
**Petroleum and natural gas industries —
Design and operating limits of drill
strings with aluminium alloy components**

*Industries du pétrole et du gaz naturel — Conception et limites de
fonctionnement des garnitures 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 20312 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

Introduction

The function of this International Standard is to define operating limits of aluminium drill pipes and recommend design criteria for the drill stem containing such aluminium drill pipes. This International Standard contains formulas and figures to aid in the design and selection of equipment to meet a specific drilling condition.

In this International Standard, data are expressed in the International System of units (SI).

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 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 provisions 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 — Design and operating limits of drill strings with aluminium alloy components

1 Scope

This International Standard applies to design and operating limits for drill strings containing aluminium alloy pipes manufactured in accordance with ISO 15546.

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 9712, *Non-destructive testing — Qualification and certification of personnel*

ISO 15546, *Petroleum and natural gas industries — Aluminium alloy drill pipe*

ASNT Recommended Practice No. SNT-TC-1A, *Personnel Qualification and Certification in Non-destructive Testing*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

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

3.1.1

aluminium alloy pipe body

aluminium alloy pipe formed by extrusion, including upsets and protector thickening

3.1.2

aluminium alloy drill pipe

aluminium alloy pipe body with threaded steel tool joints

3.1.3

box

tool joint part that has internal tool-joint thread

3.1.4

buckling

unstable lateral deflection of a drill stem component under compressive effective axial force

3.1.5

corrosion

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

3.1.6

critical buckling load

load level associated with initiation of drill stem components buckling

3.1.7

dogleg

sharp change of direction in a well bore

3.1.8

dogleg severity

measure of the amount of change in the inclination and/or direction of a borehole, usually expressed in degrees per 30 m interval

3.1.9

drill string

complete assembly from the swivel or top drive to the drill bit, which can contain the kelly, drill pipes, subs, drill collars and other bottom hole assembly (BHA) members, such as stabilizers, reamers and junk baskets

3.1.10

effective axial force

force created by adverse combinations of axial load and pressure

3.1.11

helical buckling

buckling in which drill stem components form a helix or spiral shape

3.1.12

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.

3.1.13

new class pipe

wear-based classification of pipe not having been put in service

3.1.14

pin

tool joint part that has external tool-joint thread

3.1.15

premium class, class 2 pipe

wear-based classification of pipe worn to an extent listed in Tables 12 and 13

3.1.16

sinusoidal buckling

buckling of drill stem components in a sinusoidal shape

3.1.17

slip area

area within a small distance along the pipe body from the box end, clamped by the pipe slips during the pulling and running operations

3.1.18

tool joint

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

3.1.19**TT type thread**

trapezoidal-shaped thread connecting aluminium pipe body and steel joint

NOTE See ISO 15546.

3.2 Symbols

A	factor depending on the failure theory selected for calculations and adjusted for anisotropy of drill pipe material
A_b	box cross-sectional area at 9,525 mm from the bearing face
A_{dp}	drill pipe cross-sectional area
A_{OD}	cross-sectional area circumscribed by pipe outside diameter
A_p	pin cross-sectional area at 15,875 mm from the bearing face
A_{pb}	cross-sectional area of pin A_p or box A_b , whichever is smaller
A_z	cross-sectional area of drill pipe in upset part
a_e	coefficient of linear expansion of material
a_w	cross-sectional area of pipe wall with regard to pipe ovality
B	variable
b	strain reduction factor
C	pitch diameter of thread at gauge point
c	area coverage coefficient
D_{dp}	pipe body outside diameter
D_h	average diameter of the borehole at the regarded interval
D_{max}	maximum outside diameter of pipe
D_{min}	minimum outside diameter
D_{pt}	protector outside diameter
D_{tj}	tool joint outside diameter
D_U	outside diameter of drill pipe in upset part
$\bar{D}$	conventional outside diameter of drilling pipe with tool joint
d_{dp}	pipe body inside diameter
d_p	pin inside diameter

E	modulus of elasticity or Young's modulus
F	variable
f	friction factor
g	acceleration of gravity, 9,81m/s ²
H	thread height not truncated
H_{dm}	drilling mud depth
h	fluid depth
h_{DS}	drilling string setting depth
h_K	well depth at the upper limit of drill string section
h_{K-1}	well depth at the lower limit of drill string section
I	moment of inertia of the pipe body in regard to transverse axis (at bending)
J	drill pipe moment of inertia with respect to its diameter
K	transverse load factor
k	plastic-to-elastic-collapse ratio
L	strength-to-weight ratio
$L_{1/2}$	half the distance between tool joints
L_{Al}	strength-to-weight ratio of aluminium
L_{dp}	pipe length with tool joint (the distance between the tool joint box face and the pin shoulder)
L_{pc}	length of the pin that mates with the box
L_s	length of slip contact with drill pipe
L_{St}	strength-to-weight ratio of steel
l_K	length of section "K"
M_B	mass per unit length of plain end pipe body
M_{dp}	mass per unit length of drill pipe
M_K	mass per unit length of drill pipe in drill string section "K"
m_b	mass of plain end pipe body
m_p	mass gain due to protector thickening
m_{tj}	tool joint mass

m_u	mass gain due to upsets
n	number of the drill string sections
O_i	initial ovality
P	load applied to the drill string
P_0	collapse pressure
P_c	minimum collapse pressure for imperfect pipe
P_e	elastic bending pressure
P_{ext}	net external pressure
P_{hel}	helical buckling force
P_i	internal pressure
P_{iy}	internal yield pressure
P_K	tensile stress applied to the bottom cross-section
P_{max}	maximum tension yield strength of drill pipe body
P_{sin}	sinusoidal buckling force
P_T	effective tensile load on tubular
P_y	yield pressure with simultaneous tension
P_z	axis load when the stress in the body of the pipe chucked in the slips reaches yield strength
p	lead of thread
Q_c	box counter bore
R	dogleg severity radius at the beginning and the end of the build or drop interval
R_s	variable
R_t	variable
S_a	mean axial stress
S_b	maximum permissible bending stress
S_{DL}	stress produced by the buoyant weight of the drill string below dogleg
S_{rs}	root truncation
s	bending strain experienced by tubular

s_0	critical bending strain
T	torque applied to the drill string
T_j	recommended make up torque for the aluminium drill pipes tool joints
$T_{\max}$	maximum torsional yield strength of drill pipe body
T_y	torsional yield limit in connection
t_{dp}	wall thickness
t_0	operational temperature
t_u	wall thickness of drill pipe in upset part
W_p	polar sectional modulus of torsion of pipe body
w_0	weight per unit length of pipe in air
w_{DL}	buoyant weight of drill string section suspended below the dogleg
w_m	weight per unit length of pipe in mud
$Y_{\min}$	minimum yield strength of material
α	zenith angle of the borehole interval
α_0	minimum zenith angle of the borehole
α_H	zenith angle at the beginning of the build or drop interval
α_K	zenith angle at the end of the build or drop interval
α_{SL}	slips taper angle
$\bar{\alpha}$	average zenith angle of the borehole at build or drop interval
Δ	taper
ΔL	overall elongation of combined drill string
ΔL_{BHA}	elongation under the weight of the downhole sections and BHA
Δl_t	thermal elongation
Δl_w	elongation of the relevant drill string section "K" under its own weight load
δ	gap between borehole wall and the average outside diameter of drilling pipe
η	temperature gradient
$\varnothing$	dogleg severity

θ	half angle of thread
μ	Poisson's ratio
μ_{SL}	coefficient of friction between slips and master bushing
π	constant, $\pi = 3,141\ 812$
ρ_{Al}	density of aluminium, 2 800 kg/m ³
ρ_{dm}	drilling mud density
ρ_e	equivalent density
ρ_{St}	density of steel, 7 850 kg/m ³
σ	level of normal stresses applied to the design sections of drill string
σ_{-1}	fatigue limit of the drill pipe
σ_b	pipe material ultimate strength
σ_e	equivalent stress
σ_i	allowable stress intensity calculated as adjusted to the normative safety factors
σ_r	reduced yield stress
τ	level of tangential stresses applied to the drill string
τ_{min}	shear stress, reaching minimum yield strength
φ	out-of-roundness function
ψ	imperfection function
ψ_{SL}	friction angle

3.3 Abbreviated terms

ADP	aluminium alloy drill pipe
BHA	bottom hole assembly
EU	external upset
HWADP	heavy wall aluminium drill pipe
HWSDP	heavy weight steel drill pipe
HWDP	heavy wall drill pipe
ID	inside diameter
IU	internal upset

OD	outside diameter
ROP	rate of penetration
RPM	revolutions per minute
SDP	steel drill pipe
TJ	tool joint
WOB	weight on bit

4 Properties of ADP and tool joints

4.1 General

Dimensional and mechanical properties of new ADP and tool joints shall be as specified in ISO 15546. The pipes may be with external or internal upset ends, and with protector thickening. Separate tables of the chapter include the data on the drill pipe torsional strength, tensile strength, and resistance against internal and external pressure.

4.2 New pipes and tool joints data

The new pipes and tool joint data properties are given in Tables 1 and 2.

4.3 Buoyant weight

The ADP buoyant weight of different length groups in the fluids of different density could be calculated by Equation (B.5). The equivalent density of new pipes is given in Tables 1 and 2. For mass calculation purposes, the assumed aluminium alloy density in Tables 1, 2, 5, 6 and 7 is 2 800 kg/m³, and the steel density is 7 850 kg/m³. If alloys of other density are used, a correcting factor shall be applied.

EXAMPLE

Objective: Calculate the weight of 1 m of ADP 147 × 11; 11,8 m long; with internal upset ends; with protector thickening in drilling mud with gravity 1 200 kg/m³.

Solution: According to Table 2, the mass of 1 m of this pipe is 21,45 kg, equivalent density is 3 271 kg/m³.

The weight in mud will be as follows:

$$w_m = 21,45 \times 9,81 \times \left(1 - \frac{1\,200}{3\,271}\right) = 133,2 \text{ N/m}$$

4.4 Mechanical properties

The mechanical properties of new pipe (tensional yield strength, torsional yield strength, internal yield and collapse pressure values) are given in Table 3. The properties correspond to the temperature of 20 °C. The “weak section” for the calculations was assumed to be the aluminium drill pipe body.

The mechanical properties of the premium class pipe are given in Table 4.

The mechanical properties of class 2 pipe are given in Table 5.

The wear classification of ADP is based on 8.3 and Table 12.

Mechanical properties of aluminium drill pipe bodies can be affected by exposure at elevated temperature (see 5.3).

Table 1 — Dimensional and mass properties of new drill pipe with external upset ends

Outside diameter, mm	Wall thickness, mm	Plain pipe mass per 1 linear metre, kg/m	Mass gain due to upset, kg	Mass gain due to protector thickening, kg		Tool joint			Tool joint mass, kg	Mass per linear metre including all upsets, protector thickening, and tool joint ^a , kg/m			Equivalent density of pipe with tool joints ^b , kg/m ³		
						OD, mm	Minimum ID, mm	Thread							
				Range						Length range ^c			Length range ^c		
				2	3					1	2	3	1	2	3
90	8	5,77	4,00	—	—	118	68	NC 38	19,5	9,56	8,26	7,76	3 552	3 336	3 244
114	10	9,15	7,77	—	—	155	95	NC 50	38,6	16,63	14,06	13,08	3 688	3 444	3 337
129	9	9,50	21,97	—	—	172	112	5 1/2 FH	46,0	20,46	16,69	15,26	3 652	3 447	3 351
				9,57	13,99					—	17,71	16,45	—	3 402	3 318
131	13	13,49	22,32	—	—	178	105	5 1/2 FH	46,0	24,51	20,72	19,28	3 477	3 298	3 219
				17,29	25,27					—	22,55	21,43	—	3 251	3 185
133	11	11,80	17,10	—	—	172	112	5 1/2 FH	46,0	21,98	18,48	17,15	3 577	3 371	3 279
				13,37	19,53					—	19,90	18,81	—	3 323	3 245
140	13	14,52	9,72	—	—	172	112	5 1/2 FH	46,0	23,51	20,42	19,25	3 513	3 307	3 220
				20,51	29,98					—	22,59	21,79	—	3 251	3 180
147	11	13,16	29,26	—	—	195	124	6 5/8 FH	65,2	28,40	23,16	21,16	3 676	3 464	3 365
				10,37	15,15					—	24,25	22,45	—	3 427	3 338
151	13	15,78	23,69	—	—	195	124	6 5/8 FH	65,2	30,12	25,19	23,31	3 611	3 399	3 304
				28,54	41,72					—	28,21	26,85	—	3 323	3 249
155	15	18,47	18,02	—	—	195	124	6 5/8 FH	65,2	31,90	27,28	25,53	3 554	3 344	3 253
				22,80	33,32					—	29,69	28,35	—	3 292	3 216
164	9	12,27	31,69	—	—	203	124	6 5/8 FH	66,5	28,11	22,66	20,59	3 711	3 499	3 398
				19,39	28,34					—	24,71	22,99	—	3 428	3 345
168	11	15,19	25,51	—	—	203	124	6 5/8 FH	66,5	30,03	24,93	22,99	3 635	3 421	3 324
				15,89	23,23					—	26,61	24,96	—	3 374	3 290
^a Value is calculated by Equation (B.3).															
^b Value is calculated by Equation (B.4).															
^c ADP length ranges are defined by ISO 15546.															

Table 2 — Dimensional and mass properties of new drill pipe with internal upset ends

Outside diameter, mm	Wall thickness, mm	Plain pipe mass per 1 linear metre, kg/m	Mass gain due to upset, kg	Mass gain due to protector thickening, kg		Tool joint			Tool joint mass, kg	Mass per linear metre including all upsets, protector thickening, and tool joint ^a , kg/m			Equivalent density of pipe with tool joints ^b , kg/m ³		
						OD, mm	Minimum ID, mm	Thread							
				Length range						Length range ^c			Length range ^c		
				2	3					1	2	3	1	2	3
64	8	3,94	0,76	—	—	80	34	NC23	9,5	5,60	5,03	4,81	3 399	3 213	3 138
73	9	5,07	1,55	—	—	95	44	NC26	14,5	7,66	6,77	6,43	3 485	3 278	3 193
				6,90	10,09					—	7,50	7,28	—	3 225	3 156
90	9	6,41	2,05	—	—	108	54	NC31	16,5	9,40	8,38	7,98	3 423	3 234	3 155
				8,36	12,22					—	9,26	9,02	—	3 187	3 123
90	9	6,41	2,05	—	—	120,6	56	NC38	16,5	9,40	8,38	7,98	3 423	3 234	3 155
				8,36	12,22					—	9,26	9,02	—	3 187	3 123
103	9	7,44	5,83	—	—	120,6	68	NC38	21,0	11,77	10,28	9,72	3 436	3 252	3 174
				9,48	13,85					—	11,28	10,89	—	3 206	3 142
103	9	7,44	5,83	—	—	127	68	NC38	25,0	12,41	10,70	10,05	3 540	3 329	3 239
				9,48	13,85					—	11,71	11,23	—	3 276	3 202
114	10	9,15	7,34	—	—	145	82	NC44	34,9	15,96	13,62	12,73	3 622	3 392	3 292
				18,88	27,59					—	15,62	15,07	—	3 302	3 229
114	11	9,97	6,92	—	—	152	80	NC46	41,0	17,70	15,04	14,03	3 686	3 438	3 331
				18,88	27,59					—	17,04	16,37	—	3 349	3 267
129	9	9,50	11,58	—	—	162	93	NC50	43,5	18,38	15,33	14,17	3 711	3 470	3 363
				16,75	24,48					—	17,10	16,24	—	3 386	3 302
129	11	11,42	11,07	—	—	162	93	NC50	43,5	20,22	17,19	16,04	3 605	3 383	3 286
				16,75	24,48					—	18,96	18,12	—	3 318	3 240
147	11	13,16	10,17	—	—	178	105	5 1/2 FH	54,3	23,56	19,98	18,62	3 680	3 436	3 329
				22,80	33,32					—	22,39	21,45	—	3 354	3 271
147	13	15,32	11,52	—	—	178	105	5 1/2 FH	54,3	25,94	22,29	20,90	3 577	3 357	3 262
				22,80	33,32					—	24,70	23,73	—	3 293	3 217
147	15	17,42	11,07	—	—	178	105	5 1/2 FH	54,3	27,96	24,33	22,96	3 507	3 302	3 215
168	11	15,19	17,80	—	—	203	127	6 5/8 FH	71,5	29,59	24,64	22,76	3 737	3 489	3 379
				30,26	44,23					—	27,84	26,51	—	3 393	3 309
168	13	17,72	16,26	—	—	203	127	6 5/8 FH	71,5	31,88	27,01	25,16	3 649	3 415	3 313
				30,26	44,23					—	30,21	28,91	—	3 338	3 258

^a Value is calculated by Equation (B.3).^b Value is calculated by Equation (B.4).^c ADP length ranges are defined by ISO 15546.

4.5 ADP with integral tool joint and heavy wall ADP

ISO 15546 does not cover the ADP with integral tool joint and heavy wall ADP, which are manufactured in the assembled condition with steel tool joints (see Figures A.1 and A.2). Their technical properties are given in Annex A. ADP with integral rotary shouldered connections are used as technological sets in the intervals where the danger of drill string sticking exists. Heavy wall ADP are widely used in BHA to ensure smooth stiffness transition from drill collars to ADP or as diamagnetic pipe to perform directional survey inside the drill string when drilling directional or vertical wells.

Table 3 — Mechanical properties of new pipe

Nominal outside diameter, mm	Nominal wall thickness, mm	Upset type	Connection			TJ torsional yield strength ^f , kN·m	Tension yield strength ^a , kN				Torsional yield strength ^b , kN·m				Internal yield pressure ^c , MPa				Collapse pressure ^d , MPa			
							Material group ^e				Material group ^e				Material group ^e				Material group ^e			
			TJ thread type	TJ OD, mm	TJ pin ID, mm		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
64	8	IU	NC 23	80	34	8,2	457	675	478	492	5,2	7,7	5,5	5,6	81,3	120,0	85,0	87,5	72,9	104,4	76,1	78,2
73	9	IU	NC 26	95	44	10,0	588	868	615	633	7,7	11,4	8,1	8,3	80,1	118,4	83,8	86,3	71,7	102,5	74,8	76,9
90	8	EU	NC 38	118	68	21,8	669	989	700	721	11,6	17,1	12,1	12,5	57,8	85,3	60,4	62,2	46,9	63,0	48,7	49,8
90	9	IU	NC 31	108	54	16,1	744	1 099	778	801	12,6	18,6	13,2	13,5	65,0	96,0	68,0	70,0	55,2	76,3	57,4	58,9
		IU	NC 38	120,6	58	25,8																
103	9	IU	NC 38	120,6	68	24,7	863	1 275	903	930	17,1	25,3	17,9	18,4	56,8	83,9	59,4	61,2	45,7	61,2	47,4	48,5
		IU	NC 38	127	68	25,0																
114	10	IU	NC 44	145	82	35,7	1061	1 567	1 110	1 143	23,3	34,4	24,3	25,1	57,0	84,2	59,6	61,4	46,0	61,6	47,7	48,8
		EU	NC 50	155	95	49,9																
114	11	IU	NC 46	152	80	48,5	1 156	1 708	1 210	1 245	24,9	36,8	26,1	26,8	62,7	92,6	65,6	67,5	52,6	72,1	54,7	56,0
129	9	EU	5 1/2 FH	172	112	55,4	1 102	1 628	1 153	1 187	28,3	41,8	29,6	30,5	45,3	67,0	47,4	48,8	31,8	39,6	32,7	33,3
129	11	IU	NC 50	162	95	51,3	1 325	1 956	1 386	1 427	33,0	48,8	34,6	35,6	55,4	81,9	58,0	59,7	44,1	58,6	45,7	46,8
131	13	EU	5 1/2 FH	178	105	69,4	1 565	2 312	1 638	1 686	38,6	57,0	40,3	41,5	64,5	95,3	67,5	69,5	54,6	75,4	56,8	58,3
133	11	EU	5 1/2 FH	172	112	55,4	1 370	2 023	1 433	1 475	35,4	52,3	37,0	38,1	53,8	79,4	56,2	57,9	42,1	55,5	43,6	44,6
140	13	EU	5 1/2 FH	172	112	55,4	1 685	2 488	1 763	1 814	44,9	66,3	47,0	48,4	60,4	89,1	63,1	65,0	49,9	67,8	51,8	53,1
147	11	IU	5 1/2 FH	178	105	69,4	1 527	2 255	1 597	1 644	44,3	65,4	46,3	47,7	48,6	71,8	50,9	52,4	35,9	45,8	37,1	37,8
		EU	6 5/8 FH	195	124	84,5																
147	13	IU	5 1/2 FH	178	105	69,4	1 778	2 626	1 860	1 914	50,2	74,1	52,5	54,1	57,5	84,9	60,1	61,9	46,5	62,5	48,3	49,4
147	15	IU	5 1/2 FH	178	105	69,4	2 021	2 984	2 114	2 176	55,6	82,1	58,1	59,8	66,3	98,0	69,4	71,4	56,7	78,7	59,0	60,5
151	13	EU	6 5/8 FH	195	124	84,5	1 831	2 704	1 915	1 972	53,3	78,8	55,8	57,5	56,0	82,6	58,5	60,3	44,8	59,6	46,4	47,5
155	15	EU	6 5/8 FH	195	124	84,5	2 143	3 165	2 242	2 308	62,8	92,7	65,7	67,6	62,9	92,9	65,8	67,7	52,8	72,5	54,9	56,3
164	9	EU	6 5/8 FH	203	124	107,2	1 424	2 103	1 489	1 533	47,9	70,8	50,1	51,6	35,7	52,7	37,3	38,4	19,7	22,6	20,1	20,3
168	11	EU	6 5/8 FH	203	124	107,2	1 762	2 603	1 844	1 898	59,5	87,9	62,3	64,1	42,6	62,9	44,5	45,8	28,3	34,4	29,1	29,6
		IU	6 5/8 FH	203	127	99,5																
168	13	IU	6 5/8 FH	203	127	99,5	2 056	3 037	2 151	2 214	67,8	100,2	70,9	73,0	50,3	74,3	52,6	54,2	37,9	48,9	39,2	40,0

^a Value is calculated by Equation (B.6).^b Value is calculated by Equation (B.7).^c Value is calculated by Equation (B.8).^d Value is calculated by Equation (B.9).^e Material groups are as defined in ISO 15546.^f Calculated values are based on Equation (B.15), yield strength of the material and dimensions of tool joint connection as defined in ISO 15546.

Table 4 — Mechanical properties of premium class pipe^a

Nominal outside diameter, mm	Nominal wall thickness, mm	Minimum outside diameter ^a , mm	Minimum wall thickness ^a , mm	Upset type	Connection			TJ torsional yield strength ^g , kN·m	Tension yield strength ^b , kN				Torsional yield strength ^c , kN·m				Internal yield pressure ^d , MPa				Collapse pressure ^e , MPa			
					TJ thread type	TJ OD, mm	TJ pin ID, mm		Material group ^f				Material group ^f				Material group ^f				Material group ^f			
									I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
64	8	60,8	6,4	IU	NC 23	77,2	34	7,3	355	525	372	383	4,0	5,9	4,2	4,3	68,4	101,1	71,6	73,7	59,0	82,4	61,4	63,0
73	9	69,4	7,2	IU	NC 26	91,0	44	10,0	457	675	478	492	5,9	8,7	6,2	6,4	67,4	99,6	70,5	72,6	57,9	80,6	60,3	61,8
90	8	86,8	6,4	IU	NC 38	115,0	68	17,5	525	776	549	566	9,0	13,3	9,4	9,7	47,9	70,8	50,1	51,6	35,0	44,4	36,1	36,8
90	9	86,4	7,2	EU	NC 31	104,0	54	16,1	582	859	609	627	9,8	14,4	10,2	10,5	54,2	80,0	56,7	58,3	42,6	56,2	44,1	45,1
				IU	NC 38	117,1	58	20,7																
103	9	99,4	7,2	IU	NC 38	117,1	68	20,7	677	1 001	709	730	13,3	19,7	14,0	14,4	47,1	69,5	49,3	50,7	34,0	42,8	35,0	35,7
				IU	NC 38	122,4	68	25,0																
114	10	110,0	8	IU	NC 44	139,9	82	35,7	833	1 230	871	897	18,1	26,8	19,0	19,5	47,3	69,8	49,5	50,9	34,2	43,2	35,3	36,0
				IU	NC 50	150,9	95	39,9																
114	11	109,6	8,8	EU	NC 46	146,7	80	47,9	905	1 337	947	975	19,4	28,6	20,3	20,9	52,2	77,1	54,6	56,2	40,2	52,5	41,6	42,5
129	9	125,4	7,2	IU	5 1/2 FH	167,6	112	53,2	868	1 283	909	935	22,2	32,8	23,3	24,0	37,3	55,1	39,0	40,2	21,7	25,3	22,2	22,5
129	11	124,6	8,8	EU	NC 50	156,7	95	51,3	1 040	1 536	1 088	1 120	25,8	38,1	27,0	27,8	45,9	67,8	48,0	49,4	32,5	40,6	33,5	34,1
131	13	125,8	10,4	IU	5 1/2 FH	172,5	105	68,5	1 225	1 809	1 281	1 319	29,9	44,2	31,3	32,2	53,7	79,4	56,2	57,9	42,1	55,4	43,6	44,6
133	11	128,6	8,8	EU	5 1/2 FH	167,6	112	53,2	1 076	1 589	1 126	1 159	27,6	40,8	28,9	29,8	44,5	65,7	46,5	47,9	30,7	38,0	31,6	32,2
140	13	134,8	10,4	EU	5 1/2 FH	167,6	112	53,2	1 320	1 950	1 381	1 422	35,0	51,6	36,6	37,6	50,1	74,1	52,5	54,0	37,8	48,6	39,0	39,8
147	11	142,6	8,8	EU	5 1/2 FH	172,5	105	68,5	1 202	1 775	1 257	1 294	34,7	51,2	36,3	37,4	40,1	59,2	42,0	43,2	25,2	30,1	25,8	26,2
				IU	6 5/8 FH	190,7	124	67,6																
147	13	141,8	10,4	EU	5 1/2 FH	172,5	105	68,5	1 395	2 060	1 459	1 502	39,1	57,8	40,9	42,1	47,7	70,4	49,9	51,3	34,7	43,9	35,8	36,5
147	15	141,0	12	IU	5 1/2 FH	172,5	105	68,5	1 580	2 333	1 653	1 701	43,1	63,6	45,1	46,4	55,3	81,7	57,9	59,6	44,0	58,4	45,6	46,6
151	13	145,8	10,4	IU	6 5/8 FH	190,7	124	67,6	1 437	2 122	1 503	1 548	41,6	61,5	43,5	44,8	46,4	68,5	48,5	49,9	33,1	41,5	34,1	34,7
155	15	149,0	12	EU	6 5/8 FH	190,7	124	67,6	1 678	2 478	1 755	1 807	48,8	72,0	51,0	52,5	52,3	77,3	54,8	56,4	40,4	52,8	41,8	42,7
164	9	160,4	7,2	EU	6 5/8 FH	197,2	124	94,3	1 126	1 663	1 178	1 212	37,8	55,8	39,5	40,7	29,2	43,1	30,5	31,4	12,3	13,3	12,4	12,5
168	11	163,6	8,8	EU	6 5/8 FH	197,2	124	94,3	1 390	2 053	1 454	1 497	46,8	69,1	48,9	50,4	35,0	51,6	36,6	37,7	18,9	21,5	19,2	19,4
				EU	6 5/8 FH	197,2	127	94,3																
168	13	162,8	10,4	IU	6 5/8 FH	197,2	127	94,3	1 617	2 389	1 692	1 742	53,1	78,4	55,5	57,2	41,5	61,3	43,4	44,7	27,0	32,6	27,7	28,1

^a Wear criterion based on maximum percentage of uniform wear stated in Table 12.^b Value is calculated by Equation (B.6).^c Value is calculated by Equation (B.7).^d Value is calculated by Equation (B.8).^e Value is calculated by Equation (B.9).^f Material groups are as defined in ISO 15546.^g Calculated values based on Equation (B.15); yield strength of material and dimensions of tool joint connection as defined in ISO 15546.

Table 5 — Mechanical properties of class 2 pipe^a

Nominal outside diameter, mm	Nominal wall thickness, mm	Minimum outside diameter ^a , mm	Minimum wall thickness ^a , mm	Thread type	Upset type	Thread torsional yield kN·m	Tension yield strength ^b , kN				Torsional yield strength ^c , kN·m				Internal yield pressure ^d , MPa				Collapse pressure ^e , MPa			
							Material group ^f				Material group ^f				Material group ^f				Material group ^f			
							I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
64	8	59,2	5,6	NC 23	IU	6,2	306	452	320	330	3,4	5,1	3,6	3,7	61,5	90,8	64,3	66,2	51,2	69,9	53,2	54,5
73	9	67,6	6,3	NC 26	IU	10,0	394	582	412	424	5,1	7,5	5,3	5,5	60,6	89,5	63,4	65,2	50,1	68,2	52,1	53,4
90	8	85,2	5,6	NC 38	EU	15,0	455	672	476	490	7,8	11,5	8,1	8,4	42,7	63,1	44,7	46,0	28,5	34,7	29,3	29,8
90	9	84,6	6,3	NC 31	IU	16,9	503	743	527	542	8,4	12,4	8,8	9,1	48,4	71,5	50,6	52,1	35,6	45,3	36,7	37,5
				NC 38	IU	14,6																
103	9	97,6	6,3	NC 38	IU	17,6	587	867	614	632	11,5	17,0	12,1	12,4	42,0	62,0	43,9	45,2	27,5	33,4	28,3	28,7
				NC 38	IU	24,5																
114	10	108,0	7,0	NC 44	IU	35,2	721	1 066	755	777	15,7	23,2	16,4	16,9	42,1	62,2	44,1	45,4	27,8	33,7	28,5	29,0
				NC 50	EU	34,2																
114	11	107,4	7,7	NC 46	IU	40,6	783	1 157	820	844	16,7	24,7	17,5	18,0	46,6	68,8	48,8	50,2	33,4	41,9	34,4	35,0
129	9	123,6	6,3	5 1/2 FH	EU	45,5	754	1 114	789	812	19,3	28,5	20,2	20,8	33,1	48,9	34,7	35,7	16,7	18,7	17,0	17,1
129	11	122,4	7,7	NC 50	IU	46,5	901	1 331	943	971	22,3	32,9	23,3	24,0	40,9	60,4	42,8	44,0	26,2	31,4	26,9	27,3
131	13	123,2	9,1	5 1/2 FH	EU	58,3	1 060	1 565	1 108	1 141	25,8	38,1	27,0	27,8	48,0	70,9	50,2	51,7	35,1	44,6	36,2	36,9
133	11	126,4	7,7	5 1/2 FH	EU	45,5	933	1 378	976	1 004	23,9	35,3	25,0	25,8	39,6	58,5	41,4	42,6	24,6	29,2	25,2	25,5
140	13	132,2	9,1	5 1/2 FH	EU	45,5	1 143	1 688	1 196	1 231	30,2	44,6	31,6	32,5	44,7	66,1	46,8	48,2	31,0	38,5	31,9	32,5
				5 1/2 FH	IU	58,3	1 043	1 540	1 091	1 123	30,1	44,4	31,4	32,4	35,6	52,6	37,3	38,4	19,7	22,6	20,1	20,3
				6 5/8 FH	EU	58,0																
147	13	139,2	9,1	5 1/2 FH	IU	58,3	1 208	1 784	1 264	1 301	33,8	49,9	35,4	36,4	42,5	62,8	44,5	45,8	28,2	34,3	29,0	29,5
147	15	138,0	10,5	5 1/2 FH	IU	58,3	1 366	2 018	1 429	1 471	37,1	54,8	38,8	40,0	49,5	73,0	51,7	53,3	36,9	47,3	38,1	38,9
151	13	143,2	9,1	6 5/8 FH	EU	58,0	1 245	1 839	1 303	1 341	36,0	53,1	37,6	38,7	41,3	61,0	43,2	44,5	26,7	32,2	27,4	27,8
155	15	146,0	10,5	6 5/8 FH	EU	58,0	1 452	2 144	1 519	1 564	42,1	62,1	44,0	45,3	46,7	69,0	48,9	50,3	33,6	42,2	34,6	35,2
164	9	158,6	6,3	6 5/8 FH	EU	80,5	979	1 446	1 024	1 054	32,9	48,5	34,4	35,4	25,8	38,1	27,0	27,8	8,9	9,5	9,0	9,1
				6 5/8 FH	EU	80,5																
168	11	161,4	7,7	6 5/8 FH	IU	80,5	1 208	1 784	1 263	1 301	40,6	59,9	42,5	43,7	31,0	45,8	32,4	33,4	14,3	15,7	14,5	14,6
				6 5/8 FH	IU	80,5																
168	13	160,2	9,1	6 5/8 FH	IU	80,5	1 403	2 072	1 468	1 511	46,0	67,9	48,1	49,5	36,9	54,5	38,6	39,8	21,3	24,6	21,7	22,0

^a Wear criterion based on maximum percentage of uniform wear stated in Table 12.^b Value is calculated by Equation (B.6).^c Value is calculated by Equation (B.7).^d Value is calculated by Equation (B.8).^e Value is calculated by Equation (B.9).^f Material groups are as defined in ISO 15546.