INTERNATIONAL STANDARD ISO 2644

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Materials and equipment for petroleum and natural gas industries — Steel drill pipe for oil or natural gas wells

Matériel d'équipement pour les industries du pétrole et du gaz naturel — Tiges de forage en acier pour puits de pétrole ou de gaz naturel

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2644, which incorporates Addendum 1, was drawn up by Technical Committee ISO/TC 67, *Materials and equipment for petroleum and natural gas industries*, and circulated to the Member Bodies in May 1972. Addendum 1 was circulated to the Member Bodies in January 1973.

This International Standard has been approved by the Member Bodies of the following countries :

Belgium	Hungary	Spain
Brazil	India	Switzerland
Czechoslovakia	Italy	Thailand
Egypt, Arab Rep. of	Japan	Turkey
France	Poland	United Kingdom
Germany	Romania	U.S.S.R.

Addendum 1 has been approved by the Member Bodies of the following countries :

Bulgaria	India	Romania
Canada	Iran	Thailand
Czechoslovakia	Italy	Turkey
France	Mexico	United Kingdom
Germany	Poland	U.S.S.R.
Hungary	Portugal	Yugoslavia

No Member Body expressed disapproval of the documents.

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CONTENTS

Materials and equipment for petroleum and natural gas industries — Steel drill pipe for oil or natural gas wells

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the characteristics of steel drill pipe and work tubing intended for use in the drilling and servicing of oil or natural gas wells.

It specifies the sizes, diameters, thicknesses and grades of steel.

It applies only to seamless drill pipe.

2 REFERENCES

ISO/R 202, *Flattening test on steel tubes.*

ISO 375, *Steel — Tensile testing of tubes.*

ISO/R 404, *General technical delivery requirements for steel.*

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

3 DEFINITIONS

3.1 drill pipe : A metal pipe constituting an element of a drilling string.

3.2 work tubing : Small diameter pipe used in a well for servicing.

4 MANUFACTURING PROCESS

A seamless drill pipe is a steel tubular product manufactured by hot working from a solid steel blank and, if necessary, by cold finishing to produce the desired shapes, dimensions and properties.

5 DATA TO BE GIVEN BY THE PURCHASER

5.1 In placing orders, the purchaser shall specify the following :

a) the reference number of this International Standard;

b) quantity (length or number of lengths);

c) type of pipe :

drill pipe

- with external upsetting,
- with internal upsetting,
- with external and internal upsetting;

d) size (outside diameter) in millimetres (see table 12);

e) mass per unit length in kilograms per metre, or wall thickness in millimetres (see table 12);

f) grade of steel;

g) length range (see clause 9);

h) delivery date, shipping instructions and marking;

i) mill inspection (if required).

5.2 The purchaser shall also state on the order his requirements concerning the following optional stipulations :

- normalizing of D 38 drill pipe;
- ladle and supplementary analyses;
- pipe coating.

5.3 Attention is also called to the following stipulations which are subject to agreement at the time of ordering :

a) marking;

b) special finish (lubricant, upset);

c) non-destructive tests.

6 DESIGNATION

A pipe manufactured according to this International Standard shall be designated by

a) its type;

b) the type of its ends;

c) its size (outside diameter) in millimetres;

d) its mass per unit length in kilograms per metre, or its wall thickness in millimetres;

e) the grade of steel;

f) its length range;

g) a reference to this International Standard.

Example :

Drill pipe, external upsetting, 101,6 X 8,4, D 38 range 2, according to ISO 2644.

7 STEELS

7.1 Steelmaking

The only processes permitted by this International Standard are the following :

— open-hearth, electric furnace or basic oxygen steelmaking processes.

7.2 Chemical composition

A pipe shall have a maximum sulphur content of 0,060 % and a maximum phosphorus content of 0,040 % whatever its grade.

7.3 Mechanical properties

The limits of the test piece mechanical properties (see 11.3.1) are given in table 1 for each steel concerned.

TABLE 1 — **Mechanical properties**

Grade of steel	Proof stress, R_p	Minimum tensile strength, R_m	Minimum elongation, A, on $5{,}65\sqrt{S_o}$ *
	N/mm²	N/mm²	%
D 38	R_p 0,5 ⩾ 379	655	14,3
E 52	R_p 0,5 ⩾ 517	690	13,0
N 56	R_p 0,5 ⩾ 552	690	13,0
X 66	660 ⩽ R_p 0,5 ⩽ 860	730	12
G 73	730 ⩽ R_p 0,6 ⩽ 930	800	11,5
S 93	930 ⩽ R_p 0,7 ⩽ 1 140	1 000	9,5

* If other gauge lengths are used, the corresponding elongation shall be obtained according to ISO 2566. In cases of dispute, the gauge length of $5{,}65\sqrt{S_o}$ shall be used.

7.4 Heat treatment

As a function of the steel quality (steelmaking and analysis), the manufacturer shall indicate the heat treatment to obtain the properties given in table 1 (normalizing, through-hardening or quenching and tempering).

8 DRILL PIPE CONDITION

8.1 Diameters, wall thicknesses and masses

The pipes supplied shall have the diameters, wall thicknesses and masses shown in table 12.

8.2 Pipe ends

Drill pipe shall be furnished with upset ends with a view to rotary connection welding. Upsetting shall be either internal or external, or internal and external. If so provided for in the order, the end finish may be different. In this case all requirements other than end finishing and mass will be maintained.

9 PERMISSIBLE DIMENSIONAL DEVIATIONS

9.1 Outside diameter

9.1.1 *Drill pipe body*

The tolerance on the outside diameter of the pipe shall be ± 0,79 mm for $D < 114{,}3$ mm, and ± 0,75 % for $D \geqslant 114{,}3$ mm.

9.1.2 *Upset ends*

Close to the upset end, at the part of the pipe affected by heating and upsetting, the outside diameter may be within the tolerances given in table 2.

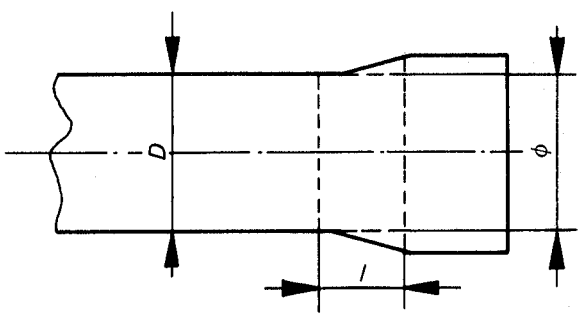


FIGURE 1 — **Upset end**

TABLE 2 — **Tolerances on upset ends**

Outside diameter D	Tolerances	on length/
$D \leqslant 88{,}9$ mm	+ 2,4 mm — 0,8 mm	127 mm
101,6 ⩽ D ⩽ 127,0 mm	+ 2,8 mm — 0,75 % D	
$D \geqslant 139{,}7$ mm	+ 3,2 mm — 0,75 % D	≈ D

NOTE — Stepping of diameter ϕ over length l shall be smooth and progressive, not abrupt.

9.2 Wall thickness

Each pipe length wall thickness shall conform to the following specifications :

At any place the minimum thickness shall not be less than 87,5 % of the tabulated thickness, the maximum thickness being limited by the mass tolerance (see 9.5.3). Measurements shall be made with a gauge fitted with contact pins having a diameter of 6,35 mm. The end of the pin contacting the inside surface of the pipe shall be rounded to a radius of 38 mm; the end of the pin contacting the outside surface shall be flat or rounded to a radius of 38 mm.

Thickness measurements can also be made using appropriately calibrated non-destructive equipment of adequate accuracy. In case of dispute the mechanical gauge measurement will, however, be relied upon.

9.3 Eccentricity

9.3.1 *On outside diameter*

The maximum eccentricity, as measured with a saddle gauge at a distance of 127 to 150 mm from the upset end (see figure 2), shall not exceed 2,4 mm (total reading of the measuring instrument).

9.3.2 *On inside diameter*

The maximum eccentricity of the upset bore hole with respect to the external surface of the drill pipe shall not exceed 1,6 mm (total reading on the measuring instrument : 3,2 mm).

9.4 Ovality

The maximum ovality, as measured with a micrometer on the external upset diameter, shall not exceed 2,4 mm.

9.5 Mass

9.5.1 Each drill pipe shall be weighed separately. In the case of pipes fitted with rotary connections, either integral or attached, make allowance for the effective connection mass.

9.5.2 The masses determined shall conform to the specified (or adjusted calculated) masses for the end finishes provided for in the order within the tolerances stipulated in 9.5.3. Calculated masses shall be determined in accordance with the formula :

$$W_L = (W_{pe} L) + e_w$$

where

W_L is the calculated mass of a drill pipe of length L, in kilograms;

W_{pe} is the plain end mass per unit length, in kilograms per metre;

L is the length of drill pipe, as defined in 9.6, in metres;

e_w is the mass gain or loss due to end finishing, in kilograms.

9.5.3 On one drill pipe the tolerance shall be $^{+\ 6,5}_{-\ 3,5}$ %. On a complete wagon (i.e. 18 t minimum) the tolerance shall be $^{0}_{-\ 1,75}$ %.

NOTE – Tolerances per drill pipe or per wagon load are applicable simultaneously, except for loads less than 18 t where the tolerance $^{+\ 6,5}_{-\ 3,5}$ % only is obligatory.

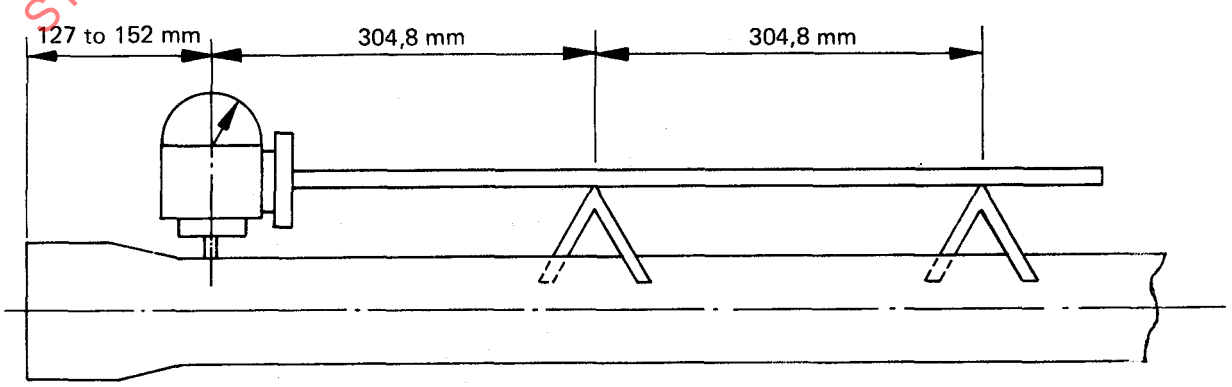


FIGURE 2 – **Saddle gauge for measurement of eccentricity of drill pipe upset end**

9.6 Length

Drill pipes shall be delivered in the length range specified on the order. The ranges shall conform with table 3. The lengths as defined here are measured as the overall lengths of the drill pipes including upset ends for welding.

TABLE 3 – **Length ranges**

	Range 1	Range 2	Range 3
	5,5 to 6,7 m	8,2 to 9,1 m	11,6 to 13,7 m
On 95 % min. of a shipment (see table 4)			
– maximum variation	0,6		
– minimum length	6,1		
On 90 % min. of a shipment (see table 4)			
– maximum variation		0,6	0,9
– minimum length		8,2	11,6

9.7 Inside diameter

Each externally upset drill pipe shall be tested over its whole length of upsetting with a mandrel 102 mm (4 in) long and of diameter 4,8 mm (3/16 in) less than the inside diameter of the pipe as stated in the tables 12. This test shall not be made on pipes of 89 mm (3 1/2 in) diameter and of a mass per unit length equal to 19,8 kg/m (13.30 lb/ft).

9.8 Straightness

All drill pipes shall be delivered with a reasonable straightness.

9.9 Loads

Wagon loads shall comply with table 4.

TABLE 4 – **Wagon loads (see ranges – table 3)**

Order smaller than one wagon load	Order larger than one wagon load	
	Railway shipment direct from mill to final consignee	Railway shipment, interrupted from mill to final consignee
Total tolerances of ranges	Total variation on 5 % maximum of shipment required per wagon load, in the corresponding range.	Total variation on 5 % maximum of shipment, required for total load in the corresponding range.

10 CHEMICAL ANALYSES

10.1 Ladle analysis

When requested by the purchaser, the manufacturer shall furnish a ladle analysis of each steel heat used. In addition the purchaser, upon request, shall be furnished with the results of such other chemical analyses as may be obtained. The analyses so determined shall conform to the requirements specified in 7.2.

10.2 Check analysis

10.2.1 Two finished lengths shall be analysed by the manufacturer from each lot of 400 pipes of the same diameter. For multiple lengths, a length is considered as all of the sections cut from a particular multiple length.

10.2.2 The analysis shall be carried out on drillings representing the full wall thickness of the pipe. The minimum drill size used for taking the samples shall be 12,7 mm.

10.2.3 If the check analysis on one length representing the lot fails to conform to the requirements of 7.2 the manufacturer will be allowed to re-test two supplementary lengths. If the re-check is satisfactory, the lot shall be accepted except for the defective length. If both lengths representing the lot, or one (or both) lengths(s) of the re-check analysis fail, at the manufacturer's option the entire lot shall be rejected or individual re-check analyses carried out. These re-check analyses shall be made on defective lengths only. Samples shall be taken as specified in 10.2.2.

10.3 Mill-control check analysis

A ladle analysis of each steel heat used shall be made by the manufacturer. A record of such analyses shall be available to the purchaser.

11 MECHANICAL AND NON-DESTRUCTIVE TESTS

11.1 Nature of tests

Drill pipes of grades D 38, E 52 and N 56 shall be tested for tensile strength and flattening strengths.

Drill pipes of grades X 66, G 73 and S 93 shall be tested for tensile strength and shall be submitted to a non-destructive test.

11.2 Number of tests

The number of tests shall conform to the requirements of table 5.

11.3 Tensile tests

11.3.1 Tensile tests shall be carried out in accordance with ISO 375. Proof stress values shall be calculated for an elongation under load of 0,5 %, except for grade G 73, for which the elongation under load is 0,6 % and grade S 93, for which it is 0,7 %.

Test pieces, at the manufacturer's option, shall be either full sections on the pipe end or strips with the same heat treatment as the pipe. A test piece shall represent the full thickness of the pipe from which it is taken; it must not be flattened before testing.

TABLE 5 — **Number of tests**

Test	Number of tests
Tensile test on test piece	1 per 400 lengths[1) 2)]
Mill-control tensile test	1 per heat
Flattening test on test piece	On non-upset or untreated drill pipes : on each end of each drill pipe[3)] On upset and treated drill pipes : test pieces shall be taken at each end of each drill pipe before upsetting and treatment, or on drill pipes at the rate of 1 per 20 lengths before treatment. In this case, test pieces shall be treated in a similar way to that specified for the grade concerned.

1) In the case of treated drill pipes, all drill pipes in a lot shall have been submitted to the same treatment.

2) In the case of seamless drill pipes in multiple lengths, a length is classed as the sum of the sections obtained from this multiple length.

3) In the case of seamless drill pipes in multiple lengths cut in sections, tests shall be made at each end of the multiple length.

11.3.2 The width of the test piece gauge length shall be about 38 mm if suitable face testing grips are used or if the ends of the test piece are machined to reduce the curvature in the grip area; otherwise it shall be approximately 19 mm for drill pipes 88,9 mm and smaller, 25,4 mm for drill pipes from 101,6 to 193,7 mm, and approximately 38 mm for drill pipes 219,1 mm and larger. In no case shall the test piece gauge length width be greater than four times the thickness of the test piece.

11.3.3 If any tensile test piece shows defective machining or develops flaws, it may be discarded and another test piece substituted.

When the elongation of any tensile test piece is less than that specified, a re-test is allowed if any part of the fracture is outside the middle third of the gauge length as indicated by scribe scratches marked on the test piece before testing.

11.4 Flattening test

The flattening test shall be carried out in accordance with ISO/R 202.

No cracks or breaks shall occur anywhere in the test piece until the distance between plates z is less than that specified in table 6.

11.5 Re-tests

In a case where a test on a drill pipe sample representative of a lot is not satisfactory the manufacturer may decide to re-test the product using test pieces taken on two additional drill pipes in the same lot.

These test pieces shall be cut as indicated in 11.3 and 11.4. If these test pieces meet the requirements, then all drill pipes in the lot shall be accepted except the one initially selected and from which the first defective test piece was cut.

If one or both of the test pieces fail to meet the requirements of the re-test, the manufacturer may choose to test individually all remaining drill pipes in the lot. In this case the test shall be carried out only for those properties which were not satisfactory at the re-test.

In case of unsatisfactory flattening re-tests per lot, the manufacturer may decide to re-treat and then re-test the lot. In case of individual testing the manufacturer may re-test test pieces cut on the same pipe end until satisfactory results are obtained. However, the drill pipe length shall not then be less than 80 % of that before the first cropping.

TABLE 6 — **Distance z between plates**

Grade of steel	Distance z with	
	$D \geqslant 16\,a$	$D < 16\,a$
D 38 E 52 N 56	$0{,}7 \times D$	$(0{,}965 - 0{,}0206\,D/a)\,D$

D = outside diameter in millimetres
a = wall thickness in millimetres

11.6 Non-destructive testing

11.6.1 *Applications and options*

In a case where such testing is specified in addition to visual inspection, and always in the case of grades X 66, G 73 and S 93, drill pipes shall be tested over their full length to detect longitudinal defects, by magnetic particle inspection, or by an ultrasonic method, or by an electromagnetic method. Furthermore the ends of drill pipes shall be inspected for transverse defects by the magnetic particle method. The location of the equipment in the mill will be at the discretion of the manufacturer. However the non-destructive testing shall take place after all heat-treating operations, but may take place before cropping or threading.

11.6.2 *Magnetic particle inspection*

When magnetic particle inspection is employed for longitudinal defect detection, the entire outside surface of the pipe and the inside surface for a distance equal to twice the outside diameter of the pipe without exceeding 300 mm from the end should be inspected. The inside and outside surface of the ends of drill pipes shall be inspected for transverse defects by the magnetic particle method. Magnetic particle inspection may be employed on inside surfaces after heat treatment and before end cropping.

If defects are found, further cropping is permissible provided that the inside surface is again inspected by the magnetic particle method as stipulated above. The depth of all defects revealed by this inspection shall be determined.

11.6.3 *Electromagnetic or ultrasonic inspection*

a) Equipment

For drill pipe inspection, any equipment utilizing the electromagnetic or ultrasonic principles may be used provided that it is capable of continuous and uninterrupted inspection of the outer surface of the drill pipe.

The equipment shall have sufficient sensitivity to indicate injurious defects and it shall be checked as prescribed in 11.6.3 b).

b) Reference standard

A reference standard taken from the drill pipes as supplied and having the same nominal diameter and wall thickness as the product being tested shall be used at least once every working turn to demonstrate the effectiveness of the inspection equipment.

The reference standard shall have any convenient length as determined by the manufacturer; it shall be scanned by the inspection unit in a manner simulating the inspection of the product.

c) Notch (see table 7)

Standard notches (types 12,5 % and 5 %) shall be made in the reference standards.

When using internal and external notches it is not necessary that they be farther apart than the distance required for signal differentiation.

The notch sides shall be theoretically parallel and the bottom shall be perpendicular to the sides. Unless otherwise specified, notches shall be longitudinal.

Lengths

— ultrasonic or diverted flux testing

a) 5 % *a* notch : 50 mm (2 in) maximum at full depth;

b) 12,5 % *a* notch : twice the probe length maximum at full depth.

— eddy current testing

total maximum length : 38 mm (1.5 in).

Width

1 mm (0.04 in) maximum.

Depth

Two types are used :

a) 5 % *a* notch : 5 % of the specified wall thickness with a minimum of 0,3 mm (≈ 0.012 in).

b) 12,5 % *a* notch : 12,5 % of the specified wall thickness with a minimum of 0,6 mm (≈ 0.024 in), with a depth tolerance ± 15 % and a minimum of ± 0,05 mm (0.002 in).

11.6.4 *Permissible depth of defects*

For drill pipe checked with 5 % *a* reference notch, all detected defects the depth of which is greater than 5 % of the wall thickness shall be removed by grinding or machining.

The maximum depth of grinding or machining is limited by the observance of the thickness tolerance, i.e. the remaining thickness at the bottom of the ground or machined part shall not be less than 87,5 % of the nominal thickness.

Where grinding or machining is done, use generous radii to prevent abrupt changes in wall thickness. After reducing these imperfections such areas shall be reinspected by one of the non-destructive testing methods specified above to verify complete removal of the defect.

TABLE 7 — **Non-destructive testing**

Conditions	Standards						
	Ultrasonic inspection			Electromagnetic methods			
	Depth	Notch area		Depth	Notch area		Hole (diameter)
		Width	Length		Width	Length	
100 % by agreement	0,05 *a*	1 mm	50 mm	0,05 *a*	1 mm	38 mm	1,6 mm (0.062 5 in)
	0,125 *a*	1 mm	2 widths of probe	0,125 *a*	1 mm	38 mm	3,2 mm (0.125 in)

NOTE — The widths given for the notch are meant at full depth.

a = wall thickness in millimetres

12 INSPECTION RIGHTS

When drill pipe is accepted by an inspector representing the purchaser, acceptance shall be in accordance with the requirements of clause 5 of ISO/R 404.

Drill pipe which shows injurious defects on mill inspection or subsequently when applied in service may be rejected, and the manufacturer notified so that he will have the possibility to check the justice of the claim.

13 TEST REPORTS

Test reports may be required by the purchaser. They shall conform to the requirements of clause 4 of ISO/R 404.

14 MINIMUM MECHANICAL CHARACTERISTICS

The body of the drill pipe shall show values of the load corresponding to pipe body proof stress R_p and collapse strength at least equal to those given in tables 13.

The method of calculation of these minimum values is given in the annex.

15 SURFACE PROTECTION

Unless otherwise specified in the order, drill pipes shall be given a mill coating to protect them from rusting in transit.

If bare or specially coated drill pipes are required by the purchaser, this shall be specified in the order.

For special coatings the order shall state whether the coating is to be applied to the full length, or whether a certain specified distance from the ends shall be left uncoated. Unless otherwise specified, such bare ends shall be given a coating with oil for protection in transit.

16 MARKING

16.1 Drill pipes manufactured in accordance with this International Standard shall be marked by the manufacturer as specified below.

Markings shall be die-stamped or paint-stencilled according to 16.2; they shall not overlap and shall be applied in such a manner as not to injure the pipes.

When authorized, die-stamped markings shall be applied on the upset part.

Paint-stencilled markings shall be placed on the outer surface of the drill pipe, starting 600 mm from the end.

Additional paint-stencilled or hot die-stamped markings are possible before final heat treatment, at the discretion of the manufacturer, or at the request of the purchaser.

16.2 The particulars shall be the following :

a) die stamping

- manufacturer's name or trade-mark;
- ISO mark;
- wall thickness in millimetres;
- grade of steel (possibility heat treatment : A = annealed; N = normalized; Q = quenched; T = tempered).

b) Paint stencilling

- size (outside diameter) in millimetres;
- mass per unit length in kilograms per metre;
- grade of steel (possibility heat treatment : A = annealed; N = normalized; Q = quenched; T = tempered);
- length in metres with two decimals;
- total mass in kilograms.

ANNEX

BASES FOR CALCULATING THE PIPE BODY CHARACTERISTICS

(The formulae given below are identical with those of API specification 5C3.)

A.1 LOAD CORRESPONDING TO PIPE BODY PROOF STRESS

This value is calculated as the product of the theoretical pipe section by the minimum specified yield strength of the steel used :

$$P_y = \frac{\pi}{4}(D^2 - d^2)\, R_p$$

where

P_y is the pipe body proof stress, in newtons;

D is the theoretical outside diameter of the drill pipe, in millimetres;

d is the theoretical inside diameter of the drill pipe, in millimetres;

R_p is the minimum proof stress of the grade used, in newtons per square millimetres.

A.2 COLLAPSE STRENGTH

A.2.1 The accurate mathematical representation of the drill pipe collapse strength results in a homogeneous but complicated formula for which it is preferable to substitute four empirical formulae which are simpler and established on the basis of over 2 000 tests.

This simplified representation has been obtained by overlooking very important unfavourable parameters such as lack of circularity or ovality of the outside wall, and eccentricity. It is then advisable to rely on these values only when

— lack of circularity does not exceed 0,75 % of the outside diameter;

— lack of concentricity is within tolerances;

— average wall thickness is not below nominal thickness as a result of internal or external repair.

A.2.2 The formula for calculation varies with ratio D/a and the steel grade used. Different formulae correspond to the plastic or elastic range.

TABLE 8 — **Plastic range with minimum yield strength limitation**

Grade of steel	D/a
D 38	$\leqslant$ 14,80
E 52	$\leqslant$ 13,67

$$P_c = 2\, R_p \left[\frac{(D/a)-1}{(D/a)^2}\right]$$

where

P_c is the collapse strength, in newtons per square millimetre;

R_p is the minimum proof stress, in newtons per square millimetre;

a is the theoretical wall thickness, in millimetres;

D is the theoretical outside diameter, in millimetres.

TABLE 9 — **Plastic range**

Grade of steel	D/a	A	B	C
D 38	14,80 to 24,99	2,990	0,054 1	83,02
E 52	13,67 to 23,09	3,060	0,064 2	124,36

$$P_c = R_p \left(\frac{A}{D/a} - B\right) - C$$

TABLE 10 — **Transitional range between plastic and elastic ranges**

Grade of steel	D/a	A	B
D 38	24,99 to 37,20	1,990	0,036 0
E 52	23,09 to 32,05	1,985	0,041 7

$$P_c = R_p \left(\frac{A}{D/a} - B\right)$$

TABLE 11 — **Elastic range**

Grade of steel	D/a
D 38	$>$ 37,20
E 52	$>$ 32,05

$$P_c = \frac{0{,}3237 \times 10^6}{(D/a)\,[(D/a) - 1]^2}$$

A.3 INTERNAL YIELD PRESSURE

The internal yield pressure is determined by the formula

$$P_c = 175\, R_p \frac{a}{D}\, 10^{-1}$$

where

P_c is the internal yield pressure, in bars;

R_p is the minimum proof stress of the drill pipe, in newtons per square millimetre;

a is the theoretical wall thickness, in millimetres;

D is the theoretical diameter, in millimetres.

A.4 TORSION TORQUE CORRESPONDING TO PROOF STRESS OF DRILL PIPE BODY

The torsion corresponding to the proof stress of drill pipe bodies is given by the formula

$$Q = 1{,}154 \frac{J}{D} R_p\, 10^{-4}$$

where

Q is the torsion torque corresponding to the yield strength of the drill pipe, in newton metres;

J is the pole inertial torque in millimetres to the fourth

$$(\text{mm}^4) = \frac{\pi}{32}(D^4 - d^4)$$

D is the outside diameter of the drill pipe, in millimetres;

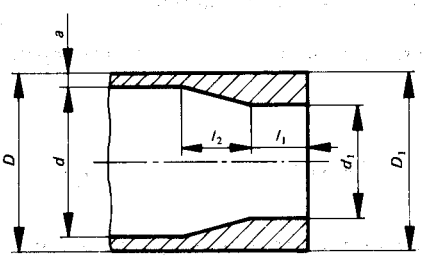
d is the inside diameter of the drill pipe, in millimetres;

R_c is the minimum proof stress of the drill pipe, in newtons per square millimetre.

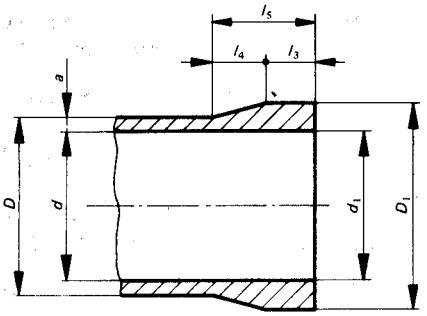
To align on current practices the characteristics of tables 13a, 13b, 13c and 14a have been calculated from values of the inch system with the following conversion factors :

- collapse ($68{,}95 \times 10^{-4}$)
- internal pressure ($68{,}95 \times 10^{-3}$)
- load corresponding to proof stress (4,44822)
- torsion torque corresponding to proof stress (1,3552)

Internal upset



External upset



Internal and external upset

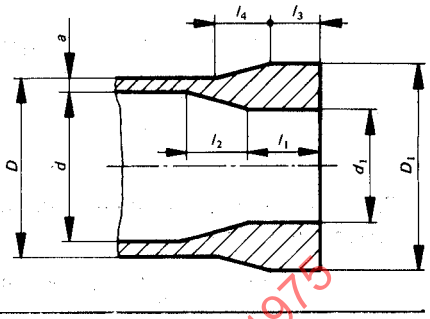


TABLE 12a — **Upset drill pipe for weld-on tool joints — Grades D 38 and E 52**

Pipe												Upset[3]															
Outside diameter D		Mass per unit length[1]		Wall thickness a		Inside diameter d		Calculated mass				Outside diameter[4] D_1		Inside diameter[5] d_1		Length of internal upset l_1		Length of internal taper l_2 min.		Length of external upset l_3 min.		Length of external taper l_4				Length to taper fade-out l_5 max.	
								Plain end		Upset[2]												min.		max.			
												+ 3,18 − 0,79	+ 0.125 − 0.031	± 1,59	+ 0.062 5	+ 38 − 12,7	+ 1.500 − 0.500										
mm	in	kg/m	lb/ft	mm	in	mm	in	kg/m	lb/ft	kg	lb	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
Internal upset																											
73,0	2.875	15,5	10.40	9,19	0,362	54,6	2.151	14,48	9.72	1,45	3.20	73,0	2.875	33,3	1.312	44,4	1.750	38,1	1.500								
88,9	*3.500	14,1	9.50	6,45	0.254	76,0	2.992	13,12	8.81	2,00	4.40	88,9	3.500	57,2	2.250	44,4	1.750										
88,9	3.500	19,8	13.30	9,35	0.368	70,2	2.764	18,34	12.31	2,00	4.40	88,9	3.500	49,2	1.937	44,4	1.750	38,1	1.500								
88,9	3.000	23,1	15.50	11,40	0.449	66,1	2.602	21,79	14.63	1,54	3.40	88,9	3.500	49,2	1.937	44,4	1.750	38,1	1.500								
101,6	*4.000	17,6	11.85	6,65	0.262	88,3	3.476	15,58	10.46	1,91	4.20	101,6	4.000	74,6	2.937	44,4	1.750										
101,6	4.000	20,8	14.00	8,38	0.330	84,8	3.340	19,26	12.93	2,09	4.60	101,6	4.000	69,8	2.750	44,4	1.750	50,8	2.000								
114,3	*4.500	20,5	13.75	6,88	0.271	100,5	3.958	18,23	12.24	2,36	5.20	114,3	4.500	85,7	3.375	44,4	1.750										
114,3	4.500	24,7	16.60	8,56	0.337	97,2	3.826	22,31	14.98	2,63	5.80	114,3	4.500	80,2	3.156	44,4	1.750	50,8	2.000								
127,0	*5.000	24,2	16.25	7,52	0.296	112,0	4.408	22,15	14.87	3,00	6.60	127,0	5.000	95,2	3.750	44,4	1.750										
External upset																											
60,3	2.375	9,9	6.65	7,11	0.280	46,1	1.815	9,32	6.26	0,82	1.80	67,5	2.656	46,1	1.815					38,1	1.500	38,1	1.500			101,6	4.000
73,0	2.875	15,5	10.40	9,19	0.362	54,6	2.151	14,48	9.72	1,09	2.40	81,8	3.219	54,6	2.151					38,1	1.500	38,1	1.500			101,6	4.000
88,9	*3.500	14,1	9.50	6,45	0.254	76,0	2.992	13,12	8.81	1,18	2.60	97,1	3.824	76,0	2.992					38,1	1.500	38,1	1.500			101,6	4.000
88,9	3.500	19,8	13.30	9,35	0.368	70,2	2.764	18,34	12.31	1,82	4.00	97,1	3.824	66,1	2.602	57,2	2.250	50,8	2.000	38,1	1.500	38,1	1.500			101,6	4.000
88,9	3.500	23,1	15.50	11,40	0.449	66,1	2.602	21,79	14.63	1,27	2.80	97,1	3.824	66,1	2.602					38,1	1.500	38,1	1.500			101,6	4.000
101,6	*4.000	17,6	11.85	6,65	0.262	88,3	3.476	15,58	10.46	2,27	5.00	114,3	4.500	88,3	3.476					38,1	1.500	38,1	1.500			101,6	4.000
101,6	4.000	20,8	14.00	8,38	0.330	84,8	3.340	19,26	12.93	2,27	5.00	114,3	4.500	84,3	3.340					38,1	1.500	38,1	1.500			101,6	4.000
114,3	*4.500	20,5	13.75	6,88	0.271	100,5	3.958	18,23	12.24	2,54	5.60	127,0	5.000	100,5	3.958					38,1	1.500	38,1	1.500			101,6	4.000
114,3	4.500	24,7	16.60	8,56	0.337	97,2	3.826	22,31	14.98	2,54	5.60	127,0	5.000	97,2	3.826					38,1	1.500	38,1	1.500			101,6	4.000
114,3	4.500	29,8	20.00	10,92	0.430	92,5	3.640	27,84	18.69	2,54	5.60	127,0	5.000	92,5	3.640					38,1	1.500	38,1	1.500			101,6	4.000
Internal and external upset																											
114,3	4.500	29,8	20.00	10,92	0.430	92,5	3.640	27,84	18.69	3,90	8.60	121,4	4.781	76,2	3.000	57,2	2.250	50,8	2.000	38,1	1.500	25,4	1.000	38,1	1.500		
127,0	5.000	29,0	19.50	9,19	0.362	108,6	4.276	26,71	17.93	3,90	8.60	131,8	5.188	93,7	3.687	57,2	2.250	50,8	2.000	38,1	1.500	25,4	1.000	38,1	1.500		
127,0	5.000	38,1	25.60	12,70	0.500	101,6	4.000	35,79	24.03	3,51	7.80	131,8	5.188	87,3	3.437	57,2	2.250	50,8	2.000	38,1	1.500	25,4	1.000	38,1	1.500		
139,7	5.500	32,6	21.90	9,17	0.361	121,4	4.778	29,51	19.81	4,81	10.60	141,3	5.563	101,6	4.000	57,2	2.250	50,8	2.000	38,1	1.500	25,4	1.000	38,1	1.500		
139,7	5.500	36,8	24.70	10,54	0.415	118,6	4.670	33,57	22.54	4,09	9.00	141,3	5.563	101,6	4.000	57,2	2.250	50,8	2.000	38,1	1.500	25,4	1.000	38,1	1.500		

1) Nominal masses are shown for the purpose of identification in ordering.

2) Mass gain or loss due to end finishing (see 9.5).

3) The specified upset dimensions do not necessarily agree with the bore and outside diameter of finished weld-on assemblies. Upset dimensions were chosen to accommodate the various between-tool joints and to maintain a satisfactory cross-section in the weld zone after final machining of the assembly.

4) The ends of the internal upset drill pipe shall not be smaller in outside diameter D than D_1 min. They may be delivered with slight external upset within the limit D_1 max.

5) Maximum taper on inside diameter of internal upset and internal and external upset : 1/4 in per foot on diameter.

* These values are only applicable to grade E 52.

TABLE 12b — **Upset drill pipe for weld-on tool joints — Grade N 56**

Pipe												Upset[3]													
Outside diameter D		Mass per unit length[1]		Wall thickness a		Inside diameter d		Calculated mass				Outside diameter[4] D_1		Inside diameter[5] d_1		Length of internal upset l_1		Length of internal taper l_2 min.		Length of external upset l_3 min.		Length of external taper l_4			Length to taper fade-out l_5 max.	
								Plain end		Upset[2]												min.		max.			
								+ 3,18 − 0,79	+ 0.125 − 0.031	± 1,59	± 0.062 5	+ 38 − 12,7	+ 1.500 − 0.500												
mm	in	kg/m	lb/ft	mm	in	mm	in	kg/f	lb/ft	kg	lb	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
26,7	1.050	2,310	1.550	3,91	0.154	18,8	0.742	2,19	1.47	0,68	1.50	36,50	1.437	17,47	0.668	50,8	2.000	6,35	0.250	38,10	1.5	25,40	1	31,75	1.275	76,20	3.000
33,4	1.315	3,43	2.300	4,32	0.170	24,3	0.957	3,23	2.17	0,82	1.80	42,85	1.687	21,44	0.844	50,8	2.000	9,52	0.375	38,10	1.5	25,40	1	31,75	1.275	76,20	3.000
42,2	1.660	4,90	3.290	5,03	0.198	32,1	1.264	4,60	3.09	1,09	2.40	47,60	1.874	22,23	0.875	50,8	2.000	19,05	0.750	38,10	1.5	25,40	1	31,75	1.275	76,20	3.000
48,3	1.900	6,24	4.190	5,56	0.219	37,1	1.462	5,65	3.93	1,50	3.30	55,55	2.187	23,83	0.938	50,8	2.000	22,23	0.875	38,10	1.5	25,40	1	31,75	1.275	76,20	3.000

TABLE 12c — **Upset drill pipe for weld-on tool joints — Grades X 66, G 73 and S 93**

Pipe												Upset[3]									
Outside diameter D		Mass per unit length[1]		Wall thickness a		Inside diameter d		Calculated mass				Outside diameter[4] D_1		Inside diameter[5] d_1		Length of internal upset l_1		Length of external upset l_3 min.		Length to taper fade-out l_5 max.	
								Plain end		Upset[2]											
mm	in	kg/m	lb/ft	mm	in	mm	in	kg/m	lb/ft	kg	lb	mm	in	mm	in	mm	in	mm	in	mm	in
Internal upset																					
73,0	2.875	15,5	10.40	9,19	0.362	54,6	2.151	14,48	9.72			73,0	2.875	23,8	0.938	88,9	3.500				
88,9	3.500	19,8	13.30	9,35	0.368	70,2	2.764	18,34	12.31			88,9	3.500	49,2	1.938	88,9	3.500				
101,6	4.000	20,8	14.00	8,38	0.330	84,8	3.340	19,26	12.93			101,6	4.000	66,7	2.625	88,9	3.500				
114,3	4.500	24,7	16.60	8,56	0 337	97,2	3 825	22,31	14.98			114,3	4.500	71,4	2.813	88,9	3.500				
127,0	5.000	24,2	16.25	7,52	0.296	112,0	4.408	22,15	14.87			127,0	5.000	90,5	3.563	88,9	3.500				
External upset																					
60,3	2.375	9,9	6.65	7,11	0.280	46,1	1.815	9,32	6.26			67,5	2.656	39,7	1.563	108,0	4.250	76,2	3.000	139,7	5.500
73,0	2.875	15,5	10.40	9,19	0.362	54,6	2.151	14,48	9.72			82,6	3.250	33,4	1.313	108,0	4.250	76,2	3.000	139,7	5.500
88,9	3.500	19,8	13.30	9,35	0.368	70,2	2.764	18,34	12.31			101,6	4.000	63,5	2.500	108,0	4.250	76,2	3.000	139,7	5.500
88,9	3.500	23,1	15.50	11,40	0.449	66,1	2.602	21,79	14.63			101,6	4.000	63,5	2.500	108,0	4.250	76,2	3.000	139,7	5.500
101,6	4.000	20,8	14.00	8,38	0.330	84,8	3.340	19,26	12.93			117,5	4.625	77,8	3.063	108,0	4.250	76,2	3.000	139,7	5.500
114,3	4.500	24,7	16.60	8,56	0.337	97,2	3.826	22,31	14.98			131,8	5.188	90,5	3.563	108,0	4.250	76,2	3.000	139,7	5.500
114,3	4.500	29,8	20.00	10,92	0.430	92,5	3.640	27,84	18.69			131,8	5.188	87,3	3.438	108,0	4.250	76,2	3.000	139,7	5.500
127,0	5.000	29,0	19.50	9,19	0.362	108,6	4.276	26,71	17.93			146,1	5.750	100,0	3.938	108,0	4.250	76,2	3.000	139,7	5.500
127,0	5.000	38,1	25.60	12,70	0.500	101,6	4.000	35,79	24.03			149,2	5.875	96,8	3.813	108,0	4.250	76,2	3.000	139,7	5.500
Internal and external upset																					
88,9	3.500	23,1	15.50	11,40	0.449	66,1	2.602	21,79	14.63			96,0	3.781	49,2	1.938	108,0	4.250	76,2	3.000	139,7	5.500
114,3	4.500	29,8	20.00	10,92	0.430	92,5	3.640	27,84	18.69			121,4	4.781	71,5	2.813	108,0	4.250	76,2	3.000	139,7	5.500
127,0	5.000	29,0	19.50	9,19	0.362	108,6	4.276	26,71	17.93			131,8	5.188	90,5	3.563	108,0	4.250	76,2	3.000	139,7	5.500
127,0	5.000	38,1	25.60	12,70	0.500	101,6	4.000	35,79	24.03			131,8	5.188	84,2	3.313	108,0	4.250	76,2	3.000	139,7	5.500
139,7	5.500	32,6	21.90	9,17	0.361	121,4	4.778	29,51	19.81			141,3	5.563	100,0	3.813	108,0	4.250	76,2	3.000	139,7	5.500
139,7	5.500	36,8	24.70	10,54	0.415	118,6	4.670	33,57	22.54			141,3	5.563	100,0	3.813	108,0	4.250	76,2	3.000	139,7	5.500

TABLE 13a — **New drill pipe characteristics — Grades D 38 and E 52**

Outside diameter		Mass per unit length		Wall thickness		Collapse				Internal pressure				Load corresponding to pipe body proof stress				Torsion torque corresponding to pipe body proof stress			
						D 38		E 52		D 38		E 52		D 38		E 52		D 38		E 52	
mm	in	kg/m	lb/ft	mm	in	N/mm^2	lbf/in^2	N/mm^2	lbf/in^2	bar	lbf/in^2	bar	lbf/in^2	N	lbf	N	lbf	N·m	lbf·ft	N·m	lbf·ft
60,3	2.375	9,9	6.65	7,1	0.280	78,9	11 440	107,6	15 600	783	11 350	1 067	15 470	450 900	101 360	614 800	138 220	6 210	4 580	8 460	6 240
73,0	2.875	15,5	10.40	9,2	0.362	83,5	12 110	113,8	16 510	836	12 120	1 140	16 530	699 200	157 190	953 400	214 340	11 470	8 460	15 630	11 530
		14,1	9.50	6,4	0.254			69,2	10 010			656	9 520			864 100	194 260			19 140	14 120
88,9	3.500	19,8	13.30	9,3	0.368	71,4	10 350	97,3	14 110	698	10 120	952	13 800	885 900	199 160	1 208 000	271 570	18 410	13 580	25 110	18 520
		23,1	15.50	11,4	0.449	84,8	12 300	115,6	16 770	852	12 350	1 161	16 840	1 053 000	236 720	1 435 800	322 780	20 930	15 440	28 540	21 050
		17,6	11.85	6,7	0.262			58,0	8 410			593	8 600			1 026 400	230 750			26 360	19 440
101,6	4.000	20,8	14.00	8,4	0.330	57,4	8 330	78,3	11 350	547	7 940	747	10 830	930 900	209 280	1 269 300	285 360	23 120	17 050	31 520	23 250
		20,5	13.75	6,9	0.271			49,6	7 200			545	7 900			1 201 200	270 030			35 060	25 860
114,3	4.500	24,7	16.60	8,6	0.337	52,5	7 620	71,6	10 390	497	7 210	678	9 830	1 078 200	242 380	1 470 400	330 560	30 570	22 550	41 690	30 750
		29,8	20.00	10,9	0.430	65,6	9 510	89,4	12 960	634	9 200	865	12 540	1 345 100	302 390	1 834 300	412 360	36 620	27 010	49 950	36 840
		24,2	16.25	7,5	0.296			48,1	6 970			536	7 770			1 459 300	328 070			47 430	34 980
127	5.000	29,0	19.50	9,2	0.362	50,6	7 340	69,0	10 000	480	6 960	655	9 500	1 290 400	290 100	1 759 700	395 600	40 860	30 135	55 710	41 090
		38,1	25.60	12,7	0.500	68,3	9 900	93,1	13 500	663	9 620	905	13 120	1 729 300	388 770	2 358 200	530 140	51 860	38 250	70 720	52 160
		32,6	21.90	9,2	0.361	45,6	6 610	58,2	8 440	436	6 320	594	8 620	1 425 900	320 550	1 944 400	437 120	50 330	37 120	68 630	50 620
139,7	5.500	36,8	24.70	10,5	0.415	52,9	7 670	72,1	10 460	501	7 260	683	9 900	1 622 000	364 630	2 211 700	497 220	56 140	41 410	76 560	56 470