Institut Français du Pétrole

drilling data handbook

SIXTH EDITION

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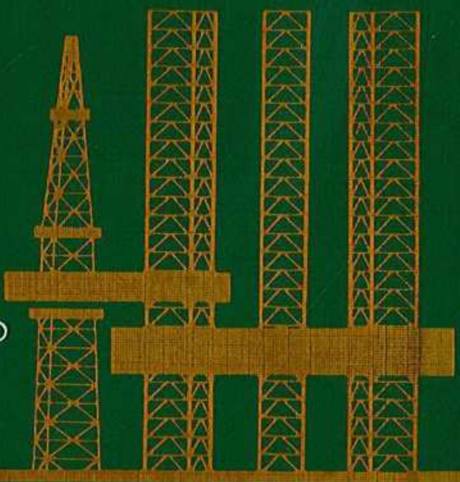

drilling data handbook

Sixth Edition
expanded and updated

INSTITUT FRANÇAIS DU PÉTROLE

ÉCOLE NATIONALE SUPÉRIEURE DU PÉTROLE ET DES MOTEURS
FORMATION INDUSTRIE
(ENSPM FI)

drilling data handbook

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Foreword by
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Translation from the French
by Nissim MARSHALL

SIXTH EDITION
EXPANDED AND UPDATED

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Translation of
« Formulaire du foreur », 6th Edition,
Gilles Gabolde, Jean-Paul Nguyen

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Foreword

to the Sixth Edition

This **Sixth Edition** of the **Drilling Data Handbook,** brought completely up-to-date, has nevertheless been prepared in the same spirit as the previous one, in other words to provide users with a working tool offering them all the data, charts and procedures employed in drilling operations.

The authors of this edition, Gilles Gabolde and Jean-Paul Nguyen, of *École Nationale Supérieure du Pétrole et des Moteurs, Formation Industrie (ENSPM FI),* have taken account of the latest Standards and recommendations issued by international bodies, such as *API* and the *International Association of Drilling Contractors (IADC),* and have expressed the characteristics of the equipment in the International System of Units (SI), adding standard English and American units in routine use whenever necessary.

The presentation of some of the chapters of this Handbook has sometimes been altered to include new data and to make it easier to find certain parameters.

This search is facilitated by the index at the end of the Handbook.

These changes should satisfy practised users, who will be happy to find all the information they could possibly need in this book.

A. LEBLOND
Director of Drilling, Production and Reservoirs
ENSPM Formation Industrie

Publisher's Note :
This is the second English-language version of *Formulaire du Foreur,* now in its sixth edition in French. We have chosen to refer to this as the sixth edition so that the reader will know that it corresponds to the same edition in French.

NOTICE

The numerical values and characteristics of the equipment described in this book are only given for guidance purposes, and do not engage the responsibility of the authors or the companies mentioned. Further information can be obtained directly from the companies concerned.

A

general data

INTERNATIONAL SYSTEM OF UNITS (SI)

	International System SI or MKSA				Submultiple system CGS			Other multiples and submultiples of SI
	Quantity	Dimension	Unit	Symbol	Unit	Symbol	SI equivalent	
Basic Units	Length	L	meter	m	centimeter	cm	10^{-2} m	10^3 m = 1 km ; 10^{-3} m = 1 mm ; 10^{-6} m = 1 micron (µ) ; 10^{-10} m = 1 angström (Å)
	Mass	M	kilogram	kg	gram	g	10^{-3} kg	10^3 kg = 1 tonne (t) ; 10^2 kg = 1 quintal (q)
	Time	T	second	s	second	s	s	3 600 s = 1 hour (h) ; 60 s = 1 minute (min) ; 10^{-3} s = 1 millisecond (ms)
	Electric current		ampere	A				10^{-3} A = 1 milliampere (mA) ; 10^{-6} A = 1 microampere (1 µ A)
	Temperature		kelvin	K				The temperature in degrees Celsius (°C) is the difference between two thermodynamic temperatures $T - T_0$ where T_0 = 273.15 kelvin
	Amount of substance		mole	mol				
	Luminous intensity		candela	cd				
Supplementary	Plane angle Solid angle		radian stéradian	rad sr				
Derived Units	Area	L^2	square meter	m^2	square centimeter	cm^2	10^{-4} m^2	10^4 m^2 = 1 hectare (1 ha) ; 10^2 m^2 = 1 are (a) ; 10^{-6} m^2 = 1 mm^2
	Volume	L^3	cubic meter	m^3	cubic centimeter	cm^3	10^{-6} m^3	10^{-3} m^3 = 1 dm^3 = 1 liter (l)
	Force	MLT^{-2}	newton	N	dyne	dyn	10^{-5} N	10^4 N = 10^3 daN ; 10^3 N = 1 kilonewton (kN) ; 10 N = 1 decanewton (daN)
	Energy - Work Heat	$ML^2 T^{-2}$	joule	J	erg	erg	10^{-7} J	10^6 J = 1 kilonewton.km (kN.km) ; 10 J = 1 daN.m ; 1 J = 1 Nm ; 4.18 J = 1 calorie (cal) ; 4.18 10^6 J = 1 therm (th)
	Power	$ML^2 T^{-3}$	watt	W	erg per second	erg/s	10^{-7} W	10^6 W = 1 megawatt (1 MW)
	Velocity	LT^{-1}	meter per second	m/s	centimeter per second	cm/s	10^{-2} m/s	$\frac{1}{3.6}$ m/s = 1 km/h ; $\frac{1\,852}{3\,600}$ m/s = 1 knot
	Acceleration	LT^{-2}	meter per square second	m/s^2	gal	cm/s^2	10^{-2} m/s^2	
	Pressure stress	$ML^{-1}T^{-2}$	pascal	Pa	barye	dyn/cm^2	10^{-1} Pa	10^7 Pa = 1 hectobar (hbar) ; 10^5 Pa = 1 bar ; 10^2 Pa = 1 millibar (mbar)
	Dynamic viscosity	$ML^{-1}T^{-1}$	pascal-second	Pa.s	poise	P	10^{-1} Pa.s	10^{-3} Pa.s = 1 centipoise (cP)
	Kinematic viscosity	$L^2 T^{-1}$	square meter per second	m^2/s	stokes	St	10^{-4} m^2/s	10^{-6} m^2/s = 1 centistoke (cSt)

OBSOLETE SYSTEMS OF UNITS

Quantity	Dimension	Symbol	MTS					MKpS				
			Unit	S	MKpS	CGS	SI	Unit	S	MTS	CGS	SI
Length	L	l	meter	m	1	10^2	1	meter	m	1	10^2	1
Mass	M	M	tonne	t	$\frac{1}{9.81} \times 10^3$	10^6	10^3			9.81×10^{-3}	9.81×10^3	9.81
Area	L^2	S	square meter	m^2	1	10^4	1	square meter	m^2	1	10^4	1
Volume	L^3	V	cubic meter	m^3	1	10^6	1	cubic meter	m^3	1	10^6	1
Time	T	T	second	s	1	1	1	second	s	1	1	1
Force	MLT^{-2}	F	sthene	sn	$\frac{1}{9.81} \times 10^3$	10^8	10^3	kilogram-force	kgf	9.81×10^{-3}	9.81×10^3	9.81
Energy-work	ML^2T^{-2}	ζ or W	kilojoule	kJ	$\frac{1}{9.81} \times 10^3$	10^{10}	10^3	kilogram-meter	kgm	9.81×10^{-3}	9.81×10^7	9.81
Power.	ML^2T^{-3}	P	kilowatt	kW	$\frac{1}{9.81} \times 10^3$	10^{10}	10^3	kilogram-meter per second	kgm/s	9.81×10^{-3}	9.81×10^7	9.81
Velocity.	LT^{-1}	V	meter per second	m/s	1	10^2	1	meter per second	m/s	1	10^2	1
Acceleration	LT^{-2}	γ	meter per second, per second	m/s^2	1	10^2	1	meter per second, per second	m/s^2	1	10^2	1
Pressure/Stress . . .	$ML^{-1}T^{-2}$	p	pieze	pz	$\frac{1}{9.81} \times 10^3$	10^4	10^3	kilogram-force per square meter	kgf/m^2	9.81×10^{-3}	98.1	9.81
Dynamic viscosity	$ML^{-1}T^{-1}$	η or μ	myriapoise	maPo	$\frac{1}{9.81} \times 10^3$	10^4	10^3			9.81×10^{-3}	98.1	9.81
Kinematic viscosity	L^2T^{-1}	ν	myriastokes	maSt	1	10^4	1	myriastokes	maSt	1	10^4	1
Quantity of heat . .		Q	thermie	th	10^3	10^6	4.18×10^6	kilocalorie or millithermie	kcal mth	10^{-3}	10^3	4.18×10^3

IMPORTANT NOTICE

The measurements and formulas in this handbook are given in legal units (unless otherwise specified).

The user must remember the various correspondences with practical units.

The legal unit for pressure is the Pascal (Pa)

1 Pa = 10^{-5} bar

1 kPa = 10^{-2} bar

1 MPa = 10 bar

The legal unit for force is the Newton (N)

1 N = 0.102 kgf

1 daN = 1.02 kgf

The legal unit for torque is the Newton meter (N.m)

1 N.m = 0.1 daN.m

1 N.m = 0.102 kgf.m

DECIMAL MULTIPLES AND SUBMULTIPLES OF A UNIT

MULTIPLES

Unit multiplier	Prefix to put before the name of the unit	Symbol to put before the unit symbol
10^{12} = 1 000 000 000 000	tera	T
10^9 = 1 000 000 000	giga	G
10^6 = 1 000 000	mega	M
10^3 = 1 000	kilo	k
10^2 = 100	hecto	h
10^1 = 10	deca	da

SUBMULTIPLES

Unit multiplier	Prefix to put before the name of the unit	Symbol to put before the unit symbol
10^{-1} = 0.1	deci	d
10^{-2} = 0.01	centi	c
10^{-3} = 0.001	milli	m
10^{-6} = 0.000 001	micro	μ
10^{-9} = 0.000 000 001	nano	n
10^{-12} = 0.000 000 000 001	pico	p
10^{-15} = 0.000 000 000 000 001	femto	f
10^{-18} = 0.000 000 000 000 000 001	atto	a

Examples: 1 megameter (Mm) = 10^6 meters (m)
1 micrometer (μm) (micron or μ) = 10^{-6} meters (m)

BRITISH AND AMERICAN UNITS

Name	Symbol	Value	
		Relative*	In metric units
Length :			(meter)
Inch (pouce)	in		0.02540
Foot (pied)	ft	12 in	0.30479
Yard	yd	3 ft	0.91438
Fathom (brasse) . .	—	2 yd	1.82876
Mile (statute)	—	1760 yd	1609.3149
Mile (nautical) . . .	—	2029 yd	1853.1232
Area :			(square meter)
Square inch	sq. in.		0.00064513
Square foot	sq. ft.	144 sq. in.	0.0928997
Acre		4840 sq. yd.	4046.81
Square mile (stat.)	*sq. mile*	*640 acres*	259.0 ha
Volume :			(cubic meter)
Cubic inch	cu. in.		0.000016386
Cubic foot	cu. ft.	*1728 cu. in.*	*0.02831531*
Capacity :			(liter)
Gallon (US)	gal (US)		3.785
Barrel of oil	bbl	42 gal (US)	158.98
Mass :			(kilogram)
Ounce	oz		0.02835
Pound (livre)	lb	16 oz	0.453593
Ton (short ton) . . .	sh tn	2000 lb	907.1853

MISCELLANEOUS CONSTANTS

0.0764 = air density in lb/ft^3 at 60 °F and 14.7 psia
14.691 = normal atmospheric pressure (76 cm Hg) in psi
32.174 = gravitational acceleration in ft/s^2 (980.665 cm/s^2)
550 = number of lb. ft/s one horse power (hp)
778.2 = number of lb. ft in one Btu
62.43 = water density in lbf/cu. ft. à 4 °C
8.345 = water density in lbf/gal at 4 °C

°C + 273.16 = K (Kelvin)
°F + 459.69 = °R (Rankine)

DECIMAL AND METRIC EQUIVALENTS OF FRACTIONS OF AN INCH

Fraction	Decimal equivalent	mm	Fraction	Decimal equivalent	mm
1/64	0.015625	0.39688	33/64	0.515625	13.09690
1/32	0.03125	0.79375	17/32	0.53125	13.49378
3/64	0.046875	1.19063	35/64	0.546875	13.89065
1/16	0.0625	1.58750	9/16	0.5625	14.28753
5/64	0.078125	1.98438	37/64	0.578125	14.68440
3/32	0.09375	2.38125	19/32	0.59375	15.08128
7/64	0.109375	2.77813	39/64	0.609375	15.47816
1/8	0.125	3.17501	**5/8**	0.625	15.87503
9/64	0.140625	3.57188	41/64	0.640625	16.27191
5/32	0.15625	3.96876	21/32	0.65625	16.66878
11/64	0.171875	4.36563	43/64	0.671875	17.06566
3/16	0.1875	4.76251	11/16	0.6875	17.46253
13/64	0.203125	5.15939	45/64	0.703125	17.85941
7/32	0.21875	5.55626	23/32	0.71875	18.25629
15/64	0.234375	5.95314	47/64	0.734375	18.65316
1/4	0.25	6.35001	**3/4**	0.75	19.05004
17/64	0.265625	6.74689	49/64	0.765625	19.44691
9/32	0.28125	7.14376	25/32	0.78125	19.84379
19/64	0.296875	7.54064	51/64	0.796875	20.24067
5/16	0.3125	7.93752	13/16	0.8125	20.63754
21/64	0.328125	8.33439	53/64	0.828125	21.03442
11/32	0.34375	8.73127	27/32	0.84375	21.43129
23/64	0.359375	9.12814	55/64	0.859375	21.82817
3/8	0.375	9.52502	**7/8**	0.875	22.22504
25/64	0.390625	9.92189	57/64	0.890625	22.62192
13/32	0.40625	10.31877	29/32	0.90625	23.01880
27/64	0.421875	10.71565	59/64	0.921875	23.41567
7/16	0.4375	11.11252	15/16	0.9375	23.81255
29/64	0.453125	11.50940	61/64	0.953125	24.20942
15/32	0.46875	11.90627	31/32	0.96875	24.60630
31/64	0.484375	12.30315	63/64	0.984375	25.00318
1/2	0.5	12.70003	**1**	1.0	25.40005

CONVERSION FACTORS FROM ENGLISH TO METRIC UNITS

Length :
in × 2.54 = cm
cm × 0.3937 = in
ft × 0.3048 = m
m × 3.281 = ft

Volume (gas) :
std ft^3 × 0.2832 = std m^3
std m^3 × 35.314 = std ft^3

Volume (liquid) :
US gal × 3.7853 = liters
bbl × 0.159 = m^3
ft^3 × 0.0283 = m^3

Pressure :
psi × 6.8948 = kPa
kPa × 0.145 = psi

Mass :
lb × 0.4536 = kg

Force :
lb × 0.4448 = daN

Density :
lb/gal × 0.1198 = kg/liter
lb/ft^3 × 0.01602 = kg/liter

Pressure gradient :
psi/ft × 22.62 = kPa/m

Torque :
ft.lbf × 0.1356 = daN.m

Power :
hp × 0.746 = kW

CONVERSION TABLE METRIC TO ENGLISH

Symbol	Multiply	by	to obtain
mm	Millimeters	0.03937	Inches
m	Meters	3.28084	Feet
m	Meters	1.09361	Yards
km	Kilometers	0.621373	Statute miles (land miles)
km	Kilometers	0.539613	Nautical miles (UK sea miles)
km	Kilometers	0.539957	Nautical miles (other countries)
cm^2	Square centimeters	0.155	Square inches
m^2	Square meters	10.7639	Square feet
ha	Hectares	2.47105	Acres
km^2	Square kilometers	0.386102	Square miles
km^2	Square kilometers	247.1	Acres
cm^3	Cubic centimeters	0.0610236	Cubic inches
l	Liters	0.0353147	Cubic feet
l	Liters	0.264178	US Gallons
l	Liters	0.219976	Imperial gallons
m^3	Cubic meters	35.3147	Cubic feet
m^3	Cubic meters	6.28994	US Barrels

CONVERSION TABLE ENGLISH TO METRIC

Symbol	Multiply	by	to obtain
in	Inches	25.4	Millimeters
ft	Feet	0.3048	Meters
yd	Yards	0.9144	Meters
mile (st)	Statute miles (land miles)	1.60934	Kilometers
mile (Nau) UK	Nautical miles (UK sea miles)	1.85318	Kilometers
mile (Nau)	Nautical miles (other countries)	1.852	Kilometers
in^2	Square inches	6.4516	Square centimeters
ft^2	Square feet	0.0929	Square meters
	Acres	0.404686	Hectares
sq. mile	Square miles	2.58999	Square kilometers
	Acres	0.004047	Square kilometers
in^3	Cubic inches	16.3871	Cubic centimeters
ft^3	Cubic feet	28.3168	Liters
gal(US)	US gallons	3.78533	Liters
gal(UK)	Imperial Gallons	4.54596	Liters
ft^3	Cubic feet	0.0283168	Cubic meters
bbl	US barrels	0.158984	Cubic meters

CONVERSION TABLE METRIC TO ENGLISH

Symbol	Multiply	by	to obtain
gf	Grams-force	15.4324	Grains-force
gf	Grams-force	0.035274	Ounces-force
N	Newtons	0.224809	Pounds-force
kgf	Kilograms-force	2.20462	Pounds-force
kgf	Kilograms-force	0.0234534	Sacks (cement)
tf	Tons-force	1.10231	Short tons-force
tf	Tons-force	0.984204	Long tons-force
kPa	Kilopascals	0.145038	Pounds-force per square inch
MPa	Megapascals	145.038	Pounds-force per square inch
bar	Bars	14.5038	Pounds-force per square inch
kgf/cm^2	Kilograms-force per square centimeter	14.2233	Pounds-force per square inch
kgf/mm^2	Kilograms-force per square millimeter	0.711167	Short tons-force per square inch
kgf/mm^2	Kilograms-force per square millimeter	102.408	Short tons-force per square foot

CONVERSION TABLE ENGLISH TO METRIC

Symbol	Multiply	by	to obtain
grf	Grains-force	0.0647998	Grams-force
ozf	Ounces-force	28.3495	Grams-force
lbf	Pounds-force	4.44822	Newtons
lbf	Pounds-force	0.453592	Kilograms-force
	Sacks (cement)	42.6377	Kilograms-force
sh tonf	Short tons-force	0.907185	Tons-force
lg tonf	Long tons-force	1.01605	Tons-force
psi	Pounds-force per square inch	6.894745	Kilopascals
psi	Pounds-force per square inch	0.0068947	Megapascals
psi	Pounds-force per square inch	0.0689475	Bars
psi	Pounds-force per square inch	0.070307	Kilograms-force per square centimeter
sh tonf/ in^2	Short tons-force per square inch	1.40614	Kilograms-force per square millimeter
sh tonf/ ft^2	Short tons-force per square foot	0.0097648	Kilograms-force per square millimeter

CONVERSION TABLE METRIC TO ENGLISH

Symbol	Multiply	by	to obtain
J	Joules	0.737561	Foot pounds-force
N.m	Newtons-meters	0.737561	Foot pounds-force
kg.m	Kilogram meters	7.23301	Foot pounds-force
tf.km	Tons-force kilometers	0.684944	Short ton-force miles
J	Joules	0.00094781	British thermal units
kcal	*Kilocalories*	3.96707	*British thermal units*
W	Watts	0.00134102	Horse power
kW	Kilowatts	1.34102	Horse power
ch	Steam horse power	0.98632	Horse power
kgf/m	Kilograms-force per meter	0.671971	Pounds-force per foot
kgf/l	Kilograms-force per liter	8.34523	Pounds-force per US gallon
kgf/l	Kilograms-force *per liter*	62.4278	Pounds-force per *cubic foot*
kgf/m^3	Kilograms-force per cubic meter	0.3505	Pounds-force per barrel
m^3/h	Cubic meters per hour	150.959	Barrels per day

CONVERSION TABLE ENGLISH TO METRIC

Symbol	Multiply	by	to obtain
ft.lbf	Foot pounds-force	1.35582	Joules
ft.lbf	Foot pounds-force	1.35582	Newtons-meters
ft.lbf	Foot pounds-force	0.138255	Kilogram meters
sh tonf.mile	Short ton-force miles	1.45997	Ton-force kilometers
Btu	British thermal units	1055.06	Joules
Btu	*British thermal units*	*0.252075*	*Kilocalories*
hp	Horse power	745.7	Watts
hp	Horse power	0.7457	Kilowatts
hp	Horse power	1.01387	Steam horse power
lbf/ft	Pounds-force per foot	1.48816	Kilograms-force per meter
lbf/gal	Pounds-force per US gallons	0.119829	Kilograms-force per liter
lbf/ft^3	Pounds-force per *cubic foot*	0.0160185	Kilograms-force *per liter*
lbf/bbl	Pounds-force per barrel	2.85307	Kilograms-force per cubic meter
bbl/day	Barrels per day	0.00662433	Cubic meters per hour

CONVERSION TABLE METRIC TO ENGLISH

Symbol	Multiply	by	to obtain
kcal/kg	Kilocalories per kilogram	1.79943	British thermal units per pound
kcal/m^2	Kilocalories per square meter	0.368553	British thermal units per square foot
kcal/m^3	Kilocalories per cubic meter	0.112335	British thermal units per cubic foot
l/m	Liters per meter	0.0805214	US gallons per foot
l/m^3	Liters per cubic meter	0.042	US gallons per barrel
m^3/m^3	Cubic meters by cubic meter	5.61448	Cubic feet per barrel

CONVERSION TABLE ENGLISH TO METRIC

Symbol	Multiply	by	to obtain
Btu/lb	British thermal units per pound	0.55573	Kilocalories per kilogram
Btu/ft^2	British thermal units per square foot	2.71331	Kilocalories per square meter
Btu/ft^3	British thermal units per cubic foot	8.90195	Kilocalories per cubic meter
gal/ft	US gallons per foot	12.4191	Liters per meter
gal/bbl	US gallons per barrel	23.8095	Liters per cubic meter
ft^3/bbl	Cubic feet per barrel	0.178111	Cubic meters by cubic meter

CONVERSION TABLE POUNDS PER SQUARE INCH (lb/in² or psi) TO KILOPASCALS (kPa)

(6.894745 × psi = kPa)

psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa
100	689	2 600	17 926	5 100	35 163	7 600	52 400	10 100	69 637	12 600	86 874
200	1 379	2 700	18 616	5 200	35 853	7 700	53 090	10 200	70 326	12 700	87 563
300	2 068	2 800	19 305	5 300	36 542	7 800	53 779	10 300	71 016	12 800	88 253
400	2 758	2 900	19 995	5 400	37 232	7 900	54 468	10 400	71 705	12 900	88 942
500	3 447	3 000	**20 684**	5 500	37 921	8 000	55 158	10 500	72 395	13 000	89 632
600	4 137	3 100	21 374	5 600	38 611	8 100	55 847	10 600	73 084	13 100	90 321
700	4 826	3 200	22 063	5 700	39 300	8 200	56 537	10 700	73 774	13 200	91 011
800	5 516	3 300	22 753	5 800	39 990	8 300	57 226	10 800	74 463	13 300	91 700
900	6 205	3 400	23 442	5 900	40 679	8 400	57 916	10 900	75 153	13 400	92 390
1 000	6 895	3 500	24 132	6 000	41 368	8 500	58 605	11 000	75 842	13 500	93 079
1 100	7 584	3 600	24 821	6 100	42 058	8 600	59 295	11 100	76 532	13 600	93 769
1 200	8 274	3 700	25 511	6 200	42 747	8 700	59 984	11 200	77 221	13 700	94 458
1 300	8 963	3 800	26 200	6 300	43 437	8 800	60 674	11 300	77 911	13 800	95 147
1 400	9 653	3 900	26 890	6 400	44 126	8 900	61 363	11 400	78 600	13 900	95 837
1 500	**10 342**	4 000	27 579	6 500	44 816	9 000	62 053	11 500	79 290	14 000	96 526
1 600	11 032	4 100	28 268	6 600	45 505	9 100	62 742	11 600	79 979	14 100	97 216
1 700	11 721	4 200	28 958	6 700	46 195	9 200	63 432	11 700	80 669	14 200	97 905
1 800	12 411	4 300	29 647	6 800	46 884	9 300	64 121	11 800	81 358	14 300	98 595
1 900	13 100	4 400	30 337	6 900	47 574	9 400	64 811	11 900	82 047	14 400	99 284
2 000	13 789	4 500	31 026	7 000	48 263	9 500	65 500	12 000	82 737	14 500	99 974
2 100	14 479	4 600	31 716	7 100	48 953	9 600	66 190	12 100	83 426	14 600	100 663
2 200	15 168	4 700	32 405	7 200	49 642	9 700	66 879	12 200	84 116	14 700	101 353
2 300	15 858	4 800	33 095	7 300	50 332	9 800	67 569	12 300	84 805	14 800	102 042
2 400	16 547	4 900	33 784	7 400	51 021	9 900	68 258	12 400	85 495	14 900	102 732
2 500	17 237	5 000	**34 474**	7 500	51 711	10 000	**68 947**	12 500	86 184	15 000	**103 421**

CONVERSION TABLE
KILOPASCALS (kPa) TO POUNDS PER SQUARE INCH (lb/in² or psi)
(0.145038 × kPa = psi)

kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi
500	73	15 500	2 248	30 500	4 424	45 500	6 599	60 500	8 775	75 500	10 950
1 000	145	16 000	2 321	31 000	4 496	46 000	6 672	61 000	8 847	76 000	11 023
1 500	218	16 500	2 393	31 500	4 569	46 500	6 744	61 500	8 920	76 500	11 095
2 000	290	17 000	2 466	32 000	4 641	47 000	6 817	62 000	8 992	77 000	11 168
2 500	363	17 500	2 538	32 500	4 714	47 500	6 889	62 500	9 065	77 500	11 240
3 000	435	18 000	2 611	33 000	4 786	48 000	6 962	63 000	9 137	78 000	11 313
3 500	508	18 500	2 683	33 500	4 859	48 500	7 034	63 500	9 210	78 500	11 385
4 000	580	19 000	2 756	34 000	4 931	49 000	7 107	64 000	9 282	79 000	11 458
4 500	653	19 500	2 828	34 500	5 004	49 500	7 179	64 500	9 355	79 500	11 531
5 000	725	20 000	2 901	35 000	5 076	50 000	7 252	65 000	9 427	80 000	11 603
5 500	798	20 500	2 973	35 500	5 149	50 500	7 324	65 500	9 500	80 500	11 676
6 000	870	21 000	3 046	36 000	5 221	51 000	7 397	66 000	9 573	81 000	11 748
6 500	943	21 500	3 118	36 500	5 294	51 500	7 469	66 500	9 645	81 500	11 821
7 000	1 015	22 000	3 191	37 000	5 366	52 000	7 542	67 000	9 718	82 000	11 893
7 500	1 088	22 500	3 263	37 500	5 439	52 500	7 614	67 500	9 790	82 500	11 966
8 000	1 160	23 000	3 336	38 000	5 511	53 000	7 687	68 000	9 863	83 000	12 038
8 500	1 233	23 500	3 408	38 500	5 584	53 500	7 760	68 500	9 935	83 500	12 111
9 000	1 305	24 000	3 481	39 000	5 656	54 000	7 832	69 000	10 008	84 000	12 183
9 500	1 378	24 500	3 553	39 500	5 729	54 500	7 905	69 500	10 080	84 500	12 256
10 000	1 450	25 000	3 626	40 000	5 802	55 000	7 977	70 000	10 153	85 000	12 328
10 500	1 523	25 500	3 698	40 500	5 874	55 500	8 050	70 500	10 225	85 500	12 401
11 000	1 595	26 000	3 771	41 000	5 947	56 000	8 122	71 000	10 298	86 000	12 473
11 500	1 668	26 500	3 844	41 500	6 019	56 500	8 195	71 500	10 370	86 500	12 546
12 000	1 740	27 000	3 916	42 000	6 092	57 000	8 267	72 000	10 443	87 000	12 618
12 500	1 813	27 500	3 989	42 500	6 164	57 500	8 340	72 500	10 515	87 500	12 691
13 000	1 885	28 000	4 061	43 000	6 237	58 000	8 412	73 000	10 588	88 000	12 763
13 500	1 958	28 500	4 134	43 500	6 309	58 500	8 485	73 500	10 660	88 500	12 836
14 000	2 031	29 000	4 206	44 000	6 382	59 000	8 557	74 000	10 733	89 000	12 908
14 500	2 103	29 500	4 279	44 500	6 454	59 500	8 630	74 500	10 805	89 500	12 981
15 000	2 176	30 000	4 351	45 000	6 527	60 000	8 702	75 000	10 878	90 000	13 053

CONVERSION TABLE INCHES TO MILLIMETERS
(from 0 to 26 inches)

Inches	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
0	0	1.6	3.2	4.8	6.3	7.9	9.5	11.1	12.7	14.3	15.9	17.5	19.0	20.6	22.2	23.8
1	25.4	27.0	28.6	30.2	31.7	33.3	34.9	36.5	38.1	39.7	41.3	42.9	44.4	46.0	47.6	49.2
2	50.8	52.4	54.0	55.6	57.1	58.7	60.3	61.9	63.5	65.1	66.7	68.3	69.8	71.4	73.0	74.6
3	76.2	77.8	79.4	81.0	82.5	84.1	85.7	87.3	88.9	90.5	92.1	93.7	95.2	96.8	98.4	100.0
4	101.6	103.2	104.8	106.4	107.9	109.5	111.1	112.7	114.3	115.9	117.5	119.1	120.6	122.2	123.8	125.4
5	127.0	128.6	130.2	131.8	133.3	134.9	136.5	138.1	139.7	141.3	142.9	144.5	146.0	147.6	149.2	150.8
6	152.4	154.0	155.6	157.2	158.7	160.3	161.9	163.5	165.1	166.7	168.3	169.9	171.4	173.0	174.6	176.2
7	177.8	179.4	181.0	182.6	184.1	185.7	187.3	188.9	190.5	192.1	193.7	195.3	196.8	198.4	200.0	201.6
8	203.2	204.8	206.4	208.0	209.5	211.1	212.7	214.3	215.9	217.5	219.1	220.7	222.2	223.8	225.4	227.0
9	228.6	230.2	231.8	233.4	234.9	236.5	238.1	239.7	241.3	242.9	244.5	246.1	247.6	249.2	250.8	252.4
10	254.0	255.6	257.2	258.8	260.3	261.9	263.5	265.1	266.7	268.3	269.9	271.5	273.0	274.6	276.2	277.8
11	279.4	281.0	282.6	284.2	285.7	287.3	288.9	290.5	292.1	293.7	295.3	296.9	298.4	300.0	301.6	303.2
12	304.8	306.4	308.0	309.6	311.1	312.7	314.3	315.9	317.5	319.1	320.7	322.3	323.8	325.4	327.0	328.6
13	330.2	331.8	333.4	335.0	336.5	338.1	339.7	341.3	342.9	344.5	346.1	347.7	349.2	350.8	352.4	354.0
14	355.6	357.2	358.8	360.4	361.9	363.5	365.1	366.7	368.3	369.9	371.5	373.1	374.6	376.2	377.8	379.4
15	381.0	382.6	384.2	385.8	387.3	388.9	390.5	392.1	393.7	395.3	396.9	398.5	400.0	401.6	403.2	404.8
16	406.4	408.0	409.6	411.2	412.7	414.3	415.9	417.5	419.1	420.7	422.3	423.9	425.4	427.0	428.6	430.2
17	431.8	433.4	435.0	436.6	438.1	439.7	441.3	442.9	444.5	446.1	447.7	449.3	450.8	452.4	454.0	455.6
18	457.2	458.8	460.4	462.0	463.5	465.1	466.7	468.3	469.9	471.5	473.1	474.7	476.2	477.8	479.4	481.0
19	482.6	484.2	485.8	487.4	488.9	490.5	492.1	493.7	495.3	496.9	498.5	500.1	501.6	503.2	504.8	506.4
20	508.0	509.6	511.2	512.8	514.3	515.9	517.5	519.1	520.7	522.3	523.9	525.5	527.0	528.6	530.2	531.8
21	533.4	535.0	536.6	538.2	539.7	541.3	542.9	544.5	546.1	547.7	549.3	550.9	552.4	554.0	555.6	557.2
22	558.8	560.4	562.0	563.6	565.1	566.7	568.3	569.9	571.5	573.1	574.7	576.3	577.8	579.4	581.0	582.6
23	584.2	585.8	587.4	589.0	590.5	592.1	593.7	595.3	596.9	598.5	600.1	601.7	603.2	604.8	606.4	608.0
24	609.6	611.2	612.8	614.4	615.9	617.5	619.1	620.7	622.3	623.9	625.5	627.1	628.6	630.2	631.8	633.4
25	635.0	636.6	638.2	639.8	641.4	642.9	644.5	646.1	647.7	649.3	650.9	652.5	654.1	655.6	657.2	658.8
26	660.4	662.0	663.6	665.2	666.8	668.3	669.9	671.5	673.1	674.7	676.3	677.9	679.5	681.0	682.6	684.2

CONVERSION TABLE INCHES TO MILLIMETERS
(from 27 to 53 inches)

Inches	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
27	685.8	687.4	689.0	690.6	692.2	693.7	695.3	696.9	698.5	700.1	701.7	703.3	704.9	706.4	708.0	709.6
28	711.2	712.8	714.4	716.0	717.6	719.1	720.7	722.3	723.9	725.5	727.1	726.7	730.3	731.8	733.4	735.0
29	736.6	738.2	739.8	741.4	743.0	744.5	746.1	747.7	749.3	750.9	752.5	754.1	755.7	757.2	758.8	760.4
30	762.0	763.6	765.2	766.8	768.4	769.9	771.5	773.1	774.7	776.3	777.9	779.5	781.1	782.6	784.2	785.8
31	787.4	789.0	790.6	792.2	793.8	795.3	796.9	798.5	800.1	801.7	803.3	804.9	806.5	808.0	809.6	811.2
32	812.8	814.4	816.0	817.6	819.2	820.7	822.3	823.9	825.5	827.1	828.7	830.3	831.9	833.4	835.0	836.6
33	838.2	839.8	841.4	843.0	844.6	846.1	847.7	849.3	850.9	852.5	854.1	855.7	857.3	858.8	860.4	862.0
34	863.6	865.2	866.8	868.4	870.0	871.5	873.1	874.7	876.3	877.9	879.5	881.1	882.7	884.2	885.8	887.4
35	889.0	890.6	892.2	893.3	895.4	896.9	898.5	900.1	901.7	903.3	904.9	906.5	908.1	909.6	911.2	912.8
36	914.4	916.0	917.6	919.2	920.8	922.3	923.9	926.5	927.1	928.7	930.3	931.9	933.5	935.0	936.6	938.2
37	939.8	941.4	943.0	944.6	946.2	947.7	949.3	950.9	952.5	954.1	955.7	957.3	958.9	960.4	962.0	963.6
38	965.2	966.8	968.4	970.0	971.6	973.2	974.7	976.3	977.9	979.5	981.1	982.7	984.3	985.9	987.5	989.0
39	990.6	992.2	993.8	995.4	997.0	998.5	1 000.1	1 001.7	1 003.3	1 004.9	1 006.5	1 008.1	1 009.7	1 011.2	1 012.8	1 014.4
40	1 016.0	1 017.6	1 019.2	1 020.8	1 022.4	1 024.0	1 025.5	1 027.1	1 028.7	1 030.3	1 031.9	1 033.5	1 035.1	1 036.6	1 038.2	1 039.8
41	1 041.4	1 043.0	1 044.6	1 046.2	1 047.8	1 049.3	1 050.9	1 052.5	1 054.1	1 055.7	1 057.3	1 058.9	1 060.4	1 062.0	1 063.6	1 065.2
42	1 066.8	1 068.4	1 070.0	1 071.6	1 073.2	1 074.7	1 076.3	1 077.9	1 079.5	1 081.1	1 082.7	1 084.3	1 085.8	1 087.4	1 089.9	1 090.6
43	1 092.2	1 093.8	1 095.4	1 097.0	1 098.6	1 100.1	1 101.7	1 103.3	1 104.9	1 106.5	1 108.1	1 109.7	1 111.2	1 112.8	1 114.4	1 116.0
44	1 117.6	1 119.2	1 120.8	1 122.4	1 124.0	1 125.5	1 127.1	1 128.7	1 130.3	1 131.9	1 133.5	1 135.1	1 136.6	1 138.2	1 139.8	1 141.4
45	1 143.0	1 144.6	1 146.2	1 147.8	1 149.4	1 150.9	1 152.5	1 154.1	1 155.7	1 157.3	1 158.9	1 160.5	1 162.0	1 163.6	1 165.2	1 166.8
46	1 168.4	1 170.0	1 171.6	1 173.2	1 174.8	1 176.3	1 177.9	1 179.5	1 181.1	1 182.7	1 184.3	1 185.9	1 187.4	1 189.0	1 190.6	1 192.2
47	1 193.8	1 195.4	1 197.0	1 198.6	1 200.2	1 201.7	1 203.3	1 204.9	1 206.5	1 208.1	1 209.7	1 211.3	1 212.8	1 214.4	1 216.0	1 217.6
48	1 219.2	1 220.8	1 222.4	1 224.0	1 225.6	1 227.1	1 228.7	1 230.3	1 231.9	1 233.5	1 235.1	1 236.7	1 238.2	1 239.8	1 241.4	1 243.0
49	1 244.6	1 246.2	1 247.8	1 249.4	1 251.0	1 252.5	1 254.1	1 255.7	1 257.3	1 258.9	1 260.5	1 262.1	1 263.6	1 265.2	1 266.8	1 268.4
50	1 270.0	1 271.6	1 273.2	1 274.8	1 276.4	1 277.9	1 279.5	1 281.1	1 282.7	1 284.3	1 285.9	1 287.5	1 289.0	1 290.6	1 292.2	1 293.8
51	1 295.4	1 297.0	1 298.6	1 300.2	1 301.8	1 303.3	1 304.9	1 306.5	1 308.1	1 309.7	1 311.3	1 312.9	1 314.4	1 316.0	1 317.6	1 319.2
52	1 320.8	1 322.4	1 324.0	1 325.6	1 327.2	1 328.7	1 330.3	1 331.9	1 333.5	1 335.1	1 336.7	1 338.3	1 339.8	1 341.4	1 343.0	1 344.6
53	1 346.2	1 347.8	1 349.4	1 351.0	1 352.6	1 354.1	1 355.7	1 357.3	1 358.9	1 360.5	1 362.1	1 363.7	1 365.2	1 366.8	1 368.4	1 370.0

CONVERSION TABLE FEET TO METERS

(from 1 to 100 feet)

Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
1	0.3048	26	7.9248	51	15.545	76	23.165
2	0.6096	27	8.2296	52	15.850	77	23.470
3	0.9144	28	8.5344	53	16.154	78	23.774
4	1.2192	29	8.8392	54	16.459	79	24.079
5	1.5240	30	9.1440	55	16.764	80	24.384
6	1.8288	31	9.4488	56	17.069	81	24.689
7	2.1336	32	9.7536	57	17.374	82	24.994
8	2.4384	33	10.058	58	17.678	83	25.298
9	2.7432	34	10.363	59	17.983	84	25.603
10	3.0480	35	10.668	60	18.288	85	25.908
11	3.3528	36	10.973	61	18.593	86	26.213
12	3.6576	37	11.278	62	18.898	87	26.518
13	3.9624	38	11.582	63	19.202	88	26.822
14	4.2672	39	11.887	64	19.507	89	27.127
15	4.5720	40	12.192	65	19.812	90	27.432
16	4.8768	41	12.497	66	20.117	91	27.737
17	5.1816	42	12.802	67	20.422	92	28.042
18	5.4864	43	13.106	68	20.726	93	28.346
19	5.7912	44	13.411	69	21.031	94	28.651
20	6.0960	45	13.716	70	21.336	95	28.956
21	6.4008	46	14.021	71	21.641	96	29.261
22	6.7056	47	14.326	72	21.946	97	29.566
23	7.0104	48	14.630	73	22.250	98	29.870
24	7.3152	49	14.935	74	22.555	99	30.175
25	7.6200	50	15.240	75	22.860	100	30.480

CONVERSION TABLE FEET TO METERS
(from 100 to 20 000 feet)

Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
100	30.48	4 100	1 249.68	8 100	2 468.88	12 100	3 688.08	16 100	4 907.28
200	60.96	4 200	1 280.16	8 200	2 499.36	12 200	3 718.56	16 200	4 937.76
300	91.44	4 300	1 310.64	8 300	2 529.84	12 300	3 749.04	16 300	4 968.24
400	121.92	4 400	1 341.12	8 400	2 560.32	12 400	3 779.52	16 400	4 998.72
500	152.40	4 500	1 371.60	8 500	2 590.80	12 500	3 810.00	16 500	5 029.20
600	182.88	4 600	1 402.08	8 600	2 621.28	12 600	3 840.48	16 600	5 059.68
700	213.36	4 700	1 432.56	8 700	2 651,70	12 700	3 870.96	16 700	5 090.16
800	243.84	4 800	1 463.04	8 800	2 682.24	12 800	3 901.44	16 800	5 120.64
900	274.32	4 900	1 493.52	8 900	2 712.72	12 900	3 931.92	16 900	5 151.12
1 000	304.80	5 000	1 524.00	9 000	2 743.20	13 000	3 962.40	17 000	5 181.60
1 100	335.28	5 100	1 554.48	9 100	2 773.68	13 100	3 992.88	17 100	5 212.08
1 200	365.76	5 200	1 584.96	9 200	2 804.16	13 200	4 023.36	17 200	5 242.56
1 300	396.24	5 300	1 615.44	9 300	2 834.64	13 300	4 053.84	17 300	5 273.04
1 400	426.72	5 400	1 645.92	9 400	2 865.12	13 400	4 084.32	17 400	5 303.52
1 500	457.20	5 500	1 676.40	9 500	2 895.60	13 500	4 114.80	17 500	5 335.00
1 600	487.68	5 600	1 706.88	9 600	2 926.08	13 600	4 145.28	17 600	5 364.48
1 700	518.16	5 700	1 737.36	9 700	2 956.56	13 700	4 175.76	17 700	5 394.96
1 800	548.64	5 800	1 767.84	9 800	2 987.04	13 800	4 206.24	17 800	5 425.44
1 900	579.12	5 900	1 798.32	9 900	3 017.52	13 900	4 236.72	17 900	5 455.92
2 000	609.60	6 000	1 828.80	10 000	3 048.00	14 000	4 267.20	18 000	5 486.40
2 100	640.08	6 100	1 859.28	10 100	3 078.48	14 100	4 297.68	16 100	5 516.66
2 200	670.56	6 200	1 889.76	10 200	3 108.96	14 200	4 328.16	18 200	5 547.36
2 300	701.04	6 300	1 920.24	10 300	3 139.44	14 300	4 358.64	18 300	5 577.84
2 400	731.52	6 400	1 950.72	10 400	3 169.92	14 400	4 389.12	18 400	5 608.32
2 500	762.00	6 500	1 961.20	10 500	3 200.40	14 500	4 419.60	18 500	5 638.80
2 600	792.48	6 600	2 011.68	10 600	3 230.88	14 600	4 450.08	18 600	5 669.28
2 700	822.96	6 700	2 042.16	10 700	3 261.36	14 700	4 480.56	18 700	5 699.76
2 800	853.44	6 800	2 072.64	10 800	3 291.84	14 800	4 511.04	18 800	5 730.24
2 900	863.92	6 900	2 103.12	10 900	3 322.32	14 900	4 541.52	18 900	5 760.72
3 000	914.40	7 000	2 133.60	11 000	3 352.80	15 000	4 572.00	19 000	5 791.20
3 100	944.88	7 100	2 164.08	11 100	3 383.28	15 100	4 602.48	19 100	5 821.68
3 200	975.36	7 200	2 194.56	11 200	3 413.76	15 200	4 632.96	19 200	5 852.16
3 300	1 005.84	7 300	2 225.04	11 300	3 444.24	15 300	4 663.44	19 300	5 882.64
3 400	1 036.32	7 400	2 255.52	11 400	3 474.72	15 400	4 693.92	19 400	5 913.12
3 500	1 066.80	7 500	2 286.00	11 500	3 505.20	15 500	4 724.40	19 500	5 943.60
3 600	1 097.28	7 600	2 316.48	11 600	3 535.68	15 600	4 754.88	19 600	5 974.08
3 700	1 127.76	7 700	2 346.96	11 700	3 566.16	15 700	4 785.36	19 700	6 004.56
3 800	1 158.24	7 800	2 377.44	11 800	3 596.64	15 800	4 815.84	19 800	6 035.04
3 900	1 188.72	7 900	2 407.92	11 900	3 627.12	15 900	4 846.32	19 900	6 065.52
4 000	1 219.20	8 000	2 438.40	12 000	3 657.60	16 000	4 876.80	20 000	6 096.00

FLOW RATE CONVERSION TABLE

l/min to US gal/min					
l/min	US gal/min	l/min	US gal/min	l/min	US gal/min
100	26.4	**1 750**	462	**3 400**	898
150	39.6	**1 800**	476	**3 450**	911
200	52.8	**1 850**	489	**3 500**	925
250	66.0	**1 900**	502	**3 550**	938
300	79.3	**1 950**	515	**3 600**	951
350	92.5	**2 000**	528	**3 650**	964
400	105.7	**2 050**	542	**3 700**	977
450	118.9	**2 100**	555	**3 750**	991
500	132.1	**2 150**	568	**3 800**	1 004
550	145.3	**2 200**	581	**3 850**	1 017
600	158.5	**2 250**	594	**3 900**	1 030
650	171.7	**2 300**	608	**3 950**	1 044
700	184.9	**2 350**	621	**4 000**	1 057
750	198.1	**2 400**	634	**4 050**	1 070
800	211.3	**2 450**	647	**4 100**	1 083
850	224.6	**2 500**	660	**4 150**	1 096
900	237.8	**2 550**	674	**4 200**	1 110
950	251.0	**2 600**	687	**4 250**	1 123
1 000	264.2	**2 650**	700	**4 300**	1 136
1 050	277.4	**2 700**	713	**4 350**	1 149
1 100	290.6	**2 750**	726	**4 400**	1 162
1 150	303.8	**2 800**	740	**4 450**	1 176
1 200	317.0	**2 850**	753	**4 500**	1 189
1 250	330.2	**2 900**	766	**4 550**	1 202
1 300	343.4	**2 950**	779	**4 600**	1 215
1 350	356.6	**3 000**	793	**4 650**	1 228
1 400	369.8	**3 050**	806	**4 700**	1 242
1 450	383.1	**3 100**	819	**4 750**	1 255
1 500	396.3	**3 150**	832	**4 800**	1 268
1 550	409.5	**3 200**	845	**4 850**	1 281
1 600	422.7	**3 250**	859	**4 900**	1 294
1 650	435.9	**3 300**	872	**4 950**	1 308
1 700	449.1	**3 350**	885	**5 000**	1 321

US gal/min to l/min							
US gal/min	l/min	US gal/min	l/min	US gal/min	l/min	US gal/min	l/min
40	151	**370**	1 401	**700**	2 650	**1 030**	3 899
50	189	**380**	1 438	**710**	2 688	**1 040**	3 937
60	227	**390**	1 476	**720**	2 725	**1 050**	3 975
70	265	**400**	1 514	**730**	2 763	**1 060**	4 012
80	303	**410**	1 552	**740**	2 801	**1 070**	4 050
90	341	**420**	1 590	**750**	2 839	**1 080**	4 088
100	379	**430**	1 628	**760**	2 877	**1 090**	4 126
110	416	**440**	1 666	**770**	2 915	**1 100**	4 164
120	454	**450**	1 703	**780**	2 953	**1 110**	4 202
130	492	**460**	1 741	**790**	2 990	**1 120**	4 240
140	530	**470**	1 779	**800**	3 028	**1 130**	4 277
150	568	**480**	1 817	**810**	3 066	**1 140**	4 315
160	606	**490**	1 855	**820**	3 104	**1 150**	4 353
170	644	**500**	1 893	**830**	3 142	**1 160**	4 391
180	681	**510**	1 931	**840**	3 180	**1 170**	4 429
190	719	**520**	1 968	**850**	3 218	**1 180**	4 467
200	757	**530**	2 006	**860**	3 255	**1 190**	4 505
210	795	**540**	2 044	**870**	3 293	**1 200**	4 542
220	833	**550**	2 082	**880**	3 331	**1 210**	4 580
230	871	**560**	2 120	**890**	3 369	**1 220**	4 618
240	908	**570**	2 158	**900**	3 407	**1 230**	4 656
250	946	**580**	2 195	**910**	3 445	**1 240**	4 694
260	984	**590**	2 233	**920**	3 483	**1 250**	4 732
270	1 022	**600**	2 271	**930**	3 520	**1 260**	4 770
280	1 060	**610**	2 309	**940**	3 558	**1 270**	4 807
290	1 098	**620**	2 347	**950**	3 596	**1 280**	4 845
300	1 136	**630**	2 385	**960**	3 634	**1 290**	4 883
310	1 173	**640**	2 423	**970**	3 672	**1 300**	4 921
320	1 211	**650**	2 460	**980**	3 710	**1 310**	4 959
330	1 249	**660**	2 498	**990**	3 747	**1 320**	4 997
340	1 287	**670**	2 536	**1 000**	3 785	**1 330**	5 034
350	1 325	**680**	2 574	**1 010**	3 823	**1 340**	5 072
360	1 363	**690**	2 612	**1 020**	3 861	**1 350**	5 110

CONVERSION TABLE BARRELS (US OIL) TO CUBIC METERS

	0	1	2	3	4	5	6	7	8	9
0		0.159	0.318	0.477	0.636	0.795	0.954	1.113	1.272	1.431
10	1.590	1.749	1.908	2.067	2.226	2.385	2.544	2.703	2.862	3.021
20	3.180	3.339	3.498	3.657	3.816	3.975	4.134	4.293	4.452	4.611
30	4.770	4.929	5.088	5.247	5.406	5.565	5.724	5.883	6.042	6.201
40	6.360	6.519	6.678	6.837	6.996	7.155	7.314	7.473	7.632	7.791
50	7.950	8.109	8.268	8.427	8.586	8.745	8.904	9.063	9.222	9.381
60	9.540	9.699	9.858	10.017	10.176	10.335	10.494	10.653	10.812	10.971
70	11.130	11.289	11.448	11.607	11.766	11.925	12.084	12.243	12.402	12.561
80	12.720	12.879	13.038	13.197	13.356	13.515	13.674	13.833	13.992	14.151
90	14.310	14.469	14.628	14.787	14.946	15.105	15.264	15.423	15.582	15.741
100	15.900	16.059	16.218	16.377	16.536	16.695	16.854	17.013	17.172	17.331
110	17.490	17.649	17.808	17.967	18.126	18.285	18.444	18.603	18.762	18.921
120	19.080	19.239	19.398	19.557	19.716	19.875	20.034	20.193	20.352	20.511
130	20.670	20.829	20.988	21.147	21.306	21.465	21.624	21.783	21.842	22.101
140	22.260	22.419	22.578	22.737	22.896	23.055	23.214	23.373	23.532	23.691
150	23.850	24.009	24.168	24.327	24.486	24.645	24.804	24.963	25.122	25.281
160	25.440	25.599	25.758	25.917	26.076	26.235	26.394	26.553	26.712	26.871
170	27.030	27.169	27.346	27.507	27.666	27.825	27.984	28.143	28.302	28.461
180	28.620	28.779	28.938	29.097	29.256	29.415	29.574	29.733	29.892	30.051
190	30.210	30.369	30.528	30.687	30.846	31.005	31.164	31.323	31.482	31.641

CONVERSION TABLE BARRELS (US OIL) TO US GALLONS

	0	1	2	3	4	5	6	7	8	9
0		42	84	126	168	210	252	294	336	378
10	420	462	504	546	588	630	672	714	756	798
20	840	882	924	966	1 008	1 050	1 092	1 134	1 176	1 218
30	1 260	1 302	1 344	1 386	1 428	1 470	1 512	1 554	1 596	1 638
40	1 680	1 722	1 764	1 806	1 848	1 890	1 932	1 974	2 016	2 058
50	2 100	2 142	2 184	2 226	2 268	2 310	2 352	2 394	2 436	2 478
60	2 520	2 562	2 604	2 646	2 688	2 730	2 772	2 814	2 856	2 898
70	2 940	2 982	3 024	3 066	3 108	3 150	3 192	3 234	3 276	3 318
80	3 360	3 402	3 444	3 486	3 528	3 570	3 612	3 654	3 696	3 738
90	3 780	3 822	3 864	3 906	3 948	3 990	4 032	4 074	4 116	4 158
100	4 200	4 242	4 284	4 326	4 368	4 410	4 452	4 494	4 536	4 578
110	4 620	4 662	4 704	4 746	4 788	4 830	4 872	4 914	4 956	4 998
120	5 040	5 082	5 124	5 166	5 208	5 250	5 292	5 334	5 376	5 418
130	5 460	5 502	5 544	5 586	5 628	5 670	5 712	5 754	5 796	5 838
140	5 880	5 922	5 964	6 006	6 048	6 090	6 132	6 174	6 216	6 258
150	6 300	6 342	6 384	6 426	6 468	6 510	6 552	6 594	6 636	6 678
160	6 720	6 762	6 804	6 846	6 888	6 930	6 972	7 014	7 056	7 098
170	7 140	7 182	7 224	7 266	7 308	7 350	7 392	7 434	7 476	7 518
180	7 560	7 602	7 644	7 686	7 728	7 770	7 812	7 854	7 896	7 938
190	7 980	8 022	8 064	8 106	4 148	8 190	8 232	8 274	8 316	8 358

TEMPERATURE CONVERSION TABLE

$$\left(t\ ^\circ F = \frac{9}{5}\ t\ ^\circ C + 32 \qquad t\ ^\circ C = \frac{5}{9}\ (t\ ^\circ F - 32) \right)$$

EXAMPLE: The central figures refer to the temperatures either in degrees Celsius or degrees Fahrenheit which require conversion. The corresponding temperatures in degrees Fahrenheit or degrees Celsius will be found to the right or left respectively.

C		F
6.67	44	111.2

44° Fahrenheit → 6,67° Celsius

44° Celsius → 111.2° Fahrenheit

°C		°F	°C		°F	°C		°F	°C		°F	°C		°F
− 56.7	**− 70**	− 94.0	− 11.1	**12**	53.6	11.1	**52**	125.6	33.3	**92**	197.6	216	**420**	788
− 53.9	**− 65**	− 85.0	− 10.0	**14**	57.2	12.2	**54**	129.2	34.4	**94**	201.2	227	**440**	824
− 51.2	**− 60**	− 76.0	− 8.89	**16**	60.8	13.3	**56**	132.8	35.6	**96**	204.8	238	**460**	860
− 48.4	**− 55**	− 67.0	− 7.78	**18**	64.4	14.4	**58**	136.4	36.7	**98**	208.4	249	**480**	896
− 45.6	**− 50**	− 58.0	− 6.67	**20**	68.0	15.6	**60**	140.0	37.8	**100**	212.0	260	**500**	932
− 42.8	**− 45**	− 49.0	− 5.55	**22**	71.6	16.7	**62**	143.6	48.9	**120**	248	271	**520**	968
− 40.0	**− 40**	− 40.0	− 4.44	**24**	75.2	17.8	**64**	147.2	60.0	**140**	284	282	**540**	1 004
− 37.2	**− 35**	− 31.0	− 3.33	**26**	78.8	18.9	**66**	150.8	71.1	**160**	320	293	**560**	1 040
− 34.4	**− 30**	− 22.0	− 2.22	**28**	82.4	20.0	**68**	154.4	82.2	**180**	356	304	**580**	1 076
− 31.7	**− 25**	− 13.0	− 1.11	**30**	86.0	21.1	**70**	158.0	93.3	**200**	392	316	**600**	1 112
− 28.9	**− 20**	− 4.0	0	**32**	89.6	22.2	**72**	161.6	104.4	**220**	428	327	**620**	1 148
− 26.1	**− 15**	5.0	1.11	**34**	93.2	23.3	**74**	165.2	115.6	**240**	464	338	**640**	1 184
− 23.3	**− 10**	14.0	2.22	**36**	96.8	24.4	**76**	168.8	126.7	**260**	500	349	**660**	1 220
− 20.6	**− 5**	23.0	3.33	**38**	100.4	25.6	**78**	172.4	137.6	**280**	536	360	**680**	1 256
− 17.8	**0**	32.0	4.44	**40**	104.0	26.7	**80**	176.0	148.9	**300**	572	371	**700**	1 292
− 16.7	**2**	35.6	5.55	**42**	107.6	27.8	**82**	179.6	160	**320**	608	382	**720**	1 328
− 15.6	**4**	39.2	6.67	**44**	111.2	28.9	**84**	183.2	171	**340**	644	393	**740**	1 364
− 14.4	**6**	42.8	7.78	**46**	114.8	30.0	**88**	186.8	182	**360**	680	404	**760**	1 400
− 13.3	**8**	46.4	8.89	**48**	118.4	31.1	**88**	190.4	193	**380**	716	416	**780**	1 436
− 12.2	**10**	50.0	10.0	**50**	122.0	32.2	**90**	194.0	204	**400**	752	427	**800**	1 472

INTERPOLATION TABLE

°C	0.56	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5	5.56	6.11	6.67	7.22	7.78	8.33	8.89	9.44	10	10.56	11.11
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
°F	1.8	3.6	5.4	7.2	9	10.8	12.6	14.4	16.2	18	19.8	21.6	23.4	25.2	27	28.8	30.6	32.4	34.2	36

CORRESPONDENCE BETWEEN SPECIFIC GRAVITY AND DEGREES API
(at 15.56 °C in relation to water at 15.56 °C and 760 mmHg)

Specific gravity	Degrees API	Specific gravity	Degrees API	Specific gravity	Degrees API	Specific gravity	Degrees API	Specific gravity	Degrees API	Specific gravity	Degrees API	Specific gravity	Degrees API	Specific gravity	Degrees API	Specific gravity	Degrees API
0.600	104.3	0.650	86.2	0.700	70.6	0.750	57.2	0.800	45.4	0.850	35.0	0.900	25.7	0.950	17.5	1.000	10.0
0.602	103.5	0.652	85.5	0.702	70.1	0.752	56.7	0.802	44.9	0.852	34.6	0.902	25.4	0.952	17.1	1.002	9.7
0.604	102.8	0.654	84.9	0.704	69.5	0.754	56.2	0.804	44.5	0.854	34.2	0.904	25.0	0.954	16.8	1.004	9.4
0.606	102.0	0.656	84.2	0.706	68.9	0.756	55.7	0.806	44.1	0.856	33.8	0.906	24.7	0.956	16.5	1.006	9.2
0.608	101.2	0.658	83.6	0.708	68.4	0.758	55.2	0.808	43.6	0.858	33.4	0.908	24.3	0.958	16.2	1.008	8.9
0.610	100.5	0.660	82.9	0.710	67.8	0.760	54.7	0.810	43.2	0.860	33.0	0.910	24.0	0.960	15.9	1.010	8.6
0.612	99.7	0.662	82.2	0.712	67.2	0.762	54.2	0.812	42.8	0.862	32.7	0.912	23.7	0.962	15.6	1.012	8.3
0.614	99.0	0.664	81.6	0.714	66.7	0.764	53.7	0.814	42.3	0.864	32.3	0.914	23.3	0.964	15.3	1.014	8.1
0.616	98.2	0.666	81.0	0.716	66.1	0.766	53.2	0.816	41.9	0.866	31.9	0.916	23.0	0.966	15.0	1.016	7.8
0.618	97.5	0.668	80.3	0.718	65.6	0.768	52.7	0.818	41.5	0.868	31.5	0.918	22.6	0.968	14.7	1.018	7.5
0.620	96.7	0.670	79.7	0.720	65.0	0.770	52.3	0.820	41.1	0.870	31.1	0.920	22.3	0.970	14.4	1.020	7.2
0.622	96.0	0.672	79.1	0.722	64.5	0.772	51.8	0.822	40.6	0.872	30.8	0.922	22.0	0.972	14.1	1.022	7.0
0.624	95.3	0.674	78.4	0.724	63.9	0.774	51.3	0.824	40.2	0.874	30.4	0.924	21.6	0.974	13.8	1.024	6.7
0.626	94.5	0.676	77.8	0.726	63.4	0.776	50.9	0.826	39.8	0.876	30.0	0.926	21.3	0.976	13.5	1.026	6.4
0.628	93.8	0.678	77.2	0.728	62.9	0.778	50.4	0.828	39.4	0.878	29.7	0.928	21.0	0.978	13.2	1.028	6.2
0.630	93.1	0.680	76.6	0.730	62.3	0.780	49.9	0.830	39.0	0.880	29.3	0.930	20.7	0.980	12.9	1.030	5.9
0.632	92.4	0.682	76.0	0.732	61.8	0.782	49.5	0.832	38.6	0.882	28.9	0.932	20.3	0.982	12.6	1.032	5.6
0.634	91.7	0.684	75.4	0.734	61.3	0.784	49.0	0.834	38.2	0.884	28.6	0.934	20.0	0.984	12.3	1.034	5.4
0.636	91.0	0.686	74.8	0.736	60.8	0.786	48.5	0.836	37.8	0.886	28.2	0.936	19.7	0.986	12.0	1.036	5.1
0.638	90.3	0.688	74.2	0.738	60.2	0.788	48.1	0.838	37.4	0.888	27.9	0.938	19.4	0.988	11.7	1.038	4.8
0.640	89.6	0.690	73.6	0.740	59.7	0.790	47.6	0.840	37.0	0.890	27.5	0.940	19.0	0.990	11.4	1.040	4.6
0.642	88.9	0.692	73.0	0.742	59.2	0.792	47.2	0.842	36.6	0.892	27.1	0.942	18.7	0.992	11.1	1.042	4.3
0.644	88.2	0.694	72.4	0.744	58.7	0.794	46.7	0.844	36.2	0.894	26.8	0.944	18.4	0.994	10.9	1.044	4.0
0.646	87.5	0.696	71.8	0.746	58.2	0.796	46.3	0.846	35.8	0.896	26.4	0.946	18.1	0.996	10.6	1.046	3.8
0.648	86.9	0.698	71.2	0.748	57.7	0.798	45.8	0.848	35.4	0.898	26.0	0.948	17.8	0.998	10.3	1.048	3.5

$$\text{Degrees API} = \frac{141.5}{d(15.56\ ^\circ\text{C}/15.56\ ^\circ\text{C})} - 131.5$$

$$d(15.56\ ^\circ\text{C}/15.56\ ^\circ\text{C}) = \underset{(60\ ^\circ\text{F}/60\ ^\circ\text{F})}{\text{Specific gravity}}$$

Specific gravity	Correction for 1 °C
0.600 to 0.700	0.0009
0.700 to 0.800	0.0008
0.800 to 0.840	0.00075
0.840 to 0.880	0.0007
0.880 to 0.920	0.00065
0.920 to 1.000	0.0006

Approximate temperature correction to obtain temperatures at 15 °C

— add if t > 15 °C
— subtract if t < 15 °C

NUMERICAL CONSTANTS AND MATHEMATICAL FORMULAS

π	3.1415927	$\frac{1}{\pi}$	0.3183099	$\frac{\pi}{2}$	1.5707963	$\frac{\pi}{180}$	0.0174533
π^2	9.8696044	$\frac{1}{\pi^2}$	0.1013212	$\frac{\pi}{3}$	1.0471976	$\frac{\pi}{200}$	0.0157080
π^3	31.0062767	$\frac{1}{\pi^3}$	0.0322515	$\frac{\pi}{4}$	0.7853982	$\frac{180}{\pi}$	57.2957795
$\sqrt{\pi}$	1.7724539	$\frac{1}{\sqrt{\pi}}$	0.5641896	$\frac{4\pi}{3}$	4.1887902	$\frac{200}{\pi}$	63.6619763
$\sqrt[3]{\pi}$	1.4645919	$\frac{1}{\sqrt[3]{\pi}}$	0.6827840				
$\sqrt{2}$	1.414214	$\sqrt{3}$	1.732051	$\sqrt{5}$	2.236068	$\sqrt{10}$	3.162278
$\frac{1}{\sqrt{2}}$	0.70711	$\frac{1}{\sqrt{3}}$	0.57735	$\frac{1}{\sqrt{5}}$	0.44721	$\frac{1}{\sqrt{10}}$	0.31623
e	2.7182818	$\frac{1}{e}$	0.3678794	$\log_{10} e = 0.4342945$		$g = 9{,}80665\ m/s^2$	
$\frac{1}{\log_{10} e} = \text{colog } e = \log_e 10 = 2.3025851$				$\log_e x = 2.3025851 \log_{10} x$		$\log_{10} x = 0.4342945 \log_e x$	

Arithmetic progression

$a \quad a + r \quad a + 2r \quad a + 3r \ldots \quad a + (n - 1)r$

$$S_n = \left(\frac{a + \ell}{2}\right)n = \frac{n}{2}\,[2a + (n - 1)r]$$

a = first term
r = common difference
n = number of terms
ℓ = last term = $a + (n - 1)r$

Geometric progression

$a \quad aq \quad aq^2 \quad aq^3 \ldots aq^{n-1}$

$$\text{Si } q \neq 1 \quad S_n = \frac{\ell q - a}{q - 1} = a\,\frac{(q^n - 1)}{q - 1}$$

a = first term
q = common ratio
n = number of terms
ℓ = last term = aq^{n-1}

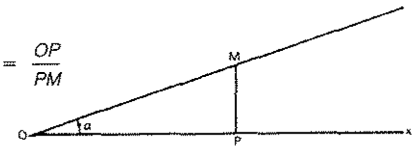
TRIGONOMETRIC FORMULAS

DEFINITION

$$\cos\alpha = \frac{OP}{OM}$$

$$\sin\alpha = \frac{PM}{OM} \quad \text{cotan}\ \alpha = \frac{1}{\tan\alpha} = \frac{OP}{PM}$$

$$\tan\alpha = \frac{PM}{OP}$$



GEOMETRIC INTERPRETATION

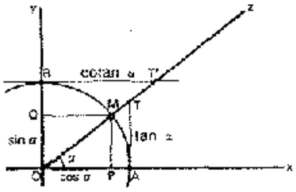
$\overline{OA} = \overline{OM} = R = 1$

$\overline{OQ} = \sin\alpha$

$\overline{OP} = \cos\alpha$

$\overline{AT} = \tan\alpha$

$\overline{BT'} = \text{cotan}\ \alpha$



TRIGONOMETRIC RELATIONS

$$\cos^2\alpha + \sin^2\alpha = 1$$

$$\tan\alpha = \frac{\sin\alpha}{\cos\alpha}$$

$$\text{cotan}\ \alpha = \frac{\cos\alpha}{\sin\alpha} = \frac{1}{\tan\alpha}$$

$$\sin 2\alpha = 2\sin\alpha\cos\alpha$$

$$\cos 2\alpha = \cos^2\alpha - \sin^2\alpha$$

$$= 1 - 2\sin^2\alpha$$

$$\tan 2\alpha = \frac{2\tan\alpha}{1 - \tan^2\alpha}$$

$$\sin(\alpha + \beta) = \sin\alpha\ \cos\beta + \cos\alpha\ \sin\beta$$

$$\cos(\alpha + \beta) = \cos\alpha\ \cos\beta - \sin\alpha\ \sin\beta$$

$$\sin(\alpha - \beta) = \sin\alpha\ \cos\beta - \cos\alpha\ \sin\beta$$

$$\cos(\alpha - \beta) = \cos\alpha\ \cos\beta + \sin\alpha\ \sin\beta$$

$$\tan(\alpha + \beta) = \frac{\tan\alpha + \tan\beta}{1 - \tan\alpha\ \tan\beta}$$

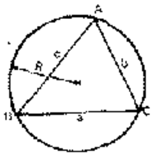
$$\tan(\alpha - \beta) = \frac{\tan\alpha - \tan\beta}{1 + \tan\alpha\ \tan\beta}$$

VALUES OF TRIGONOMETRIC FUNCTIONS RELATED TO HALF-ANGLE TANGENTS

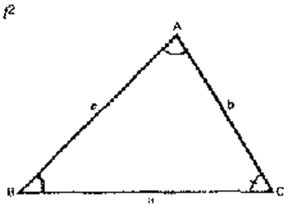
$$\tan\frac{\alpha}{2} = t \qquad \cos\alpha = \frac{1 - t^2}{1 + t^2} \qquad \tan\alpha = \frac{2t}{1 - t^2}$$

$$\sin\alpha = \frac{2t}{1 + t^2}$$

RELATIONS BETWEEN SIDES AND ANGLE OF ANY TRIANGLE



$$\hat{A} + \hat{B} + \hat{C} = \pi$$



$$\frac{e}{\sin\hat{A}} = \frac{b}{\sin\hat{B}} = \frac{c}{\sin\hat{C}} = 2R$$

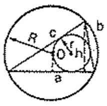
$$a^2 = b^2 + c^2 - 2bc\ \cos\hat{A}$$

$$b^2 = c^2 + a^2 - 2ca\ \cos\hat{B}$$

$$c^2 = a^2 + b^2 - 2ab.\ \cos\hat{C}$$

GEOMETRY
FORMULAS FOR AREAS AND VOLUMES

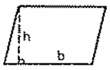
AREA



Triangle

$$p = \frac{a + b + c}{2}$$

$$S = \frac{ah}{2} = \frac{abc}{4R} = pr$$

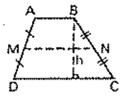


Parallelogram

$$S = b\,h$$

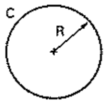
Square : $S = a^2$

Rectangle : $S = ab$



Trapezoid

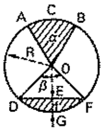
$$S = \frac{AB + CD}{2} h = MN \,.\, h$$



Circle

$$C = 2\,\pi\,R = \pi\,D$$

$$S = \pi\,R^2 = \frac{\pi\,D^2}{4} = \frac{C^2}{4\,\pi}$$



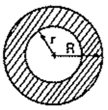
Sector of a circle

$$S = \frac{\text{arc ACB} \,.\, R}{2} = \frac{\pi\,R^2\,\alpha}{360}$$

(α is the number of degrees of arc ACB)

Segment of a circle

$$S = \frac{\pi\,R^2\,\beta}{360} - \frac{DF}{2}(R - f)$$

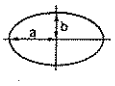


Annulus

$$S = \frac{\pi}{4}(D^2 - d^2) = \pi\,(R^2 - r^2)$$

$$= \frac{\pi}{4}(D + d)\,(D - d)$$

$$= \pi\,(R + r)\,(R - r)$$

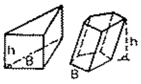


Ellipse

a = semimajor axis
b = semiminor axis

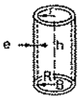
$$S = \pi\,ab$$

VOLUME



Regular or oblique prism

$$V = B\,h$$

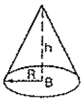


Right cylinder

$$V = \pi\,R^2\,h = Bh$$

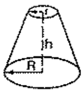
Hollow cylinder

$$V = \pi\,(R^2 - r^2)\,h = \pi\,(R + r)\,eh$$



Right cone

$$V = \frac{\pi\,R^2\,h}{3}$$

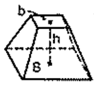


Truncated right cone

$$V = \frac{\pi\,h}{3}(R^2 + r^2 + Rr)$$

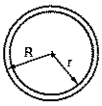
Pyramid

$$V = \frac{1}{3}Bh$$



Truncated pyramid with parallel bases

$$V = \frac{1}{3}h\,(B + b + \sqrt{Bb})$$



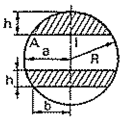
Sphere $S = 4\,\pi\,R^2 = \pi\,D^2$

$$V = \frac{4}{3}\pi\,R^3 = 4{,}189\,R^3$$

Hollow sphere

$$V = \frac{4}{3}\pi\,(R^3 - r^3)$$

Spherical segment with one base



$$1^\circ)\ V = \frac{1}{6}\pi\,h\,(h^2 + 3\,\overline{AI}^2)$$

$$2^\circ)\ V = \frac{1}{3}\pi\,h^2\,(3R - h)$$

Spherical segment with two bases

$$V = \frac{1}{6}\pi\,h\,(3a^2 + 3b^2 + h^2)$$

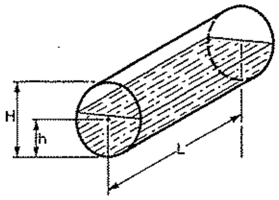
CONTENT OF HORIZONTAL CYLINDRICAL TANKS

Tank characteristics : Volume : V ; Height : H
Concordance table of fraction of H and fraction of V

Fraction of H	Fraction of V	Fraction of H	Fraction of V	Fraction of H	Fraction of V
0.01	0.0017	0.34	0.2998	0.67	0.7122
0.02	0.0047	0.35	0.3119	0.68	0.7241
0.03	0.0087	0.36	0.3241	0.69	0.7360
0.04	0.0134	0.37	0.3364	0.70	0.7477
0.05	0.0187	0.38	0.3487	0.71	0.7593
0.06	0.0245	0.39	0.3611	0.72	0.7708
0.07	0.0308	0.40	0.3736	0.73	0.7821
0.08	0.0375	0.41	0.3860	0.74	0.7934
0.09	0.0446	0.42	0.3986	0.75	0.8045
0.10	0.0520	0.43	0.4111	0.76	0.8155
0.11	0.0599	0.44	0.4237	0.77	0.8263
0.12	0.0680	0.45	0.4364	0.78	0.8369
0.13	0.0764	0.46	0.4490	0.79	0.8474
0.14	0.0851	0.47	0.4617	0.80	0.8576
0.15	0.0941	0.48	0.4745	0.81	0.8677
0.16	0.1033	0.49	0.4872	0.82	0.8776
0.17	0.1127	0.50	0.5000	0.83	0.8873
0.18	0.1223	0.51	0.5128	0.84	0.8967
0.19	0.1323	0.52	0.5255	0.85	0.9059
0.20	0.1424	0.53	0.5383	0.86	0.9149
0.21	0.1526	0.54	0.5510	0.87	0.9236
0.22	0.1631	0.55	0.5636	0.88	0.9320
0.23	0.1737	0.56	0.5763	0.89	0.9401
0.24	0.1845	0.57	0.5889	0.90	0.9480
0.25	0.1955	0.58	0.6014	0.91	0.9554
0.26	0.2066	0.59	0.6140	0.92	0.9625
0.27	0.2179	0.60	0.6264	0.93	0.9692
0.28	0.2292	0.61	0.6389	0.94	0.9755
0.29	0.2407	0.62	0.6513	0.95	0.9813
0.30	0.2523	0.63	0.6636	0.96	0.9866
0.31	0.2640	0.64	0.6759	0.97	0.9913
0.32	0.2759	0.65	0.6881	0.98	0.9952
0.33	0.2878	0.66	0.7002	0.99	0.9983

Example : Consider a tank of volume $V = 12\,000$ l and height $H = 2$ m. Measurements show a liquid height of 0.20 m in the tank. How much liquid does the tank contain ?

Answer : Fraction of height 0.20/2 = 0.10 corresponding in the table to a volume fraction of 0.0520. The content is thus : 0.0520 × 12 000 = 624 liters.



V = total volume :

$$V = \frac{\pi\ H^2}{4}\ L$$

$$\text{Fraction of } H = \frac{h}{H}$$

h = liquid height

MECHANICS AND STRENGTH OF MATERIALS

MOMENT OF A FORCE ABOUT A POINT. MOMENT OF A TORQUE

$M_0^t\vec{F} = Fd$

$M_0^tC = Fd$

(M_0^t en newtons-mètres, F en newtons et d en mètres)

UNIFORM STRAIGHT LINE MOTION

$l = l_0 + vt$

l = distance travelled (m)
l_0 = initial distance (m)
v = velocity (m/s)
t = time (s)

UNIFORMLY-ACCELERATED MOTION

$$l = l_0 + v_0t + \frac{\gamma t^2}{2}$$

l = distance travelled (m)
l_0 = initial distance (m)
v_0 = initial velocity (m/s)
t = time (s)
γ = acceleration (m/s^2)

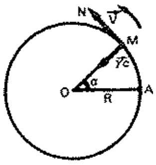
UNIFORM CIRCULAR MOTION

Angular velocity $\omega = \frac{\alpha}{t}$ α: angle of rotation during time t

or $\alpha = \omega t$

Angular velocity as a function of revolutions per minute

$$\omega = \frac{2\pi N}{60}$$



(ω in radians per second and N in revolutions per minute).

Circumferential velocity: $v(\text{m/min}) = 2\pi RN$

or $v(\text{m/s}) = \omega R = \frac{2\pi RN}{60}$

(ω in radians per second, R in meters and N in revolutions per minute)

Centripetal acceleration γ_c

$$\gamma_c = \omega^2 R \qquad \text{or} \qquad \gamma_c = \frac{V^2}{R}$$

(γ_c in meters per second per seconde, ω in radians per second, R in meters and V in meters per second)

FUNDAMENTAL FORMULA OF DYNAMICS

$F = m\gamma$ m = mass, γ = acceleration

(F in newtons, m in kilograms and γ in meters per second per second)

Specific case of gravity $P = m\vec{g}$

$\vec{g}$ = gravitational acceleration
$\vec{g}$ = about 9.81 m/s^2

MECHANICS AND STRENGTH OF MATERIALS
(continued)

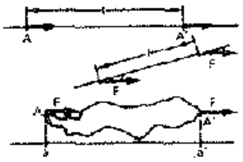
CENTRIFUGAL FORCE

$$f_c = m\omega^2 R \qquad \text{or} \qquad f_c = m\frac{V^2}{R}$$

(f_c in newtons, m in kilograms, ω in radians per second, R in meters and v in meters per second)

WORK OF A FORCE

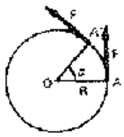
Constant force in quantity and direction displacing its point of application



1°) on its action line $T = Fl$
2°) on an oblique line to its action line $T = Fl\cos\alpha$
3°) on a curve in its plane $T = Faa'$

(T in joules, F in newtons and l in meters)

Constant force moving tangentially to a circle

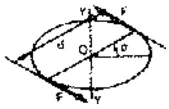


$T = FR\alpha = M_0^t F\alpha$
for one rotation $T = 2\pi RF$

(T in joules, F in newtons, R in meters, α in radians and M_0^t in meter Newtons)

WORK OF A TORQUE

Torque rotating about an axis perpendicular to its plane



$T = Fd\alpha = M'_0 C\alpha$
for one rotation $T = 2\pi M'_0 C = 2\pi Fd$

(T in joules, F in newtons, d in meters, α in radians and M'_0 in meter Newtons)

POWER

Work produced per unit time $P = \dfrac{T}{t}$

(P in watts, T in joules and t in seconds)

Power of a torque rotating at constant speed ω

$$P = M'_0 C\omega \qquad \text{or} \qquad P = Fd\omega = \boldsymbol{Fd\,\frac{2\pi N}{60}}$$

(P in watts, M'_0 in meter newtons, ω in radians per second, F in newtons, d in meters and N in revolution per minute)

MECHANICS AND STRENGTH OF MATERIALS (continued)

KINETIC ENERGY

$$W = \frac{1}{2} mv^2$$

(W in joules, m in kilograms and v in meters per second)

STRENGTH OF MATERIALS

Tension and compression

Stress: $n = \frac{N}{S} 10^{-6}$

n = stress (MPa)
N = tensile or compressive force (N)
S = cross-sectional area (m^2)

Hooke's law: $\boldsymbol{n = E \frac{\Delta\ell}{\ell}}$

E = Young's modulus or longitudinal elastic modulus: approximately 200 000 to 220 000 MPa for steel
$\Delta\ell$ = elongation } expressed in the same units
ℓ = length

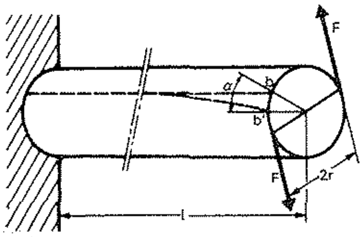
Torsion

Torsional moment: $M_t = 2Fr$

(M_t in meter newtons, F in newtons and r in meters)

Unit torsion $\theta = \frac{\alpha}{\ell}$ $\qquad \frac{\alpha}{\ell} = \frac{\boldsymbol{M_t}}{\frac{\boldsymbol{I_0}}{\boldsymbol{r}}}$

Hooke's law: $\boldsymbol{t = Gr\theta}$



θ = unit torsion(rad/m)
α = *angle of rotation (rad)*
ℓ = length (m)
t = torsional or tangential shear stress (MPa)
G = transverse elastic modulus:
  $G = 0.4 \times E$ (Young's modulus)
  G = 80 000 MPa for steel
r = radius of cylinder (m)
I_0 = polar moment of inertia
  $I_0 = \frac{\pi}{2} r^4$ for a cylinder
  $I_0 = \frac{\pi}{32} (D^4 - d^4)$ for a tube with outside diameter D and inside diameter d

ELECTRICITY
direct current

CURRENT : I

Unit : Ampere (A)

Constant current which, maintained in two straight parallel conductors of infinite length and negligible circular cross-sectional area, and placed one meter apart in a vacuum, produces a force of 2.10^{-7} newtons per meter of length between these conductors.

QUANTITY OF ELECTRICITY : Q

Unit : Coulomb (C)

Quantity of electricity transmitted in one second by a current of one ampere.

Practical unit : ampere-hour (Ah)

Quantity of electricity transmitted in one hour by a current of one ampere (1 Ah = 3 600 C)

$$\underset{(\mathrm{Ah})}{Q} = \underset{(\mathrm{A})}{I}\ \underset{(\mathrm{h})}{t}$$

POTENTIAL DIFFERENCE (VOLTAGE) : U

Unit : Volt (V)

Potential difference between two points of a conducting wire carrying a constant current of one ampere when the power dissipated between these points is one watt.

RESISTANCE : R

Unit : Ohm (Ω)

Resistance between two points of a conducting wire when a potential difference of one volt, applied between these two points, produces a current of one ampere in the conductor, the conductor not *being a source of any electromotive force.*

Resistivity : ρ (Ω/m/mm²) at 15 °C

Resistance of a wire one meter long with a cross-sectional area of one square *millimeter*

	ρ(Ω/m per mm²)		ρ(Ω/m per mm²)
Copper	0.017 - 0.0175	Iron	0.11
Silver	0.016 - 0.018	Steel	0.10 - 0.25
Aluminium	0.029 - 0.0175	Nickel/silver (Cu 60 %, Zn 20 %, Ni 20 %)	0.36 - 0.39

$$R = \rho \frac{\ell}{S}$$

l: length of conductor (m) ; S: cross-sectional area of conductor (mm²)

TEMPERATURE COEFFICIENT OF A RESISTANCE AND RESISTIVITY

$$R_t = R_0 (1 + \alpha t) \qquad \rho_t = \rho_0 (1 + \alpha t)$$

R_t, ρ_t = resistance, *resistivity at t degrees Celsius*
R_0, ρ_0 = resistance, resistivity at 0 degree Celsius
α = temperature coefficient at 15 °C

	α		α
Copper	$3.93\ 10^{-3}$	Iron	$4.7\ 10^{-3}$
Silver	$3.6\ 10^{-3}$	Steel	$5\ 10^{-3}$
Aluminium	$8.5\ 10^{-3}$	Nickel/silver (Cu 60 %, Zn 20 %, Ni 20 %)	$3\ 10^{-4}$

ELECTRICITY

direct current (continued)

RESISTANCE CONNECTIONS

1) Connection in series:

$R = R_1 + R_2 + R_3 \dots$

$U = U_1 + U_2 + U_3 \dots$ I constant

2) Connection in parallel:

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$

$I = I_1 + I_2 + I_3 \dots$ U constant

For two resistances in parallel:

$$R = \frac{R_1 R_2}{R_1 + R_2} \qquad I_1 = I\frac{R_2}{R_1 + R_2} \qquad I_2 = I\frac{R_1}{R_1 + R_2}$$

OHM'S LAW

$U = RI$ $I = \frac{U}{R}$ $R = \frac{U}{I}$ $R(\Omega)$, $I(A)$, $U(V)$

ELECTRICAL ENERGY (W) OR QUANTITY OF HEAT : Q

Unit: joule (J)

Electrical energy generated each second by a current of one ampere flowing through a resistance of one ohm.

$$\underset{(J)}{W} = \underset{(\Omega)}{R}\ \underset{(A)}{I^2}\ \underset{(s)}{t} \qquad \underset{(J)}{W} = \underset{(V)}{U}\ \underset{(A)}{I}\ \underset{(s)}{t}$$

Non SI units:

1) Watt-hour (Wh)

Energy expended in 1 hour by a power of 1 watt

$$\underset{(Wh)}{W} = \underset{(\Omega)}{R}\ \underset{(A)}{I^2}\ \underset{(h)}{t} \qquad 1\ \text{Wh} = 3\,600\ \text{J}$$

2) Calorie (cal)

$$\underset{(cal)}{Q} = 0.24\ \underset{(\Omega)}{R}\ \underset{(A)}{I^2}\ \underset{(s)}{t} \qquad 1\ \text{cal} = 4.1855\ \text{J} \qquad 1\ \text{J} = 0.2389\ \text{cal}$$

4.1855 is an experimental value.

ELECTRICAL POWER (P) : P

Unit: Watt (W)

Power of 1 joule per second

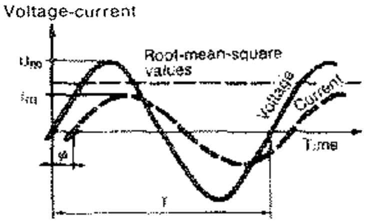
$$\underset{(W)}{P} = \underset{(\Omega)}{R}\ \underset{(A)}{I^2} \qquad \underset{(W)}{P} = \underset{(V)}{U}\ \underset{(A)}{I} \qquad \underset{(W)}{P} = \frac{U^2\ (V)}{R\ (\Omega)}$$

ELECTRICITY
alternating current

period $T = \frac{1}{F}$

frequency $F = \frac{1}{T}$ (Hz)

angular frequency $\omega = 2\pi F$ (rd/s)



Instantaneous values :

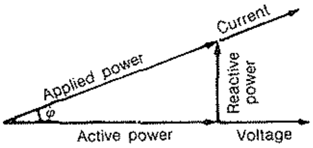
$u = U_m \cos \omega t$
$i = I_m \cos (\omega t - \varphi)$
φ = angle of phase difference between current and voltage

Root-mean-square values *(nms values)* :

$U = \frac{U_m}{\sqrt{2}}$ $I = \frac{I_m}{\sqrt{2}}$

Power :

1) Applied power $S = UI$ in volt-amperes (VA)
2) Active power $P = UI \cos \varphi$ in watts (W)
3) Reactive power $Q = UI \sin \varphi$ in reactive volt-amperes (VAR)



$S^2 = P^2 + Q^2$

$\tan \varphi = \frac{Q}{P}$

$\cos \varphi = \frac{P}{S}$ (power factor)

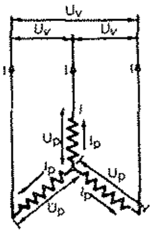
THREE-PHASE SYSTEM

Phases windings

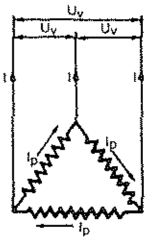
(formulas valid with same load for all 3 phases)

Star connection
$U_v = 1.73\ U_p$ $I = I_p$

Mesh or Delta connection
$U_v = U_p$ $I = 1.73\ I_p$



1) Applied power $S = UI$ (VA)
2) Active power $P = 1.73\ U_v\ I \cos \varphi$ (W)
$= 3\ U_p\ I_p \cos \varphi$ (W)
3) Reactive power $Q = \sqrt{S^2 - P^2}$
$= 1.73\ U_v\ I \sin \varphi$ (VAR)
$= 3\ U_p I_p \varphi$ (VAR)



where :

U_v = voltage in volts between two conductors of the three-phase winding
U_p = voltage for each phase
I = current in amperes through each conductor of the three-phase winding
I_v = current in each phase
φ = phase difference between current and voltage

ELECTRICITY
alternating current, three-phase system (continued)

Capacitance : C

Unit : farad (F). A capacitance of one farad requires one coulomb of electricity to raise its potential one volt.

$$1 \text{ farad} = \frac{1 \text{ Coulomb}}{1 \text{ volt}} \qquad C = \frac{Q}{U}$$

Connections of capacitors (or condensers)

Capacitors in parallel:

$$C = C_1 + C_2 + C_3 + \ldots$$

Capacitors in series:

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \text{ for 2 capacitors: } C = \frac{C_1 \cdot C_2}{C_1 + C_2}$$

Permissible current through conductors

Nominal cross-sectional area (mm²)	Current Temperature rise = 45 °C		
	Number of conductors		
	2	3	4
	(A)	(A)	(A)
2	20	17	15
3	27	22.5	21
5	35	31	28
10	53	47	44
16	66	60	55
25	88	81	70
40	110	103	88
50	130	123	105
75	167	154	132
95	192	184	155

For temperature rises different from 45 °C multiply the currents opposite by the following coefficients:	
Temperature rise	Coefficient
20	0.67
25	0.75
30	0.82
35	0.88
40	0.94
45	1
50	1.05
55	1.10
60	1.15

PRINCIPAL CHEMICAL SYMBOLS, ATOMIC NUMBERS AND WEIGHTS

Name	Symbol	Atomic number	Atomic weight	Name	Symbol	Atomic number	Atomic weight
Aluminium . .	Al	13	27	Mercury. . .	Hg	80	200.6
Antimony. . .	Sb	51	122	Molybdenum	Mo	42	96
Argon	A	18	40	Neon.	Ne	10	20
Arsenic	As	33	75	Nickel	Ni	28	58.7
Barium	Ba	56	137	Nitrogen . .	N	7	14
Bismuth. . . .	Bi	83	*209*	*Oxygen . . .*	*O*	*8*	*16*
Boron	B	5	11	Phosphorus	P	15	31
Bromine. . . .	*Br*	*35*	*80*	*Platinium. .*	Pt	78	195
Cadmium. . .	Cd	48	112	Plutonium .	Pu	94	242
Calcium. . . .	Ca	20	40	Potassium .	K	19	397
Carbon	C	6	12	Radium . . .	Ra	88	226
Chlorine . . .	Cl	17	35.5	Selenium . .	Se	34	79
Chromium . .	Cr	24	52	Silicon. . . .	Si	14	28
Chlorine . . .	Cl	17	35.5	Selenium . .	Se	34	79
Chromium . .	Cr	24	52	Silicon. . . .	Si	14	28
Cobalt.	Co	27	59	Silver.	Ag	47	108
Copper	Cu	29	63.5	Sodium . . .	Na	11	23
Fluorine. . . .	F	9	19	Strontium. .	Sr	38	87.6
Gold	Au	79	197	Sulfur	S	16	32
Helium.	He	2	4	Tin	Sn	50	119
Hydrogen. . .	*H*	1	*1*	*Titanium . .*	*Ti*	*22*	*48*
Iodine	I	53	127	Tungsten. .	W	74	184
Iron.	*Fe*	26	56	Uranium . .	U	92	238
Lead	Pb	82	207	Vanadium .	V	23	51
Lithium	Li	3	7	Xenon	Xe	54	131.3
Magnesium .	Mg	12	24	Zinc	Zn	30	65.4
Manganese .	Mn	25	55	Zirconium .	Zr	40	91

SPECIFIC GRAVITY OF VARIOUS MATERIALS AND FLUIDS

Name	Specific Gravity	Name	Specific Gravity
Rock :		Materials :	
Dry sand	2.6	Baryte (barium sulfate)	4.2 to 4.3
Gypsum	2.30 to 2.37	Compact brick	2.2
Granite	2.4 to 3.0	Compact clay	2.1
Hard limestone	2.4 to 2.7	Concrete	2.25
Marble	2.5 to 2.9	Glass	2.53
Medium-hard limestone	1.9 to 2.3	Portland cement (powder)	3.0 to 3.3
Quartzite	2.2 à 2.8	Portland cement (slurry)	1.8 to 2.0
Rock salt	2.16	Walnut shells	1.3
Sandstone	1.9 to 2.6	Gas (at 10 °C and 760 mmHg in relation to air) :	
Liquids (at 25 °C) :		Air	1
Acetone	0.791	Isobutane	2.067
Benzene	0.878	N-butane (710 mmHg)	2.0854
Carbon tetrachloride	1.595	Carbon dioxide	1.529
Chloroform	1.482	Carbon monoxide	0.9671
Ether	0.714	Ethane	1.0493
Ethyl alcohol	0.816	Ethylene	0.9749
Glycerin	1.260	Hydrogen	0.06952
Methyl alcohol	0.792	Hydrogen sulfide	1.19
Trichloroethylene	1.455	Methane	0.5544
Water at 4 °C	1	Oxygen	1.10527
		Propane	1.554

PHYSICAL PROPERTIES OF METALS

Name	Symbol	Specific gravity	Melting point (°C)	Brinell hardness	Mohs scale
Aluminium	Al	2.7	660	16	2.5
Antimony	Sb	6.7	631	—	3.2
Bismuth	Bi	9.75	271	—	2.5
Cadmium	Cd	8.65	321	23	2
Chromium	Cr	7.19	1890	70-130	9
Cobalt	Co	8.9	1495	124	—
Copper	Cu	8.94	1083	—	2.5
Gold	Au	19.32	1063	—	2.5
Iron	Fe	7.88	1535	77	4.5
Lead	Pb	11.34	327	4	1.5
Magnesium.	Mg	1.74	651	29	2
Manganese.	Mn	7.2	1260	—	5
Mercury	Hg	13.55	-39	—	—
Molybdenum.	Mo	10.2	2620	150-200	—
Nickel	Ni	8.9	1455	110-300	—
Platinium	Pt	21.45	1774	64	4.3
Silver	Ag	10.5	961	—	2.5-7
Tin	Sn	7.3	232	—	1.7
Titanium.	Ti	4.5	1800	—	—
Tungsten	W	19.3	3370	350	—
Vanadium.	V	5.96	1710	—	—
Zinc.	Zn	7.14	419	—	2.5

STRATIGRAPHIC SCALE

Era	Period	Formations
Quaternary (Psychozoic)	Holocene (Neolithic) Pleistocene (Paleolithic)	Flandrian Tyrrhenian Sicilian
Tertiary (Cenozoic)	Pliocene	*Calabrian* (Villafranchian) Astian Plaisancian
	Miocene	Sahelian (Pontian) Vindobonian Burdigalian
	Oligocene	Aquitanian Chattian Stampian Sannoisian
	Eocene	Ludian Bartonian Lutetian Ypresian Sparnacian Thanetian Montian

Era	Period	Formations
Secondary (Mesozoic)	Upper Cretaceous	Danian Senonian Turonian Cenomanian
	Lower Cretaceous (Eocretaceous)	Albian Aptian Barremian (Urgonian) Hauterivian Valanginian
	Upper Jurassic (Malm)	(Purbeckian) Portlandian (Tithonic) Kimmeridgian Sequanian Rauracian Argovian Oxfordian Callovian
	Middle Jurassic (Dogger)	Bathonian Bajocian
	Lower Jurassic (Lias)	Aalenian Toarcian Charmouthian Sinemurian Hettangian Rhetian
	Trias	Keuper Muschelkalk Bunter

Era	Period	Formations
Primary (Paleozoic)	Permian	Zechstein or Thuringian Saxonian Autunian
	Carboniferous	Coal form. (Stephanian) (Wesphalian) Dinantian (Culm)
	Devonian	Fammennian Frasnian Givetian Eifelian Coblencian Gedinnian Downtonian
	Silurian	Gothlandian Ordovician
	Cambrian	Potsdamian Acadian Georgian
	Precambrian (algonkian)	
	Archean	

BUOYANCY FACTOR. BUOYANCY
(Steel specific gravity = 7.85)

Mud density			Factor *k*	*Mud density*			Factor *k*
(kg/l)	(lb/gal)	(lb/cu.ft)		(kg/l)	(lb/gal)	(lb/ft^3)	
1.00	8.35	62.4	0.873	**1.62**	13.52	101.2	0.793
1.02	8.51	63.7	0.869	**1.64**	13.68	102.4	0.791
1.04	8.68	64.9	0.867	**1.66**	13.85	103.7	0.789
1.06	8.85	66.2	0.864	**1.68**	14.02	104.9	0.786
1.08	9.01	67.4	0.862	**1.70**	14.18	106.2	0.783
1.10	9.18	68.7	0.859	**1.72**	14.35	107.4	0.781
1.12	9.31	69.9	0.857	**1.74**	14.52	108.7	0.779
1.14	9.51	71.2	0.854	**1.76**	14.68	109.9	0.776
1.16	9.68	72.4	0.852	**1.78**	14.85	111.2	0.773
1.18	9.85	73.7	0.849	**1.80**	15.02	112.4	0.771
1.20	10.01	74.9	0.847	**1.82**	15.18	113.7	0.768
1.22	10.18	76.2	0.844	**1.84**	15.35	114.9	0.765
1.24	10.35	77.4	0.842	**1.86**	15.53	116.2	0.763
1.26	10.52	78.7	0.839	**1.88**	15.69	117.4	0.760
1.28	10.68	79.9	0.837	**1.90**	15.86	118.7	0.758
1.30	10.85	81.2	0.834	**1.92**	16.02	119.9	0.755
1.32	11.02	82.4	0.832	**1.94**	16.18	121.2	0.752
1.34	11.18	83.7	0.829	**1.96**	16.36	122.4	0.749
1.36	11.35	84.9	0.827	**1.98**	16.53	123.7	0.747
1.38	11.52	86.2	0.824	**2.00**	16.69	124.9	0.745
1.40	11.68	87.4	0.822	**2.02**	16.86	126.2	0.742
1.42	11.85	88.7	0.819	**2.04**	17.02	127.4	0.739
1.44	12.02	89.9	0.817	**2.06**	17.18	128.7	0.737
1.46	12.18	91.2	0.814	**2.08**	17.36	129.9	0.734
1.48	12.35	92.4	0.812	**2.10**	17.53	131.2	0.732
1.50	12.52	93.7	0.809	**2.12**	17.69	132.4	0.729
1.52	12.68	94.9	0.807	**2.14**	17.86	133.7	0.727
1.54	12.85	96.2	0.804	**2.16**	18.02	134.9	0.725
1.56	13.02	97.4	0.801	**2.18**	18.19	136.2	0.722
1.58	13.18	98.7	0.798	**2.20**	18.36	137.4	0.719
1.60	13.35	99.9	0.796	**2.22**	18.54	138.7	0.717

$$k = 1 - \frac{\text{Mud density}}{\text{Steel density}}$$

Calculation of apparent string weight in mud

$$\text{Apparent weight} = \text{Real weight} - \text{Buoyancy}$$

$$\text{Buoyancy} = \frac{\text{Real weight} \times \text{Mud density}}{\text{Steel density}}$$

hence:

$$\text{Apparent weight} = \text{Real weight} \left[\frac{\text{Steel density} - \text{Mud density}}{\text{Steel density}} \right]$$

$$\text{Apparent weight} = \text{Real weight} \times \text{Buoyancy factor}$$

Example: Steel weight of a string = 125 t.
Mud density = 1.18 kg/l.
Apparent weight of string = 125 × 0.849 = 106.1 t.

B

drill string standards

API STEEL GRADES AND PROPERTIES
(API Spec 5D - 7)

	Yield strength				Minimum tensile strength	
	Minimum		Maximum			
	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)
Drill pipe						
Steel grade :						
E75	75 000	515	105 000	725	100 000	690
X95	95 000	655	125 000	860	105 000	725
G105	105 000	725	135 000	930	115 000	790
S135	135 000	930	165 000	1140	145 000	1000
Tool joints	*120 000*	*830*	—	—	*140 000*	*970*
Drill collars and cross-over sub						
Outside diameter (in) :						
3 1/8 to 6 7/8	110 000	760	—	—	140 000	970
7 to 10	100 000	690	—	—	135 000	930

PROPERTIES OF NON-API SPECIAL H_2S STEELS FOR DRILL PIPES

	H_2S steel *grade*	Yield strength				Minimum tensile strength		Maximum Rockwell hardness HR_c
		Minimum		Maximum				
		(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	
Vallourec	DP-80 VH	80 000	550	95 000	655	95 000	655	22.0
	DP-95 VH	95 000	655	110 000	760	105 000	725	25.4
Mannesmann	MW-CE-75.	75 000	515	90 000	620	95 000	655	22.0
	MW-CX-95.	95 000	655	110 000	760	105 000	725	28.0
	These drill pipes are equipped with special grade tool joints:							
	Special H_2S grade of tool joints. . . .	95 000	655	110 000	760	105 000	725	28.0

API DRILL PIPE LIST AND BODY AND UPSET GEOMETRY

(API Spec 5D)

Nominal diameter		Nominal weight (lb/ft)	Wall thickness of pipe body (mm)	Inside diameter of pipe body (mm)	Steel grade	Upset					
						IU		EU		IEU	
(in)	(mm)					OD (mm)	ID (mm)	OD (mm)	ID (mm)	OD (mm)	ID (mm)
2 3/8	60.3	6.65	7.11	46.1	E	—	—	67.5	46.1	—	—
2 3/8	60.3	6.65	7.11	46.1	X-G-S	—	—	67.5	39.7	—	—
2 7/8	73.0	10.40	9.19	54.6	E	73.0	33.3	81.8	54.6	—	—
2 7/8	73.0	10.40	9.19	54.6	X-G-S	73.0	41.4	82.6	49.2	—	—
3 1/2	*88.9*	*9.50*	*6.45*	*76.0*	*E*	*88.9*	*57.2*	*97.1*	*76.0*	-	—
3 1/2	88.9	13.30	9.35	70.2	E	88.9	49.2	97.1	66.1	—	—
3 1/2	88.9	13.30	9.35	70.2	X-G-S	88.9	49.2	101.6	63.5	—	—
3 1/2	88.9	15.50	11.40	66.1	E	88.9	49.2	97.1	66.1	—	—
3 1/2	88.9	15.50	11.40	66.1	X-G-S	—	—	101.6	63.5	96.0	49.2
4*	101.6	11.85	6.65	88.3	E	101.6	76.4	114.3	88.3	—	—
4	*101.6*	*14.00*	*8.36*	*84.8*	*E*	*101.6*	*69.8*	*114.3*	*84.8*	—	—
4	101.6	14.00	8.38	84.8	X-G-S	101.6	66.8	117.5	77.8	—	—
4 1/2*	114.3	13.75	6.88	100.5	E	114.3	85.7	127.0	100.5	—	—
4 1/2	114.3	16.60	8.56	97.2	E	—	—	127.0	97.2	118.3	80.2
4 1/2	114.3	16.60	8.56	97.2	X-G-S	—	—	131.8	90.5	118.3	73.0
4 1/2	114.3	20.00	10.92	92.5	E	—	—	127.0	92.5	121.4	76.2
4 1/2	114.3	20.00	10.92	92.5	X-G-S	—	—	131.8	87.3	121.4	71.5
5*	127.0	16.25	7.52	112.0	E	127.0	95.2	—	—	—	—
5	127.0	19.50	9.19	108.6	E	—	—	—	—	131.8	93.7
5	127.0	19.50	9.19	108.6	X-G-S	—	—	146.1	100	131.8	90.5
5	127.0	25.60	12.70	101.6	E	—	—	—	—	131.8	87.3
5	127.0	25.60	12.70	101.6	X-G-S	—	—	149.2	96.9	131.8	84.2
5 1/2	139.7	21.90	9.17	121.4	E	—	—	—	—	141.3	101.6
5 1/2	139.7	21.90	9.17	121.4	X-G-S	—	—	—	—	141.3	96.9
5 1/2	139.7	24.70	10.54	118.6	E	—	—	—	—	141.3	101.6
5 1/2	139.7	24.70	10.54	118.6	X-G-S	—	—	—	—	141.3	96.9
6 5/8	168.3	25.20	8.38	151.5	E	Non-API					

* Tentative dimensions and weights.

mm × 0.0394 = in

UPSET TUBING FOR SMALL-DIAMETER WORK STRINGS (1)
(API Standard 5A and Spec 7) (Grade N80)

Outside diameter		Nominal weight (lb/ft)	Wall thickness (mm)	Weight with tool-joints (kg/m)	Inside diameter		Upset outside diameter (mm)	Cross section area (mm²)	Inside capacity (l/m)	Volume of steel (l/m)	Tensile yield strength (2) (10³ daN)	Torsio-nal yield strength (daN.m)	Internal pressure (2) (MPa)	Collapse resis-tance (2) (MPa)
(in)	(mm)				Body (mm)	Upset (mm)								
1.050	26.7	1.55	3.91	2.20	18.9	17.5	36.5	280	0.280	0.280	15.8	89	141	139
1.315	33.4	2.30	4.55	3.36	24.3	21.4	42.8	413	0.464	0.428	23.4	168	131	131
1.660	42.2	3.29	5.03	4.77	32.1	22.2	47.6	588	0.810	0.607	33.4	310	115	116
1.900	48.3	4.19	5.56	6.10	37.2	23.8	55.5	746	1.085	0.777	42.3	455	111	111

(1) These drill pipes are derived from IEU tubing pipes for welding tool joints with API numbered rotary shouldered connections NC 10, NC 12, NC 13 and NC 16.

The dimensions specified for upsets do not necessarily agree with the dimensions of the bore and the outside diameter of the finished welded assemblies.

The dimensions specified for upsets were selected to accommodate the various bores of the tool joints and to maintain a satisfactory cross-section in the weld zone after final machining of the assembly.

(2) These pipes are generally of N80 steel. The mechanical properties are given for this steel grade.

mm × 0.0394 = in kg/m × 0.672 = lb/ft mm^2 × 0.00155 = in^2 l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft
daN × 2.25 = lb daN.m × 7.38 = lb.ft bar × 14.5 = psi

CLASSIFICATION OF USED DRILL PIPE AND USED TUBING WORK STRINGS
(API RP 7G, 12th Edition, May 1987)

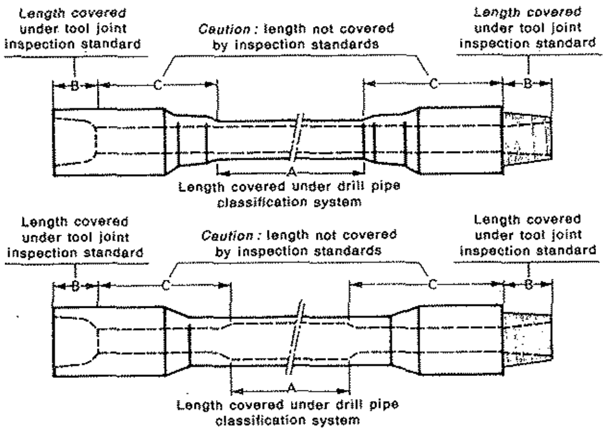
(All size, weights and grades. The nominal dimension is the basis for all calculations)

Pipe condition	**Class I** White Band	**Premium class** Two White Bands	**Class II** Yellow Band	Class III Orange Band
Exterior conditions				
A) OD wear wall	Nominal dimension	Remaining wall not less than 80%	Remaining wall not less than 70%	Any imperfections or damages exceeding *class II*
B) Dents and mashes	None	Not over 3% of OD	Not over 4% of OD	
C) Slip area diameter variations				
1. Crushing	None	Not over 3% of OD	Not over 4% of OD	
2. Necking	None	Not over 3% of OD	Not over 4% of OD	
D) Stress induced diameter variations				
1. Stretched	None	Not over 3% of OD reduction	Not over 4% of OD reduction	
2. String shot	None	Not over 3% of OD increase	Not over 4% of OD increase	
E) Cuts, gouges and corrosion				
1. Round bottom	None	Remaining wall not less than 80%	Remaining wall not less than 70%	
2. Sharp bottom a) *longitudinal*	None	Remaining wall not less than 80%	Remaining wall not less than 70%	
b) transverse	None	Remaining wall not less than 80% and length not over 10% of circumference	Remaining wall not less than 80% and length not over 10% of circumference	
F) Fatigue cracks	None	None	None	None
Interior conditions				
A) Corrosive pitting Wall	Nominal dimension	Remaining wall not less than 80% measured from base of deepest pit	Remaining wall not less than 70% measured from base of deepest pit	
B) Erosion and wear Wall	Nominal dimension	Remaining wall not less than 80%	Remaining wall not less than 70%	
C) Fatigue cracks	None	None	None	None

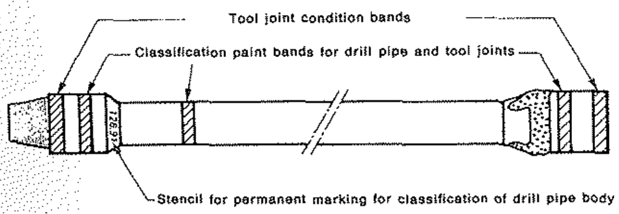
INSPECTION STANDARDS

Zones and color code identification (API RP 7G, 12th Edition, May 1987)

IDENTIFICATION OF LENGTHS COVERED BY INSPECTION STANDARDS



DRILL PIPE AND TOOL JOINT COLOR CODE IDENTIFICATION

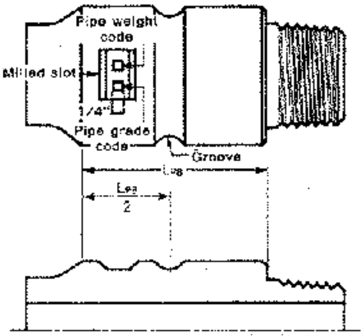


Tool joint and drill pipe classification	Number and color of bands
Premium Class	Two White
Class 2	One yellow
Class 3	*One orange*
Scrap	One red

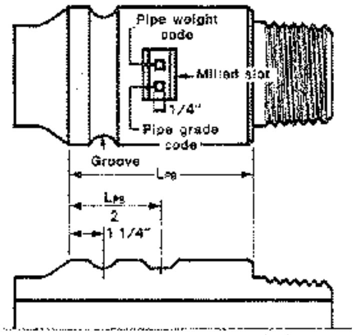
Tool joint condition	Color of bands
Scrap or shop repairable	Red
Field repairable	Green

RECOMMENDED PRACTICE FOR MILL SLOT AND GROOVE METHOD OF DRILL STRING IDENTIFICATION

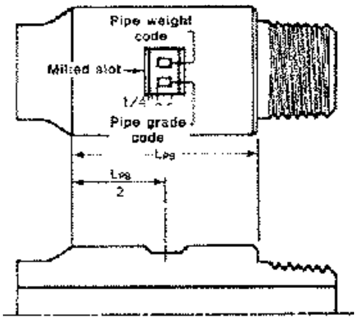
(API RP 7G, 12th Edition, May 1987)



Standard weight high strength drill pipe



Heavy weight high strength drill pipe



Heavy weight grade E drill pipe

L_{PB} = pin tong space length.

RECOMMENDED PRACTICE FOR MILL SLOT AND GROOVE METHOD OF DRILL STRING IDENTIFICATION

(API RP 7G, 12th Edition, May 1987)

(continued)

Drill pipe grade code			
Standard grades		High strength grades	
Grade	Symbol	Grade	Symbol
N-80	N	X-95	X
E	E	G-105	G
C-75	C	S-135	S
		V-150	V

Drill pipe weight code			
1	2	3	4
Size *OD* (in)	Nominal weight (lb/ft)	*Wall thickness* (in)	*Weight* code number
2 3/8	4.85	.190	1
	6.65*	.280	2
2 7/8	6.85	.217	1
	10.40*	.362	2
3 1/2	9.50	.254	1
	13.30*	.368	2
	15.50	.449	3
4	11.85	.262	1
	14.00*	.330	2
	15.70	.380	3
4 1/2	13.75	.271	1
	16.60*	.337	2
	20.00	.430	3
	22.82	.500	4
	24.66	.550	5
	25.50	.575	6
5	16.25	.296	1
	19.50*	.362	2
	25.60	.500	3
5 1/2	19.20	.304	1
	21.90*	.361	2
	24.70	.415	3
6 5/8	25.20*	.330	2

* Designates standard weight for drill pipe size.

Note: Standard weight grade E drill pipe designated by an asterisk (*) in the drill pipe weight code will have no groove or milled slot for identification.

Grade E heavy weight drill pipe will have a milled slot only, in the center of the tong space.

GEOMETRIC CHARACTERISTICS OF DRILL PIPES
(New pipe bodies and tool joints)

Nominal diameter (in)	Nominal weight (lb/ft)	Wall thickness (mm)	ID		Cross-section (mm^2)	Polar moment of inertia (mm^4)	Polar modulus (mm^3)	Upset and grade		Type of tool joint	Tool joint OD (mm)	Tool joint ID (mm)	Approximate weight including tool joint	
			(in)	(mm)									(kg/m)	(lb/ft)
2 3/8 (60.33 mm)	4.85	4.83	1.995	50.67	842	653 421	21 662	**EU**	**E**	**NC26 (IF)**	**85.7**	**44.5**	**7.89**	**5.30**
								EU	E	WO	85.7	50.8	7.59	5.10
								EU	E	OH	79.4	50.8	7.29	4.90
								EU	E	SL-H90	82.6	50.8	7.44	5.00
	6.65	7.11	1.815	46.11	1 189	856 775	28 403	**EU**	**E**	**NC26 (IF)**	**85.7**	**44.5**	**10.43**	**7.01**
								EU	E	OH	82.6	44.5	10.27	6.90
								IU	E	PAC	73.0	34.9	10.12	6.80
								EU	**X**	**NC26 (IF)**	**85.7**	**44.5**	**10.57**	**7.10**
								EU	X	SL-H90	82.6	46.0	10.42	7.00
								EU	**G**	**NC26 (IF)**	**85.7**	**44.5**	**10.57**	**7.10**
								EU	G	SL-H90	82.6	46.0	10.42	7.00
2 7/8 (73.03 mm)	6.85	5.51	2.441	62.01	1 169	1 340 977	36 724	**EU**	**E**	**NC31 (IF)**	**104.8**	**54.0**	**11.16**	**7.50**
								EU	E	WO	104.8	61.9	10.86	7.30
								EU	E	OH	95.3	61.9	10.27	6.90
								EU	E	SL-H90	98.4	61.9	10.57	7.10
	10.40	9.19	2.151	54.65	1 843	1 916 866	52 495	**EU**	**E**	**NC31 (IF)**	**104.8**	**54.0**	**16.21**	**10.90**
								EU	E	OH	98.4	54.8	15.78	10.60
								EU	E	SL-H90	98.4	54.8	15.78	10.60
								IU	E	XH	108.0	47.6	16.67	11.20
								IU	**E**	**NC26**	**85.7**	**44.5**	**15.48**	**10.40**
								IU	E	PAC	79.4	38.1	15.33	10.30
								EU	**X**	**NC31 (IF)**	**104.8**	**50.8**	**16.50**	**11.09**
								EU	X	SL-H90	98.4	54.8	16.22	10.90
								EU	**G**	**NC31 (IF)**	**104.8**	**50.8**	**16.50**	**11.09**
								EU	G	SL-H90	101.6	50.8	16.22	10.90
								EU	**S**	**NC31 (IF)**	**111.1**	**41.3**	**17.19**	**11.55**
								EU	S	SL-H90	104.8	41.3	16.82	11.30

mm × 0.0394 = in $mm^2 \times 0.00155 = in^2$ $mm^3 \times 6.10\ 10^{-5} = in^3$ $mm^4 \times 2.40\ 10^{-6} = in^4$

GEOMETRIC CHARACTERISTICS OF DRILL PIPES
(New pipe bodies and tool joints) (continued)

Nominal diameter (in)	Nominal weight (lb/ft)	Wall thickness (mm)	ID		Cross-section (mm²)	Polar moment of inertia (mm⁴)	Polar modulus (mm³)	Upset and grade		Type of tool joint	Tool joint OD (mm)	Tool joint ID (mm)	Approximate weight including tool joint	
			(in)	(mm)									(kg/m)	(lb/ft)
3 1/2 (88.90 mm)	9.50	6.45	2.992	76.00	1 671	2 856 744	64 269	**EU**	**E**	**NC38 (IF)**	**120.7**	**68.3**	**15.38**	**10.34**
								EU	E	NC38 (WO)	120.7	76.2	15.33	10.30
								EU	E	OH	114.3	76.2	14.88	10.00
								EU	E	SL-H90	117.5	76.2	15.18	10.20
	13.30	9.35	2.764	70.20	2 337	3 747 637	84 316	**EU**	**E**	**NC38 (IF)**	**120.7**	**68.3**	**20.76**	**13.95**
								EU	E	OH	120.7	68.3	20.76	13.95
								IU	E	XH	120.7	61.9	21.13	14.20
								IU	E	NC31 (SH)	104.8	54.0	20.24	13.60
								EU	**X**	**NC38 (IF)**	**127.0**	**65.1**	**21.75**	**14.61**
								EU	X	SL-H90	120.7	65.1	21.13	14.20
								EU	**G**	**NC38 (IF)**	**127.0**	**61.9**	**21.89**	**14.71**
								EU	G	SL-H90	120.7	65.1	21.13	14.20
								EU	**S**	**NC38 (IF)**	**127.0**	**54.0**	**22.21**	**14.92**
								EU	S	SL-H90	127.0	54.0	22.21	14.92
								EU	**S**	**NC40 (4FH)**	**136.5**	**61.9**	**22.77**	**15.30**
	15.50	11.40	2.602	66.10	2 776	4 257 912	95 791	**EU**	**E**	**NC38 (IF)**	**127.0**	**65.1**	**24.65**	**16.57**
								EU	**X**	**NC38 (IF)**	**127.0**	**61.9**	**25.05**	**16.83**
								EU	**G**	**NC38 (IF)**	**127.0**	**54.0**	**25.37**	**17.05**
								EU	**S**	**NC40 (4FH)**	**139.7**	**57.2**	**26.47**	**17.78**
4 (101.60 mm)	11.85	6.65	3.476	88.30	1 984	4 492 846	88 442	**EU**	**E**	**NC46 (IF)**	**152.4**	**82.6**	**20.09**	**13.50**
								EU	**E**	**NC46 (WO)**	**146.1**	**87.3**	**19.79**	**13.30**
								EU	E	OH	133.4	88.1	18.10	12.10
								IU	E	H90	139.7	71.4	19.50	13.10
	14.00	8.38	3.340	84.84	2 454	5 374 730	105 802	**EU**	**E**	**NC46 (IF)**	**152.4**	**82.6**	**23.64**	**15.89**
								EU	E	OH	139.7	82.6	22.32	15.00
								IU	**E**	**NC40 (FH)**	**139.7**	**71.4**	**22.39**	**15.04**
								IU	E	SH	117.5	65.1	21.43	14.40
								EU	**X**	**NC46 (IF)**	**152.4**	**82.6**	**24.09**	**16.19**
								IU	**X**	**NC40 (FH)**	**133.4**	**68.3**	**22.73**	**15.27**
								IU	X	H90	139.7	71.4	23.22	15.60

mm × 0.0394 = in mm² × 0.00155 = in² mm³ × 6.10 10⁻⁵ = in³ mm⁴ × 2.40 10⁻⁶ = in⁴

GEOMETRIC CHARACTERISTICS OF DRILL PIPES
(New pipe bodies and tool joint) (continued)

Nominal diameter (in)	Nominal weight (lb/ft)	Wall thickness (mm)	ID		Cross-section (mm^2)	Polar moment of inertia (mm^4)	Polar modulus (mm^3)	Upset and grade		Type of tool joint	Tool joint OD (mm)	Tool joint ID (mm)	Approximate weight including tool joint	
			(in)	(mm)									(kg/m)	(lb/ft)
4 (101.60 mm)	14.00	8.38	3.340	84.84	2 454	5 374 730	105 802	**EU**	**G**	**NC46 (IF)**	**152.4**	**82.6**	**24.09**	**16.19**
								IU	**G**	**NC40 (FH)**	**139.7**	**61.9**	**23.59**	**15.85**
								IU	G	H90	139.7	71.4	23.22	15.60
								EU	**S**	**NC46 (IF)**	**152.4**	**76.2**	**24.43**	**16.42**
								IU	**S**	**NC40 (FH)**	**139.7**	**50.8**	**24.00**	**16.13**
								IU	S	H90	139.7	71.4	23.22	15.60
4 1/2 (114.30 mm)	13.75	6.88	3.958	100.54	2 322	6 725 300	117 678	**EU**	**E**	**NC50 (IF)**	**161.9**	**95.3**	**22.37**	**15.03**
								EU	E	NC50 (WO)	155.6	98.4	22.03	14.80
								EU	E	OH	146.1	100.8	20.98	14.10
								IU	E	H90	152.4	82.6	22.62	15.20
	16.60	8.56	3.826	97.18	2 844	8 000 523	139 992	**EU**	**E**	**NC50 (IF)**	**161.9**	**95.3**	**26.77**	**17.99**
								EU	E	OH	149.2	95.3		17.10
								IEU	**E**	**NC46 (XH)**	**158.8**	**82.6**	**27.33**	**18.37**
								IEU	E	FH	152.4	76.2	26.99	18.14
								IEU	E	H90	152.4	82.6	26.64	17.90
								IEU	E	NC38 (SH)	127.0	68.3	25.00	16.80
								EU	***X***	***NC50 (IF)***	***161.9***	***95.3***	***27.33***	***18.36***
								IEU	X	NC46 (XH)	158.8	76.2	27.70	18.61
								IEU	X	FH	152.4	76.2	27.02	18.16
								IEU	X	H90	152.4	82.6	26.79	18.00
								EU	**G**	**NC50 (IF)**	**161.9**	**95.3**	**27.33**	**18.36**
								IEU	G	NC46 (XH)	158.8	76.2	27.70	18.61
								IEU	G	FH	152.4	76.2	27.02	18.16
								IEU	G	H90	152.4	82.6	26.79	18.00
								EU	**S**	**NC50 (IF)**	**161.9**	**88.9**	**27.71**	**18.62**
								IEU	S	NC46 (XH)	158.8	69.9	28.02	18.82
								IEU	S	FH	158.8	63.5	28.30	19.02
								IEU	S	H90	152.4	76.2	27.02	18.16
	20.00	*10.92*	*3.640*	*92.46*	*3 547*	*9 581 665*	*167 658*	***EU***	**E**	***NC50 (IF)***	**161.9**	**92.1**	**32.19**	**21.63**
								IEU	E	NC46 (XH)	158.8	76.2	32.91	22.12
								IEU	E	FH	152.4	76.2	32.24	21.66
								IEU	E	H90	152.4	76.2	32.24	21.66
								EU	**X**	**NC50 (IF)**	**161.9**	**88.9**	**32.88**	**22.09**
								IEU	X	NC46 (XH)	158.6	69.9	33.66	22.62
								IEU	X	FH	152.4	63.5	33.25	22.35
								IEU	X	H90	152.4	82.6	32.29	21.70

mm × 0.0394 = in $mm^2 \times 0.00155 = in^2$ $mm^3 \times 6.10\ 10^{-5} = in^3$ $mm^4 \times 2.40\ 10^{-6} = in^4$

GEOMETRIC CHARACTERISTICS OF DRILL PIPES
(New pipe bodies and tool joints) (continued)

Nominal diameter (in)	Nominal weight (lb/ft)	Wall thickness (mm)	ID		Cross-section (mm^2)	Polar moment of inertia (mm^4)	Polar modulus (mm^3)	Upset and grade		Type of tool joint	Tool joint OD (mm)	Tool joint ID (mm)	Approximate weight including tool joint	
			(in)	(mm)									(kg/m)	(lb/ft)
4 1/2 (114.30 mm)	20.00	10.92	3,640	92.46	3 547	9 581 665	167 658	**EU**	**G**	**NC50 (IF)**	**161.9**	**88.9**	**32.88**	**22.09**
								IEU	**G**	**NC46 (XH)**	**158.8**	**63.5**	**33.94**	**22.81**
								IEU	G	FH	152.4	63.5	33.25	22.35
								IEU	G	H90	152.4	76.2	32.59	21.90
								EU	**S**	**NC50 (IF)**	**168.3**	**76.2**	**34.31**	**23.06**
								IEU	S	NC46 (XH)	158.8	57.2	34.20	22.98
5 (127 mm)	19.50	9.19	4.276	108.62	3 401	11 873 714	186 988	**IEU**	**E**	**NC50 (XH)**	**161.9**	**95.3**	**31.06**	**20.87**
								IEU	E	5 1/2 FH	177.8	95.3	33.19	22.30
								IEU	**X**	**NC50 (XH)**	**161.9**	**88.9**	**31.83**	**21.39**
								IEU	X	5 1/2 FH	177.8	95.3	33.58	22.56
								IEU	**G**	**NC50 (XH)**	**165.1**	**82.6**	**32.55**	**21.87**
								IEU	G	5 1/2 FH	177.8	95.3	33.58	22.56
								IEU	**S**	**NC50 (XH)**	**168.3**	**69.9**	**33.57**	**22.56**
								IEU	S	5 1/2 FH	184.2	88.9	34.86	23.42
	25.60	12,70	4,000	101.60	4 560	15 078 604	237 458	**IEU**	**E**	**NC50 (XH)**	**161.9**	**95.3**	**40.00**	**26.88**
								IEU	E	5 1/2 FH	177.8	95.3	42.12	28.30
								IEU	**X**	**NC50 (XH)**	**165.1**	**76.2**	**41.40**	**27.82**
								IEU	X	5 1/2 FH	177.8	88.9	42.48	28.54
								IEU	**G**	**NC50 (XH)**	**168.3**	**69.9**	**42.08**	**28.28**
								IEU	G	5 1/2 FH	184.2	88.9	43.32	29.11
								IEU	**S**	**5 1/2 FH**	**184.2**	**82.6**	**43.73**	**29.38**
5 1/2 (139.70 mm)	21.90	9.17	4.778	121.36	3 760	16 096 385	230 442	**IEU**	**E**	**FH**	**177.8**	**101.6**	**35.40**	**23.79**
								IEU	**X**	**FH**	**177.8**	**95.3**	**36.33**	**24.41**
								IEU	**G**	**FH**	**184.2**	**88.9**	**37.59**	**25.26**
								IEU	**S**	**FH**	**190.5**	**76.2**	**39.24**	**26.37**
	24.70	10.54	4.670	118.62	4 277	17 955 483	257 058	**IEU**	**E**	**FH**	**177.8**	**101.6**	**39.16**	**26.31**
								IEU	**X**	**FH**	**184.2**	**88.9**	**41.29**	**27.75**
								IEU	**G**	**FH**	**184.2**	**88.9**	**41.29**	**27.75**
								IEU	**S**	**FH**	**190.5**	**76.2**	**42.94**	**28.86**
6 5/8 (168.28 mm)	25.20	8.38	5.955	151.52	4 210	26 981 773	320 677	**IEU**	**E**	**FH**	**203.2**	**127.0**	**40.63**	**27.30**

$mm \times 0.0394 = in$ $mm^2 \times 0.00156 = in^2$ $mm^3 \times 6.10\ 10^{-5} = in^3$ $mm^4 \times 2.40\ 10^{-6} = in^4$

MECHANICAL PROPERTIES OF DRILL PIPES
2 3/8 (4.85 lb/ft) and 2 3/8 (6.65 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
2 3/8	4.85	I	E	43.5	650	72.4	76.1
			X95	55.1	820	91.7	96.4
			G105	61	900	101.3	106.6
			S135	78.3	1 160	130.0	131.5
		Premium	E	34.2	510	66.2	58.9
			X95	43.3	640	83.8	70.0
			G105	47.9	710	92.7	75.1
			S135	61.6	910	119.1	89.1
		II	E	29.7	440	57.9	47.2
			X95	37.6	550	73.4	55.1
			G105	41.5	610	81.1	58.5
			S135	53.4	790	104.2	66.6
2 3/8	6.65	I	E	61.5	850	106.7	107.5
			X95	77.9	1 070	135.1	136.2
			G105	86.1	1 190	149.3	150.6
			S135	110.7	1 530	192.0	193.6
		Premium	E	47.9	650	97.6	92.2
			X95	60.7	830	123.5	116.9
			G105	67.1	910	136.6	129.1
			S135	86.2	1 170	175.6	166.0
		II	E	41.3	560	85.3	83.7
			X95	52.3	710	108.1	106.0
			G105	57.8	780	119.5	117.1
			S135	74.4	1 010	153.6	150.6

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb   daN.m × 7.38 = lb.ft   MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
2 7/8 (6.85 lb/ft) and 2 7/8 (10.40 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
2 7/8	6.85	I	E	60.5	1 100	68.3	72.2
			X95	76.6	1 390	86.5	89.1
			G105	84.7	1 530	95.6	96.6
			S135	108.9	1 970	122.9	117.6
		Premium	E	47.6	860	62.5	52.9
			X95	60.3	1 090	79.1	62.0
			G105	66.6	1 200	87.4	66.3
			S135	85.7	1 550	112.4	77.3
		II	E	41.3	744	54.6	41.7
			X95	52.3	940	69.2	48.0
			G105	57.8	1 040	76.5	50.6
			S135	74.3	1 340	98.4	56.0
2 7/8	10.40	I	E	95.4	1 570	114.0	113.8
			X95	120.8	1 990	144.3	144.2
			G105	133.5	2 190	159.5	159.3
			S135	171.7	2 820	205.1	204.9
		Premium	E	74.1	1 200	104.2	98.0
			X95	93.8	1 520	132.0	124.2
			G105	103.7	1 680	145.8	137.3
			S135	133.4	2 160	187.5	176.5
		II	E	63.9	1 030	91.2	89.2
			X95	80.9	1 300	115.5	113.0
			G105	89.4	1 440	127.6	124.9
			S135	114.9	1 850	164.1	160.6

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb daN.m × 7.38 = lb.ft MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
3 1/2 (9.50 lb/ft) and 3 1/2 (13.30 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
3 1/2	9.50	I	E	86.4	1 920	65.6	69.2
			X95	109.5	2 430	83.2	83.1
			G105	121.0	2 680	92. 0	90.0
			S135	155.6	3 450	118.2	108.8
		Premium	E	68.1	1 500	60.0	48.9
			X95	86.2	1 910	76.0	57.0
			G105	95.3	2 110	84.0	60.7
			S135	122.5	2 710	108.1	69.8
		II	E	59.1	1 300	52.5	38.2
			X95	74.8	1 650	66.5	43.4
			G105	82.7	1 820	73.6	45.5
			S135	106.3	2 350	94.6	49.2
3 1/2	13.30	I	E	120.8	2 520	95.1	97.3
			X95	153.1	3 190	120.5	123.3
			G105	169.2	3 520	133.2	136.2
			S135	217.5	4 530	171.2	175.1
		Premium	E	94.4	1 950	87.0	82.9
			X95	119.6	2 470	110.2	104.9
			G105	132.2	2 720	121.7	116.0
			S135	170.0	3 510	156.6	149.1
		II	E	81.6	1 680	76.1	74.9
			X95	103.3	2 120	96.4	94.8
			G105	114.2	2 350	106.6	103.7
			S135	146.8	3 020	137.0	126.9

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb   daN.m × 7.38 = lb.ft   MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
3 1/2 (15.50 lb/ft) and 4 (11.85 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
3 1/2	15.50	I	E	143.6	2 860	116.1	115.6
			X95	181.9	3 620	147.0	146.5
			G105	201.1	4 000	162.5	161.9
			S135	258.5	5 150	209.0	208.1
		Premium	E	111.5	2 190	106.1	99.8
			X95	141.2	2 770	134.4	126.4
			G105	156.1	3 060	148.6	139.7
			S135	200.6	3 960	191.0	179.6
		II	E	96.1	1 870	92.9	90.8
			X95	121.7	2 370	117.6	115.0
			G105	134.5	2 620	130.0	127.2
			S135	172.9	3 370	167.2	163.5
4	11.85	I	E	102.7	2 640	59.3	58.0
			X95	130.1	3 340	75.1	68.7
			G105	143.8	3 700	83.0	73.8
			S135	184.8	4 750	106.7	87.2
		Premium	E	81.0	2 080	54.2	39.5
			X95	102.6	2 630	68.7	44.7
			G105	113.4	2 910	75.8	47.0
			S135	145.8	3 740	97.6	51.5
		II	E	70.3	1 800	47.4	29.7
			X95	89.1	2 280	60.1	32.4
			G105	98.5	2 520	66.4	33.6
			S135	126.6	3 240	85.4	37.5

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb daN.m × 7.38 = lb.ft MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
4 (14 lb/ft) and 4 1/2 (13.75 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
4	14.00	I	E	127.0	3 160	74.7	78.2
			X95	160.8	4 000	94.6	99.1
			G105	177.8	4 420	104.5	109.6
			S135	228.6	5 680	134.4	139.1
		Premium	E	99.8	2 470	68.3	62.3
			X95	126.4	3 120	86.5	74.3
			G105	139.7	3 450	95.6	80.0
			S135	179.6	4 440	122.9	95.6
		II	E	86.5	2 130	59.7	50.3
			X95	109.5	2 700	75.7	59.1
			G105	121.0	2 990	83.6	63.0
			S135	155.6	3 840	107.5	72.5
4 1/2	13.75	I	E	120.2	3 510	54.5	49.6
			X95	152.2	4 450	69.0	57.9
			G105	168.2	4 920	76.3	61.7
			S135	216.3	6 320	98.1	71.1
		Premium	E	94.9	2 770	49.8	32.5
			X95	120.2	3 500	63.1	35.6
			G105	132.8	3 870	69.8	36.8
			S135	170.8	4 980	89.7	40.7
		II	E	82.5	2 400	43.6	23.4
			X95	104.5	3 040	55.2	26.5
			G105	115.5	3 360	61.0	27.7
			S135	148.4	4 320	78.5	29.6

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb daN.m × 7.38 = lb.ft MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
4 1/2 (16.60 lb/ft) and 4 1/2 (20.00 lb/ft)
(API RP 7G)

Nominal *diameter* (in)	Nominal *weight* (lb/ft)	*Class*	*Grade*	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
4 1/2	16.60	I	E	147.1	4 180	67.8	71.6
			X95	166.3	5 290	85.8	87.9
			G105	205.9	5 850	94.9	95.3
			S135	264.8	7 520	122.0	115.6
		Premium	E	115.7	3 270	62.0	52.0
			X95	146.6	4 150	78.5	61.0
			G105	162.0	4 580	86.7	65.2
			S135	208.3	5 890	111.5	75.8
		II	E	100.4	2 830	54.2	41.0
			X95	127.2	3 590	68.7	47.1
			G105	140.6	3 970	75.9	49.5
			S135	180.8	5 100	97.6	54.6
4 1/2	20.00	I	E	183.5	5 000	86.5	89.3
			X95	232.4	6 340	109.5	113.2
			G105	256.9	7 010	121.1	125.1
			S135	330.3	9 010	155.7	160.8
		Premium	E	143.7	3 890	79.1	75.7
			X95	182.0	4 930	100.1	95.8
			G105	201.2	5 440	110.6	105.8
			S135	258.7	7 000	142.3	129.9
		II	E	124.3	3 360	69.2	66.4
			X95	157.5	4 250	87.6	80.0
			G105	174.1	4 700	96.8	86.3
			S135	223.8	6 040	124.5	103.6

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for *Premium class and 30% for class II.*

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb daN.m × 7.38 = lb.ft MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
5 (19.50 lb/ft) and 5 (25.60 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
5	19.50	I	E	176.0	5 580	65.5	68.9
			X95	223.0	7 070	83.0	82.8
			G105	246.4	7 810	91.7	89.6
			S135	316.9	10 500	118.0	108.2
		Premium	E	138.6	4 380	59.9	48.7
			X95	175.6	5 540	75.8	56.7
			G105	194.1	6 130	83.8	60.4
			S135	249.5	7 880	107.8	69.3
		II	E	120.3	3 790	52.4	38.0
			X95	152.4	4 800	66.4	43.2
			G105	168.4	5 310	73.4	45.2
			S135	216.5	6 830	94.3	48.9
5	25.60	I	E	239.9	7 090	90.4	93.1
			X95	298.8	8 980	114.6	117.9
			G105	330.3	9 920	126.7	130.3
			S135	424.6	12 750	162.8	167.5
		Premium	E	184.5	5 500	82.7	79.0
			X95	233.7	6 960	104.8	100.0
			G105	258.3	7 700	115.8	110.6
			S135	332.2	9 900	148.9	141.6
		II	E	159.6	4 740	72.4	71.3
			X95	202.1	6 000	91.7	87.1
			G105	223.4	6 630	101.4	94.4
			S135	287.2	8 530	130.3	114.4

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb daN.m × 7.38 = lb.ft MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
5 1/2 (21.90 lb/ft) and 5 1/2 (24.70 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
5 1/2	21.90	I	E	194.5	6 880	59.4	58.2
			X95	246.4	8 710	75.2	68.9
			G105	272.3	9 630	83.1	74.0
			S135	350.1	12 380	106.9	87.6
		Premium	E	153.4	5 410	54.3	39.7
			X95	194.3	6 850	68.8	45.0
			G105	214.8	7 570	76.0	47.3
			S135	276.2	9 730	97.8	51.8
		II	E	133.2	4 720	47.5	29.9
			X95	168.8	5 940	60.2	32.6
			G105	186.5	6 560	66.5	33.8
			S135	239.8	8 440	85.5	37.7
5 1/2	24.70	I	E	221.3	7 670	68.5	72.1
			X95	280.3	9 720	86.5	89.1
			G105	309.8	10 740	95.6	96.5
			S135	398.3	13 810	122.9	117.5
		Premium	E	174.1	6 010	62.4	52.9
			X95	220.6	7 610	79.1	62.0
			G105	243.8	8 410	87.4	66.3
			S135	313.4	10 810	112.4	77.2
		II	E	151.0	5 200	54.6	41.7
			X95	191.3	6 590	69.2	48.0
			G105	211.4	7 290	76.5	50.5
			S135	271.9	9 370	98.3	56.0

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb daN.m × 7.38 = lb.ft MPa × 145 = psi

MECHANICAL PROPERTIES OF DRILL PIPES
6 5/8 (25.20 lb/ft)
(API RP 7G)

Nominal diameter (in)	Nominal weight (lb/ft)	Class	Grade	Tensile yield strength (1) (10^3 daN)	Torsional strength (2) (daN.m)	Burst pressure (3) (KPa)	Collapse pressure (3) (KPa)
6 5/8	25.20	I	E	217.8	9 570	45.1	33.2
			X95	275.9	12 120	57.1	36.6
			G105	304.9	13 400	63.1	37.8
			S135	392.1	17 230	81.1	41.6
		Premium	E	172	8 200	41.2	20.2
			X95	218	10 440	52.2	22.4
			G105	242	11 520	57.7	23.1
			S135	310	14 800	74.2	23.6
		II	E	150.0	6 580	36.1	15.4
			X95	190.0	8 330	45.7	16.2
			G105	210.0	9 210	50.5	16.2
			S135	270.0	11 840	64.9	16.2

(1) Based on uniform wear of 20% for Premium class and 30% for class II.

(2) Based on shear strength of 57.7% of minimum yield strength and uniform wear of 20% for Premium class and 30% for class II.

(3) Based on uniform wear of 20% for Premium class and 30% for class II.

daN × 2.25 = lb daN.m × 7.38 = lb.ft MPa × 145 = psi

MINIMUM OD AND MAKE-UP TORQUE RECOMMENDED FOR WELDED TOOL JOINTS, BASED ON TORSIONAL YIELD STRENGTH OF THE FEMALE TOOL JOINT AND THE DRILL PIPE (API RP 7G, 12th Edition, May 1987)

Nominal diameter (in)	Nominal weight (lb/ft)	Upset and Grade	Tool joint Type	Class I tool joint			Premium Class tool joint			Class II tool joint		
				Tool joint OD (mm)	Tool joint ID (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)
2 3/8 (60.33 mm)	4.85	EU E	NC26 (IF)	85.7	44.5	**439**	80.2	2.4	**251**	79.4	2.4	**220**
		EU E	WO	85.7	50.8	**307**	78.2	2.4	**251**	77.4	2.4	**220**
		EU E	OH	79.4	50.8	**307**	77.0	2.4	**251**	76.2	2.4	**220**
		EU E	SL-H90	82.6	50.8	**347**	75.4	2.4	**251**	74.6	2.4	**220**
	6.65	EU E	NC26 (IF)	85.7	44.5	**439**	81.8	2.4	**329**	81.0	2.4	**290**
		EU E	OH	82.6	44.5	**427**	78.6	2.8	**329**	77.8	2.4	**290**
		IU E	P.A.C.	73.0	34.9	**318**	71.0	4.0	**329**	69.8	3.2	**290**
		EU X	NC26 (IF)	85.7	44.5	**439**	83.7	3.6	**418**	82.5	2.8	**367**
		EU X	SL-H90	82.6	46.0	**467**	79.0	3.2	**418**	77.8	2.8	**367**
		EU G	NC26 (IF)	85.7	44.5	**439**	84.5	4.0	**462**	83.3	3.2	**406**
		EU G	SL-H90	82.6	46.0	**467**	79.8	3.6	**462**	78.6	3.2	**406**
2 7/8 (73.03 mm)	6.85	EU E	NC31 (IF)	104.8	54.0	**805**	94.5	2.4	**425**	93.7	2.4	**374**
		EU E	WO	104.8	61.9	**509**	92.9	2.4	**425**	92.1	2.4	**374**
		EU E	OH	95.3	61.9	**379**	88.9	2.8	**425**	88.1	2.4	**374**
		EU E	SL-H90	98.4	61.9	**517**	88.9	2.4	**425**	87.7	2.4	**374**
	10.40	EU E	NC31 (IF)	104.8	54.0	**805**	97.6	4.0	**609**	96.4	3.2	**536**
		EU E	OH	98.4	54.8	**598**	92.5	4.4	**609**	90.9	3.6	**536**
		EU E	SL-H90	98.4	54.8	**766**	91.7	3.6	**609**	90.5	3.2	**536**
		IU E	XH	108.0	47.6	**922**	95.6	4.0	**609**	94.5	3.6	**536**
		IU E	NC26	85.7	44.5	**439**	85.7	5.6	**527**	85.7	5.6	**527**
		IU E	PAC	79.4	38.1	**467**	79.4	7.1	**467**	79.4	7.1	**467**
		EU X	NC31 (IF)	104.8	50.8	**894**	100.0	5.2	**772**	98.4	4.4	**679**
		EU X	SL-H90	98.4	54.8	**897**	94.1	4.8	**772**	92.5	4.0	**679**
		EU G	NC31 (IF)	104.8	50.8	**894**	101.2	5.6	**853**	99.6	4.8	**751**
		EU G	SL-H90	101.6	50.8	**897**	95.3	5.6	**853**	93.7	4.8	**751**
		EU S	NC31 (IF)	111.1	41.3	**1149**	104.8	7.6	**1097**	102.8	6.3	**966**
		EU S	SL-H90	104.8	41.3	**1168**	98.4	7.1	**1097**	96.8	6.3	**966**

(1) The make-up torque calculations recommended for the tool joint imply the use of thread grease containing 40 to 60% by weight of finely powdered zinc, totally applied to all the threads and shoulders and not containing more than 0.3% sulfur. The calculation basis accounts for a tensile stress of 50% of the minimum tensile yield strength for Class I tool joints and of 60% of the minimum tensile yield strength for the other classes.

(2) Minimum box shoulder does not take account of bevel.

mm x 0.0394 = in daN.m x 7.38 = lb.ft

MINIMUM OD AND MAKE-UP TORQUE RECOMMENDED FOR WELDED TOOL JOINTS, BASED ON TORSIONAL YIELD STRENGTH OF THE FEMALE TOOL JOINT AND THE DRILL PIPE (API RP 7G, 12th Edition, May 1987) (continued)

Nominal diameter (in)	Nominal weight (lb/ft)	Upset and Grade	Tool joint Type	Class I tool joint			Premium tool joint			Class II tool joint		
				Tool joint OD (mm)	Tool joint ID (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)
3 1/2 (88.90 mm)	9.50	EU E	NC38 (IF)	120.7	68.3	**1228**	112.3	3.2	**744**	111.1	2.8	**654**
		EU E	NC38 (WO)	120.7	76.2	**904**	112.3	3.2	**744**	111.1	2.8	**654**
		EU E	OH	114.3	76.2	**805**	109.1	3.6	**744**	108.0	2.8	**654**
		EU E	SL-H90	117.5	76.2	**857**	106.8	3.2	**744**	105.6	2.4	**654**
	13.30	EU E	NC38 (IF)	120.7	68.3	**1228**	115.1	4.8	**978**	113.9	4.0	**860**
		EU E	OH	120.7	68.3	**1173**	111.9	4.8	**978**	110.7	4.4	**860**
		EU E	XH	120.7	61.9	**1186**	111.1	5.2	**978**	109.5	4.4	**860**
		EU E	H90	133.4	69.9	**1617**	116.3	4.0	**978**	115.1	3.2	**860**
		IU E	NC31 (SH)	104.8	54.0	**805**	104.8	7.5	**978**	101.2	5.6	**860**
		EU X	NC38 (IF)	127.0	65.1	**1378**	117.9	5.9	**1238**	116.3	5.2	**1090**
		EU X	SL-H90	120.7	65.1	**1415**	111.9	5.6	**1238**	110.3	4.8	**1090**
		EU X	H90	133.4	69.9	**1617**	118.7	5.2	**1238**	117.5	4.4	**1090**
		EU G	NC38 (IF)	127.0	61.9	**1506**	119.5	6.7	**1369**	117.5	6.0	**1204**
		EU G	SL-H90	120.7	65.1	**1415**	113.5	6.4	**1369**	111.5	5.6	**1204**
		EU S	NC38 (IF)	127.0	54.0	**1764**	123.4	8.7	**1760**	121.4	7.9	**1548**
		EU S	SL-H90	127.0	54.0	**1903**	117.5	8.3	**1760**	115.1	7.1	**1548**
		EU S	NC40 (4FH)	136.5	61.9	**2029**	128.6	7.9	**1760**	126.2	6.7	**1548**
	15.50	EU E	NC38 (IF)	127.0	65.1	**1378**	116.7	5.6	**1112**	115.1	4.8	**979**
		EU X	NC38 (IF)	127.0	61.9	**1506**	119.9	7.1	**1409**	117.9	6.0	**1240**
		EU G	NC38 (IF)	127.0	54.0	**1764**	121.4	7.9	**1557**	119.5	6.7	**1371**
		EU G	NC40 (4FH)	133.4	65.1	**1882**	126.6	7.1	**1557**	124.6	6.0	**1371**
		EU S	NC40 (4FH)	139.7	57.2	**2233**	130.6	9.1	**2002**	128.6	7.9	**1762**
4 (101.60 mm)	11.85	EU E	NC46 (IF)	152.4	82.6	**2280**	133.0	3.2	**1023**	132.2	2.8	**899**
		EU E	NC46 (WO)	146.1	87.3	**1998**	133.0	3.2	**1023**	132.2	2.8	**899**
		EU E	OH	133.4	88.1	**1489**	127.0	3.6	**1023**	125.8	3.2	**899**
		IU E	H90	139.7	71.4	**2403**	124.6	3.2	**1023**	123.4	2.8	**899**

(1) The make-up torque calculations recommended for the tool joint imply the use of thread grease containing 40 to 60% by weight of finely-powdered zinc, totally applied to all the threads and shoulders and not containing more than 0.3% sulfur. The calculation basis accounts for a tensile stress of 50% of the minimum tensile yield strength for Class I tool joints and of 60% of the minimum tensile yield strength for the other classes.

(2) Minimum box shoulder does not take account of bevel.

mm × 0.0394 = in   daN.m × 7.38 = lb.ft

MINIMUM OD AND MAKE-UP TORQUE RECOMMENDED FOR WELDED TOOL JOINTS, BASED ON TORSIONAL YIELD STRENGTH OF THE FEMALE TOOL JOINT AND THE DRILL PIPE (API RP 7G, 12th Edition, May 1987) (continued)

Nominal diameter (in)	Nominal weight (lb/ft)	Upset and Grade	Tool joint Type	Class I tool joint			Premium tool joint			Class II tool joint		
				Tool joint OD (mm)	Tool joint ID (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)
4 (101.60 mm)	14.00	EU E	NC46 (IF)	152.4	82.6	**2280**	134.9	4.0	**1226**	133.7	3.6	**1077**
		EU E	OH	139.7	82.6	**1849**	128.6	4.4	**1226**	127.4	4.0	**1077**
		IU E	H90	139.7	71.4	**2403**	126.2	4.0	**1226**	125.0	3.6	**1077**
		IU E	NC40 (FH)	133.4	71.4	**1592**	123.0	5.2	**1226**	121.8	4.8	**1077**
		IU E	SH	117.5	65.1	**1056**	113.9	6.7	**1226**	112.3	6.0	**1077**
		EU X	NC46 (IF)	152.4	82.6	**2280**	137.7	5.6	**1552**	136.1	4.8	**1365**
		IU X	NC40 (FH)	133.4	68.3	**1740**	126.2	6.7	**1552**	124.6	6.0	**1365**
		IU X	H90	139.7	71.4	**2403**	129.0	5.6	**1552**	127.4	4.8	**1365**
		EU G	NC46 (IF)	152.4	82.6	**2280**	138.9	6.0	**1716**	137.3	5.2	**1508**
		IU G	NC40 (FH)	139.7	61.9	**2042**	127.8	7.5	**1716**	125.8	6.7	**1508**
		IU G	H90	139.7	71.4	**2403**	130.6	6.4	**1716**	128.6	5.2	**1508**
		EU S	NC46 (IF)	152.4	76.2	**2559**	142.5	7.9	**2206**	140.5	6.7	**1939**
		IU S	NC40 (FH)	139.7	50.8	**2465**	132.6	9.9	**2206**	130.2	8.7	**1939**
		IU S	H90	139.7	71.4	**2402**	134.1	7.9	**2206**	132.2	7.1	**1939**
4 1/2 (114.30 mm)	13.75	EU E	NC50 (IF)	161.9	95.3	**2554**	144.9	4.0	**1360**	143.3	3.2	**1195**
		EU E	NC50 (WO)	155.6	98.4	**2335**	144.9	4.0	**1360**	143.3	3.2	**1195**
		EU E	OH	146.1	100.8	**1421**	136.9	4.4	**1360**	135.7	3.6	**1195**
		IU E	H90	152.4	82.6	**2645**	134.9	4.0	**1360**	133.4	3.2	**1195**
	16.60	EU E	NC50 (IF)	161.9	95.3	**2554**	146.4	4.8	**1620**	145.3	4.0	**1424**
		EU E	OH	149.2	95.3	**1849**	138.9	5.2	**1620**	137.7	4.8	**1424**
		IEU E	NC46 (XH)	158.8	82.6	**2305**	138.1	5.6	**1620**	136.5	4.8	**1424**
		IEU E	FH	152.4	76.2	**2358**	137.7	6.0	**1620**	136.1	5.2	**1424**
		IEU E	H90	152.4	82.6	**2645**	130.5	4.8	**1620**	135.3	4.4	**1424**
		EU X	NC50 (IF)	161.9	95.3	**2554**	149.6	6.4	**2052**	147.6	5.2	**1804**
		IEU X	NC46 (XH)	158.8	76.2	**2688**	141.3	7.1	**2052**	139.7	6.4	**1804**
		IEU X	FH	152.4	69.9	**2358**	141.3	7.5	**2052**	139.3	6.7	**1804**
		IEU X	H90	152.4	76.2	**2645**	139.4	6.4	**2052**	138.1	5.6	**1804**

(1) The make-up torque calculations recommended for the tool joint imply the use of thread grease containing 40 to 60% by weight of finely-powdered zinc, totally applied to all the threads and shoulders and not containing more than 0.3% sulfur. The calculation basis accounts for a tensile stress of 50% of the minimum tensile yield strength for Class I tool joints and of 60% of the minimum tensile yield strength for the other classes.

(2) Minimum box shoulder does not take account of bevel.

mm × 0.0394 = in   daN.m × 7.38 = lb.ft

MINIMUM OD AND MAKE-UP TORQUE RECOMMENDED FOR WELDED TOOL JOINTS, BASED ON TORSIONAL YIELD STRENGTH OF THE FEMALE TOOL JOINT AND THE DRILL PIPE (API RP 7G, 12th Edition, May 1987) (continued)

Nominal diameter (in)	Nominal weight (lb/ft)	Upset and Grade		Tool joint Type	Class I tool joint			Premium tool joint			Class II tool joint		
					Tool joint OD (mm)	Tool joint ID (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)
4 1/2 (114.30 mm)	16.60	EU	G	NC50 (IF)	161.9	95.3	**2554**	150.8	6.7	**2266**	149.2	6.0	**1994**
		IEU	G	NC46 (XH)	158.8	76.2	**2689**	143.3	8.3	**2268**	140.9	7.1	**1994**
		IEU	G	FH	152.4	69.9	**2358**	143.3	8.7	**2268**	140.9	7.5	**1994**
		IEU	G	H90	152.4	76.2	**2645**	141.3	7.1	**2266**	139.3	6.4	**1994**
		EU	S	NC50 (IF)	161.9	88.9	**3028**	155.2	9.1	**2916**	152.8	7.9	**2563**
		IEU	S	NC46 (XH)	158.8	69.9	**3042**	148.0	10.7	**2916**	145.3	9.1	**2563**
		IEU	S	FH	158.8	63.5	**3035**	148.0	11.1	**2916**	145.7	9.9	**2563**
		IEU	S	H90	152.4	76.2	**3068**	145.7	9.5	**2916**	143.3	8.3	**2563**
	20.00	EU	E	NC50 (IF)	161.9	92.1	**2795**	148.8	6.0	**1944**	147.2	5.2	**1710**
		IEU	E	NC46 (XH)	158.8	76.2	**2689**	140.5	6.7	**1944**	138.9	6.0	**1710**
		IEU	E	FH	152.4	76.2	**2358**	140.5	7.1	**1944**	138.5	6.4	**1710**
		IEU	E	H90	152.4	76.2	**3068**	138.9	6.0	**1944**	137.3	5.2	**1710**
		EU	X	NC50 (IF)	161.9	88.9	**3028**	152.4	7.5	**2462**	150.4	6.7	**2165**
		IEU	X	NC46 (XH)	158.8	69.9	**3042**	144.5	8.7	**2462**	142.5	7.9	**2165**
		IEU	X	FH	152.4	63.5	**2932**	144.9	9.5	**2462**	142.5	8.3	**2165**
		IEU	X	H90	152.4	76.2	**2645**	142.9	7.9	**2462**	140.5	6.7	**2165**
		EU	G	NC50 (IF)	161.9	88.9	**3028**	154.0	8.3	**2721**	152.0	7.5	**2393**
		IEU	G	NC46 (XH)	158.8	63.5	**3365**	146.4	9.9	**2721**	144.1	8.7	**2393**
		IEU	G	FH	152.4	63.5	**2932**	146.8	10.3	**2721**	144.1	9.1	**2393**
		IEU	G	H90	152.4	76.2	**2645**	144.5	8.7	**2721**	142.1	7.5	**2393**
		EU	S	NC50 (IF)	168.3	76.2	**3777**	159.1	11.1	**3499**	156.4	9.5	**3077**
		IEU	S	NC46 (XH)	158.8	57.2	**3656**	152.0	12.7	**3499**	149.2	11.1	**3077**
5 (127 mm)	19.50	IEU	E	NC50 (XH)	161.9	95.3	**2554**	150.4	6.7	**2164**	148.4	5.6	**1902**
		IEU	E	5 1/2 FH	177.8	95.3	**4159**	162.7	5.2	**2164**	161.1	4.4	**1902**
		IEU	X	NC50 (XH)	161.9	88.9	**3028**	154.0	8.3	**2741**	152.0	7.5	**2409**
		IEU	X	H90	165.1	82.6	**3516**	149.6	7.9	**2741**	147.6	7.1	**2409**
		IEU	X	5 1/2 FH	177.8	95.3	**4159**	165.9	6.7	**2741**	164.3	6.0	**2409**

(1) The make-up torque calculations recommended for the tool joint imply the use of thread grease containing 40 to 60% by weight of finely-powdered zinc, totally applied to all the threads and shoulders and not containing more than 0.3% sulfur. The calculation basis accounts for a tensile stress of 50% of the minimum tensile yield strength for Class I tool joints and of 60% of the minimum tensile yield strength for the other classes.

(2) Minimum box shoulder does not take account of bevel.

mm × 0.0394 = in daN.m × 7.38 = lb.ft

MINIMUM OD AND MAKE-UP TORQUE RECOMMENDED FOR WELDED TOOL JOINTS, BASED ON TORSIONAL YIELD STRENGTH OF THE FEMALE TOOL JOINT AND THE DRILL PIPE (API RP 7G, 12th Edition, May 1987) (continued)

Nominal diameter (in)	Nominal weight (lb/ft)	Upset and Grade	Tool joint Type	Class I tool joint			Premium tool joint			Class II tool joint		
				Tool joint OD (mm)	Tool joint ID (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)	Tool joint minimum OD (mm)	Minimum box shoulder with eccentric wear (2) (mm)	Make-up torque (1) (daN.m)
5 (127 mm)	19.50	IEU G	NC50 (XH)	165.1	82.6	**3488**	156.0	9.5	**3030**	153.6	8.3	**2663**
		IEU G	H90	165.1	76.2	**3964**	151.2	8.7	**3030**	149.2	7.9	**2663**
		IEU G	5 1/2 FH	177.8	95.3	**4159**	167.5	7.5	**3030**	165.5	6.7	**2663**
		IEU S	NC50 (XH)	168.3	69.9	**4229**	161.5	12.3	**3896**	158.4	10.7	**3424**
		IEU S	5 1/2 FH	184.2	88.9	**4914**	172.2	9.9	**3896**	169.9	8.7	**3424**
	25.60	IEU E	NC50 (XH)	161.9	88.9	**3028**	154.4	8.7	**2753**	152.0	7.5	**2422**
		IEU E	5 1/2 FH	177.8	88.9	**4159**	165.9	6.7	**2753**	164.3	6.0	**2422**
		IEU X	NC50 (XH)	165.1	76.2	**3777**	158.8	10.7	**3488**	156.4	9.5	**3068**
		IEU X	5 1/2 FH	177.8	88.9	**4159**	170.3	9.1	**3488**	167.9	7.9	**3068**
		IEU G	NC50 (XH)	168.3	69.9	**4229**	161.1	11.9	**3855**	158.4	10.7	**3391**
		IEU G	5 1/2 FH	184.2	88.9	**4914**	172.2	9.9	**3855**	169.5	8.7	**3391**
		IEU S	5 1/2 FH	184.2	82.6	**5230**	177.8	12.7	**4956**	174.6	11.1	**4360**
5 1/2 (139.70 mm)	21.90	IEU E	FH	177.8	101.6	**3792**	165.5	6.7	**2665**	163.9	6.0	**2341**
		IEU X	FH	177.8	95.3	**4159**	169.5	8.7	**3375**	167.1	7.5	**2965**
		IEU X	H90	177.8	88.9	**4012**	158.4	9.1	**3375**	156.0	7.9	**2965**
		IEU G	FH	184.2	88.9	**4914**	171.5	9.5	**3730**	169.1	8.3	**3277**
		IEU S	FH	190.5	76.2	**5909**	177.0	12.3	**4796**	173.8	10.7	**4214**
	24.70	IEU E	FH	177.8	101.6	**3792**	167.5	7.5	**2975**	165.1	6.4	**2615**
		IEU X	FH	184.2	88.9	**4914**	171.5	9.5	**3769**	169.1	8.3	**3313**
		IEU G	FH	184.2	88.9	**4914**	173.8	10.7	**4166**	171.1	9.5	**3661**
		IEU S	FH	190.5	76.2	**5909**	179.8	13.9	**5356**	176.6	12.3	**4703**

(1) The make-up torque calculations recommended for the tool joint imply the use of thread grease containing 40 to 60% by weight of finely-powdered zinc, totally applied to all the threads and shoulders and not containing more than 0.3% sulfur. The calculation basis accounts for a tensile stress of 50% of the minimum tensile yeld strength for Class I tool joints and of 60% of the minimum tensile yield strength for the other classes.

(2) Minimum box shoulder does not take account of bevel.

mm × 0.0394 = in daN.m × 7.38 = lb.ft

THREAD DIMENSIONS OF ROTARY SHOULDERED CONNECTIONS

(API Spec 7)

(See Fig. B 28) All dimensions in mm

Connection No. or size (1)	Thread form	Threads per inch	Taper (%)	Pitch diameter at gage point	Large pin diameter	Flat diameter on pin ± 0.40	Small pin diameter	Pin length + 0 − 3.18	Minimum length of box thread	Box counterbore + 9.52 − 0	Box inside diameter + 0.79 − 0.40
				C	D_L	D_{LF}	D_S	L_{PC}	L_{BT}	L_{BC}	Q_C
+ NC10	V-0.055	6	12.5	27.0	30.2		25.5	38.1	41.3	54.0	30.6
+ NC12	V-0.055	6	12.5	32.1	35.4		29.8	44.4	47.6	60.3	35.7
+ NC13	V-0.055	6	12.5	35.3	38.6		33.0	44.4	47.6	60.3	38.9
+ NC16	V-0.055	6	12.5	40.9	44.1		38.5	44.4	47.6	60.3	44.5
NC23	V-0.038R	4	16.66	59.8	65.1	61.9	52.4	76.2	79.4	92.1	66.7
NC26*	V-0.038R	4	16.66	67.8	73.1	69.8	60.4	76.2	79.4	92.1	74.6
NC31*	V-0.038R	4	16.66	80.8	86.1	83.0	71.3	88.9	92.1	104.8	87.7
NC35	V-0.038R	4	16.66	89.7	95.0	92.1	79.1	95.2	98.4	111.1	96.8
NC38*	V-0.038R	4	16.66	96.7	102.0	98.8	85.1	101.6	104.8	117.5	103.6
NC40*	V-0.038R	4	16.66	103.4	108.7	105.6	89.7	114.3	117.5	130.2	110.3
NC44	V-0.038R	4	16.66	112.2	117.5	114.3	98.4	114.3	117.5	130.2	119.1
NC46*	V-0.038R	4	16.66	117.5	122.8	119.6	103.7	114.3	117.5	130.2	124.6
NC50*	V-0.038R	4	16.66	128.1	133.4	130.4	114.3	114.3	117.5	130.2	134.9
NC56	V-0.038R	4	25.00	142.6	149.3	144.9	117.5	127.0	130.2	142.9	150.8
NC61	V-0.038R	4	25.00	156.9	163.5	159.2	128.6	139.7	142.9	155.6	165.1
NC70	V-0.038R	4	25.00	179.1	185.8	181.4	147.7	152.4	155.6	168.3	187.3
NC77	V-0.038R	4	25.00	196.6	203.2	198.8	162.0	165.1	168.3	181.0	204.8
2 3/8 REG	V-0.040	5	25.00	60.1	66.7	—	47.6	76.2	79.4	92.1	68.3
2 7/8 REG	V-0.040	5	25.00	69.6	76.2	—	54.0	88.9	92.1	104.8	77.8
3 1/2 REG	V-0.040	5	25.00	82.2	88.9	—	65.1	95.2	98.4	111.1	90.5
4 1/2 REG	V-0.040	5	25.00	110.9	117.5	—	90.5	108.0	111.1	123.8	119.1
5 1/2 REG	V-0.050	4	25.00	132.9	140.2	—	110.1	120.6	123.8	136.5	141.7
6 5/8 REG	V-0.050	4	16.66	146.2	152.2	—	131.0	127.0	130.2	142.9	154.0
7 5/8 REG	V-0.050	4	25.00	170.5	177.8	—	144.5	133.4	136.5	149.2	180.2
8 5/8 REG	V-0.050	4	25.00	194.7	202.0	—	167.8	136.5	139.7	152.4	204.4
5 1/2 FH	V-0.050	4	16.66	142.0	148.0	—	126.8	127.0	130.2	142.9	150.0

Note: Connections marked with a + are tentative.

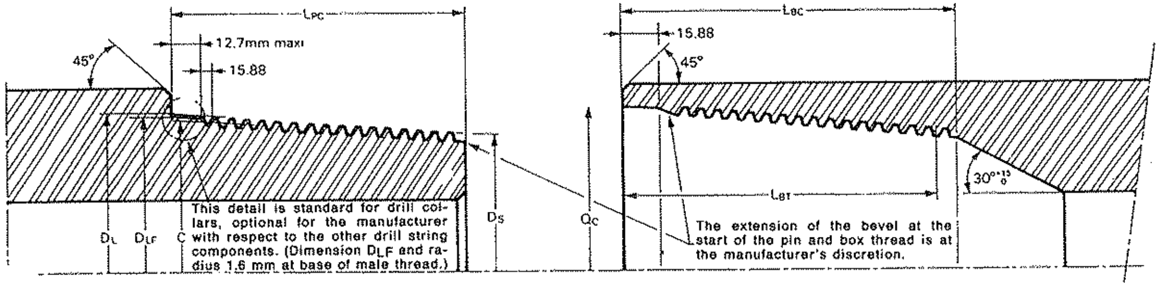
(1) The NC connection No. is the pitch diameter in inches of the pin thread at the gage point (C), rounded off to units and tenths of an inch.

* NC connections are interchangeable with connections having the same pitch diameter in the FH and IF styles. These connections differ only in the form of the thread. Like the thread, the connections are interchangeable:

NC26	2 3/8 IF
NC31	2 7/8 IF
NC38	3 1/2 IF
NC40	4 FH
NC46	4 IF
NC50	4 1/2 IF

mm × 0.0394 = in

SHOULDERED CONNECTIONS



This detail is standard for drill collars, optional for the manufacturer with respect to the other drill string components. (Dimension D_{LF} and radius 1.6 mm at base of male thread.)

The extension of the bevel at the start of the pin and box thread is at the manufacturer's discretion.

DIMENSIONS OF OBSOLETE SHOULDERED CONNECTIONS
(API Spec 7, Appendix I)

(See Fig. B 28) All dimensions in mm

Connection No. or size	Thread form	Threads per inch	Taper (%)	Pitch diameter at gage point	Large pin diameter	Flat diameter on pin ± 0.40	Small pin diameter	Pin length + 0 − 3.18	Minimum length of box thread	Box counterbore + 9.52 − 0	Box inside diameter + 0.79 − 0.40
				C	D_L	D_{LF}	D_S	L_{PC}	L_{BT}	L_{BC}	Q_C
3 1/2 FH	V-0.040	5	25.00	94.8	101.4	—	77.6	95.2	98.4	111.1	102.8
4 FH	V-0.065	4	16.66	103.4	108.7	105.6	89.7	114.3	117.5	130.2	110.3
4 1/2 FH	V-0.040	5	25.00	115.1	121.7	—	96.3	101.6	104.8	117.5	123.8
6 5/8 FH	V-0.050	4	16.66	165.6	171.5	—	150.4	127.0	130.2	142.9	173.8
2 3/8 IF	V-0.065	4	16.66	67.8	73.1	69.8	60.4	76.2	79.4	92.1	74.6
2 7/8 IF	V-0.065	4	16.66	80.8	86.1	83.0	71.3	88.9	92.1	104.8	87.7
3 1/2 IF	V-0.065	4	16.66	96.7	102.0	98.8	85.1	101.6	104.8	117.5	103.6
4 IF	V-0.065	4	16.66	117.5	122.8	119.6	103.7	114.3	117.5	130.2	124.6
4 1/2 IF	V-0.065	4	16.66	128.1	133.4	130.4	114.3	114.3	117.5	130.2	134.9
5 1/2 IF	V-0.065	4	16.66	157.2	162.5	—	141.3	127.0	130.2	142.9	163.9

mm × 0.0394 = in

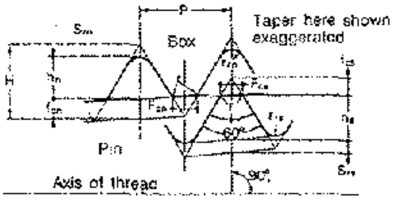
API THREAD FORMS AND DIMENSIONS
(API Spec 7)

All dimensions in mm

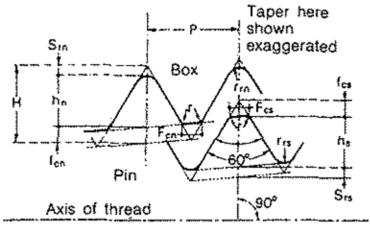
Thread form	Taper (%)	Thread height not truncated	Thread height truncated	Root truncation	Crest truncation	Width of flat		Root radius	Radius at thread corners
						Crest	Root		
	(1)	H	$h_n = h_s$	$S_{rn} = S_{rs}$ $f_{rn} = f_{rs}$	$f_{cn} = f_{cs}$	$F_{cn} = F_{cs}$	$F_{rn} = F_{rs}$	$r_{rn} = r_{rs}$	r
V-0.038R	16.66	5.5	3.1	1.0	1.4	1.7	—	1.0	0.4
V-0.038R	25.00	5.5	3.1	1.0	1.4	1.7	—	1.0	0.4
V-0.040	25.00	4.4	3.0	0.5	0.9	1.0	—	0.5	0.4
V-0.050	25.00	5.5	3.7	0.6	1.1	1.3	—	0.6	0.4
V-0.050	16.66	5.5	3.8	0.6	1.1	1.3	—	0.6	0.4
V-0.065 (2)	16.66	5.5	2.8	1.2	1.4	1.7	1.4	—	0.4

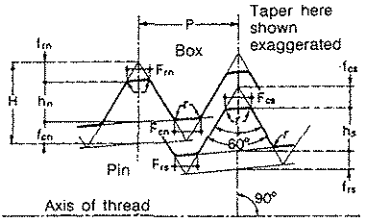
(1) Taper (%) equal 8.33 × taper in in/ft.

(2) Obsolete thread form, to be removed from the Standards at a later date.



V-0.038 R product thread form





V-0.040 and V-0.050 product thread form

V-0.065 product thread form
Obsolescent. To be removed at a later date

mm × 0.0394 = in

CHARACTERISTICS OF SOME NON-API TOOL JOINT THREADS

The dimensions in the tables below are given only to identify the type of thread. In particular, the joint outside and inside diameters, the diameter of the cylindrical part possibly turned at the base of the pin, and the lengths of the threaded parts, which differ, for the same shape, from one manufacturer to another, have not been indicated below.

Size (in)	Pin		Box Q_C (1) (mm)	Taper (%)	Threads/ in	Thread form	Make-up torque (daN.m)
	D_{LF} (1) (mm)	C (mm)					
Extra Hole (XH) style							
2 7/8	84.5	79.2	85.3	16.66	4	V-0.065	760-950
3 1/2	96.8	91.5	98.4	16.66	4	V-0.065	975-1220
4 1/2	122.8	117.5	124.6	16.66	4	V-0.065	1950-2440
5	133.3	128.1	134.9	16.66	4	V-0.065	2140-2515
Double streamline style							
3 1/2	84.5	79.2	85.3	16.66	4	V-0.065	570-705
4	98.7	93.4	99.6	16.66	4	V-0.065	870-1080
4 1/2	108.7	103.4	110.3	16.66	4	V-0.065	1060-1330
5 1/2	133.3	128.1	134.9	16.66	4	V-0.065	1900-2370
Slim Hole (SH) style							
2 7/8	73.1	67.8	74.6	16.66	4	V-0.065	390-490
3 1/2	86.1	80.8	87.7	16.66	4	V-0.065	650-800
4	96.8	91.5	98.4	16.66	4	V-0.065	870-1080
4 1/2	102.0	96.7	103.6	16.66	4	V-0.065	1060-1330
Hughes H90 style							
3 1/2	104.8	99.8	106.4	16.66	3 1/2	H90	1300-1630
4	114.3	109.3	115.9	16.66	3 1/2	H90	2000-2450
4 1/2	122.8	117.8	124.2	16.66	3 1/2	H90	2200-2700
Reed Wide Open (WO) style							
2 3/8	71.5	66.2	72.6	16.66	4	V-0.065	245-300
2 7/8	84.5	79.3	85.7	16.66	4	V-0.065	405-515
3 1/2	102.0	96.7	103.6	16.66	4	V-0.065	730-920
4	122.8	117.5	124.6	16.66	4	V-0.065	670-2050
4 1/2	133.3	128.1	134.9	16.66	4	V-0.065	900-2370

(1) Identical to those used to define the characteristics of API too joint threads.

mm × 0.0394 = in   daN.m × 7.38 = lb.ft

CHARACTERISTICS OF SOME NON-API TOOL JOINT THREADS
(continued)

Size (in)	Pin		Box Q_C (1) (mm)	Taper (%)	Threads/ in	Thread form	Make-up torque (daN.m)
	D_{LF} (1) (mm)	C (mm)					
American Open Hole (OH) style							
2 3/8	69.8	65.7	71.4	12.5	4	Special American	260- 325
2 7/8	79.9	75.8	81.8	12.5	4		490- 610
3 1/2	98.8	94.7	100.4	12.5	4		650- 810
4	116.3	112.2	117.9	12.5	4		1520-1900
4 1/2	124.8	120.7	126.6	12.5	4		1170-1460

Size (in)	Pin		Taper (%)	Threads/ in	Hydril special thread	Make-up torque (daN.m)
	D_{LF} (1) (mm)	C (mm)				
Hydril IF style						
2 3/8	71.3	100.0	4.17	3	2 steps	515
2 7/8	80.8	100.0	4.17	3	2 steps	730
3 1/2	97.5	100.0	4.17	3	2 steps	895
4 1/2	*132.1*	*101.6*	*4.47*	*3*	*2 steps*	*1550*
Hydril EIU style						
3 1/2	95.0	107.9	4.17	3	2 steps	895
4	118.4	109.6	4.17	3	2 steps	1550
4 1/2	120.4	112.7	4.17	3	2 steps	1550
5 1/2	148.2	139.7	4.17	2	2 steps	2060
Hydril SH style						
2 7/8	71.3	100.0	4.17	3	2 steps	580
3 1/2	80.8	100.0	4.17	3	2 steps	730
4	97.5	100.0	4.17	3	2 steps	895
4 1/2	106.5	104.8	4.17	3	2 steps	1180
5 1/2	132.1	101.6	4.17	3	2 steps	1550
Hydril F style						
2 3/8	48.9	65.1	4.17	4	1 step	215
2 7/8	60.1	90.5	4.17	4	2 steps	365
3 1/2	71.3	101.6	4.17	3	2 steps	580
4	84.8	100.0	4.17	3	2 steps	730
4 1/2	97.5	100.0	4.17	3	2 steps	895
5 1/2	118.4	106.4	4.17	3	2 steps	1550

(1) Identical to those used to define the characteristics of API tool joint threads.

mm × 0.0394 = in   daN.m × 7.38 = lb.ft

ROTARY SHOULDERED CONNECTION INTERCHANGE LIST

Common name		Pin base diameter tapered D_L (mm)	Threads per in	Taper (%)	Thread form (1)	Same as or interchanges with (2)
Style	Size					
Internal Flush (IF)	2 3/8	73.1	4	16.66	V-0.065 (V-0.038R)	2 7/8 Slim Hole **NC26**
	2 7/8	86.1	4	16.66	V-0.065 (V-0.038R)	3 1/2 Slim Hole **NC31**
	3 1/2	102.0	4	16.66	V-0.065 (V-0.038R)	4 1/2 Slim Hole **NC38**
	4	122.8	4	16.66	V-0.065 (V-0.038R)	4 1/2 Extra Hole **NC38**
	4 1/2	133.4	4	16.66	V-0.065 (V-0.038R)	5 Extra Hole **NC50** 5 1/2 Double Streamline
Full Hole (FH)	4	108.7	4	16.66	V-0.065 (V-0.038R)	4 1/2 Double Streamline **NC40**
Extra Hole (XH) EH	2 7/8	84.5	4	16.66	V-0.065 (V-0.038R)	3 1/2 Double Streamline
	3 1/2	96.8	4	16.66	V-0.065 (V-0.038R)	4 Slim Hole 4 1/2 External Flush
	4 1/2	122.8	4	16.66	V-0.065 (V-0.038R)	4 Internal Flush **NC46**
	5	133.4	4	16.66	V-0.065 (V-0.038R)	4 1/2 Internal Flush **NC50** 5 1/2 Double Streamline
Slim Hole (SH)	2 7/8	73.1	4	16.66	V-0.065 (V-0.038R)	2 3/8 Internal Flush **NC26**
	3 1/2	86.1	4	16.66	V-0.065 (V-0.038R)	2 7/8 Internal Flush **NC31**
	4	96.8	4	16.66	V-0.065 (V-0.038R)	3 1/2 Extra Hole 4 1/2 External Flush
	4 1/2	102.0	4	16.66	V-0.065 (V-0.038R)	3 1/2 Internal Flush **NC38**

(1) Connections with two thread forms shown may be machined with either thread form without affecting gaging or interchangeability.

(2) Numbered connections (NC) may be machined only with the V-0.038 radius thread form.

mm × 0.0394 = in

ROTARY SHOULDERED CONNECTION INTERCHANGE LIST (continued)

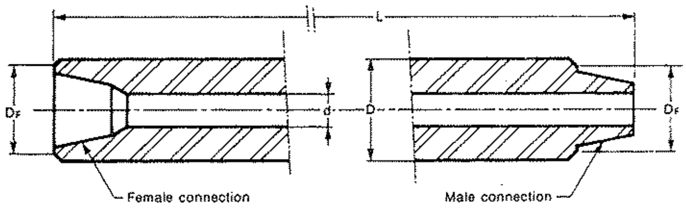
Common name		Pin base diameter tapered D_L (mm)	Threads per in	Taper (%)	Thread form (1)	Same as or interchanges with (2)
Style	Size					
Double Streamline (DSL)	3 1/2	84.5	4	16.66	V-0.065 (V-0.038R)	2 7/8 Extra Hole
	4 1/2	108.7	4	16.66	V-0.065 (V-0.038R)	4 Full Hole **NC40**
	5 1/2	133.4	4	16.66	V-0.065 (V-0.038R)	4 1/2 Internal Flush 5 Extra Hole **NC50**
Numbered Connection (NC)	**26**	73.1	4	16.66	V-0.038R	2 3/8 Internal Flush 2 7/8 Slim Hole
	31	86.1	4	16.66	V-0.038R	2 7/8 Internal Flush 3 1/2 Slim Hole
	38	102.0	4	16.66	V-0.038R	3 1/2 Internal Flush 4 1/2 Slim Hole
	40	108.7	4	16.66	V-0.038R	4 Full Hole 4 1/2 Double Streamline
	46	122.8	4	16.66	V-0.038R	4 Internal Flush 4 1/2 Extra Hole
	50	133.4	4	16.66	V-0.038R	4 1/2 Internal Flush 5 Extra Hole 5 1/2 Double Streamline
External Flush (EF)	4 1/2	96.8	4	16.66	V-0.065 (V-0.038R)	4 Slim Hole 3 1/2 Extra Hole

(1) Connections with two thread forms shown may be machined with either thread form without affecting gaging or interchangeability.

(2) Numbered connections (NC) may be machined only with the V-0.038 radius thread form.

mm × 0.0394 = in

CYLINDRICAL DRILL COLLARS
Dimensions and threads (API Spec 7)



Drill collar No. (1)	Outside diameter D		Bore *d*		Length ± 0.15 *L* (m)	Diameter at bevel ± 0.4 D_F (mm)	BSR
	(in)	(mm)	+ 1/16 − 0 (in)	+ 1.6 − 0 (mm)			
NC23-31	3 1/8	79.4	1 1/4	31.8	9.1	76.2	2.57
NC26-35 (2 3/8 IF) . .	3 1/2	88.9	1 1/2	38.1	9.1	82.9	2.42
NC31-41 (2 7/8 IF) . .	4 1/8	104.8	2	50.8	9.1	100.4	2.43
NC35-47	4 3/4	120.7	2	50.8	9.1	114.7	2.58
NC38-50 (3 1/2 IF) . .	5	127.0	2 1/4	57.2	9.1	121.0	2.38
NC44-60	6	152.4	2 1/4	57.2	9.1 or 9.4	144.5	2.49
NC44-60	6	152.4	2 13/16	71.4	9.1 or 9.4	144.5	2.84
NC44-62	6 1/4	158.8	2 1/4	57.2	9.1 or 9.4	149.2	2.91
NC46-62 (4 IF)	6 1/4	158.8	2 13/16	71.4	9.1 or 9.4	150.0	2.63
NC46-65 (4 IF)	6 1/2	165.1	2 1/4	57.2	9.1 or 9.4	154.8	2.76
NC46-65 (4 IF)	6 1/2	165.1	2 13/16	71.4	9.1 or 9.4	154.8	3.05
NC46-67 (4 IF)	6 3/4	171.5	2 1/4	57.2	9.1 or 9.4	159.5	3.18
NC50-70 (4 1/2 IF) . .	7	177.8	2 1/4	57.2	9.1 or 9.4	164.7	2.54
NC50-70 (4 1/2 IF) . .	7	177.8	2 13/16	71.4	9.1 or 9.4	164.7	2.73
NC50-72 (4 1/2 IF) . .	7 1/4	184.2	2 13/16	71.4	9.1 or 9.4	169.5	3.12
NC56-77	7 3/4	196.9	2 13/16	71.4	9.1 or 9.4	185.3	2.70
NC56-80	8	203.2	2 13/16	71.4	9.1 or 9.4	190.1	3.02
6 5/8 REG	8 1/4	209.6	2 13/16	71.4	9.1 or 9.4	195.7	2.93
NC61-90	9	228.6	2 13/16	71.4	9.1 or 9.4	212.7	3.17
7 5/8 REG	9 1/2	241.3	3	76.2	9.1 or 9.4	223.8	2.81
NC70-97	9 3/4	247.7	3	76.2	9.1 or 9.4	232.6	2.57
NC70-100	10	254.0	3	76.2	9.1 or 9.4	237.3	2.81
NC77-110	11	279.4	3	76.2	9.1 or 9.4	260.7	2.78

(1) The drill collar number consists of two parts separated by a hyphen. The first part is the connection number in the NC style. The second part, consisting of 2 (or 3) digits, indicates the drill collar outside diameter in units and tenths of inches. The connections shown in parentheses in Col. 1 are not a part of the drill collar number; they indicate interchangeability of drill collars made with the standard (NC) connections as shown. If the connections shown in parentheses in column 1 are made with the V-0.038R thread form the connections, and drill collars, are identical with those in the NC style. Drill collars with 8 1/4 and 9 1/2 inches outside diameters are shown with 6 5/8 and 7 5/8 REG connections, since there are no NC connections in the recommended bending strength ratio range.

mm × 0.0394 = in m × 3.28 = ft

WEIGHT OF DRILL COLLARS (kg/m)

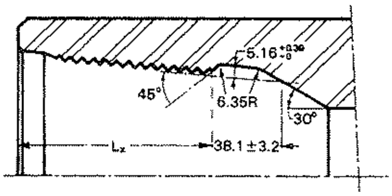
Size outside diameter		Inside diameter (in and mm)														
		1.00	1.25	1.50	1.75	2.00	**2.25**	2.50	2.75	**2.8125**	2.875	**3.00**	3.25	3.50	3.75	4.00
(in)	(mm)	25.40	31.75	38.10	44.45	50.80	**57.15**	63.50	69.85	**71.44**	73.03	**76.20**	82.55	88.90	95.25	101.60
2.875	73.0	28.9	26.7	23.9												
3.000	76.2	31.8	29.6	26.8												
3.125	79.4	34.9	32.6	29.9												
3.250	82.6	38.0	35.8	33.1												
3.500	88.9	44.7	42.5	39.8												
3.750	95.3	52.0	49.7	47.0	43.8											
4.000	101.6	59.7	57.4	54.7	51.5	47.7	43.5									
4.125	104.8	63.7	61.5	58.7	55.5	51.8	47.5									
4.250	108.0	67.9	65.6	62.9	59.7	55.9	51.7									
4.500	114.3	76.6	74.3	71.6	68.4	64.6	60.4									
4.750	**120.7**	**85.8**	**83.5**	**80.8**	**77.6**	**73.8**	**69.6**	**64.9**								
5.000	127.0			90.5	87.3	83.5	79.3	74.6	69.4							
5.250	133.4			100.7	97.5	93.7	89.5	84.8	79.6	78.2	76.8	73.8				
5.500	139.7			111.4	108.1	104.4	100.2	95.5	90.2	88.9	87.4	84.5				
5.750	146.1			122.6	119.3	115.6	111.4	106.7	101.4	100.0	98.6	95.7	89.5			
6.000	152.4			134.2	131.0	127.3	123.1	118.3	113.1	111.7	110.3	107.4	101.2	94.5	87.3	
6.250	158.8			146.4	143.2	139.5	135.2	130.5	125.3	123.9	122.6	119.6	113.4	106.7	99.4	
6.375	161.9			152.7	149.5	145.7	141.5	136.8	131.6	130.2	128.8	125.9	119.6	112.9	105.7	
6.500	165.1			159.1	155.9	152.1	147.9	143.2	136.0	136.6	135.2	132.3	126.0	119.3	112.1	
6.625	168.3			165.6	162.4	158.7	154.4	149.7	144.5	143.1	141.7	138.8	132.6	125.9	118.6	
6.750	**171.5**			**172.3**	**169.1**	**165.3**	**161.1**	**156.4**	**151.2**	**149.8**	**148.4**	**145.4**	139.2	132.5	125.3	117.6
7.000	177.8			186.0	182.7	179.0	174.8	170.0	164.8	163.4	162.0	159.1	152.9	146.2	139.0	131.3
7.250	184.2			200.1	196.9	193.2	188.9	184.2	179.0	177.6	176.2	173.3	167.1	160.3	153.1	145.4
7.500	190.5			214.8	211.6	207.8	203.6	198.9	193.7	192.3	190.9	187.9	181.7	175.0	167.8	160.1
7.750	196.9			230.0	226.7	223.0	218.8	214.0	208.6	207.4	206.0	203.1	196.9	190.2	183.0	175.3
8.000	**203.2**			**245.6**	**242.4**	**238.7**	**234.4**	**229.7**	**224.5**	**223.1**	**221.7**	**218.8**	212.6	205.8	198.6	190.9
8.250	209.6			261.8	258.5	254.8	250.6	245.9	240.6	239.3	237.9	234.9	228.7	222.0	214.8	207.1
8.500	215.9			278.4	275.2	271.5	267.2	262.5	257.3	255.9	254.5	251.6	245.4	238.7	231.4	223.7
8.750	222.3			295.6	292.4	288.6	284.4	279.7	274.5	273.1	271.7	268.7	262.5	255.8	248.6	240.9
9.000	228.6				310.0	306.3	302.1	297.3	292.1	290.7	289.3	286.4	280.2	273.5	266.3	258.5
9.250	235.0				328.2	324.4	320.2	315.5	310.3	308.9	307.5	304.5	298.3	291.6	284.4	276.7
9.500	**241.3**				**346.8**	**343.1**	**338.8**	**334.1**	**328.9**	**327.5**	**326.1**	**323.2**	317.0	310.3	303.0	295.3
9.750	247.7				365.9	362.2	358.0	353.3	348.0	346.7	345.2	342.3	336.1	329.4	322.2	314.5
10.000	254.0					381.9	377.6	372.9	367.7	366.3	364.9	362.0	355.8	349.0	341.8	334.1
10.500	266.7					422.6	418.4	413.7	408.5	407.1	405.7	402.7	396.5	389.8	382.6	374.9
10.750	273.1					443.8	439.5	434.8	429.6	428.2	426.8	423.9	417.7	410.9	403.7	396.0
11.000	279.4							456.4	451.2	449.8	448.4	445.5	439.3	432.6	425.4	417.7
11.250	**285.8**							**478.6**	**473.3**	**472.0**	**470.5**	**467.6**	**461.4**	454.7	447.5	439.8
12.000	304.8							547.9	542.7	541.3	539.9	537.0	530.8	524.1	516.8	509.1
14.000	355.6								749.5	748.2	746.7	743.8	737.6	730.9	723.7	716.0

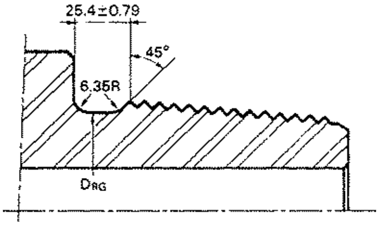
kg/m × 0.672 = lb/ft

STRESS-RELIEF GROOVE
FOR DRILL COLLAR CONNECTIONS
(API Spec 7)

Number of size and style of connection	Length, shoulder face to groove of box member L_x (1)		Diameter of pin member at groove D_{RG} (2)	
	(mm)	(in)	(mm)	(in)
NC 35	85.7	3 3/8	82.15	3 15/64
NC 38 - 3 1/2 IF	92.1	3 5/8	89.3	3 33/64
NC 40 - 4 FH	104.8	4 1/8	96.0	3 25/32
NC 44	104.8	4 1/8	106.4	4 3/16
NC 46 - 4 IF	104.8	4 1/8	109.9	4 21/64
NC 50-4 1/2 IF	104.8	4 1/8	120.6	4 3/4
NC 56	117.5	4 5/8	134.5	5 19/64
NC 61	130.2	5 1/8	148.8	5 55/64
NC 70	142.9	5 5/8	171.1	6 47/64
NC 77	155.6	6 1/8	188.5	7 27/64
4 1/2 FH	92.1	3 5/8	106.8	4 13/64
5 1/2 REG	111.2	4 3/8	123.4	4 55/64
6 5/8 REG	117.5	4 5/8	137.5	5 27/64
7 5/8 REG	123.8	4 7/8	162.7	6 13/32

(1) Tol + 0 − 3.2 mm (+ 0 − 1/8").
(2) Tol + 0 − 0.8 mm (+ 0 − 1/32").





Remarks:

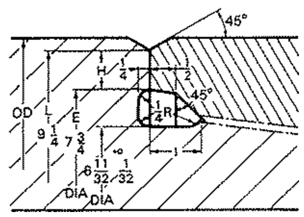
Dimensions in mm.

Connections NC 23, NC 26 and NC 31 (2 3/8 IF and 2 7/8 IF) do not have a sufficient steel thickness for machining stress-relief grooves.

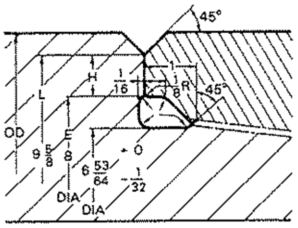
Most manufacturers have modified the API female stress-relief groove: Drilco Bore-Back stress-relief groove, SMFI long relief groove etc.

LARGE-DIAMETER DRILL COLLARS FROM 8 3/4 TO 11 1/4 INCHES SHOULDER MODIFICATIONS FOR LOW-TORQUE CONNECTIONS

7 5/8 REG Section



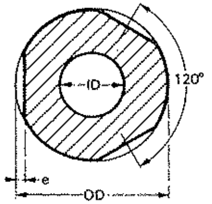
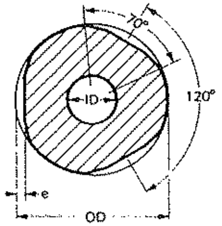
7 5/8 H90 Section



DIMENSIONS OF LOW-TORQUE SHOULDERED

Connection size and style	Outside diameter OD (in)	Bevel diameter L		Inside diameter of shouldered E		Width of flat H N : Normal R : modified		
		(in)	(mm)	(in)	(mm)	(in)	(mm)	
7 H 90	8 1/4	8	203.2	6 9/16	166.7	23/32	18.25	N
	8 1/2	8 1/4	209.5	6 9/16	166.7	27/32	21.40	N
	8 3/4	8 1/2	215.9	7 1/8	181.0	11/16	17.45	R
	9	8 5/8	219.1	7 1/8	181.0	3/4	19.05	R
7 H 90	9 1/2	9 1/4	234.9	7 29/64	189.6	57/64	22.60	N
	9 3/4	9 1/4	234.9	8	203.2	5/8	15.90	R
	10	9 5/8	244.5	8	203.2	13/16	20.60	R
	10 1/4	9 5/8	244.5	8	203.2	13/16	20.60	R
7 5/8 REG	9 1/2	8 7/8	225.4	7 3/32	180.2	57/64	22.60	N
	9 3/4	9 1/4	234.9	7 3/4	196.8	3/4	19.05	R
	10	9 1/4	234.9	7 3/4	196.8	3/4	19.05	R
8 5/8 H 90	10 1/2	10 3/8	263.5	8 11/32	211.9	1 1/64	25.8	N
	10 3/4	10 1/2	266.7	9 3/8	238.1	9/16	14.3	R
	11	10 1/2	266.7	9 3/8	238.1	9/16	14.3	R
	11 1/4	10 3/4	273.0	9 3/8	238.1	11/16	17.5	R
8 5/8 REG	10 1/2	9 3/4	247.7	8 1/16	204.8	27/32	21.4	N
	10 3/4	11 1/2	266.7	9	228.6	3/4	19.05	R
	11	10 1/2	266.7	9	228.6	3/4	19.05	R

SPIRAL DRILL COLLARS
(Drilco)

	Size OD (in)	Depth of cut *e* (mm)	Number of spirals	Direction	Pitch (mm)	Length of cylindrical end			
						Pin end (mm)		Box end (mm)	
						mini	maxi	mini	maxi
Cross section for drill collars 3 7/8" to 7" 	3 7/8" 4" to 4 3/8" 4 1/2" to 5 1/8" 5 1/4" to 5 3/4" 5 7/8" to 6 3/8" 6 1/2" to 7" 7"	1.98 ± 0.79 4.76 ± 0.79 5.56 ± 0.79 6.35 ± 0.79 7.14 ± 1.59 7.14 ± 1.59 7.94 ± 1.59	3 3 3 3 3 3 3	to the right to the right to the right to the right to the right to the right to the right	914.4 ± 25.4 914.4 ± 25.4 965.2 ± 25.4 1066.8 ± 25.4 1066.8 ± 25.4 1168.4 ± 25.4 1625.6 ± 25.4	340.8	457.2	457.2	609.6
Cross section for drill collars 7 1/8" to 12" 	7 1/8 to 7 7/8" 8" to 8 7/8" 9" to 9 7/8" 10" to 10 7/8" 11 to 12"	8.73 ± 1.59 9.53 ± 1.59 10.32 ± 2.38 11.11 ± 2.38 11.91 ± 2.38	3 3 3 3 3	to the right to the right to the right to the right to the right	1625.6 ± 25.4 1727.2 ± 25.4 1828.8 ± 25.4 1930.4 ± 25.4 2032.0 ± 25.4	304.8	457.2	457.2	609.6

Note: The weight of a spiral drill-collar will be reduced approximately of 4%.

mm × 0.0394 = in

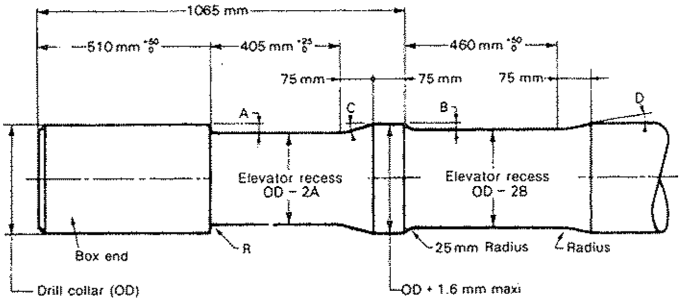
DRILL COLLAR SLIP AND ELEVATOR RECESS AND ELEVATOR BORE DIMENSIONS
(API RP 7G)

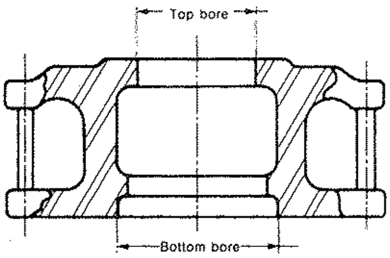
Drill collar OD range (in)	Dimensions					Elevator bore	
	Elevator			Slip			
	A (1) (mm)	R (mm)	C (2) (°)	B (1) (mm)	D (2) (°)	Top Bore (3) + 0 − 1 (mm)	Bottom Bore (3) + 2 − 0 (mm)
4 to 4 5/8	5.6	3.2	4	4.8	3.5	OD − 7.9	OD + 3.2
4 3/4 to 5 5/8	6.4	3.2	5	4.8	3.5	OD − 9.5	OD + 3.2
5 3/4 to 6 5/8	7.9	3.2	6	6.4	5	OD − 12.7	OD + 3.2
6 3/4 to 8 5/8	9.5	4.8	7.5	6.4	5	OD − 14	OD + 3.2
8 3/4 and up	11.1	6.4	9	6.4	5	OD − 15.9	OD + 3.2

(1) A and B dimensions are from nominal OD of new drill collar.

(2) Angle C and D dimensions are reference and approximate.

(3) OD is the outside diameter in millimeters of the new drill-collar.





Drill collar elevator

Note: These dimensions must not be used as API Standards.

mm × 0.0394 = in

RECOMMENDED MAKE-UP TORQUE (1) FOR SHOULDERED DRILL COLLAR CONNECTIONS (CAODC Drilling Manual)

(See notes on page B 45)

Connection		Outside diameter		MINIMUM MAKE-UP TORQUE (2) (daN.m)								
				Inside diameter (in and mm)								
Size (in)	Type	(in)	(mm)	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	3 13/16	3
				25.4	31.8	38.1	44.5	50.8	57.2	63.5	71.4	76.2
API	NC23	3 3 1/8 3 1/4	76.2 79.4 82.6	*339 *447 542	*339 *447 461	*339 352 352						
2-7/8	PAC (3)	3 3 1/8 3 1/4	76.2 79.4 82.6		*515 *664 705	*515 569 569	393 393 393					
2-3/8 API 2-7/8	IF NC26 Slim Hole	3 1/2 3 3/4	88.9 95.3		*623 745	*623 637	501 501					
2-7/8 3-1/2 2-7/8	Extra Hole Dbl. Streamline Mod. Open	3 3/4 3 7/8 4 1/8	95.3 98.4 104.8		*555 *718 *1084	*555 *718 *1084	*555 *718 1003					
2-7/8 API 3-1/2	IF NC31 Slim Hole	3 7/8 4 1/8 4 1/4 4 1/2	98.4 104.8 108.0 114.3		*623 *989 *1193 1355	*623 *989 *1193 1260	*623 *989 1098 1098	*623 922 922 922				
API	NC35	4 1/2 4 3/4 5	114.3 120.7 127.0				*1260 1640 1640	*1206 1464 1464	*1206 1247 1247	1003 1003 1003		
3-1/2 4 3-1/2	Extra Hole Slim Hole Mod. Open	4 1/4 4 1/2 4 3/4 5 5 1/4	108.0 114.3 120.7 127.0 133.4				*691 *1138 *1613 1789 1789	*691 *1138 1586 1586 1586	*691 *1138 1355 1355 1355	*691 *1111 1111 1111 1111		
3-1/2 API 4-1/2	IF NC38 Slim Hole	4 3/4 5 5 1/4 5 1/2	120.7 127.0 133.4 139.7				*1342 *1871 2169 2169	*1342 *1871 1979 1979	*1342 1735 1735 1735	*1342 1477 1477 1477	1125 1125 1125 1125	
3-1/2	H90 (4)	4 3/4 5 5 1/4 5 1/2	120.7 127.0 133.4 139.7				*1179 *1721 *2291 2508	*1179 *1721 2264 2264	*1179 *1721 2033 2033	*1179 *1721 1776 1776	*1179 1410 1410 1410	

daN.m × 7.38 = lb.ft

RECOMMENDED MAKE-UP TORQUE (1) FOR SHOULDERED DRILL COLLAR CONNECTIONS (CAODC Drilling Manual) (continued)

(See notes on page B 45)

Connection		Outside diameter		MINIMUM MAKE-UP TORQUE (2) (daN.m)								
				Inside diameter (in and mm)								
Size (in)	Type	(in)	(mm)	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	3 13/16	3
				25.4	31.8	38.1	44.5	50.8	57.2	63.5	71.4	76.2
4 API 4 4-1/2	Full Hole NC40 Mod. Open Dbl. Streamline	5	127.0				*1464	*1464	*1464	*1464	*1464	
		5 1/4	133.4				*2047	*2047	*2047	2006	1640	
		5 1/2	139.7				*2671	2521	2291	2006	1640	
		5 3/4	146.1				2765	2521	2291	2006	1640	
		6	152.4				2765	2521	2291	2006	1640	
4	H90 (4)	5 1/4	133.4					*1694	*1694	*1694	*1694	
		5 1/2	139.7					*2345	*2345	*2345	*2237	
		5 3/4	146.1					*3023	2915	2630	2237	
		6	152.4					3186	2915	2630	2237	
		6 1/4	158.8					3186	2915	2630	2237	
4-1/2	Regular	5 1/2	139.7					*2088	*2088	*2088	*2088	
		5 3/4	146.1					*2752	*2752	2630	2196	
		6	152.4					3172	2928	2630	2196	
		6 1/4	158.8					3172	2928	2630	2196	
API	NC44	5 3/4	146.1					*2793	*2793	*2793	*2440	
		6	152.4					3389	3159	2874	2440	
		6 1/4	158.8					3389	3159	2874	2440	
		6 1/2	165.1					3389	3159	2874	2440	
4-1/2	Full Hole	5 1/2	139.7					*1749	*1749	*1749	*1749	*1749
		5 3/4	146.1					*2426	*2426	*2426	*2426	2399
		6	152.4					*3159	*3159	3091	2684	2399
		6 1/4	158.8					3660	3389	3091	2684	2399
		6 1/2	165.1					3660	3389	3091	2684	2399
4-1/2 API 4 4-1/2 5 4 1/2	Extra Hole NC46 IF Semi IF Dbl. Streamline Mod. Open	5 3/4	146.1						*2386	*2386	*2386	*2386
		6	152.4						*3145	*3145	3009	2738
		6 1/4	158.8						3796	3457	3009	2738
		6 1/2	165.1						3796	3457	3009	2738
		6 3/4	171.5						3796	3457	3009	2738
4 1/2	H90 (4)	5 3/4	146.1						*2386	*2386	*2386	*2386
		6	152.4						*3172	*3172	3118	2847
		6 1/4	158.8						3864	3525	3118	2847
		6 1/2	165.1						3864	3525	3118	2847
		6 3/4	171.5						3864	3525	3118	2847
5	H90 (4)	6 1/4	158.8						*3389	*3389	*3389	*3389
		6 1/2	165.1						*4270	*4270	3999	3660
		6 3/4	171.5						4745	4474	3999	3660
		7	177.8						4745	4474	3999	3660

RECOMMENDED MAKE-UP TORQUE (1) FOR SHOULDERED DRILL COLLAR CONNECTIONS (CAODC Drilling Manual) (continued)

(See notes on page B 45)

Connection		Outside diameter		MINIMUM MAKE-UP TORQUE (2) (daN.m)						
				Inside diameter (in and mm)						
Size (in)	Type	(in)	(mm)	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
				57.2	63.5	71.4	76.2	82.6	88.9	95.3
4-1/2	IF	6 1/4	158.8	*3090	*3090	*3090	*3090	*3090		
API	NC50	6 1/2	165.1	*4000	*4000	*4000	*4000	3590		
5	Extra Hole	6 3/4	171.5	*4880	4810	4340	4070	3590		
5	Mod. Open	7	177.8	5150	4810	4340	4070	3590		
5-1/2	Dbl. Streamline	7 1/4	184.2	5100	4810	4340	4070	3590		
5	Semi-IF									
5-1/2	H90 (4)	6 3/4	171.5	*4610	*4610	*4610	4610			
		7	177.8	*5630	5420	4950	4610			
		7 1/4	184.2	5760	5420	4950	4610			
		7 1/2	190.5	5760	5420	4950	4610			
5-1/2	Regular	6 3/4	171.5	*4270	*4270	*4270	*4270			
		7	177.8	*5290	*5290	4880	4540			
		7 1/4	184.2	5690	5360	4880	4540			
		7 1/2	190.5	5690	5360	4880	4540			
5-1/2	API Full Hole	7	177.8		*4410	*4410	*4410	*4410		
		7 1/4	184.2		*5490	*5490	*5490	*5490		
		7 1/2	190.5		*6640	6370	6100	5630		
		7 3/4	196.9		6910	6370	6100	5630		
API	NC56	7 1/4	184.2		*5420	*5420	*5420	*5420		
		7 1/2	190.5		*6580	6510	6100	5690		
		7 3/4	196.9		6910	6510	6100	5690		
		8	203.2		6910	6510	6100	5690		
6-5/8	Regular	7 1/2	190.5		*6240	*6240	*6240	*6240		
		7 3/4	196.9		*7460	7190	6780	6370		
		8	203.2		7730	7190	6780	6370		
		8 1/4	209.6		7730	7190	6780	6370		
6-5/8	H90 (4)	7 1/2	190.5		*6240	*6240	*6240	*6240		
		7 3/4	196.9		*7460	*7460	7190	6710		
		8	203.2		8070	7590	7190	6710		
		8 1/4	209.6		8070	7590	7190	6710		
API	NC61	8	203.2		*7320	*7320	*7320	*7320		
		8 1/4	209.6		*8680	*8680	*8680	8270		
		8 1/2	215.9		9760	9220	8810	8270		
		8 3/4	222.3		9760	9220	8810	8270		
		9	228.6		9760	9220	8810	8270		

daN.m × 7.38 = lb.ft

RECOMMENDED MAKE-UP TORQUE (1) FOR SHOULDERED DRILL COLLAR CONNECTIONS (CAODC Drilling Manual) (continued)

(See notes on page B 45)

Connection		Outside diameter		MINIMUM MAKE-UP TORQUE (2) (daN.m)						
				Inside diameter (in and mm)						
Size (in)	Type	(in)	(mm)	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
				57.2	63.5	71.4	76.2	82.6	88.9	95.3
5-1/2	IF	8	203.2		*7 590	*7 590	*7 590	*7 590	*7 590	
		8 1/4	209.6		*8 950	*8 950	*8 950	8 540	8 000	
		8 1/2	215.9		10 030	9 490	9 080	8 540	8 000	
		8 3/4	222.3		10 030	9 490	9 080	8 540	8 000	
		9	228.6		10 030	9 490	9 080	8 540	8 000	
		9 1/4	235.0		10 030	9 490	9 080	8 540	8 000	
6-5/8	Full Hole	8 1/2	215.9			*9 080	*9 080	*9 080	*9 080	9 020
		8 3/4	222.3			*10 580	*10 580	10 300	9 760	9 020
		9	228.6			11 250	10 850	10 300	9 760	9 020
		9 1/4	235.0			11 250	10 850	10 300	9 760	9 020
		9 1/2	241.3			11 250	10 850	10 300	9 760	9 020
API	NC70	9	228.6			*10 170	*10 170	*10 170	*10 170	*10 170
		9 1/4	235.0			*11 930	*11 930	*11 930	*11 930	*11 930
		9 1/2	241.3			*13 690	*13 690	13 560	12 880	12 200
		9 3/4	247.7			14 510	14 240	13 560	12 880	12 200
		10	247.7			14 510	14 240	13 560	12 880	12 200
		10 1/4	247.7			14 510	14 240	13 560	12 880	12 200
API	NC77	10	254.0				*14 510	*14 510	*14 510	*14 510
		10 1/4	260.4				*16 540	*16 540	*16 540	*16 540
		10 1/2	266.7				*18 710	*18 710	18 030	17 350
		10 3/4	273.1				19 390	18 710	18 030	17 350
		11	279.4				19 390	18 710	18 030	17 350
7	H90 (4)	8	203.2			*7 190	*7 190	*7 190	*7 190	
		8 1/4	209.6			*8 540	*8 540	*8 540	8 200	
		8 1/2	215.9			9 690	9 290	8 810	8 200	
7-5/8	Regular	8 1/2	215.9				*8 130	*8 130	*8 130	*8 130
		8 3/4	222.3				*9 630	*9 630	*9 630	*9 630
		9	228.6				*11 250	*11 250	10 710	10 030
		9 1/4	235.0				11 930	11 250	10 710	10 030
		9 1/2	241.3				11 930	11 250	10 710	10 030
7-5/8	H90 (4)	9	228.6				*9 760	*9 760	*9 760	*9 760
		9 1/4	235.0				*11 590	*11 590	*11 590	*11 590
		9 1/2	241.3				*13 290	*13 290	*13 290	12 950
8-7/8	Regular	10	254.0				*14 640	*14 640	*14 640	*14 640
		10 1/4	260.4				*16 680	*16 680	*16 680	16 680
		10 1/2	266.7				18 850	18 170	17 490	16 680

daN.m × 7.38 = lb.ft

RECOMMENDED MAKE-UP TORQUE (1) FOR SHOULDERED DRILL COLLAR CONNECTIONS (CAODC Drilling Manual) (continued)

Connection		Outside diameter		MINIMUM MAKE-UP TORQUE (2) (daN.m)						
				Inside diameter (in and mm)						
Size (in)	Type	(in)	(mm)	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
				57.2	63.5	71.4	76.2	82.5	88.9	95.3
8-5/8	H90 (4)	10 1/4 10 1/2	260.4 266.7				*15 250 *17 420	*15 250 *17 420	*15 250 *17 420	*15 250 *17 420
7	H90 (4) (with low torque face)	8 3/4 9	222.3 228.6			*9 150 10 030	*9 150 9 630	9 020 9 020	8 410 8 410	
7-5/8	Regular (with low torque face)	9 1/4 9 1/2 9 3/4 10	235.0 241.3 247.7 254.0				*9 760 *11 520 12 340 12 340	*9 760 *11 520 11 800 11 800	*9 760 11 120 11 120 11 120	*9 760 10 440 10 440 10 440
7-5/8	H90 (4) (with low torque face)	9 3/4 10 10 1/4 10 1/2	247.7 254.0 260.4 266.7				*12 340 *14 240 15 250 15 250	*12 340 *14 240 14 640 14 640	*12 340 14 030 14 030 14 030	*12 340 13 290 13 290 13 290
8-5/8	Regular (with low torque face)	10 3/4 11	273.1 279.4				*15 190 *17 490	*15 190 *17 490	*15 190 *17 490	*15 190 *17 490
8-5/8	H90 (4) *(with low* torque face)	10 3/4 11 11 1/4	273.1 *279.4* 285.8				*12 540 *14 910 *17 350	*12 540 *14 910 *17 350	*12 540 14 910 *17 350	*12 540 14 910 *17 350

- Torque figures preceded by an asterisk indicate that the weaker member for the corresponding outside diameter (OD) and bore is the **box**. For all other torque values the weaker member is the **pin**.

- In each connection size and type group, torque values apply to all connection types in the group, when used with the same drill collar outside *diameter and bore; i.e.* 2 3/8 API IF, API NC26 and 2 7/8 Slim Hole connections used with 3 1/2 × 1 1/4 drill collars all have the same minimum make-up torque of 624 k N.m, and the box is the weaker member.

(1) Basis of calculations of recommended make-up torque assumed the use of a thread compound contained 40-60% by weight of finely powdered metallic zinc or 60% by weight of finely powdered metallic lead applied thoroughly to all threads and shoulders and using the modified Jack Screw formula in Appendix A, paragraph A.8, and a unit stress of 430 875 kPa in the box or pin, whichever is weaker.

(2) Normal torque range is tabulated valued plus 10%. Higher torque values may be used under extreme conditions.

(3) Make-up torque for 2 7/8 PAC connection is based on 603 225 kPa stress and other factors listed in footnote.

(4) Make-up torque for H90 connection is based on 387 400 kPa stress and other factors listed in footnote.

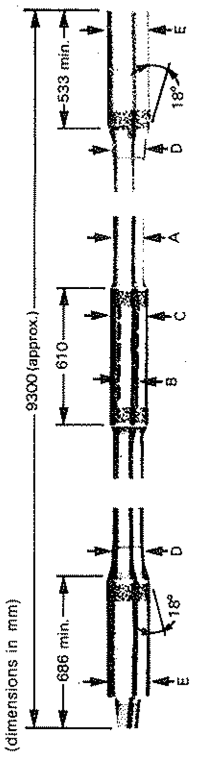
daN.m × 7.38 = lb.ft

HEAVY WALL DRILL PIPES (Drilco, Division of Smith International, Inc)

Characteristics, Range II										
Nominal Size (A) (in)	Drill pipe body							Tool joint		
	Body nominal dimensions			Central upset Outside diameter (C) (in / mm)	End upset Outside diameter (D) (in / mm)	Pipe mechanical properties		Connection	Outside diameter (E) (in / mm)	Inside diameter (in / mm)
	Inside diameter (B) (in / mm)	Wall thickness (mm)	Cross-sectional area (mm^2)			Tensile yield (10^3 daN)	Torsional yield (daN.m)			
3 1/2	2 1/16 52.4	18.2	4051	4 101.6	3 5/8 92.1	153	2654	NC38 (3 1/2 IF)	4 3/4 120.7	2 3/16 55.6
4	2 9/16 65.1	18.2	4779	4 1/2 114.3	4 1/8 104.8	181	3747	NC40 (4 FH)	5 1/4 133.4	2 11/16 68.3
4 1/2	2 3/4 69.9	22.2	6427	5 127.0	4 5/8 117.5	244	5520	NC46 (4 IF)	6 1/4 158.8	2 7/8 73.0
5	3 76.2	25.4	8106	5 1/2 139.7	5 1/8 130.2	307	7660	NC50 (4 1/2 IF)	6 1/2 165.1	3 1/8 79.4

Characteristics, Range II (continued)									
Nominal size (A) (in)	Tool joint			Weight		Make-up torque (daN.m)	Volumes		
	Connection	Mechanical properties		Pipe + tool joint			Exterior (l/m)	Interior (l/m)	Steel volume (l/m)
		Tensile yield (10^3 daN)	Torsional yield (daN.m)	Linear weight (kg/m)	Pipe weight (30 ft) (kg)				
3 1/2	NC38 (3 1/2 IF)	333	2383	**37.7**	**344.3**	1342	7.00	2.19	**4.81**
4	NC40 (4 FH)	316	3190	**44.2**	**404.2**	1797	9.01	3.37	**5.64**
4 1/2	NC46 (4 IF)	456	5260	**61.0**	**557.9**	2956	11.66	3.87	**7.79**
5	NC50 (4 1/2 IF)	563	6966	**73.4**	**670.9**	3985	13.97	4.61	**9.36**

mm × 0.0394 = in mm^2 × 0.00155 = in^2 daN.m × 7.38 = lb.ft daN × 2.25 = lb
kg/m × 0.672 = lb/ft kg × 2.20 = lb l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

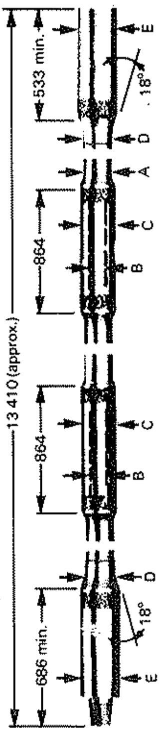


HEAVY WALL DRILL PIPES
(Drilco, Division of Smith International, Inc) (continued)

Characteristics, Range III											
Nominal size (A) (in)	Drill pipe body							Tool joint		
	Body nominal dimensions			Central upset Outside diameter (C) (in / mm)	End upset Outside diameter (D) (in / mm)	Pipe mechanical properties		Connection	Outside diameter (E) (in / mm)	Inside diameter (in / mm)
	Inside diameter (B) (in / mm)	Wall thickness (mm)	Cross-sectional area (mm^2)			Tensile yield (10^3 daN)	Torsional yield (daN.m)			
4 1/2	2 3/4 69.9	22.2	6427	5 127.0	4 5/8 117.5	244	5520	NC46 (4 IF)	6 1/4 158.8	2 7/8 73.0
5	3 76.2	25.4	8106	5 1/2 139.7	5 1/8 130.2	307	7660	NC50 (4 1/2 IF)	6 1/2 165.1	3 1/8 79.4

Characteristics, Range III (continued)									
Nominal size (A) (in)	Tool joint			Weight		Make-up torque (daN.m)	Volumes		
	Connection	Mechanical properties		Pipe + tool joint			Exterior (l/m)	Interior (l/m)	Steel volume (l/m)
		Tensile yield (10^3 daN)	Torsional yield (daN.m)	Linear weight (kg/m)	Pipe weight (44 ft) (kg)				
4 1/2	NC46 (4 IF)	456	5260	**59.4**	**796.3**	2956	11.66	3.87	**7.57**
5	NC50 (4 1/2 IF)	563	6966	**72.2**	**968.0**	3985	13.81	4.61	**9.20**

mm × 0.0394 = in mm^2 × 0.00155 = in^2 daN.m × 7.38 = lb.ft   daN × 2.25 = lb
kg/m × 0.672 = lb/ft   kg × 2.20 = lb   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

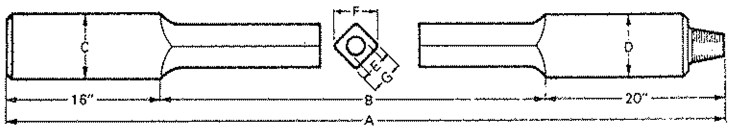


(dimensions in mm)

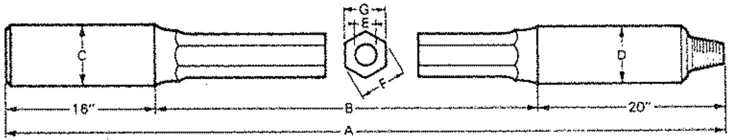
KELLYS
(API Spec 7)

Kelly size G (in)	Inside diameter E (in)	Length (m)				Upper box connection left hand female thread				Lower pin connection right hand male thread				Drive connection		Total weight (kg)	
		Overall A		Drive section B		Size and style		Outside diameter C		Size and style		Outside diameter D		Across flats	Across corners		
		Std	Opt.	Std	Opt.	Std	Opt.	Std	Opt.	Std	Opt.	Std	Opt.	G (in)	F (in)	Std	Opt.
Square kellys																	
2 1/2	1 1/4	12.19	—	11.28	—	6 5/8 REG	4 1/2 REG	7 3/4	5 3/4	NC26	2 3/8 IF	3 3/8	—	2 1/2	3 9/32	**404**	358
3	1 3/4	12.19	—	11.28	—	6 5/8 REG	4 1/2 REG	7 3/4	5 3/4	NC31	2 7/8 IF	4 1/8	—	3	3 15/16	**490**	445
3 1/2	2 1/4	12.19	—	11.28	—	6 5/8 REG	4 1/2 REG	7 3/4	5 3/4	NC38	3 1/2 IF	4 3/4	—	3 1/2	4 17/32	**600**	552
4 1/4	2 13/16	12.19	16.46	11.28	15.54	6 5/8 REG	4 1/2 REG	7 3/4	5 3/4	NC46 NC50	4 IF 4 1/2 IF	6 1/4 6 3/8	—	4 1/4	5 9/16	**840**	788
5 1/4	3 1/4	12.19	16.46	11.28	15.54	6 5/8 REG	—	7 3/4	—	NC56	5 1/2 FH	7	—	5 1/4	6 29/32	**1260**	—
Hexagonal kellys																	
3	1 1/2	12.19	—	11.28	—	6 5/8 REG	4 1/2 REG	7 3/4	5 3/4	NC26	2 3/8 IF	3 3/8	—	3	3 3/8	**440**	395
3 1/2	1 3/4	12.19	—	11.28	—	6 5/8 REG	4 1/2 REG	7 3/4	5 3/4	NC31	2 7/8 IF	4 1/8	—	3 1/2	3 15/16	**567**	532
4 1/4	2 1/4	12.19	16.46	11.28	15.54	6 5/8 REG	4 1/2 REG	7 3/4	5 3/4	NC38	3 1/2 IF	4 3/4	—	4 1/4	4 25/32	**886**	840
5 1/4	3	12.19	16.46	11.28	15.54	6 5/8 REG	—	7 3/4	—	NC46	4 IF	6	—	5 1/4	5 29/32	**990**	—
5 1/4	3 1/4	12.19	16.46	11.28	15.54	6 5/8 REG	—	7 3/4	—	NC50	4 1/2 IF	6 1/8	—	5 1/4	5 29/32	**965**	
5 1/4	2 13/16	12.19	16.46	11.28	15.54	6 5/8 REG	—	7 3/4	—	NC46	4 IF	6 1/4	—	5 1/4	5 29/32	**1007**	
5 1/4	2 13/16	12.19	16.46	11.28	15.54	6 5/8 REG	—	7 3/4	—	NC 50	4 1/2 IF	6 3/8	—	5 1/4	5 29/32	**1007**	—
6	3 1/2	12.19	16.46	11.28	15.54	6 5/8 REG	—	7 3/4	—	NC56	5 1/2 FH	7	—	6	6 13/16	**1095**	—

Square kellys



Hexagonal kellys



m × 3.28 = ft kg × 2.20 = lb

STRENGTH OF KELLYS (1)
(API RP 7G, 12th Edition, May 1987)

Kelly size and style (in)	Inside diameter (in)	Lower pin connection		Minimum recom mended casing OD (2) (in)	Tensile yield		Torsional yield		Yield in bending	Internal pressure at yield stress
		Size and style	Outside diameter (in)		Lower pin connection (3) (10^3 daN)	Drive section (10^3 daN)	Lower pin connection (daN.m)	Drive section (daN.m)	Drive section (m.daN)	Drive section (MPa)
Square										
2 1/2	1 1/4	NC 26 (2 3/8 IF)	3 3/8	4 1/2	185	198	1310	1680	1680	205.5
3	1 3/4	NC 31 (2 7/8 IF)	4 1/8	5 1/2	238	259	1960	2670	2710	175.8
3 1/2	2 1/4	NC 38 (3 1/2 IF)	4 3/4	6 5/8	322	323	3080	3930	4010	153.1
4 1/4	2 13/16	NC 46 (4 IF)	6 1/4	8 5/8	468	466	5335	6810	7000	134.5
4 1/4	2 13/16	NC 50 (4 1/2 IF)	6 3/8	8 5/8	632	466	7760	6810	7000	134.5
5 1/4	3 1/4	5 1/2 FH	7	9 5/8	715	758	9900	13700	13940	142.0
Hexagonal										
3	1 1/2	NC 26 (2 3/8 IF)	3 3/8	4 1/2	158	240	1125	2780	2520	184.1
3 1/2	1 7/8	NC 31 (2 7/8 IF)	4 1/8	5 1/2	220	316	1815	4270	3880	175.8
4 1/4	2 1/4	NC 38 (3 1/2 IF)	4 3/4	6 5/8	322	466	3080	7700	6980	172.4
5 1/4	3	NC 46 (4 IF)	6 1/4	8 5/8	426	671	4805	13870	12610	142.0
5 1/4	3 1/4	NC 50 (4 1/2 IF)	6 3/8	8 5/8	512	621	6335	13030	11880	142.0
6	3 1/2	5 1/2 FH	7	9 5/8	650	861	8990	20400	18580	125.5

(1) None of the values is corrected by a safety factor. They are based on a minimum tensile yield strength of 758 MPa (110 000 psi) for connections, and 620 MPa (90 000 psi) for the drive section, and on a shear strength of 57.7% of the minimum tensile yield strength.

(2) Clearance between protector rubber on kelly saver sub and casing inside diameter should also be checked.

(3) Tensile area calculated at thread root 3/4 inch from pin shoulder.

daN × 2.25 = lb   daN.m × 7.38 = lb.ft   MPa × 145 = psi

STRETCH OF SUSPENDED DRILL PIPE

STRETCH DUE TO ITS OWN WEIGHT

$$A_a = 0.0785 \frac{L^2}{2E}$$

L = length of string (m)
E = modulus of elasticity = 210 000 MPa

$$\boxed{A_a \text{ in meters } = 1.87 \ 10^{-7} \ L^2}$$

SHRINKAGE DUE TO BUOYANCY IN MUD

$$A_b = - \frac{d_b L^2}{E} (1 - \upsilon)$$

d_b = mud specific gravity
L = length of string (m)
E = modulus of elasticity = 210 000 MPa
υ = Poisson's ratio = 0.3 for steel

$$\boxed{A_b \text{ in meters } = - 0.334 \ 10^{-7} \ d_b L^2}$$

STRETCH DUE TO TEMPERATURE

$$\boxed{A_t = 11.8 \ 10^{-6} \ L \ dt}$$

L = length of string (m)
dt = temperature variation of the mud

TOTAL STRETCH

$$A = A_a + A_b + A_t$$

$$\boxed{A = L^2 \ 10^{-7} \ (1.87 - 0.334 \ d_b) + 11.8 \ 10^{-6} \ L \ dt}$$

DRILL STEM DESIGN CALCULATIONS
(API RP 7G, 12th Edition, May 1987)

A. DESIGN PARAMETERS

a) Anticipated total depth with this string.
b) Hole size.
c) *Mud weight.*
d) Desired Factor of Safety in tension and/or Margin of Over Pull.
e) Desired Factor of safety in collapse.
f) Length of drill collars, OD, ID and weight per meter.
g) Drill pipe sizes and inspection class.

B. TENSION LOADING

$$T = 0.981 \times 10^{-3} (L_{DP}P_{DP} + L_{DC}P_{DC}) k$$

where :

T = submerged load hanging below the upper end of this section of drill pipe (10^3 daN)
L_{DP} = length of drill pipe of section considered (m)
L_{DC} = length of drill collars (m)
P_{DP} = weight per meter of drill pipe assembly in air (kg/m)
P_{DC} = weight per meter of drill collar in air (kg/m)
k = buoyancy factor

C. ALLOWABLE LOAD. FACTOR OF SAFETY. MARGIN OF OVER PULL

$$T_a = 0.9\ T_e$$

where :

T_a = maximum allowable load on this pipe in tension (10^3daN)
T_e = yield strength of this pipe (10^3daN)

$$R_T = T_a - T$$

R_T = Margin of Over Pull (MOP) (10^3 daN) on this drill pipe

$$F_S = \frac{T_a}{T}$$

F_S = safety factor in tension on this drill pipe

DRILL STEM DESIGN CALCULATIONS
(API RP 7G, 12th Edition, May 1987) (continued)

D. MAXIMUM DRILLING DEPTH

Considering the type of drill pipe, the load and the desired safety, the string length is limited to the following:

$$L_{DP\max} = \frac{0.9\ T_e\ 10^3}{F_S P_{DP} k} - \frac{P_{DC} L_{DC}}{P_{DP}}$$

or:

$$L_{DP\max} = \frac{10^3\ (0.9\ T_e - R_T)}{k P_{DP}} - \frac{P_{DC} L_{DC}}{P_{DP}}$$

$L_{DP\max}$ = maximum length (in m) of this drill string taking account of the desired safety, the pipe mechanical properties, the load of the drill collars and the mud.

Composite drill strings

If the drill string is composite, i.e. consisting of sections of pipes which differ in their nominal size, grade or wear class, the weakest section in tension must be placed above the drill collars and its maximum length is calculated as above. A stronger section is placed above and its maximum length can be calculated by using the equation for D, but by replacing the term $P_{DC}\ L_{DC}$ by the weight in air of the drill collars plus the weight of the weakest section.

E. COLLAPSE DUE TO ANNULAR HYDROSTATIC PRESSURE

$$P_{ca} = \frac{P_{cl}}{F_c}$$

where:

P_{cl} = limit collapse pressure (kPa)
P_{ca} = maximum allowable collapse pressure (kPa)
F_c = collapse safety factor

When the fluid levels inside and outside the drill pipe are equal, the collapse pressure (equal to the differential hydrostatic pressure) is zero.

DRILL STEM DESIGN CALCULATIONS
(API RP 7G, 12th Edition, May 1987) (continued)

If there is no fluid inside the pipe (for example, during testing), the collapse pressure is :

$$P_C = 9.81\,Zd$$

where :

P_C = collapse pressure (kPa)
Z = vertical depth (m)
d = mud weight (kg/l)

F. TORSIONAL STRENGTH

The torque applied to the drill string should not exceed the actual tool joint make-up torque. For a composite string, the torsional torque at the rotary table should be limited to the lowest value of the tool joint make-up torque.

Torsional deformation

The following formula can be used to calculate the number of rotations causing torsional deformation of a drill string, ignoring friction and tool joints :

$$N = 1.49\,\frac{ML}{\left(\frac{I_0}{R}\right)D}$$

where :

N = number of torsional rotations
M = applied torque (daN.m)
L = length of drill pipes (m)
$\frac{I_0}{R}$ = polar modulus (mm^3)
D = pipe outside diameter (in)

Torsion limit taking account of tensile load

In certain drilling configurations, such as washover, deep holes, highly-deviated holes, use of a power swivel etc., it may be necessary to apply a high torque to the drill string. The pipes must withstand both the tensile and torsional loads.

The API criterion is as follows :

$$n^2 + 3t^2 \leqslant Y_P^2$$

where :

Y_P = yield strength
n = normal stress
t = tangential stress

DRILL STEM DESIGN CALCULATIONS
(API RP 7G, 12th Edition, May 1987) (continued)

The following formula can be used to calculate the maximum allowable torque:

$$\left(\frac{T}{T_e}\right)^2 + \left(\frac{M}{M_e}\right)^2 \leqslant 1$$

where:

T = tensile load on pipe
T_e = tensile yield strength
M = torsional torque on pipe
M_e = torque at maximum allowable stress

- Calculation of the maximum allowable torque for a tensile load T and the pipe mechanical properties:

$$M < M_e \sqrt{1 - \left(\frac{T}{T_e}\right)^2}$$

- Calculation of the maximum allowable tensile load for a torque M and the pipe mechanical properties:

$$T < T_e \sqrt{1 - \left(\frac{M}{M_e}\right)^2}$$

DRILL STEM DESIGN CALCULATIONS
CALCULATION EXAMPLES

(API RP 7G, 12th Edition, May 1987)

Design parameters

Depth = 3800 m
Hole size = 8 1/2
Mud weight = 1.16
Desired MOP = 30 10^3 daN
Safety factor in collapse = 1.15
Size of drill collars = 6 3/4 × 2 13/16
Length of drill collars = 185 m

The following formula can be used to calculate the length of the drill collars (if necessary) :

$$L_{DC} = \frac{10^5\ WOB}{\cos\ \alpha\ F_{PN} P_{DC} k}$$

where :

L_{DC} = length of drill collars (m)
WOB = maximum weight on bit (t)
α = hole angle from vertical
F_{PN} = neutral point position as percentage of the total drill collar string length
P_{DC} = weight per meter of drill collars (kg/m)
k = buoyancy factor

I Numerical Application

α = 3 degrees
WOB = 20 t
F_{PN} = 85%
k = 0.852
P_{DC} = 149.8 kg/m

$$L_{DC} = \frac{20.10^5}{(0.998)(85)(149.8)0.852} = 185 \text{ m or } 20\ DC$$

DRILL STEM DESIGN CALCULATIONS
CALCULATION EXAMPLES
(API RP 7G, 12th Edition, May 1987) (continued)

II Pipe size, weight and grade used

5 in × 19.50 lb/ft, Grade E, NC50 tool joints, Inspection Class II

P_{DP1} = 31.06 kg/m
T_{e1} = 120.3 10^3 daN
P_{ct} = 38 000 kPa

- Calculation of the maximum pipe length taking account of the desired MOP :

$$L_{DP1} = \frac{10^3\ (0.9 \times 120.3 - 30)1.02}{0.852 \times 31.06} - \frac{(185 \times 149.8)}{31.06}$$

$$L_{DP1} = 2125 \text{ m}$$

It is apparent that drill pipe of a higher strength will be required to reach 3800 m. For example, the following pipes can be used :

5 in × 19.50 lb/ft, Grade X, NC50 tool joint, Premium Class

P_{DP2} = 31.83 kg/m
T_{e2} = 175.6 10^3 daN

- Calculation of the maximum pipe length considering the MOP and weight of the first section :

$$L_{DP2} = \frac{10^3\ (0.9 \times 175.6 - 30)1.02}{0.852 \times 31.83} - \frac{(2125 \times 31.06) + (185 \times 149.8)}{31.83}$$

$$L_{DP2} = 1872 \text{ m}$$

The depth of 3800 m can therefore be reached with these drill strings and in the requisite conditions.

DRILL STEM DESIGN CALCULATIONS CALCULATION EXAMPLES (API RP 7G, 12th Edition, May 1987) (continued)

Summary of string weights and dimensions:

	Length (m)	Weight in air (t)	Weight in mud (t)
Drill collars P_{DC} = 149.8 kg/m	185	27.7	23.6
No. 1 pipe 5 in × 19.50, Grade E Class II P_{DP1} = 31.06 kg/m	2125	66	56.2
No. 2 pipe 5 in × 19.50, Grade X Premium Class P_{DP2} = 31.83 kg/m	1490	47.4	40.4
Total	3800	141.1	120.2

III Collapse pressure

For the No. 1 pipes, the limit collapse pressure is:

$$P_{cl1} = 38 \text{ MPa}$$

The maximum *hydrostatic pressure on the No. 1 pipes is:*

$$P_h = 9.81 \times 1.16 \times (3800 - 185)$$
$$P_h = 41\,140 \text{ kPa or } 41.14 \text{ MPa}$$

The string cannot be run empty to the final depth.

- Calculation of the maximum depth that can be reached by empty No. 1 pipes with a Safety Factor of 1.15:

$$L_{\max} = \frac{38\,000}{9.81 \times 1.16 \times 1.15} = 2904 \text{ m}$$

DRILL STEM DESIGN CALCULATIONS
CALCULATION EXAMPLES
(API RP 7G, 12th Edition, May 1987) (continued)

IV Combination of tensile and torsional loads

Let us consider the use of a power swivel to pull out the string in rotation to release it. In this case, the combination of the tensile load and torque may be high.

The string is at the maximum depth.

- Maximum allowable tensile load at surface: 120.3 + 30 = 150.3 10^3 daN.

Torque at maximum allowable stress of No. 1 pipes: $M_e = 3790$ daN.m.

Make-up torque of tool joints: 1900 daN.m.

Load on No. 1 pipes: (56.2 + 23.6) 0.981 + 30 = 108.3 10^3 daN.

Tensile yield strength: $T_{e1} = 120.3\ 10^3$ daN.

$$M < M_e \sqrt{1 - \left(\frac{T}{T_{e1}}\right)^2}$$

$$M < 3790 \sqrt{1 - \left(\frac{108.3}{120.3}\right)^2} = 1650 \text{ daN.m}$$

The torque limit should be **1650** daN.m.

- Calculation of maximum torque with extra tensile load of 15 10^3 daN.

Load on No. 1 pipes: (56.2 + 23.6) 0.981 + 15 = 93.3 10^3 daN

$$M < 3790 \sqrt{1 - \left(\frac{93.3}{120.3}\right)^2} = 2393 \text{ daN.m}$$

The torque limit remains the minimum make-up torque, i.e. **1900** daN.m.

C

casing, tubing line pipe standards

TENSILE REQUIREMENTS

Casing and tubing
(API Standard 5CT, 15 March 1988)

Properties / Grade	H40	J55	K55 (2)	C75 (1) (6)	L80 (1) (7)	N80	C90 (1)	C95 (1) (2)	P105 (3)	P110	Q125	V150 (4)
Color band identification (5)	1 black	1 green	2 green	1 blue	1 red and 1 brown	1 red	1 purple	1 brown	1 white	1 white	1 orange	
Minimum yiel strength												
(MPa)	276	379	379	517	552	552	620	655	724	758	862	1034
(psi)	40 000	55 000	55 000	75 000	80 000	80 000	90 000	95 000	105 000	110 000	125 000	150 000
Maximum yield strength												
(MPa)	552	552	552	620	655	758	724	758	930	965	1034	1241
(psi)	80 000	80 000	80 000	90 000	95 000	110 000	105 000	110 000	135 000	140 000	150 000	180 000
Minimum tensile strength												
(MPa)	414	517	655	655	655	689	689	724	827	862	931	1103
(psi)	60 000	75 000	95 000	95 000	95 000	100 000	100 000	105 000	120 000	125 000	135 000	160 000

(1) Special corrosion. (2) For casing only. (3) For tubing only. (4) Non-API grade.
(5) Special clearance couplings (smaller diameter) must have a black line at the center of the color band. (6) C75,9Cr 1 blue and 2 yellow bands C75,13Cr 1 blue and 1 yellow bands. (7) L80,9Cr 1 red and 1 brown and 2 yellow bands L80,13Cr 1 red and 1 brown and 1 yellow bands.

Line pipe
(API Standard 5L, 31 May 1988)

Properties / Grade	A25	A	B	X42	X46	X52	X56	X 60 (1)	X65 (1)	X70 (1)	X80 (1)
Minimum yield strength											
(MPa)	172	207	241	289	317	359	385	414	448	483	551
(psi)	25 000	30 000	35 000	42 000	46 000	52 000	56 000	60 000	65 000	70 000	80 000
Minimum tensile strength											
(MPa)	310	331	414	414	435	455	490	517	531	565	620
(psi)	45 000	48 000	60 000	60 000	63 000	66 000	71 000	75 000	77 000	82 000	90 000

(1) Non-weldable.

TENSILE REQUIREMENTS OF SPECIAL STEELS (NON-API)
(Vallourec documentation)

Properties	H_2S-resistant			Collapse-resistant		
	Grade					
	L80 VH	C90 VHS	C95 VH	C95 VT	P110 VT	C95 VTS
Color band identification	Red + purple band + brown band	Purple + white band	Brown + purple band	Brown + red band	White + red band	Brown + purple/ red band
Minimum yield strength						
(MPa)	552	620	655	655	758	655
(psi)	80 000	90 000	95 000	95 000	110 000	95 000
Maximum yield strength						
(MPa)	655	724	758	862	965	758
(psi)	95 000	105 000	110 000	125 000	140 000	110 000
Minimum tensile strength						
(MPa)	655	689	724	724	862	724
(psi)	95 000	100 000	105 000	105 000	125 000	105 000

Properties	Special deep wells			Special arctic (Permafrost)			
	Grade						
	Q125 VY	T140 VY	V150 VY	L80 VK	C95 VK	P105 VK	P110 VK
Color band identification	Orange + green band	Orange + brown band	Orange + yellow band				
Minimum yield strength							
(MPa)	862	965	1034	552	655	724	75.8
(psi)	125 000	140 000	150 000	80 000	95 000	105 000	110 000
Maximum yield strength							
(MPa)	1034	1138	1241	655	758	931	965
(psi)	150 000	165 000	180 000	95 000	110 000	135 000	140 000
Minimum tensile strength							
(MPa)	930	1034	1103	655	724	827	862
(psi)	135 000	150 000	160 000	95 000	105 000	120 000	125 000

API CASINGS LIST
(API Standard 5CT, 15 March 1988)

Nominal outside diameter (in)	Nominal weight (lb/ft)	Wall thickness (mm)	Grade										Joint type			
			H40	J55	K55	C75	L80	N80	C90	C95	P110	Q125	Short	Long	Buttress	X-line
4 1/2	9.50	5.21	●	●	●								x			
	10.50	5.69		●	●								x		x	
	11.60	6.35		●	●								x	x	x	
	11.60	6.35				●	●	●	●	●	●			x	x	
	13.50	7.37				●	●	●	●	●	●			x	x	
	15.10	8.56									●	●		x	x	
5	11.50	5.59		●	●								x			
	13.00	6.43		●	●								x	x	x	
	15.00	7.52		●	●								x	x	x	x
	15.00	7.52				●	●	●	●	●	●			x	x	x
	18.00	9.19				●	●	●	●	●	●	●		x	x	x
	21.40	11.10				●	●	●	●	●	●	●		x	x	
	23.20	12.14				●	●	●	●	●	●	●		x	x	
	24.10	12.70				●	●	●	●	●	●	●		x	x	
5 1/2	14.00	6.20	●	●	●								x			
	15.50	6.98		●	●								x	x	x	x
	17.00	7.72		●	●								x	x	x	x
	17.00	7.72				●	●	●	●	●	●			x	x	x
	20.00	9.17				●	●	●	●	●	●			x	x	x
	23.00	10.54				●	●	●	●	●	●	●		x	x	x
	28.60	12.70							●							
	29.70	14.27							●							
	32.60	15.86							●							
	35.30	17.45							●							
	38.00	19.05							●							
	40.50	20.62							●							
	43.10	22.23							●							
6 5/8	20.00	7.32	●										x			
	20.00	7.32		●	●								x	x	x	
	24.00	8.94		●	●								x	x	x	x
	24.00	8.94				●	●	●	●	●	●			x	x	x
	28.00	10.59				●	●	●	●	●	●			x	x	x
	32.00	12.06				●	●	●	●	●	●			x	x	x
7	17.00	5.87	●										x			
	20.00	6.91	●	●	●								x			
	23.00	8.05		●	●								x	x	x	x
	23.00	8.05				●	●	●	●	●				x	x	x
	26.00	9.19		●	●								x	x	x	x
	26.00	9.19				●	●	●	●	●	●			x	x	x
	29.00	10.36				●	●	●	●	●	●			x	x	x
	32.00	11.51				●	●	●	●	●	●			x	x	x
	35.00	12.65				●	●	●	●	●	●	●		x	x	x
	38.00	13.72				●	●	●	●	●	●	●		x	x	x
	42.70	15.86							●							
	46.40	17.45							●							
	50.10	19.05							●							
	53.60	20.62							●							
	57.10	22.23							●							
7 5/8	24.00	7.62	●										x			
	26.40	8.33		●	●								x	x	x	x
	26.40	8.33				●	●	●	●	●				x	x	x
	29.70	9.52				●	●	●	●	●	●			x	x	x
	33.70	10.92				●	●	●	●	●	●			x	x	x
	39.00	12.70				●	●	●	●	●	●	●		x	x	x
	42.80	14.27				●	●	●	●	●	●	●		x	x	
	45.30	15.11				●	●	●	●	●	●			x	x	
	47.10	15.86				●	●	●	●	●	●			x	x	
	51.20	17.45							●							
	55.30	19.05							●							
7 3/4	46.10	15.11				●	●	●	●	●	●	●				

mm × 0.0394 = in

API CASINGS LIST (continued)
(API Standard 5CT, 15 March 1988)

Nominal outside diameter (in)	Nominal weight (lb/ft)	Wall thickness (mm)	Grade										Joint type			
			H40	J55	K55	C75	L80	N80	C90	C95	P110	Q125	Short	Long	Buttress	X-line
8 5/8	24.00	6.71		●	●								x			
	28.00	7.72	●										x			
	32.00	8.94	●										x			
	32.00	8.94		●	●								x	x	x	x
	36.00	10.16		●	●								x	x	x	x
	36.00	10.16				●	●	●	●	●				x	x	x
	40.00	11.43				●	●	●	●	●	●			x	x	x
	44.00	12.70				●	●	●	●	●	●			x	x	x
	49.00	14.15				●	●	●	●	●	●	●		x	x	x
9 5/8	32.30	7.92	●										x			
	36.00	8.94	●										x			
	36.00	8.94		●	●								x	x	x	
	40.00	10.03		●	●								x	x	x	x
	40.00	10.03				●	●	●	●	●				x	x	x
	43.50	11.05				●	●	●	●	●	●			x	x	x
	47.00	11.99				●	●	●	●	●	●	●		x	x	x
	53.50	13.84				●	●	●	●	●	●	●		x	x	x
	59.40	15.47							●							
	64.90	17.07							●							
	70.30	18.64							●							
	75.60	20.24							●							
10 3/4	32.75	7.09	●										x			
	40.50	8.89	●										x			
	40.50	8.89		●	●								x		x	
	45.50	10.16		●	●								x		x	x
	51.00	11.43		●	●	●	●	●	●	●	●		x		x	x
	55.50	12.57				●	●	●	●	●	●		x		x	x
	59.40	13.84							●							
	60.70	13.84									●	●	x		x	x
	65.70	15.11							●							
	65.70	15.11									●	●	x		x	
	73.20	17.07							●							
	79.20	18.64							●							
	85.30	20.24							●							
11 3/4	42.00	8.46	●										x			
	47.00	9.52		●	●								x		x	
	54.00	11.05		●	●								x		x	
	60.00	12.42		●	●	●	●	●	●	●	●	●	x		x	
13 3/8	48.00	8.38	●										x			
	54.50	9.65		●	●								x		x	
	61.00	10.92		●	●								x		x	
	68.00	12.19		●	●	●	●	●	●	●	●		x		x	
	72.00	13.06				●	●	●	●	●	●	●	x		x	
16	65.00	9.52	●										x			
	75.00	11.13		●	●								x		x	
	84.00	12.57		●	●								x		x	
18 5/8	87.50	11.05	●	●	●								x			
	87.50	11.05		●	●										x	
20	94.00	11.13	●	●	●								x	x		
	94.00	11.13		●	●										x	
	106.50	12.70		●	●								x	x	x	
	133.00	16.13		●	●								x	x	x	

mm × 0.0394 = in

API TUBING LIST
(API Standard 5CT, 15 March 1988)

Nominal outside diameter		Nominal weight (lb/ft)	Wall thickness		Grade							Joint type
(in)	(mm)		(in)	(mm)	H40	J55	C75	L80	N80	C90	P105	
1.050	26.7	1.14	0.113	2.87	●	●	●	●	●	●		Non-Upset
		1.20	0.113	2.87	●	●	●	●	●	●		Ext. Upset
		1.50	0.154	3.91				●		●		Non-Upset
1.315	33.4	1.70	0.133	3.38	●	●	●	●	●	●		Non-Upset
		1.72	0.133	3.38	●	●	●	●	●	●		Integral Joint
		1.80	0.133	3.38	●	●	●	●	●	●		Ext. Upset
		2.25	0.179	4.55				●		●		Non-Upset
1.660	42.2	2.10	0.125	3.18	●	●						Integral Joint
		2.30	0.140	3.56	●	●	●	●	●	●		Non-Upset
		2.33	0.140	3.56	●	●	●	●	●	●		Integral Joint
		2.40	0.140	3.56	●	●	●	●	●	●		Ext. Upset
		3.24	0.198	5.03				●		●		Non-Upset
1.900	48.3	2.40	0.125	3.18	●	●						Integral Joint
		2.75	0.145	3.68	●	●	●	●	●	●		Non-Upset
		2.76	0.145	3.68	●	●	●	●	●	●		Integral Joint
		2.90	0.145	3.68	●	●	●	●	●	●		Ext. Upset
		3.64	0.200	5.08				●				Non-Upset
		4.41	0.250	6.35				●				Non-Upset
		5.13	0.300	7.62				●				Non-Upset
2.063	52.4	3.25	0.156	3.96	●	●	●	●	●	●		Integral Joint
		4.50	0.225	5.72				●		●		Non-Upset
2.375	60.3	4.00	0.167	4.24	●	●	●	●	●	●		Non-Upset
		4.60	0.190	4.83	●	●	●	●	●	●	●	Non-Upset
		4.70	0.190	4.83	●	●	●	●	●	●	●	Ext. Upset
		5.80	0.254	6.45			●	●	●	●	●	Non-Upset
		5.95	0.254	6.45			●	●	●	●	●	Ext. Upset
		6.55	0.295	7.49			●	●		●		Non-Upset
		7.70	0.336	8.53			●	●		●		Non-Upset
2.875	73.0	6.40	0.217	5.51	●	●	●	●	●	●	●	Non-Upset
		6.50	0.217	5.51	●	●	●	●	●	●	●	Ext. Upset
		7.80	0.276	7.01			●	●	●	●	●	Non-Upset
		7.90	0.276	7.01			●	●	●	●	●	Ext. Upset
		8.60	0.308	7.82			●	●	●	●	●	Non-Upset
		8.70	0.308	7.82			●	●	●	●	●	Ext. Upset
		9.50	0.340	8.64				●		●		Non-Upset
		10.70	0.392	9.96				●		●		Non-Upset
		11.65	0.440	11.18				●		●		Non-Upset
3.500	88.9	7.70	0.216	5.49	●	●	●	●	●	●		Non-Upset
		9.20	0.254	6.45	●	●	●	●	●	●	●	Non-Upset
		9.30	0.254	6.45	●	●	●	●	●	●	●	Ext. Upset
		10.20	0.289	7.34	●	●	●	●	●	●		Non-Upset
		12.70	0.375	9.52			●	●	●	●	●	Non-Upset
		12.95	0.375	9.52			●	●	●	●	●	Ext. Upset
		14.11	0.430	10.92				●		●		Non-Upset
		15.80	0.476	12.09				●		●		Non-Upset
		17.05	0.530	13.46				●		●		Non-Upset
4.000	101.6	9.50	0.226	5.74	●	●	●	●	●	●		Non-Upset
		11.00	0.262	6.65	●	●	●	●	●	●		Ext. Upset
		13.40	0.330	8.38				●		●		Non-Upset
		15.89	0.415	10.54				●		●		Non-Upset
		19.00	0.500	12.70				●		●		Non-Upset
		22.50	0.610	15.49				●		●		Non-Upset
4.500	114.3	12.60	0.271	6.88	●	●	●	●	●	●		Non-Upset
		12.75	0.271	6.88	●	●	●	●	●	●		Ext. Upset
		15.50	0.337	8.56			●	●		●		Non-Upset
		16.90	0.380	9.65			●	●		●		Non-Upset
		19.20	0.430	10.92			●	●		●		Non-Upset
		21.60	0.500	12.70			●	●		●		Non-Upset
		24.60	0.560	14.22			●	●		●		Non-Upset
		26.50	0.630	16.00			●	●		●		Non-Upset

DRIFT DIAMETER
(API Standard 5CT)

The drift (or mandrel diameter) is the diameter of the cylindrical mandrel (1) that should pass freely inside the tube under the action of a force equal to its own weight.

The mandrel has the following geometric characteristics:

Casing diameter (in)	Mandrel length		Mandrel diameter	
	(in)	(mm)	(in)	(mm)
8 5/8 or less	6	152	$d-1/8$	$d-3.18$
9 5/8 to 13 3/8	12	305	$d-5/32$	$d-3.97$
16 or more	12	305	$d-3/16$	$d-4.76$

Casing diameter (in)	Mandrel length		Mandrel diameter	
	(in)	(mm)	(in)	(mm)
2" 7/8 or less	42	1067	$d-3/32$	$d-2.38$
3" 1/2 or more.	42	1067	$d-1/8$	$d-3.18$

Example: 7 inch (177.8 mm) casing 26.00 lb/ft, wall thickness $t = 9.2$ mm:

$$d = 177.8 - 2 \times 9.2 = 159.4 \text{ mm}$$

Mandrel diameter:

$$d - 3.18 = 159.4 - 3.18 = 156.22 \text{ mm}$$

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(1) Cylindrical and not dumb-bell shaped.

EFFICIENCY OF A CONNECTION

In this section, the efficiency is the ratio of the critical cross-section of the connection (pin or box end) to the steel cross-section of the pipe body (line 5). It is expressed as a percentage.

The efficiency also represents the ratio of the tension at the yield strength of the connection to the tension at the yield strength of the smooth pipe (line 11), unless the coupling is of a different grade from the pipe body.

Since the API 5C3 formulas for calculating the strength of API round and buttress joints employ considerations of pull-out and only account for the minimum tensile strength, it is not possible to apply the concept of efficiency to these connections for casings. For API tubings since the strength is calculated at the yield stress, the concept of efficiency can be applied:

An efficiency under 100 means that the connection is weaker than the pipe body.

The efficiency hence serves to calculate three parameters:

a) **critical cross-section of the joint**: the value in line 5 is multiplied by the efficiency.

Example:

Hydril Super FJ/FJP 7 in 29 lb/ft, line 22, efficiency: 59.3

Critical cross-section of Super FJ/FJP: $5450\ \text{mm}^2 \times 0.593 = 3232\ \text{mm}^2$

$$8.45\ \text{in}^2 \times 0.593 = 5.011\ \text{in}^2$$

b) **Tension at yield stress of the joint**: the value in line 11 is multiplied by the efficiency.

Example:

Hydril Super FJ/FJP 7 in 29 lb/ft, tension at the yield stress for N80:

$$301 \times 0.593 = 178\ 10^3\ \text{daN}$$

c) **The minimum tensile strength of the joint**: the critical cross-section of the joint is multiplied by the minimum tensile strength (100 000 psi for N80).

Example:

$$\begin{aligned} 5.011\ \text{in}^2 \times 100\,000 &= 501\ 10^3\ \text{lb} \\ &= 223\ 10^3\ \text{daN} \end{aligned}$$

Or the value in line 11 is multiplied by the efficiency and by the ratio of the minimum tensile strength to the yield strength:

$$301 \times 0.593 \times \frac{100\,000}{80\,000} = 223\ 10^3\ \text{daN}$$

MAKE-UP TORQUE

The make-up torques in the tables in the following pages correspond to the values and recommendations below:

Buttress	**Torque at the base of the triangle**
API STC or LTC	**Optimal value** minimum value = optimal value − 25% maximum value = optimal value + 25%
Atlas Bradford	**Minimum value**
Hydril	**Minimum value** optimal value = minimum value + 12.5% maximum value = minimum value + 25% (maximum value = minimum value + 15% for CS)
Mannesmann	**Minimum value** maximum value = minimum value + 25%
Vallourec	**Optimal value** minimum value = optimal value − 10% maximum value = optimal value + 10%

CORRECTION FACTOR FOR MAKE-UP TORQUE ACCORDING TO TYPE OF GREASE

Type of grease	Correction factor
Bestolife 270	1
Houghton Stap Pb 6	1
Houghton joint No 1	1
Jet-Lube Tef Kote (made in UK)	1
Jet-Lube API modified (made in UK)	1
Jet-Lube Polar (made in UK)	1
Molykote HSC (Mo S_2)	1
Shell API modified compound	1
Shell France modified thread compound	1
Shell Myrina S 7715	1
Shell Lub 179 A	1
Shell Lub 179 B	1
Techlube TL 60 Zn	1
Bakerseal	0.60
Bestolife Honey-Koat	0.70
BP Energrease AS 13	0.75
BP AS 11	0.80
Houghton Stap Zn 6	0.70
Jet-Lube 21	0.70
Het-Lube Kopr-kote (made in UK)	0.85
Jet-Lube TF-15 (made in UK)	0.90
Jet-Lube TF-25 (made in UK)	0.80
Jet-Lube TF-65 Pb (made in UK)	0.70
Jet-Lube TL-60 Z 15 (made in UK)	0.80
Liquid O Ring 104	0.70
Research Laboratories API modified HP 300	0.85
Shell HP API modified (Shell Oil Company Code 72732)	0.80
Shell HP API modified (Shell Canada Ltd Code 504-599)	0.80
Shell HP (Japan)	0.85
Techlube API modified thread compound	0.70
Techlube TL-65 Pb	0.70
Thredkote 706	0.85
Thredkote 709	0.75
Het-Lube SS-30 (made in UK)	1.15
Molykote HSC	1.20
Shell S 982	1.30
Bakerlok	1.60
Gelokote T7.285	0.70
Halliburton Weld-A	0.90
Thread Lock	0.60

The make-up torques given in the tables are valid for the API grease (Standard 5A2) with *the factor 1.*

To obtain the torque to be applied with another grease, multiply the value of the torque read in the tables by the correction factor.

Example : to make up a new VAM 7 in, 26 lb/ft, N80 joint with a Jet-Lube 21 grease : the torque read in the table is 1130 daN.m and the correction factor is 0.70, giving a torque of :

1130 × 0.70 = 790 daN.m

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBINGS

Pipe body	**1**	Nominal size (OD)	**1.050** in		26.7 mm			**1.050** in		26.7 mm		
	2	Nominal weight	1.14/1.20 lb/ft		1.7/1.8 daN/m			1.50 lb/ft		2.2 daN/m		
	3	Wall thickness	0.113 in		2.9 mm			0.154 in		3.9 mm		
	4	Inside diameter	0.824 in		20.9 mm			0.742 in		18.8 mm		
	5	Steel cross-section	0.333 in^2		215 mm^2			0.433 in^2		280 mm^2		
	6	Capacity	0.028 gal/ft		0.34 l/m			0.022 gal/ft		0.28 l/m		
	7	Displacement	0.045 gal/ft		0.56 l/m			0.045 gal/ft		0.56 l/m		
	8	Grade	J55	C75	N80	P105		J55	C75	N80	P105	
	9	Collapse resistance (MPa)	72.8	99.3	105.9	139.1		94.9	129.4	138.1	181.2	
	10	Internal yield pressure (MPa)	71.4	97.4	103.9	136.3		97.3	132.7	141.6	185.8	
	11	Pipe body yield strength (10^3 daN)	8.1	11.1	11.8	15.5		10.6	14.5	15.4	20.2	
Connection efficiency	**12**	API Non-Upset	47.8									
	13	API External Upset	100.0									
	14	API Integral Joint										
	15	Atlas Bradford DSS-HTC	125.0					108.0				
	16	Hydril CS	139.0					107.0				
	17	Vallourec mini VAM	+ 100.0					+ 100.0				
Connection characteristics			Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)	Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)
			J55	C75/LN80				J55	C75/LN80			
	18	API Non-Upset	20	30	33.4		18.5					
	19	API External Upset	80	110	42.2		18.5					
	20	API Integral Joint										
	21	Atlas Bradford DSS-HTC			33.7	20.5	18.5			34.3	18.6	16.5
	22	Hydril CS	30	40	33.7	17.4	18.5	30	40	33.7	17.4	16.5
	23	Vallourec mini VAM	20	30	33.0		18.5			34.0		16.5

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**1.315** in		33.4 mm		**1.315** in		33.4 mm	
	2	Nominal weight	1.70/1.80 lb/ft		2.5/2.6 daN/m		2.20/2.25 lb/ft		3.2/3.3 daN/m	
	3	Wall thickness	0.133 in		3.4 mm		0.179 in		4.5 mm	
	4	Inside diameter	1.049 in		26.6 mm		0.957 in		24.3 mm	
	5	Steel cross-section	0.494 in^2		319 mm^2		0.639 in^2		412 mm^2	
	6	Capacity	0.045 gal/ft		0.56 l/m		0.037 gal/ft		0.46 l/m	
	7	Displacement	0.071 gal/ft		0.88 l/m		0.071 gal/ft		0.88 l/m	
	8	Grade	J55	C75	N80	P105	J55	C75	N80	P105
	9	Collapse resistance (MPa)	68.9	94.0	100.3	131.6	89.2	121.6	129.7	170.3
	10	Internal yield pressure (MPa)	67.1	91.5	97.6	128.1	90.3	123.2	131.4	172.5
	11	Pipe body yield strength (10^3 daN)	12.1	16.5	17.6	23.1	15.6	21.3	22.7	29.8
Connection efficiency	12	API Non-Upset	55.5							
	13	API External Upset	100.0							
	14	API Integral Joint	80.8							
	15	Atlas Bradford DSS-HTC	113.0							
	16	Hydril CS	114.0				103.0			
	17	Vallourec mini VAM	+ 100.0				+ 100.0			

			Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)	Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)
			J55	C75/LN80				J55	C75/LN80			
Connection characteristics	18	API Non-Upset	40	50	42.2		24.3					
	19	API External Upset	80	100	48.3		24.3					
	20	API Integral Joint	50	70	39.4		24.3					
	21	Atlas Bradford DSS-HTC	30	40	39.7	25.0	24.3					
	22	Hydril CS	40	50	39.4	24.6	24.3	40	50	40.6	21.9	21.9
	23	Vallourec mini VAM	30	40	39.5		24.3			41.0		21.9

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**1.660** in		42.2 mm		**1.660** in		42.2 mm	
	2	Nominal weight	2.10 lb/ft		3.1 daN/m		2.30/2.40 lb/ft		3.4/3.5 daN/m	
	3	Wall thickness	0.125 in		3.2 mm		0.140 in		3.6 mm	
	4	Inside diameter	1.410 in		35.8 mm		1.380 in		35.1 mm	
	5	Steel cross-section	0.603 in^2		389 mm^2		0.669 in^2		431 mm^2	
	6	Capacity	0.081 gal/ft		1.01 l/m		0.078 gal/ft		0.96 l/m	
	7	Displacement	0.112 gal/ft		1.40 l/m		0.112 gal/ft		1.40 l/m	
	8	Grade	J55	C75	N80	P105	J55	C75	N80	P105
	9	Collapse resistance (MPa)	52.8	72.0	76.8	96.3	58.6	79.9	85.2	111.8
	10	*Internal yield pressure (MPa)*	*50.0*	*68.1*	*72.7*	*95.4*	*56.0*	*76.3*	*81.4*	*106.8*
	11	Pipe body yield strength (10^3 daN)	14.7	20.1	21.5	28.2	16.4	22.3	23.8	31.2
Connection efficiency	12	API Non-Upset	92.0				58.1			
	13	API External Upset					100.0			
	14	API Integral Joint					82.9			
	15	Atlas Bradford DSS-HTC					109.0			
	16	*Hydril CS*					110.0			
	15	Vallourec mini VAM					+ 100.0			

			Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)	Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)
			J55	C75/LN80				J55	C75/LN80			
Connection characteristics	18	API Non-Upset	70		47.8		33.4	50	60	52.2		32.7
	19	API External Upset						90	130	55.9		32.7
	20	API Integral Joint						70	90	47.8		32.7
	21	Atlas Bradford DSS-HTC						50	70	48.1	33.0	32.7
	22	Hydril CS						50	80	47.8	33.3	32.7
	23	API Vallourec mini VAM						50	70	48.6		32.7

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**1.660** in		42.2 mm		**1.660** in		42.2 mm	
	2	Nominal weight	3.02/3.05 lb/ft		4.4/4.5 daN/m		3.24 lb/ft		4.7 daN/m	
	3	Wall thickness	0.191 in		4.9 mm		0.198 in		5.0 mm	
	4	Inside diameter	1.278 in		32.5 mm		1.264 in		32.1 mm	
	5	Steel cross-section	0.881 in^2		569 mm^2		0.909 in^2		587 mm^2	
	6	Capacity	0.067 gal/ft		0.83 l/m		0.065 gal/ft		0.81 l/m	
	7	Displacement	0.112 gal/ft		1.40 l/m		0.112 gal/ft		1.40 l/m	
	8	Grade	J55	C75	N80	P105	J55	C75	N80	P105
	9	Collapse resistance (MPa)	77.2	105.3	112.3	147.4	79.7	108.6	115.9	152.1
	10	Internal yield pressure (MPa)	76.4	104.1	111.1	145.8	79.2	107.9	115.1	151.1
	11	Pipe body yield strength (10^3 daN)	21.6	29.4	31.4	41.2	22.2	30.3	32.4	42.5
Connection efficiency	12	API Non-Upset								
	13	API External Upset								
	14	API Integral Joint								
	15	Atlas Bradford DSS-HTC	105.0				102.0			
	16	Hydril CS	102.0				103.0			
	17	Vallourec mini VAM	+ 100.0							

			Make-up torque (daN.m)		OD (mm)	ID (mm)	API *Drift* (mm)	Make-up torque (daN.m)		OD (mm)	ID (mm)	API *Drift* (mm)
			J55	C75/LN80				J55	C75/LN80			
Connection characteristics	18	API Non-Upset										
	19	API External Upset										
	20	API Integral Joint										
	21	Atlas Bradford DSS-HTC			49.8	30.6	30.1			49.8	30.6	29.7
	22	Hydril CS	50	80	48.9	30.9	30.1	50	80	48.9	30.5	29.7
	23	API Vallourec mini VAM			50.2		30.1					

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**1.900** in		48.3 mm		**1.900** in		48.3 mm	
	2	Nominal weight	2.40 lb/ft		3.5 daN/m		2.75/2.90 lb/ft		4.0/4.2 daN/m	
	3	Wall thickness	0.125 in		3.2 mm		0.145 in		3.7 mm	
	4	Inside diameter	1.650 in		41.9 mm		1.610 in		40.9 mm	
	5	Steel cross-section	0.697 in^2		450 mm^2		0.799 in^2		516 mm^2	
	6	Capacity	0.111 gal/ft		1.38 l/m		0.106 gal/ft		1.31 l/m	
	7	Displacement	0.147 gal/ft		1.83 l/m		0.147 gal/ft		1.83 l/m	
	8	Grade	J55	C75	N80	P105	J55	C75	N80	P105
	9	Collapse resistance (MPa)	45.8	58.2	61.1	74.5	53.5	72.9	77.8	98.6
	10	Internal yield pressure (MPa)	43.7	59.5	63.5	83.3	50.6	69.1	73.7	96.7
	11	Pipe body yield strength(10^3 daN)	17.1	23.3	24.8	32.6	19.6	26.7	28.4	37.3
Connection efficiency	12	API Non-Upset	96.4				59.7			
	13	API External Upset					100.0			
	14	API Integral Joint					84.1			
	15	Atlas Bradford DSS-HTC					106.0			
	16	Hydril CS					107.0			
	17	Vallourec mini VAM					+ 100.0			

			Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)	Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)
			J55	C75/LN80				J55	C75/LN80			
Connection characteristics	18	API Non-Upset	80		53.3		39.5	60	80	55.9		38.5
	19	API External Upset						120	160	63.5		38.5
	20	API Integral Joint						80	110	53.3		38.5
	21	Atlas Bradford DSS-HTC						70	80	53.9	38.9	38.5
	22	Hydril CS						80	110	53.7	38.9	38.5
	23	Vallourec mini VAM						60	80	54.4		38.5

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**1.900** in		48.3 mm			**1.900** in		48.3 mm		
	2	Nominal weight	3.64/4.10 lb/ft		5.3/6.0 daN/m			4.19 lb/ft		6.1 daN/m		
	3	Wall thickness	0.200 in		5.1 mm			0.219 in		5.6 mm		
	4	Inside diameter	1.500 in		38.1 mm			1.462 in		37.1 mm		
	5	Steel cross-section	1.068 in^2		689 mm^2			1.157 in^2		746 mm^2		
	6	Capacity	0.092 gal/ft		1.14 l/m			0.087 gal/ft		1.08 l/m		
	7	Displacement	0.147 gal/ft		1.83 l/m			0.147 gal/ft		1.83 l/m		
	8	Grade	J55	C75	N80	P105		J55	C75	N80	P105	
	9	Collapse resistance (MPa)	71.4	97.4	103.9	136.4		77.3	105.5	112.5	147.7	
	10	Internal yield pressure (MPa)	69.9	95.3	101.6	133.4		76.5	104.3	111.3	146.0	
	11	Pipe body yield strength (10^3 daN)	26.1	35.6	38.0	49.9		28.3	38.6	41.2	54.0	
Connection efficiency	12	API Non-Upset										
	13	API External Upset										
	14	API Integral Joint										
	15	Atlas Bradford DSS-HTC										
	16	Hydril CS	100.0					102.0				
	17	Vallourec mini VAM	+ 100.0									
Connection characteristics			Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)	Make-up torque (daN.m)		OD (mm)	ID (mm)	API Drift (mm)
			J55	C75/LN80				J55	C75/LN80			
	18	API Non-Upset										
	19	API External Upset										
	20	API Integral Joint										
	21	Atlas Bradford DSS-HTC										
	22	Hydril CS	80	110	54.9	36.6	35.7	80	110	55.3	35.3	34.8
	23	Vallourec mini VAM			56.4		35.7					

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**2.063** in		52.4 mm		**2.063** in		52.4 mm	
	2	Nominal weight	3.25/3.40 lb/ft		4.7/5.0 daN/m		4.50 lb/ft		6.6 daN/m	
	3	Wall thickness	0.156 in		4.0 mm		0.225 in		5.7 mm	
	4	Inside diameter	1.751 in		44.5 mm		1.613 in		41.0 mm	
	5	Steel cross-section	0.935 in^2		603 mm^2		1.299 in^2		838 mm^2	
	6	Capacity	0.125 gal/ft		1.55 l/m		0.106 gal/ft		1.32 l/m	
	7	Displacement	0.174 gal/ft		2.16 l/m		0.174 gal/ft		2.16 l/m	
	8	Grade	J55	C75	N80	P105	J55	C75	N80	P105
	9	Collapse resistance (MPa)	53.0	72.3	77.1	97.0	73.7	100.5	107.2	140.7
	10	Internal yield pressure (MPa)	50.2	68.4	73.0	95.8	72.4	98.7	105.3	138.2
	11	Pipe body yield strength (10^3 daN)	22.9	31.2	33.3	43.7	31.8	43.3	46.2	60.7
Connection efficiency	12	API Non-Upset								
	13	API External Upset								
	14	API Integral Joint	95.3							
	15	Atlas Bradford DSS-HTC	115.0				109.0			
	16	Hydril CS	108.0				102.0			
	17	Vallourec mini VAM	+ 100.0				+ 100.0			

			Make-up torque (daN.m)		OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)		OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80				J55	C75/LN80			
Connection characteristics	18	API Non-Upset										
	19	API External Upset										
	20	API Integral Joint	100	140	59.1		42.1					
	21	Atlas Bradford DSS-HTC	80	110	59.4	43.2	42.1			62.5	39.2	38.6
	22	Hydril CS	90	120	59.2	43.2	42.1	90	120	62.5	39.4	38.6
	23	API Vallourec mini VAM	70	90	59.2		42.1			61.8		38.6

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS

Pipe body	1	Nominal size (OD)	**2.375** in				60.3 mm				**2.375** in				60.3 mm			
	2	Nominal weight	4.00 lb/ft				5.8 daN/m				4.60/4.70 lb/ft				6.7/6.9 daN/m			
	3	Wall thickness	0.167 in				4.2 mm				0.190 in				4.8			
	4	Inside diameter	2.041 in				51.8 mm				1.995 in				50.7 mm			
	5	Steel cross-section	1.158 in^2				747 mm^2				1.304 in^2				841 mm^2			
	6	Capacity	0.170 gal/ft				2.11 l/m				0.162 gal/ft				2.02 l/m			
	7	Displacement	0.230 gal/ft				2.86 l/m				0.230 gal/ft				2.86 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	49.6	65.4	68.8	68.8	75.4	78.7	84.9	96.4	55.8	76.1	81.2	81.2	91.3	96.4	106.6	123.4
	10	Internal yield pressure (MPa)	46.7	63.6	67.9	67.9	76.4	80.6	89.1	106.1	53.1	72.4	77.2	77.2	86.9	91.7	101.4	120.7
	11	Pipe body yield strength (10^3 daN)	28.3	38.6	41.2	41.2	46.4	49.0	54.1	64.4	31.9	43.5	46.4	46.4	52.1	55.1	60.9	72.5
Connection efficiency	12	API Non-Upset	65.0								68.9							
	13	API External Upset									100.0							
	14	Atlas Bradford TC4S									91.1							
	15	Atlas Bradford FL4S									45.0							
	16	Atlas Bradford IJ4S									108.3							
	17	Hydril PH-4/PH-6																
	18	Hydril CFJ/CFJ-P									65.1							
	19	Hydril CS									106.0							
	20	Mannesman TDS									100.0							
	21	Vallourec New VAM Stdt (SC)									106.8 (81.5)							
	22	Vallourec VAM ACE									108.9							

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset	80	110	120			73.0		49.5	100	130	150	170		73.0		48.3
	24	API External Upset									170	240	260	310		77.8		48.3
	25	Atlas Bradford TC4S									180	270	270	330		69.9		48.3
	26	Atlas Bradford FL4S									50	70	70	70		60.3	48.9	48.3
	27	Atlas Bradford IJ4S									150	180	180	200		68.8	49.4	48.3
	28	*Hydril PH-4/PH-6*																
	29	Hydril CFJ/CFJ-P									110	150		150		64.1	49.4	48.3
	30	Hydril CS									150	200		200		68.6	49.4	48.3
	31	Mannesman TDS									120	140	150	150		73.0		48.3
	32	Vallourec New VAM Stdt									160	220	250	280	310	68.8		48.3
	33	Vallourec VAM ACE									130	140	150	160	170	68.5		48.3

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	2.375 in				60.3 mm				2.375 in				60.3 mm			
	2	Nominal weight	5.10/5.30 lb/ft				7.4/7.7 daN/m				5.80/5.95 lb/ft				8.5/8.7 daN/m			
	3	Wall thickness	0.218 in				5.5 mm				0.254 in				6.5 mm			
	4	Inside diameter	1.939 in				49.3 mm				1.867 in				47.4 mm			
	5	Steel cross-section	1.477 in^2				953 mm^2				1.692 in^2				1 092 mm^2			
	6	Capacity	0.153 gal/ft				1.91 l/m				0.142 gal/ft				1.77 l/m			
	7	Displacement	0.230 gal/ft				2.86 l/m				0.230 gal/ft				2.86 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	63.2	86.2	92.0	92.0	103.5	109.2	120.7	143.7	72.4	98.8	105.4	105.4	118.5	125.1	138.3	164.6
	10	Internal yield pressure (MPa)	60.9	83.1	88.6	88.6	99.7	105.2	116.3	138.4	71.0	96.8	103.2	103.2	116.1	122.6	135.5	161.3
	11	Pipe body yield strength (10^3 daN)	36.1	49.3	52.6	52.6	59.1	62.4	69.0	82.1	41.4	56.5	60.2	60.2	67.8	71.5	79.0	94.1
Connection efficiency	12	API Non-Upset									76.1							
	13	API External Upset									100.0							
	14	Atlas Bradford TC4S	92.1								93.2							
	15	Atlas Bradford FL4S									55.0							
	16	Atlas Bradford IJ4S	106.1								108.1							
	17	Hydril PH-4/PH-6									109.0							
	18	Hydril CFJ/CFJ-P	68.8															
	19	Hydril CS	104.0															
	20	Mannesman TDS									100.0							
	21	Vallourec New VAM Stdt (SC)	102.9 (72.0)								102.4 (82.3)							
	22	Vallourec VAM ACE	119.1								103.9							
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset										190	210	250		73.0		45.0
	24	API External Upset										300	320	380		77.8		45.0
	25	Atlas Bradford TC4S	180	270	270	330		69.9		46.9	240	340	340	410		71.1		45.0
	26	Atlas Bradford FL4S									50	70	70	70		60.3	46.3	45.0
	27	Atlas Bradford IJ4S	180	200	200	230		68.8	48.0	46.9	200	230	230	260		73.9	45.8	45.0
	28	Hydril PH-4/PH-6										300		370		73.8	45.8	45.0
	29	Hydril CFJ/CFJ-P	110	150		150		64.1	48.0	46.9								
	30	Hydril CS	150	200		200		69.9	48.0	46.9								
	31	Mannesman TDS										150	180	200		73.0		45.0
	32	Vallourec New VAM Stdt	160	220	250	280	310	69.5		46.9	170	230	260	290	320	70.7		45.0
	33	Vallourec VAM ACE	130	140	150	160	170	70.5		46.9	160	180	190	210	220	70.5		45.0

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**2.375** in				60.3 mm				**2.375** in				60.3 mm			
	2	Nominal weight	6.20 lb/ft				9.0 daN/m				6.30/6.65 lb/ft				9.2/9.7 daN/m			
	3	Wall thickness	0.261 in				6.6 mm				0.280 in				7.1 mm			
	4	Inside diameter	1.853 in				47.1 mm				1.815 in				46.1 mm			
	5	Steel cross-section	1.733 in^2				1 118 mm^2				1.843 in^2				1 189 mm^2			
	6	Capacity	0.140 gal/ft				1.74 l/m				0.134 gal/ft				1.67 l/m			
	7	Displacement	0.230 gal/ft				2.86 l/m				0.230 gal/ft				2.86 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	74.2	101.2	107.9	107.9	121.4	128.1	141.6	168.6	78.9	107.6	114.7	114.7	129.1	136.2	150.6	179.3
	10	Internal yield pressure (MPa)	72.9	99.4	106.1	106.1	119.3	126.0	139.2	165.7	78.2	106.7	113.8	113.8	128.0	135.1	149.4	177.8
	11	Pipe body yield strength (10^3 daN)	42.4	57.8	61.7	61.7	69.4	73.2	81.0	96.4	45.1	61.5	65.6	65.6	73.8	77.9	86.1	102.5
Connection efficiency	12	API Non-Upset																
	13	API External Upset																
	14	Atlas Bradford TC4S	93.3															
	15	Atlas Bradford FL4S									55.0							
	16	Atlas Bradford IJ4S	106.7															
	17	Hydril PH-4/PH-6	108.0															
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS																
	20	Mannesman TDS																
	21	Vallourec *New VAM Stdt (SC)*																
	22	Vallourec VAM ACE									102.1							

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S	240	340	340	410		71.1		44.7								
	26	Atlas Bradford FL4S									70	80	80	80		60.3	45.0	43.7
	27	Atlas Bradford IJ4S	230	260	260	280		73.9	45.6	44.7								
	28	Hydril PH-4/PH-6		300		370		74.6	45.6	44.7								
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt																
	33	Vallourec VAM ACE									200	220	230	250	280	71.2		43.7

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	**1**	Nominal size (OD)	**2.375** in				60.3 mm				**2.875** in				73.0 mm			
	2	Nominal weight	7.30/7.70 lb/ft				10.7/11.2 daN/m				6.40/6.50 lb/ft				9.3/9.5 daN/m			
	3	Wall thickness	0.336 in				8.5 mm				0.217 in				5.5			
	4	Inside diameter	1.703 in				43.3 mm				2.441 in				62.0 mm			
	5	Steel cross-section	2.152 in^2				1389 mm^2				1.812 in^2				1169 mm^2			
	6	Capacity	0.118 gal/ft				1.47 l/m				0.243 gal/ft				3.02 l/m			
	7	Displacement	0.230 gal/ft				2.86 l/m				0.337 gal/ft				4.19 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	92.1	125.6	134.0	134.0	150.7	159.1	175.9	209.4	52.9	72.2	77.0	77.0	85.4	89.2	96.7	110.8
	10	Internal yield pressure (MPa)	93.9	128.0	136.6	136.6	153.6	162.2	179.2	213.4	50.1	68.3	72.9	72.9	82.0	86.5	95.6	113.8
	11	Pipe body yield strength (10^3 daN)	52.7	71.8	76.6	76.6	86.2	91.0	100.5	119.7	44.3	60.5	64.5	64.5	72.5	76.6	84.6	100.8
Connection efficiency	**12**	API Non-Upset												72.8				
	13	API External Upset												100.0				
	14	Atlas Bradford TC4S				94.6								92.3				
	15	*Atlas Bradford FL4S*												45.0				
	16	Atlas Bradford IJ4S				105.3								111.3				
	17	Hydril PH-4/PH-6				106.0												
	18	Hydril CFJ/CFJ-P												65.8				
	19	Hydril CS												101.0				
	20	Mannesman TDS												100.0				
	21	Vallourec New VAM Stdt (SC)												106.2 (83.9)				
	22	Vallourec VAM ACE				102.0								104.4				

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	**23**	API Non-Upset									140	190	210	250		88.9		59.6
	24	API External Upset									220	310	330	390		93.2		59.6
	25	*Atlas Bradford TC4S*	350	430	430	520		73.7		40.9	230	350	350	410		82.6		59.6
	26	Atlas Bradford FL4S									80	110	110	110		73.0	60.2	59.6
	27	Atlas Bradford IJ4S	270	300	300	330		79.6	41.8	40.9	220	240	240	300		82.0	60.4	59.6
	28	Hydril PH-4/PH-6		300		370		79.4	41.8	40.9								
	29	Hydril CFJ/CFJ-P									150	200		200		76.2	60.3	59.6
	30	Hydril CS									200	280		280		81.5	60.2	59.6
	31	Mannesman TDS									170	180	210	240		88.9		59.6
	32	Vallourec New VAM Stdt									240	320	380	430	480	82.3		59.6
	33	Vallourec VAM ACE	250	290	300	320	340	73.0		40.9	200	250	260	290	310	82.0		59.6

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**2.875** in	73.0 mm	**2.875** in	73.0 mm
	2	Nominal weight	7.70/7.90 lb/ft	11.2/11.5 daN/m	8.60/8.70 lb/ft	12.6/12.7 daN/m
	3	Wall thickness	0.276 in	7.0 mm	0.308 in	7.8 mm
	4	Inside diameter	2.323 in	59.0 mm	2.259 in	57.4 mm
	5	Steel cross-section	2.254 in^2	1 454 mm^2	2.484 in^2	1 602 mm^2
	6	Capacity	0.220 gal/ft	2.73 l/m	0.208 gal/ft	2.59 l/m
	7	Displacement	0.337 gal/ft	4.19 l/m	0.337 gal/ft	4.19 l/m

Pipe body	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	65.8	89.8	95.7	95.7	107.7	113.7	125.7	149.6	72.5	98.9	105.5	105.5	118.7	125.3	138.5	164.9
	10	Internal yield pressure (MPa)	63.7	86.9	92.7	92.7	104.2	110.0	121.6	144.8	71.1	96.9	103.4	103.4	116.3	122.8	135.7	161.6
	11	Pipe body yield strength (10^3 daN)	55.1	75.2	80.2	80.2	90.2	95.2	105.3	125.3	60.8	82.9	88.4	88.4	99.4	105.0	116.0	138.1

Connection efficiency	12	API Non-Upset	78.1	80.2
	13	API External Upset	100.0	100.0
	14	Atlas Bradford TC4S	93.8	94.3
	15	Atlas Bradford FL4S	55.0	55.0
	16	Atlas Bradford IJ4S	108.4	107.5
	17	Hydril PH-4/PH-6	108.0	107.0
	18	Hydril CFJ/CFJ-P		
	19	Hydril CS		
	20	Mannesman TDS	100.0	100.0
	21	Vallourec New VAM Stdt (SC)	107.6 (93.1)	103.4 (84.4)
	22	Vallourec VAM ACE	106.1	102.2

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset		260	280	330		88.9		56.6		290	320	380		88.9		55.0
	24	API External Upset		370	400	470		93.2		56.6		400	440	520		93.2		55.0
	25	Atlas Bradford TC4S	270	410	410	470		85.7		56.6	270	410	410	470		85.7		55.0
	26	Atlas Bradford FL4S	80	110	110	110		73.0	57.9	56.6	90	120	120	120		73.0	56.3	55.0
	27	Atlas Bradford IJ4S	300	350	350	410		86.0	57.5	56.6	350	410	410	470		89.2	55.9	55.0
	28	Hydril PH-4/PH-6		410		470		87.3	57.5	56.6		410		470		88.9	55.9	55.0
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS		230	260	280		88.9		56.6		260	300	320		88.9		55.0
	32	Vallourec New VAM Stdt	250	340	390	450	500	84.8		56.6	280	380	440	510	570	85.4		55.0
	33	Vallourec VAM ACE	250	280	300	330	350	84.5		56.6	290	330	360	390	420	85.2		55.0

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**2.875** in				73.0 mm				**2.875** in				73.0 mm			
	2	Nominal weight	9.50 lb/ft				13.9 daN/m				9.80/10.40 lb/ft				14.3/15.2 daN/m			
	3	Wall thickness	0.340 in				8.6 mm				0.362 in				9.2 mm			
	4	Inside diameter	2.195 in				55.8 mm				2.151 in				54.6 mm			
	5	Steel cross-section	2.708 in^2				1 747 mm^2				2.858 in^2				1 844 mm^2			
	6	Capacity	0.197 gal/ft				2.44 l/m				0.189 gal/ft				2.34 l/m			
	7	Displacement	0.337 gal/ft				4.19 l/m				0.337 gal/ft				4.19 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	79.1	107.8	115.0	115.0	129.4	136.6	151.0	179.7	83.5	113.8	121.4	121.4	136.6	144.2	159.4	189.7
	10	Internal yield pressure (MPa)	78.5	107.0	114.2	114.2	128.4	135.6	149.8	178.4	83.6	113.9	121.5	121.5	136.7	144.3	159.5	189.9
	11	Pipe body yield strength (10^3 daN)	66.2	90.3	96.4	96.4	108.4	114.4	126.5	150.6	69.9	95.3	101.7	101.7	114.4	120.8	133.5	158.9
Connection efficiency	12	API Non-Upset																
	13	API External Upset																
	14	Atlas Bradford TC4S	94.8															
	15	Atlas Bradford FL4S									65.0							
	16	Atlas Bradford IJ4S	107.1								106.7							
	17	Hydril PH-4/PH-6	107.0															
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS																
	20	Mannesman TDS																
	21	Vallourec New VAM Stdt (SC)									103.1 (84.8)							
	22	Vallourec VAM ACE									102.1							
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S	270	410	410	470		87.6		53.4								
	26	Atlas Bradford FL4S									90	120	120	120		73.0	53.5	52.3
	27	Atlas Bradford IJ4S	410	470	470	540		92.3	54.2	53.4						92.3	53.1	52.3
	28	Hydril PH-4/PH-6		610		750		92.1	54.1	53.4								
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt									320	440	510	580	650	87.2		52.3
	33	Vallourec VAM ACE									340	420	460	490	540	87.0		52.3

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**2.875** in	73.0 mm	**2.875** in	73.0 mm
	2	Nominal weight	10.70/11.00 lb/ft	15.6/16.1 daN/m	11.65 lb/ft	17.0 daN/m
	3	Wall thickness	0.405 in	10.3 mm	0.440 in	11.2 mm
	4	Inside diameter	2.065 in	52.5 mm	1.995 in	50.7 mm
	5	Steel cross-section	3.143 in^2	2 028 mm^2	3.366 in^2	2 172 mm^2
	6	Capacity	0.174 gal/ft	2.16 l/m	0.162 gal/ft	2.02 l/m
	7	Displacement	0.337 gal/ft	4.19 l/m	0.337 gal/ft	4.19 l/m

Pipe body	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	91.8	125.2	133.5	133.5	150.2	158.5	175.2	208.6	98.3	134.1	143.0	143.0	160.9	169.8	187.7	223.4
	10	Internal yield pressure (MPa)	93.5	127.5	136.0	136.0	153.0	161.5	178.5	212.5	101.6	138.5	147.7	147.7	166.2	175.4	193.9	230.8
	11	Pipe body yield strength (10^3 daN)	76.9	104.8	111.8	111.8	125.8	132.8	146.8	174.7	82.3	112.3	119.8	119.8	134.8	142.2	157.2	187.2

Connection efficiency	12	API Non-Upset		
	13	API External Upset		
	14	Atlas Bradford TC4S	95.5	95.8
	15	Atlas Bradford FL4S		
	16	Atlas Bradford IJ4S	105.8	105.3
	17	Hydril PH-4/PH-6	106.0	104.8
	18	Hydril CFJ/CFJ-P		
	19	Hydril CS		
	20	Mannesman TDS		
	21	Vallourec New VAM Stdt (SC)		
	22	Vallourec VAM ACE	102.1	

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S	340	490	490	570		88.9		50.1	340	490	490	570		90.2		48.3
	26	Atlas Bradford FL4S																
	27	Atlas Bradford IJ4S	490	540	540	600		95.5	50.9	50.1	540	610	610	680		95.5	49.1	48.3
	28	Hydril PH-4/PH-6		680		880		95.3	50.8	50.1		680		880		95.3	49.4	48.3
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt																
	33	Vallourec VAM ACE	390	470	520	570	620	88.4		50.1								

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**3.500** in				88.9 mm				**3.500** in				88.9 mm			
	2	Nominal weight	7.70 lb/ft				11.2 daN/m				9.20/9.30 lb/ft				13.4/13.6 daN/m			
	3	Wall thickness	0.216 in				5.5 mm				0.254 in				6.5 mm			
	4	Inside diameter	3.068 in				77.9 mm				2.992 in				76.0 mm			
	5	Steel cross-section	2.228 in^2				1 438 mm^2				2.590 in^2				1 671 mm^2			
	6	Capacity	0.384 gal/ft				4.77 l/m				0.365 gal/ft				4.54 l/m			
	7	Displacement	0.500 gal/ft				6.21 l/m				0.500 gal/ft				6.21 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	41.2	51.8	54.2	54.2	58.9	61.0	65.2	72.4	51.0	69.0	72.6	72.6	79.8	83.3	90.0	102.7
	10	Internal yield pressure (MPa)	41.0	55.8	59.6	59.6	67.0	70.7	78.2	93.1	48.2	65.7	70.1	70.1	78.8	83.2	91.9	109.5
	11	Pipe body yield strength (10^3 daN)	54.5	74.3	79.3	79.3	89.2	94.2	104.1	123.9	63.4	86.4	92.2	92.2	103.7	109.5	121.0	144.0
Connection efficiency	12	API Non-Upset	73.0								76.8							
	13	API External Upset									100.0							
	14	Atlas Bradford TC4S									93.4							
	15	Atlas Bradford FL4S	45.0								55.0							
	16	Atlas Bradford IJ4S									105.9							
	17	Hydril PH-4/PH-6																
	18	Hydril CFJ/CFJ-P									67.2							
	19	Hydril CS									105.0							
	20	Mannesman TDS									100.0							
	21	Vallourec New VAM Stdt (SC)	104.1								103.4 (80.8)							
	22	Vallourec VAM ACE	101.9								101.7							
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset	160	230	250			108.0		74.8	200	280	300	360		108.0		72.8
	24	API External Upset									310	420	470	550		114.3		72.8
	25	Atlas Bradford TC4S									310	430	430	560		100.3		72.8
	26	Atlas Bradford FL4S	190	220	220	220		88.9	75.4	74.8	190	220	220	220		88.9	74.1	72.8
	27	Atlas Bradford IJ4S									300	350	350	410		98.4	74.2	72.8
	28	Hydril PH-4/PH-6																
	29	Hydril CFJ/CFJ-P									200	260		260		91.7	74.2	72.8
	30	Hydril CS									340	410		410		99.4	74.2	72.8
	31	Mannesman TDS									260	320	360	400		108.0		72.8
	32	Vallourec New VAM Stdt	310	420	490	550	620	97.5		74.8	320	440	510	580	650	99.1		72.8
	33	Vallourec VAM ACE	240	260	280	310	330	97.3		74.8	330	380	410	440	470	98.8		72.8

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	3.500 in				88.9 mm				3.500 in				88.9 mm			
	2	Nominal weight	10.20/10.30 lb/ft				14.9/15.0 daN/m				12.70/12.95 lb/ft				18.5/18.9 daN/m			
	3	Wall thickness	0.289 in				7.3 mm				0.375 in				9.5 mm			
	4	Inside diameter	2.922 in				74.2 mm				2.750 in				69.9 mm			
	5	Steel cross-section	2.915 in^2				1 881 mm^2				3.682 in^2				2 375 mm^2			
	6	Capacity	0.348 gal/ft				4.33 l/m				0.309 gal/ft				3.83 l/m			
	7	Displacement	0.500 gal/ft				6.21 l/m				0.500 gal/ft				6.21 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	57.5	78.3	83.6	83.6	94.0	99.2	109.7	130.6	72.6	98.9	105.5	105.5	118.7	125.3	138.5	164.9
	10	Internal yield pressure (MPa)	54.8	74.7	79.7	79.7	89.7	94.6	104.6	124.5	71.1	97.0	103.4	103.4	116.3	122.8	135.7	161.6
	11	Pipe body yield strength (10^3 daN)	*71.3*	*97.3*	*103.7*	*103.7*	*116.7*	*123.2*	*136.2*	*162.1*	*90.1*	*122.8*	*131.0*	*131.0*	*147.4*	*155.8*	*172.0*	*204.7*
Connection efficiency	12	API Non-Upset	79.4								83.7							
	13	API External Upset									100.0							
	14	Atlas Bradford TC4S	94.1								95.4							
	15	*Atlas Bradford FL4S*	55.0								65.0							
	16	Atlas Bradford IJ4S	106.8								107.4							
	17	Hydril PH-4/PH-6									119.0							
	18	Hydril CFJ/CFJ-P	65.5															
	19	Hydril CS	101.0															
	20	Mannesman TDS	100.0								100.0							
	21	Vallourec New VAM Stdt (SC)	*104.7 (84.0)*								*103.2 (82.9)*							
	22	Vallourec VAM ACE	103.0								101.9							
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset	230	320	350			108.0		71.0		430	470	550		108.0		66.7
	24	API External Upset										570	630	740		114.3		66.7
	25	Atlas Bradford TC4S	310	430	430	560		100.3		71.0	380	500	500	640		104.1		66.7
	26	Atlas Bradford FL4S	190	220	220	220		88.9	72.3	71.0	200	230	230	230		88.9	67.9	66.7
	27	Atlas Bradford IJ4S	350	410	410	470		100.3	73.1	71.0	410	470	470	540		108.2	68.2	66.7
	28	Hydril PH-4/PH-6										750		950		109.6	68.2	66.7
	29	Hydril CFJ/CFJ-P	*200*	*260*		*260*		*91.7*	*73.1*	*71.0*								
	30	Hydril CS	340	410		410		99.4	72.9	71.0								
	31	Mannesman TDS	290	350	390	450		108.0		71.0		400	500	610		108.0		66.7
	32	Vallourec New VAM Stdt	360	500	580	660	730	100.6		71.0	430	580	670	760	850	103.6		66.7
	33	Vallourec VAM ACE	420	470	500	540	580	100.3		71.0	590	670	720	760	830	103.4		66.7

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**3.500** in				88.9 mm				**3.500** in				88.9 mm			
	2	Nominal weight	13.70 lb/ft				20.0 daN/m				14.70 lb/ft				21.5 daN/m			
	3	Wall thickness	0.413 in				10.5 mm				0.450 in				11.4 mm			
	4	Inside diameter	2.674 in				67.9 mm				2.600 in				66.0 mm			
	5	Steel cross-section	4.005 in^2				2 584 mm^2				4.312 in^2				2 782 mm^2			
	6	Capacity	0.292 gal/ft				3.62 l/m				0.276 gal/ft				3.43 l/m			
	7	Displacement	0.500 gal/ft				6.21 l/m				0.500 gal/ft				6.21 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	78.9	107.6	114.8	114.8	129.2	136.3	150.7	179.4	85.0	115.9	123.6	123.6	139.0	146.8	162.2	193.1
	10	Internal yield pressure (MPa)	78.3	106.8	113.9	113.9	128.1	135.3	149.5	178.0	85.3	116.3	124.1	124.1	139.6	147.4	162.9	193.9
	11	Pipe body yield strength (10^3 daN)	98.0	133.6	142.5	142.5	160.3	169.3	187.1	222.7	105.5	143.8	153.4	153.4	172.6	182.2	201.4	239.7
Connection efficiency	12	API Non-Upset																
	13	API External Upset																
	14	Atlas Bradford TC4S																
	15	Atlas Bradford FL4S																
	16	Atlas Bradford IJ4S																
	17	Hydril PH-4/PH-6																
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS																
	20	Mannesman TDS																
	21	Vallourec New VAM Stdt (SC)	104.4 (89.6)								105.3 (83.2)							
	22	Vallourec VAM ACE	104.8								106.8							

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S																
	26	Atlas Bradford FL4S																
	27	Atlas Bradford IJ4S																
	28	Hydril PH-4/PH-6																
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt	500	680	790	890	1030	105.1		64.7	580	790	880	1030	1130	106.5		62.9
	33	Vallourec VAM ACE	640	730	790	880	930	105.1		64.7	730	830	930	1030	1080	106.7		62.9

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**3.500** in	88.9 mm	**3.500** in	88.9 mm
	2	Nominal weight	15.80 lb/ft	23.1 daN/m	16.70 lb/ft	24.4 daN/m
	3	Wall thickness	0.476 in	12.1 mm	0.510 in	13.0 mm
	4	*Inside diameter*	*2.548 in*	*64.7 mm*	*2.480 in*	*63.0 mm*
	5	Steel cross-section	4.522 in²	2 917 mm²	4.791 in²	3 091 mm²
	6	Capacity	0.265 gal/ft	3.29 l/m	0.251 gal/ft	3.12 l/m
	7	Displacement	0.500 gal/ft	6.21 l/m	0.500 gal/ft	6.21 l/m

Pipe body	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	89.1	121.5	129.6	129.6	145.8	153.9	170.1	202.5	94.4	128.7	137.3	137.3	154.5	163.1	180.2	214.6
	10	Internal yield pressure (MPa)	90.3	123.1	131.3	131.3	147.7	155.9	172.3	205.1	96.7	131.9	140.7	140.7	158.2	167.0	184.6	219.8
	11	Pipe body yield strength (10^3 daN)	110.6	150.9	160.9	160.9	181.0	191.1	211.2	251.4	117.2	159.8	170.5	170.5	191.8	202.4	223.8	266.4

Connection efficiency	12	API Non-Upset		
	13	API External Upset		
	14	Atlas Bradford TC4S	96.2	96.4
	15	Atlas Bradford FL4S	61.9	
	16	Atlas Bradford IJ4S	107.0	105.0
	17	Hydril PH-4/PH-6	106.0	105.0
	18	Hydril CFJ/CFJ-P		
	19	Hydril CS		
	20	Mannesman TDS		
	21	Vallourec New VAM Stdt (SC)	103.0 (92.4)	
	22	Vallourec VAM ACE	101.8	

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S	410	540	540	680		106.7		61.5	410	540	540	680		108.0		59.8
	26	Atlas Bradford FL4S						88.9		61.5								
	27	Atlas Bradford IJ4S	540	610	610	680		111.4	62.7	61.5	610	680	680	750		116.2	61.5	59.8
	28	Hydril PH-4/PH-6		750		950		114.3	63.1	61.5		1020		290		114.3	61.1	59.8
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt	590	800	880	1030	1130	106.9		61.5								
	33	Vallourec VAM ACE	790	880	980	1080	1180	106.7		61.5								

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**4.000** in				101.6 mm				**4.000** in				101.6 mm			
	2	Nominal weight	9.50 lb/ft				13.9 daN/m				10.90/11.00 lb/ft				15.9/16.1 daN/m			
	3	Wall thickness	0.226 in				5.7 mm				0.262 in				6.7 mm			
	4	Inside diameter	3.548 in				90.1 mm				3.476 in				88.3 mm			
	5	Steel cross-section	2.680 in^2				1 729 mm^2				3.077 in^2				1 985 mm^2			
	6	Capacity	0.514 gal/ft				6.38 l/m				0.493 gal/ft				6.12 l/m			
	7	Displacement	0.653 gal/ft				8.11 l/m				0.653 gal/ft				8.11 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	35.3	43.6	45.4	45.4	48.8	50.4	53.2	57.8	45.5	57.8	60.7	60.7	66.2	68.8	73.8	82.9
	10	Internal yield pressure (MPa)	37.5	51.1	54.5	54.5	61.4	64.8	71.6	85.2	43.5	59.3	63.2	63.2	71.1	75.1	83.0	98.8
	11	Pipe body yield strength (10^3 daN)	65.6	89.4	95.4	95.4	107.3	113.2	125.2	149.0	75.3	102.6	109.5	109.5	123.2	130.0	143.7	171.1
Connection efficiency	12	API Non-Upset	67.2															
	13	API External Upset									100.0							
	14	Atlas Bradford TC4S									91.5							
	15	Atlas Bradford FL4S	45.0								55.0							
	16	Atlas Bradford IJ4S									104.5							
	17	Hydril PH-4/PH-6																
	18	Hydril CFJ/CFJ-P									67.0							
	19	Hydril CS									105.0							
	20	Mannesman TDS									100.0							
	21	Vallourec New VAM Stdt (SC)	104.0								103.8 (86.8)							
	22	Vallourec VAM ACE	101.8								101.9							
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset	170	230	250			120.7		86.9								
	24	API External Upset									350	480	520			127.0		85.1
	25	Atlas Bradford TC4S									410	540	540	610		113.0		85.1
	26	Atlas Bradford FL4S	270	310	310	310		101.6	87.6	86.9	300	340	340	340		101.6	86.4	85.1
	27	Atlas Bradford IJ4S									330	380	380	430		111.4	86.4	85.1
	28	Hydril PH-4/PH-6																
	29	Hydril CFJ/CFJ-P									270	370		370		104.1	86.2	85.1
	30	Hydril CS									410	470		470		112.2	86.2	85.1
	31	Mannesman TDS									310	370	430	480		120.7		85.1
	32	Vallourec New VAM Stdt	390	540	630	710	790	110.4		86.9	410	560	650	730	810	111.9		85.1
	33	Vallourec VAM ACE	340	390	440	490	540	110.2		86.9	440	520	570	620	670	111.7		85.1

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS *(continued)*

Pipe body	1	Nominal size (OD)	**4.000** in				101.6 mm				**4.000** in				101.6 mm			
	2	*Nominal weight*	*13.00/13.40 lb/ft*				*19.0/19.6 daN/m*				14.80 lb/ft				21.6 daN/m			
	3	Wall thickness	0.330 in				8.4 mm				0.380 in				9.7 mm			
	4	Inside diameter	3.340 in				84.8 mm				3.240 in				82.3 mm			
	5	Steel cross-section	3.805 in^2				2 455 mm^2				4.322 in^2				2 788 mm^2			
	6	Capacity	*0.455 gal/ft*				*5.65 l/m*				*0.428 gal/ft*				*5.32 l/m*			
	7	Displacement	0.653 gal/ft				8.11 l/m				0.653 gal/ft				8.11 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	57.4	*78.3*	83.5	*83.5*	*93.9*	*99.2*	*109.6*	*130.4*	*65.2*	*88.9*	*94.8*	*94.8*	*106.7*	*112.5*	*124.5*	*148.2*
	10	Eclatement (MPa)	54.7	74.7	79.6	79.6	89.6	94.6	104.5	124.4	63.0	86.0	91.7	91.7	103.2	108.9	120.4	143.3
	11	Tension corps tube (10^3 daN)	93.1	126.9	135.4	135.4	152.3	160.8	177.7	211.6	105.7	144.2	153.8	153.8	173.0	182.6	201.8	240.3
Connection efficiency	12	API Non-Upset																
	13	API External Upset																
	14	Atlas Bradford TC4S	93.1															
	15	Atlas Bradford FL4S	55.0															
	16	Atlas Bradford IJ4S	109.7															
	17	Hydril PH-4/PH-6	108.0															
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS																
	20	Mannesman TDS																
	21	Vallourec New VAM Stdt (SC)	103.9 (76.5)								106.5 (83.8)							
	22	Vallourec VAM ACE	102.0								106.6							
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					*OD (mm)*	ID* (mm)	*API drift* (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset																
	24	*API External Upset*																
	25	Atlas Bradford TC4S	470	610	610	750		114.9		81.7								
	26	Atlas Bradford FL4S	330	370	370	370		101.6	82.9	81.7								
	27	Atlas Bradford IJ4S	430	490	490	540		116.1	83.2	81.7								
	28	Hydril PH-4/PH-6		750		950		117.5	83.2	81.7								
	29	*Hydril CFJ/CFJ-P*																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt	470	650	750	840	950	114.7		81.7	590	810	940	1080	1230	117.0		79.1
	33	Vallourec VAM ACE	490	590	640	690	730	114.4		81.7	640	760	830	910	980	117.0		79.1

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**4.000** in				101.6 mm				**4.000** in				101.6 mm			
	2	Nominal weight	16.50 lb/ft				24.1 daN/m				19.00 lb/ft				27.7 daN/m			
	3	Wall thickness	0.430 in				10.9 mm				0.500 in				12.7 mm			
	4	Inside diameter	3.140 in				79.8 mm				3.000 in				76.2 mm			
	5	Steel cross-section	4.823 in^2				3 111 mm^2				5.498 in^2				3 547 mm^2			
	6	Capacity	0.402 gal/ft				5.00 l/m				0.367 gal/ft				4.56 l/m			
	7	Displacement	0.653 gal/ft				8.11 l/m				0.653 gal/ft				8.11 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	72.8	99.2	105.8	105.8	119.1	125.7	138.9	165.4	83.0	113.1	120.7	120.7	135.7	143.3	158.4	188.5
	10	Internal yield pressure (MPa)	71.3	97.3	103.8	103.8	116.7	123.2	136.2	162.1	83.0	113.1	120.7	120.7	135.7	143.3	158.4	188.5
	11	Pipe body yield strength (10^3 daN)	118.0	160.9	171.6	171.6	193.1	203.8	225.2	268.2	134.5	183.4	195.6	195.6	220.1	232.3	256.8	305.7
Connection efficiency	12	API Non-Upset																
	13	API External Upset																
	14	Atlas Bradford TC4S												95.3				
	15	Atlas Bradford FL4S																
	16	Atlas Bradford IJ4S												107.1				
	17	Hydril PH-4/PH-6												106.0				
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS																
	20	Mannesman TDS																
	21	Vallourec New VAM Stdt (SC)				102.8												
	22	Vallourec VAM ACE				101.5												
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S														121.9		73.0
	26	Atlas Bradford FL4S																
	27	Atlas Bradford IJ4S														120.9	74.3	73.0
	28	Hydril PH-4/PH-6										1150		1420		127.0	74.2	73.0
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt	610	820	960	1080	1230	118.2		76.6								
	33	Vallourec VAM ACE	730	880	980	1080	1180	118.0		76.6								

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**4.000** in	101.6 mm	**4.500** in	114.3 mm
	2	*Nominal weight*	22.50 lb/ft	32.8 daN/m	10.50 lb/ft	15.3 daN/m
	3	Wall thickness	0.610 in	15.5 mm	0.224 in	5.7 mm
	4	Inside diameter	2.780 in	70.6 mm	4.052 in	102.9 mm
	5	Steel cross-section	6.496 in^2	4 191 mm^2	3.009 in^2	1 941 mm^2
	6	Capacity	0.315 gal/ft	3.92 l/m	0.670 gal/ft	8.32 l/m
	7	Displacement	0.653 gal/ft	8.11 l/m	0.826 gal/ft	10.26 l/m

			4.000 in								4.500 in							
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	98.0	133.7	142.6	142.6	160.4	169.3	187.1	222.8	27.6	33.0	34.0	34.0	35.9	36.6	37.8	40.2
	10	Internal yield pressure (MPa)	101.2	138.0	147.2	147.2	165.6	174.8	193.2	230.0	33.0	45.0	48.0	48.0	54.1	57.1	63.1	75.1
	11	Pipe body yield strength (10^3 daN)	158.9	216.7	231.2	231.2	260.1	274.5	303.4	361.2	73.6	100.4	107.1	107.1	120.5	127.2	140.5	167.3

			4.000 in	4.500 in
Connection efficiency	12	API Non-Upset		
	13	API External Upset		
	14	Atlas Bradford TC4S		
	15	Atlas Bradford FL4S		45.0
	16	Atlas Bradford IJ4S	105.7	
	17	Hydril PH-4/PH-6	105.0	
	18	Hydril CFJ/CFJ-P		
	19	Hydril CS		
	20	Mannesman TDS		
	21	Vallourec New VAM Stdt (SC)		113.7 (101.3)
	22	Vallourec VAM ACE		112.3

			Make-up torque (daN.m)					OD (mm)	ID (mm)	*API drift* (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S																
	26	Atlas Bradford FL4S									340					114.3	100.4	99.7
	27	Atlas Bradford IJ4S	540	610	610	680		124.1	68.7	67.4								
	28	Hydril PH-4/PH-6		1290		1560		131.8	68.6	67.4								
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt									460	610	710	790	690	123.5		99.7
	33	Vallourec VAM ACE									370	450	490	540	590	123.5		99.7

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**4.500** in				114.3 mm				**4.500** in				114.3 mm			
	2	Nominal weight	11.60 lb/ft				16.9 daN/m				12.60/12.75 lb/ft				18.4/18.6 daN/m			
	3	Wall thickness	0.250 in				6.4 mm				0.271 in				6.9 mm			
	4	Inside diameter	4.000 in				101.6 mm				3.958 in				100.5 mm			
	5	Steel cross-section	3.338 in^2				2 154 mm^2				3.600 in^2				2 323 mm^2			
	6	Capacity	0.653 gal/ft				8.11 l/m				0.639 gal/ft				7.94 l/m			
	7	Displacement	0.826 gal/ft				10.26 l/m				0.826 gal/ft				10.26 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	34.2	42.1	43.8	43.8	47.0	48.4	51.1	55.2	39.5	49.5	51.7	51.7	56.0	58.0	61.7	68.2
	10	Internal yield pressure (MPa)	36.9	50.3	53.6	53.6	60.3	63.7	70.4	83.8	40.0	54.5	58.1	58.1	65.4	69.0	76.3	90.8
	11	Pipe body yield strength (10^3 daN)	81.7	111.4	118.8	118.8	133.6	141.1	155.9	185.6	88.1	120.1	128.1	128.1	144.1	152.1	168.2	200.2
Connection efficiency	12	API Non-Upset									72.5							
	13	API External Upset									100.0							
	14	Atlas Bradford TC4S									91.8							
	15	Atlas Bradford FL4S	55.0								55.0							
	16	Atlas Bradford IJ4S									111.3							
	17	Hydril PH-4/PH-6																
	18	Hydril CFJ/CFJ-P									71.2							
	19	Hydril CS									105.0							
	20	Mannesman TDS									100.0							
	21	Vallourec New VAM Stdt (SC)	102.5 (91.3)								101.3 (84.6)							
	22	Vallourec VAM ACE	104.1								115.2							
Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
	23	API Non-Upset									240	330	360			132.1		97.4
	24	API External Upset									390	530	590			141.3		97.4
	25	Atlas Bradford TC4S									390	540	540	680		125.7		97.4
	26	Atlas Bradford FL4S	370	430	430	430		114.3	99.7	98.4	370	430	430	430		114.3	97.4	97.4
	27	Atlas Bradford IJ4S									340	410	410	470		125.5	98.6	97.4
	28	Hydril PH-4/PH-6																
	29	Hydril CFJ/CFJ-P									410	540		540		117.1	98.2	97.4
	30	Hydril CS									470	610		610		125.0	98.2	97.4
	31	Mannesman TDS									360	430	460	540		132.1		97.4
	32	Vallourec New VAM Stdt	470	630	730	810	910	123.5		98.4	480	650	750	830	930	124.3		97.4
	33	Vallourec VAM ACE	440	540	590	640	690	123.8		98.4	440	490	540	590	640	126.0		97.4

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**4.500** in				114.3 mm				**4.500** in				114.3 mm			
	2	Nominal weight	13.50 lb/ft				19.7 daN/m				15.10/15.50 lb/ft				22.0/22.6 daN/m			
	3	*Wall thickness*	*0.290 in*				*7.4 mm*				0.337 in				8.6 mm			
	4	Inside diameter	3.920 in				99.6 mm				3.826 in				97.2 mm			
	5	Steel cross-section	3.836 in²				2 475 mm²				4.407 in²				2 844 mm²			
	6	Capacity	0.627 gal/ft				7.79 l/m				0.597 gal/ft				7.42 l/m			
	7	Displacement	0.826 gal/ft				10.26 l/m				0.826 gal/ft				10.26 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	44.3	56.1	58.9	58.9	64.1	66.6	71.4	80.0	52.5	71.7	76.4	76.4	84.3	88.0	95.3	109.1
	10	Internal yield pressure (MPa)	42.8	58.3	62.2	62.2	70.0	73.9	81.6	97.2	49.7.	67.8	72.3	72.3	81.3	85.8	94.9	112.9
	11	Pipe body yield strength (10^3 daN)	93.8	128.0	136.5	136.5	153.6	162.1	179.1	213.3	107.8	147.0	156.8	156.8	176.4	186.2	205.9	245.1
Connection *efficiency*	12	API Non-Upset																
	13	API External Upset																
	14	Atlas Bradford TC4S	92.3								93.3							
	15	Atlas Bradford FL4S	55.0								55.0							
	16	Atlas Bradford IJ4S	104.5								109.5							
	17	Hydril PH-4/PH-6									107.0							
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS	103.0															
	20	*Mannesman* TDS	100.0								100.0							
	21	Vallourec New VAM Stdt (SC)	109.0 (79.4)								103.6 (69.1)							
	22	Vallourec VAM ACE	108.1								101.9							

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID, (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S	390	540	540	680		125.7		96.4	470	610	610	760		129.5		94.0
	26	Atlas Bradford FL4S	410	470	470	470		114.3	97.7	96.4	410	470	470	470		114.3	95.3	94.0
	27	Atlas Bradford IJ4S	410	470	470	540		125.5	97.7	96.4	470	540	540	610		128.5	95.6	94.0
	28	Hydril PH-4/PH-6										810		1020		130.2	95.6	94.0
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS	470	610		610		125.9	97.5	96.4								
	31	Mannesman TDS	380	470	540	590		132.1		96.4	460	520	590	660		132.1		94.0
	32	Vallourec New VAM Stdt	500	670	760	860	950	126.0		96.4	570	790	900	1030	1130	127.3		94.0
	33	Vallourec VAM ACE	490	570	620	670	730	126.0		96.4	590	730	790	830	880	127.1		94.0

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**4.500** in				114.3 mm				**4.500** in				114.3 mm			
	2	Nominal weight	16.90 lb/ft				24.7 daN/m				18.80/19.20 lb/ft				27.4/28.0 daN/m			
	3	Wall thickness	0.373 in				9.5 mm				0.430 in				10.9 mm			
	4	Inside diameter	3.754 in				95.4 mm				3.640 in				92.5 mm			
	5	Steel cross-section	4.836 in^2				3 120 mm^2				5.498 in^2				3 547 mm^2			
	6	Capacity	0.575 gal/ft				7.14 l/m				0.541 gal/ft				6.71 l/m			
	7	Displacement	0.826 gal/ft				10.26 l/m				0.826 gal/ft				10.26 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	57.7	78.6	83.9	83.9	94.3	99.6	110.1	131.0	65.5	89.4	95.3	95.3	107.3	113.2	125.1	149.0
	10	Internal yield pressure (MPa)	55.0	75.0	80.0	80.0	90.0	95.0	105.0	125.0	63.4	86.5	92.2	92.2	103.8	109.5	121.1	144.1
	11	Pipe body yield strength (10^3 daN)	118.3	161.3	172.1	172.1	193.6	204.4	225.9	268.9	134.5	183.4	195.7	195.7	220.1	232.3	256.8	305.7
Connection efficiency	12	API Non-Upset																
	13	API External Upset																
	14	Atlas Bradford TC4S	93.9								94.7							
	15	Atlas Bradford FL4S	65.0								65.0							
	16	Atlas Bradford IJ4S	110.2								108.8							
	17	Hydril PH-4/PH-6									107.0							
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS																
	20	Mannesman TDS																
	21	Vallourec New VAM Stdt (SC)	110.3								102.8							
	22	Vallourec VAM ACE	109.4								110.3							

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S	540	810	810	880		129.5		92.2	680	810	810	980		132.1		89.3
	26	Atlas Bradford FL4S	430	500	500	500		114.3	93.4	92.2	430	500	500	500		114.3	90.6	89.3
	27	Atlas Bradford IJ4S	540	610	610	680		130.8	93.4	92.2	610	680	680	750		133.6	90.6	89.3
	28	Hydril PH-4/PH-6										1020		1290		135.0	90.4	89.3
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	Mannesman TDS																
	32	Vallourec New VAM Stdt	690	940	1080	1230	1380	129.7		92.2	710	960	1130	1270	1420	130.7		89.3
	33	Vallourec VAM ACE	730	880	930	980	1080	129.7		92.2	880	1030	1130	1230	1320	132.1		89.3

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBINGS (continued)

Pipe body	1	Nominal size (OD)	**4.500** in				114.3 mm				**4.500** in				114.3 mm			
	2	Nominal weight	21.60 lb/ft				31.5 daN/m				24.00/24.60 lb/ft				35.0/35.9 daN/m			
	3	Wall thickness	0.500 in				12.7 mm				0.563 in				14.3 mm			
	4	Inside diameter	3.500 in				88.9 mm				3.374 in				85.7 mm			
	5	Steel cross-section	6.283 in^2				4 050 mm^2				6.963 in^2				4 493 mm^2			
	6	Capacity	0.500 gal/ft				6.21 l/m				0.464 gal/ft				5.77 l/m			
	7	Displacement	0.826 gal/ft				10.26 l/m				0.826 gal/ft				10.26 l/m			
	8	Grade	J55	C75	L80	N80	C90	C95	P105	Q125	J55	C75	L80	N80	C90	C95	P105	Q125
	9	Collapse resistance (MPa)	74.9	102.1	109.0	109.0	122.6	129.4	143.0	170.2	83.0	113.2	120.6	120.8	135.6	143.4	158.5	188.7
	10	Internal yield pressure (MPa)	73.7	100.5	107.3	107.3	120.7	127.4	140.8	167.6	83.0	113.2	120.8	120.8	135.9	143.4	158.5	188.7
	11	Pipe body yield strength (10^3 daN)	153.7	209.6	223.6	223.6	251.5	265.5	293.5	349.4	170.4	232.3	247.8	247.8	278.8	294.3	325.2	387.2
Connection efficiency	12	API Non-Upset																
	13	API External Upset																
	14	Atlas *Bradford TC4S*	*95.3*															
	15	Atlas Bradford FL4S	65.0															
	16	Atlas Bradford IJ4S	107.5								104.3							
	17	Hydril PH-4/PH-6	106.0								105.0							
	18	Hydril CFJ/CFJ-P																
	19	Hydril CS																
	20	Mannesman TDS																
	21	Vallourec New VAM Stdt (SC)	107.4								103.2							
	22	Vallourec VAM ACE	106.8								101.4							

			Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
			J55	C75/LN80	C90/C95	P110	Q125				J55	C75/LN80	C90/C95	P110	Q125			
Connection characteristics	23	API Non-Upset																
	24	API External Upset																
	25	Atlas Bradford TC4S	680	*810*	*810*	*1020*		*134.6*		*85.7*								
	26	Atlas Bradford FL4S						114.3	87.0	85.7								
	27	Atlas Bradford IJ4S	680	750	750	810		136.5	87.0	85.7						141.6	84.6	82.5
	28	Hydril PH-4/PH-6		1290		1630		139.7	86.9	85.7		1360		1760		141.3	83.8	82.5
	29	Hydril CFJ/CFJ-P																
	30	Hydril CS																
	31	*Mannesman TDS*																
	32	Vallourec New VAM Stdt	830	1180	1380	1620	1760	134.1		85.7	850	1230	1420	1620	1820	135.5		82.5
	33	Vallourec VAM ACE	1080	1270	1380	1470	1570	134.1		85.7	1270	1570	1670	1760	1860	135.2		82.5

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (1)

Note : For further details concerning API casings, refer *to :*

(a) the foregoing pages and API 5CT for standard dimensions

(b) API 5B for thread characteristics

(c) API 5CT for geometric characteristics

(d) API 5C3 for formulas and calculations

(e) API 5C2 for mechanical properties

(1) The following tables give the properties of API and non-API casings.

Notes to tables C36 to C73

(2) The closed-end displacement does not account for couplings.

(3) Grade J55 is not mentioned in the tables because it has the same properties as grade K55, except for the tensile strength, which is higher for K55 (see page C1).

(4) To obtain better efficiency, it is a possible practice to use a higher grade for couplings, as shown in the table bellow :

Casing grade	Higher grade for coupling
K55	N80
C75	Not allowed*
N80	P110
C95	Not allowed
P105	Q125
P110	V150
Q125	V150

* C95 is sometimes used as a higher grade.

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS

1		**4.500** in				114.3 mm				**4.500** in				114.3 mm		
2		*9.50 lb/ft*				*13.9 da N/m*				*10.50 lb/ft*				15.3 da N/m		
3		0.205 in				5.2 mm				0.224 in				5.7 mm		
4		4.090 in				103.9 mm				4.052 in				102.9 mm		
5		2.77 in^2				1786 mm^2				3.01 in^2				1941 mm^2		
6		0.68 gal/ft				8.48 l/m				0.67 gal/ft				8.32 l/m		
7		0.83 gal/ft				10.26 l/m				0.83 gal/ft				10.26 l/m		
8	K55	*C75*	L80	*N80*	*C90*	*C95*	*P110*	*Q125*	*K55*	*C75*	*L80*	*N80*	*C90*	*C95*	*P110*	*Q125*
9	22.9	26.3	26.9	26.9	28.1	29.0	31.1	32.6	27.6	33.0	34.0	34.0	35.9	36.6	38.3	40.2
10	30.2	41.2	44.0	44.0	49.5	52.2	60.5	68.7	33.0	45.0	48.1	48.1	54.1	57.1	66.1	75.1
11	68	92	98	98	111	117	135	154	74	100	107	107	120	127	147	167
12	102	106	107	112	114	120	142	155	111	115	117	122	124	130	154	168
13	102			112			142	155	111			122			154	168
14	102	106	107	112	114	120	142	155	111	115	117	122	124	130	154	168
15	102			112			142	155	111			122			154	168
16	57	69	71	73	75	79	94	101	65	78	81	83	85	90	107	115
17	60	71	71	75	75	79	94	101	69	81	81	85	85	90	107	115
18																
19				45.0								45.0				
20																
21																
22																
23																
24																
25																
26												113.7 (101.3)				
27												112.3				
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						127.0		100.7						127.0		99.7
30						127.0		100.7						127.0		99.7
31						123.8		100.7						123.8		99.7
32						123.8		100.7						123.8		99.7
33	150					127.0		100.7	200					127.0		99.7
34						127.0		100.7						127.0		99.7
35																
36	340					114.3	101.3	100.7	340					114.3	100.4	99.7
37																
38						114.3		100.7						114.3		99.7
39																
40																
41																
42																
43									460	610	710	790	890	123.5		99.7
44									370	450	450	540	590	123.5		99.7
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**4.500** in	114.3 mm	**4.500** in	114.3 mm
2	11.60 lb/ft	16.9 daN/m	13.50 lb/ft	19.7 daN/m
3	0.250 in	6.4 mm	0.290 in	7.4 mm
4	*4.000 in*	*101.6 mm*	*3.920 in*	*99.6 mm*
5	3.34 in^2	2154 mm^2	3.84 in^2	2476 mm^2
6	0.65 gal/ft	8.11 l/m	0.63 gal/ft	7.79 l/m
7	0.83 gal/ft	10.26 l/m	0.83 gal/ft	10.26 l/m

8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	34.2	42.1	43.8	43.8	47.0	48.4	52.2	55.2	44.3	56.2	58.9	58.9	64.2	66.7	73.8	80.1
10	36.9	50.3	53.6	53.6	60.3	63.7	73.7	83.8	42.8	58.3	62.2	62.2	70.0	73.9	85.6	97.2
11	82	111	119	119	134	141	163	186	94	128	137	137	154	162	188	213
12	123	126	129	135	138	145	171	187	141	147	149	155	158	166	197	215
13	123			135			171	187	141			155			197	215
14	123	128	129	135	138	145	171	187	141	142	142	150	150	157	187	202
15	123			135			171	187	141			155			197	215
16	76	91	94	96	99	104	124	134								
17	80	94	94	99	99	104	124	134	97	114	114	120	120	126	150	162
18												92.3				
19				55.0								55.0				
20												104.4				
21												49.3				
22												58.8				
23				65.5								69.9				
24												69.9				
25																
26				102.5 (91.3)								109.0 (79.4)				
27				*104.1*								108.0				
28												53.0				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						127.0		98.4						127.0		96.4
30						127.0		98.4						127.0		96.4
31						123.8		98.4						123.8		96.4
32						123.8		98.4						123.8		96.4
33	230					127.0		98.4						127.0		96.4
34	240	300	350	410		127.0		98.4		370	420	500		127.0		96.4
35									390	540	540	680		125.7		96.4
36	370	430	430	430		114.3	99.7	98.4	410	470	470	470		114.3	97.7	96.4
37									410	470	470	540		125.5		96.4
38						114.3		98.4	200	200	300	300	340	114.3		96.4
39									270	340	340	340	470	116.7	97.5	96.4
40	430	430	570	570	680	119.9	99.6	98.4	430	430	570	570	680	119.9	97.5	96.4
41									430	430	570	570	680	120.7	97.5	96.4
42																
43	470	630	730	810	910	123.5		98.4	500	670	760	860	950	126.0		96.4
44	440	540	590	640	690	123.8		98.4	490	570	620	670	730	126.0		96.4
45														114.3	97.7	96.4

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**4.500** in	114.3 mm	**4.500** in	114.3 mm
2	15.10 lb/ft	22.0 daN/m	16.90 lb/ft	24.7 daN/m
3	0.337 in	8.6 mm	0.380 in	9.7 mm
4	3.826 in	97.2 mm	3.740 in	95.0 mm
5	4.41 in^2	2844 mm^2	4.92 in^2	3173 mm^2
6	0.60 gal/ft	7.42 l/m	0.57 gal/ft	7.09 l/m
7	0.83 gal/ft	10.26 l/m	0.83 gal/ft	10.26 l/m

8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	52.5	71.7	76.4	76.4	84.3	88.0	98.9	109.2	58.6	79.9	85.3	85.3	95.9	101.3	117.3	133.2
10	49.7	67.8	72.3	72.3	81.3	85.8	99.4	113.0	56.0	76.4	81.5	81.5	91.7	96.8	112.1	127.3
11	108	147	157	157	176	186	216	245	120	164	175	175	197	208	241	273
12	162	169	171	178	182	191	226	246	181	181	181	191	191	200	238	258
13	162			178			226	246	181			199			252	275
14	142	142	142	150	150	157	187	202	142	142	142	150	150	157	187	202
15	150			178			226	240	150			187			240	240
16																
17	116	137	137	144	144	152	180	195								
18												92.4				
19				55.0								63.9				
20												108.4				
21				52.6												
22				56.3								54.6				
23				73.4												
24				73.9												
25												+ 100.0				
26				103.6 (82.8)								108.4				
27				101.9								107.6				
28				59.1								63.3				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						127.0		94.0						127.0		91.8
30						127.0		94.0						127.0		91.8
31						123.8		94.0						123.8		91.8
32						123.8		94.0						123.8		91.8
33																
34				600	660	127.0		94.0								
35									540	810	810	880		129.5		91.8
36	410	470	470	470		114.3	95.3	94.0	430	500	500	500		114.3	93.4	91.8
37									540	610	610	680		130.8		91.8
38	200	200	300	300	340	114.3		94.0								
39	330	430	430	430	610	116.7	95.1	94.0	330	430	430	430	610	117.7	93.3	91.8
40	430	430	570	570	680	120.7	95.1	94.0								
41	430	430	570	570	680	122.8	95.1	94.0								
42									520	590	690	800	920	127.0		91.8
43	570	790	900	1030	1130	127.3		94.0	690	940	1080	1230	1380	129.7		91.8
44	590	730	790	830	880	127.1		94.0	730	880	930	980	1080	129.7		91.8
45		310	350	390	430	114.3	95.4	94.0		340	380	420	460	114.3	93.3	91.8

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**4.500** in				114.3 mm				**4.500** in				114.3 mm			
2	17.70 lb/ft				25.8 daN/m				18.80 lb/ft				27.4 daN/m			
3	0.402 in				10.2 mm				0.430 in				10.9 mm			
4	3.697 in				93.9 mm				3.640 in				92.5 mm			
5	5.17 in^2				3336 mm^2				5.50 in^2				3547 mm^2			
6	0.56 gal/ft				6.93 l/m				0.54 gal/ft				6.71 l/m			
7	0.83 gal/ft				10.26 l/m				0.83 gal/ft				10.26 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	61.6.	84.1	89.7	89.7	100.9	106.5	123.3	140.1	65.5	89.4	95.3	95.3	107.2	113.2	131.1	148.9
10	59.2	80.8	86.1	86.1	96.9	102.3	118.4	134.6	63.4	86.5	92.2	92.2	103.7	109.5	126.8	144.1
11	126	172	184	184	207	218	253	287	134	183	196	196	220	232	269	306
12	181	181	181	191	191	200	238	258	181	181	181	191	191	200	238	258
13	191			209			265	289	191			222			282	305
14	142	142	142	150	150	157	187	202	142	142	142	150	150	157	187	202
15	*150*			*187*			*240*	*240*	*150*			*187*			240	240
16									145	174	181	185	190	200	238	257
17									153	181	181	190	190	200	238	257
18																
19													65.0			
20																
21													42.2			
22													*55.1*			
23													58.9			
24													79.0			
25													+ 100.0			
26													102.8			
27					102.3								110.3			
28													65.1			

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	*Make-up torque (daN.m)*					OD (mm)	ID (mm)	Api drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						127.0		90.7						127.0		89.3
30						127.0		90.7						127.0		89.3
31						123.8		90.7						123.8		89.3
32						123.8		90.7						123.8		89.3
33														127.0		89.3
34														127.0		89.3
35																
36									430	500	500	500		114.3	90.6	89.3
37																
38									200	200	300	300	340	114.3		89.3
39									330	430	430	430	610	116.7	90.4	89.3
40									430	430	570	570	680	120.7	90.4	89.3
41									430	430	570	570	680	126.8	90.4	89.3
42														127.0		89.3
43									710	960	1130	1270	1420	130.7		89.3
44	790	930	1030	1130	1230	129.7		90.7	880	1030	1130	1230	1320	132.1		89.3
45														114.3	90.8	89.3

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 ≈ in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1		**5.000** in				127.0 mm				**5.000** in				127.0 mm		
2		11.50 lb/ft				16.8 daN/m				13.00 lb/ft				19.0 daN/m		
3		0.220 in				5.6 mm				0.253 in				6.4 mm		
4		4.560 in				115.8 mm				4.494 in				114.1 mm		
5		3.30 in^2				2132 mm^2				3.78 in^2				2436 mm^2		
6		0.85 gal/ft				10.54 l/m				0.82 gal/ft				10.23 l/m		
7		1.02 gal/ft				12.67 l/m				1.02 gal/ft				12.67 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	21.1	23.9	24.6	24.6	26.2	26.9	28.6	29.7	28.6	34.3	35.5	35.5	37.5	38.4	40.4	41.7
10	29.2	39.8	42.5	42.5	47.8	50.5	58.4	66.4	33.6	45.8	48.9	48.9	55.0	58.0	67.2	76.4
11	81	110	118	118	132	140	162	184	92	126	134	134	151	160	185	210
12	120	126	127	133	136	143	169	184	138	144	146	152	155	163	193	210
13	120			133			169	184	138			152			193	210
14	120	126	127	133	136	143	169	184	138	144	146	152	155	163	193	210
15	120			133			169	184	138			152			193	210
16	68	82	86	87	93	98	116	126	83	100	104	106	113	119	141	152
17									90	107	107	113	113	119	141	152
18												91.3				
19				45.0								55.0				
20												91.3				
21																
22																
23												66.0				
24																
25																
26												145.6 (100.7)				
27												140.4				
28												45.9				

	Make-up torque (daN.m)								Make-up torque (daN.m)							
	K55	C75/LN80	C90/C95	P110	Q125	OD (mm)		API drift (mm)	K55	C75/LN80	C90/C95	P110	Q125	OD (mm)	ID (mm)	Api drift (mm)
29						141.3		112.6						141.3		111.0
30						141.3		112.6						141.3		111.0
31						136.5		112.6						136.5		111.0
32						136.5		112.6						136.5		111.0
33	200					141.3		112.6	250					141.3		111.0
34									270					141.3		111.0
35									410	540	540	680		136.5		111.0
36	410					127.0	113.3	112.6	410					127.0	112.2	111.0
37									410	540	540	680		136.9		111.0
38																
39																
40									520	520	680	680	810	112.1	132.6	111.0
41																
42																
43									570	620	660	690	720	141.9		111.0
44									490	540	590	640	690	141.3		111.0
45														127.0	112.1	111.0

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**5.000** in				127.0 mm				**5.000** in				127.0 mm			
2	15.00 lb/ft				21.9 daN/m				18.00 lb/ft				26.3 daN/m			
3	0.296 in				7.5 mm				0.362 in				9.2 mm			
4	*4.408 in*				*112.0 mm*				*4.276 in*				*108.6 mm*			
5	4.38 in^2				2823 mm^2				5.27 in^2				3401 mm^2			
6	0.79 gal/ft				9.84 l/m				0.75 gal/ft				9.27 l/m			
7	1.02 gal/ft				12.67 l/m				1.02 gal/ft				12.67 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	38.3	47.9	50.0	50.0	54.0	55.9	61.1	65.4	50.9	68.6	72.3	72.3	79.4	82.8	92.8	102.1
10	39.3	53.6	57.2	57.2	64.3	67.9	78.6	89.3	48.0	65.5	69.8	69.8	78.6	82.9	96.0	109.1
11	107	146	156	156	175	185	214	243	129	176	188	188	211	223	258	293
12	160	167	169	176	180	189	224	244	192	201	203	212	216	228	270	294
13	160			176			224	244	192			212			270	294
14	160	162	162	171	171	179	213	230	162	162	162	171	171	179	213	230
15	160			176			224	244	171			212			270	273
16	101	127	127	129	138	145	172	187								
17	110	131	131	138	138	145	173	187	140	167	167	176	176	185	220	238
18				92.5								93.9				
19				55.0								65.0				
20				*92.5*								*93.9*				
21				50.4								53.2				
22				54.4								57.0				
23				70.7								70.6				
24				70.7								75.7				
25				+ 100.0								+ 100.0				
26				125.7 (86.9)								104.3 (72.1)				
27				121.1								102.0				
28				52.7								60.7				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						141.3		108.8						141.3		105.4
30						141.3		108.8						141.3		105.4
31						136.5		108.8						136.5		105.4
32						*136.5*		*108.8*						*136.5*		*105.4*
33	310					141.3		108.8								
34	330	420	480	570		141.3		108.8		540	620	720	800	141.3		105.4
35	410	540	540	680		138.4		108.8	540	680	680	840		141.0		105.4
36	470	540	540	540		127.0	110.1	108.8	470	540	540	540		127.0	102.2	105.4
37	410	540	540	680		138.8		108.8	540	680	680	840		141.4		105.4
38	260	260	380	380	430	127.0		108.8	260	260	380	380	430	127.0		105.4
39	300	410	410	410	530	129.4	109.9	108.8	380	520	520	520	750	129.4	106.6	105.4
40	520	520	680	680	810	132.6	109.9	108.8	520	520	680	680	810	133.4	106.6	105.4
41	520	520	680	680	810	133.7	109.9	108.8	520	520	680	680	810	136.8	106.6	105.4
42	410	450	510	580	600	141.3		108.8	480	580	640	720	800	141.3		105.4
43	*640*	*700*	*590*	*760*	*790*	*141.9*		*108.8*	*770*	*830*	*870*	*910*	*960*	*141.9*		*105.4*
44	490	540	590	640	690	141.3		108.8	640	790	880	930	1030	141.5		105.4
45						127.0	110.1	108.8		390	440	490	540	127.0	106.8	105.4

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**5.000** in					127.0 mm			**5.500** in					139.7 mm		
2	20.80 lb/ft					30.4 daN/m			14.00 lb/ft					20.4 daN/m		
3	0.422 in					10.7 mm			0.244 in					6.2 mm		
4	*4.156 in*					*105.6 mm*			5.012 in					127.3 mm		
5	6.07 in^2					3916 mm^2			4.03 in^2					2600 mm^2		
6	0.70 gal/ft					8.75 l/m			1.02 gal/ft					12.73 l/m		
7	1.02 gal/ft					12.67 l/m			1.23 gal/ft					15.33 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	58.6	79.9	85.3	85.3	95.9	101.2	117.2	133.2	21.5	24.4	25.0	25.0	26.6	27.4	29.2	30.4
10	56.0	76.4	81.5	81.5	91.7	96.8	112.0	127.3	29.5	40.2	42.8	42.8	48.2	50.9	58.9	66.9
11	149	203	216	216	243	257	297	338	99	134	143	143	161	170	197	224
12	221	227	227	239	239	251	299	322	145	153	155	161	165	173	205	224
13	*221*			*244*			310	338	145			161			205	224
14	162	162	162	171	171	179	213	230	145	153	155	161	165	173	205	224
15	171			213			273	273	145			161			205	224
16									84	102	106	108	117	123	144	161
17																
18				94.6												
19				65.0								45.0				
20				94.6												
21				46.2												
22				59.3												
23												64.9				
24																
25																
26				90.6 (62.6)												
27				114.7												
28				65.9												

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						141.3		102.4						153.7		124.1
30						141.3		102.4						153.7		124.1
31						136.5		102.4						149.2		124.1
32						136.5		102.4						149.2		124.1
33									260					153.7		124.1
34																
35	680	810	810	980		143.5		102.4								
36		610	610	610		127.0	103.7	102.4	520					139.7	124.8	124.1
37	680	810	810	980		141.4		102.4								
38	260	260	380	380	430	127.0		102.4								
39	380	520	520	520	750	129.4	103.5	102.4								
40									610	610	810	810	950	146.1	125.3	124.1
41																
42																
43	950	1030	1080	1180	1230	141.9		102.4								
44	830	980	1080	1230	1320	146.1		102.4								
45		430	480	530	580	127.0	103.9	102.4								

MPa × 145 = psi *daN × 2.25 = lb* *daN.m × 7.38 = lb.ft* mm × *0.0394 = in*

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**5.500** in					139.7 mm			**5.500** in					139.7 mm		
2	15.50 lb/ft					22.6 daN/m			17.00 lb/ft					24.8 daN/m		
3	0.275 in					7.0 mm			0.304 in					7.7 mm		
4	4.950 in					125.7 mm			4.892 in					124.3 mm		
5	4.51 in^2					2910 mm^2			4.96 in^2					3201 mm^2		
6	1.00 gal/ft					12.42 l/m			0.98 gal/ft					12.13 l/m		
7	1.23 gal/ft					15.33 l/m			1.23 gal/ft					15.33 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	27.8	33.3	34.3	34.3	36.2	37.0	38.7	40.5	33.8	41.6	43.3	43.3	46.4	47.8	51.5	54.4
10	33.2	45.2	48.2	48.2	54.3	57.3	66.3	75.4	36.7	50.0	53.3	53.3	60.0	63.3	73.3	83.3
11	110	150	161	161	181	191	221	251	121	166	177	177	199	210	243	276
12	163	171	173	180	185	194	230	251	179	188	190	198	203	213	253	276
13	163			180			230	251	179			198			253	276
14	163	171	173	180	185	194	230	251	179	179	179	189	189	198	236	255
15	163			180			230	251	179			198			253	276
16	98	119	124	126	137	144	168	188	112	135	141	144	155	164	191	214
17	106	128	132	136	139	146	174	188	121	146	150	155	158	166	198	214
18				92.1								92.8				
19				55.0								55.0				
20				92.1								92.8				
21												50.8				
22												54.7				
23				68.7								71.6				
24																
25				+ 100.0								+ 100.0				
26				132.5 (93.9)								120.4 (85.4)				
27				128.6								116.9				
28				47.5								51.4				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	*Make-up torque (daN.m)*					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						153.7		122.6						153.7		121.1
30						153.7		122.6						153.7		121.1
31						149.2		122.6						149.2		121.1
32						149.2		122.6						149.2		121.1
33	300					153.7		122.6	340					153.7		121.1
34	320					153.7		122.6	370	460	540	630		153.7		121.1
35	530	680	680	810		152.4		122.6	680	810	810	960		152.4		121.1
36	520					139.7	123.8	122.6	520	610	610	610		139.7	122.4	121.1
37	530	680	680	810		152.8		122.6	680	810	810	960		152.8		121.1
38									310	310	460	460	540	139.7		121.1
39									350	470	470	470	720	142.9	122.2	121.1
40	610	610	810	810	950	146.1	123.7	122.6	610	610	810	810	950	146.8	122.2	121.1
41																
42	400	450	510	580	590	153.7		122.6	470	540	620	700	720	153.7		121.1
43	640	700	730	770	810	154.3		122.6	690	750	790	820	860	154.3		121.1
44	390	490	540	590	640	153.7		122.6	540	690	730	790	830	153.7		121.1
45						139.7	123.7	122.6						139.7	122.4	121.1

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**5.500** in				139.7 mm				**5.500** in				139.7 mm			
2	20.00 lb/ft				29.2 daN/m				23.00 lb/ft				33.6 daN/m			
3	0.361 in				9.2 mm				0.415 in				10.5 mm			
4	4.778 in				121.4 mm				4.670 in				118.6 mm			
5	5.83 in^2				3760 mm^2				6.63 in^2				4277 mm^2			
6	0.93 gal/ft				11.57 l/m				0.89 gal/ft				11.05 l/m			
7	1.23 gal/ft				15.33 l/m				1.23 gal/ft				15.33 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	45.6	58.0	60.9	60.9	66.4	69.1	76.6	83.3	52.9	72.1	77.0	77.0	85.3	89.2	100.2	110.7
10	43.6	59.4	63.4	63.4	71.3	75.2	87.1	99.0	50.1	68.3	72.8	72.8	81.9	86.5	100.1	113.8
11	143	194	207	207	233	246	285	324	162	221	236	236	265	280	324	369
12	210	221	224	233	238	251	297	324	239	245	245	258	258	271	322	348
13	210			233			297	324	239			265			337	368
14	179	179	179	189	189	198	236	255	179	179	179	189	189	198	236	255
15	189			233			297	302	189			236			302	302
16																
17	149	179	185	190	195	205	244	263	175	210	217	223	229	240	286	309
18				93.8								94.6				
19				65.0								65.0				
20				93.8								94.6				
21				53.4								47.0				
22				56.9								62.1				
23				75.2								66.1				
24				75.8								78.7				
25				+ 100.0								+ 100.0				
26				102.5 (72.7)								90.1 (63.9)				
27				115.7								101.7				
28				58.7								63.6				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						153.7		118.2						153.7		115.4
30						153.7		118.2						153.7		115.4
31						149.2		118.2						149.2		115.4
32						149.2		118.2						149.2		115.4
33																
34		570	660	770		153.7		118.2		670	780	910	1010	153.7		115.4
35	680	810	810	960		156.2		118.2	810	950	950	1060		156.2		115.4
36	570	680	680	680		139.7	119.5	118.2	570	680	680	680		139.7	116.7	115.4
37	680	810	810	960		156.6		118.2	810	950	950	1060		156.6		115.4
38	310	310	460	460	540	139.7		118.2	310	310	460	460	540	139.7		115.4
39	460	610	610	610	880	142.9	119.3	118.2	460	610	610	610	880	142.9	116.6	115.4
40	610	610	810	810	950	146.8	119.3	118.2	610	610	810	810	950	146.8	116.6	115.4
41	610	610	810	810	950	149.6	119.3	118.2	610	610	810	810	950	152.0	116.6	115.4
42	540	700	800	880	920	153.7		118.2	600	760	880	960	1000	153.7		115.4
43	800	880	920	970	1030	154.3		118.2	960	1080	1130	1180	1270	154.3		115.4
44	730	880	980	1030	1130	156.2		118.2	880	1080	1180	1320	1420	156.2		115.4
45		480	540	610	690	139.7	119.6	118.2		520	580	650	720	139.7	116.9	115.4

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**6.625** in					168.3 mm			**6.625** in					168.3 mm		
2	20.00 lb/ft					29.2 daN/m			24.00 lb/ft					35.0 daN/m		
3	0.288 in					7.3 mm			0.352 in					8.9 mm		
4	6.049 in					153.6 mm			5.921 in					150.4 mm		
5	5.74 in^2					3701 mm^2			6.94 in^2					4475 mm^2		
6	1.49 gal/ft					18.54 l/m			1.43 gal/ft					17.76 l/m		
7	1.79 gal/ft					22.24 l/m			1.79 gal/ft					22.24 l/m		
8	K55	C75	L80	N80	C90	C95	P110	O125	K55	C75	L80	N80	C90	C95	P110	O125
9	20.5	23.1	24.0	24.0	25.5	26.2	27.8	28.8	31.4	38.2	39.7	39.7	42.3	43.5	46.4	48.4
10	28.9	39.4	42.0	42.0	47.2	49.9	57.7	65.6	35.3	48.1	51.3	51.3	57.7	60.9	70.5	80.1
11	140	191	204	204	230	242	281	319	170	231	247	247	278	293	339	386
12	202	214	218	226	233	245	289	316	244	259	263	274	281	296	350	383
13	202			226			289	316	244			274			350	383
14	202	214	218	226	231	243	289	312	220	220	220	231	231	243	289	312
15	202			226			289	316	231			*274*			*350*	*370*
16	119	145	151	154	167	176	205	230	152	186	194	197	214	225	263	295
17	129	157	164	167	180	189	223	244	166	201	210	214	231	243	285	312
18				92.4								93.8				
19				*55.0*								*55.0*				
20				92.4								93.8				
21												48.6				
22												53.2				
23																
24																
25				+ 100.0								+ 100.0				
26				168.5 (90.0)								139.4 (74.4)				
27				164.0								135.6				
28												57.6				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						187.7		150.5						187.7		147.2
30						187.7		150.5						187.7		147.2
31						177.8		150.5						177.8		147.2
32						177.8		150.5						177.8		147.2
33	360					187.7		150.5	460					187.7		147.2
34	390					187.7		150.5	500	640	740	870		187.7		147.2
35	680	810	810	980		180.3		150.5	840	950	950	1110		182.9		147.2
36	*610*					*168.3*	*151.7*	*150.5*	*640*	*810*	*810*	*810*		*168.3*	148.5	147.2
37	680	810	810	980		180.7		150.5	840	950	950	1110		183.3		147.2
38									430	430	650	650	720	168.3		147.2
39									490	650	650	650	760	171.5	148.4	147.2
40																
41																
42	600	600	720	800	880	187.7		150.5	640	800	960	1000	1100	187.7		147.2
43	760	860	910	970	1030	188.3		150.5	940	1080	1130	1180	1270	188.3		147.2
44	540	690	730	790	830	187.7		150.5	790	980	1080	1130	1230	187.7		147.2
45										630	730	830	940	168.3	148.5	147.2

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	***6.625*** *in*				*168.3 mm*				***6.625*** *in*				*168.3 mm*			
2	28.00 lb/ft				40.9 daN/m				32.00 lb/ft				46.7 daN/m			
3	0.417 in				10.6 mm				0.475 in				12.1 mm			
4	5.791 in				147.1 mm				5.675 in				144.2 mm			
5	8.13 in^2				5246 mm^2				9.17 in^2				5919 mm^2			
6	1.37 gal/ft				16.99 l/m				1.31 gal/ft				16.32 l/m			
7	*1.79 gal/ft*				*22.24 l/m*				1.79 gal/ft				22.24 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	42.5	53.7	56.3	56.3	61.2	63.5	70.0	75.8	50.5	67.5	71.1	71.1	78.1	81.4	91.1	100.2
10	41.8	57.0	60.7	60.7	68.3	72.1	83.5	94.9	47.6	64.9	69.2	69.2	77.8	82.2	95.1	108.1
11	199	271	289	289	326	344	398	452	224	306	326	326	367	388	449	510
12	286	304	308	321	330	347	410	448	323	343	348	362	372	391	463	506
13	286			321			410	448	323			362			463	506
14	220	220	220	231	231	243	289	312	220	220	220	231	231	243	289	312
15	231			289			370	370	231			289			370	370
16																
17	202	245	256	260	282	296	347	380	233	284	296	301	326	342	402	440
18	94.7								95.3							
19	65.0								65.0							
20	94.7								95.3							
21	53.0								47.0							
22	57.6								61.3							
23																
24																
25	+ 100.0								+ 100.0							
26	*118.9 (63.5)*								*105.4 (56.3)*							
27	115.7								102.6							
28	63.8								65.9							

	Make-up torque (daN.m)								Make-up torque (daN.m)							
	K55	C75/LN80	C90/C95	P110	Q125	OD (mm)	ID (mm)	API drift (mm)	K55	C75/LN80	C90/C95	P110	Q125	OD (mm)	ID (mm)	API drift (mm)
29						187.7		143.9						187.7		141.0
30						187.7		143.9						187.7		141.0
31						177.8		143.9						177.8		141.0
32						177.8		143.9						177.8		141.0
33																
34		780	910	1060		187.7		143.9		900	1050	1230	1370	187.7		141.0
35	990	1080	1080	1220		185.4		143.9	1080	1220	1220	1290		188.0		141.0
36	680	850	850	850		168.3	145.2	143.9		880	880	880		168.3	142.2	141.0
37	990	1080	1080	1220		185.8		143.9	1080	1220	1220	1290		188.3		141.0
38	430	430	650	650	610	168.3		143.9	430	430	650	650	750	168.3		141.0
39	610	810	810	810	1080	171.5	145.1	143.9	610	810	810	810	1080	172.2	142.1	141.0
40																
41																
42	800	1100	1300	1500	1600	187.7		143.9	960	1300	1500	1700	1700	187.7		141.0
43	1180	1320	1420	1520	1570	188.3		143.9	1230	1420	1520	1570	1670	188.3		141.0
44	1080	1270	1380	1470	1670	187.7		143.9	1380	1570	1760	1960	2160	187.7		141.0
45		670	770	870	970	168.3	145.4	143.9		720	810	910	1030	168.3	142.5	141.0

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**7.000** in				177.8 mm				**7.000** in				177.8 mm			
2	17.00 lb/ft				24.8 daN/m				20.00 lb/ft				29.2 daN/m			
3	0.231 in				5.9 mm				0.272 in				6.9 mm			
4	6.538 in				166.1 mm				6.456 in				164.0 mm			
5	4.91 in^2				3171 mm^2				5.75 in^2				3710 mm^2			
6	1.74 gal/ft				21.66 l/m				1.70 gal/ft				21.12 l/m			
7	2.00 gal/ft				24.83 l/m				2.00 gal/ft				24.83 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	11.3	12.3	12.4	12.4	12.5	12.5	12.5	12.5	15.7	18.4	18.9	18.9	19.7	20.0	20.5	20.6
10	21.9	29.9	31.9	31.9	35.9	37.8	43.8	49.8	25.8	35.2	37.5	37.5	42.2	44.5	51.6	58.6
11	120	164	175	175	197	208	240	273	141	192	205	205	230	243	281	320
12	171	183	186	193	199	209	247	270	200	214	217	226	233	245	289	316
13	171			193			247	270	200			226			289	316
14	171	183	186	193	199	209	247	270	200	214	217	226	233	245	289	316
15	171			193			247	270	200			226			289	316
16	91	111	116	118	128	135	157	176	113	138	145	147	160	168	197	220
17																
18												92.0				
19				45.0								55.0				
20												92.0				
21																
22																
23												65.8				
24																
25																
26																
27																
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						194.5		162.9						194.5		160.8
30						194.5		162.9						194.5		160.8
31						187.3		162.9						187.3		160.8
32						187.3		162.9						187.3		160.8
33						194.5		182.9	340					194.5		160.8
34																
35									750	980	980	1150		189.2		160.8
36						177.8	163.5	162.9	540					177.8	162.1	160.8
37									750	980	980	1150		189.6		160.8
38																
39																
40									880	880	1150	1150	1360	185.8	162.0	160.8
41																
42																
43																
44																
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**7.000** in				177.8 mm				**7.000** in				177.8 mm			
2	23.00 lb/ft				33.6 daN/m				26.00 lb/ft				37.9 daN/m			
3	0.317 in				8.1 mm				0.362 in				9.2 mm			
4	6.366 in				161.7 mm				6.276 in				159.4 mm			
5	6.65 in^2				4293 mm^2				7.55 in^2				4868 mm^2			
6	1.65 gal/ft				20.54 l/m				1.61 gal/ft				19.96 l/m			
7	2.00 gal/ft				24.83 l/m				2.00 gal/ft				24.83 l/m			
8	*K55*	*C75*	*L80*	*N80*	*C90*	*C95*	*P110*	*Q125*	*K55*	*C75*	*L80*	*N80*	*C90*	*C95*	*P110*	*Q125*
9	22.5	25.9	26.4	26.4	27.7	28.6	30.6	32.0	29.8	36.0	37.3	37.3	39.5	40.5	42.9	44.4
10	30.0	41.0	43.7	43.7	49.2	51.9	60.1	68.3	34.3	46.8	49.9	49.9	56.1	59.2	68.6	78.0
11	163	222	237	237	266	281	326	370	185	252	269	269	302	319	369	420
12	232	248	251	261	269	283	335	366	263	281	285	296	305	321	379	415
13	232			261			335	366	263			296			379	415
14	232	237	237	250	250	262	312	337	237	237	237	250	250	262	312	337
15	232			261			335	366	250			296			379	399
16	138	168	176	179	194	205	239	267	162	198	207	210	228	240	281	314
17	152	185	193	196	213	225	262	291	178	217	227	231	250	264	308	342
18				93.2								94.0				
19				55.0								65.0				
20				93.2								94.0				
21				51.5								53.0				
22				55.3								57.0				
23				70.5								74.0				
24																
25				+ 100.0								+ 100.0				
26				136.2 (84.4)								120.2 (74.4)				
27				131.2								115.7				
28				51.1								56.9				
	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						194.5		158.5						194.5		156.2
30						194.5		158.5						194.5		156.2
31						187.3		158.5						187.3		156.2
32						187.3		158.5						187.3		156.2
33	420					194.5		158.5	490					194.5		156.2
34	460	590	680			194.5		158.5	540	690	800	940		194.5		156.2
35	750	980	980	1150		193.0		158.5	950	1080	1080	1290		193.0		156.2
36	540	750	750	750		177.8	159.8	158.5	680	950	950	950		177.8	157.5	156.2
37	750	980	980	1150		193.4		158.5	950	1080	1080	1290		193.4		156.2
38	470	470	610	710	810	177.8		158.5	470	470	680	810	950	177.8		156.2
39	420	610	610	610	710	181.0	159.7	158.5	470	680	680	680	810	181.0	157.4	156.2
40	880	880	1150	1150	1360	185.8	159.7	158.5	880	880	1150	1150	1360	185.8	157.4	156.2
41																
42	740	800	880	960	1000	194.5		158.5	800	960	1100	1300	1400	194.5		156.2
43	840	950	1030	1080	1130	195.1		158.5	980	1130	1180	1270	1380	195.1		156.2
44	640	790	830	880	980	194.5		158.5	880	1080	1180	1270	1380	194.5		156.2
45		720	830	960	1080	177.8	159.8	158.5		730	850	980	1080	177.8	157.7	156.2

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**7.000** in					177.8 mm			**7.000** in					177.8 mm		
2	29.00 lb/ft					42.3 daN/m			32.00 lb/ft					46.7 daN/m		
3	0.408 in					10.4 mm			0.453 in					11.5 mm		
4	6.184 in					157.1 mm			6.094 in					154.8 mm		
5	8.45 in^2					5450 mm^2			*9.32 in^2*					*6013 mm^2*		
6	1.56 gal/ft					19.38 l/m			1.52 gal/ft					18.82 l/m		
7	2.00 gal/ft					24.83 l/m			2.00 gal/ft					24.83 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	37.3	46.4	48.4	48.4	52.2	54.0	58.8	62.8	44.6	56.6	59.4	59.4	64.7	67.2	74.4	80.8
10	38.7	52.7	56.2	56.2	63.3	66.8	77.3	87.9	43.0	58.6	62.5	62.5	70.3	74.2	85.9	97.6
11	207	282	301	301	338	357	413	470	228	311	332	332	373	394	456	518
12	294	314	319	332	342	359	425	465	325	347	352	366	377	396	469	513
13	294			332			425	465	325			366			469	513
14	237	237	237	250	250	262	312	337	237	237	237	250	250	262	312	337
15	*250*			*312*			*399*	*399*	*250*			*312*			399	399
16																
17	205	250	261	266	288	303	354	393	231	282	294	299	324	342	399	443
18	94.6								95.1							
19	65.0								65.0							
20	94.6								95.1							
21	52.2								51.6							
22	59.3								*61.3*							
23	76.0								72.2							
24	76.8								78.9							
25	+ 100.0								+ 100.0							
26	107.3 (66.5)								97.3 (60.3)							
27	103.3								126.7							
28	61.5								65.1							

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C80/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						194.5		153.9						194.5		151.6
30						194.5		153.9						194.5		151.6
31						*187.3*		*153.9*						187.3		151.6
32						187.3		153.9						187.3		151.6
33																
34		800	930	1080		194.5		153.9		900	1040	1220		194.5		151.6
35	1020	1220	1220	1360		198.1		153.9	1150	1360	1360	1490		198.1		151.6
36		950	950	950		177.8	155.2	153.9		1020	1020	1020		177.8	152.9	151.6
37	1020	1220	1220	1360		198.5		153.9	1150	1360	1360	1490		198.5		151.6
38	*470*	*470*	*680*	*810*	*950*	*177.8*		*153.9*	*470*	*470*	*680*	*810*	*950*	*177.8*		151.6
39	540	750	750	750	1080	181.0	156.5	153.9	680	880	880	880	1220	181.8	153.3	151.6
40	880	880	1150	1150	1360	185.8	155.0	153.9	880	880	1150	1150	1360	186.5	153.4	151.6
41	880	880	1150	1150	1360	189.6	155.0	153.9	880	880	1150	1150	1360	191.7	152.8	151.6
42	960	1200	1500	1700	1700	194.5		153.9	1000	1300	1600	1700	1700	194.5		151.6
43	1130	1270	1380	1470	1570	195.1		153.9	1230	1380	1470	1570	1670	195.1		151.6
44	1080	1270	1380	1570	1670	194.5		153.9	1270	1470	1670	1860	1960	200.9		151.6
45		*760*	*880*	*980*	*1130*	*177.8*	*155.4*	*153.9*		*790*	*910*	*1030*	*1180*	*177.8*	153.1	151.6

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1		**7.000** in				177.8 mm				**7.000** in				177.8 mm		
2		35.00 lb/ft				51.1 daN/m				38.00 lb/ft				55.5 daN/m		
3		0.498 in				12.7 mm				0.540 in				13.7 mm		
4		6.004 in				152.5 mm				5.920 in				150.4 mm		
5		10.17 in^2				6563 mm^2				10.96 in^2				7072 mm^2		
6		1.47 gal/ft				18.27 l/m				1.43 gal/ft				17.76 l/m		
7		2.00 gal/ft				24.83 l/m				2.00 gal/ft				24.83 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	50.1	66.7	70.2	70.2	77.0	80.4	89.8	98.7	54.0	73.6	78.6	78.6	88.4	92.7	104.4	115.5
10	47.2	64.4	68.7	68.7	77.3	81.6	94.4	107.3	51.2	69.8	74.5	74.5	83.8	88.5	102.4	116.4
11	249	339	362	362	407	430	498	566	268	366	390	390	439	463	536	610
12	355	370	370	390	390	409	487	526	370	370	370	390	390	409	487	526
13	355			400			511	560	382			431			551	603
14	237	237	237	250	250	262	312	337	237	237	237	250	250	262	312	337
15	250			312			399	399	250			312			399	399
16																
17	256	313	327	332	360	379	443	492	280	341	356	362	393	414	484	537
18				95.5								95.8				
19				65.0								65.0				
20				95.5								95.8				
21				52.5								48.7				
22				56.9								60.0				
23																
24				80.7								82.1				
25				+ 100.0								+ 100.0				
26				89.1 (55.2)								82.7 (51.2)				
27				116.1								107.7				
28				65.5								65.3				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	*Make-up torque (daN.m)*					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						194.5		149.3						194.5		147.2
30						194.5		149.3						194.5		147.2
31						187.3		149.3						187.3		147.2
32						187.3		149.3						187.3		147.2
33																
34		1000	1160	1350	1510	194.5		149.3		1090	1260	1470	1650	194.5		147.2
35	1150	1360	1360	1490		198.1		149.3	1220	1420	1420	1560		201.7		147.2
36		1020	1020	1020		177.8	150.6	149.3		1020	1020	1020		177.8	148.5	147.2
37	1150	1360	1360	1490		198.5		149.3	1220	1420	1420	1560		202.1		147.2
38	470	470	680	810	950	177.8		149.3	470	470	680	810	950	177.8		147.2
39	680	880	880	880	1220	182.6	150.5	149.3	680	880	880	880	1220	182.6	150.1	147.2
40																
41	880	880	1150	1150	1360	193.7	150.5	149.3	880	880	1150	1150	1360	195.6	148.3	147.2
42	1000	1400	1700	1700	1700	194.5		149.3	1100	1500	1700	1700	1700	194.5		147.2
43	1270	1420	1520	1620	1720	195.1		149.3	1320	1520	1570	1670	1760	195.1		147.2
44	1470	1760	1960	2160	2160	200.9		149.3	1670	2060	2160	2160	2160	200.9		147.2
45		820	940	1080	1180	177.8	150.8	149.3		860	980	1080	1230	177.8	148.7	147.2

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**7,000** in					177.8 mm			**7.000** in					177.8 mm		
2	41.00 lb/ft					59.8 daN/m			44.00 lb/ft					64.2 daN/m		
3	*0.590 in*					*15.0 mm*			*0.640 in*					*16.3 mm*		
4	5.820 in					147.8 mm			5.720 in					145.3 mm		
5	11.88 in^2					7662 mm^2			12.78 in^2					8247 mm^2		
6	1.38 gal/ft					17.17 l/m			1.34 gal/ft					16.58 l/m		
7	2.00 gal/ft					24.83 l/m			2.00 gal/ft					24.83 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	58.5	79.8	85.1	85.1	95.8	101.1	117.0	133.0	63.0	85.9	91.6	91.6	103.1	108.8	126.0	143.1
10	55.9	76.2	81.3	81.3	91.5	96.6	111.8	127.1	60.7	82.7	88.2	88.2	99.2	104.8	121.3	137.8
11	*291*	*396*	*423*	*423*	*475*	*502*	*581*	*660*	*313*	426	455	455	512	540	625	711
12	370	370	370	390	390	409	487	526	370	370	370	390	390	409	487	526
13	390			467			597	624	390			487			624	624
14	237	237	237	250	250	262	312	337	237	237	237	250	250	262	312	337
15	250			312			399	399	250			312			399	399
16																
17																
18				96.2								96.5				
19				65.0												
20				96.2								96.5				
21																
22				55.3												
23																
24				78.1								79.7				
25				+ 100.0												
26				76.3 (47.3)								70.9				
27				102.7												
28				65.2												

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						194.5		144.7						194.5		142.1
30						194.5		144.7						194.5		142.1
31						187.3		144.7						187.3		142.1
32						187.3		144.7						187.3		142.1
33																
34																
35	1220	1420	1420	1560		201.7		144.7						203.2		142.1
36						177.8	145.9	144.7								
37	1220	1420	1420	1560		202.1		144.7						203.2		142.1
38																
39	680	880	880	880		184.0	145.8	144.7								
40																
41		1630	1900	1900	2370	193.0		144.7		1630	1900	1900	2370	195.2		142.1
42						194.5		144.7								
43	1420	1570	1670	1760	1860	195.1		144.7	1670	1860	1960	2060	2160	195.1		142.1
44	1960	2160	2160	2160	2160	201.7		144.7								
45		910	1030	1130	1270	177.8	146.1	144.7								

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**7.625** in				193.7 mm				**7.625** in				193.7 mm			
2	24.00 lb/ft				35.0 daN/m				26.40 lb/ft				38.5 daN/m			
3	0.300 in				7.6 mm				0.328 in				8.3 mm			
4	7.025 in				178.4 mm				6.969 in				177.0 mm			
5	6.90 in^2				4454 mm^2				7.52 in^2				4850 mm^2			
6	2.01 gal/ft				25.01 l/m				1.98 gal/ft				24.61 l/m			
7	2.37 gal/ft				29.46 l/m				2.37 gal/ft				29.46 l/m			
6	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	16.0	18.9	19.4	19.4	20.3	20.7	21.3	21.4	20.0	22.6	23.4	23.4	24.9	25.5	27.0	27.9
10	26.1	35.6	38.0	38.0	42.7	45.1	52.2	59.3	28.5	38.9	41.5	41.5	46.7	49.3	57.1	64.9
11	169	230	246	246	276	292	338	384	184	251	268	268	301	318	368	418
12	237	255	259	269	278	292	345	378	258	277	282	293	303	318	376	412
13	237			269			345	378	258			293			376	412
14	237	255	259	269	278	292	345	378	258	277	282	293	303	318	376	412
15	237			269			345	378	258			293			376	412
16	136	167	175	178	193	203	237	266	152	187	195	198	216	227	265	297
17									167	205	214	218	237	249	291	326
18				92.8								93.4				
19				55.0								55.0				
20				92.8								93.4				
21												49.3				
22												53.2				
23												71.5				
24																
25												+ 100.0				
26												171.6 (104.4)				
27												166.8				
28												51.8				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						215.9		175.3						215.9		173.8
30						215.9		175.3						215.9		173.8
31						206.4		175.3						206.4		173.8
32						206.4		175.3						206.4		173.8
33						215.9		175.3	460					215.9		173.8
34									510	650	760			215.9		173.8
35	920	1080	1080	1220		206.4		175.3	920	1080	1080	1220		206.4		173.8
36						193.7	176.5	175.3	680	880	880	880		193.7	175.1	173.8
37	920	1080	1080	1220		206.8		175.3	920	1080	1080	1220		206.8		173.8
38									570	570	680	680	950	193.7		173.8
39									570	680	680	680	810	196.9	175.0	173.8
40									1020	1020	1360	1360	1630	201.6	175.0	173.8
41																
42									680	880	1000	1100	1200	215.9		173.8
43									970	1080	1180	1230	1320	216.6		173.8
44									730	830	930	1030	1130	215.9		173.8
45										860	1030	1180	1320	193.7	175.2	173.8

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1		**7.625** in				193.7 mm				**7.625** in				193.7 mm		
2		29.70 lb/ft				43.3 daN/m				33.70 lb/ft				49.2 daN/m		
3		0.375 in				9.5 mm				0.430 in				10.9 mm		
4		6.875 in				174.6 mm				6.765 in				171.8 mm		
5		8.54 in^2				5508 mm^2				9.72 in^2				6270 mm^2		
6		1.93 gal/ft				23.95 l/m				1.87 gal/ft				23.19 l/m		
7		2.37 gal/ft				29.46 l/m				2.37 gal/ft				29.46 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	26.9	32.0	33.0	33.0	34.7	35.3	36.8	39.1	35.1	43.4	45.2	45.2	48.6	50.1	54.2	57.5
10	32.6	44.5	47.4	47.4	53.4	56.3	65.2	74.1	37.4	51.0	54.4	54.4	61.2	64.6	74.8	85.0
11	209	285	304	304	342	361	418	475	238	324	346	346	389	411	476	540
12	293	315	321	333	344	361	427	468	334	359	365	379	391	411	486	533
13	293			333			427	468	334			379			486	533
14	293	315	321	333	344	361	427	465	327	327	327	344	344	361	430	465
15	293			333			427	468	334			379			486	533
16																
17	197	241	252	256	278	293	342	383	231	282	295	300	326	343	401	449
18				94.2								94.9				
19				65.0								65.0				
20				94.2								94.9				
21				53.4								54.8				
22				57.4								58.8				
23				75.0								73.9				
24												78.0				
25				+ 100.0								+ 100.0				
26				151.1 (91.9)								132.7 (80.8)				
27				146.9								129.1				
28				57.6								62.7				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						215.9		171.5						215.9		168.7
30						215.9		171.5						215.9		168.7
31						206.4		171.5						206.4		168.7
32						206.4		171.5						206.4		168.7
33																
34		770	890	1040		215.9		171.5		900	1050	1220		215.9		168.7
35	*990*	*1150*	*1150*	*1290*		*210.8*		*171.5*	*1190*	*1360*	*1360*	*1490*		*210.8*		*168.7*
36		1020	1020	1020		193.7	172.7	171.5		1020	1020	1020		193.7	169.9	168.7
37	990	1150	1150	1290		211.2		171.5	1190	1360	1360	1490		211.2		168.7
38	570	570	810	810	950	193.7		171.5	570	570	810	810	950	193.7		168.7
39	610	810	810	810	950	196.9	172.6	171.5	680	810	810	810	1080	196.9	169.8	168.7
40	1020	1020	1360	1360	1630	201.6	172.6	171.5	1020	1020	1360	1360	1630	203.2	169.8	168.7
41									1020	1020	1360	1360	1630	206.6	169.8	168.7
42	880	1100	1300	1500	1600	215.9		171.5	1000	1400	1600	1700	1700	215.9		168.7
43	1130	1270	1380	1470	1570	216.6		171.5	1380	1570	1670	1820	1910	216.6		168.7
44	980	1180	1270	1380	1470	215.9		171.5	1180	1380	1570	1670	1760	215.9		168.7
45		880	1030	1180	1320	193.7	172.8	171.5		910	1080	1230	1380	193.7	170.1	168.7

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**7.625** in				193.7 mm				**8.625** in				219.1 mm			
2	39.00 lb/ft				56.9 daN/m				24.00 lb/ft				35.0 daN/m			
3	0.500 in				12.7 mm				0.264 in				6.7 mm			
4	6.625 in				168.3 mm				8.097 in				205.7 mm			
5	11.19 in^2				7221 mm^2				6.94 in^2				4477 mm^2			
6	1.79 gal/ft				22.24 l/m				2.67 gal/ft				33.22 l/m			
7	2.37 gal/ft				29.46 l/m				3.04 gal/ft				37.69 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	45.5	57.9	60.8	60.8	66.3	68.9	76.4	83.1	9.5	9.9	9.9	9.9	9.9	9.9	9.9	9.9
10	43.5	59.3	63.3	63.3	71.2	75.2	87.0	98.9	20.3	27.7	29.6	29.6	33.3	35.1	40.7	46.2
11	274	373	398	398	448	473	548	622	170	231	247	247	278	293	340	386
12	385	413	420	436	451	474	560	613	233	253	258	267	277	292	344	378
13	385			436			560	613	233			267			344	378
14	327	327	327	344	344	361	430	465	233	253	258	267	277	292	344	378
15	344			430			551	551	233			267			344	378
16									124	154	161	163	178	187	219	245
17	273	334	350	355	386	406	474	531								
18				95.6												
19				65.0								55.0				
20				95.6												
21				53.0												
22				56.4												
23				69.4												
24				80.9												
25				+ 100.0												
26				115.3 (70.1)												
27				112.1												
28				65.2												

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						215.9		165.1						244.5		202.5
30						215.9		165.1						244.5		202.5
31						206.4		165.1						231.8		202.5
32						206.4		165.1						231.8		202.5
33									360					244.5		202.5
34		1070	1240	1450	1620	215.9		165.1								
35	1330	1490	1490	1630		214.6		165.1								
36		1020	1020	1020		193.7	166.4	165.1	680					219.1	203.8	202.5
37	1330	1490	1490	1630		215.0		165.1								
38	570	570	810	810	950	193.7		165.1								
39	750	950	950	950	1360	198.4	166.2	165.1								
40	1020	1020	1360	1360	1630	203.6	166.2	165.1								
41	1020	1020	1360	1360	1630	209.9	166.2	165.1								
42	1200	1600	1700	1700	1700	215.9		165.1								
43	1470	1670	1820	1910	2060	216.6		165.1								
44	1570	1760	1960	2060	2160	215.9		165.1								
45		960	1130	1270	1420	193.7	166.5	165.1								

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**8.625** in					219.1 mm			**8.625** in					219.1 mm		
2	28.00 lb/ft					40.9 daN/m			32.00 lb/ft					46.7 daN/m		
3	0.304 in					7.7 mm			0.352 in					8.9 mm		
4	8.017 in					203.6 mm			7.921 in					201.2 mm		
5	7.95 in^2					5126 mm^2			9.15 in^2					5902 mm^2		
6	2.62 gal/ft					32.57 l/m			2.56 gal/ft					31.79 l/m		
7	3.04 gal/ft					37.69 l/m			3.04 gal/ft					37.69 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	12:9	14.6	14.9	14.9	15.2	15.2	15.2	15.2	17.5	20.4	21.0	21.0	22.2	22.6	23.6	23.9
10	23.4	31.9	34.0	34.0	38.3	40.4	46.8	53.1	27.1	36.9	39.4	39.4	44.3	46.8	54.2	61.5
11	194	265	283	283	318	336	389	442	224	305	326	326	366	387	448	509
12	267	290	295	306	317	334	394	433	307	333	340	352	366	384	454	498
13	267			306			394	433	307			352			454	498
14	267	290	295	306	317	334	394	433	307	333	340	352	366	384	454	498
15	267			306			394	433	307			352			454	498
16	149	184	193	196	213	225	262	294	179	221	232	235	256	270	315	353
17									201	247	259	263	286	302	352	394
18				92.9								93.8				
19				55.0								55.0				
20				92.9								93.8				
21												50.1				
22												53.9				
23																
24																
25												+ 100.0				
26				206.4 (112.1)								179.3 (97.3)				
27				202.9								176.2				
28												54.5				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						244.5		200.5						244.5		198.0
30						244.5		200.5						244.5		198.0
31						231.8		200.5						231.8		198.0
32						231.8		200.5						231.8		198.0
33						244.5		200.5	550					244.5		198.0
34									610					244.5		198.0
35	990	1150	1150	1290		231.8		200.5	1060	1220	1220	1360		235.0		198.0
36	680					219.1	201.7	200.5	750					219.1	199.3	198.0
37	990	1150	1150	1290		232.2		200.5	1060	1220	1220	1360		235.3		198.0
38									690	690	810	810	1080	219.1		198.0
39									690	810	810	810	1080	222.3	198.4	198.0
40																
41																
42									880	1000	1200	1400	1500	244.5		198.0
43	1030	1180	1270	1380	1470	245.1		200.5	1130	1270	1380	1470	1570	245.1		198.0
44	730	830	880	930	980	244.5		200.5	880	980	1080	1180	1270	244.5		198.0
45										1130	1320	1520	1720	219.1	194.4	198.0

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1		**8.625** in				219.1 mm				**8.625** in				219.1 mm		
2		36.00 lb/ft				52.5 daN/m				40.00 lb/ft				58.4 daN/m		
3		0.400 in				10.2 mm				0.450 in				11.4 mm		
4		7.825 in				198.8 mm				7.725 in				196.2 mm		
5		10.34 in^2				6668 mm^2				11.56 in^2				7456 mm^2		
6		2.50 gal/ft				31.03 l/m				2.43 gal/ft				30.24 l/m		
7		3.04 gal/ft				37.69 l/m				3.04 gal/ft				37.69 l/m		
8	K55	C75	L80	N80	C90	C95	P110	O125	K55	C75	L80	N80	C90	C95	P110	O125
9	23.8	27.6	28.3	28.3	29.3	30.0	32.3	34.0	30.3	36.7	38.1	38.1	40.5	41.5	44.1	45.7
10	30.8	42.0	44.8	44.8	50.4	53.2	61.6	69.9	34.6	47.2	50.4	50.4	56.7	59.8	69.2	78.7
11	253	345	368	368	414	437	506	575	283	386	411	411	463	488	565	643
12	347	377	384	398	413	434	512	563	388	421	430	445	462	486	573	629
13	347			398			512	563	388			445			573	629
14	347	373	373	393	393	412	491	530	373	373	373	393	393	412	491	530
15	347			398			512	563	388			445			573	628
16	208	257	270	273	298	314	366	411								
17	234	288	302	306	333	351	410	459	268	330	345	351	381	402	469	526
18				94.6								95.1				
19				65.0								65.0				
20				94.6								95.1				
21				52.5								49.9				
22				56.1								58.8				
23																
24																
25				+ 100.0								+ 100.0				
26				158.7 (86.2)								141.9 (77.1)				
27				156.0								139.5				
28				59.7								64.0				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	O125				K55	C75/LN80	C90/C95	P110	O125			
29						244.5		195.6						244.5		193.0
30						244.5		195.6						244.5		193.0
31						231.8		195.6						231.8		193.0
32						231.8		195.6						231.8		193.0
33	630					244.5		195.6								
34	710	920	1070			244.5		195.6		1050	1230	1430		244.5		193.0
35	1220	1360	1360	1560		235.0		195.6	1360	1490	1490	1690		241.3		193.0
36	750	950	950	950		219.1	196.9	195.6		1080	1080	1080		219.1	194.3	193.0
37	1220	1360	1360	1560		235.3		195.6	1360	1490	1490	1690		241.7		193.0
38	690	690	950	950	1080	219.1		195.6	690	690	1020	1020	1150	219.1		193.0
39	*750*	*950*	*950*	*950*	*1360*	*222.3*	*196.7*	*195.6*	*810*	*1080*	*1060*	*1080*	*1490*	*222.3*	*194.2*	*193.0*
40																
41																
42	1000	1200	1400	1600	1700	244.5		195.6	1200	1500	1700	1700	1700	244.5		193.0
43	1380	1570	1670	1820	1960	245.1		195.6	1470	1670	1820	1910	2060	245.1		193.0
44	1080	1230	1380	1470	1570	244.5		195.6	1380	1570	1760	1860	1960	244.5		193.0
45		1130	1320	1520	1720	219.1	197.0	195.6		1180	1320	1520	1760	219.1	194.6	193.0

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**8.625** in					219.1 mm			**8.625** in					219.1 mm		
2	44.00 lb/ft					64.2 daN/m			49.00 lb/ft					71.5 daN/m		
3	0.500 in					12.7 mm			0.557 in					14.2 mm		
4	7.625 in					193.7 mm			7.511 in					190.8 mm		
5	12.76 in^2					8234 mm^2			14.12 in^2					9110 mm^2		
6	2.37 gal/ft					29.46 l/m			2.30 gal/ft					28.58 l/m		
7	3.04 gal/ft					37.69 l/m			3.04 gal/ft					37.69 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	36.9	45.9	47.9	47.9	51.7	53.4	58.1	61.9	44.4	56.3	59.1	59.1	64.4	66.9	74.0	80.4
10	38.5	52.5	56.0	56.0	63.0	66.4	76.9	87.4	42.9	58.4	62.3	62.3	70.1	74.0	85.7	97.4
11	312	426	454	454	511	539	624	710	345	471	502	502	565	597	691	785
12	428	465	474	492	510	536	633	695	474	515	525	544	564	593	700	769
13	428			492			633	695	474			544			700	769
14	373	373	373	393	393	412	491	530	373	373	373	393	393	412	491	530
15	393			491			628	628	393			491			628	628
16																
17	302	371	389	394	429	452	528	592	339	418	437	444	483	509	594	666
18				95.6								96.0				
19				65.0								65.0				
20				95.6								96.0				
21				53.0								47.9				
22				59.3								63.0				
23																
24																
25				+ 100.0								+ 100.0				
26				128.5 (69.8)								116.1 (63.1)				
27				126.3								114.2				
28				65.5								69.3				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						244.5		190.5						244.5		187.6
30						244.5		190.5						244.5		187.6
31						231.8		190.5						231.8		187.6
32						231.8		190.5						231.8		187.6
33																
34		1180	1380	1610		244.5		190.5		1330	1550	1810	2020	244.5		187.6
35	1420	1630	1630	1830		241.3		190.5	1490	1760	1760	1970		241.3		187.6
36		1150	1150	1150		219.1	191.8	190.5		1150	1150	1150		219.1	188.9	187.6
37	1420	1630	1630	1830		241.7		190.5	1490	1760	1760	1970		241.7		187.6
38	690	690	1020	1020	1150	219.1		190.5	690	690	1020	1020	1150	219.1		187.6
39	810	1080	1080	1080	1490	222.3	191.6	190.5	810	1080	1080	1080	1490	222.3	188.7	187.6
40																
41																
42	1400	1700	1700	1700	1700	244.5		190.5	1600	1700	1700	1700	1700	244.5		187.6
43	1570	1760	1910	2060	2160	245.1		190.5	1670	1860	2060	2160	2160	245.1		187.6
44	1670	1860	2060	2160	2160	244.5		190.5	1960	2160	2160	2160	2160	244.5		187.6
45		1180	1380	1570	1760	219.1	192.1	190.5		1230	1420	1620	1820	219.1	189.2	187.6

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**9.625** in				244.5 mm				**9.625** in				244.5 mm			
2	32.30 lb/ft				47.1 daN/m				36.00 lb/ft				52.5 daN/m			
3	0.312 in				7.9 mm				0.352 in				8.9 mm			
4	9.001 in				228.6 mm				8.921 in				226.6 mm			
5	9.12 in^2				5886 mm^2				10.25 in^2				6615 mm^2			
6	3.31 gal/ft				41.06 l/m				3.25 gal/ft				40.33 l/m			
7	3.78 gal/ft				46.94 l/m				3.78 gal/ft				46.94 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	10.8	11.7	11.8	11.8	11.8	11.8	11.8	11.8	13.9	16.0	16.4	16.4	16.8	17.0	17.1	17.1
10	21.5	29.3	31.3	31.3	35.2	37.1	43.0	48.9	24.3	33.1	35.3	35.3	39.7	41.9	48.5	55.2
11	223	304	325	325	365	386	446	507	251	342	365	365	410	433	502	570
12	299	328	336	347	362	381	448	493	336	369	377	390	407	428	504	555
13	299			347			448	493	336			390			504	555
14	299	328	336	347	362	381	448	493	336	369	377	390	407	428	504	555
15	299			347			448	493	336			390			504	555
16	162	201	211	214	234	246	287	322	188	234	245	249	271	286	334	374
17									217	269	282	286	312	328	383	430
18				93.2								93.9				
19																
20				93.2								93.9				
21												50.0				
22												53.9				
23												66.4				
24																
25																
26												177.6 (96.7)				
27												173.9				
28												53.5				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						269.9		224.7						269.9		222.6
30						269.9		224.7						269.9		222.6
31						257.2		224.7						257.2		222.6
32						257.2		224.7						257.2		222.6
33						269.9		224.7	570					269.9		222.6
34									660					269.9		222.6
35	1080	1290	1290	1420		260.4		224.7	1080	1290	1290	1420		260.4		222.6
36																
37	1080	1290	1290	1420		260.7		224.7	1080	1290	1290	1420		260.7		222.6
38									840	840	1080	1080	1360	244.5		222.6
39									840	1080	1080	1080	1360	247.7	223.0	222.6
40									1490	1490	2030	2030	2440	254.0	223.0	222.6
41																
42																
43									1180	1380	1520	1620	1760	270.5		222.6
44									980	1180	1270	1380	1470	269.9		222.6
45										1380	1670	1910	2160	244.5	224.0	222.6

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1		**9.625** in				244.5 mm				**9.625** in				244.5 mm		
2		40.00 lb/ft				58.4 daN/m				43.50 lb/ft				63.5 daN/m		
3		0.395 in				10.0 mm				0.435 in				11.1 mm		
4		8.835 in				224.4 mm				8.755 in				222.4 mm		
5		11.45 in^2				7387 mm^2				12.56 in^2				8103 mm^2		
6		3.18 gal/ft				39.55 l/m				3.13 gal/ft				38.84 l/m		
7		3.78 gal/ft				46.94 l/m				3.78 gal/ft				46.94 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	17.7	20.6	21.3	21.3	22.4	22.9	23.9	24.3	22.4	25.7	26.3	26.3	27.6	28.5	30.5	31.9
10	27.2	37.1	39.6	39.6	44.6	47.0	54.5	61.9	30.0	40.9	43.6	43.6	49.1	51.8	60.0	68.2
11	280	382	407	407	458	484	560	637	307	419	447	447	503	531	615	698
12	375	412	421	436	454	478	563	619	411	452	462	478	498	524	617	679
13	375			436			563	619	411			478			617	679
14	375	412	416	436	437	459	547	591	411	416	416	437	437	459	547	591
15	375			436			563	619	411			478			617	679
16	216	268	281	285	311	328	383	430								
17	250	309	323	328	357	377	439	493	279	345	362	367	400	422	492	552
18				94.5								95.0				
19																
20				94.5								95.0				
21				51.7								53.0				
22				55.6								56.8				
23				69.9								72.5				
24																
25				+ 100.0								+ 100.0				
26				159.0 (86.6)								145.0 (78.9)				
27				155.7								141.9				
28				58.3								62.0				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						269.9		220.4						269.9		218.4
30						269.9		220.4						269.9		218.4
31						257.2		220.4						257.2		218.4
32						257.2		220.4						257.2		218.4
33	660					269.9		220.4								
34	760	990	1150			269.9		220.4		1100	1290	1500		269.9		218.4
35	1220	1360	1360	1630		260.4		220.4	1360	1490	1490	1830		266.7		218.4
36																
37	1220	1360	1360	1630		260.7		220.4	1360	1490	1490	1830		267.1		218.4
38	840	840	1220	1220	1360	244.5		220.4	840	840	1220	1220	1360	244.5		218.4
39	950	1220	1220	1220	1490	247.7	222.4	220.4	950	1220	1220	1220	1490	247.7	220.3	218.4
40	1490	1490	2030	2030	2440	254.0	222.4	220.4	1490	1490	2030	2030	2440	254.0	220.3	218.4
41																
42	1100	1400	1700	1700	1700	269.9		220.4	1300	1600	1700	1700	1700	269.9		218.4
43	1420	1670	1820	1960	2160	270.5		220.4	1620	1910	2060	2160	2160	270.5		218.4
44	1180	1380	1570	1670	1860	269.9		220.4	1470	1670	1860	1960	2160	269.9		218.4
45		1420	1670	1910	2160	244.5	222.4	220.4		1420	1670	1910	2160	244.5	220.4	218.4

MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1		**9.625** in				244.5 mm				**9.625** in				244.5 mm		
2		*47.00 lb/ft*				*68.6 daN/m*				*53.50 lb/ft*				*78.1 daN/m*		
3		0.472 in				12.0 mm				0.545 in				13.8 mm		
4		8.681 in				220.5 mm				8.535 in				216.8 mm		
5		13.57 in^2				8757 mm^2				15.54 in^2				10028 mm^2		
6		3.07 gal/ft				38.18 l/m				2.97 gal/ft				36.91 l/m		
7		3.78 gal/ft				46.94 l/m				3.78 gal/ft				46.94 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	26.8	31.8	32.8	32.8	34.4	35.1	36.5	38.9	35.4	43.8	45.6	45.6	49.0	50.6	54.8	58.1
10	32.5	44.4	47.3	47.3	53.3	56.2	65.1	74.0	37.6	51.2	54.6	54.6	61.5	64.9	75.1	85.4
11	*332*	*453*	*483*	*483*	*543*	*574*	*664*	*755*	*380*	*519*	*553*	*553*	*622*	*657*	*761*	*864*
12	445	488	499	516	538	566	667	734	509	559	572	591	616	648	764	841
13	445			516			667	734	509			591			764	841
14	416	416	416	437	437	459	547	591	416	416	416	437	437	459	547	591
15	437			516			667	700	437			547			700	700
16																
17	306	379	397	403	439	463	540	605	359	444	465	472	515	542	633	710
18				95.4								96.0				
19												65.1				
20				*95.4*								96.0				
21				53.8								55.7				
22				57.9								58.9				
23				74.6								72.8				
24												77.8				
25				+ 100.0								+ *100.0*				
26				134.1 (73.0)								117.1 (63.8)				
27				131.3								114.7				
28				65.0								65.2				

	Make-up torque (daN.m)								Make-up torque (daN.m)							
	K55	C75/LN80	C90/C95	P110	Q125	OD (mm)	ID (mm)	API drift (mm)	K55	C75/LN80	C90/C95	P110	Q125	OD (mm)	ID (mm)	API drift (mm)
29						269.9		216.5						269.9		212.8
30						269.9		216.5						269.9		212.8
31						257.2		216.5						257.2		212.8
32						257.2		216.5						257.2		212.8
33																
34		1210	1410	1640	1840	269.9		216.5		1420	1650	1930	2160	269.9		212.8
35	1490	1630	1630	1970		266.7		216.5	1690	1900	1900	2170		266.7		212.8
36										1150	1150	1150		244.5	214.9	212.8
37	1490	1630	1630	1970		267.1		216.5	1690	1900	1900	2170		267.1		212.8
38	840	840	1220	1220	1360	244.5		216.5	840	840	1220	1220	1360	244.5		212.8
39	*1080*	*1360*	*1360*	*1360*	*1630*	*247.7*	*218.5*	*216.5*	*1080*	*1360*	*1360*	*1360*	*1630*	*247.7*	*217.0*	*212.8*
40	1490	1490	2030	2030	2440	254.0	218.5	216.5	1490	1490	2030	2030	2440	255.6	216.8	212.8
41									1490	1490	2030	2030	2440	261.4	214.8	212.8
42	1500	1700	1700	1700	1700	269.9		216.5	1700	1700	1700	1700	1700	269.9		212.8
43	1670	1960	2160	2160	2160	270.5		216.5	1820	2160	2160	2160	2160	270.5		212.8
44	1760	1960	2160	2160	2160	269.9		216.5	1960	2160	2160	2160	2160	269.9		212.8
45		1470	1720	1960	2250	244.5	218.5	216.5		1520	1760	1960	2250	244.5	214.8	212.8

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**9.625** in					244.5 mm			**9.625**"in					244.5 mm		
2	58.40 lb/ft					85.2 daN/m			61.10 lb/ft					89.2 daN/m		
3	0.595 in					15.1 mm			0.625 in					15.9 mm		
4	8.435 in					214.3 mm			8.375 in					212.7 mm		
5	16.88 in^2					10888 mm^2			*17.67 in^2*					*11398 mm^2*		
6	2.90 gal/ft					36.05 l/m			2.86 gal/ft					35.54 l/m		
7	3.78 gal/ft					46.94 l/m			3.78 gal/ft					46.94 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	41.3	52.0	54.4	54.4	59.0	61.2	67.3	72.6	44.8	56.9	59.7	59.7	65.0	67.6	74.8	81.3
10	41.0	55.9	59.7	59.7	67.1	70.8	82.0	93.2	43.1	58.7	62.7	62.7	70.5	74.4	86.2	97.9
11	413	563	601	601	676	713	826	938	432	589	629	629	707	747	864	982
12	553	607	621	642	669	704	830	913	579	636	650	672	700	737	868	956
13	553			642			830	913	579			672			868	956
14	*416*	*416*	*416*	*437*	*437*	*459*	*547*	*591*	*416*	416	416	437	437	459	547	591
15	437			547			700	700	437			547			700	700
16																
17																
18				96.3												
19																
20																
21				51.3												
22				62.2												
23																
24				79.6												
25				+ 100.0								+ 100.0				
26				107.9 (58.7)												
27				105.6												
28				65.3												

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						269.9		210.3						269.9		208.8
30						269.9		210.3						269.9		208.8
31						257.2		210.3						257.2		208.8
32						257.2		210.3						257.2		208.8
33																
34																
35						268.6		210.3								
36																
37																
38	840	840	1220	1220	1360	*244.5*		*210.3*								
39	1080	1360	1360	1360	1630	250.0	212.2	210.3								
40																
41						263.7	212.2	210.3								
42						269.9		210.3						269.9		208.8
43	1910	2160	2160	2160	2160	270.5		210.3								
44	2160	2160	2160	2160	2160	269.9		210.3								
45		1570	1820	2060	2250	244.5	212.3	210.3								

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1		**9.625** in				244.5 mm				**10.750** in				273.1 mm .		
2		71.80 lb/ft				104.8 daN/m				32.75 lb/ft				47.8 daN/m		
3		0.750 in				19.1 mm				0.279 in				7.1 mm		
4		8.125 in				206.4 mm				10.192 in				258.9 mm		
5		20.91 in^2				13491 mm^2				9.18 in^2				5924 mm^2		
6		2.69 gal/ft				33.45 l/m				4.24 gal/ft				52.63 l/m		
7		3.78 gal/ft				46.94 l/m				4.72 gal/ft				58.56 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	54.5	74.3	79.3	79.3	89.2	94.1	106.2	117.6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
10	51.7	70.5	75.2	75.2	84.6	89.3	103.4	117.5	17.2	23.5	25.1	25.1	28.2	29.8	34.5	39.2
11	512	698	744	744	837	884	1023	1163	225	306	327	327	368	388	449	511
12	685	743	743	782	782	821	977	1055	292	326	334	344	361	380	447	493
13	685			795			1028	1131	292			344			447	493
14	416	416	416	437	437	459	547	591	292	326	334	344	361	380	447	493
15	437			547			700	700	292			344			447	493
16	436	541	567	575	628	662	772	866	150	188	197	200	218	230	268	301
17	503	622	652	661	721	760	886	994								
18												92.3				
19																
20																
21																
22																
23																
24																
25				+ 100.0												
26																
27																
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						269.9		202.4						298.5		254.9
30						269.9		202.4						298.5		254.9
31						257.2		202.4						285.8		254.9
32						257.2		202.4						285.8		254.9
33														298.5		254.9
34																
35														287.0		254.9
36																
37																
38																
39																
40																
41																
42						269.9		202.4								
43																
44																
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7:38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**10.750** in				273.1 mm				**10.750** in				273.1 mm			
2	40.50 lb/ft				59.1 daN/m				45.50 lb/ft				66.4 daN/m			
3	0.350 in				8.9 mm				0.400 in				10.2 mm			
4	10.050 in				255.3 mm				9.950 in				252.7 mm			
5	11.44 in^2				7378 mm^2				13.01 in^2				8391 mm^2			
6	4.12 gal/ft				51.18 l/m				4.04 gal/ft				50.17 l/m			
7	4.72 gal/ft				58.56 l/m				4.72 gal/ft				58.56 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	10.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	14.4	16.7	17.1	17.1	17.6	17.8	18.0	18.0
10	21.6	29.5	31.4	31.4	35.4	37.3	43.2	49.1	24.7	33.7	35.9	35.9	40.4	42.7	49.4	56.1
11	280	382	407	407	458	483	560	636	318	434	463	463	521	550	636	723
12	364	405	416	429	449	473	557	614	414	461	473	488	511	538	633	698
13	364			429			557	614	414			488			633	698
14	364	405	416	429	449	473	557	614	414	461	463	488	488	512	610	658
15	364			429			557	614	414			488			633	698
16	200	250	262	266	291	306	357	401	235	293	308	312	341	359	419	471
17																
18				93.9								94.6				
19																
20																
21																
22												55.6				
23				66.3								70.3				
24																
25				+ 100.0								+ 100.0				
26				177.0 (97.2)								155.6 (85.5)				
27				173.7								152.7				
28				52.3								58.1				

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						298.5		251.3						298.5		248.8
30						298.5		251.3						298.5		248.8
31						285.8		251.3						285.8		248.8
32						285.8		251.3						285.8		248.8
33	610					298.5		251.3	720					298.5		248.8
34																
35						287.0		251.3						292.1		248.8
36																
37																
38									950	950	1220	1220	1490	273.1		248.8
39									950	1220	1220	1220	1490	276.2	250.7	248.8
40	1760	1760	2440	2440	2440	284.2	251.7	251.3	1760	1760	2440	2440	2440	284.2	250.7	248.8
41																
42	1100	1500	1700	1700	1700	298.5		251.3	1500	1700	1700	1700	1700	298.5		248.8
43	1270	1520	1670	1820	1960	299.0		251.3	1570	1910	2060	2160	2160	299.0		248.8
44	1080	1270	1470	1570	1670	298.5		251.3	1380	1570	1760	1960	2160	298.5		248.8
45		1760	2060	2450	2750	273.1	252.7	251.3		1760	2060	2450	2750	273.1	250.2	248.8

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**10.750** in				273.1 mm				**10.750** in				273.1 mm			
2	51.00 lb/ft				74.4 daN/m				55.50 lb/ft				81.0 daN/m			
3	0.450 in				11.4 mm				0.495 in				12.6 mm			
4	9.850 in				250.2 mm				9.760 in				247.9 mm			
5	14.56 in^2				9394 mm^2				15.94 in^2				10286 mm^2			
6	3.96 gal/ft				49.16 l/m				3.89 gal/ft				48.27 l/m			
7	4.72 gal/ft				58.56 l/m				4.72 gal/ft				58.56 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	18.7	21.4	22.2	22.2	23.5	24.0	25.2	25.8	23.4	27.1	27.7	27.7	28.7	29.6	31.8	33.4
10	27.8	37.9	40.4	40.4	45.5	48.0	55.6	63.1	30.6	41.7	44.4	44.4	50.0	52.8	61.1	69.4
11	356	486	518	518	583	615	712	810	390	532	567	567	638	674	760	887
12	464	516	529	546	572	602	709	782	508	565	580	598	627	659	776	856
13	464			546			709	782	508			598			776	856
14	463	463	463	488	488	512	610	658	463	463	463	488	488	512	610	658
15	464			546			709	780	488			598			776	780
16	269	336	353	358	391	412	480	539	300	375	393	398	435	459	535	601
17																
18				95.2								95.6				
19																
20																
21																
22				57.2								58.1				
23				73.5								75.8				
24																
25				+ 100.0								+ 100.0				
26				139.0 (76.3)								126.9 (69.7)				
27				136.4								124.6				
28				62.6								65.4				

	Make-up torque(daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						298.5		246.2						298.5		243.9
30						298.5		246.2						298.5		243.9
31						285.8		246.2						285.8		243.9
32						285.8		246.2						285.8		243.9
33	820	1080	1260	1460		298.5		246.2		1200	1400	1630		298.5		243.9
34																
35						292.1		246.2						297.2		243.9
36																
37																
38	950	950	1220	1220	1490	273.1		246.2	1360	1360	1630	1630	1900	273.1		243.9
39	950	1220	1220	1220	1490	276.2	248.2	246.2	1360	1630	1630	1630	1760	276.2	245.9	243.9
40	1760	1760	2440	2440	2440	284.2	248.2	246.2	1760	1760	2440	2440	2440	284.2	245.9	243.9
41																
42	1700	1700	1700	1700	1700	298.5		246.2	1700	1700	1700	1700	1700	298.5		243.9
43	1670	1960	2160	2160	2160	299.0		246.2	1760	2060	2160	2160	2160	299.0		243.9
44	1670	1860	2060	2160	2160	298.5		246.2	1960	2160	2160	2160	2160	298.5		243.9
45		1820	2160	2450	2750	273.1	247.6	246.2		1820	2160	2450	2850	273.1	245.5	243.9

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**10.750** in				273.1 mm				**10.750** in				273.1 mm			
2	60.70 lb/ft				88.6 daN/m				65.70 lb/ft				95.9 daN/m			
3	0.545 in				13.8 mm				0.595 in				15.1 mm			
4	9.660 in				245.4 mm				9.560 in				242.8 mm			
5	17.47 in^2				11270 mm^2				18.98 in^2				12244 mm^2			
6	3.81 gal/ft				47.29 l/m				3.73 gal/ft				46.31 l/m			
7	4.72 gal/ft				58.56 l/m				4.72 gal/ft				58.56 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	28.7	34.4	35.6	35.6	37.6	38.5	40.5	41.8	33.9	41.7	43.4	43.4	46.6	48.0	51.7	54.6
10	33.6	45.9	48.9	48.9	55.0	58.1	67.3	76.4	36.7	50.1	53.4	53.4	60.1	63.4	73.4	83.5
11	427	583	622	622	699	738	855	971	464	633	675	675	760	802	929	1055
12	556	619	635	655	687	723	850	938	605	673	690	712	746	785	924	1019
13	556			655			850	938	605			712			924	1019
14	463	463	463	488	488	512	610	658	463	463	463	488	512	512	610	658
15	488			610			780	780	488			610			780	780
16	334	417	437	443	484	511	595	668	367	458	481	487	533	562	655	735
17																
18	96.0								96.3							
19	65.1								65.8							
20																
21																
22	55.9								59.4							
23	77.1								78.2							
24	77.9								79.7							
25	+ 100.0								+ 100.0							
26	115.8 (63.6)								106.6 (58.6)							
27	113.7								104.7							
28	65.8								65.8							

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						298.5		241.4						298.5		238.9
30						298.5		241.4						298.5		238.9
31						285.8		241.4						285.8		238.9
32						285.8		241.4						285.8		238.9
33				1810	2030	298.5		241.4				2000	2240	298.5		238.9
34																
35						297.2		241.4						297.2		238.9
36						273.1	243.5	241.4		1900	1900	1900		273.1		238.9
37																
38	1360	1360	1760	1760	2030	273.1		241.4	1360	1360	1760	1760	2030	273.1		238.9
39	1490	1760	1760	1760	2030	277.0	243.3	241.4	1490	1760	1760	1760	2030	279.4	242.4	238.9
40	1760	1760	2440	2440	2440	285.8	243.3	241.4	1760	1760	2440	2440	2440	287.4	242.5	238.9
41	1760	1760	2440	2440	2440	290.2	243.3	241.4	1760	1760	2440	2440	2440	292.5	240.8	238.9
42	1700	1700	1700	1700	1700	298.5		241.4	1700	1700	1700	1700	1700	298.5		238.9
43	1860	2160	2160	2160	2160	299.0		241.4	1960	2160	2160	2160	2160	299.0		238.9
44	2160	2160	2160	2160	2160	298.5		241.4	2160	2160	2160	2160	2160	298.5		238.9
45		1860	2160	2550	2850	273.1	243.0	241.4		1910	2250	2550	2850	273.1	240.5	238.9

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**11.750** in				298.5 mm				**11.750** in				298.5 mm			
2	42.00 lb/ft				61.3 daN/m				47.00 lb/ft				68.6 daN/m			
3	0.333 in				8.5 mm				0.375 in				9.5 mm			
4	11.084 in				281.5 mm				11.000 in				279.4 mm			
5	11.95 in^2				7707 mm^2				13.39 in^2				8641 mm^2			
6	5.01 gal/ft				62.25 l/m				4.94 gal/ft				61.32 l/m			
7	5.63 gal/ft				69.96 l/m				5.63 gal/ft				69.96 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.8	10.4	11.2	11.2	11.2	11.2	11.2	11.2	11.2
10	18.8	25.7	27.4	27.4	30.8	32.5	37.6	42.8	21.2	28.9	30.8	30.8	34.6	36.6	42.3	48.1
11	292	399	425	425	478	505	585	664	328	447	477	477	536	566	655	745
12	371	418	430	442	466	490	576	637	416	469	482	496	522	550	646	714
13	371			442			576	637	416			496			646	714
14	371	418	430	442	466	490	576	637	416	469	482	496	522	550	646	714
15	371			442			576	637	416			496			646	7,14
16	196	246	258	261	286	301	351	395	226	284	298	302	330	348	406	456
17																
18																
19																
20																
21																
22												52.7				
23												68.5				
24																
25												+ 100.0				
26												164.6 (90.6)				
27												161.5				
28																
	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						323.9		277.6						323.9		275.4
30						323.9		277.6						323.9		275.4
31						323.9		277.6						323.9		275.4
32						323.9		277.6						323.9		275.4
33						323.9		277.6	690					323.9		275.4
34																
35																
36																
37																
38									1030	1030	1360	1360	1630	298.5		275.4
39									1030	1360	1360	1360	1630	303.2	276.6	275.4
40									2030	2030	2850	2850		309.6	275.8	275.4
41																
42									1700	1700	1700	1700	1700	323.9		275.4
43									1420	1720	1910	2060	2160	324.4		275.4
44									1470	1670	1760	1960	2160	323.9		275.4
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**11.750** in				298.5 mm				**11.750** in				298.5 mm			
2	54.00 lb/ft				78.8 daN/m				60.00 lb/ft				87.6 daN/m			
3	0.435 in				11.1 mm				0.489 in				12.4 mm			
4	10.880 in				276.4 mm				10.772 in				273.6 mm			
5	15.46 in^2				9977 mm^2				17.30 in^2				11160 mm^2			
6	4.83 gal/ft				59.98 l/m				4.73 gal/ft				58.80 l/m			
7	5.63 gal/ft				69.96 l/m				5.63 gal/ft				69.96 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	14.3	16.5	16.9	16.9	17.4	17.6	17.7	17.7	18.4	21.2	21.9	21.9	23.2	23.7	24.9	25.4
10	24.6	33.5	35.7	35.7	40.2	42.4	49.1	55.8	27.6	37.7	40.2	40.2	45.2	47.7	55.2	62.8
11	378	516	550	550	619	653	757	860	423	577	616	616	693	731	846	962
12	*480*	*541*	*556*	*573*	*603*	*635*	*746*	*825*	*537*	*605*	*622*	*641*	*675*	*710*	*835*	*923*
13	480			573			746	825	537			641			835	923
14	480	541	556	573	603	635	746	825	537	605	622	641	675	710	835	923
15	480			573			746	825	537			641			835	923
16	270	338	355	360	394	415	484	543	308	386	406	411	450	474	553	621
17																
18																
19																
20																
21																
22				56.5								61.3				
23				72.7								75.6				
24																
25				+ 100.0								+ 100.0				
26				142.5 (78.5)								127.4 (70.1)				
27				139.9								125.1				
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						323.9		272.4						323.9		269.6
30						*323.9*		*272.4*						*323.9*		*269.6*
31						323.9		272.4						323.9		269.6
32						323.9		272.4						323.9		269.6
33	820					323.9		272.4	940	1240	1450	1680	1890	323.9		269.6
34																
35																
36																
37																
38	1030	1030	1490	1490	1630	298.5		272.4	1490	1490	1760	1760	1900	298.5		269.6
39	1360	1760	1760	1760	1900	303.2	274.3	272.4	1490	1760	1760	1760	1900	303.2	271.6	269.6
40	2030	2030	2850	2850		309.6	274.3	272.4	2030	2030	2850	2850		309.6	271.6	269.6
41																
42	1700	1700	1700	1700	1700	323.9		272.4	1700	1700	1700	1700	1700	323.9		269.6
43	1960	2160	2160	2160	2160	324.4		272.4	2060	2160	2160	2160	2160	324.4		269.6
44	1860	2060	2160	2160	2160	323.9		272.4	2160	2160	2160	2160	2160	323.9		269.6
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**13.375** in				339.7 mm				**13.375** in				339.7 mm			
2	48.00 lb/ft				70.1 daN/m				54.50 lb/ft				79.5 daN/m			
3	0.330 in				8.4 mm				0.380 in				9.7 mm			
4	12.715 in				323.0 mm				12.615 in				320.4 mm			
5	13.52 in^2				8723 mm^2				15.51 in^2				10007 mm^2			
6	6.60 gal/ft				81.92 l/m				6.49 gal/ft				80.64 l/m			
7	7.30 gal/ft				90.65 l/m				7.30 gal/ft				90.65 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	7.8	7.9	7.9	7.9	7.9	7.9	7.9	7.9
10	16.4	22.3	23.8	23.6	26.8	28.3	32.7	37.2	18.9	25.7	27.4	27.4	30.8	32.6	37.7	42.8
11	331	451	481	481	541	571	662	752	379	517	552	552	621	655	759	862
12	402	463	478	490	521	548	643	713	461	531	548	562	597	629	738	818
13	402			490			643	713	461			562			738	818
14	402	463	478	490	521	548	643	713	461	531	548	562	597	629	738	818
15	402			490			643	713	461			562			738	818
16	205	258	271	274	301	317	370	416	243	307	322	326	358	377	439	494
17																
18																
19																
20																
21																
22																
23																
24																
25												+ 100.0				
26												161.1 (121.8)				
27												158.0				
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						365.1		319.0						365.1		316.5
30						365.1		319.0						365.1		316.5
31						365.1		319.0						365.1		316.5
32						365.1		319.0						365.1		316.5
33						365.1		319.0	740					365.1		316.5
34																
35																
36																
37																
38																
39																
40																
41																
42									1700	1700	1700	1700	1700	365.1		316.5
43									1570	1960	2160	2160	2160	365.7		316.5
44									1670	1960	2160	2160	2160	365.1		316.5
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS *(continued)*

1	**13.375** in					339.7 mm			**13.375**'in					339.7 mm		
2	61.00 lb/ft					89.0 daN/m			68.00 lb/ft					99.2 daN/m		
3	0.430 in					10.9 mm			0.480 in					12.2 mm		
4	12.515 in					317.9 mm			12.415 in					315.3 mm		
5	17.48 in^2					11280 mm^2			19.44 in^2					12543 mm^2		
6	6.39 gal/ft					79.37 l/m			6.29 gal/ft					78.10 l/m		
7	7.30 gal/ft					90.65 l/m			7.30 gal/ft					90.65 l/m		
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	10.6	11.4	11.5	11.5	11.5	11.5	11.5	11.5	13.4	15.3	15.6	15.6	16.0	16.1	16.1	16.1
10	21.3	29.1	31.0	31.0	34.9	36.8	42.7	48.5	23.8	32.5	34.6	34.6	39.0	41.1	47.6	54.1
11	428	583	622	622	700	739	856	972	476	649	692	692	*778*	*822*	*951*	*1081*
12	520	598	618	634	673	709	832	922	578	665	687	705	749	788	925	1026
13	520			634			832	922	578			705			925	1026
14	520	598	618	634	673	709	832	922	578	665	687	705	749	788	925	1026
15	*520*			*634*			*832*	*922*	*578*			*705*			*925*	*1026*
16	281	355	373	377	414	437	508	572	319	403	424	428	470	496	577	649
17																
18																
19				*60.0*								64.0				
20																
21																
22				54.7								59.2				
23												68.9				
24																
25				+ 100.0								+ 100.0				
26				142.9 (108.1)								128.5 (97.2)				
27				140.2								126.1				
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						365.1		313.9						365.1		311.4
30						365.1		313.9						365.1		311.4
31						365.1		313.9						365.1		311.4
32						365.1		313.9						365.1		311.4
33	860					365.1		313.9	970	1290	1510	1760		365.1		311.4
34																
35																
36	1110					*339.7*	*315.6*	*313.9*	*1190*					*339.7*	*313.1*	*311.4*
37																
38									1630	1630	1900	1900	2030	339.7		311.4
39	1360	1760	1760	1760	1900	344.5	315.8	313.9	1630	2030	2030	2030	2170	344.5	312.5	311.4
40									2710	2710	3660	3660	4070	350.9	312.5	311.4
41																
42	1700	1700	1700	1700	1700	365.1		313.9	1700	1700	1700	1700	1700	365.1		311.4
43	2060	2160	2160	2160	2160	365.7		313.9	2160	2160	2160	2160	2160	365.7		311.4
44	2060	2160	2160	2160	2160	365.1		313.9	2160	2160	2160	2160	2160	365.1		311.4
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**13.375** in				339.7 mm				**16.000** in				406.4 mm			
2	72.00 lb/ft				105.1 daN/m				65.00 lb/ft				94.9 daN/m			
3	0.514 in				13.1 mm				0.375 in				9.5 mm			
4	12.347 in				313.6 mm				15.250 in				387.4 mm			
5	20.77 in^2				13403 mm^2				18.40 in^2				11870 mm^2			
6	6.22 gal/ft				77.24 l/m				9.49 gal/ft				117.85 l/m			
7	7.30 gal/ft				90.65 l/m				10.45 gal/ft				129.72 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	15.4	17.9	18.4	18.4	19.2	19.5	19.9	19.9	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
10	25.5	34.8	37.1	37.1	41.7	44.1	51.0	58.0	15.5	21.2	22.6	22.6	25.4	26.9	31.1	35.3
11	508	693	739	739	832	878	1016	1155	450	614	655	655	737	777	900	1023
12	618	711	734	753	800	842	988	1096	509	607	632	644	694	731	855	954
13	618			753			988	1096	509			644			855	954
14	618	711	734	753	800	842	988	1096	509	607	632	644	694	731	855	954
15	618			753			988	1096	509			644			855	954
16	345	435	458	463	508	536	624	702	278	352	371	375	412	435	506	570
17																
18																
19				66.3												
20																
21																
22				61.8												
23				70.9												
24																
25				+ 100.0												
26				120.2 (90.9)												
27				118.0												
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						365.1		309.6						431.8		382.6
30						365.1		309.6						431.8		382.6
31						365.1		309.6						431.8		382.6
32						365.1		309.6						431.8		382.6
33		1400	1630	1900	2130	365.1		309.6						431.8		382.6
34																
35																
36						339.7	311.3	309.6								
37																
38	1630	1630	1900	1900	2030	339.7		309.6								
39	1630	2030	2030	2030	2170	344.5	312.3	309.6								
40	2710	2710	3660	3660	4070	350.9	312.4	309.6								
41																
42	1700	1700	1700	1700	1700	365.1		309.6								
43	2160	2160	2160	2160	2160	365.7		309.6								
44	2160	2160	2160	2160	2160	365.1		309.6								
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**16.000** in				406.4 mm				**16.000** in				406.4 mm			
2	75.00 lb/ft				109.5 daN/m				84.00 lb/ft				122.6 daN/m			
3	0.438 in				11.1 mm				0.495 in				12.6 mm			
4	15.124 in				384.1 mm				15.010 in				381.3 mm			
5	21.42 in^2				13821 mm^2				24.11 in^2				15552 mm^2			
6	9.33 gal/ft				115.90 l/m				9.19 gal/ft				114.16 l/m			
7	10.45 gal/ft				129.72 l/m				10.45 gal/ft				129.72 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	9.7	10.2	10.2	10.2	10.2	10.2	10.2	10.2
10	18.2	24.8	26.4	26.4	29.7	31.4	36.3	41.3	20.5	28.0	29.9	29.9	33.6	35.5	*41.1*	*46.6*
11	524	715	762	762	858	905	1048	1191	590	804	858	858	965	1019	1180	1340
12	592	707	736	750	808	851	995	1110	666	796	828	844	909	957	1120	1249
13	592			750			995	1110	666			844			1120	1249
14	592	707	736	750	808	851	995	1110	666	796	828	844	909	957	1120	1249
15	*592*			*750*			*995*	*1110*	*666*			*844*			*1120*	*1249*
16	334	424	447	451	496	523	609	686	385	488	514	519	571	602	701	789
17																
18																
19																
20																
21																
22																
23																
24																
25																
26																
27																
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						431.8		379.4						431.8		376.5
30						431.8		379.4						431.8		376.5
31						431.8		379.4						431.8		376.5
32						431.8		379.4						431.8		376.5
33	1020					431.8		379.4	1170					431.8		376.5
34																
35																
36																
37																
38																
39																
40																
41																
42																
43																
44																
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**18.625** in				473.1 mm				**20.000** in				508.4 mm			
2	87.50 lb/ft				127.7 daN/m				94.00 lb/ft				137.2 daN/m			
3	0.435 in				11.1 mm				0.438 in				11.1 mm			
4	17.755 in				451.0 mm				19.124 in				485.7 mm			
5	24.86 in^2				16039 mm^2				26.93 in^2				17374 mm^2			
6	12.86 gal/ft				159.73 l/m				14.92 gal/ft				185.31 l/m			
7	14.15 gal/ft				175.77 l/m				16.32 gal/ft				202.68 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
10	15.5	21.1	22.5	22.5	25.4	26.8	31.0	35.2	14.5	19.8	21.1	21.1	23.8	25.1	29.1	33.0
11	608	829	885	885	995	1051	1216	1382	659	898	958	958	1078	1138	1318	1497
12	635	790	829	840	917	967	1127	1265	658	838	883	892	982	1036	1205	1357
13	635			840			1127	1265	658			892			1205	1357
14	635	790	829	840	917	967	1127	1265	658	838	883	892	982	1036	1205	1357
15	635			840			1127	1265	658			892			1205	1357
16	353	451	475	480	529	558	649	731	367	469	495	499	551	581	675	761
17									425	543	572	577	636	671	780	879
18																
19																
20																
21																
22																
23																
24																
25																
26																
27																
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						508.0		446.2						533.4		481.0
30						508.0		446.2						533.4		481.0
31						508.0		446.2						533.4		481.0
32						508.0		446.2						533.4		481.0
33	1080					508.0		446.2	1120					533.4		481.0
34									1290					533.4		481.0
35																
36																
37																
38																
39																
40																
41																
42																
43																
44																
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASINGS (continued)

1	**20.000** in				508.0 mm				**20.000** in				508.0 mm			
2	106.50 lb/ft				155.4 daN/m				133.00 lb/ft				194.1 daN/m			
3	0.500 in				12.7 mm				0.635 in				16.1 mm			
4	19.000 in				482.6 mm				18.730 in				475.7 mm			
5	30.63 in^2				19762 mm^2				38.63 in^2				24925 mm^2			
6	14.73 gal/ft				182.92 l/m				14.31 gal/ft				177.76 l/m			
7	16.32 gal/ft				202.68 l/m				16.32 gal/ft				202.68 l/m			
8	K55	C75	L80	N80	C90	C95	P110	Q125	K55	C75	L80	N80	C90	C95	P110	Q125
9	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	10.3	11.0	11.1	11.1	11.1	11.1	11.1	11.1
10	16.6	22.6	24.1	24.1	27.1	28.7	33.2	37.7	21.1	28.7	30.6	30.6	34.5	36.4	42.1	47.9
11	749	1022	1090	1090	1226	1294	1499	1703	945	1289	1375	1375	1547	1633	1890	2148
12	749	954	1005	1015	1117	1178	1371	1544	944	1203	1267	1280	1409	1486	1729	1947
13	749			1015			1371	1544	944			1280			1729	1947
14	749	954	1005	1015	1117	1178	1371	1544	944	1203	1267	1280	1409	1486	1729	1947
15	749			1015			1371	1544	944			1280			1729	1947
16	427	546	576	581	641	676	787	887	557	714	753	759	837	883	1027	1158
17	495	632	666	672	741	781	909	1024	647	825	870	878	967	1020	1187	1337
18																
19																
20																
21																
22																
23																
24																
25																
26																
27																
28																

	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	API drift (mm)
	K55	C75/LN80	C90/C95	P110	Q125				K55	C75/LN80	C90/C95	P110	Q125			
29						533.4		477.8						533.4		471.0
30						533.4		477.8						533.4		471.0
31						533.4		477.8						533.4		471.0
32						533.4		477.8						533.4		471.0
33	1300					533.4		477.8	1700					533.4		471.0
34	1510					533.4		477.8	1970					533.4		471.0
35																
36																
37																
38																
39																
40																
41																
42																
43																
44																
45																

MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

PHYSICAL PROPERTIES OF LINE PIPE, RISER AND CONDUCTOR PIPE

Outside diameter																						
(in)	**22**						**24**								**26**							
(mm)	558.8						609.6								660.4							
Wall thickness																						
(mm)	9.52		12.70		19.05		12.70		15.88		19.05		25.4		12.70		15.88		19.05		25.4	
(in)	0.375		0.500		0.750		0.500		0.625		0.750		1.000		0.500		0.625		0.750		1.000	
Inside diameter																						
(mm)	539.8		533.4		520.7		584.2		577.8		571.5		558.8		635.0		628.6		622.3		609.6	
(in)	21.25		21.00		20.50		23.00		22.75		22.50		22.00		25.00		24.75		24.50		24.00	
Cross section area																						
(cm^2)	164		217		323		239		296		354		467		257		321		383		506	
(in^2)	25.4		33.6		50.1		37.0		45.9		54.9		72.4		39.8		49.8		59.4		78.4	
Weight																						
(kg/m)	129.0		171.0		253.5		186.9		232.4		277.4		365.9		202.8		252.3		301.3		397.7	
(lb/ft)	86.6		114.8		170.2		125.5		156.0		186.2		245.6		136.2		169.4		202.3		267.0	
Displacement closed-end																						
(l/m)	245.2		245.2		245.2		291.9		291.9		291.9		291.9		342.5		342.5		342.5		342.5	
(cu.ft/ft)	2.64		2.64		2.64		3.14		3.14		3.14		3.14		3.69		3.69		3.69		3.69	
Capacity																						
(l/m)	228.8		223.5		212.9		268.0		262.3		256.5		245.2		316.8		310.4		304.2		291.9	
(cu.ft/ft)	2.46		2.41		2.29		2.89		2.82		2.76		2.64		3.41		3.34		3.27		3.14	
Steel grade	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52
Collapse resistance (1)																						
(MPa)	1.65	1.65	4.0	4.0	9.0	11.5	3.0	3.0	5.1	6.0	7.7	9.4	12.8	16.8	2.4	2.4	4.1	4.7	6.5	7.7	11.2	14.6
(psi)	239	239	580	580	1305	1668	435	435	740	870	1117	1363	1856	2436	348	348	595	682	943	1117	1624	2117
Yield strength (1)																						
(10^3 daN)	403	600	533	795	794	1183	588	875	728	1084	870	1296	1148	1710	632	941	789	1175	941	1402	1244	1853
(10^3 lb)	906	1349	1198	1787	1785	2659	1322	1967	1637	2437	1956	2913	2581	3844	1421	2115	1774	2641	2115	3152	2797	4166
Standard test pressures (2)																						
(MPa)	6.2	11.0	8.2	14.7	12.3	20.7	7.5	13.4	9.4	16.8	11.3	20.2	15.1	20.7	7.0	12.4	8.7	15.5	10.4	18.7	13.8	20.7
(psi)	890	1600	1190	2130	1790	2500	1090	1950	1370	2300	1640	2300	2190	2300	1010	1800	1260	2000	1510	2000	2000	2000

(1) Collapse resistance and yield strength are calculated according to API 5C3.
(2) Standard test pressures are API pressures calculated taking stress equal to 75% of the specified minimum yield strength for Grade B and 90% for Grade X52 (API Standard 5L).

PHYSICAL PROPERTIES OF LINE PIPE, RISER AND CONDUCTOR PIPE (continued)

Outside diameter (in) (mm)	30 762.0								32 812.8								36 914.4							
Wall thickness (mm) (in)	12.70 0.500		15.88 0.625		19.05 0.750		25.4 1.000		12.70 0.500		15.88 0.625		19.05 0.750		25.4 1.000		12.70 0.500		15.88 0.625		19.05 0.750		25.4 1.000	
Inside diameter (mm) (in)	736.6 29.00		730.2 28.75		723.9 28.50		711.2 28.00		787.4 31.00		781.0 30.75		774.7 30.50		762.0 30.00		889.0 35.00		882.6 34.75		876.3 34.50		863.6 34.00	
Cross section area (cm^2) (in^2)	300 46.5		372 57.7		444 68.8		588 91.1		320 49.6		396 61.4		476 73.8		628 97.3		360 55.8		448 69.4		536 83.1		712 110.4	
Weight (kg/m) (lb/ft)	234.6 157.5		292.1 196.1		349.0 234.0		461.3 309.7		250.6 168.2		312.0 209.4		372.8 250.3		493.1 331.1		282.4 189.6		351.7 236.1		420.6 282.4		556.8 373.8	
Displacement closed-end (l/m) (cu.ft/ft)	456.0 4.91		456.0 4.91		456.0 4.91		456.0 4.91		518.8 5.58		518.8 5.58		518.8 5.58		518.8 5.58		656.8 7.07		656.8 7.07		656.8 7.07		656.8 7.07	
Capacity (l/m) (cu.ft/ft)	426.0 4.59		418.8 4.51		411.6 4.43		397.2 4.28		486.8 5.24		479.2 5.16		471.2 5.07		456.0 4.91		620.8 6.68		612.0 6.59		603.2 6.49		585.6 6.30	
Steel grade	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52
Collapse resistance (1) (MPa) (psi)	1.5 218	1.5 218	3.0 435	3.0 435	4.6 667	4.9 711	8.7 1262	10.9 1581	1.3 189	1.3 189	2.5 363	2.5 363	4.4 638	4.4 638	7.7 1120	9.4 1363	0.9 131	0.9 131	1.8 261	1.8 261	3.0 435	3.0 435	6.0 870	6.9 1000
Yield strength (1) (10^3 daN) (10^3 lb)	642 *1443*	1077 *2421*	796 *1789*	1335 *3000*	1070 *2450*	1594 *3583*	1417 *3185*	2110 *4743*	771 *1733*	1149 *2583*	954 *2145*	1422 *3197*	1147 *2578*	1709 *3842*	1513 *3401*	2255 *5069*	868 *1951*	1292 2904	1080 2428	1608 3615	1292 2904	1924 4325	1715 3858	2556 5753
Standard test pressures (2) (MPa) (psi)	6.1 880	10.7 1560	7.5 1090	13.4 1950	9.0 1310	16.1 2340	12.1 1750	20.7 3000	5.6 820	10.1 1460	7.1 1030	12.6 1830	8.5 1230	15.1 2190	11.3 1640	20.1 2920	5.0 730	9.0 1300	6.3 910	11.2 1620	7.5 1090	13.4 1950	10.1 1460	17.9 2600

(1) Collapse resistance and yield strength are calculated according to API 5C3.
(2) Standard test pressures are API pressures calculated taking stress equal to 75% of the specified minimum yield strength for Grade B and 90% for Grade X52 (API Standard 5L).

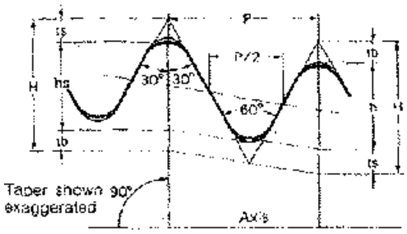
PHYSICAL PROPERTIES OF LINE PIPE, RISER AND CONDUCTOR PIPE (continued)

Outside diameter (in) (mm)	**40** 1016.0								**42** 1066.8							
Wall thickness																
(mm)	12.70		15.88		19.05		25.4		12.70		15.88		19.05		25.4	
(in)	0.500		0.625		0.750		1.000		0.500		0.625		0.750		1.000	
Inside diameter																
(mm)	990.6		984.2		977.9		965.2		1041.4		1035.0		1028.7		1016.0	
(in)	39.00		38.75		38.50		38.00		41.00		40.75		40.50		40.00	
Cross section area																
(cm^2)	400		499		596		790		420		525		627		831	
(in^2)	62.0		77.3		92.4		122.5		65.1		81.4		97.2		128.8	
Weight																
(kg/m)	314.2		391.5		468.3		620.4		330.1		411.4		492.2		652.2	
(lb/ft)	210.9		262.8		314.4		416.5		221.6		276.2		330.4		437.9	
Displacement closed-end																
(l/m)	810.7		810.7		810.7		810.7		893.8		893.8		893.8		893.8	
(cu.ft/ft)	8.73		8.73		8.73		8.73		9.63		9.63		9.63		9.63	
Capacity																
(l/m)	770.7		760.8		751.1		731.7		851.8		841.3		831.1		810.7	
(cu.ft/ft)	8.30		8.19		8.09		7.88		9.17		9.06		8.95		8.73	
Steel grade	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52	B	X52
Collapse resistance (1)																
(MPa)	0.65	0.65	1.3	1.3	2.2	2.2	4.8	5.3	0.56	0.56	1.1	1.1	1.9	1.9	4.0	4.6
(psi)	94	94	189	189	319	319	696	769	81	81	160	160	276	276	580	667
Yield strength (1)																
(10^3 daN)	964	1436	1203	1791	1436	2140	1904	2836	1012	1508	1265	1884	1511	2251	2003	2983
(10^3 lb)	2167	3228	2704	4026	3228	4810	4280	6375	2275	3390	2844	4235	3397	5060	4503	6706
Standard test pressures (2)																
(MPa)	4.5	8.1	5.6	10.1	6.8	12.1	9.0	16.1	4.3	7.6	5.4	9.6	6.5	11.5	8.6	15.4
(psi)	660	1170	820	1460	980	1760	1310	2340	620	1110	780	1390	940	1670	1250	2230

(1) Collapse resistance and yield strength are calculated according to API 5C3.
(2) Standard test pressures are API pressures calculated taking stress equal to 75% of the specified minimum yield strength for Grade B and 90% for Grade X52 (API Standard 5L).

API AND BUTTRESS CASING THREAD FORMS

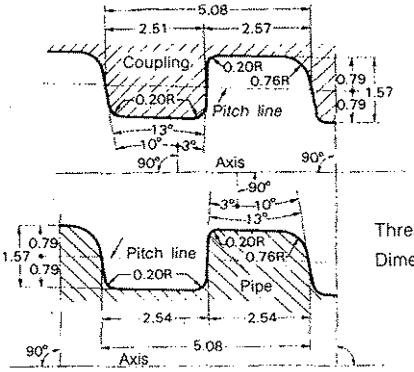
API round thread form



Taper: 6.25%
8 threads/in, $p = 3.175$ mm

$H = 0.866\,p = 2.750$ mm
$h = 0.626\,p - 0.178 = 1.810$ mm
$tb = 0.120\,p + 0.051 = 0.432$ mm
$ts = 0.120\,p + 0.127 = 0.508$ mm

Buttress thread form

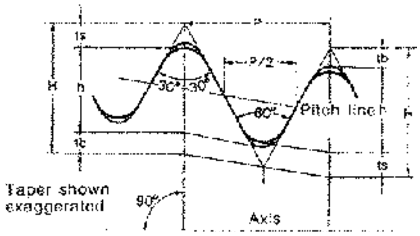


Taper: 6.25%
5 threads/in

Thread crests and roots are parallel to cone.
Dimensions in mm unless otherwise indicated.

mm × 0,0394 = in

API TUBING THREAD FORM



Taper: 6.25%

Thread element	10 threads per inch p = 2.540 mm	8 threads per inch p = 3.175 mm
$H = 0.866\,p$	2.200 mm	2.750 mm
$h = 0.626\,p - 0.178$	1.412 mm	1.810 mm
$tb = 0.120\,p + 0.051$	0.356 mm	0.432 mm
$ts = 0.120\,p + 0.127$	0.432 mm	0.508 mm

OD (in)	Threads per inch		
	Tubing without upset	Tubing with external upset	Tubing with integral joint
1.050	10	10	—
1.315	10	10	10
1.660	10	10	10
1.900	10	10	10
2.063	—	—	10
2 3/8	10	8	—
2 7/8	10	8	—
3 1/2	10	8	—
4	8	8	—
4 1/2	8	8	—

mm × 0.0394 = in

EFFECT OF TENSILE LOAD ON COLLAPSE RESISTANCE

Formula

$$P_{CA} = \left(\sqrt{1 - 0.75 \left[\frac{S_A}{Y_P}\right]^2} - 0.5 \frac{S_A}{Y_P}\right) P_{CO}$$

with :

P_{CA} = *minimum collapse pressure under axial tensile stress, psi or MPa*
P_{CO} = minimum collapse pressure without axial tensile stress, psi or MPa
S_A = axial tensile stress, psi or MPa
Y_P = *minimum yield strength of pipe, psi or MPa*

This formula is based on the Hencky/Von Mises maximum strain energy of distorsion theory of yielding. It is applicable where the collapse pressure is directly proportional to the yield strength.

The part of this curve concerning the collapse resistance is shown by the part of the ellipse on the next page.

Example of how to use this curve

Let us assume that 100.10^3 daN of casing are suspended below a 9 5/8 inch, 43.50 lb/ft N80 joint. Using the ellipse of biaxial yield stress, determine the effective collapse resistance of the pipe as a function of the applied load.

Solution: Determination of the tensile stress :

$$S_A = \frac{\text{tensile load applied}}{\text{pipe cross-section area}} = \frac{1\,000\,000}{8\,103 \; 10^{-6}} = 123.4 \text{ MPa}$$

Determination of the percent of minimum yield stress :

$$\frac{\text{tensile stress}}{\text{minimum yield strength of pipe}} \times 100 = \frac{S_A}{Y_P} \times 100 = \frac{123.4}{551} = 22.4\%$$

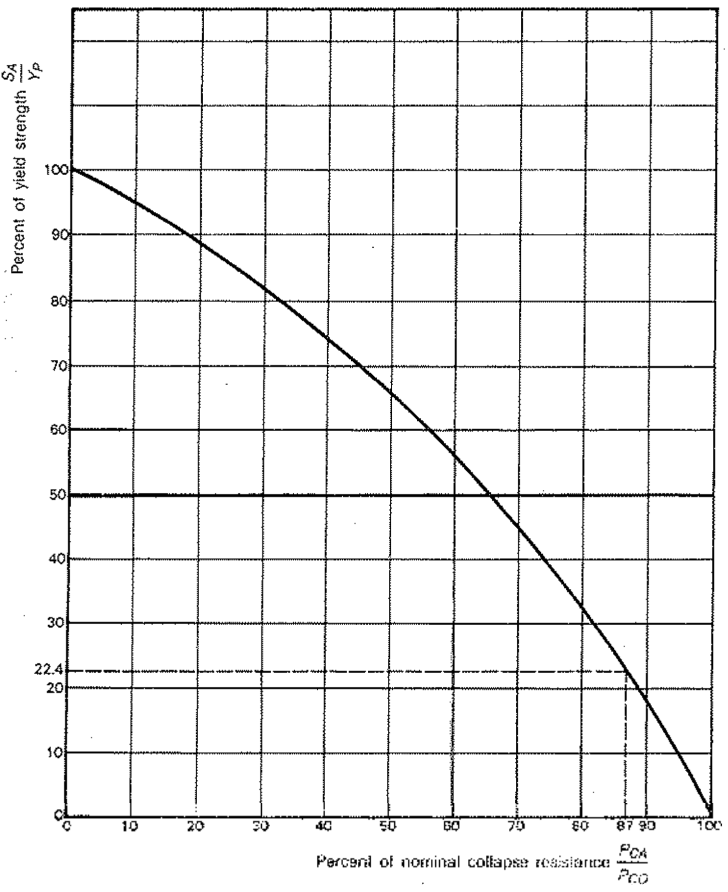
The plasticy ellipse gives for $S_A/Y_P = 22.4\%$; $P_{CA}/P_{CO} = 87.0\%$.

For the 9 5/8 inch, 43.50 lb/ft N80 casing, $P_{CO} = 26.3$ MPa (table of casing characteristics), hense :

$$P_{CA} = P_{CO} \times 87\% = 22.9 \text{ MPa}$$

ELLIPSE OF BIAXIAL YIELD STRESS
Effect of tensile load on collapse resistance

$$P_{CA} = \left(\sqrt{1 - 0.75\left[\frac{S_A}{Y_P}\right]^2} - 0.5\,\frac{S_A}{Y_P}\right) P_{CO}$$



QUALITATIVE INFLUENCE OF VARIOUS OPERATIONS ON THE STRESSES IN A PARTIALLY-CEMENTED CASING STRING

Operations	Tension	Collapse	Bursting	Buckling tendency
Decrease of average temperature	Increases			Decreases
Increase of average *temperature*	*Decreases*			Increases
Increase of internal pressure	Increases		Increases	Increases
Decrease of internal pressure	Decreases		Decreases	*Decreases*
Increase of external pressure	Decreases	Increases		Decreases
Decrease of external pressure	Increases	Decreases		Increases
Substitution of internal fluid by a heavier fluid	Increases		Increases	Increases
Substitution of internal fluid by a lighter fluid	Decreases		Decreases	Decreases
Substitution of *external* fluid by a heavier fluid	Decreases	Increases		Decreases
Substitution of external fluid by a lighter fluid	Increases	Decreases		Increases
Swabbing	Decreases		Decreases	Decreases

QUANTITATIVE INFLUENCE OF TEMPERATURE AND PRESSURE VARIATIONS ON THE STRESSES IN A PARTIALLY-CEMENTED CASING STRING

Influence of temperature changes

The increase or decrease of the tension at the top of a casing string due to a decrease or increase of the average temperature is given by:

$$T = 25.5\, S\, \Delta t \qquad \text{or} \qquad T = 32.7\, W\, \Delta t$$

where:

T = tension variation (daN)
S = cross section of casing (cm^2)
W = linear weight of casing (daN/m)
Δt = average temperature variation of casing (°C)

The average temperature of the free part of the casing is given by the formula:

$$t = t_0 + \frac{(t_1 - t_0)\, L_2}{2\, L_1}$$

with:

t = average temperature of the free part of the casing (°C)
t_0 = surface temperature (°C)
t_1 = bottom hole temperature (°C)
L_1 = depth of hole (m)
L_2 = depth of top of cement (m)

Influence of internal pressure changes

The increase or decrease of the tension at the top of a casing string due to an increase or decrease of the internal pressure is given by the formula:

$$T = 6A_i\, \Delta p_i$$

where:

T = tension variation (daN)
A_i = internal section area of casing (cm^2)
Δp_i = variation of internal average pressure (MPa)

Influence of external pressure changes

The increase or decrease of the tension at the top of a casing string due to a decrease or increase of the external pressure is given by the formula:

$$T = 6A_e\, \Delta p_e$$

where:

T = tension variation (daN)
A_e = external section area of casing (cm^2)
Δp_e = variation of external average pressure (MPa)

QUANTITATIVE INFLUENCE OF TEMPERATURE AND PRESSURE VARIATIONS ON THE STRESSES IN A PARTIALLY-CEMENTED CASING STRING (continued)

If the average internal or external pressure change is due to a change in the mud weight, *the average pressure change is given by:*

$$\Delta p = 9.81 \ (d_2 - d_1) \ \frac{L_2}{2}$$

where:

d_1 = initial mud specific gravity
d_2 = new mud specific gravity
L_2 = depth at the top of cement (m)
Δp = *average pressure change* (kPa)

Critical buckling force

The critical buckling force is given by:

$$F_c = 10(P_e \ A_e - P_i \ A_i)$$

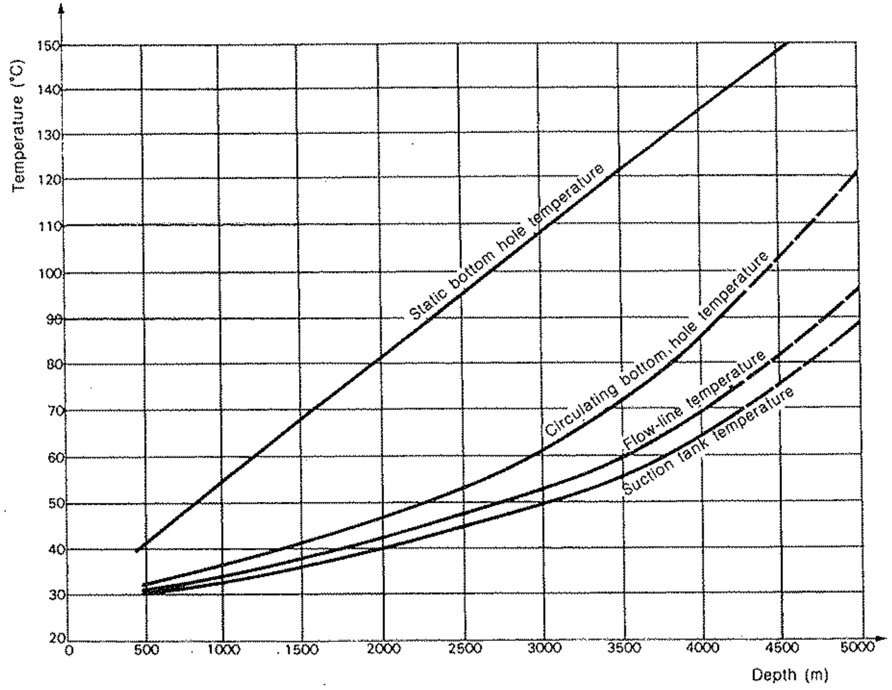
where:

F_c = critical buckling force (daN)
P_e = annulus pressure at top of cement level (MPa)
P_i = *internal pressure at top of cement level* (MPa)
A_e, A_i = external and internal section areas of casing (cm^3)

If F_c is positive, the string can withstand a maximum compression load at the top of the cement level equal to F_c without buckling.

If F_c is negative, the string will buckle for a tensile load lower than F_c.

HOLE TEMPERATURES (From Gulf)



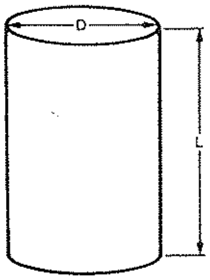
D

capacities and annular volumes

D

GENERAL FORMULAS

Volume of a cylinder



$$\boxed{V = \frac{\pi}{4} D^2 L}$$

Volume in l/m :

$V = 0.0007854\ D^2$ (with D in mm)
$V = 0.5067\ D^2$ (with D in inches)

Approximate formula :

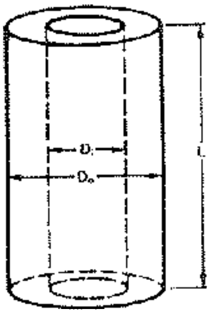
$$V = \frac{D^2}{2} \qquad \text{(with } D \text{ in inches)}$$

Example :

D = 3 inches
= 76.2 mm

Exact formula : V = 4.560 l/m
Approximate formula : V = 4.5 l/m

Volume of an annular space



$$\boxed{V = \frac{\pi}{4} (D_o^2 - D_i^2)\ L}$$

Volume in l/m :

$V = 0.0007854\ (D_o^2 - D_i^2)$ (with D_o in mm) (with D_i in mm)

$V = 0.5067\ (D_o^2 - D_i^2)$ (with D_o in inches) (with D_i in inches)

l/m × 0.0805 = gal/ft l/m x 0.00192 = bbl/ft

CLEARANCE BETWEEN STANDARD BITS AND CASING SIZES

Casing dimensions						Drift	Bit size (1) immediately below drift		Clearance between bit and casing sizes
Outside diameter		Nominal weight		Thickness	Inside diameter				
(in)	(mm)	(lb/ft)	(kg/m)	(mm)	(mm)	(mm)	(in)	(mm)	(mm)
4 1/2	114.3	9.50	14.14	5.21	103.88	100.71	**3 7/8**	98.43	5.5
		10.50	15.63	5.69	102.92	99.75	**3 7/8**	98.43	4.5
		11.60	17.26	6.35	101.60	98.43	**3 7/8**	98.43	3.2
		13.50	20.09	7.37	99.56	96.39	**3 3/4**	95.25	4.3
		15.10	22.47	8.56	97.18	94.01	**3 5/8**	92.08	5.1
		16.90	25.15	9.65	95.00	91.83	**3 1/2**	88.90	6.1
		17.70	26.34	10.20	93.90	90.73	**3 1/2**	88.90	5.0
		18.80	27.98	10.92	92.46	89.29	**3 1/2**	88.90	3.6
5	127.0	11.50	17.11	5.59	115.82	112.65	**4 3/8**	111.13	4.7
		13.00	19.35	6.43	114.14	110.97	**4 1/4**	107.95	6.2
		15.00	22.32	7.52	111.96	108.79	**4 1/4**	107.95	4.0
		18.00	26.79	9.19	108.62	105.45	**4 1/8**	104.78	3.8
		20.80	30.95	10.72	105.56	102.39	**4**	101.60	4.0
5 1/2	139.7	14.00	20.83	6.20	127.30	124.13	**4 7/8**	123.83	3.5
		15.50	23.07	6.98	125.74	122.57	**4 3/4**	120.65	5.1
		17.00	25.30	7.72	124.26	121.09	**4 3/4**	120.65	3.6
		20.00	29.76	9.17	121.36	118.19	**4 5/8**	117.48	3.9
		23.00	34.23	10.54	118.62	115.45	**4 1/2**	114.30	4.3
6 5/8	168.3	20.00	29.76	7.32	153.64	150.46	**5 7/8**	149.23	4.4
		24.00	35.72	8.94	150.40	147.22	**5 3/4**	146.05	4.3
		28.00	41.67	10.59	147.10	143.92	**5 5/8**	142.88	4.2
		32.00	47.62	12.06	144.16	140.98	**5 1/2**	139.70	4.5
7	177.8	17.00	25.30	5.87	166.06	162.89	**6 3/8**	161.93	4.1
		20.00	29.76	6.91	163.98	160.81	**6 1/4**	158.75	5.2
		23.00	34.23	8.05	161.70	158.53	**6 1/8**	155.58	6.1
		26.00	38.69	9.19	159.42	156.25	**6 1/8**	155.58	3.8
		29.00	43.16	10.36	157.08	153.91	**6**	152.40	4.7
		32.00	47.62	11.51	154.78	151.61	**5 7/8**	149.23	5.6
		35.00	52.09	12.65	152.50	149.33	**5 7/8**	149.23	3.3
		38.00	56.55	13.72	150.36	147.19	**5 3/4**	146.05	4.3
		41.00	61.01	14.98	147.84	144.67	**5 5/8**	142.88	5.0
		44.00	65.48	16.25	145.30	142.13	**5 1/2**	139.70	5.6
7 5/8	193.7	24.00	35.72	7.62	178.44	175.26	**6 7/8**	174.63	3.8
		26.40	39.29	8.33	177.02	173.84	**6 3/4**	171.45	5.6
		29.70	44.20	9.52	174.64	171.46	**6 3/4**	171.45	3.2
		33.70	50.15	10.92	171.84	168.66	**6 5/8**	168.28	3.6
		39.00	58.04	12.70	168.28	165.10	**6 1/2**	165.10	3.2

(1) Drift rounded off to the lower 1/8 inch. Not necessarily a size proposed by a bit manufacturer.

mm × 0.0394 = in

CLEARANCE BETWEEN STANDARD BITS AND CASING SIZES (continued)

Casing dimensions						Drift	Bit size (1) immediately below drift		Clea-rance between bit and casing sizes
Outside diameter		Nominal weight		Thickness	Inside diameter				
(in)	(mm)	(lb/ft)	(kg/m)	(mm)	(mm)	(mm)	(in)	(mm)	(mm)
8 5/8	219.1	24.00	35.72	6.71	205.66	202.48	**7 7/8**	200.03	5.6
		28.00	*41.67*	*7.72*	*203.64*	*200.46*	**7 7/8**	200.03	3.6
		32.00	47.62	8.94	201.20	198.02	**7 3/4**	196.85	4.3
		36.00	53.57	10.16	198.76	195.58	**7 5/8**	193.68	5.1
		40.00	59.53	11.43	196.22	193.04	**7 1/2**	190.50	5.7
		44.00	65.46	12.70	193.68	190.50	**7 1/2**	190.50	3.2
		49.00	72.92	14.15	190.78	187.60	**7 3/8**	187.33	3.5
9 5/8	244.5	32.30	48.07	7.92	228.64	224.67	**8 3/4**	222.25	6.4
		36.00	53.57	8.94	226.60	222.63	**8 3/4**	222.25	4.3
		40.00	59.53	10.03	224.42	220.45	**8 5/8**	219.08	5.3
		43.50	*64.74*	*11.05*	*222.38*	*218.41*	**8 1/2**	*215.90*	6.5
		47.00	69.94	11.99	220.50	216.53	**8 1/2**	215.90	4.6
		53.50	79.62	13.84	216.80	212.83	**8 3/8**	212.73	4.1
		58.40	86.91	15.11	214.26	210.29	**8 1/4**	209.55	4.7
		61.10	90.93	15.87	212.74	208.77	**8 1/8**	206.38	6.4
		71.80	106.85	19.05	206.38	202.41	**7 7/8**	200.03	6.4
10 3/4	273.1	32.75	48.74	7.09	258.87	254.90	**10**	254.00	4.9
		40.50	60.27	8.89	255.27	251.30	**9 7/8**	250.83	4.4
		45.50	67.71	10.16	252.73	248.76	**9 3/4**	247.65	5.1
		51.00	*75.90*	*11.43*	*250.19*	*246.22*	**9 5/8**	*244.48*	5.7
		55.50	82.59	12.57	247.91	243.94	**9 1/2**	241.30	6.6
		60.70	90.33	13.84	245.37	241.40	**9 1/2**	241.30	4.1
		65.70	97.77	15.11	242.83	238.86	**9 3/8**	238.13	4.7
11 3/4	298.5	42.00	62.50	8.46	281.53	277.56	**10 7/8**	276.23	5.3
		47.00	69.94	9.52	279.41	275.44	**10 3/4**	273.05	6.4
		54.00	80.36	11.05	276.35	272.38	**10 5/8**	269.88	6.5
		60.00	89.29	12.42	273.61	269.64	**10 1/2**	266.70	6.9
13 3/8	*339.7*	*46.00*	*71.43*	*8.38*	*322.97*	*319.00*	**12 1/2**	*317.50*	5.5
		54.50	81.10	9.65	320.43	316.46	**12 3/8**	314.33	6.1
		61.00	90.78	10.92	317.69	313.92	**12 1/4**	311.15	6.7
		68.00	101.20	12.19	315.35	311.38	**12 1/4**	311.15	4.2
		72.00	107.15	13.06	313.61	309.64	**12 1/8**	307.98	5.6
16	406.4	65.00	96.73	9.52	387.36	382.60	**15**	381.00	6.4
		75.00	111.61	11.13	384.14	379.38	**14 7/8**	377.83	6.3
		84.00	125.01	12.57	381.26	376.50	**14 3/4**	374.65	6.6
18 5/8	*473.1*	*87.50*	*130.21*	*11.05*	*450.98*	*446.21*	**17 1/2**	*444.50*	*6.5*
20	508.0	94.00	139.89	11.13	485.74	480.98	**18 7/8**	479.43	6.3
		106.50	158.49	12.70	482.60	477.84	**18 3/4**	476.25	6.4
		133.00	197.93	16.13	475.74	470.98	**18 1/2**	469.90	5.8

(1) Drift rounded off the lower 1/8 inch. Not necessarily a size proposed by a bit manufacturer.

mm × 0.0394 = in

CAPACITIES OF CYLINDERS

Diam. (in)	Capacity (l/m)	Diam. (in)	Capacity (l/m)	Diam. (in)	Capacity (l/m)	Diam. (in)	Capacity (l/m)	Diam. (in)	Capacity (l/m)	Diam. (in)	Capacity (l/m)
1	0.507	**5**	12.67	**9**	41.04	**13**	85.63	**17**	146.4	**21**	223.4
1 1/8	0.641	5 1/8	13.31	9 1/8	42.19	13 1/8	87.29	17 1/8	148.6	21 1/8	226.1
1 1/4	0.792	5 1/4	13.97	9 1/4	43.36	13 1/4	88.96	17 1/4	150.8	21 1/4	228.8
1 3/8	0.958	5 3/8	14.64	9 3/8	44.53	13 3/8	90.65	17 3/8	153.0	21 3/8	231.5
1 1/2	1.140	5 1/2	15.33	9 1/2	45.73	13 1/2	92.35	17 1/2	155.2	21 1/2	234.2
1 5/8	1.338	5 5/8	16.03	9 5/8	46.94	13 5/8	94.07	17 5/8	157.4	21 5/8	237.0
1 3/4	1.552	5 3/4	16.75	9 3/4	48.17	13 3/4	95.80	17 3/4	159.6	21 3/4	239.7
1 7/8	1.781	5 7/8	17.49	9 7/8	49.41	13 7/8	97.55	17 7/8	161.8	21 7/8	242.5
2	2.027	**6**	18.24	**10**	50.67	**14**	99.31	**18**	164.2	**22**	245.2
2 1/8	2.288	6 1/8	19.01	10 1/8	51.95	14 1/8	101.10	18 1/8	166.5	22 1/8	248.0
2 1/4	2.565	6 1/4	19.79	10 1/4	53.24	14 1/4	102.89	18 1/4	168.8	22 1/4	250.9
2 3/8	2.858	6 3/8	20.59	10 3/8	54.54	14 3/8	104.71	18 3/8	171.1	22 3/8	253.7
2 1/2	3.167	6 1/2	21.41	10 1/2	55.86	14 1/2	106.54	18 1/2	173.4	22 1/2	256.5
2 5/8	3.492	6 5/8	22.24	10 5/8	57.20	14 5/8	108.38	18 5/8	175.8	22 5/8	259.4
2 3/4	3.832	6 3/4	23.09	10 3/4	58.56	14 3/4	110.24	18 3/4	178.1	22 3/4	262.3
2 7/8	4.188	6 7/8	23.95	10 7/8	59.93	14 7/8	112.12	18 7/8	180.5	22 7/8	265.1
3	4.560	**7**	24.83	**11**	61.31	**15**	114.01	**19**	182.9	**23**	268.0
3 1/8	4.948	7 1/8	25.72	11 1/8	62.71	15 1/8	115.92	19 1/8	185.3	23 1/8	271.0
3 1/4	5.352	7 1/4	26.63	11 1/4	64.13	15 1/4	117.84	19 1/4	187.8	23 1/4	273.9
3 3/8	5.772	7 3/8	27.56	11 3/8	65.56	15 3/8	119.78	19 3/8	190.2	23 3/8	276.9
3 1/2	6.207	7 1/2	28.50	11 1/2	67.01	15 1/2	121.74	19 1/2	192.7	23 1/2	279.8
3 5/8	6.658	7 5/8	29.46	11 5/8	68.48	15 5/8	123.71	19 5/8	195.2	23 5/8	282.8
3 3/4	7.126	7 3/4	30.43	11 3/4	69.96	15 3/4	125.70	10 3/4	197.6	23 3/4	285.8
3 7/8	7.609	7 7/8	31.42	11 7/8	71.45	15 7/8	127.70	19 7/8	200.2	23 7/8	288.8
4	8.107	**8**	32.43	**12**	72.97	**16**	129.72	**20**	202.7	**24**	291.9
4 1/8	8.622	8 1/8	33.45	12 1/8	74.49	16 1/8	131.75	20 1/8	205.2	24 1/8	294.9
4 1/4	9.152	8 1/4	34.49	12 1/4	76.04	16 1/4	133.80	20 1/4	207.8	24 1/4	298.0
4 3/8	9.699	8 3/8	35.54	12 3/8	77.60	16 3/8	135.87	20 3/8	210.4	24 3/8	301.1
4 1/2	10.261	8 1/2	36.61	12 1/2	79.17	16 1/2	137.95	20 1/2	212.9	24 1/2	304.2
4 5/8	10.839	8 5/8	37.69	12 5/8	80.76	16 5/8	140.05	20 5/8	215.5	24 5/8	307.3
4 3/4	11.433	8 3/4	38.79	12 3/4	82.37	16 3/4	142.16	20 3/4	218.2	24 3/4	310.4
4 7/8	12.042	8 7/8	39.91	12 7/8	83.99	16 7/8	144.29	20 7/8	220.8	24 7/8	313.5

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

CAPACITIES OF CYLINDERS
(continued)

Diameter (in)	Capacity (l/m)	Diameter (in)	Capacity (l/m)	Diameter (in)	Capacity (l/m)
25	316.7	**29**	426.1	**33**	551.8
25 1/8	319.9	29 1/8	429.8	33 1/8	556.0
25 1/4	323.1	29 1/4	433.5	33 1/4	560.2
25 3/8	326.3	29 3/8	437.2	33 3/8	564.4
25 1/2	329.5	29 1/2	441.0	33 1/2	568.7
25 5/8	332.7	29 5/8	444.7	33 5/8	572.9
25 3/4	336.0	29 3/4	448.5	33 3/4	577.2
25 7/8	339.2	29 7/8	452.2	33 7/8	581.5
26	342.5	**30**	456.0	**34**	585.8
26 1/8	345.8	30 1/8	459.8	34 1/8	590.1
26 1/4	349.2	30 1/4	463.7	34 1/4	594.4
26 3/8	352.5	30 3/8	467.5	34 3/8	598.7
26 1/2	355.8	30 1/2	471.4	34 1/2	603.1
26 5/8	359.2	30 5/8	475.2	34 5/8	607.5
26 3/4	362.8	30 3/4	479.1	34 3/4	611.9
26 7/8	366.0	30 7/8	483.0	34 7/8	616.3
27	369.4	**31**	486.9	**35**	620.7
27 1/8	372.8	31 1/8	490.9	35 1/8	625.2
27 1/4	376.3	31 1/4	494.8	35 1/4	629.6
27 3/8	379.7	31 3/8	498.8	35 3/8	634.1
27 1/2	383.2	31 1/2	502.8	35 1/2	638.6
27 5/8	386.7	31 5/8	506.8	35 5/8	643.1
27 3/4	390.2	31 3/4	510.8	35 3/4	647.6
27 7/8	393.7	31 7/8	514.8	35 7/8	652.1
28	397.3	**32**	518.9	**36**	656.7
28 1/8	400.8	32 1/8	522.9	36 1/8	661.3
28 1/4	404.4	32 1/4	527.0	36 1/4	665.8
28 3/8	408.0	32 3/8	531.1	36 3/8	670.4
28 1/2	411.6	32 1/2	535.2	36 1/2	675.1
28 5/8	415.2	32 5/8	539.3	36 5/8	679.7
28 3/4	418.8	32 3/4	543.5	36 3/4	684.3
28 7/8	422.5	32 7/8	547.6	36 7/8	689.0

l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

CAPACITIES OF DRILL PIPES

Nominal size (in)	Nominal weight (lb/ft)	Upset	Grade	Threads	Approximate weight		Capacity (1) (l/m)		
					(lb/ft)	(kg/m)	Metal displacement	Capacity	Total displacement
2 3/8	6.65	EU	E75	NC26	7.01	10.43	1.33	1.66	2.99
		EU	X95	NC26	7.10	10.57	1.35	1.66	3.01
		EU	G105	NC26	7.10	10.57	1.35	1.66	3.01
2 7/8	10.40	EU	E75	NC31	10.90	16.21	2.07	2.34	4.41
		EU	X95	NC31	11.09	16.50	2.10	2.33	4.43
		EU	G105	NC31	11.09	16.50	2.10	2.33	4.43
		EU	S135	NC31	11.55	17.19	2.19	2.29	4.48
3 1/2	9.50	EU	E75	NC38	10.34	15.38	1.96	4.54	6.50
3 1/2	13.30	EU	E75	NC38	13.95	20.76	2.64	3.86	6.50
		EU	X95	NC38	14.61	21.75	2.77	3.84	6.61
		EU	G105	NC38	14.71	21.89	2.79	3.82	6.61
		EU	S135	NC38	14.92	22.21	2.83	3.78	6.61
3 1/2	15.50	EU	E75	NC38	16.57	24.65	3.14	3.42	6.57
		EU	X95	NC38	16.83	25.05	3.19	3.41	6.60
		EU	G105	NC38	17.05	25.37	3.23	3.37	6.60
		EU	S135	NC40	17.78	26.47	3.37	3.38	6.75
4	14.00	IU	E75	NC40	15.04	22.39	2.85	5.57	8.42
		IU	X95	NC40	15.27	22.73	2.90	5.55	8.44
		IU	G105	NC40	15.85	23.59	3.00	5.51	8.52
		IU	S135	NC40	16.13	24.00	3.06	5.46	8.52
		EU	E75	NC46	15.89	23.64	3.01	5.64	8.65
		EU	X95	NC46	16.19	24.09	3.07	5.64	8.71
		EU	G105	NC46	16.19	24.09	3.07	5.64	8.71
		EU	S135	NC46	16.42	24.43	3.11	5.59	8.71
4 1/2	13.75	IU	E75	NC46	15.11	22.48	2.86	7.82	10.69
		EU	E75	NC50	15.03	22.37	2.85	7.92	10.77
4 1/2	16.60	IEU	E75	NC46	18.37	27.33	3.48	7.30	10.79
		IEU	X95	NC46	18.61	27.70	3.53	7.26	10.79
		IEU	G105	NC46	18.61	27.70	3.53	7.26	10.79
		IEU	S135	NC46	18.82	28.02	3.57	7.22	10.79
		IEU	E75	FH	18.14	26.99	3.44	7.26	10.70
		IEU	X95	FH	18.16	27.02	3.44	7.26	10.71
		IEU	G105	FH	18.16	27.02	3.44	7.26	10.71
		IEU	S135	FH	19.02	28.30	3.61	7.18	10.79
		EU	E75	NC50	17.99	26.77	3.41	7.40	10.81
		EU	X95	NC50	18.36	27.33	3.48	7.40	10.88
		EU	G105	NC50	18.36	27.33	3.48	7.40	10.88
		EU	S135	NC50	18.62	27.71	3.53	7.35	10.88
4 1/2	20.00	IEU	E75	NC46	22.12	32.91	4.19	6.60	10.79
		IEU	X95	NC46	22.62	33.66	4.29	6.56	10.84
		IEU	G105	NC46	22.81	33.94	4.32	6.52	10.84
		IEU	S135	NC46	22.98	34.20	4.36	6.49	10.84
		IEU	E75	FH	21.66	32.24	4.11	6.60	10.71
		IEU	X95	FH	22.35	33.25	4.24	6.52	10.76
		IEU	G105	FH	22.35	33.25	4.24	6.52	10.76
		EU	E75	NC50	21.63	32.19	4.10	6.71	10.81
		EU	X95	NC50	22.09	32.88	4.19	6.69	10.88
		EU	G105	NC50	22.09	32.88	4.19	6.69	10.88
		EU	S135	NC50	23.06	34.31	4.37	6.59	10.97

(1) Volumes calculated using formulas for calculating the approximate weight (API RP 7G). These volumes are approximate in so far as the pipe length is not constant. Allowance made for tool joints.

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

CAPACITIES OF DRILL PIPES
(continued)

Nominal size (in)	Nominal weight (lb/ft)	Upset	Grade	Threads	Approximate weight		Capacity (1) (l/m)		
					(lb/ft)	(kg/m)	Metal displacement	Capacity	Total displacement
5	19.50	IEU	E75	NC50	20.87	31.06	3.96	9.15	13.11
		IEU	X95	NC50	21.39	31.83	4.06	9.10	13.16
		IEU	G105	NC50	21.87	32.55	4.15	9.05	13.20
		IEU	S135	NC50	22.56	33.57	4.28	8.97	13.24
		IEU	E75	FH	22.30	33.19	4.23	9.14	13.37
		IEU	X95	FH	22.56	33.58	4.28	9.14	13.42
		IEU	G105	FH	22.56	33.58	4.28	9.14	13.42
		IEU	S135	FH	23.42	34.86	4.44	9.08	13.52
5	25.60	IEU	E75	NC50	26.88	40.00	5.10	8.01	13.10
		IEU	X95	NC50	27.82	41.40	5.27	7.92	13.19
		IEU	G105	NC50	28.28	42.08	5.36	7.87	13.23
		IEU	E75	FH	28.30	42.12	5.37	7.99	13.36
		IEU	X95	FH	28.54	42.48	5.41	7.99	13.41
		IEU	G105	FH	29.11	43.32	5.52	7.99	13.51
		IEU	S135	FH	29.38	43.73	5.57	7.94	13.51
5 1/2	21.90	IEU	E75	FH	23.79	35.40	4.51	11.37	15.88
		IEU	X95	FH	24.41	36.33	4.63	11.32	15.95
		IEU	G105	FH	25.26	37.59	4.79	11.26	16.05
		IEU	S135	FH	26.37	39.24	5.00	11.15	16.15
5 1/2	24.70	IEU	E75	FH	26.31	39.16	4.99	10.89	15.87
		IEU	X95	FH	27.75	41.29	5.26	10.77	16.03
		IEU	G105	FH	27.75	41.29	5.26	10.77	16.03
		IEU	S135	FH	28.86	42.94	5.47	10.67	16.14

(1) Volumes calculated using formulas for calculating the approximate wieght (API RP 7G). These volumes are approximate in so far as the pipe length is not constant. Allowance made for tool joints.

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

CAPACITIES OF DRILL COLLARS (1)

Outside diameter (in)	Total displacement (l/m)	Standard inside diameter (in)	Capacity (l/m)	Optional inside diameter (in)	Capacity (l/m)
3 1/8	4.95	1 1/4	0.79	–	–
3 1/4	5.35	1 1/2	1.14	1 1/4	0.79
3 3/4	7.13	1 1/2		1 1/4	
4 1/8	8.62	2	2.03	1 3/4	1.55
4 1/4	9.15	2		1 3/4	
4 1/2	10.26	2		1 3/4	
4 3/4	11.43	2 1/4	2.56	1 3/4	1.55
5	12.67	2 1/4		1 3/4	
5 1/4	13.97	2 1/4		1 3/4	
5 1/2	15.33	2 1/4		1 3/4	
5 3/4	16.75	2 1/4	2.56	2 13/16	4.01
6	18.24	2 1/4		2 13/16	
6 1/4	19.79	2 1/4		2 13/16	
6 1/2	21.41	2 13/16	4.01	2 1/4	2.56
6 3/4	23.09	2 13/16		2 1/4	
7	24.83	2 13/16		2 1/4	
7 1/4	26.63	2 13/16		2 1/4	
7 1/2	28.50	2 13/16		2 1/4	
7 3/4	30.43	2 13/16	4.01	3	4.56
8	32.43	2 13/16		3	
8 1/4	34.49	2 13/16		3	
8 1/2	36.61	2 13/16		3	
8 3/4	38.79	2 13/16		3	
9	41.04	3	4.56	2 13/16	4.01
9 1/4	43.36	3		2 13/16	
9 1/2	45.73	3		2 13/16	
9 3/4	48.17	3		2 13/16	
10	50.67	3		2 13/16	
11	61.31	3		2 13/16	
11 1/4	64.13	3		2 13/16	
12	72.97	3		2 13/16	
14	99.31	3		2 13/16	

(1) Capacity per meter is calculated on the basis of simple cylinders.

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

CAPACITIES AND DISPLACEMENTS OF CASING (1)

OD and total displacement (in and l/m)	Nominal weight (lb/ft)	Thickness (mm)	Capacity (l/m)
4 1/2 (10,26)	9.50	5.21	8.48
	10.50	5.69	8.32
	11.60	6.35	8.11
	13.50	7.37	7.79
	15.10	8.56	7.42
	16.90	9.65	7.10
	17.70	10.20	6.95
	18.80	10.92	6.73
5 (12.67)	11.50	5.59	10.53
	13.00	6.43	10.22
	15.00	7.52	9.85
	18.00	9.19	9.26
	20.80	10.72	8.75
5 1/2 (15,33)	14.00	6.20	12.73
	15.50	6.98	12.41
	17.00	7.72	12.13
	20.00	9.17	11.58
	23.00	10.54	11.05
6 5/8 (22,24)	20.00	7.32	18.55
	24.00	8.94	17.77
	28.00	10.59	16.99
	32.00	12.06	16.33
7 (24,83)	17.00	5.87	21.67
	20.00	6.91	21.12
	23.00	8.05	20.54
	26.00	9.19	19.96
	29.00	10.36	19.38
	32.00	11.51	18.82
	35.00	12.65	18.27
	38.00	13.72	17.77
	41.00	14.98	17.21
	44.00	16.25	16.64

OD and total displacement (in and l/m)	Nominal weight (lb/ft)	Thickness (mm)	Capacity (l/m)
7 5/8 (29,46)	24.00	7.62	25.02
	26.40	8.33	24.61
	29.70	9.52	23.97
	33.70	10.92	23.21
	39.00	12.70	22.25
8 5/8 (37,69)	24.00	6.71	33.23
	28.00	7.72	32.59
	32.00	8.94	31.79
	36.00	10.16	31.04
	40.00	11.43	30.23
	44.00	12.70	29.47
	49.00	14.15	28.59
9 5/8 (46.94)	32.30	7.92	41.08
	36.00	8.94	40.33
	40.00	10.03	39.55
	43.50	11.05	38.84
	47.00	11.99	38.19
	53.50	13.84	36.92
	58.40	15.11	36.05
	61.10	15.87	35.53
	71.80	19.05	33.46
10 3/4 (58,56)	32.75	7.09	52.60
	40.50	8.89	51.15
	45.50	10.16	50.15
	51.00	11.43	49.13
	55.50	12.57	48.27
	60.70	13.84	47.26
	65.70	15.11	46.30

OD and total displacement (in and l/m)	Nominal weight (lb/ft)	Thickness (mm)	Capacity (l/m)
11 3/4 (69,96)	42.00	8.46	62.24
	47.00	9.52	61.31
	54.00	11.05	59.96
	60.00	12.42	58.79
13 3/8 (90,65)	48.00	8.38	81.89
	54.50	9.65	80.63
	61.00	10.92	79.37
	68.00	12.19	78.08
	72.00	13.06	77.24
16 (129,72)	65.00	9.52	117.87
	75.00	11.13	115.87
	84.00	12.57	114.19
18 5/8 (175.75)	87.50	11.05	159.74
20 202,68	94.00	11.13	185.3
	106.50	12.70	182.9
	133.00	16.13	177.8
30 (455.8)	267.00	20.60	408.1
	310.00	25.40	393.3

(1) No allowance made for couplings.

mm × 0.0394 = in   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

CAPACITIES AND DISPLACEMENTS OF TUBING (1)

Outside diameter (OD) (in and mm)	Nominal weight (lb/ft)	Thickness (mm)	Inside diameter (ID) (mm)	Total displacement (l/m)	Capacity (l/m)	Metal displacement (l/m)	Linear meters per cubic meter (m)
1.050 (26.7)	1.14-1.20	2.87	20.9	0.56	0.34	0.22	2941.2
1.315 (33,4)	1.70-1.72-1.80	3.38	26.6	0.89	0.56	0.33	1785.7
1.660 (42.2)	2.10	3.18	35.8	1.41	1.01	0.40	990.1
	2.30-2.33-2.40	3.56	35.1	1.41	0.97	0.44	1030.9
1.900 (48.3)	2.40	3.18	41.9	1.83	1.38	0.45	724.6
	2.75-2.76-2.90	3.68	40.9	1.83	1.31	0.52	763.6
2.063 (52.4)	3.25	3.96	44.5	2.16	1.56	0.60	641.0
2 3/8 (60.3)	4.00	4.24	51.8	2.88	2.11	0.77	473.9
	4.60-4.70	4.83	50.7	2.88	2.02	0.86	495.0
	5.10	5.54	49.2	2.88	1.91	0.97	523.5
	5.80-5.95	6.45	47.4	2.88	1.77	1.11	565.0
	6.30	7.12	46.1	2.88	1.67	1.21	598.8
	7.30	8.53	43.3	2.88	1.47	1.41	680.2
2 7/8 (73,0)	6.40-6.50	5.51	62.0	4.21	3.02	1.19	331.1
	7.70	7.01	59.0	4.21	2.73	1.48	366.3
	8.60-8.70	7.82	57.4	4.21	2.59	1.62	386.1
	9.70	9.19	54.6	4.21	2.34	1.87	427.3
	10.70	10.28	52.5	4.21	2.16	2.05	463.0
3 1/2 (88.9)	7.70	5.49	77.9	6.26	4.77	1.49	209.6
	9.20-9.30	6.45	76.0	6.26	4.54	1.72	220.3
	10.20	7.34	74.2	6.26	4.33	1.93	230.9
	12.70-12.95	9.52	69.8	6.26	3.83	2.43	261.1
	13.70	10.50	67.9	6.26	3.60	2.66	277.8
	14.70	11.43	66.0	6.26	3.43	2.83	291.5
	15.80	12.40	64.1	6.26	3.29	2.97	304.0
4 (101.6)	9.50	5.74	90.1	8.16	6.38	1.78	156.7
	10.90-11.00	6.65	88.3	8.16	6.12	2.04	163.4
	13.00	8.38	84.8	8.16	5.65	2.51	177.0
	14.80	9.65	82.3	8.16	5.31	2.85	188.3
	16.50	10.92	79.8	8.16	4.99	3.17	200.4
4 1/2 (114.3)	12.60-12.75	6.88	100.5	10.35	7.94	2.41	125.9

(1) Capacities with couplings. Total displacements of tubings with couplings are an average due to maximum error of 0.5 %.

mm × 0.0394 = in   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

ANNULAR VOLUME BETWEEN DRILL COLLAR AND OPEN HOLE
(liters per meter)

Diameter of open hole (in)	Outside diameter of drill collar (in)																			
	0 (1)	4 1/4	4 1/2	4 3/4	5	5 3/4	6	6 1/4	6 1/2	6 3/4	7	7 3/4	8	8 1/4	9	9 1/2	9 3/4	10	11 1/4	14
0 (2)	(l/m)	9.2	10.3	11.4	12.7	16.8	18.2	19.8	21.4	23.1	24.8	30.4	32.4	34.5	41.0	45.7	48.2	50.7	64.1	99.3
5 7/8	17.5	8.3	7.2	6.1	4.8	0.7														
6	**18.2**	**9.0**	**7.9**	**6.8**	**5.5**	**1.4**														
6 1/8	19.0	9.8	8.7	7.6	6.3	2.2	0.8													
6 1/4	19.8	10.6	9.5	8.4	7.1	3.0	1.6													
6 5/8	22.2	13.0	11.9	10.8	9.5	5.4	4.0	2.4	0.8											
6 3/4	23.1	13.9	12.8	11.7	10.4	6.3	4.9	3.3	1.7											
7 3/8	27.6	18.4	17.3	16.2	14.9	10.8	9.4	7.8	6.2	4.5	2.8									
7 7/8	31.4	22.2	21.1	20.0	18.7	14.6	13.2	11.6	10.0	8.3	6.6	1.0								
8 3/8	35.5	26.3	25.2	24.1	22.8	16.7	17.3	15.7	14.1	12.4	10.7	5.1	3.1							
8 1/2	**36.6**	**27.4**	**26.3**	**25.2**	**23.9**	**19.8**	**18.4**	**16.8**	**15.2**	**13.5**	**11.8**	**6.2**	**4.2**	**2.1**						
8 5/8	37.7	28.5	27.4	26.3	25.0	20.9	19.5	17.9	16.3	14.6	12.9	7.3	5.3	2.2						
8 3/4	38.8	29.6	28.5	27.4	26.1	22.0	20.6	19.0	17.4	15.7	14.0	8.4	6.4	4.3						
9	41.0	31.8	30.7	29.6	28.3	24.2	22.8	21.2	19.6	17.9	16.2	10.6	8.6	6.5						
9 5/8	46.9	37.7	36.6	35.5	34.2	30.1	28.7	27.1	25.5	23.8	22.1	16.5	14.5	12.4	5.9	1.2				
9 7/8	49.4	40.2	39.1	38.0	36.7	32.6	31.2	29.6	28.0	26.3	24.6	19.0	17.0	14.9	8.4	3.7				
10 5/8	57.2	48.0	46.9	45.8	44.5	40.4	39.0	37.4	35.8	34.1	32.4	26.8	24.8	22.7	16.2	11.5	9.0	6.5		
12	73.0	63.8	62.7	61.6	60.3	56.2	54.8	53.2	51.6	49.9	48.2	42.6	40.6	36.5	32.0	27.3	24.8	22.3	8.9	
12 1/4	**76.0**	**66.8**	**65.7**	**64.6**	**63.3**	**59.2**	**57.8**	**56.2**	**54.6**	**52.9**	**51.2**	**45.6**	**43.6**	**41.5**	**35.0**	**30.3**	**27.8**	**25.3**	**11.9**	
14 3/4	110.2	101.0	99.9	98.8	97.5	93.4	92.0	90.4	88.8	87.1	85.4	79.8	77.8	75.7	69.2	64.5	62.0	59.5	46.1	10.9
15	114.0	104.8	103.7	102.6	101.3	97.2	95.8	94.2	92.6	90.9	89.2	83.6	81.6	79.5	73.0	68.3	65.8	63.3	49.9	14.7
17 1/2	**155.2**	**146.0**	**144.9**	**143.8**	**142.5**	**138.4**	**137.0**	**135.4**	**133.8**	**132.1**	**130.4**	**124.8**	**122.8**	**120.7**	**114.2**	**109.5**	**107.0**	**104.5**	**91.1**	**55.9**
20	202.7	193.5	192.4	191.3	190.0	185.9	184.5	182.9	181.3	179.6	177.9	172.3	170.3	168.2	161.7	157.0	154.5	152.0	138.6	103.4
24	291.9	282.7	281.6	280.5	279.2	275.1	273.7	272.1	270.5	268.8	267.1	261.5	259.5	257.4	250.9	246.2	243.7	241.2	227.8	192.6
26	342.4	333.2	332.1	331.0	329.7	325.6	324.2	322.6	321.0	319.3	317.6	312.0	310.0	307.9	301.4	296.7	294.2	291.7	278.3	243.1
36	656.4	647.2	646.1	645.0	643.7	639.6	638.2	636.6	635.0	633.3	631.6	626.0	624.0	621.9	615.4	610.7	608.2	605.7	592.3	557.1

(1) The zero vertical column gives the capacity of open hole in liters per meter.

(2) The zero horizontal line gives the total displacement of drill collar in liters per meter.

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

ANNULAR VOLUME BETWEEN DRILL PIPE AND OPEN HOLE
(liters per meter)

			Nominal size of drill pipe (in)							
		0 (1)	2 3/8	2 7/8	3 1/2	4	4 1/2	5	5 1/2	6 5/8
	0 (2)	(l/m)	3.0*	4.4*	6.5*	8.6*	10.8*	13.3*	16.1*	22.9*
Diameter of open hole (in)	5 7/8	17.5	14.5	13.1	11.0	8.9				
	6	**18.2**	**15.2**	**13.8**	**11.7**	**9.6**				
	6 1/8	19.0	16.0	14.6	12.5	10.4				
	6 1/4	19.8	16.8	15.4	13.3	11.2	9.0			
	6 5/8	22.2	19.2	17.8	15.7	13.6	11.4	8.9		
	6 3/4	23.1	20.1	18.7	16.6	14.5	12.3	9.8		
	7 3/8	27.6	24.6	23.2	21.1	19.0	16.8	14.3	11.5	4.7
	7 7/8	31.4	28.4	27.0	24.9	22.8	20.6	18.1	15.3	8.5
	8 3/8	35.5	32.5	31.1	29.0	26.9	24.7	22.2	19.4	12.6
	8 1/2	**36.6**	**33.6**	**32.2**	**30.1**	**28.0**	**25.8**	**23.3**	**20.5**	**13.7**
	8 5/8	37.7	34.7	33.3	31.2	29.1	26.9	24.4	21.6	14.8
	8 3/4	38.8	35.8	34.4	32.3	30.2	28.0	25.5	22.7	15.9
	9	41.0	38.0	36.6	34.5	32.4	30.2	27.7	24.9	18.1
	9 5/8	46.9	43.9	42.5	40.4	38.3	36.1	33.6	30.8	24.0
	9 7/8	49.4	46.4	45.0	42.9	40.8	38.6	36.1	33.3	26.5
	10 5/8	57.2	54.2	52.8	50.7	48.6	46.4	43.9	41.1	34.3
	12	73.0	70.0	68.6	66.5	64.4	62.2	59.7	56.9	50.1
	12 1/4	**76.0**	**73.0**	**71.6**	**69.5**	**67.4**	**65.2**	**62.7**	**59.9**	**53.1**
	14 3/4	110.2	107.2	105.8	103.7	101.6	99.4	96.9	94.1	87.3
	15	114.0	111.0	109.6	107.5	105.4	103.2	100.7	97.9	91.1
	17 1/2	**155.2**	**152.2**	**150.8**	**148.7**	**146.6**	**144.4**	**141.9**	**139.1**	**132.3**
	20	202.7	199.7	198.3	196.2	194.1	191.9	189.4	186.6	179.8
	24	291.9	288.9	287.5	285.4	283.3	281.1	278.6	275.8	269.0
	26	342.5	339.5	338.1	336.0	333.9	331.7	329.2	326.4	319.6
	36	656.7	653.7	652.3	650.2	648.1	645.9	643.4	640.6	633.8

(1) The zero vertical column gives the capacity of open hole in l/m.

(2) The zero horizontal line gives the total displacement of drill pipe with tool joint (l/m).

* Drill pipe displacement is averaged to allow for various tool joint sizes.

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

ANNULAR VOLUME BETWEEN CASING AND DRILL PIPE

(liters per meter)

			Nominal size of drill pipe (in)											
		0 (1)	1.050	1.315	1.660	1.900	2 3/8	2 7/8	**3 1/2**	4	**4 1/2**	**5**	5 1/2	6 5/8
Nominal size and weight of casing (in and lb/ft)	0 (2)	l/m	0.6	0.9	1.4	1.8	3.0	4.4	**6.5**	8.6	**10.8**	**13.3**	16.1	22.9
4 1/2	9.50	8.5	7.9	7.6	7.1	6.7	5.5	x						
	10.50	8.3	7.7	7.4	6.9	6.5	5.3	x						
	11.60	8.1	7.5	7.2	6.7	6.3	5.1	x						
	13.50	7.8	7.2	6.9	6.4	6.0	4.8	x						
	15.10	*7.4*	*6.8*	*6.5*	*6.0*	*5.6*	*4.4*	*x*						
	16.90	7.1	6.5	6.2	5.7	5.3	4.1	x						
	17.70	7.0	6.4	6.1	5.6	5.2	4	x						
	18.80	6.7	6.1	5.8	5.3	4.9	3.7	x						
5	11.50	10.5	9.9	9.6	9.1	8.7	7.5	6.1	x					
	13.00	10.2	9.6	9.3	8.8	8.4	7.2	5.8	x					
	15.00	9.9	9.3	9.0	8.5	8.1	6.9	5.5	x					
	18.00	*9.3*	*8.7*	*8.4*	*7.9*	*7.5*	*6.3*	*x*						
	20.80	8.8	8.2	7.9	7.4	7.0	5.8	x						
5 1/2	14.00	12.7	12.1	11.8	11.3	10.9	9.7	8.3	x					
	15.50	12.4	11.8	11.5	11.0	10.6	9.4	8.0	x					
	17.00	12.1	11.5	11.2	10.7	10.3	9.1	7.7	x					
	20.00	11.6	11.0	10.7	10.2	9.8	8.6	7.2	x					
	23.00	11.1	10.5	10.2	9.7	9.3	8.1	6.7	x					
6 5/8	20.00	18.6	18.0	17.7	17.2	16.8	15.6	14.2	**12.1**	x				
	24.00	17.8	17.2	16.9	16.4	16.0	14.8	13.4	**11.3**	x				
	28.00	17.0	16.4	16.1	15.6	15.2	14.0	12.6	**10.5**	x				
	32.00	16.3	15.7	15.4	14.9	14.5	13.3	11.9	**9.8**	x				
7	17.00	21.7	21.1	20.8	20.3	19.9	18.7	17.3	**15.2**	13.1	x			
	20.00	21.1	20.5	20.2	19.7	19.3	18.1	16.7	**14.6**	12.5	x			
	23.00	20.5	19.9	19.6	19.1	18.7	17.5	16.1	**14.0**	11.9	x			
	26.00	20.0	19.4	19.1	18.6	18.2	17.0	15.6	**13.5**	11.4	x			
	29.00	19.4	18.8	18.5	18.0	17.6	16.4	15.0	**12.9**	10.8	x			
	32.00	18.8	18.2	17.9	17.4	17.0	15.8	14.4	**12.3**	x				
	35.00	18.3	17.7	17.4	16.9	16.5	15.3	13.9	**11.8**	x				
	38.00	17.8	17.2	16.9	16.4	16.0	14.8	13.4	**11.3**	x				
	41.00	17.2	16.6	16.3	15.8	15.4	14.2	12.8	**10.7**	x				
	44.00	16.6	16.0	15.7	15.2	14.8	13.6	12.2	**10.1**	x				
7 5/8	24.00	25.0	24.4	24.1	23.6	23.2	22.0	20.6	**18.5**	16.4	**14.2**	x		
	26.40	24.6	24.0	23.7	23.2	22.8	21.6	20.2	**18.1**	16.0	**13.8**	x		
	29.70	24.0	23.4	23.1	22.6	22.2	21.0	19.6	**17.5**	15.4	**13.2**	x		
	33.70	23.2	22.6	22.3	21.8	21.4	20.2	18.8	**16.7**	14.6	**12.4**	x		
	39.00	22.3	21.7	21.4	20.9	20.5	19.3	17.9	**15.8**	13.7	**11.4**	x		
8 5/8	24.00	33.2	32.6	32.3	31.8	31.4	30.2	28.8	**26.7**	24.6	**22.4**	**19.9**	17.1	x
	28.00	32.6	*32.0*	*31.7*	*31.2*	*30.8*	*29.6*	*28.2*	***26.1***	*24.0*	***21.8***	***19.3***	*16.5*	*x*
	32.00	31.8	31.2	30.9	30.4	30.0	28.8	27.4	**25.3**	23.2	**21.0**	**18.5**	15.7	x
	36.00	31.0	30.4	30.1	29.6	29.2	28.0	26.6	**24.5**	22.4	**20.2**	**17.7**	14.9	x

(1) The zero vertical column gives the capacity of the casings in l/m.

(2) The zero horizontal line gives the average total displacement of drill pipe with tool joint in l/m.

x The outside diameter of the tool joint is larger than the inside diameter of the casing.

l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

ANNULAR VOLUME BETWEEN CASING AND DRILL PIPE

(liters per meter) (continued)

				Nominal size of drill pipe (in)											
			0 (1)	1.050	1.315	1.660	1.900	2 3/8	2 7/8	**3 1/2**	4	**4 1/2**	**5**	5 1/2	6 5/8
		0 (2)	l/m	0.6	0.9	1.4	1.8	3.0	4.4	**6.5**	8.6	**10.8**	**13.3**	16.1	22.9
Nominal size and weight of casing (in and lb/ft)	8 5/8	40.00	30.2	29.6	29.3	28.8	28.4	27.2	25.8	**23.7**	21.6	**19.4**	**16.9**	14.1	x
		44.00	29.5	28.9	28.6	28.1	27.7	26.5	25.1	**23.0**	20.9	**18.7**	**16.2**	13.4	x
		49.00	28.6	28.0	27.7	27.2	26.8	25.6	24.2	**22.1**	20.0	**17.8**	**15.3**	12.5	x
	9 5/8	32.30	41.1	40.5	40.2	39.7	39.3	38.1	36.7	**34.6**	32.5	**30.3**	**27.8**	25.0	18.2
		36.00	40.3	39.7	39.4	38.9	38.5	37.3	35.9	**33.8**	31.7	**29.5**	**27.0**	24.2	17.4
		40.00	39.6	39.0	38.7	38.2	37.8	36.6	35.2	**33.1**	31.0	**28.8**	**26.3**	23.5	16.7
		43.50	38.8	38.2	37.9	37.4	37.0	35.8	34.4	**32.3**	30.2	**28.0**	**25.5**	22.7	15.9
		47.00	38.2	37.6	37.3	36.8	36.4	35.2	33.8	**21.7**	29.6	**27.4**	**24.9**	22.1	15.3
		53.50	36.9	36.3	36.0	35.5	35.1	33.9	32.5	**30.4**	28.3	**26.1**	**23.6**	20.8	14.0
		58.40	36.1	35.5	35.2	34.7	34.3	33.1	31.7	**29.6**	27.5	**25.3**	**22.8**	20.0	13.2
		61.10	35.5	34.9	34.6	34.1	33.7	32.5	31.1	**29.0**	26.9	**24.7**	**22.2**	19.4	12.6
		71.80	33.5	32.9	32.6	32.1	31.7	30.5	29.1	**27.0**	24.9	**22.7**	**20.2**	17.8	x
	10 3/4	32.75	52.6	52.0	51.7	51.2	50.8	49.6	48.2	**46.1**	44.0	**41.8**	**39.3**	36.5	29.7
		40.50	51.2	50.6	50.3	49.8	49.4	48.2	46.8	**44.7**	42.6	**40.4**	**37.9**	35.1	28.3
		45.50	50.2	49.6	49.3	48.8	48.4	47.2	45.8	**43.7**	41.6	**39.4**	**36.9**	34.1	27.3
		51.00	49.1	48.5	48.2	47.7	47.3	46.1	44.7	**42.6**	40.5	**38.4**	**35.8**	33.0	26.2
		55.50	48.3	47.7	47.4	46.9	46.5	45.3	43.9	**41.8**	39.7	**37.5**	**35.0**	32.2	25.4
		60.70	47.3	46.7	46.4	45.9	45.5	44.3	42.9	**40.8**	38.7	**36.5**	**34.0**	31.2	24.4
		65.70	46.3	45.7	45.4	44.9	44.5	43.3	41.9	**39.8**	37.7	**35.5**	**33.0**	30.2	23.4
	11 3/4	42.00	62.2	61.6	61.3	60.8	60.4	59.2	57.8	**55.7**	53.6	**51.4**	**48.9**	46.1	39.3
		47.00	61.3	60.7	60.4	59.9	59.5	58.3	56.9	**54.8**	52.7	**50.5**	**48.0**	45.2	38.4
		54.00	60.0	59.4	59.1	58.6	58.2	57.0	55.6	**53.5**	51.4	**49.2**	**46.7**	43.9	37.1
		60.00	58.8	58.2	57.9	57.4	57.0	55.8	54.4	**52.3**	50.2	**48.0**	**45.5**	42.7	35.9
	13 3/8	48.00	81.9	81.3	81.0	80.5	80.1	78.9	77.5	**75.4**	73.3	**71.1**	**68.6**	65.8	59.0
		54.50	80.6	80.0	79.7	79.2	78.8	77.6	76.2	**74.1**	72.0	**69.8**	**67.3**	64.5	57.7
		61.00	79.4	78.8	78.5	78.0	77.6	76.4	75.0	**72.9**	70.8	**68.6**	**66.1**	63.3	56.5
		68.00	78.1	77.5	77.2	76.7	76.3	75.1	73.7	**71.6**	69.5	**67.3**	**64.8**	62.0	55.2
		72.00	77.2	76.6	76.3	75.8	75.4	74.2	72.8	**70.7**	68.6	**66.4**	**63.9**	61.1	54.3
	16	65.00	117.9	117.3	117.0	116.5	116.1	114.9	113.5	**111.4**	109.3	**107.0**	**104.6**	101.8	95.0
		75.00	115.9	115.3	115.0	114.5	114.1	112.9	111.5	**109.4**	107.3	**105.1**	**102.6**	99.8	93.0
		84.00	114.2	113.6	113.3	112.8	112.4	111.2	109.8	**107.7**	105.6	**103.4**	**100.9**	98.1	91.3
	18 5/8	87.50	159.7	159.1	158.8	158.3	157.9	156.7	155.3	**153.2**	151.1	**148.9**	**146.4**	143.6	136.8
	20	94.00	185.3	184.7	184.4	183.9	183.5	182.3	180.9	**178.8**	176.7	**174.5**	**172.0**	169.2	162.4
		106.50	182.9	182.3	182.0	181.5	181.1	179.9	178.5	**176.4**	174.3	**172.1**	**169.6**	166.8	160.0
		133.00	177.8	177.2	176.9	176.4	176.0	174.8	173.4	**171.3**	169.2	**167.0**	**164.5**	161.7	154.9
	30	267.0	407.8	407.2	406.9	406.4	406.0	404.8	403.4	**401.3**	399.2	**397.0**	**394.5**	391.7	384.9
		310.0	397.0	396.4	396.1	395.6	395.2	394.0	392.6	**390.5**	388.4	**386.2**	**383.7**	380.9	374.1

(1) The zero vertical column gives the capacity of the casings in l/m.

(2) The zero horizontal line gives the average total displacement of drill pipe with tool joint in l/m.

x The outside diameter of the tool joint is larger than the inside diameter of the casing.

l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

ANNULAR VOLUME BETWEEN CASING AND OPEN HOLE
(liters per meter)

			Casing outside diameter nominal size (in)														
		0 (1)	4 1/2	5	5 1/2	6 5/8	7	7 5/8	8 5/8	9 5/8	10 3/4	11 3/4	13 3/8	16	18 5/8	20	30
	0 (2)	(l/m)	10.30	12.69	15.36	22.34	24.88	29.56	37.87	47.10	58.74	70.16	90.80	130.0	176.2	203.0	455.8
Diameter of open hole (in)	5 7/8	17.49	7.19	4.80													
	6	**18.24**	**7.94**	**5.55**	x												
	6 1/8	19.01	8.71	6.32	3.65												
	6 1/4	19.79	9.49	7.10	4.43												
	6 5/8	22.24	11.94	9.55	6.88												
	6 3/4	23.09	12.79	10.40	7.73												
	7 3/8	27.56	17.26	14.87	12.20	x	x										
	7 7/8	31.42	21.12	18.73	16.06	9.08	6.54										
	8 3/8	35.54	25.24	22.85	20.18	13.20	10.66										
	8 1/2	**36.51**	**26.31**	**23.92**	**21.25**	**14.29**	**11.73**	x									
	8 5/8	37.69	27.39	25.00	22.33	15.35	12.81	8.11									
	8 3/4	38.79	28.49	26.10	23.43	16.45	13.91	9.21									
	9	41.04	30.74	28.35	25.68	18.70	16.16	11.46									
	9 5/8	46.94	36.64	34.25	31.58	24.60	22.06	17.36	x								
	9 7/8	49.41	39.11	36.72	34.05	27.07	24.53	19.83	11.54								
	10 5/8	57.20	46.90	44.51	41.84	34.86	32.32	27.62	19.33	x	x						
	12	72.97	62.67	60.28	57.61	50.63	48.09	43.39	35.10	25.87	14.23						
	12 1/4	**76.04**	**65.74**	**63.35**	**60.68**	**53.70**	**51.16**	**46.46**	**38.17**	**28.94**	**17.30**	x					
	14 3/4	110.24	99.94	97.55	94.88	87.90	85.36	80.66	72.37	63.14	51.50	40.08	x				
	15	114.01	103.71	101.32	98.65	91.67	89.13	84.43	76.14	66.91	55.27	43.85	23.21	x			
	17 1/2	**155.2**	**144.9**	**142.5**	**139.8**	**132.9**	**130.3**	**125.6**	**117.3**	**108.1**	**96.46**	**85.04**	**64.40**	**25.2**			
	20	202.7	192.4	190.0	187.3	180.4	177.8	173.1	164.8	155.6	144.0	132.5	111.9	72.7	x	x	
	24	291.9	281.6	279.2	276.6	269.6	267.0	262.3	254.0	244.8	233.2	221.7	201.1	161.9	115.7	88.9	x
	26	342.4	332.1	329.7	327.0	320.1	317.5	312.8	304.5	295.3	283.7	272.2	251.6	212.4	166.2	139.4	x
	36	656.4	646.1	643.7	641.0	634.1	631.5	626.8	618.5	609.3	597.7	586.2	565.6	526.4	480.2	453.4	200.6

(1) *The zero vertical column gives the capacity of the open hole (nominal size).*

(2) The zero horizontal line gives the total displacement of casing with coupling.

x The outside diameter of casing coupling is larger than the nominal open hole size.

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

ANNULAR VOLUMES BETWEEN TWO STRINGS OF CASING (liters per meter)

Nominal size and weight of outer string (in and lb/ft)			Nominal size of inner string (in)													
		0 (1)	4 1/2	5	5 1/2	6 5/8	7	7 5/8	8 5/8	9 5/8	10 3/4	11 3/4	13 3/8	16	18 5/8	20
	0 (2)	(l/m)	10.30	12.69	15.36	22.34	24.88	29.58	37.87	47.10	58.74	70.16	90.80	130.0	176.2	203.0
6 5/8	20.00	18.55	6.25	5.86	x											
	24.00	17.77	7.47	5.08	x											
	28.00	16.99	6.69	4.30	x											
	32.00	16.33	6.03	x	x											
7	17.00	21.66	11.36	8.97	6.30	x										
	20.00	21.12	10.82	8.43	5.76	x										
	23.00	20.53	10.23	7.84	5.17	x										
	26.00	19.95	9.65	7.26	4.59	x										
	29.00	19.38	9.08	6.69	4.02	x										
	32.00	18.82	8.52	6.13	x	x										
	35.00	18.27	7.97	5.58	x											
	38.00	17.77	7.47	5.08	x											
	41.00	17.21	6.91	4.52	x											
	44.00	16.64	6.34	3.95	x											
7 5/8	24.00	25.02	14.72	12.33	9.66	x										
	26.40	24.61	14.31	11.92	9.25	x										
	29.70	23.97	13.67	11.28	8.61	x										
	33.70	23.21	12.91	10.52	7.85	x										
	39.00	22.25	11.95	9.56	6.89	x										
8 5/8	24.00	33.23	22.93	20.54	17.87	10.89	8.35	x								
	28.00	32.59	22.29	19.90	17.23	10.25	7.71	x								
	32.00	31.79	21.49	19.10	16.43	9.45	6.91	x								
	36.00	31.04	20.74	18.35	15.68	8.70	6.16	x								
	40.00	30.23	19.93	17.54	14.87	7.89	x	x								
	44.00	29.47	19.17	16.78	14.11	7.13	x									
	49.00	28.59	18.29	15.90	13.23	6.25	x									
9 5/8	32.30	41.08	30.78	28.39	25.72	18.74	16.20	11.50	x							
	36.00	40.33	30.03	27.64	24.97	17.99	15.45	10.75	x							
	40.00	39.55	29.25	26.86	24.19	17.21	14.67	9.97	x							
	43.50	38.84	28.54	26.15	23.48	16.50	13.96	9.26	x							
	47.00	38.[illegible]9	27.89	25.50	22.83	15.85	13.31	8.61	x							
	53.50	36.92	26.62	24.23	21.56	14.58	12.04	x								

(1) The zero vertical column gives the capacity of the casing in liters per meter.

(2) The zero horizontal line gives the total displacement of the casing with coupling in liters per meter.

x The outside diameter of the coupling is larger than the inside diameter of the outer casing.

l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

ANNULAR VOLUMES BETWEEN TWO STRINGS OF CASING (liters per meter) (continued)

			Nominal size of inner string (in)													
		0 (1)	4 1/2	5	5 1/2	6 5/8	7	7 5/8	8 5/8	9 5/8	10 3/4	11 3/4	13 3/8	16	18 5/8	20
Nominal size and weight of outer string (in and lb/ft)	0 (2)	(l/m)	10.30	12.69	15.36	22.34	24.88	29.58	37.87	47.10	58.74	70.16	90.80	130.0	176.2	203.0
9 5/8	58.40	36.05	25.75	23.36	20.69	13.71	11.17	x	x							
	61.10	35.53	25.23	22.84	20.17	13.19	10.65	x	x							
	71.80	33.46	23.16	20.77	18.10	11.12	8.58	x								
10 3/4	32.75	52.60	42.30	39.91	37.24	30.26	27.72	23.02	14.73	x						
	40.50	51.15	40.85	38.46	35.79	28.81	26.27	21.57	13.28	x						
	45.50	50.15	39.85	37.46	34.79	27.81	25.27	20.57	12.28	x						
	51.00	49.13	38.83	36.44	33.77	26.79	24.25	19.55	11.26	x						
	55.50	48.27	37.97	35.58	32.91	25.93	23.39	18.69	x							
	60.70	47.26	36.96	34.57	31.90	24.92	22.38	17.68	x							
	65.70	46.30	36.00	33.61	30.94	23.96	21.42	16.72	x							
11 3/4	42.00	62.24	51.94	49.55	46.88	39.90	37.36	32.66	24.37	15.14	x					
	47.00	61.31	51.01	48.62	45.95	38.97	36.43	31.73	23.44	14.21	x					
	54.00	59.96	49.66	47.27	44.60	37.62	35.08	30.38	22.09	12.86	x					
	60.00	58.79	48.49	46.10	43.43	36.45	33.91	29.21	20.92	x						
13 3/8	48.00	81.89	71.59	69.20	66.53	59.55	57.01	52.31	44.02	34.79	23.15	x				
	54.50	80.63	70.33	67.94	65.27	58.29	55.75	51.05	42.76	33.53	21.89	x				
	61.00	79.37	69.07	66.68	64.01	57.03	54.49	49.79	41.50	32.27	20.63	x				
	68.00	78.08	67.78	65.39	62.72	55.74	53.20	48.50	40.21	30.98	19.34	x				
	72.00	77.24	66.94	64.55	61.88	54.90	52.36	47.66	39.37	30.14	18.50	x				
16	65.00	117.87	107.57	105.18	102.51	95.53	92.99	88.29	80.00	70.77	59.13	47.71	27.07	x		
	75.00	115.87	105.57	103.18	100.51	93.53	90.99	86.29	78.00	68.77	57.13	45.71	25.07	x		
	84.00	114.19	103.89	101.50	98.83	91.85	89.31	84.61	76.32	67.09	55.45	44.03	23.39	x		
18 5/8	87.50	159.74	149.44	147.05	144.36	137.40	134.86	130.16	121.87	112.64	101.00	89.58	68.94	29.74	x	
20	94.00	185.28	174.98	172.59	169.92	162.94	160.40	155.70	147.41	136.18	126.54	115.12	94.48	55.28	x	
	106.50	182.92	172.62	170.23	167.56	160.58	158.04	153.34	145.05	135.82	124.18	112.76	92.12	52.92	x	
	133.00	177.76	167.46	165.07	162.40	155.42	152.88	148.18	139.89	130.66	119.02	107.60	86.96	47.76	x	
30	267.0	407.8	397.5	395.1	392.4	385.5	382.9	378.2	369.9	360.7	349.1	337.6	317.0	277.8	231.6	204.8
	310.0	397.0	386.7	384.3	381.6	374.7	372.1	367.4	359.1	349.9	338.3	326.8	306.2	267.0	220.8	194.0

(1) The zero vertical column gives the capacity of the casing in liters per meter.

(2) The zero horizontal line gives the total displacement of the casing with coupling in liters per meter.

x The outside diameter of the coupling is larger than the inside diameter of the outer casing.

l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

ANNULAR VOLUME BETWEEN CASING AND TUBING
(liters per meter)

				Nominal size of inner string (in)									
			0 (1)	1. 050	1.315	1.660	1.900	2.063	2 3/8	2 7/8	3 1/2	4	4 1/2
		0 (2)	(l/m)	0.56	0.88	1.40	1.84	2.16	2.88	4.22	6.26	8.17	10.33
Nominal size and weight of outer string (in and lb/ft)	4 1/2	9.50	8.48	7.92	7.60	7.08	6.64	6.32	5.60	4.26			
		10.50	8.32	7.76	7.44	6.92	6.48	6.16	5.44	4.10			
		11.60	8.11	7.55	7.23	6.71	6.27	5.95	5.23	3.89			
		13.50	7.79	7.23	6.91	6.39	5.95	5.63	4.91	3.57			
		15.10	7.42	6.86	6.54	6.02	5.58	5.26	4.54	3.20			
		16.90	7.09	6.53	6.21	5.69	5.25	4.93	4.21				
		17.70	6.93	6.37	6.05	5.53	5.09	4.77	4.05				
		18.80	6.71	6.15	5.83	5.31	4.87	4.55	3.83				
	5	11.50	10.54	9.98	9.66	9.14	8.70	8.38	7.66	6.32			
		13.00	*10.23*	*9.67*	*9.35*	*8.83*	*8.39*	*8.07*	*7.35*	*6.01*			
		15.00	9.84	9.28	8.96	8.44	8.00	7.68	6.96	5.62			
		18.00	9.27	8.71	8.39	7.87	7.43	7.11	6.39	5.05			
		20.80	8.75	8.19	7.87	7.35	6.91	6.59	5.87	4.53			
	5 1/2	14.00	12.73	12.17	11.85	11.33	10.89	10.57	9.85	8.51	6.47		
		15.50	12.42	11.86	11.54	11.02	10.58	10.26	9.54	8.20	6.16		
		17.00	12.13	11.57	11.25	10.73	10.29	9.97	9.25	7.91	5.87		
		20.00	11.57	11.01	10.69	10.17	9.73	9.41	8.69	7.35	5.31		
		23.00	11.05	10.49	10.17	9.65	9.21	8.89	8.17	6.83	4.79		
	6 5/8	20.00	18.54	17.98	17.66	17.14	16.70	16.38	15.66	14.32	12.28	10.37	8.21
		24.00	17.76	17.20	16.88	16.36	15.92	15.60	14.88	13.54	11.50	9.59	7.43
		28.00	16.99	16.43	16.11	15.59	15.15	14.83	14.11	12.77	10.73	8.82	6.66
		32.00	16.32	15.76	15.44	14.92	14.48	14.16	13.44	12.10	10.06	8.15	
	7	17.00	21.66	21.10	20.78	20.26	19.82	19.50	18.78	17.44	15.40	13.49	11.33
		20.00	21.12	20.56	20.24	19.72	19.28	18.96	18.24	16.90	14.86	12.95	10.79
		23.00	20.54	19.98	19.66	19.14	18.70	18.38	17.66	16.32	14.28	12.37	10.21
		26.00	19.96	19.40	19.08	18.56	18.12	17.80	17.08	15.74	13.70	11.79	9.63
		29.00	19.38	18.82	18.50	17.98	17.54	17.22	16.50	15.16	13.12	11.21	9.05
		32.00	18.82	18.26	17.94	17.42	16.98	16.66	15.94	14.60	12.56	10.65	8.49
		35.00	18.27	17.71	17.39	16.87	16.43	16.11	15.39	14.05	12.01	10.10	7.94
		38.00	17.76	17.20	16.88	16.36	15.92	15.60	14.88	13.54	11.50	9.59	7.43
		41.00	17.17	16.61	16.29	15.77	15.33	15.01	14.29	12.95	10.91	9.00	6.84
		44.00	16.58	16.02	15.70	15.18	14.74	14.42	13.70	12.36	10.32	8.41	6.25

(1) The zero vertical column gives the capacity of the casing in liters per meter.

(2) The zero horizontal line gives the total displacement of tubing with coupling in liters per meter.

l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

ANNULAR VOLUME BETWEEN CASING AND TUBING
(liters per meter) (continued)

				Nominal size of inner string (in)									
			0 (1)	1. 050	1.315	1.660	1.900	2.063	2 3/8	2 7/8	3 1/2	4	4 1/2
		0 (2)	(l/m)	0.56	0.88	1.40	1.84	2.16	2.88	4.22	6.26	8.17	10.33
Nominal size and weight of outer string (in and lb/ft)	7 5/8	24.00	25.01	24.45	24.13	23.61	23.17	22.85	22.13	20.79	18.75	16.84	14.68
		26.40	24.61	24.05	23.73	23.21	22.77	22.45	21.73	20.39	18.35	16.44	14.28
		29.70	23.95	23.39	23.07	22.55	22.11	21.79	21.07	19.73	17.69	15.78	13.62
		33.70	23.19	22.63	22.31	21.79	21.35	21.03	20.31	18.97	16.93	15.02	12.86
		39.00	22.24	21.68	21.36	20.84	20.40	20.08	19.36	18.02	15.98	14.07	11.91
	8 5/8	24.00	33.22	32.66	32.34	31.82	31.38	31.06	30.34	29.00	26.96	25.05	22.89
		28.00	32.57	32.01	31.69	31.17	30.73	30.41	29.69	28.35	26.31	24.40	22.24
		32.00	31.79	31.23	30.91	30.39	29.95	29.63	28.91	27.57	25.53	23.62	21.46
		36.00	31.03	30.47	30.15	29.63	29.19	28.87	28.15	26.81	24.77	22.86	20.70
		40.00	30.24	29.68	29.36	28.84	28.40	28.08	27.36	26.02	23.98	22.07	19.91
		44.00	29.46	28.90	28.58	28.06	27.62	27.30	26.58	25.24	23.20	21.29	19.13
		49.00	28.58	28.02	27.70	27.18	26.74	26.42	25.70	24.36	22.32	20.41	18.25
	9 5/8	32.30	41.06	40.50	40.18	39.66	39.22	38.90	38.18	36.84	34.80	32.89	30.73
		36.00	40.33	39.77	39.45	38.93	38.49	38.17	37.45	36.11	34.07	32.16	30.00
		40.00	39.55	38.99	38.67	38.15	37.71	37.39	36.67	35.33	33.29	31.38	29.22
		43.50	38.84	38.28	37.96	37.44	37.00	36.68	35.96	34.62	32.58	30.67	28.51
		47.00	38.18	37.62	37.30	36.78	36.34	36.02	35.30	33.96	31.92	30.01	27.85
		53.50	36.91	36.35	36.03	35.51	35.07	34.75	34.03	32.69	30.65	28.74	26.58
		58.40	36.05	35.49	35.17	34.65	34.21	33.89	33.17	31.83	29.79	27.88	25.72
		61.10	35.54	34.98	34.66	34.14	33.70	33.38	32.66	31.32	29.28	27.37	25.21
		71.80	33.45	32.89	32.57	32.05	31.61	31.29	30.57	29.23	27.19	25.28	23.12

(1) The zero vertical column gives the capacity of the casing in liters per meter.

(2) The zero horizontal line gives the total displacement of tubing with coupling in liters per meter.

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

E drilling bits and downhole motors

IADC ROCK BIT CLASSIFICATION

The new IADC classification (SPE/IADC 1987 No. 16143) uses four characters, unlike the earlier classification of 1972, which used three digits.

The significance of these three digits remains unchanged. The addition of a letter to the former IADC code provides additional information about the bit characteristics.

First digit

The numbers 1, 2 and 3 designate steel tooth bits and correspond to increasing formation hardness.

The numbers 4, 5, 6, 7 and 8 designate bits with tungsten carbide inserts and also correspond to increasing formation hardness.

Second digit

The numbers 1, 2, 3 and 4 denote a sub-classification of the formation hardness in each of the eight classes determined by the first digit.

Third digit

The numbers 1 to 7 define the type of bearing and specify the presence or absence of gage protection by tungsten carbide inserts, on the leading flanks of the bit rollers:

1 = standard roller bearing.
2 = roller bearing, air-cooled.
3 = roller bearing, gage-protected.
4 = sealed roller bearing.
5 = sealed roller bearing, gage-protected.
6 = sealed friction bearing.
7 = sealed friction bearing, gage-protected.

The numbers 8 and 9 are reserved for future use.

Additional letter

A = air application: journal bearing bits with air circulation nozzles.
C = center jet.
D = deviation control.
E = extended jets.
G = extra gauge/body protection.
J = jet deflection.
R = reinforced welds: for percussion applications.
S = standard steel tooth model.
X = chisel insert.
Y = conical insert.
Z = other insert shape.

HOW TO USE THE ROCK BIT TABLES

EXAMPLE OF THE CHOICE OF A BIT

The formation to be drilled is soft, with low compressive strength and high drillability. We wish to use a milled tooth bit with sealed friction bearings.

The table on page E3 gives us the bit Code No.:

(a) First digit: soft formation with high drillability: **1**.
(b) Second digit: estimated hardness in series 1 above: **2**.
(c) Third digit: sealed bearings: **6**.

Bit Code No. 126

The table on page E4 gives a choice between:

(a) Hughes: J2.
(b) Reed: HP12.
(c) Security: S33F.
(d) Smith: FDT.
(e) Varel: L126.

HOW TO KNOW THE DESIGN OF A ROCK BIT

Let us consider Reed HP53 bit. Which formation is it designed for?

Table E6 states that it is equivalent to the Hughes ATJ33, Security S86F, Smith F3 and Varel V537 bits, and that its Code No. is 537.

Table E3 shows us that it is an insert bit for medium formations with hardness 3 and that it has sealed bearings and gage protectors.

Note

Bit classifications are general guidelines only. All bit types will drill effectively in formations other than those specified. It is the manufacturer's responsability to classify his bits in these tables.

IADC ROLLER BIT CLASSIFICATION CHART

	Series	Formations	Types	Standard roller bearing	Roller bearing Air-cooled	Roller bearing Gage protected	Sealed roller bearing	Sealed roller bearing Gage protected	Sealed friction bearing	Sealed friction bearing Gage protected
				1	2	3	4	5	6	7
Milled tooth bits	1	Soft formations with low compressive strength and high drillability	1							
			2							
			3							
			4							
	2	Medium to medium hard formations with high compressive strength	1							
			2							
			3							
			4							
	3	Hard semi-abrasive and abrasive formations	1							
			2							
			3							
			4							
Insert bits	4	Soft formations with low compressive strength and high drillability	1							
			2							
			3							
			4							
	5	Soft to medium formations with low compressive strength	1							
			2							
			3							
			4							
	6	Medium hard formations with high compressive strength	1							
			2							
			3							
			4							
	7	Hard semi-abrasive and abrasive formations	1							
			2							
			3							
			4							
	8	Extremely hard and abrasive formations	1							
			2							
			3							
			4							

COMPARISON OF ROCK BITS

Milled tooth bits

Soft formations					
Code	Hughes	Reed	Security	Smith	Varel
111	R1	Y11	S3S/S3SJD	DS/DJ	L3A
112					L3AAB
113					
114	ATX1	S11	S33S	SDS	L114.
115	ATXG1	S11G	S33SG		L115
116	ATJ1	HP11/MHP11	S33SF	FDS	L116
117					
121	R2/WS	Y12	S3/S3T	DT	L3/L3S
122	S				L3/L3SAB
123				DTT	
124			S33	SDT	L124
125			S33G		L125
126	J2	HP12	S33F	FDT	L126
127	JG2		S33GF		L127
131	R3	Y13/Y13T	S4/S4T	DG	LH3G
132					LH3GAB
133				DGT	
134	ATX3	S13	S44	SDG	L134
135	ATXG3	S13G/MS13G	S44G	SDGH	L135
136	J3	HP13	S44F	FDG	L136
137	JG3	HP13G/MHP13G	S44GF	FDGH	L137
141					
142					
143			DSJ		
144					
145			DSS		
146					
147					

Medium to medium hard formations					
Code	Hughes	Reed	Security	Smith	Varel
211	R4/WM	Y21	M4N	V2	L2
212					L2AB
213				V2H	
214	XV	S21	M44N	SV	L214
215	XDV	S21G	M44NG	SVH	L215
216	J4	HP21	M44NF	FV	L216
217	JG4	HP21G	M44NGF	FVH	L217
221	DR5	Y22R	M4		
222					
223					
224					
225					
226					
227					
231			M4L		LH2
232					LH2AB
233			DMJ	T2H	
234			M44L	ST2	L234
235			DMM		L235
236			M44LF		L236
237					L237
241					
242					
243					
244					
245					
246					
247					

COMPARISON OF ROCK BITS (continued)

Milled tooth bits

Hard formations					
Code	Hughes	Reed	Security	Smith	Varel
311		Y31/Y31RAP	H7	L4	L1
312			H7JA		L1AB
313				L4H	
314			H77	SL4	L314
315		S31G		SL4H	L315
316	J7				L316
317	JG7	HP31G			L317
321	R7/WH/DR7				LH1
322					LH1AB
323					
324					
325					
326					
327					
331					
332	HR				
333			H7SG		
334					
335			H77SG		
336					
337					
341					
342					
343					
344					
345					
346					
347	JG8				

Insert bits

Soft formations					
Code	Hughes	Reed	Security	Smith	Varel
411					
412					
413					
414					
415					
416					
417	ATJ05				
421					
422					
423					
424					
425					
426					
427	ATJ05C		S81F		
431					
432					
433					
434					
435	X11		S82		V435
436					
437	ATJ11	HP43A	S82F	F1	V437
441					
442					
443					
444					
445					
446					
447	ATJ11C			F15	

COMPARISON OF ROCK BITS (continued)

Insert bits

Soft to medium formations					
Code	Hughes	Reed	Security	Smith	Varel
511					
512					
513					
514					
515	ATX22	S51A	S84	2JS	V515
516					
517	ATJ22	HP51/HP51A	S84F/DS84F	F2/A1	V517
521					
522					
523					
524					
525		S52A			V525
526					
527	ATJ22C	HP52/HP52A	S85F	F27	V527/V527C
531					
532	HH33				DW9AB
533					DW9
534					
535	ATX33	S53A	S86	3JS	V535
536					
537	ATJ33	HP53/HP53A	S86F	F3	V537/V537C
541					
542			S8JA		
543					
544					
545	ATX33C		S88/DS88		
546					
547	ATJ33C	HP54	S88F	F37	V547/V547C

Medium hard formations					
Code	Hughes	Reed	Security	Smith	Varel
611					
612	G44			4JA/4GA	DW7AB
613					DW7
614					
615	ATX44		M84	4JS	V615/V615C
616					
617	ATJ44/ATJ44A	HP61/HP61A	M84F	F4/F45	V617/V617C
621					
622		Y62JA	M8MJA	5JA/5GA	DW77AB
623					DW77
624					
625		S62A	GM88	5JS	V625
626					
627	ATJ44C/ATJ55R	HP62/HP62A	M89TF	F5	V627/V627C
631					
632	G55				DW6AB
633					DW6
634					
635					
636					
637	ATJ55/ATJ55A	HP63	M89F	F47/F57	V637
641					
642					
643					
644					
645					
646					
647			M90F		

COMPARISON OF ROCK BITS (continued)

Insert bits

Hard formations					
Code	Hughes	Reed	Security	Smith	Varel
711					
712					
713					
714					
715					
716					
717					
721					
722					
723					
724					
725					
726					
727				F6	V727
731					
732	G77	Y73JA/Y73RAP		7JA/7GA	DW6SAB
733					DW6S
734					
735					
736					
737	ATJ77	HP73	H87F	F7	V737
741					
742			H8JA		
743					
744					
745			H88		
746					
747			H88F		

Extremely hard formations					
Code	Hughes	Reed	Security	Smith	Varel
811					
812			H9JA		DWHAB
813					DWH
814					
815					
816					
817			H99F		
821					
822					
823					
824					
825					
826					
827					
831					
832	G99	Y83JA	H10JA	9JA	
833					
834					
835			H100		
836					
837	ATJ99/ATJ99A	HP83	H100F	F9	
841					
842					
843					
844					
845					
846					
847					

IADC CLASSIFICATION OF BITS WITH FIXED CUTTERS (DIAMONDS, PDC, TSP...)

The new IADC classification (SPE/IADC 1987 No. 16142) replaces the 1981 classification which only applied to natural diamonds bits, and which was consequently barely used (*Drilling Manual Tenth Edition*).

This classification makes use of four characters. It is hence consistent with the 1987 rock bit classification (page E 1). Since the dull grading codes are common (page E 13) for rock bits and fixed cutter bits, the daily reports, bit reports and databases are filled in the same way.

First character

The letters **D, M, S, T and O** define the type of cutter (1) and the body material.

Second character

The numbers **1** to **9** define the bit profile.

Third character

The numbers **1** to **9** define the hydraulic design :

(a) Fluid exit (changeable jets, fixed ports, open throat).
(b) Cutter distribution (bladed, ribbed, open-faced).

The letters **R, X and O** may replace the numbers 6 or 9 (which correspond to most diamond and TSP bits).

Fourth character

The numbers **0** to **9** denote the cutter size and density.

Examples

Diamant Boart bit LX291 Code M269. This is a matrix body PDC bit (M) with a long taper medium cone and high gage height (2) with open throat hydraulics (6). The cutters are small and heavy (9).

Christensen bit D24 Code D4X9. This is matrix body natural diamond bit (D), with a medium taper deep cone and medium gage height (4) and cross flow hydraulics (X). The cutters and small and heavy (9).

---

(1) Cleary in a body with two or more materials (diamonds + PDC for example), only one is the cutter, and the others serve to protect the gage, for example.

IADC CLASSIFICATION OF BITS WITH FIXED CUTTERS (DIAMONDS, PDC, TSP...) (continued)

HYDRAULIC DESIGN

Type de dusage

Placement des éléments de coupe	Changeable jets	Fixed ports	Open throat
Bladed(1)	1	2	3
Ribbed	4	5	6
Open faced	7	8	9

Alternate codes(2)

R : Radial flow

X : Cross flow

O : Other

CUTTER SIZE AND DENSITY

Size	Light	Medium	Heavy
	Density		
Large	1	2	3
Medium	4	5	6
Small	7	8	9

0 - Impregnated

Cutter size ranges	Natural diamonds stones per carat	Synthetic diamonds usable cutter height
Large	< 3	> 5/8"
Medium	3-7	3/8"-5/8"
Small	> 7	< 3/8"

First character	*Second character*	*Third character*	*Fourth character*
Cutter type and body material	Bit profile	Hydraulic design	Cutter size and density

D : Natural diamond Matrix body

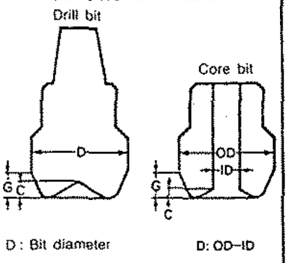
M : Matrix body PDC

S : Steel body PDC

T : TSP Matrix body

O : Other

BIT PROFILE CODES

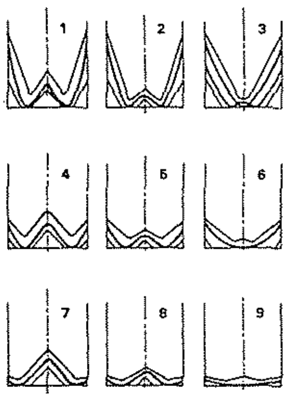


D : Bit diameter

D: OD–ID

G : Gage height	C : Cone height		
	High C > 1/4D	Medium 1/8D ⩽ C ⩽ 1/4D	Low C < 1/8D
High G > 3/8 D	1	2	3
Medium 1/8 D ⩽ G ⩽ 3/8 D	4	5	6
Low G < 1/8 D	7	8	9

BIT PROFILES



(1) **Bladed** refers to raised, continuous flow restrictors with a standoff distance from the bit body of more than 25.4 mm (1.0 in).
Ribbed refers to raised continuous flow restrictors with a standoff distance form the bit body of 25.4 mm (1.0 in) or less.
Open face refers to non-restricted flow arrangements.

(2) These letters are used in preference to numbers 6 and 9 for most natural diamond and TSP bits.

PARAMETERS FOR USING ROCK BITS
(After SPE/IADC/16143 of 1987)

Milled tooth bits

IADC code	114/116	124/126	134/136	214/216	314	335
Rotary speed (rpm)	175-80	170-50	140-50	120-50	80-50	80-50
Size (in)	Weight on bit (10^3 daN)					
4 1/2 - 4 3/4			7-9	7-9	7-11	
5 7/8 - 6 1/4		7-9	7-11	7-11	7-11	
6 1/2 - 6 3/4		7-11	7-13	9-13	9-16	
7 5/8 - 7 7/8	9-16	9-16	9-18	9-18	11-18	
8 3/8 - 9	11-16	11-16	11-18	11-18	11-20	11-20
9 1/2 - 9 7/8	11-18	11-18	11-20	13-20	13-20	
10 5/8 - 11	13-20	13-20	13-22	16-22		
12 - 12 1/4	16-22	16-22	16-24	16-24	18-27	18-29
13 1/4 - 15	16-22	16-22	18-24	18-27	18-27	
17 1/2 - 18 1/2	18-24	18-24	20-29	20-29	22-29	
20 - 26	18-27		22-29			

Insert bits with friction bearings

IADC code	437	517/527	537/547	617/627	727/647	737/747	817/837
Rotary speed (rpm)	120-55	120-50*	90-40	70-40	60-40	55-30	50-25
Size (in)	Weight on bit (10^3 daN)						
4 1/2 - 4 3/4				5-11			
5 7/8 - 6 1/4		5-11	7-13	7-13	7-13		
6 1/2 - 6 3/4		7-11	9-16	9-16	9-16	11-18	11-18
7 5/8 - 7 7/8	9-16	9-18	11-20	11-20	11-22	11-24	11-29
8 3/8 - 9	9-18	9-20	11-22	11-22	11-24	13-27	13-29
9 1/2 - 9 7/8	11-20	11-22	13-24	13-27	13-29	16-29	16-29
10 5/8 - 11		13-24	16-29	16-29			
12 - 12 1/4	16-29	16-29	18-31	18-31	18-33	20-33	20-36
13 1/4 - 15		18-33	20-38				
17 1/2 - 18 1/2		18-38	20-40	20-40	20-40		

* Except for IADC code Nos. 517 and 527 : 14 3/4 in (110-50) 17 1/2 in (100-50).
daN × 2.25 = lb.

PARAMETERS FOR USING INSERT BITS AND FRICTION BEARINGS

(After Hughes Tool)

For insert bits with friction bearings, the table below gives the number *WN*, the product of the weight (expressed in 10^3 daN) multiplied by the rotary speed (expressed in rpm). This number only accounts for bearing strength. Risks of broken inserts or loss of tightness have not been considered in its determination.

WN	J11	J11C	J22	J22C	J33	J33C	J33H	J44	J44A	J44C	J55	J55R	J77	J99
4 3/4											1150			
5 7/8					1250						1200			
6					1250			1200			1200			
6 1/8			1250		1250						1200			
6 1/4					1250						1200			
6 1/2			1250		1150			*1300*				*1300*		*1300*
6 3/4			1150								1300			
7 7/8	*1650*	*1650*	*1650*	*1650*	*1650*	*1650*	*1650*	*1600*	*1600*	*1600*	*1600*	*1600*	*1600*	*1600*
8 3/8			1650		1950						1900			
8 1/2	*1650*		*1950*	*1950*	*2150*			2100			2100	2100	2100	2100
8 3/4	1950		2150	2150	2150	2150	2150	1950		1950	1950	1950	1950	1950
9 1/2	*2150*		2250	2250	2250			2200			2200	2200	2200	2200
9 7/8	2250		2250	2250	2250			2150				2150	2150	
10 5/8			2200					2150						
11			2200		2900			2800						
12 1/4	2900	2900	2950	2950	2950			3300			3300	3300	3300	

For WN in 10^3 lb × rpm multiply the number given by the table by 2.2.

Example : 8 1/2, J22 : *WN* = 1950 × 2.2 = 4300.

The following alternatives are available :

(a) weight	*19.5 10^3 daN*	*(43.10^3 lb)*
(b) rotary speed	100 rpm	19.5 × 100 = 1950 (43 × 100 = 4300)

or :

(a) weight	25 10^3 daN	(55.10^3 lb)
(b) rotary speed	78 rpm	25 × 78 = 1950 (55 × 78 = 4300)

or any other combination, according to whether the rotary speed or weight on bit is adjusted for best action on the formation.

daN × 2.25 = lb

USED BIT DULL GRADING SYSTEM FORMAT AND CODES
(After SPE/IADC/16146 of 1987)

The dull grading system applies both to roller bits and diamond bits, PDC, TSP and core bits. The system is flexible enough for use in the bit reports, daily reports and databases.

Cutting structure				B	G	Remarks	
Inner rows	Outer rows	Dull characteristics	Location	Bearing/ seals	Gage 1/16 in	Other dull	Reason pulled
Table 1	Table 1	Table 2	Table 3	Table 4	Table 5	Table 2	Table 6

TABLE 1

Inner: inner 2/3 of bit
Outer: outer 1/3 of bit

0 = No wear
.
.
.
8 = No usable cutting structure

TABLE 2

BC = Broken Cone
BT = Broken Teeth/cutters
BU = Balled up
* CC = Cracked Cone
* CD = Cone Dragged
CI = Cone Interference
CR = Cored
CT = Chipped Teeth/cutters
ER = Erosion
FC = Flat Crested wear
HC = Heat Checking
JD = Junk Damage
* LC = Lost Cone
LN = Lost Nozzle
LT = Lost Teeth/cutters
OC = Off-Center wear
PB = Pinched Bit
PN = Plugged Nozzle/flow passage
RG = Rounded Gauge
RO = Ring Out
SD = Shirttail Damage
SS = Self Sharpening wear
TR = Tracking
WO = Washed out - bit
WT = Worn teeth/cutters
NO = No major/other dull characteristics

* Show cone number(s) under location.

USED BIT DULL GRADING SYSTEM FORMAT AND CODES
(continued)
(After SPE/IADC/16146 of 1987)

TABLE 3

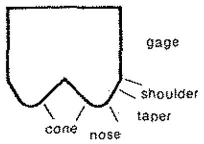
Fixed cutter bits	Roller cone bits
C = Cone N = Nose (row) T = Taper S = Shoulder G = Gauge A = All areas/rows M = Heel row 	N = Nose rows cone 1 *M = Middle rows* 2 H = Heel rows 3 A = All rows

TABLE 4

Nonsealed bearings:
0 = No life used
.
.
.
8 = All life used

Sealed bearings:
E = Seals effective
F = Seals failed

X Fixed cutter bits
(diamonds, PDS, TSP)

TABLE 5

I = in gage
0 to 1/16 in under gage
1/16 to 1/8 in under gage
.
.
.

TABLE 6

BHA = Change Bottomhole Assembly
DMF = *Downhole Motor Failure*
DSF = Drill String Failure
DST = Drill Stem Test
DTF = Downhole Tool Failure
CM = Condition Mud
CP = Core Point
DP = Drill Plug
FM = Formation change
HP = Hole Problems
HR = Hours on bit
LOG = Run Logs
PP = Pump pressure
PR = Penetration Rate
RIG = Rig repairs
TD = Total Depth/CSG. depth
TQ = Torque
TW = Twist-off
WC = Weather Conditions
WO = Washout - drill string

CRITICAL ROTARY SPEEDS
(After API RP 7G)

Drill string rotation causes two types of vibration:

(a) Nodal vibrations (violin string).

(b) Longitudinal vibration (spring pendulum type).

The nodal or transverse vibrations become critical at certain rotary speeds depending on drill pipe size. These critical speeds are given to within ± 15% by the following formula, and the critical ranges are given in the table below:

$$N = \frac{1200}{\ell^2} (D^2 + d^2)^{1/2}$$

N = rpm
D = outside diameter (cm)
d = inside diameter (cm)
ℓ = length of one pipe (m)

Pipe size (in)	Approximate critical rotary speed (rpm)
2 3/8	95 ←(110)→ 125
2 7/8	110 ←(130)→ 150
3 1/2	135 ←(160)→ 185
4	160 ←(185)→ 210
4 1/2	180 ←(210)→ 240
5	200 ←(235)→ 270
5 1/2	220 ←(260)→ 300

The longitudinal vibrations depend on the length of the drill string, and the critical speeds are given by the formula below:

$$N = \frac{78600}{L} \quad \text{where } L \text{ is expressed in meters.}$$

$$N = \frac{258000}{L} \quad \text{where } L \text{ is expressed in feet}$$

Thus for each length of drill string, i.e. for each depth, a critical rotary speed exists that is independent of pipe size. The secondary and higher harmonic vibrations will occur at 4, 9, 16, 25 etc. times the speed given by this equation.

Longitudinal vibrations are less dangerous than transverse vibrations, but, when both types become critical simultaneously, the drill string is in danger of breaking.

The table below gives the coincidence depths of these two types of critical vibration.

Drill pipe OD (in)	Critical rotary speed (rpm)	Average vibration coincidence depth							
		(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)
2 3/8	110	700	2300	2 800	9400	6 400	21000	—	—
2 7/8	130	600	1960	2 400	8000	5 500	18000	9 750	32000
3 1/2	160	500	1600	2 000	6600	4 500	14800	8 000	26000
4	185	425	1390	1 700	5600	3 900	12700	6 700	22000
4 1/2	210	370	1200	1 500	5000	3 400	11200	6 000	19700
5	235	330	1100	1 300	4500	3 000	10000	5 300	17500
5 1/2	260	300	980	1 200	4000	2 700	9000	4 850	15900

cm × 0.394 = in m × 3.28 = ft

THREADS AND MAKE-UP TORQUES FOR DRILL AND CORE BITS

(After API)

Rock bits

Size (in)	*Threads*	Make-up torque	
		(daN.m)	(lb.ft)
3 3/4 - 4 1/2	2 3/8 REG	400-480	3000-3500
4 5/8 - 5	2 7/8 REG	800-950	6000-7000
5 1/8 - 7 3/8	3 1/2 REG	950-1200	7000-9000
7 1/2 - 9 3/8	4 1/2 REG	1600-2200	12000-16000
9 1/2 - 14 1/2	6 5/8 REG	3800-4300	28000-32000
14 5/8 - 18 1/2	7 5/8 REG	4600-5400	34000-40000
18 5/8 et plus	8 5/8 REG	5400-8100	40000-60000

Diamond and PDC bits

Size (in)	Threads	Make-up torque	
		(daN.m)	(lb.ft)
3 11/16 - 4 1/2	2 3/8 REG	400-480	3000-3500
4 17/32 - 5	2 7/8 REG	800-950	6000-7000
5 1/32 - 7 3/8	3 1/2 REG	950-1200	7000-9000
7 13/32 - 9 3/8	4 1/2 REG	1600-2200	12000-16000
9 13/32 - 14 1/2	6 5/8 REG	3800-4300	28000-32000
14 9/16 - 18 1/2	7 5/8 REG	4600-5400	34000-40000
18 9/16 et plus	8 5/8 REG	5400-8100	40000-60000

Coring bits

Core barrel *size* (in)	*Threads*	Make-up torque	
		(daN.m)	(lb.ft)
4 1/8		400-490	3000-3600
4 1/2		680-800	5000-6000
4 3/4		550-660	4050-4850
5 3/4		1000-1190	7400-8800
6 1/4 × 3		2020-2410	14900-17800
6 1/4 × 4		1100-1330	8150-9800
6 3/4		1340-1630	9900-12000
8		2580-3080	19000-22700

TOLERANCE ON NEW BIT SIZE
(After API)

Rock bits

Size		Tolerance	
(in)	(mm)	(in)	(mm)
3 3/8 - 13 3/4	85.7 - 349.3	+ 1/32 ,0	+ 0.79 ,0
14-17 1/2	355.6 - 444.5	+ 1/16 ,0	+ 1.59 ,0
17 5/8 or more	447.7 or more	+ 3/32 ,0	+ 2.38 ,0

Diamond and PDC bits

Size		Tolerance	
(in)	(mm)	(in)	(mm)
6 3/4 or less	171.5 or less	0, − 0.015	0, − 0.38
6 25/32 - 9	172.2 - 228.6	0, − 0.020	0, − 0.51
9 1/32 - 13 3/4	229.4 - 349.3	0, − 0.030	0, − 0.76
13 25/32 - 17 1/2	350.0 - 444.5	0, − 0.045	0, − 1,14
17 17/32 or more	445.3 or more	0, − 0.063	0, − 1.60

TURBODRILLING

I TURBODRILL CHARACTERISTICS

Turbodrills are characterized by:

(a) Outside diameter of the body.
(b) Number of stages.
(c) Number of sections.
(d) Type of blades.
(e) Length and weight.

The hydraulic characteristics are given for a nominal pump flow Q_n and a mud specific gravity of 1.2.

These nominal characteristics are:

(a) Nominal speed N_n.
(b) Nominal horsepower output P_n.
(c) Nominal drive torque T_n.
(d) Nominal pressure drop Δp_n.
(e) Axial thrust P_a.

The nominal horsepower output is the maximum output obtained with nominal pump flow.

The efficiency of the turbodrill is equal to the ratio of the mechanical horsepower supplied by the turbodrill to the hydraulic horsepower supplied *to the turbodrill*:

$$\eta = \frac{\text{Mechanical horsepower}}{\text{Hydraulic horsepower}}$$

II VARIATIONS IN NOMINAL CHARACTERISTICS WITH PUMP FLOW AND MUD SPECIFIC GRAVITY

If N_n, P_n, T_n and Δp_n are the nominal characteristics of a turbodrill for a flow rate Q_n and specific gravity of 1.2, for a flow rate Q_1 and specific gravity d, the characteristics are:

$$\boxed{N_{n1} = N_n \frac{Q_1}{Q_n}}$$

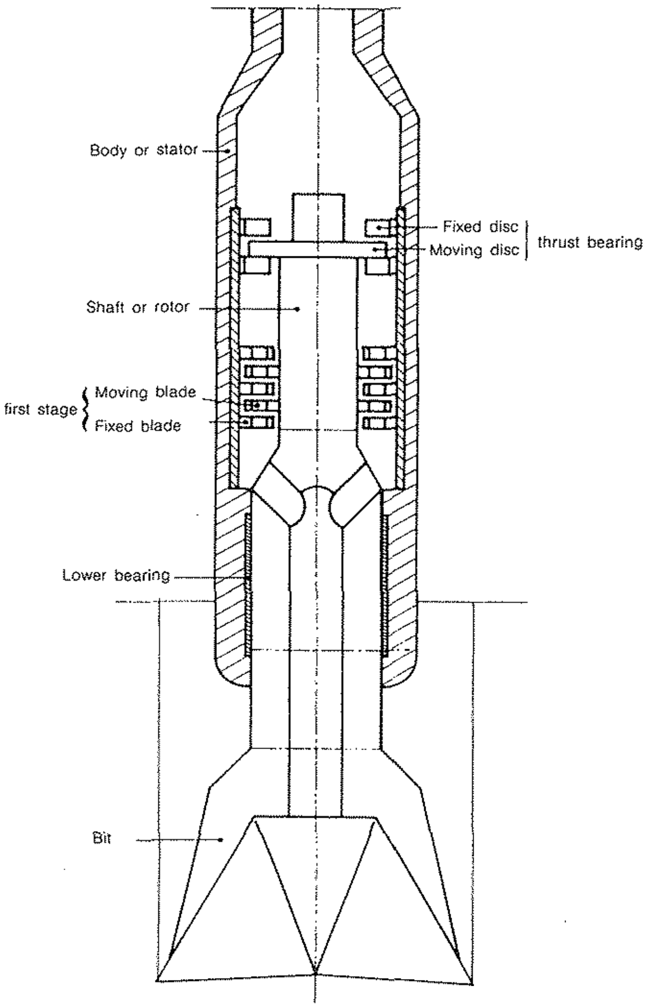
$$\boxed{T_{n1} = T_n \frac{d}{1.2} \left[\frac{Q_1}{Q_n}\right]^2}$$

$$\boxed{P_{n1} = P_n \frac{d}{1.2} \left[\frac{Q_1}{Q_n}\right]^3}$$

$$\boxed{\Delta p_{n1} = \Delta p_n \frac{d}{1.2} \left[\frac{Q_1}{Q_n}\right]^2}$$

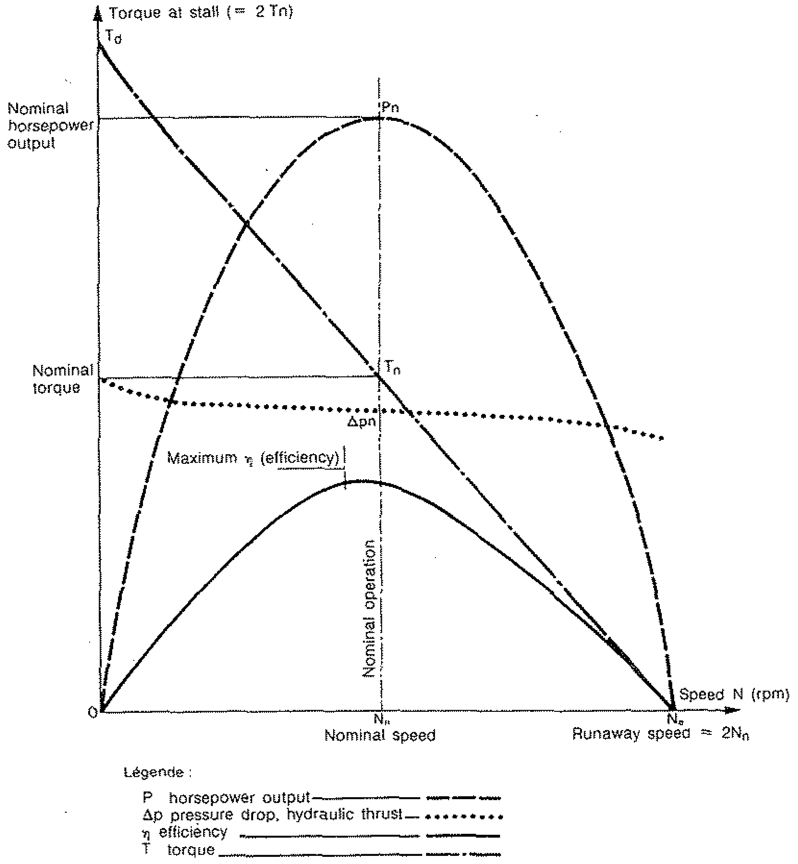
The axial thrust is approximately proportional to d and to the square of Q.

TURBODRILL


Body or stator
Fixed disc
Moving disc
thrust bearing
Shaft or rotor
first stage
Moving blade
Fixed blade
Lower bearing
Bit

VARIATION IN MECHANICAL CHARACTERISTICS OF TURBODRILLS WITH ROTARY SPEED

(Specific gravity *d*, constant pump flow Q_n)



TURBODRILL CHARACTERISTICS
(Specific gravity 1.2)

Size (in)	Manufacturer	Type	Nominal pump flow (l/min)	Nominal output (kW)	Nominal torque (daN.m)	Nominal speed (tr/min)	Pressure drops (kPa)	Number of stages	Weight (daN)	Hole size (in)
4 3/4	Neyrfor	T2AI	600	55	42	1180	9600	200	893	5 7/8 - 6 1/4
5	Neyrfor	TFI	600	30	28	1020	5300	129	765	6 - 6 3/4
	Neyrfor	T2FI	600	58	54	1020	9700	258	1256	6 - 6 3/4
	Redi Drill	ST15	600	62	56	1030	8400	150	910	6 1/8 - 7 7/8
	Redi Drill	ST25	600	100	90	1030	14000	240		6 1/8 - 7 7/8
	Redi Drill	STD1-5 (1)	600	37	34	1030	5000	90	700	6 1/8 - 7 7/8
6 5/8	Neyrfor	T2AI	1600	210	182	1100	12600	172	1888	8 3/8 - 9 7/8
	Neyrfor	T3AI	1600	314	272	1100	18400	258	2536	8 3/8 - 9 7/8
6 3/4	Eastman Christensen	2L	1600	191	214	853	10200	212	2011	8 3/8 - 9 7/8
	Eastman Christensen	3L	1600	287	321	853	15000	318	2894	8 3/8 - 9 7/8
	Eastman Christensen	D100 (1)	1600	43	49	860	2800	73	800	8 3/8 - 9 7/8
7 1/4	Neyrfor	T2AI	1800	181	197	880	10400	164	2160	8 3/8 - 9 7/8
	Neyrfor	T3AI	1800	272	295	880	14900	246	2940	8 3/8 - 9 7/8
	Neyrfor	TFST (1)	1800	41	51	750	2400	50	730	8 3/8 - 12 1/4
	Neyrfor	TFM (1)	1800	65	82	750	3700	80	1030	8 3/8 - 12 1/4
	Neyrfor	TF (1)	1800	89	113	750	5000	100	1390	8 3/8 - 12 1/4
	Redi Drill	ST1	1800	256	239	1020	12400	150	2310	8 1/2 - 12 1/4
	Redi Drill	ST2	1800	374	350	1020	16200	220		8 1/2 - 12 1/4
	Redi Drill	STD1 (1)	1800	120	112	1020	5800	70	900	8 1/2 - 12 1/4
	Redi Drill	STD2 (1)	1800	171	159	1020	8300	100	1380	8 1/2 - 12 1/4
7 1/2	Eastman Christensen	D100 (1)	1800	63	63	953	3600	73	1000	8 1/2 - 12 1/4
7 3/4	Eastman Christensen	D100 (1)	1800	63	63	953	3600	73	1080	9 7/8 - 12 1/4
9 1/2	Eastman Christensen	2L	2500	302	393	732	10700	212	4710	12 1/4 - 17 1/2
	Eastman Christensen	3L	2500	452	590	732	15500	318	6280	12 1/4 - 17 1/2
	Neyrfor	T2AI	2500	282	361	723	11000	172	4370	12 1/4 - 17 1/2
	Neyrfor	T3AI	2500	424	542	723	15700	258	5935	12 1/4 - 17 1/2
10 1/4	Neyrfor	TFST (1)	3000	137	206	630	4700	79	2260	14 3/4 - 26

(1) For directional turbodrill.

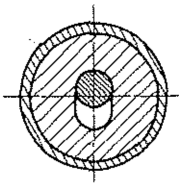
l/min × 0.264 = gal/min   kW × 1.34 = hp   daN.m × 7.38 = lb.ft   kPa × 0.145 = psi   daN × 2.25 = lb

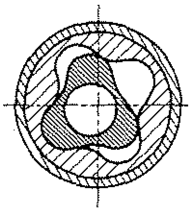
POSITIVE DISPLACEMENT MOTORS

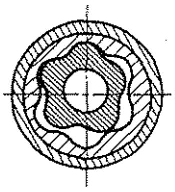
I CHARACTERISTICS OF POSITIVE DISPLACEMENT MOTORS

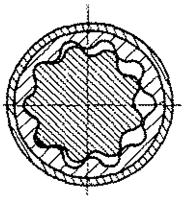
Positive displacement motors are identified by :

(a) Outside diameter of the body.
(b) Ratio of the shaft lobes (rotor) to the sleeve (stator) which may vary from 1/2 to 9/10 :


1/2 Rotor/Stator


3/4 Rotor/Stator


5/6 Rotor/Stator


9/10 Rotor/Stator

(c) Number of stages.
(d) Length and weight.

The *hydraulic characteristics* are indicated by :

(a) Minimum and maximum flow rates.
(b) *Minimum and maximum* rotary speeds.
(c) Maximum pressure drop across the motor.
(d) Maximum torque supplied.
(e) Maximum mechanical horsepower output supplied.
(f) Maximum efficiency.

II VARIATIONS IN CHARACTERISTICS

The characteristics are given by the manufacturers for a specific gravity of 1.2 (10 ppg) :

- **Rotary speed** is directly proportional to the flow rate :

$$N_2 = N_1 \frac{Q_2}{Q_1}$$

The higher the number of shaft lobes, the lower the rotary speed.

It varies only slightly with torque and pressure drop.

POSITIVE DISPLACEMENT MOTORS
(continued)

- The **torque** is directly proportional to the pressure drop across the motor :

$$T_2 = T_1 \frac{\Delta p_2}{\Delta p_1}$$

- The **mechanical horsepower output** transmitted to the rotor is the product of the rotary speed multiplied by the torque :

$$P_m = \frac{TN}{955}$$

- The **hydraulic horsepower** is the product of the pressure drop multiplied by the flow rate :

$$P_h = \frac{\Delta p Q}{60\,000}$$

where :

T = torque (in daN.m)
N = rotary speed (in rpm)
Δp = pressure drop in the motor (in kPa)
Q = mud flow rate (in l/min)
P_h = hydraulic horsepower (in kW)
P_m = mechanical horsepower output at rotor (in kW)

The efficiency is the ratio :

$$\eta = \frac{P_m}{P_h}$$

$$\eta = 62.8 \frac{TN}{\Delta p Q}$$

Example : Navi Drill Mach1 6 3/4.

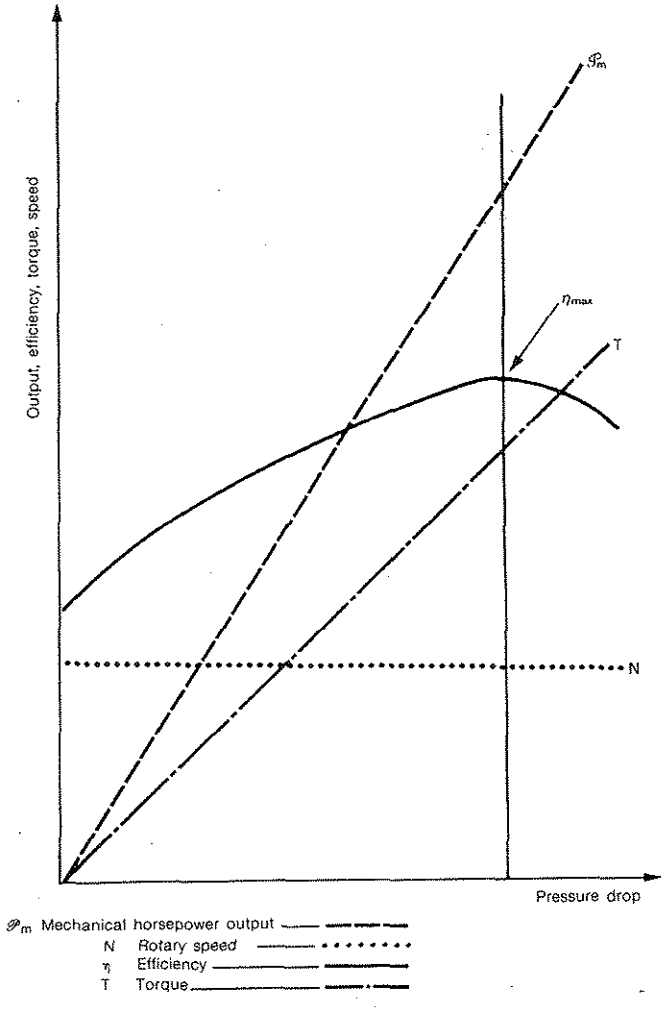
Q_{max} = 1400 l/min $\quad$ T_{max} = 345 daN.m
P_{max} = 4000 kPa $\quad$ N_{max} = 180 rpm

$$P_h = \frac{1400 \times 4000}{60000} = 93 \text{ kW}$$

$$P_m = \frac{345 \times 180}{955} = 65 \text{ kW}$$

$$\eta = \frac{65}{93} = 70\%$$

CHARACTERISTICS CURVES OF POSITIVE DISPLACEMENT MOTORS FOR A GIVEN FLOW RATE



CHARACTERISTICS OF POSITIVE DISPLACEMENT MOTORS (Moineau type)

Size (in)	Manufacturer	Type	No. of lobes	No. of stages	Flow rate (l/min)		Rotary speed (rpm)		Max. torque (daN.m)	Pressure drop (kPa)	Max. horsepower output (kW)	Hole size (in)
					Min.	Max.	Min.	Max.				
1 3/4	Dynadrill	D500	1/2	5	70	85	550	810	3.4	1400	2.7	1 7/8 - 2 3/4
	Eastman Christensen	Mach2	1/2	3	75	170	720	1750	3.5	3200	6.4	1 7/8 - 2 3/4
2 3/8	Eastman Christensen	Mach2	1/2	5	110	275	550	1370	11.5	4800	16	2 7/8 - 3 1/2
2 3/4	Dynadrill	D1000	1/2	8.5	150	300	790	1590	15	6900	25	3 - 4 5/8
3 1/2	Drilex	D350	9/10		300	415	240	330	54	5800	18	
3 3/4	Eastman Christensen	Mach1	5/6	4.5	280	550	125	250	100	4400	26	4 1/4 - 5 7/8
	Eastman Christensen	Mach2	1/2	4	280	700	280	700	52	4000	38	4 1/4 - 5 7/8
	Eastman Christensen	Mach3	1/2	4	230	550	340	855	33	4000	30	4 1/4 - 5 7/8
	Magna drill	M.Tool	1/2	6	380	680	485	874	60	5300	54	4 1/4 - 6 1/2
3 7/8	Dynadrill	D1000	1/2	5	280	660	320	745	62	5200	49	4 5/8 - 6
4 3/4	Drilex	D475	5/6		378	946	140	350	244	6800	89	
	Eastman Christensen	Mach1	5/6	4	300	700	90	215	140	4000	32	6 - 7 7/8
	Eastman Christensen	Mach2	1/2	4	380	900	245	600	79	4000	50	6 - 7 7/8
	Eastman Christensen	Mach3	1/2	4	300	700	270	680	56	4000	40	6 - 7 7/8
	Magna drill	M.Tools	1/2	4	470	850	315	580	129	5500	78	5 3/4 - 7 7/8
	Neyrfor	VM3000BB	1/2		379	700	360	665	52	3500	36	
	Neyrfor	VM5000	1/2		379	700	360	665	52	3500	36	
	Oncor	PDM1000SH	1/2	3	450	1020	250	550	76	2600	44	6 - 7 7/8
5	Baker	B.Tool	3/4	2		850		180	97	4000	18	6 - 8 3/8
	Dynadrill	D500	1/2	3	570	950	335	560	58	2500	34	6 1/2 - 7 7/8
	Dynadrill	D1000	1/2	3	570	1140	345	690	71	3100	51	6 1/2 - 7 7/8
	Eastman Christensen	Posi drill 2	1/2	3		850		430	80	2480	36	

l/min × 0.264 = gal/min   daN.m × 7.38 = lb.ft   kPa × 0.145 = psi   daN × 2.25 = lb   kW × 1.34 = hp

CHARACTERISTICS OF POSITIVE DISPLACEMENT MOTORS
(Moineau type) (continued)

Size (in)	Manufacturer	Type	No. of lobes	No. of stages	Flow rate (l/min)		Rotary speed (rpm)		Max. torque (daN.m)	Pressure drop (kPa)	Max. Horsepower output (kW)	Hole size (in)
					Min.	Max.	Min.	Max.				
5 1/4	Magna drill	M.Tool	1/2	4	570	1150	245	500	141	4400	67	6 3/4 - 8 3/4
5 3/4	Oncor	PDM1000LS	1/2	4	660	1420	80	170	344	3000	69	6 3/4 - 8 3/4
6 1/4	Eastman Christensen	Mach3	1/2	4	650	1300	200	510	138	4000	73	7 7/8 - 9 7/8
6 1/2	Dynadrill	D500	1/2	3	760	1330	275	480	94	2500	47	8 3/8 - 9 7/8
	Dynadrill	D1000	1/2	4	950	1510	280	450	181	4100	85	8 3/8 - 9 7/8
	Dynadrill	F2000S	5/6	3.5	950	1700	100	180	380	3100	72	8 3/8 - 9 7/8
	Dynadrill	F2000S	9/10	3	1140	1900	80	130	542	3700	74	8 3/8 - 9 7/8
	Eastman Christensen	*Posi-drill2*	*1/2*	*3*		*1230*		*390*	*110*	*2480*	*45*	*8 3/8 - 9 7/8*
	Oncor	PDM1000DD			850	1420	275	457	130	2600	60	8 3/8 - 9 7/8
	Oncor	PDM1000SH	1/2		850	1420	275	457	170	3500	80	8 3/8 - 9 7/8
	Oncor	PDM1000LS			850	1420	90	150	545	4200	85	8 3/8 - 9 7/8
6 5/8	Neyrfor	VM3000	1/2		625	1400	175	390	176	3500	72	
	Neyrfor	VM5000	1/2		690	1400	195	395	354	7000	148	
6 3/4	Drilex	D675	9/10	2.5	760	2460	55	185	814	6800	158	7 1/2 - 9 5/8
	Eastman Christensen	*Mach1*	*5/6*	*4*	*700*	*1400*	*90*	*180*	*345*	*4000*	*65*	*8 3/8 - 9 7/8*
	Eastman Christensen	Mach2	1/2	4	760	1800	205	485	203	4000	103	8 3/8 - 9 7/8
	Eastman Christensen	Mach3	1/2	3	600	1500	140	480	135	3200	68	8 3/8 - 9 7/8
	Magna drill	M.Tool	1/2	4	990	1700	255	460	325	5400	157	8 3/8 - 9 7/8
7 3/4	Baker	B.Tool	3/4	2		1700		140	290	2300	41	9 7/8 - 17 1/2
	Dynadrill	D500	1/2	3	1140	1700	275	415	153	2500	67	9 7/8 - 12 1/4
	Dynadrill	D1000	1/2	4	1140	1890	245	410	293	4100	125	9 7/8 - 12 1/4
	Dynadrill	F2000S	7/8	4.75	1140	2270	75	150	1030	5900	162	9 7/8 - 12 1/4
	Eastman Christensen	Posi drill 2	1/2	3		1510		305	142	2480	45	
	Oncor	*PDM1000DD*	*1/2*	*4*	*1130*	*2080*	*222*	*406*	*210*	*2580*	*89*	*9 7/8 - 12 1/4*
	Oncor	PDM1000SH			1130	2080	222	406	280	3450	119	9 7/8 - 12 1/4
	Oncor	PDM1000LS			1130	2080	80	150	810	4130	127	9 7/8 - 12 1/4

l/min × 0.264 = gal/min   daN.m × 7.38 = lb.ft   kPa × 0.145 = psi   daN × 2.25 = lb   kW × 1.34 = hp

CHARACTERISTICS OF POSITIVE DISPLACEMENT MOTORS
(Moineau type) (continued)

Size (in)	Manufacturer	Type	No. of lobes	No. of stages	Flow rate (l/min)		Rotary speed (rpm)		Max. torque (daN.m)	Pressure drop (kPa)	Max. horsepower output (kW)	Hole size (in)
					Min.	Max.	Min.	Max.				
8	Eastman Christensen	Mach1	5/6	8	1200	2300	75	150	545	3200	86	9 1/2 - 12 1/4
	Eastman Christensen	Mach2	1/2	3	930	2400	145	380	283	3200	113	9 1/2 - 12 1/4
	Eastman Christensen	Mach3	1/2	3	750	1800	160	400	200	3200	84	9 1/2 - 12 1/4
	Magna drill	M.Tool	1/2	5	1130	2270	220	440	350	6800	160	9 1/2 - 12 1/4
	Neyrfor	VM3000	1/2		1240	2200	215	380	209	2500	83	
	Neyrfor	VM3000X	1/2		1000	2200	190	420	262	3500	115	
8 1/4	Drilex	D825	9/10	2.5	760	2460	55	185	814	6800	158	9 1/2 - 12 1/4
9 1/2	Drilex	D950	10/11	2.5	1890	3220	110	190	1020	8200	203	12 1/4 - 17 1/2
	Eastman Christensen	Mach1	5/6	4.5	1500	2400	90	145	835	4400	127	12 1/4 - 17 1/2
	Eastman Christensen	Mach2	1/2	5	1500	2800	195	365	528	4800	202	12 1/4 - 17 1/2
	Eastman Christensen	Mach3	1/2	3	900	2300	130	340	309	3200	110	12 1/4 - 17 1/2
	Eastman Christensen	Mach3N	1/2	2.5	1500	3400	140	325	300	2000	102	12 1/4 - 17 1/2
	Eastman Christensen	Posi drill 2	1/2	3		2450		290	261	2480	79	
	Neyrfor	VM5000	1/2		1495	3000	198	400	448	4150	188	
9 5/8	Dynadrill	D500	1/2	3	1510	2270	215	375	262	2500	103	12 1/4 - 17 1/2
	Dynadrill	HS2000	1/2	3	1890	3020	440	705	544	8600	401	12 1/4 - 17 1/2
	Magna drill	M.Tool	1/2	4	1510	3400	170	380	490	3500	195	11 1/4 - 17 1/2
	Magna drill	M.Tool S	1/2	3	1890	3780	140	280	560	2600	164	11 1/4 - 17 1/2
	Oncor	PDM1000DD	1/2	4	1700	3210	225	425	310	2600	138	12 1/4 - 17 1/2
11 1/4	Eastman Christensen	Mach1	5/6	3.5	2000	4000	70	140	1200	3600	176	17 1/2 - 26
	Eastman Christensen	Mach2	1/2	3	2000	4000	120	250	730	3200	191	17 1/2 - 26
	Eastman Christensen	Mach3	1/2	3	1100	2600	115	290	405	3200	123	17 1/2 - 26
12	Dynadrill	D500	1/2	3	2650	4540	130	225	868	2500	205	17 1/2 - 26

l/min × 0.264 = gal/min daN.m × 7.38 = lb.ft kPa × 0.145 = psi daN × 2.25 = lb kW × 1.34 = hp

F

hoisting and derrick floor equipment

F

HOISTING MECHANICS
Reeving function

F = hook load (t)
N = number of lines
t = tension of dead line (t)
t_a = tension of fast line (t)

$$\boxed{t = \frac{F}{N}}$$

$$\begin{array}{r l} \text{in static conditions} & \left\{ \begin{array}{l} t_a = t \\ t_a = \dfrac{t}{\eta_m} \end{array} \right. \\ \text{in dynamic conditions} & \end{array}$$

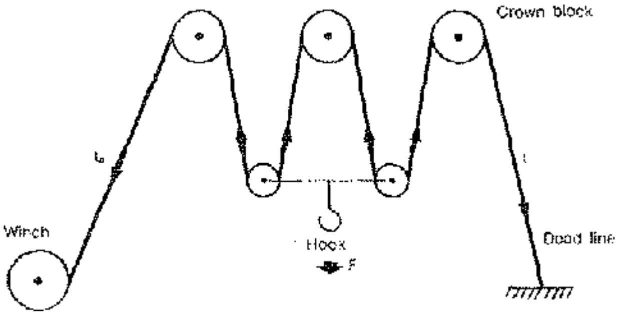
η_m = reeving efficiency (see F3)

V_c = hook speed (m/s)
V_t = fast line speed (m/s)

$$\boxed{V_t = V_c N}$$

R = winch speed of rotation (rpm)
D = winch spooling diameter (m)

$$\boxed{R = \frac{60 V_t}{\pi D}}$$



HOISTING MECHANICS
Power

I POWER DEVELOPED AT HOOK

$$\boxed{P_c = FV_c}$$

P_c = power on hook (W)
F = hook load (N)
V_c = hook speed (m/s)

$$P_c(\text{kW}) = \frac{F(\text{kg}) \times V_c(\text{m/s})}{102}$$

$$P_c(\text{hp}) = \frac{F(\text{kg}) \times V_c(\text{m/s})}{76}$$

$$P_c(\text{hp}) = \frac{F(\text{lb}) \times V_c(\text{ft/s})}{550}$$

II POWER CONSUMED AT WINCH

$$\boxed{P_t = t_a V_t}$$

P_t = winch power (W)
t_a = fast line tension (N)
V_t = fast line speed (m/s)
t = dead line tension (N)

$$P_t = \frac{t}{\eta_m} V_c N = \frac{FV_c}{\eta_m}$$

$$\boxed{P_t = \frac{FV_c}{\eta_m}}$$

F = hook load (N)
V_c = hook speed (m/s)
η_m = reeving efficiency

III TORQUE CONSUMPTION AT WINCH

$$\boxed{M = \frac{P_t}{R}}$$

M = winch torque (m.N)
R = speed of rotation (rad/s)

$$M(\text{m.daN}) = \frac{955 P_t\ (\text{kW})}{R\,(\text{rpm})}$$

$$M(\text{ft.lb}) = \frac{5252 P_t\ (\text{hp})}{R\,(\text{rpm})}$$

API WIRE ROPE

Factor of safety (RP 9B, 30 May 1986)

I DEFINITION OF FACTOR OF SAFETY

$$\boxed{f = \frac{T}{t_a}}$$

f = factor of safety
T = wire rope breaking load (t)
t_a = fast line tension (t)

II MINIMUM FACTOR OF SAFETY

Cable rig	3
Sand line	3
Rotary drilling line	3
Hoisting other than drilling line	3
Mast raising line	2.5
Drilling line when running in casing	2
Extra pull for unsticking or other occasional operations	2

III CALCULATION OF FAST LINE TENSION

$$\boxed{t_a = \frac{F}{N\eta_m}}$$

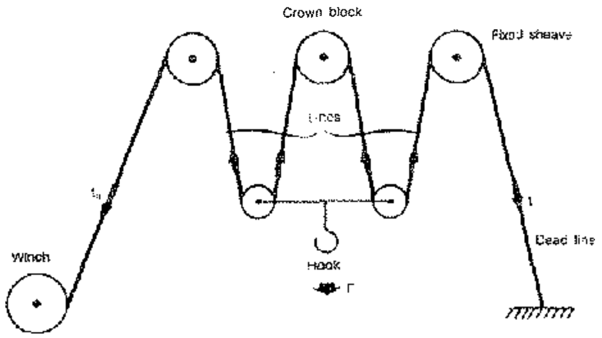
F = hook load (t)
t_a = fast line tension (t)
N = number of lines
η_m = reeving efficiency

REEVING EFFICIENCY

Friction factor \ N	2	4	6	8	10	12	14
K = 1.09 Plain bearings	0.880	0.810	0.748	0.692	0.642	0.597	0.556
K = 1.04 Roller bearings	0.943	0.907	0.874	0.842	0.811	0.782	0.755

$$\boxed{\eta_m = \frac{K^N - 1}{N(K - 1)K^N}}$$

API WIRE ROPE
Factor of safety (RP 9B, 30 May 1986) (continued)



IV EXAMPLE OF APPLICATION

The hoisting equipment is reeved with eight lines: $N = 8$.

The hook load is 150 t.

The drilling line is: 1 1/4, 6 × 19 IWRC, EIPS with breaking load $T = 72.5$ t.

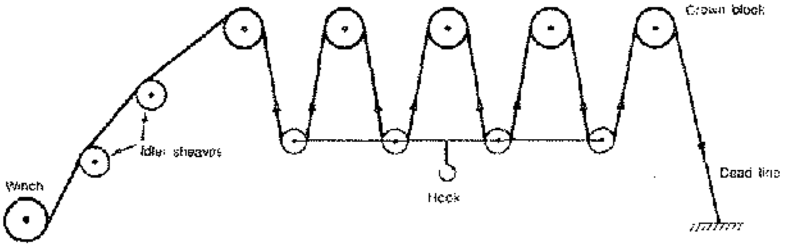
The sheaves have bearings, thus $K = 1.04$ or sheave efficiency η_P:

$$\eta_P = \frac{1}{1.04}$$

$$t_a = \frac{P}{N \times \eta_m} = \frac{150}{8 \times 0.842} = 22.27 \text{ t}$$

$$f = \frac{T}{t_a} = \frac{72.5}{22.27} = 3.26$$

Remark: if idler sheaves are placed between the drilling winch and the crown block, the fast line tension must be multiplied by the friction factor ($K = 1.04$) as many times as the number of sheaves:



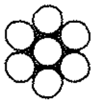
$t_a = 22.27 \times 1.04 \times 1.04 = 24$ t. The factor of safety becomes: $\frac{72.5}{24} = 3.01$

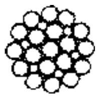
API WIRE ROPE

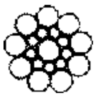
I DEFINITIONS AND USUAL ABBREVIATIONS

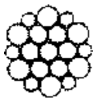
W	Warrington	The outside layer contains filling wires.
S	Seale	*All layers contain the same number of wires.*
WS	Warrington-Seale	Mixed strand, Warrington inside and Seale outside.
FS	Flattened Strand	Flat Strand.
FW	*Filler Wire*	*Inner layer with filler wires.*
PS	Plow Steel	Steel with breaking strength between 1570 and 1760 MPa.
IPS	Improved Plow Steel	Steel with breaking strength between 1770 and 1960 MPa.
EIPS	Extra Improved Plow Steel	Steel with breaking strength between 1970 and 2150 MPa.
PF	*Preformed*	*Preformed* wires.
NPF	Non Preformed	Non preformed wires.
RL	Right Lay	Normal (regular) right lay: the strands are twisted to the right and the wires to the left.
LL	Left Lay	Normal (regular) left lay; the strands are twisted to the left and the wires to the right.
FC	Fiber Core	Fiber core.
IWRC	Independant *Wire Rope Core*	*Independant wire rope core.*

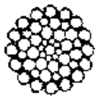
II TYPICAL STRAND CONSTRUCTION


SINGLE LAYER
e.g. strand 1-6


FILLER WIRE
Inner layer contains filling wires
e.g.: 1-6-6f-12
↗
Filler wires


SEALE
Two layers *with the same* number of wires
e.g.: 1-9-9


WARRINGTON
Two layers *with wires of* the same diameter
The outside layer contains filler wires
e.g.: 1-6-(6 + 6)


MIXED WARRINGTON SEALE
The first two layers are Warrington and the last two Seale
e.g.: 1-5-(5 + 5)-10

III DIFFERENT KINDS OF WIRE ROPE TWISTING


Right lay
regular lay


Left lay
regular lay


Right lay
lang lay


Left lay
lang lay

In ropes with " regular " lay the wires are twisted in one direction and the strands in the opposite direction.

In ropes with " lang " lay the wire and the strands are twisted in the same direction.

TYPICAL SIZES AND CONSTRUCTIONS OF WIRE ROPE

Service and well depth	Wire rope diameter (in)	Wire rope description (regular lay)
Rod and tubing pull lines:		
Shallow	1/2 to 3/4 incl.	6 × 25 FW or 6 × 26 WS or 6 × 31 WS or 18 × 7 (1) or 19 × 7 (1), PF, LL (1), IPS or EIPS, IWRC
Intermediate	3/4 to 7/8	
Deep	7/8 to 1 1/8 incl.	
Rod hanger lines	.1/4	6 × 19, PF, RL, IPS, FC
Sand lines:		
Shallow	1/4 to 1/2 incl.	6 × 7 Bright or Galv (2), PF, RL, PS or IPS, FC
Intermediate	1/2, 9/16	
Deep	9/16, 5/8	
Drilling lines. Cable tool (drilling and cleanout):		
Shallow	5/8, 3/4	6 × 21 FW, PF or NPF, RL or LL, PS or IPS, FC
Intermediate	3/4, 7/8	
Deep	7/8, 1	
Casing lines. Cable tool:		
Shallow	3/4, 7/8	6 × 25 FW or 6 × 26 WS, PF, RL, IPS or EIPS, FC or IWRC
Intermediate	7/8, 1	
Deep	1, 1 1/8	
Drilling lines. Coring and slim hole rotary rigs:		
Shallow	7/8, 1	6 × 26 WS, PF, RL, IPS or EIPS, IWRC
Intermediate	1, 1 1/8	6 × 19 S or 6 × 26 WS, PF, RL, IPS or EIPS, IWRC

(1) Single line pulling of rods and tubing requires left lay construction or 18 × 7 or 19 × 7 construction.

(2) Bright wire sand lines are regularly furnished: galvanized finish is sometimes required.

TYPICAL SIZES AND CONSTRUCTIONS OF WIRE ROPE
(continued)

Service and well depth	Wire rope diameter (in)	Wire rope description (regular lay)
Drilling lines. Rotary rigs:		
Shallows	1, 1 1/8	6 × 19 S or 6 × 21 S or 6 × 25 FW or FS, PF, RL, IPS or EIPS, IWRC
Intermediate	1 1/8, 1 1/4	
Deep	1 1/4 to 1 3/4	
Winch lines. Heavy duty	5/8 to 7/8 7/8 to 1 1/8 incl.	6 × 26 WS or 6 × 31 WS, PF, RL, IPS or EIPS, IWRC 6 × 36 WS, PF, RL, IPS or EIPS, IWRC
Horsehead pumping. Unit lines:		
Shallow	1/2 to 1 1/8 incl. (4)	6 × 19 Class or 6 × 37 Class or 19 × 7 PF, IPS, FC or IWRC
Intermediate	5/8 to 1 1/8 incl. (3)	6 × 19 Class or 6 × 37 Class, PF, IPS, FC or IWRC
Offshore anchorage lines	*7/8 to 2 3/4 incl.* 1 3/8 to 4 3/4 incl. 3 3/4 to 4 3/4 incl.	*6 × 19 Class, Bright or Galv., PF, RL, IPS or EIPS, IWRC* 6 × 37 Class, Bright or Galv., PF, RL, IPS or EIPS, IWRC 6 × 61 Class, Bright or Galv., PF, RL, IPS or EIPS, IWRC
Mast raising lines (5)	1 3/8 and smaller 1 1/2 and larger	6 × 19 Class, PF, RL, IPS or EIPS, IWRC 6 × 37 Class, PF, RL, IPS or EIPS, IWRC
Guideline tensioner line	3/4	6 × 25 FW, PF, RL, IPS or EIPS, IWRC
Riser tensioner lines	1 1/2, 2	*(Lang Lay) : 6 × 37 Class or PF, RL, IPS or EIPS, IWRC*

(3) Applies to pumping units having one piece of wire rope looped over an ear on the horsehead and both ends fastened to a polished-rod equalizer yoke.

(4) *Applies to pumping units having two vertical lines* (parallel) with sockets at both ends of each line.

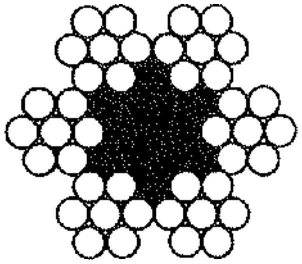
(5) See API Spec 4E.

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE

Class 6 × 7. Fiber core (FC)

Nominal diameter		Approximate weight		Breaking strength					
				Plow Steel (PS)			Improved Plow Steel (IPS)		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
3/8	9.5	0.21	0.31	10 200	45.4	4.63	11 720	52.1	5.32
7/16	11.1	0.29	0.43	13 800	61.4	6.26	15 860	70.5	7.20
1/2	12.7	0.38	0.57	17 920	79.7	8.13	20 600	91.6	9.35
9/16	14.5	0.48	0.71	22 600	101.0	10.30	26 000	116.0	11.80
5/8	15.9	0.59	0.88	27 800	124.0	12.60	31 800	141.0	14.40
3/4	19.1	0.84	1.25	39 600	176.0	18.00	45 400	202.0	20.60
7/8	22.2	1.15	1.71	53 400	238.0	24.20	61 400	273.0	27.90
1	25.4	1.50	2.23	69 000	307.0	31.30	79 400	353.0	36.00

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.



Rope configuration
6 × 7

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Classes 6 × 19 and 6 × 37. Fiber Core (FC)

Nominal diameter		Approximate weight		Breaking strength					
				Plow Steel (PS)			Improved Plow Steel (IPS)		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.42	0.63	18 700	83	8.5	21 400	95	9.7
9/16	14.5	0.53	0.79	23 600	105	10.7	27 000	120	12.2
5/8	15.9	0.66	0.98	29 000	129	13.2	33 400	149	15.1
3/4	19.1	0.95	1.41	41 400	184	18.8	47 600	212	21.6
7/8	22.2	1.29	1.92	56 000	249	25.4	64 400	286	29.2
1	25.4	1.68	2.50	72 800	324	33.0	83 600	372	37.9
1 1/8	28.6	2.13	3.17	91 400	407	41.5	105 200	468	47.7
1 1/4	31.8	2.63	3.91	112 400	500	51.0	129 200	575	58.6
1 3/8	34.9	3.18	4.73				155 400	691	70.5
1 1/2	38.1	3.78	5.63				184 000	818	83.5
1 5/8	41.3	4.44	6.61				214 000	952	97.1
1 3/4	44.5	5.15	7.66				248 000	1100	112.0
1 7/8	47.6	5.91	8.80				282 000	1250	128.0
2	50.8	6.72	10.00				320 000	1420	145.0

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE *(continued)*

Class 6 × 19. Independent Wire Core (IWRC)

Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.46	0.68	23 000	102	10.4	26 600	118	12.1
9/16	14.5	0.59	0.88	29 000	129	13.2	33 600	149	15.2
5/8	15.9	0.72	1.07	35 800	159	16.2	41 200	183	18.7
3/4	19.1	1.04	1.55	51 200	228	23.2	58 800	262	26.7
7/8	22.2	1.42	2.11	69 200	308	31.4	79 600	354	36.1
1	25.4	1.85	2.75	89 800	399	40.7	103 400	460	46.9
1 1/8	28.6	2.34	3.48	113 000	503	51.3	130 000	578	59.0
1 1/4	31.8	2.89	4.30	138 800	617	63.0	159 800	711	72.5
1 3/8	34.9	3.50	5.21	167 000	743	75.7	192 000	854	87.1
1 1/2	38.1	4.16	6.19	197 800	880	89.7	228 000	1010	103.0
1 5/8	41.3	4.88	7.26	230 000	1020	104.0	264 000	1170	120.0
1 3/4	44.5	5.67	8.44	266 000	1180	121.0	306 000	1360	139.0
1 7/8	47.6	6.50	9.67	203 000	1350	138.0	348 000	1550	158.0
2	50.8	7.39	11.00	344 000	1530	156.0	396 000	1760	180.0

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

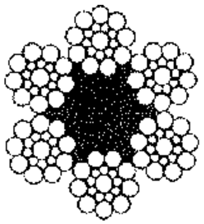
Class 6 × 37. Independent Wire Rope Core (IWRC)

Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.46	0.68	23 000	102	10.4	26 600	118	12.1
9/16	14.5	0.59	0.88	29 000	129	13.2	33 600	149	15.2
5/8	15.9	0.72	1.07	35 800	159	16.2	41 200	183	18.7
3/4	19.1	1.04	1.55	51 200	228	23.2	58 800	262	26.7
7/8	22.2	1.42	2.11	69 200	308	31.4	79 600	354	36.1
1	25.4	1.85	2.75	89 800	399	40.7	103 400	460	46.9
1 1/8	28.6	2.34	3.48	113 000	503	51.3	130 000	578	59.0
1 1/4	31.8	2.89	4.30	138 800	617	63.0	159 800	711	72.5
1 3/8	34.9	3.50	5.21	167 000	743	75.7	192 000	854	87.1
1 1/2	38.1	4.16	6.19	197 800	880	89.7	228 000	1010	103.0
1 5/8	41.3	4.88	7.26	230 000	1020	104.0	264 000	1170	120.0
1 3/4	44.5	5.67	8.44	266 000	1180	121.0	306 000	1360	139.0
1 7/8	47.6	6.50	9.67	304 000	1350	138.0	348 000	1550	158.0
2	50.8	7.39	11.00	344 000	1530	156.0	396 000	1760	180.0
2 1/8	54.0	8.35	12.40	384 000	1710	174.0	442 000	1970	200.0
2 1/4	57.2	9.36	13.90	430 000	1910	195.0	494 000	2200	224.0
2 3/8	60.3	10.40	15.50	478 000	2130	217.0	548 000	2440	249.0
2 1/2	63.5	11.60	17.30	524 000	2330	238.0	604 000	2690	274.0
2 5/8	66.7	12.80	19.00	576 000	2560	261.0	658 000	2930	299.0
2 3/4	69.9	14.00	20.80	628 000	2790	285.0	736 000	3270	333.0
2 7/8	73	15.30	22.80	682 000	3030	309.0	796 000	3540	361.0
3	76.2	16.60	24.70	740 000	3290	336.0	856 000	3810	389.0
3 1/8	79.4	18.00	26.80	798 000	3550	362.0	920 000	4090	417.0
3 1/4	82.6	19.50	29.00	858 000	3820	389.0	984 000	4380	447.0
3 3/8	85.7	21.00	31.30	918 000	4080	416.0	1 074 000	4780	487.0
3 1/2	88.9	22.70	33.80	982 000	4370	445.0	1 144 000	5090	519.0
3 3/4	95.3	26.00	38.70	1 114 000	4960	505.0	1 290 000	5740	585.0
4	101.6	29.60	44.00	1 254 000	5580	569.0	1 466 000	6520	665.0

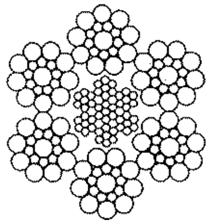
Note: The strength of galvanized wire rope is 10% less than the figures given in this table.

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

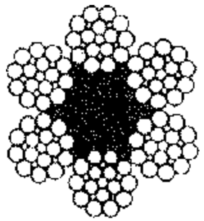
Configurations (API Spec 9A, May 1984)



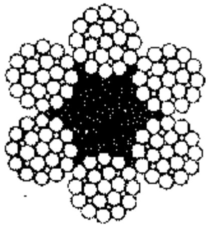
6 × 19 SEALE
FIBER CORE



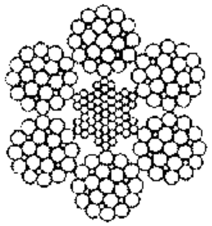
6 × 19 SEALE
INDEPENDANT WIRE-ROPE CORE



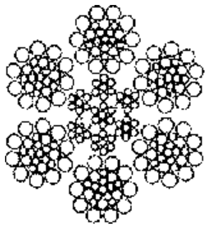
6 × 21 FILLER WIRE
FIBER CORE



6 × 25 FILLER WIRE
FIBER CORE



6 × 25 FILLER WIRE
INDEPENDANT WIRE-ROPE CORE

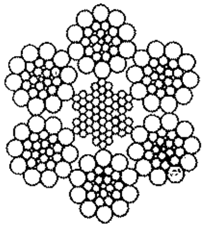


6 × 26 WARRINGTON SEALE
INDEPENDANT WIRE-ROPE CORE

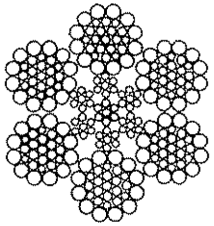
CLASSIFICATION 6 × 19

API CLASSIFICATION API OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

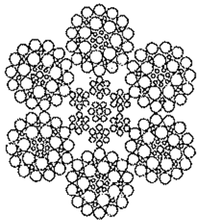
Configurations (API Spec 9A, May 1984)



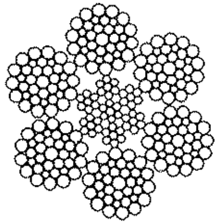
6 × 31 FILLER WIRE SEALE
INDEPENDANT WIRE-ROPE CORE



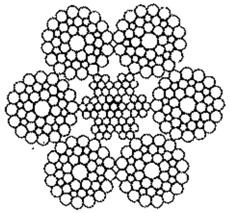
6 × 31 WARRINGTON SEALE
INDEPENDANT WIRE-ROPE CORE



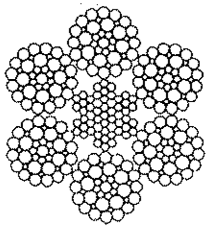
6 × 36 FILLER WIRE
INDEPENDANT WIRE-ROPE CORE



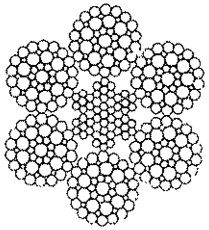
6 × 36 WARRINGTON SEALE
INDEPENDANT WIRE-ROPE CORE



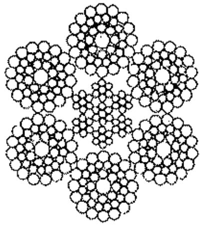
6 × 41 WARRINGTON SEALE
INDEPENDANT WIRE-ROPE CORE



6 × 41 FILLER WIRE
INDEPENDANT WIRE-ROPE CORE



6 × 46 FILLER WIRE
INDEPENDANT WIRE-ROPE CORE



6 × 49 FILLER WIRE SEALE
INDEPENDANT WIRE-ROPE CORE

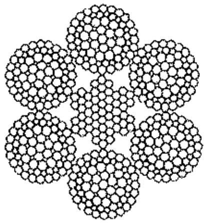
CLASSIFICATION 6 × 37.

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

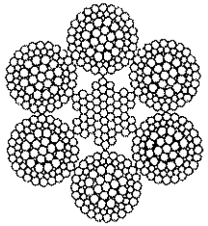
Class 6 × 61. Independent Wire Rope Core (IWRC)

Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(10^3 lb)	(kN)	(t)	(10^3 lb)	(kN)	(t)
3 1/2	88.9	22.7	33.8	966	4300	438	1 110	4940	503
3 3/4	95.3	26.0	38.7	1 098	4880	498	1 264	5620	573
4	101.6	29.6	44.0	1 240	5520	562	1 426	6340	647
4 1/4	108.0	33.3	49.6	1 388	6170	630	1 598	7110	725
4 1/2	114.3	37.4	55.7	1 544	6870	700	1 776	7900	806
4 3/4	120.7	41.7	62.1	1 706	7590	774	1 962	8730	890
5	127.0	46.2	68.8	1 874	8340	850	2 156	9590	978

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.



6 × 61 WARRINGTON SEALE
INDEPENDANT WIRE-ROPE CORE



6 × 73 FILLER WIRE SEALE
INDEPENDANT WIRE-ROPE CORE

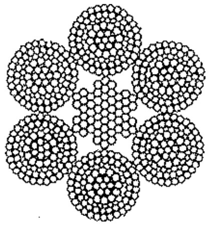
CLASSIFICATION 6 × 61

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

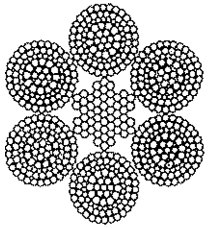
Class 6 × 91. Independent Wire Rope Core (IWRC)

Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(10^3 lb)	(kN)	(t)	(10^3 lb)	(kN)	(t)
4	101.6	29.6	44.1	1 178	5240	534	1 354	6020	614
4 1/4	108.0	33.3	49.6	1 320	5870	599	1 518	6750	689
4 1/2	114.3	37.4	55.7	1 468	6530	666	1 688	7510	766
4 3/4	120.7	41.7	62.7	1 620	7210	735	1 864	8290	846
5	127	46.2	68.7	1 782	7930	808	2 048	9110	929
5 1/4	133.4	49.8	74.1	1 948	8670	884	2 240	9960	1016
5 1/2	139.7	54.5	81.1	2 120	9430	962	2 438	10800	1106
5 3/4	146.1	59.6	88.7	2 296	10200	1049	2 640	11700	1198
6	152.4	65.0	96.7	2 480	11000	1125	2 852	12700	1294

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.



6 × 91
INDEPENDANT WIRE-ROPE CORE



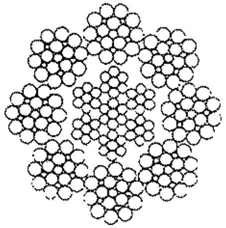
6 × 103
INDEPENDANT WIRE-ROPE CORE

CLASSIFICATION 6 × 91

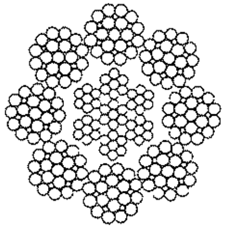
API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Class 8 × 19. Independent Wire Rope Core (IWRC)

Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.47	0.70	20 200	90	9.2	23 400	104	10.5
9/16	14.5	0.60	0.89	25 600	114	11.6	29 400	131	13.3
5/8	15.9	0.73	1.09	31 400	140	14.2	36 200	161	16.4
3/4	19.1	1.06	1.58	45 000	200	20.4	51 800	230	23.5
7/8	22.2	1.44	2.14	61 000	271	27.7	70 000	311	31.8
1	25.4	1.88	2.80	79 200	352	35.9	91 000	405	41.3
1 1/8	28.6	2.39	3.56	99 600	443	45.2	114 600	507	51.7



8 × 21 FILLER WIRE
INDEPENDANT WIRE-ROPE CORE

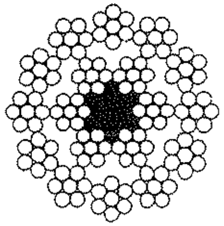


8 × 25 FILLER WIRE
INDEPENDANT WIRE-ROPE CORE

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Class 18 × 7. Fiber Core (FC)

Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.43	0.64	19 700	88	8.9	21 600	96	9.8
9/16	14.5	0.55	0.82	24 800	110	11.2	27 200	121	12.3
5/8	15.9	0.68	1.01	30 600	136	13.9	33 600	149	15.2
3/4	19.1	0.97	1.44	43 600	194	19.8	48 000	214	21.8
7/8	22.2	1.32	1.96	59 000	262	26.8	65 000	289	29.5
1	25.4	1.73	2.57	76 600	341	34.7	84 400	375	38.3
1 1/8	28.6	2.19	3.26	96 400	429	43.7	106 200	472	48.2
1 1/4	31.8	2.70	4.02	118 400	527	53.7	130 200	579	59.1
1 3/8	34.9	3.27	4.87	142 600	634	64.7	156 800	697	71.1
1 1/2	38.1	3.89	5.79	168 800	751	76.6	185 600	826	84.2

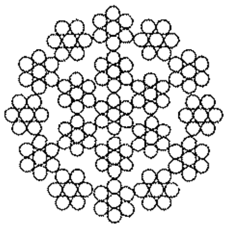


18 × 7 NON-ROTATING WIRE ROPE
FIBER CORE

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Class 19 × 7. Metal core

Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.45	0.67	19 700	88	8.9	21 600	96	9.8
9/16	14.5	0.58	0.86	24 800	110	11.2	27 200	121	12.3
5/8	15.9	0.71	1.06	30 600	136	13.9	33 600	149	15.2
3/4	19.1	1.02	1.52	43 600	194	19.8	48 000	214	21.8
7/8	22.2	1.39	2.07	59 000	262	26.8	65 000	289	29.5
1	25.4	1.82	2.71	76 600	341	34.7	84 400	375	38.3
1 1/8	28.6	2.30	3.42	96 400	429	43.7	106 200	472	48.2
1 1/4	31.8	2.84	4.23	118 400	527	53.7	130 200	579	59.1
1 3/8	34.9	3.43	5.10	142 600	634	64.7	156 800	697	71.1
1 1/2	38.1	4.08	6.07	168 800	751	76.6	185 600	826	84.2

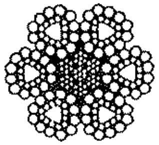


19 × 7 NON-ROTATING WIRE-ROPE

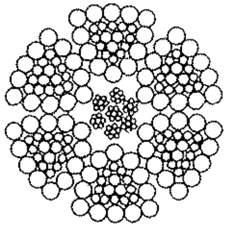
API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Classes 6 × 25 « B », 6 × 27 « H », 6 × 30 « G » and 6 × 31 « V »

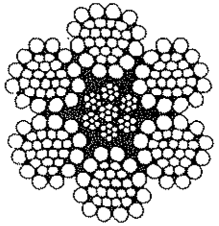
Nominal diameter		Approximate weight		Breaking strength			
				Improved Plow Steel		Extra Improved Plow Steel	
(in)	(mm)	(lb/ft)	(kg/m)	(sh.tons)	(t)	(sh.tons)	(t)
1/2	12.7	0.47	0.70	12.6	11.4	14.0	12.7
9/16	13.5	0.60	0.89	16.0	14.5	17.6	16.0
5/8	15.9	0.73	1.09	19.6	17.8	21.7	19.7
3/4	19.1	1.06	1.58	28.1	25.5	31.0	28.1
7/8	22.2	1.46	2.17	38.0	34.5	41.9	38.0
1	25.4	1.89	2.83	49.4	44.8	54.4	49.4
1 1/8	28.6	2.39	3.56	62.2	56.4	68.5	62.1
1 1/4	31.8	2.95	4.39	76.3	69.2	84.0	76.2
1 3/8	34.9	3.57	5.31	91.9	83.4	101.0	91.6
1 1/2	38.1	4.25	6.32	108.0	98.0	119.0	108.0
1 5/8	41.3	4.98	7.41	127.0	115.0	140.0	127.0
1 3/4	44.5	5.78	8.60	146.0	132.0	161.0	146.0
1 7/8	47.6	6.65	9.90	167.0	152.0	184.0	167.0
2	50.8	7.56	11.30	189.0	171.0	207.0	188.0



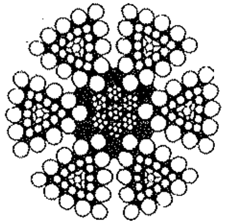
6 × 25 TYPE B
FLATTENED STRAND
DEPENDANT WIRE-ROPE CORE



6 × 27 TYPE H
FLATTENED STRAND



6 × 30 STYLE G
FLATTENED STRAND



6 × 31 TYPE V
FLATTENED STRAND

API WIRE ROPE
Sheave sizes (API RP 9B, 30 May 1986)

I WINCH DRUM

The winch drum must allow wire rope spooling with a minimum of layering. Its diameter must be more than twenty times the nominal rope diameter.

II SHEAVES

$$\boxed{D_T = dF}$$

D_T = sheave groove root diameter
d = nominal rope diameter
F = service factor

Rope Type	Service factor F	
	Conditions	
	A	B
6 × 7	72	42
6 × 17 S	56	33
6 × 19 S	51	30
6 × 21 F	45	26
6 × 25 FW	41	24
6 × 31	38	22
6 × 37	33	18
8 × 19 S	36	21
8 × 19 W	31	18
18 × 7 and 19 × 7	51	36
FS	51	45

Condition A : ideal size.

Condition B : less rigorous size but implying shorter rope life.

Example : with a 6 × 19 wire rope, diameter 1 1/4 inches, in condition A :

$$D_T = 1.25 \times 51 = 63.75 \text{ in}$$

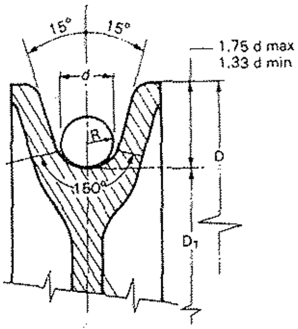
$$= 1620 \text{ mm}$$

In condition B : $D_T = 953 \text{ mm}$

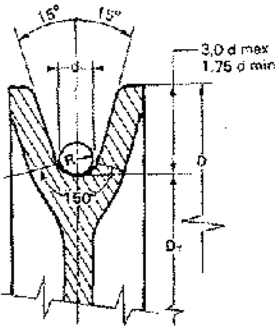
$$= 37.50 \text{ in}$$

SHEAVE GROOVES

Nominal wire rope diameter (in)	New groove root radius: *R*		Worn groove gage radius *R*	
	(in)	(mm)	(in)	(mm)
1/4	0.137	3.48	0.129	3.28
5/16	0.167	4.24	0.160	4.06
3/8	0.201	5.11	0.190	4.83
7/16	0.234	5.94	0.220	5.59
1/2	0.271	6.88	0.256	6.50
9/16	0.303	7.70	0.288	7.32
5/8	0.334	8.48	0.320	8.13
3/4	0.401	10.19	0.380	9.65
7/8	0.468	11.89	0.440	11.18
1	0.543	13.79	0.513	13.03
1 1/8	0.605	15.37	0.577	14.66
1 1/4	0.669	16.99	0.639	16.23
1 3/8	0.736	18.69	0.699	17.75
1 1/2	0.803	20.40	0.759	19.28
1 5/8	0.876	22.25	0.833	21.16
1 3/4	0.939	23.85	0.897	22.78
1 7/8	1.003	25.48	0.959	24.36
2	1.070	27.18	1.019	25.88
2 1/8	1.137	28.88	1.079	27.41
2 1/4	1.210	30.73	1.153	29.29
2 3/8	1.273	32.33	1.217	30.91
2 1/2	1.338	33.99	1.279	32.49
2 5/8	1.404	35.66	1.339	34.01
2 3/4	1.481	37.62	1.409	35.79
2 7/8	1.544	39.22	1.473	37.41
3	1.607	40.82	1.538	39.07



Drilling line and casing line sheave



Sand line sheave

WORK DONE BY A DRILLING LINE

I ROUND-TRIP OPERATIONS

Running the drill string into the hole and pulling the string out of the hole (to change the bit) at depth L:

$$\boxed{T_m = 0.981 \left[pL(L + \ell) + 4\, L\left(P + \frac{d}{2}\right)\right] 10^{-6}}$$

where:

T_m = amount of work (10^3 daN.km)
L = depth of hole (m)
ℓ = length of a stand (m) (single, double or triple) (m)
d = additional weight due to drill collars and bit (accounting for buoyancy) (kg) (See *Note*)
p = weight per meter of drillpipes with tool-joints (accounting for buoyancy) (kg/m)
P = total weight of travelling block/elevator assembly (kg)

II DRILLING OPERATIONS

To drill to depth L_1: $\boxed{T_f = 3 T_{m1}}$

To drill from depth L_1 to depth L_2: $\boxed{T_{f1-2} = 3\, [T_{m2} - T_{m1}]}$

III CORING OPERATION

Between depth L_1, and depth L_2: $\boxed{T_{c1-2} = 2\, [T_{m2} - T_{m1}]}$

Example:

Depth = 400 m; 100 m of DC 8" × 3"; DP 5" − 19.5 (TJ 6 1/4)-E.
Mud d = 1.4; weight of travelling block/elevator assembly P = 8000 kg.
Weight of drillpipes in air = 31.06 kg/m.
Apparent weight = 31.06 × 0.822 = 25.53 kg/m.
Weight of DC in air = 218.8 kg/m.
Weight of DC in mud = 179.85 kg/m.
Total additional apparent weight d = (179.85 − 25.53) × 100 = 15432 kg.

$$T_m = 0.981 \left[25.53 \times 400\ (400 + 27) + 4 \times 400 \left(8000 + \frac{15432}{2}\right)\right] 10^{-6}$$

$$T_m = 28.9 \quad 10^3 \text{ daN.km}$$

Note: If L_{DC} is the length of the drill collars
p_{DC} is the weight per meter of the drill collars accounting for buoyancy:

$$d = L_{DC}\,(p_{DC} - p)$$

CUTOFF PRACTICE FOR DRILLING LINES

Cutoff length as a function of derrick or mast height and drum diameter (API RP 9B)

Derrick or mast height (ft)	Drum diameter (in)													
	11	13	14	16	18	20	22	24	26	28	30	32	34	36
	Cutoff length in meters and number of drum laps													
151 or more										34.6 15.5	34.7 14.5	34.5 13.5	33.9 12.5	33.0 11.5
142 to 150								25.9 13.5	25.9 12.5	25.7 11.5	27.5 11.5	26.8 10.5		
133 to 140						24.7 15.5	25.5 14.5	23.9 12.5	23.9 11.5	25.7 11.5	25.1 10.5	24.3 9.5		
120 to 132				22.3 17.5	22.3 15.5	23.1 14.5	21.9 12.5	23.9 12.5	23.9 11.5	23.5 10.5	22.7 9.5	24.3 9.5		
91 to 119		20.2 19.5	19.6 17.5	18.5 14.5	18.0 12.5	18.4 11.5	18.4 10.5	18.2 9.5	19.7 9.5	19.0 8.5				
73 to 90		18.2 17.5	16.2 14.5	16.0 12.5	16.5 11.5									
up to 72	11.0 12.5	12.0 11.5												

Note: The cutoff length given is a whole number of drum laps plus one half-lap in order to change the rope crossover point, which is a point of high wear.

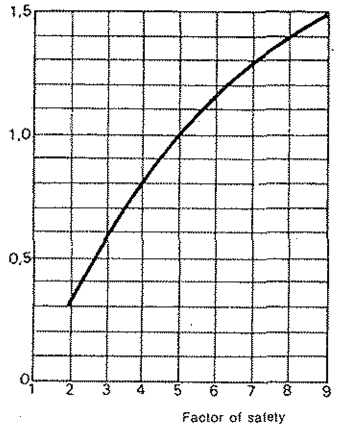
m × 3.28 = ft

CUTOFF PRACTICE FOR DRILLING LINES (1) (continued)
Cumulative work before first cutoff (API RP 9B)

Derrick or mast height (ft)	Drilling difficulties	Total work of drilling line before first cutoff, function of line diameter									
		1"		1 1/8"		1 1/4"		1 3/8"		1 1/2"	
		10^3 daN.km	ton. mile	10^3 daN.km	ton. mile	10^3 daN.km	ton. mile	10^3 daN.km	ton. mile	10^3 daN.km	ton. mile
80 to 87	Very hard	716	500								
	Hard	716	500								
	Medium	716	500								
	Low	859	600								
94 to 100	Very hard	716	500	859	600						
	Hard	716	500	1003	700						
	Medium	716	500	1146	800						
	Low	859	600	1289	900						
126 to 131	Very hard			859	600	1432	1000				
	Hard			1003	700	1575	1100				
	Medium			1146	800	1719	1200				
	Low			1289	900	1862	1300				
133 to 138	Very hard			859	600	1432	1000				
	Hard			1003	700	1575	1100				
	Medium			1146	800	1719	1200				
	Low			1289	900	1862	1300				
142 to 147	Very hard					1432	1000	2292	1600		
	Hard					1575	1100	2578	1800		
	Medium					1719	1200	2864	2000		
	Low					1862	1300	3008	2100		
187 to 189	Very hard							2292	1600	2864	2000
	Hard							2578	1800	3150	2200
	Medium							2864	2000	3437	2400
	Low							3008	2100	3724	2600

(1) This table approximately gives the work done by the drilling line before the first cutoff, for Improved Plow Steel drilling lines with a metal core, using a factor of safety of 5.

If a different factor of safety is selected, the curve opposite gives the correction factor to apply to the work given in the table above.



Example:

Mast height = 138 ft
Wire rope diameter = 1 1/4"
Drilling difficulties = hard
Drum diameter = 28 in
Factor of safety = 3

For a factor of 5, the above table gives 1575 10^3 daN.km

Factor selected = 3. The curve opposite gives a correction factor of 0.58

Work = 1575 × 0,58 = 914 10^3 daN.km before the first cutoff

The table F23 " Cutoff length as a function of drum diameter "gives 25.70 m for 28 in

***Note*: For the following cutoffs, the total work given in the table must be reduced by 100 ton. mile (143 10^3 daN.km) for 1 1/8 in in and smaller wire rope diameter, and by 200 ton.mile (286 10^3 daN.km) for other wire rope diameters.**

DRUM AND REEL CAPACITY
(From IADC Drilling Manual)

- The length of wire rope (in meters) that can be spooled on to a drum or reel is:

$$(A + D) \times A \times B \times K$$

where:

$$A = \frac{H - D}{2} \text{ (cm)}$$

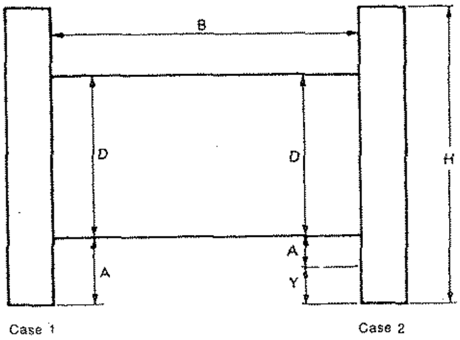
D = diameter of drum barrel (cm)
H = diameter of drum flanges (cm)
K = factor depending on the wire rope diameter *selected*
B = distance between flanges (cm)

- The length of wire rope, in meters, contained on an incompletely filled drum or reel is given by the same formula where:

$$A = \frac{H - D - 2Y}{2}$$

Y = distance between the last rope lay and the flange edge

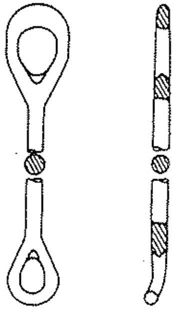
Nominal rope diameter (in)	Factor K	Nominal rope diameter (in)	Factor K	Nominal rope diameter (in)	Factor K
3/8	0.02939	13/16	0.00658	1 5/8	0.00165
7/16	0.02214	7/8	0.00573	1 3/4	0.00143
1/2	0.01721	1	0.00445	1 7/8	0.00126
9/16	0.01378	1 1/8	0.00355	2	0.00111
5/8	0.01129	1 1/4	0.00283	2 1/8	0.00099
11/16	0.00941	1 3/8	0.00236	2 1/4	0.00089
3/4	0.00796	1 1/2	0.00199	2 3/8	0.00078

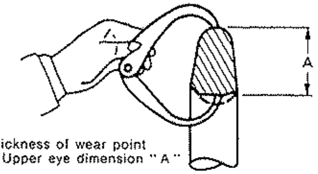


ELEVATOR LINK ARMS
Remaining capacities of worn link arms

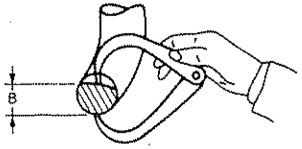
Dimensions and nominal capacity of link arms (per set)

		1 3/4-150 tons				2 1/4-250 tons				2 3/4-350 tons				3 1/2-500 tons			
Dimension A	(in)	3 1/2	3 3/8	3 1/4	3 1/8	5	4 3/4	4 5/8	4 1/2	5	4 3/4	4 5/8	4 1/2	6	5 5/8	5 1/4	5 3/16
	(mm)	88.9	85.7	82.6	79.4	127	120.7	117.5	114.3	127	120.7	117.5	114.3	152.4	142.9	133.4	131.8
Dimension B	(in)	1 3/4	1 5/8	1 9/16	1 1/2	2 1/4	2 1/8	2 1/16	2	2 3/4	2 5/8	2 1/2	2 7/16	3 1/2	3 1/4	3	2 7/8
	(mm)	44.5	41.3	39.7	38.1	57.2	54.0	52.4	50.8	69.9	66.7	63.5	61.9	88.9	82.6	76.2	73.0
Capacity per set	(ton)	150	125	110	100	250	210	188	175	350	290	262	245	500	440	375	345
	10^3 daN	135	112	98	89	222	185	168	155	312	258	234	213	445	392	334	308





Thickness of wear point
in Upper eye dimension " A "



Thickness of wear point
in Lower eye dimension " B "

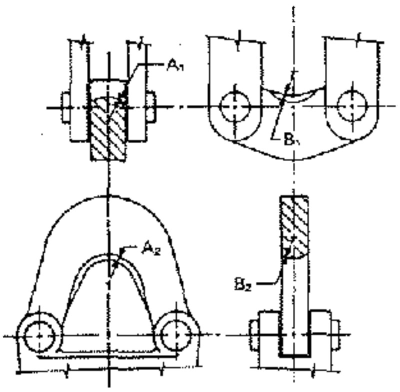
Note: The nominal size of elevator link arms is the thickness at point B.
Capacity of set is that of weakest eye.

RECOMMENDATIONS ON PIPE HANDLING EQUIPMENT CONTACT SURFACE RADII

(API Spec 8A, May 1985)

Capacity		Travelling block and hook bail							
		A_1 Max.		A_2 Min.		B_1 Min.		B_2 Max.	
(tons)	(10^3 daN)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
25-40	22-36	2 3/4	69.8	2 3/4	69.8	3 1/4	82.5	3	76.2
41-65	36-57	2 3/4	69.8	2 3/4	69.8	3 1/4	82.5	3	76.2
66-100	57-89	2 3/4	69.8	2 3/4	69.8	3 1/4	82.5	3	76.2
101-150	89-133	2 3/4	69.8	2 3/4	69.8	3 1/4	82.5	3	76.2
151-250	133-222	4	101.6	4	101.6	3 1/4	82.5	3	76.2
251-350	222-312	4	101.6	4	101.6	3 1/4	82.5	3	76.2
351-500	312-445	4	101.6	4	101.6	3 1/2	88.9	3 1/4	82.5
501-650	445-578	4	101.6	4	101.6	3 1/2	88.9	3 1/4	82.5
651-750	578-667	6	152.4	6	152.4	3 1/2	88.9	3 1/4	82.5
751-1000	667-890	6	152.4	6	152.4	6 1/4	158.75	6	152.4

Travelling block



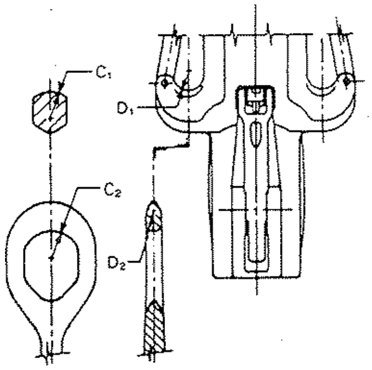
Hook bail

RECOMMENDATIONS ON PIPE HANDLING EQUIPMENT CONTACT SURFACE RADII

(API Spec 8A, May 1985)

Capacity		Elevator link and link ear							
		C_1 Max.		C_2 Min.		D_1 Min.		D_2 Max.	
(tons)	(10^3 daN)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
25-40	22-36	1 1/2	38.1	1 1/2	38.1	1 1/4	31.7	7/8	22.2
41-65	36-57	2 1/2	63.5	2 1/2	63.5	1 1/4	31.7	7/8	22.2
66-100	57-89	2 1/2	63.5	2 1/2	63.5	1 1/2	38.1	1 1/2	28.6
101-150	89-133	2 1/2	63.5	2 1/2	63.5	1 1/2	38.1	1 1/2	28.6
151-250	133-222	4	101.6	4	101.6	1 3/8	44.4	1 3/8	34.9
251-350	222-312	4	101.6	4	101.6	1 3/4	44.4	1 3/8	34.9
351-500	312-445	4	101.6	4 3/4	120.6	2 1/4	57.1	1 7/8	47.6
501-650	445-578	4	101.6	4 3/4	120.6	2 1/4	57.1	1 7/8	47.6
651-750	578-667	4	101.5	5	127.0	2 1/2	63.5	2 1/2	63.5
751-1000	667-890	4 1/2	114.3	5	127.0	3	76.2	2 3/4	69.9

Link ears

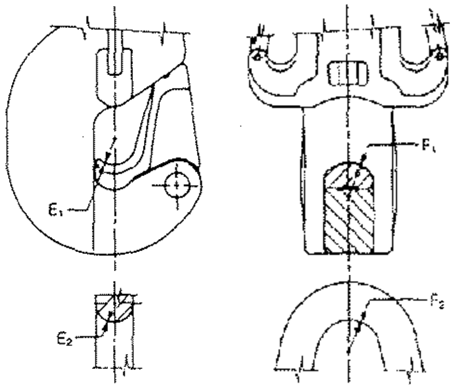


Elevator links

RECOMMENDATIONS ON PIPE HANDLING EQUIPMENT CONTACT SURFACE RADII (continued)
(API Spec 8A, May 1985)

Capacity		Hook and swivel bail							
		E_1 Min.		E_2 Max.		F_1 Max.		F_2 Min.	
(tons)	*(10^3 daN)*	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
25-40	22-36	2	50.8	1 1/2	38.1	3	76.2	3	76.2
41-65	36-57	2	50.8	1 3/4	44.4	3 1/2	88.9	3 1/2	88.9
66-100	57-89	2 1/4	57.1	2	50.8	4	101.6	4	101.6
101-150	89-133	2 1/2	63.5	2 1/4	57.1	4 1/2	114.3	4 1/2	114.3
151-250	133-222	2 3/4	69.8	2 1/2	63.5	4 1/2	114.3	4 1/2	114.3
251-350	222-312	3	76.2	2 3/4	69.8	4 1/2	114.3	4 1/2	114.3
351-500	312-445	3 1/2	88.9	3 1/4	82.5	4 1/2	114.3	4 1/2	114.3
501-650	445-578	3 1/2	88.9	3 1/4	82.5	4 1/2	114.3	4 1/2	114.3
651-750	578-667	4 1/4	107.9	4	101.6	4 1/2	114.3	4 1/2	114.3
751-1000	667-890	5 1/4	133.4	5	127.0	5	127.0	5	127.0

Hook



Swivel bail

DRILLPIPE ELEVATORS

Tool joint designation	Drillpipe type and nominal size (1)	Taper shoulder				Square shoulder			
		Neck diameter max.		Elevator bore		Neck diameter max.		Elevator bore	
		(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
NC26 (2 3/8 IF). .	2 3/8 EU	2 9/16	65.1	2 21/32	67.5	—	—	—	—
NC31 (2 7/8 IF). .	2 7/8 EU	3 3/16	81.0	3 9/32	83.3	3 3/16	81.0	3 3/8	85.7
NC38 (3 1/2 IF). .	3 1/2 EU	3 7/8	98.4	3 31/32	100.8	3 7/8	98.4	4 1/16	103.2
NC40 (4 FH) . . .	3 1/2 EU	3 7/8	98.4	3 31/32	100.8	3 7/8	98.4	4 1/16	103.2
	4 IU	4 3/16	106.4	4 9/32	108.7	4 1/8	104.8	4 5/16	109.5
NC46 (4 IF). . . .	4 EU	4 1/2	114.3	4 25/32	121.4	4 1/2	114.3	4 13/16	122.2
	4 1/2 IU	4 11/16	119.1	4 25/32	121.4	4 5/8	117.5	4 13/16	122.2
	4 1/2 IEU	4 11/16	119.1	4 25/32	121.4	4 5/8	117.5	4 13/16	122.2
4 1/2 FH	4 1/2 IU	4 11/16	119.1	4 25/32	121.4	4 5/8	117.5	4 13/16	122.2
	4 1/2 IEU	4 11/16	119.1	4 25/32	121.4	4 5/8	117.5	4 13/16	122.2
NC50 (4 1/2 IF). .	4 1/2 IEU	5	127	5 1/4	133.4	5	127	5 5/16	134.9
	5 IEU	5 1/8	130.2	5 1/4	133.4	5 1/8	130.2	5 5/16	134.9
5 1/2 FH.	5 IEU	5 1/8	130.2	5 1/4	133.4	5 1/8	130.2	5 5/16	134.9
	5 1/2 IEU	5 11/16	144.5	5 13/16	147.6	5 11/16	144.5	5 7/8	149.2

(1) For all weights and grades.

BRAKEBLOCKS (API Spec 7)

6 hole API brake block

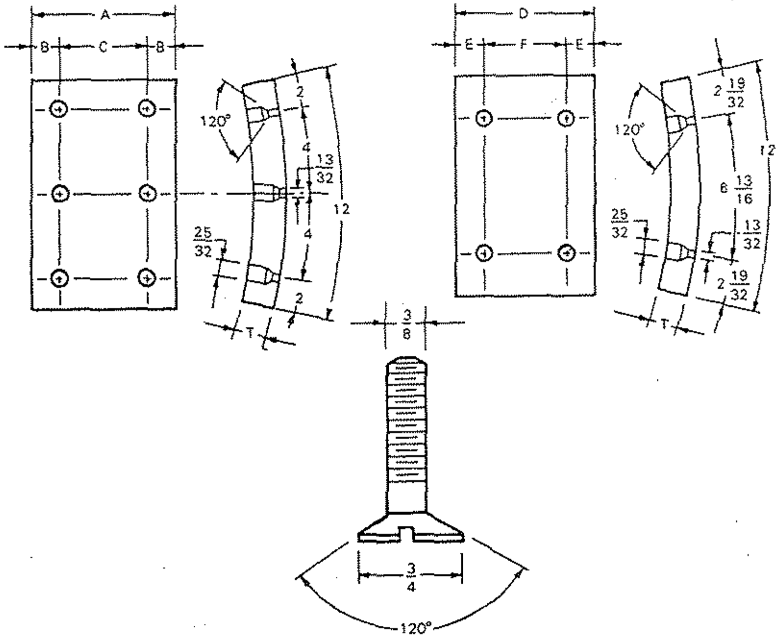
API block No	A (in)	B (in)	C (in)
1	6	1 1/4	3 1/2
2	7	1 1/2	4
3	8	1 3/4	4 1/2
4	9	2	5
5	10	2 1/4	5 1/2
6	11	2 1/2	6
7	12	2 3/4	6

4 hole API brake block

API Block No	D (in)	E (in)	F (in)
10	6	1 1/4	3 1/2
11	7	1 1/2	4
12	8	1 1/2	5
13	9	1 1/2	6
14	10	1 1/2	7

Brake block thickness: brake block thickness is not stipulated; for any given block size, however, several standard thickness are provided:

- *6 hole brake block*: *T (in)* = 5/8, 3/4, 7/8, 1, 1 1/8, 1 1/4
- 4 hole brake block: *T* (in) = 5/8, 3/4, 7/8, 1



Screws for fastening brake blocks to the brake bands shall be 3/8, 120°, flathead *brass machine screw* as shown in figure. Screw threads shall be 3/8-16 UNC-2A.

VIBRATOR AND DRILLING HOSE
(API Spec 7, April 1989)

Inside diameter *D*		Standard length (1) *L*		Line Pipe thread size *T*	Grade
(in)	(mm)	(ft)	(m)	(in)	
2	50.8	35	10.67	2 1/2	A-B
		40	12.19	2 1/2	A-B-C
2 1/2	63.5	10	3.05	3	A-B-C-D-E
		12	3.66	3	A-B-C-D-E
		15	4.57	3	A-B-C-D-E
		20	6.10	3	A-B-C-D-E
		30	9.14	3	A-B-C-D-E
		50	15.24	3	A-B-C-D-E
		55	16.76	3	A-B-C-D-E
3	76.2	10	3.05	4	C-D-E
		12	3.66	4	C-D-E
		15	4.57	4	C-D-E
		20	6.10	4	C-D-E
		30	9.14	4	C-D-E
		55	16.76	4	C-D-E
		60	18.29	4	C-D-E
		70	21.34	4	C-D-E
		75	22.86	4	C-D-E
3 1/2	88.9	10	3.05	4	C-D-E
		12	3.66	4	C-D-E
		15	4.57	4	C-D-E
		20	6.10	4	C-D-E
		30	9.14	4	C-D-E
		55	16.76	4	C-D-E
		60	18.29	4	C-D-E
		70	21.34	4	C-D-E
		75	22.86	4	C-D-E
4	101.6	10	3.05	5	C-D
		12	3.66	5	C-D
		15	4.57	5	C-D
		20	6.10	5	C-D
		30	9.14	5	C-D
		55	16.76	5	C-D
		60	18.29	5	C-D
		70	21.34	5	C-D
		75	22.86	5	C-D

(1) Non standard lengths in 5 ft (1.50 m) increments may be marked with API monogram provided the hose meets all other requirements of this specification.

VIBRATOR AND DRILLING HOSE
(API Spec 7, April 1989) (continued)

Grade	Working pressure		Test pressure	
	(psi)	(kPa)	(psi)	(kPa)
Grade A	1500	10300	3000	20600
Grade B	2000	13800	4000	27600
Grade C	4000	27600	8000	55200
Grade D	5000	34500	10000	69000
Grade E.	7500	51700	15000	103400

Hose length

$$L = \frac{L_r}{2} + \pi R + S$$

with :

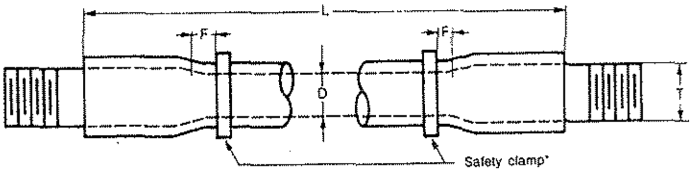
L = length of hose in feet or meters
L_r = length of hose travel in feet or meters
R = minimum bending radius of hose in feet or meters:
 R = 0.9 m (3 ft) for 2" hose
 R = 1.2 m (4 ft) for 2 1/2 cm and 3" hose
 R = 1.4 m (4 1/2 ft) for 3 1/2" hose
S = allowance for contraction in L due to maximum recommended working pressure in feet or meters, which is 0.3 m (1 ft) for all sizes of hose

Stand pipe height

$$H_s = \frac{L_r}{2} + Z$$

with :

H_s = vertical height of stand pipe in feet or meters
L_r = length of hose in feet or meters
Z = height, in ft or m, from the top of the derrick floor to the end of hose at the swivel when the swivel is in its lowest drilling position



F : For drilling hoses, this dimension must be 6 to 18 inches. For drilling pump hoses, this dimensions is 6 to 10 inches

* *Note*: Manufacturer must mark the hose: " Fix safety clamp here ".

CHAINS
(API Standard 7F)

I SINGLE AND MULTIPLE CHAIN ASSEMBLIES

Chains are designated by:

a) A number of which the right-hand digit is:
  0 for standard chain
  1 for lightweight chain
  5 for chain without roller
  and the one or two digits to the left represent(s) the pitch of the chain expressed as the number of 1/8 in increments.

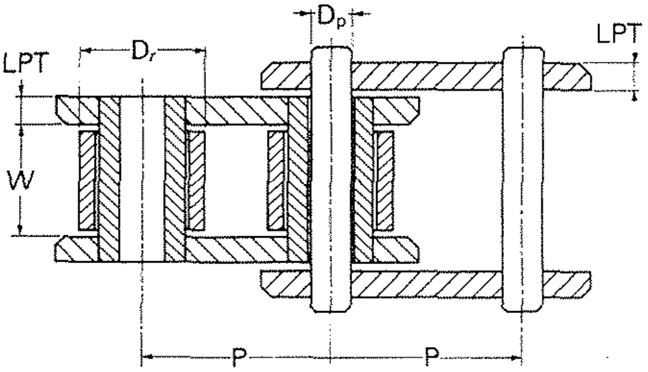
b) A number representing the number of chain strands.

c) The letter H may be inserted between these two numbers for a heavy chain.

Example: chain 160-6 or 160-H-6.

0 = standard
16 = 16/8 = 2 in
6 = six-strand chain
H = heavy

In the H series, only the flange thickness are different.



CHAINS (continued)
(API Standard 7F)

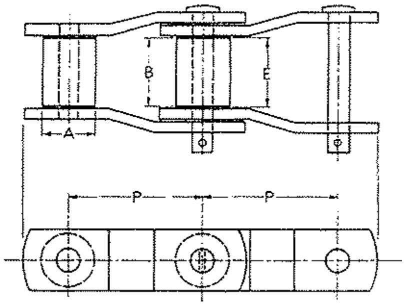
Standard chain dimensions

Chain No.	Pitch P		Roller diameter D_r		Inner link width W		Pin diameter D_p		Tension for measuring length		Flange thickness LPT			
											Standard		Heavy	
	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(lb)	(kg)	(in)	(mm)	(in)	(mm)
*25	1/4	6.4	0.130	3.3	1/8	3.2	0.0905	2.3	18	7.8	0.030	0.8	—	—
*35	3/8	9.5	0.200	5.1	3/16	4.8	0.141	3.6	18	7.8	0.050	1.3	—	—
41	1/2	12.7	0.306	7.6	1/4	6.4	0.141	3.6	18	7.8	0.050	1.3	—	—
40	1/2	12.7	0.312	7.9	5/16	7.9	0.156	4.0	31	14.1	0.060	1.5	—	—
50	5/8	15.9	0.400	10.2	3/8	9.5	0.200	5.1	49	22.2	0.080	2	—	—
60	3/4	19.1	0.469	11.9	1/2	12.7	0.234	5.9	70	31.8	0.094	2.4	0.125	3.2
80	1	25.4	0.625	15.9	5/8	15.9	0.312	7.9	125	56.7	0.125	3.2	0.156	4.0
100	1 1/4	31.8	0.750	19.1	3/4	19.1	0.375	9.5	195	88.5	0.156	4.0	0.187	4.7
120	1 1/2	38.1	0.875	22.2	1	25.4	0.437	11.1	281	127.5	0.187	4.7	0.219	5.6
140	1 3/4	44.5	1.000	25.4	1	25.4	0.500	12.7	383	173.7	0.219	5.6	0.250	6.4
160	2	50.8	1.125	28.6	1 1/4	31.8	0.562	14.3	500	226.8	0.250	6.4	0.281	7.1
180	2 1/4	57.2	1.406	35.7	1 13/32	35.7	0.687	17.4	633	287.1	0.281	7.1	0.312	7.9
200	2 1/2	63.5	1.562	39.7	1 1/2	38.1	0.781	19.8	781	354.3	0.312	7.9	0.375	9.5
240	3	76.2	1.875	47.6	7/8	47.6	0.937	23.8	1125	510.3	0.375	9.5	0.500	12.7

(*) Without roller.

CHAINS (continued)
(API Standard 7 F)

II ROTARY CHAINS



Standard rotary chains are given in the Table below.

	Nominal size (in)					
	3		3 1/8		4	
	(in)	(mm)	(in)	(mm)	(in)	(mm)
Pitch *P*	3.075	78.1	3.125	79.4	4.063	103.2
Roller diameter *A*	1 1/4	31.7	1 5/8	41.3	1 3/4	44.4
Roller length *B*	1 7/16	36.5	1 19/32	40.5	1 7/8	47.6
Distance between flanges *E*	1 1/2	38.1	1 5/8	41.3	1 15/16	49.2
Distance between center lines for Duplex chains	—	—	3 3/16	81.0	—	—
Number of links in 10 ft (3.048 m)	39		39		30	

Note: For the purpose of measuring standard length, the chains should be under a tensile load of 500 lb (225 daN).

III LENGTH OF A CHAIN

$$L = 2C + \frac{N + n}{2} + 39.5 \frac{(N - n)^2}{C}$$

where:

L = chain length in pitches
C = distance between sprocket centres in pitches
N = number of teeth on the large sprocket
n = number of teeth on the small sprocket

IV PROPER CHAIN TENSION

For a check of a chain tension, turn one sprocket to tighten the lower strand of chain; then measure the sag of upper strand. THis sag measured at midpoint should be approximately two to three per cent of the length of the tangent to the sprockets.

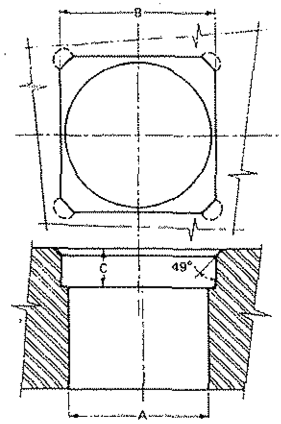
Example: If the length of the tangent between the sprockets is 200 cm, the sag shall be between 4 and 6 cm.

ROTARY TABLE OPENING AND SQUARE DRIVE MASTER BUSHING

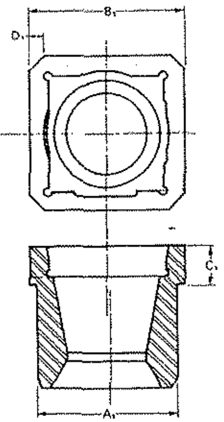
(API Spec 7)

Nominal table size (in)	Rotary-table opening								Square drive master bushing									
	A		*B*		*C*		*D* maximal		A_1		B_1		C_1		D_1		Concentricity TIR	
	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)
17 1/2	44.45	17 1/2	46.20	18 3/16	13.33	5 1/4	4.445	1 3/4	44.29	17 7/16	46.04	18 1/8	13.33	5 1/4	4.445	1 3/4	0.794	1/32
20 1/2	52.07	20 1/2	53.82	21 3/16	13.33	5 1/4	4.445	1 3/4	51.91	20 7/16	53.66	21 1/8	13.33	5 1/4	4.445	1 3/4	0.794	1/32
27 1/2	69.85	27 1/2	71.60	28 3/16	13.33	5 1/4	4.445	1 3/4	69.69	27 7/16	71.28	28 1/16	13.33	5 1/4	4.445	1 3/4	0.794	1/32
37 1/2	95.25	37 1/2	—	—	—	—	—	—	95.08	37 7/16	—	—	—	—	—	—	—	—
49 1/2	124.73	49 1/2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

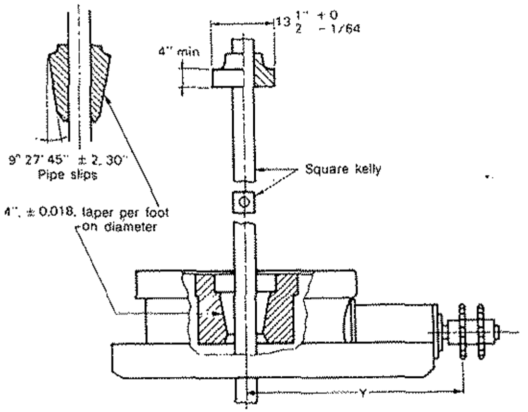
Note: Pipe slips and master bushing must have a taper of 4 in per foot on diameter (33.33%), that is an angle of 9°27′45″.



Rotary-table opening



Square drive master bushing

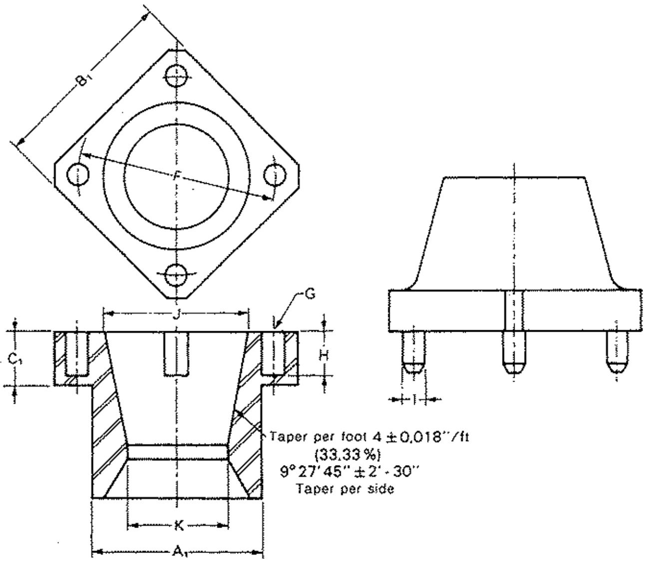


Y: the distance between the center of the rotary table and the axis of the first gear wheel is 53 1/4 inches for openings of more than 20 inches, 44 inches for openings less than 20 inches, and 65 inches for 49 1/2 inch rotary tables.

FOUR-PIN DRIVE KELLY BUSHING AND MASTER BUSHING

(API Spec 7)

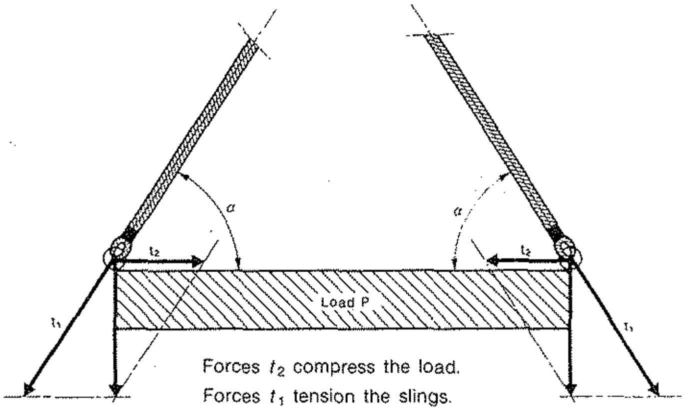
Nominal table size (in)	*F*		*G*		*H*		*I*		*J*		*K*	
	± 1.6 (mm)	± 1/16 (in)	± 0.13 (mm)	± 0.005 (in)	(mm)	(in)	± 0.13 (mm)	± 0.005 (in)	+ 1.6 − 0 (mm)	+ 1/16 − 0 (in)	+ 1/16 − 0 (mm)	+ 1/16 − 0 (in)
17 1/2	482.6	19	65.2	2.565	107.9	4 1/4	62.8	2.472	365.1	14 3/8	257.2	10 1/8
20 1/2	584.2	23	65.2	2.565	107.9	4 1/4	62.8	2.472	412.7	16 1/4	311.1	12 1/4
27 1/2	654.2	25 3/4	86.2	3.395	107.9	4 1/4	82.9	3.265	482.6	19	381.0	15
37 1/2	654.1	25 3/4	86.2	3.395	107.9	4 1/4	82.9	3.265	—	—	—	—
49 1/2		—	—	—	—	—	—	—	—	—	—	—



TENSION IN SLINGS

Two-wire slings

I PRINCIPLE OF BREAKDOWN OF FORCES



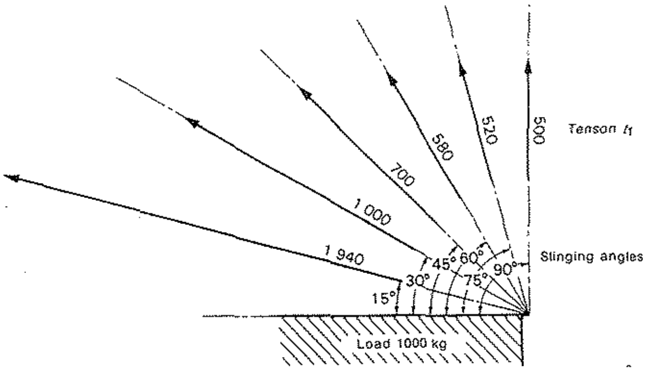
Forces t_2 compress the load.
Forces t_1 tension the slings.

$$t_1 = \frac{P}{2 \sin\alpha}$$

II TENSION IN SLINGS AS A FUNCTION OF ANGLE α

For a load $P = 1000$ kg

α(degrees)	15	30	45	60	75	90
t_1(kg)	1940	1000	700	580	520	500



G

pumping and pressure losses

MUD PUMPS

I THEORETICAL FLOWRATE

a. Duplex pump

$$\boxed{Q_t = 0.0515\ nL\left(D^2 - \frac{d^2}{2}\right)}$$

b. Single-acting Triplex pump

$$\boxed{Q_t = 0.0386\ nLD^2}$$

where :
Q_t = theoretical flow rate (l/m)
n = strokes per minute (strokes/min)
L = length of stroke (in)
D = liner diameter (in)
d = piston rod diameter (in)

II VOLUMETRIC EFFICIENCY η_v

$$\boxed{\eta_v = \frac{Q_r}{Q_t}}$$

Q_r = true measured flow rate (l/min)

III HYDRAULIC POWER P_h

$$\boxed{P_h\ (\text{kW}) = \frac{pQ_t}{60\ 000}}$$

$$P_h\ (\text{hp}) = \frac{pQ_t}{44\ 750}$$

where :
p = discharge pressure (kPa)
Q_t = flow rate (l/min)

l/m × 0.264 = gal/min

PUMPING POWER

I TRUE HYDRAULIC POWER P_{hr}

$$\boxed{P_{hr}\ (\text{kW}) = \frac{pQ_r}{60\,000}} \quad \text{or} \quad \boxed{P_{hr}\ (\text{kW}) = \frac{pQ_t\eta_v}{60\,000}}$$

$$P_{hr}\ (\text{hp}) = \frac{pQ_r}{44\,750} \quad \text{or} \quad P_{hr}\ (\text{hp}) = \frac{pQ_t\eta_v}{44\,750}$$

II ENGINE POWER REQUIRED TO PRODUCE p and Q_r

η_m = mechanical efficiency of pump
η_t = compound efficiency

$$\boxed{P_m\ (\text{kW}) = \frac{pQ_r}{60\,000\ \eta_m\ \eta_t}}$$

$$P_m\ (\text{hp}) = \frac{pQ_r}{44\,750\ \eta_m\ \eta_t}$$

III MAXIMUM SERVICE PRESSURE $p_{\max}$ (kPa)

$$p_{\max} = \frac{10F_{\max}}{S}$$

where :

$F_{\max}$ = maximum load on cross head extension (*piston load*) (N)
S = average area under pressure at $p_{\max}$ (cm^2)

$$S = 5.067\ (D^2 - \frac{d^2}{2}) \quad \text{Duplex pump}$$

$$S = 5.067\ D^2 \quad \text{Triplex pump}$$

where :

D = liner diameter (in)
d = piston rod diameter (in)

IV EFFICIENCY

η_m = mechanical efficiency of pump : 0.85 to 0.90
η_t = compound efficiency:
V-belts = 0.97
chains = 0.95
torque converter = 0.70 to 0.90
η_v = volumetric efficiency, which varies widely according to the state of the valves, the supercharging , and the type of fluid. In the best case $\eta_v = 0.98$ for a supercharged Triplex pump

OUTPUT IN LITERS PER STROKE DOUBLE ACTING DUPLEX PUMPS
based on liner size and piston rod diameter

Length of stroke 10″

Ø piston (in) Ø rod (in)	8	7 3/4	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 3/4	5 1/2	5 1/4	5	4 3/4	4 1/2	4 1/4	4	3 3/4	3 1/2	3 1/4	3
1 1/2				26.49	24.65	22.88	21.17	19.53	17.95	16.44	15.02	13.61	12.29	11.04	9.85	8.72	7.66	6.66	5.73	4.86	4.05
1 5/8				26.38	24.64	22.77	21.06	19.42	17.84	16.33	14.91	13.50	12.18	10.93	9.74	8.61	7.55	6.55	5.62	4.75	3.94
1 3/4				26.27	24.44	22.67	20.96	19.32	17.74	16.23	14.81	13.40	12.08	10.83	9.64	8.51	7.45	6.45	5.52	4.65	3.84

Length of stroke 12″

Ø piston (in) Ø rod (in)	8	7 3/4	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 3/4	5 1/2	5 1/4	5	4 3/4	4 1/2	4 1/4	4	3 3/4	3 1/2	3 1/4	3
1 5/8									21.42	19.61	17.87	16.21	14.63	13.12	11.69	10.34	9.07				
1 7/8				31.39	29.19	27.06	25.02	23.05	21.15	19.34	17.60	15.94	14.36	12.85	11.42	10.07	8.80				
2		35.87	33.51	31.24	29.04	26.91	24.87	22.90	21.00	19.19	17.45	15.79	14.21	12.70	11.27	9.92	8.65				
2 1/4				30.89	28.71	26.58	24.54	22.57	20.67	18.86	17.12	15.46	13.86	12.37	10.94	9.59	8.32				

Length of stroke 14″

Ø piston (in) Ø rod (in)	8	7 3/4	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 3/4	5 1/2	5 1/4	5	4 3/4	4 1/2	4 1/4	4	3 3/4	3 1/2	3 1/4	3
1 3/4					34.21	31.74	29.35	27.05	24.84	22.73	20.70	18.76	16.92	15.16	13.49						
2	44.68	41.85	39.10	36.44	33.87	31.40	29.01	26.71	24.50	22.39	20.36	18.42	16.58	14.82	13.15						
2 1/8	44.49	41.66	38.91	36.25	33.68	31.21	28.82	26.52	24.31	22.20	20.17	18.23	16.39	14.63	12.96						
2 1/4	44.30	41.47	38.72	36.06	33.49	31.02	28.63	26.33	24.12	22.01	19.98	18.04	16.20	14.44	12.77						
2 1/2	43.87	41.04	38.29	35.63	33.06	30.40	28.20	25.90	23.69	21.58	19.55	17.61	15.77	14.01	12.34						
2 5/8	43.64	40.81	38.06	35.40	32.83	30.36	27.97	25.67	23.46	21.35	19.32	17.38	15.54	13.78	12.11						

Length of stroke 15″

Ø piston (in) Ø rod (in)	8	7 3/4	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 3/4	5 1/2	5 1/4	5	4 34	4 1/2	4 1/4	4	3 3/4	3 1/2	3 1/4	3
2 1/4		44.43	41.46	38.63	35.88	33.23	30.67	28.21	25.84	23.58	21.40	19.33	17.35								
2 7/8		43.19	40.24	37.39	34.64	31.99	29.43	26.97	24.60	22.38	20.16	18.09	16.11								

l × 0.264 = gal

OUTPUT IN LITERS PER STROKE DOUBLE ACTING DUPLEX PUMPS
based on liner size and piston rod diameter
(continued)

Length of stroke 16″

Ø piston (in) / Ø rod (in)	8 1/2	8 1/4	8	7 3/4	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 3/4	5 1/2	5 1/4	5	4 3/4	4 1/2	4 1/4
2 1/4	57.43	53.98	50.63	47.39	44.25	41.21	38.27	35.44	32.71	30.09	27.57	25.15	22.83	20.62	18.51	16.50		
2 1/2	56.94	53.49	50.14	46.90	43.76	40.72	37.78	34.95	32.22	29.60	27.08	24.66	22.34	20.13	18.02	16.01		
2 3/4	56.40	52.95	49.60	46.36	43.22	40.18	37.24	34.41	31.68	29.06	26.54	24.12	21.80	19.59	17.48	15.48		
3	55.81	52.36	49.01	45.77	42.63	39.59	35.65	33.82	31.09	28.47	25.96	23.53	21.21	19.00	16.89	14.88		
3 1/8	55.49	52.04	48.69	45.45	42.31	39.27	36.33	33.50	30.77	28.15	25.63	23.21	20.89	18.68	16.57	14.56		
3 1/2	54.47	51.02	47.67	44.43	41.29	38.25	35.31	32.48	29.75	27.13	24.61	22.19	19.87	17.66	15.55	13.54		

Length of stroke 18″

Ø piston (in) / Ø rod (in)	8 1/2	8 1/4	8	7 3/4	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 3/4	5 1/2	5 1/4	5	4 3/4	4 1/2	4 1/4
2 1/4		60.72	56.95	53.30	49.77	46.35	43.06	39.87	36.80	33.85	31.01	28.29	25.68	23.19	20.82	18.56	16.41	14.39
2 3/8		60.45	56.68	53.03	49.50	46.08	42.78	39.60	36.53	33.58	30.74	28.02	25.41	22.92	20.55	18.29	16.14	14.12
2 1/2		60.17	56.40	52.75	49.22	45.80	42.50	39.32	36.25	33.30	30.46	27.74	25.13	22.64	20.27	18.01	15.86	13.84
2 3/4		59.57	55.80	52.15	48.62	45.20	41.90	38.72	35.65	32.70	29.86	27.14	24.53	22.04	19.67	17.41	15.26	13.24
3		58.90	55.13	51.48	47.95	44.53	41.23	38.05	34.98	32.03	29.19	26.47	23.86	21.37	19.00	16.74	14.59	12.57
3 1/8		58.55	54.78	51.13	47.60	44.18	40.88	37.70	34.63	31.68	28.84	26.12	23.51	21.02	18.65	16.39	14.24	12.22
3 1/4		58.18	54.41	50.76	47.23	43.81	40.51	37.33	34.26	31.31	28.47	25.75	23.14	20.65	18.28	16.02	13.87	11.85

Length of stroke 20″

Ø piston (in) / Ø rod (in)	8 1/2	8 1/4	8	7 3/4	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 3/4	5 1/2	5 1/4	5	4 3/4	4 1/2	4 1/4
2 1/2			62.68	58.62	54.70	50.90	47.23	43.69	40.28	37.00	33.85	30.82	27.93	25.16	22.52	20.01	17.63	
2 7/8			61.64	57.58	53.66	49.86	46.19	42.65	39.24	35.96	32.81	29.78	26.89	24.12	21.48	18.97	16.59	

l × 0.264 = gal

TRIPLEX PUMPS

Maximum pressure based on liner (kPa)

Model	Maximum input power (kW)	Maximum speed (strokes/min)	Stroke		Liner size (mm and in)													
			(mm)	(in)	101.6	114.3	120.65	127	133.35	139.7	146.05	152.4	158.75	165.1	171.45	177.8	184.1	190.5
					4	4 1/2	4 3/4	5	5 1/4	5 1/2	5 3/4	6	6 1/4	6 1/2	6 3/4	7	7 1/4	7 1/2
Continental-Emsco																		
F800	**597**	150	*226.6*	*9*	*38510*	*30440*	*27370*	*24750*	*22480*	*20440*	*18720*	*17170*	15820					
F1000	**746**	140	254.0	10		36820	33030	29850	27030	24650	22550	20750	19100					
F1300	**969**	120	304.8	12						31140	28450	26140	24090	22480	20660	19230		
F1600	**1193**	120	304.8	12						38320	35010	32160	29640	27660	25430	23600		
Gardner-Denver																		
PZ7	**410**	165	177.8	7		24520		19860		16410		13790		11760		10130		
PZ8	**559**	165	203.2	8	37100	29220		23670		19600		16440	15170					
PZ9	**746**	150	228.6	9		38130		30920		25580		21440	19820	18270		15750		
PZ10	**1006**	130	254.0	10						35790		30070		25620		22090		
PZ11	***1193***	*130*	*279.4*	*11*						38580		32420		27620		23810		
Ideco																		
T800	**597**	150	228.6	9		27460		22220		18380		15440		13170		11350		
T1000	**746**	140	254.0	10		36810		29800		24680		20700		17640		15200		
T1300	**1046**	*130*	*304.8*	*12*				*37660*		*31120*		26150		22280		19220		16740
T1600	**1292**	130	304.8	12						38300		32190		27430		23650		20600
National																		
8P80	**597**	160	215.9	8 1/2		30300		24550		20270		17030	15720					
9P100	**746**	150	234.9	9 1/4		*37130*		*30060*		*24860*		*20890*	*19240*					
10P130	**969**	140	254.0	10				38750		32030		26890	24790					
12P160	**1193**	120	304.8	12						38300		32200		27440	25440	23650	22060	
Wirth																		
TPK1000	**746**	160	234.9	9 1/4		34810	31230	28190	*25570*	23300	*21310*	*19570*	*18040*					
TPK1300	**969**	150	254.0	10				36150	32790	29880	27370	25120	23160	21400	19840	18460		
TPK1600	**1193**	120	304.8	12						38330	35020	32160	29670	27430	25440	23640		

From *SI Drilling Manual*, First Edition, Canadian Association of Oilwell Drilling Contractors, Gulf.

kW × 1.34 = hp   kPa × 0.145 = psi

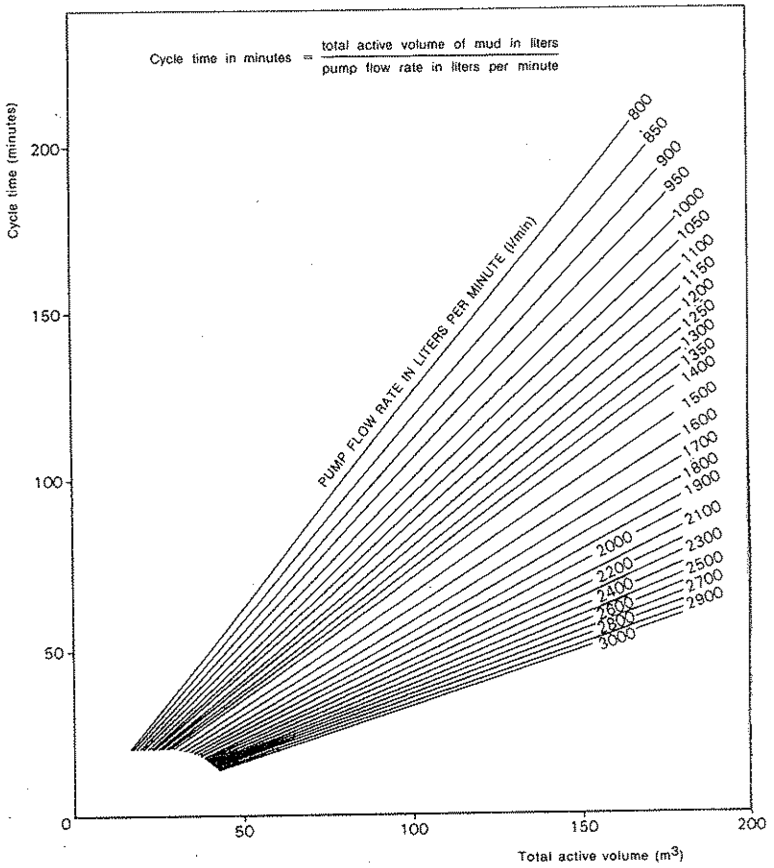
OUTPUT IN LITERS PER STROKE OF SINGLE ACTING TRIPLEX PUMPS

(Volumetric efficiency 100 %)

Length of stroke		Liner size (mm and in)																		
(mm)	(in)	190.50	184.15	177.80	171.45	165.10	158.75	152.40	146:05	139.70	133.35	127.00	120.65	114.30	107.95	101.60	95.25	88.90	76.20	63.50
		7.50	7.25	7.00	6.75	6.50	6.25	6.00	5.75	5.50	5.25	5.00	4.75	4.50	4.25	4.00	3.75	3.50	3.00	2.50
127.00	**5.00**	10.86	10.15	9.46	8.80	8.16	7.54	6.95	6.38	5.84	5.32	4.83	4.36	3.91	3.49	3.09	2.71	2.36	1.74	1.21
133.35	**5.25**	11.40	10.65	9.93	9.24	8.56	7.92	7.30	6.70	6.13	5.59	5.07	4.57	4.10	3.66	3.24	2.85	2.40	1.82	1.27
139.70	**5.50**	11.95	11.16	10.41	9.68	8.97	8.30	7.64	7.02	6.42	5.85	5.31	4.79	4.30	3.84	3.40	2.99	2.60	1.91	1.33
146.05	**5.75**	12.49	11.67	10.88	10.12	9.38	8.67	7.99	7.34	6.72	6.12	5.55	5.01	4.50	4.01	3.55	3.12	2.72	2.00	1.39
152.40	**6.00**	13.03	12.18	11.35	10.56	9.79	9.05	8.34	7.66	7.01	6.39	5.79	5.23	4.69	4.18	3.71	3.26	2.84	2.08	1.45
158.75	**6.25**	13.57	12.68	11.82	11.00	10.20	9.43	8.69	7.98	7.30	6.65	6.03	5.44	4.89	4.36	3.86	3.39	2.96	2.17	1.51
165.10	**6.50**	14.12	13.19	12.30	11.43	10.60	9.80	9.03	8.30	7.59	6.92	6.27	5.66	5.08	4.53	4.02	3.53	3.07	2.26	1.57
171.45	**6.75**	14.66	13.70	12.77	11.87	11.01	10.18	9.38	8.62	7.88	7.18	6.52	5.88	5.28	4.71	4.17	3.67	3.19	2.35	1.63
177.80	**7.00**	15.20	14.21	13.24	12.31	11.42	10.56	9.73	8.94	8.18	7.45	6.76	6.10	5.47	4.88	4.32	3.80	3.31	2.43	1.69
184.15	**7.25**	15.75	14.71	13.72	12.75	11.83	10.93	10.08	9.26	8.47	7.72	7.00	6.32	5.67	5.06	4.48	3.94	3.43	2.52	1.75
190.50	**7.50**	16.29	15.22	14.19	13.19	12.23	11.31	10.42	9.57	8.76	7.98	7.24	6.53	5.86	5.23	4.63	4.07	3.55	2.61	1.81
196.85	**7.75**	16.83	15.73	14.66	13.63	12.64	11.69	10.77	9.89	9.05	8.25	7.48	6.75	6.06	5.40	4.79	4.21	3.67	2.69	1.87
203.20	**8.00**	17.37	16.24	15.14	14.07	13.05	12.07	11.12	10.21	9.34	8.51	7.72	6.97	6.25	5.58	4.94	4.34	3.78	2.78	1.93
209.55	**8.25**	17.92	16.74	15.61	14.51	13.46	12.44	11.47	10.53	9.64	8.78	7.96	7.19	6.45	5.75	5.10	4.48	3.90	2.87	1.99
215.90	**8.50**	18.46	17.25	16.08	14.95	13.87	12.82	11.81	10.85	9.93	9.05	8.20	7.40	6.65	5.93	5.25	4.62	4.02	2.95	2.05
222.25	**8.75**	19.00	17.76	16.55	15.39	14.27	13.20	12.16	11.17	10.22	9.31	8.45	7.62	6.84	6.10	5.41	4.75	4.14	3.04	2.11
228.60	**9.00**	19.55	18.27	17.03	15.83	14.68	13.57	12.51	11.49	10.51	9.58	8.69	7.84	7.04	6.28	5.56	4.89	4.26	3.13	2.17
234.95	**9.25**	20.09	18.77	17.50	16.27	15.09	13.95	12.86	11.81	10.80	9.84	8.93	8.06	7.23	6.45	5.71	5.02	4.38	3.21	2.23
241.30	**9.50**	20.63	19.28	17.97	16.71	15.50	14.33	13.20	12.13	11.10	10.11	9.17	8.28	7.43	6.63	5.87	5.16	4.49	3.30	2.29
254.00	**10.00**	21.72	20.29	18.92	17.59	16.31	15.08	13.90	12.77	11.68	10.64	9.65	8.71	7.82	6.97	6.18	5.43	4.73	3.47	2.41
266.70	**10.50**	22.80	21.31	19.87	18.47	17.13	15.84	14.59	13.40	12.26	11.17	10.14	9.15	8.21	7.32	6.49	5.70	4.97	3.65	2.53
279.40	**11.00**	23.89	22.32	20.81	19.35	17.94	16.59	15.29	14.04	12.85	11.71	10.62	9.58	8.60	7.67	6.80	5.97	5.20	3.82	2.65
292.10	**11.50**	24.98	23.34	21.76	20.23	18.76	17.34	15.98	14.68	13.43	12.24	11.10	10.02	8.99	8.02	7.10	6.24	5.44	4.00	2.78
304.80	**12.00**	26.06	24.35	22.70	21.11	19.58	18.10	16.68	15.32	14.02	12.77	11.58	10.45	9.38	8.37	7.41	6.52	5.68	4.17	2.90

l × 0.264 = gal

MUD CYCLE TIME



l × 0.264 = gal   l/min × 0.264 = gal/min   m³ × 6.29 = bbl

CIRCULATION FLOW RATE (l/min)

as a function of mud rising velocity opposite drill pipes (V_r in meters per minute) and hole/pipe annulus (V_a in liters per meter)

$$Q = V_r \, V_a$$

Hole size (in)		4 3/4	5 7/8		6		6 1/4		7 7/8			8 1/2			9 7/8			12 1/4		17 1/2	
Pipe size (in)		2 7/8	2 7/8	3 1/2	2 7/8	3 1/2	2 7/8	3 1/2	3 1/2	4 1/2	5	3 1/2	4 1/2	5	3 1/2	4 1/2	5	4 1/2	5	4 1/2	5
Annulus volume (l/m)		**7.25**	**13.30**	**11.28**	**13.95**	**12.03**	**15.60**	**13.58**	**27.23**	**25.21**	**21.16**	**30.40**	**26.35**	**23.94**	**43.20**	**39.15**	**36.74**	**65.78**	**63.37**	**144.94**	**142.53**
Mud rising velocity (m/min)	**10**	73	133	113	140	120	156	136	272	252	212	304	264	239	432	392	367	658	634	1449	1425
	12	87	160	135	167	144	187	163	327	303	254	365	316	287	518	470	441	789	760	1739	1710
	14	102	186	158	195	168	218	190	381	353	296	426	369	335	605	548	514	921	887	2029	1995
	16	116	213	180	223	192	250	217	436	403	339	486	422	383	691	626	588	1052	1014	2319	2280
	18	131	239	203	251	217	281	244	490	454	381	547	474	431	778	705	661	1184	1141	2609	2566
	20	145	266	226	279	241	312	272	545	504	423	608	527	479	864	783	735	1316	1267	2899	2851
	22	160	293	248	307	265	343	299	599	555	466	669	580	527	950	861	808	1447	1394	3189	3136
	24	174	319	271	335	289	374	326	654	605	508	730	632	575	1037	940	882	1579	1521	3479	3421
	26	189	346	293	363	313	406	353	708	655	550	790	685	522	1123	1018	955	1710	1648	3768	3706
	28	203	372	316	391	337	437	380	762	706	592	851	738	670	1210	1096	1029	1842	1774	4058	3991
	30	218	399	338	419	361	468	407	817	756	635	912	791	718	1296	1175	1102	1973	1901	4348	4276
	32	232	426	361	446	385	499	435	871	807	677	973	843	766	1382	1253	1176	2105	2028	4638	4561
	34	247	452	384	474	409	530	462	926	857	719	1034	896	814	1469	1331	1249	2237	2155	4928	4846
	36	261	479	406	502	433	562	489	980	908	762	1094	949	862	1555	1409	1323	2368	2281		
	38	276	505	429	530	457	593	516	1035	958	804	1155	1001	910	1642	1488	1396	2500	2408		
	40	290	532	451	558	481	624	543	1089	1008	846	1216	1054	958	1728	1566	1470	2631	2535		
	42	305	559	474	586	505	655	570	1144	1059	889	1277	1107	1005	1814	1644	1543	2763	2662		
	44	319	585	496	614	529	686	598	1198	1109	931	1338	1159	1053	1901	1723	1617	2894	2788		
	46	334	612	519	642	553	718	625	1253	1160	973	1398	1212	1101	1987	1801	1690	3026	2915		
	48	348	638	541	670	577	749	652	1307	1210	1016	1469	1265	1149	2074	1879	1764	3157	3042		
	50	363	665	564	698	602	780	679	1362	1261	1058	1520	1318	1197	2160	1958	1837	3289	3169		
	52	377	692	587	725	626	811	706	1416	1311	1100	1581	1370	1245	2246	2036	1910	3421	3295		
	54	392	718	609	753	650	842	733	1470	1361	1143	1642	1423	1293	2333	2114	1984	3552	3422		

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft   m/min × 3.28 = ft/min

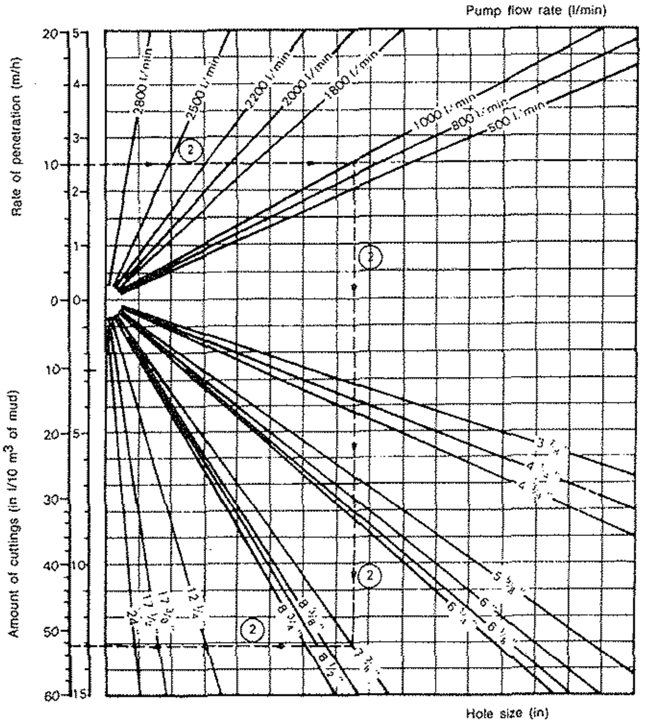
CIRCULATION RATE (l/min)
as a function of mud rising velocity opposite drill pipes (V_r in meters per minute) and hole/pipe annulus (V_a in liters per meter) *(continued)*

$$Q = V_r V_a$$

Hole size (*in*)		4 3/4	5 7/8		6		6 1/4		7 7/8			8 1/2			9 7/8			12 1/4		17 1/2	
Pipe size (in)		2 7/8	2 7/8	3 1/2	2 7/8	3 1/2	2 7/8	3 1/2	3 1/2	4 1/2	5	3 1/2	4 1/2	5	3 1/2	4 1/2	5	4 1/2	5	4 1/2	5
Annulus volume (l/m)		**7.25**	**13.30**	**11.28**	**13.95**	**12.03**	**15.60**	**13.58**	**27.23**	**25.21**	**21.16**	**30.40**	**26.35**	**23.94**	**43.20**	**39.15**	**36.74**	**65.78**	**63.37**	**144.94**	**142.53**
Mud rising velocity (m/min)	**56**	406	745	632	781	674	874	760	1525	1412	1185	1702	1476	1341	2419	2192	2057	3684	3549		
	58	421	771	654	809	698	905	788	1579	1462	1227	1763	1528	1389	2506	2271	2131	3815	3675		
	60	435	798	677	837	722	936	815	1634	1513	1270	1824	1581	1436	2592	2349	2204	3947	3802		
	62	450	825	699	865	746	967	842	1688	1563	1312	1885	1634	1484	2678	2427	2278	4078	3929		
	64	464	851	722	893	770	998	869	1743	1613	1354	1946	1686	1532	2765	2506	2351	4210	4056		
	66	479	878	744	921	794	1030	896	1797	1664	1397		1739	1580	2851	2584	2425	4341	4182		
	68	493	904	767	949	818	1061	923		1714	1439		1792	1628	2930	2662	2498	4473	4309		
	70	508	931	790	977	842	1092	951		1765	1481		1845	1676		2741	2572		4436		
	72	522	958	812	1004	866	1123	978			1524		1897	1724		2819	2645				
	74	537	984	835	1032	890	1154	1005			1566		1950	1772		2897	2719				
	76	551		857	1060	914	1186	1032			1608			1819		2975	2792				
	78	566		880	1088	938		1059			1650			1867			2866				
	80	580		902	1116	962		1086			1693			1915			2939				
	82	595		925	1144	986		1114			1735			1963							
	84	609		948	1172	1011		1141			1777										
	86			970	1200	1035		1168													
	88			993		1059		1195													
	90			1015		1083															

l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft   m/min × 3.28 = ft/min

AMOUNT OF DRILLED CUTTINGS IN MUD



Examples:

1. Rate of penetration = 6 m/h
   Pump flow rate = 2 000 l/min
   Hole size = 12.25 in
   Amount of cuttings = 38.0 l in 10 m³ of mud
2. Rate of penetration = 10 m/h
   Pump flow rate = 1 000 l/min
   Hole size = 7 7/8 in
   Amount of cuttings = 52.2 l in 10 m³ of mud

$$V = \frac{84.45\ D^2 A_v}{Q}$$

where:

V = amount of cuttings (l/10 m³)
D = hole size (in)
A_v = rate of penetration (m/h)
Q = pump flow rate (l/min)

m/h × 3.28 = ft/h l × 0.264 = gal l/min × 0.264 = gal/min

ANNULAR MUD SPECIFIC GRAVITY d_{ann}

d_{ann} depends on the following:

(a) Rate of penetration A_v (m/h).
(b) Initial specific gravity d_{init}.
(c) Mud flow rate Q (l/min).
(d) Rate of fall of cuttings V_s (m/min).
(e) Hole size D_f (in).
(f) Pipe size D_t (in).

$$\boxed{d_{ann} = d_{init} + \frac{D_f^2 \ A_v \ (2.5 - d_{init})}{118.41Q - 60 \ (D_f^2 - D_t^2) \ V_s}}$$

Example:
D_f = 17 1/2"
D_t = 5"
d_{init} = 1.15
A_v = 25 m/h
Q = 3200 l/min
V_s = 10 m/min

$$d_{ann} = d_{init} + 0.05 = 1.20$$

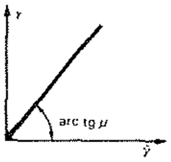
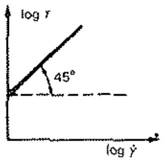
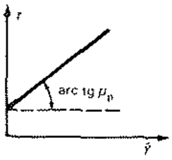
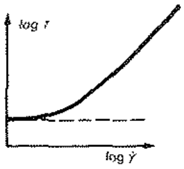
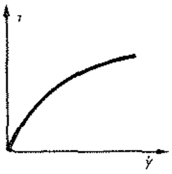
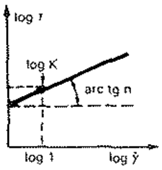
HYDRAULICS

(From the *Manuel de rhéologie des fluides de forage et laitiers de ciment*, Manual of Rheology of Drilling Fluids and Cement Slurries), Oil and Gas Exploration and Production Association, Published by Editions Technip, Paris 1979)

NOTATION
(Practical units)

Symbol	Unit	Signification
A	in^2	Total surface area of bit nozzles
d	kg/l	Fluid specific gravity
D	in	String inside diameter
D_0	in	Annulus outside diameter
D_i	in	Annulus inside diameter (outside string)
L	m	Length
p	kPa	Pressure losses, pressure
Q	l/min	Fluid flow rate
V	m/min	Fluid velocity
V_c	m/min	Critical fluid velocity
μ	cP	Dynamic viscosity
μ_p	cP	Plastic viscosity
τ_0	$lb/100\ ft^2$	Yield value
K	$lb.s^n/100\ ft^2$	Consistency index
n		Rheological behavior index

RHEOLOGY

RHEOLOGICAL SYSTEM	RHEOLOGICAL EQUATION	FLOW CURVE CARTESIAN COORDINATES	FLOW CURVE LOGARITHMIC COORDINATES
Newtonian	$\tau = \mu \gamma$		
Bingham or plastic	$\tau = \tau_o + \mu_p \gamma$		
" Power " or pseudoplastic or *Ostwald*	$\tau = K\gamma^n$		

Rheological formulas for the Fann viscometer :

Apparent viscosity . . . . $\mu_a = \frac{\Theta_{600}}{2}$ (cP)

Yield value. . . . . $\tau_0 = \Theta_{600} - 2\,(\Theta_{600} - \Theta_{300})$ (lb/100 ft^2)

Plastic viscosity . . . . . . $\mu_p = \Theta_{600} - \Theta_{300}$ (cP)

Rheological index. . . . . $n = 3.32 \ \log \ (\frac{\Theta_{600}}{\Theta_{300}})$

Consistency index . . . . $K = \frac{\Theta_{600}}{(1020)^n} = \frac{\Theta_{300}}{(510)^n}$ (lb.s^n/100 ft^2)

CRITICAL VELOCITY BASED ON RHEOLOGICAL PARAMETERS
(Practical units)

BINGHAM FLUIDS

Circulation in drill pipes and drill collars:

$$V_c = \frac{2.48}{Dd} (\mu_p + \sqrt{\mu_p^2 + 73.57 \ \tau_0 D^2 d})$$

Circulation in the annulus:

$$V_c = \frac{3.04}{(D_0 - D_i)\ d} (\mu_p + \sqrt{\mu_p^2 + 40.05 \ \tau_0 \ (D_0 - D_i)^2 d})$$

OSTWALD FLUIDS

Circulation in drill pipes and drill collars:

$$V_c = 0.6 \left(\frac{(3470 - 1370n)\ K}{1.27d}\right)^{\frac{1}{2-n}} \left(\frac{3n + 1}{1.25Dn}\right)^{\frac{n}{2-n}}$$

Circulation in the annulus:

$$V_c = 0.6 \left(\frac{(3470 - 1370n)\ K}{2.05d}\right)^{\frac{1}{2-n}} \left(\frac{2n + 1}{0.64\ (D_0 - D_i)\ n}\right)^{\frac{n}{2-n}}$$

If $V < V_c$, the flow is laminar
If $V > V_c$, the flow is turbulent
with critical Re = 2100 (Bingham fluid)
critical Re = 3470 − 1370n (Ostwald fluid).

PRESSURE LOSSES
(general)

Fluid flow in pipes

Any fluid flowing in a pipe loses part of its energy, which is absorbed by dissipation in friction forces:

(a) Internal friction due to its viscosity.
(b) External friction due to pipe roughness.

This loss of energy is called the pressure drop or loss, and is expressed by the difference in the pressure of the fluid between two points of the pipe. For example, a circulating drilling mud has an initial energy represented by the pump discharge pressure. This energy is totally lost in the mud circuit because the mud pressure is zero when it returns to the pits. In this case, the pump discharge pressure represents the total pressure losses in the mud circuit.

These pressure losses occur:

1) In the surface equipment.
2) In the drill pipes and drill collars.
3) Through the bit.
4) In the annulus between the well bore and the drill string.

The pressure loss equations are a function of:

(a) The rheology of the fluid.
(b) The type of flow (laminar or turbulent).
(c) The pipe and hole geometry.

The equations given below are used in drilling for:

(a) A Newtonian fluid, a Bingham fluid and Ostwald fluid.
(b) Laminar and turbulent flow.
(c) A cylindrical pipe and annulus.

PRESSURE LOSS EQUATIONS

NEWTONIAN FLUID

In drill string

- Laminar flow:

$$p = \frac{QL\mu}{612.95D^4}$$

- Turbulent flow:

$$p = \frac{Ld^{0.8}Q^{1.8}\mu^{0.2}}{901.63D^{4.8}}$$

Annulus

- Laminar flow:

$$p = \frac{QL\mu}{408.63\ (D_0 + D_i)\ (D_0 - D_i)^3}$$

- Turbulent flow:

$$p = \frac{Ld^{0.8}Q^{1.8}\mu^{0.2}}{706.96\ (D_0 + D_i)^{1.8}\ (D_0 - D_i)^3}$$

PRESSURE LOSS EQUATIONS (continued)

BINGHAM FLUID

In drill string

- Laminar flow:

$$p = \frac{LQ\mu_p}{612.95D^4} + \frac{\tau_0 L}{13.26D}$$

- Turbulent flow:

$$p = \frac{Ld^{0.8}Q^{1.8}\mu_p{}^{0.2}}{901.63D^{4.8}}$$

Annulus

- Laminar flow:

$$p = \frac{LQ\mu_p}{408.63\ (D_0 + D_i)(D_0 - D_i)^3} + \frac{\tau_0 L}{13.26\ (D_0 - D_i)}$$

- Turbulent flow:

$$p = \frac{Ld^{0.8}Q^{1.8}\mu_p{}^{0.2}}{706.96\,(D_0 + D_i)^{1.8}\ (D_0 - D_i)^3}$$

PRESSURE LOSS EQUATIONS (continued)

OSTWALD FLUID

In drill string

- Laminar flow:

$$p = \frac{KL}{13.26D}\left[\frac{2.59}{D^3}\,Q\frac{(3n + 1)}{n}\right]^n$$

- Turbulent flow:

$$p = \frac{(\log\ n + 2.5)\,dQ^2L}{586.94D^5}\quad \frac{D^4\ K\left(\dfrac{2.59}{D^3}\ Q\ \dfrac{3n + 1}{n}\right)^n}{18.07Q^2d}^{\frac{1.4 - \log n}{7}}$$

Annulus

- Laminar flow:

$$p = \frac{KL}{13.26(D_0 - D_i)}\left[\frac{5.18Q}{(D_0 + D_i)(D_0 - D_i)^2}\left(\frac{2n + 1}{n}\right)\right]^n$$

- Turbulent flow:

$$p = \frac{(\log n + 2.5)\ dQ^2L}{479.23(D_0 + D_i)^2\ (D_0 - D_i)^3}\left[\frac{(D_0 + D_i)^2(D_0 - D_i)^2K\left[\dfrac{5.18\,Q}{(D_0 + D_i)(D_0 - D_i)^2}\left(\dfrac{2n + 1}{n}\right)\right]^n}{22.13\,Q^2d}\right]^{\frac{1.4 - \log n}{7}}$$

PRESSURE DROP IN ORIFICES

$$\boxed{p = \frac{dQ^2}{2959.41 C^2 A^2}}$$

where :

p = pressure drop (kPa)
d = specific gravity (kg/l)
Q = flow rate (l/min)
A = total nozzle area (in²)
C = orifice coefficient
  C: 0.80 for non-jet bit
  C: 0.95 for jet bit

Example :

d = 1.15 kg/l 2 nozzles size 12/32 in
Q = 1500 l/min 1 nozzle size 13/32 in

$$p = \frac{1.15 \times (1500)^2}{2959.41 \times (0.95)^2 \left[\frac{\pi}{4} \left(\frac{12^2 + 12^2 + 13^2}{32^2} \right) \right]^2} = 7885 \text{ kPa}$$

With table G 49 : at 1 500 l/min

$$p_d = 6857 \text{ kPa} \quad \text{for } d = 1$$

$$p = 6857 \times 1.15 = 7885 \text{ kPa}$$

CALCULATION OF THE BIT NOZZLE VELOCITY

$$\boxed{V = \frac{Q}{38.71\ A}}$$

V = velocity (m/s)

Q = flow rate(l/min)

A = total nozzle area (in^2)

Order of magnitude: 100 m/s $<$ V $<$ 120 m/s

CALCULATION OF THE HYDRAULIC POWER AT THE BIT NOZZLES: P_h

$$P_h\,(\text{kW}) = \frac{p_d Q}{60\,000}$$

p_d = pressure drop in nozzles (kPa)

$$P_h\,(\text{hp}) = \frac{p_d Q}{44\,750}$$

Q = flow rate (l/min)

HYDRAULIC PRESSURE AT BIT IN RELATION TO BIT AREA: P_{hHSI}

$$\boxed{P_{hHSI} = \frac{p_d Q}{35\,140\ D^2}}$$

D = hole size (in)

P_{hHSI} = power (hp/in^2)

Order of magnitude: 2 hp/in^2 $<$ P_{hHSI} $<$ 5 hp/in^2

PRESSURE LOSS CALCULATION

The tables below can be used to calculate the pressure loss of a fluid circulating in a drilling installation.

The fluid is assumed to be a **Bingham fluid** in **turbulent** flow. The equations used are those in page 309 (G 17) of the Drilling Data Handbook. The pressure losses have the form :

$$p = NB$$

with :

$$N = \frac{LQ^{1.8}}{901.63 \; D^{4.8}} \qquad \text{(in drill string)}$$

$$N = \frac{LQ^{1.8}}{706.96 \; (D_0 + D_i)^{1.8} \; (D_0 - D_i)^3} \qquad \text{(annulus)}$$

(The tables are calculated with $L = 100$ m)

$$B = d^{0.8} \mu_p{}^{0.2}$$

Important: ***Note that the coefficients N represent pressure losses for pure water***

To calculate the pressure losses in a circuit :

a) **Find** in pages 315 to 321 the **coefficient** $\boldsymbol{B}$ corresponding *to the circulating mud.*

b) **Note** the **lengths** of the different sections of identical geometry in hundreds of meters (drill pipe interior, drill collar interior, *hole/drill collar annulus, hole/drill pipe* annulus).

c) **Find** in pages 322 to 359, the corresponding **coefficients** $\boldsymbol{N_1, N_2, N_3, N_4}$ **and** $\boldsymbol{N_5}$.

d) **Calculate** the **pressure drops** in the nozzles.

$$\boxed{\boldsymbol{p_{\text{total}} = (N_1 + L_2N_2 + L_3N_3 + L_4N_4 + L_5N_5)B + p_d d}}$$

where :

$L_2, L_3, ..., L_5$ = lengths of the different sections (100 m)
p_d = pressure drop in nozzles *for $d = 1$ kg/l (kPa), pages 339 to 347*
d = specific gravity (kg/liter)
N_1 = pressure loss coefficient in the surface equipment page *322*
N_2 = pressure loss coefficient in the drill pipes (kPa/100 m), pages 323 to 336
N_3 = pressure loss coefficient in the drill collars (kPa/100 m), pages 337 and 338
N_4 = pressure loss coefficient in hole/drill collar annulus (kPa/100 m), pages 351 to 355
N_5 = *pressure* loss coefficient in hole/drill pipe annulus (kPa/100 m), pages 356 to 359

PRESSURE LOSS CALCULATION (continued)

Calculation example

8 1/2 inch hole at a depth of 2300 m. The mud specific gravity $d = 1.15$ and its plastic viscosity $\mu_p = 22$ cP. The drilling flow rate $Q = 1500$ l/min. The surface equipment is No. 3.

The drill string consists of:

(a) 170 m of 6 3/4 × 2 13/16 in drill collars.
(b) 2 130 m of 5 inch, 19.50 – E – NC50 drill pipes.

The bit is equipped with a combination of nozzles: 11/11/12.

I. Coefficient $\boldsymbol{B} = \mathbf{2.08}$ (page 315).

II. 1) Surface equipment (page 322) $\boldsymbol{N_1} = \mathbf{95}$
2) In drill pipes (page 332) $\boldsymbol{N_2} = \mathbf{57}$
3) In drill collars (page 337) $\boldsymbol{N_3} = \mathbf{404}$
4) In nozzles (page 339) $\boldsymbol{p_d} = \mathbf{9611\ kPa}$
5) Hole/pipe annulus (page 352) $\boldsymbol{N_4} = \mathbf{102}$

III. Discharge pressure in normal circulation p_r:

$$p_r = (N_1 + 21.3\,N_2 + 1.7\,N_3 + 1.7\,N_4 + 21.3\,N_5)\,B + p_d d$$

$$= (95 + 21.3 \times 57 + 1.7 \times 404 + 1.7 \times 102 + 21.3 \times 19)\,2.08 + 9\,611 \times 1.15$$

$$= \mathbf{16\,407\ kPa}$$

TABLE OF COEFFICIENTS B

Specific gravity Viscosity	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18
2	1.15	1.16	1.17	1.18	1.19	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.28	1.29	1.30	1.31
4	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.46	1.47	1.48	1.49	1.50	1.51
6	1.43	1.44	1.45	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63
8	1.52	1.53	1.54	1.55	1.56	1.58	1.59	1.60	1.61	1.62	1.64	1.65	1.66	1.67	1.68	1.70	1.71	1.72	1.73
10	1.58	1.60	1.61	1.62	1.64	1.65	1.66	1.67	1.69	1.70	1.71	1.72	1.74	1.75	1.76	1.77	1.78	1.80	1.81
12	1.64	1.66	1.67	1.68	1.70	1.71	1.72	1.74	1.75	1.76	1.77	1.79	1.80	1.81	1.83	1.84	1.85	1.86	1.88
14	1.70	1.71	1.72	1.74	1.75	1.76	1.78	1.79	1.80	1.82	1.83	1.84	1.86	1.87	1.88	1.90	1.91	1.92	1.94
16	1.74	1.76	1.77	1.78	1.80	1.81	1.82	1.84	1.85	1.87	1.88	1.89	1.91	1.92	1.93	1.95	1.96	1.97	1.99
18	1.78	1.80	1.81	1.83	1.84	1.85	1.87	1.88	1.90	1.91	1.92	1.94	1.95	1.97	1.98	1.99	2.01	2.02	2.03
20	1.82	1.84	1.85	1.86	1.88	1.89	1.91	1.92	1.94	1.95	1.96	1.98	1.99	2.01	2.02	2.04	2.05	2.06	2.08
22	1.86	1.87	1.89	1.90	1.91	1.93	1.94	1.96	1.97	1.99	2.00	2.02	2.03	2.05	2.06	2.08	2.09	2.10	2.12
24	1.89	1.90	1.92	1.93	1.95	1.96	1.98	1.99	2.01	2.02	2.04	2.05	2.07	2.08	2.10	2.11	2.13	2.14	2.16
26	1.92	1.93	1.95	1.96	1.98	2.00	2.01	2.03	2.04	2.06	2.07	2.09	2.10	2.12	2.13	2.15	2.16	2.18	2.19
28	1.95	1.96	1.98	1.99	2.01	2.02	2.04	2.06	2.07	2.09	2.10	2.12	2.13	2.15	2.16	2.18	2.19	2.21	2.22
30	1.97	1.99	2.01	2.02	2.04	2.05	2.07	2.08	2.10	2.12	2.13	2.15	2.16	2.18	2.19	2.21	2.22	2.24	2.25
32	2.00	2.02	2.03	2.05	2.06	2.08	2.10	2.11	2.13	2.14	2.16	2.17	2.19	2.21	2.22	2.24	2.25	2.27	2.28
34	2.02	2.04	2.06	2.07	2.09	2.10	2.12	2.14	2.15	2.17	2.18	2.20	2.22	2.23	2.25	2.26	2.28	2.30	2.31
36	2.05	2.06	2.08	2.10	2.11	2.13	2.15	2.16	2.18	2.19	2.21	2.23	2.24	2.26	2.27	2.29	2.31	2.32	2.34
38	2.07	2.09	2.10	2.12	2.14	2.15	2.17	2.19	2.20	2.22	2.23	2.25	2.27	2.28	2.30	2.31	2.33	2.35	2.36
40	2.09	2.11	2.12	2.14	2.16	2.17	2.19	2.21	2.22	2.24	2.26	2.27	2.29	2.31	2.32	2.34	2.35	2.37	2.39
42	2.11	2.13	2.15	2.16	2.18	2.20	2.21	2.23	2.25	2.26	2.28	2.30	2.31	2.33	2.35	2.36	2.38	2.39	2.41
44	2.13	2.15	2.17	2.18	2.20	2.22	2.23	2.25	2.27	2.28	2.30	2.32	2.33	2.35	2.37	2.38	2.40	2.42	2.43
46	2.15	2.17	2.18	2.20	2.22	2.24	2.25	2.27	2.29	2.30	2.32	2.34	2.35	2.37	2.39	2.40	2.42	2.44	2.46
48	2.17	2.19	2.20	2.22	2.24	2.26	2.27	2.29	2.31	2.32	2.34	2.36	2.37	2.39	2.41	2.43	2.44	2.46	2.48
50	2.19	2.20	2.22	2.24	2.26	2.27	2.29	2.31	2.33	2.34	2.36	2.38	2.39	2.41	2.43	2.45	2.46	2.48	2.50
52	2.20	2.22	2.24	2.26	2.27	2.29	2.31	2.33	2.34	2.36	2.38	2.40	2.41	2.43	2.45	2.46	2.46	2.50	2.52
54	2.22	2.24	2.26	2.27	2.29	2.31	2.33	2.34	2.36	2.38	2.40	2.41	2.43	2.45	2.47	2.48	2.50	2.52	2.54
56	2.24	2.25	2.27	2.29	2.31	2.33	2.34	2.36	2.38	2.40	2.41	2.43	2.45	2.47	2.48	2.50	2.52	2.54	2.55
58	2.25	2.27	2.29	2.31	2.32	2.34	2.36	2.38	2.40	2.41	2.43	2.45	2.47	2.48	2.50	2.52	2.54	2.55	2.57
60	2.27	2.29	2.30	2.32	2.34	2.36	2.38	2.39	2.41	2.43	2.45	2.47	2.48	2.50	2.52	2.54	2.55	2.57	2.59
62	2.28	2.30	2.32	2.34	2.36	2.37	2.39	2.41	2.43	2.45	2.46	2.48	2.50	2.52	2.54	2.55	2.57	2.59	2.61
64	2.30	2.32	2.33	2.35	2.37	2.39	2.41	2.43	2.44	2.46	2.48	2.50	2.52	2.53	2.55	2.57	2.59	2.60	2.62
66	2.31	2.33	2.35	2.37	2.39	2.40	2.42	2.44	2.46	2.48	2.49	2.51	2.53	2.55	2.57	2.59	2.60	2.62	2.64
68	2.33	2.34	2.36	2.38	2.40	2.42	2.44	2.45	2.47	2.49	2.51	2.53	2.55	2.56	2.58	2.60	2.62	2.64	2.65
70	2.34	2.36	2.38	2.39	2.11	2.43	2.45	2.47	2.49	2.51	2.52	2.54	2.56	2.58	2.60	2.62	2.63	2.65	2.67

TABLE OF COEFFICIENTS B (continued)

Specific gravity Viscosity	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37
2	1.32	1.33	1.34	1.35	1.36	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.43	1.44	1.45	1.46	1.47	1.48
4	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70
6	1.64	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84
8	1.74	1.75	1.77	1.78	1.79	1.80	1.81	1.82	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.92	1.93	1.94	1.95
10	1.82	1.83	1.85	1.86	1.87	1.88	1.89	1.91	1.92	1.93	1.94	1.96	1.97	1.98	1.99	2.00	2.01	2.03	2.04
12	1.89	1.90	1.91	1.93	1.94	1.95	1.97	1.98	1.99	2.00	2.02	2.03	2.04	2.05	2.06	2.08	2.09	2.10	2.11
14	1.95	1.96	1.97	1.99	2.00	2.01	2.03	2.04	2.05	2.07	2.08	2.09	2.10	2.12	2.13	2.14	2.16	2.17	2.18
16	2.00	2.01	2.03	2.04	2.05	2.07	2.08	2.09	2.11	2.12	2.13	2.15	2.16	2.17	2.19	2.20	2.21	2.23	2.24
18	2.05	2.06	2.08	2.09	2.10	2.12	2.13	2.14	2.16	2.17	2.19	2.20	2.21	2.23	2.24	2.25	2.27	2.28	2.29
20	2.09	2.11	2.12	2.13	2.15	2.16	2.18	2.19	2.20	2.22	2.23	2.25	2.26	2.27	2.29	2.30	2.31	2.33	2.34
22	2.13	2.15	2.16	2.18	2.19	2.20	2.22	2.23	2.25	2.26	2.27	2.29	2.30	2.32	2.33	2.35	2.36	2.37	2.39
24	2.17	2.18	2.20	2.21	2.23	2.24	2.26	2.27	2.29	2.30	2.31	2.33	2.34	2.36	2.37	2.39	2.40	2.41	2.43
26	2.21	2.22	2.23	2.25	2.26	2.28	2.29	2.31	2.32	2.34	2.35	2.37	2.38	2.40	2.41	2.42	2.44	2.45	2.47
28	2.24	2.25	2.27	2.28	2.30	2.31	2.33	2.34	2.36	2.37	2.39	2.40	2.42	2.43	2.45	2.46	2.48	2.49	2.51
30	2.27	2.28	2.30	2.31	2.33	2.35	2.36	2.38	2.39	2.41	2.42	2.44	2.45	2.47	2.48	2.50	2.51	2.52	2.54
32	2.30	2.31	2.33	2.34	2.36	2.38	2.39	2.41	2.42	2.44	2.45	2.47	2.48	2.50	2.51	2.53	2.54	2.56	2.57
34	2.33	2.34	2.36	2.37	2.39	2.40	2.42	2.44	2.45	2.47	2.48	2.50	2.51	2.53	2.54	2.56	2.57	2.59	2.60
36	2.35	2.37	2.39	2.40	2.42	2.43	2.45	2.46	2.48	2.49	2.51	2.53	2.54	2.56	2.57	2.59	2.60	2.62	2.63
38	2.38	2.39	2.41	2.43	2.44	2.46	2.47	2.49	2.51	2.52	2.54	2.55	2.57	2.58	2.60	2.62	2.63	2.65	2.66
40	2.40	2.42	2.44	2.45	2.47	2.48	2.50	2.52	2.53	2.55	2.56	2.58	2.60	2.61	2.63	2.64	2.66	2.67	2.69
42	2.43	2.44	2.46	2.48	2.49	2.51	2.52	2.54	2.56	2.57	2.59	2.60	2.62	2.64	2.65	2.67	2.68	2.70	2.72
44	2.45	2.47	2.48	2.50	2.52	2.53	2.55	2.56	2.58	2.60	2.61	2.63	2.65	2.66	2.68	2.69	2.71	2.73	2.74
46	2.47	2.49	2.50	2.52	2.54	2.55	2.57	2.59	2.60	2.62	2.64	2.65	2.67	2.69	2.70	2.72	2.73	2.75	2.77
48	2.49	2.51	2.53	2.54	2.56	2.58	2.59	2.61	2.63	2.64	2.66	2.68	2.69	2.71	2.72	2.74	2.76	2.77	2.79
50	2.51	2.53	2.55	2.56	2.58	2.60	2.61	2.63	2.65	2.66	2.68	2.70	2.71	2.73	2.75	2.76	2.78	2.80	2.81
52	2.53	2.55	2.57	2.58	2.60	2.62	2.63	2.65	2.67	2.69	2.70	2.72	2.74	2.75	2.77	2.79	2.80	2.82	2.84
54	2.55	2.57	2.59	2.60	2.62	2.64	2.65	2.67	2.69	2.71	2.72	2.74	2.76	2.77	2.79	2.81	2.82	2.84	2.86
56	2.57	2.59	2.61	2.62	2.64	2.66	2.67	2.69	2.71	2.73	2.74	2.76	2.78	2.79	2.81	2.83	2.84	2.86	2.88
58	2.59	2.61	2.62	2.64	2.66	2.68	2.69	2.71	2.73	2.74	2.76	2.78	2.80	2.81	2.83	2.85	2.86	2.88	2.90
60	2.61	2.62	2.64	2.66	2.68	2.69	2.71	2.73	2.75	2.76	2.78	2.80	2.81	2.83	2.85	2.87	2.88	2.90	2.92
62	2.62	2.64	2.66	2.68	2.69	2.71	2.73	2.75	2.76	2.78	2.80	2.82	2.83	2.85	2.87	2.89	2.90	2.92	2.94
64	2.64	2.66	2.68	2.69	2.71	2.73	2.75	2.76	2.78	2.80	2.82	2.83	2.85	2.87	2.89	2.90	2.92	2.94	2.96
66	2.66	2.67	2.69	2.71	2.73	2.75	2.76	2.78	2.80	2.82	2.83	2.85	2.87	2.89	2.90	2.92	2.94	2.96	2.97
68	2.67	2.69	2.71	2.73	2.74	2.76	2.78	2.80	2.82	2.83	2.85	2.87	2.89	2.90	2.92	2.94	2.96	2.97	2.99
70	2.69	2.71	2.72	2.74	2.76	2.78	2.80	2.81	2.83	2.85	2.87	2.89	2.90	2.92	2.94	2.96	2.97	2.99	3.01

TABLE OF COEFFICIENTS B (continued)

Specific gravity / Viscosity	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56
2	1.49	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.61	1.62	1.63	1.64
4	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.83	1.84	1.85	1.86	1.87	1.88
6	1.85	1.86	1.87	1.88	1.89	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00	2.01	2.02	2.03	2.04
8	1.96	1.97	1.98	2.00	2.01	2.02	2.03	2.04	2.05	2.06	2.07	2.09	2.10	2.11	2.12	2.13	2.14	2.15	2.16
10	2.05	2.06	2.07	2.09	2.10	2.11	2.12	2.13	2.15	2.16	2.17	2.18	2.19	2.20	2.22	2.23	2.24	2.25	2.26
12	2.13	2.14	2.15	2.16	2.18	2.19	2.20	2.21	2.22	2.24	2.25	2.26	2.27	2.29	2.30	2.31	2.32	2.33	2.35
14	2.19	2.21	2.22	2.23	2.24	2.26	2.27	2.28	2.29	2.31	2.32	2.33	2.34	2.36	2.37	2.38	2.39	2.41	2.42
16	2.25	2.27	2.28	2.29	2.30	2.32	2.33	2.34	2.36	2.37	2.38	2.40	2.41	2.42	2.43	2.45	2.46	2.47	2.48
18	2.31	2.32	2.33	2.35	2.36	2.37	2.39	2.40	2.41	2.43	2.44	2.45	2.47	2.48	2.49	2.50	2.52	2.53	2.54
20	2.36	2.37	2.38	2.40	2.41	2.42	2.44	2.45	2.46	2.48	2.49	2.50	2.52	2.53	2.54	2.56	2.57	2.59	2.60
22	2.40	2.41	2.43	2.44	2.46	2.47	2.48	2.50	2.51	2.53	2.54	2.55	2.57	2.58	2.59	2.61	2.62	2.63	2.65
24	2.44	2.46	2.47	2.49	2.50	2.51	2.53	2.54	2.56	2.57	2.58	2.60	2.61	2.63	2.64	2.65	2.67	2.68	2.69
26	2.48	2.50	2.51	2.53	2.54	2.55	2.57	2.58	2.60	2.61	2.63	2.64	2.65	2.67	2.68	2.70	2.71	2.72	2.74
28	2.52	2.53	2.55	2.56	2.58	2.59	2.61	2.62	2.64	2.65	2.66	2.68	2.69	2.71	2.72	2.74	2.75	2.77	2.78
30	2.55	2.57	2.58	2.60	2.61	2.63	2.64	2.66	2.67	2.69	2.70	2.72	2.73	2.75	2.76	2.77	2.79	2.80	2.82
32	2.59	2.60	2.62	2.63	2.65	2.66	2.68	2.69	2.71	2.72	2.74	2.75	2.77	2.78	2.80	2.81	2.83	2.84	2.85
34	2.62	2.63	2.65	2.66	2.68	2.70	2.71	2.73	2.74	2.76	2.77	2.79	2.80	2.81	2.83	2.84	2.86	2.87	2.89
36	2.65	2.66	2.68	2.70	2.71	2.73	2.74	2.76	2.77	2.79	2.80	2.82	2.83	2.85	2.86	2.88	2.89	2.91	2.92
38	2.68	2.69	2.71	2.72	2.74	2.76	2.77	2.79	2.80	2.82	2.83	2.85	2.86	2.88	2.89	2.91	2.92	2.94	2.95
40	2.71	2.72	2.74	2.75	2.77	2.78	2.80	2.82	2.83	2.85	2.86	2.88	2.89	2.91	2.92	2.94	2.95	2.97	2.98
42	2.73	2.75	2.76	2.78	2.80	2.81	2.83	2.84	2.86	2.87	2.89	2.91	2.92	2.94	2.95	2.97	2.98	3.00	3.01
44	2.76	2.77	2.79	2.81	2.82	2.84	2.85	2.87	2.89	2.90	2.92	2.93	2.95	2.96	2.98	3.00	3.01	3.03	3.04
46	2.78	2.80	2.81	2.83	2.85	2.86	2.88	2.89	2.91	2.93	2.94	2.96	2.97	2.99	3.01	3.02	3.04	3.05	3.07
48	2.81	2.82	2.84	2.86	2.87	2.89	2.90	2.92	2.94	2.95	2.97	2.98	3.00	3.02	3.03	3.05	3.06	3.08	3.10
50	2.83	2.85	2.86	2.88	2.89	2.91	2.93	2.94	2.96	2.98	2.99	3.01	3.02	3.04	3.06	3.07	3.09	3.10	3.12
52	2.85	2.87	2.88	2.90	2.92	2.93	2.95	2.97	2.98	3.00	3.02	3.03	3.05	3.06	3.08	3.10	3.11	3.13	3.15
54	2.87	2.89	2.91	2.92	2.94	2.96	2.97	2.99	3.01	3.02	3.04	3.06	3.07	3.09	3.10	3.12	3.14	3.15	3.17
56	2.89	2.91	2.93	2.94	2.96	2.98	2.99	3.01	3.03	3.04	3.06	3.08	3.09	3.11	3.13	3.14	3.16	3.18	3.19
58	2.91	2.93	2.95	2.97	2.98	3.00	3.02	3.03	3.05	3.07	3.08	3.10	3.12	3.13	3.15	3.17	3.18	3.20	3.22
60	2.93	2.95	2.97	2.99	3.00	3.02	3.04	3.05	3.07	3.09	3.10	3.12	3.14	3.15	3.17	3.19	3.20	3.22	3.24
62	2.95	2.97	2.99	3.01	3.02	3.04	3.06	3.07	3.09	3.11	3.12	3.14	3.16	3.17	3.19	3.21	3.22	3.24	3.26
64	2.97	2.99	3.01	3.02	3.04	3.06	3.08	3.09	3.11	3.13	3.14	3.16	3.18	3.19	3.21	3.23	3.25	3.26	3.28
66	2.99	3.01	3.03	3.04	3.06	3.08	3.09	3.11	3.13	3.15	3.16	3.18	3.20	3.21	3.23	3.25	3.27	3.28	3.30
68	3.01	3.03	3.04	3.06	3.08	3.10	3.11	3.13	3.15	3.16	3.18	3.20	3.22	3.23	3.25	3.27	3.28	3.30	3.32
70	3.03	3.04	3.06	3.08	3.10	3.11	3.13	3.15	3.17	3.18	3.20	3.22	3.24	3.25	3.27	3.29	3.30	3.32	3.34

TABLE OF COEFFICIENTS B (continued)

Specific gravity / Viscosity	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75
2	1.65	1.66	1.66	1.67	1.68	1.69	1.70	1.71	1.71	1.72	1.73	1.74	1.75	1.76	1.76	1.77	1.78	1.79	1.80
4	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00	2.01	2.02	2.03	2.04	2.05	2.06	2.06
6	2.05	2.06	2.07	2.08	2.09	2.10	2.12	2.13	2.14	2.15	2.16	2.17	2.18	2.19	2.20	2.21	2.22	2.23	2.24
8	2.17	2.19	2.20	2.21	2.22	2.23	2.24	2.25	2.26	2.27	2.28	2.30	2.31	2.32	2.33	2.34	2.35	2.36	2.37
10	2.27	2.29	2.30	2.31	2.32	2.33	2.34	2.35	2.37	2.38	2.39	2.40	2.41	2.42	2.43	2.45	2.46	2.47	2.48
12	2.36	2.37	2.38	2.39	2.41	2.42	2.43	2.44	2.45	2.47	2.48	2.49	2.50	2.51	2.52	2.54	2.55	2.56	2.57
14	2.43	2.44	2.46	2.47	2.48	2.49	2.51	2.52	2.53	2.54	2.56	2.57	2.58	2.59	2.60	2.62	2.63	2.64	2.65
16	2.50	2.51	2.52	2.54	2.55	2.56	2.57	2.59	2.60	2.61	2.62	2.64	2.65	2.66	2.67	2.69	2.70	2.71	2.72
18	2.56	2.57	2.58	2.60	2.61	2.62	2.64	2.65	2.66	2.67	2.69	2.70	2.71	2.73	2.74	2.75	2.76	2.78	2.79
20	2.61	2.63	2.64	2.66	2.66	2.68	2.69	2.70	2.72	2.73	2.74	2.76	2.77	2.78	2.80	2.81	2.82	2.84	2.85
22	2.66	2.68	2.69	2.70	2.72	2.73	2.74	2.76	2.77	2.78	2.80	2.81	2.82	2.84	2.85	2.86	2.88	2.89	2.90
24	2.71	2.72	2.74	2.75	2.76	2.78	2.79	2.80	2.82	2.83	2.85	2.86	2.87	2.89	2.90	2.91	2.93	2.94	2.95
26	2.75	2.77	2.78	2.79	2.81	2.82	2.84	2.85	2.86	2.88	2.89	2.91	2.92	2.93	2.95	2.96	2.97	2.99	3.00
28	2.79	2.81	2.82	2.84	2.85	2.86	2.88	2.89	2.91	2.92	2.93	2.95	2.96	2.98	2.99	3.01	3.02	3.03	3.05
30	2.83	2.85	2.86	2.88	2.89	2.90	2.92	2.93	2.95	2.96	2.98	2.99	3.00	3.02	3.03	3.05	3.06	3.08	3.09
32	2.87	2.88	2.90	2.91	2.93	2.94	2.96	2.97	2.99	3.00	3.01	3.03	3.04	3.06	3.07	3.09	3.10	3.12	3.13
34	2.90	2.92	2.93	2.95	2.96	2.98	2.99	3.01	3.02	3.04	3.05	3.07	3.08	3.09	3.11	3.12	3.14	3.15	3.17
36	2.94	2.95	2.97	2.98	3.00	3.01	3.03	3.04	3.06	3.07	3.09	3.10	3.12	3.13	3.15	3.16	3.17	3.19	3.20
38	2.97	2.98	3.00	3.01	3.03	3.04	3.06	3.07	3.09	3.10	3.12	3.13	3.15	3.16	3.18	3.19	3.21	3.22	3.24
40	3.00	3.02	3.03	3.05	3.06	3.08	3.09	3.11	3.12	3.14	3.15	3.17	3.18	3.20	3.21	3.23	3.24	3.26	3.27
42	3.03	3.04	3.06	3.08	3.09	3.11	3.12	3.14	3.15	3.17	3.18	3.20	3.21	3.23	3.24	3.26	3.27	3.29	3.30
44	3.06	3.07	3.09	3.10	3.12	3.14	3.15	3.17	3.18	3.20	3.21	3.23	3.24	3.26	3.27	3.29	3.30	3.32	3.34
46	3.09	3.10	3.12	3.13	3.15	3.16	3.18	3.19	3.21	3.23	3.24	3.26	3.27	3.29	3.30	3.32	3.33	3.35	3.36
48	3.11	3.13	3.14	3.16	3.17	3.19	3.21	3.22	3.24	3.25	3.27	3.28	3.30	3.32	3.33	3.35	3.36	3.38	3.39
50	3.14	3.15	3.17	3.18	3.20	3.22	3.23	3.25	3.26	3.28	3.30	3.31	3.33	3.34	3.36	3.37	3.39	3.41	3.42
52	3.16	3.18	3.19	3.21	3.23	3.24	3.26	3.27	3.29	3.31	3.32	3.34	3.35	3.37	3.39	3.40	3.42	3.43	3.45
54	3.19	3.20	3.22	3.23	3.25	3.27	3.28	3.30	3.31	3.33	3.35	3.36	3.38	3.39	3.41	3.43	3.44	3.46	3.47
56	3.21	3.23	3.24	3.26	3.27	3.29	3.31	3.32	3.34	3.36	3.37	3.39	3.40	3.42	3.44	3.45	3.47	3.48	3.50
58	3.23	3.25	3.26	3.28	3.30	3.31	3.33	3.35	3.36	3.38	3.40	3.41	3.43	3.44	3.46	3.48	3.49	3.51	3.52
60	3.25	3.27	3.29	3.30	3.32	3.34	3.35	3.37	3.39	3.40	3.42	3.43	3.45	3.47	3.48	3.50	3.52	3.53	3.55
62	3.27	3.29	3.31	3.32	3.34	3.36	3.37	3.39	3.41	3.42	3.44	3.46	3.47	3.49	3.51	3.52	3.54	3.56	3.57
64	3.30	3.31	3.33	3.35	3.36	3.38	3.40	3.41	3.43	3.45	3.46	3.48	3.50	3.51	3.53	3.55	3.56	3.58	3.59
66	3.32	3.33	3.35	3.37	3.38	3.40	3.42	3.43	3.45	3.47	3.48	3.50	3.52	3.53	3.55	3.57	3.58	3.60	3.62
68	3.34	3.35	3.37	3.39	3.40	3.42	3.44	3.45	3.47	3.49	3.50	3.52	3.54	3.56	3.57	3.59	3.61	3.62	3.64
70	3.36	3.37	3.39	3.41	3.42	3.44	3.46	3.47	3.49	3.51	3.53	3.54	3.56	3.58	3.59	3.61	3.63	3.64	3.66

TABLE OF COEFFICIENTS B (continued)

Specific gravity / Viscosity	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94
2	1.81	1.81	1.82	1.83	1.84	1.85	1.85	1.86	1.87	1.88	1.89	1.90	1.90	1.91	1.92	1.93	1.94	1.94	1.95
4	2.07	2.08	2.09	2.10	2.11	2.12	2.13	2.14	2.15	2.16	2.17	2.18	2.19	2.20	2.21	2.21	2.22	2.23	2.24
6	2.25	2.26	2.27	2.28	2.29	2.30	2.31	2.32	2.33	2.34	2.35	2.36	2.37	2.38	2.39	2.40	2.41	2.42	2.43
8	2.38	2.39	2.40	2.41	2.43	2.44	2.45	2.46	2.47	2.48	2.49	2.50	2.51	2.52	2.53	2.54	2.55	2.56	2.58
10	2.49	2.50	2.51	2.53	2.54	2.55	2.56	2.57	2.58	2.59	2.60	2.62	2.63	2.64	2.65	2.66	2.67	2.68	2.69
12	2.58	2.60	2.61	2.62	2.63	2.64	2.65	2.67	2.68	2.69	2.70	2.71	2.72	2.74	2.75	2.76	2.77	2.78	2.79
14	2.66	2.68	2.69	2.70	2.71	2.73	2.74	2.75	2.76	2.77	2.79	2.80	2.81	2.82	2.83	2.84	2.86	2.87	2.88
16	2.74	2.75	2.76	2.77	2.79	2.80	2.81	2.82	2.84	2.85	2.86	2.87	2.89	2.90	2.91	2.92	2.93	2.95	2.96
18	2.80	2.81	2.83	2.84	2.85	2.87	2.88	2.89	2.90	2.92	2.93	2.94	2.95	2.97	2.98	2.99	3.00	3.02	3.03
20	2.86	2.87	2.89	2.90	2.91	2.93	2.94	2.95	2.97	2.98	2.99	3.00	3.02	3.03	3.04	3.06	3.07	3.08	3.09
22	2.92	2.93	2.94	2.96	2.97	2.98	3.00	3.01	3.02	3.04	3.05	3.06	3.07	3.09	3.10	3.11	3.13	3.14	3.15
24	2.97	2.98	2.99	3.01	3.02	3.04	3.05	3.06	3.08	3.09	3.10	3.12	3.13	3.14	3.16	3.17	3.18	3.20	3.21
26	3.02	3.03	3.04	3.06	3.07	3.08	3.10	3.11	3.12	3.14	3.15	3.17	3.18	3.19	3.21	3.22	3.23	3.25	3.26
28	3.06	3.07	3.09	3.10	3.12	3.13	3.14	3.16	3.17	3.19	3.20	3.21	3.23	3.24	3.25	3.27	3.28	3.30	3.31
30	3.10	3.12	3.13	3.15	3.16	3.17	3.19	3.20	3.22	3.23	3.24	3.26	3.27	3.29	3.30	3.31	3.33	3.34	3.35
32	3.14	3.16	3.17	3.19	3.20	3.21	3.23	3.24	3.26	3.27	3.29	3.30	3.31	3.33	3.34	3.36	3.37	3.38	3.40
34	3.18	3.20	3.21	3.23	3.24	3.25	3.27	3.28	3.30	3.31	3.33	3.34	3.35	3.37	3.38	3.40	3.41	3.43	3.44
36	3.22	3.23	3.25	3.26	3.28	3.29	3.31	3.32	3.34	3.35	3.36	3.38	3.39	3.41	3.42	3.44	3.45	3.47	3.48
38	3.25	3.27	3.28	3.30	3.31	3.33	3.34	3.36	3.37	3.39	3.40	3.42	3.43	3.44	3.46	3.47	3.49	3.50	3.52
40	3.29	3.30	3.32	3.33	3.35	3.36	3.38	3.39	3.41	3.42	3.44	3.45	3.47	3.48	3.49	3.51	3.52	3.54	3.55
42	3.32	3.33	3.35	3.36	3.38	3.39	3.41	3.42	3.44	3.45	3.47	3.48	3.50	3.51	3.53	3.54	3.56	3.57	3.59
44	3.35	3.37	3.38	3.40	3.41	3.43	3.44	3.46	3.47	3.49	3.50	3.52	3.53	3.55	3.56	3.58	3.59	3.61	3.62
46	3.38	3.40	3.41	3.43	3.44	3.46	3.47	3.49	3.50	3.52	2.53	3.55	3.56	3.58	3.59	3.61	3.62	3.64	3.65
48	3.41	3.42	3.44	3.46	3.47	3.49	3.50	3.52	3.53	3.55	3.56	3.58	3.59	3.61	3.62	3.64	3.66	3.67	3.69
50	3.44	3.45	3.47	3.48	3.50	3.52	3.53	3.55	3.56	3.58	3.59	3.61	3.62	3.64	3.65	3.67	3.68	3.70	3.72
52	3.46	3.48	3.50	3.51	3.53	3.54	3.56	3.57	3.59	3.61	3.62	3.64	3.65	3.67	3.68	3.70	3.71	3.73	3.74
54	3.49	3.51	3.52	3.54	3.55	3.57	3.59	3.60	3.62	3.63	3.65	3.66	3.68	3.70	3.71	3.73	3.74	3.76	3.77
56	3.52	3.53	3.55	3.56	3.58	3.60	3.61	3.63	3.64	3.66	3.67	3.69	3.71	3.72	3.74	3.75	3.77	3.79	3.80
58	3.54	3.56	3.57	3.59	3.60	3.62	3.64	3.65	3.67	3.68	3.70	3.72	3.73	3.75	3.76	3.78	3.80	3.81	3.83
60	3.56	3.58	3.60	3.61	3.63	3.65	3.66	3.68	3.69	3.71	3.73	3.74	3.76	3.77	3.79	3.81	3.82	3.84	3.85
62	3.59	3.60	3.62	3.64	3.65	3.67	3.69	3.70	3.72	3.73	3.75	3.77	3.78	3.80	3.81	3.83	3.85	3.86	3.88
64	3.61	3.63	3.64	3.66	3.68	3.69	3.71	3.73	3.74	3.76	3.77	3.79	3.81	3.82	3.84	3.86	3.87	3.89	3.90
66	3.63	3.65	3.67	3.68	3.70	3.72	3.73	3.75	3.76	3.78	3.80	3.81	3.83	3.85	3.86	3.88	3.90	3.91	3.93
68	3.66	3.67	3.69	3.70	3.72	3.74	3.75	3.77	3.79	3.80	3.82	3.84	3.85	3.87	3.89	3.90	3.92	3.94	3.95
70	3.68	3.69	3.71	3.73	3.74	3.76	3.76	3.79	3.81	3.83	3.84	3.86	3.88	3.89	3.91	3.93	3.94	3.96	3.97

TABLE OF COEFFICIENTS B (continued)

Specific gravity / Viscosity	1.95	1.96	1.97	1.98	1.99	2.00	2.01	2.02	2.03	2.04	2.05	2.06	2.07	2.08	2.09	2.10	2.11	2.12	2.13
2	1.96	1.97	1.98	1.98	1.99	2.00	2.01	2.02	2.02	2.03	2.04	2.05	2.06	2.06	2.07	2.08	2.09	2.10	2.10
4	2.25	2.26	2.27	2.28	2.29	2.30	2.31	2.32	2.32	2.33	2.34	2.35	2.36	2.37	2.38	2.39	2.40	2.41	2.42
6	2.44	2.45	2.46	2.47	2.48	2.49	2.50	2.51	2.52	2.53	2.54	2.55	2.56	2.57	2.58	2.59	2.60	2.61	2.62
8	2.59	2.60	2.61	2.62	2.63	2.64	2.65	2.66	2.67	2.68	2.69	2.70	2.71	2.72	2.73	2.74	2.75	2.76	2.78
10	2.70	2.72	2.73	2.74	2.75	2.76	2.77	2.78	2.79	2.80	2.81	2.83	2.84	2.85	2.86	2.87	2.88	2.89	2.90
12	2.80	2.82	2.83	2.84	2.85	2.86	2.87	2.88	2.90	2.91	2.92	2.93	2.94	2.95	2.96	2.98	2.99	3.00	3.01
14	2.89	2.90	2.92	2.93	2.94	2.95	2.96	2.98	2.99	3.00	3.01	3.02	3.03	3.05	3.06	3.07	3.08	3.09	3.10
16	2.97	2.98	3.00	3.01	3.02	3.03	3.04	3.06	3.07	3.08	3.09	3.10	3.12	3.13	3.14	3.15	3.16	3.18	3.19
18	3.04	3.05	3.07	3.08	3.09	3.10	3.12	3.13	3.14	3.15	3.17	3.18	3.19	3.20	3.21	3.23	3.24	3.25	3.26
20	3.11	3.12	3.13	3.14	3.16	3.17	3.18	3.20	3.21	3.22	3.23	3.25	3.26	3.27	3.28	3.30	3.31	3.32	3.33
22	3.17	3.18	3.19	3.20	3.22	3.23	3.24	3.26	3.27	3.28	3.30	3.31	3.32	3.33	3.35	3.36	3.37	3.38	3.40
24	3.22	3.23	3.25	3.26	3.27	3.29	3.30	3.31	3.33	3.34	3.35	3.37	3.38	3.39	3.41	3.42	3.43	3.44	3.46
26	3.27	3.29	3.30	3.31	3.33	3.34	3.35	3.37	3.38	3.39	3.41	3.42	3.43	3.45	3.46	3.47	3.49	3.50	3.51
28	3.32	3.34	3.35	3.36	3.38	3.39	3.40	3.42	3.43	3.44	3.46	3.47	3.49	3.50	3.51	3.53	3.54	3.55	3.57
30	3.37	3.38	3.40	3.41	3.42	3.44	3.45	3.47	3.48	3.49	3.51	3.52	3.53	3.55	3.56	3.57	3.59	3.60	3.62
32	3.41	3.43	3.44	3.45	3.47	3.48	3.50	3.51	3.52	3.54	3.55	3.57	3.58	3.59	3.61	3.62	3.63	3.65	3.66
34	3.45	3.47	3.48	3.50	3.51	3.52	3.54	3.55	3.57	3.58	3.59	3.61	3.62	3.64	3.65	3.66	3.68	3.69	3.71
36	3.49	3.51	3.52	3.54	3.55	3.57	3.58	3.59	3.61	3.62	3.64	3.65	3.66	3.68	3.69	3.71	3.72	3.74	3.75
38	3.53	3.55	3.56	3.58	3.59	3.60	3.62	3.63	3.65	3.66	3.68	3.69	3.70	3.72	3.73	3.75	3.76	3.78	3.79
40	3.57	3.58	3.60	3.61	3.63	3.64	3.66	3.67	3.68	3.70	3.71	3.73	3.74	3.76	3.77	3.79	3.80	3.81	3.83
42	3.60	3.62	3.63	3.65	3.66	3.68	3.69	3.71	3.72	3.74	3.75	3.76	3.78	3.79	3.81	3.82	3.84	3.85	3.87
44	3.64	3.65	3.67	3.68	3.70	3.71	3.73	3.74	3.76	3.77	3.79	3.80	3.81	3.83	3.84	3.86	3.87	3.89	3.90
46	3.67	3.68	3.70	3.71	3.73	3.74	3.76	3.77	3.79	3.80	3.82	3.83	3.85	3.86	3.88	3.89	3.91	3.92	3.94
48	3.70	3.72	3.73	3.75	3.76	3.78	3.79	3.81	3.82	3.84	3.85	3.87	3.88	3.90	3.91	3.93	3.94	3.96	3.97
50	3.73	3.75	3.76	3.78	3.79	3.81	3.82	3.84	3.85	3.87	3.88	3.90	3.91	3.93	3.94	3.96	3.97	3.99	4.00
52	3.76	3.78	3.79	3.81	3.82	3.84	3.85	3.87	3.88	3.90	3.91	3.93	3.94	3.96	3.97	3.99	4.01	4.02	4.04
54	3.79	3.80	3.82	3.84	3.85	3.87	3.88	3.90	3.91	3.93	3.94	3.96	3.97	3.99	4.00	4.02	4.04	4.05	4.07
56	3.82	3.83	3.85	3.86	3.88	3.89	3.91	3.93	3.94	3.96	3.97	3.99	4.00	4.02	4.03	4.05	4.07	4.08	4.10
58	3.84	3.86	3.87	3.89	3.91	3.92	3.94	3.95	3.97	3.98	4.00	4.02	4.03	4.05	4.06	4.08	4.09	4.11	4.12
60	3.87	3.89	3.90	3.92	3.93	3.95	3.96	3.98	4.00	4.01	4.03	4.04	4.06	4.07	4.09	4.11	4.12	4.14	3.15
62	3.89	3.91	3.93	3.94	3.96	3.97	3.99	4.01	4.02	4.04	4.05	4.07	4.09	4.10	4.12	4.13	4.15	4.16	4.18
64	3.92	3.94	3.95	3.97	3.98	4.00	4.02	4.03	4.05	4.06	4.08	4.10	4.11	4.13	4.14	4.16	4.18	4.19	4.21
66	3.94	3.96	3.98	3.99	4.01	4.02	4.04	4.06	4.07	4.09	4.10	4.12	4.14	4.15	4.17	4.18	4.20	4.22	4.23
68	3.97	3.98	4.00	4.02	4.03	4.05	4.06	4.08	4.10	4.11	4.13	4.15	4.16	4.18	4.19	4.21	4.23	4.24	4.26
70	3.99	4.01	4.02	4.04	4.06	4.07	4.09	4.10	4.12	4.14	4.15	4.17	4.19	4.20	4.22	4.23	4.25	4.27	4.28

TABLE OF COEFFICIENTS B (continued)

Specific gravity / Viscosity	2.14	2.15	2.16	2.17	2.18	2.19	2.20	2.21	2.22	2.23	2.24	2.25	2.26	2.27	2.28	2.29	2.30	2.31	2.32
2	2.11	2.12	2.13	2.13	2.14	2.15	2.16	2.17	2.17	2.18	2.19	2.20	2.21	2.21	2.22	2.23	2.24	2.24	2.25
4	2.43	2.43	2.44	2.45	2.46	2.47	2.48	2.49	2.50	2.51	2.52	2.52	2.53	2.54	2.55	2.56	2.57	2.58	2.59
6	2.63	2.64	2.65	2.66	2.67	2.68	2.69	2.70	2.71	2.72	2.73	2.74	2.75	2.76	2.77	2.78	2.79	2.80	2.81
8	2.79	2.80	2.81	2.82	2.83	2.84	2.85	2.86	2.87	2.88	2.89	2.90	2.91	2.92	2.93	2.94	2.95	2.96	2.97
10	2.91	2.92	2.93	2.95	2.96	2.97	2.98	2.99	3.00	3.01	3.02	3.03	3.04	3.05	3.06	3.08	3.09	3.10	3.11
12	3.02	3.03	3.04	3.05	3.07	3.08	3.09	3.10	3.11	3.12	3.13	3.14	3.16	3.17	3.18	3.19	3.20	3.21	3.22
14	3.12	3.13	3.14	3.15	3.16	3.17	3.19	3.20	3.21	3.22	3.23	3.24	3.25	3.27	3.28	3.29	3.30	3.31	3.32
16	3.20	3.21	3.22	3.24	3.25	3.26	3.27	3.28	3.30	3.31	3.32	3.33	3.34	3.35	3.37	3.38	3.39	3.40	3.41
18	3.28	3.29	3.30	3.31	3.33	3.34	3.35	3.36	3.37	3.39	3.40	3.41	3.42	3.43	3.45	3.46	3.47	3.48	3.49
20	3.35	3.36	3.37	3.38	3.40	3.41	3.42	3.43	3.45	3.46	3.47	3.48	3.50	3.51	3.52	3.53	3.54	3.56	3.57
22	3.41	3.42	3.44	3.45	3.46	3.47	3.49	3.50	3.51	3.52	3.54	3.55	3.56	3.58	3.59	3.60	3.61	3.63	3.64
24	3.47	3.48	3.50	3.51	3.52	3.54	3.55	3.56	3.57	3.59	3.60	3.61	3.63	3.64	3.65	3.66	3.68	3.69	3.70
26	3.53	3.54	3.55	3.57	3.58	3.59	3.61	3.62	3.63	3.64	3.66	3.67	3.68	3.70	3.71	3.72	3.74	3.75	3.76
28	3.58	3.59	3.61	3.62	3.63	3.65	3.66	3.67	3.69	3.70	3.71	3.73	3.74	3.75	3.77	3.78	3.79	3.80	3.82
30	3.63	3.64	3.66	3.67	3.68	3.70	3.71	3.72	3.74	3.75	3.76	3.78	3.79	3.80	3.82	3.83	3.84	3.86	3.87
32	3.68	3.69	3.70	3.72	3.73	3.74	3.76	3.77	3.79	3.80	3.81	3.83	3.84	3.85	3.87	3.88	3.89	3.91	3.92
34	3.72	3.73	3.75	3.76	3.78	3.79	3.80	3.82	3.83	3.85	3.86	3.87	3.89	3.90	3.91	3.93	3.94	3.96	3.97
36	3.76	3.78	3.79	3.81	3.82	3.83	3.85	3.86	3.88	3.89	3.90	3.92	3.93	3.95	3.96	3.97	3.99	4.00	4.01
38	3.80	3.82	3.83	3.85	3.86	3.88	3.89	3.90	3.92	3.93	3.95	3.96	3.97	3.99	4.00	4.02	4.03	4.04	4.06
40	3.84	3.86	3.87	3.89	3.90	3.92	3.93	3.94	3.96	3.97	3.99	4.00	4.02	4.03	4.04	4.06	4.07	4.09	4.10
42	3.88	3.90	3.91	3.92	3.94	3.95	3.97	3.98	4.00	4.01	4.03	4.04	4.05	4.07	4.08	4.10	4.11	4.13	4.14
44	3.92	3.93	3.95	3.96	3.98	3.99	4.01	4.02	4.03	4.05	4.06	4.08	4.09	4.11	4.12	4.14	4.15	4.16	4.18
46	3.95	3.97	3.98	4.00	4.01	4.03	4.04	4.06	4.07	4.09	4.10	4.11	4.13	4.14	4.16	4.17	4.19	4.20	4.22
48	3.99	4.00	4.02	4.03	4.05	4.06	4.08	4.09	4.11	4.12	4.13	4.15	4.16	4.18	4.19	4.21	4.22	4.24	4.25
50	4.02	4.03	4.05	4.06	4.08	4.09	4.11	4.12	4.14	4.15	4.17	4.18	4.20	4.21	4.23	4.24	4.26	4.27	4.29
52	4.05	4.07	4.08	4.10	4.11	4.13	4.14	4.16	4.17	4.19	4.20	4.22	4.23	4.25	4.26	4.28	4.29	4.31	4.32
54	4.08	4.10	4.11	4.13	4.14	4.16	4.17	4.19	4.20	4.22	4.23	4.25	4.26	4.28	4.29	4.31	4.32	4.34	4.35
56	4.11	4.13	4.14	4.16	4.17	4.19	4.20	4.22	4.23	4.25	4.26	4.28	4.29	4.31	4.32	4.34	4.36	4.37	4.39
58	4.14	4.16	4.17	4.19	4.20	4.22	4.23	4.25	4.26	4.28	4.29	4.31	4.32	4.34	4.36	4.37	4.39	4.40	4.42
60	4.17	4.18	4.20	4.22	4.23	4.25	4.26	4.28	4.29	4.31	4.32	4.34	4.35	4.37	4.39	4.40	4.42	4.43	4.45
62	4.20	4.21	4.23	4.24	4.26	4.27	4.29	4.31	4.32	4.34	4.35	4.37	4.38	4.40	4.41	4.43	4.44	4.46	4.48
64	4.22	4.24	4.25	4.27	4.29	4.30	4.32	4.33	4.35	4.36	4.38	4.40	4.41	4.43	4.44	4.46	4.47	4.49	4.50
66	4.25	4.26	4.28	4.30	4.31	4.33	4.34	4.36	4.38	4.39	4.41	4.42	4.44	4.45	4.47	4.49	4.50	4.52	4.53
68	4.27	4.29	4.31	4.32	4.34	4.35	4.37	4.39	4.40	4.42	4.43	4.45	4.46	4.48	4.50	4.51	4.53	4.54	4.56
70	4.30	4.31	4.33	4.35	4.36	4.38	4.39	4.41	4.43	4.44	4.46	4.47	4.49	4.51	4.52	4.54	4.55	4.57	4.59

TABLE OF COEFFICIENTS N_1

Calculation of pressure losses in surface equipment

$$p_{\text{surface equipment}} = N_1B \text{ (kPa)}$$

	Case 1	Case 2	Case 3	Case 4
Stand pipe	3" - 40'	3 1/2" - 40'	4" - 45'	4" - 45'
Drilling hose	2" - 45'	2 1/2" - 55'	3" - 55'	3" - 55'
Kelly	2 1/4" - 40'	3 1/4" - 40'	3 1/4" - 40'	4" - 40'
Swivel	2" - 4'	2 1/2" - 5'	2 1/2" - 5'	3" - 6'

Q (l/min)	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Q (l/min)**	**Case 1**	**Case 2**	**Case 3**	**Case 4**
500	63	24	13	10	**2250**	950	357	198	154
550	75	28	16	12	**2300**	989	371	206	161
600	88	33	18	14	**2350**	1028	386	214	167
650	102	38	21	17	**2400**	1068	401	222	173
700	116	44	24	19	**2450**	1108	416	231	180
750	132	49	27	21	**2500**	1149	431	239	187
800	148	55	31	24	**2550**	1191	447	248	193
850	165	62	34	27	**2600**	1233	463	257	200
900	183	69	38	30	**2650**	1276	479	265	207
950	201	76	42	33	**2700**	1320	495	275	214
1000	221	83	46	36	**2750**	1364	512	284	221
1050	241	90	50	39	**2800**	1409	529	293	229
1100	262	98	55	43	**2850**	1454	546	303	236
1150	284	107	59	46	**2900**	1501	563	312	244
1200	307	115	64	50	**2950**	1548	581	322	251
1250	330	124	69	54	**3000**	1595	599	332	259
1300	354	133	74	57	**3050**	1643	617	342	267
1350	379	142	79	62	**3100**	1692	635	352	275
1400	405	152	84	66	**3150**	1742	653	362	283
1450	431	162	90	70	**3200**	1792	672	373	291
1500	458	172	95	74	**3250**	1842	691	383	299
1550	486	182	101	79	**3300**	1894	711	394	307
1600	515	193	107	84	**3350**	1946	730	405	316
1650	544	204	113	88	**3400**	1998	750	416	324
1700	574	215	119	93	**3450**	2051	770	427	333
1750	605	227	126	98	**3500**	2105	790	438	342
1800	636	239	132	103	**3550**	2160	810	449	351
1850	668	251	139	108	**3600**	2215	831	461	360
1900	701	263	146	114	**3650**	2270	852	472	369
1950	735	276	153	119	**3700**	2327	873	484	378
2000	769	288	160	125	**3750**	2384	894	496	387
2050	804	302	167	130	**3800**	2441	916	508	396
2100	839	315	175	136	**3850**	2499	938	520	406
2150	876	329	182	142	**3900**	2558	960	532	415
2200	913	342	190	148	**3950**	2617	982	545	425
					4000	2677	1005	557	435

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2

Calculation of pressure losses in drill pipes $p_{int} = N_2 B$ (kPa/100 m)

Nominal pipe size (in)		2 3/8			2 7/8						
Nominal weight (lb/ft)		6.65			10.40						
Pipe inside diameter (in)		1,815			2,151						
Tool joint inside diameter (in)		1 13/16	1 3/4	1 3/8	2 5/32	2 1/8	2	1 7/8	1 3/4	1 5/8	1 1/2
Flow rate **Q** **(l/min)**	**100**	25	26	30	11	11	11	12	12	13	15
	150	52	53	62	23	23	24	25	26	28	30
	200	88	89	104	39	39	40	41	43	46	51
	250	131	133	156	58	58	60	62	65	69	76
	300	183	185	217	81	81	83	86	90	96	106
	350	241	244	286	106	107	110	113	119	127	140
	400	306	310	364	135	136	139	144	151	161	178
	450	379	383	450	167	168	172	178	187	200	220
	500	458	464	544	202	203	208	215	226	241	266
	550	544	550	645	240	241	247	256	268	286	316
	600	636	644	755	281	282	289	299	313	335	369
	650	734	743	872	324	326	334	345	362	387	426
	700	839	849	996	371	373	382	394	413	442	487
	750	950	962	1128	420	422	432	447	468	501	551
	800	1067	1080	1267	472	474	485	502	526	562	619
	850	1190	1205	1413	526	528	541	559	586	627	691
	900	1319	1335	1566	583	586	600	620	650	695	766
	950	1454	1472	1726	642	646	661	683	716	766	844
	1000	1594	1614	1893	705	708	725	749	786	840	926
	1050	1741	1762	2067	769	773	792	818	858	917	1011
	1100	1893	1916	2247	836	841	861	890	933	997	1099
	1150	2050	2076	2434	906	911	932	964	1010	1080	1190
	1200	2214	2241	2628	978	983	1007	1041	1091	1166	1285
	1250	2382	2412	2829	1053	1058	1083	1120	1174	1255	1383
	1300	2557	2588	3036	1130	1135	1163	1202	1260	1347	1484
	1350	2736	2770	3249	1209	1215	1244	1286	1348	1442	1589
	1400	2921	2958	3469	1291	1297	1329	1373	1439	1539	1696
	1450	3112	3151	3695	1375	1382	1415	1463	1533	1640	1807
	1500	3308	3349	3927	1462	1469	1504	1555	1630	1743	1920
	1550	3509	3552	4166	1551	1558	1596	1650	1729	1849	2037
	1600	3715	3761	4411	1642	1650	1690	1747	1830	1958	2157
	1650	3927	3976	4662	1736	1744	1786	1846	1935	2069	2280
	1700	4143	4195	4920	1831	1840	1884	1948	2042	2183	2406
	1750	4365	4420	5183	1929	1939	1985	2052	2151	2300	2534
	1800	4592	4650	5453	2030	2040	2089	2159	2263	2420	2666
	1850	4825	4885	5729	2132	2143	2194	2268	2377	2542	2811
	1900	5062	5125	6010	2237	2248	2302	2380	2494	2667	2939
	1950	5304	5370	6298	2344	2356	2412	2494	2613	2795	3079
	2000	5552	5621	6592	2454	2466	2525	2610	2735	2925	3223

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)
Calculation of pressure losses in drill pipes $p_{\text{int}} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		3 1/2									
Nominal weight (lb/ft)		9.50		13.30				15.50			
Pipe inside diameter (in)		2.992		2.764				2.602			
Tool joint inside diameter (in)		3	2 11/16	2 11/16	2 9/16	2 7/16	2 1/8	2 9/16	2 7/16	2 1/4	2 1/8
Flow rate *Q* (l/min)	**100**	2	2	3	3	4	4	5	5	5	5
	150	5	5	7	7	7	8	9	10	10	10
	200	8	8	12	12	12	14	16	16	17	17
	250	12	12	18	18	18	20	23	24	25	26
	300	17	17	24	25	26	28	33	33	35	36
	350	22	23	32	33	34	37	43	44	46	47
	400	28	29	41	42	43	48	55	56	58	60
	450	34	36	51	52	53	59	68	69	72	75
	500	42	43	61	63	64	71	82	83	87	90
	550	49	52	73	74	76	84	97	99	103	107
	600	58	60	85	87	89	99	113	116	120	125
	650	67	70	98	100	103	114	131	133	139	145
	700	76	80	112	115	118	130	150	153	159	165
	750	86	90	127	130	133	148	169	173	180	187
	800	97	101	143	146	150	166	190	194	202	210
	850	108	113	159	163	167	185	212	216	225	234
	900	120	125	177	180	185	205	235	240	250	260
	950	132	138	195	199	204	226	259	264	275	286
	1000	145	151	214	218	223	248	284	290	302	314
	1050	158	165	233	238	244	270	310	316	330	343
	1100	172	180	254	259	265	294	337	344	359	373
	1150	186	194	275	280	287	319	366	373	388	404
	1200	201	210	297	303	310	344	395	402	419	436
	1250	216	226	319	326	334	370	425	433	451	469
	1300	232	243	343	349	358	397	456	465	484	504
	1350	248	260	367	374	383	425	488	497	518	539
	1400	265	277	392	399	409	454	521	531	553	576
	1450	282	295	417	425	436	484	555	566	590	613

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		3 1/2									
Nominal weight (lb/ft)		9.50		13.30				15.50			
Pipe inside diameter (in)		2.992		2.764				2.602			
Tool joint inside diameter (in)		3	2 11/16	2 11/16	2 9/16	2 7/16	2 1/8	2 9/16	2 7/16	2 1/4	2 1/8
Flow rate *Q* (l/min)	**1500**	300	314	443	452	464	514	590	601	627	652
	1550	318	333	470	480	492	545	626	638	665	691
	1600	337	352	498	508	521	577	662	675	704	732
	1650	356	372	526	537	550	610	700	714	744	774
	1700	376	393	555	566	581	644	739	753	785	816
	1750	396	414	585	597	612	678	778	794	827	860
	1800	416	436	616	628	644	714	819	835	870	905
	1850	437	458	647	659	676	750	860	877	914	951
	1900	459	480	678	692	709	787	903	920	959	997
	1950	481	503	711	725	743	824	946	964	1005	1045
	2000	503	527	744	759	778	863	990	1009	1052	1094
	2050	526	551	778	793	813	902	1035	1055	1100	1143
	2100	550	575	812	828	849	942	1081	1102	1148	1194
	2150	573	600	848	864	886	983	1127	1150	1198	1246
	2200	598	625	883	901	924	1024	1175	1198	1249	1298
	2250	622	651	920	938	962	1066	1224	1248	1300	1352
	2300	647	677	957	976	1001	1109	1273	1298	1353	1407
	2350	673	704	995	1014	1040	1153	1323	1349	1406	1462
	2400	699	731	1033	1053	1080	1198	1374	1401	1460	1519
	2450	725	759	1072	1093	1121	1243	1426	1454	1515	1576
	2500	752	787	1112	1134	1163	1289	1479	1508	1572	1634
	2550	779	815	1152	1175	1205	1336	1533	1563	1629	1694
	2600	807	844	1193	1217	1248	1383	1587	1618	1687	1754
	2650	835	874	1235	1259	1291	1432	1643	1675	1745	1815
	2700	864	904	1277	1302	1335	1481	1699	1732	1805	1877
	2750	893	934	1320	1346	1380	1530	1756	1790	1866	1940
	2800	922	965	1364	1390	1426	1581	1814	1849	1927	2004
	2850	952	996	1408	1435	1472	1632	1873	1909	1990	2069

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		4						4 1/2			
Nominal weight (lb/ft)		14						13.75			
Pipe inside diameter (in)		3.340						3.958			
Tool joint inside diameter (in)		3 1/4	3	2 13/16	2 11/16	2 9/16	2 7/16	3 31/32	3 7/8	3 3/4	3 1/4
Flow rate *Q* (l/min)	**100**	1	1	1	2	2	2	1	1	1	1
	150	3	3	3	3	3	3	1	1	1	1
	200	5	5	5	5	6	6	2	2	2	2
	250	7	7	8	8	8	9	3	3	3	3
	300	10	10	11	11	11	12	4	4	4	5
	350	13	13	14	14	15	16	6	6	6	6
	400	17	17	18	18	19	20	7	7	7	8
	450	20	21	22	23	24	25	9	9	9	10
	500	25	26	27	28	29	30	11	11	11	12
	550	29	30	32	33	34	36	13	13	13	14
	600	34	36	37	38	40	42	15	15	15	17
	650	40	41	43	44	46	49	17	18	18	19
	700	45	47	49	50	53	56	20	20	20	22
	750	51	53	55	57	60	63	22	23	23	25
	800	58	60	62	64	67	71	25	25	26	28
	850	64	67	69	72	75	79	28	28	29	31
	900	71	74	77	79	83	87	31	31	32	35
	950	79	81	84	87	91	96	34	35	35	38
	1000	86	89	93	96	100	106	38	38	39	42
	1050	94	97	101	105	109	115	41	42	42	46
	1100	102	106	110	114	119	125	45	45	46	50
	1150	111	115	119	123	129	136	49	49	50	54
	1200	120	124	129	133	139	147	52	53	53	58
	1250	129	133	138	143	150	158	56	57	58	62
	1300	138	143	149	154	160	169	61	61	62	67
	1350	148	153	159	165	172	181	65	65	66	72
	1400	158	163	170	176	183	194	69	70	71	77
	1450	168	174	181	187	195	206	74	74	75	82

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)
Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		4						4 1/2			
Nominal weight (lb/ft)		14						13.75			
Pipe inside diameter (in)		3.340						3.958			
Tool joint inside diameter (in)		3 1/4	3	2 13/16	2 11/16	2 9/16	2 7/16	3 31/32	3 7/8	3 3/4	3 1/4
Flow rate Q (l/min)	**1500**	179	185	192	199	208	219	78	79	80	87
	1550	190	196	204	211	220	232	83	84	85	92
	1600	201	208	216	223	233	246	88	89	90	97
	1650	212	220	228	236	246	260	93	94	95	103
	1700	224	232	241	249	260	274	98	99	100	109
	1750	236	244	254	263	274	289	103	104	105	114
	1800	248	257	267	276	288	304	109	110	111	120
	1850	261	270	280	290	303	320	114	115	117	126
	1900	273	283	294	304	318	335	120	121	122	133
	1950	287	297	308	319	333	351	126	127	128	139
	2000	300	311	323	334	348	368	131	132	134	145
	2050	313	325	337	349	364	384	137	138	140	152
	2100	327	339	352	364	380	402	143	145	146	159
	2150	342	354	368	380	397	419	150	151	153	166
	2200	356	369	383	396	414	437	156	157	159	173
	2250	371	384	399	413	431	455	162	164	166	180
	2300	386	399	415	429	448	473	169	170	172	187
	2350	401	415	431	446	466	492	176	177	179	194
	2400	416	431	448	464	484	511	182	184	186	202
	2450	432	447	465	481	502	530	189	191	193	210
	2500	448	464	482	499	521	550	196	198	200	217
	2550	464	481	500	517	540	570	203	205	208	225
	2600	481	498	517	535	559	590	211	212	215	233
	2650	498	515	536	554	578	610	218	220	223	241
	2700	515	533	554	573	598	631	226	227	230	250
	2750	532	551	572	592	618	652	233	235	238	258
	2800	549	569	591	612	638	674	241	243	246	267
	2850	567	587	610	632	659	696	249	251	254	275

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{\text{int}} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		4						4 1/2			
Nominal weight (lb/ft)		14						13.75			
Pipe inside diameter (in)		3.340						3.958			
Tool joint inside diameter (in)		3 1/4	3	2 13/16	2 11/16	2 9/16	2 7/16	3 31/32	3 7/8	3 3/4	3 1/4
Flow rate Q (l/min)	**2900**	585	606	630	652	680	718	256	259	262	284
	2950	604	625	650	672	701	740	264	267	270	293
	3000	622	644	670	693	723	763	273	275	278	302
	3050	641	664	690	714	745	786	281	283	287	311
	3100	660	683	710	735	767	809	289	292	295	320
	3150	679	703	731	756	789	833	298	300	304	329
	3200	699	724	752	778	812	857	306	309	313	339
	3250	719	744	773	800	835	881	315	317	321	349
	3300	739	765	795	822	858	906	324	326	330	358
	3350	759	786	817	845	882	931	332	335	339	368
	3400	779	807	839	868	906	956	341	344	349	378
	3450	800	829	861	891	930	981	351	353	358	388
	3500	821	850	884	914	954	1007	360	363	367	398
	3550	842	872	906	938	979	1033	369	372	377	409
	3600	864	895	930	962	1004	1059	378	382	386	419
	3650	886	917	953	986	1029	1086	388	391	396	430
	3700	907	940	977	1010	1054	1113	398	401	406	440
	3750	930	963	1000	1035	1080	1140	407	411	416	451
	3800	952	986	1025	1060	1106	1168	417	421	426	462
	3850	975	1009	1049	1085	1133	1196	427	431	436	473
	3900	998	1033	1074	1111	1159	1224	437	441	446	484
	3950	1021	1057	1099	1136	1186	1252	447	451	457	495
	4000	1044	1081	1124	1162	1213	1281	458	461	467	506

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{\text{int}} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		4 1/2										
Nominal weight (lb/ft)		16.60							20.00			
Pipe inside diameter (in)		3.826							3.640			
Tool joint inside diameter (in)		3 3/4	3 1/2	3 1/4	3	2 11/16	2 3/4	2 1/2	3 5/8	3 1/2	3 1/4	3
Flow rate Q (l/min)	**100**	1	1	1	1	1	1	1	1	1	1	1
	150	1	2	2	2	2	2	2	2	2	2	2
	200	2	3	3	3	3	3	4	3	3	3	3
	250	4	4	4	4	5	5	5	5	5	5	5
	300	5	5	5	6	7	6	7	6	7	7	7
	350	7	7	7	8	9	8	10	9	9	9	9
	400	9	9	9	10	11	11	12	11	11	11	12
	450	11	11	11	12	14	13	15	13	14	14	15
	500	13	13	14	15	17	16	19	16	16	17	18
	550	15	16	16	17	20	19	22	19	20	20	21
	600	18	18	19	20	23	22	26	23	23	24	25
	650	21	21	22	24	27	26	30	26	26	27	29
	700	24	24	25	27	30	29	34	30	30	31	33
	750	*27*	*27*	*29*	*30*	*34*	*33*	*38*	*34*	*34*	*35*	*37*
	800	30	31	32	34	39	38	43	38	38	40	42
	850	33	34	36	38	43	42	48	42	43	44	46
	900	37	38	40	42	48	46	53	47	47	49	52
	950	41	42	44	47	53	51	59	52	52	54	57
	1000	45	46	48	51	58	56	65	57	57	59	62
	1050	49	50	52	56	63	61	70	62	62	65	68
	1100	53	55	57	61	69	67	77	67	68	70	74
	1150	58	59	62	66	74	72	83	73	74	76	80
	1200	62	64	67	71	80	78	90	78	79	82	86
	1250	67	69	72	76	86	84	96	84	86	88	93
	1300	72	74	77	82	93	90	103	91	92	95	100
	1350	77	79	82	88	99	96	111	97	98	102	107
	1400	82	84	88	94	106	103	118	104	105	108	114
	1450	87	90	94	100	113	109	126	110	112	116	122

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		**4 1/2**										
Nominal weight (lb/ft)		16.60							20.00			
Pipe inside diameter (in)		3.826							3.640			
Tool joint inside diameter (in)		3 3/4	3 1/2	3 1/4	3	2 11/16	2 3/4	2 1/2	3 5/8	3 1/2	3 1/4	3
Flow rate *Q* (l/min)	**1500**	93	96	100	106	120	116	134	117	119	123	129
	1550	98	101	106	112	127	123	142	124	126	130	137
	1600	104	107	112	119	135	131	150	132	133	138	145
	1650	110	113	118	126	142	138	159	139	141	146	153
	1700	116	120	125	133	150	146	168	147	149	154	162
	1750	123	126	131	140	158	153	177	155	157	162	171
	1800	129	133	138	147	166	161	186	163	165	171	179
	1850	135	139	145	155	175	170	195	171	173	179	188
	1900	142	146	152	162	183	178	205	179	182	188	198
	1950	149	153	160	170	192	186	215	188	190	197	207
	2000	156	160	167	178	201	195	225	197	199	206	217
	2050	163	168	175	186	210	204	235	206	208	216	227
	2100	170	175	182	194	220	213	245	215	218	225	237
	2150	177	183	190	203	229	222	256	224	227	235	247
	2200	185	190	198	211	239	232	267	234	237	245	257
	2250	193	198	207	220	249	241	278	243	246	255	268
	2300	200	206	215	229	259	251	289	253	256	265	279
	2350	208	214	223	238	269	261	300	263	266	276	290
	2400	216	223	232	247	279	271	312	273	277	286	301
	2450	225	231	241	256	290	281	324	284	287	297	312
	2500	233	240	250	266	301	292	336	294	298	308	324
	2550	241	248	259	275	311	302	348	305	309	319	336
	2600	250	257	268	285	322	313	360	316	320	331	348
	2650	259	266	277	295	334	324	373	327	331	342	360
	2700	267	275	287	305	345	335	386	338	342	354	372
	2750	276	284	296	315	357	346	399	349	354	366	385
	2800	286	294	306	326	369	358	412	361	365	378	397
	2850	295	303	316	336	380	369	425	372	377	390	410

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		**4 1/2**										
Nominal weight (lb/ft)		16.60							20.00			
Pipe inside diameter (in)		3.826							3.640			
Tool joint inside diameter (in)		3 3/4	3 1/2	3 1/4	3	2 11/16	2 3/4	2 1/2	3 5/8	3 1/2	3 1/4	3
Flow rate *Q* (l/min)	**2900**	304	313	326	347	393	381	439	384	389	402	423
	2950	314	323	336	358	405	393	452	396	401	415	436
	3000	323	333	347	369	417	405	466	408	414	428	450
	3050	333	343	357	380	430	417	480	421	426	441	463
	3100	343	353	368	391	443	430	494	433	439	454	477
	3150	353	363	379	403	456	442	509	446	452	467	491
	3200	363	374	389	414	469	455	524	459	464	480	505
	3250	373	384	401	426	482	468	538	472	478	494	520
	3300	384	395	412	438	495	481	553	485	491	508	534
	3350	394	406	423	450	509	494	569	498	504	522	549
	3400	405	417	434	462	523	507	584	512	518	536	564
	3450	416	428	446	474	537	521	599	525	532	550	579
	3500	427	439	458	487	551	534	615	539	546	564	594
	3550	438	450	469	500	565	548	631	553	560	579	609
	3600	449	462	481	512	579	562	647	567	574	594	625
	3650	460	473	494	525	594	576	663	581	589	609	640
	3700	472	485	506	538	609	591	680	596	603	624	656
	3750	483	497	518	551	623	605	697	610	618	639	672
	3800	495	509	531	565	639	620	713	625	633	655	688
	3850	506	521	543	578	654	631	730	640	648	670	705
	3900	518	533	556	592	669	649	747	655	663	686	721
	3950	530	546	569	605	685	664	765	670	679	702	738
	4000	543	558	582	619	700	680	782	685	694	718	755

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{\text{int}} = N_2 B$ (kPa/100 m)

Nominal pipe size (in)		5							
Nominal weight (lb/ft)		19.60				25.60			
Pipe inside diameter (in)		4.276				4			
Tool joint inside diameter (in)		3 3/4	3 1/2	3 1/4	2 3/4	3 1/2	3 1/4	3	2 3/4
Flow rate ***Q*** **(l/min)**	**500**	8	8	9	11	11	11	12	14
	550	9	10	11	13	13	14	15	16
	600	11	12	12	16	15	16	17	19
	650	13	13	14	18	18	18	20	22
	700	15	15	16	20	20	21	23	25
	750	16	17	18	23	23	24	26	29
	800	18	19	21	26	25	27	29	32
	850	21	22	23	29	28	30	32	36
	900	23	24	26	32	31	33	36	40
	950	25	26	28	35	35	36	39	44
	1000	28	29	31	39	38	40	43	48
	1050	30	32	34	42	42	44	47	52
	1100	33	34	37	46	45	48	51	57
	1150	35	37	40	50	49	51	55	62
	1200	38	40	43	54	53	56	60	67
	1250	41	43	46	58	57	60	64	72
	1300	44	46	49	62	61	64	69	77
	1350	47	50	53	67	65	69	74	83
	1400	51	53	57	71	70	73	79	88
	1450	54	56	60	76	74	78	84	94
	1500	57	60	64	81	79	83	89	100
	1550	61	64	68	86	84	88	95	106
	1600	64	67	72	91	89	93	100	112
	1650	68	71	76	96	94	99	106	118
	1700	72	75	80	101	99	104	112	125
	1750	76	79	84	107	104	110	118	132
	1800	80	83	89	112	110	115	124	139
	1850	84	87	93	118	115	121	130	146
	1900	88	92	98	124	121	127	137	153
	1950	92	96	103	129	127	133	143	160
	2000	96	101	107	135	133	139	150	167
	2050	100	105	112	142	139	146	157	175
	2100	105	110	117	148	145	152	164	183
	2150	109	115	122	154	151	159	171	191
	2200	114	119	128	161	157	165	178	199

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size ***(in)***		5							
Nominal weight (lb/ft)		**19.50**				25.60			
Pipe inside diameter (in)		4.276				4			
Tool joint inside diameter (in)		3 3/4	3 1/2	3 1/4	2 3/4	3 1/2	3 1/4	3	2 3/4
Flow rate ***Q*** **(l/min)**	**2250**	119	124	133	167	164	172	186	207
	2300	124	129	138	174	170	179	193	215
	2350	128	135	144	181	177	186	201	224
	2400	133	140	149	188	184	194	208	232
	2450	138	145	155	195	191	201	216	241
	2500	144	150	161	202	198	208	224	250
	2550	149	156	166	210	205	216	232	259
	2600	154	161	172	217	213	224	241	268
	2650	160	167	178	225	220	231	249	278
	2700	165	173	184	233	228	239	258	287
	2750	170	178	191	240	235	247	266	297
	2800	176	184	197	248	243	255	275	307
	2850	182	190	203	256	251	264	284	317
	2900	188	196	210	264	259	272	293	327
	2950	193	203	216	273	267	281	302	337
	3000	199	209	223	281	275	289	311	347
	3050	205	215	230	290	283	298	321	358
	3100	212	221	236	298	292	307	330	368
	3150	218	228	243	307	300	316	340	379
	3200	224	234	250	316	309	325	350	390
	3250	230	241	257	325	318	334	360	401
	3300	237	248	265	334	327	343	370	412
	3350	243	255	272	343	335	353	380	424
	3400	250	262	279	352	345	362	390	435
	3450	256	268	287	361	354	372	400	447
	3500	263	276	294	371	363	382	411	458
	3550	270	283	302	381	372	392	422	470
	3600	277	290	309	390	382	402	432	482
	3650	284	297	317	400	391	412	443	494
	3700	291	304	325	410	401	422	454	507
	3750	298	312	333	420	411	432	465	519
	3800	305	319	341	430	421	443	476	532
	3850	312	327	349	440	431	453	488	544
	3900	320	335	357	451	441	464	499	557
	3950	327	343	366	461	451	475	511	570
	4000	335	350	374	472	462	485	523	583

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)
Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		5 1/2							6 5/8
Nominal weight (lb/ft)		21.90				24.70			25.20
Pipe inside diameter (in)		4.778				4.670			5.965
Tool joint inside diameter (in)		4	3 3/4	3 1/2.	3	4	3 1/2	3	5
Flow rate **Q** **(l/min)**	**500**	5	5	5	7	5	6	7	2
	550	6	6	6	8	6	7	9	2
	600	7	7	8	10	7	8	10	2
	650	8	8	9	11	8	9	12	3
	700	9	9	10	13	10	11	13	3
	750	10	10	11	14	11	12	15	3
	800	11	12	13	16	12	14	17	4
	850	12	13	14	18	14	15	19	4
	900	14	15	16	20	15	17	21	5
	950	15	16	17	22	17	19	23	5
	1000	17	18	19	24	18	21	26	6
	1050	18	19	21	26	20	22	28	6
	1100	20	21	22	28	22	24	30	7
	1150	21	23	24	31	24	26	33	7
	1200	23	24	26	33	25	28	35	8
	1250	25	26	28	36	27	31	38	9
	1300	27	28	30	38	29	33	41	9
	1350	29	30	32	41	31	35	44	10
	1400	31	32	35	44	34	38	47	11
	1450	33	34	37	47	36	40	50	11
	1500	35	36	39	50	38	43	53	12
	1550	37	39	41	53	40	45	56	13
	1600	39	41	44	56	43	48	60	13
	1650	41	43	46	59	45	51	63	14
	1700	43	46	49	62	48	53	66	15
	1750	46	48	52	65	50	56	70	16
	1800	48	51	54	69	53	59	74	17
	1850	50	53	57	72	55	62	77	17
	1900	53	56	60	76	58	65	81	18
	1950	56	58	63	79	61	68	85	19

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		5 1/2							6 5/8
Nominal weight (lb/ft)		21.90				24.70			25.20
Pipe inside diameter (in)		4.778				4.670			5.965
Tool joint inside diameter (in)		4	3 3/4	3 1/2	3	4	3 1/2	3	5
Flow rate Q (l/min)	**2000**	58	61	66	83	64	71	89	20
	2050	61	64	69	87	67	75	93	21
	2100	63	67	72	91	70	78	97	22
	2150	66	70	75	95	73	81	101	23
	2200	69	73	78	99	76	85	106	24
	2250	72	76	81	107	79	88	110	25
	2300	75	79	84	107	82	92	114	26
	2350	78	82	88	111	85	95	119	27
	2400	81	85	91	115	89	99	123	28
	2450	84	88	95	120	92	103	128	29
	2500	87	91	98	124	95	107	133	30
	2550	90	95	102	129	99	111	138	31
	2600	93	98	105	133	102	115	143	32
	2650	96	101	109	138	106	119	148	33
	2700	100	105	113	143	110	123	153	34
	2750	103	108	116	148	113	127	158	35
	2800	106	112	120	152	117	131	163	37
	2850	110	116	124	157	121	135	168	38
	2900	113	119	128	162	125	139	174	39
	2950	117	123	132	167	129	144	179	40
	3000	121	127	136	173	132	148	184	42
	3050	124	131	140	178	136	153	190	43
	3100	128	135	144	183	141	157	196	44
	3150	132	139	149	188	145	162	201	45
	3200	135	143	153	194	149	166	207	47
	3250	139	147	157	199	153	171	213	48
	3300	143	151	162	205	157	176	219	49
	3350	147	155	166	210	162	181	225	51
	3400	151	159	171	216	166	186	231	52

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)		5 1/2							6 5/8
Nominal weight (lb/ft)		21.90				24.70			25.20
Pipe inside diameter (in)		4.778				4.670			5.965
Tool joint inside diameter (in)		4	3 3/4	3 1/2	3	4	3 1/2	3	5
Flow rate Q (l/min)	**3450**	155	163	175	222	170	191	237	53
	3500	159	167	180	228	175	196	243	55
	3550	163	172	184	234	179	201	250	56
	3600	167	176	189	240	184	206	256	58
	3650	172	181	194	246	189	211	263	59
	3700	176	185	199	252	193	216	269	61
	3750	180	190	204	258	198	221	276	62
	3800	184	194	208	264	203	227	282	64
	3850	189	199	213	270	208	232	289	65
	3900	193	203	218	277	212	238	296	67
	3950	198	208	224	283	217	243	303	68
	4000	202	213	229	290	222	249	310	70
	4050	207	218	234	296	227	254	317	71
	4100	211	223	239	303	232	260	324	73
	4150	216	228	244	309	238	266	331	74
	4200	221	232	250	316	243	272	338	76
	4250	226	237	255	323	248	277	345	78
	4300	230	243	260	330	253	283	353	79
	4350	235	248	266	337	259	289	360	81
	4400	240	253	271	344	264	295	368	83
	4450	245	258	277	351	269	301	375	84
	4500	250	263	283	358	275	307	383	86
	4550	255	269	288	365	280	314	390	88
	4600	260	274	294	372	286	320	398	90
	4650	265	279	300	380	292	326	406	91
	4700	270	285	306	387	297	332	414	93
	4750	276	290	312	395	303	339	422	95
	4800	281	296	317	402	309	345	430	97
	4850	286	301	323	410	315	352	438	99
	4900	292	307	329	417	320	358	446	100
	4950	297	312	336	425	326	365	454	102
	5000	302	318	342	433	332	372	463	104

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_3

Calculation of pressure losses in drill collars $p_{int} = N_3B$ (kPa/100 m)

Inside diameter of drill collars	(in)	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	2 13/16	3	3 1/4	3 1/2
	(mm)	38.10	44.45	50.80	57.15	63.50	69.85	71.44	76.20	82.55	88.90
Flow rate Q (l/min)	**100**	63	30	16	9	5	3	3	2	2	1
	150	131	62	33	19	11	7	6	5	3	2
	200	220	105	55	31	19	12	11	8	5	4
	250	328	157	82	47	28	18	16	12	8	6
	300	456	217	115	65	39	25	22	16	11	8
	350	601	287	151	86	52	33	29	22	15	10
	400	765	365	192	109	66	42	37	27	19	13
	450	945	451	238	135	81	52	46	34	23	16
	500	1143	545	287	163	98	62	56	41	28	20
	550	1356	647	341	194	117	74	66	49	33	23
	600	1586	757	399	227	137	86	78	57	39	27
	650	1832	874	461	262	158	100	90	66	45	31
	700	2094	999	526	299	180	114	102	75	51	36
	750	2371	1131	596	339	204	129	116	85	58	41
	800	2663	1270	669	380	229	145	130	96	65	46
	850	2970	1417	746	424	256	162	145	107	73	51
	900	3291	1570	827	470	283	179	161	118	80	56
	950	3628	1731	912	518	312	198	178	130	89	62
	1000	3979	1898	1000	568	343	217	195	143	97	68
	1050	4344	2073	1092	620	374	237	213	156	106	74
	1100	4723	2254	1187	675	407	257	231	170	115	81
	1150	5117	2441	1286	731	441	279	250	184	125	88
	1200	5524	2636	1389	789	476	301	270	198	135	95
	1250	5945	2837	1494	849	512	324	291	213	145	102
	1300	6360	3044	1604	911	549	348	312	229	156	109
	1350	6829	3258	1716	975	588	372	334	245	167	117
	1400	7291	3479	1833	1041	628	397	357	262	178	125
	1450	7766	3706	1952	1109	669	423	380	279	190	133
	1500	8255	3939	2075	1179	711	450	404	296	202	141
	1550	8757	4178	2201	1251	754	477	428	314	214	150
	1600	9271	4424	2330	1324	799	505	454	333	227	159
	1650	9800	4676	2463	1399	844	534	480	352	240	168
	1700		4934	2599	1477	891	564	506	371	253	177
	1750		5198	2738	1556	938	594	533	391	266	187
	1800		5469	2881	1637	987	625	561	411	280	196
	1850		5745	3026	1720	1037	656	589	432	294	208
	1900		6028	3175	1804	1088	689	618	453	309	216
	1950		6316	3327	1890	1140	722	648	475	324	227
	2000		6611	3482	1979	1193	755	678	497	339	237
	2050		6911	3641	2068	1247	789	709	520	354	248
	2100		7217	3802	2160	1303	824	740	543	370	259

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_3 (continued)

Calculation of pressure losses in drill collars $p_{int} = N_3 B$ (kPa/100 m)

Inside diameter of drill collars	(in)	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	2 13/16	3	3 1/4	3 1/2
	(mm)	38.10	44.45	50.80	57.15	63.50	69.85	71.44	76.20	82.55	88.90
Flow rate Q (l/min)	**2150**		7530	3967	2254	1359	860	772	566	386	270
	2200		7848	4134	2349	1417	896	805	590	402	282
	2250		8172	4305	2446	1475	933	838	615	419	293
	2300		8502	4479	2545	1535	971	872	640	436	305
	2350		8837	4655	2645	1595	1009	906	665	453	317
	2400		9178	4835	2747	1657	1048	941	691	470	329
	2450		9526	5018	2851	1719	1088	977	717	488	342
	2500		9878	5204	2957	1783	1128	1013	743	506	355
	2550			5393	3064	1848	1169	1050	770	524	367
	2600			5584	3173	1913	1211	1087	798	543	381
	2650			5779	3284	1980	1253	1125	825	562	394
	2700			5977	3396	2048	1296	1164	854	581	407
	2750			6178	3510	2117	1340	1203	882	601	421
	2800			6381	3626	2186	1384	1242	911	621	435
	2850			6588	3743	2257	1429	1282	941	641	449
	2900			6797	3862	2329	1474	1323	971	661	463
	2950			7010	3983	2402	1520	1365	1001	682	478
	3000			7225	4105	2476	1567	1407	1032	703	492
	3050			7443	4229	2550	1614	1449	1063	724	507
	3100			7664	4355	2626	1662	1492	1095	745	522
	3150			7888	4482	2703	1711	1536	1127	767	538
	3200			8115	4611	2781	1760	1580	1159	789	553
	3250			8345	4741	2859	1810	1624	1192	812	569
	3300			8577	4873	2939	1860	1670	1225	834	584
	3350			8813	5007	3020	1911	1716	1259	857	601
	3400			9051	5142	3101	1963	1762	1293	880	617
	3450			9292	5279	3184	2015	1809	1327	904	633
	3900			9536	5418	3267	2068	1856	1362	927	650
	3550			9782	5558	3352	2121	1904	1397	951	667
	3600				5700	3437	2175	1953	1433	976	684
	3650				5843	3524	2230	2002	1469	1000	701
	3700				5988	3611	2285	2052	1505	1025	718
	3750				6134	3699	2341	2102	1542	1050	736
	3800				6282	3789	2398	2152	1579	1075	753
	3850				6432	3879	2455	2204	1617	1101	771
	3900				6583	3970	2512	2256	1655	1127	790
	3950				6736	4062	2571	2308	1693	1153	808
	4000				6890	4155	2630	2361	1732	1179	826

l/min × 0.264 = gal/min

CALCULATION OF PRESSURE DROP IN NOZZLES

Combinations of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = nozzle area (in^2)

Combinations of three nozzles (1/32 in)		8-8-8	8-8-9	8-9-9	9-9-9	9-9-10	9-10-10	10-10-10	10-10-11	10-11-11	11-11-11	11-11-12	11-12-12
Flow rate Q (l/min)	200	691	583	498	431	371	322	283	247	218	193	171	152
	250	1079	911	779	674	579	504	442	386	340	302	267	238
	300	1554	1311	1121	970	834	725	636	556	490	435	384	342
	350	2115	1785	1526	1320	1136	987	866	757	667	592	523	466
	400	2762	2331	1994	1725	1483	1290	1131	988	871	773	683	609
	450	3496	2951	2523	2183	1878	1632	1432	1251	1102	978	865	770
	500	4316	3643	3115	2695	2318	2015	1768	1544	1360	1208	1068	951
	550	5223	4408	3769	3260	2805	2438	2139	1868	1646	1461	1292	1151
	600	6215	5245	4486	3880	3338	2902	2546	2224	1959	1739	1538	1370
	650	7294	6156	5265	4554	3917	3406	2988	2610	2299	2041	1805	1607
	700	8460	7140	6106	5281	4543	3950	3465	3027	2666	2367	2093	1864
	750	9712	8196	7009	6063	5215	4534	3978	3474	3061	2717	2403	2140
	800	11050	9325	7975	6898	5934	5159	4526	3953	3483	3091	2734	2435
	850	12474	10527	9003	7787	6699	5824	5109	4463	3931	3490	3086	2749
	900	13985	11802	10093	8731	7510	6529	5728	5003	4408	3912	3460	3082
	950		13150	11246	9728	8368	7274	6382	5574	4911	4359	3855	3434
	1000		14571	12461	10778	9272	8060	7072	6177	5441	4830	4272	3805
	1050			13738	11883	10222	8887	7797	6810	5999	5325	4709	4195
	1100				13042	11219	9753	8557	7474	6584	5844	5169	4604
	1150				14254	12262	10660	9352	8169	7196	6388	5649	5032
	1200					13351	11607	10183	8894	7836	6955	6151	5479
	1250					14487	12594	11050	9651	8502	7547	6674	5945
	1300						13622	11951	10439	9196	8163	7219	6430
	1350						14690	12888	11257	9917	8803	7785	6934
	1400							13861	12106	10665	9467	8372	7457
	1450							14868	12987	11441	10155	8981	7999
	1500								13898	12243	10868	9611	8561
	1550								14840	13073	11604	10263	9141
	1600									13930	12365	10935	9740
	1650									14814	13150	11630	10358
	1700										13959	12345	10996
	1750										14792	13082	11652
	1800											13840	12327
	1850											14620	13022
	1900												13735
	1950												14467
	2000												

l/min × 0.264 = gal/min kPa × 0.145 = psi kg/l = sp.gr. kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = nozzle area (in^2)

Combinations of three nozzles (1/32 in)		12-12-12	12-12-13	12-13-13	13-13-13	13-13-14	13-14-14	14-14-14	14-14-15	14-15-15	15-15-15	15-15-16
Flow rate Q (l/min)	500	853	762	685	619	558	506	460	418	381	349	319
	550	1032	922	829	749	675	612	557	506	461	423	386
	600	1228	1097	986	891	804	728	663	602	549	503	460
	650	1441	1288	1157	1046	943	854	778	706	644	590	539
	700	1671	1493	1342	1213	1094	991	902	819	747	684	626
	750	1918	1714	1541	1393	1255	1138	1035	940	858	786	718
	800	2183	1950	1753	1585	1428	1294	1178	1070	976	894	817
	850	2464	2202	1979	1789	1613	1461	1330	1208	1102	1009	923
	900	2762	2468	2219	2006	1808	1638	1491	1354	1235	1131	1034
	950	3078	2750	2472	2235	2014	1825	1661	1509	1376	1261	1152
	1000	3410	3047	2740	2476	2232	2022	1841	1672	1525	1397	1277
	1050	3760	3360	3020	2730	2461	2230	2030	1843	1681	1540	1408
	1100	4127	3687	3315	2996	2701	2447	2227	2023	1845	1690	1545
	1150	4510	4030	3623	3275	2952	2674	2434	2211	2017	1847	1689
	1200	4911	4388	3945	3565	3214	2912	2651	2407	2196	2012	1839
	1250	5329	4762	4280	3869	3487	3160	2876	2612	2383	2183	1995
	1300	5764	5150	4630	4184	3772	3418	3111	2825	2577	2361	2158
	1350	6215	5554	4993	4513	4068	3686	3355	3047	2780	2546	2327
	1400	6684	5973	5369	4853	4375	3964	3608	3277	2989	2738	2503
	1450	7170	6407	5760	5206	4693	4252	3870	3515	3207	2937	2685
	1500	7673	6857	6164	5571	5022	4550	4142	3762	3432	3143	2873
	1550	8193	7321	6582	5949	5362	4859	4423	4017	3664	3356	3068
	1600	8731	7801	7013	6339	5714	5177	4713	4280	3904	3576	3269
	1650	9285	8297	7458	6741	6076	5506	5012	4552	4152	3803	3476
	1700	9856	8807	7917	7156	6450	5844	5320	4832	4408	4037	3690
	1750	10444	9333	8390	7583	6835	6193	5638	5120	4671	4278	3911
	1800	11050	9874	8876	8022	7232	6552	5964	5417	4941	4526	4137
	1850	11672	10430	9376	8474	7639	6921	6300	5722	5220	4781	4370
	1900	12311	11001	9890	8938	8057	7300	6645	6035	5506	5043	4610
	1950	12968	11588	10417	9415	8487	7690	7000	6357	5799	5312	4855
	2000	13641	12190	10958	9904	8928	8089	7363	6687	6100	5588	5108
	2050	14332	12807	11513	10405	9380	8499	7736	7026	6409	5870	5366

l/min × 0.264 = gal/min kPa × 0.145 = psi kg/l = sp.gr. kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = nozzle area (in^2)

Combinations of three nozzles (1/32 in)		12-12-12	12-12-13	12-13-13	13-13-13	13-13-14	13-14-14	14-14-14	14-14-15	14-15-15	15-15-15	15-15-16
Flow rate Q (l/min)	**2100**	15040	13439	12081	10919	9843	8918	8118	7373	6726	6160	5631
	2150	15764	14087	12663	11445	10317	9348	8509	7728	7050	6457	5902
	2200	16506	14750	13259	11984	10803	9788	8910	8092	7382	6761	6180
	2250	17265	15428	13869	12535	11299	10238	9319	8464	7721	7072	6464
	2300	18041	16121	14492	13098	11807	10698	9738	8844	8068	7390	6755
	2350	18834	16829	15129	13674	12326	11168	10166	9233	8422	7714	7052
	2400	19644	17553	15780	14262	12856	11648	10603	9630	8785	8046	7355
	2450		18292	16444	14862	13397	12139	11050	10035	9155	8385	7665
	2500		19047	17122	15475	13950	12639	11505	10449	9532	8731	7981
	2550		19816	17814	16100	14513	13150	11970	10871	9917	9083	8303
	2600			18519	16738	15088	13671	12444	11302	10310	9443	8632
	2650			19238	17388	15674	14201	12927	11741	10710	9810	8967
	2700			19971	18050	16271	14742	13420	12188	11118	10183	9309
	2750				18725	16879	15294	13921	12643	11534	10564	9657
	2800				19412	17499	15855	14432	13107	11957	10952	10011
	2850					18129	16426	14952	13580	12388	11346	10372
	2900					18771	17007	15481	14060	12826	11748	10739
	2950					19424	17599	16020	14549	13272	12156	11112
	3000						18201	16567	15047	13726	12572	11492
	3050						18812	17124	15552	14187	12995	11878
	3100						19434	17690	16066	14656	13424	12271
	3150							18266	16589	15133	13861	12670
	3200							18850	17120	15617	14304	13076
	3250							19444	17659	16109	14755	13487
	3300								18206	16609	15212	13905
	3350								18762	17116	15677	14330
	3400								19327	17630	16148	14761
	3450								19899	18153	16626	15198
	3500									18683	17112	15642

l/min × 0.264 = gal/min   kPa × 0.145 = psi   kg/l = sp.gr.   kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = nozzle area (in^2)

Combinations of three nozzles (1/32 in)		15-16-16	16-16-16	16-16-18	16-18-18	18-18-18	20-20-20	20-20-22	20-22-22	22-22-22	24-24-24	32-32-32
Flow rate Q (l/min)	**500**	293	270	228	195	168	110	97	85	75	53	17
	550	354	326	275	236	204	134	117	103	91	64	20
	600	422	388	328	280	243	159	139	122	109	77	24
	650	495	456	385	329	285	187	163	144	128	90	28
	700	574	529	446	382	330	217	189	167	148	104	33
	750	659	607	512	438	379	249	217	191	170	120	38
	800	750	691	583	498	431	283	247	218	193	136	43
	850	847	780	658	563	487	319	279	246	218	154	49
	900	949	874	738	631	546	358	313	275	245	173	55
	950	1057	974	822	703	608	399	348	307	272	192	61
	1000	1172	1079	911	779	674	442	386	340	302	213	67
	1050	1292	1190	1004	859	743	487	426	375	333	235	74
	1100	1418	1306	1102	942	815	535	467	412	365	258	82
	1150	1550	1427	1204	1030	891	585	511	450	399	282	89
	1200	1687	1554	1311	1121	970	636	556	490	435	307	97
	1250	1831	1686	1423	1217	1053	691	603	531	472	333	105
	1300	1980	1824	1539	1316	1138	747	652	575	510	360	114
	1350	2136	1967	1660	1419	1228	806	704	620	550	388	123
	1400	2297	2115	1785	1526	1320	866	757	667	592	418	132
	1450	2464	2269	1915	1637	1416	929	812	715	635	448	142
	1500	2636	2428	2049	1752	1516	994	869	765	679	480	152
	1550	2815	2592	2188	1871	1618	1062	927	817	725	512	162
	1600	3000	2762	2331	1994	1725	1131	988	871	773	546	173
	1650	3190	2938	2479	2120	1834	1203	1051	926	822	580	184
	1700	3386	3118	2632	2251	1947	1277	1116	983	872	616	195
	1750	3588	3305	2789	2385	2063	1354	1182	1042	925	653	207
	1800	3796	3496	2951	2523	2183	1432	1251	1102	978	691	219

l/min × 0.264 = gal/min   kPa × 0.145 = psi   kg/l = sp.gr.   kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = nozzle area (in^2)

Combinations of three nozzles (1/32 in)		15-16-16	16-16-16	16-16-18	16-18-18	18-18-18	20-20-20	20-20-22	20-22-22	22-22-22	24-24-24	32-32-32
Flow rate Q (l/min)	**1850**	4010	3693	3117	2665	2306	1513	1321	1164	1033	729	231
	1900	4230	3895	3287	2812	2432	1596	1394	1228	1090	769	243
	1950	4456	4103	3463	2961	2562	1681	1468	1293	1148	810	256
	2000	4687	4316	3643	3115	2695	1768	1544	1360	1208	853	270
	2050	4924	4535	3827	3273	2831	1857	1622	1429	1269	896	283
	2100	5167	4759	4016	3435	2971	1949	1702	1500	1331	940	297
	2150	5416	4988	4210	3600	3114	2043	1784	1572	1395	985	312
	2200	5671	5223	4408	3769	3260	2139	1868	1646	1461	1032	326
	2250	5932	5463	4610	3943	3410	2238	1954	1722	1528	1079	341
	2300	6199	5708	4817	4120	3564	2338	2042	1799	1597	1128	357
	2350	6471	5959	5029	4301	3720	2441	2132	1878	1667	1177	372
	2400	6749	6215	5245	4486	3880	2546	2224	1959	1739	1228	388
	2450	7033	6477	5466	4675	4044	2653	2317	2041	1812	1279	405
	2500	7323	6744	5692	4868	4210	2762	2413	2126	1887	1332	422
	2550	7619	7017	5922	5064	4380	2874	2510	2211	1963	1386	439
	2600	7921	7294	6156	5265	4554	2988	2610	2299	2041	1441	456
	2650	8229	7578	6395	5469	4731	3104	2711	2388	2120	1497	474
	2700	8542	7866	6639	5678	4911	3222	2814	2479	2201	1554	492
	2750	8861	8160	6887	5890	5094	3342	2919	2572	2283	1612	510
	2800	9186	8460	7140	6106	5281	3465	3027	2666	2367	1671	529
	2850	9517	8765	7397	6326	5472	3590	3136	2762	2452	1731	548
	2900	9854	9075	7659	6550	5665	3717	3247	2860	2539	1793	567
	2950	10197	9391	7925	6778	5862	3846	3360	2960	2627	1855	587
	3000	10546	9712	8196	7009	6063	3978	3474	3061	2717	1918	607
	3050	10900	10038	8471	7245	6267	4112	3591	3164	2808	1983	627
	3100	11260	10370	8751	7484	6474	4247	3710	3268	2901	2048	648
	3150	11627	10707	9036	7728	6684	4386	3831	3375	2995	2115	669

l/min × 0.264 = gal/min kPa × 0.145 = psi kg/l = sp.gr. kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = nozzle area (in^2)

Combinations of three nozzles (1/32 in)		15-16-16	16-16-16	16-16-18	16-18-18	18-18-18	20-20-20	20-20-22	20-22-22	22-22-22	24-24-24	32-32-32
Flow rate Q (l/min)	**3200**	11999	11050	9325	7975	6898	4526	3953	3483	3091	2183	691
	3250	12377	11398	9619	8226	7115	4668	4078	3592	3189	2251	712
	3300	12760	11751	9917	8481	7336	4813	4204	3704	3287	2321	734
	3350	13150	12110	10220	8740	7560	4960	4332	3817	3388	2392	757
	3400	13545	12474	10527	9003	7787	5109	4463	3931	3490	2464	780
	3450	13947	12844	10839	9270	8018	5261	4595	4048	3593	2537	803
	3500	14354	13218	11156	9540	8252	5414	4729	4166	3698	2611	826
	3550	14767	13599	11477	9815	8490	5570	4865	4286	3804	2686	850
	3600	15186	13985	11802	10093	8731	5728	5003	4408	3912	2762	874
	3650	15611	14376	12132	10376	8975	5888	5143	4531	4022	2840	898
	3700	16041	14772	12467	10662	9222	6051	5285	4656	4133	2918	923
	3750	16478	15174	12806	10952	9473	6215	5429	4783	4245	2997	948
	3800	16920	15582	13150	11246	9728	6382	5574	4911	4359	3078	974
	3850	17368	15994	13498	11544	9985	6551	5722	5041	4475	3159	1000
	3900	17822	16412	13851	11846	10246	6723	5872	5173	4592	3242	1026
	3950	18282	16836	14209	12151	10511	6896	6023	5306	4710	3326	1052
	4000	18748	17265	14571	12461	10778	7072	6177	5441	4830	3410	1079
	4050	19220	17699	14937	12774	11050	7250	6332	5578	4952	3496	1106
	4100	19697	18139	15308	13092	11324	7430	6489	5717	5075	3583	1134
	4150		18584	15684	13413	11602	7612	6649	5857	5199	3671	1162
	4200		19035	16064	13738	11883	7797	6810	5999	5325	3760	1190
	4250		19491	16449	14067	12168	7983	6973	6143	5453	3850	1218
	4300		19952	16838	14400	12456	8172	7138	6288	5582	3941	1247
	4350			17232	14737	12747	8363	7305	6435	5712	4033	1276
	4400			17630	15078	13042	8557	7474	6584	5844	4127	1306
	4450			18033	15422	13340	8752	7645	6735	5978	4221	1336
	4500			18441	15771	13641	8950	7817	6887	6113	4316	1366

l/min × 0.264 = gal/min   kPa × 0.145 = psi   kg/l = sp.gr.   kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of two nozzles

$$P_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = nozzle area (in^2)

Combinations of two nozzles (1/32 in)		11-11	12-12	13-13	14-14	15-15	16-16	18-18	20-20	22-22	24-24	32-32
Flow rate Q (l/min)	**500**	2717	1918	1393	1035	786	607	379	249	170	120	38
	550	3287	2321	1685	1253	951	734	459	301	205	145	46
	600	3912	2762	2006	1491	1131	874	546	358	245	173	55
	650	4592	3242	2354	1750	1328	1026	640	420	287	203	64
	700	5325	3760	2730	2030	1540	1190	743	487	333	235	74
	750	6113	4316	3134	2330	1768	1366	853	559	382	270	85
	800	6955	4911	3565	2651	2012	1554	970	636	435	307	97
	850	7852	5544	4025	2992	2271	1754	1095	718	491	346	110
	900	8803	6215	4513	3355	2546	1967	1228	806	550	388	123
	950	9808	6925	5028	3738	2837	2191	1368	898	613	433	137
	1000	10868	7673	5571	4142	3143	2428	1516	994	679	480	152
	1050	11982	8460	6142	4566	3465	2677	1671	1096	749	529	167
	1100	13150	9283	6741	5012	3803	2938	1834	1203	822	580	184
	1150	14373	10148	7368	5478	4157	3211	2005	1315	898	634	201
	1200	15649	11050	8022	5964	4526	3496	2183	1432	978	691	219
	1250	16981	11990	8705	6472	4911	3794	2368	1554	1061	749	237
	1300	18366	12968	9415	7000	5312	4103	2562	1681	1148	810	256
	1350	19806	13985	10153	7549	5728	4425	2762	1812	1238	874	277
	1400		15040	10919	8118	6160	4759	2971	1949	1331	940	297
	1450		16133	11713	8708	6608	5105	3187	2091	1428	1008	319
	1500		17265	12535	9319	7072	5463	3410	2238	1528	1079	341
	1550		18435	13384	9951	7551	5833	3642	2389	1632	1152	365
	1600		19644	14262	10603	8046	6215	3880	2546	1739	1228	388
	1850			15167	11276	8557	6610	4127	2707	1849	1306	413
	1700			16100	11970	9083	7017	4380	2874	1963	1386	439
	1750			17061	12684	9625	7435	4642	3046	2080	1469	465
	1800			18050	13420	10183	7866	4911	3222	2201	1554	492

l/min × 0.264 = gal/min kPa × 0.145 = psi kg/l = sp.gr. kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of two nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1,\ A =$ nozzle area (in^2)

Combinations of two nozzles (1/32 in)		11-11	12-12	13-13	14-14	15-15	16-16	18-18	20-20	22-22	24-24	32-32
Flow rate Q (l/min)	**1850**			19067	14176	10757	8309	5188	3404	2325	1641	519
	1900				14952	11346	8765	5472	3590	2452	1731	548
	1950				15749	11951	9232	5764	3781	2583	1824	577
	2000				16567	12572	9712	6063	3978	2717	1918	607
	2050				17406	13208	10203	6370	4179	2854	2015	638
	2100				18266	13861	10707	6684	4386	2995	2115	669
	2150				19146	14528	11223	7006	4597	3140	2217	701
	2200					15212	11751	7336	4813	3287	2321	734
	2250					15911	12291	7673	5034	3439	2428	768
	2380					16626	12844	8018	5261	3593	2537	803
	2350					17357	13408	8371	5492	3751	2648	838
	2400					18104	13985	8731	5728	3912	2762	874
	2450					18866	14573	9098	5969	4077	2879	911
	2500					19644	15174	9473	6215	4245	2997	948
	2550						15787	9866	6466	4417	3118	987
	2600						16412	10246	6723	4592	3242	1026
	2650						17050	10644	6984	4770	3368	1066
	2700						17699	11050	7250	4952	3496	1106
	2750						18361	11463	7521	5137	3627	1148
	2800						19035	11883	7797	5325	3760	1190
	2850						19720	12311	8078	5517	3895	1233
	2800							12747	8363	5712	4033	1276
	2850							13191	8654	5911	4174	1321
	3000							13641	8950	6113	4316	1366
	2050							14100	9251	6319	4461	1412
	3100							14566	9557	6527	4609	1458
	3150							15040	9868	6740	4759	1506

l/min × 0.264 = gal/min   kPa × 0.145 = psi   kg/l = sp.gr.   kg/l × 8.35 = lb/gal

CALCULATION OF PRESSURE DROP IN NOZZLES (continued)

Combinations of two nozzles

$$P_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \quad \text{(kPa)}$$

$d = 1$, A = *nozzle area (in^2)*

Combinations of two nozzles (1/32 in)		11-11	12-12	13-13	14-14	15-15	16-16	18-18	20-20	22-22	24-24	32-32
Flow rate Q (l/min)	3200							15521	10183	6955	4911	1554
	3250							16010	10504	7174	5066	1603
	3300							16506	10830	7397	5223	1652
	3350							17010	11160	7623	5382	1703
	3400							17522	11496	7852	5544	1754
	3450							18041	11837	8085	5708	1806
	3500							18568	12182	8321	5875	1859
	3550							19102	12533	8560	6044	1912
	3600							19644	12888	8803	6215	1967
	3650								13249	9049	6389	2022
	3700								13614	9299	6565	2077
	3750								13985	9552	6744	2134
	3800								14360	9808	6925	2191
	3850								14740	10068	7109	2249
	3900								15126	10331	7294	2308
	3950								15516	10598	7483	2368
	4000								15911	10868	7673	2428
	4050								16312	11141	7866	2489
	4100								16717	11418	8062	2551
	4150								17127	11698	8260	2613
	4200								17542	11982	8460	2677
	4250								17962	12269	8662	2741
	4300								18388	12559	8867	2806
	4350								18818	12853	9075	2871
	4400								19253	13150	9285	2938
	4450								19693	13450	9497	3005
	4500									13754	9712	3073

l/min × 0.264 = gal/min   kPa × 0.145 = psi   kg/l = sp.gr.   kg/l × 8.35 = lb/gal

TABLE OF NOZZLE AREAS

Combinations of three nozzles

A = total area of nozzle combination (in^2)
S = total area of nozzle combination (cm^2)

Nozzles	*A*	*S*
8- 8- 8	0.1473	0.9501
8- 8- 9	0.1603	1.0342
8- 9- 9	0.7333	1.1183
9- 9- 9	0.1864	1.2024
9- 9-10	0.2010	1.2965
9-10-10	0.2155	1.3905
10-10-10	0.2301	1.4845
10-10-11	0.2462	1.5884
10-11-11	0.2623	1.6923
11-11-11	0.2784	1.7962
11-11-12	0.2961	1.9100
11-12-12	0.3137	2.0239
12-12-12	0.3313	2.1377
12-12-13	0.3505	2.2614
12-13-13	0.3697	2.3851
13-13-13	0.3889	2.5088
13-13-14	0.4096	2.6424
13-14-14	0.4303	2.7760
14-14-14	0.4510	2.9096
14-14-15	0.4732	3.0531
14-15-15	0.4955	3.1966
15-15-15	0.5177	3.3401
15-15-16	0.5415	3.4935
15-16-16	0.5653	3.6469
16-16-16	0.5890	3.8003
16-16-17	0.6144	3.9636
16-17-17	0.6397	4.1269
17-17-17	0.6650	4.2902
17-17-18	0.6918	4.4634
17-18-18	0.7187	4.6366
18-18-18	0.7455	4.8098
18-18-19	0.7739	4.9929
18-19-19	0.8023	5.1759
19-19-19	0.8307	5.3590
19-19-20	0.8606	5.5520
19-20-20	0.8905	5.7450
20-20-20	0.9204	5.9380
20-20-21	0.9518	6.1409
20-21-21	0.9833	6.3437
21-21-21	1.0147	6.5466
21-21-22	1.0477	6.7594
21-22-22	1.0807	6.9722
22-22-22	1.1137	7.1850
22-22-23	1.1482	7.4076
22-23-23	1.1827	7.6303
23-23-23	1.2172	7.8530
23-23-24	1.2533	8.0855
23-24-24	1.2893	8.3181
24-24-24	1.3254	8.5507
24-24-25	1.3629	8.7932
24-25-25	1.4005	9.0356
25-25-25	1.4381	9.2781
25-25-26	1.4772	9.5305
25-26-26	1.5163	9.7828
26-26-26	1.5555	10.0352
26-26-27	1.5961	10.2974
26-27-27	1.6368	10.5597
27-27-27	1.6774	10.8220
27-27-28	1.7196	11.0941
27-28-28	1.7618	11.3663
28-28-28	1.8040	11.6384
28-28-29	1.8477	11.9205
28-29-29	1.8914	12.2025
29-29-29	1.9351	12.4846
29-29-30	1.9804	12.7765
29-30-30	2.0256	13.0685
30-30-30	2.0709	13.3605
30-30-31	2.1177	13.6623
30-31-31	2.1644	13.9641
31-31-31	2.2112	14.2660
31-31-32	2.2596	14.5777
31-32-32	2.3079	14.8895
32-32-32	2.3562	15.2012

TABLE OF NOZZLE AREAS
Combinations of two nozzles

A = total area of nozzle combination (in²)
S = total area of nozzle combination (cm²)

Nozzles	*A*	*S*
8- 8	0.0982	0.6334
8- 9	0.1112	0.7175
9- 9	0.1243	0.8016
9-10	0.1388	0.8956
10-10	0.1534	0.9897
10-11	0.1695	1.0936
11-11	0.1856	1.1975
11-12	0.2033	1.3113
12-12	0.2209	1.4251
12-13	0.2401	1.5488
13-13	0.2592	1.6725
13.14	0.2800	1.8061
14-14	0.3007	1.9397
14-15	0.3229	2.0832
15-15	0.3451	2.2267
15-16	0.3689	2.3801
16-16	0.3927	2.5335
16-17	0.4180	2.6968
17-17	0.4433	2.8601
17-18	0.4702	3.0333
18-18	0.4970	3.2065
18-19	0.5254	3.3896
19-19	0.5538	3.5727
19-20	0.5837	3.7657
20-20	0.6136	3.9587
20-21	0.6450	4.1615
21-21	0.6765	4.3644
21-22	0.7095	4.5772
22-22	0.7424	4.7900
22-23	0.7770	5.0126
23-23	0.8115	5.2353
23-24	0.8475	5.4679
24-24	0.8836	5.7005
24-25	0.9212	5.9429
25-25	0.9587	6.1854
25-26	0.9979	6.4378
26-26	1.0370	6.6901
26-27	1.0776	6.9524
27-27	1.1183	7.2146
27-28	1.1605	7.4868
28-28	1.2026	7.7590
28-29	1.2464	8.0410
29-29	1.2901	8.3231
29-30	1.3353	8.6150
30-30	1.3806	8.9070
30-31	1.4274	9.2088
31-31	1.4742	9.5107
31-32	1.5225	9.8224
32-32	1.5708	10.1341

TABLE OF NOZZLE AREAS

A = area of nozzle (in^2)
S = area of nozzle (cm^2)

Nozzles	A	S
8	0.0491	0.3167
9	0.0621	0.4008
10	0.0767	0.4948
11	0.0928	0.5987
12	0.1104	0.7126
13	0.1296	0.8363
14	0.1503	0.9699
15	0.1726	1.1134
16	0.1963	1.2668
17	0.2217	1.4301
18	0.2485	1.6033
19	0.2769	1.7863
20	0.3068	1.9793
21	0.3382	2.1822
22	0.3712	2.3950
23	0.4057	2.6177
24	0.4418	2.8502
25	0.4794	3.0927
26	0.5185	3.3451
27	0.5591	3.6073
28	0.6013	3.8795
29	0.6450	4.1615
30	0.6903	4.4535
31	0.7371	4.7553
32	0.7854	5.0671

TABLE OF COEFFICIENTS N_4

Calculation of pressure loss in hole/drill collar annulus

$$p_{ann} = N_4 B \text{ (kPa/100 m)}$$

Hole size (in)		5 5/8		5 3/4		5 7/8		6		6 1/8		6 1/4	
Drill collar outside diameter (in)		4 3/4	4 1/8	4 3/4	4 1/8	4 3/4	4 1/8	4 3/4	4 1/8	4 3/4	4 1/8	4 3/4	4 1/8
Flow rate **Q** **(l/min)**	**100**	12	3	8	2	6	2	4	1	3	1	2	1
	150	26	6	17	4	12	3	8	3	6	2	5	2
	200	43	10	28	7	20	6	14	5	10	4	8	3
	250	65	14	43	11	29	9	21	7	15	6	12	5
	300	90	20	59	15	41	12	29	10	21	8	16	6
	350	119	26	78	20	54	16	38	13	28	10	21	8
	400	151	34	99	26	68	20	49	16	36	13	27	11
	450	187	41	123	32	84	25	60	20	44	16	33	13
	500	226	50	148	39	102	30	73	24	53	19	40	16
	550	268	60	176	46	121	36	86	28	64	23	48	19
	600	314	70	206	54	141	42	101	33	74	27	56	22
	650	362	80	238	62	163	48	117	38	86	31	65	25
	700	414	92	271	71	187	55	133	44	98	35	74	29
	750	469	104	307	80	211	63	151	50	111	40	84	33
	800	526	117	345	90	237	70	169	56	125	45	94	37
	850	587	130	385	100	265	78	189	62	139	50	105	41
	900	651	144	427	111	293	87	209	69	154	56	116	45
	950	717	159	470	122	323	96	231	76	170	61	128	50
	1000	787	175	516	134	355	105	253	84	186	67	141	55
	1050	859	191	563	147	387	115	276	91	203	74	153	60
	1100	934	207	612	159	421	125	301	99	221	80	167	65
	1150	1012	225	663	173	456	135	326	107	240	87	181	71
	1200	1092	242	716	186	492	146	351	116	259	93	195	76
	1250	1176	261	771	201	530	157	378	125	278	101	210	82
	1300	1262	280	827	215	569	168	406	134	299	108	225	88
	1350	1350	300	885	230	609	180	434	143	320	116	241	94
	1400	1442	320	945	246	650	193	464	153	341	123	258	101
	1450	1536	341	1007	262	692	205	494	163	364	131	274	107
	1500	1632	362	1070	279	736	218	525	173	386	140	292	114

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_4 (continued)
calculation of pressure loss in hole/drill collar annulus

$$p_{\text{ann}} = N_4 B \text{ (kPa/100 m)}$$

Hole size (in)		6 3/4		7 7/8			8 3/8					8 1/2				
Drill collar outside diameter (in)		4 3/4	5 1/2	6	6 1/4	6 3/4	6	6 1/4	6 1/2	6 3/4	7	6	6 1/4	6 1/2	6 3/4	7
Flow rate *Q* (l/min)	100	1	3	1	1	3			1	1	2			1	1	1
	150	2	7	2	2	7	1	1	1	2	3	1	1	1	2	2
	200	3	11	3	4	11	1	2	2	3	6	1	1	2	3	4
	250	5	17	4	6	16	2	2	3	5	8	2	2	3	4	6
	300	6	23	5	8	23	3	3	5	7	11	2	3	4	6	9
	350	8	30	7	11	30	3	4	6	9	15	3	4	5	7	11
	400	11	38	9	14	38	4	6	8	12	19	4	5	7	9	15
	450	13	48	11	17	47	5	7	10	15	24	4	6	8	12	18
	500	16	57	14	20	57	6	9	12	18	29	5	7	10	14	22
	550	19	68	16	24	68	7	10	14	21	34	6	8	12	17	26
	600	22	80	19	28	80	9	12	17	25	40	7	10	14	20	30
	650	25	92	22	32	92	10	14	19	29	46	9	11	16	23	35
	700	29	105	25	37	105	12	16	22	33	53	10	13	18	26	40
	750	33	119	28	42	119	13	18	25	37	60	11	15	20	29	45
	800	37	134	32	47	134	15	20	28	42	67	12	16	23	33	51
	850	41	149	35	53	149	16	22	31	47	75	14	18	25	37	57
	900	45	166	39	58	165	18	24	35	52	83	15	20	28	41	63
	950	50	182	43	64	182	20	27	38	57	91	17	22	31	45	69
	1000	55	200	47	70	200	22	30	42	62	100	18	25	34	49	76
	1050	60	218	52	77	218	24	32	46	68	109	20	27	37	54	83
	1100	65	238	56	84	237	26	35	50	74	119	22	29	40	58	90
	1150	70	257	61	91	257	28	38	54	80	128	24	32	44	63	97
	1200	76	278	66	98	277	30	41	58	87	139	26	34	47	68	105
	1250	82	299	71	105	298	33	44	62	93	149	28	37	51	73	113
	1300	88	321	76	113	320	35	47	67	100	160	30	39	54	79	122
	1350	94	343	81	121	342	38	51	72	107	171	32	42	58	84	130
	1400	100	367	87	129	366	40	54	77	114	183	34	45	62	90	139
	1450	107	391	92	138	389	43	58	82	122	196	36	48	66	96	148
	1500	114	415	98	146	414	45	61	87	129	207	38	51	70	102	157
	1550	120	440	104	155	439	48	65	92	137	220	41	54	75	108	167
	1600	128	466	110	164	465	51	69	97	145	233	43	57	79	115	177
	1650	135	493	117	174	491	54	73	103	153	246	45	60	84	121	187
	1700	142	520	123	183	519	57	77	109	162	260	48	64	88	128	197
	1750	150	548	130	193	546	60	81	114	171	273	51	67	93	135	208
	1800	158	576	136	203	575	63	85	120	180	288	53	71	98	142	218
	1850	166	606	143	213	604	66	90	126	189	302	56	74	103	149	229
	1900	174	635	150	224	633	69	94	133	198	317	59	78	108	156	241
	1950	182	666	158	234	664	73	98	139	207	332	61	82	113	164	252
	2000	191	697	165	245	695	76	103	146	217	348	64	86	118	171	264

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_4 (continued)
calculation of pressure loss in hole/drill collar annulus
$p_{ann} = N_4B$ (kPa/100 m)

Hole size (in)		8 5/8					8 3/4					9 7/8				12 1/4				
Drill collar outside diameter (in)		6 1/4	6 1/2	6 3/4	7	7 1/4	6 1/4	6 1/2	6 3/4	7	7 1/4	6 1/2	6 3/4	7 3/4	8	7 3/4	8	9 1/2	10	11 1/4
Flow rate Q (l/min)	100			1	1	1			1	1	1									2
	150	1	1	1	2	3	1	1	1	2	2			1	1					4
	200	1	2	2	3	5	1	1	2	3	4			1	2				1	7
	250	2	2	3	5	8	1	2	3	4	6		1	2	2			1	1	10
	300	2	3	5	7	11	2	3	4	5	8	1	1	2	3			1	1	14
	350	3	4	6	9	14	3	3	5	7	11	1	1	3	5			1	2	18
	400	4	5	8	11	18	3	4	6	9	14	1	1	4	6			1	2	23
	450	5	7	9	14	22	4	5	8	11	17	1	2	5	7			2	3	29
	500	6	8	11	17	27	5	7	9	13	21	2	2	6	9	1	1	2	3	35
	550	7	10	13	20	32	6	8	11	16	24	2	3	7	10	1	1	2	4	41
	600	8	11	16	23	38	7	9	13	18	29	2	3	8	12	1	1	3	5	48
	650	9	13	18	27	43	8	11	15	21	33	3	3	10	14	1	1	3	5	56
	700	11	15	21	31	50	9	12	17	24	38	3	4	11	16	1	1	4	6	64
	750	12	17	23	35	56	10	14	19	28	43	4	4	13	18	1	1	4	7	72
	800	14	19	26	39	63	12	15	21	31	48	4	5	14	20	1	1	4	8	81
	850	15	21	29	44	70	13	17	24	35	53	4	6	16	22	1	2	5	9	90
	900	17	23	33	49	78	14	19	26	38	59	5	6	18	25	1	2	6	10	100
	950	19	25	36	54	86	16	21	29	42	65	5	7	19	27	2	2	6	11	110
	1000	21	28	39	59	94	17	23	32	46	72	6	7	21	30	2	2	7	12	121
	1050	22	30	43	64	103	19	25	35	51	78	7	8	23	33	2	2	7	13	132
	1100	24	33	47	70	112	21	27	38	55	85	7	9	25	36	2	2	8	14	144
	1150	26	36	51	76	121	22	30	41	60	92	8	10	27	39	2	3	9	15	156
	1200	29	39	55	82	131	24	32	44	64	99	8	10	29	42	2	3	9	16	168
	1250	31	42	59	88	141	26	35	48	69	107	9	11	32	45	3	3	10	18	181
	1300	33	45	63	94	151	28	37	51	74	115	10	12	34	48	3	3	11	19	194
	1350	35	48	68	101	162	30	40	55	80	123	10	13	36	52	3	4	11	20	208
	1400	38	51	72	108	173	32	42	59	85	131	11	14	39	55	3	4	12	21	222
	1450	40	54	77	115	184	34	45	62	91	140	12	14	41	59	3	4	13	23	236
	1500	43	58	82	122	196	36	48	66	96	149	13	15	44	62	4	4	14	24	251
	1550	45	61	87	129	207	38	51	70	102	158	13	16	47	66	4	5	15	26	266
	1600	48	65	92	137	220	40	54	75	108	167	14	17	49	70	4	5	16	27	282
	1650	51	69	97	145	232	43	57	79	114	176	15	18	52	74	4	5	16	29	298
	1700	53	72	102	153	245	45	60	83	121	186	16	19	55	78	5	5	17	30	314
	1750	56	76	108	161	258	48	63	88	127	196	17	20	58	82	5	6	18	32	331
	1800	59	80	113	169	272	50	67	92	134	206	17	21	61	87	5	6	19	34	348
	1850	62	84	119	178	285	53	70	97	140	217	18	22	64	91	5	6	20	35	366

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_4 (continued)
calculation of pressure loss in hole/drill collar annulus
$p_{ann} = N_4B$ (kPa/100 m)

Hole size (in)		8 5/8					8 3/4					9 7/8				12 1/4				
Drill collar outside diameter (in)		6 1/4	6 1/2	6 3/4	7	7 1/4	6 1/4	6 1/2	6 3/4	7	7 1/4	6 1/2	6 3/4	7 3/4	8	7 3/4	8	9 1/2	10	11 1/4
Flow rate *Q* (l/min)	1900	65	88	125	187	299	55	73	102	147	227	19	23	67	95	6	7	21	37	384
	1950	68	93	131	196	314	58	77	106	154	238	20	25	70	100	6	7	22	39	402
	2000	72	97	137	205	328	60	81	111	162	249	21	26	74	105	6	7	23	41	421
	2050	75	101	143	214	343	63	84	116	169	261	22	27	77	109	6	7	24	43	440
	2100	78	106	150	223	328	66	88	122	176	272	23	28	80	114	7	8	25	45	460
	2150	82	111	156	233	374	69	92	127	184	284	24	29	84	119	7	8	27	46	480
	2200	85	115	163	243	390	72	96	132	192	296	25	31	87	124	7	9	28	48	500
	2250	89	120	170	253	406	75	100	138	200	308	26	32	91	129	8	9	29	50	521
	2300	92	125	176	263	422	78	104	143	208	321	27	33	95	134	8	9	30	52	542
	2350	96	130	183	274	439	81	108	149	216	333	28	34	98	140	8	10	31	55	563
	2400	99	135	190	284	456	84	112	155	224	346	29	36	102	145	9	10	32	57	585
	2450	103	140	198	295	473	87	116	160	233	359	30	37	106	151	9	10	34	59	607
	2500	107	145	205	306	491	90	120	166	241	373	31	38	110	156	9	11	35	61	629
	2550	111	150	212	317	508	94	125	172	250	386	33	40	114	162	10	11	36	63	652
	2600	115	156	220	328	526	97	129	179	259	400	34	41	118	168	10	12	37	65	676
	2650	119	161	228	340	545	100	134	185	268	414	35	43	122	174	10	12	39	68	699
	2700	123	167	235	351	563	104	138	191	277	428	36	44	126	179	11	12	40	70	723
	2750	127	172	243	363	582	107	143	198	287	442	37	46	131	186	11	13	41	72	747
	2800	131	178	251	375	602	111	148	204	296	457	38	47	135	192	11	13	43	75	772
	2850	135	184	259	387	621	114	152	211	306	472	40	49	139	198	12	14	44	77	797
	2900	140	189	268	399	641	118	157	217	315	487	41	50	144	204	12	14	45	80	822
	2950	144	195	276	412	661	122	162	224	325	502	42	52	148	210	12	14	47	82	848
	3000	149	201	285	425	681	125	167	231	335	517	44	53	153	217	13	15	48	85	874
	3050	153	207	293	437	702	129	172	238	345	533	45	55	157	224	13	15	50	87	900
	3100	158	214	302	450	723	133	177	245	355	549	46	57	162	230	14	16	51	90	927
	3150	162	220	311	464	744	137	182	252	366	565	48	58	167	237	14	16	53	92	954
	3200	167	226	320	477	765	141	188	260	376	581	49	60	172	244	14	17	54	95	982
	3250	172	233	329	490	787	145	193	267	387	597	50	62	177	251	15	17	56	98	1009
	3300	176	239	338	504	809	149	198	274	398	614	52	63	181	258	15	18	57	101	1038
	3350	181	246	347	518	831	153	204	282	409	631	53	65	186	265	16	18	59	103	1066
	3400	186	252	356	532	853	157	209	289	420	648	55	67	191	272	16	19	61	106	1095
	3450	191	259	366	546	876	161	215	297	431	665	56	69	197	279	16	19	62	109	1124
	3500	196	266	376	560	899	166	221	305	442	683	57	70	202	286	17	20	64	112	1153

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_4 (continued)
calculation of pressure loss in hole/drill collar annulus

$$p_{ann} = N_4 B \text{ (kPa/100 m)}$$

Hole size (in)		15						17 1/2						
Drill collar outside diameter (in)		7 3/4	8	9 1/2	10	11	11 1/4	7 3/4	8	9 1/2	10	11	11 1/4	14
Flow rate Q (l/min)	2000	1	1	2	3	5	7			1	1	1	1	6
	2100	1	1	3	3	6	7			1	1	1	1	6
	2200	1	2	3	4	7	8		1	1	1	1	1	7
	2300	2	2	3	4	7	8	1	1	1	1	1	2	7
	2400	2	2	3	4	8	9	1	1	1	1	2	2	8
	2500	2	2	4	5	8	10	1	1	1	1	2	2	9
	2600	2	2	4	5	9	10	1	1	1	1	2	2	9
	2700	2	2	4	5	9	11	1	1	1	1	2	2	10
	2800	2	2	4	6	10	12	1	1	1	1	2	2	11
	2900	2	2	5	6	11	13	1	1	1	1	2	2	11
	3000	2	3	5	6	11	14	1	1	1	2	2	2	12
	3100	3	3	5	7	12	14	1	1	1	2	2	3	13
	3200	3	3	5	7	13	15	1	1	1	2	3	3	14
	3300	3	3	6	7	14	16	1	1	2	2	3	3	14
	3400	3	3	6	8	14	17	1	1	2	2	3	3	15
	3500	3	3	6	8	15	18	1	1	2	2	3	3	16
	3600	3	4	7	9	16	19	1	1	2	2	3	3	17
	3700	4	4	7	9	17	20	1	1	2	2	3	4	18
	3800	4	4	7	10	17	21	1	1	2	2	3	4	18
	3900	4	4	8	10	18	22	1	1	2	3	4	4	19
	4000	4	4	8	10	19	23	1	1	2	3	4	4	20
	4100	4	5	9	11	20	24	1	2	2	3	4	4	21
	4200	4	5	9	11	21	25	2	2	2	3	4	5	22
	4300	5	5	9	12	22	26	2	2	3	3	4	5	23
	4400	5	5	10	12	23	27	2	2	3	3	4	5	24
	4500	5	5	10	13	24	28	2	2	3	3	5	5	25

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_5

Calculation of pressure loss in hole/pipe annulus

$$p_{ann} = N_5 B \text{ (kPa/100 m)}$$

Hole size (in)		5 5/8						5 3/4						5 7/8					
Nominal pipe size (in)		2 3/8	2 7/8		3 1/2			2 3/8	2 7/8		3 1/2			2 3/8	2 7/8		3 1/2		
Tool joint outside diameter (in)		2 7/8 à 3 3/8	3 1/8 à 3 7/8	4 à 4 3/8	4 1/2	4 3/4	5	2 7/8 à 3 3/8	3 1/8 à 3 7/8	4 à 4 3/8	4 1/2	4 3/4	5	2 7/8 à 3 3/8	3 1/8 à 3 7/8	4 à 4 3/8	4 1/2	4 3/4	5
Flow rate Q (l/min)	**100**		1	1	1	2	3		1	1	1	1	2				1	1	1
	150	1	1	1	3	3	6	1	1	1	2	3	4	1	1	1	2	2	3
	200	1	2	2	5	6	9	1	2	2	4	4	6	1	2	2	3	3	4
	250	2	3	4	7	9	14	2	3	3	6	7	9	2	2	3	5	5	7
	300	3	4	5	10	12	19	3	4	4	8	9	13	2	3	4	6	7	9
	350	4	6	7	13	16	26	3	5	6	10	12	17	3	4	5	8	9	12
	400	5	7	9	16	20	33	4	6	7	13	15	22	4	5	6	11	12	16
	450	6	9	11	20	25	40	5	8	9	16	19	27	5	7	7	13	15	19
	500	7	11	13	24	30	49	6	9	11	19	23	32	6	8	9	16	18	23
	550	9	13	15	29	36	58	8	11	13	23	27	38	7	9	11	19	21	28
	600	10	15	18	34	42	67	9	13	15	27	32	45	8	11	12	22	25	32
	650	12	17	20	39	48	78	10	15	17	31	37	52	9	13	14	25	29	37
	700	13	20	23	45	55	89	12	17	19	36	42	59	10	15	16	29	33	43
	750	15	23	26	51	63	101	13	19	22	40	48	67	11	16	18	33	37	48
	800	17	25	30	57	70	113	15	22	25	45	53	75	13	18	21	37	42	54
	850	19	28	33	63	78	126	17	24	27	51	60	84	14	21	23	41	47	60
	900	21	31	37	70	87	140	18	27	30	56	66	93	16	23	26	45	52	67
	950	23	35	40	78	96	154	20	29	34	62	73	103	18	25	28	50	57	74
	1000	26	38	44	85	105	169	22	32	37	68	80	113	19	28	31	55	63	81
	1050	28	41	48	93	115	185	24	35	40	74	87	123	21	30	34	60	68	88
	1100	30	45	53	101	125	201	26	38	44	81	95	134	23	33	37	65	74	96
	1150	33	49	57	109	135	218	28	41	47	87	103	145	25	35	40	71	80	104
	1200	36	53	61	118	146	235	31	45	51	94	111	156	27	38	43	76	87	112
	1250	38	57	66	127	157	253	33	48	55	101	119	168	29	41	46	82	94	121
	1300	41	61	71	136	168	271	36	52	59	109	128	181	31	44	50	88	100	130
	1350	44	65	76	146	180	290	38	55	63	116	137	193	33	47	53	94	107	139
	1400	47	69	81	156	193	310	41	59	68	124	146	206	35	50	57	101	115	148
	1450	50	74	86	166	205	330	43	63	72	132	156	220	38	54	60	107	122	158
	1500	53	79	92	177	218	351	46	67	76	141	166	234	40	57	64	114	130	168
	1550	56	83	97	187	231	372	49	71	81	149	176	248	42	61	68	121	138	178
	1600	60	88	103	198	245	394	52	75	86	158	186	262	45	64	72	128	146	189
	1650	63	93	109	210	259	417	55	79	91	167	197	277	47	68	76	135	154	199
	1700	66	99	115	221	273	440	58	84	96	176	207	293	50	72	81	143	163	210
	1750	70	104	121	233	288	163	61	88	101	186	219	308	53	75	85	151	171	222
	1800	74	109	128	245	303	487	64	93	106	195	230	324	56	79	89	158	180	233
	1850	77	115	134	257	318	512	67	98	112	205	242	341	58	83	94	166	189	245
	1900	81	120	141	270	334	537	70	102	117	215	253	358	61	87	98	175	199	257
	1950	85	126	147	283	350	563	74	107	123	226	266	375	64	92	103	183	208	269
	2000	89	132	154	296	366	589	77	112	128	236	278	392	67	96	108	191	218	282

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_5 (continued)

Calculation of pressure loss in hole/pipe annulus

$p_{ann} = N_5B$ (kPa/100 m)

Hole size (in)		6				6 1/8					6 1/4					6 3/4					
Nominal pipe size (in)		3 1/2			4	3 1/2			4		3 1/2			4		3 1/2			4		
Tool joint outside diameter (in)		4 1/2	4 3/4	5	5 1/4	4 1/2	4 3/4	5	5 1/4	5 1/2	4 1/2	4 3/4	5	5 1/4	5 1/2	4 1/2	4 3/4	5	5 1/4	5 1/2	6
Flow rate *Q* (l/min)	**500**	13	14	18	35	11	12	14	25	41	9	10	11	19	27	5	5	5	8	9	19
	550	15	17	21	41	13	14	16	30	49	11	12	13	23	32	6	6	6	10	11	22
	600	18	20	24	48	15	16	19	35	57	13	14	15	27	38	7	7	8	11	13	26
	650	21	23	28	56	17	19	22	40	66	15	16	18	31	44	8	8	9	13	15	30
	700	24	26	32	64	20	22	25	46	75	17	18	20	35	50	9	9	10	15	17	35
	750	27	30	37	72	22	24	29	52	85	19	20	23	40	57	10	11	11	17	19	39
	800	30	34	41	81	25	27	32	59	95	21	23	26	45	63	11	12	13	19	22	44
	850	34	37	46	90	28	31	36	66	106	24	25	29	50	71	13	13	14	21	24	49
	900	37	42	51	100	31	34	40	73	118	26	28	32	55	78	14	15	16	24	27	54
	950	41	46	56	110	34	37	44	80	130	29	31	35	61	86	15	16	17	26	30	60
	1000	45	50	61	121	38	41	48	88	142	32	34	39	67	95	17	18	19	29	33	66
	1050	49	55	67	132	41	45	52	96	156	34	37	42	73	104	18	19	21	31	36	72
	1100	54	60	73	143	45	49	57	104	169	37	40	46	79	113	20	21	22	34	39	78
	1150	58	65	79	155	48	53	62	113	183	41	44	50	86	122	22	23	24	37	42	84
	1200	63	70	85	168	52	57	67	122	198	44	47	54	93	132	23	24	26	40	45	91
	1250	68	75	92	181	56	61	72	131	213	47	51	58	100	142	25	26	28	43	49	98
	1300	72	81	98	194	60	66	77	141	228	51	54	62	107	152	27	28	30	46	52	105
	1350	78	86	105	207	64	70	82	151	245	54	58	66	115	163	29	30	32	49	56	113
	1400	83	92	112	221	69	75	88	161	261	58	62	71	122	174	31	32	35	52	60	120
	1450	88	98	120	236	73	80	94	171	278	62	66	75	130	185	33	34	37	56	64	128
	1500	94	104	127	251	78	85	100	182	296	65	70	80	139	197	35	37	39	59	68	136
	1550	99	110	135	266	83	90	106	193	314	69	75	85	147	209	37	39	41	63	72	145
	1600	105	117	143	282	88	96	112	205	332	73	79	90	156	221	39	41	44	67	76	153
	1650	111	124	151	298	93	101	118	216	351	78	84	95	165	234	42	43	46	70	80	162
	1700	117	130	159	314	98	107	125	228	370	82	88	100	174	247	44	46	49	74	85	171
	1750	124	137	168	331	103	112	131	241	390	86	93	106	183	260	46	48	52	78	89	180
	1800	130	145	176	348	108	118	138	253	410	91	98	111	192	273	49	51	54	82	94	189
	1850	137	152	185	366	114	124	145	266	431	95	103	117	202	287	51	53	57	87	99	199
	1900	143	159	195	384	119	130	152	279	452	100	108	123	212	301	54	56	60	91	103	209
	1950	150	167	204	402	125	136	160	292	474	105	113	128	222	316	56	59	63	95	108	219
	2000	157	175	213	421	131	143	167	306	496	110	118	134	233	330	59	61	66	100	113	229

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_5 (continued)
Calculation of pressure loss in hole/pipe annulus
$p_{ann} = N_5B$ (kPa/100 m)

Hole size (in)		7 7/8			8 3/8				8 1/2				8 5/8				8 3/4			
Nominal pipe size (in)		3 1/2	4	4 1/2	3 1/2	4	4 1/2	5	3 1/2	4	4 1/2	5	3 1/2	4	4 1/2	5	3 1/2	4	4 1/2	5
Tool joint outside diameter (in)		4 1/2 à 5	5 1/4 à 6	6 à 6 3/8	4 1/2 à 5	5 1/4 à 6	6 à 6 3/8	6 3/8 à 7	4 1/2 à 5	5 1/4 à 6	6 à 6 3/8	6 3/8 à 7	4 1/2 à 5	5 1/4 à 6	6 à 6 3/8	6 3/8 à 7	4 1/2 à 5	5 1/4 à 6	6 à 6 3/8	6 3/8 à 7
Flow rate Q (l/min)	500	2	2	4	1	1	2	3	1	1	2	3	1	1	2	2	1	1	1	2
	550	2	3	4	1	2	2	4	1	2	2	3	1	1	2	3	1	1	2	2
	600	2	3	5	1	2	3	4	1	2	3	4	1	2	2	3	1	1	2	3
	650	3	4	6	2	2	3	5	2	2	3	4	1	2	3	4	1	2	2	3
	700	3	4	7	2	3	4	5	2	2	3	5	2	2	3	4	1	2	3	4
	750	3	5	8	2	3	4	6	2	3	4	5	2	2	3	5	2	2	3	4
	800	4	5	8	3	3	5	7	2	3	4	6	2	3	4	5	2	2	3	5
	850	4	6	9	3	4	5	8	3	3	5	7	2	3	4	6	2	3	4	5
	900	5	7	10	3	4	6	9	3	4	5	7	3	3	5	6	2	3	4	6
	950	5	7	12	3	5	7	9	3	4	6	8	3	4	5	7	3	3	5	6
	1000	6	8	13	4	5	7	10	3	5	6	9	3	4	6	8	3	4	5	7
	1050	6	9	14	4	6	8	11	4	5	7	10	3	4	6	9	3	4	5	8
	1100	7	10	15	4	6	9	12	4	5	8	11	4	5	7	9	3	4	6	8
	1150	7	11	16	5	7	9	13	4	6	8	12	4	5	7	10	4	5	6	9
	1200	8	11	18	5	7	10	14	5	6	9	12	4	6	8	11	4	5	7	10
	1250	8	12	19	6	8	11	15	5	7	9	13	5	6	8	12	4	6	7	10
	1300	9	13	20	6	8	12	17	5	7	10	14	5	7	9	13	5	6	8	11
	1350	10	14	22	6	9	12	18	6	8	11	15	5	7	10	13	5	6	9	12
	1400	10	15	23	7	9	13	19	6	8	12	16	6	8	10	14	5	7	9	13
	1450	11	16	25	7	10	14	20	7	9	12	18	6	8	11	15	6	7	10	13
	1500	12	17	26	8	11	15	21	7	9	13	19	6	9	12	16	6	8	10	14
	1550	12	18	28	8	11	16	23	7	10	14	20	7	9	12	17	6	8	11	15
	1600	13	19	29	9	12	17	24	8	11	15	21	7	10	13	18	7	9	12	16
	1650	14	20	31	9	13	18	25	8	11	16	22	8	10	14	19	7	9	12	17
	1700	15	21	33	10	13	19	27	9	12	17	23	8	11	15	20	7	10	13	18
	1750	16	22	35	10	14	20	28	9	13	17	25	8	11	15	21	8	10	14	19
	1800	16	24	36	11	15	21	30	10	13	18	26	9	12	16	23	8	11	14	20
	1850	17	25	38	11	15	22	31	10	14	19	27	9	12	17	24	9	11	15	21
	1900	18	26	40	12	16	23	33	11	14	20	28	10	13	18	25	9	12	16	22
	1950	19	27	42	12	17	24	34	11	15	21	30	10	14	19	26	9	12	17	23
	2000	20	29	44	13	18	25	36	12	16	22	31	11	14	20	27	10	13	17	24
	2050	21	30	46	14	19	26	38	12	17	23	33	11	15	20	29	10	13	18	25
	2100	22	31	48	14	19	27	39	13	17	24	34	12	16	21	30	11	14	19	26
	2150	22	32	50	15	20	29	41	14	18	25	36	12	16	22	31	11	15	20	27
	2200	23	34	52	16	21	30	43	14	19	26	37	13	17	23	32	12	15	21	28

l/min × 0.264 = gal/min

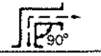
TABLE OF COEFFICIENTS N_5 (continued)
Calculation of pressure loss in hole/pipe annulus
$p_{ann} = N_5B$ (kPa/100 m)

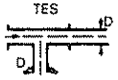
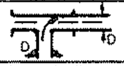
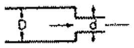
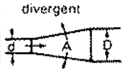
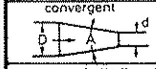
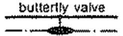
Hole size (in)		9 7/8			12 1/4			15			17 1/2		
Nominal pipe size (in)		4 1/2	5	5 1/2	4 1/2	5	5 1/2	4 1/2	5	5 1/2	4 1/2	5	5 1/2
Tool joint outside diameter (in)		6 à 6 3/8	6 3/8 à 7	7 à 7 1/2	6 à 6 3/8	6 3/8 à 7	7 à 7 1/2	6 à 6 3/8	6 3/8 à 7	7 à 7 1/2	6 à 6 3/8	6 3/8 à 7	7 à 7 1/2
Flow rate ***Q*** **(l/min)**	**1500**	4	5	7	1	1	1						
	1600	5	6	8	1	1	2						
	1700	5	7	9	1	1	2						
	1800	6	7	10	1	2	2			1			
	1900	6	8	11	2	2	2		1	1			
	2000	7	9	12	2	2	2	1	1	1			
	2100	8	10	13	2	2	3	1	1	1			
	2200	8	11	15	2	2	3	1	1	1			
	2300	9	11	16	2	3	3	1	1	1			
	2400	10	12	17	2	3	3	1	1	1			
	2500	11	13	18	3	3	4	1	1	1			
	2600	11	14	20	3	3	4	1	1	1			
	2700	12	15	21	3	3	4	1	1	1			
	2800	13	16	23	3	4	4	1	1	1			
	2900	14	17	24	3	4	5	1	1	1			1
	3000	15	19	26	4	4	5	1	1	1			1
	3100	16	20	27	4	4	5	1	1	1		1	1
	3200	16	21	29	4	5	6	1	1	2	1	1	1
	3300	17	22	30	4	5	6	1	1	2	1	1	1
	3400	18	23	32	4	5	6	1	1	2	1	1	1
	3500	19	24	34	5	5	7	1	2	2	1	1	1
	3600	20	26	35	5	6	7	2	2	2	1	1	1
	3700	21	27	37	5	6	7	2	2	2	1	1	1
	3800	22	28	39	5	6	8	2	2	2	1	1	1
	3900	24	30	41	6	7	8	2	2	2	1	1	1
	4000	25	31	43	6	7	8	2	2	2	1	1	1
	4100	26	32	45	6	7	9	2	2	2	1	1	1
	4200	27	34	47	7	8	9	2	2	2	1	1	1
	4300	28	35	49	7	8	9	2	2	3	1	1	1
	4400	29	37	51	7	8	10	2	2	3	1	1	1
	4500	30	38	53	7	9	10	2	2	3	1	1	1

l/min × 0.264 = gal/min

EQUIVALENT LENGTHS FOR SPECIAL LINE CONNECTIONS (in meter)

The values given in the table are approximate averages.
However, the table offers a quick way to find the pressure drops in a low pressure circuit.
For a change in pipe size, the calculation is always carried out in relation to the smaller size (d).

	Equivalent length for pipe size				
	3"	4"	6"	8"	10"
mud pit outlet 	0,8	1,1	1,8	2,5	3,3
	1,9	2,7	4,5	6,4	8,3
 suction by a pipe sunk in a tank	0,4	0,54	0,9	1,3	1,7
	3,4	4,8	8,1	11,5	14,8
mud pit inlet  d/D = 0,5 A = 10° " = 0,5 A = 20°	0,8 1,9	1,1 2,7	1,8 4,5	2,5 6,4	3,3 8,3
	3,8	5,4	9,0	12,7	16,5
 Elbows R ≥ 5D R = 2D R = D	1,2 1,5 2,7	1,6 2,1 3,8	2,7 3,6 6,3	3,8 5,1 8,9	5,0 6,6 11,6
	4,6	6,4	10,8	15,2	19,8
 A = 22° A = 45° A = 60°	0,6 1,5 2,3	0,8 2,1 3,2	1,4 3,6 5,4	1,9 5,1 7,6	2,5 6,6 10,0

	Equivalent length for pipe size				
TES	3"	4"	6"	8"	10"
	1,0	1,3	2,2	3,2	4,1
	5,4	7,5	12,6	17,8	23,0
	4,6	6,4	10,8	15,2	19,8
sudden change in diameter (narrowing)  d/D = 0,8 = 0,6 = 0,4 = 0,2	0,6 1,2 1,5 1,7	0,8 1,6 2,1 2,4	1,3 2,7 3,6 4,0	1,9 3,8 5,1 5,7	2,5 5,0 6,6 7,4
sudden change in diameter (widening)  d/D = 0,8 = 0,6 = 0,4 = 0,2	0,6 1,5 2,7 3,6	0,8 2,1 3,8 5,1	1,4 3,6 6,3 8,5	1,9 5,1 8,9 12,1	2,5 6,6 11,5 15,7
divergent  A = 10° d/D = 0,6 = 0,4 A = 20° d/D = 0,6 = 0,4	0,4 0,6 0,8 1,3	0,6 0,8 1,1 1,7	0,9 1,4 1,8 3,2	1,3 1,9 2,5 4,4	1,7 2,5 3,3 5,8
convergent  A = 20° A = 30° A = 45°	0,5 0,6 1,2	0,7 0,9 1,7	1,2 1,5 2,9	1,6 2,0 4,0	2,1 2,6 5,3
butterfly valve 	0,5	0,7	1,1	1,5	2,0
 direct flow valve	1,2	1,6	2,7	3,8	5,0

H

Drilling mud

RELATIONSHIP BETWEEN MUD WEIGHT AND PRESSURE HEAD OF MUD

Mud weight			**Fluid head**	
(kg/l)	(lb/gal)	(lb/ft^3)	(psi/ft)	**(kPa/m)**
0.90	7.51	56.2	0.3902	8.83
0.92	7.68	57.4	0.3988	9.03
0.94	7.84	58.7	0.4075	9.22
0.96	8.01	59.9	0.4162	9.42
0.98	8.18	61.2	0.4248	9.61
1.00	8.35	62.4	0.4335	9.81
1.02	8.51	63.7	0.4422	10.01
1.04	8.68	64.9	0.4509	10.20
1.06	8.85	66.2	0.4595	10.40
1.08	9.01	67.4	0.4682	10.59
1.10	9.18	68.7	0.4769	10.79
1.12	9.35	69.9	0.4855	10.99
1.14	9.51	71.2	0.4942	11.18
1.16	9.68	72.4	0.5029	11.38
1.18	9.85	73.7	0.5116	11.58
1.20	10.01	74.9	0.5202	11.77
1.22	10.18	76.2	0.5289	11.97
1.24	10.35	77.4	0.5376	12.16
1.26	10.51	78.7	0.5462	12.36
1.28	10.68	79.9	0.5549	12.56
1.30	10.85	81.2	0.5636	12.75
1.34	11.18	83.7	0.5809	13.15
1.38	11.52	86.1	0.5983	13.54
1.42	11.85	88.6	0.6156	13.93
1.46	12.18	91.1	0.6329	14.32
1.50	12.52	93.6	0.6503	14.72
1.54	12.85	96.1	0.6676	15.11
1.58	13.19	98.6	0.6850	15.50
1.62	13.52	101.1	0.7023	15.89
1.66	13.85	103.6	0.7196	16.28
1.70	14.19	106.1	0.7370	16.68
1.74	14.52	108.6	0.7543	17.07
1.78	14.85	111.1	0.7717	17.46
1.82	15.19	113.6	0.7890	17.85
1.86	15.52	116.1	0.8063	18.25
1.90	15.86	118.6	0.8237	18.64
1.94	16.19	121.1	0.8410	19.03
1.98	16.52	123.6	0.8584	19.42
2.02	16.86	126.1	0.8757	19.82
2.06	17.19	128.6	0.8930	20.21
2.10	17.52	131.1	0.9104	20.60
2.14	17.86	133.6	0.9277	20.99
2.18	18.19	136.1	0.9451	21.39
2.22	18.53	138.6	0.9624	21.78
2.26	18.86	141.1	0.9798	22.17
2.30	19.19	143.6	0.9971	22.56

Hydrostatic pressure

$$\boxed{P_H = 9.81Zd}$$

P_H = hydrostatic pressure (kPa)

Z = vertical depth (m)

d = mud weight (kg/l)

Conversion factors

To convert from	into	*multiply* by
kg/l	lb/gal	8.3452
kg/l	lb/ft^3	62.427
lb/gal	lb/ft^3	7.48082
lb/gal	kg/l	0.11983
lb/ft^3	kg/l	0.016019
lb/ft^3	lb/gal	0.13368
kPa/m	psi/ft	0.044213
psi/ft	kPa/m	22.618

INCREASE OF MUD SPECIFIC GRAVITY WITH BARITE ($d = 4.2$)

Weight (in kg) of barite to add to 1 m³ of mud (M)

Initial mud specific gravity d_1	Desired mud specific gravity d_2																							
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25
1.00	67	135	207	280	356	434	516	600	687	778	872	969	1071	1176	1266	1400	1519	1643	1773	1909	2051	2200	2356	2520	2692
1.05		68	138	210	285	362	442	525	611	700	792	888	988	1092	1200	1313	1430	1552	1680	1814	1953	2100	2254	2415	2585
1.10			69	140	214	290	368	450	535	622	713	808	906	1008	1114	1225	1340	1461	1587	1718	1856	2000	2151	2310	2477
1.15				70	142	217	295	375	458	544	634	727	824	924	1029	1138	1251	1370	1493	1623	1758	1900	2049	2205	2369
1.20					71	145	221	300	382	467	555	646	741	840	943	1050	1162	1278	1400	1527	1660	1800	1946	2100	2262
1.25						72	147	225	305	389	475	565	659	756	857	963	1072	1187	1307	1432	1563	1700	1844	1995	2154
1.30							74	150	229	311	396	485	576	672	771	875	983	1096	1213	1336	1465	1600	1741	1890	2046
1.35								75	153	233	317	404	494	588	686	788	894	1004	1120	1241	1367	1500	1639	1785	1938
1.40									76	156	238	323	412	504	600	700	804	913	1027	1145	1270	1400	1537	1680	1831
1.45										78	158	242	329	420	514	613	715	822	933	1050	1172	1300	1434	1575	1723
1.50											79	162	247	336	429	525	626	730	840	955	1074	1200	1332	1470	1615
1.55												81	165	252	343	438	536	639	747	859	977	1100	1229	1365	1508
1.60													82	168	257	350	447	548	653	764	879	1000	1127	1260	1400
1.65														84	171	263	357	457	560	668	781	900	1024	1155	1292
1.70															86	175	268	365	467	573	684	800	922	1050	1185
1.75																88	179	274	373	477	586	700	820	945	1077
1.80																	89	183	280	382	488	600	717	840	969
1.85																		91	187	286	391	500	615	735	862
1.90																			93	191	293	400	512	630	754
1.95																				95	195	300	410	525	646
2.00																					98	200	307	420	538
2.05																						100	205	315	431
2.10																							102	210	323
2.15																								105	215
2.20																									108

kg × 2.20 = lb   m³ × 6.29 = bbl   kg/m³ × 0.3505 = lb/bbl

$$M = 4\,200\,\frac{(d_2 - d_1)}{(4.2 - d_2)} \quad (\mathrm{kg/m^3})$$

INCREASE OF MUD SPECIFIC GRAVITY WITH CALCIUM CARBONATE (d = 2.65)

Weight (in kg) of calcium carbonate to add to 1 m³ of mud (M)

Initial mud specific gravity d_1	Desired mud specific gravity d_2														
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75
1.00	83	171	265	366	473	589	713	848	994	1152	1325	1514	1723	1953	2208
1.05		85	177	274	379	491	612	742	883	1037	1205	1388	1590	1813	2061
1.10			88	183	284	393	510	636	773	922	1084	1262	1458	1674	1914
1.15				91	189	294	408	530	663	807	964	1136	1325	1534	1767
1.20					95	196	306	424	552	691	843	1010	1193	1395	1619
1.25						98	204	318	442	576	723	883	1060	1255	1472
1.30							102	212	331	461	602	757	928	1116	1325
1.35								106	221	346	482	631	795	976	1178
1.40									110	230	361	505	663	837	1031
1.45										115	241	379	530	697	883
1.50											120	252	398	558	736
1.55												126	265	418	589
1.60													133	279	442
1.65														139	294
1.70															147

kg × 2.20 = lb $m^3 \times 6.29$ = bbl $kg/m^3 \times 0.3505$ = lb/bbl

$$M = 2\,650\,\frac{(d_2 - d_1)}{(2.65 - d_2)} \quad (\text{kg/m}^3)$$

MUD SPECIFIC GRAVITY REDUCTION WITH WATER ($d = 1$)
Water volume in liters to add to 1 m³ of mud (M)

Initial mud specific gravity d_1	Desired mud specific gravity d_2																								
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25
1.10	1000																								
1.15	2000	500																							
1.20	3000	1000	333																						
1.25	4000	1500	667	250																					
1.30	5000	2000	1000	500	200																				
1.35	6000	2500	1333	750	400	167																			
1.40	7000	3000	1667	1000	600	333	143																		
1.45	8000	3500	2000	1250	800	500	286	125																	
1.50	9000	4000	2333	1500	1000	667	429	250	111																
1.55	10000	4500	2667	1750	1200	833	571	375	222	100															
1.60	11000	5000	3000	2000	1400	1000	714	500	333	200	91														
1.65	12000	5500	3333	2250	1600	1167	857	625	444	300	182	83													
1.70	13000	6000	3667	2500	1800	1333	1000	750	556	400	273	167	77												
1.75	14000	6500	4000	2750	2000	1500	1143	875	667	500	364	250	154	71											
1.80	15000	7000	4333	3000	2200	1667	1286	1000	778	600	455	333	231	143	67										
1.85	16000	7500	4667	3250	2400	1833	1429	1125	889	700	545	417	308	214	133	63									
1.90	17000	8000	5000	3500	2600	2000	1571	1250	1000	800	636	500	385	286	200	125	59								
1.95	18000	8500	5333	3750	2800	2167	1714	1375	1111	900	727	583	462	357	267	188	118	56							
2.00	19000	9000	5667	4000	3000	2333	1857	1500	1222	1000	818	667	538	429	333	250	176	111	53						
2.05	20000	9500	6000	4250	3200	2500	2000	1625	1333	1100	909	750	615	500	400	313	235	167	105	50					
2.10	21000	10000	6333	4500	3400	2667	2143	1750	1444	1200	1000	833	692	571	467	375	294	222	158	100	48				
2.15	22000	10500	6667	4750	3600	2833	2286	1875	1556	1300	1091	917	769	643	533	438	353	278	211	150	95	45			
2.20	23000	11000	7000	5000	3800	3000	2429	2000	1667	1400	1182	1000	846	714	600	500	412	333	263	200	143	91	43		
2.25	24000	11500	7333	5250	4000	3167	2571	2125	1778	1500	1273	1083	923	786	667	563	471	389	316	250	190	136	87	42	
2.30	25000	12000	7667	5500	4200	3333	2714	2250	1889	1600	1364	1167	1000	857	733	625	529	444	368	300	238	182	130	83	40

l × 0.264 = gal m³ × 6.29 = bbl l/m³ × 0.042 = gal/bbl

$$M = 1\,000\,\frac{(d_1 - d_2)}{(d_2 - 1)} \qquad \text{(liters/m}^3\text{)}$$

MUD SPECIFIC GRAVITY REDUCTION WITH OIL ($d = 0.85$)
Oil volume in liters to add to 1 m³ of mud (M)

Initial mud specific gravity d_1	Desired mud specific gravity d_2																								
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25
1.10	250																								
1.15	500	200																							
1.20	750	400	167																						
1.25	1000	600	333	143																					
1.30	1250	800	500	286	125																				
1.35	1500	1000	667	429	250	111																			
1.40	1750	1200	833	571	375	222	100																		
1.45	2000	1400	1000	714	500	333	200	91																	
1.50	2250	1600	1167	857	625	444	300	182	83																
1.55	2500	1800	1333	1000	750	556	400	273	167	77															
1.60	2750	2000	1500	1143	875	667	500	364	250	154	71														
1.65	3000	2200	1667	1286	1000	778	600	455	333	231	143	67													
1.70	3250	2400	1833	1429	1125	889	700	545	417	308	214	133	63												
1.75	3500	2600	2000	1571	1250	1000	800	636	500	385	286	200	125	59											
1.80	3750	2800	2167	1714	1375	1111	900	727	583	462	357	267	188	118	56										
1.85	4000	3000	2333	1857	1500	1222	1000	818	667	538	429	333	250	176	111	53									
1.90	4250	3200	2500	2000	1625	1333	1100	909	750	615	500	400	313	235	167	105	50								
1.95	4500	3400	2667	2143	1750	1444	1200	1000	833	692	571	467	375	294	222	158	100	48							
2.00	4750	3600	2833	2286	1875	1556	1300	1091	917	769	643	533	438	353	278	211	150	95	45						
2.05	5000	3800	3000	2429	2000	1667	1400	1182	1000	846	714	600	500	412	333	263	200	143	91	43					
2.10	5250	4000	3167	2571	2125	1778	1500	1273	1083	923	786	667	563	471	389	316	250	190	136	87	42				
2.15	5500	4200	3333	2714	2250	1889	1600	1364	1167	1000	857	733	625	529	444	368	300	238	182	130	83	40			
2.20	5750	4400	3500	2857	2375	2000	1700	1455	1250	1077	929	800	688	588	500	421	350	286	227	174	125	80	38		
2.25	6000	4600	3667	3000	2500	2111	1800	1545	1333	1154	1000	867	750	647	556	474	400	333	273	217	167	120	77	37	
2.30	6250	4800	3833	3143	2625	2222	1900	1636	1417	1231	1071	933	813	706	611	526	450	381	318	261	208	160	115	74	36

l × 0.264 = gal m³ × 6.29 = bbl l/m³ × 0.042 = gal/bbl

$$M = 1\,000 \frac{(d_1 - d_2)}{(d_2 - 0.85)} \quad \text{(liters/m}^3\text{)}$$

FINAL VOLUME V_F (IN LITERS) AFTER ADDING WEIGHTING MATERIAL OF SPECIFIC GRAVITY d_a TO 1 m³ OF MUD

M_a weight of weighting material added (kg/m³)

d_a M_a	2.75	2.70	2.65	2.60	2.55	2.50
50	1018	1019	**1019**	1019	1020	1020
100	1036	1037	**1038**	1038	1039	1040
150	1055	1056	**1057**	1058	1059	1060
200	1073	1074	**1075**	1077	1078	1080
250	1091	1093	**1094**	1096	1098	1100
300	1109	1111	**1113**	1115	1118	1120
350	1127	1130	**1132**	1135	1137	1140
400	1145	1148	**1151**	1154	1157	1160
450	1164	1167	**1170**	1173	1176	1180
500	1182	1185	**1189**	1192	1196	1200
550	1200	1204	**1208**	1212	1216	1220
600	1218	1222	**1226**	1231	1235	1240
650	1236	1241	**1245**	1250	1255	1260
700	1255	1259	**1264**	1269	1275	1280
750	1273	1278	**1283**	1288	1294	1300
800	1291	1296	**1302**	1308	1314	1320
850	1309	1315	**1321**	1327	1333	1340
900	1327	1333	**1340**	1346	1353	1360
950	1345	1352	**1358**	1365	1373	1380
1000	1364	1370	**1377**	1385	1392	1400
1050	1382	1389	**1396**	1404	1412	1420
1100	1400	1407	**1415**	1423	1431	1440
1150	1418	1426	**1434**	1442	1451	1460
1200	1436	1444	**1453**	1462	1471	1480
1250	1455	1463	1472	1481	1490	1500
1300	1473	1481	**1491**	1500	1510	1520
1350	1491	1500	**1509**	1519	1529	1540
1400	1509	1519	**1528**	1538	1549	1560
1450	1527	1537	**1547**	1558	1569	1580
1500	1545	1556	**1566**	1577	1588	1600
1550	1564	1574	**1585**	1596	1608	1620
1600	1582	1593	**1604**	1615	1627	1640
1650	1600	1611	**1623**	1635	1647	1660
1700	1618	1630	**1642**	1654	1667	1680
1750	1636	1648	**1660**	1673	1686	1700
1800	1655	1667	**1679**	1692	1706	1720
1850	1673	1685	**1698**	1712	1725	1740
1900	1691	1704	**1717**	1731	1745	1760
1950	1709	1722	**1736**	1750	1765	1790
2000	1727	1741	**1755**	1769	1784	1800

d_a M_a	4.40	4.35	4.30	4.25	4.20	4.15
50	1011	1011	1012	1012	**1012**	1012
100	1023	1023	1023	1024	**1024**	1024
150	1034	1034	1035	1035	**1036**	1036
200	1045	1046	1047	1047	**1048**	1048
250	1057	1057	1058	1059	**1060**	1060
300	1068	1069	1070	1071	**1071**	1072
350	1080	1080	1081	1082	**1083**	1084
400	1091	1092	1093	1094	**1095**	1096
450	1102	1103	1105	1106	**1107**	1108
500	1114	1115	1116	1118	**1119**	1120
550	1125	1126	1128	1129	**1131**	1133
600	1136	1138	1140	1141	**1143**	1145
650	1148	1149	1151	1153	**1155**	1157
700	1159	1161	1163	1165	**1167**	1169
750	1170	1172	1174	1176	**1179**	1181
800	1182	1184	1186	1188	**1190**	1193
850	1193	1195	1198	1200	**1202**	1205
900	1205	1207	1209	1212	**1214**	1217
950	1216	1218	1221	1224	**1226**	1229
1000	1227	1230	1233	1235	**1238**	1241
1050	1239	1241	1244	1247	**1250**	1253
1100	1250	1253	1256	1259	**1262**	1265
1150	1261	1264	1267	1271	**1274**	1277
1200	1273	1276	1279	1282	**1286**	1289
1250	1284	1287	1291	1294	**1298**	1301
1300	1295	1299	1302	1306	**1310**	1313
1350	1307	1310	1314	1318	**1321**	1325
1400	1318	1322	1326	1329	**1333**	1337
1450	1330	1333	1337	1341	**1345**	1349
1500	1341	1345	1349	1353	**1357**	1361
1550	1352	1356	1360	1365	**1369**	1373
1600	1364	1368	1372	1376	**1381**	1386
1650	1375	1379	1384	1388	**1393**	1398
1700	1386	1391	1395	1400	**1405**	1410
1750	1398	1402	1407	1412	**1417**	1422
1800	1409	1414	1419	1424	**1429**	1434
1850	1420	1425	1430	1435	**1440**	1446
1900	1432	1437	1442	1447	**1452**	1458
1950	1443	1448	1453	1459	**1464**	1470
2000	1455	1460	1465	1471	**1476**	1482

l × 0.00629 = bbl kg × 2.20 = lb

$$\boxed{V_F = V_I + \frac{M_a}{d_a}}$$

V_F = final volume (l)
V_I = initial volume = 1 000 l
M_a = weight of weighting material (kg)
d_a = specific gravity of weighting material

MUD VOLUME (IN LITERS) REQUIRED TO PREPARE 1 m^3 OF MUD WEIGHTED WITH BARITE ($d = 4.2$)

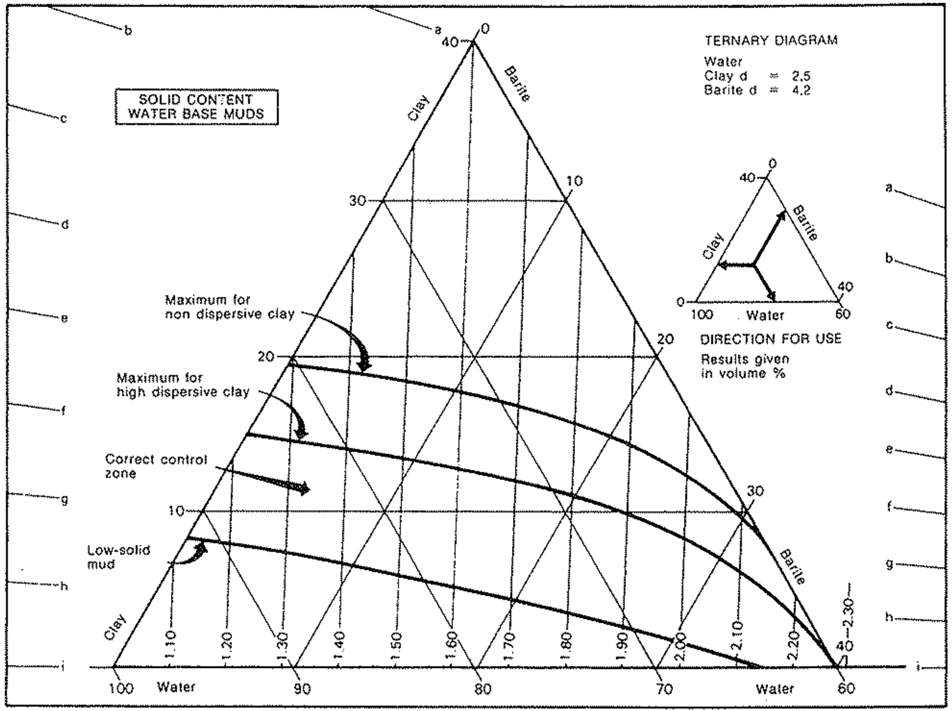
Initial mud specific gravity d_1	Desired mud specific gravity d_2																								
	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25
1.00	984	969	953	938	922	906	891	875	859	844	828	813	797	781	766	750	734	719	703	688	672	656	641	625	609
1.05		984	968	952	937	921	905	889	873	857	841	825	810	794	778	762	746	730	714	698	683	667	651	635	619
1.10			984	968	952	935	919	903	887	871	855	839	823	806	790	774	758	742	726	710	694	677	661	645	629
1.15				984	967	951	934	918	902	885	869	852	836	820	803	787	770	754	738	721	705	689	672	656	639
1.20					983	967	950	933	917	900	883	867	850	833	817	800	783	767	750	733	717	700	683	667	650
1.25						983	966	949	932	915	898	881	864	847	831	814	797	780	763	746	729	712	695	678	661
1.30							983	966	948	931	914	897	879	862	845	828	810	793	776	759	741	724	707	690	672
1.35								982	965	947	930	912	895	877	860	842	825	807	789	772	754	737	719	702	684
1.40									982	964	946	929	911	893	875	857	839	821	804	786	768	750	732	714	696
1.45										982	964	945	927	909	891	873	855	836	818	800	782	764	745	727	709
1.50											981	963	944	926	907	889	870	852	833	815	796	778	759	741	722
1.55												981	962	943	925	906	887	868	849	830	811	792	774	755	736
1.60													981	962	942	923	904	885	865	846	827	808	788	769	750
1.65														980	961	941	922	902	882	863	843	824	804	784	765
1.70															980	960	940	920	900	880	860	840	820	800	780
1.75																980	959	939	918	898	878	857	837	816	796
1.80																	979	958	938	917	896	875	854	633	813
1.85																		979	957	936	915	894	872	851	830
1.90																			978	957	935	913	891	970	848
1.95																				978	956	933	911	889	867
2.00																					977	955	932	909	886
2.05																						977	953	930	907
2.10																							976	952	929
2.15																								976	951
2.20																									975

l × 0.00629 = bbl

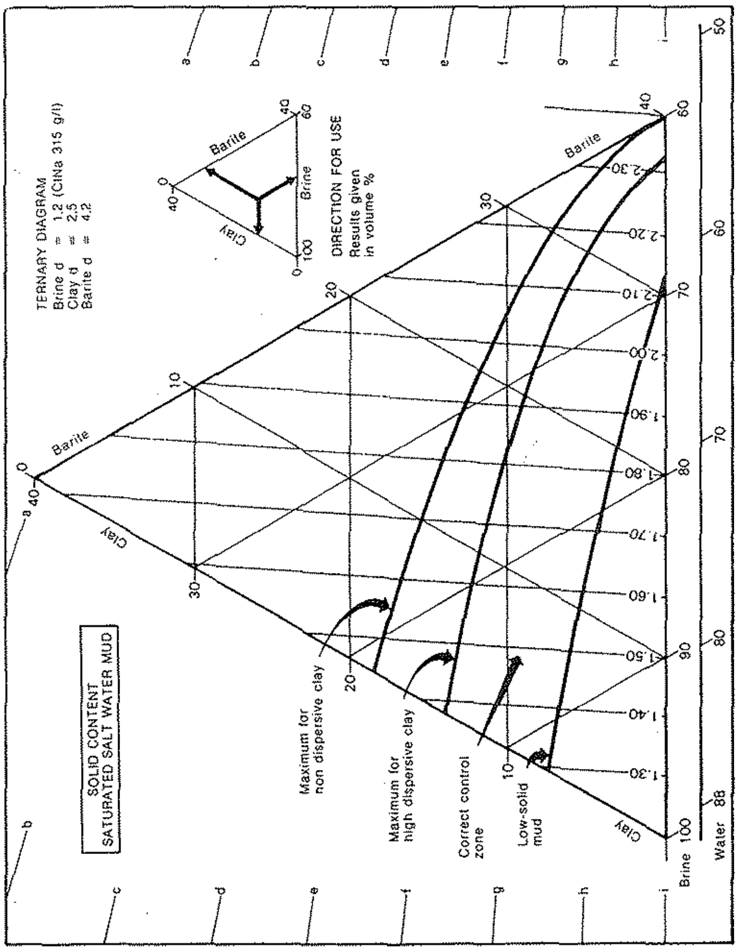
$$\boxed{V_I = V_F \frac{(4.2 - d_2)}{(4.2 - d_1)}}$$

V_I = initial volume of specific gravity d_1
V_F = final volume of mud d_2
here V_F = 1 000 l

TERNARY DIAGRAM FOR DETERMINING SOLID CONTENT OF MUD
(water base muds)



TERNARY DIAGRAM FOR DETERMINING SOLID CONTENT OF MUD
(saturated salt water mud)



PROPERTIES OF SODIUM CHLORIDE SOLUTIONS

Sp. Gr. at 15.6 °C	Solution weight at 15.6 °C (kg/m^3)	Materials to prepare 1 m^3 of solution		Freezing point (°C)	Approximate % NaCl
		Salt NaCl (kg)	Freshwater (m^3)		
1.007	1006.3	8.56	0.998	− 0.5	1
1.019	1018.3	25.68	0.993	− 1.7	3
1.031	1030.3	45.65	0.986	− 2.8	4
1.043	1042.3	62.77	0.981	− 3.3	6
1.055	1054.2	79.89	0.976	− 4.4	7
1.067	1066.2	99.86	0.969	− 5.6	9
1.079	1078.2	116.98	0.962	− 7.2	11
1.091	1090.2	134.10	0.952	− 8.3	12
1.103	1102.2	154.07	0.948	− 10.0	14
1.115	1114.1	174.04	0.940	− 11.7	15
1.127	1126.1	194.02	0.933	− 12.8	17
1.139	1138.1	211.14	0.926	− 14.4	18
1.151	1150.1	231.11	0.919	− 16.1	20
1.163	1162.1	251.08	0.909	− 18.3	21
1.175	1174.0	271.05	0.902	− 20.6	23
1.187	1186.0	291.03	0.895	− 15.0	24
1.199	1198.0	311.00	0.888	− 3.9	26

kg/m^3 × 0.00835 = lb/gal kg × 2.20 = lb m^3 × 6.29 = bbl

PROPERTIES OF CALCIUM CHLORIDE SOLUTIONS

Sp. Gr. at 15.6 °C	Solution weight at 15.6 °C (kg/m^3)	Material to prepare 1 m^3 of solution				Freezing point (°C)	Approximate % anhydrous $CaCl_2$
		With a high $CaCl_2$ content (94 to 97 %)		With a normal $CaCl_2$ content (77 to 80 %)			
		$CaCl_2$ (kg)	Freshwater (m^3)	$CaCl_2$ (kg)	Freshwater (m^3)		
1.007	1006.3	8.56	0.998	11.41	0.995	− 0.56	1
1.030	1030.3	37.09	0.993	45.65	0.983	− 2.2	3
1.055	1054.2	68.48	0.988	85.60	0.967	− 3.9	7
1.079	1078.2	99.86	0.979	122.69	0.950	− 6.1	9
1.103	1102.2	131.25	0.971	162.63	0.933	− 8.3	11
1.127	1126.1	165.48	0.962	205.43	0.914	− 11.1	14
1.151	1150.1	199.72	0.950	245.37	0.895	− 14.4	16
1.175	1174.0	231.11	0.943	285.32	0.879	− 17.8	19
1.199	1198.0	268.20	0.931	330.97	0.855	− 22.2	21
1.223	1222.0	302.44	0.919	373.77	0.833	− 27.8	23
1.247	1245.9	336.68	0.912	416.57	0.817	− 33.9	26
1.271	1269.9	370.91	0.900	456.51	0.795	− 41.7	28
1.295	1293.8	405.15	0.893	499.31	0.779	− 50.6	30
1.319	1317.8	439.39	0.879	542.11	0.755	− 30.0	32
1.343	1341.8	476.48	0.864	587.76	0.729	− 17.8	34
1.367	1365.7	513.57	0.855	633.41	0.709	− 2.78	36
1.391	1389.7	547.81	0.843	676.21	0.688	+ 6.67	38
1.415*	1413.6*	587.76	0.826	724.71	0.659	+ 15.6	40
1.439*	1437.6*	630.55	0.809	778.92	0.629	+ 21.1	42

* Calculated values, since at 15.6 °C, these are not liquids.

kg/m^3 × 0.00835 = lb/gal   kg × 2.20 = lb   m^3 × 6.29 = bbl

PROPERTIES OF POTASSIUM CHLORIDE SOLUTIONS

Sp. Gr. at 15.6 °C	Solution weight at 15.6 °C (kg/m^3)	Materials to prepare 1 m^3 of solution		Freezing point (°C)	Approximate % KCl
		KCL (kg)	Freshwater (m^3)		
1.005	1002.73	11.4	0.995	− 0.56	1
1.011	1009.91	20.0	0.990	− 1.1	2
1.024	1021.89	39.9	0.983	− 1.7	4
1.037	1035.07	62.8	0.974	− 2.8	6
1.050	1048.25	82.8	0.967	− 3.3	8
1.063	1061.43	105.6	0.957	− 4.4	10
1.077	1074.61	128.4	0.948	− 5.6	12
1.091	1088.98	154.1	0.938	− 6.7	14
1.104	1102.16	176.9	0.929	− 8.3	16
1.119	1116.54	202.6	0.917	− 9.4	18
1.133	1130.91	225.4	0.907	− 10.6	20
1.147	1134.19	251.1	0.895	+ 1.1	22
1.162	1160.86	279.6	0.883	+ 15.0	24

kg/m^3 × 0.00835 = lb/gal   kg × 2.20 = lb   m^3 × 6.29 = bbl

EFFECT OF TEMPERATURE ON DENSITIES OF CALCIUM CHLORIDE AND SODIUM CHLORIDE SOLUTIONS

(Field Data Handbook, Dowell Schlumberger)

As the temperature of the solution rises, the volume increases with a resulting decrease in density. The change in density of these solutions can be readily calculated by the formula :

$$\textbf{Density change} = \mathbf{0.647}\ (T_1 - T_2) \qquad (\mathrm{kg/m_3})$$

T_1 = initial temperature (°C)

T_2 = desired temperature (°C)

Example of application

For example, if the average well temperature is 80 °C, and an average solution density of 1 300 kg/m^3 is required at 15 °C.

$$\begin{aligned}\text{Density change (kg/m}^3) &= 0.647\ (80 - 15)\\ &= 42.06\ \text{kg/m}^3\end{aligned}$$

$$\begin{aligned}\text{Required solution density at } 15\ ^\circ\text{C} &= 1\,300 + 42.06\\ &= 1342.06\ \text{kg/m}^3 \text{ at } 15\ ^\circ\text{C}\end{aligned}$$

GRAIN SIZE CLASSIFICATION OF SOLIDS
(1μ = 0.000001 m)

Some examples of solid sizes:

	(μ)
Human hair	30 to 200
Pollen	10 to 100
Powdered cement	3 to 100
Flour	1 to 80
Talc	5 to 50
Make-up powder	35

French definition for classification of solids:

	(μ)
Coarse sand	> 200
Fine sand	20 to 200
Silt	10 to 20
Coarse clay	20 to 10
Fine clay	0.2 to 2
Colloidal clay	< 0.2

American definition in API 13C:

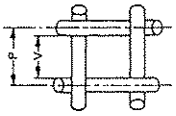
	(μ)
Coarse	> 2 000
Intermediate	2 000 to 250
Medium	250 to 74
Fine	74 to 44
Ultra fine	44 to 2
Colloidal	< 2

In drilling, another classification has been adopted:

	(μ)
Sand	> 74
Silt	2 to 74
Colloid	< 2

SHALE SHAKER SCREENS

Mesh/in	Wire diameter		Width of opening V		T	API Designation
	(in)	(10^{-3} mm)	(in)	(10^{-3} mm)	Approximate open area (%)	
8 × 8	0.028	711	0.097	2464	60.2	8 × 8 (2464 × 2464, 60.2)
10 × 10	0.025	635	0.075	1905	56.3	10 × 10 (1905 × 1905, 56.3)
12 × 12	0.023	584	0.060	1524	51.8	12 × 12 (1524 × 1524, 51.8)
14 × 14	0.020	508	0.051	1295	51.0	14 × 14 (1295 × 1295, 51.0)
16 × 16	0.018	457	0.0445	1130	50.7	16 × 16 (1130 × 1130, 50.7)
18 × 18	0.018	457	0.0376	955	45.8	18 × 18 (955 × 955, 45.8)
20 × 20	0.017	432	0.033	838	43.6	20 × 20 (838 × 838, 43.6)
8 × 20	0.032/0.020	813/508	0.093/0.030	2362/762	45.7	8 × 20 (2362 × 762, 45.7)
20 × 30	0.015	381	0.035/0.0183	889/465	39.5	20 × 30 (889 × 465, 39.5)
30 × 30	0.012	305	0.0213	541	40.8	30 × 30 (541 × 541, 40.8)
30 × 40	0.010	254	0.0233/0.015	592/381	42.5	30 × 40 (592 × 381, 42.5)
40 × 36	0.010	254	0.015/0.0178	381/452	40.5	40 × 36 (381 × 452, 40.5)
40 × 40	0.010	254	0.015	381	36.0	40 × 40 (381 × 381, 36.0)
50 × 40	0.0085	216	0.0115/ 0.0165	292/419	38.3	50 × 40 (292 × 419, 38.3)
50 × 50	0.009	229	0.011	279	30.3	50 × 50 (279 × 279, 30.3)
60 × 40	0.009	229	0.0077/0.016	200/406	31.1	60 × 40 (200 × 406, 31.1)
60 × 60	0.0075	191	0.0092	234	30.5	60 × 60 (234 × 234, 30.5)
70 × 30	0.0075	191	0.007/0.026	178/660	40.3	70 × 30 (178 × 660, 40.3)
80 × 80	0.0055	140	0.007	178	31.4	80 × 80 (178 × 178, 31.4)
100 × 100	0.0045	114	0.0055	140	30.3	100 × 100 (140 × 140, 30.3)
120 × 120	0.0037	94	0.0046	117	30.9	120 × 120 (117 × 117, 30.9)



For a square mesh

$$T\ (\%) = \frac{(\text{open area})^2}{(\text{pitch})^2} \times 100 = \frac{V^2}{P^2} \times 100$$

SCREEN STANDARDS

France		Germany	Great Britain		Italy	USSR		USA				
AFNOR Association Française de Normalisation		Deutsche Normen	British Standards Institution		Unificazione Italiano			The WS TYLER Cleveland 14 Ohio		American Society for Testing Materials		
NF X 11-501 1970		DIN 4 100 1957	BS-410 1943		UNI-2332 1943	COST-3584-53 1953		The TYLER Standard Screen Scale Sieves		ASTM E 11-61 1961		Wentworth and J. Boucard scale
Opening (mm)	Module	Opening (mm)	Opening (mm)	Designation (No)	Opening (mm)	Opening (mm)	Designation (No)	Opening (mm)	Designation (mesh)	Opening (mm)	Designation (No)	
								0.038	400+	0.037	400	Silt, loess 62.5 to 4 μ
0.040	17	0.04			0.04	0.040	004					
		0.045	0.044	350		0.045	0045	0.043	325	0.044	325	
0.050	18	0.05			0.05	0.050	005					
		0.056	0.053	300		0.056	0056	0.053	270	0.053	270+	
								0.061	250			
0.063	19	0.063	0.064	240	0.063	0.063	0063			0.063	230	
		0.071	0.076	200	0.075	0.071	0071	0.074	200 +	0.074	200+	Very fine sand 125 to 62.5 μ
0.080	20	0.08			0.08	0.080	008					
			0.089	170				0.088	170+	0.088	170	
		0.09			0.09	0.090	009					
0.100	21	0.1			0.1	0.100	01					
			0.104	150	0.106			0.104	150+	0.105	140+	
						0.112	0112					
0.125	22	0.125	0.124	120	0.125	0.125	0125	0.124	115	0.125	120	
						0.140	014					
			0.152	100	0.15			0.147	100+	0.149	100+	Fine sand 250 to 125 μ
0.160	23	0.16			0.16	0.160	016					
			0.178	85	0.18	0.180	018	0.175	80+	0.177	80	
0.200	24	0.2			0.2	0.200	02					
			0.211	72	0.212			0.208	65+	0.210	70	
						0.224	0224					
0.250	25	0.25	0.251	60	0.25	0.250	025	0.246	60	0.250	60+	
						0.280	028					
			0.295	52	0.3			0.295	48+	0.297	50+	Medium sand 0.5 to 0.25 mm
0.315	26	0.315			0.315							
			0.353	44	0.355	0.355	0355	0.351	42	0.354	45	
0.40	27	0.4			0.4	0.400	04					
			0.422	36	0.425	0.450	045	0.417	35+	0.420	40+	
0.50	28	0.5	0.500	30	0.5	0.500	05	0.495	32	0.500	35	
			0.599	25	0.6	0.560	056	0.589	28+	0.595	30+	Coarse sand 1 to 0.5 mm
0.63	29	0.63			0.63	0.630	063					
			0.699	22	0.71	0.700	07	0.701	24	0.707	25	
					0.75							
0.80	30	0.8			0.8	0.800	08					
			0.853	18	0.85			0.833	20+	0.841	20+	
						0.900	09	0.991	16			
1.00	31	1	1.003	16	1	1.00	1			1.00	18	
			1.204	14	1.18			1.168	14+	1.19	16	Very coarse sand 2 to 1 mm
1.25	32	1.25			1.25	1.25	1.25					
			1.405	12	1.4			1.397	12	1.41	14	
1.60	33	1.6			1.6	1.60	1.6					
			1.676	10	1.7			1.651	10+	1.68	12+	
2.00	34	2	2.057	8	2	2.00	2	1.981	9	2.00	10	
			2.411	7	2.36			2.362	8+	2.38	8	Granulated material 2 to 4 mm
2.50	35	2.5			2.5	2.50	2.5					
					2.8			2.794	7			
			2.812	6						2.83	7	
3.15	36	3.15			3.15							
			3.353	5	3.35			3.327	6+	3.36	6+	
4.00	37	4			4			3.962	5	4.00	5	
								4.699	4+	4.76	4	
5.00	38	5										
								5.613	312	5.66	312	

mm × 0.0394 = in

AIR/GAS FLOW RATE REQUIRED FOR DRILLING

Data for calculating approximate circulation rates required to produce a minimum annular velocity which is equivalent in lifting power to a standard air velocity of 914 m/min (3000 ft/h)

$$\boxed{Q = Q_0 + (NH)}$$

Q = flow rate required (m^3/min)
Q_0 = initial flow rate (m^3/min) (tables)
N = (tables)
H = depth (100 m) (330 ft)

Hole size		Drill pipe size		Air					Gas d = 0.60				
					Values of N					Values of N			
					Rate of penetration (m/h)					Rate of penetration (m/h)			
(in)	(mm)	(in)	(mm)		0	10	20	30		0	10	20	30
17 1/2	445	6 5/8	168	**119.18**	0.764	1.250	1.719	2.160	**153.87**	0.616	1.243	1.821	2.357
		5 1/2	140	**125.38**	0.741	1.216	1.667	2.085	**161.86**	0.574	1.158	1.711	2.263
		4 1/2	114	**129.92**	0.725	1.184	1.614	2.020	**167.75**	0.539	1.096	1.619	2.124
15	381	6 5/8	168	**82.26**	0.666	1.074	1.470	1.833	**106.22**	0.596	1.142	1.635	2.098
		5 1/2	140	**91.01**	0.638	1.027	1.389	1.742	**114.20**	0.544	1.043	1.507	1.938
		4 1/2	114	**93.02**	0.613	0.989	1.335	1.669	**120.09**	0.502	0.983	1.411	1.829
12 1/4	311	6 5/8	168	**48.14**	0.579	0.940	1.258	1.559	**62.13**	0.585	1.082	1.509	1.910
		5 1/2	140	**54.31**	0.538	0.861	1.151	1.423	**70.14**	0.523	0.942	1.332	1.682
		4 1/2	114	**58.87**	0.514	0.801	1.074	1.321	**76.08**	0.472	0.853	1.207	1.540
11	279	6 5/8	168	**35.03**	0.563	0.906	1.201	1.467	**45.22**	0.599	1.075	1.472	1.837
		5 1/2	140	**41.23**	0.509	0.803	1.066	1.312	**53.24**	0.516	0.940	1.268	1.594
		4 1/2	114	**45.76**	0.470	0.737	0.977	1.208	**59.10**	0.465	0.814	1.126	1.431
9 7/8	251	5 1/2	140	**30.55**	0.492	0.769	1.007	1.229	**39.45**	0.524	0.912	1.239	1.530
		5	127	**32.93**	0.467	0.723	0.952	1.164	**42.53**	0.486	0.846	1.156	1.434
		4 1/2	114	**35.11**	0.444	0.685	0.902	1.105	**45.31**	0.453	0.785	1.074	1.346
9	229	5	127	**25.43**	0.456	0.697	0.911	1.096	**32.85**	0.492	0.836	1.119	1.372
		4 1/2	114	**27.61**	0.428	0.653	0.853	1.042	**35.62**	0.455	0.769	1.047	1.281
		3 1/2	89	**31.23**	0.386	0.582	0.764	0.926	**40.32**	0.390	0.666	0.907	1.118
8 3/4	222	5	127	**23.43**	0.455	0.696	0.897	1.084	**30.24**	0.497	0.835	1.113	1.360
		4 1/2	114	**25.57**	0.427	0.650	0.843	1.018	**33.02**	0.456	0.768	1.062	1.266
		3 1/2	89	**29.22**	0.379	0.572	0.746	0.905	**37.72**	0.388	0.658	0.893	1.112
7 7/8	200	4 1/2	114	**18.97**	0.415	0.620	0.795	0.952	**24.49**	0.465	0.756	1.004	1.211
		3 1/2	89	**22.60**	0.364	0.540	0.700	0.842	**29.19**	0.386	0.636	0.850	1.039
7 3/8	187	3 1/2	89	**19.14**	0.358	0.524	0.669	0.802	**24.72**	0.386	0.624	0.827	1.014
6 3/4	171	3 1/2	89	**15.15**	0.347	0.503	0.634	0.753	**19.54**	0.386	0.611	0.794	0.962
6 1/4	159	3 1/2	89	**12.18**	0.344	0.488	0.613	0.721	**15.72**	0.390	0.602	0.742	0.917
		2 7/8	73	**13.99**	0.305	0.438	0.450	0.652	**18.07**	0.344	0.532	0.687	0.824
4.3/4	121	2 7/8	73	**6.46**	0.294	0.391	0.472	0.540	**8.38**	0.344	0.487	0.599	0.691
		2 3/8	60	**7.67**	0.258	0.352	0.427	0.493	**9.91**	0.300	0.432	0.538	0.628

m^3/min × 35.3 = cu.ft/min   m/h × 3.28 = ft/h

Example: $8^{3/4}$ in hole, 5 in drill pipes, depth 7900 ft

$$V_A = 10 \text{ m/h}$$

$$Q = 23.43 + 24 \times 0.696 = 40.13 \text{ m}^3\text{/min}$$

Source: R.R. Angel, Phillips Petroleum Co., AIME Paper 873 - G, *AIME Petroleum Transactions*, vol. 210, 1957.

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cementing

5

GENERAL DATA UNITS COMMONLY USED IN CEMENTING

Packaging

1 sack of cement (USA).	94 lb 42.64 kg
Cement volume in one sack of 94 lb	1 cu.ft 28.32 liters

(Hence a silo of x ft^3 contains x sacks)

Net weight of one 50 kg sack of cement (France)	49.5 kg 109 lb
Cement volume in one 50 kg sack.	32.89 liters 1.16 cu.ft

Weight

1 short ton	=	2 000 lb 907 kg 21.28 sacks of 94 lb 18.33 sacks of 50 kg
1 metric ton	=	2 205 lb 23.45 sacks of 94 lb 1.10 sh tn 0.984 long ton
1 long ton	=	2 240 lb 1 016 kg 23.83 sacks of 94 lb 20.53 sacks of 50 kg

Volume

1 cubic foot = 28.32 liters
1 US gallon = 3.785 liters
1 barrel = 0.159 m^3
1 barrel = 5.61 cu.ft

Density

1 kg/l = 8.345 lb/gal
1 kg/l = 62.428 lb/cu.ft
1 lb/gal = 0.1198 kg/l
1 lb/gal = 7.48 lb/cu.ft
1 lb/cu.ft = 0.01602 kg/l
1 lb/cu.ft = 0.1337 lb/gal

Cement specific gravity

True density of powdered cement 3.15
Apparent density of powdered cement. 1.5
True volume occupied by 1 kg of powdered cement (liters) 0.3175

CORRELATION BETWEEN SACKS AND TONS OF CEMENT

94 lb sacks

Sacks	Metric tonnes 2205 lb 1000 kg	Short tons 2000 lb 907 kg	Long tons 2240 lb 1016 kg
100	4.26	4.70	4.20
120	5.11	5.64	5.04
140	5.96	6.58	5.88
160	6.82	7.52	6.72
180	7.67	8.46	7.56
200	8.53	9.40	8.39
220	9.37	10.34	9.24
240	10.22	11.28	10.08
260	11.07	12.22	10.92
280	11.93	13.16	11.76
300	12.79	14.10	12.59
320	13.63	15.04	13.44
340	14.48	15.98	14.28
360	15.34	16.92	15.12
380	16.19	17.86	15.96
400	17.05	18.80	16.79
420	17.89	19.74	17.64
440	18.74	20.68	18.48
460	19.60	21.62	19.32
480	20.45	22.56	20.16
500	21.32	23.50	20.98
520	22.15	24.44	21.84
540	23.00	25.38	22.68
560	23.86	26.32	23.52
580	24.71	27.26	24.36
600	25.58	28.21	25.18
620	26.41	29.14	26.04
640	27.26	30.08	26.88
660	28.12	31.02	27.72
680	28.97	31.96	28.56
700	29.85	32.90	29.38
720	30.67	33.84	30.24
740	31.52	34.78	31.08
760	32.38	35.72	31.92
780	33.23	36.66	32.76
800	34.11	37.61	33.57
820	34.93	38.54	34.44
840	35.78	39.48	35.28
860	36.64	40.42	36.12
880	37.49	41.36	36.96
900	38.37	42.31	37.77
920	39.19	43.24	38.64
940	40.04	44.18	39.48
960	40.90	45.12	40.32
980	41.75	46.06	41.16

50 kg sacks

Sacks	Metric tonnes 2205 lb 1000 kg	Short tons 2000 lb 907 kg	Long tons 2240 lb 1016 kg
100	4.95	5.45	4.87
120	5.94	6.53	5.84
140	6.93	7.62	6.82
160	7.92	8.71	7.79
180	8.91	9.80	8.76
200	9.90	10.89	9.74
220	10.89	11.98	10.72
240	11.88	13.07	11.69
260	12.87	14.16	12.66
280	13.86	15.25	13.64
300	14.85	16.34	14.62
320	15.84	17.43	15.59
340	16.83	18.52	16.56
360	17.82	19.61	17.54
380	18.81	20.69	18.52
400	19.80	21.78	19.48
420	20.79	22.87	20.46
440	21.78	23.96	21.44
460	22.77	25.05	22.42
480	23.76	26.14	23.38
500	24.75	27.23	24.36
520	25.74	28.32	25.34
540	26.73	29.41	26.30
560	27.72	30.49	27.28
580	28.71	31.58	28.25
600	29.70	32.67	29.22
620	30.69	33.76	30.20
640	31.68	34.85	31.17
660	32.67	35.94	32.15
680	33.66	37.03	33.12
700	34.65	38.12	34.10
720	35.64	39.21	35.07
740	36.63	40.29	36.05
760	37.62	41.38	37.02
780	38.61	42.47	37.99
800	39.60	43.56	38.97
820	40.59	44.65	39.95
840	41.58	45.74	40.91
860	42.57	46.83	41.89
880	43.56	47.92	42.86
900	44.55	49.01	43.84
920	45.54	50.09	44.82
940	46.53	51.18	45.79
960	47.52	52.27	46.76
980	48.51	53.36	47.73

API CEMENT CLASSES AND TYPES

Class	Type
A	For use from surface to 1830 m (6000 ft) depth when special properties are not required. Ordinary type.
B	For use from surface to 1830 m (6000 ft) depth when conditions require moderate to high sulfate-resistance.
C	For use from surface to 1830 m (6000 ft) depth when conditions require high early strength. Available in low, moderate and high sulfate-resistant types.
D	For use from to 1830 m (6000 ft) to 3050 m (10,000 ft) depth under conditions of moderately high temperatures and pressures. Available in moderate and high sulfate-resistant types.
E	For use from 3050 m (10,000 ft) to 4270 m (14,000 ft) depth under conditions of high temperatures and pressures. Available in moderate and high sulfate-resistant types.
F	For use from 3050 m (10,000 ft) to 4880 m (16,000 ft) depth under conditions of extremely high temperatures and pressures. Available in moderate and high sulfate-resistant types.
G	For use from surface to 2440 m (8000 ft) depth as manufactured, or can be used with accelerators and retarders to cover a wide range of well depths and temperatures. Available in moderate and high sulfate-resistant types.
H	For use from surface to 2440 m (8000 ft) depth as manufactured, or can be used with accelerators and retarders to cover a wide range of well depths and temperatures. Available only in moderate sulfate-resistant type.
J	For use from 3660 to 4880 m (12,000 to 16,000 ft) depth under conditions of extremely high temperatures and pressures. Available only in sulfate-resistant type.

Note: For details concerning the chemical composition of the different classes of API cement, refer to API Spec 10.

API SPECIFICATIONS FOR CEMENTS
(API Spec 10)

Class	Maximum depth		Minimum thickening time (min) According to API 10 tests table 2.2	Compressive strength (kPa and psi) According to API Spec 10 tests Table 7.2						Mixing water				
	(m)	(ft)		Curing temperature and pressure		After 8 h curing time		After 24 h curing time		% by weight of cement	Per 42.5 kg (94 lb) sack		Per 50 kg (100 lb) sack	
				T (°C)	P (kPa)	(kPa)	(psi)	(kPa)	(psi)		(liters)	(gal)	(liters)	(gal)
A	0-1830	0-6000	à 305 m : 90 à 1830 m : 90	38	atm	1700	250	12400	1800	46	19.6	5.19	23	6.07
B	0-1830	0-6000	à 305 m : 90 à 1830 m : 90	38	atm	1400	200	10300	1500	46	19.6	5.19	23	6.07
C	0-1830	0-6000	à 305 m : 90 à 1830 m : 90	38	atm	2100	300	13800	2000	56	23.9	6.32	28	7.39
D	1830-3050	6000-10000	à 1830 m : 90 à 3050 m : 100	77 110	20700 20700	— 3500	— 500	6900 13800	1000 2000	38	16.2	4.29	19	5.02
E	3050-4270	10000-14000	à 3050 m : 100 à 4270 m : 154	77 143	20700 20700	— 3500	— 500	6900 13800	1000 2000	38	16.2	4.29	19	5.02
F	3050-4880	10000-16000	à 3050 m : 100 à 4880 m : 190	110 160	20700 20700	— 3500	— 500	6900 6900	1000 1000	38	16.2	4.29	19	5.02
G	0-2440	0-8000	à 2440 m : 90	38 60	atm atm	2100 10300	300 1500	— —	— —	44	18.8	4.97	22	5.81
H	0-2440	0-8000	à 2440 m : 90	38 60	atm atm	2100 10300	300 1500	— —	— —	38	16.2	4.29	19	5.02
J	3660-4880	12000-16000	à 3050 m : 180 à 4880 m : 180	143 177	20700 20700	—	—	— 6900	— 1000	(1)	(1)	(1)	(1)	(1)

Remarks :

The addition of bentoninte to cement requires an increase in the amount of water. For testing purposes, 5.3% water should be added for each 1% of bentonite in all API cement classes. For example, for a Class A or B cement slurry containing 4% bentonite, the water/cement ratio must be raised from 46% to 67.2% (46 + 4 × 5,3 = 46 + 21,2 = 67,2).

The addition of barite to cement requires an increase in the amount of water by 0.2% for each 1% of barite added for all cement classes. For example, for 60% barite added, the water/cement ratio must be raised from 38% to 50% for a Class D, E, F or G cement.

(1) As recommended by the manufacturer.

PREPARATION OF FRESHWATER SLURRY

Rule of thumb:

$$\boxed{1\ \text{sack}\left\{\begin{array}{l}94\ \text{lb}\\ \\ 1\ \text{cu.ft}\end{array}\right. +\ 5\,\text{gal water}\ \Rightarrow\ \text{cement with}\ d = 1.90}$$

$$\text{Slurry density} = \frac{\text{Cement mass} + \text{Water mass}}{\text{Cement volume} + \text{Water volume}} = \frac{\text{Total mass}}{\text{Slurry volume}}$$

For 100 kg of cement:

Slurry specific gravity:

$$\boxed{d = \frac{100 + e}{\dfrac{100}{3.15} + e}}$$

Water volume (in liters):

$$\boxed{e = \frac{100\left(1 - \dfrac{d}{3.15}\right)}{d - 1}}$$

Class	% water e in l/100 kg in relation to cement	Sp.gr. obtained
A	46	1.88
B	46	1.88
C	56	1.78
D	38	1.98
E	38	1.98
F	38	1.98
G	44	1.90

Slurry yield (in liters):

$$v = \frac{100}{3.15} + e$$

$$\boxed{v = \frac{68.3}{d - 1}}$$

Example: 100 kg of cement + 44 liters water gives:

$$\text{slurry specific gravity} = \frac{100 + 44}{\dfrac{100}{3.15} + 44} = \frac{144}{31.8 + 44} = \frac{144}{75.85} = 1.90$$

and: slurry yield = 75.8 liters

CEMENT SLURRY (FRESHWATER)

	Slurry density			Freshwater volume							Slurry volume				
	(kg/l)	(lb/gal)	(lb/cu.ft)	(l/100 kg)	(gal/94 lb sack)	(cu.ft/94 lb sack)	(l/94 lb sack)	(l/sh tn)	(gal/ sh tn)	(cu.ft/ sh tn)	(l/100 kg)	(l/94 lb sack)	(cu.ft/ 94 lb sack)	(l/sh tn)	(cu.ft/ sh tn)
	1.74	14.5	108.6	60.5	6.82	0.91	25.8	549	145.1	19.37	92.2	39.3	1.39	837	29.55
	1.75	14.6	109.2	59.3	6.68	0.89	25.3	537	142.2	18.98	91.0	38.8	1.37	826	29.16
	1.76	14.7	109.9	58.1	6.55	0.88	24.8	527	139.3	18.60	89.8	38.3	1.35	815	28.77
	1.77	14.8	110.5	56.9	6.41	0.86	24.3	516	136.5	18.22	88.6	37.8	1.33	804	28.40
Class C	**1.78**	**14.9**	**111.1**	**55.8**	**6.29**	**0.84**	**23.8**	**506**	**133.8**	**17.86**	**87.5**	**37.3**	**1.32**	**794**	**28.03**
	1.79	14.9	111.7	54.7	6.16	0.82	23.3	496	131.1	17.51	86.4	36.8	1.30	784	27.68
	1.80	15.0	112.4	53.6	6.04	0.81	22.9	486	128.5	17.16	85.3	36.4	1.28	774	27.33
	1.81	15.1	113.0	52.5	5.92	0.79	22.4	476	126.0	16.82	84.3	35.9	1.27	764	27.00
	1.82	15.2	113.6	51.5	5.81	0.78	22.0	467	123.5	16.49	83.2	35.5	1.25	755	26.67
	1.83	15.3	114.2	50.5	5.69	0.76	21.5	458	121.1	16.17	82.2	35.1	1.24	746	26.35
	1.84	15.4	114.9	49.5	5.58	0.75	21.1	449	118.8	15.86	81.3	34.6	1.22	737	26.03
	1.85	15.4	115.5	48.6	5.47	0.73	20.7	440	116.5	15.55	80.3	34.2	1.21	728	25.73
	1.86	15.5	116.1	47.6	5.37	0.72	20.3	432	114.3	15.25	79.4	33.8	1.20	720	25.43
	1.87	15.6	116.7	46.7	5.27	0.70	19.9	424	112.1	14.96	78.5	33.5	1.18	712	25.13
Class A,B	**1.88**	**15.7**	**117.4**	**45.8**	**5.17**	**0.69**	**19.6**	**416**	**109.9**	**14.67**	**77.6**	**33.1**	**1.17**	**704**	**24.85**
	1.89	15.8	118.0	44.9	5.07	0.68	19.2	408	107.8	14.40	76.7	32.7	1.15	696	24.57
Class G	**1.90**	**15.9**	**118.6**	**44.1**	**4.97**	**0.66**	**18.8**	**400**	**105.8**	**14.12**	**75.8**	**32.3**	**1.14**	**688**	**24.30**
	1.91	15.9	119.2	43.3	4.88	0.65	18.5	392	103.8	13.86	75.0	32.0	1.13	680	24.03
	1.92	16.0	119.9	42.4	4.79	0.64	18.1	385	101.8	13.59	74.2	31.6	1.12	673	23.77
	1.93	16.1	120.5	41.6	4.70	0.63	17.8	378	99.9	13.34	73.4	31.3	1.11	666	23.51
	1.94	16.2	121.1	40.9	4.61	0.62	17.4	371	98.1	13.09	72.6	31.0	1.09	659	23.26
	1.95	16.3	121.7	40.1	4.52	0.60	17.1	364	96.2	12.84	71.8	30.6	1.08	652	23.02
	1.96	16.4	122.4	39.4	4.44	0.59	16.8	357	94.4	12.60	71.1	30.3	1.07	645	22.78
	1.97	16.4	123.0	38.6	4.35	0.58	16.5	350	92.7	12.37	70.4	30.0	1.06	638	22.54
Class D,E,F	**1.98**	**16.5**	**123.6**	**37.9**	**4.27**	**0.57**	**16.2**	**344**	**90.9**	**12.14**	**69.6**	**29.7**	**1.05**	**632**	**22.31**
	1.99	16.6	124.2	37.2	4.19	0.56	15.9	337	89.3	11.91	68.9	29.4	1.04	625	22.09
	2.00	16.7	124.9	36.5	4.12	0.55	15.6	331	87.6	11.69	68.3	29.1	1.03	619	21.87
	2.02	16.9	126.1	35.2	3.97	0.53	15.0	319	84.4	11.26	66.9	28.5	1.01	607	21.44
	2.04	17.0	127.4	33.9	3.82	0.51	14.5	307	81.3	10.85	65.6	28.0	0.99	595	21.03
	2.06	17.2	128.6	32.6	3.68	0.49	13.9	296	78.3	10.46	64.4	27.5	0.97	584	20.63
	2.08	17.4	129.9	31.5	3.55	0.47	13.4	285	75.5	10.07	63.2	26.9	0.95	573	20.25
	2.10	17.5	131.1	30.3	3.42	0.46	12.9	275	72.7	9.71	62.0	26.5	0.93	563	19.88

Note : When using the same volume of sea-water instead of freshwater, the slurry specific gravity is increased by 0.01 on the average.

Example : a sea-water cement slurry with a water/cement ratio of 45 l/100 kg has a slurry density of 1.90 kg/l instead of 1.89 kg/l as shown in the table for freshwater.

PREPARATION OF ONE CUBIC METER OF FRESHWATER CEMENT SLURRY

	Slurry sp. gravity	Cement weight		Water volume (liters)
		(kg)	(94 lb sacks)	
	1.75	1099	25.8	651
	1.76	1113	26.1	647
	1.77	1128	26.5	642
Class C	**1.78**	**1143**	**26.8**	**637**
	1.79	1157	27.1	633
	1.80	1172	27.5	628
	1.81	1187	27.8	623
	1.82	1201	28.2	619
	1.83	1216	28.5	614
	1.84	1231	28.9	609
	1.85	1245	29.2	605
	1.86	1260	29.6	600
	1.87	1275	29.9	595
Class A, B	**1.88**	**1289**	**30.2**	**591**
	1.89	1304	30.6	586
Class G	**1.90**	**1319**	**30.9**	**581**
	1.91	1333	31.3	577
	1.92	1348	31.6	572
	1.93	1363	32.0	567
	1.94	1377	32.3	563
	1.95	1392	32.6	558
	1.96	1407	33.0	553
	1.97	1421	33.3	549
Class D, E, F	**1.98**	**1436**	**33.7**	**544**
	1.99	1450	34.0	540
	2.00	1465	34.4	535
	2.02	1494	35.0	526
	2.04	1524	35.7	516
	2.06	1553	36.4	507
	2.08	1582	37.1	498
	2.10	1612	37.8	488

$m^3 \times 264 = gal$ $m^3 \times 35.3 = cu.ft$ $l \times 0.264 = gal$ $l \times 0.0353 = cu.ft$

SATURATED SALT WATER SLURRY
(Brine 315 g/l. $d = 1.20$)

$$\text{Slurry density} = \frac{\text{Cement mass} + \text{brine mass}}{\text{Cement volume} + \text{brine volume}}$$

$$\text{Brine mass (kg)} = 1.20 \times \text{brine volume (liters)}$$

For 100 kg of cement:

Slurry specific gravity:

$$\boxed{d = \frac{100 + 1.2e}{\frac{100}{3.15} + e}}$$

where:

d = slurry specific gravity
e = brine volume in liters

Brine volume (in liters):

$$\boxed{e = \frac{100\left(1 - \frac{d}{3.15}\right)}{d - 1.20}}$$

Slurry yield (in liters):

$$\boxed{v = \frac{61.9}{d - 1.20}}$$

Example: 100 kg of cement + 46 liters of water gives:

$$\text{slurry specific gravity} = \frac{100 + 1.2 \times 46}{\frac{100}{3.15} + 46} = 2.00$$

and:

$$\text{slurry yield} = 77.4 \text{ liters}$$

CEMENT SLURRY (SATURATED SALT-WATER)
(Brine 315 g/l. *d* = 1.20)

Slurry density			Brine volume							Slurry volume				
(kg/l)	(lb/gal)	(lb/cu.ft)	(l/100 kg)	(gal/ 94 lb sack)	(cu.ft/ 94 lb sack)	(l/94 lb sack)	(l/sh tn)	(gal/ sh tn)	(cu.ft/ sh tn)	(l/ 100 kg)	(l/94 lb sack)	(cu.ft/ 94 lb sack)	(l/sh tn)	(cu.ft/ sh tn)
1.80	15.0	112.4	71.4	8.05	1.08	30.5	648	171.4	22.88	103.2	44.0	1.55	936	33.05
1.81	15.1	113.0	69.7	7.86	1.05	29.8	633	167.3	22.34	101.5	43.3	1.53	921	32.51
1.82	15.2	113.6	68.1	7.68	1.03	29.1	618	163.4	21.81	99.8	42.6	1.50	906	31.99
1.83	15.3	114.2	66.5	7.50	1.00	28.4	603	159.6	21.31	98.3	41.9	1.48	891	31.48
1.84	15.4	114.9	65.0	7.33	0.98	27.7	589	155.9	20.81	96.7	41.2	1.46	877	30.99
1.85	15.4	115.5	63.5	7.16	0.96	27.1	576	152.3	20.34	95.2	40.6	1.43	864	30.51
1.86	15.5	116.1	62.0	7.00	0.94	26.5	563	148.9	19.87	93.8	40.0	1.41	851	30.05
1.87	15.6	116.7	60.6	6.84	0.91	25.9	550	145.5	19.43	92.4	39.4	1.39	838	29.60
1.88	15.7	117.4	59.3	6.68	0.89	25.3	538	142.3	18.99	91.0	38.8	1.37	826	29.17
1.89	15.8	118.0	58.0	6.54	0.87	24.7	526	139.1	18.57	89.7	38.3	1.35	814	28.74
1.90	15.9	118.6	56.7	6.39	0.85	24.2	514	136.0	18.16	88.4	37.7	1.33	802	28.33
1.91	15.9	119.2	55.4	6.25	0.84	23.7	503	133.0	17.76	87.2	37.2	1.31	791	27.93
1.92	16.0	119.9	54.2	6.11	0.82	23.1	492	130.1	17.37	86.0	36.7	1.29	780	27.54
1.93	16.1	120.5	53.1	5.98	0.80	22.6	481	127.3	16.99	84.8	36.2	1.28	769	27.17
1.94	16.2	121.1	51.9	5.85	0.78	22.2	471	124.6	16.63	83.7	35.7	1.26	759	26.80
1.95	16.3	121.7	50.8	5.73	0.77	21.7	461	121.9	16.27	82.5	35.2	1.24	749	26.44
1.96	16.4	122.4	49.7	5.60	0.75	21.2	451	119.3	15.92	81.5	34.7	1.23	739	26.10
1.97	16.4	123.0	48.6	5.48	0.73	20.8	441	116.7	15.58	80.4	34.3	1.21	729	25.76
1.98	16.5	123.6	47.6	5.37	0.72	20.3	432	114.3	15.25	79.4	33.8	1.20	720	25.43
1.99	16.6	124.2	46.6	5.26	0.70	19.9	423	111.8	14.93	78.4	33.4	1.18	711	25.10
2.00	16.7	124.9	45.6	5.14	0.69	19.5	414	109.5	14.62	77.4	33.0	1.17	702	24.79
2.02	16.9	126.1	43.7	4.93	0.66	18.7	397	105.0	14.01	75.5	32.2	1.14	685	24.19
2.04	17.0	127.4	42.0	4.73	0.63	17.9	380	100.7	13.44	73.7	31.4	1.11	669	23.61
2.06	17.2	128.6	40.2	4.54	0.61	17.2	365	96.5	12.89	72.0	30.7	1.08	653	23.06
2.08	17.4	129.9	38.6	4.35	0.58	16.5	350	92.6	12.36	70.3	30.0	1.06	638	22.54
2.10	17.5	131.1	37.0	4.18	0.56	15.8	336	88.9	11.86	68.8	29.3	1.04	624	22.04
2.12	17.7	132.3	35.5	4.01	0.54	15.2	322	85.3	11.38	67.3	28.7	1.01	610	21.56
2.14	17.9	133.6	34.1	3.85	0.51	14.6	309	81.8	10.93	65.9	28.1	0.99	597	21.10
2.16	18.0	134.8	32.7	3.69	0.49	14.0	297	78.6	10.49	64.5	27.5	0.97	585	20.66

PREPARATION OF ONE CUBIC METER OF SATURATED SALT-WATER SLURRY

Slurry sp. gravity	Cement weight		Water volume. (liters)
	(kg)	(94 lb sacks)	
1.75	889	20.8	718
1.76	905	21.2	713
1.77	921	21.6	708
1.78	937	22.0	703
1.79	953	22.4	697
1.80	969	22.7	692
1.81	985	23.1	687
1.82	1002	23.5	682
1.83	1018	23.9	677
1.84	1034	24.2	672
1.85	1050	24.6	667
1.86	1066	25.0	662
1.87	1082	25.4	656
1.88	1099	25.8	651
1.89	1115	26.1	646
1.90	1131	26.5	641
1.91	1147	26.9	636
1.92	1163	27.3	631
1.93	1179	27.7	626
1.94	1195	28.0	621
1.95	1212	28.4	615
1.96	1228	28.8	610
1.97	1244	29.2	605
1.98	1260	29.6	600
1.99	1276	29.9	595
2.00	1292	30.3	590
2.02	1325	31.1	580
2.04	1357	31.8	569
2.06	1389	32.6	559
2.08	1422	33.3	549
2.10	1454	34.1	539
2.12	1486	34.9	528
2.14	1519	35.6	518
2.16	1551	36.4	508

m^3 × 264 = gal m^3 × 35.3 = cu.ft l × 0.264 = gal l × 0.0353 = cu.ft

BENTONITE CEMENTS

To prepare a lightweight cement with freshwater, bentonite (1) can be added:

(a) **Dry** to the cement in proportions ranging between 1 and 20% to obtain slurry specific gravities between 1.85 and 1.42 (for Class G).

(b) Or **prehydrated** in proportions ranging between 0.25 and 5% to obtain slurry specific gravities between 1.84 and 1.39 (also for Class G).

$$\text{Slurry density} = \frac{\text{Cement mass} + \text{water mass} + \text{bentonite mass}}{\text{Cement volume} + \text{water volume} + \text{bentonite volume}}$$

For 100 kg of cement:

Slurry specific gravity:

$$\boxed{d = \frac{100 + e + (Z + 1)\ b}{\frac{100}{3.15} + e + (Z + \frac{1}{2.65})\ b}}$$

where:

d = bentonite slurry specific gravity

b = percentage of bentonite in relation to cement (or weight of bentonite per 100 kg cement)

In general $0 < b < 20$ **if dry mixture**

$0 < b < 5$ **if prehydrated mixture**

e = volume of cement hydratation water in relation to cement

Class	% water : e (l/100 kg) in relation to cement
A	46
B	46
C	56
D	38
E	38
F	38
G	44

Z = percentage of bentonite swelling water in relation to bentonite (or liters of water per kg of bentonite)

Z = 5.3 for bentonite added dry

Z = 21.2 for prehydratation bentonite

The specific gravity of bentonite is taken as 2.65.

---

(1) Attapulgite (d = 2.89) is used with sea-water.

BENTONITE CEMENTS (continued)

Bentonite weight (in kg) :

$$\boxed{b = \frac{100\left(1 - \frac{d}{3.15}\right) - (d - 1)\,e}{d\left(\frac{1}{2.65} + Z\right) - (Z + 1)}}$$

Water volume (in liters) :

$$\boxed{E = e + Zb}$$

Slurry volume (in liters) :

$$\boxed{v = \frac{100}{3.15} + \frac{b}{2.65} + e + Zb}$$

Example: to prepare a slurry with prehydrated bentonite and class G cement, with *specific gravity* $d = 1.50$:

$d = 1.50$
$e = 44$
$Z = 21.2$

the calculation (or table I 13) gives $b = 3\%$.

For 100 kg of cement :

3 kg of bentonite
107.6 liters of water
140.5 liters of slurry.

BENTONITE CEMENT SLURRY
Class G (per 100 kg of cement)

PREHYDRATED MIXTURE

% *b* bentonite	% *E* water	Specific gravity
0.00	44.0	1.901
0.25	49.3	1.843
0.50	54.6	1.792
0.75	59.9	1.748
1.00	65.2	1.708
1.25	70.5	1.672
1.50	75.8	1.640
1.75	81.1	1.611
2.00	86.4	1.585
2.25	91.7	1.560
2.50	97.0	1.538
2.75	102.3	1.518
3.00	107.6	1.499
3.25	112.9	1.482
3.50	118.2	1.466
3.75	123.5	1.451
4.00	128.8	1.437

21.2 liters of water/kg bentonite

DRY MIXTURE

% *b* bentonite	% *E* water	Specific gravity
0	44.0	1.901
1	49.3	1.846
2	54.6	1.798
3	59.9	1.756
4	65.2	1.719
5	70.5	1.685
6	75.8	1.656
7	81.1	1.629
8 (1)	86.4	1.604
9	91.7	1.582
10	97.0	1.562
11	102.3	1.543
12	107.6	1.526
13	112.9	1.511
14	118.2	1.496
15	123.5	1.482
16	128.8	1.470
17	134.1	1.458
18	139.4	1.447
19	144.7	1.436
20	150.0	1.426

5.3 liters of water/kg bentonite

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(1) For 8 % and higher it is advisable to add a thinner.

PREPARATION OF ONE CUBIC METER OF BENTONITE CEMENT SLURRY – CLASS G CEMENT

PREHYDRATED MIXTURE

% bentonite	Cement (kg)	Bentonite (kg)	Water volume (liters)	Specific gravity
0.00	1320	0.00	581	1.901
0.25	1232	3.08	608	1.843
0.50	1156	5.78	631	1.792
0.75	1088	8.16	652	1.748
1.00	1028	10.28	670	1.708
1.25	974	12.17	686	1.672
1.50	925	13.87	701	1.640
1.75	881	15.42	714	1.611
2.00	841	16.82	727	1.585
2.25	805	18.10	738	1.560
2.50	771	19.28	748	1.538
2.75	740	20.36	757	1.518
3.00	712	21.36	766	1.499
3.25	686	22.28	774	1.482
3.50	661	23.14	781	1.466
3.75	638	23.94	788	1.451
4.00	617	24.68	795	1.437

DRY MIXTURE

% bentonite	Cement (kg)	Bentonite (kg)	Water volume (liters)	Specific gravity
0	1320	0.00	581	1.901
1	1228	12.28	605	1.846
2	1148	22.96	627	1.798
3	1078	32.34	646	1.756
4	1016	40.63	662	1.719
5	960	48.02	677	1.685
6	911	54.64	690	1.656
7	866	60.61	702	1.629
8	825	66.03	713	1.604
9	788	70.95	723	1.582
10	755	75.46	732	1.562
11	724	79.60	740	1.543
12	695	83.41	748	1.526
13	669	86.93	755	1.511
14	644	90.19	761	1.496
15	621	93.22	768	1.482
16	600	96.05	773	1.470
17	581	98.69	778	1.458
18	562	101.16	783	1.447
19	545	103.48	788	1.436
20	528	105.66	792	1.426

kg × 0.0235 = sack   l × 0.264 = gal   l × 0.0353 = cu.ft

WEIGHTED CEMENTS

For 100 kg of cement:

- Slurry specific gravity:

$$\boxed{d = \frac{100 + e + a}{\frac{100}{3.15} + e + \frac{a}{d_a}}}$$

where:

e = water volume (in liters)
a = weight of heavy weight additive (in kg)
d_a = heavy weight additive specific gravity

- Specific gravity of some heavy weight additives:

Barite = 4.20
Fer-o-bar = 4.85
Ilmenite = 4.65
Hematite = 4.95

- Specific gravity obtained:

Specific gravity	2.10	2.20	2.30	2.40	2.50	2.60	2.70
Fer-o-bar (%) .	55	75	95	115	145	175	195
Water (%)	60	60	60	60	60	60	60
Thinner (%) . . .				1	1	1.4	1.4
Barite (%)	40	87	110				
Water (%)	45	60	60				
Thinner (%) . . .			1				
Ilmenite (%) . . .		30	55				
Water (%)		42-44	42-44				
Hematite (%) . .		40	60	80	110	150	175
Water (%)		45	47	48	51	55	58
Thinner (%) . . .				0.3	0.5	0.8	1

Thinners: D65 (*Dowell*) — CFR2 (*Halliburton*) or similar.

Example: for 100 kg of cement:
87 kg of barite
60 liters of water

$$d = \frac{100 + 60 + 87}{\frac{100}{3.15} + 60 + \frac{87}{4.20}}$$

$$d = 2.20$$

CEMENTING ADDITIVES (1)

Application	Description	Halliburton	Dowell	B.J.	Western	Magcobar
Accelerators	Calcium chloride	$CaCl_2$	S-1	A-7	$CaCl_2$	$CaCl_2$
	Accelerator liquid	$CaCl_2$	D-77	A-7L	—	MCA-L
	Accelerator blend	HA-5	D-43	A-8	WA-4	MA-2
	Sodium silicate	Diacel A	D-57	Diacel A	Diacel A	Diacel A
	Sodium chloride 1-6%	Salt	D-44	A-5	Salt	Salt
Light weight (Extenders)	API cementing grade bentonite	Halliburton Gel	Bentonite	BJ Gel	Bentonite	M-Gel
	Light weight lost circulation	Gilsonite	D-24, D-92	D-7	Gilsonite	Gilsonite
	Chemical silicate	Econolite	D-79	A-2	Thrifty-Lite	Thrifty Mix
	Liquid chemical silicate	Econolite-L	D-75	A-3L	—	Thrifty Mix-L
	Artificial pozzolans (Fly Ash)	Pozmix A	Litepoz 3	Diamix F	Pozment A	Magco Poz A
	Pozzolan - lime mixtures	Pozmix 140	Litepoz 180	Thermoset	—	Magco Poz 180
	Class H-Poz Blends	Halliburton Light	Litepoz 300	—	Thriftyment	Econoblend
Retarders	Retarder - Dispersant	HR-7	—	Kembreak	WR-1	MLR-1
	Retarder - Low temperature	HR-4, HR-5	D-13	R-5	WR-2	MLR-3
	Retarder - High temperature	HR-12	D-28	R-11	WR-6	MHR-8
	Retarder - High temperature	HR-15		M-6	WR-7	MHR-9
	Diacel LWL - CMHEC	Diacel LWL	D-8	R-6	Diacel LWL	MFLR-7
	Temperature - High temperature	HR-20	D-99	—	—	MHR-600
	Liquid retarder - Low temperature	HR-6L	D-81	R-14L	WR-L1, WR2L	MLR-L
	Liquid retarder - High temperature	HR-13L	D-109	R-14L	WR6L	MHR-L
Fluid loss Additive	Fluid loss control additive	HALAD® - 9	D-59, D-112	D-19	CF-1	MFL-4
	Fluid loss control additive and dispersant	HALAD® - 14	D-60	D-22	CF-2	MFL-5
	Fluid loss control additive and dispersant	HALAD® - 22A	—	—	CF-6	—
	Diacel LWL CMHEC	Diacel LWL	D-8	R-6	Diacel LWL	MFLR-7
	Fluid loss additive liquid	CFR-2	D-73, D-108	—	—	MFL-L
Cement dispersant (Friction-turbulence inducer)	Cement dispersant	CFR-2	TIC I D-65	D-31	TF-4	MCD-3
	Cement dispersant	CFR-1	TIC II D-45	—	TF-5	MCD-4
	Liquid cement dispersant	CFR-2 HR-L	D-80	D-31-L	TF4L	MCD-L
Lost circulation additives	Granular nat. hydrocarbon	Gilsonite	D-24	D-7	Gilsonite	Gilsonite
	Cellophane flakes	Flocele	D-29	Cello-Flake	Cell-O-Seal	Cell-O-Seal
	Graded particle sizes	—	Kwik-Seal	Kwik-Seal	Kwik-Seal	Kwik-Seal
	Ground walnut shells	Walnut Shells	Tuf-plug	Tuf-plug	Tuf-plug	Nut Plug
	Ground coal	—	D-42	—	—	—
Heavy weight additives	Barite	Barite	D-31	W-1	Barite	Magcobar
	Hematite	Hi-Dense 3	D-76	W-5	WM-2	MW-2
	Ilmenite	—	D-18	W-3	Ilménite	MW-1
Special additives	Antifoam agent-liquid	NF-1	—	—	—	—
	Antifoam agent powdered	NF-P	D-46	D-6	AF-8	MFP-5
	Antifoam agent powdered	D-Air 1	—	—	—	—
	Antifoam agent liquid	D-Air 2	D-47	D-21	AF-L	MFP-L

(1) From *IADC Drilling Manual*, 10th Edition.

CEMENTING ADDITIVES (continued)

Application	Description	Halliburton	Dowell	B.J.	Western	Magcobar
Thixotropic Cement	Thixotropic cement	Thix-Set Thixotropic Thixomix	— Reg. Fill-up —	— Thixotropic —	— Thixoment —	— Thixocem —
Silica	Fine	SSA-1 Silica Flour	D-66	D-8	SF-3	MS-1
	Coarse	SSA-2 Oklahoma No. 1 Dry	D-30	D-8C	SF-4	MS-2
Mud decontaminant	Mud Kil® II	Mud-Kil-II	K-21	Firm Set II	Shur Set II	Hard Set II
Spacers & washes	Mud thinner & dispersant	MCA MSA MUD-FLUSH	— — CW-7, CW-100	— — MUD-CLEAN	— — WMW-1	— — MMW-1
	Water base mud spacer	SAM-4,5	Spacer 1000	Mud-Sweep UNIMUL	APS-1, APS-2	MCS-2
	Oil based mud spacer	SAM-4,5	Oil Base Spacer 1001	Oil Base Mud Sweep, UNIMUL	APS-1, APS-2	MCS-3
		CS-2	—	—	—	—
Fibers	Fibers blended in cement	*Tuf No.1* Tuf No. 2	— —	— —	— —	— —
Special cements	50-50 Pozzolan cement blend Pozzolan lime blend Refractory cement	Pozmix® Cement Pozmix® 140 Lumnite Cement Fondu	Litepoz 3 Litepoz 180 Same Same	Thermoset Same Same	— — —	— — —
	Pozzolan-lime-cement- Diesel oil cement Pozzolan-cement-gel	HTLD DOC Halliburton Light Cement	— SOS Litepoz 300	— Visqueez —	— LHC Thriftyment	— — Econoblend
	Gypsum cements	Cal-Seal Hydromite	D-53 —	GYPSEAL —	— —	— —
	Expanding cements	Halliburton's Expanding Cement	Self-Stress — —	— — —	— — —	— — —
	Cold weather cementing formulations	*Permafrost-* Cement	Artic Set	Coldset	—	—

EFFECTS OF SOME ADDITIVES ON CEMENT PROPERTIES (1)

		Bentonite	Perlite	Diatomaceous earth	Pozzolan	Sand	Barite	Hematite	Calcium chloride	Sodium chloride	Lignosulfonate	CMHEC (2)	Diesel Oil	Water loss additive	Lost circulation material
Density	Decreased	●	●	●	●										
	Increased					●	●	●	x	x	x				
Water required	Decreased										●				
	Increased	●	x	●	x	x	x	x							x
Viscosity	Decreased								x		●				
	Increased	x	x	x	x	x	x	x							
Thickening time	Accelerated	x					x	x	●	●					
	Retarded			x						x	●	●	x	x	
Setting time	Accelerated						x	x	●	●					
	Retarded	x	x	x	x						●	●		x	
Early strength	Decreased	x	x	x	x		x	x			●	●		x	x
	Increased								●	●					
Final strength	Decreased	x	x	●	x		x					x		x	x
	Increased														
Duration	Decreased	x	x	x									x		x
	Increased				●										
Water loss	Decreased	●									x	●	x	●	x
	Increased		x	x											

(1) From *Dowell Schlumberger Engineer's Handbook.*
x Denotes minor effect.
● Denotes major effect and/or purpose of additive.
(2) Carboxymethyl hydroxyethyl cellulose.

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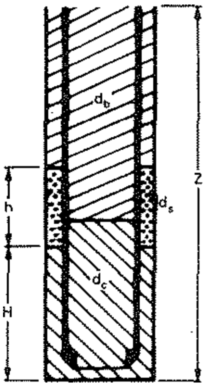
SLURRY DISPLACEMENT

Calculation of displacement volume corresponding to the time when the fluids in the annulus and the fluids in the casing reach hydrostatic equilibrium:



V_s = spacer volume at density d_s
V_c = cement volume at density d_c
V = displacement volume at density d_b at time of equilibrium
a = volume/m in casing
b = volume/m in annulus
h = spacer height in annulus in meters
H = cement height in annulus at equilibrium in meters
Z = casing setting depth in meters

$$h = \frac{V_s}{b} \tag{1}$$

$$H = \frac{V_c}{b + a} - \frac{a}{b\,(b + a)}\, V_s\, \frac{d_s - d_b}{d_c - d_b} \tag{2}$$

$$\boxed{V = \left(Z - \frac{V_c}{b + a} - \frac{V_s}{(b + a)}\, \frac{d_s - d_b}{d_c - d_b} \right) a} \tag{3}$$

SLURRY DISPLACEMENT
(continued)

Specific case without spacer:

$$\boxed{V = \left(Z - \frac{V_c}{b + a}\right) a} \qquad (4)$$

Cementing with two slurries: Formulas (1), (2) and (3) can be used for a cement gel instead of the spacer, provided that, at the time of equilibrium, the cement gel, like the spacer, is already in the annulus.

Calculation example:

$Z = 3000$ m

Hole size 12 1/4 inches

Casing 9 5/8 inches 47 lb/ft ($a = 38.18$ l/m)
($b = 28.94$ l/m)

Spacer volume	$V_s = 5\,000$ liters
Spacer specific gravity	$d_s = 1.50$
Cement volume	$V_c = 50\,000$ liters
Cement specific gravity	$d_c = 1.90$
Mud specific gravity	$d_b = 1.10$

$h = 173$ m

$H = 696$ m

$V = 85$ m^3

J directional drilling

REFERENCE COORDINATES

AZIMUTH

Azimuths measured in holes refer to one of the following:

(a) *Geographic North (meridian direction).*
(b) Magnetic North (compass direction).
(c) Lambert or UTM North (*y* axis of grid).

They are measured positively clockwise from:

(a) 0 to 360 degrees.
(b) *0 to 400 grades.*

The system of quadrants still used in certain measuring instruments refers, depending on the direction, to North or South, from 0 to 90 degrees to east or west.

Example: Azimuth 227 degrees is equivalent to S47W or 47SW.

DECLINATION

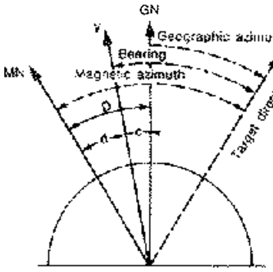
The declination is the angle between local magnetic North and geographic North (local meridian) measured positively eastward.

CONVERGENCE

Convergence is the angle between the local meridian and Lambert or UTM North (central meridian of the projection).

The values of declination related to the grid, and the values of convergence are normally indicated by a diagram on the right-hand margin of topographic maps.

REFERENCE COORDINATES (continued)



RELATIONSHIPS BETWEEN THE DIFFERENT ANGLES:

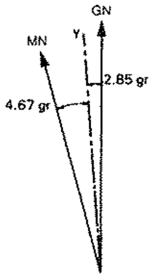
y = North of kilometric grid

D = Declination (varies according to location and time: ordinance maps provide details allowing their calculation)

d = Declination related to grid

c = Convergence angle of meridians (varies according to location)

Magnetic declination corresponds to the center of the sheet and to 1 January 1967



Magnetic declination decreases each year by 11 centesimal minutes

According to the diagram of this specific case, the declination *d* related to the grid in 1988 is:

$$d = 4.67 - 0.11 \times 21 = 2.36 \text{ gr}$$

If the magnetic azimuth (MA) of the target measured by a compass is 150 gr:

Lambert azimuth (LA) or bearing = 150 − 2.36 = 147.64 gr

Geographic azimuth = Lambert azimuth − convergence
= 147.64 − 2.85 = 144.79 gr

If the direction is marked using quadrants:

MA = 150 gr = S45E

and according to the diagram:

LA = MA + convergence
= S45E + 2.85 × 0.9 = S47.56E

RADIUS OF CURVATURE AND PROJECTION IN THE VERTICAL PLANE

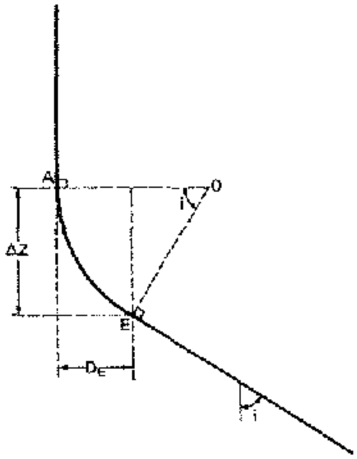
$AE = L$	length drilled from A to E
$R = \frac{360}{2\pi}\frac{\Delta L}{\Delta i}$	radius of curvature (m)
$gbu = \frac{\Delta i}{\Delta L}$	rate of buildup (°/10 m)

In general $\frac{\Delta i}{\Delta L}$ is kept as constant as possible during kickoff (constant radius of curvature). Hence:

$$\boxed{R = \frac{573}{gbu}}$$

$$D_E = R\,(1 - \cos i) \qquad \text{(m)}$$

$$\Delta Z = R \sin i \qquad \text{(m)}$$



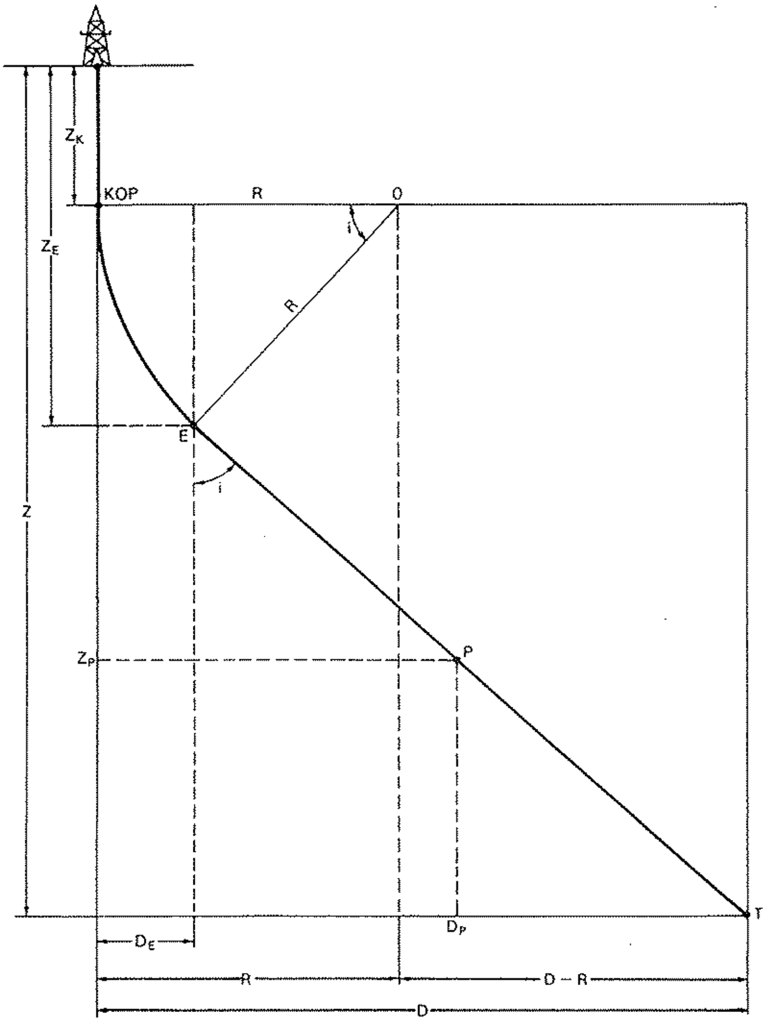
Radius of curvature for different rates of buildup:

gbu (°/10 m)	0.5	1	1.5	2	2.5
R(m)	1146	573	382	286	229

m × 3.28 = ft °/10 m × 3.048 = °/100 ft

CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE

J hole - $D > R$



CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE

J hole - *D* > *R* (continued)

$$i = 180 - \tan^{-1}\left[\frac{Z - Z_K}{D - R}\right] - \cos^{-1}\left[\frac{R}{Z - Z_K} \sin \tan^{-1} \frac{Z - Z_K}{D - R}\right]$$

Example:

Displacement	D	=	700 m	
KOP	Z_K	=	350 m	
Verticl depth of target	Z	=	2 350 m	
Rate of buildup	gbu	=	1°/10 m	(R = 573 m)

$$i = 180 - \tan^{-1} \frac{2\,000}{700 - 573} - \cos^{-1}\left[\frac{573}{2\,000} \sin \tan^{-1} \frac{2\,000}{700 - 573}\right]$$

$$i = 20°$$

(See graphic method in J13)

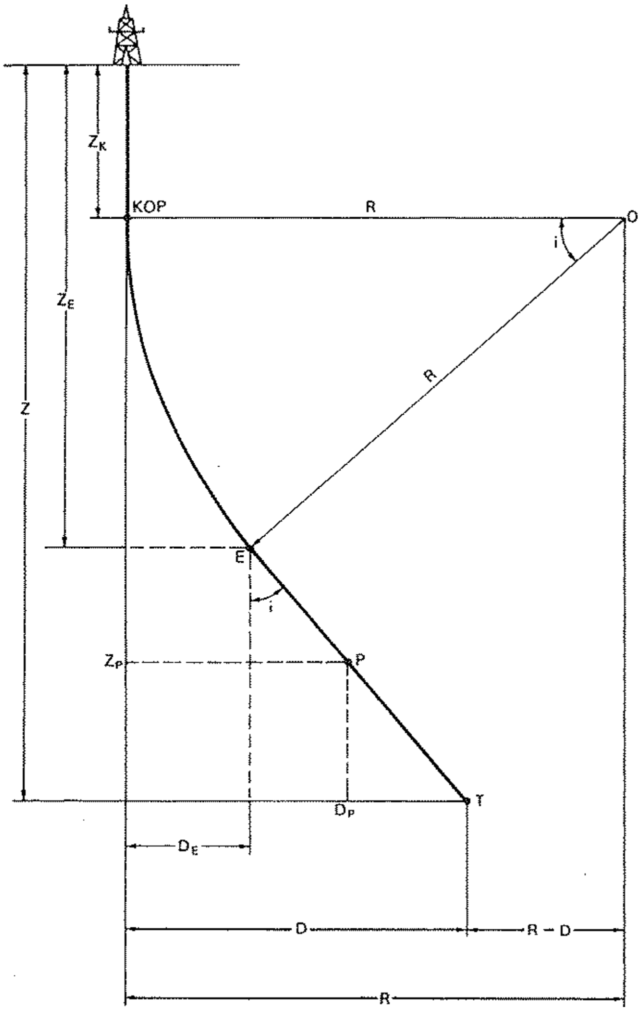
	Measured depth L (TMD)	Vertical depth Z (TVD)	Inclination	Displacement
Kickoff point (K)	Z_K	Z_K	0	0
End of deviation (E)	$L_E = Z_K + \frac{\pi i R}{180}$	$Z_E = Z_K + R \sin i$	i	$D_E = R(1 - \cos i)$
Target (T)	$L_T = Z_K + \frac{\pi i R}{180} + \frac{Z - Z_K - R \sin i}{\cos i}$	Z	i	D

Vertical depth Z_P as a function of drilled depth L_p at point P:

$$\boxed{Z_P = Z_K + \frac{573}{gbu} \sin i + \left(L_P - Z_K - \frac{10\,i}{gbu}\right) \cos i}$$

CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE

J hole - $D < R$



CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE

J hole - $D < R$ (continued)

$$i = \tan^{-1}\left[\frac{Z - Z_K}{R - D}\right] - \cos^{-1}\left[\frac{R}{Z - Z_K}\sin\tan^{-1}\frac{Z - Z_K}{R - D}\right]$$

Example :

Displacement	D	=	300 m	
KOP	Z_K	=	600 m	
Verticl depth of target	Z	=	1 800 m	
Rate of buildup	gbu	=	1°/10 m	(R = 573 m)

$i = 15°$

(See graphic method in J13)

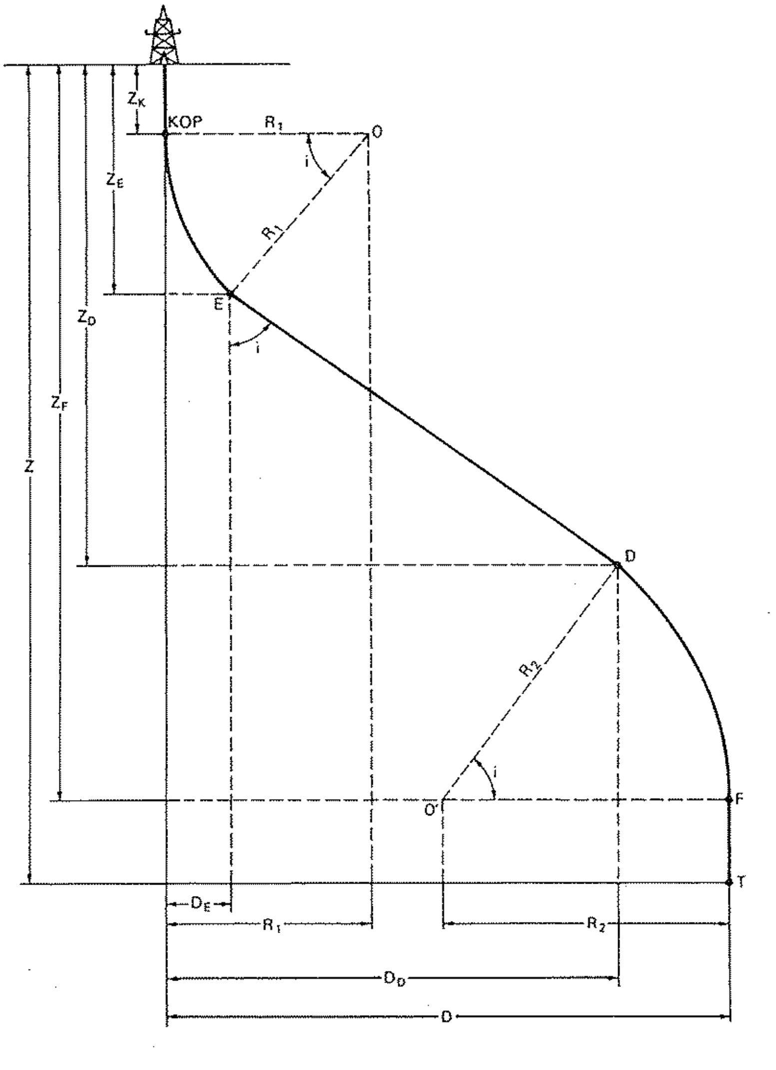
	Measured depth L (TMD)	Vertical depth Z (TVD)	Inclination	Displacement
Kickoff point (K)	Z_K	Z_K	0	0
End of deviation (E)	$L_E = Z_K + \frac{\pi i R}{180}$	$Z_E = Z_K + R\sin i$	i	$D_E = R(1 - \cos i)$
Target (T)	$L_T = Z_K + \frac{\pi i R}{180} + \frac{Z - Z_K - R\sin i}{\cos i}$	Z	i	D

Vertical depth Z_P as a function of drilled depth L_P at point P:

$$\boxed{Z_P = Z_K + \frac{573}{gbu}\sin i + \left(L_P - Z_K - \frac{10\,i}{gbu}\right)\cos i}$$

CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE

S hole - $R_1 + R_2 < D$



CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE
S hole - $R_1 + R_2 < D$ (continued)

Assuming a return of the well to the vertical at *F*, the inclination *i* depends on the depth selected for point *F*:

$$i = 180 - \tan^{-1}\left[\frac{Z_F - Z_K}{D - R_1 - R_2}\right] - \cos^{-1}\left[\frac{R_1 + R_2}{Z_F - Z_K}\sin\tan^{-1}\frac{Z_F - Z_K}{D - R_1 - R_2}\right]$$

The remaining calculations are identical to those in J5 and J7 up to D (Z_D, D_D).

Vertical projection at *D*:

$$Z_D = Z_F - R_2 \sin i$$

Measured depth at *D*:

$$L_D = Z_K + \frac{\pi i R_1}{180} + \frac{Z_D - Z_K - R_1 \sin i}{\cos i}$$

Displacement at *D*:

$$D_D = R_1 (1 - \cos i) + (Z_D - Z_K - R_1 \sin i) \tan i$$

Measured depth at *F*:

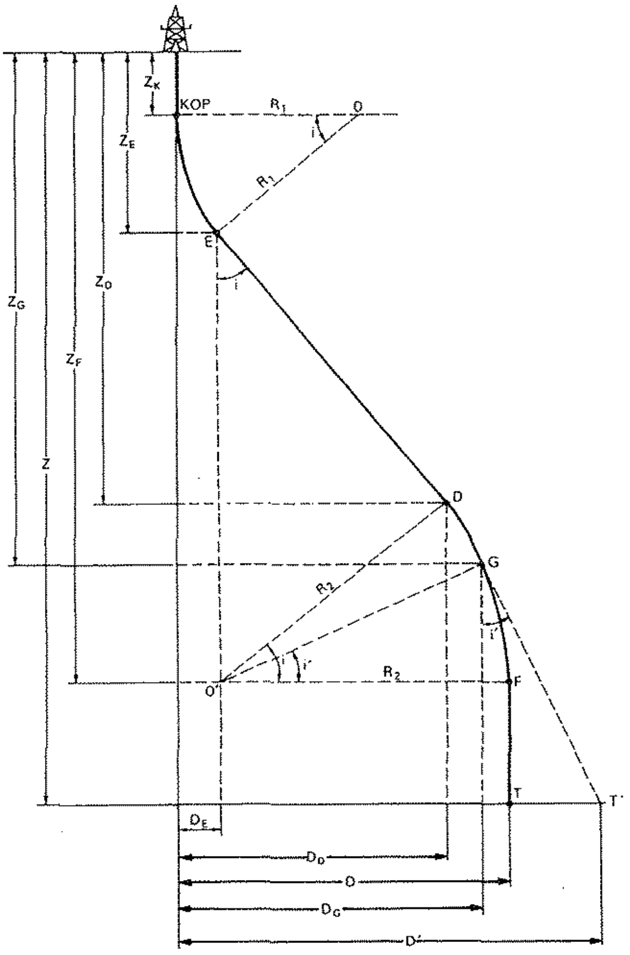
$$L_F = L_D + \frac{\pi i R_2}{180}$$

Total measured depth at *T*:

$$\boxed{L_T = Z_K + \frac{\pi i R_1}{180} + \frac{Z_D - Z_K - R_1 \sin i}{\cos i} + \frac{\pi i R_2}{180} + Z - Z_F}$$

CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE

S hole - $R_1 + R_2 > D$



CALCULATION OF CHARACTERISTICS POINTS OF THE THEORETICAL VERTICAL PROFILE

S hole - $R_1 + R_2 > D$ (continued)

Assuming a return to the vertical at *F*, the inclination *i* depends on the depth selected for point *F*:

$$i = \tan^{-1}\left[\frac{Z_F - Z_K}{R_1 + R_2 - D}\right] - \cos^{-1}\left[\frac{R_1 + R_2}{Z_F - Z_K}\sin\tan^{-1}\frac{Z_F - Z_K}{R_1 + R_2 - D}\right]$$

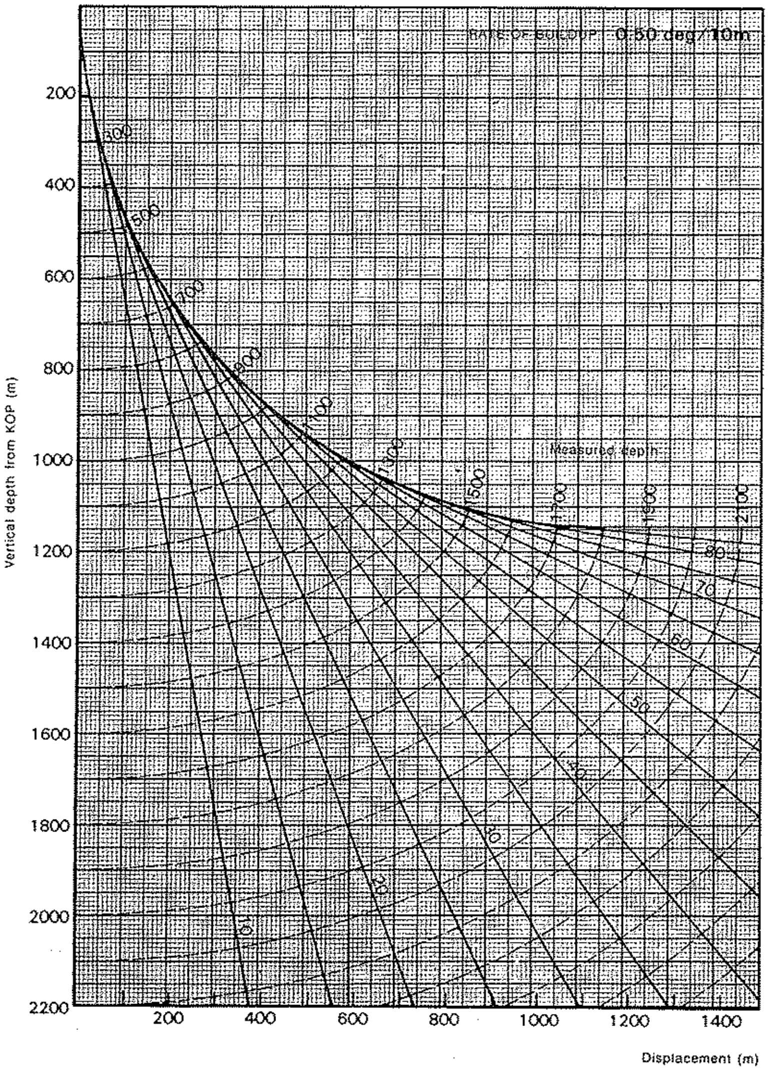
The remaining calculations are unchanged (see J 9).

If the hole does not return to the vertical, the displacement at T' from point G becomes :

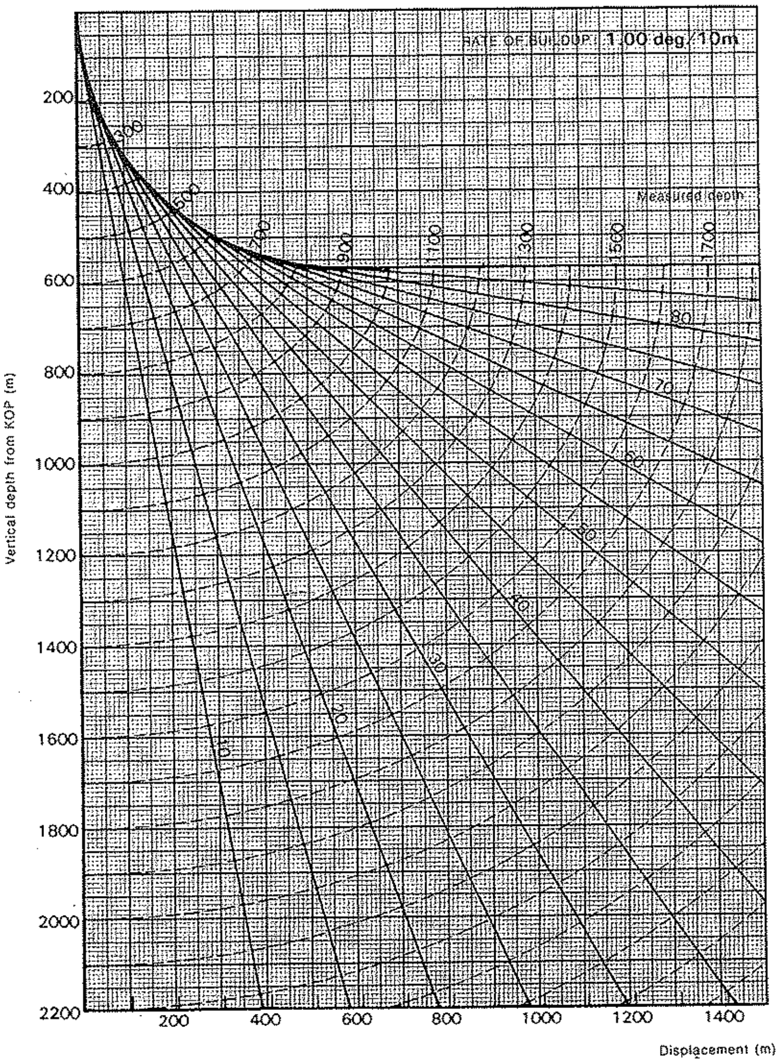
$$D' = D_G + (Z - Z_G)\tan i'$$

$$L_{T'} = L_G + \frac{(Z - Z_G)}{\cos i'}$$

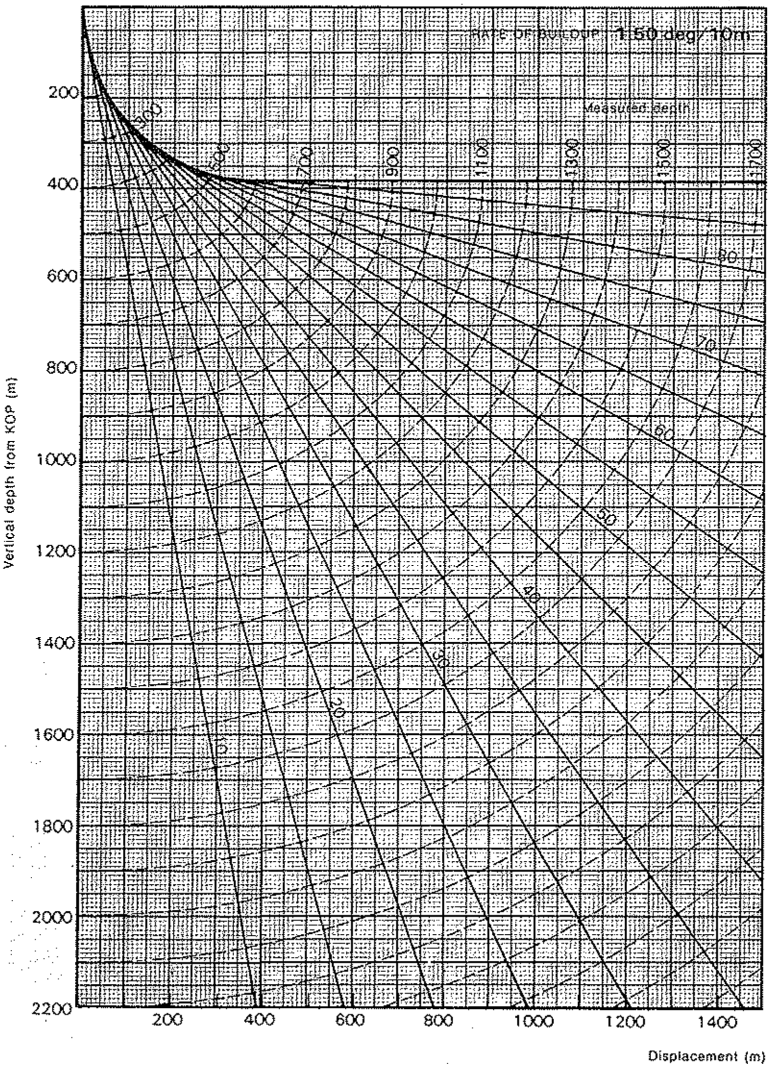
THEORETICAL VERTICAL PROFILE



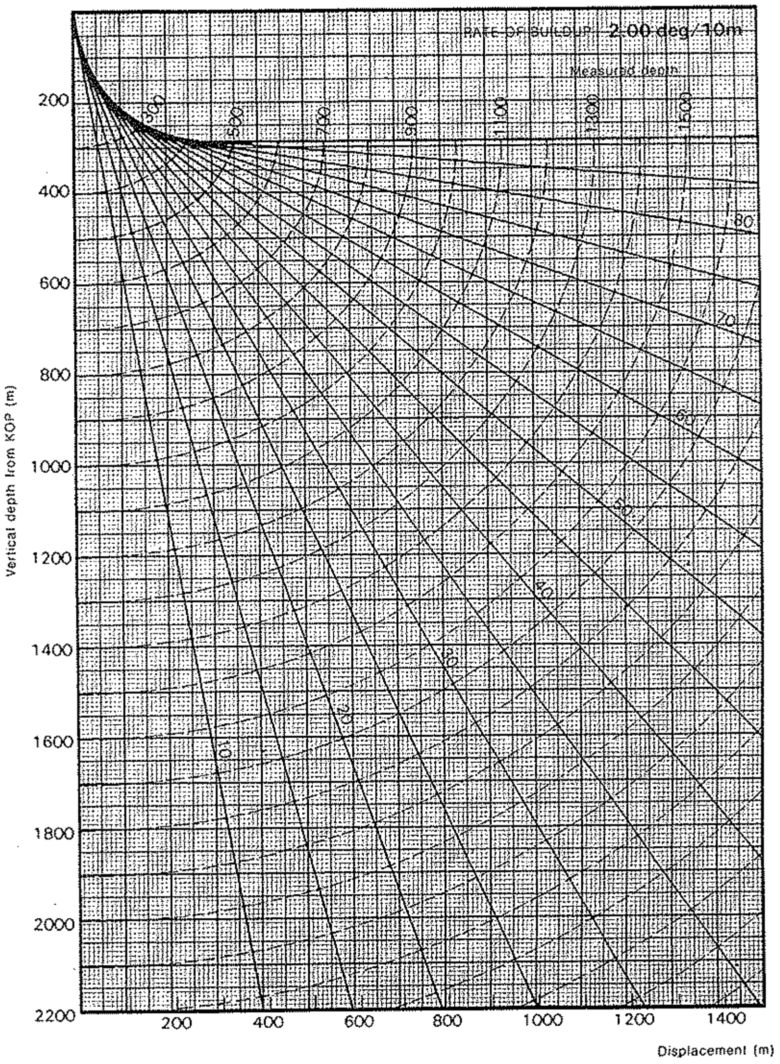
THEORETICAL VERTICAL PROFILE (continued)



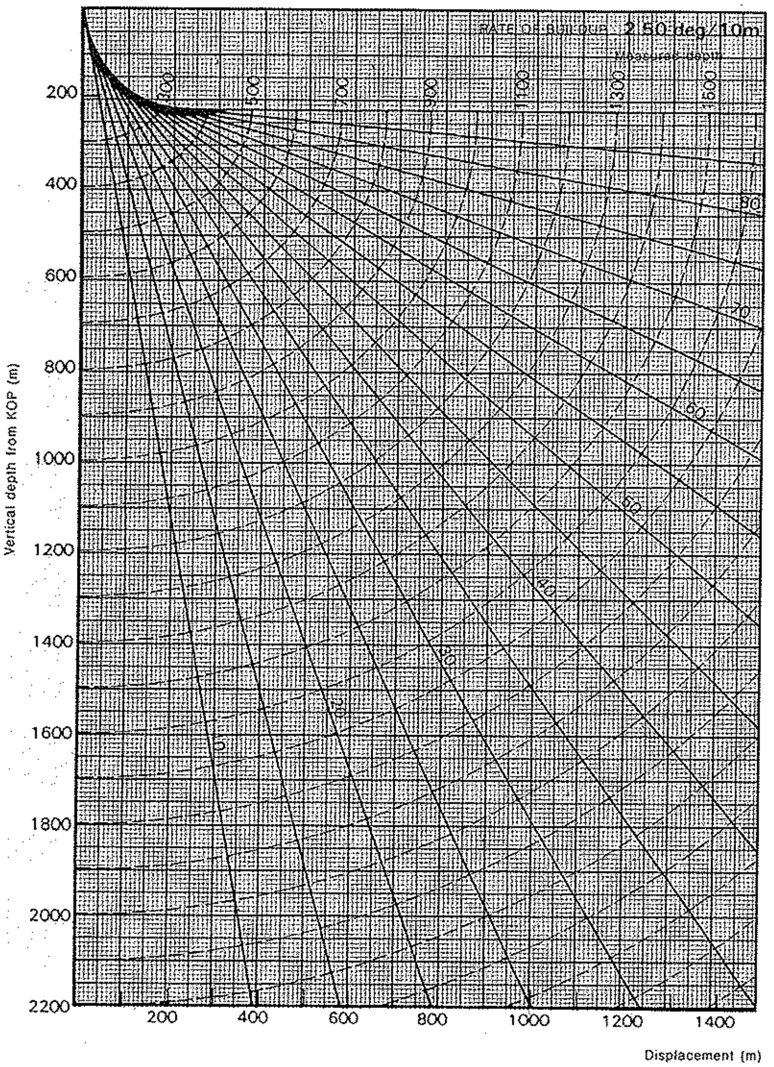
THEORETICAL VERTICAL PROFILE (continued)



THEORETICAL VERTICAL PROFILE (continued)



THEORETICAL VERTICAL PROFILE (continued)



RAGLAND DIAGRAM

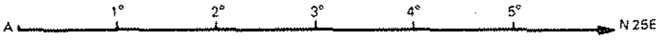
The Ragland diagram serves to determine the parameters used to calculate the orientation of the deflecting tool.

The diagram has four lines representing the characteristics of the hole and the deflecting tools.

These lines are the following:

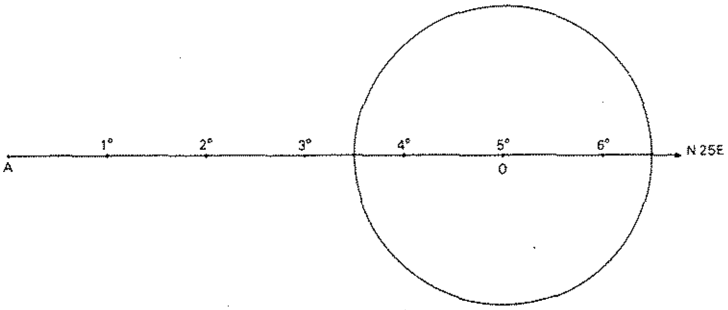
1) Original direction and inclination of a part of the hole.

Example: 5° and N25E



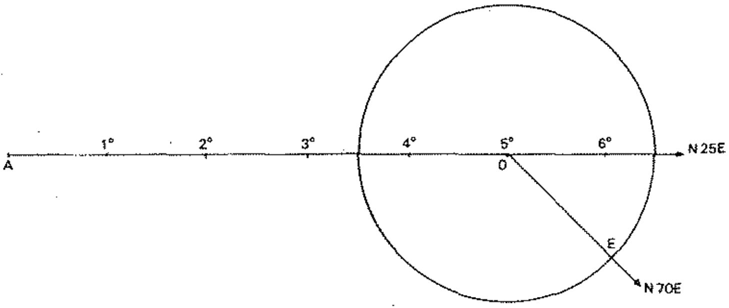
2) Dogleg circle (see dogleg formula in J 21).

Example: 1.5° dogleg



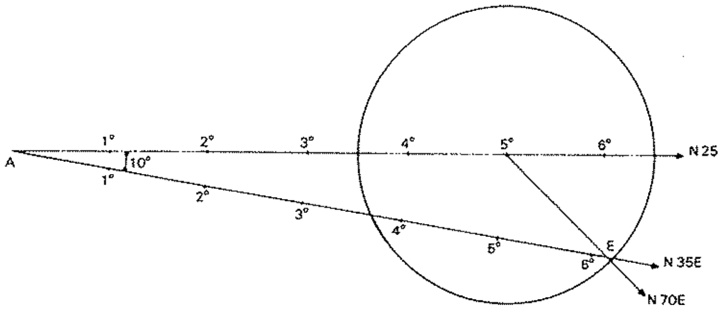
3) Orientation of deflecting tool in relation to the original direction, taking roll-off into account.

Example: deflecting tool 45° to the right of the original direction, i.e. N70E



RAGLAND DIAGRAM (continued)

4) Direction obtained in relation to the original direction.



the angle between the two directions is 10 degrees.

The new direction is N35E.

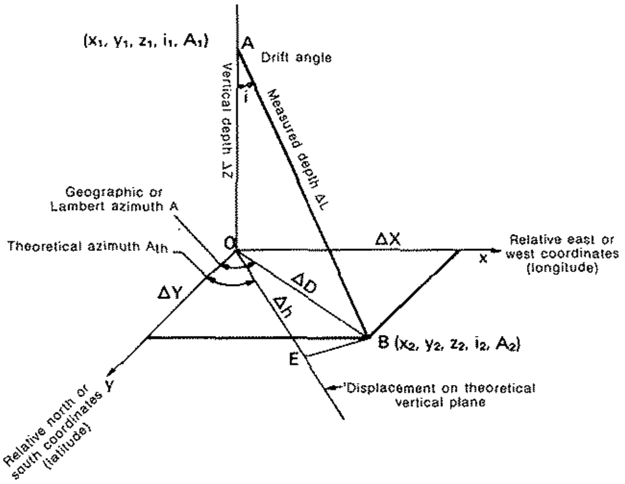
Point *E* is common to three lines :

(a) Orientation of deflecting tool.
(b) Dogleg circle.
(c) Direction obtained.

The third can be obtained if two of them are known.

CONTROL OF ACTUAL HOLE SHAPE

Calculation of projections



The following table gives the method to be used to calculate the different elements. Example of the method of the secant or average angle:

Element	Basic data		Calculation (average angle)
Vertical depth ΔZ	Course length between two consecutive surveys ΔL	Average drift angle $i = \frac{i_1 + i_2}{2}$	$\Delta Z = \Delta L \cos i$ $\Delta D = \Delta L \sin i$
Horizontal *displacement* ΔD			
Relative north or south coordinates ΔY	Horizontal displacement ΔD	Average Lambert or geographic azimuth $A = \frac{A_1 + A_2}{2}$	$\Delta Y = \Delta D \cos A$ $\Delta X = \Delta D \sin A$
Relative east or west coordinates ΔX			
Projection on theoretical plane Δh		Angular difference between geographic azimuths: survey and target $(A - A_{th})$	$\Delta h = \Delta D \cos (A - A_{th})$

CONTROL OF ACTUAL HOLE SHAPE (continued)
Different calculation formulas

The drift angle i_1 and azimuth A_1 are measured at point A.
If i_2 and A_2 are measured at point B, lying at a distance ΔL from point A:

a. Tangent method

$$\Delta Z = \Delta L \cos i_2$$
$$\Delta D = \Delta L \sin i_2$$
$$\Delta Y = \Delta D \cos A_2$$
$$\Delta X = \Delta D \sin A_2$$

b. Secant or average angle method

$$\Delta Z = \Delta L \cos \frac{i_1 + i_2}{2}$$
$$\Delta D = \Delta L \sin \frac{i_1 + i_2}{2}$$
$$\Delta Y = \Delta D \cos \frac{A_1 + A_2}{2}$$
$$\Delta X = \Delta D \sin \frac{A_1 + A_2}{2}$$

c. Balanced tangent method

$$\Delta Z = \frac{\Delta L}{2} \cos i_1 + \frac{\Delta L}{2} \cos i_2$$
$$\Delta D = \frac{\Delta L}{2} \sin i_1 + \frac{\Delta L}{2} \sin i_2$$
$$\Delta Y = \frac{\Delta L}{2} \sin i_1 \cos A_1 + \frac{\Delta L}{2} \sin i_2 \cos A_2$$
$$\Delta X = \frac{\Delta L}{2} \sin i_1 \sin A_1 + \frac{\Delta L}{2} \sin i_2 \sin A_2$$

CONTROL OF ACTUAL HOLE SHAPE (continued)
Different calculation formulas

d. Radius of curvature method

$$\Delta Z = \frac{180}{\pi} \frac{\Delta L}{i_2 - i_1} (\sin i_2 - \sin i_1)$$

$$\Delta D = \frac{180}{\pi} \frac{\Delta L}{i_2 - i_1} (\cos i_1 - \cos i_2)$$

$$\Delta Y = \frac{180}{\pi} \frac{\Delta D}{A_2 - A_1} (\sin A_2 - \sin A_1)$$

$$\Delta X = \frac{180}{\pi} \frac{\Delta D}{A_2 - A_1} (\cos A_1 - \cos A_2)$$

Dogleg

The formula for dogleg (DL) is the following:

$$\mathrm{DL} = \cos^{-1} [\cos i_1 \cos i_2 + \sin i_1 \sin i_2 \cos (A_2 - A_1)]$$

Dogleg Severity

The API formula for Dogleg Severity (DLS) is the following:

$$\mathrm{DLS} = \frac{100}{\Delta L} \cos^{-1} [\cos i_1 \cos i_2 + \sin i_1 \sin i_2 \cos (A_2 - A_1)]$$

The values are expressed in degrees/100 ft if ΔL is in feet.
Other DLS formulas are available according to the calculation methods employed.

COURSE CORRECTION

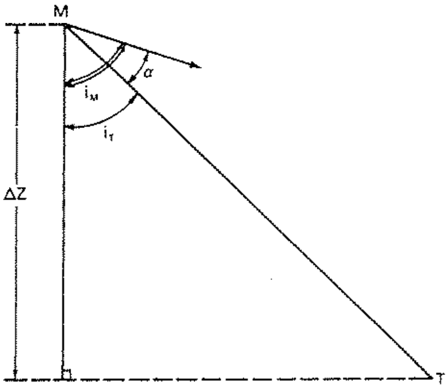
Let us assume that the last survey was made at point M:

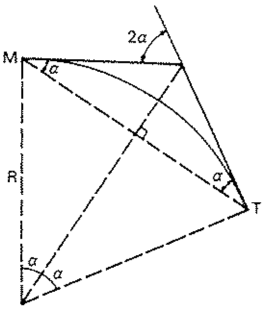
$$M \left\{ \begin{array}{ll} \text{Drift angle} & = i_M \\ \text{Azimuth} & = A_M \\ \text{Coordinates} & = X_M,\ Y_M,\ Z_M \end{array} \right.$$

The target is at point T:

T Coordinates $= X_T,\ Y_T,\ Z_T$

Drift angle correction





Change in drift angle : 2α

$$MT = \sqrt{(X_T - X_M)^2 + (Y_T - Y_M)^2 + (Z_T - Z_M)^2}$$

$$\Delta Z = Z_T - Z_M$$

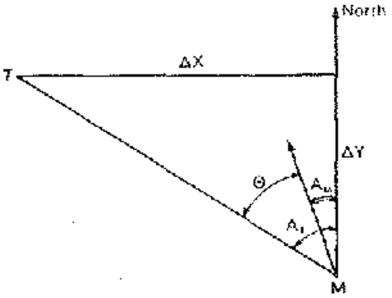
$$i_T = \cos^{-1}\left[\frac{\Delta Z}{MT}\right]$$

$$\alpha = i_T - i_M$$

$$\boxed{ROB = \frac{2\alpha}{MT}}$$ rate of buildup

COURSE CORRECTION (continued)

Azimuth correction



$$\Delta X = X_T - X_M$$

$$\Delta Y = Y_T - Y_M$$

$$A_T = \tan^{-1}\left[\frac{\Delta X}{\Delta Y}\right]$$

$$\Theta = A_T - A_M$$

$$\boxed{ROW = \frac{2\Theta}{MT}}$$ rate of azimuth change

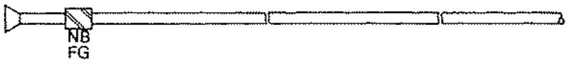
Possible azimuth variation with a deflecting tool

The maximum angle that can be turned to right or left with a deflecting tool is given by the practical formula:

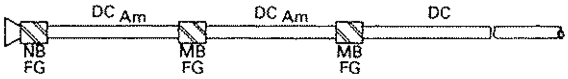
$$\Delta A = \frac{180}{i}$$

where ΔA is the maximum azimuth variation with a hole angle i.

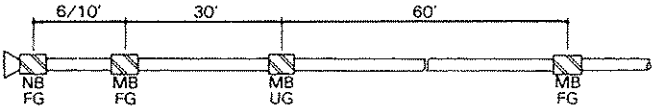
TYPICAL STRINGS FOR DIRECTIONAL DRILLING



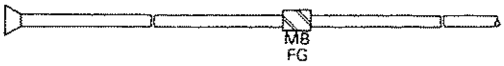
A. ANGLE BUILDING ASSEMBLIES



B. ANGLE HOLDING ASSEMBLIES



C. ANGLE HOLDING ASSEMBLIES FOR SOFT FORMATION



D. ANGLE DROPPING ASSEMBLIES (PENDULAR)

LEGEND

NB = **Near Bit**
MB = **Mid Body**
DC = **Drill Collar**
Am = **Nonmagnetic**
FG = **Full Gage**
UG = **Under Gage**

NOTES

K

kick control fishing

MAIN SYMBOLS USED

B	barite weight to be added to V m^3 of mud to raise the mud weight from d_1 to d_2 (kg)
B_r	rate of barite addition (kg/min)
BHP	Bottom Hole Pressure (kPa)
C_i	number of pump strokes corresponding to drill string internal volume V_i
C_a	number of pump strokes corresponding to total annular volume V_a
C_{oh}	number of pump strokes corresponding to open-hole annular volume V_{oh}
CP	circulating pressure (kPa)
d_1	initial specific gravity
d_2	intermediate specific gravity in case of multi-step weighting
d_e	specific gravity balancing formation pressure
d_{frac}	fracturing specific gravity
d_g	specific gravity (or density in kg/l) of gas measured with respect to water
d_r	specific gravity required to kill the well
FCP	final circulating pressure at kill rate with mud specific gravity d_r (kPa)
G	volume of kick measured at shut-in (liter)
G_{max}	maximum volume of kick to avoid fracture at shoe or exceeding the maximum working pressure (liter)
h	height of gas (m)
HP	hydrostatic pressure (kPa)
ICP	initial circulating pressure at kill rate with mud specific gravity d_1 (kPa)
ICP_2	Initial circulating pressure at kill rate with mud specific gravity d_2 (kPa)
K	ratio $\frac{Z_s}{Z_b}\frac{T_s}{T_b}$ of $ZT\left(\frac{PV}{ZT} = \text{constant}\right)$ between surface and bottom hole
$MAASP$	maximum allowable annulus pressure, well closed, corresponding to fracturing at weak zone (kPa)
N	number of pump strokes corresponding to drilling rate (strokes/min)
N_r	number of pump strokes corresponding to kill rate (strokes/min)
P_a	annulus pressure during control (kPa)
P_{afg}	static annulus pressure of gas filled well (kPa)
$P_{a\,max}$	annulus pressure when gas reaches surface (kPa)
ΔP_{cl}	pressure losses in choke line (kPa)
P_f	formation pressure (kPa)
P_{frac}	facturing pressure at weak zone (or shoe) (kPa)
ΔP_{ka}	additional pressure loss due to circulating head (kick assembly) and to pumping line between reading pressure gauge and circulating head on floating rig (kPa)
P_{max}	maximum safe casing pressure, either the working pressure of the BOP's or the bursting strength of the last casing string, whichever is the lowest. This pressure must never be exceeded (kPa)
P_s	pressure at weak zone (or shoe) (kPa)
$P_{s\,max}$	maximum pressure at weak zone (kPa)
P_{sr_1}	pressure losses at (slow) kill rate with mud specific gravity d_1, measured by the normal drilling circuit (shale shakers or riser) (kPa)
P_{sr_2}	pressure losses at (slow) kill rate with mud specific gravity d_2, measured by the normal drilling circuit (shale shakers or riser) (kPa)
P_{sr_r}	pressure losses at (slow) kill rate with mud specific gravity d_r, measured by the normal drilling circuit (shale shakers or riser) (kPa)
Q	flow rate used in drilling (l/min)
Q_r	flow rate (reduced) used to kill the well (l/min)
S	downhole pressure increase (safety margin) (kPa)

MAIN SYMBOLS USED (continued)

$SICP$	stabilized annulus (casing) pressure, well closed, after kick (kPa)
$SIDPP$	stabilized drill pipe pressure, well closed, after kick, with mud specific gravity d_1 (kPa)
$SIDPP_2$	stabilized drill pipe pressure, well closed, after kick, with mud specific gravity d_2 (kPa)
V	total volume of mud to be weighted (including tanks) (m^3)
V_a	total annulus volume (m^3)
v_a	volume per meter of annulus (l/m)
v_{ab}	volume per meter of annulus downhole (l/m)
V_B	volume increase due to barite weighting of V m^3 of mud from d_1, to d_2 (m^3)
V_i	drill string internal volume (m^3)
V_{oh}	open-hole annular volume (m^3)
V_{tk}	volume of mud in tanks (m^3)
Z	vertical depth (m)
Z_s	vertical depth at weak zone (or shoe) (m)

PRELIMINARY CALCULATIONS

To act promptly and effectively when a kick occurs, certain data, necessary to control a well, must be known or determined in advance, and the values regularly updated.

VOLUMES OF CIRCULATING FLUIDS

V_i = inside volume of drill string (m^3)
V_a = total annular volume (m^3)
V_{oh} = open-hole annular volume (m^3)
V_{tk} = volume of mud in tanks (m^3)

REDUCED MUD FLOW RATE TO CONTROL KICK

The reduced mud flow rate Q_r, selected in advance, generally ranges between a half and a quarter of the drilling mud flow rate Q (usually $Q/2$). It is selected according to the geometry of the well, and the surface installation.

NUMBER OF CIRCULATING STROKES AT REDUCED MUD FLOW RATE

a) From surface to bit:

$$C_i = \frac{V_i}{Q_r} N_r$$

b) From bit to surface:

$$C_a = \frac{V_a}{Q_r} N_r$$

c) Corresponding to open-hole annular volume:

$$C_{oh} = \frac{V_{oh}}{Q_r} N_r$$

PRESSURE LOSSES AT REDUCED MUD FLOW RATE WITH INITIAL MUD WEIGHT (P_{sri})

These pressure losses can be determined as drilling proceeds:

(a) At fixed times, at crew change for example.
(b) After running in a new bit before resuming drilling.

These pressure losses are measured onshore and offshore by the normal drilling circuit.

Additional pressure losses ΔP_{cl} occur when circulating in the control lines. They are normally negligible on land or on a fixed offshore support, but are higher on a floating rig.

Since these additional pressure losses occur in the annulus, they must not appear in the expression of the circulating pressure during control.

MAASP and d_{frac}

(see: Well strength, K11).

DRILLER'S PROCEDURES

COMPANY

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DRILLER'S PROCEDURES

for well control

(DRILLING FROM LAND OR FIXED SUPPORT)

WELL :	Phase :		Depth of weak zone :		Mud weight		Max. Pres. P_{max}	Updated on:	
	Shoe depth :		Leak-off test equiv-mud weight:		MAASP :			Supervisor:	

1. At every bit change or crew change :

Circulate off bottom for 5 minutes at reduced flow rate and record pressure loss P_{Sr_1}

Reduced flow rate		Pump N°	1	Liner size		Volume per stroke		Strokes per minute		P_{Sr_1}	--------
			2								--------

2. If any of the following occurs during drilling, coring, or circulating :

- *Increase in drilling rate.*
- *Increase of flow across shale shaker.*
- *Increase in pit level.*
- *Gas cut mud.*
- *Increase in mud chloride content.*
- *Partial or total mud losses (1).*

↓

- *Pick up kelly until T.J. is 3 ft above rotary table.*
- *Shut off mud pump - check for well flow or losses.*
- *Notify operator and contractor Tool pusher.*

IF WELL IS STABLE

- *Resume circulation.*
- *Check for mud pit level, mud weight, and shows.*
- *Resume operations.*

IF WELL IS FLOWING

- *Open the choke line, the choke being fully open.*
- *Close the bag type.*
- *Slowly close the choke and record casing and drill pipe pressure for 15 minutes.*

IF WELL IS LOOSING

- *Circulate at reduced flow rate.*
- *Check for losses.*
- *Wait for orders.*

IF Casing Pressure reaches MAASP

follow the instructions here under :

IF Casing Pressure is less than MAASP

Record this pressure SICP =

Calculate ICP as follows :

- *note the stabilized drill pipe pressure*
- *add the pressure loss at reduced flow rate*
- *add the trip margin*

TOTAL (2)

SIDPP ....

P_{SR1} ....

S = ...

ICP = ...

— *Open adjustable choke and simultaneously start pump at reduced flow rate, adjust choke to maintain a constant pressure equal to ICP. Do not take care of casing pressure as far as this pressure is less than P_{max}.*

The casing pressure must never be higher than P_{max}

(1) In the case of total losses fill up the annulus with mud or water in order to keep the level at surface. If the well is flowing, close it in as indicated above, and wait for instructions.

(2) ICP can be determined easily; when pumping is started, keep constant casing pressure equal to SICP + S for a period of few minutes. The stand pipe pressure should be close to the ICP calculated above.

3. If the well is not taking mud on trip, or flowing while out of the hole :

- *Stop tripping.*
- *Check for well flow or losses.*
- *Notify operator and contractor Tool pusher.*

IF THE WELL IS STABLE

Unless otherwise notified:

- *Run pipe back to bottom. In case of losses keep annulus full if possible.*
- *Resume circulating at reduced flow rate, eventually under control at constant DP pressure (Caution : some gas may enter the well bore).*

IF THE WELL IS FLOWING

- *Make up an inside back pressure valve in drill string.*
- *With minimum delay, run pipe back to bottom. Check mud gain.*
- *On bottom proceed as above § 2.*

IF THE FLOW IS INCREASING, OR
IF THE MUD GAIN REACHES ▨ OR
IF GAS FLOWS

- *Stop tripping.*
- *Close the bag type.*
- *Slowly close the choke.*
- *Wait for orders.*
- *Bleed off if casing pressure reaches P_{max}.*

NOTE : *The Operator Supervisor must fill up the above shadowed spaces as often as necessary.*

From *Blowout Prevention and Well Control*. Editions Technip, Paris, 1981.

CALCULATION AFTER WELL CLOSURE

Basic calculations

$$P_f = \text{SIDPP} + 9.81\ Zd_1$$

$$d_e = \frac{P_f}{9.81\ Z}$$

$$ICP = SIDPP + P_{sr_1} + S$$

$$d_r = d_1 + \frac{SIDPP + S}{9.81\ Z}$$

$$FCP = P_{sr_r} = P_{sr_1} \frac{d_r}{d_1}$$

Circulation of an intermediate mud weight d_2

From the time when the mud d_2 reaches the bit, the casing pressure becomes:

$$ICP_2 = SIDPP_2 + P_{sr_2} + S$$

with:

$$SIDPP_2 = P_f - 9.81\ Zd_2$$

$$P_{sr_2} = P_{sr_1} \frac{d_2}{d_1}$$

Special case, if:

$d_2 = \dfrac{d_1 + d_r}{2}$, then:

$$ICP_2 = \frac{ICP + FPC}{2}$$

Barite addition

Barite weight to be added to V m^3 of mud to raise the weight from d_1 to d_2:

$$B = 4.2\ V \frac{d_2 - d_1}{4.2 - d_2} \quad \text{(in metric tons)}$$

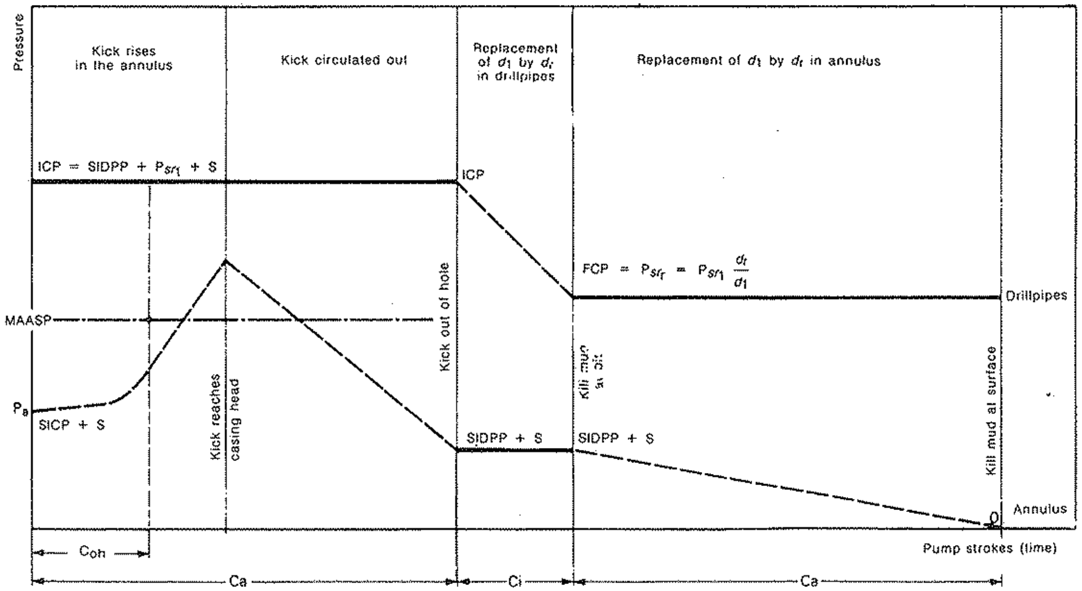
Rate of barite addition at flow rate Q_r to raise the weight from d_1 to d_2:

$$B_r = 4.2\ Q_r \frac{d_2 - d_1}{4.2 - d_2} \quad \text{(in kg/min)}$$

Volume increase due to barite addition:

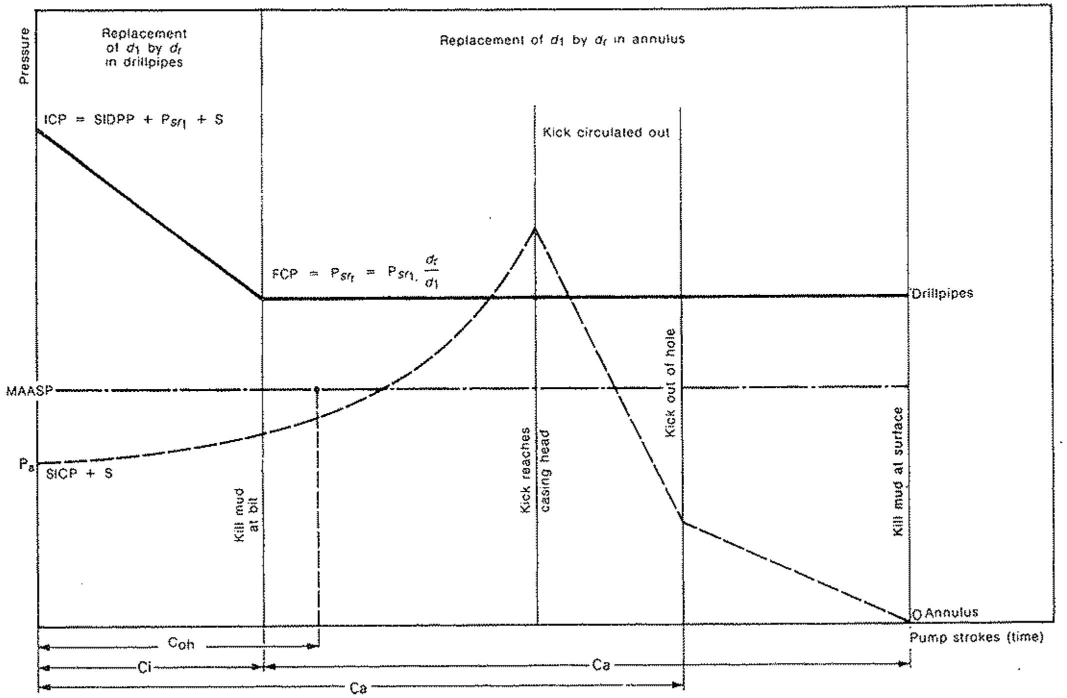
$$V_B = \frac{B}{4.2} \quad \text{(in m}^3\text{)}$$

DRILLER'S METHOD
ON LAND OR ON FIXED SUPPORT



Choke must be adjusted to follow the solid line

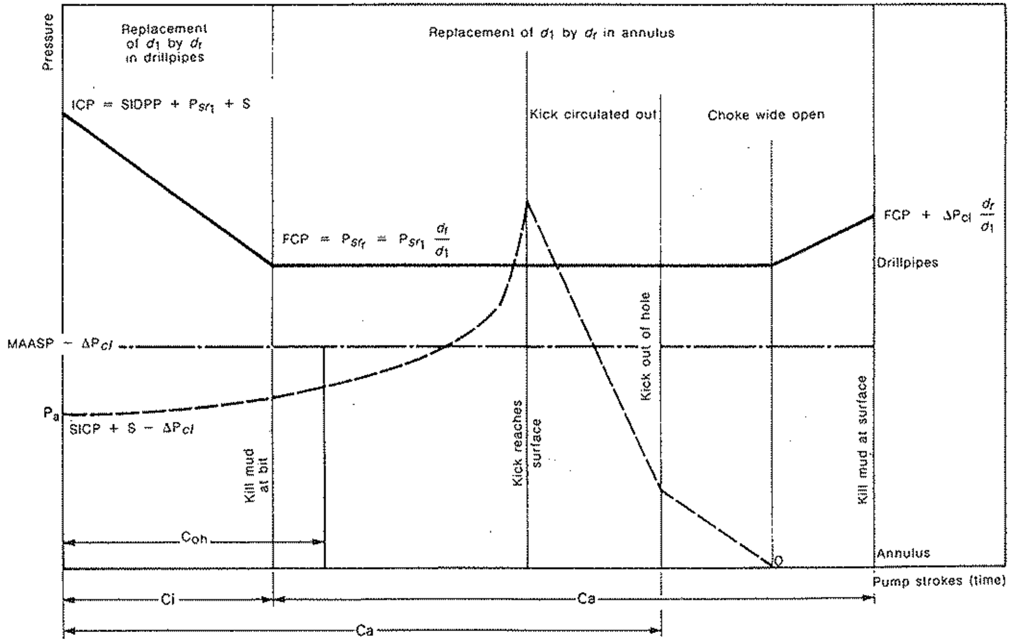
WAIT AND WEIGHT METHOD
ON LAND OR ON FIXED SUPPORT



Choke must be adjusted to follow the solid line

WAIT AND WEIGHT METHOD ON FLOATING SUPPORT

(Example without kick assembly)



Choke must be adjusted to follow the solid line

CONTROL ON FLOATING SUPPORT

Control is started with a casing pressure of:

$$ICP = P_{sr_1} + \Delta P_{ka} + SIDPP + S \text{ (1)}$$

To avoid cracking at the shoe, the starting annular pressure must be:

$$P_a < MAASP - \Delta P_{cl}$$

When the mud of the required weight reaches the bit, the casing pressure is:

$$FCP = (P_{sr_1} + \Delta P_{ka}) \frac{d_r}{d_1}$$

In very deep water, the choke line plays the role of a fixed choke. As long as the pressure loss caused by this fixed choke can be offset by opening the adjustable choke, the downhole pressure is unaffected.

As control is completed, with the adjustable choke completely open, the circulating pressure exceeds *FCP*. To limit this excess, which corresponds to a downhole overpressure of

$$\Delta P_{cl} \frac{d_r}{d_1}$$

at the end of control, the second choke line can be opened or control completed at a lower flow rate.

---

(1) ΔP_{ka}: additional pressure loss due to a kick assembly. If fluids circulate through the kelly instead of a kick assembly $\Delta P_{ka} = 0$.

WELL STRENGTH

MAASP

The maximum allowable pressure *MAASP* at the top of the annulus, with the well closed, without any risk of fracturing the formation at the weak zone, is related to the density of the fluid in the annulus between the weak zone and the surface.
The *MAASP* changes as the fluid density changes:

$$MAASP = P_{\text{frac}} - 9.81\, Z_s d_1$$

Fracturing density

$$d_{\text{frac}} = \frac{P_{\text{frac}}}{9.81\, Z_s}$$

Maximum allowable gain at shut-in to avoid cracking at the weak zone

Gas height:

$$h = \frac{MAASP - (P_f - 9.81\, Zd_1)}{9.81(d_1 - d_g)}$$

d_g is given by the chart on page K 13.

$$G_{\max} = \frac{MAASP - (P_f - 9.81\, Zd_1)}{9.81(d_1 - d_g)}\, v_{ab}$$

Maximum allowable gain at shut-in to avoid exceeding the $P_{\max}$ pressure of the well when the gas arrives below the BOP during the circulation of a gas kick:

$$G_{\max} = \frac{P_{\max}\, [9.81\, Zd_1 - (P_f - P_{\max})]}{9.81\, Kd_1 P_f}\, v_{ab}$$

K is given by the chart on page K 13.

Maximum annulus pressure, well shut-in and filled with gas

$$P_{afg} = P_f - 9.81\, Zd_g$$

d_g is given by the chart on page K 13.

WELL STRENGTH (continued)

Maximum casing pressure during the circulation of a gas kick *with the initial mud weight*

$$P_{a\,\max} = \frac{SIDPP}{2} + \sqrt{\frac{SIDPP^2}{4} + 9.81\,\frac{KGd_1P_f}{v_a}}$$

K is given by the chart on page K 13.

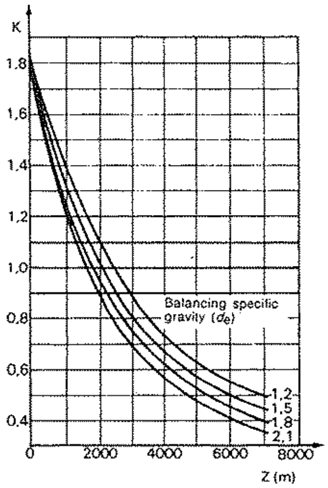
Note: this pressure is calculated when the gas arrives below the BOP. The geometry of the annulus is considered constant.

Maximum pressure at weak zone during circulation of a gas kick with mud of the initial weight

$$P_{s\,\max} = \frac{SIDPP + 9.81\ Z_sd_1}{2} + \sqrt{\frac{(SIDPP + 9.81\ Z_sd_1)^2}{4} + 9.81\,\frac{Gd_1P_f}{v_a}}$$

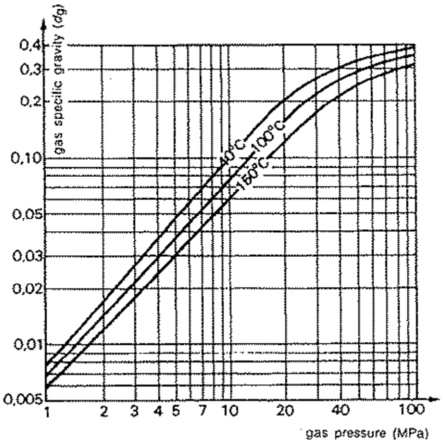
Note: this pressure is calculated when the gas arrives below the weak zone. The geometry of the annulus is considered constant. *K* is equal to 1.

CHARTS GIVING COEFFICIENT K AND GAS SPECIFIC GRAVITY



Value of the coefficient K as a function of depth and balancing mud weight for a given formation (coefficient used to calculate maximum circulating casing pressure $P_{A\,max}$ when taking a kick).

From *Blowout Prevention and Well Control*, Éditions Technip, Paris, 1981.



Specific gravity of a gas as a function of pressure and temperature (for a gas of average composition (80% C1), specific gravity of 0.675 (air = 1) and a temperature gradient of 3 °C/100 m).
From *Blowout Prevention and Well Control*, Éditions Technip, Paris, 1981.

m × 3.28 = ft   MPa × 145 = psi   kg/l = sp.gr.   kg/l × 8.35 = lb/gal

EXAMPLE OF KICK CONTROL

I INITIAL DATA

Well depth	Z	= 2 500 m
Casing size 9 5/8 in (N80-47 lb/ft)	Z_s	= 1 750 m
BOP serie 10 000		
Bit size 8 1/2 in with:		
. 5 in drillpipes, 19.5 lb/ft		2 320 m
. 6 3/4 in - 2 1/4 in drill collars		180 m
. mud weight	d_1	= 1.15
. drilling mud flow rate	Q	= 1 300 l/min (80 strokes/min)
. reduced mud flow rate	Q_r	= 650 l/min (40 strokes/min)
. pressure losses when drilling	P	= 10 900 kPa
. *pressure losses with mud d_1 at reduced* flow rate	P_{sr_1}	= 3 500 kPa
Leak Off Test at shoe with mud at d_1	*MAASP*	= 7 700 kPa

II PRELIMINARY CALCULATIONS

	(liters)	
Inside volume of drillpipes (9.15 l/m)	21 228	
Inside volume of drill collars (2.565 l/m)	462	
Inside volume of drill string V_i	21 690	(1 335 strokes)
Annulus casing (38.18 l/m) — drillpipe (13.11 l/m) volume	43 872	
Annulus hole (36.61 l/m) — drillpipe (13.11 l/m) volume	13 395	
Annulus hole (36.61 l/m) — drill collar (23.09 l/m) volume	2 434	
Total annulus volume V_a	59 701	(3 673 strokes)
Open-hole annulus volume V_{oh}	15 829	(974 strokes)

Fracturing pressure:

$$P_{\text{frac}} = MAASP + 9.81\ Z_s\ d_1 = 7\ 700 + 9.81 \times 1\ 750 \times 1.15$$

$$P_{\text{frac}} = 27\ 440\ \text{kPa}$$

Fracturing mud weight:

$$d_{\text{frac}} = \frac{P_{\text{frac}}}{9.81\ Z_s} = \frac{27\ 440}{9.81 \times 1\ 750}$$

$$d_{\text{frac}} = 1.60$$

III WELL CLOSURE

After waiting about 15 min for stabilization of the pressures, the readings are:

$SIDPP$ = 2 300 kPa
$SICP$ = 4 500 kPa
G = 4 000 liters.

EXAMPLE OF KICK CONTROL (continued)

IV CALCULATIONS AFTER SHUT-IN

$$P_f = 2\,300 + 9.81 \times 2\,500 \times 1.15 = 30\,500 \text{ kPa}$$

Given the difference between *MAASP* (7700 kPa) and *SICP* (4500 kPa), the following safety margin is used:

$$S = 1\,000 \text{ kPa}$$

$$ICP = 2\,300 + 3\,500 + 1\,000 = 6\,800 \text{ kPa}$$

$$d_r = 1.15 + \frac{2\,300 + 1\,000}{9.81 \times 2\,500} = 1.29$$

$$FCP = 3\,500 \times \frac{1.29}{1.15} = 3\,925 \text{ kPa}$$

Total volume to be weighted by considering the circulating volume of 80 m^3 at the surface:

$$V = V_i + V_a + V_{tk} = 21.690 + 59.701 + 80.000 = 161.4 \text{ m}^3$$

Barite weight to be added:

$$B = 4.2 \times 161.4 \times \frac{1.29 - 1.15}{4.20 - 1.29} = 32.6 \text{ metric tons}$$

Volume increase due to barite:

$$V_B = \frac{32.6}{4.2} = 7.8 \text{ m}^3$$

V KICK CONTROL BY THE DRILLER'S METHOD

a) After setting the pump stroke counter to zero, open the choke and start the pump at the rate of 650 l/min (40 strokes/min). Adjust the choke to read the casing pressure:

$$P_a = SICP + S = 4\,500 + 1\,000 = 5\,500 \text{ kPa}$$

b) After a few moments, the drillpipe pressure should stabilize at:

$$ICP = 6\,800 \text{ kPa}$$

If not:

. if P_{dp} read < *ICP*, the pump may be running at less than 40 strokes/min: check the pump,

. if P_{dp} read > *ICP*, the pump may be running at more than 40 strokes/min: check the pump.

EXAMPLE OF KICK CONTROL (continued)

c) When the drillpipe pressure is stabilized at *ICP*, continue to maintain *ICP* for at least 3673 strokes.

d) After 974 strokes, the entire effluent has gone into the casing. If the casing pressure then exceeds *MAASP*, there is no risk of fracture if *ICP* and Q_r are still constant.

e) After 3673 strokes (or more if the well is caved in), the effluent has been circulated out completely, and you can stop the pump and shut in the well (record the position of the choke before shut-in) to read the pressures. They must be:

$$P_{dp} = SIDPP = 2\,300 \text{ kPa}$$

$$P_a = SIDPP = 2\,300 \text{ kPa}$$

f) Reset the counter to zero. Restart the pump at 650 l/min (40 strokes/min) repositioning the choke at its value before shut-in, as d_r mud is pumped into the drillpipes.

g) Control the choke to have the following casing pressure:

$$P_a = SIDPP + S = 2\,300 + 1\,000 = 3\,300 \text{ kPa}$$

The drillpipe pressure should drop from:

$$ICP = 6\,800 \text{ kPa to } FCP = 3\,925 \text{ kPa in } 1\,335 \text{ strokes}$$

h) After 1 335 strokes, maintain the drillpipe pressure at:

$$FCP = 3\,925 \text{ kPa}$$

until the heavy d_r mud reaches the surface.

VI WELL STRENGTH

a. Maximum allowable gain at shut-in to avoid fracturing at weak zone

$$h = \frac{MAASP - (P_f - 9.81\ Zd_1)}{9.81\ (d_1 - d_g)}$$

With P_f = 30 500 kPa = 30.5 MPa and when estimating a downhole temperature of about 80 °C, we can take (chart page K 13):

mperature of

$$d_g = 0.25$$

$$h = \frac{7\,700 - (30\,500 - 9.81 \times 2\,500 \times 1.15)}{9.81\ (1.15 - 0.25)}$$

$$h = 612 \text{ m}$$

or:	180 m opposite the drill collars:	180 × 13.52	= 2424 liters
	432 m opposite the drillpipes:	432 × 23.5	= 10152 liters
		Gain	= 12586 liters

Since the maximum allowable gain is less than the open-hole annulus volume, the calculation with the gas-filled well is unacceptable.

EXAMPLE OF KICK CONTROL (continued)

b. Maximum pressure at weak zone during gas circulation

$$P_{s_{\max}} = \frac{SIDPP + 9.81\ Z_s d_1}{2} + \sqrt{\frac{(SIDPP + 9.81\ Z_s d_1)^2}{4} + 9.81\ \frac{G d_1 P_f}{v_a}}$$

$$P_{s_{\max}} = \frac{2\,300 + 9.81 \times 1\,750 \times 1.15}{2} + \sqrt{\frac{(2\,300 + 9.81 \times 1\,750 \times 1.15)^2}{4} + 9.81\ \frac{4\,000 \times 1.15 \times 30\,500}{23.5}}$$

$$P_{s_{\max}} = 24\,439\ \text{kPa} < P_{\text{frac}}$$

At shut-in, the pressure at the shoe :

$P_s = SICP + 9.81\,Z_s d_1 = 4\,500 + 9.81 \times 1\,750 \times 1.15 = 24\,242$ kPa

When circulation is started :

$$P_s = SICP + S + 9.81\ Z_s d_1 = 25\,242\ \text{kPa}$$

$P_{s_{\max}}$ calculated is lower than the value reached when starting control.

This is explained by the moderating effect of the drill collars. The gas height at the shoe is lower than downhole. This is not always the case, especially if the shoe is shallow.

c. Maximum casing pressure when circulating the kick

For $Z = 2\,500$ m and $d_e = 1.24$, we obtain $K = 0.95$ on the chart on page K 13.

$$P_{a_{\max}} = \frac{SIDPP}{2} + \sqrt{\frac{SIDPP^2}{4} + 9.81\,\frac{KGd_1\,P_f}{v_a}}$$

$$= \frac{2\,300}{2} + \sqrt{\frac{2\,300^2}{4} + \frac{9.81 \times 0.95 \times 4\,000 \times 1.15 \times 30\,500}{23.5}}$$

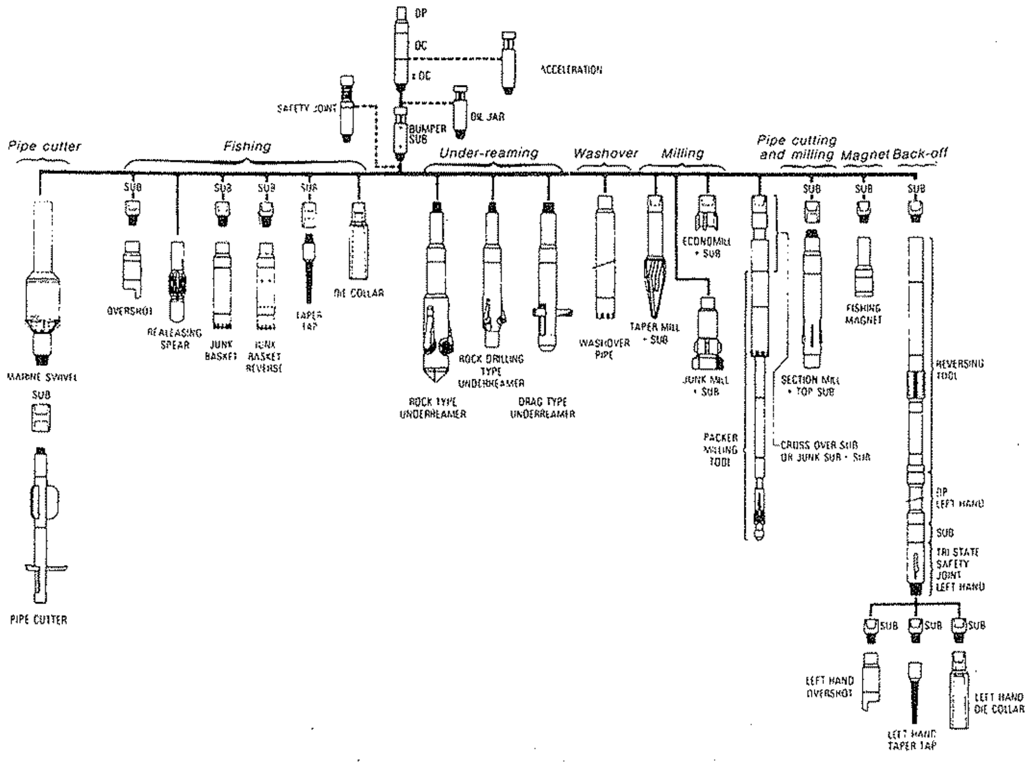
$$= 8\,697\ \text{kPa}$$

Value lower than :

(a) The BOP working pressure = 68 950 kPa.

(b) The casing bursting pressure = 47 300 kPa.

EXAMPLES OF FISHING, MILLING AND BACK-OFF STRINGS
(Servco document)



DETERMINATION OF THE LENGTH OF FREE PIPE IN A STUCK STRING

The length of free pipe in a stuck string is given by the formula:

$$L = \frac{2.675\ P_{DP}\ell}{T_2 - T_1}$$

where:

L = length of free pipe (m)
P_{DP} = weight per meter of pipe (kg/m)
ℓ = differential stretch in mm for differential pull T_2 - T_1 (10^3 daN)

Note: This method does not give high accuracy on L.

EXAMPLE OF HOW TO USE THE METHOD

Sticking at 2247 m in a 8 1/2 inch hole with a mud weight 1.40 (SG). The drill string consists of 2000 m of 5 inch, 19.50 lb/ft (NC 50) grade 95, class Premium drill pipes, 31.83 kg/m and 247 m of 6 3/4 inch by 2 13/16 inch drill collars, 149.8 kg/m.

First step. Calculate the maximum pull on drill pipe:

(a) Tension load at minimum yield strength (See B 19) = 175.6 10^3 daN.
(b) Maximum allowable pull = 175.6 × 0.9 = 158 10^3 daN.

Second step. Calculate the weight of the drill string in mud:

(a) Drill collars = 247 m × 149.8 kg/m = 37 000 kg ≃ 37.0 10^3 daN.
(b) Drill pipes = 2 000 m × 31.83 kg/m = 63 600 kg ≃ 63.6 10^3 daN.
Total = 100.6 10^3 daN.

In mud d = 1.40, the buoyancy factor is 0.822.
Weight of drill string in mud = 100.6 × 0.822 = 82.6 10^3 daN.
The allowable pull margin is 158 − 82.6 = 75.4 10^3 daN.

Third step. Pull on the drill string until the weight indicator shows a pull T_1 of 105 10^3 daN (1). Draw a mark at the kelly-drive bushing level. Apply 110 10^3 daN and return to 105 10^3 daN. Draw a second mark at the kelly-drive bushing leve. This second mark should be distinct from the first (difference caused by friction of drill pipe in the hole). Draw a datum line midway between the two marks.

---

(1) Examples only.

DETERMINATION OF THE LENGTH OF FREE PIPE IN A STUCK STRING (continued)

Fourth step. *Proceed as above by applying* $T_2 = 135\ 10^3$ daN (1). Draw a mark. Pull at 140 10^3 daN and return to 135 10^3 daN. Draw a datum line midway between these two marks. Measure the distance l in mm between the two datum lines. Assume l = 700 mm.

Fifth step. Apply the formula with :

P_{DP} = 31.8 kg/m
l = 700 mm
T_1 = 105 10^3 daN
T_2 = 135 10^3 daN

$$L = \frac{2.675 \times 31.8 \times 700}{30} = 1985 \text{ m}$$

Conclusion. The sticking point is nearly at the top of the drill collars.

---

(1) Examples only.

MAXIMUM ALLOWABLE NUMBER OF TURNS WHICH CAN BE GIVEN TO 1 000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION

(Grade E pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1 000 m of drill pipe under a tension of (10³ daN)																				
(in)	(lb/ft)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
2 3/8	6.65	18 3/4	18 1/4	17 3/4	16 1/2	14																	
2 7/8	10.40	15 1/2	15 1/4	15	14 1/2	14	13	11 3/4	10 1/2	8 1/4	5												
3 1/2	9.50	12 3/4	12 1/2	12 1/4	11 3/4	11 1/4	10 1/4	9	7 1/4	4 3/4													
3 1/2	13.30	12 3/4	12 1/2	12 1/4	12	11 3/4	11 3/4	11 1/2	10 1/4	9 1/4	8 1/4	7	5 1/2										
3 1/2	15.50	12 3/4	12 3/4	12 1/2	12 1/2	12	11 3/4	11 1/2	11	10 1/2	10	9	8	6 1/2	5 1/2	2 3/4							
4	11.85	11	11	11	10 1/2	10	9 1/2	9	8	7	5 1/2	2 1/2											
4	14.00	11	11	11	10 1/2	10 1/2	10	9 1/2	9	8 1/2	7 3/4	6 1/2	5 1/2	3 1/2									
4	15.70	11	11	10 1/2	10 1/2	10 1/2	10 1/4	10	9 1/2	9 1/4	8 1/2	8	7 1/4	6	4 1/2	2 1/2							
4 1/2	13.75	9 3/4	9 3/4	9 3/4	9 1/2	9 1/4	8 3/4	8 1/2	7 1/2	6 3/4	6	5	3 1/2										
4 1/2	16.60	9 3/4	9 3/4	9 1/2	9 1/2	9 1/4	9 1/4	8 3/4	8 1/2	8 1/4	7 3/4	7	6 1/4	5 1/2	4 1/2	3							
4 1/2	20.00	9 3/4	9 3/4	9 3/4	9 3/4	9 1/2	9 1/2	9 1/2	9 1/4	9	8 1/2	8 1/2	8 1/4	7 3/4	7 1/4	6 1/2	5 3/4	5	3 3/4	1 1/2			
5	16.25	8 3/4	8 3/4	8 3/4	8 1/2	8 1/4	8 1/4	8	8	7 1/2	7	6 1/2	5 3/4	5	4	2 1/4							
5	19.50	8 3/4	8 3/4	8 3/4	8 1/2	8 1/2	8 1/2	8 1/4	8	7 3/4	7 1/2	7 1/4	7	6 1/2	6	5 1/4	4 1/2	3 1/2	2				
5	25.60	8 3/4	8 3/4	8 1/2	8 1/2	8 1/2	8 1/2	8 1/2	8 1/4	8 1/4	8 1/4	8	8	7 3/4	7 1/2	7 1/4	6 3/4	6 1/2	6 1/4	5 3/4	5 1/4	4 3/4	4
5 1/2	19.20	8	8	8	8	7 3/4	7 3/4	7 1/2	7 1/2	7 1/4	7	6 1/2	6 1/4	5 3/4	5	4 1/4	3 1/2	2					
5 1/2	21.90	8	8	8	7 3/4	7 3/4	7 3/4	7 1/2	7 1/2	7 1/4	7	6 3/4	6 1/2	6 1/4	6	5 1/2	5 1/4	4 3/4	3 3/4	3			
5 1/2	24.70	8	8	8	8	7 3/4	7 3/4	7 1/2	7 1/4	7	7 1/2	7 1/2	7	6 3/4	6 1/2	6 1/4	6	5 1/4	5	4 1/2	4 1/4	3 1/2	2 1/2
6 5/8	25.20	6 3/4	6 3/4	6 1/2	6 1/2	6 1/2	6 1/4	6 1/4	6 1/4	6 1/4	6	6	5 3/4	5 1/2	5 1/4	5	4 3/4	4 1/2	4	3 3/4	3 1/4	2 1/2	1 1/2

daN × 2.25 = lb   m × 3.28 = ft

Note : Tabulated values are based on the following formula : $N = \frac{100LS}{\pi DG}\sqrt{1 - \frac{100T^2}{3A^2S^2}}$ where :

N = number of turns which can be given for a tension T
L = length of drill pipe string (m)
S = maximum shear strength (MPa) S is 57.7% of the minimum yield strength
D = outside diameter drill pipes (cm)
G = modulus of elasticity in shear : 84 000 MPa
T = total tensile load (daN)
A = pipe cross-sectional area (mm²)
π = 3.14159

MAXIMUM ALLOWABLE NUMBER OF TURNS WHICH CAN BE GIVEN TO 1 000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION

(Grade 95 pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1 000 m of drill pipe under a tension (10^3 daN)																					
(in)	(lb/ft)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
2 3/8	6.65	23 3/4	23 1/2	23	22	20 1/2	18 1/4	15	10 1/4														
2 7/8	10.40	19 1/2	19 1/4	19 1/4	19	18 1/2	18	17	16	14 1/2	13	10 3/4	7 3/4										
3 1/2	9.50	16	15 3/4	15 3/4	15 1/2	15	14 1/4	13 1/2	12 1/2	11	9	6 1/4											
3 1/2	13.30	16	16	15 3/4	15 3/4	15 1/2	15 1/4	15	14 1/2	14	13	12	11	10	8 1/2	6 1/4	2						
3 1/2	15.50	16	16	16	15 3/4	15 1/2	15 1/4	15	14 3/4	14 1/2	13 1/2	13	12 1/2	12	11	10	9	7 1/2	5 1/2				
4	11.85	14	14	14	13 3/4	13 1/2	13	12 1/2	12	11	10	8 1/2	7 1/4	5 1/4									
4	14.00	14	14	14	13 3/4	13 1/2	13 1/4	13	12 1/2	12	11 1/2	11	10	9	8	7	4 3/4						
4	15.70	14	14	14	13 3/4	13 3/4	13 1/2	13 1/2	13 1/4	12 3/4	12 1/4	11 3/4	10 1/2	10	10	9	8	7	5	2 1/4			
4 1/2	13.75	12 1/2	12 1/4	12 1/4	12	12	11 3/4	11 1/2	11	10 1/2	10	9 1/2	8 1/2	7 1/2	6 1/2	4 1/2							
4 1/2	16.60	12 1/2	12 1/4	12 1/4	12	12	12	11 1/2	11 1/4	11	10 3/4	10 1/2	10	9 1/2	8 3/4	8	7 1/4	6 1/4	5	3			
4 1/2	20.00	12 1/2	12 1/2	12 1/2	12 1/4	12 1/4	12	12	12	11 3/4	11 1/2	11 1/4	11	10 3/4	10 1/2	10	9 1/2	9	8 1/2	7 1/4	6 1/4	5 1/4	
5	16.25	11 1/4	11 1/4	11 1/4	11	11	10 3/4	10 1/2	10 1/4	10	9 3/4	9 1/2	9	8 1/2	8	7 1/4	6 1/2	5 1/2	4 1/2	2 1/4			
5	19.50	11 1/4	11 1/4	11 1/4	11	11	11	10 3/4	10 3/4	10 1/2	10 1/4	10	9 3/4	9 1/2	9	8 3/4	8 1/4	7 3/4	7 1/4	6 1/2	5 1/2	4 1/2	3 1/2
5	25.60	11 1/4	11 1/4	11 1/4	11	11	11	11	10 3/4	10 3/4	10 1/2	10 1/2	10 1/4	10 1/4	10	10	9 3/4	9 1/2	9 1/4	9	8 3/4	8 1/4	8
5 1/2	19.20	10 1/4	10 1/4	10 1/4	10	10	10	9 3/4	9 3/4	9 1/2	9 1/4	9	8 3/4	8 1/2	8	7 3/4	7 1/4	6 3/4	6	5 1/4	4 1/2	3 1/4	
5 1/2	21.90	10 1/4	10 1/4	10 1/4	10	10	10	9 3/4	9 3/4	9 1/2	9 1/2	9 1/4	9	8 3/4	8 1/2	8 1/4	8	7 3/4	7 1/2	7	6 1/2	5 3/4	5 1/4
5 1/2	24.70	10.1/4	10 1/4	10 1/4	10	10	10	10	9 3/4	9 3/4	9 1/2	9 1/2	9 1/4	9	9	8 3/4	8 1/2	8 1/4	8	7 3/4	7 1/2	7 1/4	7 1/4
6 5/8	25.20	8 1/2	8 1/2	8 1/2	8 1/4	8 1/4	8 1/4	8 1/4	8	8	8	7 3/4	7 1/2	7 1/2	7 1/4	7 1/4	7	7	6 1/2	6 1/2	6 1/4	5 3/4	5

daN × 2.25 = lb   m × 3.28 = ft

MAXIMUM ALLOWABLE NUMBER OF TURNS WHICH CAN BE GIVEN TO 1 000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION

(Grade 105 pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1 000 m of drill pipe under a tension of (10^3 daN)																					
(in)	(lb/ft)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
2 3/8	6.65	26 1/4	26	25 1/2	25	23 1/2	21 1/2	18 1/2	15	10													
2 7/8	10.40	21 3/4	21 1/2	21	21	20 1/2	20	19 1/4	18 1/4	17 1/4	16	14	12	9 1/4	4 1/2								
3 1/2	9.50	17 3/4	17 1/2	17 1/4	17 1/4	16 3/4	16	15 1/4	14 1/2	13 1/4	11 3/4	9 3/4	7 1/4	2									
3 1/2	13.30	17 3/4	17 1/2	17 1/4	17 1/4	17	16 3/4	16 1/2	16 1/4	15 3/4	15	14 1/4	13 1/2	12	11	9 1/2	8	5 1/2					
3 1/2	15.50	17 3/4	17 3/4	17 1/2	17 1/4	17 1/4	17	17	16 1/2	16 1/2	15 3/4	15 1/4	14 3/4	14	13 1/4	12 1/2	11 1/2	10 1/2	9 1/2	8	5 1/2		
4	11.85	15 1/2	15 1/4	15	15	14 1/2	14 1/2	14	13 1/2	13	12	11	9 3/4	8	6								
4	14.00	15 1/2	15 1/4	15 1/4	15	15	15	14 3/4	14 1/2	14	13 1/4	12 1/2	12	11 1/4	10 1/2	9 1/2	8	6 3/4	4 1/4				
4	15.70	15 1/2	15 1/2	15 1/4	15 1/4	15	15	14 3/4	14 1/2	14	13 3/4	13 1/2	13	12 1/2	11 1/2	11	10 1/4	9 1/4	8	7	5		
4 1/2	13.75	13 3/4	13 1/2	13 1/2	13 1/4	13	13	12 3/4	12 1/2	12	11 1/2	11	10 1/2	9 1/2	8 1/2	7 1/2	6 1/4	4 1/4					
4 1/2	16.60	13 3/4	13 3/4	13 1/2	13 1/2	13 1/4	13 1/4	13	12 3/4	12 1/2	12 1/2	12	11 1/2	11	10 1/2	10	9 1/2	8 1/2	7 1/2	6 1/2	4 1/2	3	
4 1/2	20.00	13 3/4	13 3/4	13 3/4	13 1/2	13 1/2	13 1/4	13 1/4	13	13	12 3/4	12 3/4	12 1/2	12 1/4	12	11 3/4	11 1/4	10 3/4	10 1/4	9 3/4	9 1/4	8 3/4	8
5	16.25	12 1/2	12 1/4	12 1/4	12	12	12	11 3/4	11 1/2	11 1/2	11 1/4	11	10 1/2	10	9 1/2	9	8 1/2	7 1/2	6 1/2	5 1/2	4 1/2	2 1/4	
5	19.50	12 1/2	12 1/4	12 1/4	12 1/4	12	12	12	11 3/4	11 1/2	11 1/2	11 1/4	11	11	10 3/4	10 1/2	10 1/4	9 3/4	9	8 1/2	7 1/2	6 1/2	6 1/4
5	25.60	12 1/2	12 1/4	12 1/4	12 1/4	12 1/4	12 1/4	12 1/4	12	12	12	12	11 3/4	11 1/2	11 1/2	11 1/4	11	10 3/4	10 1/2	10 1/4	10	9 3/4	9 1/2
5 1/2	19.20	11 1/4	11 1/4	11	11	11	11	11	10 3/4	10 3/4	10 1/2	10 1/4	10	9 3/4	9 1/2	9	8 3/4	8 1/4	7 3/4	7 1/4	6 1/2	5 1/2	4 1/2
5 1/2	21.90	11 1/4	11 1/4	11 1/4	11	11	11	11	11	10 3/4	10 3/4	10 1/2	10 1/2	10 1/4	10	9 3/4	9 1/2	9 1/4	9	8 1/2	8	7 1/2	7
5 1/2	24.70	11 1/4	11 1/4	11 1/4	11 1/4	11	11	11	11	10 3/4	10 3/4	10 3/4	10 1/2	10 1/2	10 1/4	10	10	9 3/4	9 1/2	9 1/4	9	8 1/2	8 1/4
6 5/8	25.20	9 1/4	9 1/4	9 1/4	9 1/4	9	9	9	9	9	9	8 3/4	8 3/4	8 1/2	8 1/2	8 1/4	8 1/4	8	7 3/4	7 1/2	7 1/4	7	6 1/2

daN × 2.25 = lb   m × 3.28 = ft

MAXIMUM ALLOWABLE NUMBER OF TURNS WHICH CAN BE GIVEN TO 1 000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION

(Grade 135 pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1 000 m of drill pipe under a tension of (10^3 daN)																					
(in)	(lb/ft)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
2 3/8	6.65																						
2 7/8	10.40																						
3 1/2	9.50	22 3/4	22 3/4	22 1/2	22 1/4	22	21 1/4	20 1/2	20	19 1/2	18 1/2	17 1/4	16	14 1/2	12 1/2	9 3/4	6						
3 1/2	13.30	22 3/4	22 3/4	22 1/2	22 1/2	22 1/4	22	22	21 1/2	21 1/4	20 3/4	20 1/4	19 3/4	18 3/4	18	17 1/4	16 1/2	15 1/2	14 1/2	13 1/4	11	9	6
3 1/2	15.50	22 3/4	22 3/4	22 1/2	22 1/2	22 1/2	22 1/4	22 1/4	22	21 3/4	21 1/4	20 3/4	20 1/2	20	19 1/2	19	18 1/2	18	17 1/4	16 1/2	15 1/2	14 1/2	13 1/4
4	11.85	20	19 3/4	19 3/4	19 1/2	19 1/4	19	18 3/4	18 1/4	17 3/4	17 1/4	16 1/2	16	15	14	13	11 3/4	10	7 1/2	4 1/2			
4	14.00	20	19 3/4	19 3/4	19 1/2	19 1/2	19 1/4	19 1/4	19	18 3/4	18 1/2	18	17 1/2	17	16 1/2	15 3/4	15 1/4	14 1/4	13	12	11	9 1/2	8
4	15.70	20	19 3/4	19 3/4	19 3/4	19 1/2	19 1/2	19 1/4	19 1/4	19	18 3/4	18 1/2	18 1/4	18	17 1/2	17	16 1/2	16	15 1/4	14 1/2	13 3/4	12 3/4	11 3/4
4 1/2	13.75	17 3/4	17 3/4	17 1/2	17 1/4	17 1/4	17	17	16 3/4	16 1/2	16	15 1/2	15	14 1/2	14	13 1/2	12 3/4	12	11	10	8 1/2	6 1/2	4 1/2
4 1/2	16.60	17 3/4	17 3/4	17 1/2	17 1/2	17 1/4	17 1/4	17	17	16 3/4	16 1/2	16 1/4	16	15 1/2	15 1/4	15	14 1/2	14	13 1/2	12 3/4	12 1/4	11 1/2	10 1/2
4 1/2	20.00	17 3/4	17 3/4	17 3/4	17 1/2	17 1/2	17 1/4	17 1/4	17 1/4	17	17	16 3/4	16 3/4	16 1/2	16 1/4	16	15 3/4	15 1/2	15	14 1/2	14 1/4	14	13 3/4
5	16.25	16	15 3/4	15 3/4	15 3/4	15 1/2	15 1/2	15 1/2	15 1/4	15 1/4	15	14 3/4	14 1/2	14 1/4	14	13 1/2	13	12 1/2	12	11 1/2	11	10 1/4	9 1/4
5	19.50	16	15 3/4	15 3/4	15 3/4	15 3/4	15 1/2	15 1/2	15 1/2	15 1/2	15 1/4	15 1/4	15	14 3/4	14 3/4	14 1/2	14 1/4	14	13 1/2	13	12 1/2	12 1/4	12
5	25.60	16	15 3/4	15 3/4	15 3/4	15 3/4	15 3/4	15 1/2	15 1/2	15 1/2	15 1/2	15 1/4	15 1/4	15 1/4	15	15	14 3/4	14 3/4	14 1/2	14 1/2	14 1/2	14 1/4	14
5 1/2	19.20	14 1/2	14 1/2	14 1/2	14 1/2	14 1/2	14 1/4	14 1/4	14 1/4	14	14	14	13 3/4	13 1/2	13 1/4	13	12 3/4	12 1/2	12	11 3/4	11 1/4	10 3/4	10
5 1/2	21.90																						
5 1/2	24.70																						
6 5/8	25.20																						

daN × 2.25 = lb m × 3.28 = ft

BACK-OFF

1) Before any back-off, determine the depth of the stuck point (using an extensometer or by the stretch test (see K19).

2) Make-up the drill string to a maximum of 80% of the torsional limit (see K21 to K24).

3) Set the neutral point at the level of the joint to back-off.
The tension on the Martin Decker is given by:

$$T = P + \frac{HP \times S}{100\,000}$$

where:

T = weight indicator tension (10^3daN)
P = weight in mud of free length of drillpipe plus travelling block, hook etc (10^3daN)
HP= hydrostatic pressure at back-off point (kPa)
S = area of matting surface of tool joint (cm^2) (see K26)

4) Apply leftward twist amounting to 60 to 80% of the rightward twist used to make-up the string.

Example: Back-off at 2000 m of a string of 5 in, 19.50 lb/ft (NC50), class Premium, grade 95 drill pipe, in a hole containing mud with SG = 1,40. Weight of travelling block and accessories: 8.10^3daN.

Calculations:

Weight per meter of drill pipe = 31.83 kg/m.
Buoyancy factor = 0.822.
Weight per meter of drill pipe in mud = 31.83 × 0.822 = 26.16 kg/m.
Weight of 2000 m of drill pipe in mud = 2000 × 26.16 ≃ 52 10^3daN.
Hydrostatic pressure at 2000 m HP = 9.81 × 2000 × 1.4 ≃ 28 000 kPa.
Area of matting surface of tool-joints (see K26) S = 34.73 cm^2.

First step. Make-up the drill string to 80% of the torsional limit of the drill pipes in tension. The weight of the drill string, before sticking, was 98 10^3daN on the weight indicator, or 98 − 8 = 90 10^3daN for the drill string only. For 90 10^3daN , page K22 indicates a maximum number of turns of 10 1/4 per 1000 m of drill pipe, or 20 1/2 tr turns for 2000 m. Make-up the drill string with 80% of 21 turns, or 16 turns of the right.

Second step. Set the neutral point at 2000 m. The weight indicator should show:

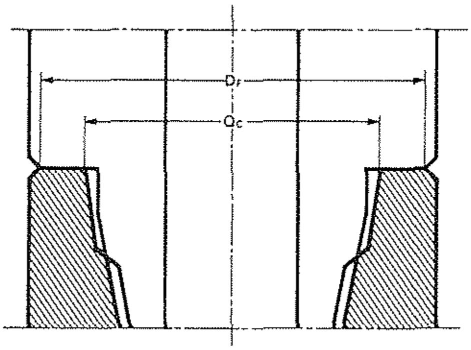
$$T = P + \frac{HP \times S}{100\,000} \text{ with: } P = 52 + 8 = 60 \quad \text{and: } \frac{HP \times S}{100\,000} = \frac{28\,000 \times 34.73}{100\,000} = 10$$

$$T = 60 + 10 = 70\ 10^3\text{daN}$$

Third step. Twist to the left to 80% of the rightward twist given above, or 80% of 16 turns or 13 turns.

TOOL JOINT MATTING SURFACE AREA

(API Spec 7)



Type of connection	Bevel diameter D_F (mm)	Inside diameter Q_C (mm)	Matting surface area	
			(mm^2)	(in^2)
NC23	76.2	66.7	1066	1.653
NC26	82.9	74.6	1027	1.591
NC31	100.4	87.7	1876	2.908
NC35	114.7	96.8	2973	4.609
NC38	116.3	103.6	2193	3.400
NC40	127.4	110.3	3192	4.948
NC44	144.5	119.1	5259	8.151
NC46	145.3	124.6	4388	6.801
NC50	150.4	134.9	3473	5.383
NC50 (1)	154.0	134.9	4334	6.717
NC56	185.3	150.8	9107	14.116
NC61	212.7	165.1	14124	21.892
NC70	232.6	187.3	14939	23.156
NC77	260.7	204.8	20437	31.678
2 3/8 REG	76.6	68.3	945	1.464
2 7/8 REG	90.9	77.8	1736	2.690
3 1/2 REG	103.6	90.5	1997	3.095
4 1/2 REG	134.5	119.1	3067	4.754
5 1/2 REG	164.3	141.7	5431	8.419
6 5/8 REG	186.1	154.0	8574	13.290
7 5/8 REG	223.8	180.2	13834	21.443
5 1/2 FH	170.7	150.0	5214	8.081

(1) Standard from June 1986.

mm × 0.0394 = in

L

wellheads

API FLANGES
Working pressure as a function of nominal size

Working pressure		Nominal size (in)	
(psi)	(MPa)	Type 6 B	Type 6 BX
2 000	13.8	2 1/16 to 21 1/4	26 3/4
3 000	20.7	2 1/16 to 20 3/4	26 3/4
5 000	34.5	2 1/16 to 11	13 5/8 to 21 1/4
10 000	69.0		1 13/16 to 21 1/4
15 000	103.5		1 13/16 to 18 3/4
20 000	138.0		1 13/16 to 13 5/8

PHYSICAL PROPERTIES OF STEEL FOR WELLHEADS (PSL0)

(API Spec 6A, 15th Edition, 1 April 1986)

Physical and chemical properties (PSL0)

Property		Type 1	Type 2	Type 3	Type 4
Minimum tensile strength	(psi). . . .	70 000	90 000	100 000	70 000
	(MPa). . .	483	621	690	483
Minimum yield strength	(psi). . . .	36 000	60 000	75 000	45 000
	(MPa). . .	248	414	517	310
Minimum elongation (% in 2 inches)		22	18	17	19
Minimum reduction in area (%) .		30	35	35	32
Maximum carbon content (%) . .		—	—	—	0,35
Maximum manganese content (%)		—	—	—	0.90
Maximum sulfur content (%) . . .		—	—	—	0.05
Maximum phosphorus content (%)		—	—	—	0.05

Type of steel for equipment (PSL0)

Equipment	Working pressure (psi)						
	1000	2000	3000	5000	10 000	15 000	20 000
Body (valve, christmas tree or wellhead equipment	—	1 or 2	1 or 2	1 or 2	1 or 2	3	3
Integral end connection : flanged.	—	2	2	2	2	3	3
threaded.	—	2	2	2	—	—	—
Bonnet	—	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4	1,2,3,4
Wellhead equipment independent screwing. .	1,2,3,4	1,2,3,4	—	—	—	—	—
Non-integral flanges : welded flange	—	4	4	4	2	3	3
blind flange	—	2	2	2	2	3	3
threaded flange.	—	2	2	2	—	—	—

PHYSICAL PROPERTIES OF STEEL FOR WELLHEADS (PSL0) (continued)

(API Spec 6A, 15th Edition, 1 April 1986)

Ring-joint gasket material and identification (PSL0)

Material	Brinell hardness number (max.) (1)	Rockwell B scale (max.) (2)	Identification mark
Soft iron (3)	90	50	D
Low carbon steel (3)	120	68	S
Type 304 stainless steel.	160	83	S304
Type 316 stainless steel.	160	83	S316

(1) Brinell hardness measured with 3 000 kg load except soft iron which is measured with 500 kg load.

(2) Rockwell B measured with 100 kg-load and 1/16 in diameter ball.

(3) Unless otherwise specified on the purchasse order, soft iron and steel gaskets to be cadmium plated 0.0002-0.0005 in.

PSL for « Product Specification Levels » existing from 0 to 4.
PSL0 has the same requirements as those of API 6A, 14th Edition, March 1983, with supplement.
PSL 1 to 4 take account of working conditions defined in Appendix A of Spec 6A, 15th Edition, 1 April 1986.

PHYSICAL PROPERTIES OF STEEL FOR WELLHEADS (PSL 1 to 4)
(API Spec 6A, 15th Edition, March 1986)

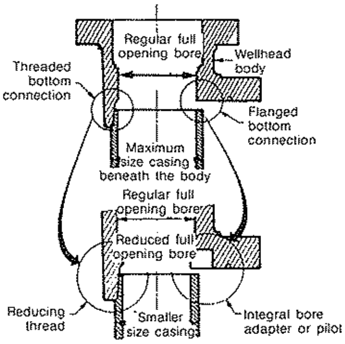
Property	API Designation of steels (PSL 1 to 4)			
	36 K	45 K	60 K	75 K
Minimum tensile strength (psi)	70 000	70 000	85 000	95 000
(MPa)	483	483	586	655
Minimum yield strength (psi)	36 000	45 000	60 000	75 000
(MPa)	248	310	414	517
Minimum elongation (% in 2 inches).	22	19	18	18
Minimum reduction in area (%). . . .	—	32	35	35

Type of steel for equipment (PSL 1 to 4)

Equipment	Working pressure (psi)						
	1000	2000	3000	5000	10000	15000	20000
Body and bonnet	—	36 K,45 K, 60 K,75 K	36 K,45 K, 60 K,75 K	36 K,45 K, 60 K,75 K	36 K,45 K, 60 K,75 K	45 K,60 K, 75 K	60 K,75 K
Integral end connection :							
flanged	—	60 K	60 K	60 K	60 K	75 K	75 K
threaded	—	60 K	60 K	60 K	—	—	—
Wellhead equipment independent screwing	36K,45K, 60K,75K	36 K,45 K, 60 K,75 K	—	—	—	—	—
Non-integral flanges :							
welded	—	45 K	45 K	45 K	60 K	75 K	75 K
blind	—	60 K	60 K	60 K	60 K	75 K	75 K
threaded	—	60 K	60 K	60 K	—	—	—

MINIMUM VERTICAL FULL-OPENING BODY BORES AND MAXIMUM CASING SIZES

Nominal flange				Casing beneath body *					Minimum vertical full-opening wellheads body bore	
Nominal size and bore of flange		Rated working pressure		Size outside diameter		Nominal weight	Specified drift diameter			
(in)	(mm)	(psi)	(MPa)	(in)	(mm)	(lb/ft)	(in)	(mm)	(in)	(mm)
7 1/16	179.39	2.000	13.8	7	177.80	17	6.413	162.9	6.45	163.8
		3.000	20.7	7	177.80	20	6.331	160.8	6.36	161.5
		5.000	34.5	7	177.80	23	6.241	158.5	6.28	159.5
7 1/16	179.39	10.000	69.0	7	177.80	29	6.059	153.9	6.09	154.7
		15.000	103.5	7	177.80	38	5.795	147.2	5.83	148.1
		20.000	138.0	7	177.80	38	5.795	147.2	5.83	148.1
9	228.60	2.000	13.8	8 5/8	219.08	24	7.972	202.5	8.00	203.2
		3.000	20.7	8 5/8	219.08	32	7.796	198.0	7.83	198.9
		5.000	34.5	8 5/8	219.08	36	7.700	195.6	7.73	196.3
9	228.60	10.000	69.0	8 5/8	219.08	40	7.600	193.0	7.62	193.5
		15.000	103.5	8 5/8	219.08	49	7.386	187.6	7.41	188.2
11	279.40	2.000	13.8	10 3/4	273.05	40.5	9.894	251.3	9.92	252.0
		3.000	20.7	10 3/4	273.05	40.5	9.894	251.3	9.92	252.0
		5.000	34.5	10 3/4	273.05	51	9.694	246.2	9.73	247.1
11	279.40	10.000	69.0	9 5/8	244.48	53.5	8.379	212.8	8.41	213.6
		15.000	103.5	9 5/8	244.48	53.5	8.379	212.8	8.41	213.6
13 5/8	346.08	2.000	13.8	13 3/8	339.73	54.5	12.459	316.5	12.50	317.5
		3.000	20.7	13 3/8	339.73	61	12.359	313.9	12.39	314.7
13 5/8	346.08	5.000	34.5	13 3/8	339.73	72	12.191	309.7	12.22	310.4
13 5/8	346.08	10.000	69.0	11 3/4	298.45	60	10.616	269.6	10.66	270.8
16 3/4	425.45	2.000	13.8	16	406.40	65	15.062	382.6	15.09	383.3
		3.000	20.7	16	406.40	84	14.822	376.5	14.86	377.4
16 3/4	425.45	5.000	34.5	16	406.40	84	14.822	376.5	14.86	377.4
		10.000	69.0	16	406.40	84	14.822	376.5	14.86	377.4
18 3/4	476.25	5.000	34.5	18 5/8	473.08	87.5	17.567	446.2	17.59	446.8
		10.000	69.0	18 5/8	473.08	87.5	17.567	446.2	18.97	481.8
21 1/4	539.75	2.000	13.8	20	508.00	94	18.936	481.0	18.97	481.8
20 3/4	527.05	3.000	20.7	20	508.00	94	18.936	481.0	18.97	481.8
21 1/4	539.75	5.000	34.5	20	508.00	94	18.936	481.0	18.97	481.8
		10.000	69.0	20	508.00	94	18.936	481.0	18.97	481.6

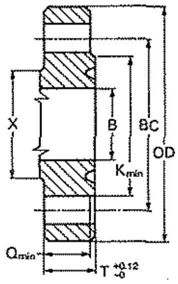


API TYPE 6B FLANGES
Working pressure 2000 psi (13.8 MPa)
(API Spec 6A, 1 April 1986)

Nominal size	Maximum bore B		Outside diameter OD		Diameter of raised face K		Total thickness T		Minimum thickness Q		Diameter of hub X	
(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
2.0625	2.09	53.09	6.50	165.10	4.25	107.95	1.31	33.27	1.00	25.40	3.31	84.07
2.5625	2.59	65.79	7.50	190.50	5.00	127.00	1.44	36.58	1.12	28.45	3.94	100.08
3.1250	3.22	81.79	8.25	209.55	5.75	146.05	1.56	39.62	1.25	31.75	4.62	117.35
4.0625	4.28	108.71	10.75	273.05	6.88	174.75	1.81	45.97	1.50	38.10	6.00	152.40
7.0625	7.16	181.86	14.00	355.60	9.50	241.30	2.19	55.63	1.88	47.75	8.75	222.25
9.0000	9.03	229.36	16.50	419.10	11.88	301.75	2.50	63.50	2.19	55.63	10.75	273.05
11.0000	11.03	280.16	20.00	508.00	14.00	355.60	2.81	71.37	2.50	63.50	13.50	342.90
13.6250	13.66	346.96	22.00	558.80	16.25	412.75	2.94	74.68	2.62	66.55	15.75	400.05
16.7500	16.78	426.21	27.00	685.80	20.00	508.00	3.31	84.07	3.00	76.20	19.50	495.30
21.2500	21.28	540.51	32.00	812.80	25.00	635.00	3.88	98.55	3.50	88.90	24.00	609.60

Bolt sizes

Nominal size	Diameter of bolt circle BC		Number of bolts	Diameter of bolts		Length of bolts L		Ring number R or RX
(in)	(in)	(mm)		(in)	(mm)	(in)	(mm)	R-RX
2.0625	5.00	127.00	8	0.625	15.88	4.50	114.30	23
2.5625	5.88	149.35	8	0.750	19.05	5.00	127.00	26
3.1250	6.62	168.15	8	0.750	19.05	5.25	133.35	31
4.0625	8.50	215.90	8	0.875	22.23	6.00	152.40	37
7.0625	11.50	292.10	12	1.000	25.40	7.00	177.80	45
9.0000	13.75	349.25	12	1.125	28.58	8.00	203.20	49
11.0000	17.00	431.80	16	1.250	31.75	8.75	222.25	53
13.6250	19.25	486.95	20	1.250	31.75	9.00	228.60	57
16.7500	23.75	603.25	20	1.500	38.10	10.25	260.35	65
21.2500	28.50	723.90	24	1.625	41.28	11.75	298.45	73

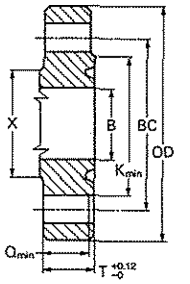


API TYPE 6B FLANGES
Working pressure 3000 psi (20.7 MPa)
(API Spec 6A, 1 April 1986)

Nominal size	Maximum bore B		Outside diameter OD		Diameter of raised face K		Total thickness T		Minimum thickness Q		Diameter of hub X	
(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
2.0625	2.09	53.09	8.50	215.90	4.88	123.95	1.81	45.97	1.50	38.10	4.12	104.65
2.5625	2.59	65.79	9.62	244.35	5.38	136.65	1.94	49.28	1.62	41.15	4.88	123.95
3.1250	3.22	81.79	9.50	241.30	6.12	155.45	1.81	45.97	1.50	38.10	5.00	127.00
4.0625	4.28	108.71	11.50	292.10	7.12	180.85	2.06	52.32	1.75	44.45	6.25	158.75
7.0625	7.16	181.86	15.00	381.00	9.50	241.30	2.50	63.50	2.19	55.63	9.25	234.95
9.0000	9.03	229.36	18.50	469.90	12.12	307.85	2.81	71.37	2.50	63.50	11.75	298.45
11.0000	11.03	280.16	21.50	546.10	14.25	361.95	3.06	77.72	2.75	69.85	14.50	368.30
13.6250	13.66	346.96	24.00	609.60	16.50	419.10	3.44	87.38	3.12	79.25	16.50	419.10
16.7500	16.78	426.21	27.75	704.85	20.62	523.75	3.94	100.08	3.50	88.90	20.00	508.00
20.7500	20.78	527.81	33.75	857.25	25.50	647.70	4.75	120.65	4.25	107.95	24.50	622.30

Bolt sizes

Nominal size	Diameter of bolt circle BC		Number of bolts	Diameter of bolts		Length of bolts L		Ring number R or RX
(in)	(in)	(mm)		(in)	(mm)	(in)	(mm)	R-RX
2.0625	6.50	165.10	8	0.875	22.23	6.00	152.40	24
2.5625	7.50	190.50	8	1.000	25.40	6.50	165.10	27
3.1250	7.50	190.50	8	0.875	22.23	6.00	152.40	31
4.0625	9.25	234.95	8	1.125	28.58	7.00	177.80	37
7.0625	12.50	317.50	12	1.125	28.58	8.00	203.20	45
9.0000	15.50	393.70	12	1.375	34.93	9.00	228.60	49
11.0000	18.50	469.90	16	1.375	34.93	9.50	241.30	53
13.6250	21.00	533.40	20	1.375	34.93	10.25	260.35	57
16.7500	24.25	615.95	20	1.625	41.28	11.75	298.45	66
20.7500	29.50	749.30	20	2.000	50.80	14.50	368.30	74

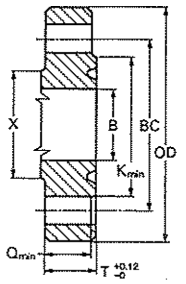


API TYPE 6B FLANGES
Working pressure 5000 psi (34.5 MPa)
(API Spec 6A, 1 April 1986)

Nominal size	Maximum bore B		Outside diameter OD		Diameter of raised face K		Total thickness T		Minimum thickness Q		Diameter of hub X	
(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
2.0625	2.09	53.09	8.50	215.90	4.88	123.95	1.81	45.97	1.50	38.10	4.12	104.65
2.5625	2.59	65.79	9.62	244.35	5.38	136.65	1.94	49.28	1.62	41.15	4.88	123.95
3.1250	3.22	81.79	10.50	266.70	6.62	168.15	2.19	55.63	1.88	47.75	5.25	133.35
4.0625	4.28	108.71	12.25	311.15	7.62	193.55	2.44	61.98	2.12	53.85	6.38	162.05
7.0625	7.16	181.86	15.50	393.70	9.75	247.65	3.62	91.95	3.25	82.55	9.00	228.60
9.0000	9.03	229.36	19.00	482.60	12.50	317.50	4.06	103.12	3.62	91.95	11.50	292.10
11.0000	11.03	280.16	23.00	584.20	14.63	371.60	4.69	119.13	4.25	107.95	14.50	368.30

Bolt sizes

Nominal size	Diameter of bolt circle BC		Number of bolts	Diameter of bolts		Length of bolts L		Ring number R or RX
(in)	(in)	(mm)		(in)	(mm)	(in)	(mm)	R-RX
2.0625	6.50	165.10	8	0.875	22.23	6.00	152.40	24
2.5625	7.50	190.50	8	1.000	25.40	6.50	165.10	27
3.1250	8.00	203.20	8	1.125	28.58	7.25	184.15	35
4.0625	9.50	241.30	8	1.250	31.75	8.00	203.20	39
7.0625	12.50	317.50	12	1.375	34.93	10.75	273.05	46
9.0000	15.50	393.70	12	1.625	41.28	12.00	304.80	50
11.0000	19.00	482.60	12	1.875	47.63	13.75	349.25	54

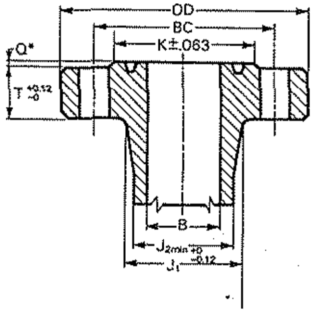


API TYPE 6BX FLANGES

Working pressures : 2000 psi (13.8 MPa), 3000 psi (20.7 MPa), 5000 psi (34.5 MPa) and 10000 psi (69 MPa)

(API Spec 6A, 1 April 1986)

Nominal size	Maximum bore B		Outside diameter OD		Diameter of raised face K		Total thickness T		Large diameter of hub J1		Small diameter of hub J2	
(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
2000 psi (13.8 MPa)												
26.7500	26.78	680.21	41.00	1041.40	31.69	804.93	4.97	126.24	32.91	835.91	29.25	742.95
3000 psi (20.7 MPa)												
26.7500	26.78	680.21	43.38	1101.85	32.75	831.85	6.34	161.04	34.25	869.95	30.56	776.22
5000 psi (34.5 MPa)												
13.6250	13.66	346.96	26.50	673.10	18.00	457.20	4.44	112.78	18.94	481.08	16.69	423.93
16.7500	16.78	426.21	30.38	771.65	21.06	534.92	5.13	130.30	21.88	555.75	20.75	527.05
18.7500	18.78	477.01	35.62	904.75	24.69	627.13	6.53	165.86	26.56	674.62	23.56	598.42
21.2500	21.28	540.51	39.00	990.60	27.62	701.55	7.12	180.85	29.88	758.95	26.75	679.45
10000 psi (69 MPa)												
1.8125	1.84	46.74	7.38	187.45	4.12	104.65	1.66	42.16	3.50	88.90	2.56	65.02
2.0625	2.09	53.09	7.88	200.15	4.38	111.25	1.73	43.94	3.94	100.08	2.94	74.68
2.5625	2.59	65.79	9.12	231.65	5.19	131.83	2.02	51.31	4.75	120.65	3.62	91.95
3.0625	3.09	78.49	10.62	269.75	6.00	152.40	2.30	58.42	5.59	141.99	4.34	110.24
4.0625	4.09	103.89	12.44	315.98	7.28	184.91	2.77	70.36	7.19	182.63	5.75	146.05
5.1250	5.16	131.06	14.06	357.12	8.69	220.73	3.12	79.25	8.81	223.77	7.19	182.63
7.0625	7.09	180.09	18.88	479.55	11.88	301.75	4.06	103.12	11.88	301.75	10.00	254.00
9.0000	9.03	229.36	21.75	552.45	14.12	358.65	4.88	123.95	14.75	374.65	12.88	327.15
11.0000	11.03	280.16	25.75	654.05	16.88	428.75	5.56	141.22	17.75	450.85	15.75	400.05
13.6250	13.66	346.96	30.25	768.35	20.38	517.65	6.62	168.15	21.75	552.45	19.50	495.30
16.7500	16.78	426.21	34.31	871.47	22.69	576.33	6.62	168.15	25.81	655.57	23.69	601.73
18.7500	18.78	477.01	40.94	1039.88	27.44	696.98	8.78	223.01	29.62	752.35	26.56	674.62
21.2500	21.28	540.51	45.00	1143.00	30.75	781.05	9.50	241.30	33.38	847.85	30.00	762.00

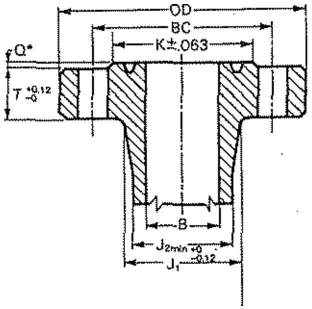


Q^*_{max} = E (Table X D3 - API 6A)
Q^*_{min} = 0.12"

API TYPE 6BX FLANGES (continued)
Working pressure : 2000 psi (13.8 MPa), 3000 psi (20.7 MPa) 5000 psi (34.5 MPa) and 10000 psi (69 MPa)
(API Spec 6A, 1 April 1986)

Bolt sizes

Nominal size	Diameter of bolt circle BC		Number of bolts	Diameter of bolts		Length of bolts L		Ring-joint type
(in)	(in)	(mm)		(in)	(mm)	(in)	(mm)	BX
2000 psi (13.8 MPa)								
26.7500	37.50	952.50	20	1.750	44.45	13.75	349.25	167
3000 psi (20.7 MPa)								
26.7500	39.38	1000.25	24	2.000	50.80	17.00	431.80	168
5000 psi (34.5 MPa)								
13.6250	23.25	590.55	16	1.625	41.28	12.50	317.50	160
16.7500	26.62	676.15	16	1.875	47.63	14.50	368.30	162
18.7500	31.62	803.15	20	2.000	50.80	17.50	444.50	163
21.2500	34.88	885.95	24	2.000	50.80	18.75	476.25	165
10000 psi (69 MPa)								
1.8125	5.75	146.05	8	750	19.05	5.00	127.00	151
2.0625	6.25	158.75	8	750	19.05	5.20	132.08	152
2.5625	7.25	184.15	8	875	22.23	6.00	152.40	153
3.0625	8.50	215.90	8	1.000	25.40	6.75	171.45	154
4.0625	10.19	258.83	8	1.125	28.58	8.00	203.20	155
5.1250	11.81	299.97	12	1.125	28.58	8.75	222.25	169
7.0625	15.88	403.35	12	1.500	38.10	11.25	285.75	156
9.0000	18.75	476.25	16	1.500	38.10	13.00	330.20	157
11.0000	22.25	565.15	16	1.750	44.45	15.00	381.00	158
13.6250	26.50	673.10	20	1.875	47.63	17.25	438.15	159
16.7500	30.56	776.22	24	1.875	47.63	17.50	444.50	162
18.7500	36.44	925.58	24	2.250	57.15	22.50	571.50	164
21.2500	40.25	1022.35	24	2.500	63.50	24.50	622.30	166



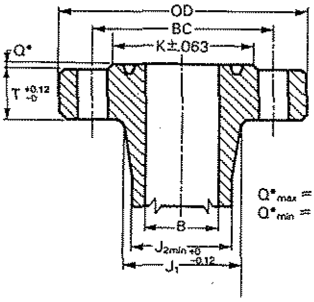
Q^*_{max} = E (Table X D3 - API 6A)
Q^*_{min} = 0.12"

API TYPE 6BX FLANGES
Working pressure : 15000 psi (103.5 MPa)
(API Spec 6A, 1 April 1986)

Nominal size	Maximum bore B		Outside diameter OD		Diameter of raised face K		Total thickness T		Large diameter of hub J1		Small diameter of hub J2	
(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
1.8125	1.84	46.74	8.19	208.03	4.19	106.43	1.78	45.21	3.84	97.54	2.81	71.37
2.0625	2.09	53.09	8.75	222.25	4.50	114.30	2.00	50.80	4.38	111.25	3.25	82.55
2.5625	2.59	65.79	10.00	254.00	5.25	133.35	2.25	57.15	5.06	128.52	3.94	100.08
3.0625	3.09	78.49	11.31	287.27	6.06	153.92	2.53	64.26	6.06	153.93	4.81	122.17
4.0625	4.09	103.89	14.19	360.43	7.62	193.55	3.09	78.49	7.69	195.33	6.25	158.75
7.0625	7.09	180.09	19.88	504.95	12.00	304.80	4.69	119.13	12.81	325.37	10.88	276.35
9.0000	9.03	229.36	25.50	647.70	15.00	381.00	5.75	146.05	17.00	431.80	13.75	349.25
11.0000	11.03	280.16	32.00	812.80	17.88	454.15	7.38	187.45	23.00	584.20	16.81	426.97
13.6250	13.66	346.96	34.88	885.95	21.31	541.27	8.06	204.72	23.44	595.38	20.81	528.57
18.7500	18.78	477.01	45.75	1162.05	28.44	722.38	10.06	255.52	32.00	812.80	28.75	730.25

Bolt sizes

Nominal size	Diameter of bolt circle BC		Number of bolts	Diameter of bolts		Length of bolts L		Ring-joint type
(in)	(in)	(mm)		(in)	(mm)	(in)	(mm)	BX
1.8125	6.31	160.27	8	0.875	22.23	5.50	139.70	151
2.0625	6.88	174.75	8	0.875	22.23	6.00	152.40	152
2.5625	7.88	200.15	8	1.000	25.40	6.75	171.45	153
3.0625	9.06	230.12	8	1.125	28.58	7.50	190.50	154
4.0625	11.44	290.58	8	1.375	34.93	9.25	234.95	155
7.0625	16.88	428.75	16	1.500	38.10	12.75	323.85	156
9.0000	21.75	552.45	16	1.875	47.63	15.75	400.05	157
11.0000	28.00	711.20	20	2.000	50.80	19.25	488.95	158
13.6250	30.38	771.65	20	2.250	57.15	21.25	539.75	159
18.7500	40.00	1016.00	20	3.000	76.20	26.75	679.45	164



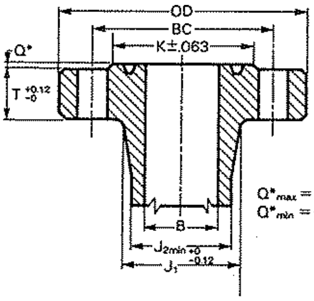
Q^*_{max} = E (Table X D3 - API 6A)
Q^*_{min} = 0.12″

API TYPE 6BX FLANGES
Working pressure : 20000 psi (138 MPa)
(API Spec 6A, 1 April 1986)

Nominal size	Maximum bore B		Outside diameter OD		Diameter of raised face K		Total thickness T		Large diameter of hub J1		Small diameter of hub J2	
(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
1.8125	1.84	46.74	10.12	257.05	4.62	117.35	2.50	63.50	5.25	133.35	4.31	109.47
2.0625	2.09	53.09	11.31	287.27	5.19	131.83	2.81	71.37	6.06	153.92	5.00	127.00
2.5625	2.59	65.79	12.81	325.37	5.94	150.88	3.12	79.25	6.81	172.97	5.69	144.53
3.0625	3.09	78.49	14.06	357.12	6.75	171.45	3.38	85.85	7.56	192.02	6.31	160.27
4.0625	4.09	103.89	17.56	446.02	8.62	218.95	4.19	106.43	9.56	242.82	8.12	206.25
7.0625	7.09	180.09	25.81	655.57	13.88	352.55	6.50	165.10	15.19	385.83	13.31	338.07
9.0000	9.03	229.36	31.69	804.93	17.38	441.45	8.06	204.72	18.94	481.08	16.88	428.75
11.0000	11.03	280.16	34.75	882.65	19.88	504.95	8.81	223.77	22.31	566.67	20.00	508.00
13.6250	13.66	346.96	45.75	1162.05	24.19	614.43	11.50	292.10	27.31	693.67	24.75	628.65

Bolt sizes

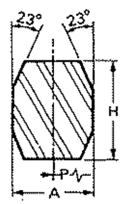
Nominal size	Diameter of bolt circle BC		Number of bolts	Diameter of bolts		Length of bolts L		Ring-joint type
(in)	(in)	(mm)		(in)	(mm)	(in)	(mm)	BX
1.8125	8.00	203.20	8	1.0000	25.40	7.50	190.50	151
2.0625	9.06	230.12	8	1.1250	28.58	8.25	209.55	152
2.5625	10.31	261.87	8	1.2500	31.75	9.25	234.95	153
3.0625	11.31	287.27	8	1.3750	34.93	10.00	254.00	154
4.0625	14.06	357.12	8	1.7500	44.45	12.25	311.15	155
7.0625	21.81	553.97	16	2.0000	50.80	17.50	444.50	156
9.0000	27.00	685.80	16	2.5000	63.50	22.38	568.45	157
11.0000	29.50	749.30	16	2.7500	69.85	23.75	603.25	158
13.6250	40.00	1016.00	20	3.1250	79.38	30.00	762.00	159



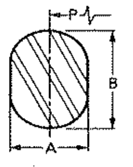
Q^*_{max} = E (Table X D3 - API 6A)
Q^*_{min} = 0.12″

API TYPE R RING-JOINT GASKETS

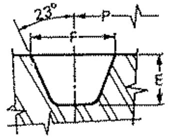
Ring No.	Pitch diameter of ring and groove P		Width of ring A		Height of oval ring B		Height of octogonal ring H		Depth of groove E		Width of groove F		Approximate distance between make-up flanges S	
R	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
20	2.688	68.28	0.313	7.95	0.56	14.22	0.50	12.70	0.25	6.35	0.344	8.74	0.16	4.06
23	3.250	82.55	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
24	3.750	95.25	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
26	4.000	101.60	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
27	4.250	107.95	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
31	4.875	123.83	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
35	5.375	136.53	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
37	5.875	149.23	0.438	11.13	0.59	14.99	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
39	6.375	161.93	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
41	7.125	180.98	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
44	7.625	193.68	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
45	8.313	211.15	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
46	8.313	211.15	0.500	12.70	0.75	19.05	0.69	17.53	0.38	9.65	0.521	13.23	0.13	3.30
47	9.000	228.60	0.750	19.05	1.00	25.40	0.94	23.88	0.50	12.70	0.781	19.84	0.16	4.06
49	10.625	269.88	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
50	10.625	269.88	0.625	15.88	0.88	22.35	0.81	20.57	0.44	11.18	0.656	16.66	0.16	4.06
53	12.750	323.85	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
54	12.750	323.85	0.625	15.88	0.88	22.35	0.81	20.57	0.44	11.18	0.656	16.66	0.16	4.06
57	15.000	381.00	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
63	16.500	419.10	1.000	25.40	1.31	33.27	1.25	31.75	0.62	15.75	1.063	27.00	0.22	5.59
65	18.500	469.90	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
66	18.500	469.90	0.625	15.88	0.88	22.35	0.81	20.57	0.44	11.18	0.656	16.66	0.16	4.06
69	21.000	533.40	0.438	11.13	0.69	17.53	0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
70	21.000	533.40	0.750	19.05	1.00	25.40	0.94	23.88	0.50	12.70	0.781	19.84	0.19	4.83
73	23.000	584.20	0.500	12.70	0.75	19.05	0.69	17.53	0.38	9.65	0.531	13.49	0.13	3.30
74	23.000	584.20	0.750	19.05	1.00	25.40	0.94	23.88	0.50	12.70	0.781	19.84	0.19	4.83
82	2.250	57.15	0.438	11.13			0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
84	2.500	63.50	0.438	11.13			0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83
85	3.125	79.38	0.500	12.70			0.69	17.53	0.38	9.65	0.531	13.49	0.13	3.30
86	3.563	90.50	0.625	15.88			0.81	20.57	0.44	11.18	0.656	16.66	0.16	4.06
87	3.938	100.03	0.625	15.88			0.81	20.57	0.44	11.18	0.656	16.66	0.16	4.06
88	4.875	123.83	0.750	19.05			0.94	23.88	0.50	12.70	0.781	19.84	0.19	4.83
89	4.500	114.30	0.750	19.05			0.94	23.88	0.50	12.70	0.781	19.84	0.19	4.83
90	6.125	155.58	0.875	22.23			1.06	26.92	0.56	14.22	0.906	23.01	0.19	4.83
91	10.250	260.35	1.250	31.75			1.50	38.10	0.69	17.53	1.313	33.35	0.16	4.06
99	9.250	234.95	0.438	11.13			0.63	16.00	0.31	7.87	0.469	11.91	0.19	4.83



Octogonal



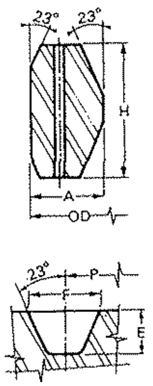
Oval



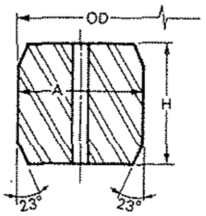
Groove

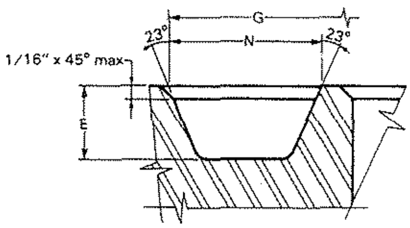
API TYPE RX RING-JOINT GASKETS

Ring No.	Pitch diameter of ring and groove P		Outside diameter of ring OD		Width of ring A		Height H		Depth of groove E		Width of groove F		Approximate distance between make-up flanges S	
RX	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
20	2.688	68.28	3.000	76.20	0.344	8.74	0.750	19.05	0.25	6.35	0.344	8.74	0.38	9.65
23	3.250	82.55	3.672	93.27	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
24	3.750	95.25	4.172	105.97	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
25	4.000	101.60	4.313	109.55	0.344	8.74	0.750	19.05	0.25	6.35	0.344	8.74		
26	4.000	101.60	4.406	111.91	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
27	4.250	107.95	4.656	118.26	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
31	4.875	123.83	5.297	134.54	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
35	5.375	136.53	5.797	147.24	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
37	5.875	149.23	6.297	159.94	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
39	6.375	161.93	6.797	172.64	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
41	7.125	180.98	7.547	191.69	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
44	7.625	193.68	8.047	204.39	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
45	8.313	211.15	8.734	221.84	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
46	8.313	211.15	8.750	222.25	0.531	13.49	1.125	28.58	0.38	9.65	0.531	13.49	0.47	11.94
47	9.000	228.60	9.656	245.26	0.781	19.84	1.625	41.28	0.50	12.70	0.781	19.84	0.91	23.11
49	10.625	269.88	11.047	280.59	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
50	10.625	269.88	11.156	283.36	0.656	16.66	1.250	31.75	0.44	11.18	0.656	16.66	0.47	11.94
53	12.750	323.85	13.172	334.57	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
54	12.750	323.85	13.281	337.34	0.656	16.66	1.250	31.75	0.44	11.18	0.656	16.66	0.47	11.94
57	15.000	381.00	15.422	391.72	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
63	16.500	419.10	17.391	441.73	1.063	27.00	2.000	50.80	0.63	16.00	1.063	27.00	0.84	21.34
65	18.500	469.90	18.922	480.62	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
66	18.500	469.90	19.031	483.39	0.656	16.66	1.250	31.75	0.44	11.18	0.656	16.66	0.47	11.94
69	21.000	533.40	21.422	544.12	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
70	21.000	533.40	21.656	550.06	0.781	19.84	1.625	41.28	0.50	12.70	0.781	19.84	0.72	18.29
73	23.000	584.20	23.469	596.11	0.531	13.49	1.250	31.75	0.38	9.65	0.531	13.49	0.59	14.99
74	23.000	584.20	23.656	600.86	0.781	19.84	1.625	41.28	0.50	12.70	0.781	19.84	0.72	18.29
82	2.250	57.15	2.672	67.87	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
84	2.500	63.50	2.922	74.22	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
85	3.125	79.38	3.547	90.09	0.531	13.49	1.000	25.40	0.38	9.65	0.531	13.49	0.38	9.65
86	3.563	90.50	4.078	103.58	0.594	15.09	1.125	28.58	0.44	11.18	0.656	16.66	0.38	9.65
87	3.938	100.03	4.453	113.11	0.594	15.09	1.125	28.58	0.44	11.18	0.656	16.66	0.38	9.65
88	4.875	123.83	5.484	139.29	0.688	17.48	1.250	31.75	0.50	12.70	0.781	19.84	0.38	9.65
89	4.500	114.30	5.109	129.77	0.719	18.26	1.250	31.75	0.50	12.70	0.781	19.84	0.38	9.65
90	6.125	155.58	6.875	174.63	0.781	19.84	1.750	44.45	0.56	14.22	0.906	23.01	0.72	18.29
91	10.250	260.35	11.297	286.94	1.388	35.26	1.781	45.24	0.69	17.53	1.313	33.35	0.75	19.05
99	9.250	234.95	9.672	245.67	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91	0.47	11.94
201	1.813	46.05	2.026	51.46	0.226	5.74	0.445	11.30	0.16	4.06	0.219	5.56		
205	2.250	57.15	2.453	62.31	0.219	5.56	0.437	11.10	0.16	4.06	0.219	5.56		
210	3.500	88.90	3.844	97.64	0.375	9.53	0.750	19.05	0.25	6.35	0.375	9.53		
215	5.125	130.18	5.547	140.89	0.469	11.91	1.000	25.40	0.31	7.87	0.469	11.91		



API TYPE BX RING-JOINT GASKETS





Ring No.	Outside diameter OD		Height H		Width of ring A		Depth of groove E		Outside diameter of groove G		Width of groove N	
BX	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
150	2.842	72.19	0.366	9.30	0.366	9.30	0.220	5.59	2.893	73.48	0.450	11.43
151	3.008	76.40	0.379	9.63	0.379	9.63	0.220	5.59	3.062	77.77	0.466	11.84
152	3.334	84.68	0.403	10.24	0.403	10.24	0.230	5.84	3.395	86.23	0.498	12.65
153	3.974	100.94	0.448	11.38	0.448	11.38	0.270	6.86	4.046	102.77	0.554	14.07
154	4.600	116.84	0.488	12.40	0.488	12.40	0.300	7.62	4.685	119.00	0.606	15.39
155	5.825	147.96	0.560	14.22	0.560	14.22	0.330	8.38	5.930	150.62	0.698	17.73
156	9.367	237.92	0.733	18.62	0.733	18.62	0.440	11.18	9.521	241.83	0.921	23.39
157	11.593	294.46	0.826	20.98	0.826	20.98	0.500	12.70	11.774	299.06	1.039	26.39
158	13.860	352.04	0.911	23.14	0.911	23.14	0.560	14.22	14.064	357.23	1.149	29.18
159	16.800	426.72	1.012	25.70	1.012	25.70	0.620	15.75	17.033	432.64	1.279	32.49
160	15.850	402.59	0.938	23.83	0.541	13.74	0.560	14.22	16.063	408.00	0.786	19.96
161	19.347	491.41	1.105	28.07	0.638	16.21	0.670	17.02	19.604	497.94	0.930	23.62
162	18.720	475.49	0.560	14.22	0.560	14.22	0.330	8.38	18.832	478.33	0.705	17.91
163	21.896	556.16	1.185	30.10	0.684	17.37	0.720	18.29	22.185	563.50	1.006	25.55
164	22.463	570.56	1.185	30.10	0.968	24.59	0.720	18.29	22.752	577.90	1.290	32.77
165	24.595	624.71	1.261	32.03	0.728	18.49	0.750	19.05	24.904	632.56	1.071	27.20
166	25.198	640.03	1.261	32.03	1.029	26.14	0.750	19.05	25.507	647.88	1.373	34.87
167	29.896	759.36	1.412	35.86	0.516	13.11	0.840	21.34	30.249	768.32	0.902	22.91
168	30.198	767.03	1.412	35.86	0.632	16.05	0.840	21.34	30.481	774.22	1.018	25.86
169	6.831	173.51	0.624	15.85	0.509	12.93	0.380	9.65	6.955	176.66	0.666	16.92
170	8.584	218.03	0.560	14.22	0.560	14.22	0.330	8.38	8.696	220.88	0.705	17.91
171	10.529	267.44	0.560	14.22	0.560	14.22	0.330	8.38	10.641	270.28	0.705	17.91
172	13.113	333.07	0.560	14.22	0.560	14.22	0.330	8.38	13.225	335.92	0.705	17.91

RECOMMENDED FLANGE BOLT TORQUE

Bolt and size (in)	40 000 psi stress (276 MPa)				52 500 psi stress (362 MPa)			
	Bolt tension		Make-up torque		Bolt tension		Make-up torque	
	(lbf)	(daN)	(ft.lb)	(daN.m)	(lbf)	(daN)	(ft.lb)	(daN.m)
1/2 — 13 UNC	5 674	2 525	45	6	7 448	3 315	59	8
5/8 — 11 UNC	9 026	4 015	86	12	11 846	5 270	113	15
3/4 — 10 UNC	13 355	5 940	150	20	17 528	7 800	196	27
7/8 — 9 UNC	18 482	8 220	239	32	24 257	10 790	313	42
1 — 8 UN	24 229	10 780	361	49	31 800	14 145	474	64
1 1/8 — 8 UN	31 617	14 065	522	71	41 497	18 460	686	93
1 1/4 — 8 UN	39 987	17 790	726	98	52 483	23 345	953	129
1 3/8 — 8 UN	49 339	21 945	976	132	64 757	28 805	1 281	174
1 1/2 — 8 UN	59 672	26 540	1 277	173	78 320	34 840	1 676	227
1 5/8 — 8 UN	70 988	31 580	1 635	222	93 171	41 445	2 146	291
1 3/4 — 8 UN	83 284	37 045	2 054	278	109 311	48 625	2 695	365
1 7/8 — 8 UN	96 563	42 950	2 538	344	126 739	56 375	3 331	452
2 — 8 UN	110 824	49 295	3 093	419	145 456	64 700	4 060	550
2 1/4 — 8 UN	142 290	63 295	4 435	601	186 755	83 075	5 821	789
2 1/2 — 8 UN	177 683	79 035	6 116	829	233 209	103 735	8 028	1 088
2 5/8 — 8 UN	196 852	87 565	7 097	962	258 368	114 930	9 314	1 263
2 3/4 — 8 UN	217 003	96 530	8 176	1 109	284 817	126 695	10 731	1 455
3 — 8 UN	260 250	115 765	10 653	1 444	341 578	151 940	13 982	1 896
3 1/4 — 8 UN	307 424	136 750	13 585	1 842	403 495	179 485	17 830	2 417
3 3/4 — 8 UN	413 554	183 960	20 967	2 843	542 790	241 445	27 519	3 731
3 7/8 — 8 UN	442 541	196 850	23 157	3 140	580 834	258 370	30 393	4 121
4 — 8 UN	472 509	210 180	25 494	3 457	620 168	275 865	33 461	4 537
4 1/2 — 8 UN	602 200	267 870	36 412	4 937	790 388	351 580	47 790	6 479
4 3/4 — 8 UN	672 936	299 335	42 879	5 814	883 229	392 880	56 289	7 632

CROSSOVER CONNECTOR WITH RESTRICTED AREA PACKING MECHANISM
(API 6A, 15th Edition, 1 April 1986)

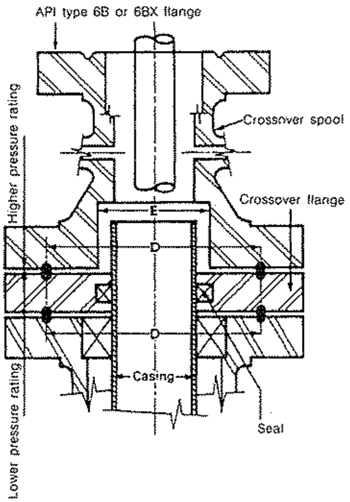
Nominal size		Flange type	Lower connection						Upper connection	
			Rated working pressure		Max. seal diameter		Max. counter-borediameter		Rated working pressure	
(in)	(mm)		(psi)	(MPa)	(in)	(mm)	(in)	(mm)	(psi)	(MPa)
9	228.60	6B	2 000	13.8	8.19	208.0	8.19	208.0	3 000	20.7
		6B	3 000	20.7	8.19	208.0	8.19	208.0	5 000	34.5
		6B	5 000	34.5	7.25	184.2	7.25	184.2	10 000	69.0
		6BX	10 000	69.0	*		6.63	168.4	15 000	103.5
		6BX	15 000	103.5	*		6.63	168.4	20 000	138.0
11	279.40	6B	2 000	13.8	9.56	242.8	9.56	242.8	3 000	20.7
		6B	3 000	20.7	9.56	242.8	9.56	242.8	5 000	34.5
		6B	5 000	34.5	9.13	231.9	9.13	231.9	10 000	69.0
		6BX	10 000	69.0	*		8.57	217.7	15 000	103.5
		6BX	15 000	103.5	*		8.57	217.7	20 000	138.0
13 5/8	346.08	6B	2 000	13.8	11.69	296.9	11.69	296.9	3 000	20.7
		6B	3 000	20.7	11.69	296.9	11.69	296.9	5 000	34.5
		6BX	5 000	34.5	*		11.16	283.5	10 000	69.0
		6BX	10 000	69.0	*		11.16	283.5	15 000	103.5
16 3/4	425.45	6B	2 000	13.8	13.94	354.1	13.94	354.1	3 000	20.7
		6B	3 000	20.7	13.94	354.1	13.94	354.1	5 000	34.5
		6BX	5 000	34.5	*		13.63	346.2	10 000	69.0
		6BX	10 000	69.0	*		13.63	346.2	15 000	103.5
18 3/4	476.25	6BX	5 000	34.5	*		16.75	425.5	10 000	69.0
		6BX	10 000	69.0			16.75	425.5	15 000	103.5
21 1/4	539.75	6B	2 000	13.8	17.44	443.0	17.44	443.0	3 000	20.7

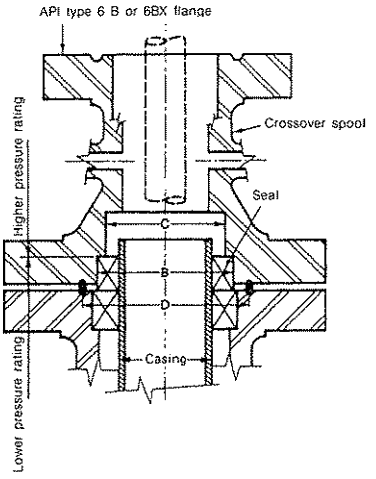
* For flanges smaller than 6BX, see API Spec above.

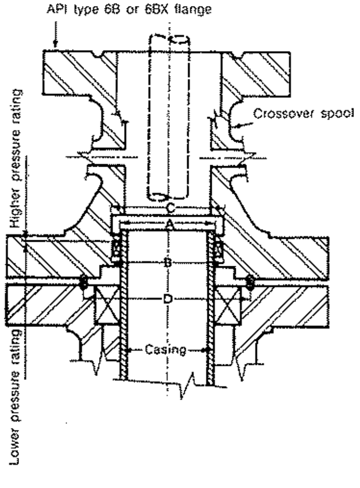
CROSSOVER CONNECTOR WITH RESTRICTED AREA PACKING MECHANISM (continued)

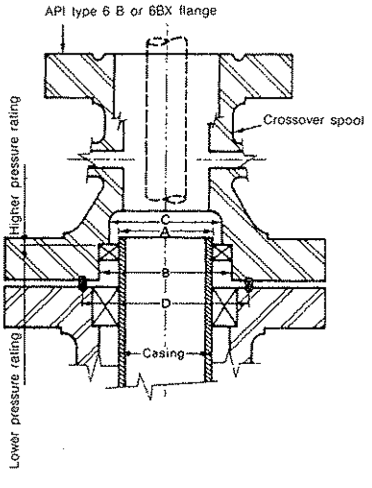
(API 6A, 15th Edition, 1 April 1986)

A Maximum sealed diameter
B Maximum seal diameter
C Maximum counter-bore diameter
D Area ring gasket
E Maximum bore at flange face





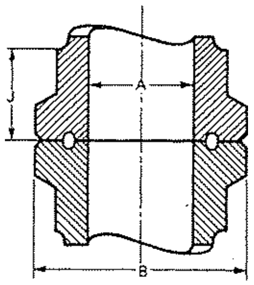




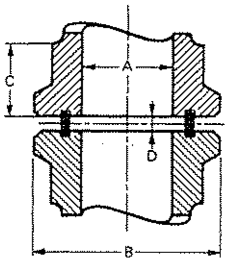
CIW CLAMP FOR FLANGES

CIW hub dimensions

With BX ring-joint



With RX ring-joint



Nominal size A		Ring-joint No.		Hub length (mm)		Outside diameter B (mm)	Clamp No.
(in)	(mm)	RX	BX	RX C (mm)	BX J (mm)		
2000 psi. Maximum working pressure = 13.8 MPa							
7 1/16	179.39	45	—	66.7	—	263.52	25
16 3/4	425.45	65	—	63.5	—	517.52	12
20 3/4	527.05	73	—	73.1	—	630.24	18
21 1/4	539.75	73	—	104.8	—	669.93	18
3000 psi. Maximum working pressure = 20.7 MPa							
11	279.40	53	—	73.0	—	396.84	9
13 5/8	346.08	57	—	76.2	—	466.72	11
16 3/4	425.45	65	—	76.2	—	539.75	14
20 3/4	527.05	73	—	95.3	—	650.87	18
5000 Psi. Maximum working pressure = 34.5 MPa							
2 1/16	52.388	23	152	54.0	—	127.79	1
2 9/16	65.088	24	153	57.2	63.5	146.84	2
3 1/8	79.375	27	154	60.3	66.7	160.33	4
4 1/16	103.19	35	155	60.3	63.5	193.67	5
7 1/16	179.39	45	—	79.4	—	276.22	7
7 1/16	179.39		156	—	92.1	336.55	8
9	228.60	49	157	85.7	92.1	336.55	8
11	279.40	53	158	92.1	101.6	412.75	10
13 5/8	346.08	57	160	108.0	142.9	523.87	13
16 3/4	425.45	65	162	152.4	152.4	650.87	19
21 1/4	539.75	—	165	—	203.2	693.75	27

mm × 0.0394 = in

CIW CLAMP FOR FLANGES (continued)
CIW hub dimensions

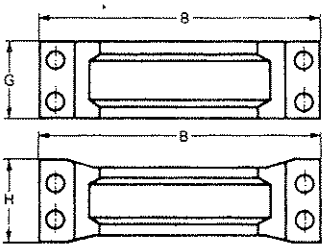
Nominal size A		Ring-joint No.		Hub length (mm)		Outside diameter B (mm)	Clamp No.
(in)	(mm)	RX	BX	RX C (mm)	BX J (mm)		
10 000 psi. Maximum working pressure = 69 MPa							
1 13/16	46.038	20	151	54.0	60.3	127.79	1
2 1/16	52.388	23	152	57.2	63.5	146.84	2
2 9/16	65.088	24	153	60.3	66.7	160.33	4
3 1/8	79.375	27	154	60.3	69.9	193.67	5
4 1/16	103.19	35	155	69.9	76.2	214.31	6
7 1/16	179.39	45	—	85.7	—	336.55	8
7 1/16	179.39	—	156	—	88.9	412.75	10
9	228.60	49	157	92.1	92.1	412.75	10
11	279.40	—	158	—	130.2	523.88	22
13 5/8	346.08	57	159	130.2	136.5	565.15	15
16 3/4	425.45	—	162	—	177.8	711.20	28
18 3/4	476.25	—	164	—	203.2	793.75	27
21 1/4	539.75	—	166	—	203.2	863.60	26
15 000 psi. Maximum working pressure = 103.5 MPa							
1 13/16	46.038	20	151	57.2	63.5	146.84	2
2 1/16	52.388	23	152	82.6	85.7	155.57	3
2 9/16	65.088	24	153	82.6	85.7	155.57	3
3 1/8	79.375	27	154	69.9	76.2	214.31	6
4 1/16	103.19	—	155	—	92.1	336.55	8
7 1/16	179.39	45	—	92.1	—	412.75	10
7 1/16	179.39	—	156	—	130.2	523.90	22
11	279.40	—	158	—	136.5	565.15	15
13 5/8	346.08	—	159	—	177.8	711.40	28
18 3/4	476.25	—	164	—	203.2	863.60	26
20 000 psi. Maximum working pressure = 138 MPa							
1 13/16	46.038	—	151	—	85.7	155.57	3
2 1/16	52.388	—	152	—	85.7	155.57	3
2 9/16	65.088	—	153	—	76.2	214.30	6
3 1/8	79.375	—	154	—	92.1	336.55	8
4 1/16	103.19	—	155	—	88.9	412.75	10
7 1/16	179.39	—	156	—	136.5	565.15	15

mm × 0.0394 = in

CIW CLAMP FOR FLANGES

CIW clamp dimensions

Plan view



Side view

Clamp No.	B (mm)	C (mm)	Nominal size of studs (in)	Length of studs F (mm)	G (mm)	H (mm)	I (mm)
1	266.7	50.8	0.875-9UN	177.8	106.43	—	97.54
2	304.8	63.5	0.875-9UN	203.2	108.71	—	108.71
3	355.6	69.85	1.000-8UN	228.6	157.23	—	127.76
4	317.5	63.5	1.000-8UN	215.9	113.54	—	119.13
5	349.25	63.5	1.000-8UN	215.9	114.3	—	134.11
6	419.1	76.2	1.125-8UN	247.65	136.65	—	153.92
7	508.0	95.25	1.375-8UN	304.8	149.35	—	187.45
8	603.25	107.95	1.500-8UN	342.9	165.1	—	223.01
9	654.05	107.95	1.375-8UN	330.2	139.7	146.05	245.36
10	723.9	139.7	1.625-8UN	412.75	171.45	—	264.41
11	771.65	141.22	1.375-8UN	381	139.7	149.39	292.1
12	771.65	133.35	1.375-8UN	381	117.35	146.05	305.56
13	838.2	153.16	2.250-8UN	508	195.07	234.95	331.22
14	793.75	165.1	1.625-8UN	463.55	146.05	146.05	328.68
15	990.6	133.35	2.500-8UN	488.95	263.65	—	371.35
16	889.0	171.45	1.625-8UN	476.25	139.7	172.97	373.13
17	968.25	162.05	2.250-8UN	501.65	172.97	234.95	393.7
18	990.6	165.1	2.250-8UN	508	184.15	241.30	412.75
19	1028.7	200.15	2.500-8UN	596.9	225.30	266.70	406.4
20	1216.2	152.4	1.500-8UN	431.8	193.55	—	505.71
21	1025.7	139.7	1.250-8UN	381	165.1	—	421.39
22	853.95	139.7	2.250-8UN	457.2	222.25	234.95	338.07
23	1397	184.15	2.250-8UN	546.1	234.95	—	607.31
24	1295.4	162.05	1.625-8UN	457.2	193.55	—	546.1
25	425.45	66.55	0.875-9UN	215.9	120.65	—	169.93
26	1384.3	290.58	4.000-8UN	939.8	401.57	—	552.20
27	1231.9	169.67	3.250-8UN	622.3	333.25	—	496.82
28	1136.9	152.4	3.000-8UN	660.4	304.8	—	450.85

mm × 0.0394 = in

CIW CLAMP FOR FLANGES

Make-up torque on bolts of CIW clamps

Clamp No.	Nominal size of studs (in)	Torque API 5A lubricant (daN.m)	Torque molybdenum lubricant (daN.m)
1	7/8	18.6	12.7
2	7/8	37.2	24.5
3	1	54.9	37.2
4	1	54.9	37.2
5	1	54.9	37.2
6	1 1/8	81.4	54.9
7	1 3/8	149	95
8	1 1/2	197	129.4
9	1 3/8	149	95
10	1 5/8	251	162.8
11	1 3/8	149	95
12	1 3/8	149	95
13	2 1/4	678.8	434.5
14	1 5/8	251	162.8
15	2 1/2	949.6	597.4
16	1 5/8	251	162.8
17	2 1/4	678.8	434.5
18	2 1/4	678.8	434.5
19	2 1/2	949.6	597.4
20	1 1/2	197	129.4
21	1 1/4	108.8	74.5
22	2 1/4	678.8	434.5
23	2 1/4	678.8	434.5
24	1 5/8	251	162.8
25	7/8	36.2	24.5
26	4	3866	2427
27	3 1/4	2062	1302
28	3	1628	1031

daN.m × 7.38 = lb.ft

CAMERON RAM-TYPE BLOW-OUT PREVENTERS
Operating data

Model	Nominal size (in)	Working pressure (psi)	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
			(gal)	(liters)	(gal)	(liters)		
Type U	7 1/16	3000 to 15000	1.3	4.9	1.3	4.9	6.9	2.2
	11	3000 to 10000	3.4	12.9	3.5	13.2	7.3	2.5
	11	15000	6.1	23.1	6.2	23.5	9.8	2.2
	13 5/8	3000 to 10000	5.4	20.4	5.8	22.0	7.0	2.3
	13 5/8	15000	10.4	39.4	10.6	40.1	10.6	3.6
	16 3/4	3000 and 5000	9.8	37.1	10.6	40.1	6.8	2.3
	16 3/4	10000	11.6	43.9	12.4	46.9	6.8	2.3
	18 3/4	10000	21.2	80.2	23.1	87.4	7.4	3.7
	20 3/4 21 1/4	3000 2000	7.9	29.9	8.4	31.8	7.0	1.3
	21 1/4	5000	27.2	103.0	29.9	113.2	6.2	4.0
	21 1/4	10000	24.5	92.7	26.9	101.8	7.2	4.0
	26 3/4	3000	10.1	38.2	10.8	40.9	7.0	1.0
Type U Special cavity (Shear ram)	11	3000 to 10000	7.4	28.0	7.6	28.8	12.0	4.8
	11	15000	8.9	33.7	9.0	34.1	15.2	3.7
	13 5/8	3000 to 10000	10.5	39.7	10.9	41.3	10.8	4.5
	13 5/8	15000	16.0	60.6	16.2	61.3	16.2	6.0
	16 3/4	3000 and 5000	18.1	68.5	19.0	71.9	10.4	4.4
	16 3/4	10000	18.2	68.9	19.1	72.3	10.4	4.4
	20 3/4 21 1/4	3000 2000	14.3	54.1	14.9	56.4	10.8	1.7
Type UII	18 3/4	10000	22.3	84.4	24.7	93.5	6.7	2.5
	18 3/4	15000	32.3	122.3	34.7	131.4	9.3	3.5
Type T	18 3/4	15000	22.2	84.0	24.2	91.6	6.7	3.1

HYDRIL RAM-TYPE BLOW-OUT PREVENTERS
Operating data

Model	Nominal size (in)	Working pressure (psi)	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
			(gal)	(liters)	(gal)	(liters)		
Manual-Lock	7 1/16	3 000 and 5 000	0.93	3.5	1	3.8	4.8	1.5
	7 1/16	10 000	1.8	6.8	1.9	7.2	7.7	1.7
	7 1/16	15 000	3.4	12.9	3.7	14.0	7.1	6.6
	9	3 000 and 5 000	1.9	7.2	1.9	7.2	4.5	2.6
	11	3 000 and 5 000	3.2	12.1	3.3	12.5	6.0	2.0
	11	10 000	5.0	18.9	5.2	19.7	6.9	2.4
	11	15 000	8.1	30.7	8.8	33.3	7.2	3.24
	13 5/8	3 000 and 5 000	4.9	18.5	5.4	20.4	4.8	2.1
	13 5/8	10 000	11.8	44.7	11.8	44.7	10.2	3.8
	20 3/4 21 1/4	3 000 2 000	7.2	27.3	8.1	30.7	4.75	0.98
	21 1/4	5 000	16.6	62.8	17.5	66.2	10.2	1.9
Manual-Lock Shear rams	11	3 000 and 5 000	5.0	18.9	5.5	20.8	5.6	4.2
	11	10 000	8.2	31.0	8.8	33.3	11.7	4.0
	11	15 000	8.1	30.7	8.8	33.3	7.2	3.24
	13 5/8	3 000 and 5 000	11.2	42.4	11.5	43.5	10.1	4.7
	20 3/4 21 1/4	3 000 2 000	16.3	61.7	17.2	65.1	10.14	2.2
	21 1/4	5 000	16.6	62.8	17.5	66.2	10.2	1.9
MPL	7 1/16	3 000 and 5 000	0.93	3.5	1.2	4.5	5.4	1.5
	7 1/16	10 000	1.8	6.8	2	7.6	8.2	1.7
	7 1/16	15 000	3.4	12.9	3.9	14.8	7.6	6.6
	9	3 000 and 5 000	1.9	7.2	2.2	8.3	5.3	2.6

HYDRIL RAM-TYPE BLOW-OUT PREVENTERS (continued)
Operating data

Model	Nominal size (in)	Working pressure (psi)	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
			(gal)	(liters)	(gal)	(liters)		
MPL	11	3 000 and 5 000	3.2	12.1	3.7	14.0	6.8	2.0
	11	10 000	5.0	18.9	5.7	21.6	7.6	2.4
	11	15 000	8.1	30.7	9.3	35.2	7.6	3.24
	13 5/8	3 000	4.9	18.5	5.9	22.3	5.2	2.1
	13 5/8	5 000	5.2	19.7	5.9	22.3	5.2	2.1
	13 5/8	10 000	11.8	44.7	12.9	48.8	10.6	3.8
	13 5/8	15 000	11	41.6	12.6	47.7	7.74	3.56
	16 3/4	10 000	14.1	53.4	15.6	59.1	10.6	2.41
	18 3/4	10 000	15.6	59.1	17.1	64.7	10.6	1.9
	18 3/4	15 000	16.7	63.2	19.4	73.4	7.27	2.15
	20 3/4 21 1/4	3 000 2 000	7.2	27.3	8.9	33.7	5.2	0.98
	21 1/4	5 000	16.6	62.8	19.3	73.1	10.6	1.9
Manual-Lock Shear rams	11	3 000 and 5 000	5	18.9	6	22.7	6	4.2
	11	10 000	8.2	31.0	9.3	35.2	12.4	4.0
	11	15 000	8.1	30.7	9.3	35.2	7.6	3.24
	13 5/8	3 000 and 5 000	11.2	42.4	12.0	45.4	10.6	4.7
	13 5/8	10 000	11.8	44.7	12.9	48.8	10.6	3.8
	13 5/8	15 000	11.0	41.6	12.6	47.7	7.74	3.56
	16 3/4	10 000	14.1	53.4	15.6	59.1	10.6	2.4
	18 3/4	10 000	15.6	59.1	17.1	64.7	10.6	1.9
	18 3/4	15 000	16.7	63.2	19.4	73.4	7.27	2.15
	20 3/4 21 1/4	3 000 2 000	16.3	61.7	18.0	68.1	10.6	2.2
	21 1/4	5 000	16.6	62.8	19.3	73.1	10.6	1.9

NL SHAFFER BLOW-OUT PREVENTERS

Operating data

Model	Nominal size (in)	Working pressure (psi)	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio	Ram size (in)
			(gal)	(liters)	(gal)	(liters)			
Sentinel	7 1/4	3000	0.26	1.1	0.29	1.1	4.0	2.5	—
LWP	7 1/16	3000	0.51	1.9	0.55	2.1	4.49	2.5	5
	9	3000	0.68	2.6	0.77	2.9	4.49	1.81	5
SL Poslock and Manual-Lock	7 1/16	10000	2.34	8.9	2.72	10.3	7.11	3.37	10
	7 1/16	10000	5.57	21.1	6.0	22.7	13.94	7.14	14
	7 1/16	15000	2.34	8.9	2.72	10.3	7.11	3.37	10
	7 1/16	15000	5.57	21.1	6.00	22.7	13.94	7.14	14
	11	10000	7.0	26.5	9.45	35.8	7.11	4.62	14
	11	15000	8.1	30.7	9.4	35.6	7.11	2.8	14
	13 5/8	3000	4.46	16.9	5.44	20.6	5.54	3.00	10
	13 5/8	5000	4.46	16.9	5.44	20.6	5.54	3.00	10
	13 5/6	5000	10.52	39.8	11.0	41.6	10.85	10.02	14
	13 5/8	10000	10.52	39.8	10.58	40.0	7.11	4.29	14
	13 5/8	15000	10.52	39.8	11.56	43.8	7.11	2.14	14
	16 3/4	5000	4.97	18.8	6.07	23.0	5.54	2.03	10
	16 3/4	5000	10.67	40.4	11.76	44.5	10.85	5.77	14
	16 3/4	10000	12.50	47.3	14.47	54.8	7.11	2.06	14
	18 3/4	10000	13.21	50.0	14.55	55.1	7.11	1.83	14
	18 3/4	15000	13.33	50.5	14.62	55.3	10.85	1.68	14
	21 1/4	10000	13.86	52.5	16.05	60.8	7.11	1.63	14
LWS Poslock and Manual-Lock	4 1/16	5000 and 10000	0.52	2.0	0.59	2.2	8.45	4.74	6
	7 1/16	5000	1.18	4.5	1.45	5.5	5.45	1.93	6 1/2
	7 1/16*	10000	5.25	19.9	5.18	19.6	10.63	15.22	14
	9	5000	2.27	8.6	2.58	9.8	5.57	3.00	8 1/2
	11	3000	1.45	5.5	1.74	6.6	5.45	1.16	6 1/2
	11	5000	2.62	9.9	2.98	11.3	5.57	2.09	8 1/2
	11	5000	8.9	33.7	9.5	36.0	16.00	3.41	14
	20 3/4	3000	4.46	16.9	5.07	19.2	5.57	0.78	8 1/2
	20 3/4	3000	6.86	26.0	7.80	29.5	8.16	1.15	10
	20 3/4	3000	13.59	51.4	14.50	54.9	16.00	2.21	14
	21 1/4	2000	4.46	16.9	5.07	19.2	5.57	0.78	8 1/2
	21 1/4	2000	6.86	26.0	7.80	29.5	8.16	1.15	10
	21 1/4	2000	13.59	51.4	14.50	54.9	16.00	2.21	14

* Replaced by 7 1/16 inch, 10000 psi type SL.

KOOMEY RAM-TYPE BLOW-OUT PREVENTERS
Operating data

Model	Nominal size (in)	Working pressure (psi)	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
			(gal)	(liters)	(gal)	(liters)		
PB-PRC (Power Ram Change)	7 1/16	3 000	0.96	3.6	1.02	3.9	4.62	1.50
	7 1/16	5 000	0.96	3.6	1.02	3.9	0.69	0.50
	7 1/16	10 000	0.96	3.6	1.02	3.9	7.75	2.50
	13 5/8	3 000	5.78	21.9	6.25	23.7	4.62	1.50
	13 5/8	5 000	5.78	21.9	6.25	23.7	7.69	2.50
	13 5/8	10 000	5.78	21.9	6.25	23.7	7.75	2.50
PL-PRC (Power Ram Change)	7 1/16	3 000	0.97	3.7	1.10	4.2	4.62	1.50
	7 1/16	5 000	0.97	3.7	1.10	4.2	7.69	2.50
	7 1/16	10 000	0.97	3.7	1.10	4.2	7.75	2.50
	11	3 000	3.3	12.5	3.6	13.6	4.44	1.50
	11	5 000	3.3	12.5	3.6	13.6	7.41	2.50
	11	10 000	3.3	12.5	3.6	13.6	7.41	2.50
	13 5/8	5 000	5.78	21.9	6.25	23.7	7.69	2.50
	13 5/8	10 000	5.78	21.9	6.25	23.7	7.75	2.50
PL hinged	7 1/16	15 000	0.75	2.8	0.75	2.8	30.0	18.99
	11	15 000	2.66	10.1	2.66	10.1	42.86	16.72
	13 5/8	10 000	2.8	10.6	2.8	10.6	28.57	20.75
	13 5/8	15 000	3.54	13.4	3.54	13.4	42.86	25.0
	18 3/4	10 000	11.5	43.5	11.5	43.5	20.0	25.0
	18 3/4	15 000	11.5	43.5	11.5	43.5	30.0	25.0
	20 3/4	3 000	12.18	46.1	12.65	47.9	1.48	0.75
	21 1/4	2 000	9.2	34.8	9.2	34.8	4.0	2.0
	21 1/4	5 000	9.7	36.7	9.7	36.7	4.94	1.60
	21 1/4	10 000	4.4	16.7	4.4	16.7	18.32	13.30

CAMERON RAM-TYPE BLOW-OUT PREVENTERS

Dimensions and weights

Model	Nominal size	Working pressure	Width bonnets closed locking rams screwed		Width bonnets open locking rams unscrewed		Single BOP				Double BOP			
							Height between flanges		Approximate weight		Height between flanges		Approximate weight	
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
Type U	7 1/16	3 000	74	188.0	109.5	278.1	24.062	61.1	2 600	1 179	41	104.1	5 000	2 268
	7 1/16	5 000	74	188.0	109.5	278.1	27.5	69.9	2 800	1 270	44.188	112.2	5 200	2 359
	7 1/16	10 000	74	188.0	109.5	278.1	30.562	77.6	3 550	1 610	48.625	123.5	6 400	2 903
	7 1/16	15 000	74	188.0	109.5	278.1	31.812	80.8	3 800	1 724	49.875	126.7	6 750	3 062
	11	3 000	96.25	244.5	146.875	373.1	29.062	73.8	5 300	2 404	49.25	125.1	9 900	4 491
	11	5 000	96.25	244.5	146.875	373.1	34.312	87.2	5 600	2 540	54.500	138.4	10 200	4 627
	11	10 000	96.25	244.5	146.875	373.1	35.688	90.6	6 400	2 903	55.875	141.9	11 300	5 126
	11 (Mod 79)	15 000	124	315.0	175.312	445.3	44.812	113.8	10 300	4 672	69.75	177.2	18 400	8 346
	13 5/8	3 000	112.125	284.8	171.5	435.6	31.312	79.5	7 200	3 266	53.375	135.6	14 300	6 486
	13 5/8	5 000	112.125	284.8	171.5	435.6	33.812	85.9	7 700	3 493	55.875	141.9	14 800	6 713
	13 5/8	10 000	114.125	289.9	172.75	438.8	41.688	105.9	10 300	4 672	66.625	169.2	18 400	8 346
	13 5/8 (Mod B)	15 000	139	353.1	214.375	544.5	53.688	136.4	23 700	10 750	81.75	207.6	43 250	19 618
	16 3/4 (Mod B)	3 000	127.25	323.2	204.562	519.6	40.062	101.8	13 700	6 214	65.875	167.3	26 650	12 088
	16 3/4 (Mod B)	5 000	129.25	328.3	202.125	513.4	43.062	109.4	13 750	6 214	68.875	174.9	26 940	12 220
	16 3/4	10 000	139	353.1	218.375	554.7	46.688	118.6	23 300	10 569	77.75	197.5	43 500	19 731
	18 3/4	10 000	156.375	397.2	242.125	615.0	56	142.2	28 900	13 109	87.125	221.3	56 950	25 832
	20 3/4	3 000	143.688	365.0	226.812	576.1	40.562	103.0	13 650	6 192	66.125	168.0	25 550	11 589
	21 1/4	2 000	143.688	365.0	226.812	576.1	37.188	94.5	13 250	6 010	62.750	159.4	25 150	11 408
	21 1/4	5 000	164.25	417.2	247.250	628.0	50.938	129.4	30 000	13 608	82.375	209.2	58 000	26 308
	21 1/4	10 000	163.375	416.0	250.375	636.0	66	167.6	34 650	15 717	100.062	254.2	65 500	29 710
	26 3/4	3 000	169.625	430.8	275.375	699.5	48.312	122.7	24 000	10 886	78.875	200.3	44 200	20 049
Type U II	18 3/4	10 000	147 (1)	373.4	185.5 (1)	471.2	43.125 (2)	109.5	—	—	87.125 74 (2)	221.3 188.0	51 809 50 706	23 500 23 000
	18 3/4	15 000	148.375 (1)	376.9	186.875 (1)	474.7	64.750 53.125 (2)	164.5 134.9	— —	— —	98.875 87.250 (2)	251.1 221.6	71 209 69 446	32 300 31 500
Type T	18 3/4	15 000	177 (1)	449.6	217 (1)	551.2	64.2 53 (2)	165.6 134.6	— —	— —	98.1 87 (2)	249.2 221.0	87 744 85 980	39 800 39 000

(1) With Wedge Lock system.

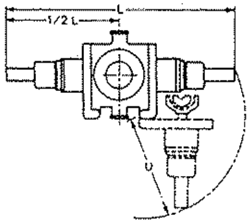
(2) Clamped upper and lower connections.

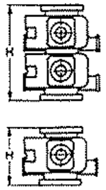
HYDRIL RAM-TYPE BLOW-OUT PREVENTERS

Dimensions and weights

Nominal size (in)	Working pressure (psi)	Width bonnets closed L		Bonnet radius U		Single BOP				Double BOP			
						Height between flanges H		Approximate weight		Height between flanges H		Approximate weight	
		(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
7 1/16	3000	77 1/16	195.7	36 3/16	91.9	22 9/16	57.3	2350	1066	35 9/16	90.3	4910	2227
7 1/16	5000	77 1/16	195.7	36 3/16	91.9	24 1/4	61.6	2465	1118	37 3/8	94.9	4930	2236
7 1/16	10000	79	200.7	37 3/16	94.0	29 1/4	74.3	5600	2540	46	116.8	10600	4808
7 1/16	15000	86 3/16	218.9	42 3/8	107.6	34 3/16	86.8	5370	2436	54 5/8	138.7	10200	4627
9	3000	82 1/2	209.6	—	—	28 3/16	71.6	5200	2359	48 9/16	123.3	10200	4627
9	5000	82 1/2	209.6	—	—	31 11/16	80.5	5400	2449	52 1/16	132.2	10400	4717
11	3000	95	241.3	44 5/8	113.3	30 1/4	76.8	5600	2540	49 3/4	126.4	10800	4899
11	5000	95	241.3	44 5/8	113.3	35 1/2	90.2	6000	2722	55	139.7	12000	5443
11	10000	106 1/4	269.9	62 1/2	158.8	36 1/4	92.1	9750	4423	56 7/8	144.5	18100	8210
11	15000	114 13/16	289.6	44 5/8	113.3	47 1/8	119.7	15900	7212	74 9/16	189.4	28200	12791
13 5/8	3000	116 3/4	296.5	52 1/4	132.7	33 1/4	84.5	8450	3833	55 1/8	140.0	16300	7394
13 5/8	5000	116 3/4	296.5	52 1/4	132.7	36 1/4	92.1	8850	4014	58 1/8	147.6	16700	7575
13 5/8	10000	124 3/4	316.9	58 1/4	148.0	41 3/4	106.0	17000	7711	66 3/4	169.5	37000	16783
13 5/8	15000	*119 1/8	302.6	45 3/8	115.3	51 3/8	130.5	21150	9593	80 5/8	204.8	41150	18665
16 3/4	10000	143	363.2	61 5/16	155.7	44 7/8	114.0	21000	9525	73	185.4	43000	19504
18 3/4	10000	*138 1/4	351.2	62	157.5	54 1/4	137.8	28500	12927	85 3/4	217.8	52000	23587
18 3/4	15000	*150 3/4	382.9	**65 15/16	167.5	65 1/2	166.4	31900	14470	103 1/2	262.9	62750	28463
20 3/4	3000	151 1/2	384.8	59 3/4	151.8	38 1/2	97.8	14500	6577	83 1/2	212.1	28000	12701
21 1/4	2000	151 1/2	384.8	59 3/4	151.8	35 1/4	89.5	14000	6350	60 1/4	153.0	27000	12247
21 1/4	5000	148	375.9	66	167.6	47	119.4	18000	8165	75 1/4	191.1	32000	14515

Note: L dimensions correspond to Manual Lock types unless marked by an asterisk *.
** : Dimension U of type MPL.





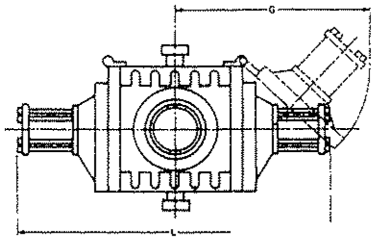
NL SHAFFER RAM-TYPE BLOW-OUT PREVENTERS

Dimensions and weights

Model	Nominal size (in)	Working pressure (psi)	Width bonnets closed L		Overall dimensions bonnets open G		Single BOP				Double BOP				Piston size (in)
							Height between flanges		Approximate weight		Height between flanges		Approximate weight		
			(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)	
Sentinel	**7 1/4	3 000	61 7/8	157.2	—	—	10	25.4	1 152	523	18 1/2	47.0	2 095	950	
LWP	7 1/16	3 000	52 3/8	133.0	33 1/2	85.1	19 1/8	48.6	1 176	533	30 1/2	77.5	2 078	943	
	9	3 000	60 1/8	152.7	33 7/16	84.9	21 7/16	54.5	1 430	649	32 3/8	82.2	2 460	1 116	
SL POSLOCK and Manual-Lock	7 1/16	10 000	79	200.7	46	116.8	39 1/4	99.7	6 200	2 812	53	134.6	10 250	4 649	10
	7 1/16	10 000	135 3/4	344.8	66 1/16	167.8	39 1/4	99.7	7 550	3 425	—	—	—	—	14
	7 1/16	15 000	79	200.7	46	116.8	39 1/4	99.7	6 200	2 812	53	134.6	10 250	4 649	10
	7 1/16	15 000	135 3/4	344.8	66 1/16	167.8	39 1/4	99.7	7 550	3 425	—	—	—	—	14

* Poslock type. All others: Manual-Lock type.

** Hydraulic control.



NL SHAFFER RAM-TYPE BLOW-OUT PREVENTERS (continued)
Dimensions and weights

Model	Nominal size (in)	Working pressure (psi)	Width bonnets closed L		Overall dimensions bonnets open G		Single BOP				Double BOP				Piston size (in)
							Height between flanges		Approximate weight		Height between flanges		Approximate weight		
			(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)	
SL POSLOCK and Manual-Lock	11	10 000	122 3/4	311.8	65	165.1	42 7/8	108.9	12 695	5 758	60 1/4	153.0	21 780	9 879	
	11	15 000	135 7/32	343.5	72 21/64	183.7	57	144.8	24 655	11 183	75 1/2	191.8	37 750	17 123	
	13 5/8	3 000	130 1/4	330.8	68 1/16	172.9	30 5/8	77.8	8 430	3 824	47 3/8	120.3	16 054	7 282	
	13 5/8	5 000	130 1/4	330.8	68 1/16	172.9	33 3/8	84.8	8 985	4 076	50 1/8	127.3	16 608	7 533	10
	13 5/8	5 000	*108	274.3	64 3/8	163.5	33 3/8	84.8	10 110	4 586	50 1/8	127.3	18 860	8 555	14
	13 5/8	10 000	128 3/4	327.0	68 3/4	174.6	48 1/8	122.2	15 295	6 938	66 1/8	168.0	25 365	11 505	
	13 5/8	15 000	142 3/4	362.6	77 1/2	196.9	64 1/2	163.8	29 050	13 177	84 1/4	214.0	45 130	20 471	
	16 3/4	5 000	141 1/2	359.4	75 11/16	192.2	43 1/2	110.5	15 460	7 013	61 3/8	155.9	26 648	12 087	10
	16 3/4	5 000	*118 3/8	300.7	71 11/16	182.1	43 1/2	110.5	—	—	61 3/8	155.9	—	—	14
	16 3/4	10 000	*127 1/4	323.2	79 5/16	201.5	55 7/8	141.9	28 420	12 891	74 1/8	188.3	43 790	19 863	
	18 3/4	10 000	*129 3/8	328.6	81	205.7	60 1/4	153.0	30 700	13 925	78 1/16	198.3	48 488	21 994	
	18 3/4	15 000	*134 3/4	342.3	77 3/4	197.5	—	—	—	—	92 1/2	235.0	60 000	27 216	
	21 1/4	10 000	*136 1/4	346.1	84 1/8	213.7	69 1/2	176.5	37 285	16 912	88 3/4	225.4	54 860	24 884	

* Poslock type. All others: Manual-Lock type.

NL SHAFFER RAM-TYPE BLOW-OUT PREVENTERS (continued)
Dimensions and weights

Model	Nominal size (in)	Working pressure (psi)	Width bonnets closed L		Overall dimensions bonnets open G		Single BOP				Double BOP				Piston size (in)
							Height between flanges		Approximate weight		Height between flanges		Approximate weight		
			(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)	
LWS POSLOCK and Manual-Lock	4 1/16	5 000 et 10 000	42 1/4	107.3	23 13/16	60.5	20 3/4	52.7	975	442	—	—	—	—	
	7 1/16	5 000	58 1/4	148.0	32 1/2	82.6	28 1/4	71.8	1 585	719	40	101.6	2 706	1 227	
	7 1/16	10 000	74 3/4	189.9	43 3/8	110.2	39 7/8	101.3	6 665	3 023	59 5/8	151.4	12 435	5 640	
	9	5 000	79 1/8	201.0	46 5/16	117.6	30 1/8	76.5	3 230	1 465	47 7/16	115.4	6 110	2 771	
	11	3 000	72 5/8	184.5	39 31/32	101.5	27 1/8	68.9	2 580	1 170	42	106.7	4 560	2 068	—
	11	5 000	89 1/4	226.7	46 5/16	117.6	37	94	4 820	2 186	50 1/2	128.3	8 385	3 803	8 1/2
	11	5 000	*101 1/4	257.2	57	144.8	37	94	6 670	3 025	50 1/2	128.3	—	—	14
	20 3/4	3 000	127 1/2	323.9	67 5/8	171.8	41 5/8	105.7	8 550	3 878	67 3/4	172.1	15 715	7 128	8 1/2
	20 3/4	3 000	*117 1/8	297.5	67 7/8	172.4	41 5/8	105.7	8 912	4 042	67 3/4	172.1	16 440	7 457	10
	20 3/4	3 000	*132 1/8	335.6	73 5/8	187.0	41 5/8	105.7	11 170	5 067	67 3/4	172.1	20 955	9 505	14
	21 1/4	2 000	127 1/2	323.9	67 5/8	171.8	37 3/4	95.9	7 985	3 622	63 7/8	162.2	15 155	6 874	8 1/2
	21 1/4	2 000	*117 1/4	297.8	67 7/8	172.4	37 3/4	95.9	8 347	3 786	63 7/8	162.2	15 880	7 203	10
	21 1/4	2 000	*132 1/4	335.9	75 1/8	190.8	37 3/4	95.9	10 605	4 810	63 7/8	162.2	20 400	9 253	14

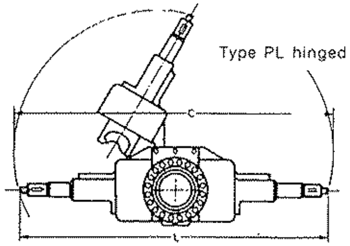
* Poslock type. All others: Manual-Lock type.

KOOMEY RAM-TYPE BLOW-OUT PREVENTERS
Dimensions and weights

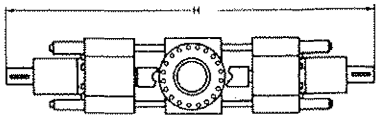
Model	Nominal size (in)	Working pressure (psi)	Width bonnets closed L		Width bonnets open C or H		Single BOP				Double BOP			
							Height between flanges		Approximate weight		Height between flanges		Approximate weight	
			(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
PL hinged	7 1/16	3 000	69.625	176.8	73.375	186.4	20.25	51.4	1 205	547	30.25	76.8	2 146	973
	7 1/16	5 000	69.625	176.8	73.375	186.4	24	61.0	1 600	726	34.125	86.7	2 800	1 270
	7 1/16	10 000	69.625	176.8	73.375	186.4	25.125	63.8	1 764	800	35.625	90.5	3 430	1 556
	13 5/8	3 000	136.625	347.0	143.5	364.5	27.125	68.9	7 246	3 287	44.25	112.4	13 714	6 221
	13 5/8	5 000	136.625	347.0	143.5	364.5	32.125	81.6	7 924	3 594	49.250	125.1	14 392	6 528
	13 5/8	10 000	136.625	347.0	143.5	364.5	38.937	98.9	9 650	4 377	54.437	138.3	15 816	7 174
PL-PRC (Power Ram Change)	7 1/16	3 000	68.94	175.1	86.94	220.8	19.5	49.5	1 816	824	31	78.7	3 692	1 675
	7 1/16	5 000	68.94	175.1	86.94	220.8	22.75	57.8	1 700	771	34.25	87.0	3 230	1 465
	7 1/16	10 000	68.94	175.1	86.94	220.8	25.125	63.8	2 325	1 055	36.625	93.0	4 201	1 906
	11	3 000	102.58	260.6	126.875	322.3	26.5	67.3	5 120	2 322	40.875	103.8	9 610	4 359
	11	5 000	102.58	260.6	126.875	322.3	31.75	80.6	5 582	2 532	46.125	117.2	10 072	4 569
	11	10 000	102.58	260.6	126.875	322.3	33.63	85.4	6 313	2 864	48	121.9	10 804	4 901
	13 5/8	5 000	126.75	321.9	157.5	400.1	35	88.9	7 033	3 190	52.125	132.4	12 612	5 721
	13 5/8	10 000	126.75	321.9	157.5	400.1	36.75	93.3	—	—	53.88	136.9	—	—

KOOMEY RAM-TYPE BLOW-OUT PREVENTERS (continued)
Dimensions and weights

Model	Nominal size (in)	Working pressure (psi)	Width bonnets closed L		Width bonnets open C or H		Single BOP				Double BOP			
							Height between flanges		Approximate weight		Height between flanges		Approximate weight	
			(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
PB - PRC (Power Ram Change)	7 1/16	15 000	91.75	233.0	111	281.9	28.375	72.1	3 200	1 451	40.875	103.8	5 825	2 642
	11	15 000	143.5	364.5	172.5	438.2	42.25	107.3	14 500	6 577	61.37	155.9	25 000	11 340
	13 5/8	10 000	136	345.4	166.5	422.9	39.375	100.0	11 678	5 297	56.5	143.5	20 520	9 308
	13 5/8	15 000	149	378.5	184.5	468.6	49.25	125.1	19 698	8 935	73.75	187.3	35 699	16 193
	18 3/4	10 000	199.125	505.8	249.125	632.8	54.56	138.6	37 274	16 907	84.25	214.0	65 524	29 721
	18 3/4	15 000	199.125	505.8	249.125	632.8	64.375	163.5	50 258	22 797	96	243.8	90 070	40 855
	20 3/4	3 000	212	538.5	260	660.4	36.0	91.4	18 826	8 539	55.13	140.0	35 657	16 174
	21 3/4	2 000	212	538.5	260	660.4	33	83.8	14 530	6 591	51.88	131.8	27 401	12 429
	21 1/4	5 000	198	502.9	246	624.8	54.5	138.4	33 698	15 285	81.75	207.6	62 418	28 312
	21 1/4	10 000	214	543.6	264	670.6	56	142.2	37 930	17 205	85	215.9	66 650	30 232


Type PL hinged

Types PL-PRC or PB-PRC



CAMERON TYPE D ANNULAR BLOW-OUT PREVENTERS

Dimensions and operating data

Model	Nominal size (in)	Working pressure (psi)	Overall height flanged		Diameter		Weight		Closing fluid volume		Opening fluid volume	
			(in)	(cm)	(in)	(cm)	(lb)	(kg)	(gal)	(liters)	(gal)	(liters)
D	7 1/16	3000	23 15/16	60.8	27 7/8	70.8	2738	1242	1.69	6.4	1.30	4.9
	7 1/16	5000	25 1/2	64.8	27 7/8	70.8	2778	1260	1.69	6.4	1.69	6.4
	7 1/16	10000	34 7/32	86.9	37 3/8	94.9	7255	3291	2.94	11.1	2.55	9.7
	7 1/16	15000	44 3/4	113.7	43 1/4	109.9	12000	5443	6.94	26.3	6.12	23.2
	7 1/16	20000	50 3/4	128.9	48	121.9	17716	8036	8.38	31.7	7.56	28.6
	11	3000	32 1/2	82.6	41 1/4	104.8	8255	3744	5.65	21.4	4.69	17.8
	11	5000	34 15/16	88.7	41 1/4	104.8	8447	3831	5.65	21.4	4.69	17.8
	11	10000	41 1/16	104.3	48 1/2	123.2	13954	6329	10.15	38.4	9.06	34.3
	11	15000	62 1/2	158.8	61	154.9	35500	16103	23.50	89.0	21.30	80.6
	13 5/8	3000	36 11/16	93.2	50	127.0	12885	5845	12.12	45.9	10.34	39.1
	13 5/8	5000	40 3/16	102.1	52 3/8	133.0	16215	7355	12.12	45.9	10.34	39.1
	13 5/8	10000	49 3/32	124.7	61	154.9	27262	12366	18.10	68.5	16.15	61.1
	13 5/8	15000	67 1/4	170.8	65 3/4	167.0	36000	16329	26.00	98.4	22.50	85.2
	16 3/4	3000	47	119.4	60 1/2	153.7	25950	11771	22.32	84.5	19.00	71.9
	16 3/4	5000	49	124.5	60 1/2	153.7	26300	11929	22.32	84.5	19.00	71.9
	16 3/4	10000	65 1/2	166.4	63	160.0	35300	16012	40.75	154.3	35.42	134.1
	18 3/4	5000	60 13/16	154.5	62	157.5	17716	8036	35.60	134.8	29.00	109.8
	18 3/4	10000	70 1/2	179.1	67	170.2	40940	18570	51.00	193.1	45.10	170.7
	20 3/4	3000	54 3/4	139.1	66	167.6	20000	9072	39.70	150.3	24.10	91.2
	21 1/4	2000	53 5/16	135.4	66	167.6	19800	8981	39.70	150.3	24.10	91.2

HYDRIL ANNULAR BLOW-OUT PREVENTERS
Dimensions and operating data

Model	Nominal size (in)	Working pressure (psi)	Overall height flanged		Overall diameter		Weight		Closing fluid volume		Opening fluid volume		Secondary chamber	
			(in)	(cm)	(in)	(cm)	(lb)	(kg)	(gal)	(liters)	(gal)	(liters)	(gal)	(liters)
GX	11	10 000	57.12	145.1	60.38	153.4	21 385	9 700	17.88	67.7	17.88	67.8		
	11	15 000	—	—	67.12	170.5	—	—	24.14	91.4	24.14	91.4		
	13 5/8	10 000	63.25	160.7	64.50	163.8	28 000	12 701	24.14	91.4	24.14	91.4		
	13 5/8	15 000	77.00	195.6	73.25	186.1	—	—	34.00	128.7	34.00	128.7		
	18 3/4	10 000	80.15	203.6	84	213.4	52 250	23 700	58.00	219.5	58.00	219.5		
GL	13 5/8	5 000	52 3/16	132.6	56	142.2	17 320	7 856	19.76	74.8	19.76	74.8	8.24	31.2
	16 3/4	5 000	64 1/8 (1)	162.9	70 3/4	179.7	31 450	14 265	35.3	133.6	35.3	133.6	16.6	62.8
	16 3/4 Dual	5 000	110 1/8 (1)	279.1	70 3/4	179.7	55 000	24 948	35.3	133.6	35.3	133.6	16.6	62.8
	18 3/4	5 000	65 1/4	165.7	76 1/4	193.7	35 000	15 876	44	166.6	44	166.6	20	75.7
	18 3/4 Dual	5 000	112	284.5	76 1/4	193.7	63 100	28 622	44	166.6	44	166.6	20	75.7
	21 1/4	5 000	77 1/2	196.9	78 1/4	198.8	45 000	20 412	58	219.5	58	219.5	29.5	111.7
GK	7 1/16	3 000	32	81.3	32 1/4	81.9	2 715	1 232	2.85	10.8	2.24	8.5		
	7 1/16	5 000	36 7/8	93.7	35 3/4	90.8	4 000	1 814	3.86	14.6	3.30	12.5		
	7 1/16	10 000	48 1/8	122.2	49 1/2	125.7	12 200	5 534	9.42	35.7	7.08	26.8		
	7 1/16	15 000	54 1/8	137.5	61	154.9	14 250	6 464	11.2	42.4	7.5	28.4		
	7 1/16	20 000	59	149.9	58	147.3	23 000	10 433	10.9	41.3	7.2	27.3		
	9 (2)	3 000	37 7/8	96.2	34 1/2	87.6	3 500	1 588	4.33	16.4	3.41	12.9		
	9 (2)	5 000	41 3/4	106.0	41	104.1	6 000	2 722	6.84	25.9	5.80	22.0		
	9	10 000	55 3/4	141.6	56 3/4	144.1	18 540	8 410	15.90	60.2	11.95	45.2		
	11	3 000	39 3/4	101.0	40	101.6	5 500	2 495	7.43	28.1	5.54	21.0		
	11	5 000	47 13/16	121.4	44 1/4	112.4	8 200	3 719	9.81	37.1	7.98	30.2		
	11 (3)	5 000	48 1/4	122.6	44 1/4	112.4	—	—	9.81	37.1	7.98	30.2		
	13 5/8	3 000	45 1/4	114.9	47 1/2	120.7	8 784	3 984	11.36	43.0	8.94	33.8		
	13 5/8 (3)	3 000	45 1/4	114.9	47 1/2	120.7	—	—	11.36	43.0	8.94	33.8		
	13 5/8	5 000	54 1/8	137.5	52 1/4	132.7	13 800	6 260	17.98	68.1	14.16	53.6		
	13 5/8 (3)	5 000	54 1/2	137.8	52 1/4	132.7	13 250	6 010	17.98	68.1	14.16	53.6		
	13 5/8 (4)	5 000	46 (5)	116.8	48 1/2	123.2	9 400 (5)	4 264	17.98	68.1	14.16	53.6		
	16 3/4	5 000	61 1/4	155.6	59 1/2	151.1	20 835	9 451	28.70	108.6	19.93	75.4		
	16 3/4 · (3)	5 000	61 19/64	155.7	59 1/2	151.1	21 230	9 630	28.70	108.6	19.93	75.4		

(1) Lowest flange of 10 000 psi series.

(2) Previous models may have a vertical bore of 8 5/16 inches.

(3) Latched head others screwed.

(4) HL : special Helirig.

(5) Equipped with a CIW lower hub.

HYDRIL ANNULAR BLOW-OUT PREVENTERS
Dimensions and operating data (continued)

Model	Nominal size (in)	Working pressure (psi)	Overall height flanged		Overall diameter		Weight		Closing fluid volume		Opening fluid volume	
			(in)	(cm)	(in)	(cm)	(lb)	(kg)	(gal)	(liters)	(gal)	(liters)
MSP	7 1/16	2000	25 3/4	65.41	29 7/8	75.88	1850	839	2.85	10.8	1.98	7.5
	9	2000	30 1/4	76.84	32	81.28	2450	1111	4.57	17.3	2.95	11.2
	11	2000	31 3/4	80.65	37 1/4	94.62	3520	1597	7.43	28.1	5.23	19.8
	20 3/4 (1)	2000	54 1/4	137.80	58 3/4	149.23	—	—	31.05	117.5	18.93	71.7
	21 1/4	2000	52 1/2	133.35	58 3/4	149.23	15100	6849	31.05	117.5	18.93	71.7
	21 1/4 (2)	2000	52 1/2	133.35	58 3/4	149.23	16320	7403	31.05	117.5	18.93	71.7
	21 1/4 (3)	2000	48	121.92	61 1/4	155.58	12700	5761	31.75	120.2	19.25	72.9
	29 1/2	500	67 13/16	172.24	82 5	209.55	24500	11113	60	227.1	—	—
	30 (2)	1000	58 1/8	147.64	90 1/2	229.87	32500	14742	87.6	331.6	27.8	105.2

(1) Available with latched head. Lower flange 3000 psi.

(2) Latched head.

(3) HL : special Helirig. Screw head and CIW lower hub.

HYDRIL ANNULAR BLOW-OUT PREVENTERS
Average closing pressure (psi)
required to establish initial seal-off
in a surface installation
Type GL

Pipe outside diameter (in)	Nominal size of type GL (secondary chamber connected to opening chamber)								
	13 5/8 — 5000 psi			16 3/4 — 5000 psi			18 3/4 — 5000 psi		
	Well pressure (psi)			Well pressure (psi)			Well pressure (psi)		
	2000	3500	5000	2000	3500	5000	2000	3500	5000
7	900	950	1100	700	825	950	700	825	950
5	900	950	1100	725	850	1000	600	900	1000
3 1/2	1200	1200	1200	800	925	1050	1000	1050	1100
Full closure	1400	1500	1500	1400	1500	1500	1500	1500	1500

For optional hook-up in which the secondary chamber is connected to the closing chamber, the average pressures above must be multiplied by the coefficient S below :

GL — 5000 psi	13 5/8	16 3/4	18 3/4	21 1/4
S	0.71	0.68	0.69	0.66

HYDRIL ANNULAR BLOW-OUT PREVENTERS
Average closing pressure (psi) required to establish initial seal-off in a surface installation (continued)
Type GK

Pipe outside diameter (in)	Nominal size and working pressure of type GK BOP																
	7 1/16	7 1/16	7 1/16	7 1/16	7 1/16	9	9	9	11	11	11	13 5/8	13 5/8	13 5/8	16 3/4	16 3/4	16 3/4
	3000	5000	10000	15000	20000	3000	5000	10000	3000	5000	10000	3000	5000	10000	2000	3000	5000
6 5/8										350		700	600		350	450	
5		400						350	450	450	500	800	650	700	400	500	
4 1/2	350	400	350	2100	2200	400	450	380	450	450	500	***900**	***650**	***700**	***500**	***500**	***600**
3 1/2	400	450	550	***2100**	***2200**	***500**	***600**	***570**	***550**	***525**	***700**	1000	700	1200	600	600	650
2 7/8	***400**	***450**	***750**	2100	2200	550	650	760	650	800	800	1100	750	1400	700	700	750
2 3/8	500	500	850	2100	2200	650	750	860	750	900	1100		950	1400	800	800	850
1,90	600	600	900			750	850	850	920				1000	1500	900	950	950
1.66	700	700	1000			850	950	1000	950				1000	1500	1000	1000	1050
Full closure	1000	1000	1150			1050	1150	1150	1150	1150	1500	1200	1150	2200	1150	1150	1150

- **For tests** : pipe size and closing pressure recommended for maximum packing unit life.

HYDRIL ANNULAR BLOW-OUT PREVENTERS
Average closing pressure (psi) required to establish initial seal-off in a surface installation (continued)
Type MSP

Pipe outside diameter (in)	Nominal size and working pressure of MSP 2000 BOP			
	7 1/16 2000	9 2000	11 *2000*	21 1/4 *2000*
5 1/2			350	500
4 1/2	350	400	450	* **700**
3 1/2	400	* **500**	* **550**	600
2 7/8	* ***400***	*550*	*650*	*650*
2 3/8	500	650	750	700
1.90	600	750	850	800
1.65	700	850	850	900
Full closure	1000	1050	1150	1100

* **For tests** : pipe size and closing pressure recommended for maximum packing unit life.

Initial closing pressure (psi) for MSP 29" 1/2 – 500 psi BOP/diverter (Well pressure : 500 psi)				Initial closing pressure (psi) for MSP 30" – 1000 psi BOP/diverter		
Pipe outside *diameter (in)*	12	5	Full *closure*	3 1/2 to 5	7 to 9 5/8	20
Closing pressure (psi)	950	1350	1500	1000	700	400

Note: For tests, the recommended pipe diameter is 5 inches.

NL SHAFFER ANNULAR BLOW-OUT PREVENTERS
Dimensions and operating data

Model (1)	Nominal size (in)	Working pressure (psi)	Overall height flanged		Diameter		Weight		Closing fluid volume		Opening fluid volume	
			(in)	(cm)	(in)	(cm)	(lb)	(kg)	(gal)	(liters)	(gal)	(liters)
B	4 1/16	10 000	25 1/2	64.8	23	58.4	1 850	839	2.38	9	1.94	7.3
B	7 1/16	3 000	29 1/8	74.0	29	73.7	2 900	1 315	4.57	17.3	3.21	12.2
B	7 1/16	5 000	30 7/8	78.4	29	73.7	3 175	1 440	4.57	17.3	3.21	12.2
B	7 1/16	10 000	42 1/4	107.3	43	109.2	10 600	4 808	17.11	64.8	13.95	52.8
B	9	3 000	32 1/2	82.6	35 1/2	90.2	4 775	2 166	7.23	27.4	5.03	19.0
B	9	5 000	36 1/2	92.7	40	101.6	6 800	3 084	11.05	41.8	8.72	33.0
B	11	3 000	32 7/8	83.5	39 7/8	101.3	5 825	2 642	11.00	41.6	6.78	25.7
B	11	5 000	41 1/2	105.4	44 3/4	113.7	9 550	4 332	18.67	70.7	14.59	55.2
W	11	10 000	53	134.6	57	144.8	23 000	10 433	30.58	115.8	24.67	93.4
B	13 5/8	3 000	40 11/16	103.3	46 3/8	117.8	9 100	4 128	23.50	89.0	14.67	55.5
B	13 5/8	5 000	44 15/16	114.1	50	127	13 650	6 192	23.58	89.3	17.41	65.9
W	13 5/8	5 000	45 1/2	115.6	54	137.2	17 250	7 824	23.58	89.3	17.41	65.9
W	13 5/8	10 000	58 3/8	148.3	64 1/2	163.8	32 475	14 730	40.16	152.0	32.64	123.6
W	16 3/4	5 000	51 15/16	131.9	60	152.4	22 900	10 387	33.26	125.9	25.61	96.9
W	18 3/4	5 000	60	152.4	66 1/4	168.3	36 100	16 375	48.16	182.3	37.61	142.4
W	18 3/4	10 000	72 3/4	184.8	76 1/4	193.7	57 050	25 877	85.0	321.8	66.0	249.8
B	21 1/4	2 000	46 1/8	117.2	49	124.5	10 850	4 921	32.59	123.4	16.92	64.0
W	21 1/4	5 000	66	167.6	71	180.3	44 500	20 185	61.37	232.3	47.76	180.8
B	30	1 000	65 5/8	166.7	71	180.3	28 750	13 041	122.00	461.8	55	208.2

(1) B for bolted cover. W for wedge cover.

Closing pressure on casing (psi)

Nominal size (1) (in)	Well pressure (psi)	Casing size (in)									
		7	7 5/8	8 5/8	9 5/8	10 3/4	11 3/4	13 3/8	16	18 5/8	20
21 1/4	5 000	1 500	1 400	1 175	975	790	640	480	300	190	150
21 1/4	2 000	1 500	1 400	1 175	975	790	640	480	300	190	150
18 3/4	10 000				385			310	325		
18 3/4	5 000	1 500	1 400	1 175	975	790	640	480	300		
16 3/4	5 000	1 500	1 400	1 175	975	790	640	480			
13 5/8	3 000/5 000	1 500	1 265	890	615	415	280				
30	1 000				1 100			1 100			900

(1) For other nominal sizes of Shaffer annular BOPs, no adjustment required to close on casing.

M geology

TERTIARY AND QUATERNARY CENOZOIC ERA

Cosuna	Odin	System / Period	Series / Era		STAGE — AGE			Orogenic phases and cycles	
Ages (Ma)					General classification	Sub-stage and/or local equivalent			
0.01		QUATERNARY	Holocene		Versilian	Flandrian			
			PLEISTOCENE	Upper	Tyrrhenian Milazzian Sicilian			Pasadenian	
				Lower	Emilian Calabrian				
		NEOGENE	Pliocene		Astian Plaisancian Zanclean Tabianian	Villafranchian	Dacian	Wallachian Rhodanian Attic	
5,3			MIOCENE	Upper Middle Lower	Messinian Tortonian Serravalian Langhian Burdigalian Aquitanian	Helvetian Vindobonian	Pontian Meotian Sarmatian		
25	23	PALEOGENE	Oligocene		Chattian Rupelian Stampian	Sannoisian			
38	38		EOCENE	Upper	Bartonian Priabonian	Ludian Marinesian Auversian	Lattorfian Tongrian	Pyrenean	ALPINE OROGENY
				Middle	Lutetian	Ledian	Biarritzian		
				Lower	Ypresian	Cuisian Sparnacian	Ilerdian Herdian		
55 67	55 65		Paleocene		Thanetian Montian Danian	Landenian		Laramian	

From J. Guillemot, *Éléments de Géologie*, Éditions Technip, Paris, 1986.

SECONDARY MESOZOIC ERA

Cosuna	Odin	System / Period	Series / Era		STAGE — AGE				Orogenic phases and cycles
Ages (Ma)					General classification	Sub-stage and/or local equivalent			
		CRETACEOUS	Upper	Senonian	Maastrichtian	Aturian	Rognacian Begudian Fuvelian Valdonian		
					Campanian				
					Santonian Coniacian	Emscherian			
					Turonian	Provencian Ligerian	Angoumian Salmurian		Austrian
100	95				Cenomanian				
			Lower		Albian	Vraconian Clansayesian Gargasian Bedoulian	Gault	Urgonian	
					Aptian				
					Barremian		Wealdian		
					Hauterivian Valanginian	Neocomian			
140	130				Berriasian		Purbeckian		Late
		JURASSIC	Upper	Malm	Portlandian Kimmeridgian	Tithonic	Volgian		Cimmerian
160	158				Oxfordian		Sequanian Rauracian Argovian		
180	178		Middle	Dogger	Callovian Bathonian Bajocian Aalenian				ALPINE OROGENY
			Lower	Lias	Toarcian				
					Pliensbachian	Charmouthian	Domerian Carixian		
					Sinemurian	Lotharingian			
200	204				Hettangian				
250	245		Trias		Rhetian Norian Carnian Ladinian Anisian Scythian	Wirglorian Werfenian	Keuper Muschelkalk Bundsandstein		Early Cimmerian Palatinian

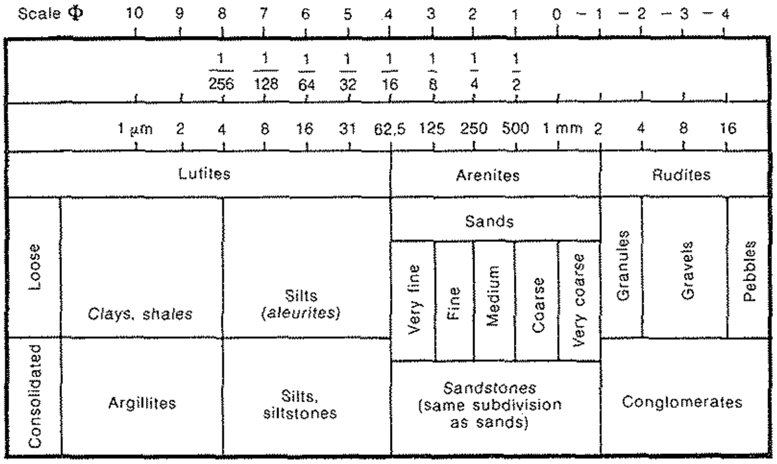
From J. Guillemot, *Éléments de Géologie*, Éditions Technip, Paris, 1986.

PRIMARY PALEOZOIC ERA

Cosuna	Odin	System / Period	Series / Era	STAGE — AGE			Orogenic phases and cycles	
Ages (Ma)				General classification	Sub-stage and/or local equivalent			
		PERMIAN	Upper	Tatarian Kazanian	Thuringian	Zechstein	Saalian	
290	290		Lower	Kungurian Artinskian Sakmarian	Saxonian Autunian	Rotliegende		
330		CARBONIFEROUS	Upper	Stephanian Westphalian Namurian	Ouralian Moscovian Bashkirian	Pennsylvanian	Asturian Sudeten	HERCYNIAN OROGENY
365	360		Lower	Dinantian	Visean Tournaisian	Mississippian	Breton	
		DEVONIAN	Upper	Famennian	Strunian	Old		
				Frasnian				
			Middle	Givetian Couvinian	Eifelian	Red		
405	400		Lower	Emsian Siegenian Gedinnian	Coblencian	Sandstones	Ardennes	
		SILURIAN	Upper	Ludlow Wenlock				CALEDONIAN OROGENY
425	418	(Gothlan-dian)	Lower	Taranon Llandoverian			Taconic	
		ORDO-VICIAN	Upper	Ashgill Caradoc				
			Middle	Llandeilian Llanvirnian			Sardinian	
500	495		Lower	Arenig Tremadoc				
570	530	CAMBRIAN		Potsdamian Acadian Georgian			Cadomian	
	1000	PRE CAMBRIAN	Protero-zoic	Brioverian Pentevrian	Algonkian	Infracambrian		
2500	2000 3000							
	4000			ARCHEAN				

From J. Guillemot, *Éléments de Géologie*, Éditions Technip, Paris, 1986.

TABLE OF GRAIN SIZE CLASSES



Sizes are expressed in millimeters or microns, in fractions of millimeters and in Φ units ($\Phi = -\log_2$ of diameter in millimeters).

From J. Guillemot, *Éléments de Géologie*, Éditions Technip, Paris, 1986.

REPRESENTATION OF SEDIMENTS (1)

1 PREDOMINANTLY SHALE ROCKS

1.1 One-component rocks

▨ Clay, shale

1.2 Two-component rocks

▨	ALS	Slightly sandy shale	▨	ACL	Calcareous shale
▨	ASB	Sandy shale	▨	ADL	Dolomitic shale
▨	ASL	Silicified claystone			

2 PREDOMINANTLY SILICA ROCKS

2.1 One-component rocks

Sh ▨	SLT	Silt	▨	GFN	Fine to very fine sandstone
▨	SFN	Fine to very fine sand	▨	GMN	Medium sandstone
▨	SMN	Medium sand	▨	GGR	Coarse to very coarse sandstone
▨	SGR	Coarse to very coarse sand	▨	QTZ	Quartzite
Sti ▨	STI	Siltstone	▨	SLX	Chert

2.2 Two-component rocks

▨	STA	Argillaceous silt	▨	GDL	Dolomitic sandstone
▨	GAR	Argillaceous sandstone	▨	GMO	Asphaltic or bituminous sandstone
▨	GCL	Calcareous sandstone	▨	GCQ	Shelly sandstone

3 PREDOMINANTLY CARBONATE ROCKS

3.1 Predominantly limestone rocks

3.1.1 One-component rocks

▨	CLC	Limestone	▨	CCN	Reefal limestone
▨	CRA	Chalk	▨	CCQ	Coquina
Coo ▨	COO	Oolitic limestone			

---

(1) From document of *French Oil and Gas Industry Association, Technical Committee.*

REPRESENTATION OF SEDIMENTS (continued)

3.1.2 Two-component rocks

▦	CSB	Sandy limestone	▦	CDL	Dolomitic limestone
▦	CAR	Argillaceous limestone			

3.2 Predominantly dolomitic rocks

3.2.1 One-component rocks

▨	DLM	Dolomite

3.2.2 Two-component rocks

▨	DSB	Sandy dolomite	▨	DCL	Calcareous dolomite
▨	DAR	Argillaceous dolomite			

4 ROCKS WITHOUT PREDOMINANT COMPONENT

Two-component rocks

▤	RAC	Clay, limestone rock (Marlstone, not recommended)	▤	RAD	Clay, dolomite rock

5 EVAPORITES

▦	EVP	Evaporite	▩	ANH	Anhydrite
▒	*HLT*	*Halite*	▒	GPS	Gypsum

6 CONGLOMERATES (one or more components)

blc ⚬	CG	Monogenic conglomerate (cobbles to boulders)	△	*BRM*	*Monogenic breccia*

7 OTHER TYPE OF SEDIMENTARY ROCK

■	CHR	Coal or lignite

8 ERUPTIVE AND METAMORPHIC ROCKS

▒	RVI	Undifferentiated volcanics	▧	MTM	Metamorphic rocks
▒	ACI	Acid rocks (granite)	▒	BSL	Basalt

9 MINERALS

×	Glauconite	▩	Pyrite

EXPLORATION SYMBOLS IN DRILLING

SHOWS

A. Shows from cuttings and cores

Oil in mass	●
Oil in fractures	Ø
Emanation of gas	☼
Direct fluorescence of mass (pale +, bright + +, very bright + + +)	▲ +
Direct fluorescence on fractures	⧗ +
Fluorescence on extraction	△
Asphalt, bitumen	-●-
Water (with indication of salinity in g/l)	⊕ 35
Odor (x) (1)	◊ x

B. In drilling mud

Oil	● B
Direct fluorescence (pale +, bright + +, very bright + + +)	▲ B +
Gas (y, z, ...) (2)	☼ B y
Gasoline, condensate	✹ B
Sulfides dissolved in mud	S^{--B}
Losses	Z↓
Gains	Σ↑

---

(1) x = hydrocarbons, H_2S etc.
(2) y, z, ... = hydrocarbons, CO_2, N_2, H_2S, H_2 etc.

GASES PRESENT IN DRILLING MUDS AND DETECTED BY CHROMATOGRAPHY (1)

Gas	*Formula*	Boiling point (°C) (3)	Density (in relation to air) (4)
Helium	He	– 268.9	0.138
Hydrogen	H_2	– 252.9	0.070
Nitrogen	N_2	– 195.8	0.967
Methane	CH_4 (C_1)	– 161.5	0.555
Carbon dioxide	CO_2	– 78.5 (2)	1.527
Ethane	C_2H_6 (C_2)	– 88.6	1.047
Hydrogen sulfide	H_2S	– 60.3	1.187
Propane	C_3H_8 (C_3)	– 42.1	1.551
Isobutane	C_4H_{10} (iC_4)	– 11.8	2.075
n-butane	C_4H_{10} (nC_4)	– 0.5	2.081
Isopentane	C_5H_{12} (iC_5)	27.8	2.626
n-pentane	C_5H_{12} (nC_5)	36.1	2.643
—	$(C_6{}^+)$	> 50	—

(1) Retention time in the chromatograph is inversely proportional to the boiling point (except for CO_2).
The detection of a gas depend on the type of chromatographic column and on its concentration.

(2) Sublimation point.

(3) At 101.325 kPa (abs.).

(4) At 101.325 kPa (abs.) and 15 °C.

Reference: J.F. Gravier, *Propriétés des fluides de gisements*, Éditions Technip, Paris, 1986.

PHYSICAL PROPERTIES OF H_2S

Color : Colorless.

Odor : Rotten eggs at low concentration, odorless at high concentration.

Density : 1.189 **hence heavier than air.**

Solubility : four volumes of gas are soluble in one volume of water.

Flammability : It forms an explosive mixture with air when it occupies between 4.3 and 46% of this mixture.
It burns with a blue flame and its combustion produces a very irritating gas, sulfur dioxide (SO_2).

H_2S is a toxic gas

For an H_2S content of :

1 ppm = 0.0001% : detection by smell (rotten eggs)
10 ppm = 0.001% : concentration limit for work lasting 8 hours (1)

USE YOUR BREATHING APPARATUS
ABOVE THIS CONCENTRATION

100 ppm = 0.01% : loss of sense of smell in 3 to 15 min
200 ppm = 0.02% : sense of smell paralyzed
500 ppm = 0.05% : loss of balance and consciousness breathing difficulty within 2 to 15 min
700 ppm = 0.07% : fainting ; respiratory arrest
1000 ppm = 0.1% : **mortal** concentration if artificial respiration is not practised

(1) 10 or 20 ppm depending on local regulations.

From publication of the *French Oil and Gas Industry Association*, Technical Committee.-

PORE PRESSURE

The main techniques for evaluating the pore pressure are based on the difference between the measured or calculated value of a parameter (resistivity, shale density, standard rate of penetration) and the extrapolated value based on the normal trend.

One of the most widely used parameters is the rate of penetration.

The « d exponent » method of Jordan and Shirley

The *d* exponent is only significant in shales.

The interpretation is based on the assumption of undercompacted shales.

$$v_a = KN \left(\frac{WOB}{D}\right)^d$$

v_a = rate of penetration (**m/h** or ft/h)
WOB = weight on bit (**t** or lb)
N = speed of rotation (**rpm**)
D = bit size (**in**)
K = proportionality factor
d = *exponent d*

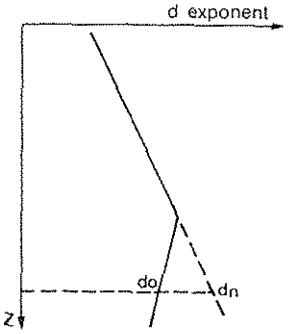
$$d = \frac{\log \frac{v_a}{N}}{\log \frac{WOB}{D}}$$

$$d = \frac{\log \frac{v_a}{60N}}{\log \frac{12WOB}{10^6 D}} \quad \text{or} \quad d = \frac{1.26 - \log \frac{v_a}{N}}{1.58 - \log \frac{WOB}{D}}$$

American units — Combined units (in bold above)

$$P_f = P_{fn} \frac{d_n}{d_0}$$

P_f = observed pore pressure
P_{fn} = normal pore pressure at depth Z
d_n = exponent *d* extrapolated on the normal curve
d_0 = exponent *d* calculated at the same depth



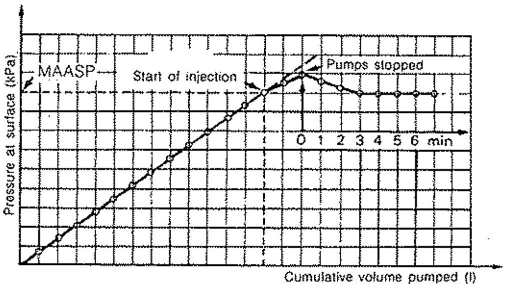
FRACTURING GRADIENT AND LEAK OFF TEST

EATON FORMULA

$$P_{frac} = P_f + \frac{\mu}{1 - \mu} (S - P_f)$$

P_{frac} = fracturing pressure
P_f = pore pressure
S = geostatic pressure (weight of formations)
μ = Poisson's ratio (0.25 to 0.5)

LEAK OFF TEST



$$P_{frac} = \text{MAASP} + 9.81\ Z_s d$$

$$d_{frac} = \frac{P_{frac}}{9.81\ Z_s}$$

where :

P_{frac} = fracturing pressure (kPa)
MAASP = pressure at start of injection point (kPa)
d_{frac} = fracture density (l/kg)
d = mud density in well (l/kg)
Z_s = depth of weak point (m).

Mud compressibility

Water compressibility: $5\ 10^{-2}$ liters/bar per m^3.
Order of magnitude for a mud:

4 to 5 liters per bar for 100 m^3
or 4 to 5 liters per m^3 for 100 bar
or 4 to 5 liters per MPa for 10 m^3
or 4 to 5 liters per m^3 for 10 MPa
or 3 liters per m^3 for 1000 psi
0.125 gal per bbl for 1000 psi.

ABBREVIATIONS USED IN WIRELINE LOGGING

Western Atlas

Resistivity

EL	Electrical Logging
IEL	Induction Electrolog
DIFL	Dual Induction Focused Log
LLL	Laterolog
DL	Dual Laterolog
ML	Minilog
MLM	Microlaterolog-Minilog
PLM	Proximity Log-Minilog
MLA	Microlaterolog
PXL	*Proximity Log*
DCLL	Proximity Log (47 MHz)
DCLH	Dielectric Log (200 MHz)
DDL	Dielectric Combo

Radioactivity

GR	Gamma Ray
GRS	Gamma Ray (Combo)
PFC	Gamma Ray (PFC)
SPL	Spectrolog
PHT	Photon Log
GRB	Gamma Ray Blanket
NL	Neutron Log (Single Det.)
SWN	*Sidewall Neutron*
CN	Compensated Neutron
NB	Neutron Blanket
CDL	Compensated Densilog
ZDL	Z-Densilog
GNL	Gamma-Neutron (TT)
PDK	Neutron-Lifetime PDK
NLL	Neutron Lifetime
NLB	Neutron Lifetime Blanket
COC	Carbon Oxygen (Continuous)
MSI	Carbon Oxygen (Multi Spect)

Production Logging

CSF	Spinner Flolog
FDL	Fluid Density
TEMP	Temperature Log
TLP	Temperature Log (In Combo)
TL	Temperature Log (Alone)
NFL	Nuclear Flolog
PFL	Packer Flowmeter
BFL	Basket Flowmeter
HPM	Surface-Recorded HP Pressure *Gauge (Run Alone)*
HPP	Surface-Recorded HP Pressure Gauge (With SPC)
SPC	Simultaneous Production Combo
RTT	Radioactive Tracer Tool
PFS	Production Fluid Sampling
FMTCH	Formation Tester Cased Hole
SNL	Sonan
TTL	Through Tubing Caliper
WHI	Water Hold-Up Indicator

Perforating

JBJ	*Jumbo Jet*
HSD	Hi Shot Density
SAP	Hi Penetration 5"
GDJ	Goldenjet
BHP	Big Hole Perforator
EGD	E-Gun
SLK	Slimkone
LKK	Link Kone
BRK	Bar Kone
TP	Tubing Puncher
TCS	Compac Perf. 3-3/8" Guns
TCM	Compac Perf. 4" Guns
TCL	Compac Perf. 5" Guns
TCC	Compac Perf. Hi Density

From *Wireline Logging Tool Catalog*, Éditions Technip, Paris, 1986.

ABBREVIATIONS USED IN WIRELINE LOGGING
Western Atlas (continued)

Acoustic	
AC	Normal Space Acoustilog
ACAL	Normal Space Acoustilog w/Cal.
ACL	Long Space Acoustilog
ACLC	Long Space Acoustilog w/Cal
CBLV	Cement Bond Log (VDL or CBL & VDL)
CBLS	Cement Bond Log Signature
AMP	Acoustic Amplitude Log
SIG	Acoustic Signature Log
VDL	Variable Density Log
AWR	Acoustic Wave Train Recorder
TTI	Acoustic Time Integration
BHTV	Borehole Televiewer
CAC	Circumferential AC
SRS	Seismic Reference Service

Directional	
DIP	4-Arm Diplog
DIPS	4-Arm Diplog Solid State
DFL	Dip Frac Log
DIR	Directional Survey

Sampling	
FMTS	Formation Multi-Tester-Fluid Sampling
FMTP	Formation Multi-Tester Pressure Test
HPFT	Formation Multi-Tester w/Hewlett-Packard Gauge
SWC	Sidewall Coring
SWS	Sidewall Coring Slim Hole

Auxiliary	
CAL	Capiler Log
BGDC	Borehole Geometry Dual Caliper
CAL	4-Arm Caliper
CAL	Simultaneous Caliper
FPI	Freepoint Indicator
BOI	Back Off (After FPI)
BO	Back Off (Alone)
TC	Tubing Cutter
CC	Chemical Cutter
CCG	Casing Cutter

Casing Evaluation	
VTL	Vertilog
MGL	Magnelog
CPP	Casing Potential Profile
MCL	Multi-Finger Caliper

Plugs and packers	
BPS	Bridge Plug Setting
TPS	Through Tubing Bridge Plug
PS	Packer Setting
DB	Dump Bailer
JB	Junk Basket
JBB	Junk Basket (Before BPS)
TBG	Tubing Gauge Run

From *Wireline Logging Tool Catalog*, Éditions Technip, Paris, 1986.

ABBREVIATIONS USED IN WIRELINE LOGGING

Gearhart

Computed Logs	
ULTRA	Ultimate Logging Tool Response Analysis
COMLITH	Complex Lithology Analysis
COMSAND	Computerized Shaly Sand Analysis
WEL	Well Site Evaluation
GOR	Gas-Oil-Ratio
FMOP	F-Moveable Oil Plot
COMSET	Complex Shale Evaluation Technique
XPLOT	Cross Plot
FRAY	Fractured Reservoir Analysis
F-PAIRS	
BHV	Borehole Volume
TVD	True Vertical Depth
NEXUS	Dipmeter
PRONTO	

Cased Hole	
HSC	Casing Gun
Go-Winder	Through Tubing Gun
FPT	Free Point
JB	Junk Basket
BP	Bridge Plug
DB	Dump Bailer

Radioactivity	
UGR	Gamma Ray
SGR	Spectral Gamma Ray
NL	Neutron Log (Single Det.)
SNT	Sidewal Neutron
CNS	Compensated Neutron Log
CDT	Compensated Density Log
GNT	Gamma Ray Neutron
TDL	Thermal Decay Tool

Sampling	
SFT	Selective Formation Tester
SWT	Sidewall Coring
RCT (SBT)	Single Bit Hard Rock Coring Tool

Production	
FMS-DA	Continuous Flowmeter
FDT	Fluid Density Tool
TLT	Temperature Logging Tool
HYD	Hydro Tool
GRT	Gamma Ray Tool
BATS	Borehole Audio Tracer Survey
RDT	Radial Differential Temperature Tool
MAC	Multi Arm Caliper
QPT	Quartz Pressure Gauge Tool
RTT	Radioactive Tracer Injector Tool
BFS	Bottom Hole Fluid Sampler Tool
XYC	X-Y Caliper
PET	Pulse Echo Tool
TGR	Tracer Gamma Ray Tool
FMS-DB	High Temperature Flowmeter
FMS-DC	Geothermal Flowmeter

Resistivity	
IEL	Induction Electric Log
DIL	Dual Induction Laterolog
DLL	Dual Laterolog
MEL	Microlog
MLL	Microlaterolog
MSF	Microspherically Focused Log
DCL	Dielectric Constant Log

Sonic	
BCT	Borehole Compensated Sonic
BCT-EA	Long Space Sonic
VDL	Variable Density Log
CBL	Cement Bond Log
SRS	Seismic Reference Service

Dipmeter	
FED	Four Electrode Dipmeter
DIR	Direction Survey
DFL	Dip Frac Log

ABBREVIATIONS USED IN WIRELINE LOGGING

Schlumberger

Resistivity	
ULSEL	Ultra long spacing electrical logging
IES	Induction electrical logging
ISF	Induction spherically focused
DLL	Dual laterolog
DIL	Dual induction laterolog
DIS	Dual induction SFL
DIT-E	Multi Frequency DIT
DPT	Deep Propagation log

Microdevices	
ML	Microlog
MLL/PL	Microlaterolog or Proximity
MSFL	Microspherically focused log
MSFL-M	Derived Microlog (from MSFL)
EPT	Electromagnetic propagation log
ML-C	Combinable Microlog

Dipmeter	
HDT	High Resolution Dipmeter
HDT-K	HDT with oil base mud kit
SHDT	Stratigraphic High Resolution Dipmeter
MEST	Microelectric Scanner Tool

Nuclear	
GR	Gamma Ray
NGS	Natural Gamma Ray Spectroscopy (Th.U.K.)
CNL	Compensated Neutron
CNT-G	Multidetector Neutron
FDC	Formation density
LDL	Litho density
NML	Nuclear Magnetic Resonance
GRL/N	Gamma Ray or Neutron thru tubing
GRN	Gamma Ray and Neutron thru tubing
TDT-K	Thermal Decay Log
TDT-M.	Multigate Thermal Decay
GST-I	Neutron Induced GR Spectroscopy Inelastic Mode
GST-C	GST Capture mode
TGP	Gravel Pack Monitoring with TDT
TDT-MB	Dual Cross Section TDT
CTL	Cement Tracer log

Sampling	
STL	Sidewal coring Large
STS	Sidewal coring Small
RFT	Repeat Formation Tester
HP-R	Hewlett Packard with RFT
FIT	Formation Tester
RFT-N	RFT-N

FPI-BO	
SIT	Free point indicator
BO	Back Off (after SIT) or with FPIT
TGC	Tubular Good Jet Cutter
FPIT	Free point indicator Combinable
BO-S	Back Off alone
CHC	Chemical Cutter
SCT	Severing Colliding Tool
CERT	Electromagnet

Producting logging	
CFM	Continuous Flowmeter
FBS	Full Bore Spinner
PFM	Packer Flowmeter
PFS	Petal Packer Flowmeter
VFS	Vortex Flowmeter
GM	Gradiomanometer
NFD	Nuclear Fluid Densimeter
XFT	X-Ray Fluid Analyser
HRT	Thermometer with PLT
HTT	Thermometer HTT-C
TTC	Thru Tubind Caliper
HP-C	Hewlett Packard in Combination
HP	Hewlett Packard run alone
MAN	Manometter
RTP	Radioactive Tracer Ejector
PST	Production Fluid Sampling
NOL	Noise Logging
PTS	Pressure Temperature Sonde

ABBREVIATIONS USED IN *WIRELINE LOGGING*

Schlumberger (continued)

Acoustic	
CC	Cable charge (EUR)
WSS-D	Seismic Reference Service with WST
WSS-O	SRS Offset with WST
DWSS	Dual WST
SAT	*Seismic Reference Service with* 3-Axis Tool
SAT-O	Seismic Reference Service with SAT, Offset
SAT-W	SAT with SATm Multi-Offset
BHC	Sonic log
BHC-VD	Sonic-Variable Density
SLS	Sonic long spacing
SLS-VD	Sonic long spacing Variable Density
WFT	Waveform taping
SDT	Digital Sonic
CMS	Circumferencial Microsonic
BHTV	Bore Hole Televiewer 3"3/8
CBL-VD	Cement Bond with or without Variable Density
CET	Cement Evaluation
CBT	Cement Bond Tool

Corrosion	
ETT-A	Casing Thickness Detection Type A
ETT-D	Casing Thickness Detection Type D
PAL	Pipe Analysis Log
MFC	*Multifinger Caliper*
AST	Ultra Sonic Casing Scanner
CPP	Casing Potential Profile
SBHTV	Bore Hole TV 1"3/4
CET-D	CET for Corrosion
Directional	
CDR	Directional survey with HDT or SHDT
CDR-BG	Bore Hole Geometry
GCT	Gyro Continuous Guidance (Deviation)
GPIT	Inclinometry Tool
Miscellaneous	
BGL	Caliper with Hole Geometry
CAL	Caliper other than BGT or TTC
DD	Depth Determination
DDS	Subsidence Logging
CIS-S	Customer Instrument Service - Seismic
CIS-D	Customer Instrument Service - Directional
CIS-O	Customer Instrument Service - Others
T	Temperature log other than HRT
OFS	Other Services

ABBREVIATIONS USED IN WIRELINE LOGGING

Welex

AVL	Compensated Acoustic Velocity Log
BOS	Back Off Service
BPS	Standard Bridge Plug Service
BRBP	Baker Retrievable Plug
CCL	Casing Collar Locator
CL	Caliper Log
CMC	Chemical Cutter
CSNG*	Compensated Spectral Natural Gamma
DB	Dump Bailer
DCT	Dielectric Constant Tool
DD	Depth Determination
DEN	Compensated Density Log
DGL	Dual Guard Log
DGMG	Dual Guard Micro-Guard
DIL	Dual Induction Guard Log
DIP	Resistivity Dip Log
DL	Continuous Drift Log
DLLT	Dual Laterolog Logging Tool
DRP	DR Plug
DSGT	Dits Short Guard Logging Tool
DSN	Dual Spaced Neutron Log
DTTBP	Dual Timer Through Tubing Bleedoff Bridge Plug Service
FD	Fluid Density Tool
FDSPT	Combination Fluid Density, Spinner and Temperature Log
FORXO	Micro-Guard Caliper Log (Forxo Caliper Log)
FP BO	Free Point and Backoff Services
FPL	Fracture Profile Log
FPS	Free Point Service
FTL	Fluid Travel Log
FWAT	Full Wave Acoustic Tool
GAU	Gauge Run
GL	Guard Log
GR	Gamma Ray Log
GRDC	Gamma Ray Depth Control
GRN	Gamma Ray Neutron Log
GRNDC	Gamma Ray Neutron Depth Control Log
GRPS	Gamma Ray Perforating Sub
IEL	Induction Electric Log
JC	Junk Catcher
JCC	Jet Cutters and Circulation Holes
MICRO	Microlog Caliper Log (Contact Caliper Log)
MG	Micro-Guard Logging Tool
MSG*B	Micro-Seismogram Bond Tool
MSG*FF	Micro-Seismogram Fracture Finder Log
MST	Multiset Tester
NDC	*Neutron Depth Control*
NEU	Neutron Log
NGRT	Natural Gamma Ray Tool
PP	Production Packer and Retainer Setting
ROS	Radioactive Orientation Service
RTL	Radioactive Tracer Log
SDLT	Spectral Density Logging Tool
SFTT	Sequential Formation Test Tool
SPN	Spinner
SPN FD	Combination Spinner and Fluid Density
SWC	Sidewall Coring
TEMP	Precision Temperature Log
TSPN	Combination Temperature and Spinner Log

* A brand of Welex, a Halliburton company.

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