INTERNATIONAL STANDARD

ISO 15546

Second edition
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Petroleum and natural gas industries — Aluminium alloy drill pipe

Industries du pétrole et du gaz naturel — Tige de forage en alliage d'aluminium

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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.

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

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

This second edition cancels and replaces the first edition (ISO 15546:2002), of which it constitutes a minor revision.

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 — 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.

Petroleum and natural gas industries — Aluminium alloy drill pipe

1 Scope

This International Standard specifies the technical delivery condition, 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.

2 Normative references

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

ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 9303, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of longitudinal imperfections*

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

ISO 11484, *Steel tubes for pressure purposes — Qualification and certification of non-destructive testing (NDT) personnel*

ISO 11960:2004, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells*

ASTM[1)] A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

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

ASTM G44, *Standard Practice for Exposure of Metals and Alloys by Alternate Immersion in Neutral 3,5 % Sodium Chloride Solution*

Manual on Statistical Planning and Analysis for Fatigue Experiments — STP-588, ASTM

1) ASTM International, 100 Bar Harbor Drive, West Conshohocken, PA 19428-2959, USA.

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1
defect
imperfection of sufficient magnitude to warrant rejection of the product based on the criteria defined in this International Standard

3.1.2
drill pipe
seamless pipe used to rotate the drill bit and circulate the drilling mud, pipes being coupled together by means of tool joints

3.1.3
heat
metal produced by a single cycle of a batch melting process

3.1.4
imperfection
discontinuity in the product wall or on the product surface that can be detected by a NDE method as given in ISO 11960:2004, Table C.62 or Table E.62

3.1.5
lot
lengths of pipe with the same specified dimensions and grade, heat treated as part of a continuous operation (or batch), and which are of a single heat or from different heats grouped according to documented procedure

NOTE The documented procedure will ensure that the appropriate requirements of this International Standard are met.

3.1.6
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.

3.1.7
pipe mill
firm, company or corporation that operates pipe-making facilities

3.1.8
processor
firm, company or corporation that operates facilities capable of cutting the threads and assembly of the pipe with the tool joints

3.1.9
seamless pipe
wrought tubular product made without a welded seam, manufactured by hot working and, if necessary, by subsequent cold finishing of the tubular product to produce the desired shape, dimensions and properties

3.2 Symbols

The following symbols are used in this International Standard.

D Pipe body outside diameter, expressed in millimetres

D_1 Outside diameter of upset end, expressed in millimetres

D_2 Diameter, thread end groove in the pipe end plane, expressed in millimetres

D_3 Pipe end outside diameter, expressed in millimetres

D_4 Pipe thread outside diameter in the end plane, expressed in millimetres

D_5 Pipe diameter at the thread run-out, expressed in millimetres

D_6 Pipe diameter in the estimated plane, expressed in millimetres

D_{pt} Outside diameter of protector thickening, expressed in millimetres

D_s Tool joint bevel diameter, expressed in millimetres

D_{se} Tool joint elevator bevel diameter, expressed in millimetres

D_{sp} Pin bevel diameter, expressed in millimetres

D_{tj} Tool joint outside diameter, expressed in millimetres

d Inside diameter, expressed in millimetres

d_1 Inside diameter of the pipe upset end, expressed in millimetres

d_2 Pipe thread inside diameter in the plane of reference, expressed in millimetres

d_3 Tool joint tapered bore diameter in the plane of the end, expressed in millimetres

d_4 Tool joint tapered bore diameter in the seal estimated plane, expressed in millimetres

d_5 Tool joint thread inside diameter in the plane of reference, expressed in millimetres

d_6 Tool joint thread inside diameter in the end plane, expressed in millimetres

d_7 Bevel diameter at the tool joint thrust inner step, expressed in millimetres

d_8 Inside bevel diameter at the pipe thrust end, expressed in millimetres

d_{tp} Tool joint pin inside diameter, expressed in millimetres

d_{tb} Tool joint box inside diameter, expressed in millimetres

f Hydrostatic pressure test factor

L_1 Length of upset end, expressed in millimetres

L_2 Length of upset end transition zone, expressed in millimetres

L_3 Length of protector thickening, expressed in millimetres

L_4 Length of protector thickening transition zone, expressed in millimetres

L_5 Distance between the pipe end and the end of the processed tapered surface of the stabilizing groove, expressed in millimetres

l Distance from tool joint end plane to inside shoulder face, expressed in millimetres

l_p Pipe length without tool joint, expressed in metres (the distance between the pipe ends)

l_{pj} Pipe length with tool joint, expressed in metres (the distance between the tool joint box face and pin shoulder)

l_{tb} Tool joint box length, expressed in millimetres

l_{tp} Tool joint pin length, expressed in millimetres

p Standard hydrostatic test pressure, expressed in megapascals

t Wall thickness of pipe body, expressed in millimetres

t_1 Wall thickness of upset end, expressed in millimetres

$\sigma_{y,min}$ Specified minimum yield strength, expressed in megapascals

4 Information to be supplied by purchaser

4.1 In placing orders for 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) internal upset, external upset, external or internal upset and protector thickening (see Tables 4 to 7);

d) drill pipe delivery condition (see 5.4 and Clause 14);

e) outside diameter (see Tables 4 to 7);

f) wall thickness (see Tables 4 to 7);

g) material group (see Table 1);

h) length (see 7.2, Table 3);

i) delivery date and shipping instructions;

j) inspection by purchaser (see Annex A);

k) alternatives of tool joints (see Figure 7).

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

a) pipe coatings (see 7.9);

b) marking requirements (see Clause 11);

c) non-destructive inspection (see 10.4);

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

e) test certificates (see 13.1);

f) alloy system (see Table 1).

5 Process of manufacture and delivery condition

5.1 General

Drill pipe furnished to this International Standard shall be made by the seamless process.

5.2 Heat treatment

Drill pipes 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.

5.3 Traceability

The manufacturer shall establish and follow procedures for maintaining heat or lot identity or both until all required heat/lot tests have been performed and conformance with specification requirements has been verified.

5.4 Delivery condition

Aluminium alloy drill pipes are normally supplied as

a) plain end pipe (with external or internal upsets but without threads),

b) threaded pipe (with external or internal upsets but without tool joints), or

c) with tool joints attached (with external or internal upsets).

6 Material requirements

6.1 Material groups

Materials for aluminium alloy drill pipes after heat treatment are divided into the following four material groups that shall be in accordance with Table 1:

— **Group I**, without additional requirements for high strength or corrosion resistance;

— **Group II**, with improved strength;

— **Group III**, with high-temperature mechanical properties;

— **Group IV**, with improved corrosion resistance.

Table 1 — Material requirements for aluminium alloy drill pipes

Characteristic[a]	Unit	Requirements			
		Material group I	Material group II	Material group III	Material group IV
Alloy system		Al-Cu-Mg	Al-Zn-Mg	Al-Cu-Mg-Si-Fe	Al-Zn-Mg
Yield strength, min. (0,2 % offset method)	MPa	325	480	340	350
Tensile strength, min.	MPa	460	530	410	400
Elongation, min.	%	12	7	8	9
Operational temperature, max.	°C	160	120	220	160
Corrosion rate in 3,5 % sodium chloride solution, max.	g/(m^{2}h)	—	—	—	0,08
It is permitted to use an alternative aluminium alloy system, provided there is purchaser agreement and that it conforms to the requirements of one of the four material group categories. The manufacturer shall have a documented procedure that demonstrates the minimum yield strength that can be achieved at the maximum operational temperature defined in Table 1. Mechanical testing shall be in accordance with ISO 6892. It is necessary that users be aware that the yield strength at ambient temperature can be reduced by up to 30 % at the maximum operational temperature for exposure times greater than 500 h.					
[a] The mechanical properties of the alloys given in this table are for a test temperature of 21 °C ± 3 °C.					

6.2 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 and ASTM B918.

6.3 Chemical composition

Chemical analysis shall be undertaken on each heat. The residual lead content shall be limited to 0,005 % by mass for all material groups.

6.4 Steel tool joints

Material for steel tool joints shall be in accordance with Table 2.

Table 2 — Mechanical property requirements for steel tool joints

Characteristic[a]	Unit	Requirement
Tensile strength, min.	MPa	880
Yield strength, min. (0,2 % offset method)	MPa	735
Elongation after fracture, min.	%	13
Longitudinal Charpy V notch absorbed energy requirement, min.[b]	J	70 average of three tests (47 single value)
Brinell hardness, min.	HBW	285
Determination of the mechanical properties of the pin shall be in accordance with ASTM A370. Other gauge lengths may be used with purchaser agreement. In such cases, the corresponding elongation values shall be obtained in accordance with ISO 2566-1. In cases of dispute, the gauge length, $l_o = 5{,}65\sqrt{S_o}$, shall be used. For location of test-pieces, see ISO 10924-2.		
[a] The mechanical properties of the tool joint material given in this table are for a test temperature of 21 °C ± 3 °C. [b] By agreement between the purchaser and the manufacturer, and when specified on the purchase order, the Charpy impact testing shall be carried out at − 10 °C ± 3 °C and shall meet these requirements.		

7 Configuration and dimensions of pipes

7.1 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 Figure 3 for pipes with protector thickening.

7.2 Length

Drill pipe length ranges shall be in accordance with Table 3.

Table 3 — Pipe length (see Figure 1)

Dimensions in metres

Pipe condition at delivery	Range		
	1	2	3
With tool joint, $l_{pj}{}^{+0,25}_{-0,15}$	6,20	9,10	12,40
Without tool joint, $l_{p}{}^{+0,25}_{-0,15}$	5,80	8,70	12,00
Other pipe lengths may be ordered by agreement between the manufacturer and purchaser.			

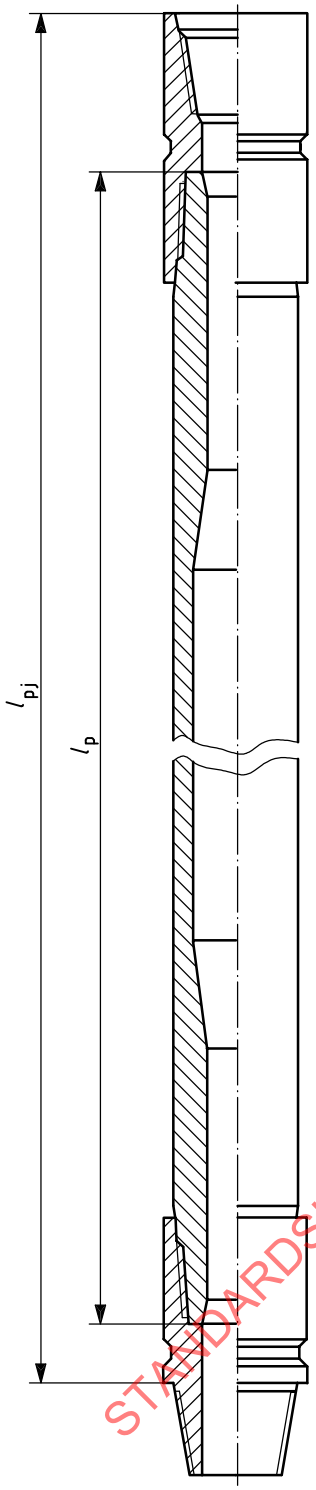


Figure 1 — Drill pipe with internal upset

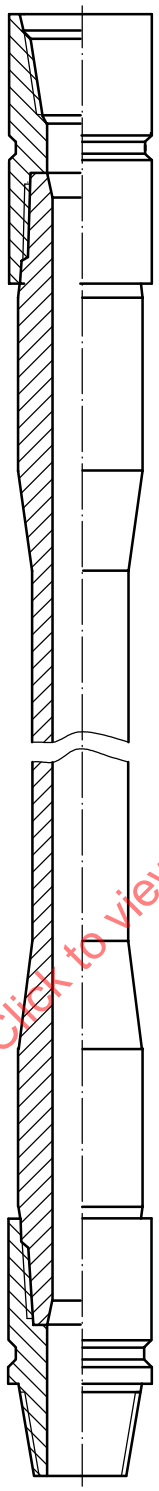


Figure 2 — Drill pipe with external upset

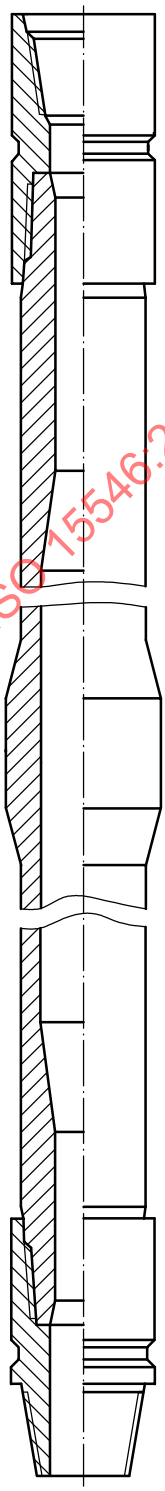


Figure 3 — Drill pipe with protector thickening

7.3 Dimensions of pipes and tool joints

7.3.1 Pipe dimensions

The dimensions of the pipe body and upset ends, together with the tolerances, shall be in accordance with

— Table 4, for pipes with external upset ends (see also Figure 4),

— Table 5, for pipes with internal upset ends (see also Figure 5), and

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

7.3.2 Tool joint dimensions

The dimensions for the tool joints shall be in accordance with Figure 7 and Table 8. If rotary shouldered threads are used, they shall be in accordance with ISO 10424-2.

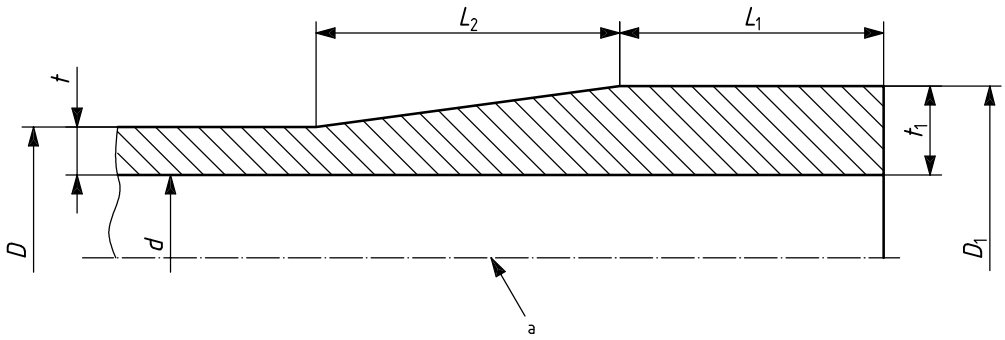
Other dimensions and design of tool joints may be used by agreement between purchaser and manufacturer.

7.3.3 TT-type thread dimensions (pipe to tool joint connection)

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

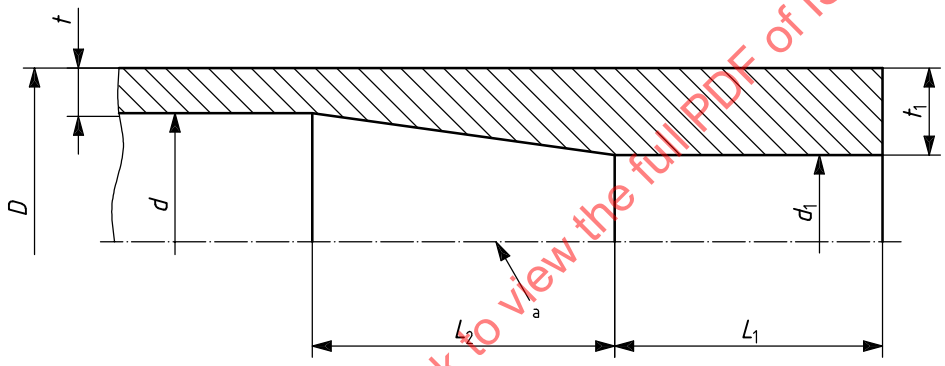
The thread dimensions for pipes [see Figure 8 b)] are given in Table 10.

The dimensions of thread form are given for the tool joints in Figure 9 a), and for the pipe in Figure 9 b).



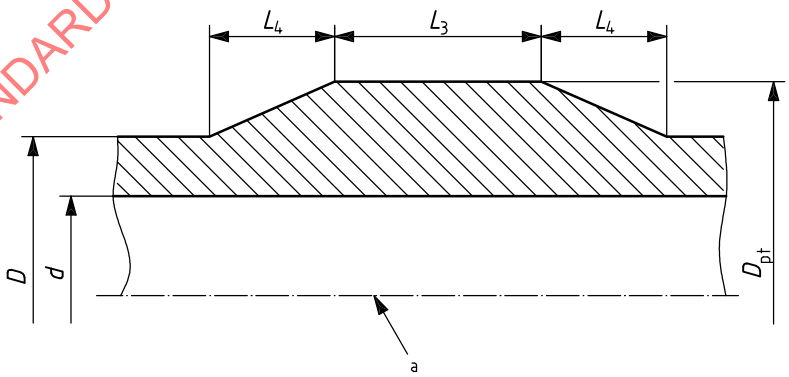
a Drill pipe axis.

Figure 4 — Drill pipe end with external upset



a Drill pipe axis.

Figure 5 — Drill pipe end with internal upset

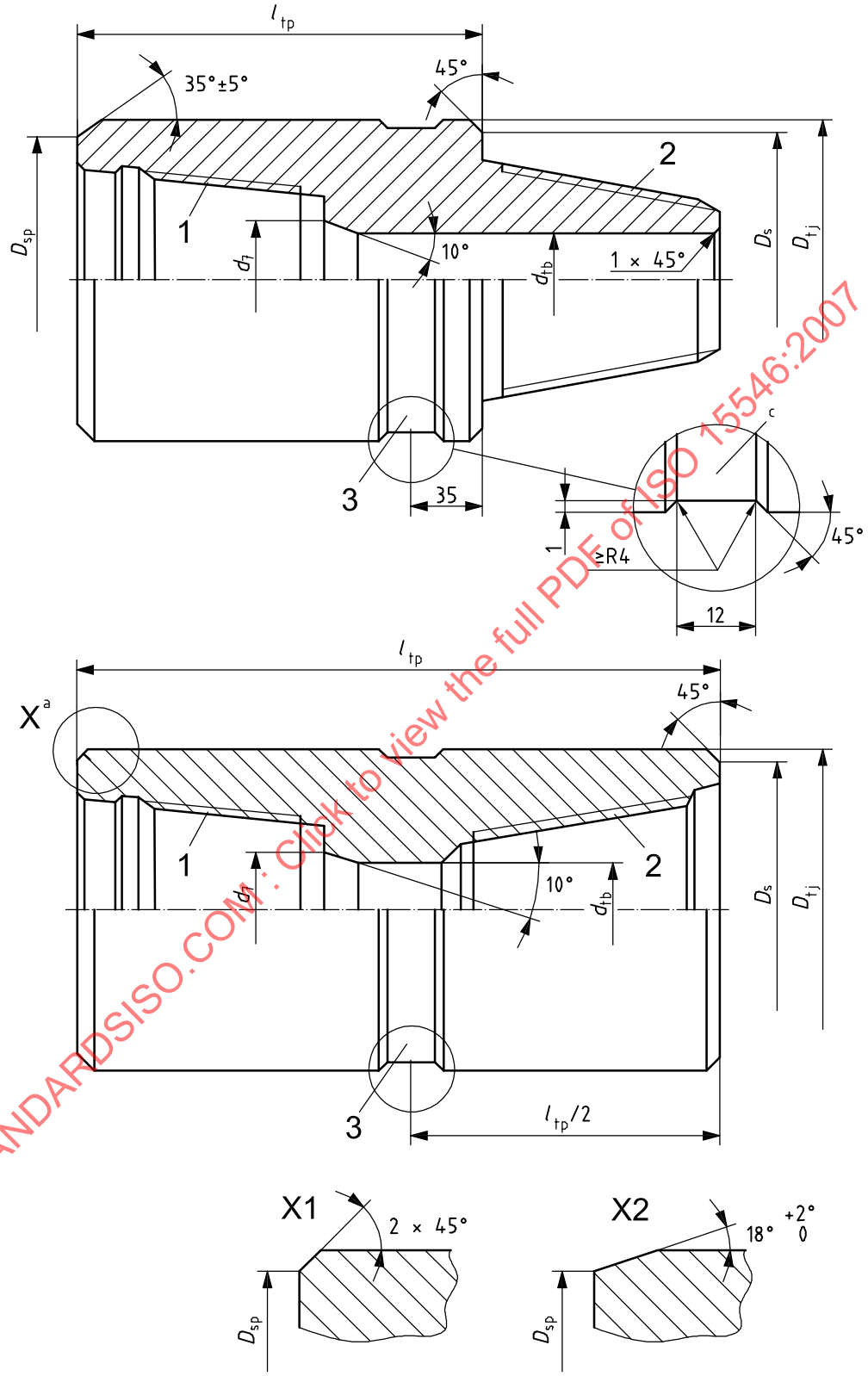


a Drill pipe axis.

NOTE For symbols, see 3.2.

Figure 6 — Drill pipe protector thickening

Dimensions in millimetres



Key

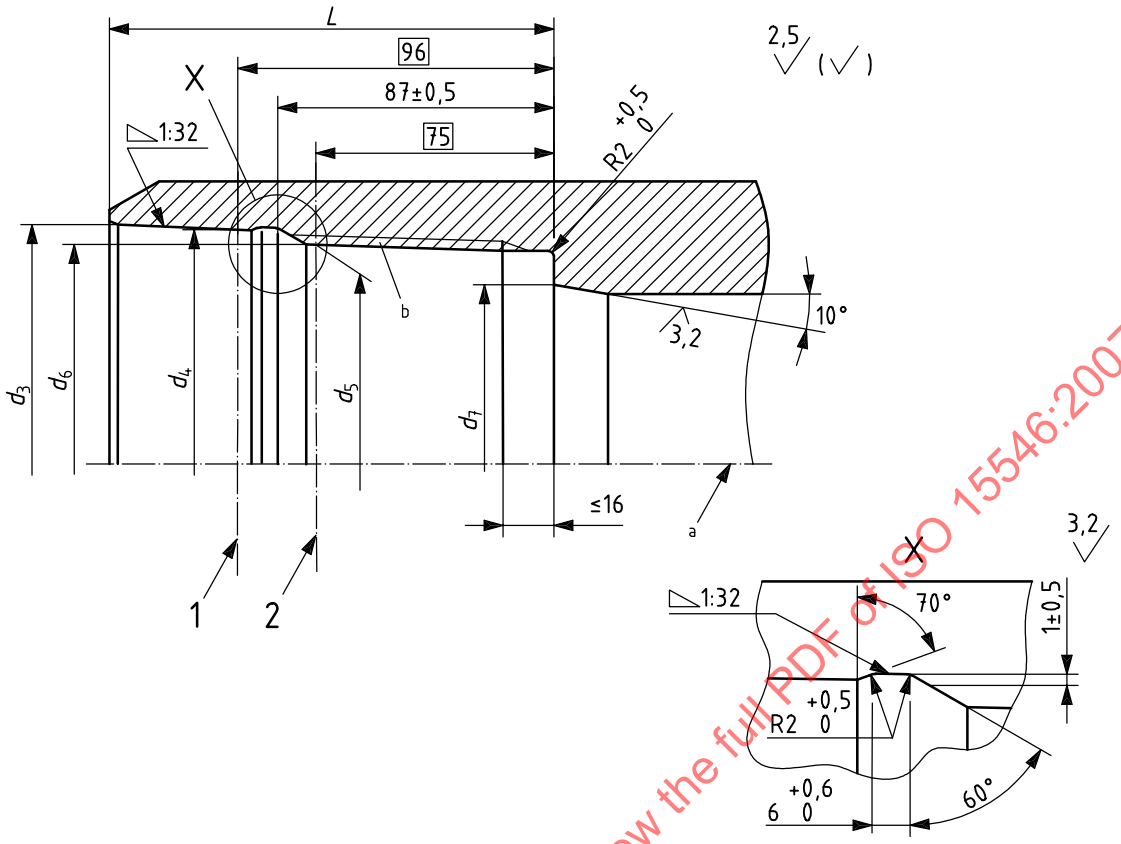
1 TT-type thread
2 rotary shouldered type thread
3 belt for marking

NOTE For symbols, see 3.2.

[a] Two variants for the box elevator diameter are shown in X1 and X2.

Figure 7 — Tool joint for aluminium alloy drill pipe

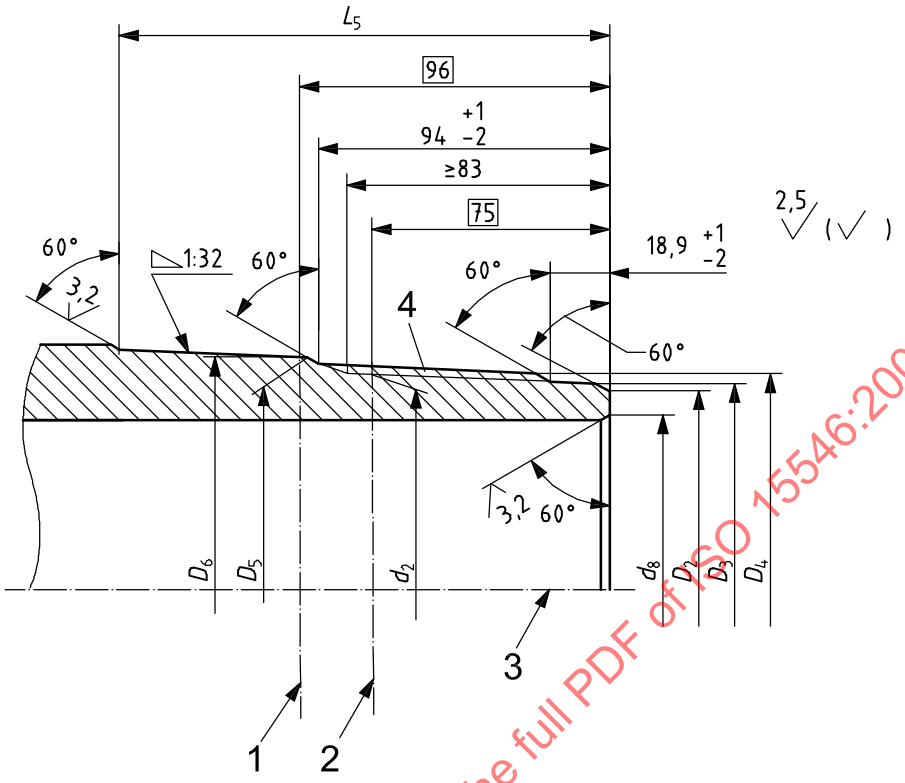
Dimensions in millimetres



a) Tool joint

Figure 8 — Drill pipe-to-tool joint thread connection

Dimensions in millimetres



b) Drill pipe

Key

1 design plane
2 reference plane
3 thread axis
4 TT thread

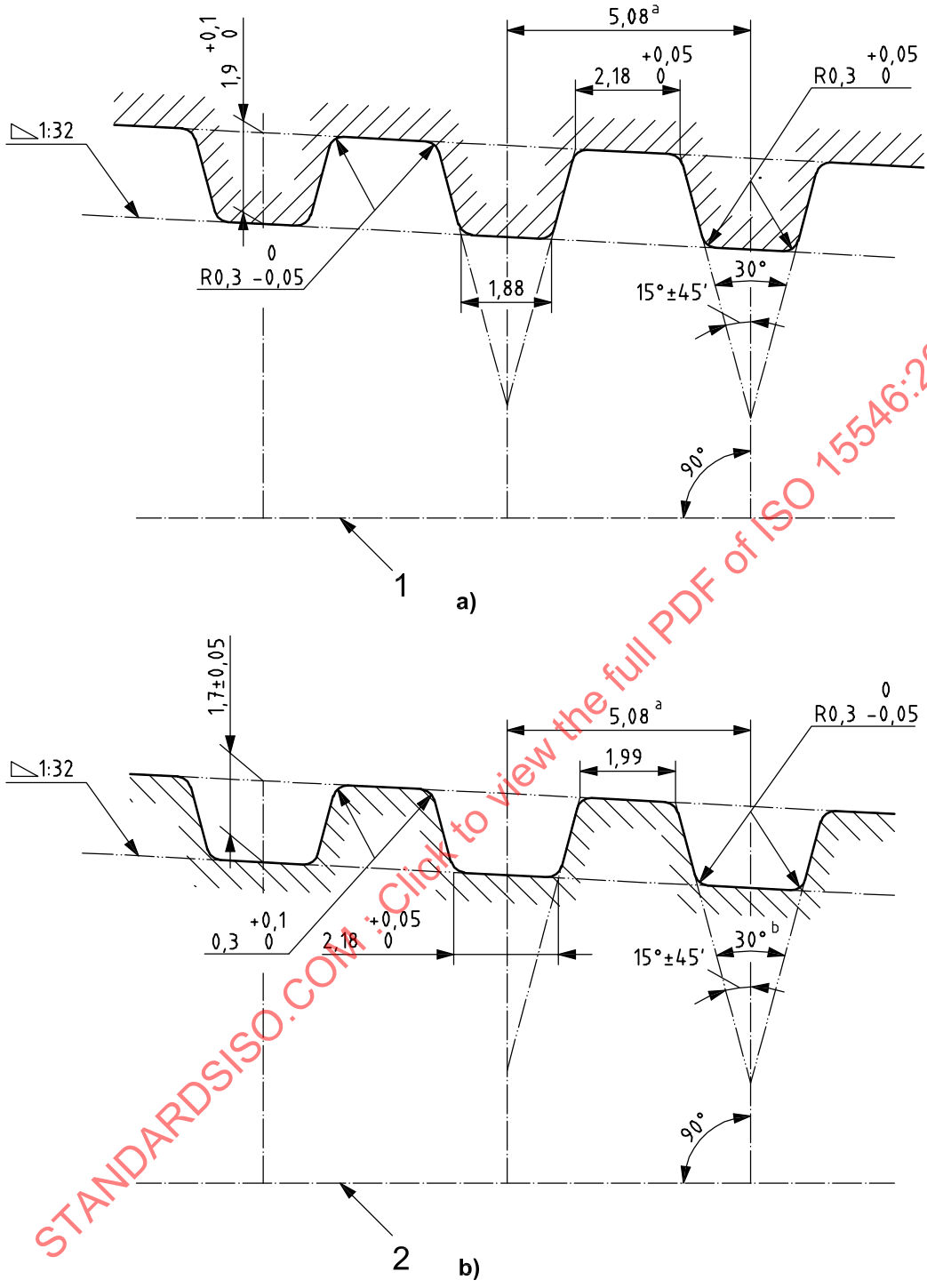
NOTE 1 For symbols, see 3.2.

NOTE 2 Boxed numbers are reference dimensions.

[a] Thread length with the full profile shall be 83 mm.

Figure 8 (*continued*)

Dimensions in millimetres



Key

1 thread axis tool joint (box)

2 thread axis

NOTE 1 For symbols, see 3.2.

NOTE 2 All tolerances on thread parameters, excluding depth of thread, are given for designing the thread-cutting tool.

NOTE 3 The thread run-out can be on the chamfer located between the thread and stabilizing taper band.

a Thread pitch (5,08 mm) shall be measured parallel to the thread axis.

b The bisectrix of the thread angle shall be perpendicular to the thread axis.

Figure 9 — TT-thread form for drill pipes and tool joints

7.4 Design mass

Calculated mass of the plain pipe per unit length, mass increase of the upset ends and protector thickening are indicated in Tables 4 to 7.

Table 4 — Drill pipe with external upset ends (see Figures 4 and 8)

Dimensions in millimetres

Dimensions of pipe body				Mass kg		Dimensions of upset ends						
Outside diameter D ± 1 %	Wall thickness t Tol.		Inside diameter d	Per metre of plain pipe body	Upset (both ends) increase	Wall thickness t_1	Outside diameter D_1 Tol.		Bevel diameter d_8 ± 0,3	Length of upset end: Box end L_{1eb} +150 −100	Length of upset end: Pin end L_{1ep} ± 50	Length of transition zone (both ends) L_{2e} +300 −450
90	8	± 1,0	74	5,726	4,65	13	100	+2,5 −1,0	74[a]	350	350	500
114	10	± 1,0	94	9,078	11,02	19	132	+2,5 −1,0	98	350	350	500
129	9	± 1,0	111	9,428	22,61	18	147	+2,5 −1,0	114	1 300	350	500
133	11	± 1,0	111	11,715	17,70	18	147	+3,5 −2,0	114	1 300	350	500
140	13	± 1,5	114	14,412	8,71	16,5	147	+3,5 −2,0	114[a]	1 300	350	850
147	11	± 1,5	125	13,059	30,12	21,5	168	+3,5 −2,0	130	1 300	350	500
151	13	± 1,5	125	15,66	24,54	21,5	168	+3,5 −2,0	130	1 300	350	500
155	15	± 1,5	125	18,331	18,79	21,5	168	+3,5 −2,0	130	1 300	350	500
164	9	± 1,5	146	12,177	33,28	19,5	185	+3,5 −2,0	146[a]	1 300	350	500
168	11	± 1,5	146	15,075	27,06	19,5	185	+3,5 −2,0	146[a]	1 300	350	500

Variations in the wall thickness in the end face plane shall not be more than ± 10 % of t_1.

[a] Dull.

Table 5 — Drill pipe with internal upset ends (see Figures 5 and 8)

Dimensions in millimetres

Dimensions of pipe body				Mass kg		Dimensions of upset ends							
Outside diameter	Wall thickness		Inside diameter	Per metre of plain pipe body	Upsets of both ends (increase)	Wall thickness	Inside diameter	Bevel diameter	Upset end length			Transition zone length	
									Box end		Pin end	Coupling end	Pin end
D	t		d			t_1	d_1	$d_8 \pm 0{,}3$	L_{1ib}	Tol.	L_{1ip}	L_{2i}	
± 1 %		Tol.									± 50	± 30	
64	8	± 1,0	48	3,911	1,42	13	38	38[a]	250	± 50	350	50	250
73	9	± 1,0	55	5,028	2,22	16	41	44	250	± 50	350	50	250
90	9	± 1,0	72	6,364	3,00	16	58	60	250	± 50	350	50	250
103	9	± 1,0	85	7,385	7,17	16	71	71[a]	1 000	± 100	350	50	250
114	10	± 1,0	94	9,078	8,43	16	82	84	1 300	± 100	350	50	300
129	9	± 1,0	111	9,428	13,17	17	95	95[a]	1 300	± 100	350	50	300
129	11	± 1,0	107	11,331	12,66	19	91	95	1 300	± 100	350	50	300
147	11	± 1,0	125	13,059	11,40	17	113	115	1 300	± 100	350	50	300
147	13	± 1,5	121	15,206	12,74	20	107	115	1 300	± 100	350	50	300
147	15	± 1,5	117	17,284	12,30	22	103	115	1 300	± 100	350	50	300
170	11	± 1,5	148	15,267	13,60	17	136	136[a]	1 300	± 100	350	50	300
170	13	± 1,5	144	17,816	15,31	20	130	136	1 300	± 100	350	50	300

Variations in the wall thickness in the end plane shall not be more than ± 10 % of t_1.

While calculating mass, aluminium alloy density shall be taken equal to 2,78 g/cm^3. In the case of using other density alloys, compensation factor shall be used.

[a] Dull.

Table 6 — Drill pipe with external upset and protector thickening (see Figure 6)

Dimensions in millimetres

Drill pipe outside diameter	Protector thickening [a]		
	Outside diameter	Length of protector thickness	Length of transition zone
D	D_{pt} $^{+3,0}_{-2,8}$	l_3 ± 50	l_4 ± 150
129	146	300	1 800
133	146	300	1 800
140	172	300	1 800
147	172	300	1 800
151	172	300	1 800
155	172	300	1 800
164	185	300	1 800
168	185	300	1 800

Pipe wall thicknesses are indicated in Table 4.

When calculating the mass, with other densities, an aluminium alloy density shall be taken equal to 2,78 g/cm^3. In the case of using alloys with other densities, a compensation factor shall be used.

[a] The mid-point of the protector thickening shall be located at the centre of the non-upset tube length (tolerance ± 100 mm).

Table 7 — Drill pipe with internal upset and protector thickening (see Figure 6)

Dimensions in millimetres

Drill pipe outside diameter	Protector thickening [a]		
	Outside diameter	Length of protector thickness	Length of transition zone
D	D_{pt} $^{+3,0}_{-2,8}$	l_3 ± 50	l_4 ± 150
129	150	300	1 800
147	172	300	1 800
170	197	300	1 800

Pipe wall thicknesses are indicated in Table 5.

When calculating the mass, with other densities, an aluminium alloy density shall be taken equal to 2,78 g/cm^3. In the case of using alloys with other densities, a compensation factor shall be used.

[a] The mid-point of the protector thickening shall be located at the centre of the non-upset tube length (tolerance ± 100 mm).

Table 8 — Tool joint dimensions (see Figure 7)

Dimensions in millimetres

Drill pipe		Tool joint							Thread type	
D	t	D_{tj}	D_s	D_{se}	d_{tp}	d_{tb}	l_{tb}	l_{tp}	Tool joint	Drill pipe
Drill pipe with external upset										
90	8	118	114	99,0	74	74	275	185	NC38	TT90
114	10	155	150	123,0	99	94	320	210	NC50	TT122
129	9	172	169	138,0	110	111	340	225	5-1/2 FH	TT138
133	11	172	169	141,9	110	111	340	225	5-1/2 FH	TT138
147	11	195	188	156,0	135	125	365	244	6-5/8 FH	TT158
151	13	195	188	160,0	135	125	365	244	6-5/8 FH	TT158
155	15	195	188	164,0	135	125	365	244	6-5/8 FH	TT158
164	9	203	196	173,0	124	146	365	244	6-5/8 FH	TT172
168	11	203	196	177,0	124	146	365	244	6-5/8 FH	TT172
Drill pipe with internal upset										
64	8	80	76	55,0	34	38	240	163	NC23	TT50
73	9	95	91	64,0	27	41	260	170	NC26	TT63
90	9	110	106	81,0	40	58	275	185	NC31	TT79
103	9	118	114	94,0	74	73	275	185	NC38	TT90
114	10	145	140	105,0	70	84	305	195	NC44	TT104
129	9	155	150	120,0	99	99	320	210	NC50	TT117
129	11	155	150	120,0	99	95	320	210	NC50	TT117
147	11	178	171	156,0	110	113	340	235	5-1/2 FH	TT138 [a]
147	13	178	171	156,0	110	107	340	235	5-1/2 FH	TT138 [a]
147	15	178	171	156,0	110	103	340	235	5-1/2 FH	TT138 [a]
170	11	203	196	161,0	124	136	365	244	6-5/8 FH	TT158
170	13	203	196	161,0	124	130	365	244	6-5/8 FH	TT158

[a] TT136 thread connections may be used by agreement between the manufacturer and purchaser.

Table 9 — Tool joint to drill pipe thread dimensions (see Figure 8)

Dimensions in millimetres

Thread type	d_3[a]	d_4 $^{0}_{-1,0}$	d_5 ± 0,05	d_6[a]	l ± 0,3
Drill pipe 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
Drill pipe with internal upset ends					
TT53	60,425	59,30	53,40	55,181	132
TT63	70,405	69,28	63,38	65,161	132
TT79	86,375	85,25	79,35	81,131	132
TT90	97,345	96,22	90,32	92,101	132
TT104	111,575	110,20	104,30	106,331	140
TT117	124,535	123,16	117,26	119,291	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.

7.5 Upset run-out

At any place on the intermediate section between the upset end and the pipe body, a transverse groove or bulge is allowed, the height or depth of which may not increase or decrease the outside diameter by more than + 2,5 mm to − 5,0 mm of the nominal size. The wall thickness shall, nevertheless, remain unreduced at the same location.

7.6 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, and deviation from straightness at pipe ends 1,5 m long shall not exceed 0,13 %.

7.7 Ovality and eccentricity of pipes

The ovality and eccentricity of pipes shall be within the tolerances on outside diameter and wall thickness (see Tables 4 to 7).

Table 10 — Drill pipe to tool joint thread dimensions (see Figure 8)

Dimensions in millimetres

Thread type	D_2 ± 0,05	D_2 ± 0,08	D_3 $^{0}_{-0,6}$	D_4	D_5	D_6 ± 0,05	l_5
Drill pipe with external upset							
TT90	90,60	82	86,5	91,656	93,5	96,5	150
TT122	122,60	112	118,5	123,656	125,5	128,5	160
TT138	138,60	129	134,5	139,656	141,5	144,5	160
TT158	158,60	148	154,5	159,656	161,5	164,5	160
TT172	172,60	163	168,5	173,656	175,5	178,5	160
Drill pipe with internal upset							
TT53	53,60	45	49,8	54,656	56,5	59,5	150
TT63	63,60	55	59,5	64,656	66,5	69,5	150
TT79	79,60	71	75,5	80,656	82,5	85,5	150
TT90	90,60	82	86,5	91,656	93,5	96,5	150
TT104	104,60	96	100,5	105,656	107,5	110,5	160
TT117	117,60	109	113,5	118,656	120,5	123,5	160
TT136	136,60	128	132,5	137,656	139,5	142,5	160
TT138	138,60	130	134,5	139,656	141,5	144,5	160
TT158	158,60	150	154,5	159,656	161,5	164,5	160

7.8 Drift requirements

Each drill pipe with external upset ends shall be tested throughout its entire length with a cylindrical drift mandrel being 3,2 mm smaller in diameter than the inside diameter, d, of the drill pipe, and a length of 10 times the inside diameter.

Each drill pipe with internal upset ends (except for the pipes with the diameter of 64 mm) shall be tested the upset with a cylindrical drift mandrel being 3,2 mm smaller in diameter than the inside diameter, d_1, of the upset end, and a length of 10 times the inside diameter. The pipes with the diameter of 64 mm shall be tested with a drift mandrel throughout the entire length of 3,2 mm smaller in diameter than the inside diameter of the tool joint (d_{tp} and d_{tb}).

7.9 Internal coating

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

7.10 Drill pipe-tool joint assembly

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

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

If hot assembly of installed 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 drill pipe-tool joint assembly. The full-scale fatigue testing shall be in accordance with Annex B.

8 Test methods

8.1 Inspect each pipe lot and test it at the pipe mill after heat treatment.

8.2 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 drill pipe mechanical properties shall be carried out on specimens taken from the upset part of the pipe. The macrostructure check shall be made on macrosections representing two pipes from each lot.

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

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

— Testing for hardness shall be carried out at the purchaser's request.

8.3 When the manufacturer supplies the drill pipes with made-up tool joints, a leak-proof test shall be performed on 100 % of the pipes.

The standard hydrostatic test pressure, p, shall be calculated using Equation (1), rounded to the nearest 0,5 MPa and limited to a maximum of 69,0 MPa.

$$p = \frac{2 \times f \times \sigma_{\mathrm{y,\,min}} \times t}{D} \tag{1}$$

where

f is a factor: 0,8;

$\sigma_{\mathrm{y,\,min}}$ is the specified minimum yield strength for the pipe body, in megapascals;

D is the specified outside diameter, in millimetres;

t is the specified wall thickness, in millimetres.

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

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.

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

The manufacturer shall establish the leak proof testing method.

8.4 The 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 drill pipes of each lot shall be subjected to the corrosion rate lest, as specified in Annex C.

9 Measuring methods

9.1 Perform dimensional measurements on each joint of pipe with calliper or snap gauges; see ISO 11961.

9.2 Measure the outside diameter of the pipe at the middle section of the pipe body in two perpendicular planes. This diameter shall be within the tolerances specified in Tables 4 to 7.

9.3 Measure the outside diameter of the upset ends in two perpendicular planes at a distance of 50 mm to 100 mm from the pipe end. This diameter shall be within the tolerances specified in Tables 4 and 5.

9.4 Check wall and upset ends thickness by the ultrasonic method at the same locations as given in 9.2 and 9.3. Their values shall be within the tolerances specified in Tables 4 and 5.

9.5 Verify the pipe end straightness against a horizontal plane in accordance with 7.6.

9.6 Measure the pipe straightness to an accuracy of ± 0,03 m.

9.7 Verify the accuracy of all measuring instruments used for acceptance/rejection 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 also 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 re-verification shall be performed before further use of the equipment.

10 Inspection

10.1 Each pipe and tool joint shall be visually inspected. The outside and inside pipe surface 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 wall thickness.

10.2 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 the tolerance on pipe wall thickness (see Tables 4 and 5).

10.3 Local hammering and/or repair-welding of defects in the pipe is not allowed.

10.4 Non-destructive inspection shall be by agreement between manufacturer and purchaser. The three levels of non-destructive inspection are

— **Level 1**, no non-destructive inspection,

— **Level 2**, non-destructive inspection by ultrasonic inspection of the transition zone only in accordance with ISO 9303, performed by a qualified inspector certified in accordance with ISO 11484, and

— **Level 3**, full body ultrasonic examination in accordance with ISO 9303, performed by a qualified inspector certified in accordance with ISO 11484.