INTERNATIONAL STANDARD

ISO 10400

First edition
1993-12-15

Petroleum and natural gas industries — Formulae and calculation for casing, tubing, drill pipe and line pipe properties

Industries du pétrole et du gaz naturel — Formules et calculs relatifs aux propriétés des cuvelages, tubes de production, tiges de forage et tubes de conduites

Reference number
ISO 10400:1993(E)

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.

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.

International Standard ISO 10400 was prepared by the American Petroleum Institute (API) (as Bul 5C3, 5th edition) and was adopted, under a special "fast-track procedure", by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, in parallel with its approval by the ISO member bodies.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Introduction

International Standard ISO 10400:1993 reproduces the content of API Bul 5C3, 5th edition, 1989. ISO, in endorsing this API document, recognizes that in certain respects the latter does not comply with all current ISO rules on the presentation and content of an International Standard. Therefore, the relevant technical body, within ISO/TC 67, will review ISO 10400:1993 and reissue it, when practicable, in a form complying with the ISO directives.

This standard is not intended to obviate the need for sound engineering judgement as to when and where this standard should be utilized and users of this standard should be aware thad additional or differing requirements may be needed to meet the needs for the particular service intended.

Standards referenced herein may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standards.

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Petroleum and natural gas industries — Formulae and calculation for casing, tubing, drill pipe and line pipe properties

1 Scope

This International Standard establishes the formulae used in the calculation of the various casing, tubing, drill pipe and line pipe properties for the oil and natural gas industries.

2 Requirements

Requirements are specified in

"API BULLETIN 5C3 (Bul 5C3), Fifth Edition, July 1989 — *Bulletin on Formulas and Calculations for Casing, Tubing, Drill Pipe, and Line Pipe Properties*",

which is adopted as ISO 10400.

For the purposes of international standardization, however, modifications shall apply to specific clauses and paragraphs of publication API Bul 5C3. These modifications are outlined below.

Throughout publication API Bul 5C3, the conversion of English units shall be made in accordance wtih ISO 31. The content of section 11, **Metrication** shall read as given below.

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Information given in the POLICY is relevant to the API publication only.

METRICATION

METRIC CONVERSIONS AND CALCULATIONS

Metric units in API Bul 5C3 are shown in italic type and in the text and most tables in parentheses. Outside diameters and wall thicknesses are converted from inch dimensions. The converted values are rounded to the nearest 0,1 mm for diameters less than 18 in, and to the nearest 1,0 mm for diameters 18 in and larger. Wall thicknesses are rounded to the nearest 0,1 mm.

Metric inside diameters and drift diameters are calculated from the metric outside diameters and wall thicknesses and rounded to the nearest 0,1mm.

Metric plain-end masses are calculated from the metric outside diameters and wall thicknesses by the following formula and rounded to the nearest 0,01 kg/m.

$$W_{pe} = 0{,}024\,66(D - t)t$$

Metric hydrostatic test pressures are calculated from the metric outside diameters and wall thicknesses and metric fiber stresses as shown in clause 8.

The factors used where conversions are appropriate are as follows:

1 inch (in)	= 25,4 mm exactly
1 square inch (in^2)	= 645,16 mm^2 exactly
1 foot (ft)	= 0,030 48 m exactly
1 pound (lb)	= 0,453 59 kg
1 pound per foot (lb/ft)	= 1,488 2 kg/m
1 pound per square inch (lbf/in^2)	= 6,895 kPa for pressure
	= 0,006 895 MPa for stress
1 footpound-force (ft-bf)	= 1,355 8 J for impact energy
	= 1,355 8 N·m for torque

The following formula was used to convert degrees Farenheit (°F) to degrees Celsius (°C): °C = 5/9 (°F - 32).

ROUNDING OF METRIC UNITS

Metric units are converted or calculated in accordance with factors given above and the number of digits shown in the table.

Table — Number of decimals to be shown in metric units

1	2	3
PROPERTY	**METRIC UNITS**	**NUMBER OF DECIMALS**
Diameter	mm	1
Thickness and imperfections	mm	1
Upset and coupling length	mm	1
Length	m	2
Mass	kg	2
Mass per foot	kg/m	2
Stress and tensile strength	MPa	0
Pressure	kPa × 100	0
Guided bend A	mm	1
Thread elements		
Major diameter	mm	1
Pitch diameter	mm	3
Thread length	mm	2
Thread height	mm	3
Recess depth	mm	1
J (distance from end of pipe to centre of coupling	mm	1

Bulletin on Formulas and Calculations for Casing, Tubing, Drill Pipe and Line Pipe Properties

API BULLETIN 5C3 (Bul 5C3)
FIFTH EDITION, JULY 1989

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Washington, DC 20005

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Issued by
AMERICAN PETROLEUM INSTITUTE
Production Department

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SEE BACK COVER FOR INFORMATION CONCERNING HOW TO OBTAIN ADDITIONAL COPIES OF THIS PUBLICATION.

Users of this publication should become familiar with its scope and content. This document is intended to supplement rather than replace individual engineering judgment.

OFFICIAL PUBLICATION

REG. U.S. PATENT OFFICE

TABLE OF CONTENTS

FOREWORD

a. This bulletin is under the jurisdiction of the Committee on Standardization of Tubular Goods.

b. The purpose of this bulletin is to show the formulas used in the calculation of the various pipe properties given in API standards, including background information regarding their development and use.

c. American Petroleum Institute (API) Bulletins are published to provide information for which there is a broad industry need but which does not constitute either Specifications or Recommended Practices.

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e. This Standard (supplement) shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.

Attention Users: Portions of this publication have been changed from the previous edition. The locations of changes have been marked with a bar in the margin, as shown to the left of this paragraph. In some cases the changes are significant, while in other cases the changes reflect minor editorial adjustments. The bar notations in the margins are provided as an aid to users as to those parts of this publication that have been changed from the previous edition, but API makes no warranty as to the accuracy of such bar notations.

Note: *This is the fifth edition of this bulletin. The first edition was authorized for publication at the 1970 Standardization Conference as detailed in Circ PS-1398 and issued in 1971. Subsequent editions were issued in 1974, 1980, and 1985.*

POLICY

1. API PUBLICATIONS NECESSARILY ADDRESS PROBLEMS OF A GENERAL NATURE. WITH RESPECT TO PARTICULAR CIRCUMSTANCES, LOCAL, STATE, AND FEDERAL LAWS AND REGULATIONS SHOULD BE REVIEWED.

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SECTION 1
COLLAPSE PRESSURE

1.1 COLLAPSE PRESSURE FORMULAS

The minimum collapse pressures given in API Bul 5C2 are calculated by means of formulas 1.1.1.1, 1.1.2.1, 1.1.3.1 and 1.1.4.1, adopted at the 1968 Standardization Conference and reported in Circular PS-1360 dated September 1968.

Formulas 1.1.1.2, 1.1.2.2 and 1.1.3.2 for the intersections between the four collapse pressure formulas have been determined algebraically and used for calculating the applicable D/t range for each collapse pressure formula. Factors A, B, C, F and G have been calculated using formulas 1.2.2.12, 1.2.2.13, 1.2.2.14, 1.2.3.2 and 1.2.3.3. Grades with alphabetic prefixes are API grades. Those without alphabetic prefixes are non API grades. When determining the appropriate formula to be used for calculating collapse resistance for a particular D/t ratio and minimum yield strength, the D/t ranges determined by formulas 1.1.1.2, 1.1.2.2 and 1.1.3.2 govern, rather than the collapse formula that gives the lowest collapse pressure. The D/t ranges for API and some non API grades are given in Tables 1.1.1.1, 1.1.2.1, 1.1.3.1 and 1.1.4.1.

The collapse pressures for Bul 5C2 are calculated using the specified values for D and t rounding D/t to two decimals carrying eight digits in all intermediate calculations and rounding the collapse pressure to the nearest 10 psi.

1.1.1 YIELD STRENGTH COLLAPSE PRESSURE FORMULA

The yield strength collapse pressure is not a true collapse pressure, but rather the external pressure, P_{Y_p}, that generates minimum yield stress, Y_p, on the inside wall of a tube as calculated by formula 1.1.1.1

$$P_{Y_p} = 2Y_p\left[\frac{(D/t) - 1}{(D/t)^2}\right] \quad \text{1.1.1.1}$$

The formula for yield strength collapse pressure formula 1.1.1.1 is applicable for D/t values up to the value of D/t corresponding to the intersection with the plastic collapse formula 1.1.2.1. This intersection is calculated by formula 1.1.1.2 as follows:

$$(D/t)_{yp} = \frac{\sqrt{(A - 2)^2 + 8\,(B + C/Y_p)} + (A - 2)}{2(B + C/Y_p)} \quad \text{1.1.1.2}$$

The applicable D/t ratios for yield strength collapse are shown in table 1.1.1.1.

TABLE 1.1.1.1
YIELD COLLAPSE PRESSURE FORMULA RANGE

1	2
Grade†	**D/t Range***
H-40	16.40 and less
-50	15.24 " "
J-K-55	14.81 " "
-60	14.44 " "
-70	13.85 " "
C-75 & E	13.60 " "
L-N-80	13.38 " "
C-90	13.01 " "
C-T-95 & X	12.85 " "
-100	12.70 " "
P-105 & G	12.57 " "
P-110	12.44 " "
-120	12.21 " "
Q-125	12.11 " "
-130	12.02 " "
S-135	11.92 " "
-140	11.84 " "
-150	11.67 " "
-155	11.59 " "
-160	11.52 " "
-170	11.37 " "
-180	11.23 " "

†Grades indicated without letter designation are not API grades but are grades in use or grades being considered for use and are shown for information purposes.

*The D/t range values were calculated from formulas 1.1.1.2, 1.2.2.12, 1.2.2.13 and 1.2.2.14 to eight or more digits.

1.1.2 PLASTIC COLLAPSE PRESSURE FORMULA

The minimum collapse pressure for the plastic range of collapse is calculated by formula 1.1.2.1.

$$P_p = Y_p\left[\frac{A}{D/t} - B\right] - C \quad \ldots\ldots 1.1.2.1$$

The formula for minimum plastic collapse pressure is applicable for D/t values ranging from $(D/t)_{PT}$, formula 1.1.1.2 for yield point collapse pressure, to the intersection with the formula 1.1.3.1 for transition collapse pressure $(D/t)_{PT}$. Values for $(D/t)_{PT}$ are calculated by means of formula 1.1.2.2.

$$(D/t)_{PT} = \frac{Y_p\,(A - F)}{C + Y_p\,(B - G)} \quad \ldots\ldots 1.1.2.2$$

The factors and applicable D/t range for the plastic collapse formula are shown in table 1.1.2.1.

TABLE 1.1.2.1

FORMULA FACTORS AND D/t RANGES FOR PLASTIC COLLAPSE

1	2	3	4	5
	Formula Factor*			
Grade†	**A**	**B**	**C**	**D/t Range***
H-40	2.950	0.0465	754	16.40 to 27.01
-50	2.976	0.0515	1056	15.24 to 25.63
J-K-55	2.991	0.0541	1206	14.81 to 25.01
-60	3.005	0.0566	1356	14.44 to 24.42
-70	3.037	0.0617	1656	13.85 to 23.38
C-75 & E	3.054	0.0642	1806	13.60 to 22.91
L-N-80	3.071	0.0667	1955	13.38 to 22.47
C-90	3.106	0.0718	2254	13.01 to 21.69
C-T-95 & X	3.124	0.0743	2404	12.85 to 21.33
-100	3.143	0.0768	2553	12.70 to 21.00
P-105 & G	3.162	0.0794	2702	12.57 to 20.70
P-110	3.181	0.0819	2852	12.44 to 20.41
-120	3.219	0.0870	3151	12.21 to 19.88
Q-125	3.239	0.0895	3301	12.11 to 19.63
-130	3.258	0.0920	3451	12.02 to 19.40
S-135	3.278	0.0946	3601	11.92 to 19.18
-140	3.297	0.0971	3751	11.84 to 18.97
-150	3.336	0.1021	4053	11.67 to 18.57
-155	3.356	0.1047	4204	11.59 to 18.37
-160	3.375	0.1072	4356	11.52 to 18.19
-170	3.412	0.1123	4660	11.37 to 17.82
-180	3.449	0.1173	4966	11.23 to 17.47

†Grades indicated without letter designation are not API grades but are grades in use or grades being considered for use and are shown for information purposes.

*The D/t range values and formula factors were calculated from formulas 1.1.1.2, 1.1.2.2, 1.2.2.12, 1.2.2.13, 1.2.2.14, 1.2.3.2 and 1.2.3.3 to eight or more digits.

1.1.3 TRANSITION COLLAPSE PRESSURE FORMULA

The minimum collapse pressure for the plastic to elastic transition zone P_T is calculated by formula 1.1.3.1.

$$P_T = Y_p\left[\frac{F}{D/t} - G\right] \quad \text{.....1.1.3.1}$$

The formula for P_T is applicable for D/t values from $(D/t)_{PT}$, formula 1.1.2.2 for plastic collapse pressure to the intersection $(D/t)_{TE}$ with the formula 1.1.4.1 for elastic collapse. Values for $(D/t)_{TE}$ are calculated by formula 1.1.3.2.

$$(D/t)_{TE} = \frac{2 + B/A}{3B/A} \quad \text{.....1.1.3.2}$$

The factors and applicable D/t range for the transition collapse pressure formula are shown in table 1.1.3.1.

TABLE 1.1.3.1

FORMULA FACTORS AND D/t RANGE FOR TRANSITION COLLAPSE

1	2	3	4
	Formula Factors*		
Grade†	F	G	D/t Range*
H-40	2.063	0.0325	27.01 to 42.64
-50	2.003	0.0347	25.63 to 38.83
J-K-55	1.989	0.0360	25.01 to 37.21
-60	1.983	0.0373	24.42 to 35.73
-70	1.984	0.0403	23.38 to 33.17
C-75 & E	1.990	0.0418	22.91 to 32.05
L-N-80	1.998	0.0434	22.47 to 31.02
C-90	2.017	0.0466	21.69 to 29.18
C-T-95 & X	2.029	0.0482	21.33 to 28.36
-100	2.040	0.0499	21.00 to 27.60
P-105 & G	2.053	0.0515	20.70 to 26.89
P-110	2.066	0.0532	20.41 to 26.22
-120	2.092	0.0565	19.88 to 25.01
Q-125	2.106	0.0582	19.63 to 24.46
-130	2.119	0.0599	19.40 to 23.94
S-135	2.133	0.0615	19.18 to 23.44
-140	2.146	0.0632	18.97 to 22.98
-150	2.174	0.0666	18.57 to 22.11
-155	2.188	0.0683	18.37 to 21.70
-160	2.202	0.0700	18.19 to 21.32
-170	2.231	0.0734	17.82 to 20.60
-180	2.261	0.0769	17.47 to 19.93

†Grades indicated without letter designation are not API grades but are grades in use or grades being considered for use and are shown for information purposes.

*The D/t range values and formula factors were calculated from formulas 1.1.2.2, 1.1.3.2, 1.2.2.12, 1.2.2.13, 1.2.2.14, 1.2.3.2 and 1.2.3.3 to eight or more digits.