — Aluminium alloy drill pipe with internal upset ends (see Figure 6)

(see Table 4 for SI units)

Dimensions of pipe body in			**Approximate calculated mass** lb		**Dimensions of upset ends** in						
Outside diameter, D_{dp}	**Wall thickness,** t_{dp}	**Inside diameter,** d_{dp} [a]	**1 m of the plain pipe body**	**Upset of both ends (increment)**	**Wall thickness,** t_u	**Inside diameter,** d_u	**Upset end length** L_{iu}			**Transition zone length (both ends)** L_2	
							Box end		**Pin end**	**Box end**	**Pin end**
Tol. ± 1 %	Tol. ± 10 %				Tol. ± 10 %			Tol.	Tol. ± 1.97	Tol. ± 1.18	Tol. ± 1.18
2.52	0.32	1.89	8.61	1.67	0.51	1.50	9.85	± 1.97	13.79	1.97	9.85
2.88	0.35	2.17	11.08	3.41	0.63	1.62	9.85	± 1.97	13.79	1.97	9.85
3.55	0.35	2.84	14.01	4.52	0.63	2.29	9.85	± 1.97	13.79	1.97	9.85
4.06	0.35	3.35	16.28	12.84	0.63	2.80	39.40	± 3.94	13.79	1.97	9.85
4.49	0.39	3.70	20.00	16.17	0.63	3.23	51.22	± 3.94	13.79	1.97	11.82
5.08	0.35	4.37	20.77	25.51	0.67	3.74	51.22	± 3.94	13.79	1.97	11.82
5.08	0.43	4.22	24.96	24.39	0.75	3.59	51.22	± 3.94	13.79	1.97	11.82
5.79	0.43	4.93	28.77	22.40	0.67	4.45	51.22	± 3.94	13.79	1.97	11.82
5.79	0.51	4.77	33.51	25.38	0.79	4.22	51.22	± 3.94	13.79	1.97	11.82
5.79	0.59	4.61	38.07	24.39	0.87	4.06	51.22	± 3.94	13.79	1.97	11.82
6.62	0.43	5.75	33.51	39.21	0.75	5.13	51.22	± 3.94	13.79	1.97	11.82
6.62	0.51	5.59	39.10	35.82	0.81	5.02	51.22	± 3.94	13.79	1.97	11.82
2.52	0.32	1.89	8.61	1.67	0.51	1.50	9.85	± 1.97	13.79	1.97	9.85

[a] Reference dimensions.

While calculating mass, aluminium alloy density shall be taken equal to 174.80 lb/ft^3. In case of using other density alloys, compensation factor shall be used.

Table A.5 — Protector thickening of aluminium alloy drill pipe body with external upset (see Figures 4 and 7)

(see Table 5 for SI units)

Aluminium alloy drill pipe outside diameter D_{dp} in	Protector thickening		
	Outside diameter D_{pt} in	Increase in pipe mass due to protector thickening lb	
		2 range	3 range
	Tol. $^{+0.12}_{-0.11}$		
5.08	5.75	21.11	30.85
5.16	6.15	38.12	55.71
5.24	5.75	29.47	43.06
5.52	6.78	45.22	66.09
5.79	6.78	22.86	33.41
5.95	6.78	62.93	91.97
6.11	6.78	50.26	73.46
6.46	7.29	42.75	62.48
6.62	7.29	35.04	51.21

While calculating mass, aluminium alloy density shall be taken equal to 174.80 lb/ft^3. In case of using other density alloys, compensation factor shall be used.

Table A.6 — Protector thickening of aluminium alloy drill pipe body with internal upset (see Figures 3 and 7)

(see Table 6 for SI units)

Aluminium alloy drill pipe outside diameter D_{dp} in	Protector thickening		
	Outside diameter D_{pt} in	Increase in pipe mass due to protector thickening lb	
		2 range	3 range
	Tol. $^{+0.12}_{-0.11}$		
2.88	3.47	15.22	22.25
3.55	4.14	18.44	26.94
4.06	4.65	20.89	30.54
4.49	5.52	41.62	60.83
5.08	5.91	36.93	53.97
5.79	6.78	50.26	73.46
6.62	7.76	66.71	97.51

While calculating mass, aluminium alloy density shall be taken equal to 174.80 lb/ft^3. In case of using other density alloys, compensation factor shall be used.

Table A.7 — Tool joint dimensions (see Figures 8 and 9)

(see Table 7 for SI units)

Aluminium alloy drill pipes		Tool joint										Thread type	
D_{dp} in	t_{dp} in	D_{tj} in	D_f in	D_e in	D_{pe} in	d_p in	d_b in	d_6 in	L_b in	L_{pb}[a] in	Mass lb	Tool joint	Pipe
		Tol. ±0.031	Tol. ±0.016	Tol. ±0.031	Tol. +0.039	Tol. $^{+0.016}_{-0.031}$	Tol. $^{+0.12}_{-0.11}$	Tol. ±0.016	Tol. $^{+0.24}_{-0.39}$	Tol. $^{+0.35}_{-0.39}$			
Aluminium alloy drill pipe with external upset													
3.55	0.32	4.65	4.49	4.18	4.29	2.68	2.68	2.92	10.84	7.29	42.96	NC38	TT90
4.49	0.39	6.11	5.91	5.48	5.63	3.74	3.74	3.86	12.61	8.27	85.04	NC50	TT122
5.08	0.35	6.78	6.66	6.15	6.30	4.41	4.41	4.49	13.40	8.87	101.34	5-1/2FH	TT138
5.16	0.51	7.01	6.72	5.91	6.30	4.14	4.14	—	12.61	8.00	101.34	5-1/2FH	TT138
5.24	0.43	6.78	6.66	6.15	6.30	4.41	4.41	4.49	13.40	8.87	101.34	5-1/2FH	TT138
5.52	0.51	6.78	6.66	6.15	6.30	4.41	4.41	4.49	13.40	8.87	101.34	5-1/2FH	TT138
5.79	0.43	7.68	7.41	6.93	7.20	4.89	4.89	5.12	14.38	9.61	143.64	6-5/8FH	TT158
5.95	0.51	7.68	7.41	6.93	7.20	4.89	4.89	5.12	14.38	9.61	143.64	6-5/8FH	TT158
6.11	0.59	7.68	7.41	6.93	7.20	4.89	4.89	5.12	14.38	9.61	143.64	6-5/8FH	TT158
6.46	0.35	8.00	7.72	7.49	7.80	4.89	5.44	5.75	14.38	9.61	146.50	6-5/8FH	TT172
6.62	0.43	8.00	7.72	7.49	7.80	4.89	5.44	5.75	14.38	9.61	146.50	6-5/8FH	TT172
Aluminium alloy drill pipe with internal upset													
2.52	0.32	3.15	2.99	2.68	2.87	1.34	1.34	1.50	9.46	6.42	20.93	NC23	TT53
2.88	0.35	3.74	3.59	3.11	3.23	1.73	1.73	1.73	10.24	6.70	31.94	NC26	TT63
3.55	0.35	4.25	4.09	—	3.94	2.13	2.20	2.36	10.63	7.09	36.34	NC31	TT82
3.55	0.35	4.75	4.57	3.94	4.02	2.28	2.20	2.36	11.81	7.20	55.95	NC38	TT82
4.06	0.35	4.75	4.57	—	4.45	2.68	2.68	2.80	11.23	7.29	46.26	NC38	TT94
4.06	0.35	5.00	4.57	4.41	4.45	2.68	2.68	2.80	11.23	7.29	55.08	NC38	TT94
4.49	0.39	5.71	5.52	4.77	4.96	3.23	3.23	3.31	12.02	7.68	76.88	NC44	TT104
4.49	0.43	5.98	5.71	5.04	5.04	3.15	3.15	3.27	12.20	7.72	90.31	NC46	TT106
5.08	0.43	6.38	6.06	5.51	5.55	3.74	3.66	3.82	12.61	8.11	95.81	NC50	TT120
5.79	0.43	7.01	6.74	6.15	6.30	4.41	4.41	4.53	13.40	8.87	116.98	5-1/2FH	TT138[b]
5.79	0.51	7.01	6.74	6.15	6.30	4.41	4.41	4.53	13.40	8.87	116.98	5-1/2FH	TT138[b]
5.79	0.59	7.01	6.74	6.15	6.30	4.41	4.41	4.53	13.40	8.87	116.98	5-1/2FH	TT138[b]
6.62	0.43	8.00	7.72	7.01	7.20	5.00	5.00	5.12	13.59	9.65	157.51	6-5/8FH	TT158
6.62	0.51	8.00	7.72	7.01	7.20	5.00	5.00	5.12	13.59	9.65	157.51	6-5/8FH	TT158

[a] Reference dimensions.

[b] TT136 thread can be used by agreement between manufacturer and purchaser.

Table A.8 — Dimensions of tool joint thread for aluminium alloy drill pipes (see Figure 9)

(see Table 8 for SI units)

Dimensions in inches

Thread type	Tool joint				
	d_2[a]	d_3	d_4[a]	d_5[a]	L_4
		Tol. $^{+0.031}_{-0.016}$			Tol. ± 0.012
Aluminium alloy drill pipes with external upset ends					
TT90	3.835	3.791	3.559	3.629	5.20
TT122	5.103	5.049	4.817	4.897	5.52
TT138	5.733	5.678	5.446	5.526	5.52
TT158	6.519	6.464	6.232	6.312	5.52
TT172	7.068	7.014	6.782	6.862	5.52
Aluminium alloy drill pipes with internal upset ends					
TT53	2.381	2.336	2.104	2.174	5.20
TT63	2.774	2.730	2.497	2.567	5.20
TT79	3.403	3.359	3.126	3.197	5.20
TT82	3.518	3.474	3.242	3.312	5.20
TT90	3.835	3.791	3.559	3.629	5.20
TT94	3.993	3.948	3.716	3.786	5.20
TT104	4.396	4.342	4.109	4.189	5.52
TT106	4.449	4.409	4.173	4.252	5.51
TT120	5.007	4.953	4.734	4.814	5.52
TT136	5.654	5.600	5.367	5.447	5.52
TT138	5.733	5.678	5.446	5.526	5.52
TT158	6.519	6.465	6.233	6.313	5.52

[a] Reference dimensions.

Table A.9 — Thread dimensions of aluminium alloy drill pipes (see Figure 10)

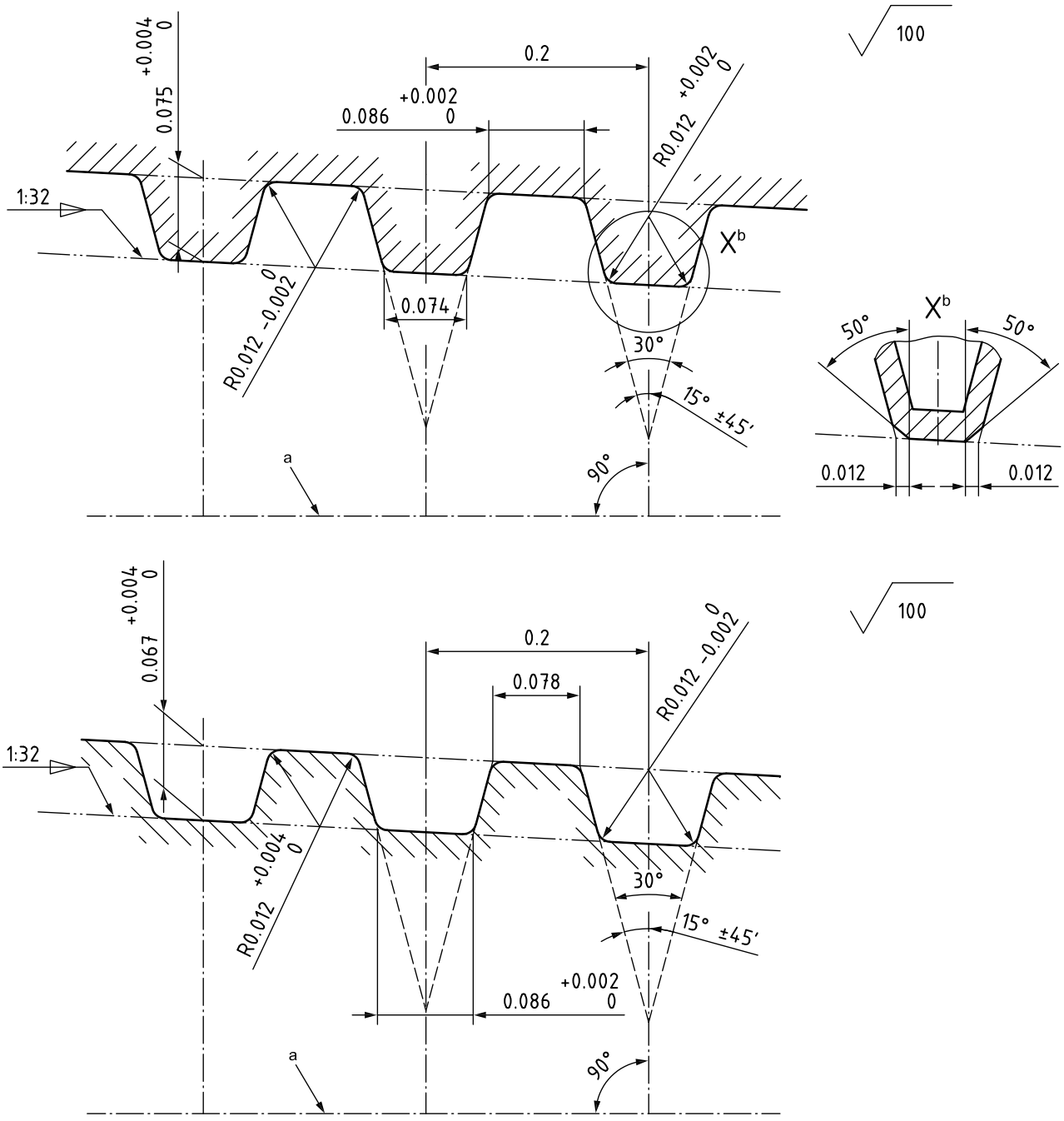
(see Table 9 for SI units)

Dimensions in inches

Thread type	Tool joint					
	d_1[a]	D_1	D_2	D_3[a]	D_4	L_5[a]
		Tol. $\pm$ 0.031	Tol. $^{0}_{-0.024}$		Tol. $\pm$ 0.002	
Aluminium alloy drill pipes with external upset ends						
TT90	90.60	82	86.5	91.656	96.5	150
TT122	122.60	112	118.5	123.656	128.5	160
TT138	138.60	129	134.5	139.656	144.5	160
TT158	158.60	148	154.5	159.656	164.5	160
TT172	172.60	163	168.5	173.656	178.5	160
Aluminium alloy drill pipes with internal upset ends						
TT53	2.112	1.773	1.962	2.153	2.344	5.91
TT63	2.506	2.167	2.344	2.547	2.738	5.91
TT79	3.136	2.797	2.975	3.178	3.369	5.91
TT82	3.252	2.894	3.091	3.294	3.484	5.91
TT90	3.570	3.231	3.408	3.611	3.802	5.91
TT94	3.727	3.369	3.566	3.769	3.960	5.91
TT104	4.121	3.782	3.960	4.163	4.354	6.30
TT106	4.173	3.819	4.116	4.213	4.409	6.30
TT120	4.748	4.390	4.587	4.790	4.967	6.30
TT136	5.382	5.043	5.221	5.424	5.615	6.30
TT138	5.461	5.122	5.299	5.502	5.693	6.30
TT158	6.249	5.910	6.087	6.290	6.481	6.30

[a] Reference dimensions.

Dimensions in inches



a Thread axis.

b Variants of the thread crest (fillet or chamfer).

NOTE 1 Upper thread shape relates to tool joint thread, lower thread shape relates to pipe thread.

NOTE 2 Thread pitch (0.2 in) is measured parallel to the thread axis.

NOTE 3 Bisectrix of the thread angle is perpendicular to the thread axis.

NOTE 4 All tolerances for the thread characteristics, except for the thread depth, are given for designing of the thread-cutting tool.

NOTE 5 Thread run-out can be located on the chamfer between the thread and seal taper shoulder.

NOTE 6 For dimensions in millimetres, see Figure 11.

Figure A.1 — TT thread shape for aluminium alloy drill pipe bodies and tool joints

Annex B
(normative)

Purchaser inspection

B.1 Inspection notice

When the inspector representing the purchaser wishes to inspect a pipe or witness a test, reasonable notice shall be given of the time at which the relevant inspection/tests are to be made.

B.2 Plant access

The inspector representing the purchaser shall have unrestricted access to all parts of the manufacturer's works that concern the manufacture of the pipes ordered, at all times whilst work on the contract of the purchaser is being performed. The manufacturer shall afford the inspector all reasonable facilities to satisfy them that the pipes are being manufactured in accordance with this International Standard. All inspections should be made at the place of manufacture prior to shipment, unless otherwise specified on the purchase order, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

B.3 Compliance

The manufacturer is responsible for complying with all of the provisions of this International Standard. The purchaser may make any investigation necessary to satisfy him of compliance by the manufacturer and may reject any material that does not comply with this International Standard.

B.4 Rejection

Unless otherwise provided, material which shows defects on inspection or subsequent to acceptance at manufacturer's works, or which proves defective when properly applied in service, may be rejected, and the manufacturer so notified. If tests that require destruction of material are made, any product that is proven to have not met the requirements of this International Standard shall be rejected. Disposition of rejected product shall be a matter of agreement between the manufacturer and purchaser.

Annex C
(normative)

Supplementary requirement — Fatigue test procedure and analysis of fatigue data

C.1 General

Full-scale fatigue design verification testing shall be performed as described below, when required by the purchaser.

Fatigue testing of aluminium alloy drill pipes, designed and manufactured in accordance with this International Standard, shall be carried out and/or certified by a department or organization independent of the design and manufacturing function.

C.2 General test methodology

Full-scale fatigue verification tests shall be performed in air of room temperature, under rotating bending via a resonance test or rotating beam test with a stress ratio of $-1 \pm 0{,}05$ and a test frequency not exceeding 40 Hz.

Tests shall be planned in order to determine the mean value of fatigue limit specified in Clause C.6. Tests shall be conducted on each anticipated weak section of the aluminium alloy drill pipe in order to determine its minimum fatigue strength. At least the following locations shall be tested:

a) aluminium alloy drill pipe body-tool joint thread connection;

b) aluminium alloy drill pipe upset area.

The cyclic bending moment shall be checked by strain gauges calibrated before testing, and the cyclic stress level, σ, expressed in megapascals (pounds per square inch), shall be calculated at the reference section (pipe body upset section at tool joint) according to Equation (C.1), as follows:

$$\sigma = K \times \frac{M_{\mathrm{b}}}{W_{\mathrm{u}}} \tag{C.1}$$

where

K is the conversion coefficient (K = 1 for SI unit calculations; K = 12 for USC unit calculations);

M_{b} is the cyclic bending moment applied to the tested location, expressed in kilonewton-metres (foot-pounds);

W_{u} is the section modulus of pipe body upset area, expressed in cubic millimetres (cubic inches), calculated according to Equation (C.2), as follows:

$$W_{\mathrm{u}} = \frac{\pi\left(D_{\mathrm{u}}{}^4 - d_{\mathrm{u}}{}^4\right)}{32 D_{\mathrm{u}}} \tag{C.2}$$

where

D_u is the outside diameter of upset end, expressed in millimetres (inches);

d_u is the inside diameter of the pipe upset, expressed in millimetres (inches).

Strain gauges shall be placed around the circumference of the anticipated weak section. The mean value of the strain gauge indications shall be used to calculate stress at that location. When it is impossible to place strain gauges over the weak section, as in thread connection, which is hidden under the steel tool joint, they shall be placed near the weak section within a distance of not more than $3\sqrt{D_u\, t_u}$ (where D_u is outside diameter of upset end and t_u is upset wall thickness) from the tool joint. Test conditions shall be such to avoid influence of any stress concentrations to the reading of the strain gauges. In this case, the actual stress in the tested section shall be calculated based on the applied loading scheme and assumed bending moment distribution. In some cases, it is recommended that two sets of gauges be used at two positions along the length of the test section to allow for an estimate of the bending moment over a region of interest.

C.3 Specimen and clamping devices

For each specimen, the “test zone” where the fatigue strength is to be characterized can be defined by the use of a reduced section, notches, etc. Examples of such test zones are the threaded joint or the aluminium alloy drill pipe upset area.

Tested specimens shall be cleared of all defects outside the “test zone” (such as dents and notches, as well as other stress concentrators). This preparation treatment will reduce the influence of accidental factors on the testing results and avoid unpredictable failures in the areas not related to anticipated weak sections.

The clamping and loading system shall be such as to guarantee minimum specified bending moment over a length of the specimen extending for at least one diameter in the axial direction on both sides of the test zone.

Boundary effects or spurious stress states due to clamping or loading devices or anomalous specimen geometry variations shall be minimized (i.e. reduced to no more than 2 % of the testing stress) outside the test zone.

Tests can be conducted either on actual components or on specially manufactured specimens. In the second case, the geometry of the specimen shall be equal to that of the full scale component at least in the region where the constant bending moment is required. Moreover, the manufacturing and assembly technology of the specimen shall be the same as that of the component.

C.4 Number of tests and analysis of data

As the estimate of fatigue limit is required, the use of specially designed test procedures is recommended.

Among these procedures, the methods of full-scale fatigue testing and statistical analysis of fatigue data described in ISO 12107 or GOST 25.507-85 can be used.

In order to reduce testing costs, shortened procedures may be employed, provided that they allow estimation of the standard deviation of the data and that their accuracy can be demonstrated. In any case, the number of these tests shall not be less than two.

C.5 Test repetition

Full-scale fatigue tests should be carried out after any design, material or manufacturing technology modifications.

C.6 Fatigue limit

The mean cyclic stress corresponding to a 2×10^7 cycle life shall be not less than 50 MPa for the anticipated weak section of aluminium alloy drill pipe (see Clause C.2).

Tests with fewer loading cycles at elevated stress values may be employed to reduce testing costs, provided that a mean value of fatigue life curve showing stress range versus number of cycles (S-N curve) can be extrapolated to the 2×10^7 cycles, and that their accuracy can be demonstrated. In any case, the maximum number of loading cycles shall not be less than 2×10^6.

Annex D
(normative)

Corrosion test

D.1 General

The corrosion rate of aluminium alloy drill pipe from material group IV (see Table 1) shall be estimated by assessing the weight reduction of specimens in 3,5 % sodium chloride solution, in accordance with ISO 11130. Three specimens cut from an upset section of an aluminium alloy drill pipe, with effective surface area at least 100 mm^2 (0.155 0 in^2), shall be used for the tests. Linear dimensions shall be measured with 0,01 mm (0.000 39 in) maximum magnitude of error. The specimen surface area-weight ratio should be as high as possible to enable maximum metal loss from corrosion. The test solution volume shall be at least 20 cm^3 (0.031 0 in^3) per 1 cm^2 (0.16 in^2) of the specimen surface area.

D.2 Preparation of test specimen

The specimen surface shall be ground to a roughness of no more than 1,6 µm (6.30×10^{-5} in). The specimen dimensions and mass shall be determined and the specimens fully degreased with acetone.

After degreasing, forceps should be used for handling specimens. The specimens shall be washed with distilled water, dried and weighed on an analytical balance with a magnitude of error below 1×10^{-4} g (3.5×10^{-6} oz). The specimens shall then be placed into the test solution.

The corrosion tests shall be performed at 21 °C ± 2 °C (70 °F ± 4 °F) and atmospheric pressure. Higher test temperatures and pressures may be agreed between the purchaser and manufacturer. The test period shall be at least 72 h. Following the test, specimens shall be visually examined and their condition noted including the form of any corrosion both before and after cleaning.

The method for specimen cleaning shall be in accordance with ASTM G1. The specimens shall then be reweighed on an analytical balance.

D.3 Processing of the test results

The corrosion rate, expressed in grams per square metre per hour (ounces per square foot per hour), can be calculated according to Equation (D.1), as follows:

$$V_k = \frac{m_1 - m_2}{S \times T_t} \tag{D.1}$$

where

m_1 is the mass of the specimen before the test, expressed in grams (ounces);

m_2 is the mass of the specimen after the test, expressed in grams (ounces);

S is the surface area of the specimen, expressed in square metres (square feet);

T_t is the test time, expressed in hours.

Annex E
(informative)

Conversion of SI units to USC units

E.1 Background

The following procedures were adopted in this International Standard for the conversion of SI units into USC units.

E.2 General

E.2.1 Unit calculation

All units were calculated using conversion coefficients expressed in Table E.1 (see Reference [10]).

Table E.1 — Conversion of SI units to USC units

Derived quantity	SI derived unit		Expressed in terms of SI base units and SI derived units
	Name	Symbol	
Length	millimetre	mm	1 mm = 0.039 37 in
	centimetre	cm	1 cm = 0.393 7 in
	metre	m	1 m = 3.280 8 ft
Roughness	micrometre	µm	1 µm = 3.937×10^{-5} in
Area	square millimetre	mm^2	1 mm^2 = 0.001 55 in^2
	square centimetre	cm^2	1 cm^2 = 0.155 in^2
Volume	cubic millimetre	mm^3	1 mm^3 = 1.55×10^{-6} in^3
Mass	kilogram	kg	1 kg = 2.202 6 lb
	gram	g	1 g = 0.003 53 oz
Temperature	degree Celsius	°C	°C = (°F − 32)/1.8
Corrosion rate	grams per square metre per hour	g/(m^2h)	1 g/(m^2h) = 3.28×10^{-4} oz/(ft^2h)
Force (weight)	kilonewton	kN	1 kN = 224.809 lb
Linear mass	weight per linear metre	kg/m	1 kg/m = 0.671 1 lb/ft
Torque	kilonewton-metre	kNm	1 kNm = 737.561 ft·lb
Density	kilogram per cubic metre	kg/m^3	1 kg/m^3 = 0.062 4 lb/cu ft 1 kg/m^3 = 0.008 35 lb/gal (ppg)
Stress, pressure	megapascal	MPa	1 MPa = 145.033 psi

E.2.2 Rounding

The converted USC values were rounded to the number having one significant digit more than the initial SI value. Temperature in degrees Fahrenheit was rounded to the nearest degree.

The last retained digit in a number was unchanged when the next digit was less than 5 and raised when it was greater than 5.

When the digit following the last retained digit was exactly 5 followed by all zeros, the last retained digit was unchanged if it was even, or was raised if it was odd (see Reference [10]).

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