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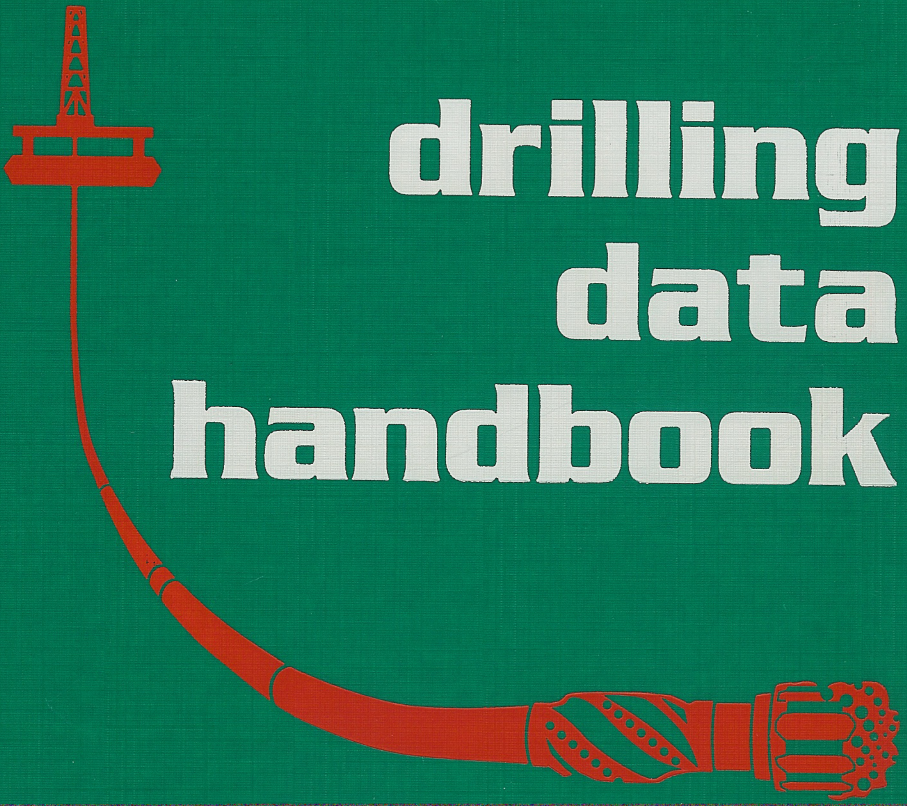
drilling data handbook



Seventh edition

ÉDITIONS TECHNIP

NOTICE

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

Front cover: Kolette

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Foreword

to the Seventh Edition

The sixth edition of the Drilling Data Handbook was published in 1991. Over the past ten years, drilling techniques have considerably evolved.

New Specifications and Recommended Practices have been published by the American Petroleum Institute and, in the meantime, manufacturers have also greatly improved their equipment.

In particular, remarkable progress has been achieved in the following fields:

- Horizontal displacements have reached a distance of over ten kilometers in directional and horizontal drilling, with the use of more complex bottom hole assemblies and drill strings.
- Coiled tubing units are now being used almost systematically during workover, and occasionally during drilling.
- The range of drilling bits has been entirely renewed, and the classifications and Used Bit Dull Grading System Format and Codes of the IADC have been modified accordingly.
- New dimensions and weights for casings have appeared with the drilling of HP-HT wells.
- Wellhead equipment and control systems were modified to keep up with deep offshore drilling.

This list is not exhaustive. However, it demonstrates that a new edition of the Drilling Data Handbook was undeniably needed in order to reflect these changes.

We indeed hope that experienced users of this handbook will appreciate the new edition in an environment which is already familiar to them.

G. GABOLDE AND J.-P. NGUYEN

A

general data

CONVERSION FACTORS TO SI UNITS

Multiply	Symbol	by	to obtain	Symbol
Acres		4046.8	Square meters	m^2
Barrels	bbl	0.158984	Cubic meters	m^3
Barrels per day	bbl/d	0.0066243	Cubic meters per hour	m^3/h
British thermal units	Btu	1055.06	Joules	J
Feet	ft	0.3048	Meters	m
Square feet	ft^2	0.0929	Square meters	m^2
Cubic feet	ft^3	28.302	Liters	l
Cubic feet per barrel	ft^3/bbl	0.17811088	Cubic meters by cubic meter	m^3/m^3
Foot.pound-force	ft.lbf	1.35582	Joules	J
Foot.pound-force	ft.lbf	1.3558	Newton.meter	N.m
Gallons (US)	gal (US)	3.7854	Liters	l
Gallons (US) per foot	gal/ft	12.4191	Liters per meter	l/m
Horsepowers	hp	0.7457	Kilowatts	kW
Inches	in	2.54	Centimeters	cm
Square inches	in^2	6.4516	Square centimeters	cm^2
Cubic inches	in^3	16.387064	Cubic centimeters	cm^3
Inches.pound-force	in.lbf	0.1129848	Newton.meter	N.m
kip		4.45E+03	Newton	N
kip per square inch	ksi	6.89E+06	Pascal	Pa
Knot		0.514444	Meters per second	m/s
Miles	mile	1609.3	Meters	m
Square miles	sq mile	258.9998	Hectares	ha
Miles (Nautical)	mile (Nau)	1.853	Kilometers	km
Miles (Statute) *land miles*	mile (st)	1.6093	Kilometers	km
Pounds per square inches/foot	psi/ft	22.62	Kilopascal/meter	kPa/m
Pounds-force	lbf	4.44822	Newtons	N
Pounds-force per cubic foot	lbf/ft^3	0.0160185	Kilograms-force per liter	kgf/l
Pounds-force per square inch	psi	0.068947448	Bars	bar
Pounds-force per square inch	psi	6.894745	Kilopascals	kPa
Pounds-force/cubic foot	lbf/ft^3	0.01602	Kilogram-force/liter	kgf/l
Pounds-force/gallon	lbf/gal	0.1198	Kilogram-force/liter	kgf/l
Tons-force (long)	lg tonf	1.01605	Tons-force	tf
Tons-force (short)	sh tonf	0.9072	Tons-force	tf
Yards	yd	0.9144027	Meters	m
Square yards	yd^2	3.22831E-07	Square miles	sq mile
Cubic yards	yd^3	764.6	Liters	l

CONVERSION FACTORS

Multiply	Symbol	by	to obtain	Symbol
Acres		0.404686	Hectares	ha
Acres		0.00404686	Square kilometers	km^2
Acres		43560	Square feet	ft^2
Acres		4840	Square yards	yd^2
Acres		43560	Square feet	ft^2
Acres		4840	Square yards	yd^2
Acres		4046.8	Square meters	m^2
Acres		0.00156	Square miles	sq mile
Acres		40.47	Ares	a
Ampere-hour	Ah	3600	Coulomb	C
Ares	a	0.0247096	Acres	
Atmospheres (mean sea level)	atm	29.92	Inches of mercury	inHg
Atmospheres (mean sea level)	atm	14.691	Pounds per square inch	psi
Atmospheres (mean sea level)	atm	76	Centimeters of mercury	cmHg
Atmospheres (mean sea level)	atm	101325	Pascals	Pa
Barrels	bbl	0.158984	Cubic meters	m^3
Barrels	bbl	9702	Cubic inches	in^3
Barrels	bbl	5.6146	Cubic feet	ft^3
Barrels	bbl	34.9726	Imperial gallons	gal (UK)
Barrels	bbl	42	Gallons (US)	gal (US)
Barrels	bbl	158.984	Liters	l
Barrels per day	bbl/d	0.0066243	Cubic meters per hour	m^3/h
Barrels per foot	bbl/ft	0.5216119	Square meters	m^2
Barrels per inch	bbl/in	6.259343	Square meters	m^2
Bars	bar	14.5038	Pounds-force per square inch	psi
Bars	bar	100 000	Pascals	Pa
Bars	bar	100	Kilopascals	kPa
Bars	bar	0.1	Megapascals	MPa
British thermal units	Btu	1055.06	Joules	J
British thermal units	Btu	0.252075	Kilocalories	kcal
British thermal units per cubic foot	Btu/ft^3	8.90036	Kilocalories per cubic meter	$kcal/m^3$
British thermal units per pound	Btu/lb	0.55573	Kilocalories per kilogram	kcal/kg
British thermal units per square foot	Btu/ft^2	2.71331396	Kilocalories per square meter	$kcal/m^2$
Calories	cal	4.186	Joules	J
Centimeters	cm	0.3937	Inches	in
Centimeters	cm	0.01094	Yards	yd
Centimeters	cm	0.03280839	Feet	ft
Centimeters	cm	0.0001	Kilometers	km
Square centimeters	cm^2	0.155	Square inches	in^2
Square centimeters	cm^2	0.00107639	Square feet	ft^2
Square centimeters	cm^2	0.0001	Square meters	m^2
Cubic centimeters	cm^3	0.0610236	Cubic inches	in^3
Cubic centimeters	cm^3	0.0353	Cubic feet	ft^3
Cubic centimeters	cm^3	0.0000013	Cubic yards	yd^3
Cubic centimeters	cm^3	0.001	Liters	l
Centimeters of mercury	cmHg	0.01315789	Atmospheres (mean sea level)	atm
Centipoises	cP	0.001	Pascals.second	Pa.s
Centistokes	cSt	0.0000001	Square meter.second	$m^2.s$
Coulombs	C	0.0002777	Ampere-hour	Ah

CONVERSION FACTORS (continued)

Multiply	Symbol	by	to obtain	Symbol
Daltons		1.66E-27	Kilograms	kg
Darcies	D	9.87E-13	Square meters	m^2
Decanewtons	daN	1.02	Kilograms-force	kgf
Decanewtons	daN	2.2482014	Pounds-force	lbf
Decanewtons.meters	daN.m	7.3746312	Feet.pound-force	ft.lbf
Decanewtons.meters	daN.m	10	Newtons.meters	N.m
Degree (angle)		1.75E-02	Radians	rad
Electronvolts	eV	1.60E-19	Joules	J
Fathoms	fth	1.8288	Meters	m
Feet	ft	0.3048	Meters	m
Feet	ft	0.3333	Yards	yd
Feet	ft	30.48	Centimeters	cm
Feet	ft	0.0003048	Kilometers	km
Feet	ft	0.0001894	Miles	mile
Feet	ft	12	Inches	in
Square feet	ft^2	144	Square inches	in^2
Square feet	ft^2	0.1111	Square yards	yd^2
Square feet	ft^2	0.0929	Square meters	m^2
Square feet	ft^2	929.03	Square centimeters	cm^2
Square feet	ft^2	2.2957E-05	Acres	
Cubic feet	ft^3	28.302	Liters	l
Cubic feet	ft^3	0.02832	Cubic meters	m^3
Cubic feet	ft^3	1728	Cubic inches	in^3
Cubic feet	ft^3	0.03704	Cubic yards	yd^3
Cubic feet	ft^3	7.4805	Gallons (US)	gal (US)
Cubic feet	ft^3	6.288	Imperial gallons	gal (UK)
Cubic feet	ft^3	0.17811	Barrels	bbl
Cubic feet	ft^3	28320	Cubic centimeters	cm^3
Cubic feet per barrel	ft^3/bbl	0.17811088	Cubic meters by cubic meter	m^3/m^3
Feet.pounds-force	ft.lbf	1.35582	Joules	J
Feet.pounds-force	ft.lbf	0.138255	Kilograms.meters	kg.m
Feet.pounds-force	ft.lbf	1.3558	Newtons.meters	N.m
Feet.pounds-force	ft.lbf	0.1356	Decanewtons.meters	daN.m
Gallons (imperial)	gal (UK)	277.42	Cubic inches	in^3
Gallons (imperial)	gal (UK)	0.0045461	Cubic meters	m^3
Gallons (imperial)	gal (UK)	4.54595	Liters	l
Gallons (imperial)	gal (UK)	0.0285938	Barrels	bbl
Gallons (imperial)	gal (UK)	0.159033	Cubic feet	ft^3
Gallons (imperial)	gal (UK)	1.200912	Gallons (US)	gal (US)
Gallons (US)	gal (US)	128	Ounces	oz
Gallons (US)	gal (US)	4	Quarts	qt
Gallons (US)	gal (US)	8	Pints	
Gallons (US)	gal (US)	0.8327	Imperial gallons	gal (UK)
Gallons (US)	gal (US)	231	Cubic inches	in^3
Gallons (US)	gal (US)	0.02380952	Barrels	bbl
Gallons (US)	gal (US)	3.7854	Liters	l
Gallons (US)	gal (US)	0.0037854	Cubic meters	m^3
Gallons (US) per barrel	gal/bbl	23.81	Liters per cubic meter	l/m^3
Gallons (US) per foot	gal/ft	12.4191	Liters/meter	l/m
Grains-force	grf	0.0647987	Grams-force	gf
Grams-force	gf	15.4324	Grains-force	grf
Grams-force	gf	0.035274	Ounces-force	ozf

CONVERSION FACTORS (continued)

Multiply	Symbol	by	to obtain	Symbol
Hectares	ha	2.47105	Acres	
Hectares	ha	10 000	Square meters	m^2
Hectares	ha	0.00386101	Square miles	sq mile
Hectares	ha	10 000	Square meters	m^2
Horsepowers	hp	0.7457	Kilowatts	kW
Horsepowers	hp	1.01387	Steam horsepowers	ch
Horsepowers	hp	745.701	Watts	W
Horsepowers (steam)	ch	0.98632	Horsepowers	hp
Horsepowers (steam)	ch	735.498	Watts	W
Inches	in	25.4	Millimeters	mm
Inches	in	2.54	Centimeters	cm
Inches	in	0.0833333	Feet	ft
Inches	in	0.02777	Yards	yd
Square inches	in^2	6.4516	Square centimeters	cm^2
Square inches	in^2	0.00694444	Square feet	ft^2
Square inches	in^2	0.0007716	Square yards	yd^2
Square inches	in^2	0.00064516	Square meters	m^2
Cubic inches	in^3	16.3871027	Cubic centimeters	cm^3
Cubic inches	in^3	0.00010307	Barrels	bbl
Cubic inches	in^3	0.0005787	Cubic feet	ft^3
Cubic inches	in^3	0.0163865	Liters	l
Cubic inches	in^3	0.5541	Ounces	oz
Cubic inches	in^3	0.0173	Quarts	qt
Cubic inches	in^3	0.004329	Gallons (US)	gal (US)
Cubic inches	in^3	0.0036046	Imperial gallon	gal (UK)
Cubic inches	in^3	1.6387E-05	Cubic meters	m^3
Cubic inches	in^3	2.1433E-05	Cubic yards	yd^3
Inches of mercury	inHg	0.03342246	Atmospheres (mean sea level)	atm
Inches of mercury	inHg	1333.22	Pascals	Pa
Inches of mercury	inHg	0.4912	Pounds-force per square inch	psi
Inches.pounds-force	in.lbf	0.1129848	Newtons.meters	N.m
Joules	J	6.2415E+18	Electronvolts	eV
Joules	J	0.23889154	Calories	cal
Joules	J	0.737561	Feet.pounds-force	ft.lbf
Joules	J	0.00094781	British thermal units	Btu
Kilocalories	kcal	3.96707	British thermal units	Btu
Kilocalories per cubic meter	$kcal/m^3$	0.112355	British thermal units per cubic foot	Btu/ft^3
Kilocalories per kilogram	kcal/kg	1.79943	British thermal units per pound	Btu/lb
Kilocalories per square meter	$kcal/m^2$	0.368553	British thermal units per square foot	Btu/ft^2
Kilograms-force	kgf	2.204586	Pounds-force	lbf
Kilograms-force	kgf	0.00098425	Long tons-force	lg tonf
Kilograms-force	kgf	0.001	Tons-force	tf
Kilograms-force	kgf	2.20462	Pounds-force	lbf
Kilograms-force	kgf	0.0234534	Sacks (cement)	
Kilograms-force	kgf	0.0011023	Short tons-force	sh tonf
Kilograms-force	kgf	9.81	Newtons	N
Kilograms-force	kgf	0.981	Decanewtons	daN
Kilograms-force per cubic meter	kgf/m^3	0.3505	Pounds-force per barrel	lbf/bbl
Kilograms-force per cubic meter	kgf/m^3	0.35050001	Pounds-force per barrel	lbf/bbl
Kilograms-force per liter	kgf/l	8.34523	Pounds-force per gallon (US)	lbf/gal
Kilograms-force per liter	kgf/l	62.4278	Pounds-force per cubic foot	lbf/ft^3

CONVERSION FACTORS (continued)

Multiply	Symbol	by	to obtain	Symbol
Kilograms-force per meter	kgf/m	0.671971	Pounds-force per foot	lbf/ft
Kilograms-force per square centimeter	kgf/cm^2	14.2233	Pound-force per square inch	psi
Kilograms-force per square millimeter	kgf/mm^2	0.711167	Short tons-force per square inch	sh $tonf/in^2$
Kilograms-force per square millimeter	kgf/mm^2	102.408	Short tons-force per square foot	sh $tonf/ft^2$
Kilograms-force.meters	kgf.m	9.81	Newtons.meters	N.m
Kilograms-force.meters	kgf.m	7.23301	Feet.pounds-force	ft.lbf
Kilograms-force/liter	kgf/l	8.3472454	Pounds-force/gallon	lbf/gal
Kilograms-force/liter	kgf/l	62.421972	Pounds-force/cubic foot	lbf/ft^3
Kilometers	km	0.621373	Statute miles (land miles)	mile (st)
Kilometers	km	0.539613	Nautical miles (UK sea miles)	mile (Nau) UK
Kilometers	km	0.539957	Nautical miles (other countries)	mile (Nau)
Kilometers	km	3280.83	Feet	ft
Kilometers	km	1093.61	Yards	yd
Kilometers	km	1000	Meters	m
Kilometers	km	10000	Centimeters	cm
Kilometers	km	0.621388	Miles	mile
Kilometers	km	0.539957	Nautical miles	mile (Nau)
Square kilometers	km^2	0.386102	Square miles	sq mile
Square kilometers	km^2	247.1	Acres	
Kilopascals	kPa	0.145038	Pounds-force per square inch	psi
Kilopascals	kPa	0.01	Bars	bar
Kilopascal/meter	kPa/m	0.0442086	Pounds square inches/foot	psi/ft
Kilowatt-hours	kWh	3.60E+06	Joules	J
Kilowatts	kW	1.34102	Horsepowers	hp
kips		4.45E+03	Newtons	N
kips per square inch	ksi	6.89E+06	Pascals	Pa
Knots		0.514444	Meters per second	m/s
Liters	l	61.025844	Cubic inches	in^3
Liters	l	0.0353147	Cubic feet	ft^3
Liters	l	0.264178	Gallons (US)	gal (US)
Liters	l	0.219976	Imperial gallons	gal (UK)
Liters	l	0.00628994	Barrels	bbl
Liters	l	1000	Cubic centimeters	cm^3
Liters	l	1.0567	Quarts	qt
Liters	l	0.0013	Cubic yards	yd^3
Liters	l	0.001	Cubic meters	m^3
Liters per cubic meter	l/m^3	0.042	Gallons (US) per barrel	gal/bbl
Liters/meter	l/m	0.0805214	Gallons (US) per foot	gal/ft
Megapascals	MPa	10	Bars	bar
Megapascals	MPa	145.038	Pounds-force per square inch	psi
Meters	m	3.28084	Feet	ft
Meters	m	1.09361	Yards	yd
Meters	m	0.001	Kilometers	km
Meters	m	0.00062137	Miles	mile
Meters	m	1000	Millimeters	mm
Square meters	m^2	0.15976117	Barrels per inch	bbl/in
Square meters	m^2	1.91713417	Barrels per foot	bbl/ft
Square meters	m^2	10.7639	Square feet	ft^2
Square meters	m^2	0.0002471	Acres	

CONVERSION FACTORS (continued)

Multiply	Symbol	by	to obtain	Symbol
Square meters	m^2	1550	Square inches	in^2
Square meters	m^2	1.1959	Square yards	yd^2
Square meters	m^2	10 000	Square centimeters	cm^2
Square meters	m^2	0.0001	Hectares	ha
Cubic meters	m^3	35.3147	Cubic feet	ft^3
Cubic meters	m^3	6.28994	Barrels (US)	bbl
Cubic meters	m^3	219.96876	Imperial gallons	gal (UK)
Cubic meters	m^3	61023.38	Cubic inches	in^3
Cubic meters	m^3	1.30796	Cubic yards	yd^3
Cubic meters	m^3	1000	Liters	l
Cubic meters	m^3	264.17	Gallons (US)	gal (US)
Cubic meters by cubic meter	m^3/m^3	5.61448	Cubic feet per barrel	ft^3/bbl
Cubic meters per hour	m^3/h	150.959	Barrels per day	bbl/d
Miles	mile	5280	Feet	ft
Miles	mile	1760	Yards	yd
Miles	mile	1609.3	Meters	m
Miles	mile	1.6093	Kilometers	km
Miles	mile	0.8684	Nautical miles	mile (Nau)
Miles	mile	0.86840005	Nautical miles	mile (Nau)
Square miles	sq mile	641.025	Acres	
Square miles	sq mile	3097600	Square yards	yd^2
Square miles	sq mile	258.9998	Hectares	ha
Square miles	sq mile	2.5899	Square kilometers	km^2
Miles (Nautical)	mile (Nau)	1.151543	Miles	mile
Miles (Nautical)	mile (Nau)	1.853	Kilometers	km
Miles (statute) *land miles*	mile (st)	1.6093	Kilometers	km
Millimeters	mm	0.03937	Inches	in
Millimeters	mm	0.001	Meters	m
Newtons	N	0.102	Kilograms-force	kgf
Newtons	N	0.224809	Pounds-force	lbf
Newtons	N	0.22480902	Pounds-force	lbf
Newtons.meters	N.m	0.1	Decanewtons.meters	daN.m
Newtons.meters	N.m	0.102	Kilograms-force.meters	kgf.m
Newtons.meters	N.m	0.737561	Feet pounds-force	ft.lbf
Ounces	oz	1.804728	Cubic inches	in^3
Ounces	oz	0.0078125	Gallons (US)	gal (US)
Ounces	oz	0.0625	Pounds	lbf
Ounces-force	ozf	28.34949	Grams-force	gf
Pascals	Pa	0.00001	Bars	bar
Pints		0.125	Gallons (US)	gal (US)
Pounds-force	lbf	0.4448	Decanewtons	daN
Pounds-force	lbf	0.00044643	Long tons-force	lg tonf
Pounds-force	lbf	0.0005	Short tons-force	sh tonf
Pounds-force	lbf	16	Ounces-force	ozf
Pounds-force	lbf	0.0005	Short tons-force	sh tonf
Pounds-force	lbf	0.4536	Kilograms-force	kgf
Pounds-force	lbf	4.44822	Newtons	N
Pounds-force per barrel	lbf/bbl	2.853067	Kilograms-force per cubic meter	kgf/m^3
Pounds-force per cubic foot	lbf/ft^3	0.0160185	Kilograms-force per liter	kgf/l
Pounds-force per foot	lbf/ft	1.4881594	Kilograms-force per meter	kgf/m

CONVERSION FACTORS (continued)

Multiply	Symbol	by	to obtain	Symbol
Pounds-force per square inch	psi	0.06894745	Bars	bar
Pounds-force per square inch	psi	0.07030717	Kilograms-force per square centimeter	kgf/cm^2
Pounds-force per square inch	psi	6.894745	Kilopascals	kPa
Pounds-force per square inch	psi	0.00689474	Megapascals	MPa
Pounds-force per square inch	psi	2.03583062	Inches of mercury	inHg
Pounds-force per square inch	psi	0.06804	Atmospheres	atm
Pounds-force per square inches/foot	psi/ft	22.62	Kilopascals/meter	kPa/m
Pounds-force/gallon	lbf/gal	0.1198	Kilogram-force/liter	kgf/l
Quarts	qt	0.25	Gallons (US)	gal (US)
Quarts	qt	57.8034682	Cubic inches	in^3
Quarts	qt	0.94634239	Liters	l
rpm		0.1047198	Radians per second	rad/s
Sacks (cement)		42.6377412	Kilograms-force	kgf
Tons-force	tf	1000	Kilograms-force	kg
Tons-force	tf	0.9842	Long tons-force	lg tonf
Tons-force	tf	1.10231	Short tons-force	sh tonf
Tons-force.kilometers	tf.km	0.684944	Short tons-force.miles	sh tonf.mile
Tons-force (long)	lg tonf	1016	Kilograms-force	kgf
Tons-force (long)	lg tonf	2240	Pounds-force	lbf
Tons-force (long)	lg tonf	1.01605	Tons-force	tf
Tons-force (long)	lg tonf	1.12	Short tons-force	sh tonf
Tons-force (short)	sh tonf	0.89287	Long tons-force	lg tonf
Tons-force (short)	sh tonf	2000	Pounds-force	lbf
Tons-force (short)	sh tonf	0.8929	Long tons-force	lg tonf
Tons-force (short)	sh tonf	0.9072	Tons-force	tf
Tons-force (short)	sh tonf	907.194	Kilograms-force	kgf
Tons-force (short).miles	sh tonf.mile	1.45997337	Tons-force.kilometers	tf.km
Tons-force (short) per square foot	sh tonf/ft^2	0.00976486	Kilograms-force per square millimeter	kgf/mm^2
Tons-force (short) per square inch	sh tonf/in^2	1.40613949	Kilograms-force per square millimeter	kgf/mm^2
Yards	yd	91.44027	Centimeters	cm
Yards	yd	0.9144027	Meters	m
Yards	yd	3	Feet	ft
Yards	yd	36	Inches	in
Yards	yd	0.0009144	Kilometers	km
Yards	yd	0.00056818	Miles	mile
Square yards	yd^2	0.00020661	Acres	
Square yards	yd^2	9	Square feet	ft^2
Square yards	yd^2	1296	Square inches	in^2
Square yards	yd^2	0.83619032	Square meters	m^2
Square yards	yd^2	3.2283E-07	Square miles	sq mile
Cubic yards	yd^3	46656	Cubic inches	in^3
Cubic yards	yd^3	764559.4	Cubic centimeters	cm^3
Cubic yards	yd^3	27	Cubic feet	ft^3
Cubic yards	yd^3	46656	Cubic inches	in^3
Cubic yards	yd^3	764.6	Liters	l
Cubic yards	yd^3	0.76454937	Cubic meters	m^3
Watts	W	0.00134102	Horsepowers	hp
Watt-hours	Wh	3600	Joules	J

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)

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	0.031250	0.79375	17/32	0.531250	13.49378
3/64	0.046875	1.19063	35/64	0.546875	13.89065
1/16	0.062500	1.58750	9/16	0.562500	14.28753
5/64	0.078125	1.98438	37/64	0.578125	14.68440
3/32	0.093750	2.38125	19/32	0.593750	15.08128
7/64	0.109375	2.77813	39/64	0.609375	15.47816
1/8	0.125000	3.17501	**5/8**	0.625000	15.87503
9/64	0.140625	3.57188	41/64	0.640625	16.27191
5/32	0.156250	3.96876	21/32	0.656250	16.66878
11/64	0.171875	4.36563	43/64	0.671875	17.06566
3/16	0.187500	4.76251	11/16	0.687500	17.46253
13/64	0.203125	5.15939	45/64	0.703125	17.85941
7/32	0.218750	5.55626	23/32	0.718750	18.25629
15/64	0.234375	5.95314	47/64	0.734375	18.65316
1/4	0.250000	6.35001	**3/4**	0.750000	19.05004
17/64	0.265625	6.74689	49/64	0.765625	19.44691
9/32	0.281250	7.14376	25/32	0.781250	19.84379
19/64	0.296875	7.54064	51/64	0.796875	20.24067
5/16	0.312500	7.93752	13/16	0.812500	20.63754
21/64	0.328125	8.33439	53/64	0.828125	21.03442
11/32	0.343750	8.73127	27/32	0.843750	21.43129
23/64	0.359375	9.12814	55/64	0.859375	21.82817
3/8	0.375000	9.52502	**7/8**	0.875000	22.22504
25/64	0.390625	9.92189	57/64	0.890625	22.62192
13/32	0.406250	10.31877	29/32	0.906250	23.01880
27/64	0.421875	10.71565	59/64	0.921875	23.41567
7/16	0.437500	11.11252	15/16	0.937500	23.81255
29/64	0.453125	11.50940	61/64	0.953125	24.20942
15/32	0.468750	11.90627	31/32	0.968750	24.60630
31/64	0.484375	12.30315	63/64	0.984375	25.00318
1/2	0.500000	12.70003	**1**	1.000000	25.40005

TEMPERATURE CONVERSION TABLE

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

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	−11.10	**12**	53.6	11.1	**52**	125.6	33.3	**92**	197.6	216	**420**	788
−53.9	**−65**	−85.0	−10.00	**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**	68.8	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**	248.0	271	**520**	968
−40.0	**−40**	−40.0	−4.44	**24**	75.2	17.8	**64**	147.2	60.0	**140**	284.0	282	**540**	1004
−37.2	**−35**	−31.0	−3.33	**26**	78.8	18.9	**66**	150.8	71.1	**160**	320.0	293	**560**	1040
−34.4	**−30**	−22.0	−2.22	**28**	82.4	20.0	**68**	154.4	82.2	**180**	356.0	304	**580**	1076
−31.7	**−25**	−13.0	−1.11	**30**	86.0	21.1	**70**	158.0	93.3	**200**	392.0	316	**600**	1112
−28.9	**−20**	−4.0	0.00	**32**	89.6	22.2	**72**	161.6	104.4	**220**	428.0	327	**620**	1148
−26.1	**−15**	5.0	1.11	**34**	93.2	23.3	**74**	165.2	115.6	**240**	464.0	328	**640**	1184
−23.3	**−10**	14.0	2.22	**36**	96.8	24.4	**76**	168.8	126.7	**260**	500.0	349	**660**	1220
−20.6	**−5**	23.0	3.33	**38**	100.4	25.6	**78**	172.4	137.8	**280**	536.0	360	**680**	1256
−17.8	**0**	32.0	4.44	**40**	104.0	26.7	**80**	176.0	148.9	**300**	572.0	371	**700**	1292
−16.7	**2**	35.6	5.55	**42**	107.6	27.8	**82**	179.6	160.0	**320**	608.0	382	**720**	1328
−15.6	**4**	39.2	6.67	**44**	111.2	28.9	**84**	183.2	171.0	**340**	644.0	393	**740**	1364
−14.4	**6**	42.8	7.78	**46**	114.8	30.0	**86**	186.8	182.0	**360**	680.0	404	**760**	1400
−13.3	**8**	46.4	8.89	**48**	118.4	31.1	**88**	190.4	193.0	**380**	716.0	416	**780**	1436
−12.2	**10**	50.0	10.00	**50**	122.0	32.2	**90**	194.0	204.0	**400**	752.0	427	**800**	1472

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	17.4	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	83.5	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	8.0
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	50.8	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	6.1
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	49.4	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	5.3
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	27.8	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	26.1	0.948	17.8	0.998	10.3	1.048	3.5

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

$d(15.56°C/15.56°C)$ = Specific gravity (60°F/60°F)

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 $t > 15°C$
- substract 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	
$a \quad a+r \quad a+2r \quad a+3r \ \ldots \ a+(n-1)r$ $S_n = \left(\frac{a+\ell}{2}\right)n = \frac{n}{2}[2a+(n-1)r]$	a = first term r = common difference n = number of terms ℓ = last term = $a + (n-1)r$

Geometric progression	
$a \quad aq \quad aq^2 \quad aq^3 \ \ldots \ aq^{n-1}$ Si $q \neq 1$ $\quad S_n = \frac{\ell q - a}{q-1} = a\frac{(q^n-1)}{q-1}$	a = first term r = common ratio n = number of terms ℓ = last term = aq^{n-1}

Miscellaneous constants

0.0764 = air density in lb/ft^3 at 60°F and 14.7 psia
14.691 = normal atmospheric pressure (76 cmHg) in psi
32.174 = gravitational acceleration in ft/s^2 (980.655 cm/s^2)
550 = number of lb.ft/s one horsepower (hp)
778.2 = number of lb.ft in one Btu
62.43 = water density in lbf/ft^3 at 4°C
8.345 = water density in lbf/gal at 4°C
°C + 273.16 = K (Kelvin)
°F + 459.69 = °R (Rankine)

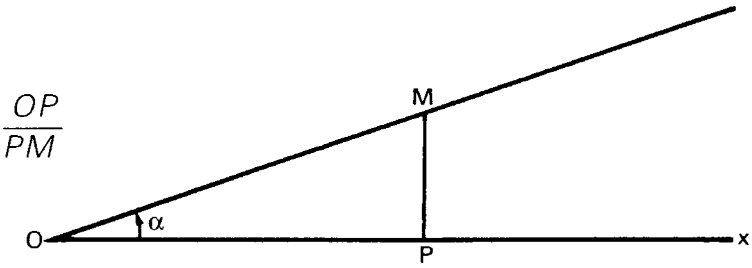
TRIGONOMETRIC FORMULAS

DEFINITION

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

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

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



GEOMETRIC INTERPRETATION

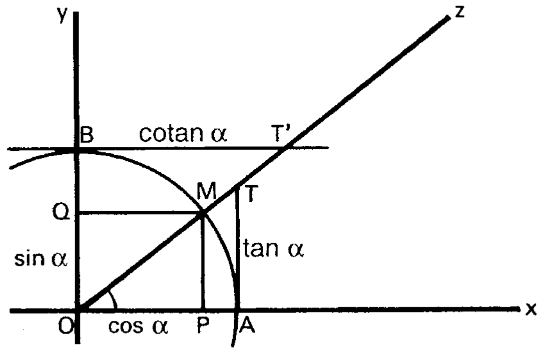
$$\overline{OA} = \overline{OM} = R = 1$$

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

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

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

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



TRIGONOMETRIC RELATIONS

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

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

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

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

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

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

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

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

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

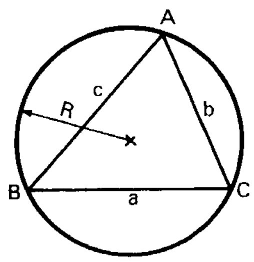
$$\tan(\alpha+\beta) = \frac{\tan\alpha + \tan\beta}{1 - \tan\alpha\,\tan\beta}$$

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

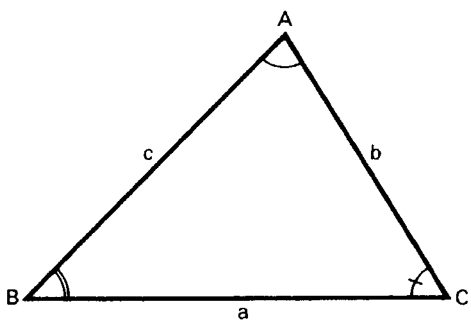
VALUES OF TRIGONOMETRIC FUNCTIONS RELATED TO HALF-ANGLE TANGENTS

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

RELATIONS BETWEEN SIDES AND ANGLE OF ANY TRIANGLE



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



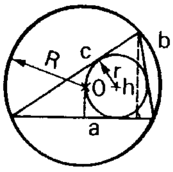
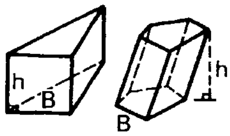
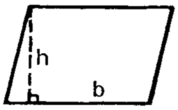
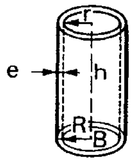
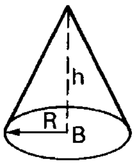
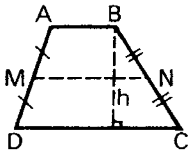
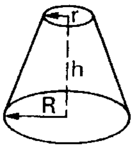
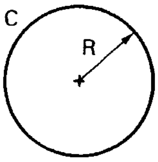
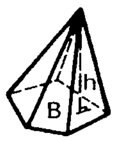
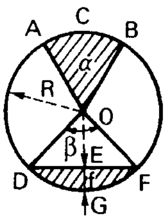
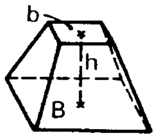
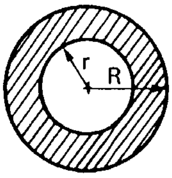
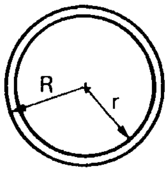
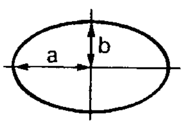
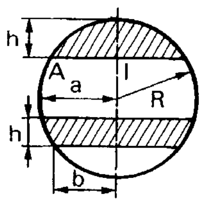
$$\frac{a}{\sin\hat{A}} = \frac{b}{\sin\hat{B}} = \frac{c}{\sin\hat{C}} = 2R$$

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

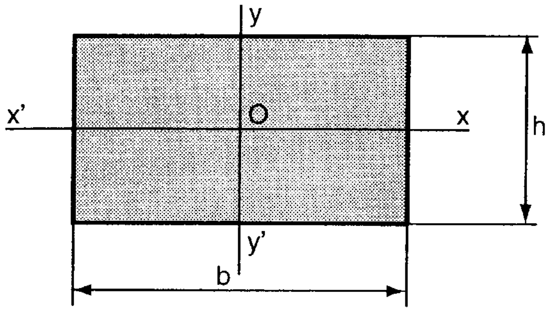
$$b^2 = c^2 + a^2 - 2ca\,\cos\hat{B}$$

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

GEOMETRY FORMULAS FOR AREAS AND VOLUMES

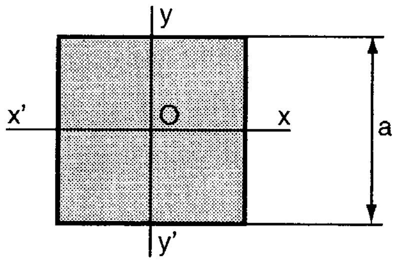
Area	Volume
 Triangle $p = \frac{a+b+c}{2}$ $S = \frac{ah}{2} = \frac{abc}{4R} = pr$	 Regular or oblique prism $V = B\,h$
 Parallelogram $S = bh$	 Right cylinder $V = \pi R^2 h = Bh$ Hollow cylinder $V = \pi(R^2 - r^2)h = \pi(R+r)eh$
Square: $S = a^2$ Rectangle: $S = ab$	 Right cone $V = \frac{\pi R^2 h}{3}$
 Trapezoid $S = \frac{AB+CD}{2}h = MN \cdot h$	 Truncated right cone $V = \frac{\pi h}{3}(R^2 + r^2 + Rr)$
 Circle $C = 2\pi\ \ R = \pi D$ $S = \pi\ \ R^2 = \frac{\pi D^2}{4} = \frac{C^2}{4\pi}$	 Pyramid $V = \frac{1}{3}Bh$
 Sector of a circle $S = \frac{\text{arc } ABC \cdot R}{2} = \frac{\pi R^2 \alpha}{360}$ (α is the number of degrees of arc ACB) Segment of a circle $S = \frac{\pi R^2 \beta}{360} - \frac{DF}{2}(R-f)$	 Truncated pyramid with parallel bases $V = \frac{1}{3}h(B + b + \sqrt{Bb})$
 Annulus $S = \frac{\pi}{4}(D^2 - d^2) = \pi(R^2 - r^2)$ $= \frac{\pi}{4}(D+d)(D-d)$ $= \pi(R+r)(R-r)$	 Sphere $S = 4\pi R^2 = \pi D^2$ $V = \frac{4}{3}\pi R^3 = 4{,}189 R^3$ Hollow sphere $V = \frac{4}{3}\pi(R^3 - r^3)$
 Ellipse a = semimajor axis b = semiminor axis $S = \pi\, ab$	 Spherical segment with one base 1°) $V = \frac{1}{6}\pi h(h^2 + 3\overline{AI}^2)$ 2°) $V = \frac{1}{3}\pi h^2(3R - h)$ Spherical segment with two bases $V = \frac{1}{6}\pi h(3a^2 + 3b^2 + h^2)$

INERTIA OF PLANE SURFACE



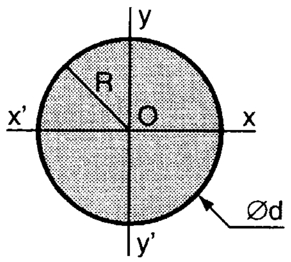
$$I_{xx'} = \frac{bh^3}{12} \qquad I_{yy'} = \frac{hb^3}{12}$$

$$I_0 = \frac{bh}{12}(b^2 + h^2)$$



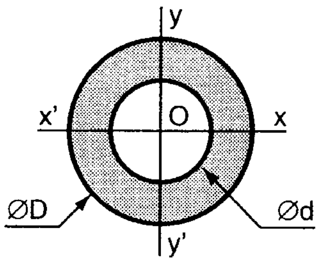
$$I_{xx'} = I_{yy'} = \frac{a^4}{12}$$

$$I_0 = \frac{a^4}{6}$$



$$I_{xx'} = I_{yy'} = \frac{\pi D^4}{64} = \frac{\pi R^4}{4}$$

$$I_0 = \frac{\pi D^4}{32} = \frac{\pi R^4}{2}$$



$$I_{xx'} = I_{yy'} = \frac{\pi}{64}(D^4 - d^4)$$

$$I_0 = \frac{\pi}{32}(D^4 - d^4)$$

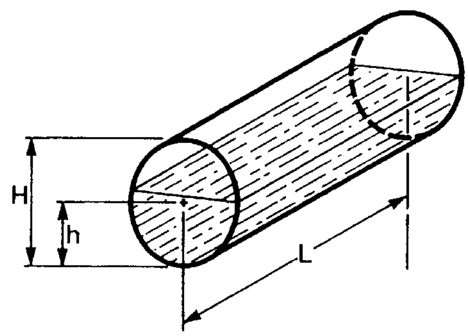
I_0 = polar moment of inertia.

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.



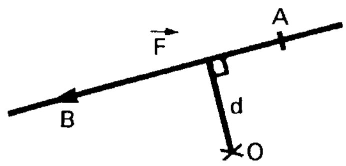
$V =$ total volume:

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

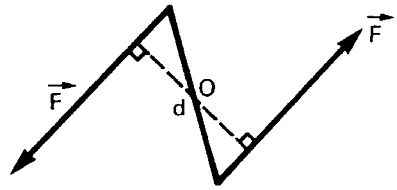
Fraction of $H = \dfrac{h}{H}$

h = liquid height

MECHANICS AND STRENGTH OF MATERIALS
Moment of a force about a point. Moment of a torque



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



$M_0^t C = Fd$

(M_0^t in newtons.meter, F in newtons and d in meters)

UNIFORM STRAIGHT LINE MOTION

$l = l_0 + vt$

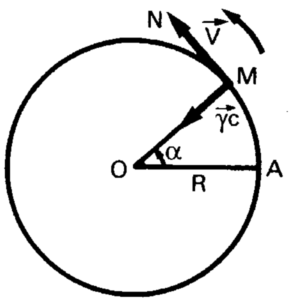
l = distance travelled (m)
l_0 = initial distance (m)
v = velocity (m/s)
t = time (s)

UNIFORMLY-ACCELERATED MOTION

$$l = l_0 + v_0 t + \frac{\gamma t^2}{2}$$

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

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

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

Centripetal acceleration γ_c

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

(γ_c in meters per second per second, 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)

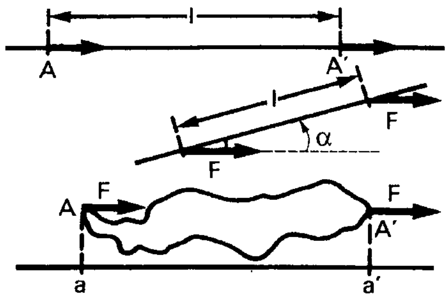
CENTRIFUGAL FORCE

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

(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

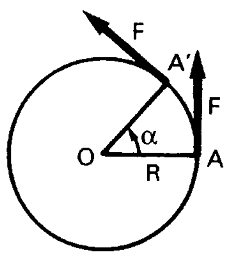
Constant force in quantity and direction displacing its point of application



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)

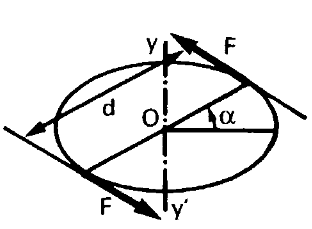
Constant force moving tangentially to a circle



$T = FR\alpha = M_0^t F\alpha$
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



$T = Fd\alpha = M_0^t C\alpha$
for one rotation $T = 2\pi M_0^t C = 2\pi Fd$
(T in joules, F in newtons, d in meters, α in radians and M_0^t in meter Newtons)

POWER

Work produced per unit time $P = \frac{T}{t}$ (P in watts, T in joules and t in seconds)
Power of a torque rotating at constant speed ω

$$P = M_0^t C\omega \quad \text{or} \quad P = Fd\omega = Fd\frac{2\pi N}{60}$$

(P in watts, M_0^t 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

$$W = \frac{1}{2} m v^2$$

(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: $$\boxed{n = E \frac{\Delta \ell}{\ell}}$$

E = Young's modulus or longitudinal elastic modulus: approximately 200 000 to 220 000 MPa for steel

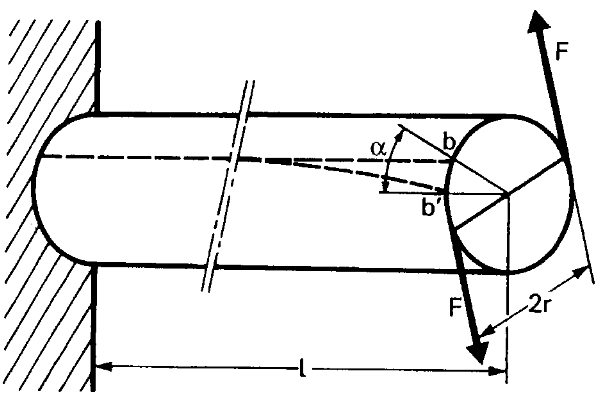
$\Delta \ell$ = elongation, ℓ = length: expressed in the same units

Torsion

Torsional moment: $M_t = 2Fr$ (M_t in meter Newtons, F in newtons and r in meters)

Unit torsion $\theta = \frac{\alpha}{\ell}$ $$\boxed{\frac{\alpha}{\ell} = \frac{M_t}{G I_0}}$$

Hooke's law: $\boxed{t_{max} = G r \theta}$ $$t_{max} = \frac{M_t}{\frac{I_0}{r}}$$



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 × E (Young's modulus)
G = 80 000 MPa for steel
r = radius of cylinder (m)
I_0 = polar moment of inertia

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 = 3600 C)

$$Q\,(\text{Ah}) = I\,(\text{A})\ t\,(\text{h})$$

POTENTIAL DIFFERENCE (VOLTAGE): U

Unit: Volt (V)

Potential difference between two points of 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 ($\Omega/m/mm^2$) at 15°C

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

	ρ(Ω/m per mm^2)		ρ(Ω/m per mm^2)
Copper	0.017 – 0.0175	Iron	0.11
Silver	0.016 – 0.018	Steel	0.10 – 0.25
Aluminium	0.229 – 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 (mm^2)

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°C

R_0, ρ_0 = resistance, resistivity at 0°C

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	$3.9\ 10^{-3}$	Nickel/silver (60%, Zn 20%, Ni 20%)	$3\ 10^{-4}$

ELECTRICITY
Direct current (continued)

RESISTANCE CONNECTIONS

1) Connection in series:

$$R = R_1 + R_2 + R_3 \ldots \qquad I \text{ constant}$$
$$U = U_1 + U_2 + U_3 \ldots$$

2) Connection in parallel:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots \qquad U \text{ constant}$$
$$I = I_1 + I_2 + I_3 \ldots$$

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

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

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.

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

Non SI units:

1) Watt-hour (Wh)

Energy expended in one hour by a power of one watt

$$\underset{(\text{Wh})}{W} = \underset{(\Omega)}{R}\ \underset{(\text{A})}{I^2}\ \underset{(\text{h})}{t} \qquad 1\ \text{Wh} = 3600\ \text{J}$$

2) Calorie (cal)

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

4.1855 is an experimental value.

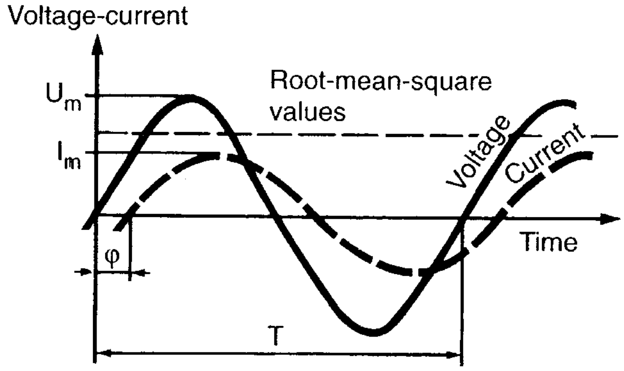
ELECTRICAL POWER (P): *P*

Unit: Watt (W)

Power of one joule per second

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

ELECTRICITY
Alternating current



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

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

Angular frequency $\omega = 2\pi F$ (rad/s)

Instantaneous values:

$u = U_m \cos \omega t$

$i = I_m \cos (\omega t - \varphi)$

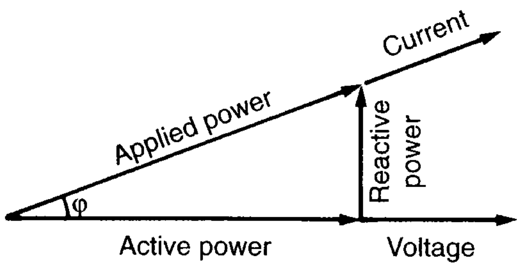
φ = angle of phase difference between current and voltage

Root-mean-square values (rms values):

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

Power:

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



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

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

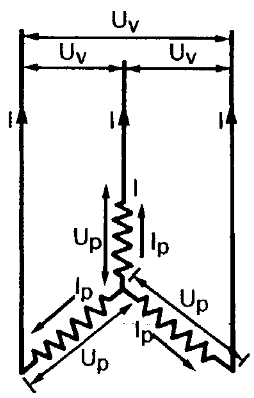
$\cos\varphi = \frac{P}{S}$ (power factor)

THREE-PHASE SYSTEM

Phases windings (formulas valid with same load for all 3 phases)

Star connection

$U_v = 1.73\ U_p$ $\quad I = I_p$



Mesh or Delta connection

$U_v = U_p$ $\quad I = 1.73\ I_p$

1) Applied power $S = UI$ (VA)

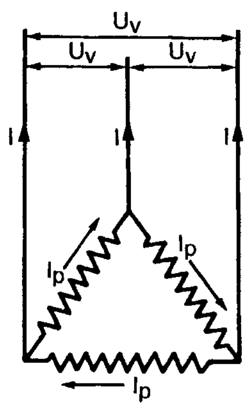
2) Active power $P = 1.73\, U_v I \cos\varphi$ (W)

$= 3\, U_p I_p \cos\varphi$ (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:

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

Permissible current through conductors

Nominal cross-sectional area (mm^2)	Current Temperature rise = 45°C		
	Numbers of conductors		
	2	3	4
	Current (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	113	27.0	Mercury	Hg	80	200.6
Antimony	Sb	51	122.0	Molybdenum	Mo	42	96.0
Argon	A	18	40.0	Neon	Ne	10	20.0
Arsenic	As	33	75.0	Nickel	Ni	28	58.7
Barium	Ba	56	137.0	Nitrogen	N	7	14.0
Bismuth	Bi	83	209.0	Oxygen	O	8	16.0
Boron	B	5	11.0	Phosphorus	P	15	31.0
Bromine	Br	35	80.0	Platinium	Pt	78	195.0
Cadmium	Cd	48	112.0	Plutonium	Pu	94	242.0
Calcium	Ca	20	40.0	Potassium	K	19	397.0
Carbon	C	6	12.0	Radium	Ra	88	226.0
Chlorine	Cl	17	35.5	Selenium	Se	34	79.0
Chromium	Cr	24	52.0	Silicon	Si	14	28.0
Cobalt	Co	27	59.0	Silver	Ag	47	108.0
Copper	Cu	29	63.5	Sodium	Na	11	23.0
Fluorine	F	9	19.0	Strontium	Sr	38	87.6
Gold	Au	79	197.0	Sulfur	S	16	32.0
Helium	He	2	4.0	Tin	Sn	50	119.0
Hydrogen	H	1	1.0	Titanium	Ti	22	48.0
Iodine	I	53	127.0	Tungsten	W	74	184.0
Iron	Fe	26	56.0	Uranium	U	92	238.0
Lead	Pb	82	207.0	Vanadium	V	23	51.0
Lithium	Li	3	7.0	Xenon	Xe	54	131.3
Magnesium	Mg	12	24.0	Zinc	Zn	30	65.4
Manganese	Mn	25	55.0	Zirconium	Zr	40	91.0

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	2.3 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 to 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):			
Acetone	0.791	Air	1
Benzene	0.878	Isobutane	2.067
Carbon tetrachloride	1.595	*n*-butane	2.0854
Chloroform	1.482	Carbon dioxide	1.529
Ether	0.714	Carbon monoxide	0.9671
Ethyl alcohol	0.816	Ethane	1.0493
Glycerin	1.260	Ethylene	0.9749
Methyl alcohol	0.792	hydrogen	0.06952
Trichloroethylene	1.455	Hydrogen sulfide	1.19
Water at 4°C	1	Methane	0.5544
		Oxygen	1.10527
		Propane	1.554

PHYSICAL PROPERTIES OF METALS

Name	Symbol	Specific gravity	Melting point (°C)	Brinell hardness	Mohs scale
Aluminium	Al	2.70	660	16	2.5
Antimony	Sb	6.70	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	8.90	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	7.20	1260	–	5
Mercury	Hg	13.55	– 39	–	–
Molybdenum	Mo	10.20	2620	150-200	–
Nickel	Ni	8.90	1455	110-300	–
Platinium	Pt	21.45	1774	64	4.3
Silver	Ag	10.50	961	–	2.5-7
Tin	Sn	7.30	232	–	1.7
Titanium	Ti	4.50	1800	–	–
Tungsten	W	19.30	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	Saphelian (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
(Steel specific gravity = 7.85)

Mud density			Factor k	Mud density			Factor k
(kg/l)	(lb/gal)	(lb/ft³)		(kg/l)	(lb/gal)	(lb/ft³)	
1.00	8.35	62.4	0.873	**1.62**	13.52	101.1	0.794
1.02	8.51	63.7	0.870	**1.64**	13.69	102.4	0.791
1.04	8.68	64.9	0.868	**1.66**	13.85	103.6	0.789
1.06	8.85	66.2	0.865	**1.68**	14.02	104.9	0.786
1.08	9.01	67.4	0.862	**1.70**	14.19	106.1	0.783
1.10	9.18	68.7	0.860	**1.72**	14.35	107.4	0.781
1.12	9.35	69.9	0.857	**1.74**	14.52	108.6	0.778
1.14	9.51	71.2	0.855	**1.76**	14.69	109.9	0.776
1.16	9.68	72.4	0.852	**1.78**	14.85	111.1	0.773
1.18	9.85	73.7	0.850	**1.80**	15.02	112.4	0.771
1.20	10.01	74.9	0.847	**1.82**	15.19	113.6	0.768
1.22	10.18	76.2	0.845	**1.84**	15.36	114.9	0.766
1.24	10.35	77.4	0.842	**1.86**	15.52	116.1	0.763
1.26	10.51	78.7	0.839	**1.88**	15.69	117.4	0.761
1.28	10.68	79.9	0.837	**1.90**	15.86	118.6	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**	16.19	121.1	0.753
1.34	11.18	83.7	0.829	**1.96**	16.36	122.4	0.750
1.36	11.35	84.9	0.827	**1.98**	16.52	123.6	0.748
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	126.1	0.743
1.42	11.85	88.6	0.819	**2.04**	17.02	127.4	0.740
1.44	12.02	89.9	0.817	**2.06**	17.19	128.6	0.738
1.46	12.18	91.1	0.814	**2.08**	17.36	129.8	0.735
1.48	12.35	92.4	0.811	**2.10**	17.52	131.1	0.732
1.50	12.52	93.6	0.809	**2.12**	17.69	132.3	0.730
1.52	12.68	94.9	0.806	**2.14**	17.86	133.6	0.727
1.54	12.85	96.1	0.804	**2.16**	18.03	134.8	0.725
1.56	13.02	97.4	0.801	**2.18**	18.19	136.1	0.722
1.58	13.19	98.6	0.799	**2.20**	18.36	137.3	0.720
1.60	13.35	99.9	0.796	**2.22**	18.53	138.6	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, 3rd edition, August 1, 1992)
(API Spec 7, 38th edition, April 1, 1994)

	Yield strength				Minimum tensile strength		
	Minimum		Maximum				
	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	
Drill pipe							
Steel grade							Box minimum hardness (Brinnel)
E75	75 000	517	105 000	724	100 000	689	
X95	95 000	655	125 000	862	105 000	724	
G105	105 000	724	135 000	931	115 000	793	
S135	135 000	931	165 000	1138	145 000	1000	
Tool joints	120 000	827	–	–	140 000	965	285
Drill collars and cross-over sub							
Outside diameter (in)							
3 1/8 to 6 7/8	110 000	758	–	–	140 000	965	285
7 to 11	100 000	689	–	–	135 000	931	285

Mechanical properties and tests
New non magnetic drill collars

Drill collar OD range	Stainless steels				Beryllium copper			
	Minimum yield strength		Minimum tensile strength		Minimum yield strength		Minimum tensile strength	
(in)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)
3 1/2 to 6 7/8	110 000	758	120 000	827	110 000	758	140 000	965
7 to 11	100 000	689	110 000	758	100 000	689	135 000	931

API DRILL PIPE LIST AND BODY AND UPSET GEOMETRY (API Spec 5D, 3rd edition, August 1, 1992)

Nominal diameter		Nominal weight	Wall thickness of pipe body	Inside diameter of pipe body	Steel grade	Upset					
						IU		EU		IEU	
(in)	(mm)	(lb/ft)	(mm)	(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 X-G-S			67.5 67.5	46.1 39.7		
2 7/8	73.0	10.40	9.19	54.6	E X-G-S	73.0 73.0	33.3 41.4	81.8 82.6	54.6 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 X-G-S	88.9 88.9	49.2 49.2	97.1 101.6	66.1 63.5		
3 1/2	88.9	15.50	11.40	66.1	E X-G-S	88.9 –	49.2 –	97.1 101.6	66.1 63.5	– 96.0	– 49.2
4	101.6	14.00	8.38	84.8	E X-G-S	101.6 101.6	69.8 66.8	114.3 117.5	84.8 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 X-G-S	– –		127.0 131.8	97.2 90.5	118.3 118.3	80.2 73.0
4 1/2	114.3	20.00	10.92	92.5	E X-G-S	– –		127.0 131.8	92.5 87.3	121.4 121.4	76.2 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 X-G-S			– 146.1	– 100.0	131.8 131.8	93.7 90.5
5	127.0	25.60	12.70	101.6	E X-G-S			– 149.2	– 96.9	131.8 131.8	87.3 84.2
5 1/2	139.7	21.90	9.17	121.4	E X-G-S					141.3 141.3	101.6 96.9
5 1/2	139.7	24.70	10.54	118.6	E X-G-S					141.3 141.3	101.6 96.9
6 5/8	168.3	25.20	8.38	151.5	E					176.0	135.0
6 5/8	168.3	25.20	8.38	151.5	X-G-S					176.0	135.0
6 5/8	168.3	27.70	9.19	149.9	E X-G-S					176.0 176.0	135.0 135.0

mm × 0.0394 = in

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

Outside diameter		Nominal weight	Wall thickness	Weight with tool-joints	Inside diameter		Upset outside diameter	Cross section area	Inside capacity	Volume of steel	Tensile yield strength (2)	Torsional yield strength (2)	Internal pressure (2)	Collapse resistance (2)
(in)	(mm)	(lb/ft)	(mm)	(kg/m)	Body (mm)	Upset (mm)	(mm)	(mm^2)	(l/m)	(l/m)	(10^3 daN)	(daN.m)	(MPa)	(MPa)
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 NC10, NC12, NC13 and NC16. 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

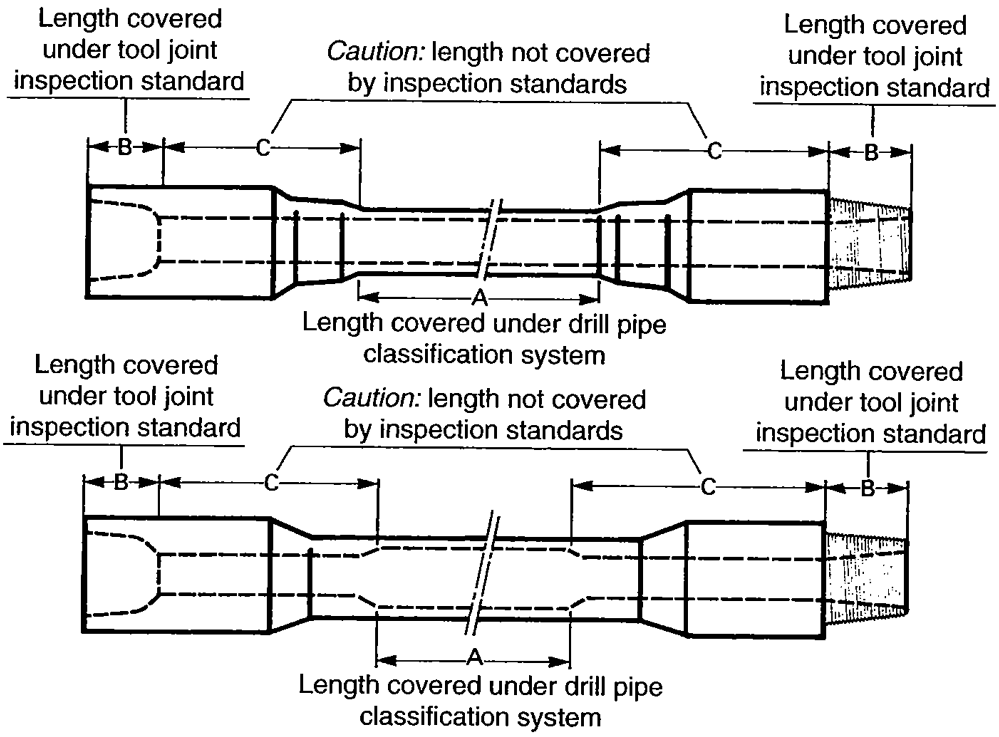
CLASSIFICATION OF USED DRILL PIPE (API RP 7G, 15th edition, January 1, 1995) (All sizes, weights and grades)

(Nominal dimension is basis for all calculations)

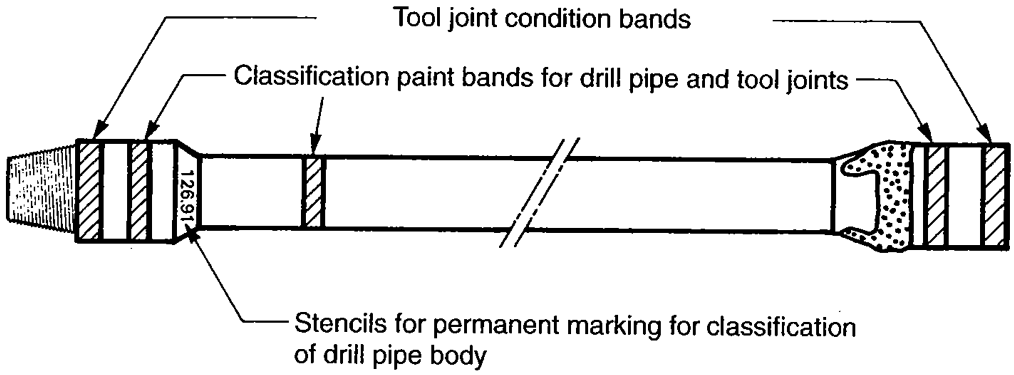
Pipe condition	PREMIUM CLASS Two white bands One center punch mark	CLASS 2 Yellow bands Two center punch marks	CLASS 3 Orange bands Three center punch marks
I EXTERIOR CONDITIONS			
A. OD wear			
Wall	Remaining wall not less than 80%	Remaining wall not less than 70%	Any imperfections or damages exceeding CLASS 2
B. Dents & mashes	Diameter reduction not over 3% of OD	Diameter reduction not over 4% of OD	
C. Slip area Mechanical damage			
1. Crushing, necking	Diameter reduction not over 3% of OD	Diameter reduction not over 4% of OD	
2. Cuts, gouges	Depth not to exceed 10% of the average adjacent wall	Depth not to exceed 20% of the average adjacent wall	
D. Stress induced Diameter variations			
1. Stretched	Diameter reduction not over 3% of OD	Diameter reduction not over 4% of OD	
2. String shot	Diameter increase not over 3% of OD	Diameter increase not over 4% of OD	
E. Corrosion, cuts and gouges			
1. Corrosion	Remaining wall not less than 80%	Remaining wall not less than 70%	
2. Cuts and gouges Longitudinal	Remaining wall not less than 80%	Remaining wall not less than 70%	
Transverse	Remaining wall not less than 80%	Remaining wall not less than 80%	
F. Cracks	None	None	None
II INTERIOR CONDITIONS			
A. Corrosive pitting			
Wall	Remaining wall not less than 80% measured from vase of deepest pit	Remaining wall not less than 70% measured from base of deepest pit	
B. Errosion and wear			
Wall	Remaining wall not less than 80%	Remaining wall not less than 70%	
C. Cracks	None	None	None

INSPECTION STANDARDS
Zones and color code identification
(API RP 7G, 15^{th} edition, January 1, 1995)

IDENTIFICATION OF LENGTHS COVERED BY INSPECTION STANDARDS



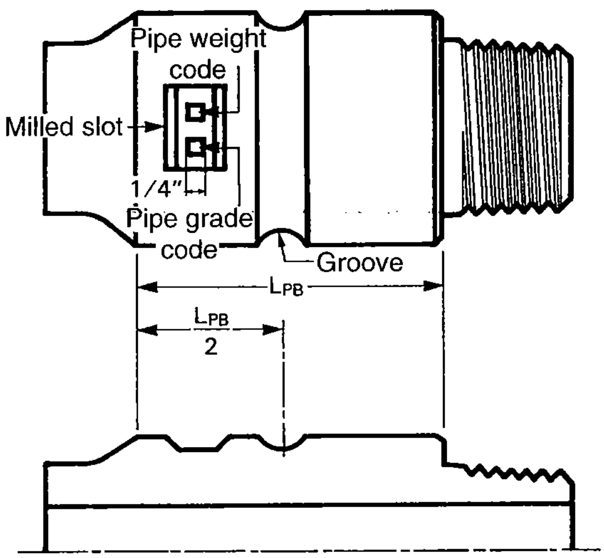
DRILL PIPE AND TOOL JOINT COLOR CODE IDENTIFICATION



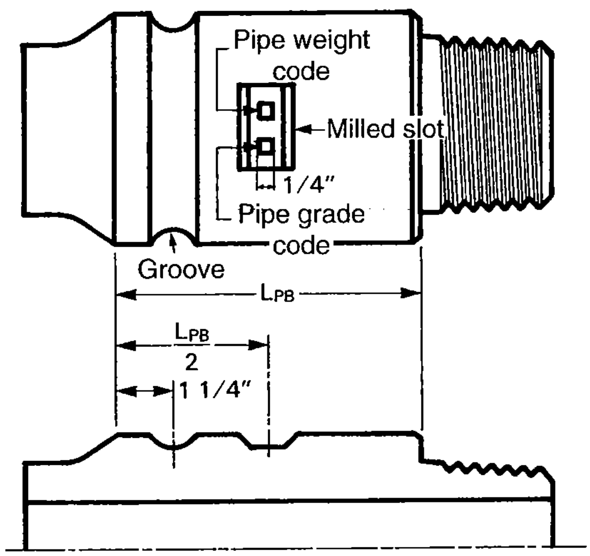
Tool joint and drill pipe classification	Number and color of bands
Premium Class	Two white
Class 2	One yellow
Class 3	One orange
Scrap	One red

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

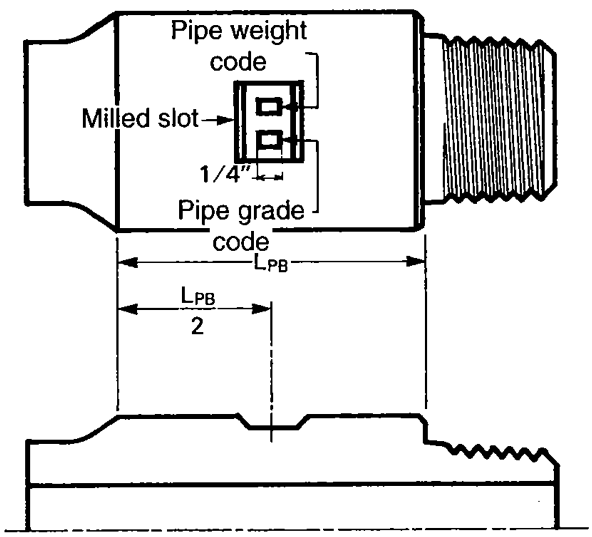
RECOMMENDED PRACTICE FOR MILL SLOT AND GROOVE METHOD OF DRILL STRING IDENTIFICATION (API RP 7G, 15th edition, January 1, 1995)



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, 15th edition, January 1, 1995)

(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

Drill pipe weight code

Size OD (in)	Nominal weight (lb/ft)	Wall thickness (in)	Weight code number
2 3/8	4.85	0.190	1
	6.65*	0.280	2
2 7/8	6.85	0.217	1
	10.40*	0.362	2
3 1/2	9.50	0.254	1
	13.30*	0.368	2
	15.50	0.449	3
4	11.85	0.262	1
	14.00*	0.330	2
	15.70	0.380	3
4 1/2	13.75	0.271	1
	16.60*	0.337	2
	20.00	0.430	3
	22.82	0.500	4
	24.66	0.550	5
	25.50	0.575	6
5	16.25	0.296	1
	19.50*	0.362	2
	25.60	0.500	3
5 1/2	19.20	0.304	1
	21.90*	0.361	2
	24.70	0.415	3
6 5/8	25.20*	0.330	2
	27.70	0.362	3

* 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	Nominal weight	Wall thickness	ID		Cross-section	Polar moment of inertia	Polar modulus	Upset and grade		Type of tool joint	Tool joint OD	Tool joint ID	Approximate weight including tool joint	
(in)	(lb/ft)	(mm)	(in)	(mm)	(mm²)	(mm⁴)*	(mm³)**				(mm)	(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**	**10.44**	**7.02**
								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**	**10.58**	**7.11**
								EU	X	SL-H90	82.6	46.0	10.42	7.00
								EU	**G**	**NC26 (IF)**	**85.7**	**44.5**	**10.58**	**7.11**
								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**	**10.89**
								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**	**16.49**	**11.08**
								EU	X	SL-H90	98.4	54.8	16.22	10.90
								EU	**G**	**NC31 (IF)**	**104.8**	**50.8**	**16.49**	**11.08**
								EU	G	SL-H90	101.6	50.8	16.22	10.90
								EU	**S**	**NC31 (IF)**	**111.1**	**41.3**	**17.18**	**11.54**
								EU	S	SL-H90	104.8	41.3	16.82	11.30

* Polar moment of inertia = $\frac{\pi}{32}(OD^4 - ID^4)$ ** Polar modulus = $\frac{\pi}{16}\left(\frac{OD^4 - ID^4}{OD}\right)$

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	Nominal weight	Wall thickness	ID		Cross-section	Polar moment of inertia	Polar modulus	Upset and grade		Type of tool joint	Tool joint OD	Tool joint ID	Approximate weight including tool joint	
(in)	(lb/ft)	(mm)	(in)	(mm)	(mm^2)	(mm^4)*	(mm^3)**				(mm)	(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**	**15.76**	**10.59**
								EU	E	NC38(WO)	120.7	76.2	15.38	10.33
								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	3 747 837	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
								EU	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**	**14.62**
								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**	**16.56**
								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**	**26.17**	**17.59**
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	12.16
								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**	**23.65**	**15.89**
								EU	E	OH	139.7	82.6	22.32	15.00
								IU	**E**	**NC40 (FH)**	**139.7**	**71.4**	**22.39**	**15.05**
								IU	E	SH	117.5	65.1	21.43	14.40
								EU	**X**	**NC46 (IF)**	**152.4**	**82.6**	**24.10**	**16.19**
								IU	**X**	**NC40 (FH)**	**133.4**	**68.3**	**22.74**	**15.28**
								IU	X	H90	139.7	71.4	23.22	15.60

*, ** See notes on page B 8.

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

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

Nominal diameter	Nominal weight	Wall thickness	ID		Cross-section	Polar moment of inertia	Polar modulus	Upset and grade		Type of tool joint	Tool joint OD	Tool joint ID	Approximate weight including tool joint	
(in)	(lb/ft)	(mm)	(in)	(mm)	(mm²)	(mm⁴)	(mm³)				(mm)	(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**	**24.10**	**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**	**24.44**	**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**	**22.91**	**15.39**
								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**	**26.78**	**18.00**
								EU	E	NC50 (IF)	168.3	95.3	27.49	18.47
								EU	E	OH	149.2	95.3	25.45	17.10
								IEU	**E**	**NC46 (XH)**	**158.8**	**82.6**	**27.34**	**18.37**
								IEU	E	FH	152.4	76.2	27.00	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**
								EU	X	NC50 (IF)	168.3	95.3	28.05	18.85
								IEU	X	NC46 (XH)	158.8	76.2	27.71	18.62
								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**
								EU	G	NC50 (IF)	168.3	95.3	28.05	18.85
								IEU	G	NC46 (XH)	158.8	76.2	27.71	18.62
								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**	**27.72**	**18.63**
								EU	S	NC50 (IF)	168.3	88.9	28.44	19.11
								IEU	S	NC46 (XH)	158.8	69.9	28.02	18.83
								IEU	S	FH	158.8	63.5	28.31	19.02
								IEU	S	H90	152.4	76.2	27.02	18.16

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	Nominal weight	Wall thickness	ID		Cross-section	Polar moment of inertia	Polar modulus	Upset and grade		Type of tool joint	Tool joint OD	Tool joint ID	Approximate weight including tool joint	
(in)	(lb/ft)	(mm)	(in)	(mm)	(mm²)	(mm⁴)	(mm³)				(mm)	(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**	**E**	**NC50 (IF)**	**161.9**	**92.1**	**32.19**	**21.63**
								EU	E	NC50 (IF)	168.3	92.1	32.91	22.11
								IEU	E	NC46 (XH)	158.8	76.2	32.92	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**
								EU	X	NC50 (IF)	168.3	88.9	33.60	22.58
								IEU	X	NC46 (XH)	158.8	69.9	33.66	22.62
								IEU	X	FH	152.4	63.5	33.26	22.35
								IEU	X	H90	152.4	82.6	32.29	21.70
								EU	**G**	**NC50 (IF)**	**161.9**	**88.9**	**32.88**	**22.09**
								EU	G	NC50 (IF)	168.3	88.9	33.60	22.58
								IEU	G	NC46 (XH)	158.8	63.5	33.95	22.81
								IEU	G	FH	152.4	63.5	33.26	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	NC50 (XH)	168.3	95.3	31.77	21.35
								IEU	E	5 1/2 FH	177.8	95.3	33.19	22.30
								IEU	**X**	**NC50 (XH)**	**161.9**	**88.9**	**31.84**	**21.40**
								IEU	X	NC50 (XH)	168.3	88.9	32.55	21.87
								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	NC50 (XH)	168.3	82.6	32.92	22.12
								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	NC50 (IF)	168.3	88.9	40.70	27.35
								IEU	E	5 1/2 FH	177.8	95.3	42.12	28.30

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	Nominal weight	Wall thickness	ID		Cross-section	Polar moment of inertia	Polar modulus	Upset and grade		Type of tool joint	Tool joint OD	Tool joint ID	Approximate weight including tool joint	
(in)	(lb/ft)	(mm)	(in)	(mm)	(mm²)	(mm⁴)	(mm³)				(mm)	(mm)	(kg/m)	(lb/ft)
5 (127 mm)	25.60	12.70	4.000	101.60	4 560	15 078 604	237 458	**IEU**	**X**	**NC50 (XH)**	**165.1**	**76.2**	**41.40**	**27.82**
								IEU	X	NC50 (IF)	168.3	73.2	41.77	28.07
								IEU	X	5 1/2 FH	177.8	88.9	42.48	28.55
								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	29.39
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**	**35.41**	**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**	**39.25**	**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**	**28.85**
6 5/8 (168.28 mm)	25.20	8.38	5.965	151.52	4 210	26 981 773	320 677	**IEU**	**E**	**FH**	**203.2**	**127.0**	**41.00**	**27.55**
								IEU	**X**	**FH**	**203.2**	**127.0**	**41.00**	**27.55**
								IEU	**G**	**FH**	**209.6**	**120.7**	**42.57**	**28.61**
								IEU	**S**	**FH**	**215.9**	**107.9**	**44.70**	**30.04**
	27.70	9.19	5.901	149.90	4 593	29 159 551	346 560	**IEU**	**E**	**FH**	**203.2**	**127.0**	**43.76**	**29.41**
								IEU	**X**	**FH**	**209.6**	**120.7**	**45.32**	**30.45**
								IEU	**G**	**FH**	**209.6**	**120.7**	**45.32**	**30.45**
								IEU	**S**	**FH**	**215.9**	**107.9**	**47.44**	**31.88**

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

NEW (N), PREMIUM CLASS (P) AND CLASS 2 (2) DRILL PIPE, TORSIONAL AND TENSILE DATA
(API RP 7G, 15th edition, January 1, 1995)

Size OD	Nominal weight	Class	Torsional yield strength[1]								Tensile yield strength							
			E		95		105		135		E		95		105		135	
(in)	(lb/ft)		(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(lb)	(10^3 daN)	(lb)	(10^3 daN)	(lb)	(10^3 daN)	(lb)	(10^3 daN)
2 3/8	4.85	N	4 763	645	6 033	817	6 668	904	8 574	1 162	97 817	43.5	123 902	55.1	136 944	60.9	176 071	78.3
		P	3 725	505	4 719	639	5 215	707	6 705	909	76 893	34.2	97 398	43.3	107 650	47.8	138 407	61.5
		2	3 224	437	4 083	553	4 513	612	5 802	786	66 686	29.6	84 469	37.5	93 360	41.5	120 035	53.3
	6.65	N	6 250	847	7 917	1 073	8 751	1 186	11 251	1 525	138 214	61.4	175 072	77.8	193 500	86.0	248 786	110.6
		P	4 811	652	6 093	826	6 735	913	8 659	1 173	107 616	47.8	136 313	60.6	150 662	67.0	193 709	86.1
		2	4 130	560	5 232	709	5 782	783	7 434	1 007	92 871	41.3	117 636	52.3	130 019	57.8	167 167	74.3
2 7/8	6.85	N	8 083	1 095	10 238	1 387	11 316	1 533	14 549	1 971	135 902	60.4	172 143	76.5	190 263	84.6	244 624	108.7
		P	6 332	858	8 020	1 087	8 865	1 201	11 397	1 544	106 946	47.5	135 465	60.2	149 725	66.5	192 503	85.6
		2	5 484	743	6 946	941	7 677	1 040	9 871	1 338	92 801	41.2	117 549	52.2	129 922	57.7	167 043	74.2
	10.40	N	11 554	1 566	14 635	1 983	16 176	2 192	20 798	2 818	214 344	95.3	271 503	120.7	300 082	133.4	385 820	171.5
		P	8 858	1 200	11 220	1 520	12 401	1 680	15 945	2 161	166 535	74.0	210 945	93.8	233 149	103.6	299 764	133.2
		2	7 591	1 029	9 615	1 303	10 627	1 440	13 663	1 851	143 557	63.8	181 839	80.8	200 980	89.3	258 403	114.8
3 1/2	9.50	N	14 146	1 917	17 918	2 428	19 805	2 684	25 463	3 450	194 264	86.3	246 068	109.4	271 970	120.9	349 676	155.4
		P	11 094	1 503	14 052	1 904	15 531	2 104	19 968	2 706	152 979	68.0	193 774	86.1	214 171	95.2	275 363	122.4
		2	9 612	1 302	12 176	1 650	13 457	1 823	17 302	2 344	132 793	59.0	168 204	74.8	185 910	82.6	239 027	106.2
	13.30	N	18 551	2 514	23 498	3 184	25 972	3 519	33 392	4 525	271 569	120.7	343 988	152.9	380 197	169.0	488 825	217.3
		P	14 361	1 946	18 191	2 465	20 106	2 724	25 850	3 503	212 150	94.3	268 723	119.4	297 010	132.0	381 870	169.7
		2	12 365	1 675	15 663	2 122	17 312	2 346	22 258	3 016	183 398	81.5	232 304	103.2	256 757	114.1	330 116	146.7
	15.50	N	21 086	2 857	26 708	3 619	29 520	4 000	37 954	5 143	322 775	143.5	408 848	181.7	451 885	200.8	580 995	258.2
		P	16 146	2 188	20 452	2 771	22 605	3 063	29 063	3 938	250 620	111.4	317 452	141.1	350 868	155.9	451 115	200.5
		2	13 828	1 874	17 515	2 373	19 359	2 623	24 890	3 373	215 967	96.0	273 558	121.6	302 354	134.4	388 741	172.8

(1) N: Based on the shear strength equal to 57.7% of minimum yield strength and nominal thickness.

P: Based on the shear strength equal to 57.7% of minimum yield strength and torsional data based on 20% of uniform wear on outside diameter and tensile data based on 20% uniform wear on outside diameter.

2: Based on the shear strength equal to 57.7% of minimum yield strength and torsional data based on 30% of uniform wear on outside diameter and tensile data based on 30% uniform wear on outside diameter

NEW (N), PREMIUM CLASS (P) AND CLASS 2 (2) DRILL PIPE, TORSIONAL AND TENSILE DATA (continued) (API RP 7G, 15th edition, January 1, 1995)

Size OD	Nominal weight	Class	Torsional yield strength[1]								Tensile yield strength							
			E		95		105		135		E		95		105		135	
(in)	(lb/ft)		(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(lb)	(10^3 daN)	(lb)	(10^3 daN)	(lb)	(10^3 daN)	(lb)	(10^3 daN)
4	11.85	N	19 474	2 639	24 668	3 343	27 264	3 694	35 054	4 750	230 755	102.6	292 290	129.9	323 057	143.6	415 360	184.6
		P	15 310	2 075	19 392	2 628	21 433	2 904	27 557	3 734	182 016	80.9	230 554	102.5	254 823	113.3	327 630	145.6
		2	13 281	1 800	16 823	2 280	18 594	2 520	23 907	3 239	158 132	70.3	200 301	89.0	221 385	98.4	284 638	126.5
	14.00	N	23 288	3 156	29 498	3 997	32 603	4 418	41 918	5 680	285 359	126.8	361 454	160.6	399 502	177.6	513 646	228.3
		P	18 196	2 466	23 048	3 123	25 474	3 452	32 752	4 438	224 182	99.6	283 963	126.2	313 854	139.5	403 527	179.3
		2	15 738	2 133	19 935	2 701	22 034	2 986	28 329	3 839	194 363	86.4	246 193	109.4	272 108	120.9	349 852	155.5
	15.70	N	25 810	3 497	32 692	4 430	36 134	4 896	46 458	6 295	324 118	144.1	410 550	182.5	453 765	201.7	583 413	259.3
		P	20 067	2 719	25 418	3 444	28 094	3 807	36 120	4 894	253 851	112.8	321 544	142.9	355 391	158.0	456 931	203.1
		2	17 315	2 346	21 932	2 972	24 241	3 285	31 166	4 223	219 738	97.7	278 335	123.7	307 633	136.7	395 528	175.8
4 1/2	13.75	N	25 907	3 510	32 816	4 447	36 270	4 915	46 633	6 319	270 034	120.0	342 043	152.0	378 047	168.0	486 061	216.0
		P	20 403	2 765	25 844	3 502	28 564	3 870	36 725	4 976	213 258	94.8	270 127	120.1	298 561	132.7	383 864	170.6
		2	17 715	2 400	22 439	3 041	24 801	3 361	31 887	4 321	185 389	82.4	234 827	104.4	259 545	115.4	333 701	148.3
	16.60	N	30 807	4 174	39 022	5 288	43 130	5 844	55 453	7 514	330 558	146.9	418 707	186.1	462 781	205.7	595 004	264.4
		P	24 139	3 271	30 576	4 143	33 795	4 579	43 450	5 888	260 165	115.6	329 542	146.5	364 231	161.9	468 297	208.1
		2	20 908	2 833	26 483	3 588	29 271	3 966	37 634	5 099	225 771	100.3	285 977	127.1	316 080	140.5	406 388	180.6
	20.00	N	36 901	5 000	46 741	6 333	51 661	7 000	66 421	9 000	412 358	183.3	522 320	232.1	577 301	256.6	742 244	329.9
		P	28 683	3 887	36 332	4 923	40 157	5 441	51 630	6 996	322 916	143.5	409 026	181.8	452 082	200.9	581 248	258.3
		2	24 747	3 353	31 346	4 247	34 645	4 694	44 544	6 036	279 502	124.2	354 035	157.3	391 302	173.9	503 103	223.6
	22.82	N	40 912	5 544	51 821	7 022	57 276	7 761	73 641	9 978	471 239	209.4	596 903	265.3	659 734	293.2	848 230	377.0
		P	31 587	4 280	40 010	5 421	44 222	5 992	56 856	7 704	367 566	163.4	465 584	206.9	514 593	228.7	661 620	294.1
		2	27 161	3 680	34 404	4 662	38 026	5 153	48 890	6 625	317 497	141.1	402 163	178.7	444 496	197.6	571 495	254.0

(1) See note B 13.

NEW (N), PREMIUM CLASS (P) AND CLASS 2 (2) DRILL PIPE, TORSIONAL AND TENSILE DATA (continued) (API RP 7G, 15th edition, January 1, 1995)

Size OD	Nominal weight	Class	Torsional yield strength[1]								Tensile yield strength							
			E		95		105		135		E		95		105		135	
(in)	(lb/ft)		(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(lb)	(10^3 daN)	(lb)	(10^3 daN)	(lb)	(10^3 daN)	(lb)	(10^3 daN)
5	16.25	N	35 044	4 749	44 389	6 015	49 062	6 648	63 079	8 547	328 073	145.8	415 559	184.7	459 302	204.1	590 531	262.5
		P	27 607	3 741	34 969	4 738	38 650	5 237	49 693	6 733	259 155	115.2	328 263	145.9	362 817	161.3	466 479	207.3
		2	23 974	3 249	30 368	4 115	33 564	4 548	43 154	5 847	225 316	100.1	285 400	126.8	315 442	140.2	405 568	180.3
	19.50	N	41 167	5 578	52 144	7 066	57 633	7 809	74 100	10 041	395 595	175.8	501 087	222.7	553 833	246.1	712 070	316.5
		P	32 285	4 375	40 895	5 541	45 199	6 125	58 113	7 874	311 535	138.5	394 612	175.4	436 150	193.8	560 764	249.2
		2	27 976	3 791	35 436	4 802	39 166	5 307	50 356	6 823	270 432	120.2	342 548	152.2	378 605	168.3	486 778	216.3
	25.60	N	52 257	7 081	66 192	8 969	73 159	9 913	94 062	12 746	530 144	235.6	671 515	298.5	742 201	329.9	954 259	424.1
		P	40 544	5 494	51 356	6 959	56 762	7 691	72 979	9 889	414 690	184.3	525 274	233.5	580 566	258.0	746 443	331.8
		2	34 947	4 735	44 267	5 998	48 926	6 630	62 905	8 524	358 731	159.4	454 392	202.0	502 223	223.2	645 715	287.0
5 1/2	19.20	N	44 074	5 972	55 826	7 564	61 703	8 361	79 332	10 750	372 181	165.4	471 429	209.5	521 053	231.6	669 925	297.7
		P	34 764	4 711	44 035	5 967	48 670	6 595	62 575	8 479	294 260	130.8	372 730	165.7	411 965	183.1	529 669	235.4
		2	30 208	4 093	38 263	5 185	42 291	5 730	54 374	7 368	255 954	113.8	324 208	144.1	358 335	159.3	460 717	204.8
	21.90	N	50 710	6 871	64 233	8 704	70 994	9 620	91 278	12 368	437 116	194.3	553 681	246.1	611 963	272.0	786 809	349.7
		P	39 863	5 401	50 494	6 842	55 809	7 562	71 754	9 723	344 780	153.2	436 721	194.1	482 692	214.5	620 604	275.8
		2	34 582	4 686	43 804	5 936	48 414	6 560	62 247	8 435	299 533	133.1	379 409	168.6	419 346	186.4	539 160	239.6
	24.70	N	56 574	7 666	71 660	9 710	79 204	10 732	101 833	13 799	497 222	221.0	629 814	279.9	696 111	309.4	894 999	397.8
		P	44 320	6 005	56 139	7 607	62 048	8 408	79 776	10 810	391 285	173.9	495 627	220.3	547 799	243.5	704 313	313.0
		2	38 383	5 201	48 619	6 588	53 737	7 281	69 090	9 362	339 533	150.9	430 076	191.1	475 347	211.3	611 160	271.6
6 5/8	25.20	N	70 580	9 564	89 402	12 114	98 812	13 389	127 044	17 215	489 464	217.5	619 988	275.6	685 250	304.6	881 035	391.6
		P	55 766	7 556	71 522	9 691	79 050	10 711	101 635	13 772	387 466	172.2	490 790	218.1	542 452	241.1	697 438	310.0
		2	48 497	6 571	61 430	8 324	67 896	9 200	87 295	11 829	337 236	149.9	427 166	189.9	472 131	209.8	607 026	269.8
	27.70	N	76 295	10 338	96 640	13 095	106 813	14 473	137 330	18 608	534 199	237.4	676 651	300.7	747 877	332.4	961 556	427.4
		P	60 192	8 156	77 312	10 476	85 450	11 579	109 864	14 887	422 419	187.7	535 064	237.8	591 387	262.8	760 354	337.9
		2	52 308	7 088	66 257	8 978	73 231	9 923	94 155	12 758	367 455	163.3	465 443	206.9	514 437	228.6	661 419	294.0

(1) See note B 13.

NEW (N), PREMIUM CLASS (P) AND CLASS 2 (2) DRILL PIPE, COLLAPSE AND BURST PRESSURE DATA (API RP 7G, 15th edition, January 1, 1995)

Size OD	Nominal weight	Class	Collapse pressure								Burst pressure							
			E		95		105		135		E		95		105		135	
(in)	(lb/ft)		(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)
2 3/8	4.85	N	11 040	76.1	13 984	96.4	15 456	106.6	19 035	131.2	10 500	72.4	13 300	91.7	14 700	101.4	18 900	130.3
		P	8 522	58.8	10 161	70.1	10 912	75.2	12 891	88.9	9 600	66.2	12 160	83.8	13 440	92.7	17 280	119.1
		2	6 852	47.2	7 996	55.1	8 491	58.5	9 664	66.6	8 400	57.9	10 640	73.4	11 760	81.1	15 120	104.2
	6.65	N	15 599	107.6	19 759	136.2	21 839	150.6	28 079	193.6	15 474	106.7	19 600	135.1	21 663	149.4	27 853	192.0
		P	13 378	92.2	16 945	116.8	18 729	129.1	24 080	166.0	14 147	97.5	17 920	123.6	19 806	136.6	25 465	175.6
		2	12 138	83.7	15 375	106.0	16 993	117.2	21 849	150.6	12 379	85.4	15 680	108.1	17 331	119.5	22 282	153.6
2 7/8	6.85	N	10 467	72.2	12 940	89.2	14 020	96.7	17 034	117.4	9 907	68.3	12 548	86.5	13 869	95.6	17 832	122.9
		P	7 640	52.7	9 017	62.2	9 633	66.4	11 186	77.1	9 057	62.4	11 473	79.1	12 680	87.4	16 303	112.4
		2	6 055	41.7	6 963	48.0	7 335	50.6	8 123	56.0	7 925	54.6	10 039	69.2	11 095	76.5	14 265	98.4
	10.40	N	16 509	113.8	20 911	144.2	23 112	159.4	29 716	204.9	16 526	113.9	20 933	144.3	23 137	159.5	29 747	205.1
		P	14 223	98.1	18 016	124.2	19 912	137.3	25 602	176.5	15 110	104.2	19 139	132.0	21 153	145.8	27 197	187.5
		2	12 938	89.2	16 388	113.0	18 113	124.9	23 288	160.6	13 221	91.2	16 746	115.5	18 509	127.6	23 798	164.1
3 1/2	9.50	N	10 001	69.0	12 077	83.3	13 055	90.0	15 748	108.6	9 525	65.7	12 065	83.2	13 335	91.9	17 145	118.2
		P	7 074	48.8	8 284	57.1	8 813	60.8	10 093	69.6	8 709	60.0	11 031	76.1	12 192	84.1	15 675	108.1
		2	5 544	38.2	6 301	43.4	6 596	45.5	7 137	49.2	7 620	52.5	9 652	66.5	10 668	73.6	13 716	94.6
	13.30	N	14 113	97.3	17 877	123.3	19 758	136.2	25 404	175.2	13 800	95.1	17 480	120.5	19 320	133.2	24 840	171.3
		P	12 015	82.8	15 218	104.9	16 820	116.0	21 626	149.1	12 617	87.0	15 982	110.2	17 664	121.8	22 711	156.6
		2	10 858	74.9	13 753	94.8	15 042	103.7	18 396	126.8	11 040	76.1	13 984	96.4	15 456	106.6	19 872	137.0
	15.50	N	16 774	115.7	21 247	146.5	23 484	161.9	30 194	208.2	16 838	116.1	21 328	147.1	23 573	162.5	30 308	209.0
		P	14 472	99.8	18 331	126.4	20 260	139.7	26 049	179.6	15 394	106.1	19 499	134.4	21 552	148.6	27 710	191.1
		2	13 174	90.8	16 686	115.0	18 443	127.2	23 712	163.5	13 470	92.9	17 062	117.6	18 858	130.0	24 246	167.2

Calculations are based on formules in API 5 C3

N: Nominal ID and OD.
P: Minimum wall of 80% nominal wall. Collapse pressures are based on uniform OD wear. Burst pressures are based on uniform wear and nominal OD.
2: Minimum wall of 70% nominal wall. Collapse pressures are based on uniform OD wear. Burst pressures are based on uniform wear and nominal OD.

NEW (N), PREMIUM CLASS (P) AND CLASS 2 (2) DRILL PIPE, COLLAPSE AND BURST PRESSURE DATA (continued) (API RP 7G, 15th edition, January 1, 1995)

Size OD	Nominal weight	Class	Collapse pressure								Burst pressure							
			E		95		105		135		E		95		105		135	
(in)	(lb/ft)		(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)
4	11.85	N	8 381	57.8	9 978	68.8	10 708	73.8	12 618	87.0	8 597	59.3	10 889	75.1	12 036	83.0	15 474	106.7
		P	5 704	39.3	6 508	44.9	6 827	47.1	7 445	51.3	7 860	54.2	9 956	68.6	11 004	75.9	14 148	97.5
		2	4 311	29.7	4 702	32.4	4 876	33.6	5 436	37.5	6 878	47.4	8 712	60.1	9 629	66.4	12 380	85.4
	14.00	N	11 354	78.3	14 382	99.2	15 896	109.6	20 141	138.9	10 828	74.7	13 716	94.6	15 159	104.5	19 491	134.4
		P	9 012	62.1	10 795	74.4	11 622	80.1	13 836	95.4	9 900	68.3	12 540	86.5	13 860	95.6	17 820	122.9
		2	7 295	50.3	8 570	59.1	9 134	63.0	10 520	72.5	8 663	59.7	10 973	75.7	12 128	83.6	15 593	107.5
	15.70	N	12 896	88.9	16 335	112.6	18 055	124.5	23 213	160.0	12 469	86.0	15 794	108.9	17 456	120.4	22 444	154.7
		P	10 914	75.2	13 825	95.3	15 190	104.7	18 593	128.2	11 400	78.6	14 440	99.6	15 960	110.0	20 520	141.5
		2	9 531	65.7	11 468	79.1	12 374	85.3	14 840	102.3	9 975	68.8	12 635	87.1	13 965	96.3	17 955	123.8
4 1/2	13.75	N	7 173	49.5	8 412	58.0	8 956	61.7	10 283	70.9	7 904	54.5	10 012	69.0	11 066	76.3	14 228	98.1
		P	4 686	32.3	5 190	35.8	5 352	36.9	5 908	40.7	7 227	49.8	9 154	63.1	10 117	69.8	13 008	89.7
		2	3 397	23.4	3 845	26.5	4 016	27.7	4 287	29.6	6 323	43.6	8 010	55.2	8 853	61.0	11 382	78.5
	16.60	N	10 392	71.7	12 765	88.0	13 825	95.3	16 773	115.6	9 829	67.8	12 450	85.8	13 761	94.9	17 693	122.0
		P	7 525	51.9	8 868	61.1	9 467	65.3	10 964	75.6	8 987	62.0	11 383	78.5	12 581	86.7	16 176	111.5
		2	5 951	41.0	6 828	47.1	7 185	49.5	7 923	54.6	7 863	54.2	9 960	68.7	11 009	75.9	14 154	97.6
	20.00	N	12 964	89.4	16 421	113.2	18 149	125.1	23 335	160.9	12 542	86.5	15 886	109.5	17 558	121.1	22 575	155.6
		P	10 975	75.7	13 901	95.8	15 350	105.8	18 806	129.7	11 467	79.1	14 524	100.1	16 053	110.7	20 640	142.3
		2	9 631	66.4	11 598	80.0	12 520	86.3	15 033	103.6	10 033	69.2	12 709	87.6	14 047	96.9	18 060	124.5
	22.82	N	14 815	102.1	18 765	129.4	20 741	143.0	26 667	183.9	14 583	100.5	18 472	127.4	20 417	140.8	26 250	181.0
		P	12 655	87.3	16 030	110.5	17 718	122.2	22 780	157.1	13 333	91.9	16 889	116.4	18 667	128.7	24 000	165.5
		2	11 458	79.0	14 514	100.1	16 042	110.6	20 510	141.4	11 667	80.4	14 779	101.9	16 333	112.6	21 000	144.8

See note B 16.

NEW (N), PREMIUM CLASS (P) AND CLASS 2 (2) DRILL PIPE, COLLAPSE AND BURST PRESSURE DATA (continued) (API RP 7G, 15th edition, January 1, 1995)

Size OD	Nominal weight	Class	Collapse pressure								Burst pressure							
			E		95		105		135		E		95		105		135	
in	(lb/ft)		(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)	(psi)	(MPa)
5	16.25	N	6 938	47.8	8 108	55.9	8 616	59.4	9 831	67.8	7 770	53.6	9 842	67.9	10 878	75.0	13 986	96.4
		P	4 490	31.0	4 935	34.0	5 067	34.9	5 661	39.0	7 104	49.0	8 998	62.0	9 946	68.6	12 787	88.2
		2	3 275	22.6	3 696	25.5	3 850	26.5	4 065	28.0	6 216	42.9	7 874	54.3	8 702	60.0	11 189	77.1
	19.50	N	9 962	68.7	12 026	82.9	12 999	89.6	15 672	108.1	9 503	65.5	12 037	83.0	13 304	91.7	17 105	117.9
		P	7 041	48.5	8 241	56.8	8 765	60.4	10 029	69.1	8 688	59.9	11 005	75.9	12 163	83.9	15 638	107.8
		2	5 514	38.0	6 262	43.2	6 552	45.2	7 079	48.8	7 602	52.4	9 629	66.4	10 643	73.4	13 684	94.3
	25.60	N	13 500	93.1	17 100	117.9	18 900	130.3	24 300	167.5	13 125	90.5	16 625	114.6	18 375	126.7	23 625	162.9
		P	11 458	79.0	14 514	100.1	16 042	110.6	20 510	141.4	12 000	82.7	15 200	104.8	16 800	115.8	21 600	148.9
		2	10 338	71.3	12 640	87.1	13 685	94.4	16 587	114.4	10 500	72.4	13 300	91.7	14 700	101.4	18 900	130.3
5 1/2	19.20	N	6 039	41.6	6 942	47.9	7 313	50.4	8 093	55.8	7 255	50.0	9 189	63.4	10 156	70.0	13 058	90.0
		P	3 736	25.8	4 130	28.5	4 336	29.9	4 714	32.5	6 633	45.7	8 401	57.9	9 286	64.0	11 939	82.3
		2	2 835	19.5	3 128	21.6	3 215	22.2	3 265	22.5	5 804	40.0	7 351	50.7	8 125	56.0	10 447	72.0
	21.90	N	8 413	58.0	10 019	69.1	10 753	74.1	12 679	87.4	8 615	59.4	10 912	75.2	12 061	83.2	15 507	106.9
		P	5 730	39.5	6 542	45.1	6 865	47.3	7 496	51.7	7 876	54.3	9 977	68.8	11 027	76.0	14 177	97.7
		2	4 334	29.9	4 733	32.6	4 899	33.8	5 464	37.7	6 892	47.5	8 730	60.2	9 649	66.5	12 405	85.5
	24.70	N	10 464	72.1	12 933	89.2	14 013	96.6	17 023	117.4	9 903	68.3	12 544	86.5	13 865	95.6	17 826	122.9
		P	7 635	52.6	9 011	62.1	9 626	66.4	11 177	77.1	9 055	62.4	11 469	79.1	12 676	87.4	16 298	112.4
		2	6 050	41.7	6 957	48.0	7 329	50.5	8 115	56.0	7 923	54.6	10 035	69.2	11 092	76.5	14 261	98.3
6 5/8	25.20	N	4 788	33.0	5 321	36.7	5 500	37.9	6 036	41.6	6 538	45.1	8 281	57.1	9 153	63.1	11 768	81.1
		P	2 931	20.2	3 252	22.4	3 353	23.1	3 429	23.6	5 977	41.2	7 571	52.2	8 368	57.7	10 759	74.2
		2	2 227	15.4	2 343	16.2	2 346	16.2	2 346	16.2	5 230	36.1	6 625	45.7	7 322	50.5	9 414	64.9
	27.70	N	5 894	40.6	6 755	46.6	7 103	49.0	7 813	53.9	7 172	49.4	9 084	62.6	10 040	69.2	12 909	89.0
		P	3 615	24.9	4 029	27.8	4 222	29.1	4 562	31.5	6 557	45.2	8 306	57.3	9 180	63.3	11 803	81.4
		2	2 765	19.1	3 037	20.9	3 113	21.5	3 148	21.7	5 737	39.6	7 267	50.1	8 032	55.4	10 327	71.2

See note B 16.

RECOMMENDED MINIMUM OD* AND MAKE-UP TORQUE OF WELD-ON TYPE TOOL JOINTS BASED ON TORSIONAL STRENGTH OF BOX AND DRILL PIPE (API RP 7G, 15th edition, January 1, 1995)

Drill pipe			New tool joint data							Premium class						Class 2					
Nominal size	Nominal weight	Type upset and grade	Connection	New OD		New ID		Make-up torque[6]		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint	
(in)	(lb/ft)			(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)
2 3/8	4.85	EU 75	NC26	3 3/8	85.7	1 3/4	44.5	4 125 B	**559**	3 1/8	79.4	3/64	1.2	1 945	**264**	3 3/32	78.6	1/32	0.8	1 689	**229**
	4.85	EU 75	WO	3 3/8	85.7	2	50.8	2 586 P	**350**	3 1/16	77.8	1/16	1.6	1 994	**270**	3 1/32	77.0	3/64	1.2	1 746	**237**
	4.85	EU 75	2 3/8 OHLW	3 1/8	79.4	2	50.8	2 713 P	**368**	3	76.2	1/16	1.6	1 830	**248**	2 31/32	75.4	3/64	1.2	1 589	**215**
	4.85	EU 75	2 3/8 SL-H90	3 1/4	82.6	2	50.8	3 074 P	**417**	2 31/32	75.4	1/16	1.6	1 996	**270**	2 15/16	74.6	3/64	1.2	1 726	**234**
2 3/8	6.65	IU 75	2 3/8 PAC[2]	2 7/8	73.0	1 3/8	34.9	2 813 P	**381**	2 25/32	70.6	9/64	3.6	2 455	**333**	2 23/32	69.1	7/64	2.8	2 055	**278**
	6.65	EU 75	NC26	3 3/8	85.7	1 3/4	44.5	4 125 B	**559**	3 3/16	81.0	5/64	2.0	2 467	**334**	3 5/32	80.2	1/16	1.6	2 204	**299**
	6.65	EU 75	2 3/8 SL-H90	3 1/4	82.6	2	50.8	3 074 P	**417**	3 1/32	77.0	3/32	2.4	2 549	**345**	2 31/32	75.4	1/16	1.6	1 996	**270**
	6.65	EU 75	2 3/8 OHSW	3 1/4	82.6	1 3/4	44.5	3 891 B	**527**	3 1/16	77.8	3/32	2.4	2 324	**315**	3 1/32	77.0	5/64	2.0	2 075	**281**
2 3/8	6.65	EU 95	NC26	3 3/8	85.7	1 3/4	44.5	4 125 B	**559**	3 1/4	82.6	7/64	2.8	3 005	**407**	3 7/32	81.8	3/32	2.4	2 734	**370**
2 3/8	6.65	EU 105	NC26[2]	3 3/8	85.7	1 3/4	44.5	4 125 B	**559**	3 9/32	83.3	1/8	3.2	3 279	**444**	3 1/4	82.6	7/64	2.8	3 005	**407**
2 7/8	6.85	EU 75	NC31	4 1/8	104.8	2 1/8	54.0	7 122 P	**965**	3 11/16	93.7	5/64	2.0	3 154	**427**	3 21/32	92.9	1/16	1.6	2 804	**380**
	6.85	EU 75	2 7/8 WO	4 1/8	104.8	2 7/16	61.9	4 318 P	**585**	3 5/8	92.1	5/64	2.0	3 216	**436**	3 19/32	91.3	1/16	1.6	2 876	**390**
	6.85	EU 75	2 7/8 OHLW[2]	3 3/4	95.3	2 7/16	61.9	3 351 P	**454**	3 1/2	88.9	7/64	2.8	3 297	**447**	3 7/16	87.3	5/64	2.0	2 666	**361**
	6.85	EU 75	2 7/8 SL-H90	3 7/8	98.4	2 7/16	61.9	4 575 P	**620**	3 1/2	88.9	3/32	2.4	3 397	**460**	3 7/16	87.3	1/16	1.6	2 666	**361**
2 7/8	10.40	EU 75	NC31	4 1/8	104.8	2 1/8	54.0	7 122 P	**965**	3 13/16	96.8	9/64	3.6	4 597	**623**	3 3/4	95.3	7/64	2.8	3 867	**524**
	10.40	IU 75	2 7/8 XH	4 1/4	108.0	1 7/8	47.6	7 969 P	**1 080**	3 23/32	94.5	9/64	3.6	4 357	**590**	3 21/32	92.9	7/64	2.8	3 664	**496**
	10.40	IU 75	NC26[2]	3 3/8	85.7	1 3/4	44.5	4 125 B	**559**	3 3/8	85.7	11/64	4.4	4 125	**559**	3 11/32	84.9	5/32	4.0	3 839	**520**
	10.40	EU 75	2 7/8 OHSW[2]	3 7/8	98.4	2 5/32	54.8	5 270 P	**714**	3 19/32	91.3	5/32	4.0	4 273	**579**	3 9/16	90.5	7/64	2.8	3 941	**534**
	10.40	EU 75	2 7/8 SL-H90	3 7/8	98.4	2 5/32	54.8	6 773 P	**918**	3 19/32	91.3	9/64	3.6	4 529	**614**	3 17/32	89.7	7/64	2.8	3 770	**511**
	10.40	IU 75	2 7/8 PAC[2]	3 1/8	79.4	1 1/2	38.1	3 439 P	**466**	3 1/8	79.4	15/64	6.0	3 439	**466**	3 1/8	79.4	15/64	6.0	3 439	**466**
2 7/8	10.40	EU 95	NC31	4 1/8	104.8	2	50.8	7 918 P	**1 073**	3 29/32	99.2	3/16	4.8	5 726	**776**	3 27/32	97.6	5/32	4.0	4 969	**673**
	10.40	EU 95	2 7/8 SL-H90[2]	3 7/8	98.4	2 5/32	54.8	6 773 P	**918**	3 11/16	93.7	3/16	4.8	5 702	**773**	3 5/8	92.1	5/32	4.0	4 915	**666**
2 7/8	10.40	EU 105	NC31	4 1/8	104.8	2	50.8	7 918 P	**1 073**	3 15/16	100.0	13/64	5.2	6 110	**828**	3 7/8	98.4	11/64	4.4	5 345	**724**
2 7/8	10.40	EU 135	NC31	4 3/8	111.1	1 5/8	41.3	10 167 P	**1 378**	4 1/16	103.2	17/64	6.7	7 694	**1 043**	4	101.6	15/64	6.0	6 893	**934**
3 1/2	9.50	EU 75	NC38	4 3/4	120.7	3	76.2	7 688 P	**1 042**	4 13/32	111.9	1/8	3.2	5 773	**782**	4 11/32	110.3	3/32	2.4	4 797	**650**
	9.50	EU 75	NC38	4 3/4	120.7	2 11/16	68.3	10 864 P	**1 472**	4 13/32	111.9	1/8	3.2	5 773	**782**	4 11/32	110.3	3/32	2.4	4 797	**650**
	9.50	EU 75	3 1/2 OHLW	4 3/4	120.7	3	76.2	7 218 P	**978**	4 9/32	108.7	1/8	3.2	5 340	**724**	4 1/4	108.0	7/64	2.8	4 868	**660**
	9.50	EU 75	3 1/2 SL-H90	4 5/8	117.5	3	76.2	7 584 P	**1 028**	4 3/16	106.4	7/64	2.8	5 521	**748**	4 5/32	105.6	3/32	2.4	5 003	**678**

See notes at the end of B 23.

RECOMMENDED MINIMUM OD* AND MAKE-UP TORQUE OF WELD-ON TYPE TOOL JOINTS BASED ON TORSIONAL STRENGTH OF BOX AND DRILL PIPE (continued) (API RP 7G, 15th edition, January 1, 1995)

Drill pipe				New tool joint data						Premium class						Class 2					
Nominal size	Nominal weight	Type upset and grade	Connection	New OD		New ID		Make-up torque[6]		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint	
(in)	(lb/ft)			(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)
3 1/2	13.30	EU 75	NC38	4 3/4	120.7	2 11/16	68.3	10 864 P	**1 472**	4 1/2	114.3	11/64	4.4	7 274	**986**	4 7/16	112.7	9/64	3.6	6 268	**849**
	13.30	IU 75	NC31[2]	4 1/8	104.8	2 1/8	54.0	7 122 P	**965**	4	101.6	15/64	6.0	6 893	**934**	3 15/16	100.0	13/64	5.2	6 110	**828**
	13.30	EU 75	3 1/2 OHSW	4 3/4	120.7	2 11/16	68.3	10 387 P	**1 407**	4 13/32	111.9	3/16	4.8	7 278	**986**	4 11/32	110.3	5/32	4.0	6 229	**844**
	13.30	EU 75	3 1/2 H90	5 1/4	133.4	2 3/4	69.9	14 300 P	**1 938**	4 17/32	115.1	1/8	3.2	7 064	**957**	4 1/2	114.3	7/64	2.8	6 487	**879**
	13.30	EU 95	NC38	5	127.0	2 9/16	65.1	12 196 P	**1 653**	4 19/32	116.7	7/32	5.6	8 822	**1 195**	4 17/32	115.1	3/16	4.8	7 785	**1 055**
	13.30	EU 95	3 1/2 SL-H90[2]	4 5/8	117.5	2 11/16	68.3	11 137 P	**1 509**	4 3/8	111.1	13/64	5.2	8 742	**1 185**	4 5/16	109.5	11/64	4.4	7 647	**1 036**
	13.30	EU 95	3 1/2 H90	5 1/4	133.4	2 3/4	69.9	14 300 P	**1 938**	4 5/8	117.5	11/64	4.4	8 826	**1 196**	4 9/16	115.9	9/64	3.6	7 646	**1 036**
3 1/2	13.30	EU 105	NC38	5	127.0	2 7/16	61.9	13 328 P	**1 806**	4 21/32	118.3	1/4	6.4	9 879	**1 339**	4 19/32	116.7	7/32	5.6	8 822	**1 195**
3 1/2	13.30	EU 135	NC40	5 3/8	136.5	2 7/16	61.9	17 958 P	**2 433**	5	127.0	9/32	7.1	12 569	**1 703**	4 29/32	124.6	15/64	6.0	10 768	**1 459**
	13.30	EU 135	NC38	5	127.0	2 1/8	54.0	15 909 P	**2 156**	4 13/16	122.2	21/64	8.3	12 614	**1 709**	4 23/32	119.9	9/32	7.1	10 957	**1 485**
3 1/2	15.50	EU 75	NC38	5	127.0	2 9/16	65.1	12 196 P	**1 653**	4 17/32	115.1	3/16	4.8	7 785	**1 055**	4 15/32	113.5	5/32	4.0	6 769	**917**
3 1/2	15.50	EU 95	NC38	5	127.0	2 7/16	61.9	13 328 P	**1 806**	4 21/32	118.3	1/4	6.4	9 879	**1 339**	4 19/32	116.7	7/32	5.6	8 822	**1 195**
3 1/2	15.50	EU 105	NC38	5	127.0	2 1/8	54.0	15 909 P	**2 156**	4 23/32	119.9	9/32	7.1	10 957	**1 485**	4 5/8	117.5	15/64	6.0	9 348	**1 267**
	15.50	EU 105	NC40	5 1/4	133.4	2 9/16	65.1	16 656 P	**2 257**	4 15/16	125.4	1/4	6.4	11 363	**1 540**	4 27/32	123.0	13/64	5.2	9 595	**1 300**
3 1/2	15.50	EU 135	NC40	5 1/2	139.7	2 1/4	57.2	19 766 P	**2 678**	5 3/32	129.4	21/64	8.3	14 419	**1 954**	4 31/32	126.2	17/64	6.7	11 963	**1 621**
4	11.85	EU 75	NC46	6	152.4	3 1/4	82.6	20 175 P	**2 734**	5 7/32	132.6	7/64	2.8	7 843	**1 063**	5 5/32	131.0	5/64	2.0	6 476	**878**
	11.85	EU 75	4 WO	5 3/4	146.1	3 7/16	87.3	17 285 P	**2 342**	5 7/32	132.6	7/64	2.8	7 843	**1 063**	5 5/32	131.0	5/64	2.0	6 476	**878**
	11.85	EU 75	4 OHLW	5 1/4	133.4	3 15/32	88.1	13 186 P	**1 787**	5	127.0	9/64	3.6	7 866	**1 066**	4 15/16	125.4	7/64	2.8	6 593	**893**
	11.85	IU 75	4 H90	5 1/2	139.7	2 13/16	71.4	21 224 P	**2 876**	4 7/8	123.8	7/64	2.8	7 630	**1 034**	4 27/32	123.0	3/32	2.4	6 962	**943**
4	14.00	IU 75	NC40	5 1/4	133.4	2 13/16	71.4	14 092 P	**1 909**	4 13/16	122.2	3/16	4.8	9 017	**1 222**	4 3/4	120.7	5/32	4.0	7 877	**1 067**
	14.00	EU 75	NC46	6	152.4	3 1/4	82.6	20 175 P	**2 734**	5 9/32	134.1	9/64	3.6	9 233	**1 251**	5 7/32	132.6	7/64	2.8	7 843	**1 063**
	14.00	IU 75	4 SH[2]	4 5/8	117.5	2 9/16	65.1	9 102 P	**1 233**	4 7/16	112.7	15/64	6.0	8 782	**1 190**	4 3/8	111.1	13/64	5.2	7 817	**1 059**
	14.00	EU 75	4 OHSW	5 1/2	139.7	3 1/4	82.6	16 320 P	**2 211**	5 1/16	128.6	11/64	4.4	9 131	**1 237**	5	127.0	9/64	3.6	7 839	**1 062**
	14.00	IU 75	4 H90	5 1/2	139.7	2 13/16	71.4	21 224 P	**2 876**	4 15/16	125.4	9/64	3.6	8 986	**1 218**	4 7/8	123.8	7/64	2.8	7 630	**1 034**
4	14.00	IU 95	NC40	5 1/4	133.4	2 11/16	68.3	15 404 P	**2 087**	4 15/16	125.4	1/4	6.4	11 363	**1 540**	4 27/32	123.0	13/64	5.2	9 595	**1 300**
	14.00	EU 95	NC46	6	152.4	3 1/4	82.6	20 175 P	**2 734**	5 3/8	136.5	3/16	4.8	11 363	**1 540**	5 5/16	134.9	5/32	4.0	9 937	**1 346**
	14.00	IU 95	4 H90	5 1/2	139.7	2 13/16	71.4	21 224 P	**2 876**	5 1/32	127.8	3/16	4.8	11 065	**1 499**	4 31/32	126.2	5/32	4.0	9 673	**1 311**

See notes at the end of B 23.

RECOMMENDED MINIMUM OD* AND MAKE-UP TORQUE OF WELD-ON TYPE TOOL JOINTS BASED ON TORSIONAL STRENGTH OF BOX AND DRILL PIPE (continued)
(API RP 7G, 15th edition, January 1, 1995)

Drill pipe			New tool joint data							Premium class						Class 2					
Nominal size	Nominal weight	Type upset and grade	Connection	New OD		New ID		Make-up torque[6]		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint	
(in)	(lb/ft)			(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)
4	14.00	IU 105	NC40	5 1/2	139.7	2 7/16	61.9	18 068 P	**2 448**	5	127.0	9/32	7.1	12 569	**1 703**	4 29/32	124.6	15/64	6.0	10 768	**1 459**
	14.00	EU 105	NC46	6	152.4	3 1/4	82.6	20 175 P	**2 734**	5 7/16	138.1	7/32	5.6	12 813	**1 736**	5 11/32	135.7	11/64	4.4	10 647	**1 443**
	14.00	IU 105	4 H90	5 1/2	139.7	2 13/16	71.4	21 224 P	**2 876**	5 3/32	129.4	7/32	5.6	12 481	**1 691**	5 1/32	127.8	3/16	4.8	11 065	**1 499**
4	14.00	EU 135	NC46	6	152.4	3	76.2	23 538 P	**3 189**	5 9/16	141.3	9/32	7.1	15 787	**2 139**	5 1/2	139.7	1/4	6.4	14 288	**1 936**
4	15.70	IU 75	NC40	5 1/4	133.4	2 11/16	68.3	15 404 P	**2 087**	4 7/8	123.8	7/32	5.6	10 179	**1 379**	4 25/32	121.4	11/64	4.4	8 444	**1 144**
	15.70	EU 75	NC46	6	152.4	3 1/4	82.6	20 175 P	**2 734**	5 5/16	134.9	5/32	4.0	9 937	**1 346**	5 1/4	133.4	1/8	3.2	8 535	**1 157**
	15.70	IU 75	4 H90	5 1/2	139.7	2 13/16	71.4	21 224 P	**2 876**	4 31/32	126.2	5/32	4.0	9 673	**1 311**	4 29/32	124.6	1/8	3.2	8 305	**1 125**
4	15.70	IU 95	NC40	5 1/2	139.7	2 7/16	61.9	18 068 P	**2 448**	5	127.0	9/32	7.1	12 569	**1 703**	4 29/32	124.6	15/64	6.0	10 768	**1 459**
	15.70	EU 95	NC46	6	152.4	3	76.2	23 538 P	**3 189**	5 7/16	138.1	7/32	5.6	12 813	**1 736**	5 11/32	135.7	11/64	4.4	10 647	**1 443**
	15.70	IU 95	4 H90	5 1/2	139.7	2 13/16	71.4	21 224 P	**2 876**	5 3/32	129.4	7/32	5.6	12 481	**1 691**	5 1/32	127.8	3/16	4.8	11 065	**1 499**
4	15.70	EU 105	NC46	6	152.4	3	76.2	23 538 P	**3 189**	5 15/32	138.9	15/64	6.0	13 547	**1 836**	5 13/32	137.3	13/64	5.2	12 085	**1 638**
	15.70	IU 105	4 H90	5 1/2	139.7	2 13/16	71.4	21 224 P	**2 876**	5 5/32	131.0	1/4	6.4	13 922	**1 886**	5 1/16	128.6	13/64	5.2	11 770	**1 595**
4	15.70	IU 135	NC46	6	152.4	2 5/8	66.7	26 982 B	**3 656**	5 21/32	143.7	21/64	8.3	18 083	**2 450**	5 17/32	140.5	17/64	6.7	15 035	**2 037**
	15.70	EU 135	NC46	6	152.4	2 7/8	73.0	25 118 P	**3 404**	5 21/32	143.7	21/64	8.3	18 083	**2 450**	5 17/32	140.5	17/64	6.7	15 035	**2 037**
4 1/2	16.60	IEU 75	4 1/2 FH	6	152.4	3	76.2	20 868 P	**2 828**	5 3/8	136.5	13/64	5.2	12 125	**1 643**	5 9/32	134.1	5/32	4.0	10 072	**1 365**
	16.60	IEU 75	NC46	6 1/4	158.8	3 1/4	82.6	20 396 P	**2 764**	5 13/32	137.3	13/64	5.2	12 085	**1 638**	5 11/32	135.7	11/64	4.4	10 647	**1 443**
	16.60	IEU 75	4 1/2 OHSW	5 7/8	149.2	3 3/4	95.3	16 346 P	**2 215**	5 7/16	138.1	13/64	5.2	11 862	**1 607**	5 3/8	136.5	11/64	4.4	10 375	**1 406**
	16.60	EU 75	NC50	6 5/8	168.3	3 3/4	95.3	22 836 P	**3 094**	5 23/32	145.3	5/32	4.0	11 590	**1 570**	5 11/16	144.5	9/64	3.6	10 773	**1 460**
	16.60	IEU 75	4 1/2 H-90	6	152.4	3 1/4	82.6	23 355 P	**3 165**	5 11/32	135.7	3/16	4.8	12 215	**1 655**	5 9/32	134.1	5/32	4.0	10 642	**1 442**
4 1/2	16.60	IEU 95	4 1/2 FH	6	152.4	2 3/4	69.9	23 843 P	**3 231**	5 1/2	139.7	17/64	6.7	14 945	**2 025**	5 13/32	137.3	7/32	5.6	12 821	**1 737**
	16.60	IEU 95	NC46	6 1/4	158.8	3 1/4	82.6	20 396 P	**2 764**	5 17/32	140.5	17/64	6.7	15 035	**2 037**	5 7/16	138.1	7/32	5.6	12 813	**1 736**
	16.60	EU 95	NC50	6 5/8	168.3	3 3/4	95.3	22 836 P	**3 094**	5 27/32	148.4	7/32	5.6	14 926	**2 022**	5 25/32	146.8	3/16	4.8	13 245	**1 795**
	16.60	IEU 95	4 1/2 H-90	6	152.4	3	76.2	27 091 P	**3 671**	5 15/32	138.9	1/4	6.4	15 441	**2 092**	5 3/8	136.5	13/64	5.2	13 102	**1 775**
4 1/2	16.60	IEU 105	4 1/2 FH	6	152.4	2 3/4	69.9	23 843 P	**3 231**	5 9/16	141.3	19/64	7.5	16 391	**2 221**	5 15/32	138.9	1/4	6.4	14 231	**1 928**
	16.60	IEU 105	NC46	6 1/4	158.8	3	76.2	23 795 P	**3 224**	5 19/32	142.1	19/64	7.5	16 546	**2 242**	5 1/2	139.7	1/4	6.4	14 288	**1 936**
	16.60	EU 105	NC50	6 5/8	168.3	3 3/4	95.3	22 836 P	**3 094**	5 29/32	150.0	1/4	6.4	16 633	**2 254**	5 13/16	147.6	13/64	5.2	14 082	**1 908**
	16.60	IEU 105	4 1/2 H-90	6	152.4	3	76.2	27 091 P	**3 671**	5 1/2	139.7	17/64	6.7	16 264	**2 204**	5 7/16	138.1	15/64	6.0	14 625	**1 982**

See notes at the end of B 23.

RECOMMENDED MINIMUM OD* AND MAKE-UP TORQUE OF WELD-ON TYPE TOOL JOINTS BASED ON TORSIONAL STRENGTH OF BOX AND DRILL PIPE (continued)
(API RP 7G, 15th edition, January 1, 1995)

Drill pipe			New tool joint data							Premium class						Class 2					
Nominal size	Nominal weight	Type upset and grade	Connection	New OD		New ID		Make-up torque[6]		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint	
(in)	(lb/ft)			(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)
4 1/2	16.60	IEU 135	NC46	6 1/4	158.8	2 3/4	69.9	26 923 P	**3 648**	5 25/32	146.8	25/64	9.9	21 230	**2 877**	5 21/32	143.7	21/64	8.3	18 083	**2 450**
	16.60	EU 135	NC50	6 5/8	168.3	3 1/2	88.9	27 076 P	**3 669**	6 1/16	154.0	21/64	8.3	21 017	**2 848**	5 31/32	151.6	9/32	7.1	18 367	**2 489**
4 1/2	20.00	IEU 75	4 1/2 FH	6	152.4	3	76.2	20 868 P	**2 828**	5 15/32	138.9	1/4	6.4	14 231	**1 928**	5 3/8	136.5	13/64	5.2	12 125	**1 643**
	20.00	IEU 75	NC46	6 1/4	158.8	3	76.2	23 795 P	**3 224**	5 1/2	139.7	1/4	6.4	14 288	**1 936**	5 13/32	137.3	13/64	5.2	12 085	**1 638**
	20.00	EU 75	NC50	6 5/8	168.3	3 5/8	92.1	24 993 P	**3 387**	5 13/16	147.6	13/64	5.2	14 082	**1 908**	5 3/4	146.1	11/64	4.4	12 415	**1 682**
	20.00	IEU 75	4 1/2 H-90	6	152.4	3	76.2	27 091 P	**3 671**	5 13/32	137.3	7/32	5.6	13 815	**1 872**	5 11/32	135.7	3/16	4.8	12 215	**1 655**
4 1/2	20.00	IEU 95	4 1/2 FH	6	152.4	2 1/2	63.5	26 559 P	**3 599**	5 5/8	142.9	21/64	8.3	17 861	**2 420**	5 17/32	140.5	9/32	7.1	15 665	**2 123**
	20.00	IEU 95	NC46	6 1/4	158.8	2 3/4	69.9	26 923 P	**3 648**	5 21/32	143.7	21/64	8.3	18 083	**2 450**	5 9/16	141.3	9/32	7.1	15 787	**2 139**
	20.00	EU 95	NC50	6 5/8	168.3	3 1/2	88.9	27 076 P	**3 669**	5 15/16	150.8	17/64	6.7	17 497	**2 371**	5 7/8	149.2	15/64	6.0	15 776	**2 138**
	20.00	IEU 95	4 1/2 H-90	6	152.4	3	76.2	27 091 P	**3 671**	5 9/16	141.3	19/64	7.5	17 929	**2 429**	5 15/32	138.9	1/4	6.4	15 441	**2 092**
4 1/2	20.00	IEU 105	NC46	6 1/4	158.8	2 1/2	63.5	29 778 P	**4 035**	5 23/32	145.3	23/64	9.1	19 644	**2 662**	5 5/8	142.9	5/16	7.9	17 311	**2 346**
	20.00	EU 105	NC50	6 5/8	168.3	3 1/2	88.9	27 076 P	**3 669**	6 1/32	153.2	5/16	7.9	20 127	**2 727**	5 29/32	150.0	1/4	6.4	16 633	**2 254**
4 1/2	20.00	EU 135	NC50	6 5/8	168.3	2 7/8	73.0	36 398 P	**4 932**	6 7/32	158.0	13/32	10.3	25 569	**3 465**	6 3/32	154.8	11/32	8.7	21 914	**2 969**
5	19.50	IEU 75	NC50	6 5/8	168.3	3 3/4	95.3	22 836 P	**3 094**	5 7/8	149.2	15/64	6.0	15 776	**2 138**	5 13/16	147.6	13/64	5.2	14 082	**1 908**
5	19.50	IEU 95	NC50	6 5/8	168.3	3 1/2	88.9	27.076 P	**3 669**	6 1/32	153.2	5/16	7.9	20 127	**2 727**	5 15/16	150.8	17/64	6.7	17 497	**2 371**
	19.50	IEU 95	5 H-90	6 1/2	165.1	3 1/4	82.6	31 084 P	**4 212**	5 27/32	148.4	19/64	7.5	19 862	**2 691**	5 3/4	146.1	1/4	6.4	17 116	**2 319**
5	19.50	IEU 105	NC50	6 5/8	168.3	3 1/4	82.6	31 025 P	**4 204**	6 3/32	154.8	11/32	8.7	21 914	**2 969**	6	152.4	19/64	7.5	19 224	**2 605**
	19.50	IEU 105	5 H-90	6 1/2	165.1	3	76.2	35 039 P	**4 748**	5 29/32	150.0	21/64	8.3	21 727	**2 944**	5 13/16	147.6	9/32	7.1	18 940	**2 566**
5	19.50	IEU 135	NC50	6 5/8	168.3	2 3/4	69.9	38 044 P	**5 155**	6 5/16	160.3	29/64	11.5	28 381	**3 846**	6 3/16	157.2	25/64	9.9	24 645	**3 339**
	19.50	IEU 135	5 1/2 FH	7 1/4	184.2	3 1/2	88.9	43 490 P	**5 893**	6 3/4	171.5	3/8	9.5	28 737	**3 894**	6 5/8	168.3	5/16	7.9	24 412	**3 308**
5	25.60	IEU 75	NC50	6 5/8	168.3	3 1/2	88.9	27 076 P	**3 669**	6 1/32	153.2	5/16	7.9	20 127	**2 727**	5 15/16	150.8	17/64	6.7	17 497	**2 371**
	25.60	IEU 75	5 1/2 FH	7	177.8	3 1/2	88.9	37 742 B	**5 114**	6 1/2	165.1	1/4	6.4	20 205	**2 738**	6 13/32	162.7	13/64	5.2	17 127	**2 321**
5	25.60	IEU 95	NC50	6 5/8	168.3	3	76.2	34 680 P	**4 699**	6 7/32	158.0	13/32	10.3	25 569	**3 465**	6 3/32	154.8	11/32	8.7	21 914	**2 969**
	25.60	IEU 95	5 1/2 FH	7	177.8	3 1/2	88.9	37 742 B	**5 114**	6 21/32	169.1	21/64	8.3	25 483	**3 453**	6 9/16	166.7	9/32	7.1	22 294	**3 021**
5	25.60	IEU 105	NC50	6 5/8	168.3	2 3/4	69.9	38 044 P	**5 155**	6 9/32	159.5	7/16	11.1	27 437	**3 718**	6 5/32	156.4	3/8	9.5	23 728	**3 215**
	25.60	IEU 105	5 1/2 FH	7 1/4	184.2	3 1/2	88.9	43 490 P	**5 893**	6 23/32	170.7	23/64	9.1	27 645	**3 746**	6 5/8	168.3	5/16	7.9	24 412	**3 308**

See notes at the end of B 23.

RECOMMENDED MINIMUM OD* AND MAKE-UP TORQUE OF WELD-ON TYPE TOOL JOINTS BASED ON TORSIONAL STRENGTH OF BOX AND DRILL PIPE (continued)

(API RP 7G, 15th edition, January 1, 1995)

Drill pipe			New tool joint data							Premium class						Class 2					
Nominal size	Nominal weight	Type upset and grade	Connection	New OD		New ID		Make-up torque[6]		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint		Minimum OD tool joint		Minimum box shoulder with eccentric wear		Make-up torque for minimum OD tool joint	
(in)	(lb/ft)			(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)	(in)	(mm)	(in)	(mm)	(ft.lb)	(daN.m)
5	25.60	IEU 135	5 1/2 FH	7 1/4	184.2	3 1/4	82.6	47 230 B	**6 400**	6 15/16	176.2	15/32	11.90	35 446	**4 803**	6 13/16	173.0	13/32	10.3	30 943	**4 193**
5 1/2	21.90	IEU 75	5 1/2 FH	7	177.8	4	101.6	33 560 P	**4 547**	6 15/32	164.3	15/64	5.95	19 172	**2 598**	6 13/32	162.7	13/64	5.2	17 127	**2 321**
5 1/2	21.90	IEU 95	5 1/2 FH	7	177.8	3 3/4	95.3	37 742 B	**5 114**	6 5/8	168.3	5/16	7.94	24 412	**3 308**	6 17/32	165.9	17/64	6.7	21 246	**2 879**
	21.90	IEU 95	5 1/2 H-90	7	177.8	3 1/2	88.9	35 454 P	**4 804**	6 3/16	157.2	21/64	8.33	24 414	**3 308**	6 3/32	154.8	9/32	7.1	21 349	**2 893**
5 1/2	21.90	IEU 105	5 1/2 FH	7 1/4	184.2	3 1/2	88.9	43 490 P	**5 893**	6 23/32	170.7	23/64	9.13	27 645	**3 746**	6 19/32	167.5	19/64	7.5	23 350	**3 164**
5 1/2	21.90	IEU 135	5 1/2 FH	7 1/2	190.5	3	76.2	53 302 P	**7 222**	6 15/16	176.2	15/32	11.91	35 446	**4 803**	6 13/16	173.0	13/32	10.3	30 943	**4 193**
5 1/2	24.70	IEU 75	5 1/2 FH	7	177.8	4	101.6	33 560 P	**4 547**	6 9/16	166.7	9/32	7.14	22 294	**3 021**	6 15/32	164.3	15/64	6.0	19 172	**2 598**
5 1/2	24.70	IEU 95	5 1/2 FH	7 1/4	184.2	3 1/2	88.9	43 490 P	**5 893**	6 23/32	170.7	23/64	9.13	27 645	**3 746**	6 19/32	167.5	19/64	7.5	23 350	**3 164**
5 1/2	24.70	IEU 105	5 1/2 FH	7 1/4	184.2	3 1/2	88.9	43 490 P	**5 893**	6 25/32	172.2	25/64	9.92	29 836	**4 043**	6 11/16	169.9	11/32	8.7	26 560	**3 599**
5 1/2	24.70	IEU 135	5 1/2 FH	7 1/2	190.5	3	76.2	52 302 P	**7 087**	7 1/32	178.6	33/64	13.10	38 901	**5 271**	6 7/8	174.6	7/16	11.1	33 180	**4 496**
6 5/8	25.20	IEU 75	6 5/8 FH	8	203.2	5	127.0	44 196 P	**5 989**	7 7/16	188.9	1/4	6.35	26 810	**3 633**	7 3/8	187.3	7/32	5.6	24 100	**3 266**
		IEU 95	6 5/8 FH	8	203.2	5	127.0	44 196 P	**5 989**	7 5/8	193.7	11/32	8.73	35 139	**4 761**	7 1/2	190.5	9/32	7.1	29 552	**4 004**
		IEU 105	6 5/8 FH	8 1/4	209.6	4 3/4	120.7	51 742 P	**7 011**	7 11/16	195.3	3/8	9.53	37 983	**5 147**	7 19/32	192.9	21/64	8.3	33 730	**4 570**
		IEU 135	6 5/8 FH	8 1/2	215.9	4 1/4	108.0	65 535 P	**8 880**	7 29/32	200.8	31/64	12.30	48 204	**6 532**	7 25/32	197.6	27/64	10.7	42 312	**5 733**
6 5/8	27.70	IEU 75	6 5/8 FH	8	203.2	5	127.0	44 196 P	**5 989**	7 1/2	190.5	9/32	7.14	29 552	**4 004**	7 13/32	188.1	15/64	6.0	25 451	**3 449**
		IEU 95	6 5/8 FH	8 1/4	209.6	4 3/4	120.7	51 742 P	**7 011**	7 11/16	195.3	3/8	9.53	37 983	**5 147**	7 9/16	192.1	5/16	7.9	32 329	**4 381**
		IEU 105	6 5/8 FH	8 1/4	209.6	4 3/4	120.7	51 742 P	**7 011**	7 3/4	196.9	13/32	10.32	40 860	**5 537**	7 21/32	194.5	23/64	9.1	36 556	**4 953**
		IEU 135	6 5/8 FH	8 1/2	215.9	4 1/4	108.0	65 535 P	**8 880**	8	203.2	17/32	13.49	52 714	**7 143**	7 27/64	188.5	29/64	11.5	45 241	**6 130**

1. The use of outside diameters (OD) smaller than those listed in the table may be acceptable due to special service requirements.
2. Tool joint with dimensions shown has lower torsional yield ratio than the 0.80 which is generally used.
3. Recommended make-up torque is based on 72 000 psi stress.
4. In calculation of torsional strengths of tool joints, both new and worn, the bevels of the tool joint shoulders are disregarded. This thickness measurement should be made in the plane of the face from the ID of the counter bore to the outside diameter of the box, disregarding the bevels.
5. Any tool joint with an outside diameter less than API bevel diameter should be provided with a minimum 1/32″ depth × 45° bevel on the outside and inside diameter of the box shoulder and outside diameter of the pin shoulder.
6. P = pin limit, B = Box limit.

* Tool joint diameters specified are required to retain torsional strength in the tool joint comparable to the torsional strength of the attached drill pipe. These should be adequate for all service. Tool joints with torsional strengths considerably below that of the drill pipe may be adequate for much drilling service.

THREAD DIMENSIONS OF ROTARY SHOULDERED CONNECTIONS (API Spec 7, 38th edition, April 1, 1994)

(see Fig. B 25) All dimensions in mm

Connection No. or size (1)	Thread form	Threads per inch	Taper (%)	Pitch diameter at gage point C	Large pin diameter D_L	Flat diameter on pin ± 0.40 D_{LF}	Small pin diameter D_S	Pin length + 0 – 3.18 L_{PC}	Minimum length of box thread L_{BT}	Box counterbore + 9.52 – 0 L_{BC}	Box inside diameter + 0.79 – 0.40 Q_C
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
6 5/8 FH	V-0.050	4	16.66	165.6	171.5	–	150.4	127.0	130.2	142.9	173.9

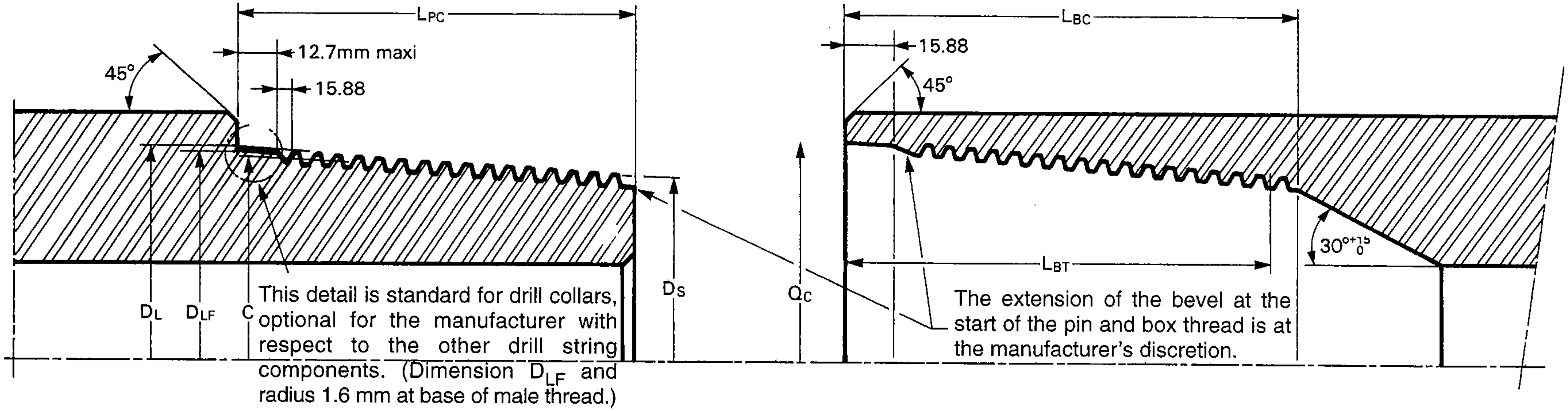
(1) The NC connection No. is the pitch diameter in inches of the pin thread at the gage point (C), rounded off to units and tenths of an inch.

* 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



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

(see Fig. B 25) 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
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-0.040	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-0.040	4	16.66	165.6	171.5	–	150.4	127.0	130.2	142.9	173.8
2 3/8 IF	V-0.040	4	16.66	67.8	73.1	69.8	60.4	76.2	79.4	92.1	74.6
2 7/8 IF	V-0.040	4	16.66	80.8	86.1	83.0	71.3	88.9	92.1	104.8	87.7
3 1/2 IF	V-0.040	4	16.66	96.7	102.0	98.8	85.1	101.6	104.8	117.5	103.6
4 IF	V-0.040	4	16.66	117.5	122.8	119.6	103.7	114.3	117.5	130.2	124.6
4 1/2 IF	V-0.040	4	16.66	128.1	133.4	130.4	114.3	114.3	117.5	130.2	134.9
5 1/2 IF	V-0.040	4	16.66	157.2	162.5	–	141.3	127.0	130.2	142.9	163.9

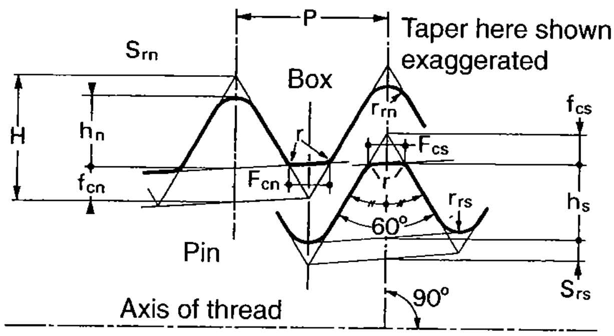
mm × 0.0394 = in

API THREAD FORMS AND DIMENSIONS
(API Spec 7, 38th edition, April 1, 1994)

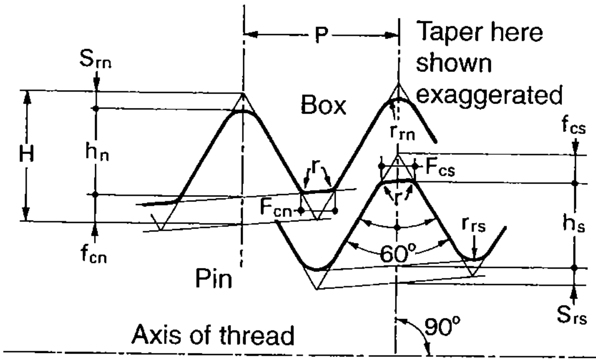
All dimensions in mm

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	$h_n = h_s$	$S_{rn} = S_{rs}$ $f_{rn} = f_{rs}$	$f_{cn} = f_{cs}$	$F_{cn} = F_{cs}$	$R_{rn} = F_{rs}$	$r_{rn} = r_{rs}$	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

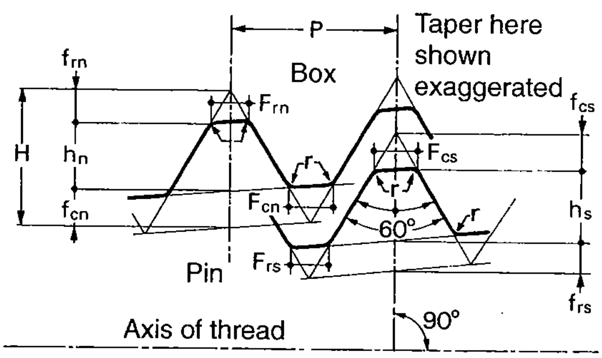
(1) Taper (%) equal 8.33 x taper in in/ft.



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 x 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 per 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 tool joints threads

mm × 0.0394 = in daN.m × 7.38 = lb.ft

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

Size (in)	Pin D_{LF} (1) (mm)	Pin C (mm)	Box Q_C (1) (mm)	Taper (%)	Threads per in	Thread form	Make-up torque (daN.m)
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 D_{LF} (1) (mm)	Pin C (mm)	Taper (%)	Threads per in	Hybrid special thread	Make-up torque (daN.m)
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	100.6	4.17	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	3	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	3	1 step	215
2 7/8	60.1	90.5	4.17	3	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 joints 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 **NC46**
	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 **NC31**
	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 form 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)

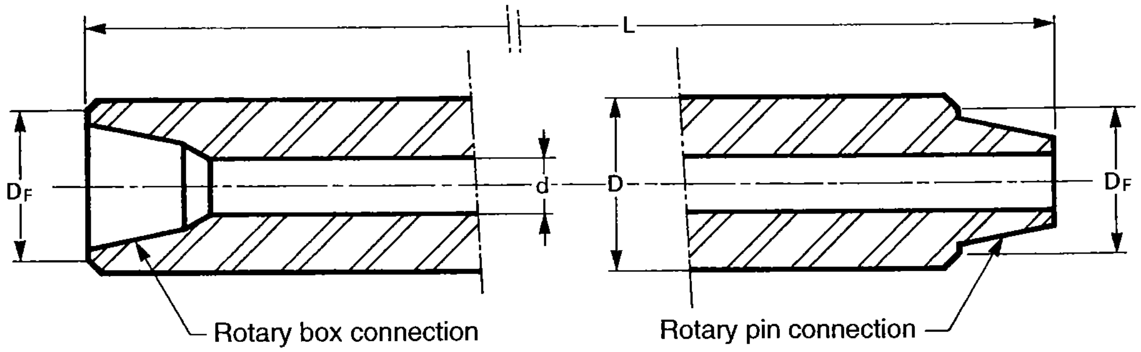
Common name: Style	Common name: Size	Pin base diameter tapered D_L (mm)	Threads per in	Taper %	Thread form (1)	Same as or interchanges with (2)
Double Streamline (DSL)	3 1/2	84.5	4	16.66	V-0.065 (V-0.038R)	2 7/8 Extra Hole
	4 1/2	108.7	4	16.66	V-0.065 (V-0.038R)	4 Full Hole **NC40**
	5 1/2	133.4	4	16.66	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 threads 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 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	Diameter at bevel ± 0.4 D_f	BSR
	(in)	(mm)	+1/16 −0 (in)	+1/16 −0 (mm)	(m)	(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
8 5/8 REG	11	279.4	3	76.2	9.1 or 9.4	266.7	2.84

(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

IDEAL DRILL COLLAR RANGE

Hole size in	Casing size to be run	Ideal drill collar range Min	Max	API drill collar sizes which fall in the ideal range
6 1/8	4 1/2	3.875	4.750	4 1/8, 4 3/4
6 1/4	4 1/2	3.750	4.875	4 1/8, 4 3/4
6 3/4	4 1/2	3.250	5.125	3 1/2, 4 1/8, 4 3/4, 5
7 7/8	4 1/2	2.125	6.250	3 1/8, 3 1/2, 4 1/8, 4 3/4, 5, 6, 6 1/4
7 7/8	5 1/2	4.225	6.250	4 3/4, 5, 6, 6 1/4
8 3/8	5 1/2	3.725	6.750	4 1/8, 4 3/4, 5, 6, 6 1/4, 6 1/2, 6 3/4
8 3/8	6 5/8	6.405	6.750	6 1/2, 6 3/4
8 1/2	6 5/8	6.280	6.750	6 1/2, 6 3/4
8 1/2	7	–	6.750	6 3/4
8 3/4	6 5/8	6.030	7.125	6 1/4, 6 1/2, 6 3/4, 7
8 3/4	7	6.562	7.125	6 3/4, 7
9 1/2	7	6.812	7.625	6, 6 1/4, 6 1/2, 6 3/4, 7, 7 1/4
9 1/2	7 5/8	7.500	7.875	7 3/4
9 7/8	7	5.437	8.000	6, 6 1/4, 6 1/2, 6 3/4, 7, 7 1/4, 7 3/4, 8
9 7/8	7 5/8	7.125	8.000	7 1/4, 7 3/4, 8
10 5/8	7 5/8	6.375	8.500	6 1/2, 6 3/4, 7, 7 1/4, 7 3/4, 8, 8 1/4
10 5/8	8 5/8	–	8.500	8 1/4
11	8 5/8	8.250	8.875	8 1/4
12 1/4	9 5/8	9.000	10.125	9, 9 1/2, 9 3/4, 10
12 1/4	10 3/4	–	10.125	10
13 3/4	10 3/4	9.750	11.250	9 3/4, 10, 11
14 3/4	11 3/4	10.750	12.000	11, *12
17 1/2	13 3/8	11.250	13.375	*12
20	16	14.000	14.750	*14
24	18 5/8	15.500	16.750	*16
26	20	16.000	19.500	*16

The minimum size drill-collar is calculated from the Lubinski and Hock equation.
* Not API standard size drill collar.

WEIGHT OF DRILL COLLARS (kg/m)

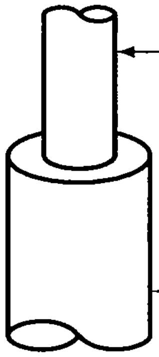
OD		Inside diameter (in and mm)														
		1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	2 4/5	2 7/8	3	3 1/4	3 1/2	3 3/4	4
in	mm	25.40	31.75	38.10	44.45	50.80	57.15	63.50	69.85	71.44	73.03	76.20	82.55	88.90	95.25	101.60
2 7/8	73.03	28.90	26.66	23.93												
3	76.20	31.82	29.58	26.85												
3 1/8	79.38	34.87	32.63	29.89												
3 1/4	82.55	38.04	35.80	33.06												
3 1/2	88.90	44.75	42.51	39.78												
3 3/4	95.25	51.96	49.72	46.99	43.75											
4	101.60	59.66	57.43	54.69	51.46	47.73	43.51									
4 1/8	104.78	63.70	61.47	58.73	55.50	51.77	47.55									
4 1/4	107.95	67.87	65.63	62.90	59.66	55.94	51.71									
4 1/2	114.30	76.57	74.33	71.60	68.37	64.64	60.41									
4 3/4	120.65	85.77	83.53	80.80	77.56	73.84	69.61	64.89								
5	127.00	95.46		90.49	87.26	83.53	79.30	74.58	69.36							
5 1/4	133.35	105.66		100.68	97.45	93.72	89.50	84.77	79.55	78.17	76.76	73.84				
5 1/2	139.70	116.35		111.37	108.14	104.41	100.19	95.46	90.24	88.86	87.45	84.53				
5 3/4	146.05	127.53		122.56	119.33	115.60	111.37	106.65	101.43	100.05	98.63	95.71	89.50			
6	152.40	139.22		134.25	131.01	127.28	123.06	118.34	113.11	111.73	110.32	107.40	101.18	94.47	87.26	
6 1/4	158.75	151.40		146.43	143.20	139.47	135.24	130.52	125.30	123.91	122.50	119.58	113.36	106.65	99.44	
6 3/8	161.93	157.68		152.70	149.47	145.74	141.52	136.79	131.57	130.19	128.78	125.86	119.64	112.93	105.72	
6 1/2	165.10	164.08		159.11	155.87	152.15	147.92	143.20	137.97	136.59	135.18	132.26	126.04	119.33	112.12	
6 5/8	168.28	170.60		165.63	162.40	158.67	154.44	149.72	144.50	143.12	141.70	138.78	132.57	125.86	118.65	
6 3/4	171.45	177.25		172.28	169.05	165.32	161.09	156.37	151.15	149.77	148.35	145.43	139.22	132.51	125.30	117.59
7	177.80	190.93		185.96	182.72	178.99	174.77	170.04	164.82	163.44	162.03	159.11	152.89	146.18	138.97	131.26
7 1/4	184.15	205.10		200.13	196.89	193.16	188.94	184.22	178.99	177.61	176.20	173.28	167.06	160.35	153.14	145.43
7 1/2	190.50	219.77		214.79	211.56	207.83	203.61	198.88	193.66	192.28	190.87	187.94	181.73	175.02	167.81	160.10
7 3/4	196.85	234.93		229.96	226.73	223.00	218.77	214.05	208.83	207.44	206.03	203.11	196.89	190.18	182.97	175.27
8	203.20	250.59		245.62	242.39	238.66	234.43	229.71	224.49	223.11	221.69	218.77	212.56	205.84	198.63	190.93
8 1/4	209.55	266.75		261.78	258.55	254.82	250.59	245.87	240.65	239.27	237.85	234.93	228.72	222.00	214.79	207.09
8 1/2	215.90	283.41		278.44	275.20	271.47	267.25	262.53	257.30	255.92	254.51	251.59	245.37	238.66	231.45	223.74
8 3/4	222.25	300.56		295.59	292.36	288.63	284.40	279.68	274.46	273.08	271.66	268.74	262.53	255.81	248.60	240.90
9 1/4	234.95	336.36			328.16	324.43	320.20	315.48	310.26	308.87	307.46	304.54	298.32	291.61	284.40	276.70
9 1/2	241.30	355.01			346.80	343.07	338.85	334.12	328.90	327.52	326.11	323.18	316.97	310.26	303.05	295.34
9 3/4	247.65	374.15			365.94	362.22	357.99	353.27	348.04	346.66	345.25	342.33	336.11	329.40	322.19	314.48
10	254.00	393.79				381.85	377.63	372.91	367.68	366.30	364.89	361.97	355.75	349.04	341.83	334.12
10 1/2	266.70	434.56				422.63	418.40	413.68	408.46	407.07	405.66	402.74	396.52	389.81	382.60	374.89
10 3/4	273.05	455.69				443.76	439.53	434.81	429.59	428.20	426.79	423.87	417.65	410.94	403.73	396.03
11	279.40	477.32						456.44	451.22	449.83	448.42	445.50	439.28	432.57	425.36	417.65
11 1/4	285.75	499.44						478.56	473.34	471.96	470.54	467.62	461.41	454.70	447.49	439.78
12	304.80	568.80						547.92	542.70	541.32	539.90	536.98	530.77	524.06	516.85	509.14
14	355.60	775.64							749.54	748.16	746.74	743.82	737.61	730.89	723.68	715.98

POLAR MODULUS OF DRILL COLLARS (in^3-mm^3)

Polar modulus $= \frac{\pi}{16}\left(\frac{OD^4 - id^4}{OD}\right)$

OD (in)	OD (mm)	id 1 1/4 in (31.75 mm) (in^3)	id 1 1/4 in (31.75 mm) (mm^3)	id 1 1/2 in (38.10 mm) (in^3)	id 1 1/2 in (38.10 mm) (mm^3)	id 2 in (50.80 mm) (in^3)	id 2 in (50.80 mm) (mm^3)	id 2 1/4 in (57.15 mm) (in^3)	id 2 1/4 in (57.15 mm) (mm^3)	id 2 13/16 in (71.44 mm) (in^3)	id 2 13/16 in (71.44 mm) (mm^3)	id 3 in (76.20 mm) (in^3)	id 3 in (76.20 mm) (mm^3)
3 1/8	79.38	5.84	95 679	5.67	92 981	4.99	81 719	4.38	71 805	2.06	33 769	0.90	14 793
3 1/4	82.55	6.59	108 037	6.43	105 442	5.77	94 613	5.19	85 081	2.96	48 507	1.85	30 262
3 1/2	88.90	8.28	135 710	8.13	133 300	7.52	123 245	6.98	114 393	4.91	80 432	3.87	63 490
3 3/4	95.25	10.23	167 583	10.09	165 334	9.52	155 949	9.01	147 687	7.08	115 991	6.11	100 178
4	101.60			12.32	201 854	11.78	193 056	11.31	185 310	9.49	155 594	8.59	140 770
4 1/8	104.78			13.54	221 892	13.02	213 361	12.56	205 850	10.80	177 035	9.93	162 659
4 1/4	107.95			14.84	243 168	14.33	234 887	13.89	227 597	12.18	199 630	11.33	185 677
4 1/2	114.30					17.19	281 763	16.77	274 878	15.16	248 464	14.36	235 286
4 3/4	120.65					20.38	333 997	19.98	327 475	18.46	302 451	17.69	289 967
5	127.00					23.92	391 903	23.54	385 706	22.09	361 934	21.36	350 074
5 1/4	133.35					27.81	455 790	27.45	449 888	26.07	427 248	25.38	415 953
5 1/2	139.70					32.10	525 967	31.75	520 334	30.43	498 722	29.78	487 941
5 3/4	146.05					36.78	602 741	36.45	597 353	35.19	576 681	34.56	566 368
6	152.40							41.57	681 256	40.36	661 446	39.76	651 562
6 1/4	158.75							47.13	772 351	45.97	753 333	45.39	743 845
6 3/8	161.93							50.08	820 691	48.94	802 046	48.38	792 744
6 1/2	165.10							53.15	870 945	52.03	852 658	51.48	843 535
6 5/8	168.28							56.33	923 149	55.24	905 208	54.69	896 257
6 3/4	171.45							59.64	977 344	58.57	959 734	58.03	950 949
7	177.80							66.63	1 091 854	65.59	1 074 873	65.08	1 066 402
7 1/4	184.15							74.13	1 214 780	73.13	1 198 385	72.63	1 190 206
7 1/2	190.50							82.16	1 346 427	81.20	1 330 578	80.71	1 322 672
7 3/4	196.85							90.75	1 487 099	89.81	1 471 761	89.35	1 464 110
8	203.20									99.00	1 622 242	98.54	1 614 829
8 1/4	209.55									108.76	1 782 325	108.33	1 775 138
8 1/2	215.90									119.14	1 952 319	118.71	1 945 342
8 3/4	222.25									130.13	2 132 527	129.72	2 125 750
9 1/4	234.95									154.07	2 524 809	153.68	2 518 398
9 1/2	241.30									167.05	2 737 491	166.67	2 731 249
9 3/4	247.65									180.73	2 961 607	180.36	2 955 525
10	254.00											194.76	3 191 530
10 1/2	266.70											225.78	3 699 944
10 3/4	273.05											242.44	3 972 961
11	279.40											259.90	4 258 922
11 1/4	285.75											278.15	4 558 132

DRILL COLLAR ASSEMBLY RIGIDITY *R*



$$R = \frac{E_1 \times \text{Lower DC polar modulus}}{E_2 \times \text{Upper DC polar modulus}} = \frac{\text{id}}{\text{OD}} \times \frac{\text{OD}^4 - \text{ID}^4}{\text{od}^4 - \text{id}^4}$$

E = Young's modulus of material

$$\frac{I_0}{V} = \text{Polar modulus} = \frac{\pi}{16} \frac{\text{OD}^4 - \text{ID}^4}{\text{OD}}$$

Drilco recommendation: $R \leq 5.5$

Flexion stress at yield Y (psi): t

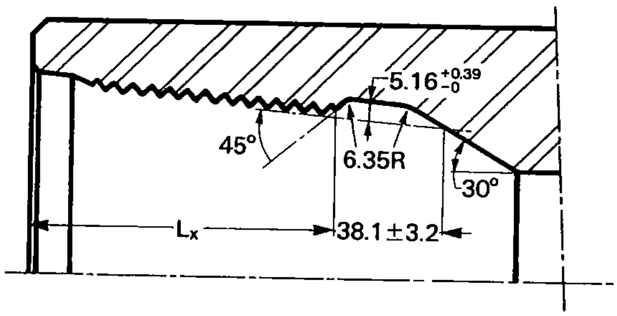
$$t = \frac{Y}{2} \frac{I_0}{V} = Y \frac{\text{OD}^4 - \text{id}^4}{122.23 \times \text{OD}}$$

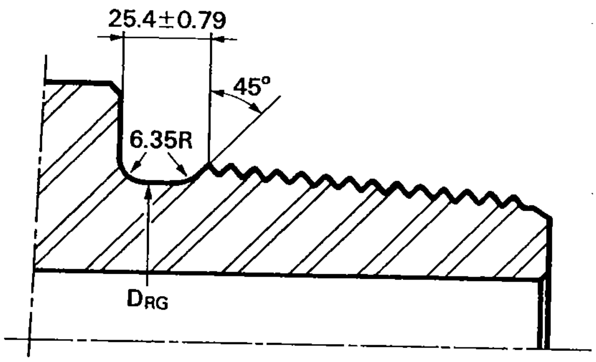
Lower DC (in)	Upper DC	*R*
11 × 3	9 1/2 × 3 8 1/2 × 2 13/16 7 1/4 × 2 13/16 6 1/2 × 2 13/16	1.6 2.2 3.5 5.0
9 1/2 × 3	8 1/2 × 2 13/16 7 1/4 × 2 13/16 6 1/2 × 2 13/16	1.4 2.3 3.2
8 1/4 × 2 13/16	7 1/4 × 2 13/16 6 1/2 × 2 13/16 HW 5 × 3	1.5 2.1 5.1
8 × 2 13/16	7 1/4 × 2 13/16 6 1/2 × 2 13/16 HW 5 × 3	1.4 1.9 4.6
7 1/4 × 2 13/16	6 1/2 × 2 13/16 HW 5 × 3	1.4 3.4
6 1/2 × 2 13/16	HW 5 × 3 DPS × 4.276	2.4 4.6
HW 5 × 3	DPS × 4.276	1.9
4 3/4 × 2 1/4	3 1/2 × 2.764	3.9

STRESS-RELIEF FEATURES 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)
NC35	85.7	3 3/8	82.2	3 15/64
NC38 (3 1/2 IF)	92.1	3 5/8	89.3	3 33/64
NC40 (4 FH)	104.8	4 1/8	96.0	3 25/32
NC44	104.8	4 1/8	106.4	4 3/16
NC46 (4 IF)	104.8	4 1/8	109.9	4 21/64
NC50 (4 1/2 IF)	104.8	4 1/8	120.7	4 3/4
NC56	117.5	4 5/8	134.5	5 19/64
NC61	130.2	5 1/8	148.8	5 55/64
NC70	142.9	5 5/8	171.1	6 47/64
NC77	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	111.1	4 3/8	123.4	4 55/64
6 5/8 REG	117.5	4 5/8	137.7	5 27/64
7 5/8 REG	123.8	4 7/8	162.7	6 13/32
8 5/8 REG	123.8	4 7/8	184.9	7 18/64

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





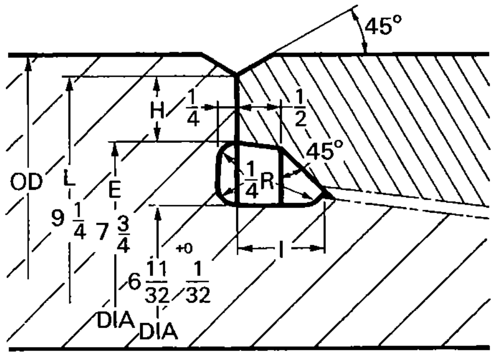
Remarks:

Dimensions in mm.

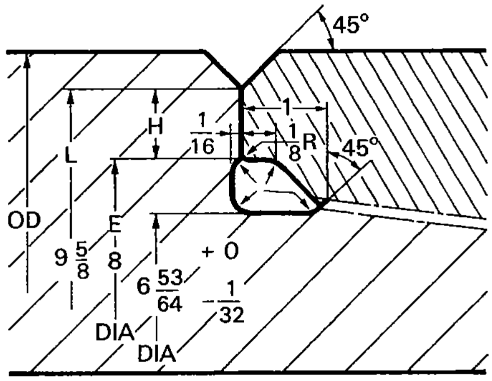
Connections NC23, NC26 and NC31 (2 3/8 IF and 2 7/8 IF) do not have a sufficient metal to accomodate stress-relief features.

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

7 5/8 REG Section



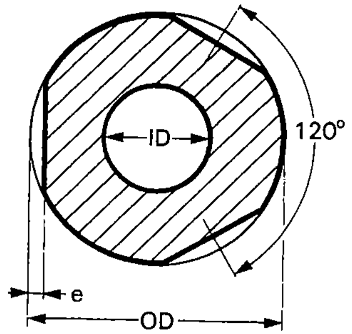
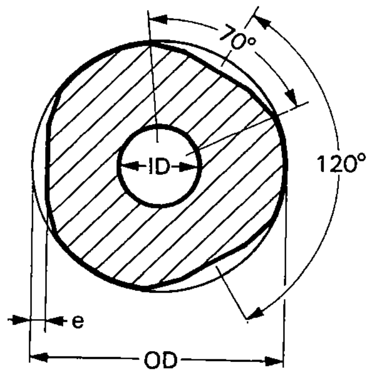
7 5/8 H90 Section



DIMENSIONS OF LOW-TORQUE SHOULDERED

Connection size and style	Outside diameter OD	Bevel diameter L		Inside diameter of shouldered E		Width of flat H N: normal R: modified		
	(in)	(in)	(mm)	(in)	(mm)	(in)	(mm)	
7 H 90	8 1/4	8	203.2	6 9/16	166.7	23/32	18.26	N
	8 1/2	8 1/4	209.6	6 9/16	166.7	27/32	21.43	N
	8 3/4	8 1/2	215.9	7 1/8	181.0	11/16	17.46	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	235.0	7 29/64	189.3	57/64	22.62	N
	9 3/4	9 1/4	235.0	8	203.2	5/8	15.88	R
	10	9 5/8	244.5	8	203.2	13/16	20.64	R
	10 1/4	9 5/8	244.5	8	203.2	13/16	20.64	R
7 5/8 REG	9 1/2	8 7/8	225.4	7 3/32	180.2	57/64	22.62	N
	9 3/4	9 1/4	235.0	7 3/4	196.9	3/4	19.05	R
	10	9 1/4	235.0	7 3/4	196.9	3/4	19.05	R
8 5/8 H 90	10 1/2	10 3/8	263.5	8 11/32	211.9	11/64	25.80	N
	10 3/4	10 1/2	266.7	9 3/8	238.1	9/16	14.29	R
	11	10 1/2	266.7	9 3/8	238.1	9/16	14.29	R
	11 1/4	10 3/4	273.1	9 3/8	238.1	11/16	17.46	R
8 5/8 REG	10 1/2	9 3/4	247.7	8 1/16	204.8	27/32	21.43	N
	10 3/4	11 1/2	292.1	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)

Cross section	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	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	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

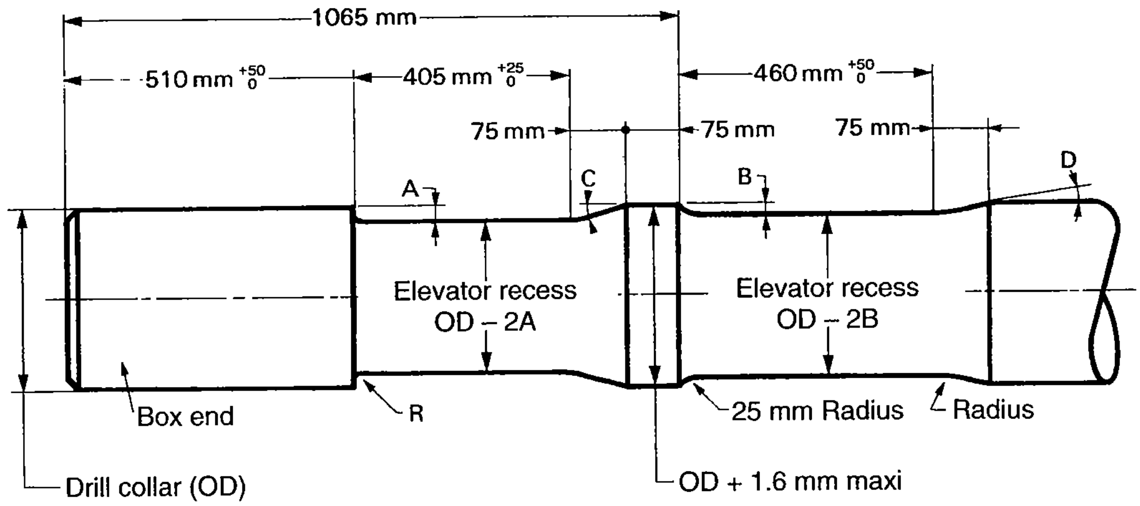
DRILL COLLAR SLIP AND ELEVATOR RECESS ELEVATOR BORE DIMENSIONS (API RP 7G, 15th edition, January 1, 1995)

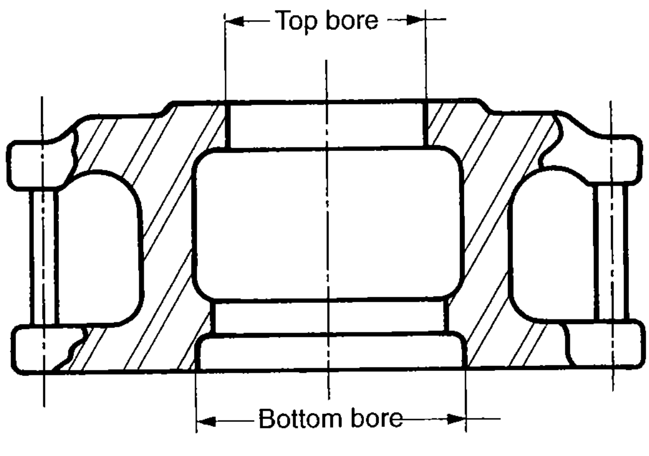
Drill collar OD range (in)	Dimensions					Elevator bore	
	Elevator			Slip			
	A (1) (mm)	R (mm)	C (2) (°)	B (1) (mm)	D (2) (°)	Top bore (3) + 0 − 1 (mm)	Bottom bore (3) + 2 − 0 (mm)
4 to 4 5/8	5.6	3.2	4	4.8	3.5	OD − 7.9	OD + 3.2
4 3/4 to 5 5/8	6.4	3.2	5	4.8	3.5	OD − 9.5	OD + 3.2
5 3/4 to 6 5/8	7.9	3.2	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 ROTARY SHOULDERED DRILL COLLAR CONNECTIONS (API RP 7G, 15th edition, January 1, 1995)

Connection				Minimum make-up torque – Bore of drill collars													
Size	Type	OD		1		1 1/4		1 1/2		1 3/4		2		2 1/4		2 1/2	
(in)		(in)	(mm)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)
API	NC23	3	76.2	*2 508	340	*2 508	340	*2 508	340								
		3 1/8	79.4	*3 330	451	*3 330	451	2 647	359								
		3 1/4	82.6	4 000	542	3 387	459	2 647	359								
2 3/8	Regular	3	76.2			*2 241	304	*2 241	304	1 749	237						
		3 1/8	79.4			*3 028	410	2 574	349	1 749	237						
		3 1/4	82.6			3 285	445	2 574	349	1 749	237						
2 7/8	PAC[3]	3	76.2			*3 797	514	*3 797	514	2 926	396						
		3 1/8	79.4			*4 966	673	4 151	562	2 926	396						
		3 1/4	82.6			5 206	705	4 151	562	2 926	396						
2 3/8	API IF	3 1/2	88.9			*4 606	624	*4 606	624	3 697	501						
API	NC26	3 3/4	95.3			5 501	745	4 668	633	3 697	501						
2 7/8	Regular	3 1/2	88.9			*3 838	520	*3 838	520	*3 838	520						
		3 3/4	95.3			5 766	781	4 951	671	4 002	542						
		3 7/8	98.4			5 766	781	4 951	671	4 002	542						
2 7/8	Extra Hole	3 3/4	95.3			*4 089	554	*4 089	554	*4 089	554						
3 1/2	Dbl. Streamline	3 7/8	98.4			*5 352	725	*5 352	725	*5 352	725						
2 7/8	Mod. Open	4 1/8	104.8			*8 059	1 092	*8 059	1 092	7 433	1 007						
2 7/8	API IF	3 7/8	98.4			*4 640	629	*4 640	629	*4 640	629	*4 640	629				
API	NC31	4 1/8	104.8			*7 390	1 001	*7 390	1 001	*7 390	1 001	6 853	929				
3 1/2	Regular	4 1/8	104.8			*6 466	876	*6 466	876	*6 466	876	*6 466	876	5 685	770		
		4 1/4	108.0			*7 886	1 069	*7 886	1 069	*7 886	1 069	7 115	964	5 685	770		
		4 1/2	114.3			10 471	1 419	9 514	1 289	8 394	1 137	7 115	964	5 685	770		
3 1/2	Slim Hole	4 1/4	108.0			*8 858	1 200	*8 858	1 200	8 161	1 106	6 853	929	5 391	730		
		4 1/2	114.3			10 286	1 394	9 307	1 261	8 161	1 106	6 853	929	5 391	730		
API	NC35	4 1/2	114.3							*9 038	1 225	*9 038	1 225	*9 038	1 225	7 411	1 004
		4 3/4	120.7							12 273	1 663	10 826	1 467	9 202	1 247	7 411	1 004
		5	127.0							12 273	1 663	10 826	1 467	9 202	1 247	7 411	1 004
3 1/2	Extra Hole	4 1/4	108.0							*5 161	699	*5 161	699	*5 161	699	*5 161	699
4	Slim Hole	4 1/2	114.3							*8 479	1 149	*8 479	1 149	*8 479	1 149	8 311	1 126
3 1/2	Mod. Open	4 3/4	120.7							*12 074	1 636	11 803	1 599	10 144	1 375	8 311	1 126
		5	127.0							13 283	1 800	11 803	1 599	10 144	1 375	8 311	1 126
		5 1/4	133.4							13 283	1 800	11 803	1 599	10 144	1 375	8 311	1 126

See notes at the end of B 46.

RECOMMENDED MAKE-UP TORQUE[1] FOR ROTARY SHOULDERED DRILL COLLAR CONNECTIONS (continued) (API RP 7G, 15th edition, January 1, 1995)

Connection				Minimum make-up torque											
				Bore of drill collars											
Size	Type	OD		1 3/4		2		2 1/4		2 1/2		2 13/16		3	
(in)		(in)	(mm)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)
3 1/2	API IF	4 3/4	120.7	*9 986	1 353	*9 986	1 353	*9 986	1 353	*9 986	1 353	8 315	1 127		
API	NC38	5	127.0	*13 949	1 890	*13 949	1 890	12 907	1 749	10 977	1 487	8 315	1 127		
4 1/2	Slim Hole	5 1/4	133.4	16 207	2 196	14 643	1 984	12 907	1 749	10 977	1 487	8 315	1 127		
		5 1/2	139.7	16 207	2 196	14 643	1 984	12 907	1 749	10 977	1 487	8 315	1 127		
3 1/2	H-90[4]	4 3/4	120.7	*8 786	1 191	*8 786	1 191	*8 786	1 191	*8 786	1 191	*8 786	1 191		
		5	127.0	*12 794	1 734	*12 794	1 734	*12 794	1 734	*12 794	1 734	10 408	1 410		
		5 1/4	133.4	*17 094	2 316	16 929	2 294	15 137	2 051	13 151	1 782	10 408	1 410		
		5 1/2	139.7	18 522	2 510	16 929	2 294	15 137	2 051	13 151	1 782	10 408	1 410		
4	Full Hole	5	127.0	*10 910	1 478	*10 910	1 478	*10 910	1 478	*10 910	1 478	*10 910	1 478		
API	NC40	5 1/4	133.4	*15 290	2 072	*15 290	2 072	*15 290	2 072	14 969	2 028	12 125	1 643		
4	Mod. Open	5 1/2	139.7	*19 985	2 708	18 886	2 559	17 028	2 307	14 969	2 028	12 125	1 643		
4 1/2	Dbl.Streamline	5 3/4	146.1	20 539	2 783	18 886	2 559	17 028	2 307	14 969	2 028	12 125	1 643		
		6	152.4	20 539	2 783	18 886	2 559	17 028	2 307	14 969	2 028	12 125	1 643		
	H-90[4]	5 1/4	133.4	*12 590	1 706	*12 590	1 706	*12 590	1 706	*12 590	1 706	*12 590	1 706		
		5 1/2	139.7	*17 401	2 358	*17 401	2 358	*17 401	2 358	*17 401	2 358	16 536	2 241		
		5 3/4	146.1	*22 531	3 053	*22 531	3 053	21 714	2 942	19 543	2 648	16 536	2 241		
		6	152.4	25 408	3 443	23 671	3 207	21 714	2 942	19 543	2 648	16 536	2 241		
		6 1/4	158.8	25 408	3 443	23 671	3 207	21 714	2 942	19 543	2 648	16 536	2 241		
4 1/2	API Regular	5 1/2	139.7	*15 576	2 111	*15 576	2 111	*15 576	2 111	*15 576	2 111	*15 576	2 111		
		5 3/4	146.1	*20 609	2 793	*20 609	2 793	*20 609	2 793	19 601	2 656	16 629	2 253		
		6	152.4	25 407	3 443	23 686	3 209	21 749	2 947	19 601	2 656	16 629	2 253		
		6 1/4	158.8	25 407	3 443	23 686	3 209	21 749	2 947	19 601	2 656	16 629	2 253		
API	NC44	5 3/4	146.1	*20 895	2 831	*20 895	2 831	*20 895	2 831	*20 895	2 831	18 161	2 461		
		6	152.4	*26 453	3 584	25 510	3 457	23 493	3 183	21 257	2 880	18 161	2 461		
		6 1/4	158.8	27 300	3 699	25 510	3 457	23 493	3 183	21 257	2 880	18 161	2 461		
		6 1/2	165.1	27 300	3 699	25 510	3 457	23 493	3 183	21 257	2 880	18 161	2 461		
4 1/2	API Full Hole	5 1/2	139.7			*12 973	1 758	*12 973	1 758	*12 973	1 758	*12 973	1 758	*12 973	1 758
		5 3/4	146.1			*18 119	2 455	*18 119	2 455	*18 119	2 455	*18 119	2 455	17 900	2 425
		6	152.4			*23 605	3 199	*23 605	3 199	23 028	3 120	19 921	2 699	17 900	2 425
		6 1/4	158.8			27 294	3 698	25 272	3 424	22 028	2 985	19 921	2 699	17 900	2 425
		6 1/2	165.1			27 294	3 698	25 272	3 424	22 028	2 985	19 921	2 699	17 900	2 425
4 1/2	Extra Hole	5 3/4	146.1					*17 738	2 404	*17 738	2 404	*17 738	2 404	*17 738	2 404
API	NC46	6	152.4					*23 422	3 174	*23 422	3 174	22 426	3 039	20 311	2 752
4	API IF	6 1/4	158.8					28 021	3 797	25 676	3 479	22 426	3 039	20 311	2 752
4 1/2	Semi IF	6 1/2	165.1					28 021	3 797	25 676	3 479	22 426	3 039	20 311	2 752
5	Dbl. Streamline	6 3/4	171.5					28 021	3 797	25 676	3 479	22 426	3 039	20 311	2 752

See notes at the end of B 46.

RECOMMENDED MAKE-UP TORQUE[1] FOR ROTARY SHOULDERED DRILL COLLAR CONNECTIONS (continued) (API RP 7G, 15th edition, January 1, 1995)

Connection				Minimum make-up torque – Bore of drill collars													
Size	Type	OD		2 1/4		2 1/2		2 13/16		3		3 1/4		3 1/2		3 3/4	
(in)		(in)	(mm)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)
4 1/2	H-90[4]	5 3/4	146.1	*18 019	2 442	*18 019	2 442	*18 019	2 442	*18 019	2 442						
		6	152.4	*23 681	3 209	*23 681	3 209	23 159	3 138	21 051	2 852						
		6 1/4	158.8	28 732	3 893	26 397	3 577	23 159	3 138	21 051	2 852						
		6 1/2	165.1	28 732	3 893	26 397	3 577	23 159	3 138	21 051	2 852						
		6 3/4	171.5	28 732	3 893	26 397	3 577	23 159	3 138	21 051	2 852						
5	H-90[4]	6 1/4	158.8	*25 360	3 436	*25 360	3 436	*25 360	3 436	*25 360	3 436	23 988	3 250				
		6 1/2	165.1	*31 895	4 322	*31 895	4 322	29 400	3 984	27 167	3 681	23 988	3 250				
		6 3/4	171.5	35 292	4 782	32 825	4 448	29 400	3 984	27 167	3 681	23 988	3 250				
		7	177.8	35 292	4 782	32 825	4 448	29 400	3 984	27 167	3 681	23 988	3 250				
4 1/2	API IF	6 1/4	158.8	*23 004	3 117	*23 004	3 117	*23 004	3 117	*23 004	3 117	*23 004	3 117				
API	NC50	6 1/2	165.1	*29 679	4 022	*29 679	4 022	*29 679	4 022	*29 679	4 022	26 675	3 614				
5	Extra Hole	6 3/4	171.5	*36 742	4 979	35 824	4 854	32 277	4 374	29 966	4 060	26 675	3 614				
5	Mod. Open	7	177.8	38 379	5 200	35 824	4 854	32 277	4 374	29 966	4 060	26 675	3 614				
5 1/2	Dbl. Streamline	7 1/4	184.2	38 379	5 200	35 824	4 854	32 277	4 374	29 966	4 060	26 675	3 614				
5	Semi-IF	7 1/2	190.5	38 379	5 200	35 824	4 854	32 277	4 374	29 973	4 061	26 675	3 614				
5 1/2	H-90[4]	6 3/4	171.5	*34 508	4 676	*34 508	4 676	*34 508	4 676	34 142	4 626	30 781	4 171				
		7	177.8	*41 993	5 690	40 117	5 436	36 501	4 946	34 142	4 626	30 781	4 171				
		7 1/4	184.2	42 719	5 788	40 117	5 436	36 501	4 946	34 142	4 626	30 781	4 171				
		7 1/2	190.5	42 719	5 788	40 117	5 436	36 501	4 946	34 142	4 626	30 781	4 171				
5 1/2	API Regular	6 3/4	171.5	*31 941	4 328	*31 941	4 328	*31 941	4 328	*31 941	4 328	30 495	4 132				
		7	177.8	*39 419	5 341	*39 419	5 341	36 235	4 910	33 868	4 589	30 495	4 132				
		7 1/4	184.2	42 481	5 756	39 866	5 402	36 235	4 910	33 868	4 589	30 495	4 132				
		7 1/2	190.5	42 481	5 756	39 866	5 402	36 235	4 910	33 868	4 589	30 495	4 132				
5 1/2	API Full Hole	7	177.8	*32 762	4 439	*32 762	4 439	*32 762	4 439	*32 762	4 439	*32 762	4 439				
		7 1/4	184.2	*40 998	5 555	*40 998	5 555	*40 998	5 555	*40 998	5 555	*40 998	5 555				
		7 1/2	190.5	*49 661	6 729	*49 661	6 729	47 756	6 471	45 190	6 123	41 533	5 628				
		7 3/4	196.9	54 515	7 387	51 687	7 004	47 756	6 471	45 190	6 123	41 533	5 628				
API	NC56	7 1/4	184.2			*40 498	5 488	*40 498	5 488	*40 498	5 488	*40 498	5 488				
		7 1/2	190.5			*49 060	6 648	48 221	6 534	45 680	6 190	42 058	5 699				
		7 3/4	196.9			52 115	7 062	48 221	6 534	45 680	6 190	42 058	5 699				
		8	203.2			52 115	7 062	48 221	6 534	45 680	6 190	42 058	5 699				

See notes at the end of B 46.

RECOMMENDED MAKE-UP TORQUE[1] FOR ROTARY SHOULDERED DRILL COLLAR CONNECTIONS (continued)
(API RP 7G, 15th edition, January 1, 1995)

Connection				Minimum make-up torque – Bore of drill collars													
Size	Type	OD		2 1/4		2 1/2		2 13/16		3		3 1/4		3 1/2		3 3/4	
(in)		(in)	(mm)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)
6 5/8	API Regular	7 1/2	190.5			*46 399	6 287	*46 399	6 287	*46 399	6 287	*46 399	6 287				
		7 3/4	196.9			*55 627	7 538	53 346	7 228	50 704	6 870	46 936	6 360				
		8	203.2			57 393	7 777	53 346	7 228	50 704	6 870	46 936	6 360				
		8 1/4	209.6			57 393	7 777	53 346	7 228	50 704	6 870	46 936	6 360				
6 5/8	H-90[4]	7 1/2	190.5			*46 509	6 302	*46 509	6 302	*46 509	6 302	*46 509	6 302				
		7 3/4	196.9			*55 708	7 549	*55 708	7 549	53 629	7 267	49 855	6 755				
		8	203.2			60 321	8 174	56 273	7 625	53 629	7 267	49 855	6 755				
		8 1/4	209.6			60 321	8 174	56 273	7 625	53 629	7 267	49 855	6 755				
API	NC61	8	203.2			*55 131	7 470	*55 131	7 470	*55 131	7 470	*55 131	7 470				
		8 1/4	209.6			*65 438	8 867	*65 438	8 867	*65 438	8 867	61 624	8 350				
		8 1/2	215.9			72 670	9 847	68 398	9 268	65 607	8 890	61 624	8 350				
		8 3/4	222.3			72 670	9 847	68 398	9 268	64 607	8 754	61 624	8 350				
		9	228.6			72 670	9 847	68 398	9 268	65 607	8 890	61 624	8 350				
5 1/2	API IF	8	203.2			*56 641	7 675	*56 641	7 675	*56 641	7 675	*56 641	7 675	*56 641	7 675		
		8 1/4	209.6			*67 133	9 097	*67 133	9 097	*67 133	9 097	63 381	8 588	59 027	7 998		
		8 1/2	215.9			74 626	10 112	70 277	9 523	67 436	9 138	63 381	8 588	59 027	7 998		
		8 3/4	222.3			74 626	10 112	70 277	9 523	67 436	9 138	63 381	8 588	59 027	7 998		
		9	228.6			74 626	10 112	70 277	9 523	67 436	9 138	63 381	8 588	59 027	7 998		
		9 1/4	235.0			74 626	10 112	70 277	9 523	67 436	9 138	63 381	8 588	59 027	7 998		
6 5/8	API Full Hole	8 1/2	215.9			*67 789	9 186	*67 789	9 186	*67 789	9 186	*67 789	9 186	*67 789	9 186	67 184	9 104
		8 3/4	222.3			*79 544	10 778	*79 544	10 778	*79 544	10 778	76 706	10 394	72 102	9 770	67 184	9 104
		9	228.6			88 582	12 003	83 992	11 381	80 991	10 974	76 706	10 394	72 102	9 770	67 184	9 104
		9 1/4	235.0			88 582	12 003	83 992	11 381	80 991	10 974	76 706	10 394	72 102	9 770	67 184	9 104
		9 1/2	241.3			88 582	12 003	83 992	11 381	80 991	10 974	76 706	10 394	72 102	9 770	67 184	9 104
API	NC70	9	228.6			*75 781	10 268	*75 781	10 268	*75 781	10 268	*75 781	10 268	*75 781	10 268	*75 781	10 268
		9 1/4	235.0			*88 802	12 033	*88 802	12 033	*88 802	12 033	*88 802	12 033	*88 802	12 033	*88 802	12 033
		9 1/2	241.3			*102 354	13 869	*102 354	13 869	*102 354	13 869	101 107	13 700	96 214	13 037	90 984	12 328
		9 3/4	247.7			113 710	15 408	108 841	14 748	105 657	14 317	101 107	13 700	96 214	13 037	90 984	12 328
		10	254.0			113 710	15 408	108 841	14 748	105 657	14 317	101 107	13 700	96 214	13 037	90 984	12 328
		10 1/4	260.4			113 710	15 408	108 841	14 748	105 657	14 317	101 107	13 700	96 214	13 037	90 984	12 328

See notes at the end of B 46.

RECOMMENDED MAKE-UP TORQUE[1] FOR ROTARY SHOULDERED DRILL COLLAR CONNECTIONS (continued) (API RP 7G, 15th edition, January 1, 1995)

Connection				Minimum make-up torque													
				Bore of drill collars													
Size	Type	OD		2 1/4		2 1/2		2 13/16		3		3 1/4		3 1/2		3 3/4	
(in)		(in)	(mm)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)
API	NC77	10	254.0			*108 194	14 660	*108 194	14 660	*108 194	14 660	*108 194	14 660	*108 194	14 660	*108 194	14 660
		10 1/4	260.4			*124 051	16 809	*124 051	16 809	*124 051	16 809	*124 051	16 809	*124 051	16 809	*124 051	16 809
		10 1/2	266.7			*140 491	19 037	*140 491	19 037	*140 491	19 037	140 488	19 036	135 119	18 309	129 375	17 530
		10 3/4	273.1			154 297	20 907	148 965	20 185	145 476	19 712	140 488	19 036	135 119	18 309	129 375	17 530
		11	279.4			154 297	20 907	148 965	20 185	145 476	19 712	140 488	19 036	135 119	18 309	129 375	17 530
7	H-90[4]	8	203.2			*53 454	7 243	*53 454	7 243	*53 454	7 243	*53 454	7 243	*53 454	7 243	*53 454	7 243
		8 1/4	209.6			*63 738	8 637	*63 738	8 637	*63 738	8 637	*63 738	8 637	60 971	8 262	56 382	7 640
		8 1/2	215.9			*74 478	10 092	72 066	9 765	69 265	9 386	65 267	8 844	60 971	8 262	56 382	7 640
7 5/8	API Regular	8 1/2	215.9			*60 402	8 185	*60 402	8 185	*60 402	8 185	*60 402	8 185	*60 402	8 185	*60 402	8 185
		8 3/4	222.3			*72 169	9 779	*72 169	9 779	*72 169	9 779	*72 169	9 779	*72 169	9 779	*72 169	9 779
		9	228.6			*84 442	11 442	*84 442	11 442	*84 442	11 442	84 221	11 412	79 536	10 777	74 529	10 099
		9 1/4	235.0			96 301	13 049	91 633	12 416	88 580	12 003	84 221	11 412	79 536	10 777	74 529	10 099
		9 1/2	241.3			96 301	13 049	91 633	12 416	88 580	12 003	84 221	11 412	79 536	10 777	74 529	10 099
7 5/8	H-90[4]	9	228.6			*73 017	9 894	*73 017	9 894	*73 017	9 894	*73 017	9 894	*73 017	9 894	*73 017	9 894
		9 1/4	235.0			*86 006	11 654	*86 006	11 654	*86 006	11 654	*86 006	11 654	*86 006	11 654	*86 006	11 654
		9 1/2	241.3			*99 508	13 483	*99 508	13 483	*99 508	13 483	*99 508	13 483	*99 508	13 483	96 285	13 047
8 5/8	API Regular	10	254.0			*109 345	14 816	*109 345	14 816	*109 345	14 816	*109 345	14 816	*109 345	14 816	*109 345	14 816
		10 1/4	260.4			*125 263	16 973	*125 263	16 973	*125 263	16 973	*125 263	16 973	*125 263	16 973	125 034	16 942
		10 1/2	266.7			*141 767	19 210	*141 767	19 210	141 134	19 124	136 146	18 448	130 277	17 653	125 034	16 942
8 5/8	H-90[4]	10 1/4	260.4			*113 482	15 377	*113 482	15 377	*113 482	15 377	*113 482	15 377	*113 482	15 377	*113 482	15 377
		10 1/2	266.7			*130 063	17 624	*130 063	17 624	*130 063	17 624	*130 063	17 624	*130 063	17 624	*130 063	17 624
7	H-90[4] (with low torque face)	8 3/4	222.3					*68 061	9 222	*68 061	9 222	67 257	9 113	62 845	8 516	58 131	7 877
		9	228.6					74 235	10 059	71 361	9 670	67 257	9 113	62 845	8 516	58 131	7 877
7 5/8	API Regular (with low torque face)	9 1/4	235.0							*73 099	9 905	*73 099	9 905	*73 099	9 905	*73 099	9 905
		9 1/2	241.3							*86 463	11 716	*86 463	11 716	82 457	11 173	77 289	10 473
		9 3/4	247.7							91 789	12 438	87 292	11 828	82 457	11 173	77 289	10 473
		10	254.0							91 789	12 438	87 292	11 828	82 457	11 173	77 289	10 473

See notes at the end of B 46.

RECOMMENDED MAKE-UP TORQUE[1] FOR ROTARY SHOULDERED DRILL COLLAR CONNECTIONS (continued) (API RP 7G, 15th edition, January 1, 1995)

Connection				Minimum make-up torque													
				Bore of drill collars													
Size	Type	OD		2 1/4		2 1/2		2 13/16		3		3 1/4		3 1/2		3 3/4	
(in)		(in)	(mm)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)	(ft.lb)	(daN.m)
7 5/8	H-90[4] (with low torque face)	9 3/4	247.7					*91 667	12 421	*91 667	12 421	*91 667	12 421	*91 667	12 421	*91 667	12 421
		10	254.0					*106 260	14 398	*106 260	14 398	*106 260	14 398	104 171	14 115	98 804	13 388
		10 1/4	260.4					117 112	15 869	113 851	15 427	109 188	14 795	104 171	14 115	98 804	13 388
		10 1/2	266.7					117 112	15 869	113 851	15 427	109 188	14 795	104 171	14 115	98 804	13 388
8 5/8	API Regular (with low torque face)	10 3/4	273.1							*112 883	15 296	*112 883	15 296	*112 883	15 296	*112 883	15 296
		11	279.4							*130 672	17 706	*130 672	17 706	*130 672	17 706	*130 672	17 706
		11 1/4	285.8							147 616	20 002	14 243	1 930	136 846	18 543	130 871	17 733
8 5/8	H-90[4] (with low torque face)	10 3/4	273.1							*92 960	12 596	*92 960	12 596	*92 960	12 596	*92 960	12 596
		11	279.4							*110 781	15 011	*110 781	15 011	*110 781	15 011	*110 781	15 011
		11 1/4	285.8							*129 203	17 507	*129 203	17 507	*129 203	17 507	*129 203	17 507

Notes

(1) 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.

(2) 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, 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 4600 ft.lb, and the BOX is the weaker member.

(3) Stress relief features are disregarded for make-up torque.

1. Basis of calculations for recommended make-up torque assume the use of a thread compound containing 40-60% by weight of finely powdered metallic zinc or 60% by weight of finely powdered metallic lead, with not more than 0.3% total active sulfur (reference the caution regarding the use of hazardous materials in Appendix F of Specification 7) applied thoroughly to all threads and shoulders and using the modified Screw Jack formula in Appendix A, paragraph A.8, and a unit stress of 62 500 psi in the box or pin, whichever is weaker.
2. Normal torque range is tabulated value plus 10%. Higher torque values may be used under extreme conditions.
3. Make-up torque for 2 7/8 PAC connection is based on 87 500 psi stress and other factors listed in footnote 1.
4. Make-up torque for H-90 connection is based on 56 200 psi stress and other factors listed in footnote 1.

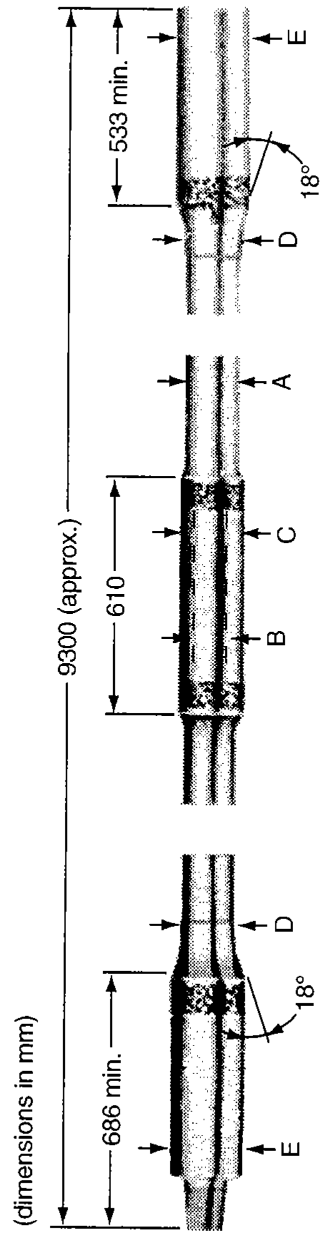
HEAVY WALL DRILL PIPES (Drilco, Division of Smith International, Inc)

Nominal size (A) (in)	Drill pipe body: Body nominal dimensions: Inside diameter (B) (in) (mm)	Wall thickness (mm)	Cross-sectional area (mm^2)	Central upset outside diameter (C) (in) (mm)	End upset outside diameter (D) (in) (mm)	Pipe mechanical properties: Tensile yield (10^3 daN)	Torsional yield (daN.m)	Tool joint: Connection	Outside diameter (E) (in) (mm)	Inside diameter (in) (mm)
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 1/2 165.12	3 1/8 79.4

Characteristics, Range II (continued)

Nominal size (A) (in)	Tool joint: Connection	Mechanical properties: Tensile yield (10^3 daN)	Torsional yield (daN.m)	Weight, Pipe + tool joint: Linear weight (kg/m)	Pipe weight (30 ft) (kg)	Make-up torque (daN.m)	Volumes: Exterior (l/m)	Interior (l/m)	Steel volume (l/m)
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 x 0.0394 = in mm^2 x 0.00155 = in^2 daN.m x 7.38 = lb.ft   daN x 2.25 = lb
kg/m x 0.672 = lb/ft   kg x 2.20 = lb   l/m x 0.0805 = gal/ft   l/m x 0.00192 = bbl/ft

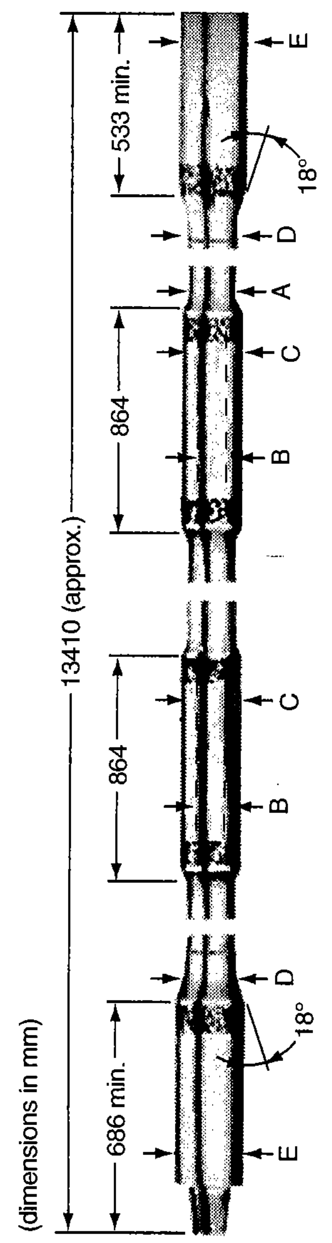


HEAVY WALL DRILL PIPES
(Drilco, Division of Smith International, Inc) (continued)

Characteristics, Range III										
Nominal size (A)	Drill pipe body							Tool joint		
	Body nominal dimensions			Central upset outside diameter (C)	End upset outside diameter (D)	Pipe mechanical properties		Connection	Outside diameter (E)	Inside diameter
(in)	Inside diameter (B) (in) (mm)	Wall thickness (mm)	Cross-sectional area (mm^2)	(in) (mm)	(in) (mm)	Tensile yield (10^3 daN)	Torsional yield (daN.m)		(in) (mm)	(in) (mm)
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)	Tool joint			Weight		Make-up torque	Volumes		
	Connection	Mechanical properties		Pipe + tool joint			Exterior	Interior	Steel volume
(in)		Tensile yield (10^3 daN)	Torsional yield (daN.m)	Linear weight (kg/m)	Pipe weight (44 ft) (kg)	(daN.m)	(l/m)	(l/m)	(l/m)
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**

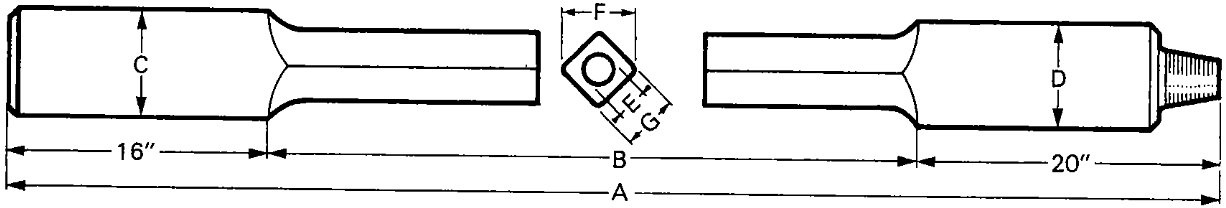
mm x 0.0394 = in mm^2 x 0.00155 = in^2 daN.m x 7.38 = lb.ft   daN x 2.25 = lb
kg/m x 0.672 = lb/ft   kg x 2.20 = lb   l/m x 0.0805 = gal/ft   l/m x 0.00192 = bbl/ft



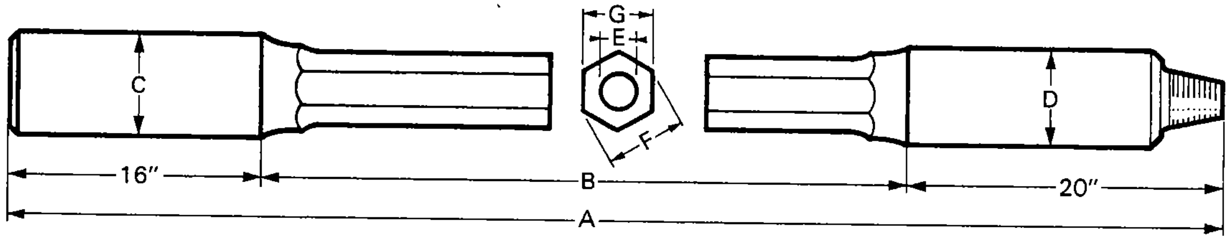
KELLYS
(API Spec 7, 38th edition, April 1, 1994)

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	–	NC50	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 IF	7	–	6	6 13/16	**1095**	–

Square kellys



Hexagonal kellys



m x 3.28 = ft   kg x 2.20 = lb

STRENGTH OF KELLYS (1)
(API RP 7G, 15th edition, January 1, 1995)

Kelly size and style	Inside diameter	Lower pin connection		Minimum recommended casing OD (2)	Tensile yield		Torsional yield		Yield in bending	Internal pressure at yield stress
		Size and style	Outside diameter		Lower pin connection (3)	Drive section	Lower pin connection	Drive section	Drive section	Drive section
(in)	(in)		(in)	(in)	(10^3 daN)	(10^3 daN)	(daN.m)	(daN.m)	(m.daN)	(MPa)
Square										
2 1/2	1 1/4	NC26 (2 3/8 IF)	3 3/8	4 1/2	185	198	1 310	1 680	1 680	205.5
3	1 3/4	NC31 (2 7/8 IF)	4 1/8	5 1/2	238	259	1 960	2 670	2 710	175.8
3 1/2	2 1/4	NC38 (3 1/2 IF)	4 3/4	6 5/8	322	323	3 080	3 930	4 010	153.1
4 1/4	2 13/16	NC46 (4 IF)	6 1/4	8 5/8	468	466	5 335	6 810	7 000	134.5
4 1/4	2 13/16	NC50 (4 1/2 IF)	6 3/8	8 5/8	632	466	7 760	6 810	7 000	134.5
5 1/4	3 1/4	5 1/2 FH	7	9 5/8	715	758	9 900	13 700	13 940	142.0
Hexagonal										
3	1 1/2	NC26 (2 3/8 IF)	3 3/8	4 1/2	158	240	1 125	2 780	2 520	184.1
3 1/2	1 7/8	NC31 (2 7/8 IF)	4 1/8	5 1/2	220	316	1 815	4 270	3 880	175.8
4 1/4	2 1/4	NC38 (3 1/2 IF)	4 3/4	6 5/8	322	466	3 080	7 700	6 980	172.4
5 1/4	3	NC46 (4 IF)	6 1/4	8 5/8	426	671	4 805	13 870	12 610	142.0
5 1/4	3 1/4	NC50 (4 1/2 IF)	6 3/8	8 5/8	512	621	6 335	13 030	11 880	142.0
6	3 1/2	5 1/2 FH	7	9 5/8	650	861	8 990	20 400	18 580	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 x 2.25 = lb   daN.m x 7.38 = lb.ft   MPa x 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

$$\boxed{A_t = 11.88\ 10^{-6}\ L dt}$$

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, 15th edition, January 1, 1995)

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 (10^3 daN)
T_e = yield strength of this pipe (10^3 daN)

$$R_T = T_a - T$$

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 (continued) (API RP 7G, 15th edition, January 1, 1995)

D. MAXIMUM DRILLING DEPTH

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

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

or:

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

$L_{\text{DP max}}$ = 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 $P_{\text{DC}}\ L_{\text{DC}}$ by the weight in air of the drill collars plus the weight of the weakest section.

E. COLLAPSE DUE TO ANNULAR HYDROSTATIC PRESSURE

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

where:

- P_{ct} = 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 (continued) (API RP 7G, 15th edition, January 1, 1995)

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 folows:

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

where:

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

DRILL STEM DESIGN CALCULATIONS (continued)
(API RP 7G, 15th edition, January 1, 1995)

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

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

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

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 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

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

DRILL STEM DESIGN CALCULATIONS
CALCULATION EXAMPLES (continued)

II Pipe size, weight and grade used

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

$P_{DP\,1} = 31.06$ kg/m
$T_{e1} = 120.3\ 10^3$ daN
$P_{ct} = 30\ 000$ kPa

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

$$L_{DP\,1} = \frac{10^3(0.9 \times 120.3 - 30)1.02}{0.852 \times 31.06} - \frac{(185 \times 149.8)}{31.06}$$

$$L_{DP\,1} = 2125 \text{ m}$$

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

$P_{DP\,2} = 31.83$ kg/m
$T_{e2} = 175.6\ 10^3$ daN

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

$$L_{DP\,2} = \frac{10^3(0.9 \times 175.6 - 30)1.02}{0.852 \times 31.83} - \frac{(2125 \times 31.06) + (185 \times 149.8)}{31.83}$$

$$L_{DP\,2} = 1872 \text{ m}$$

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

DRILL STEM DESIGN CALCULATIONS
CALCULATION EXAMPLES (continued)

Summary of string weights and dimensions:

	Length (m)	Weight on 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 $P_{DP\,1}$ = 31.06 kg/m	2125	66.0	56.2
No. 2 pipe 5 in – 19.50, Grade X Premium Class $P_{DP\,1}$ = 31.06 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:

$$P_{ct1} = 38 \text{ MPa}$$

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

$$P_h = 9.81 \times 1.16 \times (3800 - 185)$$

$$P_h = 41\ 140 \text{ kPa} \quad \text{or} \quad 41.14 \text{ MPa}$$

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:

$$L_{max} = \frac{38\ 000}{9.81 \times 1.16 \times 1.15} = 2\ 904 \text{ m}$$

DRILL STEM DESIGN CALCULATIONS CALCULATION EXAMPLES (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.

CRITICAL BUCKLING FORCE (Baker Hughes INTEQ)

Formula Critical Buckling force in drill pipe (Dawson and Paslay):

$$F_{cr} = 2\,(EIW \sin\theta / r)^{1/2} \quad \text{(lbs)}$$

E = Young's modulus (psi)
I = Axial moment of inertia (in^4)
W = Buoyed weight per unit length (lb/in)
θ = Bore-hole inclination
r = Radial clearance between the pipe and the bore-hole wall (in)

If the compressive force reaches F_{cr}, then **sinusoidal buckling** occurs

Metric formula:

$$F_{cr} = 2/99.03\,(EIW \sin\theta / r)^{1/2} \quad \text{(kgf)}$$

E (MPa) ; I (mm^4) ; W (kg/m) ; r (mm)

Application:

E = **29 10^6** psi (199 950 MPa)

4 1/2 DP – E – 16.66 lb/ft: approximate weight = 17.99 lb/ft (26.77 kg/m) B 10

8 1/2 Hole – Inclination = 50° – Mud weight = 14 ppg, buoyancy factor = **0.786**. A 37

$I = \pi/64\,(4.5^4 - 3.826^4)$ = **9.61** in^4 (8 000 523/2 = 4 000 263 mm^4) B 10

W = (17.99/12)*0.786=**1,178** lb/in (26.77*0.786 = 21.04 kg/m)

sin 50 = **0.766** r = 8.5 – 4.5 = **2** in (50.8 mm)

F_{cr} = 2 (29 × 106 × 9.61 × 1.178 × 0.766/2)$^{1/2}$= **22 420** lbs

Metric formula:

F_{cr} = 2/99.03(199 950 × 4 000 263 × 21.04 × 0.766/50.8)$^{1/2}$ = **10 170** kgf

C

casing, tubing line pipe standards

TENSILE REQUIREMENTS
Casing and tubing
(API Standard 5CT, 5th edition, April 1, 1995)

Properties \ Grade	H40	J55	K55	N80	L80 (1)	C90 (2)	C95	T95 (3)	P110	Q125 (4)
Grade color band codes (5)	1 black	1 green	2 green	1 red	1 red and 1 brown	1 purple	1 brown	1 silver	1 white	1 orange
Minimum yield strength (MPa)	276	379	379	551	551	620	655	655	758	862
(psi)	40 000	55 000	55 000	80 000	80 000	90 000	95 000	95 000	110 000	125 000
Maximum yield strength (MPa)	551	551	551	758	655	724	758	758	965	1034
(psi)	80 000	80 000	80 000	110 000	95 000	105 000	110 000	110 000	140 000	150 000
Minimum tensile strength (MPa)	413	517	655	689	655	689	724	724	862	931
(psi)	60 000	75 000	95 000	100 000	95 000	100 000	105 000	105 000	125 000	135 000

(1) L80 9Cr: 1 red, 1 brown and 2 yellow bands; L80 13Cr: 1 red, 1 brown and 1 yellow bands.
(2) C90 Type 1: 1 purple band; C90 Type 2: 1 purple and 1 yellow bands.
(3) T95 Type 1: 1 silver band; T95 Type 2: 1 silver and 1 yellow bands.
(4) Q125 Type 1: 1 orange band; Q125 Type 2: 1 orange and one yellow bands; Q125 Type 3: 1 orange and 1 green bands; Q125 Type 4: 1 orange and 1 brown bands.
(5) Special clearance couplings shall also be painted with a black band around the center.

Line pipe
(API Standard 5L, April 1, 1995)

Properties \ Grade	A25	A	B	X42	X46	X52	X56	X60 (1)	X65 (1)	X70 (1)	X80 (1)
Minimum yield strength (MPa)	172	207	241	289	317	358	386	413	448	482	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	413	413	434	455	489	517	530	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 & Mannesmann documentation)

Properties \ Grade	H_2S-resistant						Collapse resistant			
	VM 80SS	VM 90S SS*	VM 95S SS*	VM 100SS	VM 110SS	VM 125SS	VM 80HC	VM 95HC	VM 110HC	VM 125HC
Color band identification	Red + orange and orange bands	Purple + orange *and orange	Brown + orange *and orange	Black + orange and orange bands	White + orange and orange bands	Yellow + orange and orange bands	Red + green band	Brown + green band	White + green band	Orange + green band
Minimum yield strength (MPa)	551	620	655	690	758	862	551	655	758	862
(psi)	80 000	90 000	95 000	100 000	110 000	125 000	80 000	95 000	110 000	125 000
Maximum yield strength (MPa)	655	724	758	792	862	965	758	862	965	1069
(psi)	95 000	105 000	110 000	115 000	125 000	140 000	110 000	125 000	140 000	155 000
Minimum tensile strength (MPa)	655	689	724	758	828	931	689	758	862	931
(psi)	95 000	100 000	105 000	110 000	120 000	135 000	100 000	110 000	125 000	135 000

Properties \ Grade	Special deep wells				Special arctic (Permafrost)				
	VM80 HCSS	VM 90HCS HCSS*	VM 95HCS HCSS*	VM 110 HCSS	VM 55LT	VM 80LT	VM 95LT	VM 110LT	VM 125LT
Color band identification	Red + green orange and orange bands	Purple + green and orange bands	Brown + green and orange bands	White + green orange and orange bands	Green + blue band	Red + blue band	Brown + blue band	White + blue band	Orange + blue band
Minimum yield strength (MPa)	551	621	655	758	379	551	655	758	862
(psi)	80 000	90 000	95 000	110 000	55 000	80 000	95 000	110 000	125 000
Maximum yield strength (MPa)	655	724	758	862	551	655	758	965	1034
(psi)	95 000	105 000	110 000	125 000	80 000	95 000	110 000	140 000	150 000
Minimum tensile strength (MPa)	655	690	724	828	517	655	724	862	931
(psi)	95 000	100 000	105 000	120 000	75 000	95 000	105 000	125 000	135 000

* + orange.

API CASING LIST
(API Specification 5CT, 5^{th} edition, April 1, 1995)

Nominal outside diameter (in)	Nominal weight (lb/ft)	Wall thickness		Type of end finish*						
				Grade						
		(in)	(mm)	H40	J55 K55	L80 C95	N80	C90 T95	P110	Q125
4 1/2	9.50	0.205	5.21	PS	PS					
4 1/2	10.50	0.224	5.69		PSB					
4 1/2	11.60	0.250	6.35		PSLB	PLB	PLB	PLB	PLB	
4 1/2	13.50	0.290	7.37			PLB	PLB	PLB	PLB	
4 1/2	15.10	0.337	8.56						PLB	PLB
5	11.50	0.220	5.59		PS					
5	13.00	0.253	6.43		PSLB					
5	15.00	0.296	7.52		PSLBE	PLBE	PLBE	PLBE		
5	18.00	0.362	9.19			PLBE	PLBE	PLBE	PLBE	PLBE
5	21.40	0.437	11.10			PLB	PLB	PLB	PLBE	PLB
5	23.20	0.478	12.14			PLB	PLB	PLB	PLB	PLB
5	24.10	0.500	12.70			PLB	PLB	PLB	PLB	PLB
5 1/2	14.00	0.244	6.20	PS	PS					
5 1/2	15.50	0.275	6.99		PSLBE					
5 1/2	17.00	0.304	7.72		PSLBE	PLBE	PLBE	PLBE	PLBE	
5 1/2	20.00	0.361	9.17			PLBE	PLBE	PLBE	PLBE	
5 1/2	23.00	0.415	10.54			PLBE	PLBE	PLBE	PLBE	PLBE
5 1/2	26.80	0.500	12.70					P		
5 1/2	29.70	0.562	14.27					P		
5 1/2	32.60	0.625	15.88					P		
5 1/2	35.30	0.687	17.45					P		
5 1/2	38.00	0.750	19.05					P		
5 1/2	40.50	0.812	20.62					P		
5 1/2	43.10	0.875	22.23					P		
6 5/8	20.00	0.288	7.32	PS	PSLB					
6 5/8	24.00	0.352	8.94		PSLBE	PLBE	PLBE	PLBE	PLBE	
6 5/8	28.00	0.417	10.59			PLBE	PLBE	PLBE	PLBE	
6 5/8	32.00	0.475	12.07			PLBE	PLBE	PLBE	PLBE	PLBE
7	17.00	0.231	5.87	PS						
7	20.00	0.272	6.91	PS	PS					
7	23.00	0.317	8.05		PSLBE	PLBE	PLBE	PLBE		
7	26.00	0.362	9.19		PSLBE	PLBE	PLBE	PLBE	PLBE	
7	29.00	0.408	10.36			PLBE	PLBE	PLBE	PLBE	
7	32.00	0.453	11.51			PLBE	PLBE	PLBE	PLBE	
7	35.00	0.498	12.65			PLBE	PLBE	PLBE	PLBE	PLBE
7	38.00	0.540	13.72			PLBE	PLBE	PLBE	PLBE	PLBE
7	42.70	0.625	15.88					P		
7	46.40	0.687	17.45					P		
7	50.10	0.750	19.05					P		
7	53.60	0.812	20.62					P		
7	57.10	0.875	22.23					P		
7 5/8	24.00	0.300	7.62	PS						
7 5/8	26.40	0.328	8.33		PSLBE	PLBE	PLBE	PLBE		
7 5/8	29.70	0.375	9.53			PLBE	PLBE	PLBE	PLBE	
7 5/8	33.70	0.430	10.92			PLBE	PLBE	PLBE	PLBE	
7 5/8	39.00	0.500	12.70			PLBE	PLBE	PLBE	PLBE	PLBE
7 5/8	42.80	0.562	14.27			PLB	PLB	PLB	PLB	PLB
7 5/8	45.30	0.595	15.11			PLB	PLB	PLB	PLB	PLB
7 5/8	47.10	0.625	15.88			PLB	PLB	PLB	PLB	PLB
7 5/8	51.20	0.687	17.45					P		
7 5/8	55.30	0.750	19.05					P		

* P = plain end; S = short round thread; L = long round thread; B = buttress thread; E = extreme-line.

API CASING LIST (continued)
(API Specification 5CT, 5th edition, April 1, 1995)

Nominal outside diameter (in)	Nominal weight (lb/ft)	Wall thickness		Type of end finish*						
				Grade						
		(in)	(mm)	H40	J55 K55	L80 C95	N80	C90 T95	P110	Q125
7 3/4	46.10	0.595	15.11			P	P	P	P	P
8 5/8	24.00	0.264	6.71		PS					
8 5/8	28.00	0.304	7.72	PS						
8 5/8	32.00	0.352	8.94	PS	PSLBE					
8 5/8	36.00	0.400	10.16		PSLBE	PLBE	PLBE	PLBE		
8 5/8	40.00	0.450	11.43			PLBE	PLBE	PLBE	PLBE	
8 5/8	44.00	0.500	12.70			PLBE	PLBE	PLBE	PLBE	
8 5/8	49.00	0.557	14.15			PLBE	PLBE	PLBE	PLBE	PLBE
9 5/8	32.30	0.312	7.92	PS						
9 5/8	36.00	0.352	8.94	PS	PSLB					
9 5/8	40.00	0.395	10.03		PSLBE	PLBE	PLBE	PLBE		
9 5/8	43.50	0.435	11.05			PLBE	PLBE	PLBE	PLBE	
9 5/8	47.00	0.472	11.99			PLBE	PLBE	PLBE	PLBE	PLBE
9 5/8	53.50	0.545	13.84			PLBE	PLBE	PLBE	PLBE	PLBE
9 5/8	58.40	0.595	15.11			PLB	PLB	PLB	PLB	PLB
9 5/8	59.40	0.609	15.47					P		
9 5/8	64.90	0.672	17.07					P		
9 5/8	70.30	0.734	18.64					P		
9 5/8	75.60	0.797	20.24					P		
10 3/4	32.75	0.279	7.09	PS						
10 3/4	40.50	0.350	8.89	PS	PSB					
10 3/4	45.50	0.400	10.16		PSBE					
10 3/4	51.00	0.450	11.43		PSBE	PSBE	PSBE	PSBE	PSBE	
10 3/4	55.50	0.495	12.57			PSBE	PSBE	PSBE	PSBE	
10 3/4	60.70	0.545	13.84					PSBE	PSBE	PSBE
10 3/4	65.70	0.595	15.11					PSB	PSB	PSB
10 3/4	73.20	0.672	17.07					P		
10 3/4	79.20	0.734	18.64					P		
10 3/4	85.30	0.797	20.24					P		
11 3/4	42.00	0.333	8.46	PS						
11 3/4	47.00	0.375	9.53		PSB					
11 3/4	54.00	0.435	11.05		PSB					
11 3/4	60.00	0.489	12.42		PSB	PSB	PSB	PSB	PSB	PSB
11 3/4	65.00	0.534	13.56			P	P	P	P	P
11 3/4	71.00	0.582	14.78			P	P	P	P	P
13 3/8	48.00	0.330	8.38	PS						
13 3/8	54.50	0.380	9.65		PSB					
13 3/8	61.00	0.430	10.92		PSB					
13 3/8	68.00	0.480	12.19		PSB	PSB	PSB	PSB	PSB	
13 3/8	72.00	0.514	13.06			PSB	PSB	PSB	PSB	PSB
16	65.00	0.375	9.53	PS						
16	75.00	0.438	11.13		PSB					
16	84.00	0.495	12.57		PSB					
16	109.00	0.656	16.66		P	P	P	P	P	P
18 5/8	87.50	0.435	11.05	PS	PSB					
20	94.00	0.438	11.13	PSL	PSLB					
20	106.50	0.500	12.70		PSLB					
20	133.00	0.635	16.13		PSLB					

* P = plain end; S = short round thread; L = long round thread; B = buttress thread; E = extreme-line.

API TUBING LIST
(API Specification 5CT, 5th edition, April 1, 1995)

Nominal outside diameter (in)	Weight designation: Non-upset (N) (lb/ft)	External upset (U) (lb/ft)	Integral joint (I) (lb/ft)	Wall thickness (in)	Wall thickness (mm)	Type of end finish* Grade: H40	J55	L80	N80	C90	T95	P110
1.050	1.14	1.20		0.113	2.87	PNU	PNU	PNU	PNU	PNU	PNU	
1.050	1.48	1.54		0.154	3.91	PU	PU	PU	PU	PU	PU	PU
1.315	1.70	1.80	1.72	0.133	3.38	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	
1.315	2.19	2.24		0.179	4.55	PU	PU	PU	PU	PU	PU	PU
1.660			2.10	0.125	3.18	PI	PI					
1.660	2.30	2.40	2.33	0.140	3.56	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	
1.660	3.03	3.07		0.191	4.85	PU	PU	PU	PU	PU	PU	PU
1.900			2.40	0.125	3.18	PI	PI					
1.900	2.75	2.90	2.76	0.145	3.68	PNUI	PNUI	PNUI	PNUI	PNUI	PNUI	
1.900	3.65	3.73		0.200	5.08	PU	PU	PU	PU	PU	PU	PU
1.900	4.42			0.250	6.35			P		P	P	
1.900	5.15			0.300	7.62			P		P	P	
2.063			3.25	0.156	3.96	PI	PI	PI	PI	PI	PI	
2.063	4.50			0.225	5.72	P	P	P	P	P	P	P
2.375	4.00			0.167	4.24	PN	PN	PN	PN	PN	PN	
2.375	4.60	4.70		0.190	4.83	PNU	PNU	PNU	PNU	PNU	PNU	PNU
2.375	5.80	5.95		0.254	6.45			PNU	PNU	PNU	PNU	PNU
2.375	6.60			0.295	7.49			P		P	P	
2.375	7.35	7.45		0.336	8.53			PU		PU	PU	
2.875	6.40	6.50		0.217	5.51	PNU	PNU	PNU	PNU	PNU	PNU	PNU
2.875	7.80	7.90		0.276	7.01			PNU	PNU	PNU	PNU	PNU
2.875	8.60	8.70		0.308	7.82			PNU	PNU	PNU	PNU	PNU
2.875	9.35	9.45		0.340	8.64			PU		PU	PU	
2.875	10.50			0.392	9.96			P		P	P	
2.875	11.50			0.440	11.18			P		P	P	
3.500	7.70			0.216	5.49	PN	PN	PN	PN	PN	PN	
3.500	9.20	9.30		0.254	6.45	PNU	PNU	PNU	PNU	PNU	PNU	PNU
3.500	10.20			0.289	7.34	PN	PN	PN	PN	PN	PN	
3.500	12.70	12.95		0.375	9.53			PNU	PNU	PNU	PNU	PNU
3.500	14.30			0.430	10.92			P		P	P	
3.500	15.50			0.476	12.09			P		P	P	
3.500	17.00			0.530	13.46			P		P	P	
4.000	9.50			0.226	5.74	PN	PN	PN	PN	PN	PN	
4.000		11.00		0.262	6.65	PU	PU	PU	PU	PU	PU	
4.000	13.20			0.330	8.38			P		P	P	
4.000	16.10			0.415	10.54			P		P	P	
4.000	18.90			0.500	12.70			P		P	P	
4.000	22.20			0.610	15.49			P		P	P	
4.500	12.60	12.75		0.271	6.88	PNU	PNU	PNU	PNU	PNU	PNU	
4.500	15.20			0.337	8.56			P		P	P	
4.500	17.00			0.380	9.65			P		P	P	
4.500	18.90			0.430	10.92			P		P	P	
4.500	21.50			0.500	12.70			P		P	P	
4.500	23.70			0.560	14.22			P		P	P	
4.500	26.10			0.630	16.00			P		P	P	

* P = plain end; N = non-upset T & C; U = external upset T & C; I = integral joint.

DRIFT DIAMETER
(API Standard 5CT, 5th edition, April 1, 1995)

All drift testing shall be performed with a drift mandrel containing a cylindrical portion conforming to the requirements shown below. The ends of the drift mandrel extending beyond the specified cylindrical portion shall be shaped to permit easy entry in the pipe. The drift mandrel shall pass freely through pipe by the use of a manual or power drift procedure. In case of dispute, the manual drift procedure shall be used.

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

Tubing 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 in (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:

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

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 pipe body (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) **The critical cross-section of the joint:** the value in line 5 is multiplied by the efficiency.

Example:

Hydril 511 7 in 29 lb/ft, line 20, efficiency: 60.6

Critical cross-section of Hydril 511:

$$5451 \text{ mm}^2 \times 0.606 = 3303 \text{ mm}^2$$

$$8.45 \text{ in}^2 \times 0.606 = 5.121 \text{ in}^2$$

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

Example:

Hydril 511 7 in 29 lb/ft, tension at the yield stress for N80:

$$301 \times 0.606 = 182\ 10^3 \text{ daN}$$

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:

$$5.121 \text{ in}^2 \times 100\,000 = 512\ 10^3 \text{ lb}$$

$$= 228\ 10^3 \text{ daN}$$

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

$$301 \times 0.606 \times \frac{100\,000}{80\,000} = 228\ 10^3 \text{ daN}$$

MAKE-UP TORQUE

The make-up torques in the tables C 9-C 15, C 16-C 34, C 35-C 79 correspond to the values and recommendations below:

Buttress

In sizes 4 1/2" through 13 3/8", make-up torque values should be determined by carefully noting the torque required to make up each of several connections to the base of the triangle; then using the torque value thus established, make up the balance of the pipe of that particular weight and grade in the string.

For buttress thread sizes 16", 18 5/8" and 20", see API STC or LTC.

API STC or LTC

In sizes 4 1/2" through 13 3/8", values listed are optimum values. The minimum torque should be not below 75 percent of the optimum value. The maximum torque should be not over 125 percent of the optimum value.

In sizes 16", 18 5/8" and 20", values listed are minimum values. Make-up shall be to a position on each connection represented by the thread vanish point on 8-round thread and the base of triangle on buttress thread using the minimum torque.

Grant Prideco

Make-up torque values listed are optimum values. Minimum value is generally 5 to 10 percent below optimum value and maximum value is generally 5 to 10 percent over optimum value.

Hydril

Make-up torque values listed are optimum values for SLX, 511, 533, CS, PH-4, PH-6.

For 563, the torque is a minimum make-up torque and applies to all grades of steel.

For 521, values listed are minimum make-up torque. A field target torque 15 percent over minimum is recommended.

For MAC-II, values listed are minimum make-up torque. A field target torque 10 percent over minimum is recommended.

Vallourec & Mannesmann

Make-up torque values listed are optimum values. Minimum value is 10 percent below optimum value and maximum value is 10 percent over optimum value.

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBING

	No.							
Pipe body	1	Nominal size (OD)	**1.050** in			26.7 mm		
	2	Nominal weight	**1.14/1.20** lb/ft			1.66/1.75 daN/m		
	3	Wall thickness	0.113 in			2.9 mm		
	4	Inside diameter	0.824 in			20.9 mm		
	5	Steel cross-section	0.333 in²			215 mm²		
	6	Capacity	0.028 gal/ft			0.34 l/m		
	7	Displacement	0.045 gal/ft			0.56 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	72.8	105.9	105.9	119.2	125.8	145.7
	10	Internal yield pressure (MPa)	71.4	103.9	103.9	116.9	123.4	142.8
	11	Pipe body yield strength (1000 daN)	8.1	11.8	11.8	13.3	14.1	16.3

	No.							
Pipe body	1	Nominal size (OD)	**1.050** in			26.7 mm		
	2	Nominal weight	**1.48/1.54** lb/ft			2.16/2.25 daN/m		
	3	Wall thickness	0.154 in			3.9 mm		
	4	Inside diameter	0.742 in			18.8 mm		
	5	Steel cross-section	0.433 in²			280 mm²		
	6	Capacity	0.022 gal/ft			0.28 l/m		
	7	Displacement	0.045 gal/ft			0.56 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	94.9	138.1	138.1	155.3	164.0	189.8
	10	Internal yield pressure (MPa)	97.3	141.6	141.6	159.3	168.1	194.7
	11	Pipe body yield strength (1000 daN)	10.6	15.4	15.4	17.4	18.3	21.2

	No.		1.050 in – 1.14/1.20 lb/ft	1.050 in – 1.48/1.54 lb/ft
Connection efficiency	12	API Non-Upset	47.8	
	13	API External Upset	100.0	
	14	API Integral Joint		
	15	Grant Prideco RTS-8	100.0	100.0
	16	Hydril CS	100.0	100.0
	17	Vallourec & Mannesmann mini VAM	100.0	100.0

Connection characteristics – 1.050 in, 1.14/1.20 lb/ft

	No.		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110			
Connection characteristics	18	API Non-Upset	24	33	35			33.4		18.5
	19	API External Upset	81	111	119			42.2		18.5
	20	API Integral Joint								
	21	Grant Prideco RTS-8						33.7	17.4	18.5
	22	Hydril CS	34	47	47	47	47	33.7	17.4	18.5
	23	Vallourec & Mannesmann mini VAM	20	30				33.0		18.5

Connection characteristics – 1.050 in, 1.48/1.54 lb/ft

	No.		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110			
Connection characteristics	18	API Non-Upset								
	19	API External Upset								
	20	API Integral Joint								
	21	Grant Prideco RTS-8						33.7	17.4	16.5
	22	Hydril CS	34	47	47	47	47	33.7	17.4	16.5
	23	Vallourec & Mannesmann mini VAM						34.0		16.5

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBING (continued)

	No.		1.315 in			33.4 mm		
Pipe body	1	Nominal size (OD)	**1.315** in			33.4 mm		
	2	Nominal weight	**1.70/1.80** lb/ft			2.48/2.63 daN/m		
	3	Wall thickness	0.133 in			3.4 mm		
	4	Inside diameter	1.049 in			26.6 mm		
	5	Steel cross-section	0.494 in^2			319 mm^2		
	6	Capacity	0.045 gal/ft			0.56 l/m		
	7	Displacement	0.071 gal/ft			0.88 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	68.9	100.3	100.3	112.8	119.1	137.9
	10	Internal yield pressure (MPa)	67.1	97.6	97.6	109.8	115.9	134.2
	11	Pipe body yield strength (1000 daN)	12.1	17.6	17.6	19.8	20.9	24.2
Connection efficiency	12	API Non-Upset	55.5					
	13	API External Upset	100.0					
	14	API Integral Joint	80.8					
	15	Grant Prideco RTS-8	100.0					
	16	Hydril CS	100.0					
	17	Vallourec & Mannesmann mini VAM	100.0					

	No.		1.315 in			33.4 mm		
Pipe body	1	Nominal size (OD)	**1.315** in			33.4 mm		
	2	Nominal weight	**2.19/2.24** lb/ft			3.20/3.27 daN/m		
	3	Wall thickness	0.179 in			4.5 mm		
	4	Inside diameter	0.957 in			24.3 mm		
	5	Steel cross-section	0.639 in^2			412 mm^2		
	6	Capacity	0.037 gal/ft			0.46 l/m		
	7	Displacement	0.071 gal/ft			0.88 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	89.2	129.7	129.7	145.9	154.0	178.4
	10	Internal yield pressure (MPa)	90.3	131.4	131.4	147.8	156.0	180.7
	11	Pipe body yield strength (1000 daN)	15.6	22.7	22.7	25.6	27.0	31.3
Connection efficiency	12	API Non-Upset						
	13	API External Upset						
	14	API Integral Joint						
	15	Grant Prideco RTS-8	100.0					
	16	Hydril CS	100.0					
	17	Vallourec & Mannesmann mini VAM	100.0					

Connection characteristics (1.70/1.80 lb/ft):

No.		Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)
18	API Non-Upset	37	51	54			42.2		24.3
19	API External Upset	77	105	113			48.3		24.3
20	API Integral Joint	54	72	79			39.4		24.3
21	Grant Prideco RTS-8	46	61			61	39.4	24.6	24.3
22	Hydril CS	47	61	61	61	61	39.4	24.6	24.3
23	Vallourec & Mannesmann mini VAM	30	40				39.5		24.3

Connection characteristics (2.19/2.24 lb/ft):

No.		Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)
18	API Non-Upset								
19	API External Upset								
20	API Integral Joint								
21	Grant Prideco RTS-8	46	61			61	40.6	21.9	21.9
22	Hydril CS	47	61	61	61	61	40.6	21.9	21.9
23	Vallourec & Mannesmann mini VAM						41.0		21.9

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBING (continued)

	No.													
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			3.06 daN/m			**2.30/2.40** lb/ft			3.36/3.50 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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	52.8	76.8	76.8	85.1	88.9	99.9	58.6	85.2	85.2	95.8	101.2	117.1
	10	Internal yield pressure (MPa)	50.0	72.7	72.7	81.8	86.3	99.9	56.0	81.4	81.4	91.6	96.7	111.9
	11	Pipe body yield strength (1000 daN)	14.7	21.5	21.5	24.1	25.5	29.5	16.4	23.8	23.8	26.8	28.3	32.7

Connection efficiency	No.		1.660 in (2.10 lb/ft)	1.660 in (2.30/2.40 lb/ft)
	12	API Non-Upset	92.0	58.1
	13	API External Upset		100.0
	14	API Integral Joint		82.9
	15	Grant Prideco RTS-8		100.0
	16	Hydril CS		100.0
	17	Vallourec & Mannesmann mini VAM		100.0

Connection characteristics	No.		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
	18	API Non-Upset									47	65	69			52.2		32.7
	19	API External Upset									94	129	138			55.9		32.7
	20	API Integral Joint	68					47.8		33.4	68	93	99			47.8		32.7
	21	Grant Prideco RTS-8									61	92			92	47.8	33.0	32.7
	22	Hydril CS									61	95	95	95	95	47.8	33.3	32.7
	23	Vallourec & Mannesmann 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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBING (continued)

Pipe body	1	Nominal size (OD)	**1.660** in			42.2 mm			**1.900** in			48.3 mm		
	2	Nominal weight	**3.03/3.07** lb/ft			4.42/4.48 daN/m			**2.40** lb/ft			3.50 daN/m		
	3	Wall thickness	0.191 in			4.9 mm			0.125 in			3.2 mm		
	4	Inside diameter	1.278 in			32.5 mm			1.650 in			41.9 mm		
	5	Steel cross-section	0.881 in^2			569 mm^2			0.697 in^2			450 mm^2		
	6	Capacity	0.067 gal/ft			0.83 l/m			0.111 gal/ft			1.38 l/m		
	7	Displacement	0.112 gal/ft			1.40 l/m			0.147 gal/ft			1.83 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	77.2	112.3	112.3	126.4	133.4	154.4	45.8	61.1	61.1	66.7	69.4	76.9
	10	Internal yield pressure (MPa)	76.4	111.1	111.1	124.9	131.9	152.7	43.7	63.5	63.5	71.4	75.4	87.3
	11	Pipe body yield strength (1000 daN)	21.6	31.4	31.4	35.3	37.2	43.1	17.1	24.8	24.8	27.9	29.5	34.1
Connection efficiency	12	API Non-Upset												
	13	API External Upset												
	14	API Integral Joint							96.4					
	15	Grant Prideco RTS-8	100.0											
	16	Hydril CS	100.0											
	17	Vallourec & Mannesmann mini VAM	100.0											

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
	18	API Non-Upset																
	19	API External Upset																
	20	API Integral Joint									79					53.5		39.5
	21	Grant Prideco RTS-8	61	92			92	48.9	30.9	30.1								
	22	Hydril CS	61	95	95	95	95	48.9	30.9	30.1								
	23	Vallourec & Mannesmann mini VAM						50.2		30.1								

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBING (continued)

Pipe body

1	Nominal size (OD)	**1.900** in	48.3 mm	**1.900** in	48.3 mm
2	Nominal weight	**2.75/2.90** lb/ft	4.01/4.23 daN/m	**3.65/3.73** lb/ft	5.33/5.44 daN/m
3	Wall thickness	0.145 in	3.7 mm	0.200 in	5.1 mm
4	Inside diameter	1.610 in	40.9 mm	1.500 in	38.1 mm
5	Steel cross-section	0.799 in^2	516 mm^2	1.068 in^2	689 mm^2
6	Capacity	0.106 gal/ft	1.31 l/m	0.092 gal/ft	1.14 l/m
7	Displacement	0.147 gal/ft	1.83 l/m	0.147 gal/ft	1.83 l/m

8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
9	Collapse resistance (MPa)	53.5	77.8	77.8	87.0	90.9	102.3	71.4	103.9	103.9	116.9	123.4	142.9
10	Internal yield pressure (MPa)	50.6	73.7	73.7	82.9	87.5	101.3	69.9	101.6	101.6	114.3	120.7	139.7
11	Pipe body yield strength (1000 daN)	19.6	28.4	28.4	32.0	33.8	39.1	26.1	38.0	38.0	42.8	45.1	52.3

Connection efficiency

		1.900 in – 2.75/2.90 lb/ft	1.900 in – 3.65/3.73 lb/ft
12	API Non-Upset	59.7	
13	API External Upset	100.0	
14	API Integral Joint	84.1	
15	Grant Prideco RTS-8	100.0	100.0
16	Hydril CS	100.0	100.0
17	Vallourec & Mannesmann mini VAM	100.0	100.0

Connection characteristics

1.900 in – 2.75/2.90 lb/ft:

		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
		J55	LN80	C90	C95	P110			
18	API Non-Upset	56	77	83			55.9		38.5
19	API External Upset	119	163	176			63.5		38.5
20	API Integral Joint	79	108	117			53.3		38.5
21	Grant Prideco RTS-8	92	122			122	53.7		38.5
22	Hydril CS	95	122	122	122	122	53.7		38.5
23	Vallourec & Mannesmann mini VAM	60	80				54.4		38.5

1.900 in – 3.65/3.73 lb/ft:

		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
		J55	LN80	C90	C95	P110			
18	API Non-Upset								
19	API External Upset								
20	API Integral Joint								
21	Grant Prideco RTS-8	92	122			122	54.9	36.6	35.7
22	Hydril CS	95	122	122	122	122	54.9	36.6	35.7
23	Vallourec & Mannesmann mini VAM					.	56.4		35.7

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBING (continued)

Pipe body	1	Nominal size (OD)	**1.900** in			48.3 mm			**1.900** in			48.3 mm		
	2	Nominal weight	**4.42** lb/ft			6.45 daN/m			**5.15** lb/ft			7.52 daN/m		
	3	Wall thickness	0.250 in			6.3 mm			0.300 in			7.6 mm		
	4	Inside diameter	1.400 in			35.6 mm			1.300 in			33.0 mm		
	5	Steel cross-section	1.296 in^2			836 mm^2			1.508 in^2			973 mm^2		
	6	Capacity	0.080 gal/ft			0.99 l/m			0.069 gal/ft			0.86 l/m		
	7	Displacement	0.147 gal/ft			1.83 l/m			0.147 gal/ft			1.83 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	86.7	126.1	126.1	141.8	149.7	173.3	100.8	146.7	146.7	165.0	174.2	201.7
	10	Internal yield pressure (MPa)	87.3	127.0	127.0	142.9	150.8	174.6	104.8	152.4	152.4	171.5	181.0	209.6
	11	Pipe body yield strength (1000 daN)	31.7	46.1	46.1	51.9	54.8	63.4	36.9	53.7	53.7	60.4	63.7	73.8
Connection efficiency	12	API Non-Upset												
	13	API External Upset												
	14	API Integral Joint												
	15	Grant Prideco RTS-8												
	16	Hydril CS												
	17	Vallourec & Mannesmann mini VAM												

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	18	API Non-Upset																
	19	API External Upset																
	20	API Integral Joint																
	21	Grant Prideco RTS-8																
	22	Hydril CS																
	23	Vallourec & Mannesmann mini VAM																

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF SMALL-DIAMETER TUBING (continued)

Pipe body

1	Nominal size (OD)	**2.063** in	52.4 mm	**2.063** in	52.4 mm
2	Nominal weight	**3.25** lb/ft	4.74 daN/m	**4.50** lb/ft	6.57 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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
9	Collapse resistance (MPa)	53.0	77.1	77.1	85.7	89.5	100.6	73.7	107.2	107.2	120.6	127.3	147.4
10	Internal yield pressure (MPa)	50.2	73.0	73.0	82.1	86.7	100.4	72.4	105.3	105.3	118.4	125.0	114.8
11	Pipe body yield strength (1000 daN)	22.9	33.3	33.3	37.4	39.5	45.7	31.8	46.2	46.2	52.0	54.9	63.6

Connection efficiency

		2.063 in, 3.25 lb/ft	2.063 in, 4.50 lb/ft
12	API Non-Upset		
13	API External Upset		
14	API Integral Joint	95.3	
15	Grant Prideco RTS-8	100.0	100.0
16	Hydril CS	100.0	100.0
17	Vallourec & Mannesmann mini VAM	100.0	100.0

Connection characteristics

		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
		J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
18	API Non-Upset																
19	API External Upset																
20	API Integral Joint	100	138	149			59.1		42.1								
21	Grant Prideco RTS-8	107	137			137	59.2	43.2	42.1	107	137			137	62.5	39.4	38.6
22	Hydril CS	108	142	142	142	142	59.2	43.2	42.1	108	142	142	142	142	62.5	39.4	38.6
23	Vallourec & Mannesmann 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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING

Pipe body	1	Nominal size (OD)	**2.375** in			60.3 mm			**2.375** in			60.3 mm		
	2	Nominal weight	**4** lb/ft			5.84 daN/m			**4.60/4.70** lb/ft			6.71/6.86 daN/m		
	3	Wall thickness	0.167 in			4.2 mm			0.190 in			4.8 mm		
	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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	49.6	68.8	68.8	75.4	78.7	87.8	55.8	81.2	81.2	91.3	96.4	111.2
	10	Internal yield pressure (MPa)	46.7	67.9	67.9	76.4	80.6	93.3	53.1	77.2	77.2	86.9	91.7	106.2
	11	Pipe body yield strength (1000 daN)	28.3	41.2	41.2	46.4	49.0	56.7	31.9	46.4	46.4	52.2	55.1	63.8

Connection efficiency			2.375 in / 60.3 mm (4 lb/ft)	2.375 in / 60.3 mm (4.60/4.70 lb/ft)
	12	API Non-Upset	65.0	68.9
	13	API External Upset		100.0
	14	Grant Prideco CSTCP		100.0
	15	Grant Prideco STL		44.1
	16	Grant Prideco TCII		100.0
	17	Hydril CS		100.0
	18	Hydril PH4-PH6		
	19	Vallourec & Mannesmann TDS		100.0
	20	Vallourec & Mannesmann New VAM		106.8
	21	Vallourec & Mannesmann VAM ACE		108.9
	22	Vallourec & Mannesmann VAM PRO		100.0
	23	Vallourec & Mannesmann FJL		44.9

Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
	24	API Non-Upset	83	114	123			73.0		49.5	99	136	146		174	73.0		48.3
	25	API External Upset									175	241	260		308	77.8		48.3
	26	Grant Prideco CSTCP									168	229			229	68.6	49.4	48.3
	27	Grant Prideco STL									68	81	81	81	81	60.3	48.8	48.3
	28	Grant Prideco TCII														67.9		48.3
	29	Hydril CS									169	230	230	230	230	68.6	49.4	48.3
	30	Hydril PH4-PH6																
	31	Vallourec & Mannesmann TDS														73.0	49.7	48.3
	32	Vallourec & Mannesmann New VAM									157	216	245	245	275	68.8		48.3
	33	Vallourec & Mannesmann VAM ACE									127	137	146	146	157	68.5		48.3
	34	Vallourec & Mannesmann VAM PRO														67.5		48.3
	35	Vallourec & Mannesmann FJL										79	88	88	94	60.3	49.1	48.3

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

	No.													
Pipe body	1	Nominal size (OD)	**2.375** in			60.3 mm			**2.375** in			60.3 mm		
	2	Nominal weight	**5.10** lb/ft			7.44 daN/m			**5.80/5.90** lb/ft			8.46/8.68 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 in²			953 mm²			1.692 in²			1092 mm²		
	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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	63.2	92.0	92.0	103.5	109.2	126.5	72.4	105.4	105.4	118.5	125.1	144.9
	10	Internal yield pressure (MPa)	60.9	88.6	88.6	99.7	105.2	121.8	71.0	103.2	103.2	116.1	122.6	141.9
	11	Pipe body yield strength (1000 daN)	36.1	52.6	52.6	59.1	62.4	72.3	41.4	60.2	60.2	67.8	71.5	82.8
Connection efficiency	12	API Non-Upset							76.1					
	13	API External Upset							100.0					
	14	Grant Prideco CSTCP	100.0						100.0					
	15	Grant Prideco STL							53.4					
	16	Grant Prideco TCII	100.0						100.0					
	17	Hydril CS	100.0											
	18	Hydril PH4-PH6							100.0					
	19	Vallourec & Mannesmann TDS	100.0						100.0					
	20	Vallourec & Mannesmann New VAM	102.8						102.4					
	21	Vallourec & Mannesmann VAM ACE	119.3						104.1					
	22	Vallourec & Mannesmann VAM PRO	100.0						100.0					
	23	Vallourec & Mannesmann FJL	51.4						55.3					

	No.		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
	24	API Non-Upset										195	210		249	73.0		45.0
	25	API External Upset									175	241	260		384	77.8		45.0
	26	Grant Prideco CSTCP	168	229			229	69.8	48.0	46.9		339			414	73.8	45.8	45.0
	27	Grant Prideco STL									95	122	122	122	122	60.3	45.4	45.0
	28	Grant Prideco TCII						69.0		46.9		290	290	290	290	70.3	47.1	45.0
	29	Hydril CS	169	230	230	230	230	69.8	48.0	46.9								
	30	Hydril PH4-PH6										339	366	380	414	73.8	45.8	45.0
	31	Vallourec & Mannesmann TDS						73.0	48.3	46.9						73.0	46.5	45.0
	32	Vallourec & Mannesmann New VAM	157	216	255	255	285	69.5		46.9	167	225	264	264	294	70.7		45.0
	33	Vallourec & Mannesmann VAM ACE	127	137	146	146	157	70.5		46.9	157	176	186	186	206	70.5		45.0
	34	Vallourec & Mannesmann VAM PRO						68.5		46.9						69.8		45.0
	35	Vallourec & Mannesmann FJL		88	94	94	107	60.3	47.7	46.9		98	107	107	118	60.3	46.0	45.0

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**2.375** in			60.3 mm			**2.375** in			60.3 mm		
	2	Nominal weight	**6.60** lb/ft			9.63 daN/m			**7.35/7.45** lb/ft			10.73/10.87 daN/m		
	3	Wall thickness	0.295 in			7.5 mm			0.336 in			8.5 mm		
	4	Inside diameter	1.785 in			45.3 mm			1.703 in			43.3 mm		
	5	Steel cross-section	1.928 in^2			1244 mm^2			2.152 in^2			1389 mm^2		
	6	Capacity	0.130 gal/ft			1.61 l/m			0.118 gal/ft			1.47 l/m		
	7	Displacement	0.230 gal/ft			2.86 l/m			0.230 gal/ft			2.86 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	82.5	120.0	120.0	135.0	142.5	165.0	92.1	134.0	134.0	150.7	159.1	184.2
	10	Internal yield pressure (MPa)	82.4	119.9	119.9	134.9	142.4	164.9	93.9	136.6	136.6	153.6	162.2	187.8
	11	Pipe body yield strength (1000 daN)	47.2	68.6	68.6	77.2	81.5	94.3	52.7	76.6	76.6	86.2	91.0	105.3

			2.375 in / 6.60 lb/ft	2.375 in / 7.35/7.45 lb/ft
Connection efficiency	12	API Non-Upset		
	13	API External Upset		
	14	Grant Prideco CSTCP		100.0
	15	Grant Prideco STL		
	16	Grant Prideco TCII		
	17	Hydril CS		
	18	Hydril PH4-PH6	100.0	100.0
	19	Vallourec & Mannesmann TDS		
	20	Vallourec & Mannesmann New VAM		
	21	Vallourec & Mannesmann VAM ACE	102.0	102.0
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL		55.0

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP										339			414	79.4	41.8	40.9
	27	Grant Prideco STL																
	28	Grant Prideco TCII																
	29	Hydril CS																
	30	Hydril PH4-PH6		339	366	380	414	77.0	43.8	43.0		339	366	380	414	79.4	41.8	40.9
	31	Vallourec & Mannesmann TDS																
	32	Vallourec & Mannesmann New VAM																
	33	Vallourec & Mannesmann VAM ACE						71.7		43.0	245	294	304	304	324	73.0		40.9
	34	Vallourec & Mannesmann VAM PRO						70.5		43.0						71.8		40.9
	35	Vallourec & Mannesmann FJL										118	127	127	137	60.3	42.0	40.9

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**2.875** in			73.0 mm			**2.875** in			73.0 mm		
	2	Nominal weight	**6.40/6.50** lb/ft			9.34/9.49 daN/m			**7.80/7.90** lb/ft			11.38/11.53 daN/m		
	3	Wall thickness	0.217 in			5.5 mm			0.276 in			7.0 mm		
	4	Inside diameter	2.441 in			62.0 mm			2.323 in			59.0 mm		
	5	Steel cross-section	1.812 in^2			1169 mm^2			2.254 in^2			1454 mm^2		
	6	Capacity	0.243 gal/ft			3.02 l/m			0.220 gal/ft			2.73 l/m		
	7	Displacement	0.337 gal/ft			4.19 l/m			0.337 gal/ft			4.19 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	52.9	77.0	77.0	85.4	89.2	100.3	65.8	95.7	95.7	107.7	113.7	131.6
	10	Internal yield pressure (MPa)	50.1	72.9	72.9	82.0	86.5	100.2	63.7	92.7	92.7	104.2	110.0	127.4
	11	Pipe body yield strength (1000 daN)	44.3	64.5	64.5	72.5	76.6	88.7	55.1	80.2	80.2	90.2	95.2	110.3

			2.875 in (6.40/6.50 lb/ft)	2.875 in (7.80/7.90 lb/ft)
Connection efficiency	12	API Non-Upset	72.8	78.1
	13	API External Upset	100.0	100.0
	14	Grant Prideco CSTCP	100.0	100.0
	15	Grant Prideco STL	49.2	55.2
	16	Grant Prideco TCII	100.0	100.0
	17	Hydril CS	100.0	
	18	Hydril PH4-PH6		100.0
	19	Vallourec & Mannesmann TDS	100.0	100.0
	20	Vallourec & Mannesmann New VAM	106.3	107.5
	21	Vallourec & Mannesmann VAM ACE	104.4	106.1
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL	48.9	52.0

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset	142	197	213		251	88.9		59.6		262	283		335	88.9		56.6
	25	API External Upset	224	308	334		395	93.2		59.6		371	403		475	93.2		56.6
	26	Grant Prideco CSTCP	229	320			320	81.5	60.2	59.6		461			536	87.3	57.5	56.6
	27	Grant Prideco STL	95	122	122	122	122	73.0	85.8	59.6	122	163	163	163	163	73.0	57.1	56.6
	28	Grant Prideco TCII		351	351	351	351	81.6	61.7	59.6		351	351	351	351	83.7	58.7	56.6
	29	Hydril CS	230	319	319	319	319	81.5	60.2	59.6								
	30	Hydril PH4-PH6										461	488	502	536	87.3	57.5	56.6
	31	Vallourec & Mannesmann TDS						88.9	61.0	59.6						88.9	58.0	56.6
	32	Vallourec & Mannesmann New VAM	236	324	382	382	431	82.3		59.6	255	343	392	392	451	84.8		56.6
	33	Vallourec & Mannesmann VAM ACE	197	245	264	264	294	82.0		59.6	245	275	304	304	334	84.5		56.6
	34	Vallourec & Mannesmann VAM PRO						81.0		59.6						83.3		56.6
	35	Vallourec & Mannesmann FJL		118	127	127	133	73.0	60.5	59.6		137	157	157	176	73.0	57.8	56.6

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**2.875** in			73.0 mm			**2.875** in			73.0 mm		
	2	Nominal weight	**8.60/8.70** lb/ft			12.55/12.70 daN/m			**9.35/9.45** lb/ft			13.65/13.79 daN/m		
	3	Wall thickness	0.308 in			7.8 mm			0.340 in			8.6 mm		
	4	Inside diameter	2.259 in			57.4 mm			2.195 in			55.8 mm		
	5	Steel cross-section	2.484 in^2			1602 mm^2			2.708 in^2			1747 mm^2		
	6	Capacity	0.208 gal/ft			2.59 l/m			0.197 gal/ft			2.44 l/m		
	7	Displacement	0.337 gal/ft			4.19 l/m			0.337 gal/ft			4.19 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	72.5	105.5	105.5	118.7	125.3	145.1	79.1	115.0	115.0	129.4	136.6	158.2
	10	Internal yield pressure (MPa)	71.1	103.4	103.4	116.3	122.8	142.2	78.5	114.2	114.2	128.4	135.6	157.0
	11	Pipe body yield strength (1000 daN)	60.8	88.4	88.4	99.4	105.0	121.5	66.2	96.4	96.4	108.4	114.4	132.5

			2.875 in, 8.60/8.70 lb/ft	2.875 in, 9.35/9.45 lb/ft
Connection efficiency	12	API Non-Upset	80.2	
	13	API External Upset	100.0	
	14	Grant Prideco CSTCP	100.0	100.0
	15	Grant Prideco STL	56.6	
	16	Grant Prideco TCII	100.0	
	17	Hydril CS		
	18	Hydril PH4-PH6	100.0	100.0
	19	Vallourec & Mannesmann TDS	100.0	
	20	Vallourec & Mannesmann New VAM	103.5	
	21	Vallourec & Mannesmann VAM ACE	102.2	100.3
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL	55.5	

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset		296	321		378	88.9		55.0								
	25	API External Upset		405	438		517	93.2		55.0								
	26	Grant Prideco CSTCP		461			536	88.9	55.9	55.0		691			841	92.1	54.1	53.4
	27	Grant Prideco STL	149	176	176	176	176	73.0	55.8	55.0								
	28	Grant Prideco TCII		351	351	351	351	84.9	57.1	55.0								
	29	Hydril CS																
	30	Hydril PH4-PH6		461	488	502	536	88.9	55.9	55.0		685	746	780	841	92.1	54.1	53.4
	31	Vallourec & Mannesmann TDS						88.9	56.4	55.0								
	32	Vallourec & Mannesmann New VAM	285	382	441	441	510	85.4		55.0								
	33	Vallourec & Mannesmann VAM ACE	294	334	363	363	392	85.2		55.0	324	382	422	422	451	86.3		53.4
	34	Vallourec & Mannesmann VAM PRO						84.4		55.0						85.5		53.4
	35	Vallourec & Mannesmann FJL		176	195	195	226	73.0	56.2	55.0								

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**2.875** in			73.0 mm			**2.875** in			73.0 mm		
	2	Nominal weight	**9.80** lb/ft			14.30 daN/m			**10.50** lb/ft			15.32 daN/m		
	3	Wall thickness	0.362 in			9.2 mm			0.392 in			10.0 mm		
	4	Inside diameter	2.151 in			54.6 mm			2.091 in			53.1 mm		
	5	Steel cross-section	2.858 in^2			1844 mm^2			3.058 in^2			1973 mm^2		
	6	Capacity	0.189 gal/ft			2.34 l/m			0.178 gal/ft			2.22 l/m		
	7	Displacement	0.337 gal/ft			4.19 l/m			0.337 gal/ft			4.19 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	83.5	121.4	121.4	136.6	144.2	166.9	89.3	129.9	129.9	146.1	154.3	178.6
	10	Internal yield pressure (MPa)	83.6	121.5	121.5	136.7	144.3	167.1	90.5	131.6	131.6	148.1	156.3	181.0
	11	Pipe body yield strength (1000 daN)	69.9	101.7	101.7	114.4	120.8	139.8	74.8	108.8	108.8	122.4	129.2	149.6
Connection efficiency	12	API Non-Upset												
	13	API External Upset												
	14	Grant Prideco CSTCP												
	15	Grant Prideco STL												
	16	Grant Prideco TCII												
	17	Hydril CS												
	18	Hydril PH4-PH6							100.0					
	19	Vallourec & Mannesmann TDS												
	20	Vallourec & Mannesmann New VAM	103.1											
	21	Vallourec & Mannesmann VAM ACE	102.0						101.3					
	22	Vallourec & Mannesmann VAM PRO	100.0						100.0					
	23	Vallourec & Mannesmann FJL	55.0											

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP																
	27	Grant Prideco STL																
	28	Grant Prideco TCII																
	29	Hydril CS																
	30	Hydril PH4-PH6										685	746	780	841	93.7	51.6	50.7
	31	Vallourec & Mannesmann TDS																
	32	Vallourec & Mannesmann New VAM	324	441	510	510	579	87.2		52.3								
	33	Vallourec & Mannesmann VAM ACE	343	422	461	461	491	87.0		52.3						88.0		50.7
	34	Vallourec & Mannesmann VAM PRO						85.3		52.3						86.3		50.7
	35	Vallourec & Mannesmann FJL		206	226	226	245	73.0	53.5	52.3								

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**2.875** in			73.0 mm			**3.500** in			88.9 mm		
	2	Nominal weight	**11.50** lb/ft			16.78 daN/m			**7.70** lb/ft			11.24 daN/m		
	3	Wall thickness	0.440 in			11.2 mm			0.216 in			5.5 mm		
	4	Inside diameter	1.995 in			50.7 mm			3.068 in			77.9 mm		
	5	Steel cross-section	3.366 in^2			2172 mm^2			2.228 in^2			1438 mm^2		
	6	Capacity	0.162 gal/ft			2.02 l/m			0.384 gal/ft			4.77 l/m		
	7	Displacement	0.337 gal/ft			4.19 l/m			0.500 gal/ft			6.21 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	98.3	143.0	143.0	160.9	169.8	196.6	41.2	54.2	54.2	58.9	61.0	67.1
	10	Internal yield pressure (MPa)	101.6	147.7	147.7	166.2	175.4	203.1	41.0	59.6	59.6	67.0	70.7	81.9
	11	Pipe body yield strength (1000 daN)	82.3	119.8	119.8	134.8	142.2	164.7	54.5	79.3	79.3	89.2	94.2	109.0

Connection efficiency			2.875 in	3.500 in
	12	API Non-Upset		73.0
	13	API External Upset		
	14	Grant Prideco CSTCP		
	15	Grant Prideco STL		
	16	Grant Prideco TCII		100.0
	17	Hydril CS		
	18	Hydril PH4-PH6	100.0	
	19	Vallourec & Mannesmann TDS		100.0
	20	Vallourec & Mannesmann New VAM		104.1
	21	Vallourec & Mannesmann VAM ACE	98.8	101.7
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL		47.5

Connection characteristics — 2.875 in

		Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)
24	API Non-Upset								
25	API External Upset								
26	Grant Prideco CSTCP								
27	Grant Prideco STL								
28	Grant Prideco TCII								
29	Hydril CS								
30	Hydril PH4-PH6		766	854	902	990	95.3	49.4	48.3
31	Vallourec & Mannesmann TDS								
32	Vallourec & Mannesmann New VAM								
33	Vallourec & Mannesmann VAM ACE	441	500	540	540	598	89.6		48.3
34	Vallourec & Mannesmann VAM PRO						87.7		48.3
35	Vallourec & Mannesmann FJL								

Connection characteristics — 3.500 in

		Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)
24	API Non-Upset	164	228	247			108.0		74.8
25	API External Upset								
26	Grant Prideco CSTCP								
27	Grant Prideco STL	163	217	217	217	217			74.8
28	Grant Prideco TCII		427	427	427	427	97.2	77.6	74.8
29	Hydril CS								
30	Hydril PH4-PH6								
31	Vallourec & Mannesmann TDS						107.9	76.0	74.8
32	Vallourec & Mannesmann New VAM	313	422	491	491	549	97.6		74.8
33	Vallourec & Mannesmann VAM ACE	236	264	285	285	313	97.3		74.8
34	Vallourec & Mannesmann VAM PRO						96.5		74.8
35	Vallourec & Mannesmann FJL		146	157	157	176	88.9	76.6	74.8

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body

#					
1	Nominal size (OD)	**3.500** in	88.9 mm	**3.500** in	88.9 mm
2	Nominal weight	**9.20/9.30** lb/ft	13.43/13.57 daN/m	**10.20** lb/ft	14.89 daN/m
3	Wall thickness	0.254 in	6.5 mm	0.289 in	7.3 mm
4	Inside diameter	2.992 in	76.0 mm	2.922 in	74.2 mm
5	Steel cross-section	2.590 in^2	1671 mm^2	2.915 in^2	1881 mm^2
6	Capacity	0.365 gal/ft	4.54 l/m	0.348 gal/ft	4.33 l/m
7	Displacement	0.500 gal/ft	6.21 l/m	0.500 gal/ft	6.21 l/m

#													
8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
9	Collapse resistance (MPa)	51.0	72.6	72.6	79.8	83.3	93.3	57.5	83.6	83.6	94.0	99.2	114.9
10	Internal yield pressure (MPa)	48.2	70.1	70.1	78.8	83.2	96.3	54.8	79.7	79.7	89.7	94.6	109.6
11	Pipe body yield strength (1000 daN)	63.4	92.2	92.2	103.7	109.5	126.7	71.3	103.7	103.7	116.7	123.2	142.6

Connection efficiency

#		3.500 in, 9.20/9.30 lb/ft	3.500 in, 10.20 lb/ft
12	API Non-Upset	76.8	79.4
13	API External Upset	100.0	
14	Grant Prideco CSTCP	100.0	100.0
15	Grant Prideco STL	50.0	56.4
16	Grant Prideco TCII	100.0	100.0
17	Hydril CS	100.0	100.0
18	Hydril PH4-PH6		
19	Vallourec & Mannesmann TDS	100.0	100.0
20	Vallourec & Mannesmann New VAM	103.4	104.8
21	Vallourec & Mannesmann VAM ACE	101.5	102.9
22	Vallourec & Mannesmann VAM PRO	100.0	100.0
23	Vallourec & Mannesmann FJL	54.8	54.8

Connection characteristics

#		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
		J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
24	API Non-Upset	201	278	301		355	108.0		72.8	233	323	351			108.0		71.0
25	API External Upset	309	430	465		549	114.3		72.8								
26	Grant Prideco CSTCP	381	458			458	99.4	74.2	72.8	381	458			458	101.1	72.9	71.0
27	Grant Prideco STL	163	217	217	217	217	88.9	76.0	72.8	163	217	217	217	217	88.9	72.3	71.0
28	Grant Prideco TCII		427	427	427	427	98.7	75.7	72.8		427	427	427	427	100.1	73.9	71.0
29	Hydril CS	380	461	461	461	461	99.4	74.2	72.8	380	461	461	461	461	99.4	72.9	71.0
30	Hydril PH4-PH6																
31	Vallourec & Mannesmann TDS						107.9	76.0	72.8						107.9	74.2	71.0
32	Vallourec & Mannesmann New VAM	324	441	510	510	579	99.1		72.8	363	500	579	579	658	100.6		71.0
33	Vallourec & Mannesmann VAM ACE	334	382	412	412	441	97.0		72.8	422	470	500	500	540	100.3		71.0
34	Vallourec & Mannesmann VAM PRO						98.0		72.8						99.4		71.0
35	Vallourec & Mannesmann FJL		167	176	176	186	88.9	74.7	72.8		186	195	195	216	88.9	72.6	71.0

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

	No.		3.500 in			88.9 mm			3.500 in			88.9 mm		
Pipe body	1	Nominal size (OD)	**3.500** in			88.9 mm			**3.500** in			88.9 mm		
	2	Nominal weight	**12.70/12.95** lb/ft			18.53/18.90 daN/m			**13.70** lb/ft			20.00 daN/m		
	3	Wall thickness	0.375 in			9.5 mm			0.413 in			10.5 mm		
	4	Inside diameter	2.750 in			69.9 mm			2.674 in			67.9 mm		
	5	Steel cross-section	3.682 in^2			2375 mm^2			4.005 in^2			2584 mm^2		
	6	Capacity	0.309 gal/ft			3.83 l/m			0.292 gal/ft			3.62 l/m		
	7	Displacement	0.500 gal/ft			6.21 l/m			0.500 gal/ft			6.21 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	72.6	105.5	105.5	118.7	125.3	145.1	78.9	114.8	114.8	129.2	136.3	157.9
	10	Internal yield pressure (MPa)	71.1	103.4	103.4	116.3	122.8	142.2	78.3	113.9	113.9	128.1	135.3	156.6
	11	Pipe body yield strength (1000 daN)	90.1	131.0	131.0	147.4	155.6	180.1	98.0	142.5	142.5	160.3	169.3	196.0

	No.		3.500 in	3.500 in
Connection efficiency	12	API Non-Upset	83.7	
	13	API External Upset	100.0	
	14	Grant Prideco CSTCP	100.0	
	15	Grant Prideco STL	64.7	
	16	Grant Prideco TCII	100.0	
	17	Hydril CS		
	18	Hydril PH4-PH6	100.0	
	19	Vallourec & Mannesmann TDS	100.0	
	20	Vallourec & Mannesmann New VAM	103.2	104.4
	21	Vallourec & Mannesmann VAM ACE	101.8	104.7
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL	64.9	67.7

	No.		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset		430	466		550	108.0		66.7								
	25	API External Upset		576	625		736	114.3		66.7								
	26	Grant Prideco CSTCP		841			1071	109.6	68.2	66.7								
	27	Grant Prideco STL	244	312	312	312	312	88.9	67.4	66.7								
	28	Grant Prideco TCII		427	427	427	427	103.2	69.5	66.7								
	29	Hydril CS																
	30	Hydril PH4-PH6		841	929	976	1071	109.6	68.2	66.7								
	31	Vallourec & Mannesmann TDS						107.9	69.8	66.7								
	32	Vallourec & Mannesmann New VAM	431	579	667	667	755	103.6		66.7	500	677	785	785	892	105.1		64.7
	33	Vallourec & Mannesmann VAM ACE	588	667	716	716	765	103.4		66.7	637	735	785	785	883	105.1		64.7
	34	Vallourec & Mannesmann VAM PRO						102.5		66.7						102.5		64.7
	35	Vallourec & Mannesmann FJL		236	264	264	294	88.9	67.9	66.7		255	285	285	324	88.9	65.9	64.7

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

	No.													
Pipe body	1	Nominal size (OD)	**3.500** in			88.9 mm			**3.500** in			88.9 mm		
	2	Nominal weight	**14.30** lb/ft			20.87 daN/m			**14.70** lb/ft			21.45 daN/m		
	3	Wall thickness	0.430 in			10.9 mm			0.449 in			11.4 mm		
	4	Inside diameter	2.640 in			67.1 mm			2.602 in			66.1 mm		
	5	Steel cross-section	4.147 in^2			2676 mm^2			4.304 in^2			2777 mm^2		
	6	Capacity	0.284 gal/ft			3.53 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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	81.7	118.9	118.9	133.7	141.2	163.5	84.8	123.4	123.4	138.8	146.5	169.6
	10	Internal yield pressure (MPa)	81.5	118.6	118.6	133.4	140.8	163.1	85.1	123.8	123.8	139.3	147.0	170.3
	11	Pipe body yield strength (1000 daN)	101.5	147.6	147.6	166.0	175.3	202.9	105.3	153.1	153.1	172.3	181.9	210.6

	No.		3.500 in – 14.30 lb/ft	3.500 in – 14.70 lb/ft
Connection efficiency	12	API Non-Upset		
	13	API External Upset		
	14	Grant Prideco CSTCP		
	15	Grant Prideco STL		
	16	Grant Prideco TCII		
	17	Hydril CS	100.0	
	18	Hydril PH4-PH6		
	19	Vallourec & Mannesmann TDS		
	20	Vallourec & Mannesmann New VAM		105.6
	21	Vallourec & Mannesmann VAM ACE	101.9	106.9
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL		68.1

	No.		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP																
	27	Grant Prideco STL																
	28	Grant Prideco TCII																
	29	Hydril CS																
	30	Hydril PH4-PH6		841	929	976	1071	112.0	64.8	63.9								
	31	Vallourec & Mannesmann TDS																
	32	Vallourec & Mannesmann New VAM									579	795	883	883	1029	106.5		62.9
	33	Vallourec & Mannesmann VAM ACE						105.2		63.9	735	834	931	931	1029	106.7		62.9
	34	Vallourec & Mannesmann VAM PRO						103.0		63.9						103.7		62.9
	35	Vallourec & Mannesmann FJL										275	304	304	343	88.9	64.1	62.9

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

	No.	Property	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
Pipe body	1	Nominal size (OD)	**3.500** in			88.9 mm			**3.500** in			88.9 mm		
	2	Nominal weight	**15.50** lb/ft			22.62 daN/m			**17.00** lb/ft			24.81 daN/m		
	3	Wall thickness	0.476 in			12.1 mm			0.530 in			13.5 mm		
	4	Inside diameter	2.548 in			64.7 mm			2.440 in			62.0 mm		
	5	Steel cross-section	4.522 in²			2917 mm²			4.945 in²			3190 mm²		
	6	Capacity	0.265 gal/ft			3.29 l/m			0.243 gal/ft			3.02 l/m		
	7	Displacement	0.500 gal/ft			6.21 l/m			0.500 gal/ft			6.21 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	89.1	129.6	129.6	145.8	153.9	178.2	97.5	141.8	141.8	159.5	168.3	194.9
	10	Internal yield pressure (MPa)	90.3	131.3	131.3	147.7	155.9	180.5	100.5	146.2	146.2	164.4	173.6	201.0
	11	Pipe body yield strength (1000 daN)	110.6	160.9	160.9	181.0	191.1	221.3	121.0	176.0	176.0	198.0	209.0	242.0
Connection efficiency	12	API Non-Upset												
	13	API External Upset												
	14	Grant Prideco CSTCP	100.0											
	15	Grant Prideco STL	66.7											
	16	Grant Prideco TCII	100.0											
	17	Hydril CS												
	18	Hydril PH4-PH6	100.0						100.0					
	19	Vallourec & Mannesmann TDS												
	20	Vallourec & Mannesmann New VAM	103.0											
	21	Vallourec & Mannesmann VAM ACE	101.7											
	22	Vallourec & Mannesmann VAM PRO	100.0											
	23	Vallourec & Mannesmann FJL	68.0											

	No.	Connection	Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP		841			1071	114.3	63.1	61.5								
	27	Grant Prideco STL	312	393	393	393	393	88.9	63.2	61.5								
	28	Grant Prideco TCII		427	427	427	427	107.0	64.7	61.5								
	29	Hydril CS																
	30	Hydril PH4-PH6		841	929	976	1071	114.3	63.1	61.5		1220	1342	1403	1525	115.9	60.3	58.8
	31	Vallourec & Mannesmann TDS																
	32	Vallourec & Mannesmann New VAM	588	804	883	883	1029	107.0		61.5								
	33	Vallourec & Mannesmann VAM ACE	785	883	980	980	1079	106.7		61.5								
	34	Vallourec & Mannesmann VAM PRO						104.5		61.5								
	35	Vallourec & Mannesmann FJL		294	324	324	373	88.9	62.8	61.5								

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (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			13.86 daN/m			**11.00** lb/ft			16.05 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			1729 mm^2			3.077 in^2			1985 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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
9	Collapse resistance (MPa)	35.3	45.4	45.4	48.8	50.4	54.5	45.5	60.7	60.7	66.2	68.8	76.2
10	Internal yield pressure (MPa)	37.5	54.5	54.5	61.4	64.8	75.0	43.5	63.2	63.2	71.1	75.1	86.9
11	Pipe body yield strength (1000 daN)	65.6	95.4	95.4	107.3	113.2	131.1	75.3	109.5	109.5	123.2	130.0	150.5

Connection efficiency

		4.000 in – 9.50 lb/ft	4.000 in – 11.00 lb/ft
12	API Non-Upset	67.2	
13	API External Upset		100.0
14	Grant Prideco CSTCP		100.0
15	Grant Prideco STL	47.0	55.1
16	Grant Prideco TCII	100.0	100.0
17	Hydril CS		100.0
18	Hydril PH4-PH6		
19	Vallourec & Mannesmann TDS	100.0	100.0
20	Vallourec & Mannesmann New VAM	104.0	103.8
21	Vallourec & Mannesmann VAM ACE	101.9	101.9
22	Vallourec & Mannesmann VAM PRO	100.0	100.0
23	Vallourec & Mannesmann FJL	48.1	54.8

Connection characteristics — 4.000 in, 9.50 lb/ft

		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
		J55	LN80	C90	C95	P110			
24	API Non-Upset	165	230	264			120.7		86.9
25	API External Upset								
26	Grant Prideco CSTCP								
27	Grant Prideco STL	149	190	190	190	190	101.6	88.1	86.9
28	Grant Prideco TCII		488	488	488	488	110.6	89.8	86.9
29	Hydril CS								
30	Hydril PH4-PH6								
31	Vallourec & Mannesmann TDS						120.7	88.3	86.9
32	Vallourec & Mannesmann New VAM	392	540	628	628	706	110.4		86.9
33	Vallourec & Mannesmann VAM ACE	343	392	441	441	491	110.2		86.9
34	Vallourec & Mannesmann VAM PRO						110.0		86.9
35	Vallourec & Mannesmann FJL		176	206	206	236	101.6	88.4	86.9

Connection characteristics — 4.000 in, 11.00 lb/ft

		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
		J55	LN80	C90	C95	P110			
24	API Non-Upset								
25	API External Upset	347	485	525			127.0		85.1
26	Grant Prideco CSTCP	458	534			534	112.2	86.2	85.1
27	Grant Prideco STL	176	217	217	217	217	101.6	86.0	85.1
28	Grant Prideco TCII		488	488	488	488	112.1	88.0	85.1
29	Hydril CS	461	536	536	536	536	112.2	86.2	85.1
30	Hydril PH4-PH6								
31	Vallourec & Mannesmann TDS						120.7	88.3	85.1
32	Vallourec & Mannesmann New VAM	412	559	647	647	735	111.9		85.1
33	Vallourec & Mannesmann VAM ACE	441	519	569	569	618	111.7		85.1
34	Vallourec & Mannesmann VAM PRO						111.4		85.1
35	Vallourec & Mannesmann FJL		195	216	216	245	101.6	86.3	85.1

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**4.000** in			101.6 mm			**4.000** in			101.6 mm		
	2	Nominal weight	**13.20** lb/ft			19.26 daN/m			**14.80** lb/ft			21.60 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			2455 mm^2			4.322 in^2			2788 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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	57.4	83.5	83.5	93.9	99.2	114.8	65.2	94.8	94.8	106.7	112.6	130.4
	10	Internal yield pressure (MPa)	54.7	79.6	79.6	89.6	94.6	109.5	63.0	91.7	91.7	103.2	108.9	126.1
	11	Pipe body yield strength (1000 daN)	93.1	135.4	135.4	152.3	160.8	186.2	105.7	153.8	153.8	173.0	182.6	211.5
Connection efficiency	12	API Non-Upset												
	13	API External Upset												
	14	Grant Prideco CSTCP	100.0											
	15	Grant Prideco STL	58.4											
	16	Grant Prideco TCII	100.0											
	17	Hydril CS												
	18	Hydril PH4-PH6	100.0											
	19	Vallourec & Mannesmann TDS												
	20	Vallourec & Mannesmann New VAM	103.9						106.5					
	21	Vallourec & Mannesmann VAM ACE	102.0						106.5					
	22	Vallourec & Mannesmann VAM PRO	100.0						100.0					
	23	Vallourec & Mannesmann FJL	55.0						60.4					

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP		841			1071	117.5	83.2	81.7								
	27	Grant Prideco STL	227	285	285	285	285	101.6	83.2	81.7								
	28	Grant Prideco TCII		488	488	488	488	114.8	86.4	81.7								
	29	Hydril CS																
	30	Hydril PH4-PH6		841	929	976	1071	117.5	83.2	81.7								
	31	Vallourec & Mannesmann TDS																
	32	Vallourec & Mannesmann New VAM	470	647	746	746	843	114.7		81.7	588	813	941	941	1079	117.0		79.1
	33	Vallourec & Mannesmann VAM ACE	491	588	637	637	686	114.4		81.7	637	765	834	834	912	117.0		79.1
	34	Vallourec & Mannesmann VAM PRO						114.1		81.7						114.4		79.1
	35	Vallourec & Mannesmann FJL		304	343	343	373	101.6	82.8	81.7		353	382	382	412	101.6	80.4	79.1

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**4.000** in			101.6 mm			**4.000** in			101.6 mm		
	2	Nominal weight	**16.10** lb/ft			23.50 daN/m			**16.50** lb/ft			24.08 daN/m		
	3	Wall thickness	0.415 in			10.5 mm			0.430 in			10.9 mm		
	4	Inside diameter	3.170 in			80.5 mm			3.140 in			79.8 mm		
	5	Steel cross-section	4.674 in²			3015 mm²			4.823 in²			3111 mm²		
	6	Capacity	0.410 gal/ft			5.09 l/m			0.402 gal/ft			5.00 l/m		
	7	Displacement	0.653 gal/ft			8.11 l/m			0.653 gal/ft			8.11 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	70.5	102.6	102.6	115.4	121.8	141.0	72.8	105.8	105.8	119.1	125.7	145.5
	10	Internal yield pressure (MPa)	68.9	100.1	100.1	112.7	118.9	137.7	71.3	103.8	103.8	116.7	123.2	142.7
	11	Pipe body yield strength (1000 daN)	114.3	166.3	166.3	187.1	197.5	228.7	118.0	171.6	171.6	193.1	203.8	236.0

			4.000 in – 16.10 lb/ft	4.000 in – 16.50 lb/ft
Connection efficiency	12	API Non-Upset		
	13	API External Upset		
	14	Grant Prideco CSTCP		
	15	Grant Prideco STL		
	16	Grant Prideco TCII		
	17	Hydril CS		
	18	Hydril PH4-PH6	100.0	
	19	Vallourec & Mannesmann TDS		
	20	Vallourec & Mannesmann New VAM		102.8
	21	Vallourec & Mannesmann VAM ACE	102.0	101.5
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL		64.5

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP																
	27	Grant Prideco STL																
	28	Grant Prideco TCII																
	29	Hydril CS																
	30	Hydril PH4-PH6		841	929	976	1071	121.0	78.2	77.3								
	31	Vallourec & Mannesmann TDS																
	32	Vallourec & Mannesmann New VAM									607	824	961	961	1079	118.3		76.6
	33	Vallourec & Mannesmann VAM ACE						117.6		77.3	735	883	980	980	1079	118.0		76.6
	34	Vallourec & Mannesmann VAM PRO						115.7		77.3						116.2		76.6
	35	Vallourec & Mannesmann FJL										392	422	422	451	101.6	92.2	76.6

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body	1	Nominal size (OD)	**4.000** in			101.6 mm			**4.000** in			101.6 mm		
	2	Nominal weight	**18.90** lb/ft			27.58 daN/m			**22.20** lb/ft			32.40 daN/m		
	3	Wall thickness	0.500 in			12.7 mm			0.610 in			15.5 mm		
	4	Inside diameter	3.000 in			76.2 mm			2.780 in			70.6 mm		
	5	Steel cross-section	5.498 in^2			3547 mm^2			6.496 in^2			4191 mm^2		
	6	Capacity	0.367 gal/ft			4.56 l/m			0.315 gal/ft			3.92 l/m		
	7	Displacement	0.653 gal/ft			8.11 l/m			0.653 gal/ft			8.11 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	83.0	120.7	120.7	135.7	143.3	165.9	98.0	142.6	142.6	160.4	169.3	196.0
	10	Internal yield pressure (MPa)	83.0	120.7	120.7	135.7	143.3	165.9	101.2	147.2	147.2	165.6	174.8	202.4
	11	Pipe body yield strength (1000 daN)	134.5	195.6	195.6	220.1	232.3	269.0	158.9	231.2	231.2	260.1	274.5	317.9
Connection efficiency	12	API Non-Upset												
	13	API External Upset												
	14	Grant Prideco CSTCP												
	15	Grant Prideco STL												
	16	Grant Prideco TCII												
	17	Hydril CS												
	18	Hydril PH4-PH6	100.0						100.0					
	19	Vallourec & Mannesmann TDS												
	20	Vallourec & Mannesmann New VAM												
	21	Vallourec & Mannesmann VAM ACE	102.2						102.0					
	22	Vallourec & Mannesmann VAM PRO	100.0											
	23	Vallourec & Mannesmann FJL												

Connection characteristics			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP																
	27	Grant Prideco STL																
	28	Grant Prideco TCII																
	29	Hydril CS																
	30	Hydril PH4-PH6		1295	1417	1478	1600	127.0	74.2	73.0		1451	1573	1634	1756	131.8	68.6	67.4
	31	Vallourec & Mannesmann TDS																
	32	Vallourec & Mannesmann New VAM																
	33	Vallourec & Mannesmann VAM ACE	883	956	1029	1029	1125	120.5		73.0						123.9		67.4
	34	Vallourec & Mannesmann VAM PRO						118.6		73.0								
	35	Vallourec & Mannesmann FJL																

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body

1	Nominal size (OD)	**4.500** in			114.3 mm			**4.500** in			114.3 mm		
2	Nominal weight	**12.60/12.75** lb/ft			18.39/18.61 daN/m			**15.20** lb/ft			22.18 daN/m		
3	Wall thickness	0.271 in			6.9 mm			0.337 in			8.6 mm		
4	Inside diameter	3.958 in			100.5 mm			3.826 in			97.2 mm		
5	Steel cross-section	3.600 in^2			2323 mm^2			4.407 in^2			2844 mm^2		
6	Capacity	0.639 gal/ft			7.94 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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
9	Collapse resistance (MPa)	39.5	51.7	51.7	56.0	58.0	63.5	52.5	76.4	76.4	84.3	88.0	98.9
10	Internal yield pressure (MPa)	40.0	58.1	58.1	65.4	69.0	79.9	49.7	72.3	72.3	81.3	85.8	99.4
11	Pipe body yield strength (1000 daN)	88.1	128.1	128.1	144.1	152.1	176.2	107.8	156.8	156.8	176.4	186.2	215.7

Connection efficiency

		4.500 in – 12.60/12.75 lb/ft	4.500 in – 15.20 lb/ft
12	API Non-Upset	72.5	
13	API External Upset	100.0	
14	Grant Prideco CSTCP	100.0	100.0
15	Grant Prideco STL	55.9	58.9
16	Grant Prideco TCII	100.0	100.0
17	Hydril CS	100.0	
18	Hydril PH4-PH6		100.0
19	Vallourec & Mannesmann TDS	100.0	100.0
20	Vallourec & Mannesmann New VAM	101.4	103.6
21	Vallourec & Mannesmann VAM ACE	115.2	101.9
22	Vallourec & Mannesmann VAM PRO	100.0	100.0
23	Vallourec & Mannesmann FJL	49.9	59.1

Connection characteristics

		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
		J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
24	API Non-Upset	236	328	357			132.1		97.4								
25	API External Upset	388	540	587			141.3		97.4								
26	Grant Prideco CSTCP	534	686			686	125.0	98.2	97.4		915			1146	130.2	96.5	94.0
27	Grant Prideco STL	203	258	258	258	258	114.3	98.7	97.4	258	339	339	339	339	114.3	95.9	94.0
28	Grant Prideco TCII		549	549	549	549	125.3	100.2	97.4		549	549	549	549	127.9	96.8	94.0
29	Hydril CS	536	685	685	685	685	125.0	98.2	97.4								
30	Hydril PH4-PH6										915	1010	1051	1146	130.2	95.6	94.0
31	Vallourec & Mannesmann TDS						132.1	100.5	97.4						132.1	97.2	94.0
32	Vallourec & Mannesmann New VAM	480	647	746	746	834	124.3		97.4	569	785	902	902	1029	127.3		94.0
33	Vallourec & Mannesmann VAM ACE	441	491	540	540	588	126.0		97.4	588	735	785	785	834	127.1		94.0
34	Vallourec & Mannesmann VAM PRO						124.9		97.4						125.3		94.0
35	Vallourec & Mannesmann FJL		304	334	334	373	114.3	98.5	97.4		343	373	373	412	114.3	95.4	94.0

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

Pipe body

1	Nominal size (OD)	**4.500** in			114.3 mm			**4.500** in			114.3 mm		
2	Nominal weight	**17.00** lb/ft			24.81 daN/m			**18.90** lb/ft			27.58 daN/m		
3	Wall thickness	0.380 in			9.7 mm			0.430 in			10.9 mm		
4	Inside diameter	3.740 in			95.0 mm			3.640 in			92.5 mm		
5	Steel cross-section	4.918 in^2			3173 mm^2			5.498 in^2			3547 mm^2		
6	Capacity	0.571 gal/ft			7.09 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	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
9	Collapse resistance (MPa)	58.6	85.3	85.3	96.0	101.3	117.3	65.5	95.3	95.3	107.3	113.2	131.1
10	Internal yield pressure (MPa)	56.0	81.5	81.5	91.7	96.8	112.1	63.4	92.2	92.2	103.8	109.5	126.8
11	Pipe body yield strength (1000 daN)	120.3	175.0	175.0	196.9	207.8	240.7	134.5	195.7	195.7	220.1	232.3	269.0

Connection efficiency

		4.500 in, 17.00 lb/ft	4.500 in, 18.90 lb/ft
12	API Non-Upset		
13	API External Upset		
14	Grant Prideco CSTCP		
15	Grant Prideco STL		
16	Grant Prideco TCII		
17	Hydril CS		
18	Hydril PH4-PH6	100.0	100.0
19	Vallourec & Mannesmann TDS		100.0
20	Vallourec & Mannesmann New VAM	108.5	102.8
21	Vallourec & Mannesmann VAM ACE	107.6	110.3
22	Vallourec & Mannesmann VAM PRO	100.0	100.0
23	Vallourec & Mannesmann FJL	63.3	65.1

Connection characteristics — 4.500 in, 17.00 lb/ft

		Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)
24	API Non-Upset								
25	API External Upset								
26	Grant Prideco CSTCP								
27	Grant Prideco STL								
28	Grant Prideco TCII								
29	Hydril CS								
30	Hydril PH4-PH6		1024	1132	1173	1281	132.3	92.7	91.8
31	Vallourec & Mannesmann TDS						127.0	95.0	91.8
32	Vallourec & Mannesmann New VAM	686	941	1079	1079	1227	129.7		91.8
33	Vallourec & Mannesmann VAM ACE	735	883	931	931	980	129.7		91.8
34	Vallourec & Mannesmann VAM PRO						127.0		91.8
35	Vallourec & Mannesmann FJL		373	412	412	451	114.3	93.3	91.8

Connection characteristics — 4.500 in, 18.90 lb/ft

		Make-up torque (daN.m) J55	LN80	C90	C95	P110	OD (mm)	ID (mm)	Drift API (mm)
24	API Non-Upset								
25	API External Upset								
26	Grant Prideco CSTCP								
27	Grant Prideco STL								
28	Grant Prideco TCII								
29	Hydril CS								
30	Hydril PH4-PH6		1146	1268	1329	1451	135.0	90.4	89.3
31	Vallourec & Mannesmann TDS						127.0	92.5	89.3
32	Vallourec & Mannesmann New VAM	706	961	1125	1125	1274	130.7		89.3
33	Vallourec & Mannesmann VAM ACE	883	1029	1125	1125	1227	132.1		89.3
34	Vallourec & Mannesmann VAM PRO						128.8		89.3
35	Vallourec & Mannesmann FJL		403	442	442	500	114.3	90.8	89.3

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

	#													
Pipe body	1	Nominal size (OD)	**4.500** in			114.3 mm			**4.500** in			114.3 mm		
	2	Nominal weight	**21.50** lb/ft			31.38 daN/m			**23.70** lb/ft			34.59 daN/m		
	3	Wall thickness	0.500 in			12.7 mm			0.560 in			14.2 mm		
	4	Inside diameter	3.500 in			88.9 mm			3.380 in			85.9 mm		
	5	Steel cross-section	6.283 in^2			4054 mm^2			6.932 in^2			4472 mm^2		
	6	Capacity	0.500 gal/ft			6.21 l/m			0.466 gal/ft			5.79 l/m		
	7	Displacement	0.826 gal/ft			10.26 l/m			0.826 gal/ft			10.26 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	74.9	109.0	109.0	122.6	129.4	149.8	82.6	120.2	120.2	135.2	142.7	165.3
	10	Internal yield pressure (MPa)	73.7	107.3	107.3	120.7	127.4	147.5	82.6	120.1	120.1	135.1	142.6	165.2
	11	Pipe body yield strength (1000 daN)	153.7	223.6	223.6	251.5	265.5	307.4	169.6	246.7	246.7	277.5	292.9	339.2

Connection efficiency	#		4.500 in – 21.50 lb/ft	4.500 in – 23.70 lb/ft
	12	API Non-Upset		
	13	API External Upset		
	14	Grant Prideco CSTCP		
	15	Grant Prideco STL		
	16	Grant Prideco TCII		
	17	Hydril CS		
	18	Hydril PH4-PH6	100.0	100.0
	19	Vallourec & Mannesmann TDS	100.0	
	20	Vallourec & Mannesmann New VAM	107.4	103.7
	21	Vallourec & Mannesmann VAM ACE	106.8	101.9
	22	Vallourec & Mannesmann VAM PRO	100.0	100.0
	23	Vallourec & Mannesmann FJL	65.0	65.1

Connection characteristics	#		Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110				J55	LN80	C90	C95	P110			
	24	API Non-Upset																
	25	API External Upset																
	26	Grant Prideco CSTCP																
	27	Grant Prideco STL																
	28	Grant Prideco TCII																
	29	Hydril CS																
	30	Hydril PH4-PH6		1451	1600	1681	1830	139.7	86.9	85.7		1559	1708	1803	1986	141.3	83.8	82.7
	31	Vallourec & Mannesmann TDS						127.0	92.5	85.7								
	32	Vallourec & Mannesmann New VAM	834	1180	1376	1376	1620	134.1		85.7	853	1227	1424	1424	1620	135.5		82.7
	33	Vallourec & Mannesmann VAM ACE	1079	1274	1376	1376	1471	134.1		85.7	1274	1566	1668	1668	1760	135.2		82.7
	34	Vallourec & Mannesmann VAM PRO						131.3		85.7						133.4		82.7
	35	Vallourec & Mannesmann FJL		451	491	491	549	114.3	87.7	85.7		451	530	530	588	114.3	84.7	82.7

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF TUBING (continued)

	No.	Item						
Pipe body	1	Nominal size (OD)	**4.500** in			114.3 mm		
	2	Nominal weight	**26.10** lb/ft			38.09 daN/m		
	3	Wall thickness	0.630 in			16.0 mm		
	4	Inside diameter	3.240 in			82.3 mm		
	5	Steel cross-section	7.660 in^2			4942 mm^2		
	6	Capacity	0.428 gal/ft			5.32 l/m		
	7	Displacement	0.826 gal/ft			10.26 l/m		
	8	Grade	J55	L80	N80	C90	T95	P110
	9	Collapse resistance (MPa)	91.3	132.8	132.8	149.4	157.7	182.6
	10	Internal yield pressure (MPa)	92.9	135.1	135.1	152.0	160.5	185.8
	11	Pipe body yield strength (1000 daN)	187.4	272.6	272.6	306.6	323.7	374.8
Connection efficiency	12	API Non-Upset						
	13	API External Upset						
	14	Grant Prideco CSTCP						
	15	Grant Prideco STL						
	16	Grant Prideco TCII						
	17	Hydril CS						
	18	Hydril PH4-PH6	100.0					
	19	Vallourec & Mannesmann TDS						
	20	Vallourec & Mannesmann New VAM						
	21	Vallourec & Mannesmann VAM ACE						
	22	Vallourec & Mannesmann VAM PRO						
	23	Vallourec & Mannesmann FJL						

	No.	Connection	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			J55	LN80	C90	C95	P110			
Connection characteristics	24	API Non-Upset								
	25	API External Upset								
	26	Grant Prideco CSTCP								
	27	Grant Prideco STL								
	28	Grant Prideco TCII								
	29	Hydril CS								
	30	Hydril PH4-PH6		1756	1939	2027	2210	144.5	80.3	79.1
	31	Vallourec & Mannesmann TDS								
	32	Vallourec & Mannesmann New VAM								
	33	Vallourec & Mannesmann VAM ACE								
	34	Vallourec & Mannesmann VAM PRO								
	35	Vallourec & Mannesmann FJL								

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING

Pipe body

1	Nominal size (OD)	**4.500** in	114.3 mm	**4.500** in	114.3 mm
2	Nominal weight	**10.50** lb/ft	15.3 daN/m	**11.60** lb/ft	16.9 daN/m
3	Wall thickness	0.224 in	5.7 mm	0.250 in	6.3 mm
4	Inside diameter	4.052 in	102.9 mm	4.000 in	101.6 mm
5	Steel cross-section	3.01 in^2	1941 mm^2	3.34 in^2	2154 mm^2
6	Capacity	0.67 gal/ft	8.32 l/m	0.65 gal/ft	8.11 l/m
7	Displacement (1)	0.83 gal/ft	10.26 l/m	0.83 gal/ft	10.26 l/m

		10.50 lb/ft							11.60 lb/ft						
8	Grade	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
9	Collapse resistance (MPa)	27.6	34.0	34.0	35.9	36.6	38.3	40.2	34.2	43.8	43.8	47.0	48.4	52.2	55.2
10	Internal yield pressure (MPa)	33.0	48.0	48.0	54.1	57.1	66.1	75.1	36.9	53.6	53.6	60.3	63.7	73.7	83.8
11	Pipe body yield strength (1000 daN)	74	107	107	120	127	147	167	82	119	119	134	141	163	186

Tensile strength (10^3 daN)

		10.50 lb/ft							11.60 lb/ft						
12	Buttress Standard	111	117	122	124	130	154	168	123	129	135	138	145	171	187
13	Buttress Special Clearance	111	117	122	124	130	154	168	123	129	135	138	145	171	187
14	API STC	65	81	83	85	90	107	115	76	94	96	99	104	124	134
15	API LTC	69	81	85	85	90	107	115	80	94	99	99	104	124	134

Connection efficiency

		10.50 lb/ft	11.60 lb/ft
16	Grant Prideco TCII		
17	Grant Prideco STL	48.5	52.8
18	Hydril LX		
19	Hydril 563		91.1
20	Hydril 511	63.2	63.2
21	Hydril 521	60.5	64.1
22	Vallourec & Mannesmann New VAM	113.7	102.5
23	Vallourec & Mannesmann VAM ACE	112.4	104.1
24	Vallourec & Mannesmann VAM PRO	100.0	100.0
25	Vallourec & Mannesmann VAM TOP		
26	Vallourec & Mannesmann FJL		45.9

Connection characteristics

4.500 in – 10.50 lb/ft

		Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard						127.0		99.7
28	Buttress Special Clearance						123.8		99.7
29	API STC	198					127.0		99.7
30	API LTC								
31	Grant Prideco TCII		549	549	549	549	123.3	104.4	99.7
32	Grant Prideco STL	149	190	190	190	190	114.3	100.4	99.7
33	Hydril LX								
34	Hydril 563								
35	Hydril 511	230	230	230	230	230	114.3	100.6	99.7
36	Hydril 521	420	420	420	420	420	118.1	101.0	99.7
37	Vallourec & Mannesmann New VAM	461	607	706	795	892	123.5		99.7
38	Vallourec & Mannesmann VAM ACE	373	451	491	540	588	123.5		99.7
39	Vallourec & Mannesmann VAM PRO						122.9		99.7
40	Vallourec & Mannesmann VAM TOP								
41	Vallourec & Mannesmann FJL								

4.500 in – 11.60 lb/ft

		Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard						127.0		98.4
28	Buttress Special Clearance						123.8		98.4
29	API STC	230					127.0		98.4
30	API LTC	244	306	350	409		127.0		98.4
31	Grant Prideco TCII		549	549	549	549	124.4	103.1	98.4
32	Grant Prideco STL	176	230	230	230	230	114.3	99.8	98.4
33	Hydril LX								
34	Hydril 563	407	407	407	407		132.1	100.3	98.4
35	Hydril 511	244	244	244	244	244	114.3	99.3	98.4
36	Hydril 521	488	488	488	488	488	119.3	100.6	98.4
37	Vallourec & Mannesmann New VAM	470	628	725	813	912	123.5		98.4
38	Vallourec & Mannesmann VAM ACE	441	540	588	637	686	123.8		98.4
39	Vallourec & Mannesmann VAM PRO						124.0		98.4
40	Vallourec & Mannesmann VAM TOP								
41	Vallourec & Mannesmann FJL		294	324	363	403	114.3	99.5	98.4

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section							
Pipe body	1	Nominal size (OD)	1	**4.500** in	114.3 mm	**4.500** in	114.3 mm
Pipe body	2	Nominal weight	2	**13.50** lb/ft	19.7 daN/m	**15.10** lb/ft	22.0 daN/m
Pipe body	3	Wall thickness	3	0.290 in	7.4 mm	0.337 in	8.6 mm
Pipe body	4	Inside diameter	4	3.920 in	99.6 mm	3.826 in	97.2 mm
Pipe body	5	Steel cross-section	5	3.84 in^2	2475 mm^2	4.41 in^2	2844 mm^2
Pipe body	6	Capacity	6	0.63 gal/ft	7.79 l/m	0.60 gal/ft	7.42 l/m
Pipe body	7	Displacement (1)	7	0.83 gal/ft	10.26 l/m	0.83 gal/ft	10.26 l/m

Section																	
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	44.3	58.9	58.9	64.1	66.6	73.7	80.0	52.5	76.4	76.4	84.3	88.0	98.9	109.1
Pipe body	10	Internal yield pressure (MPa)	10	42.8	62.2	62.2	70.0	73.9	85.5	97.2	49.7	72.3	72.3	81.3	85.8	99.4	112.9
Pipe body	11	Pipe body yield strength (1000 daN)	11	94	136	136	154	162	188	213	108	157	157	176	186	216	245
Tensile strength (10^3 daN)	12	Buttress Standard	12	141	149	155	158	166	197	214	162	171	178	182	191	226	246
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	141	142	150	150	157	187	202	142	142	150	150	157	187	202
Tensile strength (10^3 daN)	14	API STC	14	92	114	117	120	126	150	162	110	137	140	144	152	180	195
Tensile strength (10^3 daN)	15	API LTC	15	97	114	120	120	126	150	162	116	137	144	144	152	180	195

Section				4.500 in, 13.50 lb/ft	4.500 in, 15.10 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	56.9	58.9
Connection efficiency	18	Hydril LX	18	73.8	72.8
Connection efficiency	19	Hydril 563	19	92.2	93.3
Connection efficiency	20	Hydril 511	20	60.6	61.2
Connection efficiency	21	Hydril 521	21	68.2	
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	109.0	103.6
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	108.1	101.9
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25		
Connection efficiency	26	Vallourec & Mannesmann FJL	26	52.9	59.1

Section				Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27						127.0		96.4						127.0		94.0
Connection characteristics	28	Buttress Special Clearance	28						123.8		96.4						123.8		94.0
Connection characteristics	29	API STC	29																
Connection characteristics	30	API LTC	30		371	424	496		127.0		96.4				597	666	127.0		94.0
Connection characteristics	31	Grant Prideco TCII	31		549	549	549	549	126.0	101.1	96.4		549	549	549	549	127.9	98.7	94.0
Connection characteristics	32	Grant Prideco STL	32	217	285	285	285	285	114.3	97.9	96.4	258	339	339	339	339	114.3	95.9	94.0
Connection characteristics	33	Hydril LX	33	339	400	441	475	508	116.5	97.5	96.4	407	488	529	583	630	116.8	95.1	94.0
Connection characteristics	34	Hydril 563	34	542	542	542	542		132.1	98.3	96.4	800	800	800	800		132.1		94.0
Connection characteristics	35	Hydril 511	35	285	285	285	285	285	114.3	97.2	96.4	380	380	380	380	380	114.3	94.8	94.0
Connection characteristics	36	Hydril 521	36	569	569	569	569	569	120.9	98.6	96.4								
Connection characteristics	37	Vallourec & Mannesmann New VAM	37	500	667	765	864	952	126.0		96.4	569	785	902	1029	1125	127.3		94.0
Connection characteristics	38	Vallourec & Mannesmann VAM ACE	38	491	569	618	667	735	126.0		96.4	588	735	785	834	883	127.1		94.0
Connection characteristics	39	Vallourec & Mannesmann VAM PRO	39						125.6		96.4						125.3		94.0
Connection characteristics	40	Vallourec & Mannesmann VAM TOP	40																
Connection characteristics	41	Vallourec & Mannesmann FJL	41		315	343	382	422	114.3	97.6	96.4		343	373	412	451	114.3	95.4	94.0

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	5.000 in	127.0 mm	5.000 in	127.0 mm
Pipe body	1	Nominal size (OD)	1	**5.000** in	127.0 mm	**5.000** in	127.0 mm
	2	Nominal weight	2	**13.00** lb/ft	19.0 daN/m	**15.00** lb/ft	21.9 daN/m
	3	Wall thickness	3	0.253 in	6.4 mm	0.296 in	7.5 mm
	4	Inside diameter	4	4.494 in	114.1 mm	4.408 in	112.0 mm
	5	Steel cross-section	5	3.77 in^2	2434 mm^2	4.37 in^2	2822 mm^2
	6	Capacity	6	0.82 gal/ft	10.23 l/m	0.79 gal/ft	9.85 l/m
	7	Displacement (1)	7	1.02 gal/ft	12.67 l/m	1.02 gal/ft	12.67 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	28.6	35.4	35.4	37.4	38.3	40.3	41.7	38.3	50.0	50.0	54.0	55.9	61.0	65.4
	10	Internal yield pressure (MPa)	10	33.6	48.8	48.8	54.9	58.0	67.2	76.3	39.3	57.1	57.1	64.3	67.9	78.6	89.3
	11	Pipe body yield strength (1000 daN)	11	92	134	134	151	159	185	210	107	156	156	175	185	214	243
Tensile strength (10^3 daN)	12	Buttress Standard	12	138	145	152	155	163	193	210	159	169	176	180	189	224	244
	13	Buttress Special Clearance	13	138	145	152	155	163	193	210	159	162	171	171	179	213	230
	14	API STC	14	83	104	106	113	118	140	152	101	127	129	138	145	172	187
	15	API LTC	15	89	107	113	113	118	141	152	110	131	138	138	145	173	187

Section	No.	Property	No.	13.00 lb/ft	15.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	54.4	57.0
	18	Hydril LX	18		71.9
	19	Hydril 563	19	88.8	90.3
	20	Hydril 511	20		60.7
	21	Hydril 521	21	64.4	64.4
	22	Vallourec & Mannesmann New VAM	22	145.7	125.7
	23	Vallourec & Mannesmann VAM ACE	23	140.4	121.1
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25		102.0
	26	Vallourec & Mannesmann FJL	26	55.1	55.0

Section	No.	Property	No.	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27						141.3		111.0						141.3		108.8
	28	Buttress Special Clearance	28						136.5		111.0						136.5		108.8
	29	API STC	29	252					141.3		111.0	309					141.3		108.8
	30	API LTC	30	273					141.3		111.0	334	422	483			141.3		108.8
	31	Grant Prideco TCII	31										502	502	502	502	137.9	109.6	108.8
	32	Grant Prideco STL	32	203	271	271	271	271	127.0	112.3	111.0	258	325	325	325	325	127.0	110.4	108.8
	33	Hydril LX	33									407	488	536	590	637	129.3	109.9	108.8
	34	Hydril 563	34	610	610	610	610	610	141.3	112.9	111.0	746	746	746	746	746	141.3	110.7	108.8
	35	Hydril 511	35									312	312	312	312	312	127.0	109.7	108.8
	36	Hydril 521	36	556	556	556	556	556	131.7	112.9	111.0	556	556	556	556	556	133.5	110.7	108.8
	37	Vallourec & Mannesmann New VAM	37	569	618	658	686	716	141.9		111.0	637	697	725	755	795	141.9		108.8
	38	Vallourec & Mannesmann VAM ACE	38	491	540	588	637	686	141.3		111.0	491	540	588	637	686	141.3		108.8
	39	Vallourec & Mannesmann VAM PRO	39						141.8		111.0						141.8		108.8
	40	Vallourec & Mannesmann VAM TOP	40									588	686	785	883	980	138.9		108.8
	41	Vallourec & Mannesmann FJL	41		245	285	324	390	127.0	112.2	111.0		264	304	343	373	127.0	112.5	108.8

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

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

	No.		No.														
Pipe body	1	Nominal size (OD)	1	**5.000** in			127.0 mm				**5.000** in			127.0 mm			
	2	Nominal weight	2	**18.00** lb/ft			26.3 daN/m				**21.40** lb/ft			31.2 daN/m			
	3	Wall thickness	3	0.362 in			9.2 mm				0.437 in			11.1 mm			
	4	Inside diameter	4	4.276 in			108.6 mm				4.126 in			104.8 mm			
	5	Steel cross-section	5	5.27 in^2			3403 mm^2				6.26 in^2			4042 mm^2			
	6	Capacity	6	0.75 gal/ft			9.26 l/m				0.69 gal/ft			8.63 l/m			
	7	Displacement (1)	7	1.02 gal/ft			12.67 l/m				1.02 gal/ft			12.67 l/m			
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	50.9	72.3	72.3	79.5	82.9	92.9	102.2	60.5	88.0	88.0	99.0	104.5	121.0	137.5
	10	Internal yield pressure (MPa)	10	48.0	69.9	69.9	78.6	83.0	96.1	109.2	58.0	84.4	84.4	94.9	100.2	116.0	131.8
	11	Pipe body yield strength (1000 daN)	11	129	188	188	211	223	258	293	153	223	223	251	265	307	348
Tensile strength (10^3 daN)	12	Buttress Standard	12	192	203	212	217	228	270	294	227	227	239	239	251	299	322
	13	Buttress Special Clearance	13	162	162	171	171	179	213	230	162	162	171	171	179	213	230
	14	API STC	14	129	162	165	176	185	219	238	160	200	204	218	229	271	294
	15	API LTC	15	140	167	176	176	185	220	238	173	207	218	218	229	273	294

	No.		No.	5.000 in, 18.00 lb/ft	5.000 in, 21.40 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	58.2	
	18	Hydril LX	18	70.1	79.2
	19	Hydril 563	19	92.0	88.8
	20	Hydril 511	20	62.8	
	21	Hydril 521	21	73.8	
	22	Vallourec & Mannesmann New VAM	22	104.2	87.8
	23	Vallourec & Mannesmann VAM ACE	23	102.0	111.1
	24	Vallourec & Mannesmann VAM PRO	24	100.0	91.0
	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.1
	26	Vallourec & Mannesmann FJL	26	60.8	65.2

5.000 in, 18.00 lb/ft:

	No.		No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						141.3		105.4
	28	Buttress Special Clearance	28						136.5		105.4
	29	API STC	29								
	30	API LTC	30		538	617			141.3		105.4
	31	Grant Prideco TCII	31		556	556	556	556	140.5	109.6	105.4
	32	Grant Prideco STL	32	325	380	380	380	380	127.0	106.4	105.4
	33	Hydril LX	33	515	597	644	691	739	129.7	106.6	105.4
	34	Hydril 563	34	881	881	881	881	881	141.3		105.4
	35	Hydril 511	35	542	542	542	542	542	127.0	106.3	105.4
	36	Hydril 521	36	827	827	827	827	827	136.1	107.3	105.4
	37	Vallourec & Mannesmann New VAM	37	774	834	873	912	961	141.9		105.4
	38	Vallourec & Mannesmann VAM ACE	38	637	785	883	931	1029	141.5		105.4
	39	Vallourec & Mannesmann VAM PRO	39						141.8		105.4
	40	Vallourec & Mannesmann VAM TOP	40	686	785	834	931	1029	141.7		105.4
	41	Vallourec & Mannesmann FJL	41		264	304	343	373	127.0	106.9	105.4

5.000 in, 21.40 lb/ft:

	No.		No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						141.3		101.6
	28	Buttress Special Clearance	28						136.5		101.6
	29	API STC	29								
	30	API LTC	30		665	762			141.3		101.6
	31	Grant Prideco TCII	31		922	922	922	922	143.4	106.3	101.6
	32	Grant Prideco STL	32								
	33	Hydril LX	33	563	651	705	759	813	130.0	102.8	101.6
	34	Hydril 563	34	1885	1885	1885	1885	1885	146.1	103.5	101.6
	35	Hydril 511	35								
	36	Hydril 521	36								
	37	Vallourec & Mannesmann New VAM	37	971	1079	1125	1180	1227	141.9		101.6
	38	Vallourec & Mannesmann VAM ACE	38	883	1079	1180	1274	1376	146.1		101.6
	39	Vallourec & Mannesmann VAM PRO	39						141.8		101.6
	40	Vallourec & Mannesmann VAM TOP	40	931	1125	1274	1376	1471	144.6		101.6
	41	Vallourec & Mannesmann FJL	41		530	569	588	607	127.0	103.6	101.6

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

	1	Nominal size (OD)	1	**5.000** in	127.0 mm						**5.000** in	127.0 mm					
	2	Nominal weight	2	**23.20** lb/ft	33.9 daN/m						**24.10** lb/ft	35.2 daN/m					
Pipe body	3	Wall thickness	3	0.478 in	12.1 mm						0.500 in	12.7 mm					
Pipe body	4	Inside diameter	4	4.044 in	102.7 mm						4.000 in	101.6 mm					
Pipe body	5	Steel cross-section	5	6.79 in^2	4381 mm^2						7.07 in^2	4560 mm^2					
Pipe body	6	Capacity	6	0.67 gal/ft	8.29 l/m						0.65 gal/ft	8.11 l/m					
Pipe body	7	Displacement (1)	7	1.02 gal/ft	12.67 l/m						1.02 gal/ft	12.67 l/m					
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	65.6	95.4	95.4	107.3	113.3	131.1	149.0	68.3	99.3	99.3	111.7	117.9	136.5	155.1
Pipe body	10	Internal yield pressure (MPa)	10	63.4	92.3	92.3	103.8	109.6	126.9	144.2	66.4	96.5	96.5	108.6	114.6	132.7	150.8
Pipe body	11	Pipe body yield strength (1000 daN)	11	166	242	242	272	287	332	378	173	252	252	283	299	346	393
Tensile strength (10^3 daN)	12	Buttress Standard	12	227	227	239	239	251	299	322	227	227	239	239	251	299	322
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	162	162	171	171	179	213	230	162	162	171	171	179	213	230
Tensile strength (10^3 daN)	14	API STC	14	176	221	225	240	252	299	324	185	232	236	252	265	314	340
Tensile strength (10^3 daN)	15	API LTC	15	191	228	240	240	252	300	324	200	239	252	252	265	315	340

				5.000 in – 23.20 lb/ft	5.000 in – 24.10 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	67.6	57.6
Connection efficiency	18	Hydril LX	18	79.0	79.7
Connection efficiency	19	Hydril 563	19	89.7	90.1
Connection efficiency	20	Hydril 511	20		
Connection efficiency	21	Hydril 521	21		
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	81.0	77.8
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	102.5	105.6
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	89.0	85.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25	102.0	
Connection efficiency	26	Vallourec & Mannesmann FJL	26	67.4	64.7

				Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27						141.3		99.5						141.3		98.4
Connection characteristics	28	Buttress Special Clearance	28						136.5		99.5						136.5		98.4
Connection characteristics	29	API STC	29																
Connection characteristics	30	API LTC	30										768	881			141.3		98.4
Connection characteristics	31	Grant Prideco TCII	31		1139	1139	1139	1139	144.9	104.4	99.5		1207	1207	1207	1207	145.7	103.5	98.4
Connection characteristics	32	Grant Prideco STL	32	461	590	590	590	590	127.0	101.3	99.5	420	529	529	529	529	127.0	103.0	98.4
Connection characteristics	33	Hydril LX	33	583	678	739	766	847	130.3	100.7	99.5	630	725	780	841	902	130.4	99.6	98.4
Connection characteristics	34	Hydril 563	34	1966	1966	1966	1966	1966	146.1	101.4	99.5	2034	2034	2034	2034	2034	146.1	100.3	98.4
Connection characteristics	35	Hydril 511	35																
Connection characteristics	36	Hydril 521	36																
Connection characteristics	37	Vallourec & Mannesmann New VAM	37	1029	1125	1180	1227	1274	141.9		99.5	1029	1125	1180	1274	1322	141.9		98.4
Connection characteristics	38	Vallourec & Mannesmann VAM ACE	38	980	1274	1376	1519	1668	146.1		99.5	1079	1376	1471	1668	1763	147.5		98.4
Connection characteristics	39	Vallourec & Mannesmann VAM PRO	39						141.8		99.5						141.8		98.4
Connection characteristics	40	Vallourec & Mannesmann VAM TOP	40	1079	1322	1424	1620	1817	146.1		99.5								
Connection characteristics	41	Vallourec & Mannesmann FJL	41		540	588	637	697	127.0	101.5	99.5		549	607	667	716	127.0	100.5	98.4

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

	No.		No.	5.500 in	139.7 mm	5.500 in	139.7 mm
	1	Nominal size (OD)	1	**5.500** in	139.7 mm	**5.500** in	139.7 mm
	2	Nominal weight	2	**14.00** lb/ft	20.4 daN/m	**15.50** lb/ft	22.6 daN/m
Pipe body	3	Wall thickness	3	0.244 in	6.2 mm	0.275 in	7.0 mm
Pipe body	4	Inside diameter	4	5.012 in	127.3 mm	4.950 in	125.7 mm
Pipe body	5	Steel cross-section	5	4.03 in²	2599 mm²	4.51 in²	2912 mm²
Pipe body	6	Capacity	6	1.02 gal/ft	12.73 l/m	1.00 gal/ft	12.42 l/m
Pipe body	7	Displacement (1)	7	1.23 gal/ft	15.33 l/m	1.23 gal/ft	15.33 l/m

	No.		No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	21.5	24.9	24.9	26.6	27.3	29.2	30.4	27.9	34.4	34.4	36.3	37.1	38.8	40.6
Pipe body	10	Internal yield pressure (MPa)	10	29.4	42.8	42.8	48.2	50.9	58.9	66.9	33.2	48.3	48.3	54.3	57.3	66.4	75.4
Pipe body	11	Pipe body yield strength (1000 daN)	11	99	143	143	161	170	197	224	110	161	161	181	191	221	251
Tensile strength (10^3 daN)	12	Buttress Standard	12	145	155	161	165	173	205	224	163	173	181	185	194	230	251
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	145	155	161	165	173	205	224	163	173	181	185	194	230	251
Tensile strength (10^3 daN)	14	API STC	14	84	106	108	117	123	144	161	99	124	126	137	144	168	188
Tensile strength (10^3 daN)	15	API LTC	15	91	113	116	119	125	149	161	106	132	136	139	146	174	188

	No.		No.	5.500 in – 14.00 lb/ft	5.500 in – 15.50 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	53.5	49.3
Connection efficiency	18	Hydril LX	18		
Connection efficiency	19	Hydril 563	19	88.5	89.7
Connection efficiency	20	Hydril 511	20		60.4
Connection efficiency	21	Hydril 521	21	63.3	66.9
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	148.3	132.4
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23		128.5
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25		102.1
Connection efficiency	26	Vallourec & Mannesmann FJL	26		55.1

	No.		No.	Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						153.7		124.1						153.7		122.6
Connection characteristics	28	Buttress Special Clearance	28						149.2		124.1						149.2		122.6
Connection characteristics	29	API STC	29	256					153.7		124.1	301					153.7		122.6
Connection characteristics	30	API LTC	30									324					153.7		122.6
Connection characteristics	31	Grant Prideco TCII	31														149.8	124.2	122.6
Connection characteristics	32	Grant Prideco STL	32	217	271	271	271	271	139.7	125.5	124.1	230	339	339	339	339	139.7	124.2	122.6
Connection characteristics	33	Hydril LX	33																
Connection characteristics	34	Hydril 563	34	610	610	610	610	610	153.7	126.0	124.1	705	705	705	705	705	153.7	124.5	122.6
Connection characteristics	35	Hydril 511	35									312	312	312	312	312	139.7	123.4	122.6
Connection characteristics	36	Hydril 521	36	542	542	542	542	542	143.8	125.7	124.1	624	624	624	624	624	145.1	124.5	122.6
Connection characteristics	37	Vallourec & Mannesmann New VAM	37	540	647	686	725	765	154.3		124.1	637	697	735	774	813	154.3		122.6
Connection characteristics	38	Vallourec & Mannesmann VAM ACE	38									392	491	540	588	637	153.7		122.6
Connection characteristics	39	Vallourec & Mannesmann VAM PRO	39						154.2		124.1						154.2		122.6
Connection characteristics	40	Vallourec & Mannesmann VAM TOP	40									540	686	785	883	980	150.6		122.6
Connection characteristics	41	Vallourec & Mannesmann FJL	41										363	412	470	519	139.7	123.8	122.6

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Characteristic	No.				
Pipe body	1	Nominal size (OD)	1	**5.500** in	139.7 mm	**5.500** in	139.7 mm
Pipe body	2	Nominal weight	2	**17.00** lb/ft	24.8 daN/m	**20.00** lb/ft	29.2 daN/m
Pipe body	3	Wall thickness	3	0.304 in	7.7 mm	0.361 in	9.2 mm
Pipe body	4	Inside diameter	4	4.892 in	124.3 mm	4.778 in	121.4 mm
Pipe body	5	Steel cross-section	5	4.96 in^2	3202 mm^2	5.83 in^2	3760 mm^2
Pipe body	6	Capacity	6	0.98 gal/ft	12.13 l/m	0.93 gal/ft	11.57 l/m
Pipe body	7	Displacement (1)	7	1.23 gal/ft	15.33 l/m	1.23 gal/ft	15.33 l/m

Section	No.	Characteristic	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	33.9	43.3	43.3	46.5	47.9	51.6	54.4	45.6	60.9	60.9	66.4	69.1	76.6	83.3
Pipe body	10	Internal yield pressure (MPa)	10	36.7	53.4	53.4	60.0	63.4	73.4	83.4	43.6	63.4	63.4	71.3	75.2	87.1	99.0
Pipe body	11	Pipe body yield strength (1000 daN)	11	121	177	177	199	210	243	276	143	207	207	233	246	285	324
Tensile strength (10^3 daN)	12	Buttress Standard	12	179	190	198	203	213	253	276	210	224	233	238	251	297	324
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	179	179	189	189	198	236	255	179	179	189	189	198	236	255
Tensile strength (10^3 daN)	14	API STC	14	112	141	144	155	164	191	214	138	174	177	191	202	235	263
Tensile strength (10^3 daN)	15	API LTC	15	121	150	155	158	166	198	214	149	185	190	195	205	244	263

Section	No.	Characteristic	No.	5.500 in – 17.00 lb/ft	5.500 in – 20.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	52.9	59.0
Connection efficiency	18	Hydril LX	18	71.9	71.0
Connection efficiency	19	Hydril 563	19	90.6	92.0
Connection efficiency	20	Hydril 511	20	60.9	62.4
Connection efficiency	21	Hydril 521	21	69.6	73.8
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	120.5	102.6
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	116.9	115.7
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.1
Connection efficiency	26	Vallourec & Mannesmann FJL	26	55.1	58.7

Section	No.	Characteristic	No.	Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						153.7		121.1						153.7		118.2
Connection characteristics	28	Buttress Special Clearance	28						149.2		121.1						149.2		118.2
Connection characteristics	29	API STC	29	342					153.7		121.1								
Connection characteristics	30	API LTC	30	369	467	537	626		153.7		121.1		575	660	771		153.7		118.2
Connection characteristics	31	Grant Prideco TCII	31		590	590	590	590	151.0	122.3	121.1		630	630	630	630	153.3	122.3	118.2
Connection characteristics	32	Grant Prideco STL	32	271	380	380	380	380	139.7	122.4	121.1	298	447	447	447	447	139.7	119.3	118.2
Connection characteristics	33	Hydril LX	33	475	576	644	705	766	142.2	122.2	121.1	583	685	746	807	868	142.4	119.3	118.2
Connection characteristics	34	Hydril 563	34	786	786	786	786	786	153.7	123.0	121.1	895	895	895	895	895	153.7		118.2
Connection characteristics	35	Hydril 511	35	339	339	339	339	339	139.7	122.0	121.1	529	529	529	529	529	139.7	119.1	118.2
Connection characteristics	36	Hydril 521	36	705	705	705	705	705	146.3	123.0	121.1	854	854	854	854	854	148.6	120.1	118.2
Connection characteristics	37	Vallourec & Mannesmann New VAM	37	686	746	785	824	864	154.3		121.1	804	883	922	971	1029	154.3		118.2
Connection characteristics	38	Vallourec & Mannesmann VAM ACE	38	540	686	735	785	834	153.7		121.1	735	883	980	1029	1125	156.2		118.2
Connection characteristics	39	Vallourec & Mannesmann VAM PRO	39						154.2		121.1						154.2		118.2
Connection characteristics	40	Vallourec & Mannesmann VAM TOP	40	588	735	834	931	1029	151.8		121.1	735	883	980	1029	1125	154.2		118.2
Connection characteristics	41	Vallourec & Mannesmann FJL	41		382	431	480	540	139.7	122.5	121.1		480	549	607	677	139.7	119.6	118.2

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

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

				23.00 lb/ft		26.00 lb/ft	
Pipe body	1	Nominal size (OD)	1	**5.500** in	139.7 mm	**5.500** in	139.7 mm
	2	Nominal weight	2	**23.00** lb/ft	33.6 daN/m	**26.00** lb/ft	37.9 daN/m
	3	Wall thickness	3	0.415 in	10.5 mm	0.476 in	12.1 mm
	4	Inside diameter	4	4.670 in	118.6 mm	4.548 in	115.5 mm
	5	Steel cross-section	5	6.63 in^2	4277 mm^2	7.51 in^2	4847 mm^2
	6	Capacity	6	0.89 gal/ft	11.05 l/m	0.84 gal/ft	10.48 l/m
	7	Displacement (1)	7	1.23 gal/ft	15.33 l/m	1.23 gal/ft	15.33 l/m

				K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	52.9	77.0	77.0	85.3	89.2	100.2	110.7	60.0	87.2	87.2	98.1	103.6	119.9	136.3
	10	Internal yield pressure (MPa)	10	50.1	72.8	72.8	81.9	86.5	100.1	113.8	57.4	83.5	83.5	94.0	99.2	114.9	130.5
	11	Pipe body yield strength (1000 daN)	11	162	236	236	265	280	324	369	184	267	267	301	317	368	418
Tensile strength (10^3 daN)	12	Buttress Standard	12	239	245	258	258	271	322	348	245	245	258	258	271	322	348
	13	Buttress Special Clearance	13	179	179	189	189	198	236	255	179	179	189	189	198	236	255
	14	API STC	14	162	204	208	224	237	276	309	188	237	241	261	275	321	359
	15	API LTC	15	175	217	223	229	240	286	309	203	253	260	266	279	333	359

				23.00 lb/ft	26.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	62.9	67.0
	18	Hydril LX	18	77.7	76.3
	19	Hydril 563	19	93.0	89.7
	20	Hydril 511	20		
	21	Hydril 521	21	76.5	
	22	Vallourec & Mannesmann New VAM	22	90.2	79.6
	23	Vallourec & Mannesmann VAM ACE	23	101.7	102.0
	24	Vallourec & Mannesmann VAM PRO	24	92.0	89.0
	25	Vallourec & Mannesmann VAM TOP	25	101.9	101.9
	26	Vallourec & Mannesmann FJL	26	63.7	67.0

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						153.7		115.4						153.7		112.3
	28	Buttress Special Clearance	28						149.2		115.4						149.2		112.3
	29	API STC	29																
	30	API LTC	30		675	776	906	1013	153.7		115.4								
	31	Grant Prideco TCII	31		1017	1017	1017	1017	155.4	119.9	115.4		1254	1254	1254	1254	157.8	117.2	112.3
	32	Grant Prideco STL	32	353	569	569	569	569	139.7	116.8	115.4	515	651	651	651	651	139.7	114.1	112.3
	33	Hydril LX	33	590	698	766	827	895	142.7	116.6	115.4	651	780	854	929	1003	143.0	115.2	112.3
	34	Hydril 563	34	1044	1044	1044	1044	1044	153.7		115.4	1491	1491	1491	1491	1491	155.6	114.2	112.3
	35	Hydril 511	35																
	36	Hydril 521	36	990	990	990	990	990	150.8	117.3	115.4								
	37	Vallourec & Mannesmann New VAM	37	961	1079	1125	1180	1274	154.3		115.4	1029	1125	1227	1274	1322	154.3		112.3
	38	Vallourec & Mannesmann VAM ACE	38	883	1079	1180	1322	1424	156.2		115.4	1125	1424	1566	1715	1864	158.6		112.3
	39	Vallourec & Mannesmann VAM PRO	39						154.2		115.4						154.2		112.3
	40	Vallourec & Mannesmann VAM TOP	40	931	1125	1227	1424	1519	156.4		115.4	1180	1471	1620	1864	2061	158.7		112.3
	41	Vallourec & Mannesmann FJL	41		579	598	658	716	139.7	116.9	115.4		574	667	706	765	139.7	114.3	112.3

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

				5.500 in	139.7 mm	6.625 in	168.3 mm
Pipe body	1	Nominal size (OD)	1	**5.500** in	139.7 mm	**6.625** in	168.3 mm
	2	Nominal weight	2	**26.80** lb/ft	39.1 daN/m	**20.00** lb/ft	29.2 daN/m
	3	Wall thickness	3	0.500 in	12.7 mm	0.288 in	7.3 mm
	4	Inside diameter	4	4.500 in	114.3 mm	6.049 in	153.6 mm
	5	Steel cross-section	5	7.85 in²	5067 mm²	5.73 in²	3699 mm²
	6	Capacity	6	0.83 gal/ft	10.26 l/m	1.49 gal/ft	18.54 l/m
	7	Displacement (1)	7	1.23 gal/ft	15.33 l/m	1.79 gal/ft	22.24 l/m

				5.500 in							6.625 in						
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	62.7	91.2	91.2	102.6	108.3	125.4	142.5	20.5	24.0	24.0	25.5	26.2	27.8	28.7
	10	Internal yield pressure (MPa)	10	60.3	87.8	87.8	98.7	104.2	120.7	137.1	28.8	42.0	42.0	47.2	49.8	57.7	65.6
	11	Pipe body yield strength (1000 daN)	11	192	279	279	314	332	384	437	140	204	204	230	242	281	319
Tensile strength (10^3 daN)	12	Buttress Standard	12	245	245	258	258	271	322	348	202	217	226	233	245	289	316
	13	Buttress Special Clearance	13	179	179	189	189	198	236	255	202	217	226	231	243	289	312
	14	API STC	14	198	250	255	275	290	339	379	119	151	154	167	176	205	230
	15	API LTC	15	214	267	274	281	295	351	379	129	164	167	180	189	222	243

				5.500 in	6.625 in
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	63.4	57.0
	18	Hydril LX	18	78.7	
	19	Hydril 563	19	90.2	88.6
	20	Hydril 511	20		
	21	Hydril 521	21		65.5
	22	Vallourec & Mannesmann New VAM	22		168.6
	23	Vallourec & Mannesmann VAM ACE	23	102.0	164.1
	24	Vallourec & Mannesmann VAM PRO	24		100.0
	25	Vallourec & Mannesmann VAM TOP	25		101.9
	26	Vallourec & Mannesmann FJL	26	65.1	

				Make-up torque (daN.m) 5.500 in								Make-up torque (daN.m) 6.625 in							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						153.7		111.1						187.7		150.5
	28	Buttress Special Clearance	28						149.2		111.1						177.8		150.5
	29	API STC	29									362					187.7		150.5
	30	API LTC	30									393					187.7		150.5
	31	Grant Prideco TCII	31		1356	1356	1356	1356	158.7	116.1	111.1		644	644	644	644	178.8	152.1	150.5
	32	Grant Prideco STL	32	515	651	651	651	651	139.7	113.5	111.1	325	420	420	420	420	168.3	152.1	150.5
	33	Hydril LX	33	780	902	976	1051	1119	143.1	112.3	111.1								
	34	Hydril 563	34	1627	1627	1627	1627	1627	155.6	113.0	111.1	800	800	800	800	800	187.7	152.4	150.5
	35	Hydril 511	35																
	36	Hydril 521	36									746	746	746	746	746	173.2	152.4	150.5
	37	Vallourec & Mannesmann New VAM	37									765	864	912	971	1029	188.3		150.5
	38	Vallourec & Mannesmann VAM ACE	38	1125	1424	1566	1715	1864	159.5		111.1	540	686	735	785	834	187.7		150.5
	39	Vallourec & Mannesmann VAM PRO	39														188.2		150.5
	40	Vallourec & Mannesmann VAM TOP	40									637	834	931	1079	1180	179.9		150.5
	41	Vallourec & Mannesmann FJL	41						139.7	111.5	111.1								

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

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	**6.625** in	168.3 mm	**6.625** in	168.3 mm
	2	Nominal weight	**23.20** lb/ft	33.9 daN/m	**24.00** lb/ft	35.0 daN/m
	3	Wall thickness	0.330 in	8.4 mm	0.352 in	8.9 mm
	4	Inside diameter	5.965 in	151.5 mm	5.921 in	150.4 mm
	5	Steel cross-section	6.53 in^2	4210 mm^2	6.94 in^2	4475 mm^2
	6	Capacity	1.45 gal/ft	18.03 l/m	1.43 gal/ft	17.76 l/m
	7	Displacement (1)	1.79 gal/ft	22.24 l/m	1.79 gal/ft	22.24 l/m

			K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	27.7	34.1	34.1	35.9	36.7	38.4	40.2	31.4	39.7	39.7	42.3	43.5	46.4	48.4
	10	Internal yield pressure (MPa)	33.1	48.1	48.1	54.1	57.1	66.1	75.1	35.3	51.3	51.3	57.7	60.9	70.5	80.1
	11	Pipe body yield strength (1000 daN)	160	232	232	261	276	319	363	170	247	247	278	293	339	386
Tensile strength (10^3 daN)	12	Buttress Standard	229	248	258	265	278	329	360	244	263	274	281	296	350	383
	13	Buttress Special Clearance	220	220	231	231	243	289	312	220	220	231	231	243	289	312
	14	API STC	141	179	182	198	208	243	272	152	194	197	214	225	263	295
	15	API LTC	153	194	198	214	224	264	289	166	210	214	231	243	285	312

			23.20 lb/ft	24.00 lb/ft
Connection efficiency	16	Grant Prideco TCII		
	17	Grant Prideco STL		59.8
	18	Hydril LX	63.6	66.6
	19	Hydril 563		90.6
	20	Hydril 511		63.3
	21	Hydril 521		71.0
	22	Vallourec & Mannesmann New VAM	148.2	139.4
	23	Vallourec & Mannesmann VAM ACE		135.6
	24	Vallourec & Mannesmann VAM PRO	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	102.0	102.1
	26	Vallourec & Mannesmann FJL	54.9	57.6

Connection characteristics — 23.20 lb/ft

			Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard						187.7		148.3
	28	Buttress Special Clearance						177.8		148.3
	29	API STC								
	30	API LTC								
	31	Grant Prideco TCII		1064	1064	1064	1064	180.6	150.0	148.3
	32	Grant Prideco STL								
	33	Hydril LX	732	922	1037	1152	1274	171.1	149.6	148.3
	34	Hydril 563								
	35	Hydril 511								
	36	Hydril 521								
	37	Vallourec & Mannesmann New VAM	843	941	980	1079	1125	188.3		148.3
	38	Vallourec & Mannesmann VAM ACE								
	39	Vallourec & Mannesmann VAM PRO						188.2		148.3
	40	Vallourec & Mannesmann VAM TOP	686	883	980	1125	1227	181.7		148.3
	41	Vallourec & Mannesmann FJL		637	736	834	931	168.3	149.8	148.3

Connection characteristics — 24.00 lb/ft

			Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard						187.7		147.2
	28	Buttress Special Clearance						177.8		147.2
	29	API STC	464					187.7		147.2
	30	API LTC	504	647	744	869		187.7		147.2
	31	Grant Prideco TCII		1139	1139	1139	1139	181.6	148.3	147.2
	32	Grant Prideco STL	420	529	529	529	529	168.3	149.3	147.2
	33	Hydril LX	800	990	1098	1200	1308	171.2	148.4	147.2
	34	Hydril 563	1017	1017	1017	1017	1017	187.7	149.1	147.2
	35	Hydril 511	691	691	691	691	691	168.3	148.1	147.2
	36	Hydril 521	936	936	936	936	936	175.9	149.1	147.2
	37	Vallourec & Mannesmann New VAM	941	1079	1125	1180	1274	188.3		147.2
	38	Vallourec & Mannesmann VAM ACE	785	980	1079	1125	1227	187.7		147.2
	39	Vallourec & Mannesmann VAM PRO						188.2		147.2
	40	Vallourec & Mannesmann VAM TOP	735	931	1029	1180	1274	182.7		147.2
	41	Vallourec & Mannesmann FJL		658	755	853	952	168.3	148.8	147.2

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.				
Pipe body	1	Nominal size (OD)	1	**6.625** in	168.3 mm	**6.625** in	168.3 mm
	2	Nominal weight	2	**28.00** lb/ft	40.9 daN/m	**32.00** lb/ft	46.7 daN/m
	3	Wall thickness	3	0.417 in	10.6 mm	0.475 in	12.1 mm
	4	Inside diameter	4	5.791 in	147.1 mm	5.675 in	144.1 mm
	5	Steel cross-section	5	8.13 in^2	5247 mm^2	9.18 in^2	5921 mm^2
	6	Capacity	6	1.37 gal/ft	16.99 l/m	1.31 gal/ft	16.32 l/m
	7	Displacement (1)	7	1.79 gal/ft	22.24 l/m	1.79 gal/ft	22.24 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	42.6	56.3	56.3	61.2	63.6	70.1	75.8	50.5	71.2	71.2	78.1	81.5	91.2	100.2
	10	Internal yield pressure (MPa)	10	41.8	60.8	60.8	68.4	72.1	83.5	94.9	47.6	69.2	69.2	77.9	82.2	95.2	108.1
	11	Pipe body yield strength (1000 daN)	11	199	289	289	326	344	398	452	225	327	327	367	388	449	510
Tensile strength (10^3 daN)	12	Buttress Standard	12	286	308	321	330	347	410	449	323	348	362	372	391	463	506
	13	Buttress Special Clearance	13	220	220	231	231	243	289	312	220	220	231	231	243	289	312
	14	API STC	14	185	236	240	261	275	321	359	215	273	278	301	318	371	415
	15	API LTC	15	202	256	261	282	296	347	380	233	296	301	326	342	402	440

Section	No.	Connection	No.	6.625 in – 28.00 lb/ft	6.625 in – 32.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	66.9	68.1
	18	Hydril LX	18	77.9	79.3
	19	Hydril 563	19	92.0	92.9
	20	Hydril 511	20	59.9	
	21	Hydril 521	21	74.7	77.3
	22	Vallourec & Mannesmann New VAM	22	118.9	105.4
	23	Vallourec & Mannesmann VAM ACE	23	115.7	102.5
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25	101.9	
	26	Vallourec & Mannesmann FJL	26	63.8	65.8

Section	No.	Connection	No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						187.7		143.9						187.7		141.0
	28	Buttress Special Clearance	28						177.8		143.9						177.8		141.0
	29	API STC	29																
	30	API LTC	30		788	907	1059		187.7		143.9		911	1049	1226	1371	187.7		141.0
	31	Grant Prideco TCII	31		1254	1254	1254	1254	184.3	148.3	143.9		1552	1552	1552	1552	186.6	145.7	141.0
	32	Grant Prideco STL	32	563	705	705	705	705	168.3	145.1	143.9	637	800	800	800	800	168.3	142.5	141.0
	33	Hydril LX	33	793	949	1051	1146	1220	171.5	145.1	143.9	949	1105	1207	1329	1437	171.8	142.1	141.0
	34	Hydril 563	34	1166	1166	1166	1166	1166	187.7		143.9	1342	1342	1342	1342	1342	187.7		141.0
	35	Hydril 511	35	895	895	895	895	895	168.3	144.8	143.9								
	36	Hydril 521	36	1125	1125	1125	1125	1125	178.5	145.8	143.9	1302	1302	1302	1302	1302	180.8	142.9	141.0
	37	Vallourec & Mannesmann New VAM	37	1180	1322	1424	1519	1566	188.3		143.9	1227	1424	1519	1566	1668	188.3		141.0
	38	Vallourec & Mannesmann VAM ACE	38	1079	1274	1376	1471	1668	187.7		143.9	1376	1566	1763	1966	2156	187.7		141.0
	39	Vallourec & Mannesmann VAM PRO	39						188.2		143.9						188.2		141.0
	40	Vallourec & Mannesmann VAM TOP	40	1079	1274	1376	1519	1668	185.3		143.9								
	41	Vallourec & Mannesmann FJL	41		706	803	902	980	168.3	145.6	143.9		755	853	952	1030	168.3	143.0	141.0

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

				6.625 in	168.3 mm	7.000 in	177.8 mm
Pipe body	1	Nominal size (OD)	1	**6.625** in	168.3 mm	**7.000** in	177.8 mm
	2	Nominal weight	2	**35.00** lb/ft	51.1 daN/m	**20.00** lb/ft	29.2 daN/m
	3	Wall thickness	3	0.525 in	13.3 mm	0.272 in	6.9 mm
	4	Inside diameter	4	5.575 in	141.6 mm	6.456 in	164.0 mm
	5	Steel cross-section	5	10.06 in^2	6491 mm^2	5.75 in^2	3709 mm^2
	6	Capacity	6	1.27 gal/ft	15.75 l/m	1.70 gal/ft	21.12 l/m
	7	Displacement (1)	7	1.79 gal/ft	22.24 l/m	2.00 gal/ft	24.83 l/m

				6.625 in							7.000 in						
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	55.3	80.5	80.5	90.6	95.6	109.4	121.3	15.7	18.9	18.9	19.7	20.0	20.5	20.6
	10	Internal yield pressure (MPa)	10	52.6	76.5	76.5	86.1	90.8	105.2	119.5	25.8	37.5	37.5	42.2	44.5	51.6	58.6
	11	Pipe body yield strength (1000 daN)	11	246	358	358	403	425	492	559	141	205	205	230	243	281	320
Tensile strength (10^3 daN)	12	Buttress Standard	12	354	382	397	408	429	507	555	200	217	226	233	245	289	316
	13	Buttress Special Clearance	13	220	220	231	231	243	289	312	200	217	226	233	245	289	316
	14	API STC	14	239	305	310	336	354	413	463	113	145	147	160	168	196	220
	15	API LTC	15	260	330	336	363	381	448	490	125	159	162	175	185	216	240

				6.625 in	7.000 in
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17		55.7
	18	Hydril LX	18	80.6	
	19	Hydril 563	19		88.0
	20	Hydril 511	20		
	21	Hydril 521	21		63.1
	22	Vallourec & Mannesmann New VAM	22	96.1	
	23	Vallourec & Mannesmann VAM ACE	23	102.0	
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25		
	26	Vallourec & Mannesmann FJL	26	67.4	

				6.625 in: Make-up torque (daN.m)								7.000 in: Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						187.7		138.4						194.5		160.8
	28	Buttress Special Clearance	28						177.8		138.4						187.3		160.8
	29	API STC	29									344					194.5		160.8
	30	API LTC	30																
	31	Grant Prideco TCII	31		1817	1817	1817	1817	188.5	143.5	138.4								
	32	Grant Prideco STL	32									325	407	407	407	407	177.8	162.4	160.8
	33	Hydril LX	33	1024	1220	1342	1451	1559	172.0	139.6	138.4								
	34	Hydril 563	34									759	759	759	759	759	194.5	162.7	160.8
	35	Hydril 511	35																
	36	Hydril 521	36									705	705	705	705	705	181.6	162.1	160.8
	37	Vallourec & Mannesmann New VAM	37	1322	1471	1566	1668	1763	188.3		138.4								
	38	Vallourec & Mannesmann VAM ACE	38	1566	1864	2061	2156	2156	189.6		138.4								
	39	Vallourec & Mannesmann VAM PRO	39						188.2		138.4						195.0		160.8
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41		804	902	980	1079	168.3	140.4	138.4								

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	7.000 in		7.000 in	
Pipe body	1	Nominal size (OD)	1	**7.000** in	177.8 mm	**7.000** in	177.8 mm
Pipe body	2	Nominal weight	2	**23.00** lb/ft	33.6 daN/m	**26.00** lb/ft	37.9 daN/m
Pipe body	3	Wall thickness	3	0.317 in	8.1 mm	0.362 in	9.2 mm
Pipe body	4	Inside diameter	4	6.366 in	161.7 mm	6.276 in	159.4 mm
Pipe body	5	Steel cross-section	5	6.66 in^2	4294 mm^2	7.55 in^2	4870 mm^2
Pipe body	6	Capacity	6	1.65 gal/ft	20.53 l/m	1.61 gal/ft	19.96 l/m
Pipe body	7	Displacement (1)	7	2.00 gal/ft	24.83 l/m	2.00 gal/ft	24.83 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	22.5	26.4	26.4	27.8	28.6	30.6	32.0	29.8	37.3	37.3	39.6	40.6	43.0	44.5
Pipe body	10	Internal yield pressure (MPa)	10	30.1	43.7	43.7	49.2	51.9	60.1	68.3	34.3	49.9	49.9	56.2	59.3	68.6	78.0
Pipe body	11	Pipe body yield strength (1000 daN)	11	163	237	237	266	281	326	370	185	269	269	302	319	369	420
Tensile strength (10^3 daN)	12	Buttress Standard	12	232	251	261	269	283	335	366	263	285	297	305	321	380	415
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	232	237	250	250	262	312	337	237	237	250	250	262	312	337
Tensile strength (10^3 daN)	14	API STC	14	138	176	179	194	205	239	267	162	207	210	228	240	281	314
Tensile strength (10^3 daN)	15	API LTC	15	152	193	197	213	225	262	291	178	227	231	250	264	308	342

Section	No.	Property	No.	23.00 lb/ft	26.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	58.2	59.2
Connection efficiency	18	Hydril LX	18	73.3	74.2
Connection efficiency	19	Hydril 563	19	89.6	90.9
Connection efficiency	20	Hydril 511	20	60.8	60.9
Connection efficiency	21	Hydril 521	21	67.7	71.2
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	136.2	120.1
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	133.1	117.3
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25	102.0	101.9
Connection efficiency	26	Vallourec & Mannesmann FJL	26	51.1	56.9

Section	No.	Connection	No.	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27						194.5		158.5						194.5		156.2
Connection characteristics	28	Buttress Special Clearance	28						187.3		158.5						187.3		156.2
Connection characteristics	29	API STC	29	419					194.5		158.5	494					194.5		156.2
Connection characteristics	30	API LTC	30	462	595	685			194.5		158.5	544	698	804	940		194.4		156.2
Connection characteristics	31	Grant Prideco TCII	31		915	915	915	915	189.2	160.2	158.5		1193	1193	1193	1193	191.1	158.2	156.2
Connection characteristics	32	Grant Prideco STL	32	393	502	502	502	502	177.8	160.4	158.5	508	651	651	651	651	177.8	157.8	156.2
Connection characteristics	33	Hydril LX	33	820	942	1051	1159	1281	180.6	159.7	158.5	868	1058	1166	1302	1410	180.8	157.4	156.2
Connection characteristics	34	Hydril 563	34	908	908	908	908	908	194.5	160.4	158.5	1058	1058	1058	1058	1058	194.5	158.1	156.2
Connection characteristics	35	Hydril 511	35	515	515	515	515	515	177.8	159.7	158.5	813	813	813	813	813	177.8	157.1	156.2
Connection characteristics	36	Hydril 521	36	841	841	841	841	841	183.5	159.8	158.5	976	976	976	976	976	185.4	157.5	156.2
Connection characteristics	37	Vallourec & Mannesmann New VAM	37	843	952	1029	1079	1125	195.1		158.5	980	1125	1180	1274	1376	195.1		156.2
Connection characteristics	38	Vallourec & Mannesmann VAM ACE	38	637	785	834	883	980	194.5		158.5	883	1079	1180	1274	1376	194.5		156.2
Connection characteristics	39	Vallourec & Mannesmann VAM PRO	39						195.0		158.5						195.0		156.2
Connection characteristics	40	Vallourec & Mannesmann VAM TOP	40	834	1029	1125	1274	1376	190.2		158.5	931	1125	1227	1376	1471	192.2		156.2
Connection characteristics	41	Vallourec & Mannesmann FJL	41		795	912	1030	1128	177.8	160.0	158.5		824	941	1079	1177	177.8	157.8	156.2

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	7.000 in	177.8 mm	7.000 in	177.8 mm
Pipe body	1	Nominal size (OD)	1	**7.000** in	177.8 mm	**7.000** in	177.8 mm
	2	Nominal weight	2	**29.00** lb/ft	42.3 daN/m	**32.00** lb/ft	46.7 daN/m
	3	Wall thickness	3	0.408 in	10.4 mm	0.453 in	11.5 mm
	4	Inside diameter	4	6.184 in	157.1 mm	6.094 in	154.8 mm
	5	Steel cross-section	5	8.45 in^2	5451 mm^2	9.32 in^2	6011 mm^2
	6	Capacity	6	1.56 gal/ft	19.38 l/m	1.52 gal/ft	18.82 l/m
	7	Displacement (1)	7	2.00 gal/ft	24.83 l/m	2.00 gal/ft	24.83 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	37.3	48.4	48.4	52.3	54.0	58.8	62.8	44.6	59.3	59.3	64.6	67.2	74.3	80.7
	10	Internal yield pressure (MPa)	10	38.7	56.3	56.3	63.3	66.8	77.4	87.9	42.9	62.5	62.5	70.3	74.2	85.9	97.6
	11	Pipe body yield strength (1000 daN)	11	207	301	301	338	357	413	470	228	332	332	373	394	456	518
Tensile strength (10^3 daN)	12	Buttress Standard	12	295	319	332	342	359	425	465	325	352	366	377	396	468	513
	13	Buttress Special Clearance	13	237	237	250	250	262	312	337	237	237	250	250	262	312	337
	14	API STC	14	186	238	242	262	277	323	362	209	268	272	295	311	363	407
	15	API LTC	15	205	261	266	288	304	354	394	231	294	299	324	342	399	443

Section	No.	Connection	No.	29.00 lb/ft	32.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	63.9	67.0
	18	Hydril LX	18	76.5	79.5
	19	Hydril 563	19	91.8	92.6
	20	Hydril 511	20	60.6	
	21	Hydril 521	21	73.9	76.1
	22	Vallourec & Mannesmann New VAM	22	107.3	97.3
	23	Vallourec & Mannesmann VAM ACE	23	104.8	128.1
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.1
	26	Vallourec & Mannesmann FJL	26	61.5	65.1

Connection characteristics — 7.000 in, 29.00 lb/ft

No.	Connection	No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard	27						194.5		153.9
28	Buttress Special Clearance	28						187.3		153.9
29	API STC	29								
30	API LTC	30		803	926	1081		194.4		153.9
31	Grant Prideco TCII	31		1281	1281	1281	1281	193.0	158.2	153.9
32	Grant Prideco STL	32	569	732	732	732	732	177.8	157.2	153.9
33	Hydril LX	33	786	963	1064	1173	1295	181.1	156.5	153.9
34	Hydril 563	34	1139	1139	1139	1139	1139	194.5		153.9
35	Hydril 511	35	908	908	908	908	908	177.8	154.8	153.9
36	Hydril 521	36	1125	1125	1125	1125	1125	187.3	155.2	153.9
37	Vallourec & Mannesmann New VAM	37	1125	1274	1376	1471	1566	195.1		153.9
38	Vallourec & Mannesmann VAM ACE	38	1079	1274	1376	1566	1668	194.5		153.9
39	Vallourec & Mannesmann VAM PRO	39						195.0		153.9
40	Vallourec & Mannesmann VAM TOP	40	1079	1274	1376	1566	1668	194.2		153.9
41	Vallourec & Mannesmann FJL	41		864	980	1079	1226	177.8	155.5	153.9

Connection characteristics — 7.000 in, 32.00 lb/ft

No.	Connection	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard						194.5		151.6
28	Buttress Special Clearance						187.3		151.6
29	API STC								
30	API LTC		904	1041	1216		194.5		151.6
31	Grant Prideco TCII		1519	1519	1519	1519	194.9	156.2	151.6
32	Grant Prideco STL	637	813	813	813	813	177.8	153.1	151.6
33	Hydril LX	969	1146	1241	1349	1458	181.7	153.3	151.6
34	Hydril 563	1288	1288	1288	1288	1288	194.5		151.6
35	Hydril 511								
36	Hydril 521	1261	1261	1261	1261	1261	189.2	153.7	151.6
37	Vallourec & Mannesmann New VAM	1227	1376	1471	1566	1668	195.1		151.6
38	Vallourec & Mannesmann VAM ACE	1274	1519	1668	1864	1959	200.9		151.6
39	Vallourec & Mannesmann VAM PRO						195.0		151.6
40	Vallourec & Mannesmann VAM TOP	1274	1519	1668	1864	2007	196.0		151.6
41	Vallourec & Mannesmann FJL		912	1030	1128	1274	177.8	153.3	151.6

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**7.000** in	177.8 mm	**7.000** in	177.8 mm
	2	Nominal weight	2	**35.00** lb/ft	51.1 daN/m	**38.00** lb/ft	55.5 daN/m
	3	Wall thickness	3	0.498 in	12.6 mm	0.540 in	13.7 mm
	4	Inside diameter	4	6.004 in	152.5 mm	5.920 in	150.4 mm
	5	Steel cross-section	5	10.17 in^2	6563 mm^2	10.96 in^2	7070 mm^2
	6	Capacity	6	1.47 gal/ft	18.27 l/m	1.43 gal/ft	17.76 l/m
	7	Displacement (1)	7	2.00 gal/ft	24.83 l/m	2.00 gal/ft	24.83 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	50.1	70.2	70.2	77.0	80.3	89.8	98.7	54.0	78.5	78.5	88.4	92.6	104.3	115.4
	10	Internal yield pressure (MPa)	10	47.2	68.7	68.7	77.3	81.5	94.4	107.3	51.2	74.5	74.5	83.8	88.4	102.4	116.3
	11	Pipe body yield strength (1000 daN)	11	249	362	362	407	430	498	566	268	390	390	439	463	536	609
Tensile strength (10^3 daN)	12	Buttress Standard	12	355	370	390	390	409	487	526	370	370	390	390	409	487	526
	13	Buttress Special Clearance	13	237	237	250	250	262	312	337	237	237	250	250	262	312	337
	14	API STC	14	232	297	302	328	346	403	452	254	324	330	358	377	440	493
	15	API LTC	15	256	327	332	360	379	443	492	280	356	362	393	414	483	537

Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	67.9	68.6
	18	Hydril LX	18	80.7	81.8
	19	Hydril 563	19	89.4	90.1
	20	Hydril 511	20		
	21	Hydril 521	21		
	22	Vallourec & Mannesmann New VAM	22	89.1	82.7
	23	Vallourec & Mannesmann VAM ACE	23	117.4	108.9
	24	Vallourec & Mannesmann VAM PRO	24	91.0	85.0
	25	Vallourec & Mannesmann VAM TOP	25	102.0	101.9
	26	Vallourec & Mannesmann FJL	26	65.3	65.3

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						194.5		149.3						194.5		147.2
	28	Buttress Special Clearance	28						187.3		149.3						187.3		147.2
	29	API STC	29																
	30	API LTC	30		1003	1157	1350	1512	194.5		149.3		1095	1262	1474	1649	194.5		147.2
	31	Grant Prideco TCII	31		1769	1769	1769	1769	196.7	154.2	149.3		2020	2020	2020	2020	198.3	152.3	147.2
	32	Grant Prideco STL	32	705	895	895	895	895	177.8	150.5	149.3	773	976	976	976	976	177.8	148.3	147.2
	33	Hydril LX	33	976	1173	1322	1437	1546	181.5	150.5	149.3	1017	1213	1342	1451	1559	182.1	150.1	147.2
	34	Hydril 563	34	2007	2007	2007	2007	2007	196.8	151.2	149.3	2196	2196	2196	2196	2196	196.8	149.1	147.2
	35	Hydril 511	35																
	36	Hydril 521	36																
	37	Vallourec & Mannesmann New VAM	37	1274	1424	1519	1620	1715	195.1		149.3	1322	1519	1566	1668	1763	195.1		147.2
	38	Vallourec & Mannesmann VAM ACE	38	1471	1763	1959	2156	2156	200.9		149.3	1668	2061	2156	2156	2156	200.9		147.2
	39	Vallourec & Mannesmann VAM PRO	39						195.0		149.3						195.0		147.2
	40	Vallourec & Mannesmann VAM TOP	40	1471	1817	2061	2257	2454	197.8		149.3	1715	2102	2352	2549	2847	199.4		147.2
	41	Vallourec & Mannesmann FJL	41		961	1079	1177	1325	177.8	151.3	149.3		1030	1128	1226	1376	177.8	149.2	147.2

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body

1	Nominal size (OD)	1	**7.000** in	177.8 mm	**7.000** in	177.8 mm
2	Nominal weight	2	**41.00** lb/ft	59.8 daN/m	**44.00** lb/ft	64.2 daN/m
3	Wall thickness	3	0.590 in	15.0 mm	0.640 in	16.3 mm
4	Inside diameter	4	5.820 in	147.8 mm	5.720 in	145.3 mm
5	Steel cross-section	5	11.88 in^2	7665 mm^2	12.79 in^2	8250 mm^2
6	Capacity	6	1.38 gal/ft	17.16 l/m	1.33 gal/ft	16.58 l/m
7	Displacement (1)	7	2.00 gal/ft	24.83 l/m	2.00 gal/ft	24.83 l/m

8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
9	Collapse resistance (MPa)	9	58.5	85.1	85.1	95.8	101.1	117.1	133.0	63.0	91.6	91.6	103.1	108.8	126.0	143.2
10	Internal yield pressure (MPa)	10	55.9	81.4	81.4	91.5	96.6	111.9	127.1	60.7	88.3	88.3	99.3	104.8	121.3	137.9
11	Pipe body yield strength (1000 daN)	11	291	423	423	476	502	581	661	313	455	455	512	540	626	711

Tensile strength (10^3 daN)

12	Buttress Standard	12	370	370	390	390	409	487	526	370	370	390	390	409	487	526
13	Buttress Special Clearance	13	237	237	250	250	262	312	337	237	237	250	250	262	312	337
14	API STC	14	279	356	362	393	414	483	541	303	387	394	427	450	526	589
15	API LTC	15	307	391	398	431	455	531	589	334	426	433	469	495	577	641

Connection efficiency

			41.00 lb/ft	44.00 lb/ft
16	Grant Prideco TCII	16		
17	Grant Prideco STL	17	68.1	65.0
18	Hydril LX	18	82.2	
19	Hydril 563	19	90.9	
20	Hydril 511	20		
21	Hydril 521	21		
22	Vallourec & Mannesmann New VAM	22	76.3	70.9
23	Vallourec & Mannesmann VAM ACE	23	103.7	
24	Vallourec & Mannesmann VAM PRO	24	85.0	79.0
25	Vallourec & Mannesmann VAM TOP	25	102.0	
26	Vallourec & Mannesmann FJL	26	65.1	

Connection characteristics

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
27	Buttress Standard	27						194.5		144.7						194.5		142.1
28	Buttress Special Clearance	28						187.3		144.7						187.3		142.1
29	API STC	29																
30	API LTC	30																
31	Grant Prideco TCII	31		2318	2318	2318	2318	200.2	150.1	144.7								
32	Grant Prideco STL	32	841	1071	1071	1071	1071	177.8	145.9	144.7	841	1071	1071	1071	1071	177.8	146.3	142.1
33	Hydril LX	33	1173	1376	1491	1627	1830	181.9	145.8	144.7								
34	Hydril 563	34	2346	2346	2346	2346	2346	196.8		144.7								
35	Hydril 511	35																
36	Hydril 521	36																
37	Vallourec & Mannesmann New VAM	37	1424	1566	1668	1763	1864	195.1		144.7	1668	1864	1959	2061	2156	195.1		142.1
38	Vallourec & Mannesmann VAM ACE	38	1959	2156	2156	2156	2156	201.7		144.7								
39	Vallourec & Mannesmann VAM PRO	39						195.0		144.7						195.0		142.1
40	Vallourec & Mannesmann VAM TOP	40	1959	2454	2746	2942	3139	201.4		144.7								
41	Vallourec & Mannesmann FJL	41		1079	1177	1325	1424	177.8	146.6	144.7								

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	7.000 in	177.8 mm	7.625 in	193.7 mm
Pipe body	1	Nominal size (OD)	**7.000** in	177.8 mm	**7.625** in	193.7 mm
Pipe body	2	Nominal weight	**46.00** lb/ft	67.1 daN/m	**26.40** lb/ft	38.5 daN/m
Pipe body	3	Wall thickness	0.670 in	17.0 mm	0.328 in	8.3 mm
Pipe body	4	Inside diameter	5.660 in	143.8 mm	6.969 in	177.0 mm
Pipe body	5	Steel cross-section	13.32 in^2	8596 mm^2	7.52 in^2	4851 mm^2
Pipe body	6	Capacity	1.31 gal/ft	16.23 l/m	1.98 gal/ft	24.61 l/m
Pipe body	7	Displacement (1)	2.00 gal/ft	24.83 l/m	2.37 gal/ft	29.46 l/m

Section	No.	Grade	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	65.6	95.5	95.5	107.4	113.4	131.3	149.2	20.0	23.5	23.5	24.9	25.6	27.1	27.9
Pipe body	10	Internal yield pressure (MPa)	63.5	92.4	92.4	103.9	109.7	127.0	144.4	28.5	41.5	41.5	46.7	49.3	57.1	64.9
Pipe body	11	Pipe body yield strength (1000 daN)	326	474	474	533	563	652	741	184	268	268	301	318	368	418
Tensile strength (10^3 daN)	12	Buttress Standard	370	370	390	390	409	487	526	258	282	293	303	318	376	412
Tensile strength (10^3 daN)	13	Buttress Special Clearance	237	237	250	250	262	312	337	258	282	293	303	318	376	412
Tensile strength (10^3 daN)	14	API STC	317	406	412	448	472	551	617	152	196	198	216	227	265	297
Tensile strength (10^3 daN)	15	API LTC	350	446	453	492	518	605	672	167	214	218	237	249	291	326

Section	No.	Connection	7.000 in	7.625 in
Connection efficiency	16	Grant Prideco TCII		
Connection efficiency	17	Grant Prideco STL	64.6	58.2
Connection efficiency	18	Hydril LX		74.1
Connection efficiency	19	Hydril 563		90.0
Connection efficiency	20	Hydril 511		61.6
Connection efficiency	21	Hydril 521		67.7
Connection efficiency	22	Vallourec & Mannesmann New VAM	68.0	171.6
Connection efficiency	23	Vallourec & Mannesmann VAM ACE		166.8
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	75.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP		
Connection efficiency	26	Vallourec & Mannesmann FJL		51.8

Section	No.	Connection	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard						194.5		140.6						215.9		173.8
Connection characteristics	28	Buttress Special Clearance						187.3		140.6						206.4		173.8
Connection characteristics	29	API STC									464					215.9		173.8
Connection characteristics	30	API LTC									511	659	759			215.9		173.8
Connection characteristics	31	Grant Prideco TCII										1044	1044	1044	1044	205.9	175.5	173.8
Connection characteristics	32	Grant Prideco STL	881	1112	1112	1112	1112	177.8	147.3	140.6	447	576	576	576	576	193.7	175.0	173.8
Connection characteristics	33	Hydril LX									929	1166	1308	1430	1620	196.7	175.0	173.8
Connection characteristics	34	Hydril 563									1058	1058	1058	1058	1058	215.9	175.7	173.8
Connection characteristics	35	Hydril 511									583	583	583	583	583	193.7	174.8	173.8
Connection characteristics	36	Hydril 521									976	976	976	976	976	199.8	175.1	173.8
Connection characteristics	37	Vallourec & Mannesmann New VAM	1763	1912	1959	2061	2156	195.1		140.6	971	1079	1180	1227	1322	216.6		173.8
Connection characteristics	38	Vallourec & Mannesmann VAM ACE									735	834	931	1029	1125	215.9		173.8
Connection characteristics	39	Vallourec & Mannesmann VAM PRO						195.0		140.6						216.4		173.8
Connection characteristics	40	Vallourec & Mannesmann VAM TOP																
Connection characteristics	41	Vallourec & Mannesmann FJL										961	1128	1274	1424	193.7	175.4	173.8

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

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

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	7.625 in (in)	193.7 mm (SI)	No.	7.625 in (in)	193.7 mm (SI)
Pipe body	1	Nominal size (OD)	1	**7.625** in	193.7 mm	1	**7.625** in	193.7 mm
Pipe body	2	Nominal weight	2	**29.70** lb/ft	43.3 daN/m	2	**33.70** lb/ft	49.2 daN/m
Pipe body	3	Wall thickness	3	0.375 in	9.5 mm	3	0.430 in	10.9 mm
Pipe body	4	Inside diameter	4	6.875 in	174.6 mm	4	6.765 in	171.8 mm
Pipe body	5	Steel cross-section	5	8.54 in^2	5510 mm^2	5	9.72 in^2	6271 mm^2
Pipe body	6	Capacity	6	1.93 gal/ft	23.95 l/m	6	1.87 gal/ft	23.19 l/m
Pipe body	7	Displacement (1)	7	2.37 gal/ft	29.46 l/m	7	2.37 gal/ft	29.46 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	27.0	33.0	33.0	34.7	35.4	36.9	39.1	35.1	45.2	45.2	48.6	50.2	54.3	57.5
Pipe body	10	Internal yield pressure (MPa)	10	32.6	47.5	47.5	53.4	56.4	65.3	74.2	37.4	54.4	54.4	61.2	64.6	74.8	85.1
Pipe body	11	Pipe body yield strength (1000 daN)	11	209	304	304	342	361	418	475	238	346	346	389	411	476	540
Tensile strength (10^3 daN)	12	Buttress Standard	12	293	321	333	344	362	427	468	334	365	379	391	412	486	533
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	293	321	333	344	361	427	465	327	327	344	344	361	430	465
Tensile strength (10^3 daN)	14	API STC	14	179	230	233	254	267	312	350	210	269	273	297	313	366	410
Tensile strength (10^3 daN)	15	API LTC	15	197	252	256	278	293	342	383	231	295	300	326	343	401	449

Section	No.	Connection	No.	29.70 lb/ft	33.70 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	65.0	66.8
Connection efficiency	18	Hydril LX	18	74.4	78.4
Connection efficiency	19	Hydril 563	19	91.2	92.3
Connection efficiency	20	Hydril 511	20	61.1	60.1
Connection efficiency	21	Hydril 521	21	71.2	74.3
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	151.0	132.7
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	146.9	129.0
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25	102.0	102.0
Connection efficiency	26	Vallourec & Mannesmann FJL	26	57.5	62.7

Connection characteristics — 29.70 lb/ft

No.	Connection	No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard	27						215.9		171.4
28	Buttress Special Clearance	28						206.4		171.4
29	API STC	29								
30	API LTC	30		774	893	1043		215.9		171.4
31	Grant Prideco TCII	31		1342	1342	1342	1342	207.9	173.0	171.4
32	Grant Prideco STL	32	569	719	719	719	719	193.7	172.3	171.4
33	Hydril LX	33	1071	1322	1444	1559	1763	196.9	172.6	171.4
34	Hydril 563	34	1166	1166	1166	1166	1166	215.9		171.4
35	Hydril 511	35	922	922	922	922	922	193.7	172.4	171.4
36	Hydril 521	36	1139	1139	1139	1139	1139	201.9	172.7	171.4
37	Vallourec & Mannesmann New VAM	37	1125	1274	1376	1471	1566	216.6		171.4
38	Vallourec & Mannesmann VAM ACE	38	980	1180	1274	1376	1471	215.9		171.4
39	Vallourec & Mannesmann VAM PRO	39						216.4		171.4
40	Vallourec & Mannesmann VAM TOP	40	1079	1274	1471	1668	1763	208.6		171.4
41	Vallourec & Mannesmann FJL	41		980	1128	1274	1424	193.7	173.1	171.4

Connection characteristics — 33.70 lb/ft

No.	Connection	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard						215.9		168.7
28	Buttress Special Clearance						206.4		168.7
29	API STC								
30	API LTC		907	1047	1222		215.9		168.7
31	Grant Prideco TCII		1458	1458	1458	1458	210.2	173.0	168.7
32	Grant Prideco STL	664	841	841	841	841	193.7	169.8	168.7
33	Hydril LX	1003	1220	1335	1458	1627	197.2	169.8	168.7
34	Hydril 563	1369	1369	1369	1369	1369	215.9		168.7
35	Hydril 511	1180	1180	1180	1180	1180	193.7	169.6	168.7
36	Hydril 521	1329	1329	1329	1329	1329	204.1	169.9	168.7
37	Vallourec & Mannesmann New VAM	1376	1566	1668	1817	1912	216.6		168.7
38	Vallourec & Mannesmann VAM ACE	1180	1376	1566	1668	1763	215.9		168.7
39	Vallourec & Mannesmann VAM PRO						216.4		168.7
40	Vallourec & Mannesmann VAM TOP	1180	1376	1566	1763	1864	210.9		168.7
41	Vallourec & Mannesmann FJL		1030	1177	1325	1471	193.7	170.4	168.7

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body

1	Nominal size (OD)	1	**7.625** in	193.7 mm	**7.625** in	193.7 mm
2	Nominal weight	2	**35.80** lb/ft	52.2 daN/m	**39.00** lb/ft	56.9 daN/m
3	Wall thickness	3	0.465 in	11.8 mm	0.500 in	12.7 mm
4	Inside diameter	4	6.695 in	170.1 mm	6.625 in	168.3 mm
5	Steel cross-section	5	10.46 in^2	6748 mm^2	11.19 in^2	7221 mm^2
6	Capacity	6	1.83 gal/ft	22.71 l/m	1.79 gal/ft	22.24 l/m
7	Displacement (1)	7	2.37 gal/ft	29.46 l/m	2.37 gal/ft	29.46 l/m

			35.80 lb/ft							39.00 lb/ft						
8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
9	Collapse resistance (MPa)	9	40.3	53.0	53.0	57.5	59.6	65.3	70.3	45.5	60.8	60.8	66.3	68.9	76.4	83.1
10	Internal yield pressure (MPa)	10	40.5	58.9	58.9	66.2	69.9	80.9	92.0	43.5	63.3	63.3	71.2	75.2	87.0	98.9
11	Pipe body yield strength (1000 daN)	11	256	372	372	419	442	512	582	274	398	398	448	473	548	622

Tensile strength (10^3 daN)

12	Buttress Standard	12	359	393	408	421	443	523	573	385	420	436	451	474	560	613
13	Buttress Special Clearance	13	327	327	344	344	361	430	465	327	327	344	344	361	430	465
14	API STC	14	229	294	299	325	342	399	448	248	319	324	352	371	433	485
15	API LTC	15	252	323	328	356	375	438	490	273	350	355	386	406	474	531

Connection efficiency

			35.80 lb/ft	39.00 lb/ft
16	Grant Prideco TCII	16		
17	Grant Prideco STL	17		63.8
18	Hydril LX	18		79.2
19	Hydril 563	19		89.5
20	Hydril 511	20		
21	Hydril 521	21		77.3
22	Vallourec & Mannesmann New VAM	22	123.3	115.2
23	Vallourec & Mannesmann VAM ACE	23	119.9	112.1
24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
25	Vallourec & Mannesmann VAM TOP	25	102.0	102.0
26	Vallourec & Mannesmann FJL	26	65.2	65.2

Connection characteristics (35.80 lb/ft)

			Make-up torque (daN.m)							
			K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard	27						215.9		166.9
28	Buttress Special Clearance	28						206.4		166.9
29	API STC	29								
30	API LTC	30								
31	Grant Prideco TCII	31		1668	1668	1668	1668	211.7	171.5	166.9
32	Grant Prideco STL	32								
33	Hydril LX	33								
34	Hydril 563	34								
35	Hydril 511	35								
36	Hydril 521	36								
37	Vallourec & Mannesmann New VAM	37	1424	1620	1763	1864	1959	216.6		166.9
38	Vallourec & Mannesmann VAM ACE	38	1376	1566	1763	1864	1959	215.9		166.9
39	Vallourec & Mannesmann VAM PRO	39						216.4		166.9
40	Vallourec & Mannesmann VAM TOP	40	1376	1668	1864	2061	2257	212.4		166.9
41	Vallourec & Mannesmann FJL	41		1079	1226	1376	1519	193.7	168.8	166.9

Connection characteristics (39.00 lb/ft)

			Make-up torque (daN.m)							
			K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard	27						215.9		165.1
28	Buttress Special Clearance	28						206.4		165.1
29	API STC	29								
30	API LTC	30		1074	1239	1445	1619	215.9		165.1
31	Grant Prideco TCII	31		1891	1891	1891	1891	213.1	169.9	165.1
32	Grant Prideco STL	32	759	963	963	963	963	193.7	166.8	165.1
33	Hydril LX	33	1220	1471	1627	1695	1830	197.5	166.2	165.1
34	Hydril 563	34	2183	2183	2183	2183	2183	215.9	167.0	165.1
35	Hydril 511	35								
36	Hydril 521	36	1573	1573	1573	1573	1573	207.0	166.4	165.1
37	Vallourec & Mannesmann New VAM	37	1471	1668	1817	1912	2061	216.6		165.1
38	Vallourec & Mannesmann VAM ACE	38	1566	1763	1959	2061	2156	215.9		165.1
39	Vallourec & Mannesmann VAM PRO	39						216.4		165.1
40	Vallourec & Mannesmann VAM TOP	40	1566	1959	2156	2454	2746	213.8		165.1
41	Vallourec & Mannesmann FJL	41		1128	1274	1424	1566	193.7	167.0	165.1

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

	No.		No.				
Pipe body	1	Nominal size (OD)	1	**7.625** in	193.7 mm	**7.625** in	193.7 mm
Pipe body	2	Nominal weight	2	**42.80** lb/ft	62.5 daN/m	**45.30** lb/ft	66.1 daN/m
Pipe body	3	Wall thickness	3	0.562 in	14.3 mm	0.595 in	15.1 mm
Pipe body	4	Inside diameter	4	6.501 in	165.1 mm	6.435 in	163.4 mm
Pipe body	5	Steel cross-section	5	12.47 in^2	8045 mm^2	13.14 in^2	8478 mm^2
Pipe body	6	Capacity	6	1.72 gal/ft	21.41 l/m	1.69 gal/ft	20.98 l/m
Pipe body	7	Displacement (1)	7	2.37 gal/ft	29.46 l/m	2.37 gal/ft	29.46 l/m

	No.		No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	51.8	74.6	74.6	82.0	85.6	96.0	105.8	54.6	79.4	79.4	89.3	94.2	106.5	117.9
Pipe body	10	Internal yield pressure (MPa)	10	48.9	71.1	71.1	80.0	84.5	97.8	111.2	51.8	75.3	75.3	84.7	89.4	103.6	117.7
Pipe body	11	Pipe body yield strength (1000 daN)	11	305	444	444	499	527	610	693	321	468	468	526	555	643	731
Tensile strength (10^3 daN)	12	Buttress Standard	12	428	468	486	502	528	624	683	451	493	512	529	556	657	720
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	327	327	344	344	361	430	465	327	327	344	344	361	430	465
Tensile strength (10^3 daN)	14	API STC	14	281	362	367	399	421	491	550	299	384	390	424	447	522	584
Tensile strength (10^3 daN)	15	API LTC	15	310	397	403	437	461	538	603	329	421	428	465	490	572	640

	No.		No.	7.625 in – 42.80 lb/ft	7.625 in – 45.30 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	69.5	69.9
Connection efficiency	18	Hydril LX	18	81.6	82.3
Connection efficiency	19	Hydril 563	19	90.6	91.0
Connection efficiency	20	Hydril 511	20		
Connection efficiency	21	Hydril 521	21		
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	103.5	98.2
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	102.0	102.0
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25		
Connection efficiency	26	Vallourec & Mannesmann FJL	26	65.1	66.0

	No.		No.	Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						215.9		162.0						215.9		160.3
Connection characteristics	28	Buttress Special Clearance	28						206.4		162.0						206.4		160.3
Connection characteristics	29	API STC	29																
Connection characteristics	30	API LTC	30		1218	1406	1641	1837	215.9		162.0								
Connection characteristics	31	Grant Prideco TCII	31		2285	2285	2285	2285	215.6	167.2	162.0								
Connection characteristics	32	Grant Prideco STL	32						193.7	163.9	162.0	936	1180	1180	1180	1180	193.7	162.8	160.3
Connection characteristics	33	Hydril LX	33	1200	1458	1559	1695	1898	197.8	163.1	162.0	1288	1491	1695	1830	1966	197.9	161.4	160.3
Connection characteristics	34	Hydril 563	34	2413	2413	2413	2413	2413	215.9		162.0	2576	2576	2576	2576	2576	215.9		160.3
Connection characteristics	35	Hydril 511	35																
Connection characteristics	36	Hydril 521	36																
Connection characteristics	37	Vallourec & Mannesmann New VAM	37	1620	1817	1912	2061	2156	216.6		162.0	1668	1864	1959	2061	2156	216.6		160.3
Connection characteristics	38	Vallourec & Mannesmann VAM ACE	38	1864	2061	2156	2156	2156	216.2		162.0	2061	2156	2156	2156	2156	217.5		160.3
Connection characteristics	39	Vallourec & Mannesmann VAM PRO	39						216.4		162.0						216.4		160.3
Connection characteristics	40	Vallourec & Mannesmann VAM TOP	40																
Connection characteristics	41	Vallourec & Mannesmann FJL	41		1177	1325	1471	1620	193.7	163.9	162.0		1177	1376	1519	1715	193.7	162.2	160.3

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

				7.625 in	193.7 mm	8.625 in	219.1 mm
Pipe body	1	Nominal size (OD)	1	**7.625** in	193.7 mm	**8.625** in	219.1 mm
	2	Nominal weight	2	**47.10** lb/ft	68.7 daN/m	**28.00** lb/ft	40.9 daN/m
	3	Wall thickness	3	0.625 in	15.9 mm	0.304 in	7.7 mm
	4	Inside diameter	4	6.375 in	161.9 mm	8.017 in	203.6 mm
	5	Steel cross-section	5	13.74 in^2	8867 mm^2	7.95 in^2	5127 mm^2
	6	Capacity	6	1.66 gal/ft	20.59 l/m	2.62 gal/ft	32.57 l/m
	7	Displacement (1)	7	2.37 gal/ft	29.46 l/m	3.04 gal/ft	37.69 l/m

				7.625 in							8.625 in						
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	57.1	83.0	83.0	93.4	98.6	114.1	128.9	13.0	14.9	14.9	15.2	15.2	15.2	15.2
	10	Internal yield pressure (MPa)	10	54.4	79.1	79.1	89.0	94.0	108.8	123.6	23.4	34.0	34.0	38.3	40.4	46.8	53.2
	11	Pipe body yield strength (1000 daN)	11	336	489	489	550	581	673	764	194	283	283	318	336	389	442
Tensile strength (10^3 daN)	12	Buttress Standard	12	472	516	536	551	579	687	744	267	295	306	318	334	394	433
	13	Buttress Special Clearance	13	327	327	344	344	361	430	465	267	295	306	318	334	394	433
	14	API STC	14	315	404	411	446	470	549	615	149	193	196	213	225	262	294
	15	API LTC	15	346	443	450	489	516	602	674	168	216	219	239	252	293	329

				7.625 in	8.625 in
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	70.2	57.1
	18	Hydril LX	18	82.3	
	19	Hydril 563	19		
	20	Hydril 511	20		
	21	Hydril 521	21		
	22	Vallourec & Mannesmann New VAM	22	93.9	206.4
	23	Vallourec & Mannesmann VAM ACE	23		202.8
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25		
	26	Vallourec & Mannesmann FJL	26		

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						215.9		158.8						244.5		200.5
	28	Buttress Special Clearance	28						206.4		158.8						231.8		200.5
	29	API STC	29																
	30	API LTC	30		1367	1571	1834	2054	215.9		158.8								
	31	Grant Prideco TCII	31		2712	2712	2712	2712	224.8	164.4	158.8		976	976	976	976	230.7	202.1	200.5
	32	Grant Prideco STL	32	976	1241	1241	1241	1241	193.7	161.5	158.8	461	583	583	583	583	219.1	202.2	200.5
	33	Hydril LX	33	1383	1627	1830	1966	2169	198.1	159.9	158.8								
	34	Hydril 563	34																
	35	Hydril 511	35																
	36	Hydril 521	36																
	37	Vallourec & Mannesmann New VAM	37	1715	1912	2061	2156	2156	216.6		158.8	1029	1180	1274	1376	1471	245.1		200.5
	38	Vallourec & Mannesmann VAM ACE	38									735	834	883	931	980	244.5		200.5
	39	Vallourec & Mannesmann VAM PRO	39						216.4		158.8						244.5		200.5
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi   daN × 2.25 = lb   daN.m × 7.38 = lb.ft   mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**8.625** in	219.1 mm	**8.625** in	219.1 mm
	2	Nominal weight	2	**32.00** lb/ft	46.7 daN/m	**36.00** lb/ft	52.5 daN/m
	3	Wall thickness	3	0.352 in	8.9 mm	0.400 in	10.2 mm
	4	Inside diameter	4	7.921 in	201.2 mm	7.825 in	198.8 mm
	5	Steel cross-section	5	9.15 in^2	5902 mm^2	10.34 in^2	6668 mm^2
	6	Capacity	6	2.56 gal/ft	31.79 l/m	2.50 gal/ft	31.03 l/m
	7	Displacement (1)	7	3.04 gal/ft	37.69 l/m	3.04 gal/ft	37.69 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	17.5	21.0	21.0	22.2	22.6	23.6	23.9	23.8	28.3	28.3	29.3	30.0	32.3	34.0
	10	Internal yield pressure (MPa)	10	27.1	39.4	39.4	44.3	46.8	54.2	61.6	30.8	44.8	44.8	50.4	53.2	61.6	69.9
	11	Pipe body yield strength (1000 daN)	11	224	326	326	366	387	448	509	253	368	368	414	437	506	575
Tensile strength (10^3 daN)	12	Buttress Standard	12	307	340	352	366	384	454	498	347	384	398	413	434	512	563
	13	Buttress Special Clearance	13	307	340	352	366	384	454	498	347	373	393	393	412	491	530
	14	API STC	14	179	232	235	256	270	315	353	208	270	273	298	314	366	411
	15	API LTC	15	201	259	263	286	302	352	394	234	302	306	333	351	410	459

Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	59.3	66.0
	18	Hydril LX	18		73.3
	19	Hydril 563	19	90.7	91.8
	20	Hydril 511	20	57.3	61.4
	21	Hydril 521	21	68.1	71.4
	22	Vallourec & Mannesmann New VAM	22	179.3	158.7
	23	Vallourec & Mannesmann VAM ACE	23	176.2	156.0
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25		102.1
	26	Vallourec & Mannesmann FJL	26	54.5	59.7

				Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27						244.5		198.0						244.5		195.6
	28	Buttress Special Clearance	28						231.8		198.0						231.8		195.6
	29	API STC	29	545					244.5		198.0	635					244.5		195.6
	30	API LTC	30	613					244.5		198.0	713	926	1070			244.5		195.6
	31	Grant Prideco TCII	31		1369	1369	1369	1369	232.8	199.7	198.0		1478	1478	1478	1478	234.9	199.7	195.6
	32	Grant Prideco STL	32	556	705	705	705	705	219.1	200.2	198.0	691	881	881	881	881	219.1	196.9	195.6
	33	Hydril LX	33									1173	1458	1627	1763	1966	222.6	196.7	195.6
	34	Hydril 563	34	1274	1274	1274	1274	1274	244.5	201.6	198.0	1424	1424	1424	1424	1424	244.5		195.6
	35	Hydril 511	35	746	746	746	746	746	219.1	201.1	198.0	1098	1098	1098	1098	1098	219.1	196.7	195.6
	36	Hydril 521	36	1166	1166	1166	1166	1166	225.8	201.3	198.0	1383	1383	1383	1383	1383	227.8	196.8	195.6
	37	Vallourec & Mannesmann New VAM	37	1125	1274	1376	1471	1566	245.1		198.0	1376	1566	1668	1817	1959	245.1		195.6
	38	Vallourec & Mannesmann VAM ACE	38	883	980	1079	1180	1274	244.5		198.0	1079	1227	1376	1471	1566	244.5		195.6
	39	Vallourec & Mannesmann VAM PRO	39						244.5		198.0						244.5		195.6
	40	Vallourec & Mannesmann VAM TOP	40									1079	1227	1376	1471	1566	235.4		195.6
	41	Vallourec & Mannesmann FJL	41		1226	1424	1620	1817	219.1	199.7	198.0		1274	1471	1668	1864	219.1	197.3	195.6

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**8.625** in			219.1 mm				**8.625** in			219.1 mm			
	2	Nominal weight	2	**40.00** lb/ft			58.4 daN/m				**44.00** lb/ft			64.2 daN/m			
	3	Wall thickness	3	0.450 in			11.4 mm				0.500 in			12.7 mm			
	4	Inside diameter	4	7.725 in			196.2 mm				7.625 in			193.7 mm			
	5	Steel cross-section	5	11.56 in²			7456 mm²				12.76 in²			8234 mm²			
	6	Capacity	6	2.43 gal/ft			30.24 l/m				2.37 gal/ft			29.46 l/m			
	7	Displacement (1)	7	3.04 gal/ft			37.69 l/m				3.04 gal/ft			37.69 l/m			
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	30.3	38.1	38.1	40.5	41.5	44.1	45.7	36.9	47.9	47.9	51.7	53.4	58.1	61.9
	10	Internal yield pressure (MPa)	10	34.6	50.4	50.4	56.7	59.8	69.2	78.7	38.5	56.0	56.0	63.0	66.4	76.9	87.4
	11	Pipe body yield strength (1000 daN)	11	283	411	411	463	488	565	643	312	454	454	511	539	624	710
Tensile strength (10^3 daN)	12	Buttress Standard	12	388	430	445	462	486	573	629	428	474	492	510	536	633	695
	13	Buttress Special Clearance	13	373	373	393	393	412	491	530	373	373	393	393	412	491	530
	14	API STC	14	239	309	313	341	360	419	470	268	347	352	384	405	472	529
	15	API LTC	15	268	345	351	381	402	469	526	302	389	394	429	452	528	592

				8.625 in – 40.00 lb/ft	8.625 in – 44.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	67.3	58.2
	18	Hydril LX	18	75.7	76.8
	19	Hydril 563	19	92.6	89.5
	20	Hydril 511	20	58.6	
	21	Hydril 521	21	74.2	76.3
	22	Vallourec & Mannesmann New VAM	22	141.9	128.5
	23	Vallourec & Mannesmann VAM ACE	23	139.5	126.3
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.0
	26	Vallourec & Mannesmann FJL	26	63.9	65.4

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						244.5		193.0						244.5		190.5
	28	Buttress Special Clearance	28						231.8		193.0						231.8		190.5
	29	API STC	29																
	30	API LTC	30		1060	1226	1430		244.5		193.0		1194	1379	1608		244.5		190.5
	31	Grant Prideco TCII	31		1830	1830	1830	1830	237.1	197.4	193.0		2196	2196	2196	2196	239.1	195.2	190.5
	32	Grant Prideco STL	32	786	1003	1003	1003	1003	219.1	194.7	193.0	759	963	963	963	963	219.1	194.8	190.5
	33	Hydril LX	33	1363	1627	1830	1966	2169	222.8	194.6	193.0	1396	1695	1898	2102	2305	223.1	191.6	190.5
	34	Hydril 563	34	1627	1627	1627	1627	1627	244.5		193.0	2468	2468	2468	2468	2468	244.5	192.4	190.5
	35	Hydril 511	35	1369	1369	1369	1369	1369	219.1	194.8	193.0								
	36	Hydril 521	36	1573	1573	1573	1573	1573	229.9	194.9	193.0	1763	1763	1763	1763	1763	232.0	191.8	190.5
	37	Vallourec & Mannesmann New VAM	37	1471	1668	1817	1912	2061	245.1		193.0	1566	1763	1912	2061	2156	245.1		190.5
	38	Vallourec & Mannesmann VAM ACE	38	1376	1566	1763	1864	1959	244.5		193.0	1668	1864	2061	2156	2156	244.5		190.5
	39	Vallourec & Mannesmann VAM PRO	39						244.5		193.0						244.5		190.5
	40	Vallourec & Mannesmann VAM TOP	40	1376	1668	1864	2061	2257	237.5		193.0	1763	2257	2454	2746	2942	239.6		190.5
	41	Vallourec & Mannesmann FJL	41		1325	1519	1668	1864	219.1	194.9	193.0		1376	1566	1763	1959	219.1	192.6	190.5

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	8.625 in	219.1 mm	8.625 in	219.1 mm
Pipe body	1	Nominal size (OD)	1	**8.625** in	219.1 mm	**8.625** in	219.1 mm
Pipe body	2	Nominal weight	2	**49.00** lb/ft	71.5 daN/m	**52.00** lb/ft	75.9 daN/m
Pipe body	3	Wall thickness	3	0.557 in	14.1 mm	0.595 in	15.1 mm
Pipe body	4	Inside diameter	4	7.511 in	190.8 mm	7.435 in	188.8 mm
Pipe body	5	Steel cross-section	5	14.12 in²	9108 mm²	15.01 in²	9684 mm²
Pipe body	6	Capacity	6	2.30 gal/ft	28.59 l/m	2.26 gal/ft	28.01 l/m
Pipe body	7	Displacement (1)	7	3.04 gal/ft	37.69 l/m	3.04 gal/ft	37.69 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	44.4	59.1	59.1	64.4	66.9	74.0	80.4	48.7	66.6	66.6	72.9	75.9	84.6	92.7
Pipe body	10	Internal yield pressure (MPa)	10	42.9	62.3	62.3	70.1	74.0	85.7	97.4	45.8	66.6	66.6	74.9	79.1	91.6	104.0
Pipe body	11	Pipe body yield strength (1000 daN)	11	345	502	502	565	597	691	785	367	534	534	601	634	734	835
Tensile strength (10^3 daN)	12	Buttress Standard	12	474	525	544	564	593	700	769	504	558	578	600	631	744	817
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13	373	373	393	393	412	491	530	373	373	393	393	412	491	530
Tensile strength (10^3 daN)	14	API STC	14	302	391	396	432	455	531	595	324	419	425	463	488	570	639
Tensile strength (10^3 daN)	15	API LTC	15	339	437	444	483	509	594	665	364	469	476	518	546	637	714

Section	No.	Connection	No.	49.00 lb/ft	52.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	59.1	
Connection efficiency	18	Hydril LX	18	79.4	79.0
Connection efficiency	19	Hydril 563	19	90.6	91.1
Connection efficiency	20	Hydril 511	20		
Connection efficiency	21	Hydril 521	21		
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	116.2	109.3
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	114.2	107.4
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25	102.0	102.0
Connection efficiency	26	Vallourec & Mannesmann FJL	26	69.2	65.1

Section	No.	Connection	No.	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27						244.5		187.6						244.5		185.7
Connection characteristics	28	Buttress Special Clearance	28						231.8		187.6						231.8		185.7
Connection characteristics	29	API STC	29																
Connection characteristics	30	API LTC	30		1342	1551	1810	2028	244.5		187.6								
Connection characteristics	31	Grant Prideco TCII	31		2624	2624	2624	2624	241.5	192.7	187.6								
Connection characteristics	32	Grant Prideco STL	32	759	963	963	963	963	219.1	192.6	187.6								
Connection characteristics	33	Hydril LX	33	1627	1966	2102	2305	2508	223.3	189.2	187.6	1627	1966	2169	2440	2644	223.5	186.8	185.7
Connection characteristics	34	Hydril 563	34	2685	2685	2685	2685	2685	244.5		187.6	2874	2874	2874	2874	2874	244.5		185.7
Connection characteristics	35	Hydril 511	35																
Connection characteristics	36	Hydril 521	36																
Connection characteristics	37	Vallourec & Mannesmann New VAM	37	1668	1864	2061	2156	2156	245.1		187.6	1763	1959	2061	2156	2156	245.1		185.7
Connection characteristics	38	Vallourec & Mannesmann VAM ACE	38	1959	2156	2156	2156	2156	244.5		187.6	2156	2156	2156	2156	2156	244.5		185.7
Connection characteristics	39	Vallourec & Mannesmann VAM PRO	39						244.5		187.6						244.5		185.7
Connection characteristics	40	Vallourec & Mannesmann VAM TOP	40	2257	2847	3037	3139	3139	242.0		187.6	2549	3139	3139	3139	3139	243.5		185.7
Connection characteristics	41	Vallourec & Mannesmann FJL	41		1471	1620	1817	1959	219.1	189.7	187.6		1519	1715	1912	2061	219.1	187.8	185.7

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**9.625** in	244.5 mm	**9.625** in	244.5 mm
	2	Nominal weight	2	**36.00** lb/ft	52.5 daN/m	**40.00** lb/ft	58.4 daN/m
	3	Wall thickness	3	0.352 in	8.9 mm	0.395 in	10.0 mm
	4	Inside diameter	4	8.921 in	226.6 mm	8.835 in	224.4 mm
	5	Steel cross-section	5	10.25 in^2	6616 mm^2	11.45 in^2	7390 mm^2
	6	Capacity	6	3.25 gal/ft	40.33 l/m	3.18 gal/ft	39.55 l/m
	7	Displacement (1)	7	3.78 gal/ft	46.94 l/m	3.78 gal/ft	46.94 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	14.0	16.4	16.4	16.9	17.0	17.1	17.1	17.7	21.3	21.3	22.4	22.9	24.0	24.3
	10	Internal yield pressure (MPa)	10	24.3	35.3	35.3	39.7	41.9	48.5	55.2	27.2	39.6	39.6	44.6	47.0	54.5	61.9
	11	Pipe body yield strength (1000 daN)	11	251	365	365	411	433	502	570	280	408	408	459	484	560	637
Tensile strength (10^3 daN)	12	Buttress Standard	12	336	377	390	407	428	504	555	375	421	436	454	478	563	620
	13	Buttress Special Clearance	13	336	377	390	407	428	504	555	375	416	436	437	459	547	591
	14	API STC	14	188	245	249	271	286	334	374	216	282	285	312	328	383	430
	15	API LTC	15	218	282	286	312	328	383	430	250	323	328	358	377	440	493

Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17		59.9
	18	Hydril LX	18		
	19	Hydril 563	19	90.7	91.7
	20	Hydril 511	20		59.6
	21	Hydril 521	21	66.7	70.0
	22	Vallourec & Mannesmann New VAM	22	177.6	159.0
	23	Vallourec & Mannesmann VAM ACE	23	173.9	155.6
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25		102.1
	26	Vallourec & Mannesmann FJL	26	53.5	58.4

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						269.9		222.6						269.9		220.4
	28	Buttress Special Clearance	28						257.2		222.6						257.2		220.4
	29	API STC	29	574					269.9		222.6	659					269.9		220.4
	30	API LTC	30	663					269.9		222.6	761	992	1148			269.9		220.4
	31	Grant Prideco TCII	31		1593	1593	1593	1593	258.1	225.2	222.6		1708	1708	1708	1708	260.0	225.2	220.4
	32	Grant Prideco STL	32									691	881	881	881	881	244.5	223.8	220.4
	33	Hydril LX	33																
	34	Hydril 563	34	1356	1356	1356	1356	1356	269.9	225.3	222.6	1464	1464	1464	1464	1464	269.9		220.4
	35	Hydril 511	35									1180	1180	1180	1180	1180	244.5	223.4	220.4
	36	Hydril 521	36	1247	1247	1247	1247	1247	251.0	224.7	222.6	1424	1424	1424	1424	1424	252.9	223.5	220.4
	37	Vallourec & Mannesmann New VAM	37	1180	1376	1519	1620	1763	270.5		222.6	1424	1668	1817	1959	2156	270.5		220.4
	38	Vallourec & Mannesmann VAM ACE	38	980	1180	1274	1376	1471	269.9		222.6	1180	1376	1566	1668	1864	269.9		220.4
	39	Vallourec & Mannesmann VAM PRO	39						269.9		222.6						269.9		220.4
	40	Vallourec & Mannesmann VAM TOP	40									1079	1274	1376	1566	1668	260.7		220.4
	41	Vallourec & Mannesmann FJL	41		1519	1763	2061	2156	244.5	224.3	222.6		1566	1817	2061	2156	244.5	222.2	220.4

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body

			9.625 in	244.5 mm	9.625 in	244.5 mm
1	Nominal size (OD)	1	**9.625** in	244.5 mm	**9.625** in	244.5 mm
2	Nominal weight	2	**43.50** lb/ft	63.5 daN/m	**47.00** lb/ft	68.6 daN/m
3	Wall thickness	3	0.435 in	11.0 mm	0.472 in	12.0 mm
4	Inside diameter	4	8.755 in	222.4 mm	8.681 in	220.5 mm
5	Steel cross-section	5	12.56 in^2	8103 mm^2	13.57 in^2	8756 mm^2
6	Capacity	6	3.13 gal/ft	38.84 l/m	3.07 gal/ft	38.19 l/m
7	Displacement (1)	7	3.78 gal/ft	46.94 l/m	3.78 gal/ft	46.94 l/m

			K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
9	Collapse resistance (MPa)	9	22.4	26.3	26.3	27.6	28.4	30.5	31.9	26.8	32.8	32.8	34.4	35.1	36.5	38.8
10	Internal yield pressure (MPa)	10	30.0	43.6	43.6	49.1	51.8	60.0	68.2	32.5	47.3	47.3	53.3	56.2	65.1	74.0
11	Pipe body yield strength (1000 daN)	11	307	447	447	503	531	615	698	332	483	483	543	574	664	755

Tensile strength (10^3 daN)

			K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
12	Buttress Standard	12	411	462	478	498	524	617	679	445	499	516	538	566	667	734
13	Buttress Special Clearance	13	411	416	437	437	459	547	591	416	416	437	437	459	547	591
14	API STC	14	242	315	319	348	367	428	481	265	346	350	382	403	470	527
15	API LTC	15	279	362	367	400	422	492	552	306	397	403	439	463	540	605

Connection efficiency

			43.50 lb/ft	47.00 lb/ft
16	Grant Prideco TCII	16		
17	Grant Prideco STL	17	67.0	66.0
18	Hydril LX	18	74.1	75.7
19	Hydril 563	19	92.4	93.0
20	Hydril 511	20	62.5	61.2
21	Hydril 521	21	72.3	74.1
22	Vallourec & Mannesmann New VAM	22	145.0	134.2
23	Vallourec & Mannesmann VAM ACE	23	141.9	131.4
24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
25	Vallourec & Mannesmann VAM TOP	25	102.0	102.0
26	Vallourec & Mannesmann FJL	26	62.0	64.9

Connection characteristics

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
27	Buttress Standard	27						269.9		218.4						269.9		216.5
28	Buttress Special Clearance	28						257.2		218.4						257.2		216.5
29	API STC	29																
30	API LTC	30		1110	1285	1498		269.9		218.4		1219	1410	1645	1844	269.9		216.5
31	Grant Prideco TCII	31		2054	2054	2054	2054	261.7	223.4	218.4		2373	2373	2373	2373	263.3	221.8	216.5
32	Grant Prideco STL	32	868	1098	1098	1098	1098	244.5	219.7	218.4	908	1234	1234	1234	1234	244.5	219.6	216.5
33	Hydril LX	33	1491	1830	2034	2237	2508	248.4	220.3	218.4	1627	2034	2305	2440	2644	248.5	218.5	216.5
34	Hydril 563	34	1613	1613	1613	1613	1613	269.9		218.4	1790	1790	1790	1790	1790	269.9		216.5
35	Hydril 511	35	1315	1315	1315	1315	1315	244.5	220.2	218.4	1627	1627	1627	1627	1627	244.5	217.7	216.5
36	Hydril 521	36	1586	1586	1586	1586	1586	254.6	220.5	218.4	1735	1735	1735	1735	1735	256.2	218.6	216.5
37	Vallourec & Mannesmann New VAM	37	1620	1912	2061	2156	2156	270.5		218.4	1668	1959	2156	2156	2156	270.5		216.5
38	Vallourec & Mannesmann VAM ACE	38	1471	1668	1864	1959	2156	269.9		218.4	1763	1959	2156	2156	2156	269.9		216.5
39	Vallourec & Mannesmann VAM PRO	39						269.9		218.4						269.9		216.5
40	Vallourec & Mannesmann VAM TOP	40	1471	1763	1959	2156	2352	262.5		218.4	1763	2156	2352	2746	2942	264.1		216.5
41	Vallourec & Mannesmann FJL	41		1620	1864	2061	2156	244.5	220.2	218.4		1668	1912	2156	2156	244.5	219.4	216.5

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**9.625** in	244.5 mm	**9.625** in	244.5 mm
	2	Nominal weight	2	**53.50** lb/ft	78.1 daN/m	**58.40** lb/ft	85.2 daN/m
	3	Wall thickness	3	0.545 in	13.8 mm	0.595 in	15.1 mm
	4	Inside diameter	4	8.535 in	216.8 mm	8.435 in	214.2 mm
	5	Steel cross-section	5	15.55 in^2	10 030 mm^2	16.88 in^2	10 890 mm^2
	6	Capacity	6	2.97 gal/ft	36.91 l/m	2.90 gal/ft	36.05 l/m
	7	Displacement (1)	7	3.78 gal/ft	46.94 l/m	3.78 gal/ft	46.94 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	35.4	45.6	45.6	49.1	50.6	54.8	58.2	41.3	54.4	54.4	59.1	61.3	67.3	72.7
	10	Internal yield pressure (MPa)	10	37.6	54.7	54.7	61.5	64.9	75.2	85.4	41.0	59.7	59.7	67.1	70.9	82.0	93.2
	11	Pipe body yield strength (1000 daN)	11	380	553	553	622	657	761	864	413	601	601	676	713	826	939
Tensile strength (10^3 daN)	12	Buttress Standard	12	509	572	591	616	648	764	841	553	621	642	669	704	830	913
	13	Buttress Special Clearance	13	416	416	437	437	459	547	591	416	416	437	437	459	547	591
	14	API STC	14	311	405	411	448	473	551	618	342	446	452	493	520	606	680
	15	API LTC	15	359	466	472	515	543	633	710	395	512	519	566	596	696	780

Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	62.9	65.0
	18	Hydril LX	18	77.6	76.9
	19	Hydril 563	19	93.9	91.2
	20	Hydril 511	20		
	21	Hydril 521	21	77.0	
	22	Vallourec & Mannesmann New VAM	22	117.1	107.9
	23	Vallourec & Mannesmann VAM ACE	23	114.7	105.6
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.0
	26	Vallourec & Mannesmann FJL	26	65.1	68.1

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						269.9		212.8						269.9		210.3
	28	Buttress Special Clearance	28						257.2		212.8						257.2		210.3
	29	API STC	29																
	30	API LTC	30		1430	1654	1928	2163	269.9		212.8								
	31	Grant Prideco TCII	31		2861	2861	2861	2861	266.4	219.8	212.8		3512	3512	3512	3512	268.4	216.3	210.3
	32	Grant Prideco STL	32	1098	1383	1383	1383	1383	244.5	217.6	212.8	1112	1410	1410	1410	1410	244.5	215.2	210.3
	33	Hydril LX	33	1763	2169	2373	2644	2847	249.5	216.8	212.8	1966	2373	2576	2847	3118	249.7	214.5	210.3
	34	Hydril 563	34	2102	2102	2102	2102	2102	269.9		212.8	3064	3064	3064	3064	3064	269.9		210.3
	35	Hydril 511	35																
	36	Hydril 521	36	2020	2020	2020	2020	2020	259.2	216.8	212.8								
	37	Vallourec & Mannesmann New VAM	37	1817	2156	2156	2156	2156	270.5		212.8	1912	2156	2156	2156	2156	270.5		210.3
	38	Vallourec & Mannesmann VAM ACE	38	1966	2156	2156	2156	2156	269.9		212.8	2156	2156	2156	2156	2156	269.9		210.3
	39	Vallourec & Mannesmann VAM PRO	39						269.9		212.8						269.9		210.3
	40	Vallourec & Mannesmann VAM TOP	40	2454	3139	3139	3139	3139	267.2		212.8	2942	3139	3139	3139	3139	269.2		210.3
	41	Vallourec & Mannesmann FJL	41		1763	1959	2156	2156	244.5	217.6	212.8		1817	2061	2156	2156	244.5	212.4	210.3

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**9.625** in	244.5 mm	**9.625** in	244.5 mm
	2	Nominal weight	2	**59.40** lb/ft	86.7 daN/m	**61.10** lb/ft	89.2 daN/m
	3	Wall thickness	3	0.609 in	15.5 mm	0.625 in	15.9 mm
	4	Inside diameter	4	8.407 in	213.5 mm	8.375 in	212.7 mm
	5	Steel cross-section	5	17.25 in^2	11 129 mm^2	17.67 in^2	11 401 mm^2
	6	Capacity	6	2.88 gal/ft	35.81 l/m	2.86 gal/ft	35.54 l/m
	7	Displacement (1)	7	3.78 gal/ft	46.94 l/m	3.78 gal/ft	46.94 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	42.9	56.9	56.9	61.9	64.2	70.9	76.7	44.8	59.7	59.7	65.1	67.6	74.9	81.4
	10	Internal yield pressure (MPa)	10	42.0	61.1	61.1	68.7	72.5	84.0	95.4	43.1	62.7	62.7	70.5	74.4	86.2	97.9
	11	Pipe body yield strength (1000 daN)	11	422	614	614	691	729	844	959	432	629	629	707	747	865	983
Tensile strength (10^3 daN)	12	Buttress Standard	12	565	634	656	684	720	848	933	579	650	672	701	737	869	956
	13	Buttress Special Clearance	13	416	416	437	437	459	547	591	416	416	437	437	459	547	591
	14	API STC	14	351	457	463	505	533	621	697	360	469	476	519	548	638	716
	15	API LTC	15	405	525	532	580	611	713	800	416	539	547	596	629	733	822

Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17		
	18	Hydril LX	18		
	19	Hydril 563	19	91.4	91.6
	20	Hydril 511	20		
	21	Hydril 521	21		
	22	Vallourec & Mannesmann New VAM	22	105.6	103.1
	23	Vallourec & Mannesmann VAM ACE	23	103.3	102.0
	24	Vallourec & Mannesmann VAM PRO	24	100.0	100.0
	25	Vallourec & Mannesmann VAM TOP	25		
	26	Vallourec & Mannesmann FJL	26	66.7	65.1

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						269.9		209.6						269.9		208.8
	28	Buttress Special Clearance	28						257.2		209.6						257.2		208.8
	29	API STC	29																
	30	API LTC	30																
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32																
	33	Hydril LX	33																
	34	Hydril 563	34	3146	3146	3146	3146	3146	269.9		209.6	3254	3254	3254	3254	3254	269.9		208.8
	35	Hydril 511	35																
	36	Hydril 521	36																
	37	Vallourec & Mannesmann New VAM	37	1966	2156	2156	2156	2156	270.5		209.6	1966	2156	2156	2156	2156	270.5		208.8
	38	Vallourec & Mannesmann VAM ACE	38	2156	2156	2156	2156	2156	269.9		209.6	2156	2156	2156	2156	2156	270.2		208.8
	39	Vallourec & Mannesmann VAM PRO	39						269.9		209.6						269.9		208.8
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41		1817	2061	2156	2156	244.5	212.4	209.6		1864	2061	2156	2156	244.5	212.4	208.8

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

	1	Nominal size (OD)	1	**9.875** in	250.8 mm	**10.750** in	273.0 mm
	2	Nominal weight	2	**62.80** lb/ft	91.6 daN/m	**40.50** lb/ft	59.1 daN/m
Pipe body	3	Wall thickness	3	0.625 in	15.9 mm	0.350 in	8.9 mm
	4	Inside diameter	4	8.625 in	219.1 mm	10.050 in	255.3 mm
	5	Steel cross-section	5	18.16 in^2	11 718 mm^2	11.44 in^2	7378 mm^2
	6	Capacity	6	3.04 gal/ft	37.69 l/m	4.12 gal/ft	51.18 l/m
	7	Displacement (1)	7	3.98 gal/ft	49.41 l/m	4.72 gal/ft	58.56 l/m

				9.875 in							10.750 in						
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	43.0	56.9	56.9	61.9	64.3	70.9	76.8	10.9	11.9	11.9	11.9	11.9	11.9	11.9
	10	Internal yield pressure (MPa)	10	42.0	61.1	61.1	68.7	72.5	84.0	95.5	21.6	31.4	31.4	35.4	37.3	43.2	49.1
	11	Pipe body yield strength (1000 daN)	11	444	646	646	727	768	889	1010	280	407	407	458	483	560	636
Tensile strength (10^3 daN)	12	Buttress Standard	12								364	416	429	449	473	557	614
	13	Buttress Special Clearance	13														
	14	API STC	14								200	262	266	291	306	357	401
	15	API LTC	15														

Connection efficiency				9.875 in	10.750 in
	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	70.3	59.9
	18	Hydril LX	18	79.1	
	19	Hydril 563	19	91.6	90.7
	20	Hydril 511	20		
	21	Hydril 521	21		63.2
	22	Vallourec & Mannesmann New VAM	22		176.6
	23	Vallourec & Mannesmann VAM ACE	23	102.1	173.7
	24	Vallourec & Mannesmann VAM PRO	24	90.0	
	25	Vallourec & Mannesmann VAM TOP	25	102.0	
	26	Vallourec & Mannesmann FJL	26	68.1	52.4

Connection characteristics				Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
	27	Buttress Standard	27														298.4		251.3
	28	Buttress Special Clearance	28														285.8		251.3
	29	API STC	29									610					298.5		251.3
	30	API LTC	30																
	31	Grant Prideco TCII	31		3925	3925	3925	3925	275.8	221.3	215.1		1830	1830	1830	1830	286.6	253.5	251.3
	32	Grant Prideco STL	32	1302	1661	1661	1661	1661	250.8	216.3	215.1	691	881	881	881	881	273.0	254.5	251.3
	33	Hydril LX	33	2169	2576	2915	3186	3457	255.7	216.8	215.1								
	34	Hydril 563	34	3254	3254	3254	3254	3254	269.9		215.1	1654	1654	1654	1654	1654	298.4	254.0	251.3
	35	Hydril 511	35																
	36	Hydril 521	36									1356	1356	1356	1356	1356	275.9	253.4	251.3
	37	Vallourec & Mannesmann New VAM	37									1274	1519	1668	1817	1959	299.0		251.3
	38	Vallourec & Mannesmann VAM ACE	38	2752	3186	3186	3186	3186	276.8		215.1	1079	1274	1471	1566	1668	298.4		251.3
	39	Vallourec & Mannesmann VAM PRO	39						269.9		215.1								
	40	Vallourec & Mannesmann VAM TOP	40	3139	3139	3139	3139	3139	277.0		215.1								
	41	Vallourec & Mannesmann FJL	41		1959	2156	2156	2156	250.8	217.9	215.1		1959	2156	2156	2156	273.0	253.2	251.3

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

	1	Nominal size (OD)	1	**10.750** in	273.0 mm	**10.750** in	273.0 mm
	2	Nominal weight	2	**45.50** lb/ft	66.4 daN/m	**51.00** lb/ft	74.4 daN/m
Pipe body	3	Wall thickness	3	0.400 in	10.2 mm	0.450 in	11.4 mm
Pipe body	4	Inside diameter	4	9.950 in	252.7 mm	9.850 in	250.2 mm
Pipe body	5	Steel cross-section	5	13.01 in^2	8391 mm^2	14.56 in^2	9394 mm^2
Pipe body	6	Capacity	6	4.04 gal/ft	50.17 l/m	3.96 gal/ft	49.16 l/m
Pipe body	7	Displacement (1)	7	4.72 gal/ft	58.56 l/m	4.72 gal/ft	58.56 l/m

				K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	14.4	17.1	17.1	17.6	17.8	18.0	18.0	18.7	22.2	22.2	23.5	24.0	25.2	25.8
Pipe body	10	Internal yield pressure (MPa)	10	24.7	35.9	35.9	40.4	42.7	49.4	56.1	27.8	40.4	40.4	45.5	48.0	55.6	63.1
Pipe body	11	Pipe body yield strength (1000 daN)	11	318	463	463	521	550	636	723	356	518	518	583	615	712	810
Tensile strength (10^3 daN)	12	Buttress Standard	12	414	473	488	511	538	633	698	464	529	546	572	602	709	782
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13														
Tensile strength (10^3 daN)	14	API STC	14	235	308	312	341	359	419	471	269	353	358	391	412	480	539
Tensile strength (10^3 daN)	15	API LTC	15														

Connection efficiency				10.750 in – 45.50 lb/ft	10.750 in – 51.00 lb/ft
	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	59.9	67.5
	18	Hydril LX	18		73.9
	19	Hydril 563	19	91.8	92.7
	20	Hydril 511	20	59.0	62.9
	21	Hydril 521	21	66.5	70.4
	22	Vallourec & Mannesmann New VAM	22	155.2	138.6
	23	Vallourec & Mannesmann VAM ACE	23	152.7	136.4
	24	Vallourec & Mannesmann VAM PRO	24		
	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.1
	26	Vallourec & Mannesmann FJL	26	58.1	62.6

Connection characteristics				Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
	27	Buttress Standard	27						298.4		248.8						298.4		246.2
	28	Buttress Special Clearance	28						285.8		248.8						285.8		246.2
	29	API STC	29	716					298.5		248.8	822	1083	1257	1463		298.5		246.2
	30	API LTC	30																
	31	Grant Prideco TCII	31		1993	1993	1993	1993	288.8	253.5	248.8		2481	2481	2481	2481	291.0	251.2	246.2
	32	Grant Prideco STL	32	786	1003	1003	1003	1003	273.0	252.7	248.8	1017	1274	1274	1274	1274	273.0	248.0	246.2
	33	Hydril LX	33									1830	2305	2508	2847	3051	277.2	248.2	246.2
	34	Hydril 563	34	1830	1830	1830	1830	1830	298.4		248.8	2102	2102	2102	2102	2102	298.4		246.2
	35	Hydril 511	35	1329	1329	1329	1329	1329	273.0	252.0	248.8	1722	1722	1722	1722	1722	273.0	247.4	246.2
	36	Hydril 521	36	1600	1600	1600	1600	1600	278.1	252.1	248.8	1844	1844	1844	1844	1844	280.3	248.3	246.2
	37	Vallourec & Mannesmann New VAM	37	1566	1912	2061	2156	2156	299.0		248.8	1668	1959	2156	2156	2156	299.0		246.2
	38	Vallourec & Mannesmann VAM ACE	38	1376	1566	1763	1959	2156	298.4		248.8	1668	1840	2061	2156	2156	298.4		246.2
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40	1180	1471	1566	1763	1959	289.6		248.8	1668	2156	2352	2644	2942	291.8		246.2
	41	Vallourec & Mannesmann FJL	41		1959	2156	2156	2156	273.0	250.6	248.8		1959	2156	2156	2156	273.0	248.1	246.2

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body

1	Nominal size (OD)	1	**10.750** in	273.0 mm	**10.750** in	273.0 mm
2	Nominal weight	2	**55.50** lb/ft	81.0 daN/m	**60.70** lb/ft	88.6 daN/m
3	Wall thickness	3	0.495 in	12.6 mm	0.545 in	13.8 mm
4	Inside diameter	4	9.760 in	247.9 mm	9.660 in	245.4 mm
5	Steel cross-section	5	15.95 in^2	10 289 mm^2	17.47 in^2	11 273 mm^2
6	Capacity	6	3.89 gal/ft	48.27 l/m	3.81 gal/ft	47.28 l/m
7	Displacement (1)	7	4.72 gal/ft	58.56 l/m	4.72 gal/ft	58.56 l/m

8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
9	Collapse resistance (MPa)	9	23.4	27.7	27.7	28.7	29.6	31.8	33.4	28.7	35.6	35.6	37.6	38.5	40.5	41.9
10	Internal yield pressure (MPa)	10	30.6	44.4	44.4	50.0	52.8	61.1	69.4	33.6	48.9	48.9	55.1	58.1	67.3	76.5
11	Pipe body yield strength (1000 daN)	11	390	568	568	638	674	780	887	427	622	622	700	738	855	972
Tensile strength (10^3 daN)																
12	Buttress Standard	12	508	580	598	627	660	776	856	557	635	655	687	723	851	938
13	Buttress Special Clearance	13														
14	API STC	14	300	393	398	435	459	535	601	334	437	443	484	511	595	668
15	API LTC	15														

Connection efficiency

16	Grant Prideco TCII	16		
17	Grant Prideco STL	17	59.9	69.7
18	Hydril LX	18	75.8	76.7
19	Hydril 563	19	90.5	91.3
20	Hydril 511	20	60.4	64.4
21	Hydril 521	21	71.9	74.0
22	Vallourec & Mannesmann New VAM	22	126.6	115.6
23	Vallourec & Mannesmann VAM ACE	23	124.6	113.7
24	Vallourec & Mannesmann VAM PRO	24		
25	Vallourec & Mannesmann VAM TOP	25	101.9	102.1
26	Vallourec & Mannesmann FJL	26	65.2	65.6

Connection characteristics

			Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
			K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
27	Buttress Standard	27						298.4		243.9						298.4		241.4
28	Buttress Special Clearance	28						285.8		243.9						285.8		241.4
29	API STC	29		1206	1399	1630		298.5		243.9				1813	2036	298.5		241.4
30	API LTC	30																
31	Grant Prideco TCII	31		2922	2922	2922	2922	293.0	249.2	243.9		3464	3464	3464	3464	295.1	247.0	241.4
32	Grant Prideco STL	32	976	1234	1234	1234	1234	273.0	249.3	243.9	1070	1349	1349	1349	1349	273.0	243.5	241.4
33	Hydril LX	33	2034	2440	2779	2983	3322	277.4	245.9	243.9	2237	2779	3118	3457	3661	277.6	243.3	241.4
34	Hydril 563	34	3091	3091	3091	3091	3091	298.4	246.6	243.9	3390	3390	3390	3390	3390	298.4		241.4
35	Hydril 511	35	1871	1871	1871	1871	1871	273.0	245.7	243.9	2495	2495	2495	2495	2495	273.0	242.6	241.4
36	Hydril 521	36	2400	2400	2400	2400	2400	279.7	246.0	243.9	2698	2698	2698	2698	2698	281.8	243.5	241.4
37	Vallourec & Mannesmann New VAM	37	1763	2061	2156	2156	2156	299.0		243.9	1864	2156	2156	2156	2156	299.0		241.4
38	Vallourec & Mannesmann VAM ACE	38	1959	2156	2156	2156	2156	298.4		243.9	2156	2156	2156	2156	2156	298.4		241.4
39	Vallourec & Mannesmann VAM PRO	39																
40	Vallourec & Mannesmann VAM TOP	40	2156	2746	3139	3139	3139	293.8		243.9	2746	3139	3139	3139	3139	296.0		241.4
41	Vallourec & Mannesmann FJL	41		2061	2156	2156	2156	273.0	246.0	243.9		2156	2156	2156	2156	273.0	243.5	241.4

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**10.750** in	273.0 mm	**11.750** in	298.4 mm
	2	Nominal weight	2	**65.70** lb/ft	95.9 daN/m	**47.00** lb/ft	68.6 daN/m
	3	Wall thickness	3	0.595 in	15.1 mm	0.375 in	9.5 mm
	4	Inside diameter	4	9.560 in	242.8 mm	11.000 in	279.4 mm
	5	Steel cross-section	5	18.98 in^2	12 247 mm^2	13.40 in^2	8646 mm^2
	6	Capacity	6	3.73 gal/ft	46.31 l/m	4.94 gal/ft	61.31 l/m
	7	Displacement (1)	7	4.72 gal/ft	58.56 l/m	5.63 gal/ft	69.96 l/m

				10.750 in							11.750 in						
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	33.9	43.5	43.5	46.6	48.0	51.7	54.6	10.4	11.2	11.2	11.2	11.2	11.2	11.2
	10	Internal yield pressure (MPa)	10	36.7	53.4	53.4	60.1	63.4	73.5	83.5	21.2	30.8	30.8	34.7	36.6	42.4	48.1
	11	Pipe body yield strength (1000 daN)	11	464	675	675	760	802	929	1055	328	477	477	536	566	656	745
Tensile strength (10^3 daN)	12	Buttress Standard	12	605	690	712	746	785	924	1019	416	482	496	523	550	647	715
	13	Buttress Special Clearance	13														
	14	API STC	14	367	481	487	533	562	655	735	226	298	302	330	348	406	456
	15	API LTC	15														

				10.750 in	11.750 in
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	59.9	
	18	Hydril LX	18	78.2	
	19	Hydril 563	19	92.0	91.3
	20	Hydril 511	20	59.6	
	21	Hydril 521	21	75.7	64.0
	22	Vallourec & Mannesmann New VAM	22	106.3	164.1
	23	Vallourec & Mannesmann VAM ACE	23	104.6	161.5
	24	Vallourec & Mannesmann VAM PRO	24		
	25	Vallourec & Mannesmann VAM TOP	25	102.0	
	26	Vallourec & Mannesmann FJL	26	65.6	55.9

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						298.4		238.9						323.9		275.4
	28	Buttress Special Clearance	28						285.8		238.9								275.4
	29	API STC	29				1994	2240	298.5		238.9	690					323.9		275.4
	30	API LTC	30																
	31	Grant Prideco TCII	31		4013	4013	4013	4013	297.2	244.8	238.9		2332	2332	2332	2332	313.0	277.2	275.4
	32	Grant Prideco STL	32	1152	1458	1458	1458	1458	273.0	245.8	238.9								
	33	Hydril LX	33	2373	2915	3254	3525	3796	278.5	242.4	238.9								
	34	Hydril 563	34	3661	3661	3661	3661	3661	298.4		238.9	1763	1763	1763	1763	1763	323.9		275.4
	35	Hydril 511	35	2495	2495	2495	2495	2495	273.0	242.5	238.9								
	36	Hydril 521	36	2996	2996	2996	2996	2996	283.9	242.6	238.9	1546	1546	1546	1546	1546	302.1	277.5	275.4
	37	Vallourec & Mannesmann New VAM	37	1959	2156	2156	2156	2156	299.0		238.9	1424	1715	1912	2061	2156	324.4		275.4
	38	Vallourec & Mannesmann VAM ACE	38	2156	2156	2156	2156	2156	298.4		238.9	1471	1668	1763	1959	2156	323.9		275.4
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40	3139	3139	3139	3139	3139	298.0		238.9								
	41	Vallourec & Mannesmann FJL	41		2156	2156	2156	2156	273.0	241.0	238.9		2156	2156	2156	2156	298.4	278.4	275.4

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

	#		#														
Pipe body	1	Nominal size (OD)	1	**11.750** in			298.4 mm				**11.750** in			298.4 mm			
	2	Nominal weight	2	**54.00** lb/ft			78.8 daN/m				**60.00** lb/ft			87.6 daN/m			
	3	Wall thickness	3	0.435 in			11.0 mm				0.489 in			12.4 mm			
	4	Inside diameter	4	10.880 in			276.4 mm				10.772 in			273.6 mm			
	5	Steel cross-section	5	15.46 in^2			9976 mm^2				17.30 in^2			11 161 mm^2			
	6	Capacity	6	4.83 gal/ft			59.98 l/m				4.73 gal/ft			58.80 l/m			
	7	Displacement (1)	7	5.63 gal/ft			69.96 l/m				5.63 gal/ft			69.96 l/m			
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	14.3	16.9	16.9	17.4	17.6	17.7	17.7	18.4	21.9	21.9	23.2	23.7	24.9	25.4
	10	Internal yield pressure (MPa)	10	24.6	35.7	35.7	40.2	42.4	49.1	55.8	27.6	40.2	40.2	45.2	47.7	55.2	62.8
	11	Pipe body yield strength (1000 daN)	11	378	550	550	619	653	757	860	423	616	616	693	731	846	962
Tensile strength (10^3 daN)	12	Buttress Standard	12	480	556	573	603	635	746	825	537	622	641	675	710	835	923
	13	Buttress Special Clearance	13														
	14	API STC	14	270	355	359	394	415	484	543	308	406	411	450	474	553	621
	15	API LTC	15														

Connection efficiency	#		#	11.750 in, 54.00 lb/ft	11.750 in, 60.00 lb/ft
	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17		59.9
	18	Hydril LX	18		72.5
	19	Hydril 563	19	92.5	90.4
	20	Hydril 511	20		60.7
	21	Hydril 521	21	68.5	70.6
	22	Vallourec & Mannesmann New VAM	22	142.2	127.1
	23	Vallourec & Mannesmann VAM ACE	23	139.9	125.1
	24	Vallourec & Mannesmann VAM PRO	24		
	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.0
	26	Vallourec & Mannesmann FJL	26	59.7	63.5

Connection characteristics	#		#	Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
	27	Buttress Standard	27						323.9		272.4						323.9		269.6
	28	Buttress Special Clearance	28																
	29	API STC	29	822					323.9		272.4	940	1245	1445	1684	1891	323.9		269.6
	30	API LTC	30																
	31	Grant Prideco TCII	31		2569	2569	2569	2569	315.7	277.2	272.4		3173	3173	3173	3173	318.1	274.8	269.6
	32	Grant Prideco STL	32									1058	1329	1329	1329	1329	298.4	275.0	269.6
	33	Hydril LX	33									2305	2915	3254	3593	4000	303.0	271.6	269.6
	34	Hydril 563	34	2088	2088	2088	2088	2088	323.9		272.4	3051	3051	3051	3051	3051	323.9	272.3	269.6
	35	Hydril 511	35									2413	2413	2413	2413	2413	298.4	271.1	269.6
	36	Hydril 521	36	1844	1844	1844	1844	1844	304.7	271.4	272.4	2427	2427	2427	2427	2427	303.0	271.4	269.6
	37	Vallourec & Mannesmann New VAM	37	1959	2156	2156	2156	2156	324.4		272.4	2061	2156	2156	2156	2156	324.4		269.6
	38	Vallourec & Mannesmann VAM ACE	38	1864	2061	2156	2156	2156	323.9		272.4	2156	2156	2156	2156	2156	323.9		269.6
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40	1668	2061	2257	2549	2847	316.6		272.4	2257	2942	3139	3139	3139	318.9		269.6
	41	Vallourec & Mannesmann FJL	41		2156	2156	2156	2156	298.4	275.2	272.4		2156	2156	2156	2156	298.4	272.2	269.6

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.														
Pipe body	1	Nominal size (OD)	1		**11.750** in			298.4 mm				**11.750** in			298.4 mm		
	2	Nominal weight	2		**65.00** lb/ft			94.9 daN/m				**71.00** lb/ft			103.6 daN/m		
	3	Wall thickness	3		0.534 in			13.6 mm				0.582 in			14.8 mm		
	4	Inside diameter	4		10.682 in			271.3 mm				10.586 in			268.9 mm		
	5	Steel cross-section	5		18.82 in²			12 139 mm²				20.42 in²			13 174 mm²		
	6	Capacity	6		4.66 gal/ft			57.82 l/m				4.57 gal/ft			56.78 l/m		
	7	Displacement (1)	7		5.63 gal/ft			69.96 l/m				5.63 gal/ft			69.96 l/m		
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	22.7	26.7	26.7	28.0	28.8	30.9	32.3	27.4	33.6	33.6	35.4	36.1	37.7	39.7
	10	Internal yield pressure (MPa)	10	30.2	43.9	43.9	49.4	52.1	60.3	68.5	32.9	47.8	47.8	53.8	56.8	65.7	74.7
	11	Pipe body yield strength (1000 daN)	11	460	670	670	753	795	921	1046	500	727	727	817	863	999	1135
Tensile strength (10^3 daN)	12	Buttress Standard	12	584	677	697	734	772	908	1004	634	734	756	796	838	985	1089
	13	Buttress Special Clearance	13														
	14	API STC	14	340	448	453	496	523	610	685	374	492	498	546	575	670	753
	15	API LTC	15														
Connection efficiency	16	Grant Prideco TCII	16														
	17	Grant Prideco STL	17				58.8							59.9			
	18	Hydril LX	18				74.4							76.7			
	19	Hydril 563	19				91.2							91.9			
	20	Hydril 511	20				55.8										
	21	Hydril 521	21				70.1							74.6			
	22	Vallourec & Mannesmann New VAM	22				116.9										
	23	Vallourec & Mannesmann VAM ACE	23				115.0										
	24	Vallourec & Mannesmann VAM PRO	24														
	25	Vallourec & Mannesmann VAM TOP	25				102.1										
	26	Vallourec & Mannesmann FJL	26				64.6										

Section	No.	Connection	No.	Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						323.9		267.4						323.9		264.9
	28	Buttress Special Clearance	28																
	29	API STC	29																
	30	API LTC	30																
	31	Grant Prideco TCII	31		3701	3701	3701	3701	320.0	272.8	267.4		4291	4291	4291	4291	322.1	270.7	264.9
	32	Grant Prideco STL	32	1125	1424	1424	1424	1424	298.4	271.6	267.4	1251	1566	1566	1566	1566	298.4	271.8	264.9
	33	Hydril LX	33	2373	2983	3322	3661	4000	303.9	271.0	267.4	2915	3457	3796	4135	4474	304.2	266.8	264.9
	34	Hydril 563	34	3254	3254	3254	3254	3254	323.9		267.4	3661	3661	3661	3661	3661	323.9		264.9
	35	Hydril 511	35	2413	2413	2413	2413	2413	298.4	271.1	267.4								
	36	Hydril 521	36	2657	2657	2657	2657	2657	303.9	271.2	267.4	3037	3037	3037	3037	3037	308.0	266.7	264.9
	37	Vallourec & Mannesmann New VAM	37	2156	2156	2156	2156	2156	324.4		267.4								
	38	Vallourec & Mannesmann VAM ACE	38	2156	2156	2156	2156	2156	323.9		267.4								
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40	2847	3139	3139	3139	3139	321.0		267.4								
	41	Vallourec & Mannesmann FJL	41		2156	2156	2156	2156	298.4	271.8	267.4								

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**13.375** in	339.7 mm	**13.375** in	339.7 mm
	2	Nominal weight	2	**54.50** lb/ft	79.5 daN/m	**61.00** lb/ft	89.0 daN/m
	3	Wall thickness	3	0.380 in	9.7 mm	0.430 in	10.9 mm
	4	Inside diameter	4	12.615 in	320.4 mm	12.515 in	317.9 mm
	5	Steel cross-section	5	15.51 in^2	10 009 mm^2	17.49 in^2	11 282 mm^2
	6	Capacity	6	6.49 gal/ft	80.64 l/m	6.39 gal/ft	79.36 l/m
	7	Displacement (1)	7	7.30 gal/ft	90.65 l/m	7.30 gal/ft	90.65 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	7.8	7.9	7.9	7.9	7.9	7.9	7.9	10.6	11.5	11.5	11.5	11.5	11.5	11.5
	10	Internal yield pressure (MPa)	10	18.9	27.4	27.4	30.9	32.6	37.7	42.9	21.3	31.0	31.0	34.9	36.9	42.7	48.5
	11	Pipe body yield strength (1000 daN)	11	380	552	552	621	656	759	863	428	622	622	700	739	856	972
Tensile strength (10^3 daN)	12	Buttress Standard	12	462	548	563	597	629	738	818	520	618	634	673	709	832	923
	13	Buttress Special Clearance	13														
	14	API STC	14	243	322	326	358	377	439	494	282	373	377	414	437	509	572
	15	API LTC	15														
Connection efficiency	16	Grant Prideco TCII	16														
	17	Grant Prideco STL	17											59.9			
	18	Hydril LX	18														
	19	Hydril 563	19				90.3							91.4			
	20	Hydril 511	20														
	21	Hydril 521	21				61.0							65.0			
	22	Vallourec & Mannesmann New VAM	22				160.4							142.3			
	23	Vallourec & Mannesmann VAM ACE	23				158.0							140.2			
	24	Vallourec & Mannesmann VAM PRO	24														
	25	Vallourec & Mannesmann VAM TOP	25											102.0			
	26	Vallourec & Mannesmann FJL	26														

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						365.1		316.5						365.1		313.9
	28	Buttress Special Clearance	28																
	29	API STC	29	742					365.1		316.5	858					365.1		313.9
	30	API LTC	30																
	31	Grant Prideco TCII	31		2657	2657	2657	2657	354.3	318.6	316.5		2874	2874	2874	2874	356.5	318.6	313.9
	32	Grant Prideco STL	32									1058	1349	1349	1349	1349	339.7	318.6	313.9
	33	Hydril LX	33																
	34	Hydril 563	34	2359	2359	2359	2359	2359	365.1	318.5	316.5	2712	2712	2712	2712	2712	365.1	316.0	313.9
	35	Hydril 511	35																
	36	Hydril 521	36	2061	2061	2061	2061	2061	343.7	318.5	316.5	2386	2386	2386	2386	2386	320.5	316.0	313.9
	37	Vallourec & Mannesmann New VAM	37	1566	1959	2156	2156	2156	365.7		316.5	2061	2156	2156	2156	2156	365.7		313.9
	38	Vallourec & Mannesmann VAM ACE	38	1668	1959	2156	2156	2156	365.1		316.5	2061	2156	2156	2156	2156	365.1		313.9
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40									1763	2257	2549	2847	3139	357.8		313.9
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	in	mm	in	mm
	1	Nominal size (OD)	1	**13.375** in	339.7 mm	**13.375** in	339.7 mm
	2	Nominal weight	2	**68.00** lb/ft	99.2 daN/m	**72.00** lb/ft	105.1 daN/m
Pipe body	3	Wall thickness	3	0.480 in	12.2 mm	0.514 in	13.1 mm
Pipe body	4	Inside diameter	4	12.415 in	315.3 mm	12.347 in	313.6 mm
Pipe body	5	Steel cross-section	5	19.45 in^2	12 545 mm^2	20.77 in^2	13 398 mm^2
Pipe body	6	Capacity	6	6.29 gal/ft	78.10 l/m	6.22 gal/ft	77.25 l/m
Pipe body	7	Displacement (1)	7	7.30 gal/ft	90.65 l/m	7.30 gal/ft	90.65 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	9	Collapse resistance (MPa)	9	13.4	15.6	15.6	16.0	16.1	16.1	16.1	15.4	18.4	18.4	19.2	19.5	19.9	19.9
Pipe body	10	Internal yield pressure (MPa)	10	23.8	34.6	34.6	39.0	41.1	47.6	54.1	25.5	37.1	37.1	41.7	44.1	51.0	58.0
Pipe body	11	Pipe body yield strength (1000 daN)	11	476	692	692	778	822	951	1081	508	739	739	831	878	1016	1155
Tensile strength (10^3 daN)	12	Buttress Standard	12	578	687	705	749	788	925	1026	618	734	753	800	842	988	1096
Tensile strength (10^3 daN)	13	Buttress Special Clearance	13														
Tensile strength (10^3 daN)	14	API STC	14	320	424	428	470	496	577	649	345	458	463	508	535	623	701
Tensile strength (10^3 daN)	15	API LTC	15														

Section	No.	Connection	No.	68.00 lb/ft	72.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
Connection efficiency	17	Grant Prideco STL	17	59.9	69.0
Connection efficiency	18	Hydril LX	18	72.1	73.6
Connection efficiency	19	Hydril 563	19	92.2	92.7
Connection efficiency	20	Hydril 511	20		
Connection efficiency	21	Hydril 521	21	68.2	70.0
Connection efficiency	22	Vallourec & Mannesmann New VAM	22	127.9	119.8
Connection efficiency	23	Vallourec & Mannesmann VAM ACE	23	126.0	118.0
Connection efficiency	24	Vallourec & Mannesmann VAM PRO	24		
Connection efficiency	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.1
Connection efficiency	26	Vallourec & Mannesmann FJL	26		

Connection characteristics — 13.375 in, 68.00 lb/ft

No.	Connection	No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard	27						365.1		311.4
28	Buttress Special Clearance	28								
29	API STC	29	973	1298	1510	1758		365.1		311.4
30	API LTC	30								
31	Grant Prideco TCII	31		3539	3539	3539	3539	358.8	316.3	311.4
32	Grant Prideco STL	32	1180	1505	1505	1505	1505	339.7	316.8	311.4
33	Hydril LX	33	2779	3457	3932	4339	4813	344.5	312.5	311.4
34	Hydril 563	34	2847	2847	2847	2847	2847	365.1		311.4
35	Hydril 511	35								
36	Hydril 521	36	2725	2725	2725	2725	2725	348.2	313.4	311.4
37	Vallourec & Mannesmann New VAM	37	2156	2156	2156	2156	2156	365.7		311.4
38	Vallourec & Mannesmann VAM ACE	38	2156	2156	2156	2156	2156	365.1		311.4
39	Vallourec & Mannesmann VAM PRO	39								
40	Vallourec & Mannesmann VAM TOP	40	2549	3139	3139	3139	3139	360.0		311.4
41	Vallourec & Mannesmann FJL	41								

Connection characteristics — 13.375 in, 72.00 lb/ft

No.	Connection	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
27	Buttress Standard						365.1		309.6
28	Buttress Special Clearance								
29	API STC		1403	1632	1900	2138	365.1		309.6
30	API LTC								
31	Grant Prideco TCII		3762	3762	3762	3762	360.3	316.1	309.6
32	Grant Prideco STL	1464	1674	1674	1674	1674	339.7	313.4	309.6
33	Hydril LX	2847	3729	4000	4474	4881	345.5	312.3	309.6
34	Hydril 563	3118	3118	3118	3118	3118	365.1		309.6
35	Hydril 511								
36	Hydril 521	2956	2956	2956	2956	2956	349.7	312.9	309.6
37	Vallourec & Mannesmann New VAM	2156	2156	2156	2156	2156	365.7		309.6
38	Vallourec & Mannesmann VAM ACE	2156	2156	2156	2156	2156	365.1		309.6
39	Vallourec & Mannesmann VAM PRO								
40	Vallourec & Mannesmann VAM TOP	2942	3139	3139	3139	3139	361.6		309.6
41	Vallourec & Mannesmann FJL								

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	13.375 in / 339.7 mm	13.375 in / 339.7 mm
Pipe body	1	Nominal size (OD)	1	**13.375** in — 339.7 mm	**13.375** in — 339.7 mm
	2	Nominal weight	2	**77.00** lb/ft — 112.4 daN/m	**80.70** lb/ft — 117.8 daN/m
	3	Wall thickness	3	0.550 in — 14.0 mm	0.580 in — 14.7 mm
	4	Inside diameter	4	12.275 in — 311.8 mm	12.215 in — 310.3 mm
	5	Steel cross-section	5	22.16 in^2 — 14 297 mm^2	23.31 in^2 — 15 041 mm^2
	6	Capacity	6	6.15 gal/ft — 76.35 l/m	6.09 gal/ft — 75.60 l/m
	7	Displacement (1)	7	7.30 gal/ft — 90.65 l/m	7.30 gal/ft — 90.65 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	17.8	21.4	21.4	22.5	23.0	24.1	24.5	20.4	23.8	23.8	25.4	26.0	27.6	28.5
	10	Internal yield pressure (MPa)	10	27.3	39.7	39.7	44.7	47.1	54.6	62.0	28.8	41.9	41.9	47.1	49.7	57.6	65.4
	11	Pipe body yield strength (1000 daN)	11	542	789	789	887	936	1084	1232	570	830	830	933	985	1141	1296
Tensile strength (10^3 daN)	12	Buttress Standard	12	659	783	804	853	898	1054	1169	694	824	845	898	945	1109	1230
	13	Buttress Special Clearance	13														
	14	API STC	14	372	493	499	548	577	672	756	395	523	529	580	612	713	802
	15	API LTC	15														

Section	No.	Property	No.	13.375 in, 77.00 lb/ft	13.375 in, 80.70 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17	59.9	
	18	Hydril LX	18	75.7	75.9
	19	Hydril 563	19	90.6	91.1
	20	Hydril 511	20		
	21	Hydril 521	21	70.3	71.6
	22	Vallourec & Mannesmann New VAM	22	112.3	106.7
	23	Vallourec & Mannesmann VAM ACE	23	110.6	105.1
	24	Vallourec & Mannesmann VAM PRO	24		
	25	Vallourec & Mannesmann VAM TOP	25	102.1	102.0
	26	Vallourec & Mannesmann FJL	26		

Section	No.	Connection	No.	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27						365.1		307.8						365.1		306.3
	28	Buttress Special Clearance	28																
	29	API STC	29																
	30	API LTC	30																
	31	Grant Prideco TCII	31		4528	4528	4528	4528	361.9	313.2	307.8		4969	4969	4969	4969	363.2	311.9	306.3
	32	Grant Prideco STL	32	1356	1708	1708	1708	1708	339.7	314.4	307.8								
	33	Hydril LX	33	3118	3864	4339	4745	5220	345.7	309.8	307.8	3322	4271	4813	5355	5898	345.8	308.3	306.3
	34	Hydril 563	34	4610	4610	4610	4610	4610	365.1	309.9	307.8	4881	4881	4881	4881	4881	365.1	308.4	306.3
	35	Hydril 511	35																
	36	Hydril 521	36	3756	3756	3756	3756	3756	347.6	309.9	307.8	4000	4000	4000	4000	4000	348.9	308.4	306.3
	37	Vallourec & Mannesmann New VAM	37	2156	2156	2156	2156	2156	365.7		307.8	2156	2156	2156	2156	2156	365.7		306.3
	38	Vallourec & Mannesmann VAM ACE	38	2156	2156	2156	2156	2156	365.1		307.8	2156	2156	2156	2156	2156	365.1		306.3
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40	3139	3139	3139	3139	3139	363.2		307.8	3139	3139	3139	3139	3139	364.5		306.3
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**13.625** in	346.1 mm	**14.000** in	355.6 mm
	2	Nominal weight	2	**88.20** lb/ft	128.7 daN/m	**82.50** lb/ft	120.4 daN/m
	3	Wall thickness	3	0.625 in	15.9 mm	0.562 in	14.3 mm
	4	Inside diameter	4	12.375 in	314.3 mm	12.876 in	327.1 mm
	5	Steel cross-section	5	25.53 in^2	16 468 mm^2	23.73 in^2	15 307 mm^2
	6	Capacity	6	6.25 gal/ft	77.60 l/m	6.76 gal/ft	84.01 l/m
	7	Displacement (1)	7	7.57 gal/ft	94.07 l/m	8.00 gal/ft	99.31 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	23.2	27.4	27.4	28.5	29.3	31.5	33.1	16.7	20.3	20.3	21.3	21.7	22.6	22.7
	10	Internal yield pressure (MPa)	10	30.4	44.3	44.3	49.8	52.6	60.9	69.2	26.6	38.7	38.7	43.6	46.0	53.3	60.5
	11	Pipe body yield strength (1000 daN)	11	624	908	908	1022	1079	1249	1419	580	844	844	950	1003	1161	1319
Tensile strength (10^3 daN)	12	Buttress Standard	12														
	13	Buttress Special Clearance	13														
	14	API STC	14														
	15	API LTC	15														
Connection efficiency	16	Grant Prideco TCII	16														
	17	Grant Prideco STL	17				70.7										
	18	Hydril LX	18														
	19	Hydril 563	19				91.7										
	20	Hydril 511	20														
	21	Hydril 521	21				73.3										
	22	Vallourec & Mannesmann New VAM	22				100.0										
	23	Vallourec & Mannesmann VAM ACE	23														
	24	Vallourec & Mannesmann VAM PRO	24														
	25	Vallourec & Mannesmann VAM TOP	25														
	26	Vallourec & Mannesmann FJL	26														

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27																
	28	Buttress Special Clearance	28																
	29	API STC	29																
	30	API LTC	30																
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32	1844	2346	2346	2346	2346	346.1	312.3	309.6								
	33	Hydril LX	33																
	34	Hydril 563	34	5017	5017	5017	5017	5017	371.5		309.6								
	35	Hydril 511	35																
	36	Hydril 521	36	4393	4393	4393	4393	4393	356.6	312.5	309.6								
	37	Vallourec & Mannesmann New VAM	37	2156	2156	2156	2156	2156	365.7		309.6								
	38	Vallourec & Mannesmann VAM ACE	38																
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**14.000** in	355.6 mm	**14.000** in	355.6 mm
	2	Nominal weight	2	**94.80** lb/ft	138.4 daN/m	**99.00** lb/ft	144.5 daN/m
	3	Wall thickness	3	0.656 in	16.7 mm	0.688 in	17.5 mm
	4	Inside diameter	4	12.688 in	322.3 mm	12.624 in	320.6 mm
	5	Steel cross-section	5	27.50 in^2	17 742 mm^2	28.77 in^2	18 563 mm^2
	6	Capacity	6	6.57 gal/ft	81.57 l/m	6.50 gal/ft	80.75 l/m
	7	Displacement (1)	7	8.00 gal/ft	99.31 l/m	8.00 gal/ft	99.31 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	24.3	29.1	29.1	30.2	30.7	33.1	34.9	26.9	33.0	33.0	34.6	35.3	36.8	39.0
	10	Internal yield pressure (MPa)	10	31.1	45.2	45.2	50.9	53.7	62.2	70.7	32.6	47.4	47.4	53.4	56.3	65.2	74.1
	11	Pipe body yield strength (1000 daN)	11	673	979	979	1101	1162	1346	1529	704	1024	1024	1152	1216	1408	1600

Tensile strength (10^3 daN)	12	Buttress Standard	12		
	13	Buttress Special Clearance	13		
	14	API STC	14		
	15	API LTC	15		
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17		
	18	Hydril LX	18		
	19	Hydril 563	19		
	20	Hydril 511	20		
	21	Hydril 521	21		
	22	Vallourec & Mannesmann New VAM	22		
	23	Vallourec & Mannesmann VAM ACE	23		
	24	Vallourec & Mannesmann VAM PRO	24		
	25	Vallourec & Mannesmann VAM TOP	25		
	26	Vallourec & Mannesmann FJL	26		

				Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m)					OD (mm)	ID (mm)	Drift API (mm)
				K55	LN80	C90/95	P110	Q125				K55	LN80	C90/95	P110	Q125			
Connection characteristics	27	Buttress Standard	27																
	28	Buttress Special Clearance	28																
	29	API STC	29																
	30	API LTC	30																
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32																
	33	Hydril LX	33																
	34	Hydril 563	34																
	35	Hydril 511	35																
	36	Hydril 521	36																
	37	Vallourec & Mannesmann New VAM	37																
	38	Vallourec & Mannesmann VAM ACE	38																
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Item	No.	14.000 in	355.6 mm	16.000 in	406.4 mm
Pipe body	1	Nominal size (OD)	1	**14.000** in	355.6 mm	**16.000** in	406.4 mm
	2	Nominal weight	2	**114.00** lb/ft	166.4 daN/m	**65.00** lb/ft	94.9 daN/m
	3	Wall thickness	3	0.800 in	20.3 mm	0.375 in	9.5 mm
	4	Inside diameter	4	12.400 in	315.0 mm	15.250 in	387.4 mm
	5	Steel cross-section	5	33.18 in^2	21 403 mm^2	18.41 in^2	11 876 mm^2
	6	Capacity	6	6.27 gal/ft	77.91 l/m	9.49 gal/ft	117.84 l/m
	7	Displacement (1)	7	8.00 gal/ft	99.31 l/m	10.44 gal/ft	129.72 l/m

Section	No.	Item	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	36.0	46.5	46.5	50.1	51.7	56.1	59.6	4.4	4.4	4.4	4.4	4.4	4.4	4.4
	10	Internal yield pressure (MPa)	10	37.9	55.2	55.2	62.1	65.5	75.8	86.2	15.6	22.6	22.6	25.5	26.9	31.1	35.3
	11	Pipe body yield strength (1000 daN)	11	812	1181	1181	1328	1402	1623	1845	450	655	655	737	778	901	1024
Tensile strength (10^3 daN)	12	Buttress Standard	12								509	632	645	694	731	855	954
	13	Buttress Special Clearance	13														
	14	API STC	14								278	371	375	412	435	506	570
	15	API LTC	15														
Connection efficiency	16	Grant Prideco TCII	16														
	17	Grant Prideco STL	17														
	18	Hydril LX	18														
	19	Hydril 563	19				93.5										
	20	Hydril 511	20														
	21	Hydril 521	21														
	22	Vallourec & Mannesmann New VAM	22														
	23	Vallourec & Mannesmann VAM ACE	23														
	24	Vallourec & Mannesmann VAM PRO	24														
	25	Vallourec & Mannesmann VAM TOP	25														
	26	Vallourec & Mannesmann FJL	26														

Section	No.	Item	No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27														431.8		382.6
	28	Buttress Special Clearance	28																
	29	API STC	29																
	30	API LTC	30																
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32																
	33	Hydril LX	33																
	34	Hydril 563	34	7593	7593	7593	7593	7593	381.0		310.2								
	35	Hydril 511	35																
	36	Hydril 521	36																
	37	Vallourec & Mannesmann New VAM	37																
	38	Vallourec & Mannesmann VAM ACE	38																
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Section	No.	Property	No.	16.000 in	406.4 mm	16.000 in	406.4 mm
Pipe body	1	Nominal size (OD)	1	**16.000** in	406.4 mm	**16.000** in	406.4 mm
	2	Nominal weight	2	**75.00** lb/ft	109.5 daN/m	**84.00** lb/ft	122.6 daN/m
	3	Wall thickness	3	0.438 in	11.1 mm	0.495 in	12.6 mm
	4	Inside diameter	4	15.124 in	384.1 mm	15.010 in	381.3 mm
	5	Steel cross-section	5	21.41 in^2	13 815 mm^2	24.11 in^2	15 556 mm^2
	6	Capacity	6	9.33 gal/ft	115.90 l/m	9.19 gal/ft	114.16 l/m
	7	Displacement (1)	7	10.44 gal/ft	129.72 l/m	10.44 gal/ft	129.72 l/m

Section	No.	Property	No.	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	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	Internal yield pressure (MPa)	10	18.2	26.4	26.4	29.7	31.4	36.3	41.3	20.5	29.9	29.9	33.6	35.5	41.1	46.7
	11	Pipe body yield strength (1000 daN)	11	524	762	762	857	905	1048	1191	590	858	858	965	1019	1180	1341
Tensile strength (10^3 daN)	12	Buttress Standard	12	592	735	750	807	850	995	1110	667	828	844	909	958	1120	1250
	13	Buttress Special Clearance	13														
	14	API STC	14	334	446	451	496	523	609	685	385	514	519	571	602	701	789
	15	API LTC	15														

Section	No.	Connection	No.	16.000 in – 75.00 lb/ft	16.000 in – 84.00 lb/ft
Connection efficiency	16	Grant Prideco TCII	16		
	17	Grant Prideco STL	17		
	18	Hydril LX	18		
	19	Hydril 563	19	91.6	92.5
	20	Hydril 511	20		
	21	Hydril 521	21	65.6	69.0
	22	Vallourec & Mannesmann New VAM	22		
	23	Vallourec & Mannesmann VAM ACE	23		
	24	Vallourec & Mannesmann VAM PRO	24		
	25	Vallourec & Mannesmann VAM TOP	25		
	26	Vallourec & Mannesmann FJL	26		

Section	No.	Connection	No.	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	Make-up torque (daN.m) K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						431.8		379.4						431.8		376.5
	28	Buttress Special Clearance	28																
	29	API STC	29	1020					431.8		379.4	1173					431.8		376.5
	30	API LTC	30																
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32																
	33	Hydril LX	33																
	34	Hydril 563	34	3254	3254	3254	3254	3254	431.8	382.2	379.4	3525	3525	3525	3525	3525	431.8		376.5
	35	Hydril 511	35																
	36	Hydril 521	36	2725	2725	2725	2725	2725	410.3	382.2	379.4	3159	3159	3159	3159	3159	412.9	379.3	376.5
	37	Vallourec & Mannesmann New VAM	37																
	38	Vallourec & Mannesmann VAM ACE	38																
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**16.000** in			406.4 mm				**16.000** in			406.4 mm			
	2	Nominal weight	2	**94.50** lb/ft			137.9 daN/m				**109.00** lb/ft			159.1 daN/m			
	3	Wall thickness	3	0.562 in			14.3 mm				0.656 in			16.7 mm			
	4	Inside diameter	4	14.876 in			377.9 mm				14.688 in			373.1 mm			
	5	Steel cross-section	5	27.26 in^2			17 585 mm^2				31.62 in^2			20 401 mm^2			
	6	Capacity	6	9.03 gal/ft			112.13 l/m				8.80 gal/ft			109.32 l/m			
	7	Displacement (1)	7	10.44 gal/ft			129.72 l/m				10.44 gal/ft			129.72 l/m			
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	12.9	14.8	14.8	15.0	15.1	15.1	15.1	17.7	21.2	21.2	22.4	22.9	23.9	24.3
	10	Internal yield pressure (MPa)	10	23.3	33.9	33.9	38.1	40.3	46.6	53.0	27.2	39.6	39.6	44.5	47.0	54.4	61.8
	11	Pipe body yield strength (1000 daN)	11	667	970	970	1091	1152	1334	1516	774	1125	1125	1266	1336	1547	1758
Tensile strength (10^3 daN)	12	Buttress Standard	12	754	936	955	1027	1083	1266	1413	874	1086	1107	1192	1256	1469	1639
	13	Buttress Special Clearance	13														
	14	API STC	14	444	593	599	658	694	808	910	526	702	709	780	822	957	1077
	15	API LTC	15														
Connection efficiency	16	Grant Prideco TCII	16														
	17	Grant Prideco STL	17														
	18	Hydril LX	18														
	19	Hydril 563	19											92.2			
	20	Hydril 511	20														
	21	Hydril 521	21											74.3			
	22	Vallourec & Mannesmann New VAM	22														
	23	Vallourec & Mannesmann VAM ACE	23														
	24	Vallourec & Mannesmann VAM PRO	24														
	25	Vallourec & Mannesmann VAM TOP	25														
	26	Vallourec & Mannesmann FJL	26														

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						431.8		373.1						431.8		368.3
	28	Buttress Special Clearance	28																
	29	API STC	29																
	30	API LTC	30																
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32																
	33	Hydril LX	33																
	34	Hydril 563	34									6644	6644	6644	6644	6644	431.8		368.3
	35	Hydril 511	35																
	36	Hydril 521	36									5355	5355	5355	5355	5355	418.2	371.2	368.3
	37	Vallourec & Mannesmann New VAM	37																
	38	Vallourec & Mannesmann VAM ACE	38																
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**16.000** in	406.4 mm	**18.625** in	473.1 mm
	2	Nominal weight	2	**128.00** lb/ft	186.8 daN/m	**87.50** lb/ft	127.7 daN/m
	3	Wall thickness	3	0.781 in	19.8 mm	0.435 in	11.0 mm
	4	Inside diameter	4	14.438 in	366.7 mm	17.755 in	451.0 mm
	5	Steel cross-section	5	37.34 in^2	24 091 mm^2	24.86 in^2	16 038 mm^2
	6	Capacity	6	8.51 gal/ft	105.63 l/m	12.86 gal/ft	159.73 l/m
	7	Displacement (1)	7	10.44 gal/ft	129.72 l/m	14.15 gal/ft	175.77 l/m

Pipe body	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	26.5	32.4	32.4	34.0	34.6	36.1	38.4	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	10	Internal yield pressure (MPa)	10	32.4	47.1	47.1	53.0	56.0	64.8	73.6	15.5	22.5	22.5	25.4	26.8	31.0	35.2
	11	Pipe body yield strength (1000 daN)	11	914	1329	1329	1495	1578	1827	2076	608	885	885	995	1050	1216	1382
Tensile strength (10^3 daN)	12	Buttress Standard	12	1032	1282	1308	1402	1472	1735	1893	635	829	840	917	967	1127	1265
	13	Buttress Special Clearance	13														
	14	API STC	14	633	845	854	939	990	1152	1297	353	475	480	529	557	649	731
	15	API LTC	15														
Connection efficiency	16	Grant Prideco TCII	16														
	17	Grant Prideco STL	17														
	18	Hydril LX	18														
	19	Hydril 563	19														
	20	Hydril 511	20														
	21	Hydril 521	21											65.3			
	22	Vallourec & Mannesmann New VAM	22														
	23	Vallourec & Mannesmann VAM ACE	23														
	24	Vallourec & Mannesmann VAM PRO	24														
	25	Vallourec & Mannesmann VAM TOP	25														
	26	Vallourec & Mannesmann FJL	26														

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						431.8		362.0						508.0		446.2
	28	Buttress Special Clearance	28																
	29	API STC	29									1077					508.0		446.2
	30	API LTC	30																
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32																
	33	Hydril LX	33																
	34	Hydril 563	34														508.0	449.1	446.2
	35	Hydril 511	35																
	36	Hydril 521	36									3539	3539	3539	3539	3539	478.9	448.0	446.2
	37	Vallourec & Mannesmann New VAM	37																
	38	Vallourec & Mannesmann VAM ACE	38																
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**20.000** in	508.0 mm						**20.000** in	508.0 mm						
	2	Nominal weight	2	**94.00** lb/ft	137.2 daN/m						**106.50** lb/ft	155.4 daN/m						
	3	Wall thickness	3	0.438 in	11.1 mm						0.500 in	12.7 mm						
	4	Inside diameter	4	19.124 in	485.7 mm						19.000 in	482.6 mm						
	5	Steel cross-section	5	26.92 in^2	17 366 mm^2						30.63 in^2	19 762 mm^2						
	6	Capacity	6	14.92 gal/ft	185.32 l/m						14.73 gal/ft	182.92 l/m						
	7	Displacement (1)	7	16.32 gal/ft	202.68 l/m						16.32 gal/ft	202.68 l/m						
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	3.6	3.6	3.6	3.6	3.6	3.6	3.6	5.3	5.3	5.3	5.3	5.3	5.3	5.3
	10	Internal yield pressure (MPa)	10	14.5	21.1	21.1	23.8	25.1	29.1	33.0	16.6	24.1	24.1	27.1	28.7	33.2	37.7
	11	Pipe body yield strength (1000 daN)	11	659	958	958	1078	1137	1317	1497	749	1090	1090	1226	1294	1499	1703
Tensile strength (10^3 daN)	12	Buttress Standard	12	658	883	892	982	1035	1205	1357	749	1005	1015	1117	1178	1371	1544
	13	Buttress Special Clearance	13														
	14	API STC	14	366	495	499	550	580	675	761	427	576	581	641	676	787	887
	15	API LTC	15	425	572	577	636	670	780	879	495	666	672	741	781	909	1024
Connection efficiency	16	Grant Prideco TCII	16														
	17	Grant Prideco STL	17														
	18	Hydril LX	18														
	19	Hydril 563	19														
	20	Hydril 511	20														
	21	Hydril 521	21														
	22	Vallourec & Mannesmann New VAM	22														
	23	Vallourec & Mannesmann VAM ACE	23														
	24	Vallourec & Mannesmann VAM PRO	24														
	25	Vallourec & Mannesmann VAM TOP	25														
	26	Vallourec & Mannesmann FJL	26														

				Make-up torque (daN.m)								Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)	K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						533.4		481.0						533.4		477.8
	28	Buttress Special Clearance	28																
	29	API STC	29	1116					533.4		481.0	1300					533.4		477.8
	30	API LTC	30	1295					533.4		481.0	1509					533.4		477.8
	31	Grant Prideco TCII	31																
	32	Grant Prideco STL	32																
	33	Hydril LX	33																
	34	Hydril 563	34																
	35	Hydril 511	35																
	36	Hydril 521	36																
	37	Vallourec & Mannesmann New VAM	37																
	38	Vallourec & Mannesmann VAM ACE	38																
	39	Vallourec & Mannesmann VAM PRO	39																
	40	Vallourec & Mannesmann VAM TOP	40																
	41	Vallourec & Mannesmann FJL	41																

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF CASING (continued)

Pipe body	1	Nominal size (OD)	1	**20.000** in			508.0 mm			
	2	Nominal weight	2	**133.00** lb/ft			194.1 daN/m			
	3	Wall thickness	3	0.635 in			16.1 mm			
	4	Inside diameter	4	18.730 in			475.7 mm			
	5	Steel cross-section	5	38.63 in^2			24 923 mm^2			
	6	Capacity	6	14.31 gal/ft			177.76 l/m			
	7	Displacement (1)	7	16.32 gal/ft			202.68 l/m			
	8	Grade	8	K55	L80	N80	C90	T95	P110	Q125
	9	Collapse resistance (MPa)	9	10.3	11.1	11.1	11.1	11.1	11.1	11.1
	10	Internal yield pressure (MPa)	10	21.1	30.6	30.6	34.5	36.4	42.1	47.9
	11	Pipe body yield strength (1000 daN)	11	945	1375	1375	1547	1632	1890	2148
Tensile strength (10^3 daN)	12	Buttress Standard	12	944	1267	1280	1409	1486	1729	1947
	13	Buttress Special Clearance	13							
	14	API STC	14	557	752	759	837	883	1027	1158
	15	API LTC	15	647	870	878	967	1020	1187	1337
Connection efficiency	16	Grant Prideco TCII	16							
	17	Grant Prideco STL	17							
	18	Hydril LX	18							
	19	Hydril 563	19							
	20	Hydril 511	20							
	21	Hydril 521	21							
	22	Vallourec & Mannesmann New VAM	22							
	23	Vallourec & Mannesmann VAM ACE	23							
	24	Vallourec & Mannesmann VAM PRO	24							
	25	Vallourec & Mannesmann VAM TOP	25							
	26	Vallourec & Mannesmann FJL	26							

				Make-up torque (daN.m)							
				K55	LN80	C90/95	P110	Q125	OD (mm)	ID (mm)	Drift API (mm)
Connection characteristics	27	Buttress Standard	27						533.4		471.0
	28	Buttress Special Clearance	28								
	29	API STC	29	1697					533.4		471.0
	30	API LTC	30	1970					533.4		471.0
	31	Grant Prideco TCII	31								
	32	Grant Prideco STL	32								
	33	Hydril LX	33								
	34	Hydril 563	34								
	35	Hydril 511	35								
	36	Hydril 521	36								
	37	Vallourec & Mannesmann New VAM	37								
	38	Vallourec & Mannesmann VAM ACE	38								
	39	Vallourec & Mannesmann VAM PRO	39								
	40	Vallourec & Mannesmann VAM TOP	40								
	41	Vallourec & Mannesmann FJL	41								

(1) The closed-end displacement does not account for couplings. MPa × 145 = psi daN × 2.25 = lb daN.m × 7.38 = lb.ft mm × 0.0394 = in

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
0.750	0.59	55 000	0.083	0.078	0.584	0.174	0.165	40	79	188	0.173	0.112	0.285
0.750	0.59	75 000	0.083	0.078	0.584	0.174	0.165	55	108	256	0.173	0.112	0.285
0.750	0.62	80 000	0.087	0.082	0.576	0.181	0.172	61	121	282	0.168	0.117	0.285
1.000	0.81	55 000	0.083	0.078	0.834	0.239	0.226	55	59	364	0.352	0.154	0.507
1.000	0.79	70 000	0.080	0.075	0.840	0.231	0.218	68	72	450	0.358	0.149	0.507
1.000	0.81	70 000	0.083	0.078	0.834	0.239	0.226	70	75	463	0.352	0.154	0.507
1.000	0.85	70 000	0.087	0.082	0.826	0.250	0.236	74	79	479	0.346	0.161	0.507
1.000	0.92	70 000	0.095	0.090	0.810	0.270	0.257	80	87	511	0.332	0.174	0.507
1.000	0.98	70 000	0.102	0.097	0.796	0.288	0.275	86	94	537	0.321	0.186	0.507
1.000	1.04	70 000	0.109	0.104	0.782	0.305	0.293	91	100	561	0.310	0.197	0.507
1.000	1.17	70 000	0.125	0.117	0.750	0.344	0.325	101	113	613	0.285	0.222	0.507
1.000	0.81	75 000	0.083	0.078	0.834	0.239	0.226	75	81	496	0.352	0.154	0.507
1.000	0.85	75 000	0.087	0.082	0.826	0.250	0.236	79	85	513	0.346	0.161	0.507
1.000	0.79	80 000	0.080	0.075	0.840	0.231	0.218	78	83	515	0.358	0.149	0.507
1.000	0.85	80 000	0.087	0.082	0.826	0.250	0.236	84	90	548	0.346	0.161	0.507
1.000	0.92	80 000	0.095	0.090	0.810	0.270	0.257	92	99	584	0.332	0.174	0.507
1.000	0.98	80 000	0.102	0.097	0.796	0.288	0.275	98	107	613	0.321	0.186	0.507
1.000	1.04	80 000	0.109	0.104	0.782	0.305	0.293	104	115	641	0.310	0.197	0.507
1.000	1.17	80 000	0.125	0.117	0.750	0.344	0.325	115	129	700	0.285	0.222	0.507
1.000	0.79	90 000	0.080	0.075	0.840	0.231	0.218	87	93	579	0.358	0.149	0.507
1.000	0.85	90 000	0.087	0.082	0.826	0.250	0.236	95	102	616	0.346	0.161	0.507
1.000	0.92	90 000	0.095	0.090	0.810	0.270	0.257	103	112	657	0.332	0.174	0.507
1.000	0.98	90 000	0.102	0.097	0.796	0.288	0.275	110	120	690	0.321	0.186	0.507
1.000	1.04	90 000	0.109	0.104	0.782	0.305	0.293	117	129	722	0.310	0.197	0.507
1.000	1.17	90 000	0.125	0.117	0.750	0.344	0.325	130	145	788	0.285	0.222	0.507
1.000	0.79	100 000	0.080	0.075	0.840	0.231	0.218	97	103	643	0.358	0.149	0.507
1.000	0.85	100 000	0.087	0.082	0.826	0.250	0.236	105	113	685	0.346	0.161	0.507
1.000	0.92	100 000	0.095	0.090	0.810	0.270	0.257	114	124	729	0.332	0.174	0.507
1.000	0.98	100 000	0.102	0.097	0.796	0.288	0.275	122	134	767	0.321	0.186	0.507
1.000	1.17	100 000	0.125	0.117	0.750	0.344	0.325	144	161	876	0.285	0.222	0.507
1.250	1.03	55 000	0.083	0.078	1.084	0.304	0.287	70	47	598	0.595	0.196	0.792
1.250	1.17	55 000	0.095	0.090	1.060	0.345	0.328	80	55	664	0.569	0.222	0.792

kN × 0.225 = kip   MPa × 145 = psi   N.m × 0.738 = lb.ft   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING (continued)

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in²)	Minimum (in²)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
1.250	1.00	70 000	0.080	0.075	1.090	0.294	0.277	86	58	739	0.602	0.190	0.792
1.250	1.03	70 000	0.083	0.078	1.084	0.304	0.287	89	60	761	0.595	0.196	0.792
1.250	1.08	70 000	0.087	0.082	1.076	0.318	0.301	94	63	790	0.587	0.205	0.792
1.250	1.17	70 000	0.095	0.090	1.060	0.345	0.328	102	69	846	0.569	0.222	0.792
1.250	1.25	70 000	0.102	0.097	1.046	0.368	0.351	109	75	893	0.554	0.237	0.792
1.250	1.33	70 000	0.109	0.104	1.032	0.391	0.374	117	80	938	0.540	0.252	0.792
1.250	1.50	70 000	0.125	0.117	1.000	0.442	0.416	130	90	1 034	0.507	0.285	0.792
1.250	1.60	70 000	0.134	0.126	0.982	0.470	0.445	139	97	1 084	0.489	0.303	0.792
1.250	1.82	70 000	0.156	0.148	0.938	0.536	0.512	160	114	1 196	0.446	0.346	0.792
1.250	2.01	70 000	0.175	0.167	0.900	0.591	0.568	177	129	1 281	0.410	0.381	0.792
1.250	1.03	75 000	0.083	0.078	1.084	0.304	0.287	96	65	815	0.595	0.196	0.792
1.250	1.08	75 000	0.087	0.082	1.076	0.318	0.301	100	68	846	0.587	0.205	0.792
1.250	1.17	75 000	0.095	0.090	1.060	0.345	0.328	109	74	906	0.569	0.222	0.792
1.250	1.33	75 000	0.109	0.104	1.032	0.391	0.374	125	86	1 005	0.540	0.252	0.792
1.250	1.00	80 000	0.080	0.075	1.090	0.294	0.277	99	66	844	0.602	0.190	0.792
1.250	1.08	80 000	0.087	0.082	1.076	0.318	0.301	107	72	902	0.587	0.205	0.792
1.250	1.17	80 000	0.095	0.090	1.060	0.345	0.328	117	79	966	0.569	0.222	0.792
1.250	1.25	80 000	0.102	0.097	1.046	0.368	0.351	125	86	1 020	0.554	0.237	0.792
1.250	1.33	80 000	0.109	0.104	1.032	0.391	0.374	133	92	1 071	0.540	0.252	0.792
1.250	1.50	80 000	0.125	0.117	1.000	0.442	0.416	148	103	1 182	0.507	0.285	0.792
1.250	1.60	80 000	0.134	0.126	0.982	0.470	0.445	158	111	1 239	0.489	0.303	0.792
1.250	1.82	80 000	0.156	0.148	0.938	0.536	0.512	182	131	1 367	0.446	0.346	0.792
1.250	2.01	80 000	0.175	0.167	0.900	0.591	0.568	202	147	1 463	0.410	0.381	0.792
1.250	1.00	90 000	0.080	0.075	1.090	0.294	0.277	111	74	950	0.602	0.190	0.792
1.250	1.08	90 000	0.087	0.082	1.076	0.318	0.301	120	81	1 015	0.587	0.205	0.792
1.250	1.17	90 000	0.095	0.090	1.060	0.345	0.328	131	89	1 087	0.569	0.222	0.792
1.250	1.25	90 000	0.102	0.097	1.046	0.368	0.351	141	96	1 148	0.554	0.237	0.792
1.250	1.33	90 000	0.109	0.104	1.032	0.391	0.374	150	103	1 205	0.540	0.252	0.792
1.250	1.50	90 000	0.125	0.117	1.000	0.442	0.416	167	116	1 329	0.507	0.285	0.792
1.250	1.60	90 000	0.134	0.126	0.982	0.470	0.445	178	125	1 394	0.489	0.303	0.792
1.250	1.82	90 000	0.156	0.148	0.938	0.536	0.512	205	147	1 538	0.446	0.346	0.792
1.250	2.01	90 000	0.175	0.167	0.900	0.591	0.568	227	166	1 646	0.410	0.381	0.792
1.250	1.00	100 000	0.080	0.075	1.090	0.294	0.277	123	83	1 055	0.602	0.190	0.792
1.250	1.08	100 000	0.087	0.082	1.076	0.318	0.301	134	90	1 128	0.587	0.205	0.792
1.250	1.17	100 000	0.095	0.090	1.060	0.345	0.328	146	99	1 208	0.569	0.222	0.792
1.250	1.25	100 000	0.102	0.097	1.046	0.368	0.351	156	107	1 275	0.554	0.237	0.792

kN × 0.225 = kip   MPa × 145 = psi   N.m × 0.738 = lb.ft   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING (continued)

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
1.250	1.33	100 000	0.109	0.104	1.032	0.391	0.374	167	115	1 339	0.540	0.252	0.792
1.250	1.50	100 000	0.125	0.117	1.000	0.442	0.416	185	129	1 477	0.507	0.285	0.792
1.250	1.60	100 000	0.134	0.126	0.982	0.470	0.445	198	139	1 549	0.489	0.303	0.792
1.250	1.82	100 000	0.156	0.148	0.938	0.536	0.512	228	163	1 708	0.446	0.346	0.792
1.250	2.01	100 000	0.175	0.167	0.900	0.591	0.568	253	184	1 829	0.410	0.381	0.792
1.500	1.43	75 000	0.095	0.090	1.310	0.419	0.399	133	62	1 356	0.870	0.271	1.140
1.500	1.62	75 000	0.109	0.104	1.282	0.476	0.456	152	72	1 512	0.833	0.307	1.140
1.500	1.43	80 000	0.095	0.090	1.310	0.419	0.399	142	66	1 446	0.870	0.271	1.140
1.500	1.52	80 000	0.102	0.097	1.296	0.448	0.428	152	71	1 531	0.851	0.289	1.140
1.500	1.62	80 000	0.109	0.104	1.282	0.476	0.456	162	76	1 613	0.833	0.307	1.140
1.500	1.84	80 000	0.125	0.117	1.250	0.540	0.508	181	86	1 790	0.792	0.348	1.140
1.500	1.95	80 000	0.134	0.126	1.232	0.575	0.544	194	93	1 884	0.769	0.371	1.140
1.500	2.24	80 000	0.156	0.148	1.188	0.659	0.629	224	109	2 098	0.715	0.425	1.140
1.500	2.48	80 000	0.175	0.167	1.150	0.728	0.699	249	123	2 263	0.670	0.470	1.140
1.500	1.43	90 000	0.095	0.090	1.310	0.419	0.399	160	74	1 627	0.870	0.271	1.140
1.500	1.52	90 000	0.102	0.097	1.296	0.448	0.428	171	80	1 722	0.851	0.289	1.140
1.500	1.62	90 000	0.109	0.104	1.282	0.476	0.456	183	86	1 815	0.833	0.307	1.140
1.500	1.84	90 000	0.125	0.117	1.250	0.540	0.508	204	97	2 014	0.792	0.348	1.140
1.500	1.95	90 000	0.134	0.126	1.232	0.575	0.544	218	104	2 120	0.769	0.371	1.140
1.500	2.24	90 000	0.156	0.148	1.188	0.659	0.629	252	122	2 360	0.715	0.425	1.140
1.500	2.48	90 000	0.175	0.167	1.150	0.728	0.699	280	138	2 546	0.670	0.470	1.140
1.500	1.43	100 000	0.095	0.090	1.310	0.419	0.399	177	83	1 808	0.870	0.271	1.140
1.500	1.52	100 000	0.102	0.097	1.296	0.448	0.428	190	89	1 914	0.851	0.289	1.140
1.500	1.62	100 000	0.109	0.104	1.282	0.476	0.456	203	96	2 016	0.833	0.307	1.140
1.500	1.84	100 000	0.125	0.117	1.250	0.540	0.508	226	108	2 238	0.792	0.348	1.140
1.500	1.95	100 000	0.134	0.126	1.232	0.575	0.544	242	116	2 356	0.769	0.371	1.140
1.500	2.24	100 000	0.156	0.148	1.188	0.659	0.629	280	136	2 622	0.715	0.425	1.140
1.500	2.48	100 000	0.175	0.167	1.150	0.728	0.699	311	154	2 829	0.670	0.470	1.140
1.750	1.48	55 000	0.083	0.078	1.584	0.435	0.410	100	34	1 241	1.271	0.280	1.552
1.750	1.55	55 000	0.087	0.082	1.576	0.455	0.430	105	36	1 292	1.259	0.293	1.552
1.750	1.68	55 000	0.095	0.090	1.560	0.494	0.469	115	39	1 391	1.233	0.319	1.552
1.750	1.91	70 000	0.109	0.104	1.532	0.562	0.538	167	57	1 983	1.189	0.363	1.552
1.750	2.17	70 000	0.125	0.117	1.500	0.638	0.600	187	65	2 211	1.140	0.412	1.552
1.750	2.31	70 000	0.134	0.126	1.482	0.680	0.643	200	69	2 334	1.113	0.439	1.552
1.750	2.66	70 000	0.156	0.148	1.438	0.781	0.745	232	82	2 614	1.048	0.504	1.552

kN × 0.225 = kip   MPa × 145 = psi   N.m × 0.738 = lb.ft   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING (continued)

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
1.750	2.94	70 000	0.175	0.167	1.400	0.866	0.831	259	92	2 837	0.993	0.559	1.552
1.750	3.14	70 000	0.188	0.180	1.374	0.923	0.888	276	99	2 979	0.957	0.595	1.552
1.750	1.68	75 000	0.095	0.090	1.560	0.494	0.469	157	53	1 897	1.233	0.319	1.552
1.750	1.68	80 000	0.095	0.090	1.560	0.494	0.469	167	57	2 024	1.233	0.319	1.552
1.750	1.91	80 000	0.109	0.104	1.532	0.562	0.538	191	66	2 266	1.189	0.363	1.552
1.750	2.17	80 000	0.125	0.117	1.500	0.638	0.600	214	74	2 527	1.140	0.412	1.552
1.750	2.31	80 000	0.134	0.126	1.482	0.680	0.643	229	79	2 667	1.113	0.439	1.552
1.750	2.66	80 000	0.156	0.148	1.438	0.781	0.745	265	93	2 988	1.048	0.504	1.552
1.750	2.94	80 000	0.175	0.167	1.400	0.866	0.831	296	105	3 242	0.993	0.559	1.552
1.750	3.14	80 000	0.188	0.180	1.374	0.923	0.888	316	113	3 405	0.957	0.595	1.552
1.750	3.17	80 000	0.190	0.182	1.370	0.931	0.897	319	115	3 429	0.951	0.601	1.552
1.750	1.80	90 000	0.102	0.097	1.546	0.528	0.504	202	69	2 415	1.211	0.341	1.552
1.750	1.91	90 000	0.109	0.104	1.532	0.562	0.538	215	74	2 549	1.189	0.363	1.552
1.750	2.17	90 000	0.125	0.117	1.500	0.638	0.600	240	83	2 843	1.140	0.412	1.552
1.750	2.31	90 000	0.134	0.126	1.482	0.680	0.643	257	89	3 000	1.113	0.439	1.552
1.750	2.66	90 000	0.156	0.148	1.438	0.781	0.745	298	105	3 361	1.048	0.504	1.552
1.750	2.94	90 000	0.175	0.167	1.400	0.866	0.831	332	118	3 647	0.993	0.559	1.552
1.750	3.17	90 000	0.190	0.182	1.370	0.931	0.897	359	129	3 858	0.951	0.601	1.552
1.750	1.68	100 000	0.095	0.090	1.560	0.494	0.469	209	71	2 530	1.233	0.319	1.552
1.750	1.91	100 000	0.109	0.104	1.532	0.562	0.538	239	82	2 833	1.189	0.363	1.552
1.750	2.17	100 000	0.125	0.117	1.500	0.638	0.600	267	92	3 159	1.140	0.412	1.552
1.750	2.31	100 000	0.134	0.126	1.482	0.680	0.643	286	99	3 334	1.113	0.439	1.552
1.750	2.66	100 000	0.156	0.148	1.438	0.781	0.745	331	117	3 735	1.048	0.504	1.552
1.750	2.94	100 000	0.175	0.167	1.400	0.866	0.831	369	132	4 053	0.993	0.559	1.552
1.750	3.14	100 000	0.188	0.180	1.374	0.923	0.888	395	142	4 256	0.957	0.595	1.552
2.000	2.20	70 000	0.109	0.104	1.782	0.648	0.619	193	50	2 652	1.609	0.418	2.027
2.000	2.50	70 000	0.125	0.117	1.750	0.736	0.692	216	56	2 968	1.552	0.475	2.027
2.000	2.67	70 000	0.134	0.126	1.732	0.786	0.742	231	61	3 138	1.520	0.507	2.027
2.000	3.07	70 000	0.156	0.148	1.688	0.904	0.861	268	71	3 533	1.444	0.583	2.027
2.000	3.41	70 000	0.175	0.167	1.650	1.003	0.962	299	81	3 850	1.380	0.647	2.027
2.000	3.64	70 000	0.188	0.180	1.624	1.070	1.029	320	87	4 054	1.336	0.690	2.027
2.000	3.67	70 000	0.190	0.182	1.620	1.080	1.039	324	88	4 085	1.330	0.697	2.027
2.000	3.90	70 000	0.203	0.195	1.594	1.146	1.106	344	94	4 279	1.287	0.739	2.027
2.000	2.20	80 000	0.109	0.104	1.782	0.648	0.619	220	57	3 031	1.609	0.418	2.027
2.000	2.50	80 000	0.125	0.117	1.750	0.736	0.692	246	65	3 392	1.552	0.475	2.027

kN × 0.225 = kip   MPa × 145 = psi   N.m × 0.738 = lb.ft   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING (continued)

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
2.000	2.67	80 000	0.134	0.126	1.732	0.786	0.742	264	69	3 587	1.520	0.507	2.027
2.000	3.07	80 000	0.156	0.148	1.688	0.904	0.861	306	82	4 038	1.444	0.583	2.027
2.000	3.41	80 000	0.175	0.167	1.650	1.003	0.962	342	92	4 400	1.380	0.647	2.027
2.000	3.64	80 000	0.188	0.180	1.624	1.070	1.029	366	99	4 634	1.336	0.690	2.027
2.000	3.67	80 000	0.190	0.182	1.620	1.080	1.039	370	100	4 669	1.330	0.697	2.027
2.000	3.90	80 000	0.203	0.195	1.594	1.146	1.106	393	108	4 890	1.287	0.739	2.027
2.000	2.20	90 000	0.109	0.104	1.782	0.648	0.619	248	65	3 410	1.609	0.418	2.027
2.000	2.50	90 000	0.125	0.117	1.750	0.736	0.692	277	73	3 816	1.552	0.475	2.027
2.000	2.67	90 000	0.134	0.126	1.732	0.786	0.742	297	78	4 035	1.520	0.507	2.027
2.000	3.07	90 000	0.156	0.148	1.688	0.904	0.861	345	92	4 543	1.444	0.583	2.027
2.000	3.41	90 000	0.175	0.167	1.650	1.003	0.962	385	104	4 950	1.380	0.647	2.027
2.000	3.67	90 000	0.190	0.182	1.620	1.080	1.039	416	113	5 252	1.330	0.697	2.027
2.000	2.20	100 000	0.109	0.104	1.782	0.648	0.619	276	72	3 789	1.609	0.418	2.027
2.000	2.50	100 000	0.125	0.117	1.750	0.736	0.692	308	81	4 240	1.552	0.475	2.027
2.000	2.67	100 000	0.134	0.126	1.732	0.786	0.742	330	87	4 484	1.520	0.507	2.027
2.000	3.07	100 000	0.156	0.148	1.688	0.904	0.861	383	102	5 047	1.444	0.583	2.027
2.000	3.41	100 000	0.175	0.167	1.650	1.003	0.962	428	115	5 500	1.380	0.647	2.027
2.000	3.64	100 000	0.188	0.180	1.624	1.070	1.029	458	124	5 792	1.336	0.690	2.027
2.000	3.90	100 000	0.203	0.195	1.594	1.146	1.106	492	134	6 112	1.287	0.739	2.027
2.375	2.64	70 000	0.109	0.104	2.157	0.776	0.742	231	42	3 839	2.358	0.501	2.858
2.375	3.00	70 000	0.125	0.117	2.125	0.884	0.830	258	48	4 313	2.288	0.570	2.858
2.375	3.21	70 000	0.134	0.126	2.107	0.943	0.890	277	51	4 571	2.250	0.609	2.858
2.375	3.70	70 000	0.156	0.148	2.063	1.088	1.035	322	60	5 173	2.157	0.702	2.858
2.375	4.11	70 000	0.175	0.167	2.025	1.210	1.158	361	68	5 663	2.078	0.780	2.858
2.375	4.39	70 000	0.188	0.180	1.999	1.292	1.241	386	73	5 983	2.025	0.833	2.858
2.375	4.43	70 000	0.190	0.182	1.995	1.304	1.254	390	74	6 031	2.017	0.841	2.858
2.375	4.71	70 000	0.203	0.195	1.969	1.385	1.335	416	79	6 337	1.964	0.894	2.858
2.375	2.64	80 000	0.109	0.104	2.157	0.776	0.742	264	48	4 387	2.358	0.501	2.858
2.375	3.00	80 000	0.125	0.117	2.125	0.884	0.830	295	54	4 929	2.288	0.570	2.858
2.375	3.21	80 000	0.134	0.126	2.107	0.943	0.890	317	59	5 224	2.250	0.609	2.858
2.375	3.70	80 000	0.156	0.148	2.063	1.088	1.035	368	69	5 912	2.157	0.702	2.858
2.375	4.11	80 000	0.175	0.167	2.025	1.210	1.158	412	78	6 472	2.078	0.780	2.858
2.375	4.39	80 000	0.188	0.180	1.999	1.292	1.241	442	84	6 838	2.025	0.833	2.858
2.375	4.43	80 000	0.190	0.182	1.995	1.304	1.254	446	85	6 893	2.017	0.841	2.858
2.375	4.71	80 000	0.203	0.195	1.969	1.385	1.335	475	91	7 242	1.964	0.894	2.858

kN × 0.225 = kip   MPa × 145 = psi   N.m × 0.738 = lb.ft   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING (continued)

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
2.375	3.00	90 000	0.125	0.117	2.125	0.884	0.830	332	61	5 546	2.288	0.570	2.858
2.375	3.21	90 000	0.134	0.126	2.107	0.943	0.890	356	66	5 877	2.250	0.609	2.858
2.375	3.70	90 000	0.156	0.148	2.063	1.088	1.035	415	77	6 651	2.157	0.702	2.858
2.375	4.11	90 000	0.175	0.167	2.025	1.210	1.158	464	87	7 281	2.078	0.780	2.858
2.375	4.43	90 000	0.190	0.182	1.995	1.304	1.254	502	95	7 754	2.017	0.841	2.858
2.375	4.73	90 000	0.204	0.196	1.967	1.391	1.342	537	102	8 177	1.960	0.898	2.858
2.375	2.64	100 000	0.109	0.104	2.157	0.776	0.742	330	60	5 484	2.358	0.501	2.858
2.375	3.00	100 000	0.125	0.117	2.125	0.884	0.830	369	68	6 162	2.288	0.570	2.858
2.375	3.21	100 000	0.134	0.126	2.107	0.943	0.890	396	73	6 530	2.250	0.609	2.858
2.375	3.70	100 000	0.156	0.148	2.063	1.088	1.035	461	86	7 390	2.157	0.702	2.858
2.375	4.11	100 000	0.175	0.167	2.025	1.210	1.158	515	97	8 090	2.078	0.780	2.858
2.375	4.39	100 000	0.188	0.180	1.999	1.292	1.241	552	105	8 547	2.025	0.833	2.858
2.375	4.71	100 000	0.203	0.195	1.969	1.385	1.335	594	113	9 052	1.964	0.894	2.858
2.875	3.67	70 000	0.125	0.117	2.625	1.080	1.014	316	39	6 499	3.492	0.697	4.188
2.875	3.92	70 000	0.134	0.126	2.607	1.154	1.088	339	42	6 901	3.444	0.744	4.188
2.875	4.53	70 000	0.156	0.148	2.563	1.333	1.268	395	50	7 849	3.329	0.860	4.188
2.875	5.05	70 000	0.175	0.167	2.525	1.484	1.421	442	56	8 630	3.231	0.958	4.188
2.875	5.40	70 000	0.188	0.180	2.499	1.587	1.524	475	60	9 144	3.164	1.024	4.188
2.875	5.45	70 000	0.190	0.182	2.495	1.603	1.540	479	61	9 221	3.154	1.034	4.188
2.875	5.79	70 000	0.203	0.195	2.469	1.704	1.642	511	65	9 717	3.089	1.099	4.188
2.875	3.67	80 000	0.125	0.117	2.625	1.080	1.014	361	45	7 427	3.492	0.697	4.188
2.875	3.92	80 000	0.134	0.126	2.607	1.154	1.088	387	48	7 887	3.444	0.744	4.188
2.875	4.53	80 000	0.156	0.148	2.563	1.333	1.268	451	57	8 970	3.329	0.860	4.188
2.875	5.05	80 000	0.175	0.167	2.525	1.484	1.421	506	64	9 862	3.231	0.958	4.188
2.875	5.40	80 000	0.188	0.180	2.499	1.587	1.524	542	69	10 450	3.164	1.024	4.188
2.875	5.45	80 000	0.190	0.182	2.495	1.603	1.540	548	70	10 539	3.154	1.034	4.188
2.875	5.79	80 000	0.203	0.195	2.469	1.704	1.642	584	75	11 105	3.089	1.099	4.188
2.875	3.92	90 000	0.134	0.126	2.607	1.154	1.088	436	54	8 873	3.444	0.744	4.188
2.875	4.53	90 000	0.156	0.148	2.563	1.333	1.268	508	64	10 092	3.329	0.860	4.188
2.875	5.05	90 000	0.175	0.167	2.525	1.484	1.421	569	72	11 095	3.231	0.958	4.188
2.875	5.45	90 000	0.190	0.182	2.495	1.603	1.540	616	79	11 856	3.154	1.034	4.188
2.875	5.82	90 000	0.204	0.196	2.467	1.712	1.650	660	85	12 542	3.084	1.104	4.188
2.875	6.34	90 000	0.224	0.216	2.427	1.866	1.804	722	93	13 482	2.985	1.204	4.188
2.875	3.67	100 000	0.125	0.117	2.625	1.080	1.014	451	56	9 284	3.492	0.697	4.188
2.875	3.92	100 000	0.134	0.126	2.607	1.154	1.088	484	60	9 858	3.444	0.744	4.188
2.875	4.53	100 000	0.156	0.148	2.563	1.333	1.268	564	71	11 213	3.329	0.860	4.188

kN × 0.225 = kip   MPa × 145 = psi   N.m × 0.738 = lb.ft   l/m × 0.0805 = gal/ft   l/m × 0.00192 = bbl/ft

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING (continued)

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
2.875	5.05	100 000	0.175	0.167	2.525	1.484	1.421	632	80	12 328	3.231	0.958	4.188
2.875	5.40	100 000	0.188	0.180	2.499	1.587	1.524	678	86	13 062	3.164	1.024	4.188
2.875	5.79	100 000	0.203	0.195	2.469	1.704	1.642	730	94	13 882	3.089	1.099	4.188
3.500	4.82	70 000	0.134	0.126	3.232	1.417	1.336	416	35	10 489	5.293	0.914	6.207
3.500	5.57	70 000	0.156	0.148	3.188	1.639	1.559	485	41	11 981	5.150	1.057	6.207
3.500	6.21	70 000	0.175	0.167	3.150	1.828	1.749	544	46	13 220	5.028	1.179	6.207
3.500	6.65	70 000	0.188	0.180	3.124	1.956	1.877	585	50	14 042	4.945	1.262	6.207
3.500	6.72	70 000	0.190	0.182	3.120	1.976	1.897	591	50	14 167	4.932	1.275	6.207
3.500	7.15	70 000	0.203	0.195	3.094	2.103	2.025	630	54	14 966	4.851	1.357	6.207
3.500	7.18	70 000	0.204	0.196	3.092	2.112	2.034	633	54	15 027	4.844	1.363	6.207
3.500	7.84	70 000	0.224	0.216	3.052	2.305	2.228	694	60	16 215	4.720	1.487	6.207
3.500	4.82	80 000	0.134	0.126	3.232	1.417	1.336	475	40	11 988	5.293	0.914	6.207
3.500	5.57	80 000	0.156	0.148	3.188	1.639	1.559	555	47	13 692	5.150	1.057	6.207
3.500	6.21	80 000	0.175	0.167	3.150	1.828	1.749	622	53	15 108	5.028	1.179	6.207
3.500	6.65	80 000	0.188	0.180	3.124	1.956	1.877	668	57	16 048	4.945	1.262	6.207
3.500	6.72	80 000	0.190	0.182	3.120	1.976	1.897	675	57	16 191	4.932	1.275	6.207
3.500	7.15	80 000	0.203	0.195	3.094	2.103	2.025	720	61	17 104	4.851	1.357	6.207
3.500	7.18	80 000	0.204	0.196	3.092	2.112	2.034	724	62	17 173	4.844	1.363	6.207
3.500	7.84	80 000	0.224	0.216	3.052	2.305	2.228	793	68	18 531	4.720	1.487	6.207
3.500	4.82	90 000	0.134	0.126	3.232	1.417	1.336	535	45	13 486	5.293	0.914	6.207
3.500	5.57	90 000	0.156	0.148	3.188	1.639	1.559	624	52	15 404	5.150	1.057	6.207
3.500	6.21	90 000	0.175	0.167	3.150	1.828	1.749	700	59	16 997	5.028	1.179	6.207
3.500	6.72	90 000	0.190	0.182	3.120	1.976	1.897	759	65	18 215	4.932	1.275	6.207
3.500	7.18	90 000	0.204	0.196	3.092	2.112	2.034	814	69	19 320	4.844	1.363	6.207
3.500	7.84	90 000	0.224	0.216	3.052	2.305	2.228	892	77	20 848	4.720	1.487	6.207
3.500	4.82	100 000	0.134	0.126	3.232	1.417	1.336	594	50	14 985	5.293	0.914	6.207
3.500	5.57	100 000	0.156	0.148	3.188	1.639	1.559	693	58	17 115	5.150	1.057	6.207
3.500	6.21	100 000	0.175	0.167	3.150	1.828	1.749	778	66	18 885	5.028	1.179	6.207
3.500	6.65	100 000	0.188	0.180	3.124	1.956	1.877	835	71	20 060	4.945	1.262	6.207
3.500	7.15	100 000	0.203	0.195	3.094	2.103	2.025	901	77	21 380	4.851	1.357	6.207
4.500	8.75	70 000	0.190	0.182	4.120	2.573	2.469	769	39	24 294	8.601	1.660	10.261
4.500	9.36	70 000	0.204	0.196	4.092	2.753	2.650	825	42	25 838	8.485	1.776	10.261
4.500	10.23	70 000	0.224	0.216	4.052	3.009	2.907	905	46	27 991	8.319	1.941	10.261
4.500	11.35	70 000	0.250	0.242	4.000	3.338	3.237	1 008	52	30 695	8.107	2.154	10.261

kN × 0.225 = kip MPa × 145 = psi N.m × 0.738 = lb.ft l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

GEOMETRICAL CHARACTERISTICS AND MECHANICAL PROPERTIES OF COILED TUBING (continued)

Coiled tubing dimensions and specifications						Tube area		Calculated coiled tubing performance properties					
Outside diameter (in)	Body weight (lb/ft)	Yield strength (psi)	Wall thickness Nominal (in)	Wall thickness Minimum (in)	Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Tension yield (kN)	Internal yield (MPa)	Torsional yield (N.m)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
4.500	8.75	80 000	0.190	0.182	4.120	2.573	2.469	879	45	27 764	8.601	1.660	10.261
4.500	9.36	80 000	0.204	0.196	4.092	2.753	2.650	943	48	29 530	8.485	1.776	10.261
4.500	10.23	80 000	0.224	0.216	4.052	3.009	2.907	1 034	53	31 990	8.319	1.941	10.261
4.500	11.35	80 000	0.250	0.242	4.000	3.338	3.237	1 152	59	35 080	8.107	2.154	10.261
4.500	8.75	90 000	0.190	0.182	4.120	2.573	2.469	988	50	31 235	8.601	1.660	10.261
4.500	9.36	90 000	0.204	0.196	4.092	2.753	2.650	1 061	54	33 221	8.485	1.776	10.261
4.500	10.23	90 000	0.224	0.216	4.052	3.009	2.907	1 164	60	35 988	8.319	1.941	10.261
4.500	11.35	90 000	0.250	0.242	4.000	3.338	3.237	1 296	67	39 465	8.107	2.154	10.261
5.000	11.43	70 000	0.224	0.216	4.552	3.361	3.246	1 011	42	35 083	10.499	2.168	12.668
5.000	12.68	70 000	0.250	0.242	4.500	3.731	3.617	1 126	47	38 542	10.261	2.407	12.668
5.000	11.43	80 000	0.224	0.216	4.552	3.361	3.246	1 155	48	40 095	10.499	2.168	12.668
5.000	12.68	80 000	0.250	0.242	4.500	3.731	3.617	1 287	53	44 048	10.261	2.407	12.668

kN × 0.225 = kip MPa × 145 = psi N.m × 0.738 = lb.ft l/m × 0.0805 = gal/ft l/m × 0.00192 = bbl/ft

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF LINE PIPE, RISER AND CONDUCTOR PIPE

Outside diameter (in) / (mm)	22 / 558.8			24 / 609.6				26 / 660.4			
Wall thickness (mm)	9.53	12.70	19.05	12.70	15.88	19.05	25.40	12.70	15.88	19.05	25.40
Wall thickness (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	577.9	571.5	558.8	635.0	628.7	622.3	609.6
Inside diameter (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)	164.4	217.9	323.0	238.2	296.1	353.4	466.2	258.4	321.4	383.8	506.7
Cross section area (in^2)	25.5	33.8	50.1	36.9	45.9	54.8	72.3	40.1	49.8	59.5	78.5
Weight (daN/m)	126.6	167.8	248.8	183.4	228.0	272.2	359.0	199.0	247.5	295.6	390.2
Weight (lb/ft)	86.7	115.0	170.5	125.7	156.2	186.5	246.0	136.4	169.6	202.5	267.4
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
Displacement closed-end (ft^3/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	316.7	310.4	304.2	291.9
Capacity (ft^3/ft)	2.47	2.41	2.30	2.89	2.83	2.77	2.65	3.42	3.35	3.28	3.15

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
Collapse resistance (1) (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) (1000 daN)	397	589	526	781	780	1158	575	854	715	1062	853	1267	1125	1671	624	927	776	1152	926	1376	1223	1817
Yield strength (1) (1000 lb)	892	1325	1182	1756	1752	2604	1292	1920	1606	2387	1917	2849	2529	3757	1402	2083	1744	2591	2082	3094	2749	4084
Standard test pressure (2) (MPa)	6.1	11.0	8.2	14.7	12.3	17.2	7.5	13.4	9.4	15.9	11.3	15.9	15.1	15.9	7.0	12.4	8.7	13.8	10.4	13.8	13.8	13.8
Standard test pressure (2) (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).

GEOMETRIC CHARACTERISTICS AND MECHANICAL 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)	12.70	15.88	19.05	25.40	12.70	15.88	19.05	25.40	12.70	15.88	19.05	25.40
(in)	0.500	0.625	0.750	1.000	0.500	0.625	0.750	1.000	0.500	0.625	0.750	1.000
Inside diameter												
(mm)	736.6	730.3	723.9	711.2	787.4	781.1	774.7	762.0	889.0	882.7	876.3	863.6
(in)	29.00	28.75	28.50	28.00	31.00	30.75	30.50	30.00	35.00	34.75	34.50	34.00
Cross section area												
(cm^2)	299.0	372.1	444.6	587.8	319.2	397.4	475.0	628.3	359.8	448.1	535.8	709.4
(in^2)	46.3	57.7	68.9	91.1	49.5	61.6	73.6	97.4	55.8	69.5	83.1	110.0
Weight												
(daN/m)	230.2	286.6	342.4	452.6	245.8	306.1	365.8	483.9	277.0	345.1	412.6	546.3
(lb/ft)	157.8	196.4	234.6	310.2	168.4	209.7	250.7	331.5	189.8	236.5	282.8	374.3
Displacement closed-end												
(l/m)	456.0	456.0	456.0	456.0	518.9	518.9	518.9	518.9	656.7	656.7	656.7	656.7
(ft^3/ft)	4.91	4.91	4.91	4.91	5.59	5.59	5.59	5.59	7.07	7.07	7.07	7.07
Capacity												
(l/m)	426.1	418.8	411.6	397.3	486.9	479.1	471.4	456.0	620.7	611.9	603.1	585.8
(ft^3/ft)	4.60	4.52	4.44	4.29	5.26	5.17	5.09	4.92	6.70	6.60	6.51	6.32

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)	1.5	1.5	3.0	3.0	4.6	4.9	8.7	10.9	1.3	1.3	2.5	2.5	4.4	4.4	7.7	9.4	0.9	0.9	1.8	1.8	3.0	3.0	6.0	6.9
(psi)	218	218	435	435	667	711	1262	1581	189	189	363	363	638	638	1120	1363	131	131	261	261	435	435	870	1000
Yield strength (1)																								
(1000 daN)	721	1072	898	1334	1073	1594	1418	2107	770	1145	959	1425	1146	1703	1516	2253	868	1290	1081	1607	1293	1921	1712	2543
(1000 lb)	1622	2410	2019	2999	2412	3584	3189	4738	1732	2573	2156	3203	2577	3829	3409	5064	1952	2900	2431	3612	2907	4319	3848	5718
Standard test pressure (2)																								
(MPa)	6.1	10.8	7.5	13.4	9.0	16.1	12.1	20.7	5.7	10.1	7.1	12.6	8.5	15.1	11.3	20.1	5.0	9.0	6.3	11.2	7.5	13.4	10.1	17.9
(psi)	880	1560	1090	1950	1310	2340	1750	3000	820	1460	1030	1830	1230	2190	1640	2920	730	1300	910	1620	1090	1950	1460	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).

GEOMETRIC CHARACTERISTICS AND MECHANICAL PROPERTIES OF LINE PIPE, RISER AND CONDUCTOR PIPE (continued)

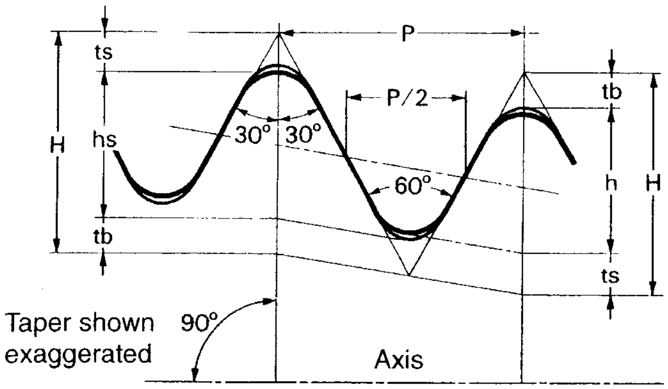
Outside diameter (in) (mm)	40 1016.0				42 1066.8			
Wall thickness								
(mm)	12.70	15.88	19.05	25.40	12.70	15.88	19.05	25.40
(in)	0.500	0.625	0.750	1.000	0.500	0.625	0.750	1.000
Inside diameter								
(mm)	990.6	984.3	977.9	965.2	1041	1035	1029	1016
(in)	39.00	38.75	38.50	38.00	41.00	40.75	40.50	40.00
Cross section area								
(cm^2)	400.3	498.8	596.6	790.5	420.6	524.1	627.0	831.0
(in^2)	62.0	77.3	92.5	122.5	65.2	81.2	97.2	128.8
Weight								
(daN/m)	308.3	384.1	459.5	608.7	323.9	403.6	482.9	639.9
(lb/ft)	211.2	263.2	314.8	417.1	221.9	276.6	330.9	438.5
Displacement closed-end								
(l/m)	810.7	810.7	810.7	810.7	893.8	893.8	893.8	893.8
(ft^3/ft)	8.73	8.73	8.73	8.73	9.62	9.62	9.62	9.62
Capacity								
(l/m)	770.7	760.9	751.1	731.7	851.8	841.4	831.1	810.7
(ft^3/ft)	8.32	8.21	8.11	7.90	9.19	9.08	8.97	8.75

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)																
(1000 daN)	966	1435	1204	1788	1440	2139	1908	2834	1015	1508	1265	1879	1513	2248	2005	2979
(1000 lb)	2172	3226	2706	4020	3237	4809	4288	6371	2282	3390	2843	4224	3402	5054	4508	6698
Standard test pressure (2)																
(MPa)	4.6	8.1	5.7	10.1	6.8	12.1	9.0	16.1	4.3	7.7	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 (1/8 in)

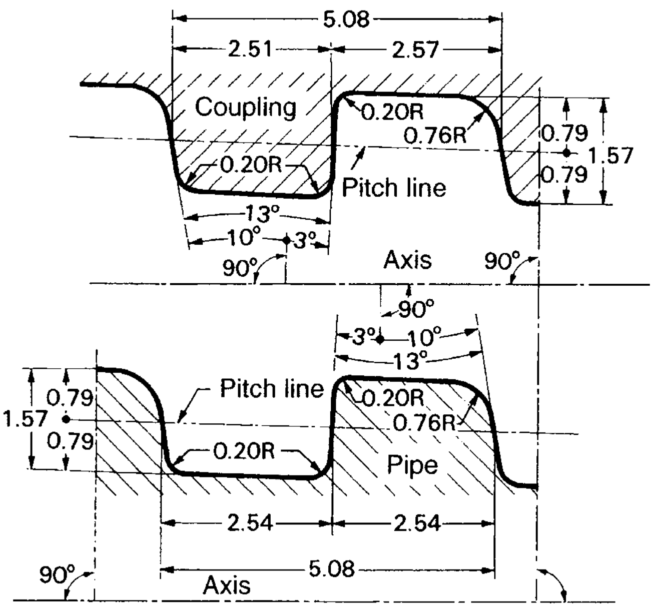
$H = 0.866\,p$ = 2.750 mm

$h = 0.626\,p - 0.178$ = 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%

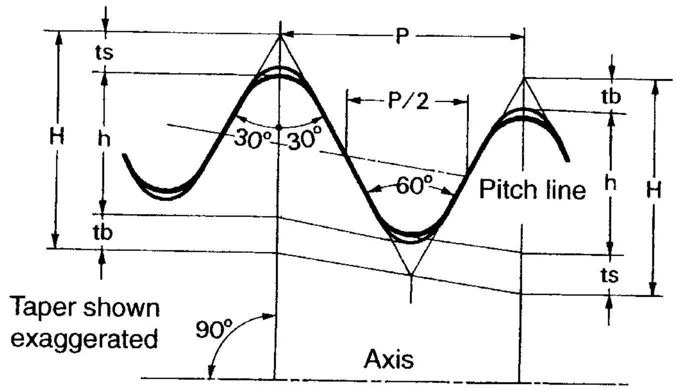
5 threads/in

Threads 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 (1/10 in)	8 threads per inch p = 3.175 mm (1/8 in)
$H = 0.866\ p$	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

The collapse resistance of casing in the presence of an axial stress is calculated by modifying the yield stress to an axial stress equivalent grade according to formula:

$$Y_{pa} = \left[\sqrt{1 - 0.75\left(\frac{S_a}{Y_p}\right)^2} - 0.5\,\frac{S_a}{Y_p}\right] Y_p$$

where:

S_a = axial stress, psi or MPa (tension is positive)

Y_p = minimum yield strength of the pipe, psi or MPa

Y_{pa} = yield strength of axial stress equivalent grade, psi or MPa

This formula is based on the Hencky-Von Mises maximum strain energy of distortion theory of yielding.

Example of how to use this formula:

Let use assume that 150 10^3 daN of casing are suspended below a 9 5/8 in, 43.50 lb/ft T95 joint. Using the formula, determine the effective collapse resistance of the pipe as a function of the applied load:

Solution: Determine the axial stress:

$$S_a = \frac{\text{Tensile load applied}}{\text{Pipe cross-section area}} = \frac{1\,000\,000}{8\,103\ 10^{-6}} = 123.4 \text{ MPa}$$

S_a = 17 898 psi

$$Y_{pa} = \left[\sqrt{1 - 0.75\left(\frac{17\,898}{95\,000}\right)^2} - 0.5\,\frac{17\,898}{95\,000}\right] 95\,000$$

Y_{pa} = 84 778 psi

The collapse resistance of this 9 5/8 in, 43.50 lb/ft T95 casing under a tensile load of 100 10^3 daN is an intermediate value between the collapse resistance of a LN80 grade casing and a T95 grade casing:

Collapse pressure for LN80 43.50 lb/ft: 26.3 MPa

Collapse pressure for T95 43.50 lb/ft: 28.5 MPa

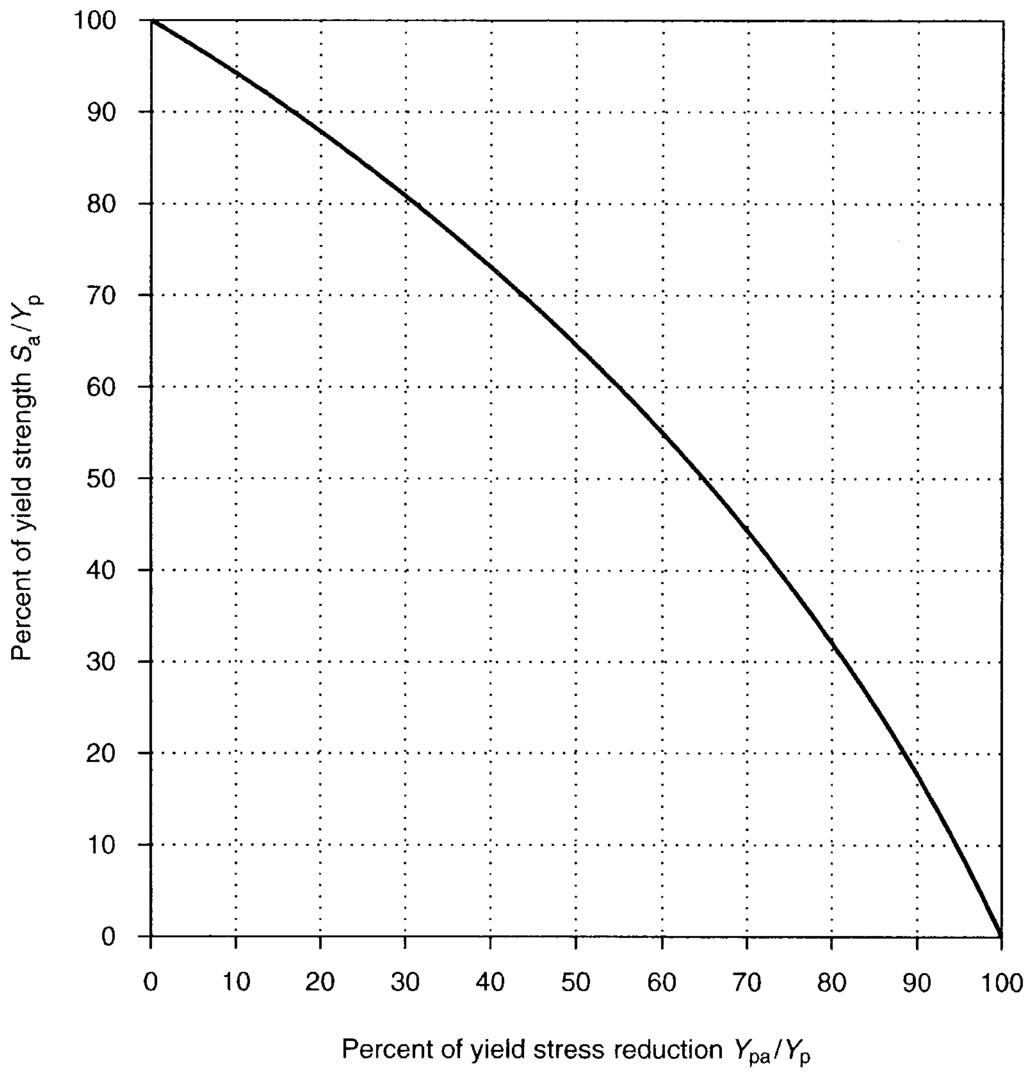
Approximated collapse pressure for '84 778' grade 43.50 lb/ft is:

$$P_{co} = 26.3 + (28.5 - 26.3)\,\frac{84\,778 - 80\,000}{95\,000 - 80\,000} = 27.0 \text{ MPa}$$

Note: Exact calculation using API 5C3 formulas gives: 26.7 MPa

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

$$Y_{pa} = \left[\sqrt{1 - 0.75\left(\frac{S_a}{Y_p}\right)^2} - 0.5\,\frac{S_a}{Y_p}\right] Y_p$$



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:

$$T = 25.5\, S\, \Delta t \quad \text{or} \quad T = 32.W\, \Delta t$$

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 or K)

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 the 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:

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

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:

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

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 the top of cement (MPa)

P_i = internal pressure at the top of cement (MPa)

A_e = external section area of casing (cm^2)

A_i = internal section area of casing (cm^2)

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

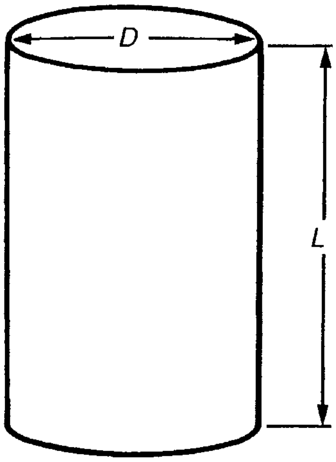
If F_c is negative, the string will buckle for a tensile load lower than F_c.

D

capacities and annular volumes

GENERAL FORMULAS

Volume of a cylinder



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

Volume in l/m:

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

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

Approximate formula: $V = \frac{D^2}{2}$ (with D in inches)

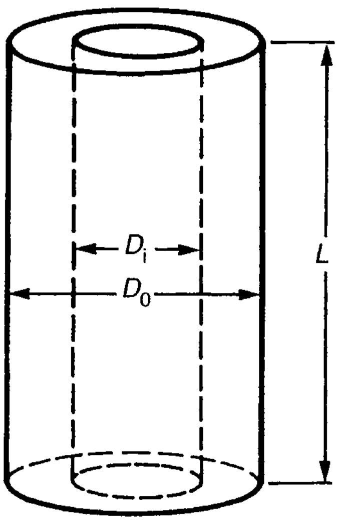
Example:

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



$$V = \frac{\Pi}{4} (D_0^2 - D_i^2) L$$

Volume in l/m:

$V = 0.0007854\ (D_0^2 - D_i^2)$ (with D_0 in mm)
(with D_i in mm)

$V = 0.5067\,(D_0^2 - D_i^2)$ (with D_0 in inches)
(with D_i in inches)

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

CLEARANCE BETWEEN STANDARD BITS AND CASING SIZES

Casing dimensions						Drift (mm)	Bit size (1) immediately below drift		Clearance between bit and casing size (mm)
Outside diameter		Nominal weight		Thickness (mm)	Inside diameter (mm)				
(in)	(mm)	(lb/ft)	(daN/m)				(in)	(mm)	
4 1/2	114.3	9.50	13.86	5.21	103.88	100.71	3 7/8	98.43	5.5
		10.50	15.32	5.69	102.92	99.75	3 7/8	98.43	4.5
		11.60	16.93	6.35	101.60	98.43	3 7/8	98.43	3.2
		13.50	19.70	7.37	99.56	96.39	3 3/4	95.25	4.3
		15.10	22.04	8.56	97.18	94.01	3 5/8	92.08	5.1
		16.90	24.66	9.65	95.00	91.83	3 1/2	88.90	6.1
		17.70	25.83	10.20	93.90	90.73	3 1/2	88.90	5.0
		18.80	27.44	10.92	92.46	89.29	3 1/2	88.90	3.6
5	127.0	11.50	16.78	5.59	115.82	112.65	4 3/8	111.13	4.7
		13.00	18.97	6.43	114.14	110.97	4 1/4	107.95	6.2
		15.00	21.89	7.52	111.96	108.79	4 1/4	107.95	4.0
		18.00	26.27	9.19	108.62	105.45	4 1/8	104.78	3.8
		21.40	31.23	11.10	104.80	101.63	4	101.60	3.2
		23.20	33.86	12.14	102.72	99.54	3 7/8	98.43	4.3
		24.10	35.17	12.70	101.60	98.43	3 7/8	98.43	3.2
5 1/2	139.7	14.00	20.43	6.20	127.30	124.13	4 7/8	123.83	3.5
		15.50	22.62	6.98	125.74	122.57	4 3/4	120.65	5.1
		17.00	24.81	7.72	124.26	121.09	4 3/4	120.65	3.6
		20.00	29.19	9.17	121.36	118.19	4 5/8	117.48	3.9
		23.00	33.57	10.54	118.62	115.44	4 1/2	114.30	4.3
		26.00	37.94	12.09	115.52	112.34	4 3/8	111.13	4.4
		26.80	39.11	12.70	114.30	111.13	4 3/8	111.13	3.2
6 5/8	168.3	20.00	29.19	7.32	153.64	150.46	5 7/8	149.23	4.4
		23.20	33.86	8.38	151.52	148.34	5 3/4	146.05	5.5
		24.00	35.03	8.94	150.40	147.22	5 3/4	146.05	4.3
		28.00	40.86	10.59	147.10	143.92	5 5/8	142.88	4.2
		32.00	46.70	12.07	144.15	140.97	5 1/2	139.70	4.4
		35.00	51.08	13.34	141.60	138.42	5 3/8	136.53	5.1
7	177.8	17.00	24.81	5.87	166.06	162.89	6 3/8	161.93	4.1
		20.00	29.19	6.91	163.98	160.81	6 1/4	158.75	5.2
		23.00	33.57	8.05	161.70	158.53	6 1/8	155.58	6.1
		26.00	37.94	9.19	159.42	156.25	6 1/8	155.58	3.8
		29.00	42.32	10.36	157.08	153.91	6	152.40	4.7
		32.00	46.70	11.51	154.78	151.61	5 7/8	149.23	5.5
		35.00	51.08	12.65	152.50	149.33	5 7/8	149.23	3.3
		38.00	55.46	13.72	150.36	147.19	5 3/4	146.05	4.3
		41.00	59.83	14.98	147.84	144.67	5 5/8	142.88	5.0
		44.00	64.21	16.25	145.30	142.13	5 1/2	139.70	5.6
		46.00	67.13	17.02	143.76	140.59	5 1/2	139.70	4.1
7 5/8	193.7	24.00	35.03	7.62	178.44	175.26	6 7/8	174.63	3.8
		26.40	38.53	8.33	177.02	173.84	6 3/4	171.45	5.6
		29.70	43.34	9.52	174.64	171.46	6 3/4	171.45	3.2
		33.70	49.18	10.92	171.84	168.66	6 5/8	168.28	3.6
		35.80	52.25	11.81	170.06	166.88	6 1/2	165.10	5.0
		39.00	56.92	12.70	168.28	165.10	6 1/2	165.10	3.2
		42.80	62.46	14.27	165.14	161.96	6 3/8	161.93	3.2
		45.30	66.11	15.11	163.46	160.28	6 1/4	158.75	4.7
		47.10	68.74	15.88	161.92	158.74	6 1/4	158.75	3.2

(1) Drift rounded 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 (mm)	Bit size (1) immediately below drift		Clearance between bit and casing size (mm)
Outside diameter		Nominal weight		Thickness (mm)	Inside diameter (mm)				
(in)	(mm)	(lb/ft)	(daN/m)				(in)	(mm)	
8 5/8	219.1	24.00	35.03	6.71	205.66	202.48	7 7/8	200.03	5.6
		28.00	40.86	7.72	203.64	200.46	7 7/8	200.03	3.6
		32.00	46.70	8.94	201.20	198.02	7 3/4	196.85	4.3
		36.00	52.54	10.16	198.76	195.58	7 5/8	193.68	5.1
		40.00	58.38	11.43	196.22	193.04	7 1/2	190.50	5.7
		44.00	64.21	12.70	193.68	190.50	7 1/2	190.50	3.2
		49.00	71.51	14.15	190.78	187.60	7 3/8	187.33	3.4
		52.00	75.89	15.11	188.86	185.68	7 1/4	184.15	4.7
9 5/8	244.5	32.30	47.14	7.92	228.64	224.67	8 3/4	222.25	6.4
		36.00	52.54	8.94	226.60	222.63	8 3/4	222.25	4.3
		40.00	58.38	10.03	224.42	220.45	8 5/8	219.08	5.3
		43.50	63.48	11.05	222.38	218.41	8 1/2	215.90	6.5
		47.00	68.59	11.99	220.50	216.53	8 1/2	215.90	4.6
		53.50	78.08	13.84	216.80	212.83	8 3/8	212.73	4.1
		58.40	85.23	15.11	214.26	210.29	8 1/4	209.55	4.7
		59.40	86.69	15.47	213.54	209.57	8 1/4	209.55	4.0
		61.10	89.17	15.87	212.74	208.77	8 1/8	206.38	6.4
		71.80	104.78	19.05	206.38	202.41	7 7/8	200.03	6.4
9 7/8	250.8	62.80	91.65	15.88	219.07	215.10	8 3/8	212.73	6.3
10 3/4	273.1	32.75	47.80	7.09	258.87	254.90	10	254.00	4.9
		40.50	59.56	8.89	255.27	251.30	9 7/8	250.83	4.4
		45.50	66.91	10.16	252.73	248.76	9 3/4	247.65	5.1
		51.00	75.00	11.43	250.19	246.22	9 5/8	244.48	5.7
		55.50	81.61	12.57	247.91	243.94	9 1/2	241.30	6.6
		60.70	89.26	13.84	245.37	241.40	9 1/2	241.30	4.1
		65.70	95.88	15.11	242.83	238.86	9 3/8	238.13	4.7
11 3/4	298.5	42.00	61.29	8.46	281.53	277.56	10 7/8	276.23	5.3
		47.00	68.59	9.52	279.41	275.44	10 3/4	273.05	6.4
		54.00	78.81	11.05	276.35	272.38	10 5/8	269.88	6.5
		60.00	87.56	12.42	273.61	269.64	10 1/2	266.70	6.9
		65.00	94.86	13.56	271.33	267.36	10 1/2	266.70	4.6
		71.00	103.62	14.78	268.89	264.92	10 3/8	263.53	5.4
13 3/8	339.7	48.00	70.05	8.38	322.97	319.00	12 1/2	317.50	5.5
		54.50	79.54	9.65	320.43	316.46	12 3/8	314.33	6.1
		61.00	89.02	10.92	317.89	313.92	12 1/4	311.15	6.7
		68.00	99.24	12.19	315.35	311.38	12 1/4	311.15	4.2
		72.00	105.08	13.06	313.61	309.64	12 1/8	307.98	5.6
		77.00	112.37	13.97	311.79	307.82	12	304.80	7.0
		80.70	117.77	14.73	310.27	306.30	12	304.80	5.5
13 5/8	346.1	88.20	128.72	15.88	314.33	309.57	12 1/8	307.98	6.4
14	355.6	82.50	120.40	14.27	327.06	322.30	12 5/8	320.68	6.4
		94.80	138.35	16.66	322.28	317.52	12 1/2	317.50	4.8
		99.00	144.48	17.48	320.64	315.88	12 3/8	314.33	6.3
		114.00	166.37	20.32	314.96	310.20	12 1/8	307.98	7.0
16	406.4	65.00	94.86	9.52	387.36	382.60	15	381.00	6.4
		75.00	109.45	11.13	384.14	379.38	14 7/8	377.83	6.3
		84.00	122.59	12.57	381.26	376.50	14 3/4	374.65	6.6
		94.50	137.91	14.27	377.86	373.10	14 5/8	371.48	6.4
		109.00	159.07	16.66	373.08	368.32	14 1/2	368.30	4.8
		128.00	186.80	19.84	366.72	361.96	14 1/4	361.95	4.8
18 5/8	473.1	87.50	127.70	11.05	450.98	446.21	17 1/2	444.50	6.5
20	508.0	94.00	137.18	11.13	485.74	480.98	18 7/8	479.43	6.3
		106.50	155.43	12.70	482.60	477.84	18 3/4	476.25	6.4
		133.00	194.10	16.13	475.74	470.98	18 1/2	469.90	5.8

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

mm × 0.0394 = in

CAPACITIES OF CYLINDERS

Diameter (in)	Capacity (l/m)	Diameter (in)	Capacity (l/m)	Diameter (in)	Capacity (l/m)	Diameter (in)	Capacity (l/m)	Diameter (in)	Capacity (l/m)
1	0.507	**5**	12.67	**9**	41.04	**13**	85.63	**17**	146.4
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
1 1/4	0.792	5 1/4	13.97	9 1/4	43.35	13 1/4	88.96	17 1/4	150.8
1 3/8	0.958	5 3/8	14.64	9 3/8	44.53	13 3/8	90.64	17 3/8	153.0
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
1 5/8	1.338	5 5/8	16.03	9 5/8	46.94	13 5/8	94.06	17 5/8	157.4
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
1 7/8	1.781	5 7/8	17.49	9 7/8	49.41	13 7/8	97.55	17 7/8	161.9
2	2.027	**6**	18.24	**10**	50.67	**14**	99.31	**18**	164.2
2 1/8	2.288	6 1/8	19.01	10 1/8	51.94	14 1/8	101.1	18 1/8	166.5
2 1/4	2.565	6 1/4	19.79	10 1/4	53.24	14 1/4	102.9	18 1/4	168.8
2 3/8	2.858	6 3/8	20.59	10 3/8	54.54	14 3/8	104.7	18 3/8	171.1
2 1/2	3.167	6 1/2	21.41	10 1/2	55.86	14 1/2	106.5	18 1/2	173.4
2 5/8	3.491	6 5/8	22.24	10 5/8	57.20	14 5/8	108.4	18 5/8	175.8
2 3/4	3.832	6 3/4	23.09	10 3/4	58.56	14 3/4	110.2	18 3/4	178.1
2 7/8	4.188	6 7/8	23.95	10 7/8	59.93	14 7/8	112.1	18 7/8	180.5
3	4.560	**7**	24.83	**11**	61.31	**15**	114.0	**19**	182.9
3 1/8	4.948	7 1/8	25.72	11 1/8	62.71	15 1/8	115.9	19 1/8	185.3
3 1/4	5.352	7 1/4	26.63	11 1/4	64.13	15 1/4	117.8	19 1/4	187.8
3 3/8	5.772	7 3/8	27.56	11 3/8	65.56	15 3/8	119.8	19 3/8	190.2
3 1/2	6.207	7 1/2	28.50	11 1/2	67.01	15 1/2	121.7	19 1/2	192.7
3 5/8	6.658	7 5/8	29.46	11 5/8	68.48	15 5/8	123.7	19 5/8	195.2
3 3/4	7.125	7 3/4	30.43	11 3/4	69.96	15 3/4	125.7	19 3/4	197.6
3 7/8	7.608	7 7/8	31.42	11 7/8	71.45	15 7/8	127.7	19 7/8	200.2
4	8.107	**8**	32.43	**12**	72.96	**16**	129.7	**20**	202.7
4 1/8	8.622	8 1/8	33.45	12 1/8	74.49	16 1/8	131.7	20 1/8	205.2
4 1/4	9.152	8 1/4	34.49	12 1/4	76.04	16 1/4	133.8	20 1/4	207.8
4 3/8	9.699	8 3/8	35.54	12 3/8	77.60	16 3/8	135.9	20 3/8	210.4
4 1/2	10.26	8 1/2	36.61	12 1/2	79.17	16 1/2	137.9	20 1/2	212.9
4 5/8	10.84	8 5/8	37.69	12 5/8	80.76	16 5/8	140.0	20 5/8	215.5
4 3/4	11.43	8 3/4	38.79	12 3/4	82.37	16 3/4	142.2	20 3/4	218.2
4 7/8	12.04	8 7/8	39.91	12 7/8	83.99	16 7/8	144.3	20 7/8	220.8

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)	Diameter (in)	Capacity (l/m)
21	223.5	**25**	316.7	**29**	426.1	**33**	551.8
21 1/8	226.1	25 1/8	319.9	29 1/8	429.8	33 1/8	556.0
21 1/4	228.8	25 1/4	323.1	29 1/4	433.5	33 1/4	560.2
21 3/8	231.5	25 3/8	326.3	29 3/8	437.2	33 3/8	564.4
21 1/2	234.2	25 1/2	329.5	29 1/2	441.0	33 1/2	568.6
21 5/8	237.0	25 5/8	332.7	29 5/8	444.7	33 5/8	572.9
21 3/4	239.7	25 3/4	336.0	29 3/4	448.5	33 3/4	577.2
21 7/8	242.5	25 7/8	339.2	29 7/8	452.2	33 7/8	581.4
22	245.2	**26**	342.5	**30**	456.0	**34**	585.7
22 1/8	248.0	26 1/8	345.8	30 1/8	459.8	34 1/8	590.1
22 1/4	250.8	26 1/4	349.1	30 1/4	463.7	34 1/4	594.4
22 3/8	253.7	26 3/8	352.5	30 3/8	467.5	34 3/8	598.7
22 1/2	256.5	26 1/2	355.8	30 1/2	471.4	34 1/2	603.1
22 5/8	259.4	26 5/8	359.2	30 5/8	475.2	34 5/8	607.5
22 3/4	262.2	26 3/4	362.6	30 3/4	479.1	34 3/4	611.9
22 7/8	265.1	26 7/8	366.0	30 7/8	483.0	34 7/8	616.3
23	268.0	**27**	369.4	**31**	486.9	**35**	620.7
23 1/8	271.0	27 1/8	372.8	31 1/8	490.9	35 1/8	625.1
23 1/4	273.9	27 1/4	376.3	31 1/4	494.8	35 1/4	629.6
27 3/8	379.7	27 3/8	379.7	31 3/8	498.8	35 3/8	634.1
23 1/2	279.8	27 1/2	383.2	31 1/2	502.8	35 1/2	638.6
23 5/8	282.8	27 5/8	386.7	31 5/8	506.8	35 5/8	643.1
23 3/4	285.8	27 3/4	390.2	31 3/4	510.8	35 3/4	647.6
23 7/8	288.8	27 7/8	393.7	31 7/8	514.8	35 7/8	652.1
24	291.9	**28**	397.3	**32**	518.9	**36**	656.7
24 1/8	294.9	28 1/8	400.8	32 1/8	522.9	36 1/8	661.3
24 1/4	298.0	28 1/4	404.4	32 1/4	527.0	36 1/4	665.8
24 3/8	301.1	28 3/8	408.0	32 3/8	531.1	36 3/8	670.4
24 1/2	304.1	28 1/2	411.6	32 1/2	535.2	36 1/2	675.1
24 5/8	307.3	28 5/8	415.2	32 5/8	539.3	36 5/8	679.7
24 3/4	310.4	28 3/4	418.8	32 3/4	543.5	36 3/4	684.3
24 7/8	313.5	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	Thread	Tool joint		Volumes (1) (l/m)		
					OD (in)	ID (in)	Metal displa-cement	Capacity	Total displa-cement
2 3/8	6.65	EU	E75	NC26(IF)	3 3/8	1 3/4	1.33	1.66	2.99
2 3/8	6.65	EU	X95	NC26(IF)	3 3/8	1 3/4	1.35	1.66	3.01
2 3/8	6.65	EU	G105	NC26(IF)	3 3/8	1 3/4	1.35	1.66	3.01
2 7/8	10.40	EU	E75	NC31(IF)	4 1/8	2 1/8	2.06	2.34	4.41
2 7/8	10.40	EU	X95	NC31(IF)	4 1/8	2	2.10	2.33	4.43
2 7/8	10.40	EU	G105	NC31(IF)	4 1/8	2	2.10	2.33	4.43
2 7/8	10.40	EU	S135	NC31(IF)	4 3/8	1 5/8	2.19	2.29	4.48
3 1/2	9.50	EU	E75	NC38(IF)	4 3/4	2 11/16	2.01	4.49	6.50
3 1/2	9.50	EU	E75	NC38(IF)	4 3/4	3	1.96	4.54	6.50
3 1/2	13.30	EU	E75	NC38(IF)	4 3/4	2 11/16	2.64	3.86	6.50
3 1/2	13.30	EU	X95	NC38(IF)	5	2 9/16	2.77	3.84	6.61
3 1/2	13.30	EU	G105	NC38(IF)	5	2 7/16	2.79	3.82	6.61
3 1/2	13.30	EU	S135	NC38(IF)	5	2 1/8	2.83	3.78	6.61
3 1/2	15.50	EU	E75	NC38(IF)	5	2 9/16	3.14	3.42	6.57
3 1/2	15.50	EU	X95	NC38(IF)	5	2 7/16	3.19	3.41	6.60
3 1/2	15.50	EU	G105	NC38(IF)	5	2 1/8	3.23	3.37	6.60
3 1/2	15.50	EU	S135	NC40(FH)	5 1/2	2 1/4	3.33	3.38	6.72
4	14.00	IU	E75	NC40(FH)	5 1/4	2 13/16	2.85	3.46	6.31
4	14.00	IU	X95	NC40(FH)	5 1/4	2 11/16	2.90	5.55	8.45
4	14.00	IU	G105	NC40(FH)	5 1/2	2 7/16	3.01	5.51	8.52
4	14.00	IU	S135	NC40(FH)	5 1/2	2	3.06	5.46	8.52
4	14.00	EU	E75	NC46(IF)	6	3 1/4	3.01	5.64	8.65
4	14.00	EU	X95	NC46(IF)	6	3 1/4	3.07	5.64	8.71
4	14.00	EU	G105	NC46(IF)	6	3 1/4	3.07	5.64	8.71
4	14.00	EU	S135	NC46(IF)	6	3	3.11	5.59	8.71
4 1/2	13.75	EU	E75	NC50(IF)	6 3/8	3 3/4	2.92	7.89	10.81
4 1/2	13.75	EU	E75	NC50(IF)	6 5/8	3 7/8	2.98	7.92	10.90
4 1/2	16.60	IEU	E75	NC46(XH)	6 1/4	3 1/4	3.48	7.30	10.79
4 1/2	16.60	IEU	X95	NC46(XH)	6 1/4	3	3.53	7.26	10.79
4 1/2	16.60	IEU	G105	NC46(XH)	6 1/4	3	3.53	7.26	10.79
4 1/2	16.60	IEU	S135	NC46(XH)	6 1/4	2 3/4	3.57	7.22	10.79
4 1/2	16.60	IEU	E75	FH	6	3	3.44	7.26	10.70
4 1/2	16.60	IEU	X95	FH	6	3	3.44	7.26	10.71
4 1/2	16.60	IEU	G105	FH	6	3	3.44	7.26	10.71
4 1/2	16.60	IEU	S135	FH	6 1/4	2 1/2	3.61	7.18	10.79
4 1/2	16.60	EU	E75	NC50(IF)	6 3/8	3 3/4	3.41	7.40	10.81
4 1/2	16.60	EU	E75	NC50(IF)	6 5/8	3 3/4	3.50	7.40	10.90
4 1/2	16.60	EU	X95	NC50(IF)	6 3/8	3 3/4	3.48	7.40	10.88
4 1/2	16.60	EU	X95	NC50(IF)	6 5/8	3 3/4	3.57	7.40	10.97
4 1/2	16.60	EU	G105	NC50(IF)	6 3/8	3 3/4	3.48	7.40	10.88
4 1/2	16.60	EU	G105	NC50(IF)	6 5/8	3 3/4	3.57	7.40	10.97
4 1/2	16.60	EU	S135	NC50(IF)	6 3/8	3 1/2	3.53	7.35	10.88
4 1/2	16.60	EU	S135	NC50(IF)	6 5/8	3 1/2	3.62	7.35	10.97
4 1/2	20.00	IEU	E75	NC46(XH)	6 1/4	3	4.19	6.60	10.79
4 1/2	20.00	IEU	X95	NC46(XH)	6 1/4	2 3/4	4.29	6.56	10.84
4 1/2	20.00	IEU	G105	NC46(XH)	6 1/4	2 1/2	4.32	6.52	10.84
4 1/2	20.00	IEU	S135	NC46(XH)	6 1/4	2 1/4	4.36	6.49	10.84

(1) Approximate volumes calculated with the approximate weight (API RP 7G).

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	Thread	Tool joint		Volumes (1) (l/m)		
					OD (in)	ID (in)	Metal displa-cement	Capacity	Total displa-cement
4 1/2	20.00	IEU	E75	FH	6	3	4.11	6.60	10.71
4 1/2	20.00	IEU	X95	FH	6	2 1/2	4.24	6.52	10.76
4 1/2	20.00	IEU	G105	FH	6	2 1/2	4.24	6.52	10.76
4 1/2	20.00	EU	E75	NC50(IF)	6 3/8	3 5/8	4.10	6.71	10.81
4 1/2	20.00	EU	E75	NC50(IF)	6 5/8	3 5/8	4.19	6.71	10.90
4 1/2	20.00	EU	X95	NC50(IF)	6 3/8	3 1/2	4.19	6.69	10.88
4 1/2	20.00	EU	X95	NC50(IF)	6 5/8	3 1/2	4.28	6.69	10.97
4 1/2	20.00	EU	G105	NC50(IF)	6 3/8	3 1/2	4.19	6.69	10.88
4 1/2	20.00	EU	G105	NC50(IF)	6 5/8	3 1/2	4.28	6.69	10.97
4 1/2	20.00	EU	S135	NC50(IF)	6 5/8	3	4.37	6.59	10.97
5	19.50	IEU	E75	NC50(XH)	6 3/8	3 3/4	3.96	9.15	13.11
5	19.50	IEU	E75	NC50(XH)	6 5/8	3 3/4	4.05	9.15	13.19
5	19.50	IEU	X95	NC50(XH)	6 3/8	3 1/2	4.06	9.10	13.16
5	19.50	IEU	X95	NC50(XH)	6 5/8	3 1/2	4.15	9.10	13.24
5	19.50	IEU	G105	NC50(XH)	6 1/2	3 1/4	4.15	9.05	13.20
5	19.50	IEU	G105	NC50(XH)	6 5/8	3 1/4	4.19	9.05	13.24
5	19.50	IEU	S135	NC50(XH)	6 5/8	2 3/4	4.28	8.97	13.24
5	19.50	IEU	E75	5 1/2 FH	7	3 3/4	4.23	9.14	13.37
5	19.50	IEU	X95	5 1/2 FH	7	3 3/4	4.28	9.14	13.42
5	19.50	IEU	G105	5 1/2 FH	7	3 3/4	4.28	9.14	13.42
5	19.50	IEU	S135	5 1/2 FH	7 1/4	3 1/2	4.44	9.08	13.52
5	25.60	IEU	E75	NC50(IF)	6 3/8	3 1/2	5.10	8.01	13.10
5	25.60	IEU	E75	NC50(IF)	6 5/8	3 1/2	5.19	8.00	13.19
5	25.60	IEU	X95	NC50(IF)	6 1/2	3	5.27	7.92	13.19
5	25.60	IEU	X95	NC50(IF)	6 5/8	3	5.32	7.91	13.23
5	25.60	IEU	G105	NC50(IF)	6 5/8	2 3/4	5.36	7.87	13.23
5	25.60	IEU	E75	5 1/2 FH	7	3 1/2	5.37	7.99	13.36
5	25.60	IEU	X95	5 1/2 FH	7	3 1/2	5.41	7.99	13.41
5	25.60	IEU	G105	5 1/2 FH	7 1/4	3 1/2	5.52	7.99	13.51
5	25.60	IEU	S135	5 1/2 FH	7 1/4	3 1/4	5.57	7.94	13.51
5 1/2	21.90	IEU	E75	5 1/2 FH	7	4	4.51	11.37	15.88
5 1/2	21.90	IEU	X95	5 1/2 FH	7	3 3/4	4.63	11.32	15.95
5 1/2	21.90	IEU	G105	5 1/2 FH	7 1/4	3 1/2	4.79	11.26	16.05
5 1/2	21.90	IEU	S135	5 1/2 FH	7 1/2	3	5.00	11.15	16.15
5 1/2	24.70	IEU	E75	5 1/2 FH	7	4	4.99	10.89	15.87
5 1/2	24.70	IEU	X95	5 1/2 FH	7 1/4	3 1/2	5.26	10.77	16.03
5 1/2	24.70	IEU	G105	5 1/2 FH	7 1/4	3 1/2	5.26	10.77	16.03
5 1/2	24.70	IEU	S135	5 1/2 FH	7 1/2	3	5.47	10.67	16.14
6 5/8	25.20	IEU	E75	6 5/8 FH	8	5	5.22	17.72	22.95
6 5/8	25.20	IEU	X95	6 5/8 FH	8	5	5.22	17.72	22.95
6 5/8	25.20	IEU	G105	6 5/8 FH	8 1/4	4 3/4	5.42	17.64	23.07
6 5/8	25.20	IEU	S135	6 5/8 FH	8 1/2	4 1/4	5.69	17.50	23.19
6 5/8	27.70	IEU	E75	6 5/8 FH	8	5	5.57	17.36	22.93
6 5/8	27.70	IEU	X95	6 5/8 FH	8 1/4	4 3/4	5.77	17.28	23.05
6 5/8	27.70	IEU	G105	6 5/8 FH	8 1/4	4 3/4	5.77	17.28	23.05
6 5/8	27.70	IEU	S135	6 5/8 FH	8 1/2	4 1/4	6.04	17.13	23.18

(1) Approximate volumes calculated with the approximate weight (API RP 7G).
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 1/2	6.21	1 1/2	1.14	1 1/4	0.79
3 3/4	7.13	1 1/2	1.14	1 1/4	0.79
4 1/8	8.62	2	2.03	1 3/4	1.55
4 1/4	9.15	2	2.03	1 3/4	1.55
4 1/2	10.26	2	2.03	1 3/4	1.55
4 3/4	11.43	2	2.03	1 3/4	1.55
5	12.67	2 1/4	2.57	1 3/4	1.55
5 1/4	13.97	2 1/4	2.57	1 3/4	1.55
5 1/2	15.33	2 1/4	2.57	1 3/4	1.55
5 3/4	16.75	2 1/4	2.57	2 13/16	4.01
6	18.24	2 1/4	2.57	2 13/16	4.01
6 1/4	19.79	2 1/4	2.57	2 13/16	4.01
6 1/2	21.41	2 1/4	2.57	2 13/16	4.01
6 3/4	23.09	2 1/4	2.57	2 13/16	4.01
7	24.83	2 1/4	2.57	2 13/16	4.01
7 1/4	26.63	2 13/16	4.01	2 1/4	2.57
7 1/2	28.50	2 13/16	4.01	2 1/4	2.57
7 3/4	30.43	2 13/16	4.01	3	4.56
8	32.43	2 13/16	4.01	3	4.56
8 1/4	34.49	2 13/16	4.01	3	4.56
8 1/2	36.61	2 13/16	4.01	3	4.56
8 3/4	38.79	2 13/16	4.01	3	4.56
9	41.04	2 13/16	4.01	3	4.56
9 1/4	43.35	3	4.56	2 13/16	4.01
9 1/2	45.73	3	4.56	2 13/16	4.01
9 3/4	48.17	3	4.56	2 13/16	4.01
10	50.67	3	4.56	2 13/16	4.01
11	61.31	3	4.56	2 13/16	4.01
11 1/4	64.13	3	4.56	2 13/16	4.01

(1) Capacity per meter is calculated on the basis of simples 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	7.09
	17.70	10.20	6.92
	18.80	10.92	6.71
5 12.67	11.50	5.59	10.54
	13.00	6.43	10.23
	15.00	7.52	9.84
	18.00	9.19	9.27
	21.40	11.10	8.63
	23.20	12.14	8.29
	24.10	12.70	8.11
5 1/2 15.33	14.00	6.20	12.73
	15.50	6.98	12.42
	17.00	7.72	12.13
	20.00	9.17	11.57
	23.00	10.54	11.05
	26.00	12.09	10.48
	26.80	12.70	10.26
6 5/8 22.24	20.00	7.32	18.54
	23.20	8.38	18.03
	24.00	8.94	17.76
	28.00	10.59	16.99
	32.00	12.07	16.32
	35.00	13.34	15.75
7 24.83	17.00	5.87	21.66
	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	17.76
	41.00	14.98	17.17
	44.00	16.25	16.58
	46.00	17.02	16.23
7 5/8 29.46	24.00	7.62	25.01
	26.40	8.33	24.61
	29.70	9.52	23.95
	33.70	10.92	23.19
	35.80	11.81	22.71
	39.00	12.70	22.24
	42.80	14.27	21.42
	45.30	15.11	20.98
	47.10	15.88	20.59
8 5/8 37.69	24.00	6.71	33.22
	28.00	7.72	32.57
	32.00	8.94	31.79
	36.00	10.16	31.03
	40.00	11.43	30.24
	44.00	12.70	29.46
	49.00	14.15	28.58
	52.00	15.11	28.01

(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 CASING (1) (continued)

OD and total displacement (in and l/m)	Nominal weight (lb/ft)	Thickness (mm)	Capacity (l/m)
9 5/8 46.94	32.30	7.92	41.06
	36.00	8.94	40.33
	40.00	10.03	39.55
	43.50	11.05	38.84
	47.00	11.99	38.18
	53.50	13.84	36.91
	58.40	15.11	36.05
	59.40	15.47	35.81
	61.10	15.87	35.54
	71.80	19.05	33.45
9 7/8 49.41	62.80	15.88	45.73
10 3/4 58.56	32.75	7.09	52.63
	40.50	8.89	51.18
	45.50	10.16	50.16
	51.00	11.43	49.16
	55.50	12.57	48.27
	60.70	13.84	47.29
	65.70	15.11	46.31
11 3/4 69.96	42.00	8.46	62.25
	47.00	9.52	61.32
	54.00	11.05	59.98
	60.00	12.42	58.80
	65.00	13.56	57.82
	71.00	14.78	56.78
13 3/8 90.64	48.00	8.38	81.92
	54.50	9.65	80.64
	61.00	10.92	79.36
	68.00	12.19	78.10
	72.00	13.06	77.24
	77.00	13.97	76.35
	80.70	14.73	75.60
13 5/8 94.06	88.20	15.88	74.49
14 99.31	82.50	14.27	76.05
	94.80	16.66	73.74
	99.00	17.48	72.95
	114.00	20.32	70.25
16 129.72	65.00	9.52	117.8
	75.00	11.13	115.9
	84.00	12.57	114.2
	94.50	14.27	112.1
	109.00	16.66	109.3
	128.00	19.84	105.6
18 5/8 175.77	87.50	11.05	159.7
20 202.68	94.00	11.13	185.3
	106.50	12.70	182.9
	133.00	16.13	177.8

(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)

OD and total displacement (in and l/m)	Nominal weight (lb/ft)	Thickness (mm)	Capacity (l/m)	OD and total displacement (in and l/m)	Nominal weight (lb/ft)	Thickness (mm)	Capacity (l/m)
1.050 0.56	1.14/1.20 1.48/1.54	2.87 3.91	0.34 0.28	**3 1/2** 6.21	7.70 9.20/9.30 10.20 12.70/12.95 13.70 14.30 14.70 15.50 17.00	5.49 6.45 7.34 9.53 10.49 10.92 11.40 12.09 13.46	4.77 4.54 4.33 3.83 3.62 3.53 3.43 3.29 3.02
1.315 0.88	1.70/1.80 2.19/2.24	3.38 4.55	0.56 0.46				
1.660 1.40	2.10 2.30/2.40 3.03/3.07	3.18 3.56 4.85	1.01 0.96 0.83				
1.900 1.83	2.4 2.75/2.90 3.65/3.73 4.42 5.15	3.18 3.68 5.08 6.35 7.62	1.38 1.31 1.14 0.99 0.86	**4** 8.11	9.50 11.00 13.20 14.80 16.10 16.50 18.90 22.20	5.74 6.65 8.38 9.65 10.54 10.92 12.70 15.49	6.38 6.12 5.65 5.32 5.09 5.00 4.56 3.92
2.063 2.16	3.25 4.50	3.96 5.72	1.55 1.32				
2 3/8 2.86	4.00 4.60/4.70 5.10 5.80/5.90 6.60 7.35/7.45	4.24 4.83 5.54 6.45 7.49 8.53	2.11 2.02 1.90 1.77 1.61 1.47	**4 1/2** 10.26	12.60/12.75 15.20 17.00 18.90 21.50 23.70 26.10	6.88 8.56 9.65 10.92 12.70 14.22 16.00	7.9 7.4 7.1 6.7 6.2 5.8 5.3
2 7/8 4.19	6.40/6.50 7.80/7.90 8.60/8.70 9.35/9.45 9.80 10.50 11.50	5.51 7.01 7.82 8.64 9.19 9.96 11.18	3.02 2.73 2.59 2.44 2.35 2.21 2.02				

(1) No allowance made for couplings.

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)	3 1/8	3 1/2	4 1/8	4 3/4	5	6	6 1/4	6 1/2	6 3/4	7	7 1/4	7 3/4	8	8 1/4	9	9 1/2	9 3/4	10	11
0 (2)	(l/m)	4.9	6.2	8.6	11.4	12.7	18.2	19.8	21.4	23.1	24.8	26.6	30.4	32.4	34.5	41.0	45.7	48.2	50.7	61.3
4 3/4	11.4	6.5	5.2	2.8																
5 7/8	17.5	12.5	11.3	8.9	6.1	4.8														
6	**18.2**	13.3	12.0	9.6	6.8	5.6														
6 1/8	19.0	14.1	12.8	10.4	7.6	6.3														
6 1/4	19.8	14.8	13.6	11.2	8.4	7.1	1.6													
6 5/8	22.2	17.3	16.0	13.6	10.8	9.6	4.0	2.4												
6 3/4	23.1	18.1	16.9	14.5	11.7	10.4	4.8	3.3	1.7											
7 3/8	27.6	22.6	21.4	18.9	16.1	14.9	9.3	7.8	6.2	4.5	2.7									
7 7/8	31.4	26.5	25.2	22.8	20.0	18.8	13.2	11.6	10.0	8.3	6.6	4.8								
8 3/8	35.5	30.6	29.3	26.9	24.1	22.9	17.3	15.7	14.1	12.5	10.7	8.9	5.1	3.1						
8 1/2	**36.6**	31.7	30.4	28.0	25.2	23.9	18.4	16.8	15.2	13.5	11.8	10.0	6.2	4.2						
8 5/8	37.7	32.7	31.5	29.1	26.3	25.0	19.5	17.9	16.3	14.6	12.9	11.1	7.3	5.3	3.2					
8 3/4	38.8	33.8	32.6	30.2	27.4	26.1	20.6	19.0	17.4	15.7	14.0	12.2	8.4	6.4	4.3					
9	41.0	36.1	34.8	32.4	29.6	28.4	22.8	21.2	19.6	18.0	16.2	14.4	10.6	8.6	6.6					
9 5/8	46.9	42.0	40.7	38.3	35.5	34.3	28.7	27.1	25.5	23.9	22.1	20.3	16.5	14.5	12.5	5.9				
9 7/8	49.4	44.5	43.2	40.8	38.0	36.7	31.2	29.6	28.0	26.3	24.6	22.8	19.0	17.0	14.9	8.4	3.7			
10 5/8	57.2	52.3	51.0	48.6	45.8	44.5	39.0	37.4	35.8	34.1	32.4	30.6	26.8	24.8	22.7	16.2	11.5	9.0	6.5	
12	73.0	68.0	66.8	64.3	61.5	60.3	54.7	53.2	51.6	49.9	48.1	46.3	42.5	40.5	38.5	31.9	27.2	24.8	22.3	11.7
12 1/4	**76.0**	71.1	69.8	67.4	64.6	63.4	57.8	56.2	54.6	53.0	51.2	49.4	45.6	43.6	41.5	35.0	30.3	27.9	25.4	14.7
14 3/4	110.2	105.3	104.0	101.6	98.8	97.6	92.0	90.4	88.8	87.2	85.4	83.6	79.8	77.8	75.8	69.2	64.5	62.1	59.6	48.9
15	114.0	109.1	107.8	105.4	102.6	101.3	95.8	94.2	92.6	90.9	89.2	87.4	83.6	81.6	79.5	73.0	68.3	65.8	63.3	52.7
16	129.7	124.8	123.5	121.1	118.3	117.0	111.5	109.9	108.3	106.6	104.9	103.1	99.3	97.3	95.2	88.7	84.0	81.5	79.0	68.4
17 1/2	**155.2**	150.2	149.0	146.6	143.7	142.5	136.9	135.4	133.8	132.1	130.3	128.5	124.7	122.7	120.7	114.1	109.4	107.0	104.5	93.9
20	202.7	197.7	196.5	194.1	191.2	190.0	184.4	182.9	181.3	179.6	177.9	176.0	172.2	170.3	168.2	161.6	157.0	154.5	152.0	141.4
22	245.2	240.3	239.0	236.6	233.8	232.6	227.0	225.4	223.8	222.2	220.4	218.6	214.8	212.8	210.8	204.2	199.5	197.1	194.6	183.9
24	291.9	286.9	285.7	283.2	280.4	279.2	273.6	272.1	270.5	268.8	267.0	265.2	261.4	259.4	257.4	250.8	246.1	243.7	241.2	230.5
26	**342.5**	337.6	336.3	333.9	331.1	329.9	324.3	322.7	321.1	319.4	317.7	315.9	312.1	310.1	308.0	301.5	296.8	294.4	291.9	281.2
36	656.7	651.7	650.5	648.1	645.3	644.0	638.4	636.9	635.3	633.6	631.9	630.0	626.2	624.3	622.2	615.6	611.0	608.5	606.0	595.4

(1) The zero vertical column gives the capacity of open hole.
(2) The zero horizontal line gives the total displacement of drill collar.

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

ANNULAR VOLUME BETWEEN DRILL PIPE AND OPEN HOLE (liters per meter)

Diameter of open hole (in)	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)	3.01	4.44	6.58	8.58	10.84	13.29	16.01	23.05
5 7/8	17.5	14.5	13.0	10.9	8.9				
6	**18.2**	**15.2**	**13.8**	**11.7**	**9.7**				
6 1/8	19.0	16.0	14.6	12.4	10.4				
6 1/4	19.8	16.8	15.4	13.2	11.2	9.0			
6 5/8	22.2	19.2	17.8	15.7	13.7	11.4	8.9		
6 3/4	23.1	20.1	18.6	16.5	14.5	12.2	9.8		
7 3/8	27.6	24.5	23.1	21.0	19.0	16.7	14.3	11.5	4.5
7 7/8	31.4	28.4	27.0	24.8	22.8	20.6	18.1	15.4	8.4
8 3/8	35.5	32.5	31.1	29.0	27.0	24.7	22.3	19.5	12.5
8 1/2	**36.6**	**33.6**	**32.2**	**30.0**	**28.0**	**25.8**	**23.3**	**20.6**	**13.6**
8 5/8	37.7	34.7	33.3	31.1	29.1	26.9	24.4	21.7	14.6
8 3/4	38.8	35.8	34.4	32.2	30.2	28.0	25.5	22.8	15.7
9	41.0	38.0	36.6	34.5	32.5	30.2	27.8	25.0	18.0
9 5/8	46.9	43.9	42.5	40.4	38.4	36.1	33.7	30.9	23.9
9 7/8	49.4	46.4	45.0	42.8	40.8	38.6	36.1	33.4	26.4
10 5/8	57.2	54.2	52.8	50.6	48.6	46.4	43.9	41.2	34.2
12	73.0	70.0	68.5	66.4	64.4	62.1	59.7	57.0	49.9
12 1/4	**76.0**	**73.0**	**71.6**	**69.5**	**67.5**	**65.2**	**62.7**	**60.0**	**53.0**
14 3/4	110.2	107.2	105.8	103.7	101.7	99.4	96.9	94.2	87.2
15	114.0	111.0	109.6	107.4	105.4	103.2	100.7	98.0	91.0
16	129.7	126.7	125.3	123.1	121.1	118.9	116.4	113.7	106.7
17 1/2	**155.2**	**152.2**	**150.7**	**148.6**	**146.6**	**144.3**	**141.9**	**139.2**	**132.1**
20	202.7	199.7	198.2	196.1	194.1	191.8	189.4	186.7	179.6
22	245.2	242.2	240.8	238.7	236.7	234.4	232.0	229.2	222.2
24	291.9	288.8	287.4	285.3	283.3	281.0	278.6	275.8	268.8
26	**342.5**	**339.5**	**338.1**	**335.9**	**333.9**	**331.7**	**329.2**	**326.5**	**319.5**
36	656.7	653.7	652.2	650.1	648.1	645.8	643.4	640.7	633.6

(1) The zero vertical column gives the capacity of open hole.
(2) The zero horizontal line gives the total displacement of drill pipe with tool joint (average value).

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

ANNULAR VOLUME BETWEEN DRILL PIPE AND CASING
(liters per meter)

Casing size (in)	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)	3.01	4.44	6.58	8.58	10.84	13.29	16.01	23.05
4 1/2	9.50	8.48	5.47							
	10.50	8.32	5.31							
	11.60	8.11	5.10							
	13.50	7.79	4.78							
	15.10	7.42	4.41							
	16.90	7.09	4.08							
	17.70	6.92	3.91							
	18.80	6.71	3.70							
5	11.50	10.54	7.53	6.10						
	13.00	10.23	7.22	5.79						
	15.00	9.84	6.83	5.40						
	18.00	9.27	6.83							
	21.40	8.63	6.83							
	23.20	8.29	5.28							
	24.10	8.11	5.10							
5 1/2	14.00	12.73	9.72	8.29						
	15.50	12.42	9.41	7.98						
	17.00	12.13	9.12	7.69						
	20.00	11.57	8.56	7.13						
	23.00	11.05	8.04	6.61						
	26.00	10.48	7.47	6.04						
	26.80	10.26	7.25	5.82						
6 5/8	20.00	18.54	15.53	14.10	11.96					
	23.20	18.03	15.02	13.59	11.45					
	24.00	17.76	14.75	13.32	11.18					
	28.00	16.99	13.98	12.55	10.41					
	32.00	16.32	13.31	11.88	9.74					
	35.00	15.75	12.74	11.31	9.17					
7	17.00	21.66	18.65	17.22	15.08	13.08				
	20.00	21.12	18.11	16.68	14.54	12.54				
	23.00	20.54	17.53	16.10	13.96	11.96				
	26.00	19.96	16.95	15.52	13.38	11.38				
	29.00	19.38	16.37	14.94	12.80	10.80				
	32.00	18.82	15.81	14.38	12.24					
	35.00	18.27	15.26	13.83	11.69					
	38.00	17.76	14.75	13.32	11.18					
	41.00	17.17	14.16	12.73	10.59					
	44.00	16.58	13.57	12.14	10.00					
	46.00	16.23	13.22	11.79	9.65					
7 5/8	24.00	25.01	22.00	20.57	18.43	16.43	14.17			
	26.40	24.61	21.60	20.17	18.03	16.03	13.77			
	29.70	23.95	20.94	19.51	17.37	15.37	13.11			
	33.70	23.19	20.18	18.75	16.61	14.61	12.35			
	35.80	22.71	19.70	18.27	16.13	14.13	11.87			
	39.00	22.24	19.23	17.80	15.66	13.66	11.40			
	42.80	21.42	18.41	16.98	14.84	12.84	10.58			
	45.30	20.98	17.97	16.54	14.40	12.40	10.14			
	47.10	20.59	17.58	16.15	14.01	12.01	9.75			
8 5/8	24.00	33.22	30.21	28.78	26.64	24.64	22.38	19.93	17.21	
	28.00	32.57	29.56	28.13	25.99	23.99	21.73	19.28	16.56	
	32.00	31.79	28.78	27.35	25.21	23.21	20.95	18.50	15.78	
	36.00	31.03	28.02	26.59	24.45	22.45	20.19	17.74	15.02	
	40.00	30.24	27.23	25.80	23.66	21.66	19.40	16.95	14.23	
	44.00	29.46	26.45	25.02	22.88	20.88	18.62	16.17	13.45	
	49.00	28.58	25.57	24.14	22.00	20.00	17.74	15.29	12.57	
	52.00	28.01	25.00	23.57	21.43	19.43	17.17	14.72	12.00	

(1) The zero vertical column gives the capacity of the casing.
(2) The zero horizontal line gives the average total displacement of drill pipe with tool joint.

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

ANNULAR VOLUME BETWEEN DRILL PIPE AND CASING
(liters per meter) (continued)

Casing size (in)	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)	3.01	4.44	6.58	8.58	10.84	13.29	16.01	23.05
9 5/8	32.30	41.1	38.1	36.6	34.5	32.5	30.2	27.8	25.1	18.0
	36.00	40.3	37.3	35.9	33.8	31.8	29.5	27.0	24.3	17.3
	40.00	39.6	36.5	35.1	33.0	31.0	28.7	26.3	23.5	16.5
	43.50	38.8	35.8	34.4	32.3	30.3	28.0	25.6	22.8	15.8
	47.00	38.2	35.2	33.7	31.6	29.6	27.3	24.9	22.2	15.1
	53.50	36.9	33.9	32.5	30.3	28.3	26.1	23.6	20.9	13.9
	58.40	36.1	33.0	31.6	29.5	27.5	25.2	22.8	20.0	13.0
	59.40	35.8	32.8	31.4	29.2	27.2	25.0	22.5	19.8	12.8
	61.10	35.5	32.5	31.1	29.0	27.0	24.7	22.3	19.5	12.5
	71.80	33.5	30.4	29.0	26.9	24.9	22.6	20.2	17.4	
9 7/8	62.80	45.7	42.7	41.3	39.2	37.2	34.9	32.4	29.7	
10 3/4	32.75	52.6	49.6	48.2	46.1	44.1	41.8	39.3	36.6	29.6
	40.50	51.2	48.2	46.7	44.6	42.6	40.3	37.9	35.2	28.1
	45.50	50.2	47.2	45.7	43.6	41.6	39.3	36.9	34.2	27.1
	51.00	49.2	46.2	44.7	42.6	40.6	38.3	35.9	33.2	26.1
	55.50	48.3	45.3	43.8	41.7	39.7	37.4	35.0	32.3	25.2
	60.70	47.3	44.3	42.9	40.7	38.7	36.5	34.0	31.3	24.2
	65.70	46.3	43.3	41.9	39.7	37.7	35.5	33.0	30.3	23.3
11 3/4	42.00	62.3	59.2	57.8	55.7	53.7	51.4	49.0	46.2	39.2
	47.00	61.3	58.3	56.9	54.7	52.7	50.5	48.0	45.3	38.3
	54.00	60.0	57.0	55.5	53.4	51.4	49.1	46.7	44.0	36.9
	60.00	58.8	55.8	54.4	52.2	50.2	48.0	45.5	42.8	35.8
	65.00	57.8	54.8	53.4	51.2	49.2	47.0	44.5	41.8	34.8
	71.00	56.8	53.8	52.3	50.2	48.2	45.9	43.5	40.8	33.7
13 3/8	48.00	81.9	78.9	77.5	75.3	73.3	71.1	68.6	65.9	58.9
	54.50	80.6	77.6	76.2	74.1	72.1	69.8	67.4	64.6	57.6
	61.00	79.4	76.4	74.9	72.8	70.8	68.5	66.1	63.4	56.3
	68.00	78.1	75.1	73.7	71.5	69.5	67.3	64.8	62.1	55.1
	72.00	77.2	74.2	72.8	70.7	68.7	66.4	64.0	61.2	54.2
	77.00	76.4	73.3	71.9	69.8	67.8	65.5	63.1	60.3	53.3
	80.70	75.6	72.6	71.2	69.0	67.0	64.8	62.3	59.6	52.6
13 5/8	88.20	74.5	71.5	70.1	67.9	65.9	63.7	61.2	58.5	51.4
14	82.50	76.1	73.0	71.6	69.5	67.5	65.2	62.8	60.0	53.0
	94.80	73.7	70.7	69.3	67.2	65.2	62.9	60.5	57.7	50.7
	99.00	73.0	69.9	68.5	66.4	64.4	62.1	59.7	56.9	49.9
	114.00	70.3	67.2	65.8	63.7	61.7	59.4	57.0	54.2	47.2
16	65.00	117.8	114.8	113.4	111.2	109.2	107.0	104.5	101.8	94.8
	75.00	115.9	112.9	111.5	109.3	107.3	105.1	102.6	99.9	92.9
	84.00	114.2	111.2	109.8	107.6	105.6	103.4	100.9	98.2	91.2
	94.50	112.1	109.1	107.7	105.5	103.5	101.3	98.8	96.1	89.1
	109.00	109.3	106.3	104.9	102.7	100.7	98.5	96.0	93.3	86.3
	128.00	105.6	102.6	101.2	99.0	97.0	94.8	92.3	89.6	82.6
18 5/8	87.50	159.7	156.7	155.3	153.1	151.1	148.9	146.4	143.7	136.7
20	94.00	185.3	182.3	180.9	178.7	176.7	174.5	172.0	169.3	162.3
	106.50	182.9	179.9	178.5	176.3	174.3	172.1	169.6	166.9	159.9
	133.00	177.8	174.8	173.4	171.2	169.2	167.0	164.5	161.8	154.8
30	267.00	407.8	404.8	403.4	401.2	399.2	397.0	394.5	391.8	384.8
	310.00	397.0	394.0	392.6	390.4	388.4	386.2	383.7	381.0	374.0

(1) The zero vertical column gives the capacity of the casing.

(2) The zero horizontal line gives the average total displacement of drill pipe with tool joint.

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

ANNULAR VOLUME BETWEEN CASING AND OPEN HOLE
(liters per meter)

Diameter of open hole (in)	Casing outside diameter (in)																		
	0 (1)	4 1/2	5	5 1/2	6 5/8	7	7 5/8	8 5/8	9 5/8	9 7/8	10 3/4	11 3/4	13 3/8	13 5/8	14	16	18 5/8	20	30
0 (2)	(l/m)	10.26	12.67	15.33	22.24	24.83	29.46	37.69	46.94	49.41	58.56	69.96	90.64	94.06	99.31	129.7	175.8	202.7	456.0
5 7/8	17.49	7.2	4.8																
6	**18.24**	**8.0**	**5.6**																
6 1/8	19.01	8.7	6.3	3.7															
6 1/4	19.79	9.5	7.1	4.5															
6 5/8	22.24	12.0	9.6	6.9															
6 3/4	23.09	12.8	10.4	7.8															
7 3/8	27.56	17.3	14.9	12.2															
7 7/8	31.42	21.2	18.8	16.1	9.2	6.6													
8 3/8	35.54	25.3	22.9	20.2	13.3	10.7													
8 1/2	**36.61**	**26.3**	**23.9**	**21.3**	**14.4**	**11.8**													
8 5/8	37.69	27.4	25.0	22.4	15.5	12.9	8.2												
8 3/4	38.79	28.5	26.1	23.5	16.6	14.0	9.3												
9	41.04	30.8	28.4	25.7	18.8	16.2	11.6												
9 5/8	46.94	36.7	34.3	31.6	24.7	22.1	17.5												
9 7/8	49.41	39.2	36.7	34.1	27.2	24.6	20.0	11.7											
10 5/8	57.20	46.9	44.5	41.9	35.0	32.4	27.7	19.5											
12	72.96	62.7	60.3	57.6	50.7	48.1	43.5	35.3	26.0	23.6	14.4								
12 1/4	**76.04**	**65.8**	**63.4**	**60.7**	**53.8**	**51.2**	**46.6**	**38.3**	**29.1**	**26.6**	**17.5**								
14 3/4	110.2	100.0	97.6	94.9	88.0	85.4	80.8	72.5	63.3	60.8	51.7	40.3							
15	114.0	103.7	101.3	98.7	91.8	89.2	84.5	76.3	67.1	64.6	55.5	44.1	23.4						
16	129.7	119.5	117.0	114.4	107.5	104.9	100.3	92.0	82.8	80.3	71.2	59.8	39.1	35.7					
17 1/2	**155.2**	**144.9**	**142.5**	**139.8**	**132.9**	**130.3**	**125.7**	**117.5**	**108.2**	**105.8**	**96.6**	**85.2**	**64.5**	**61.1**	**55.9**				
20	202.7	192.4	190.0	187.4	180.4	177.9	173.2	165.0	155.7	153.3	144.1	132.7	112.0	108.6	103.4				
22	245.2	235.0	232.6	229.9	223.0	220.4	215.8	207.5	198.3	195.8	186.7	175.3	154.6	151.2	145.9				
24	291.9	281.6	279.2	276.5	269.6	267.0	262.4	254.2	244.9	242.4	233.3	221.9	201.2	197.8	192.5	162.1	116.1	89.2	
26	**342.5**	**332.3**	**329.9**	**327.2**	**320.3**	**317.7**	**313.1**	**304.8**	**295.6**	**293.1**	**284.0**	**272.6**	**251.9**	**248.5**	**243.2**	**212.8**	**166.8**	**139.8**	
36	656.7	646.4	644.0	641.4	634.4	631.9	627.2	619.0	609.7	607.3	598.1	586.7	566.0	562.6	557.4	527.0	480.9	454.0	200.7

(1) The zero vertical column gives the capacity of open hole.
(2) The zero horizontal line gives the total displacement of casing without coupling.

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

ANNULAR VOLUME BETWEEN TWO STRINGS OF CASING
(liters per meter)

Outer casing (in)	Nominal size of inner casing (in)																		
		0 (1)	4 1/2	5	5 1/2	6 5/8	7	7 5/8	8 5/8	9 5/8	9 7/8	10 3/4	11 3/4	13 3/8	13 5/8	14	16	18 5/8	20
	0 (2)	(l/m)	10.26	12.67	15.33	22.24	24.83	29.46	37.69	46.94	49.41	58.56	69.96	90.64	94.06	99.31	129.7	175.8	202.7
6 5/8	20.00	18.54	8.28	5.87															
	23.20	18.03	7.77	5.36															
	24.00	17.76	7.50	5.09															
	28.00	16.99	6.73	4.32															
	32.00	16.32	6.06																
	35.00	15.75	5.49																
7	17.00	21.66	11.40	8.99	6.33														
	20.00	21.12	10.86	8.45	5.79														
	23.00	20.54	10.28	7.87	5.21														
	26.00	19.96	9.70	7.29	4.63														
	29.00	19.38	9.12	6.71	4.05														
	32.00	18.82	8.56	6.15															
	35.00	18.27	8.01	5.60															
	38.00	17.76	7.50	5.09															
	41.00	17.17	6.91	4.50															
	44.00	16.58	6.32	3.91															
	46.00	16.23	5.97	3.56															
7 5/8	24.00	25.01	14.75	12.34	9.68														
	26.40	24.61	14.35	11.94	9.28														
	29.70	23.95	13.69	11.28	8.62														
	33.70	23.19	12.93	10.52	7.86														
	35.80	22.71	12.45	10.04	7.38														
	39.00	22.24	11.98	9.57	6.91														
	42.80	21.42	11.16	8.75	6.09														
	45.30	20.98	10.72	8.31	5.65														
	47.10	20.59	10.33	7.92	5.26														
8 5/8	24.00	33.23	22.97	20.56	17.90	10.99	8.40												
	28.00	32.59	22.33	19.92	17.26	10.35	7.76												
	32.00	31.79	21.53	19.12	16.46	9.55	6.96												
	36.00	31.04	20.78	18.37	15.71	8.80	6.21												
	40.00	30.23	19.97	17.56	14.90	7.99													
	44.00	29.47	19.21	16.80	14.14	7.23													
	49.00	28.59	18.33	15.92	13.26	6.35													

(1) The zero vertical column gives the capacity of casing.
(2) The zero horizontal line gives the total displacement of casing without coupling.

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

ANNULAR VOLUME BETWEEN TWO STRINGS OF CASING (continued)
(liters per meter)

Outer casing (in)	Nominal size of inner casing (in)															
		0 (1)	4 1/2	5	5 1/2	6 5/8	7	7 5/8	8 5/8	9 5/8	9 7/8	10 3/4	11 3/4	13 3/8	13 5/8	14
	0 (2)	(l/m)	10.26	12.67	15.33	22.24	24.83	29.46	37.69	46.94	49.41	58.56	69.96	90.64	94.06	99.31
9 5/8	32.30	41.06	30.80	28.39	25.73	18.82	16.23	11.60								
	36.00	40.33	30.07	27.66	25.00	18.09	15.50	10.87								
	40.00	39.55	29.29	26.88	24.22	17.31	14.72	10.09								
	43.50	38.84	28.58	26.17	23.51	16.60	14.01	9.38								
	47.00	38.18	27.92	25.51	22.85	15.94	13.35	8.72								
	53.50	36.91	26.65	24.24	21.58	14.67	12.08									
	58.40	36.05	25.79	23.38	20.72	13.81	11.22									
	59.40	35.81	25.55	23.14	20.48	13.57	10.98									
	61.10	35.54	25.28	22.87	20.21	13.30	10.71									
	71.80	33.45	23.19	20.78	18.12	11.21	8.62									
9 7/8	62.80	45.73	35.47	33.06	30.40	23.49	20.90									
10 3/4	32.75	52.63	42.37	39.96	37.30	30.39	27.80	23.17	14.94							
	40.50	51.18	40.92	38.51	35.85	28.94	26.35	21.72	13.49							
	45.50	50.16	39.90	37.49	34.83	27.92	25.33	20.70	12.47							
	51.00	49.16	38.90	36.49	33.83	26.92	24.33	19.70	11.47							
	55.50	48.27	38.01	35.60	32.94	26.03	23.44	18.81								
	60.70	47.29	37.03	34.62	31.96	25.05	22.46	17.83								
	65.70	46.31	36.05	33.64	30.98	24.07	21.48	16.85								
11 3/4	42.00	62.25	51.99	49.58	46.92	40.01	37.42	32.79	24.56	15.31						
	47.00	61.32	51.06	48.65	45.99	39.08	36.49	31.86	23.63	14.38						
	54.00	59.98	49.72	47.31	44.65	37.74	35.15	30.52	22.29	13.04						
	60.00	58.80	48.54	46.13	43.47	36.56	33.97	29.34	21.11							
	65.00	57.82	47.56	45.15	42.49	35.58	32.99	28.36	20.13							
	71.00	56.78	46.52	44.11	41.45	34.54	31.95	27.32	19.09							
13 3/8	48.00	81.92	71.66	69.25	66.59	59.68	57.09	52.46	44.23	34.98	23.36					
	54.50	80.64	70.38	67.97	65.31	58.40	55.81	51.18	42.95	33.70	22.08					
	61.00	79.36	69.10	66.69	64.03	57.12	54.53	49.90	41.67	32.42	20.80					
	68.00	78.10	67.84	65.43	62.77	55.86	53.27	48.64	40.41	31.16	19.54					
	72.00	77.24	66.98	64.57	61.91	55.00	52.41	47.78	39.55	30.30	18.68					
	77.00	76.35	66.09	63.68	61.02	54.11	51.52	46.89	38.66	29.41	17.79					
	80.70	75.60	65.34	62.93	60.27	53.36	50.77	46.14	37.91	28.66	17.04					
13 5/8	88.20	74.49	64.23	61.82	59.16	52.25	49.66	45.03	36.80	27.55	15.93					

(1) The zero vertical column gives the capacity of casing.
(2) The zero horizontal line gives the total displacement of casing without coupling.

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

ANNULAR VOLUME BETWEEN TWO STRINGS OF CASING (continued)
(liters per meter)

Outer casing (in)	Nominal size of inner casing (in)															
		0 (1)	4 1/2	5	5 1/2	6 5/8	7	7 5/8	8 5/8	9 5/8	9 7/8	10 3/4	11 3/4	13 3/8	13 5/8	14
	0 (2)	(l/m)	10.26	12.67	15.33	22.24	24.83	29.46	37.69	46.94	49.41	58.56	69.96	90.64	94.06	99.31
14	82.50	76.05	65.79	63.38	60.72	53.81	51.22	46.59	38.36	29.11	17.49					
	94.80	73.74	63.48	61.07	58.41	51.50	48.91	44.28	36.05	26.80	15.18					
	99.00	72.95	62.69	60.28	57.62	50.71	48.12	43.49	35.26	26.01	14.39					
	114.00	70.25	59.99	57.58	54.92	48.01	45.42	40.79	32.56	23.31	11.69					
16	65.00	117.80	107.54	105.13	102.47	95.56	92.97	88.34	80.11	70.86	59.24	47.84	27.16			
	75.00	115.90	105.64	103.23	100.57	93.66	91.07	86.44	78.21	68.96	57.34	45.94	25.26			
	84.00	114.20	103.94	101.53	98.87	91.96	89.37	84.74	76.51	67.26	55.64	44.24	23.56			
	94.50	112.10	101.84	99.43	96.77	89.86	87.27	82.64	74.41	65.16	53.54	42.14	21.46			
	109.00	109.30	99.04	96.63	93.97	87.06	84.47	79.84	71.61	62.36	50.74	39.34	18.66			
	128.00	105.60	95.34	92.93	90.27	83.36	80.77	76.14	67.91	58.66	47.04	35.64	14.96			
18 5/8	87.50	159.70	149.44	147.03	144.37	137.46	134.87	130.24	122.01	112.76	101.14	89.74	69.06	29.98		
20	94.00	185.30	175.04	172.63	169.97	163.06	160.47	155.84	147.61	138.36	126.74	115.34	94.66	55.58		
	106.50	182.90	172.64	170.23	167.57	160.66	158.07	153.44	145.21	135.96	124.34	112.94	92.26	53.18		
	133.00	177.80	167.54	165.13	162.47	155.56	152.97	148.34	140.11	130.86	119.24	107.84	87.16	48.08		
30	267.00	407.80	397.54	395.13	392.47	385.56	382.97	378.34	370.11	360.86	349.24	337.84	317.16	278.08	232.03	205.12
	310.00	397.00	386.74	384.33	381.67	374.76	372.17	367.54	359.31	350.06	338.44	327.04	306.36	267.28	221.23	194.32

(1) The zero vertical column gives the capacity of casing.
(2) The zero horizontal line gives the total displacement of casing without coupling.

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

ANNULAR VOLUME BETWEEN CASING AND TUBING
(liters per meter)

Outer casing (in)	Nominal size of inner tubing (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	1.83	2.16	2.86	4.19	6.21	8.11	10.26
4 1/2	9.50	8.48	7.92	7.60	7.08	6.65	6.32	5.62	4.29			
	10.50	8.32	7.76	7.44	6.92	6.49	6.16	5.46	4.13			
	11.60	8.11	7.55	7.23	6.71	6.28	5.95	5.25	3.92			
	13.50	7.79	7.23	6.91	6.39	5.96	5.63	4.93	3.60			
	15.10	7.42	6.86	6.54	6.02	5.59	5.26	4.56	3.23			
	16.90	7.09	6.53	6.21	5.69	5.26	4.93	4.23				
	17.70	6.92	6.36	6.04	5.52	5.09	4.76	4.06				
	18.80	6.71	6.15	5.83	5.31	4.88	4.55	3.85				
5	11.50	10.54	9.98	9.66	9.14	8.71	8.38	7.68	6.35			
	13.00	10.23	9.67	9.35	8.83	8.40	8.07	7.37	6.04			
	15.00	9.84	9.28	8.96	8.44	8.01	7.68	6.98	5.65			
	18.00	9.27	8.71	8.39	7.87	7.44	7.11	6.41	5.08			
	21.40	8.63	8.07	7.75	7.23	6.80	6.47	5.77	4.44			
	23.20	8.29	7.73	7.41	6.89	6.46	6.13	5.43	4.10			
	24.10	8.11	7.55	7.23	6.71	6.28	5.95	5.25	3.92			
5 1/2	14.00	12.73	12.17	11.85	11.33	10.90	10.57	9.87	8.54	6.52		
	15.50	12.42	11.86	11.54	11.02	10.59	10.26	9.56	8.23	6.21		
	17.00	12.13	11.57	11.25	10.73	10.30	9.97	9.27	7.94	5.92		
	20.00	11.57	11.01	10.69	10.17	9.74	9.41	8.71	7.38	5.36		
	23.00	11.05	10.49	10.17	9.65	9.22	8.89	8.19	6.86	4.84		
	26.00	10.48	9.92	9.60	9.08	8.65	8.32	7.62	6.29	4.27		
	26.80	10.26	9.70	9.38	8.86	8.43	8.10	7.40	6.07	4.05		
6 5/8	20.00	18.54	17.98	17.66	17.14	16.71	16.38	15.68	14.35	12.33	10.43	8.28
	23.20	18.03	17.47	17.15	16.63	16.20	15.87	15.17	13.84	11.82	9.92	7.77
	24.00	17.76	17.20	16.88	16.36	15.93	15.60	14.90	13.57	11.55	9.65	7.50
	28.00	16.99	16.43	16.11	15.59	15.16	14.83	14.13	12.80	10.78	8.88	6.73
	32.00	16.32	15.76	15.44	14.92	14.49	14.16	13.46	12.13	10.11	8.21	6.06
	35.00	15.75	15.19	14.87	14.35	13.92	13.59	12.89	11.56	9.54	7.64	5.49
7	17.00	21.66	21.10	20.78	20.26	19.83	19.50	18.80	17.47	15.45	13.55	11.40
	20.00	21.12	20.56	20.24	19.72	19.29	18.96	18.26	16.93	14.91	13.01	10.86
	23.00	20.53	19.97	19.65	19.13	18.70	18.37	17.67	16.34	14.32	12.42	10.27
	26.00	19.95	19.39	19.07	18.55	18.12	17.79	17.09	15.76	13.74	11.84	9.69
	29.00	19.38	18.82	18.50	17.98	17.55	17.22	16.52	15.19	13.17	11.27	9.12
	32.00	18.82	18.26	17.94	17.42	16.99	16.66	15.96	14.63	12.61	10.71	8.56
	35.00	18.27	17.71	17.39	16.87	16.44	16.11	15.41	14.08	12.06	10.16	8.01
	38.00	17.77	17.21	16.89	16.37	15.94	15.61	14.91	13.58	11.56	9.66	7.51
	41.00	17.21	16.65	16.33	15.81	15.38	15.05	14.35	13.02	11.00	9.10	6.95
	44.00	16.58	16.02	15.70	15.18	14.75	14.42	13.72	12.39	10.37	8.47	6.32
	46.00	16.23	15.67	15.35	14.83	14.40	14.07	13.37	12.04	10.02	8.12	5.97

(1) The zero vertical column gives the capacity of the casing.
(2) The zero horizontal line gives the total displacement of tubing without coupling.

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

ANNULAR VOLUME BETWEEN CASING AND TUBING
(liters per meter) (continued)

Outer casing (in)	Nominal size of inner tubing (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	1.83	2.16	2.86	4.19	6.21	8.11	10.26
7 5/8	24.00	25.01	24.45	24.13	23.61	23.18	22.85	22.15	20.82	18.80	16.90	14.75
	26.40	24.61	24.05	23.73	23.21	22.78	22.45	21.75	20.42	18.40	16.50	14.35
	29.70	23.95	23.39	23.07	22.55	22.12	21.79	21.09	19.76	17.74	15.84	13.69
	33.70	23.19	22.63	22.31	21.79	21.36	21.03	20.33	19.00	16.98	15.08	12.93
	35.80	22.71	22.15	21.83	21.31	20.88	20.55	19.85	18.52	16.50	14.60	12.45
	39.00	22.24	21.68	21.36	20.84	20.41	20.08	19.38	18.05	16.03	14.13	11.98
	42.80	21.42	20.86	20.54	20.02	19.59	19.26	18.56	17.23	15.21	13.31	11.16
	45.30	20.98	20.42	20.10	19.58	19.15	18.82	18.12	16.79	14.77	12.87	10.72
	47.10	20.59	20.03	19.71	19.19	18.76	18.43	17.73	16.40	14.38	12.48	10.33
8 5/8	24.00	33.22	32.66	32.34	31.82	31.39	31.06	30.36	29.03	27.01	25.11	22.96
	28.00	32.57	32.01	31.69	31.17	30.74	30.41	29.71	28.38	26.36	24.46	22.31
	32.00	31.79	31.23	30.91	30.39	29.96	29.63	28.93	27.60	25.58	23.68	21.53
	36.00	31.03	30.47	30.15	29.63	29.20	28.87	28.17	26.84	24.82	22.92	20.77
	40.00	30.24	29.68	29.36	28.84	28.41	28.08	27.38	26.05	24.03	22.13	19.98
	44.00	29.46	28.90	28.58	28.06	27.63	27.30	26.60	25.27	23.25	21.35	19.20
	49.00	28.58	28.02	27.70	27.18	26.75	26.42	25.72	24.39	22.37	20.47	18.32
	52.00	28.01	27.45	27.13	26.61	26.18	25.85	25.15	23.82	21.80	19.90	17.75
9 5/8	32.30	41.06	40.50	40.18	39.66	39.23	38.90	38.20	36.87	34.85	32.95	30.80
	36.00	40.33	39.77	39.45	38.93	38.50	38.17	37.47	36.14	34.12	32.22	30.07
	40.00	39.55	38.99	38.67	38.15	37.72	37.39	36.69	35.36	33.34	31.44	29.29
	43.50	38.84	38.28	37.96	37.44	37.01	36.68	35.98	34.65	32.63	30.73	28.58
	47.00	38.19	37.63	37.31	36.79	36.36	36.03	35.33	34.00	31.98	30.08	27.93
	53.50	36.91	36.35	36.03	35.51	35.08	34.75	34.05	32.72	30.70	28.80	26.65
	58.40	36.05	35.49	35.17	34.65	34.22	33.89	33.19	31.86	29.84	27.94	25.79
	59.40	35.81	35.25	34.93	34.41	33.98	33.65	32.95	31.62	29.60	27.70	25.55
	61.10	35.54	34.98	34.66	34.14	33.71	33.38	32.68	31.35	29.33	27.43	25.28
	71.80	33.45	32.89	32.57	32.05	31.62	31.29	30.59	29.26	27.24	25.34	23.19

(1) The zero vertical column gives the capacity of the casing.
(2) The zero horizontal line gives the total displacement of tubing without coupling.

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

CAPACITIES OF COILED TUBING

Coiled tubing dimensions					Tube area		Volumes		
Outside diameter (in)	Body weight (lb/ft)	Wall thickness		Inside diameter (in)	Nominal (in^2)	Minimum (in^2)	Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
		Nominal (in)	Minimum (in)						
0.750	0.59	0.083	0.078	0.584	0.174	0.165	0.173	0.112	0.285
0.750	0.62	0.087	0.082	0.576	0.181	0.172	0.168	0.117	0.285
1.000	0.79	0.080	0.075	0.840	0.231	0.218	0.358	0.149	0.507
1.000	0.81	0.083	0.078	0.834	0.239	0.226	0.352	0.154	0.507
1.000	0.85	0.087	0.082	0.826	0.250	0.236	0.346	0.161	0.507
1.000	0.92	0.095	0.090	0.810	0.270	0.257	0.332	0.174	0.507
1.000	0.98	0.102	0.097	0.796	0.288	0.275	0.321	0.186	0.507
1.000	1.04	0.109	0.104	0.782	0.305	0.293	0.310	0.197	0.507
1.000	1.17	0.125	0.117	0.750	0.344	0.325	0.285	0.222	0.507
1.250	1.00	0.080	0.075	1.090	0.294	0.277	0.602	0.190	0.792
1.250	1.03	0.083	0.078	1.084	0.304	0.287	0.595	0.196	0.792
1.250	1.08	0.087	0.082	1.076	0.318	0.301	0.587	0.205	0.792
1.250	1.17	0.095	0.090	1.060	0.345	0.328	0.569	0.222	0.792
1.250	1.25	0.102	0.097	1.046	0.368	0.351	0.554	0.237	0.792
1.250	1.33	0.109	0.104	1.032	0.391	0.374	0.540	0.252	0.792
1.250	1.50	0.125	0.117	1.000	0.442	0.416	0.507	0.285	0.792
1.250	1.60	0.134	0.126	0.982	0.470	0.445	0.489	0.303	0.792
1.250	1.82	0.156	0.148	0.938	0.536	0.512	0.446	0.346	0.792
1.250	2.01	0.175	0.167	0.900	0.591	0.568	0.410	0.381	0.792
1.500	1.43	0.095	0.090	1.310	0.419	0.399	0.870	0.271	1.140
1.500	1.52	0.102	0.097	1.296	0.448	0.428	0.851	0.289	1.140
1.500	1.62	0.109	0.104	1.282	0.476	0.456	0.833	0.307	1.140
1.500	1.84	0.125	0.117	1.250	0.540	0.508	0.792	0.348	1.140
1.500	1.95	0.134	0.126	1.232	0.575	0.544	0.769	0.371	1.140
1.500	2.24	0.156	0.148	1.188	0.659	0.629	0.715	0.425	1.140
1.500	2.48	0.175	0.167	1.150	0.728	0.699	0.670	0.470	1.140
1.750	1.48	0.083	0.078	1.584	0.435	0.410	1.271	0.280	1.552
1.750	1.55	0.087	0.082	1.576	0.455	0.430	1.259	0.293	1.552
1.750	1.68	0.095	0.090	1.560	0.494	0.469	1.233	0.319	1.552
1.750	1.80	0.102	0.097	1.546	0.528	0.504	1.211	0.341	1.552
1.750	1.91	0.109	0.104	1.532	0.562	0.538	1.189	0.363	1.552
1.750	2.17	0.125	0.117	1.500	0.638	0.600	1.140	0.412	1.552
1.750	2.31	0.134	0.126	1.482	0.680	0.643	1.113	0.439	1.552
1.750	2.66	0.156	0.148	1.438	0.781	0.745	1.048	0.504	1.552
1.750	2.94	0.175	0.167	1.400	0.866	0.831	0.993	0.559	1.552
1.750	3.14	0.188	0.180	1.374	0.923	0.888	0.957	0.595	1.552
1.750	3.17	0.190	0.182	1.370	0.931	0.897	0.951	0.601	1.552
2.000	2.20	0.109	0.104	1.782	0.648	0.619	1.609	0.418	2.027
2.000	2.50	0.125	0.117	1.750	0.736	0.692	1.552	0.475	2.027
2.000	2.67	0.134	0.126	1.732	0.786	0.742	1.520	0.507	2.027

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

CAPACITIES OF COILED TUBING (continued)

Coiled tubing dimensions					Tube area		Volumes		
Outside diameter (in)	Body weight (lb/ft)	Wall thickness		Inside diameter (in)			Capacity (l/m)	Wall displacement (l/m)	External displacement (l/m)
		Nominal (in)	Minimum (in)		Nominal (in^2)	Minimum (in^2)			
2.000	3.07	0.156	0.148	1.688	0.904	0.861	1.444	0.583	2.027
2.000	3.41	0.175	0.167	1.650	1.003	0.962	1.380	0.647	2.027
2.000	3.64	0.188	0.180	1.624	1.070	1.029	1.336	0.690	2.027
2.000	3.67	0.190	0.182	1.620	1.080	1.039	1.330	0.697	2.027
2.000	3.90	0.203	0.195	1.594	1.146	1.106	1.287	0.739	2.027
2.375	2.64	0.109	0.104	2.157	0.776	0.742	2.358	0.501	2.858
2.375	3.00	0.125	0.117	2.125	0.884	0.830	2.288	0.570	2.858
2.375	3.21	0.134	0.126	2.107	0.943	0.890	2.250	0.609	2.858
2.375	3.70	0.156	0.148	2.063	1.088	1.035	2.157	0.702	2.858
2.375	4.11	0.175	0.167	2.025	1.210	1.158	2.078	0.780	2.858
2.375	4.39	0.188	0.180	1.999	1.292	1.241	2.025	0.833	2.858
2.375	4.43	0.190	0.182	1.995	1.304	1.254	2.017	0.841	2.858
2.375	4.71	0.203	0.195	1.969	1.385	1.335	1.964	0.894	2.858
2.375	4.73	0.204	0.196	1.967	1.391	1.342	1.960	0.898	2.858
2.875	3.67	0.125	0.117	2.625	1.080	1.014	3.492	0.697	4.188
2.875	3.92	0.134	0.126	2.607	1.154	1.088	3.444	0.744	4.188
2.875	4.53	0.156	0.148	2.563	1.333	1.268	3.329	0.860	4.188
2.875	5.05	0.175	0.167	2.525	1.484	1.421	3.231	0.958	4.188
2.875	5.40	0.188	0.180	2.499	1.587	1.524	3.164	1.024	4.188
2.875	5.45	0.190	0.182	2.495	1.603	1.540	3.154	1.034	4.188
2.875	5.79	0.203	0.195	2.469	1.704	1.642	3.089	1.099	4.188
2.875	5.82	0.204	0.196	2.467	1.712	1.650	3.084	1.104	4.188
2.875	6.34	0.224	0.216	2.427	1.866	1.804	2.985	1.204	4.188
3.500	4.82	0.134	0.126	3.232	1.417	1.336	5.293	0.914	6.207
3.500	5.57	0.156	0.148	3.188	1.639	1.559	5.150	1.057	6.207
3.500	6.21	0.175	0.167	3.150	1.828	1.749	5.028	1.179	6.207
3.500	6.65	0.188	0.180	3.124	1.956	1.877	4.945	1.262	6.207
3.500	6.72	0.190	0.182	3.120	1.976	1.897	4.932	1.275	6.207
3.500	7.15	0.203	0.195	3.094	2.103	2.025	4.851	1.357	6.207
3.500	7.18	0.204	0.196	3.092	2.112	2.034	4.844	1.363	6.207
3.500	7.84	0.224	0.216	3.052	2.305	2.228	4.720	1.487	6.207
4.500	8.75	0.190	0.182	4.120	2.573	2.469	8.601	1.660	10.261
4.500	9.36	0.204	0.196	4.092	2.753	2.650	8.485	1.776	10.261
4.500	10.23	0.224	0.216	4.052	3.009	2.907	8.319	1.941	10.261
4.500	11.35	0.250	0.242	4.000	3.338	3.237	8.107	2.154	10.261
5.000	11.43	0.224	0.216	4.552	3.361	3.246	10.499	2.168	12.668
5.000	12.68	0.250	0.242	4.500	3.731	3.617	10.261	2.407	12.668

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

E

drilling bits and downhole motors

COMMON SIZES AND TOLERANCE ON NEW BITS (API RP 7G, January 1, 1995)

COMMON SIZES

Sizes other than those shown may be available in limited cutting structure types:

Roller bits

Diameter (in)	
3 3/4	9 1/2
3 7/8	9 7/8
4 1/4	10 3/4
5 7/8	11
6	12 1/4
6 1/8	13 1/2
6 1/4	14 3/4
6 1/2	16
6 3/4	17 1/2
7 7/8	20
8 3/8	22
8 1/2	24
8 3/4	26

Fixed cutter bit

Diameter (in)	
3 7/8	8 1/2
4 1/2	8 3/4
4 3/4	9 1/2
5 7/8	9 7/8
6	10 3/4
6 1/8	12 1/4
6 1/4	14 3/4
6 1/2	16
6 3/4	17 1/2
7 7/8	

TOLERANCE ON NEW BITS

Rock bits

Nominal bit size		Tolerance	
(in)	(mm)	(in)	(mm)
3 3/8 – 13 3/4 incl.	85.7 – 349.3	– 0, + 1/32	– 0, + 0.79
14 – 17 1/2 incl.	355.6 – 444.5	– 0, + 1/16	– 0, + 1.59
17 5/8 and larger	447.7 and larger	– 0, 3/32	– 0, + 2.38

Diamond and PDC bits

Nominal bit size		Tolerance	
(in)	(mm)	(in)	(mm)
up to 6 1/4	up to 158.8	+ 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 and larger	350.0 and larger	+ 0, – 0.045	+ 0, – 1.14

IADC ROLLER BIT CLASSIFICATION SYSTEM

The 1992 version of the IADC classification (SPE/IADC 1992 No. 123937) contains minor changes from the 1987 Roller Bit Classification System.

In 1987, the Classification System was changed to include a fourth character to denote features available. The 1992 revision added some letters to the classification (B, H, L, M, T and W) and deleted the R letter.

First digit: Cutting Structure Series (1 – 8)

Eight categories or "Series" numbers describe general formation characteristics.

Series 1, 2 and 3 refer to steel tooth (milled tooth) bits.

Series 4, 5, 6, 7 and 8 refer to insert (tungsten carbide) bits.

Within the steel tooth and insert groups, the formation becomes harder and more abrasive as the Series numbers increase.

Second digit: Cutting Structure Types (1 – 4)

Each Series is divided into 4 "Types" or degrees of hardness. Type 1 refers to bits designed for the softest formation in a particular Series. Type 4 refers to the hardest formation within the Series.

Third digit: Bearing/Gage (1 – 7)

Seven categories of bearing design and gage protection are defined as "Bearing/Gage":

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.

Categories 8 and 9 are reserved for future use.

Additional letter

A = air application
B = special bearing seal
C = center jet
D = deviation control
E = extended jets
G = gauge/body protection
H = horizontal/steering application
J = jet deflection
L = lug pads
M = motor application
S = standard steel tooth model
T = two cone bits
W = enhanced cutting structure
X = predominantly chisel tooth insert
Y = conical tooth insert
Z = other shape insert

IADC ROLLER BIT CLASSIFICATION TABLE
(IADC/SPE 23937, February, 1992)

	Formations	Series	Types	Standard roller bearing 1	Roller bearing air-cooled 2	Roller bearing gage protected 3	Sealed roller bearing 4	Sealed roller bearing gage protected 5	Sealed friction bearing 6	Sealed friction bearing gage protected 7
Steel tooth bits	Soft formations with low compressive strength and high drillability	1	1							
			2							
			3							
			4							
	Medium to medium hard formations with high compressive strength	2	1							
			2							
			3							
			4							
	Hard semi-abrasive and abrasive formations	3	1							
			2							
			3							
			4							
Insert bits	Soft formations with low compressive strength and high drillability	4	1							
			2							
			3							
			4							
	Soft to medium soft formations with low compressive strength	5	1							
			2							
			3							
			4							
	Medium hard formations with high compressive strength	6	1							
			2							
			3							
			4							
	Hard semi-abrasive and abrasive formations	7	1							
			2							
			3							
			4							
	Extremely hard and abrasive formations	8	1							
			2							
			3							
			4							

Features Available

- A Air application
- B Special bearing seal
- C Center jet
- D Deviation control
- E Extended jets (full length)
- G Gage/body protection (additional)
- H Horizontal/steering applications
- J Jet deflection
- L Lug pads
- M Motor application
- S Standard steel tooth model
- T Two cone bit
- W Enhanced cutting structure
- X Predominantely chisel tooth insert
- Y Conical tooth insert
- Z Other shape insert

HOW TO USE THE ROLLER BIT TABLE

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 E 3 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 E 5 gives a choice between:

(a) Hughes: ATJ2, J2, J2T

(b) Reed: EHP12, HP12

(c) Security: S33F

(d) Smith: FDT

(e) Varel: L126

HOW TO KNOW THE DESIGN OF A ROCK BIT

Let us consider Reed HP52 bit. Which formation is it designed for?

Table E 7 states that it is equivalent to the Hughes ATJ22C, ATM22C, ATJ28, ATM28, Security S85F, S85CF, Smith F27, MF27 and Varel ETD527, V527 bits, and its code No. is **527**.

Table E 3 shows us that it is an **insert bit** for **soft to medium soft formations** with **hardness 2** 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 responsibility to classify his bits in these tables.

COMPARISON OF ROLLER BITS

Milled tooth bits

Code	Hughes Christ.	Reed	Security DBS	Smith	Varel
111	R1	Y11	S3SJ 2S3JD	DSJ	L111
114	ATX1, GTX1 X3A		S33S, MS33S SS33S	SDS	L114
115	GTXG1, MAXG1 MAXGT1	EMS11G S11G	SS33SG ERA 1RD	MSDSH MSDSSH	ETR1G
116	ATJ1, ATJS ATM1/H/S, GT1	HP11 HP11+	S33SF, PSF S33SFX	FDS, FDS+ FDSS+	L116
117	ATJG1H, GT1H ATMG1/S, GTG1 ATMGT1	MHP11G MHP11DH	S33SGF ERA MPSF	MFDSH MSDSHOD	L117 L117GT ETD1G
121	R2	Y12	S3J, S3TJ	DTJ	L3S, L121
126	ATJ2, J2, J2T	EHP12, HP12	S33F	FDT	L126
131	R3	Y13	S4J, S4TJ, S4T	DGJ	L3, L131
135	GTXG3, MAXG3 MAXGT3, XGG	EMS13G ETS13G	S44G SS44G	MSDGH SDGH	L135 ETR3G
136		HP13		FDG	L136
137	JG3, ATMG3 ATMGT3	HP13G MHP13G/DH	S44GF S44F	FDGH MFDGH	L137
215		MS21G, S21G	M44NG MM44NG	SVH	
217	JG4	HP21G	M44NGF	FVH	
317	JG7	HP31G			

COMPARISON OF ROLLER BITS
(continued)

Insert tooth bits

Code	Hughes Christ.	Reed	Security DBS	Smith	Varel
415	AT05, GTX03 MAX00/03/05	MS41H-M MS41HD-M	SS80	M02S	ETD415
417	ATJ00/05 ATM00/05 ATMGT00/03 GT00, GT03	EHP41H	S80F ERA03 ERA03D	F05	ETD417
425	ATX05C, MAX05C		SS81	M05S	
427	ATJ05C, ATM05C GT03C, GT05C		S81F	F07	
435	ATX11H/S ATX11, GTX09 MAX11H/GT09	MS43A, MS43A-M MS43ADM, S43A MS43HM/HDM	S82 SS82	M1S	ETD435
437	ATJ11/H/S ATM11/H/HG ATMGT09, GT09	EHP43/A/H EHP43AD/AH HP43/A/AM/M	S82F S82CF SS82F	F1, F1S	ETD437 V437
445	GTX18, ATX11C MAX09C/GT18	MS44A MS44AD		15JS, M15S	ETD445
447	ATJ11C, ATJ18 ATM11C/11CG ATM18/GT18 GT09C/18/18C	HP44M	S83F SS83F	F15 F15S MF15	ETD437C

COMPARISON OF ROLLER BITS
(continued)

Insert tooth bits

Code	Hughes Christ.	Reed	Security DBS	Smith	Varel
515	ATX22 MAX22/G	MS51A/AM MS51ADM, S51A	S84, SS84	2JS, M2S	ETD515
517	ATJ22/G/S, GT20 ATM22/G, GT09C	EHP51/A/H/X/AD HP51/A/AM/H/HM	S84F, S84CF DS84F, SS84F	A1, F15H, F17, F2 F2H, F25/A, MF2H	ETD517/C V517
525				M27S	ETD525
527	ATJ22C, ATM22C ATJ28, ATM28 GT20C, GT28	HP52/A/X/M	S85F, S85CF	F27, MF27, F27i	ETD527/C V527 EDT527CB/CH
535	ATX33	MS53, MS53D	S86, SS86	3JS, M3S	ETD535
537	ATJ33/S/A ATM33, ATJ35/G	EHP53/A/D/AD HP53/A/AM/D/AD			ETD537 V537
545			S88		ETD545
547	ATJ33C, ATJ35C ATJ35CG ATM33C	HP54	S88F, S88CF S88FA	F35, F37 F37D, F37A	V537C EDT537C/CH ETD547A
615	ATX44		M84	4JS	ETD615, V615
617	ATJ44/A/CA ATJ44D, ATJ44G	EHP61/A/D/AD HP61/A/AD	M84, M84CF M84FA, M85F	F4, F4H F45A, F45H	ETD617 V617/A
625	ATX44C	MS62/D, S62A	M88, MM88, M89T	5GA, 5JA	ETD625, V625
627	ATJ44C	EHP62/A HP62/A/JAK/D/AD	M85F, M88F M88FA, M89TF	F47, F47H, F5	ETD627 V627
637	ATJ55/A/D/R	EHP63, HP63/D	M89F	F57, F57A	ETD637, V637
647	ATJ66		F67	M90F	
737	ATJ77, ATM77	EHP73, HP73/D	H87F	F7	V737
747	ATJ88		H88F	F8	
837	ATJ99/A, ATM99	EHP83/D, HP83/D	H100F	F9	

IADC FIXED CUTTER DRILL BIT CLASSIFICATION SYSTEM (IADC/SPE February 18-21, 1992)

Fixed-Cutter Drill Bit Classification System (SPE/IADC 1987 No. 16142), which attempted to describe each bit style individually was not being used.

The new classification system is composed of four characters, designating body material, cutter density, cutter size or type, and profile, respectively. It is presented as an attempt to improve the ability to classify and thus employ fixed-cutter PDC and diamond drill bits more effectively.

The proposed system is notably simpler than the former system. It no longer considers hydraulics.

The benefit of the new fixed-cutter classification system is that it allows classification and grouping of similar bits.

First character

The first character becomes **M** for **matrix** or **S** for **steel** body construction respectively.

Second character

The second character is labeled **density**, and ranges from 1 to 4 for PDC bits, and from 6 to 8 for surface-set bits using diamond-type cutters. Numerals 0, 5 and 9 are reserved for future use.

Third character

The third character (digits 1 to 4) represents:
(a) The size of PDC cutter on this type of bit, or
(b) The diamond type for surface-set bits.

Fourth character

The fourth character (digits 1 to 4) gives an idea of basic **appearance** of the bit, based on overall length of the cutting face of the bit.

Examples

- **Code S423**

This is a (**S**) Steel body PDC bit with a cutters density (**4**) of 50 cutters or more and a size (**2**) (14 to 24 mm) for the cutters. The profile (**3**) is a medium profile.

In the tables E 10-E 11, several bits correspond to the code S423 or M423:
Christensen G547, R547, G549, R549
Diamant Boart Stratabit FM2563, FM2565, FM2865
Hycalog DS68, DS78H, DS77H, DS70H
Crystal Profor RD51
Geodiamond M44, M61, M68, M61V.

- **Code M713**

This is a (M) Matrix body Surface-Set bit using diamond-type cutter with a density/size (**7**) of 3 to 7 stones per carat of (**1**) natural diamonds. The profile (**3**) is medium longer.

In the tables E 12-E 13, several bits correspond to the code M713:
Christensen D262, D331
Diamant Boart Stratabit TB16
Hycalog 730, 733, 744, 753, 901
Crystal Profor H300
Geodiamond D54, D73.

IADC FIXED CUTTER DRILL BIT CLASSIFICATION SYSTEM (IADC/SPE February 18-21, 1992) (continued)

First character: body material

M = matrix body construction
S = steel body construction

Second character: density

PDC bits
1 = 30 or fewer 1/2 in cutters
2 = 30 to 40 1/2 in cutters
3 = 40 to 50 1/2 in cutters
4 = 50 or more 1/2 in cutters

Surface-set cutters bits
6 = diamond sizes larger than 3 SPC*
7 = from 3 SPC to 7 SPC*
8 = diamond size smaller than 7 SPC*

Third character: size or type

PDC size
1 = cutters larger than 24 mm
2 = cutters from 14 mm to 24 mm
3 = cutters of 13.3 mm (1/2 in)
4 = cutters of 8 mm

Surface-set cutters bits type
1 = natural diamonds
2 = TSP material
3 = combination cutter type
4 = impregnated diamond

Fourth character: body style

1 = fishtail PDC bit or flat TSP and natural diamond bit
2 = short bit profile
3 = medium bit profile
4 = long bit profile

for example, a long-flanked "turbine style" bit would be clearly categorized as a 4.

* SPC means Stones per Carat (1 carat = 0.2 grams).

IADC COMPARISON OF PDC BITS

Cutters density	Size		Body style									
			1 Fishtail					2 Short				
			HC	DBS	HYC	CRYST	GEO	HC	DBS	HYC	CRYST	GEO
1	1	> 24		B9-44								
	2	14-24	R523 G573 G554 AG574	B9-33 FM2466	DS40H	S45	S94 M94 M96 M97	G536	FM2862			
	3	< 14	R443 R423	FM2445 FM2446 FM2648						DS100H DS43ST		
2	1	> 24		B9-44								
	2	14-24	G/R526 G526 AR526 AG526	B9-33	DS61H	S65 I			TD19L	DS105H	S66	
	3	< 14	R426 AR426	FM2445 TD13L	DS53H DS39H			R482	HZ23-2	DS95H DS35 DS35H DS44ST		M53 M53V
3	1	> 24										
	2	14-24		FM2465 FM2665					FM2862	DS68H DS88H DS81		
	3	< 14		FM2643 FM2445				G/R435 AG435 AR435 R335		DS107H DS102H DS48H	RD3	
4	1	> 24										
	2	14-24		FM2365 FM2463 FM2365	DS103H		M83 M83V		FM2563 FM2565 FM2865		S75	
	3	< 14							FM2643 FM2745 FM2545 FM2845	DS90H DS56H DS85H DS84H	RD1001 RD1002	M22 M27 M22V M27V

HC = Hughes Christensen; DBS = Security Diamant Boart Stratabit; HYC = Hycalog; CRYST = Crystal Profor; GEO = Geodiamond.

IADC COMPARISON OF PDC BITS (continued)

Cutters density	Size		Body style									
			3 Medium					4 Long				
			HC	DBS	HYC	CRYST	GEO	HC	DBS	HYC	CRYST	GEO
1	1	> 24										
	2	14-24					S81 S91 M80 S76		FM2566			
	3	< 14			DS38							
2	1	> 24										
	2	14-24		B25 FM2565	DS80H DS76H DS34H DS76H	S250	M91 M75 M88 S82					
	3	< 14		FM2743 FM2943	DS46H		M75V					
3	1	> 24										
	2	14-24	G/R535 AG545		DS104 DS90 DS86 DS70	RD50	M71 M71V		FM2862	DS68H		
	3	< 14		FM2943 FM2643 FM2943			M42 M50	R445 AG445 AR445		DS92		
4	1	> 24										
	2	14-24	G/R547 G/R549 AR547	FM2563 FM2565 FM2865	DS68 DS78H DS77H DS70H	RD51	M44 M61 M68 M61V		FM2665 FM2865		S265H	
	3	< 14	G/R437 AG437 AR437 G/R447	FM2643 FM2745 FM2546 FM2845	DS93H DS75H DS47H DS47H	RD90H	M34/M35 M36/M37 M39/M40 M41/M42	G417	B10-25 B36-2 FM2745 FM2846	DS65H DS92H DS92H DS57H	S280H S280HY	

HC = Hughes Christensen; DBS = Security Diamant Boart Stratabit; HYC = Hycalog; CRYST = Crystal Profor; GEO = Geodiamond.

IADC COMPARISON OF TPS & NATURAL DIAMONDS BITS

Cutters size	Element		Body style: 1 Flat HC	1 Flat DBS	1 Flat HYC	1 Flat CRYST	1 Flat GEO	2 Short HC	2 Short DBS	2 Short HYC	2 Short CRYST	2 Short GEO
6 < 3 SPC*	1	NAT*										
	2	TSP*				DK320			TT521			
	3	COMB*				DK320RC						
7 3-7 SPC*	1	NAT*	D411ST(M) D42SM(M)			K300 DK300		D41 D24			H400	D42
	2	TSP*	S296ST(M)		828ST					263 263ND		
	3	COMB*										
8 > 7 SPC*	1	NAT*		TB26						585		
	2	TSP*										
	3	COMB*		TBT26								
	4	IMP*	S279(M)		480		K33 K35			460, 461 462, 463 464, 470 471/72/73		

HC = Hughes Christensen; DBS = Security Diamant Boart Stratabit; HYC = Hycalog; CRYST = Crystal Profor; GEO = Geodiamond.
* NAT = Natural Diamond Bits; TSP = Thermostable; COMB = Combination Cutter Bits; IMP = Impregnated Diamond Bits; SPC = Stones Per Carat.

IADC COMPARISON OF TPS & NATURAL DIAMONDS BITS
(continued)

Cutters size	Element		3 Medium HC	3 Medium DBS	3 Medium HYC	3 Medium CRYST	3 Medium GEO	4 Long HC	4 Long DBS	4 Long HYC	4 Long CRYST	4 Long GEO
6 < 3 SPC*	1	NAT*				H200	D62 D62HT D71 D72	T18				D51 D52
	2	TSP*			211 241			S725	TT561			
	3	COMB*	S225 Z437					SD248	TBT17		M320 M320RC	
7 3-7 SPC*	1	NAT*	D262 D311	TB16	753 901 744 730, 733	H300	D54 D73	T51 D331(M)				D53
	2	TSP*	226		223 243 223ND 243ND			S248	TT593			
	3	COMB*							TBT703			
8 > 7 SPC*	1	NAT*									H600	
	2	TSP*										
	3	COMB*										
	4	IMP*		TBT601MP	445 442 443 450							

HC = Hughes Christensen; DBS = Security Diamant Boart Stratabit; HYC = Hycalog; CRYST = Crystal Profor; GEO = Geodiamond.
* NAT = Natural Diamond Bits; TSP = Thermostable; COMB = Combination Cutter Bits; IMP = Impregnated Diamond Bits; SPC = Stones Per Carat.

IADC DULL BIT GRADING
(After IADC/SPE 23938-23939 of 1992)

The dull grading system applies both to roller bits and fixed cutter bits. The system is flexible enough for use in bit reports, daily reports and databases.

Cutting structure				Bearing seals	Gage	Other dull char.	Reason pulled
Inner	Outer	Dull char.	Location				
Table **1**	Table **1**	Table **3**	Table **4**	Table **5**	Table **6**	Table **3**	Table **8**

Table 1

Inner cutting structure (inner = inner 2/3 of the bit)
Outer cutting structure (outer = outer 1/3 of the bit – gage row only)

In columns 1 and 2 a linear scale from **0** to **8** is used to describe the condition of the cutting structure according to the following:

Steel tooth bits

A measure of lost tooth height due to abrasion and/or damage:

0 = No loss of tooth height
1
⋮
8 = Total loss of tooth height

Insert bits

A measure of total cutting structure reduction due to lost, worn and/or broken inserts:

0 = No lost, worn and/or broken inserts
1
⋮
8 = All inserts lost, worn and/or broken

Fixed cutter bits

A measure of lost, worn and/or broken cutting structure:

0 = No lost, worn and/or broken cutting structure
1
⋮
8 = All of cutting structure lost, worn and/or broken.

IADC DULL BIT GRADING
(After IADC/SPE 23938-23939 of 1992) (continued)

Table 2 – Dull characteristics

(Use only cutting structure related codes)

BC* = Broken Cone
BF = Bond Failure
BT = Broken Teeth/Cutters
BU = Balled Up Bit
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 Gage
RO = Ring Out
SD = Shirttail Damage
SS = Self Sharpening Wear
TR = Tracking
WO = Washed Out Bit
WT = Worn Teeth/Cutters
NO = No Dull Characteristics

* Show cone # or #'s under location (table 3).

Table 3 – Location

Roller cone		Fixed cutter
N = nose row	Cone #	C = cone
M = middle row	1	N = nose
G = gage row	2	T = taper
A = all rows	3	S = shoulder
		G = gage
		A = all rows

Table 4 – Bearings/seals

Non-sealed bearings	Sealed bearings
A linear scale estimating bearing life used:	E = seals effective
0 = no life used	F = seals failed
8 = all life used	N = not able to grade
	X = fixed cutter bit

Table 5 – Gage

Measure in fraction of an inch:

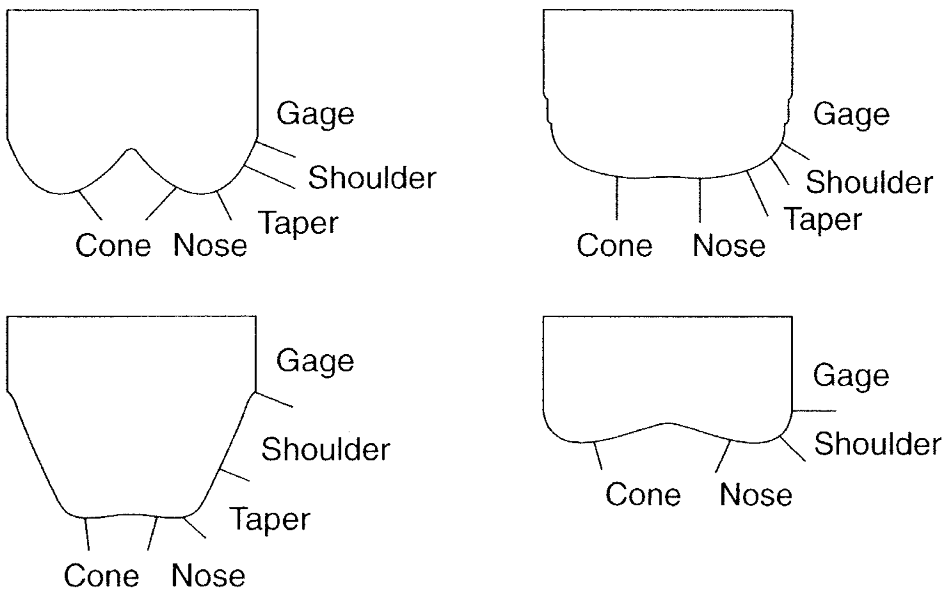
I	in gage
0 – 1/16 in	out of gage
2/16 – 1/8 in	out of gage
....	

IADC DULL BIT GRADING
(After IADC/SPE 23938-23939 of 1992) (continued)

Table 6 – Reason pulled or run terminated

BHA	= Change Bottom Hole Assembly	LIH	= Left In Hole
DMF	= Downhole Motor Failure	HR	= Hours On Bit
DTF	= Downhole Tool Failure	LOG	= Run Logs
DSF	= Drill String Failure	PP	= Pump Pressure
DST	= Drill Stem Test	PR	= Penetration Rate
DP	= Drill Plug	RIG	= Rig Repair
CM	= Condition Mud	TD	= Total Depth/Casing Depth
CP	= Core Point	TW	= Twist Off
FM	= Formation Change	TQ	= Torque
HP	= Hole Problems	TR	= Weather Conditions

Location designation



PARAMETERS FOR USING INSERT BITS AND FRICTION BEARINGS
(After Baker-Hughes)

For ATJ and ATM series, the numbers in the table indicate the product of bit weight (*W*) in 1000 daN times rotary speed (*N*) in revolution per minute that the bearing can safely handle.

Note: This table only considers bearing capability and does not consider compact breakage or seal failure, which may be the limiting factors for bit performance.

WN	4 3/4	5 7/8	6	6 1/8	6 1/2	7 7/8	8 3/8	8 1/2	8 3/4	9 1/2	9 7/8	10 5/8	12 1/4	14 3/4	17 1/2
ATJ05											1975		2850		
ATJ11								1625		2125	1975		2850		
ATM11						1450		1450	1725		1975		2550		3325
ATJ1								1650					2850		
ATJ22		1225	1225	1225	1225		1725	1925		2225	2225	2175	2900		
ATM22						1525		1625	1775	2225	2075		2625	2425	3550
ATJ2C								1925		2225	2225		2900		
ATJ33	1150	1225	1225	1225	1225		1725	1925		2225	2225	2175	2900		
ATM33						1525	1525	1625	1625		2075		2625		3950
ATJ33C								1925		2225	2225	2175	2900		
ATJ44			1175		1300		1675	2050		2150	2150	2125	2775		
ATJ44C								2050		2150	2150	2125	2775		
ATJ55	1100	1175	1175	1175			1675	2050		2150	2150		2775		
ATJ55R					1300		1675	2050		2150	2150		2775		
ATJ77					1300			2050		2150	2150		2775		
ATJ99					1300			2050		2150	2125				

For *WN* in 1000 lb × rpm, multiply the number given in the table by 2.25.

Example: 8 1/2 in bit – ATM22: *WN* = 1625 (1000 daN × rpm)

WN = 1625 × 2.25 = 3650 (1000 lb × rpm)

The following alternatives are available:

(a) WOB	16 250 daN	(36 500 lb)
(b) rotary speed	100 rpm	(100 rpm)

or:

(a) WOB	20 000 daN	(45 000 lb)
(b) rotary speed	81 rpm	(81 rpm)

or any other combination, according to whether the rotary speed or weight on bit is adjusted for best action on the formation.

daN x 2.25 = lb

THREADS AND MAKE-UP TORQUES FOR DRILL BITS AND CORING BITS (API RP 7G, January 1, 1995 – API Spec 7, April 1, 1994)

Rock bits

Bit size (in)	Bit thread
3 3/4 – 4 1/2	2 3/8 REG
4 5/8 – 5	2 7/8 REG
5 1/8 – 7 3/8	3 1/2 REG
7 1/2 – 9 3/8	4 1/2 REG
9 1/2 – 14 3/8	6 5/8 REG
14 1/2 – 18 1/2	6 5/8 or 7 5/8 REG
18 5/8 to 26	7 5/8 or 8 5/8 REG
27 and larger	8 5/8 REG

Bit thread	Make-up torque	
	(daN.m)	(ft.lb)
2 3/8 REG	400 – 480	3 000 – 3 500
2 7/8 REG	600 – 750	4 500 – 5 500
3 1/2 REG	950 – 1 200	7 000 – 9 000
4 1/2 REG	1 600 – 2 200	12 000 – 16 000
6 5/8 REG	3 800 – 4 300	28 000 – 32 000
7 5/8 REG	4 600 – 5 400	34 000 – 40 000
8 5/8 REG	5 400 – 8 100	40 000 – 60 000

Diamond and PDC bits

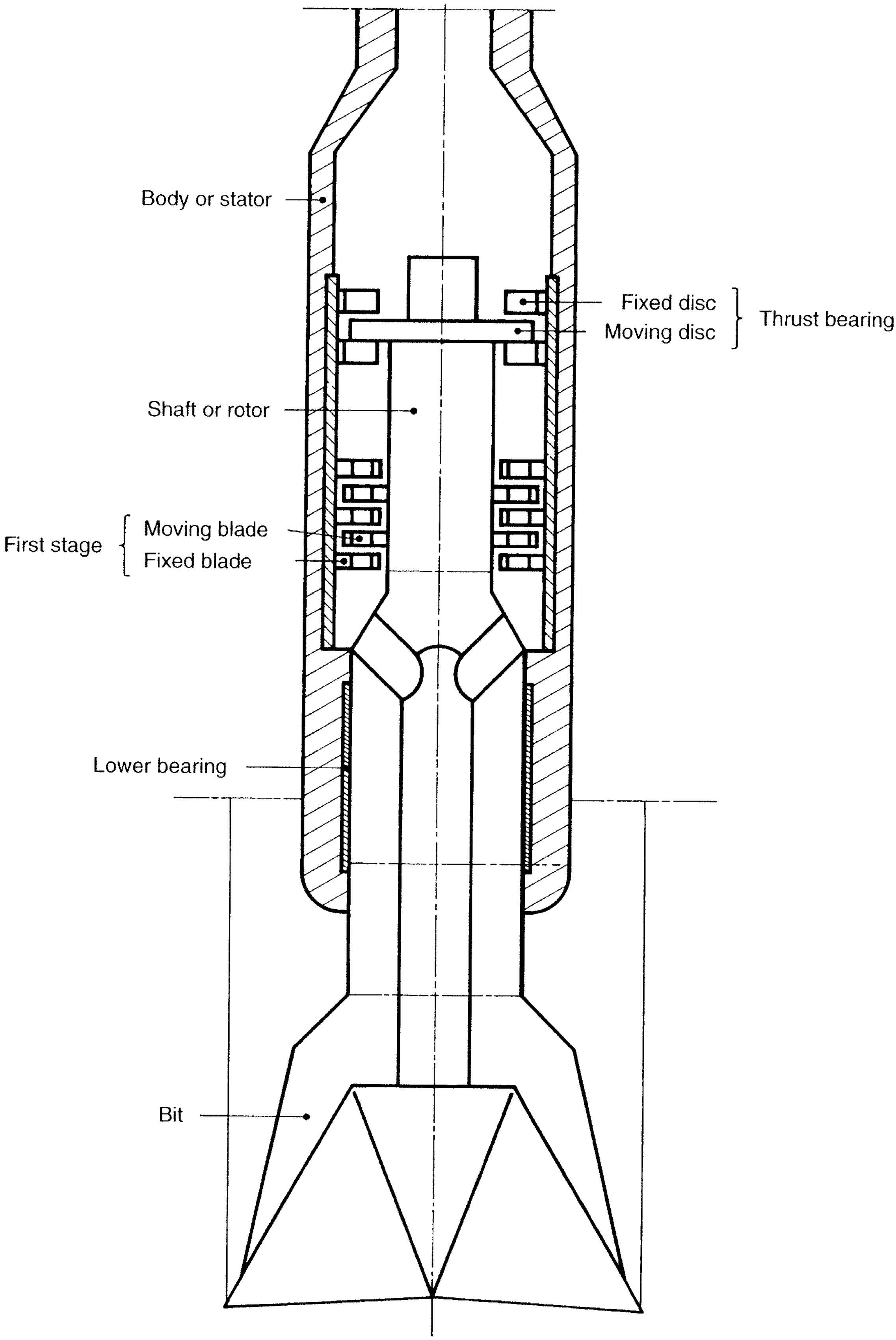
Bit size (in)	Bit thread identification	Maximum pin ID (in)	Bit sub OD (in)	Minimum make-up torque (1)	
				(daN.m)	(ft.lb)
3 11/16 – 4 1/2	2 3/8 REG	1	3 3 1/8 3 1/4	243 328 418	1 791 2 419 3 085
4 17/32 – 5	2 7/8 REG	1 1/4	3 1/2 3 3/4 3 7/8	417 626 632	3 078 4 617 4 658
5 1/32 – 7 3/8	3 1/2 REG	1 1/2	4 1/8 4 1/4 4 1/2	701 855 1 039	5 171 6 306 7 660
7 13/32 – 9 3/8	4 1/2 REG	2 1/4	5 1/2 5 3/4 6 6 1/4	1 688 2 234 2 380 2 408	12 451 16 476 17 551 17 757
9 13/32 – 14 1/2	6 5/8 REG	3 1/4	7 1/2 7 3/4 8 8 1/4	5 030 5 133 5 178 5 224	37 100 37 857 38 193 38 527
14 9/16 – 18 1/2	7 5/8 REG	3 3/4	8 1/2 8 3/4 9 9 1/4 9 1/2	6 548 7 824 8 130 8 200 8 256	48 296 57 704 59 966 60 480 60 895

(1) Normal torque range is tabulated value plus 10%.

Coring bits

Core barrel size (in)	Make-up torque	
	(daN.m)	(ft.lb)
4 1/8	400 – 490	3 000 – 3 600
4 1/2	680 – 800	5 000 – 6 000
4 3/4	550 – 660	4 050 – 4 850
5 3/4	1 000 – 1 190	7 400 – 8 800
6 1/4 x 3	2 020 – 2 410	14 900 – 17 800
6 1/4 x 4	1 100 – 1 330	8 150 – 9 800
6 3/4	1 340 – 1 630	9 900 – 12 000
8	2 580 – 3 080	19 000 – 22 700

TURBODRILL


Body or stator
Fixed disc
Moving disc
Thrust bearing
Shaft or rotor
First stage
Moving blade
Fixed blade
Lower bearing
Bit

TURBODRILLING

I TURBODRILL SPECIFICATIONS

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 specifications are given for a nominal pump flow Q_n and a mud specific gravity of 1.20.

These nominal specifications are:

(a) Nominal speed N_n
(b) Nominal horsepower output P_n
(c) Nominal 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 SPECIFICATIONS WITH PUMP FLOW AND MUD SPECIFIC GRAVITY

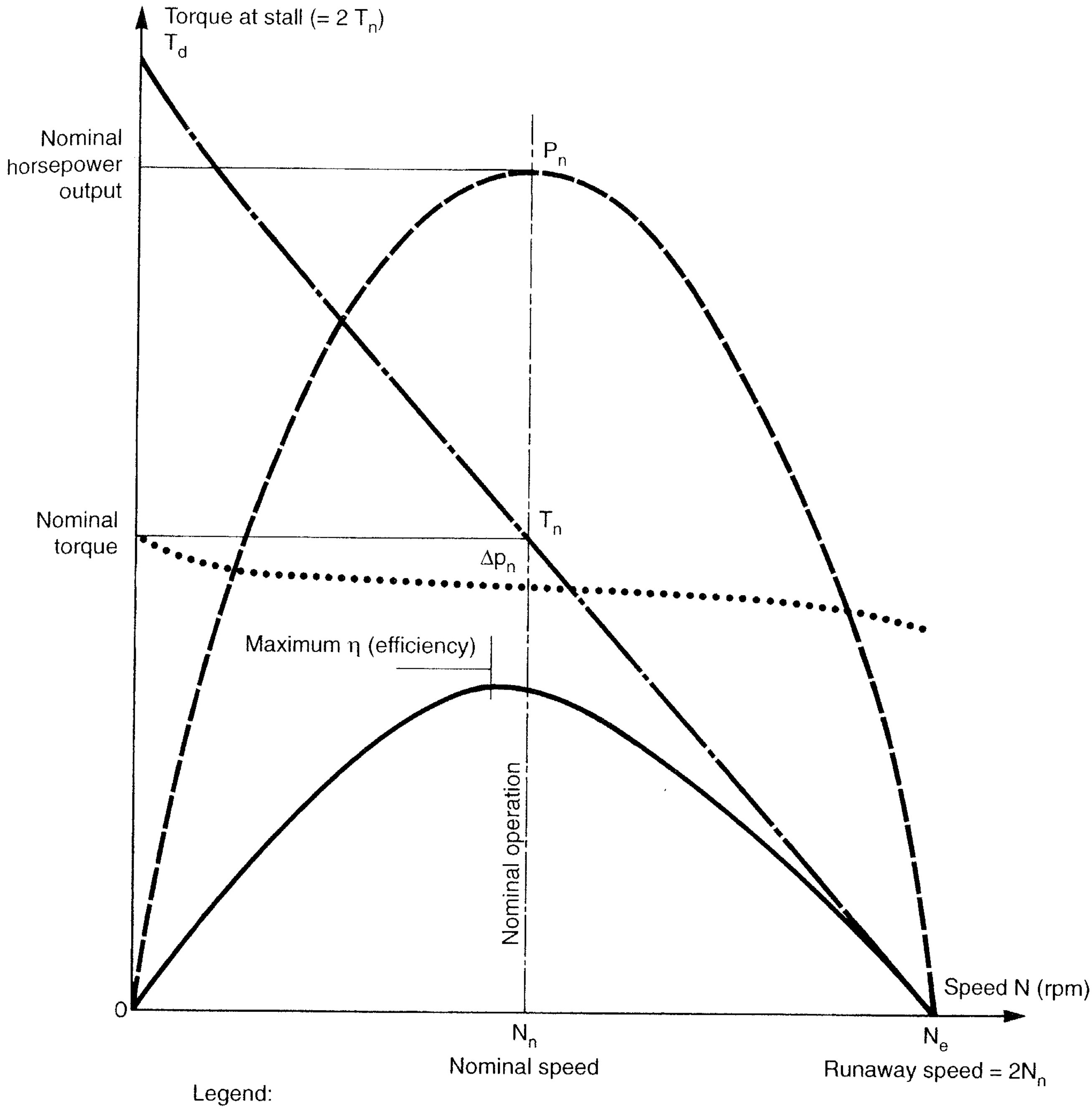
If N_n, P_n, T_n and Δp_n are the nominal specifications of a turbodrill for a flow rate Q_n and specific gravity of 1.20, for a flow rate Q and specific gravity d, the specifications are:

$$N'_n = N_n \frac{Q}{Q_n} \qquad T'_n = T_n \frac{d}{1.20}\left[\frac{Q}{Q_n}\right]^2$$

$$P'_n = P_n \frac{d}{1.20}\left[\frac{Q}{Q_n}\right]^3 \qquad \Delta p'_n = \Delta p_n \frac{d}{1.20}\left[\frac{Q}{Q_n}\right]^2$$

The axial thrust is approximately proportional to the specific gravity d and to the square of Q.

PERFORMANCE CURVES OF TURBODRILL
(Specific gravity *d*, constant flow rate Q_n)



Legend:

- P horsepower
- Δp pressure drop, hydraulic thrust
- η efficiency
- T torque

TURBODRILL SPECIFICATIONS
(Specific gravity of mud 1.20)

Size (in)	Manufacturer	Type	Nominal pump flow (lpm)	Nominal torque (N.m)	Nominal speed (rpm)	Pressure drop (kPa)	Nominal output (kW)	Number of stages	Weight (daN)	Hole size (in)
4 3/4	Neyrfor Weir	T2AI	600	420	1 180	9 600	52	200	893	5 7/8 to 6 1/4
5	Neyrfor Weir	TFI	600	280	1 020	5 300	30	129	765	6 to 6 3/4
5	Neyrfor Weir	T2FI	600	540	1 020	9 700	58	258	1 256	6 to 6 3/4
5	Redi Drill	ST15	600	560	1 030	8 400	60	150	910	6 1/8 to 7 7/8
5	Redi Drill	ST25	600	900	1 030	14 000	97	240		6 1/8 to 7 7/8
5	Redi Drill	STD1-5	600	340	1 030	5 000	37	90	700	6 1/8 to 7 7/8
6 5/8	Neyrfor Weir	T2AI	1 600	1 820	1 100	12 600	210	172	1 888	8 3/8 to 9 7/8
6 5/8	Neyrfor Weir	T3AI	1 600	2 720	1 100	18 400	313	258	2 536	8 3/8 to 9 7/8
7 1/4	Neyrfor Weir	T2AI	1 800	1 970	880	10 400	182	164	2 160	8 3/8 to 9 7/8
7 1/4	Neyrfor Weir	T3AI	1 800	2 950	880	14 900	272	246	2 940	8 3/8 to 9 7/8
7 1/4	Neyrfor Weir	TFST	1 800	510	750	2 400	40	50	730	8 3/8 to 12 1/4
7 1/4	Neyrfor Weir	TFM	1 800	820	750	3 700	64	80	1 030	8 3/8 to 12 1/4
7 1/4	Neyrfor Weir	TF	1 800	1 130	750	5 000	89	100	1 390	8 3/8 to 12 1/4
7 1/4	Redi Drill	ST1	1 800	2 390	1 020	12 400	255	150	2 310	8 1/2 to 12 1/4
7 1/4	Redi Drill	ST2	1 800	3 500	1 020	18 200	374	220		8 1/2 to 12 1/4
7 1/4	Redi Drill	STD1	1 800	1 120	1 020	5 800	120	70	900	8 1/2 to 12 1/4
7 1/4	Redi Drill	STD2	1 800	1 590	1 020	8 300	170	100	1 380	8 1/2 to 12 1/4
9 1/2	Neyrfor Weir	T2AI	2 500	3 610	723	11 000	273	172	4 370	12 1/4 to 17 1/2
9 1/2	Neyrfor Weir	T3AI	2 500	5 420	723	15 700	410	258	5 935	12 1/4 to 17 1/2
10 1/4	Neyrfor Weir	TFST	3 000	2 060	630	4 700	136	79	2 260	14 3/4 to 26

lpm × 0.264 = gpm kW × 1.34 = hp N.m × 0.738 = lb.ft kPa × 0.145 = psi daN × 2.25 = lb

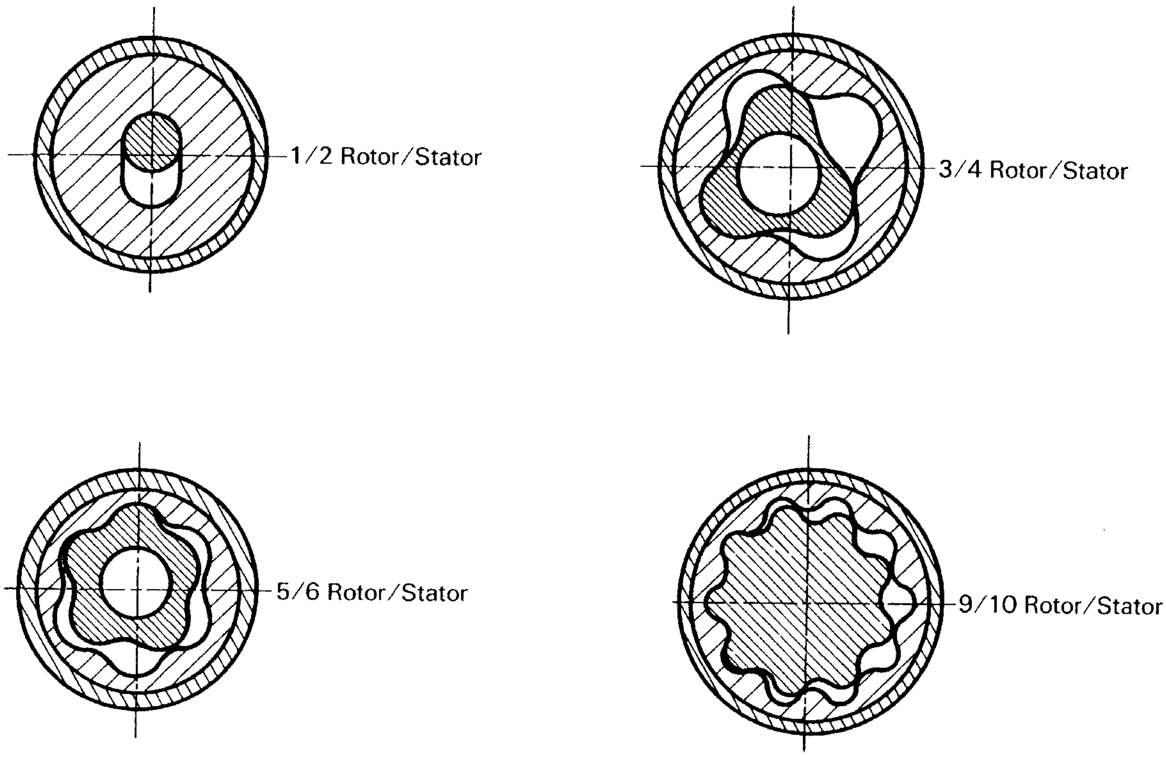
POSITIVE DISPLACEMENT MOTORS

I SPECIFICATIONS 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:



(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 SPECIFICATIONS

The specifications are given by the manufacturers for a specific gravity of 1.20 (10 ppg):

• The **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:

$$P_m = \frac{TN}{9550}$$

• 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 N.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:

$$\eta = \frac{P_m}{P_h}$$

$$\eta = 6.28 \frac{TN}{\Delta p Q}$$

Example: Halliburton 6 3/4 in F2000S

$Q_{max} = 1704$ l/min $T_{max} = 5694$ N.m
$\Delta P_{max} = 4100$ kPa $N_{max} = 170$ rpm

$$P_h = \frac{4100 \times 1704}{60\,000} = 116.4 \text{ kW}$$

$$P_m = \frac{5694 \times 170}{9550} = 101.3 \text{ kW}$$

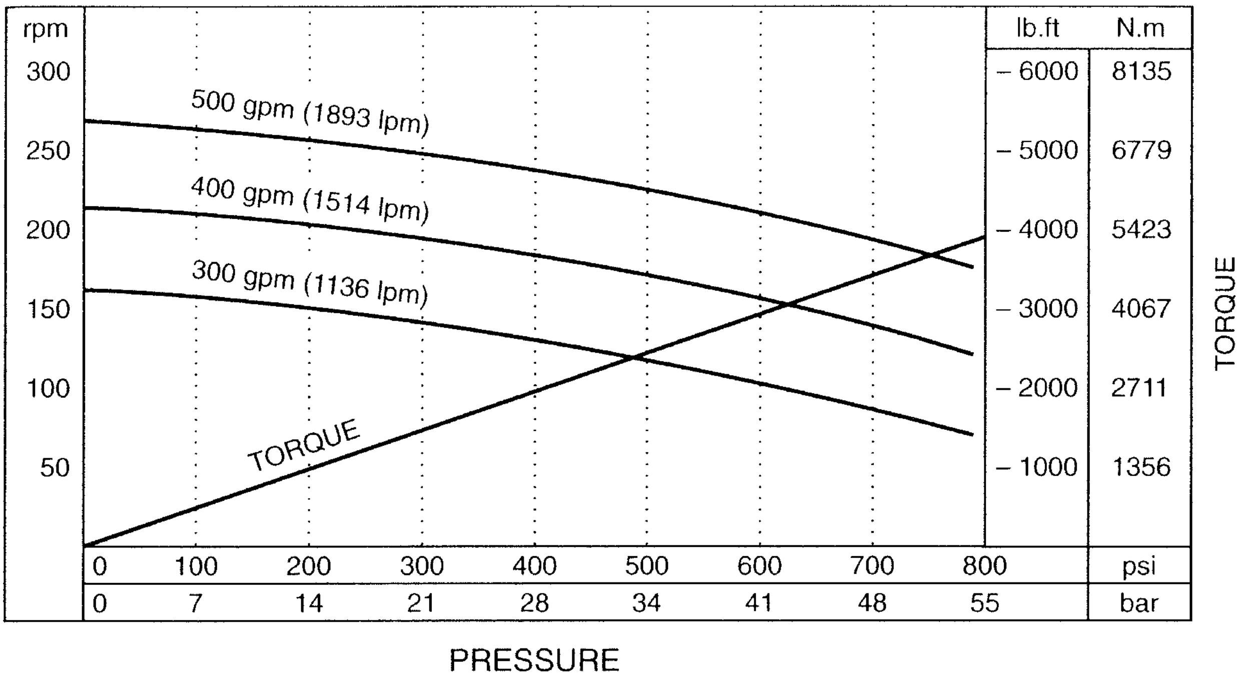
$$\eta = \frac{101.3}{116.4} = 87\%$$

In fact the rotary speed slightly decreases with torque (see diagram E 25) and the real value of efficiency is lower than 87. With a torque of 5694 N.m, the rotary speed decreases to about 120 rpm (Halliburton Dyna-Drill handbook). Real efficiency is 61%.

PERFORMANCE CURVES OF POSITIVE DISPLACEMENT MOTORS FOR DIFFERENT FLOW RATES *Q*

Example of a 6 3/4" – 4/5 lobe Performance Curves:

Motor start pressure 100 psi (7 bar)



SPECIFICATIONS OF POSITIVE DISPLACEMENT MOTORS (Moineau type)

Size (in)	Manufacturer	Type	No. of lobes	Flow rate (l/min) Min.	Flow rate (l/min) Max.	Rotary speed (rpm) Min.	Rotary speed (rpm) Max.	Maximum operating torque (N.m)	Maximum operating pressure drop (kPa)	Operating horse-power output (kW)	Overall Length (m)	Hole size (in)
1 11/16	Drilex	D170	3/4	38	83	645	1 435	52	5 500	8	2.26	1 7/8 to 2 3/4
1 11/16	Drilex	D170HF	5/6	83	159	365	700	102	3 500	7	2.38	1 7/8 to 2 3/4
1 11/16	Halliburton	MS200H	3/4	38	83	645	1 435	52	5 500	8	2.26	1 7/8 to 2 3/4
1 11/16	Halliburton	MS200HF	5/6	83	159	365	700	101	3 400	7	2.38	1 7/8 to 2 3/4
2 1/8	Drilex	D212	5/6	114	159	580	850	163	5 200	15	2.78	2 1/4 to 3 1/2
2 1/8	Drilex	D212HF	5/6	95	246	230	600	204	5 200	13	3.14	2 1/4 to 3 1/2
2 1/8	Halliburton	MS200M	5/6	114	159	580	850	163	5 200	15	2.78	2 1/4 to 3 1/2
2 1/8	Halliburton	MS200HF	5/6	132	246	325	600	169	5 200	11	3.14	2 1/4 to 3 1/2
2 3/8	Anadrill Schlum.	A238M	5/6	76	189	100	380	115	2 620	5	2.57	2 7/8 to 3 1/2
2 3/8	Anadrill Schlum.	A238M	5/6	76	189	100	400	292	5 378	12	3.81	2 7/8 to 3 1/2
2 3/8	Drilex	D237	5/6	114	159	580	850	163	5 200	15	2.78	2 7/8 to 3 1/2
2 3/8	Drilex	D237HF	5/6	151	303	300	600	251	3 500	16	2.87	2 7/8 to 3 1/2
2 3/8	Halliburton	MS200M	5/6	114	159	580	850	163	5 200	15	2.71	2 7/8 to 3 1/2
2 3/8	Halliburton	MS200HF	5/6	151	303	300	600	251	5 200	16	2.87	2 7/8 to 3 1/2
2 3/4	Halliburton	D1000H	1/2	151	303	790	1 590	152	6 200	25	3.90	3 to 4 5/8
2 7/8	Anadrill Schlum.	A287M	5/6	76	303	120	480	224	3 447	11	3.05	3 3/8 to 4 3/4
2 7/8	Anadrill Schlum.	A287XP	5/6	76	303	120	480	542	7 240	27	4.47	3 3/8 to 4 3/4
2 7/8	Anadrill Schlum.	A287M	7/8	76	303	75	300	278	3 620	9	3.05	3 3/8 to 4 3/4
2 7/8	Drilex	D287HS	7/8	151	341	285	642	360	5 200	24	2.32	3 1/4 to 4 1/2
2 7/8	Drilex	D287HF	7/8	227	473	200	415	542	2 600	24	2.59	3 1/4 to 4 1/2
2 7/8	Halliburton	MS600M	7/8	189	473	145	360	278	2 600	10	2.83	3 1/4 to 4 3/4
3 1/8	Baker Hughes Inteq	M1X		303	606	180	365	515	2 900	20	3.60	4 1/4 to 5 7/8
3 1/8	Baker Hughes Inteq	M1XL		303	606	180	365	976	5 900	37	4.50	4 1/4 to 5 7/8
3 1/2	Anadrill Schlum.	A350M	4/5	114	416	98	360	711	4 895	27	4.60	4 1/2 to 6
3 1/2	Anadrill Schlum.	A350M	7/8	114	416	48	180	746	3 378	14	4.60	4 1/2 to 6
3 1/2	Drilex	D350	9/10	303	416	290	400	542	3 400	23	3.14	3 7/8 to 4 3/4
3 1/2	Drilex	D350HS	7/8	151	341	285	642	359	5 200	24	3.45	3 7/8 to 4 3/4
3 1/2	Drilex	D350HF	5/6	284	606	175	375	881	3 400	35	3.69	3 7/8 to 4 3/4
3 1/2	Halliburton	MS500M	5/6	303	606	180	360	881	3 400	33	3.65	3 7/8 to 4 3/4

l/min × 0.264 = gal/min   N.m × 0.738 = lb.ft   kPa × 0.145 = psi   kW × 1.34 = hp   m × 3.281 = ft

SPECIFICATIONS OF POSITIVE DISPLACEMENT MOTORS (continued)
(Moineau type)

Size (in)	Manufacturer	Type	No. of lobes	Flow rate (l/min) Min.	Flow rate (l/min) Max.	Rotary speed (rpm) Min.	Rotary speed (rpm) Max.	Maximum operating torque (N.m)	Maximum operating pressure drop (kPa)	Operating horse-power output (kW)	Overall Length (m)	Hole size (in)
3 3/4	Drilex	D375	5/6	341	586	320	530	786	5 200	44	3.60	4 3/4 to 6
3 7/8	Halliburton	D1000H	1/2	284	662	320	745	617	5 200	48	6.90	4 5/8 to 6
4 3/4	Anadrill Schlum.	A475M	1/2	379	757	225	450	556	2 586	26	5.74	5 7/8 to 7
4 3/4	Anadrill Schlum.	A475M	4/5	379	946	105	262	1 423	3 447	39	5.05	5 7/8 to 7
4 3/4	Anadrill Schlum.	A475XP	4/5	379	946	105	262	2 576	5 860	71	6.86	5 7/8 to 7
4 3/4	Anadrill Schlum.	A475M	7/8	379	946	56	140	1 220	2 482	18	5.05	5 7/8 to 7
4 3/4	Baker Hughes Inteq	M1X		379	1 192	110	325	1 844	4 900	63	5.70	6 to 7 7/8
4 3/4	Baker Hughes Inteq	M1XL		397	1 192	110	325	3 525	9 500	120	8.50	6 to 7 7/8
4 3/4	Baker Hughes Inteq	M2P/XL		303	1 003	180	600	1 966	11 000	124	8.50	6 to 7 7/8
4 3/4	Drilex	DIR475	5/6	379	946	140	350	1 288	3 400	47	3.17	6 to 7 3/8
4 3/4	Drilex	D475	5/6	379	946	140	350	2 441	5 200	89	5.76	6 to 7 7/8
4 3/4	Drilex	D475SS	7/8	379	946	60	165	2 847	3 400	49	5.76	6 to 7 7/8
4 3/4	Drilex	D475TPS	5/6	379	946	140	350	4 067	10 300	149	7.12	6 to 7 7/8
4 3/4	Halliburton	F2000S	5/6	681	946	95	125	1 898	2 100	25	6.50	5 7/8 to 7 7/8
4 3/4	Halliburton	F2000M	5/6	568	946	150	240	2 135	4 100	54	6.50	5 7/8 to 7 7/8
4 3/4	Halliburton	F2000H	1/2	568	1 136	350	550	949	3 100	55	7.80	5 7/8 to 7 7/8
4 3/4	Halliburton	F2000M-tand	5/6	568	946	150	240	2 989	5 800	75	9.51	5 7/8 to 7 7/8
4 3/4	Halliburton	F2000S-tand+	5/6	681	946	95	125	3 796	4 200	50	11.30	5 7/8 to 7 7/8
4 3/4	Halliburton	F2000M-tand+	5/6	568	946	150	240	4 271	8 400	107	11.30	5 7/8 to 7 7/8
4 3/4	Neyrfor Weir	VM7000	7/8	380	950	55	134	1 956	2 500	27	5.20	5 3/4 to 6 1/2
4 3/4	Neyrfor Weir	VM5000	1/2	380	757	310	670	569	3 450	40	5.83	5 3/4 to 6 1/2
5	Halliburton	D500	1/2	568	946	335	560	576	2 500	34	5.80	6 1/2 to 7 7/8
6 1/4	Drilex	D625SS	4/5	644	1 703	75	200	8 812	4 300	185	6.09	7 7/8 to 10 5/8
6 1/2	Halliburton	D500	1/2	757	1 325	275	480	935	2 500	47	6.00	8 3/8 to 9 7/8
6 1/2	Halliburton	F2000S	5/6	946	1 704	105	190	3 797	3 100	76	6.80	8 3/8 to 9 7/8
6 1/2	Halliburton	F2000H	1/2	946	1 514	350	550	1 817	4 100	105	7.60	8 3/8 to 9 7/8
6 1/2	Halliburton	F2000S-tand+	5/6	946	1 704	105	190	7 592	6 200	151	12.60	8 3/8 to 9 7/8
6 5/8	Neyrfor Weir	VM7000	7/8	1135	2 280	86	172	5 204	3 500	94	5.88	8 3/8 to 9 7/8
6 5/8	Neyrfor Weir	VM5000	1/2	757	1 892	200	500	1 851	3 500	97	7.15	8 3/8 to 9 5/8

l/min × 0.264 = gal/min N.m × 0.738 = lb.ft kPa × 0.145 = psi kW × 1.34 = hp m × 3.281 = ft

SPECIFICATIONS OF POSITIVE DISPLACEMENT MOTORS (continued)
(Moineau type)

Size (in)	Manufacturer	Type	No. of lobes	Flow rate (l/min)		Rotary speed (rpm)		Maximum operating torque (N.m)	Maximum operating pressure drop (kPa)	Operating horse-power output (kW)	Overall Length (m)	Hole size (in)
				Min.	Max.	Min.	Max.					
6 3/4	Anadrill Schlum.	A675M	1/2	757	1 893	180	465	1 790	3 447	87	7.19	8 3/8 to 9 7/8
6 3/4	Anadrill Schlum.	A675M	4/5	1 136	2 271	150	300	4 135	4 757	130	6.50	8 3/8 to 9 7/8
6 3/4	Anadrill Schlum.	A675XP	4/5	1 136	2 271	150	300	6 169	6 964	194	8.05	8 3/8 to 9 7/8
6 3/4	Anadrill Schlum.	A675M	7/8	1 136	2 271	86	165	4 000	3 378	69	5.89	8 3/8 to 9 7/8
6 3/4	Anadrill Schlum.	A675XP	7/8	1 136	2 271	86	170	7 457	5 585	133	7.67	8 3/8 to 9 7/8
6 3/4	Baker Hughes Inteq	M1X		1 003	2 498	90	220	3 647	4 400	84	7.00	8 3/8 to 9 7/8
6 3/4	Baker Hughes Inteq	M1XL		1 003	2 498	90	220	6 847	5 900	158	9.60	8 3/8 to 9 7/8
6 3/4	Baker Hughes Inteq	M2P/XL		1 003	2 006	235	470	3 593	7 900	177	9.60	8 3/8 to 9 7/8
6 3/4	Drilex	DIR675	9/10	1 136	2 461	85	185	6 101	2 600	118	4.00	7 7/8 to 9 7/8
6 3/4	Drilex	D675SS	9/10	757	2 461	55	185	8 135	3 400	158	6.25	7 7/8 to 10 5/8
6 3/4	Drilex	D675MS	6/7	757	1 514	159	318	3 254	4 300	108	7.53	7 7/8 to 10 5/8
6 3/4	Drilex	D675TPS	9/10	757	2 461	55	185	10 850	6 900	210	8.96	7 7/8 to 10 5/8
6 3/4	Halliburton	F2000S	5/6	946	1 704	95	170	5 694	4 100	101	7.30	8 3/8 to 9 7/8
6 3/4	Halliburton	F2000M	4/5	1 135	1 893	165	265	5 084	5 200	141	7.60	8 3/8 to 9 7/8
6 3/4	Halliburton	F2000MX	4/5	1 628	2 461	211	319	7 699	6 200	257	9.13	8 3/4 to 9 7/8
6 3/4	Halliburton	F2000S-tand	5/6	946	1 704	95	170	7 972	5 800	142	11.60	8 3/8 to 9 7/8
6 3/4	Halliburton	F2000M-tand	4/5	1 135	1 893	165	265	7 117	7 200	197	11.60	8 3/8 to 9 7/8
7 5/8	Drilex	DIR775	9/10	1 136	2 461	85	185	6 101	2 600	118	4.00	9 7/8 to 14 3/4
7 5/8	Drilex	D775SS	9/10	757	2 461	55	185	8 135	3 400	158	6.44	9 7/8 to 14 3/4
7 5/8	Drilex	D775TPS	9/10	757	2 461	55	185	10 850	6 900	210	8.96	9 7/8 to 14 3/4
7 3/4	Halliburton	D500	1/2	1 135	1 704	275	415	1 532	2 500	67	6.20	9 7/8 to 12 1/4
7 3/4	Halliburton	F2000S	7/8	1 136	2 271	90	185	10 305	4 700	164	7.00	9 7/8 to 12 1/4
7 3/4	Halliburton	F2000H	1/2	1 136	1 893	230	390	2 928	4 100	120	8.00	9 7/8 to 12 1/4
7 3/4	Halliburton	F2000S-tand	7/8	1 135	2 271	90	185	11 862	6 500	230	10.50	9 7/8 to 12 1/4
8	Anadrill Schlum.	A800M	1/2	1 136	2 271	210	420	2 304	3 447	101	7.87	9 7/8 to 14 3/4
8	Anadrill Schlum.	A800M	4/5	1 136	2 271	75	225	5 437	3 585	128	7.19	9 7/8 to 14 3/4
8	Anadrill Schlum.	A800XP	4/5	1 136	2 271	75	225	8 203	5 240	193	8.92	9 7/8 to 14 3/4
8	Anadrill Schlum.	A800M	7/8	1 136	2 271	48	145	6 101	3 309	93	7.19	9 7/8 to 14 3/4
8	Anadrill Schlum.	A800XP	7/8	1 136	2 271	48	145	8 813	4 482	134	8.41	9 7/8 to 14 3/4
8	Neyrfor Weir	VM7000	7/8	1 135	3 410	50	145	9 367	3 400	142	6.69	9 1/2 to 12 1/4
8	Neyrfor Weir	VM5000	1/2	1 135	2 270	210	420	2 487	3 400	109	7.38	9 1/2 to 12 1/4
8	Halliburton	F2000MX	5/6	2 271	3 407	149	223	13 825	6 200	323	9.13	9 7/8 to 12 1/4

l/min × 0.264 = gal/min   N.m × 0.738 = lb.ft   kPa × 0.145 = psi   kW × 1.34 = hp   m × 3.281 = ft

SPECIFICATIONS OF POSITIVE DISPLACEMENT MOTORS (continued)
(Moineau type)

Size (in)	Manufacturer	Type	No. of lobes	Flow rate (l/min)		Rotary speed (rpm)		Maximum operating torque (N.m)	Maximum operating pressure drop (kPa)	Operating horse-power output (kW)	Overall Length (m)	Hole size (in)
				Min.	Max.	Min.	Max.					
8 1/4	Drilex	D825SS	9/10	757	2 461	55	185	8 135	3 400	158	6.62	9 7/8 to 14 3/4
8 1/4	Drilex	D825HF	5/6	1 325	2 839	110	235	9 491	4 300	234	7.47	9 7/8 to 14 3/4
8 1/4	Halliburton	F2000S	5/6	1 893	3 028	115	180	8 950	4 100	169	7.50	9 7/8 to 12 1/4
8 1/4	Halliburton	F2000S-tand	7/8	1 135	2 271	90	185	11 682	6 500	226	10.50	9 7/8 to 12 1/4
9 1/2	Baker Hughes Inteq	M1XL		2 006	4 012	80	165	14 602	5 900	252	10.70	12 1/4 to 17 1/2
9 1/2	Drilex	D950	10/11	1 893	3 218	110	190	10 169	3 400	202	6.50	12 1/4 to 17 1/2
9 1/2	Drilex	D950MS	5/6	1 352	2 839	110	235	9 491	4 300	234	7.35	12 1/4 to 17 1/2
9 1/2	Drilex	D950HF	7/8	2 650	4 164	115	180	13 558	3 400	256	8.69	12 1/4 to 36
9 1/2	Neyrfor Weir	VM7000	5/6	2 270	4 540	67	134	12 916	3 100	181	8.94	12 1/4 to 26
9 1/2	Neyrfor Weir	VM7000	3/4	2 270	4 540	133	266	9 475	4 280	264	8.94	12 1/4 to 26
9 1/2	Neyrfor Weir	VM5000	1/2	1 495	3 028	200	400	4 500	4 150	188	9.84	12 1/4 to 17 1/2
9 5/8	Anadrill Schlum.	A962M	1/2	1 514	3 028	190	380	4 610	4 413	183	8.89	12 1/4 to 26
9 5/8	Anadrill Schlum.	A962M	3/4	2 271	4 542	133	266	8 813	4 309	245	8.00	12 1/4 to 26
9 5/8	Anadrill Schlum.	A962XP	3/4	2 271	4 542	133	266	11 253	5 688	313	9.27	12 1/4 to 26
9 5/8	Anadrill Schlum.	A962M	5/6	2 271	4 542	67	134	10 847	3 103	152	8.00	12 1/4 to 26
9 5/8	Anadrill Schlum.	A962XP	5/6	2 271	4 542	67	134	15 050	4 137	211	9.27	12 1/4 to 26
9 5/8	Halliburton	D500	1/2	1 514	2 650	215	375	2 623	2 500	103	7.70	12 1/4 to 17 1/2
9 5/8	Halliburton	F2000S	5/6	3 028	4 542	90	140	10 575	2 600	155	7.80	12 1/4 to 26
9 5/8	Halliburton	F2000M	5/6	2 271	3 407	115	170	10 539	4 100	188	7.80	12 1/4 to 26
9 5/8	Halliburton	F2000H	1/2	2 271	3 785	240	400	6 236	4 100	261	9.10	12 1/4 to 26
9 5/8	Halliburton	F2000MX	5/6	3 028	4 921	110	178	21 842	5 200	407	9.61	12 1/4 to 26
9 5/8	Halliburton	F2000M-tand	5/6	2 271	3 407	115	170	14 944	5 800	266	11.80	12 1/4 to 26
9 5/8	Halliburton	F2000S-tand+	5/6	3 028	4 542	90	140	21 150	5 200	310	13.90	12 1/4 to 26
11 1/4	Anadrill Schlum.	A1125M	3/4	3 785	5 678	115	170	13 558	3 378	241	8.84	17 1/2 to 26
11 1/4	Neyrfor Weir	VM7000	3/4	3 780	5 670	120	180	15 010	3 500	283	9.63	15 to 26
12	Halliburton	D500	1/2	3 028	4 542	125	188	8 677	2 500	171	10.10	17 1/2 to 26

l/min × 0.264 = gal/min N.m × 0.738 = lb.ft kPa × 0.145 = psi kW × 1.34 = hp m × 3.281 = ft

F

hoisting and derrick floor equipment

HOISTING MECHANICS
Reeving function

F = hook load (t)
N = number of lines
t = dead line tension (t)
t_a = fast line tension (t)

$$t = \frac{F}{N}$$

in static conditions: $t_a = t$

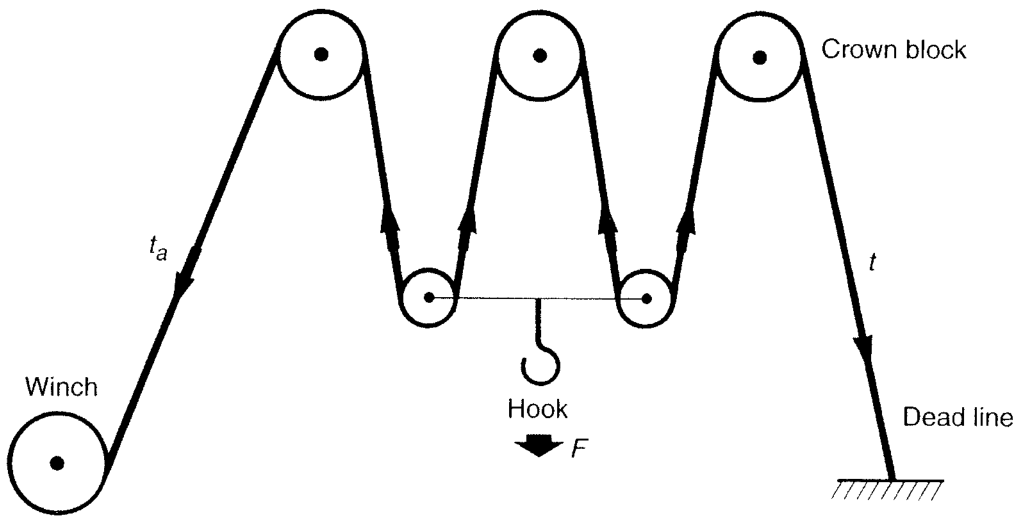
in dynamic conditions: $t_a = \dfrac{t}{\eta_m}$

η_m = reeving efficiency (see F 3)
V_c = hook speed (m/s)
V_t = fast line speed (m/s)

$$V_t = V_c N$$

R = winch speed of rotation (rpm)
D = winch spooling diameter (m)

$$R = \frac{60\,V_t}{\pi D}$$



HOISTING MECHANICS
Power

I POWER DEVELOPED AT HOOK

$$P_c = FV_c$$

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

$$P_t = t_a V_t$$

P_t = winch power (W)
t_a = fast line tension (N)
V_t = fast line speed (m/s)
t = dead line tension (N)

$$P_t = \frac{t}{\eta_m} V_c N = \frac{FV_c}{\eta_m}$$

$$P_t = \frac{FV_c}{\eta_m}$$

F = hook load (N)
V_c = hook speed (m/s)
η_m = reeving efficiency

III TORQUE CONSUMPTION AT WINCH

$$M = \frac{P_t}{R}$$

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, May 30, 1986)

I DEFINITION OF FACTOR OF SAFETY

$$f = \frac{T}{t_a}$$

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

$$t_a = \frac{F}{N\eta_m}$$

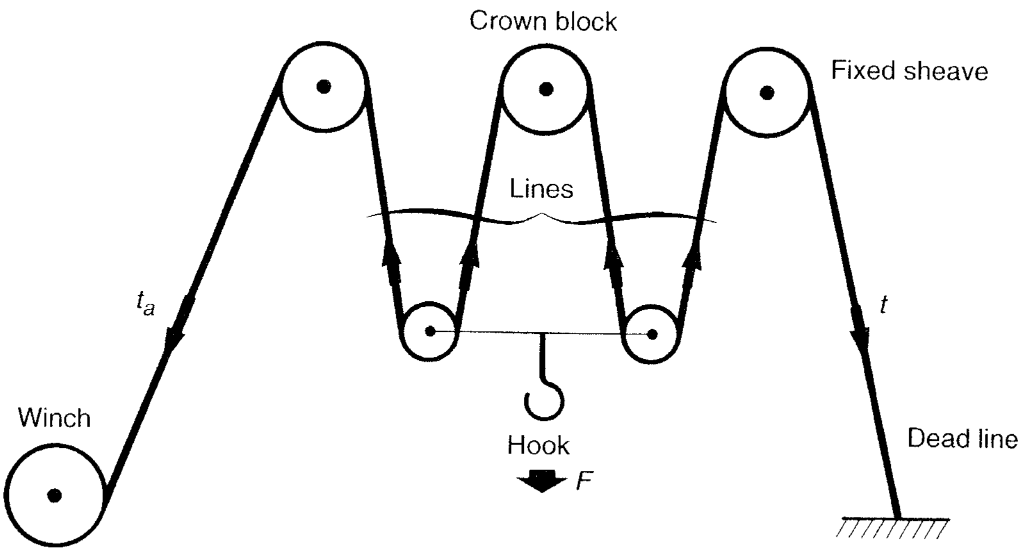
F = hook load (t)
t_a = fast line tension (t)
N = number of lines
η_m = reeving efficiency

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

$$\eta_m = \frac{K^N - 1}{N(K-1)K^N}$$

API WIRE ROPE (continued)
Factor of safety (RP 9B, May 30, 1986)



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.

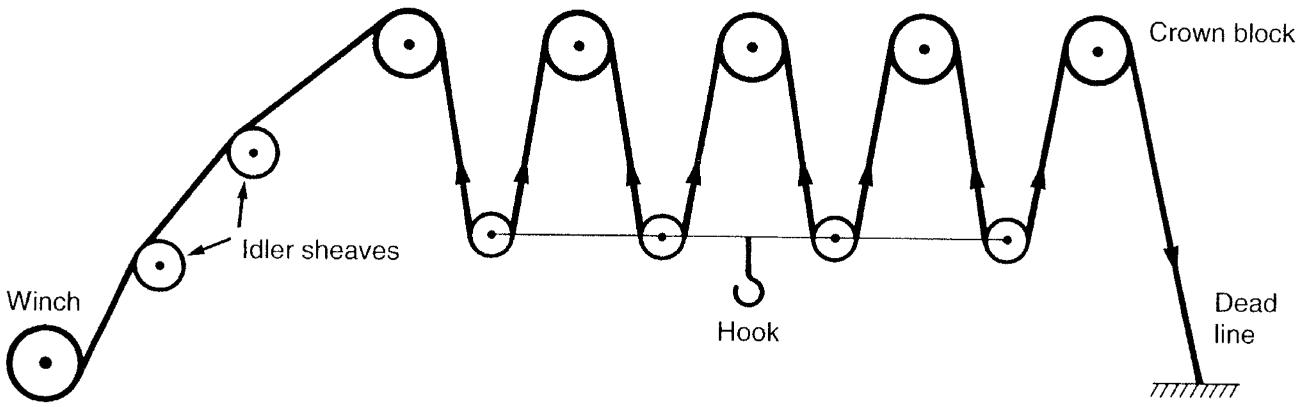
The sheaves have bearings, thus $K = 1.04$ or sheave efficiency η_P:

$$\eta_P = \frac{1}{1.04}$$

$$t_a = \frac{P}{N \times \eta_m} = \frac{150}{8 \times 0.842} = 22.27 \text{ t}$$

$$f = \frac{T}{t_a} = \frac{72.5}{22.27} = 3.26$$

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:



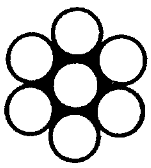
$t_a = 22.27 \times 1.04 \times 1.04 = 24$ t. The factor of safety becomes: $\frac{72.5}{24} = 3.01$.

API WIRE ROPE

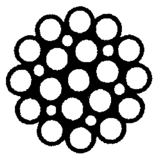
I DEFINITIONS AND USUAL ABBREVIATIONS

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) right 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

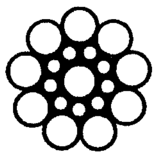
II TYPICAL STRAND CONSTRUCTION



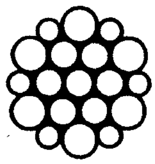
SINGLE LAYER
e.g. strand 1-6



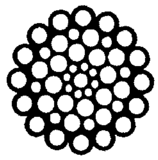
FILLER WIRE
Inner layer contains filling wires
e.g. : 1-6-6f-12
Filler wires



SEALE
Two layers with the same number of wires
e.g. : 1-9-9

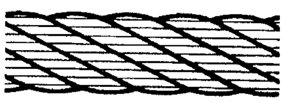


WARRINGTON
Two layers with wires of the same diameter
The outside layer contains filler wires
e.g. : 1-6-(6 + 6)

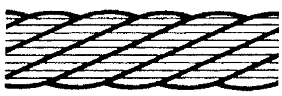


MIXED WARRINGTON-SEALE
The first two layers are Warrington and the last two Seale
e.g. : 1-5-(5 + 5)-10

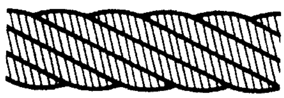
III DIFFERENT KINDS OF WIRE ROPE TWISTING



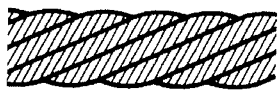
Right lay
Regular lay



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 x 19 S or 6 x 21 S or 6 x 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	6 x 26 WS or 6 x 31 WS, PF, RL, IPS or EIPS, IWRC
	7/8 to 1 1/8 incl.	6 x 36 WS, PF, RL, IPS or EIPS, IWRC
Horsehead pumping. Unit lines:		
Shallow	1/2 to 1 1/8 incl. (4)	6 x 19 Class or 6 x 37 Class or 19 x 7 PF, IPS, FC or IWRC
Intermediate	5/8 to 1 1/8 incl. (3)	6 x 19 Class or 6 x 37 Class, PF, IPS, FC or IWRC
Offshore anchorage lines	7/8 to 2 3/4 incl.	6 x 19 Class, Bright or Galv., PF, RL, IPS or EIPS, IWRC
	1 3/8 to 4 3/4 incl.	6 x 37 Class, Bright or Galv., PF, RL, IPS or EIPS, IWRC
	3 3/4 to 4 3/4 incl.	6 x 61 Class, Bright or Galv., PF, RL, IPS or EIPS, IWRC
Mast raising lines (5)	1 3/8 and smaller	6 x 19 Class, PF, RL, IPS or EIPS, IWRC
	1 1/2 and larger	6 x 37 Class, PF, RL, IPS or EIPS, IWRC
Guideline tensioner line	3/4	6 x 25 FW, PF, RL, IPS or EIPS, IWRC
Riser tensioner lines	1 1/2, 2	(Lang lay): 6 x 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 wertical lines (parallel) with sockets at both ends of each lines.
(5) See API Spec 4E

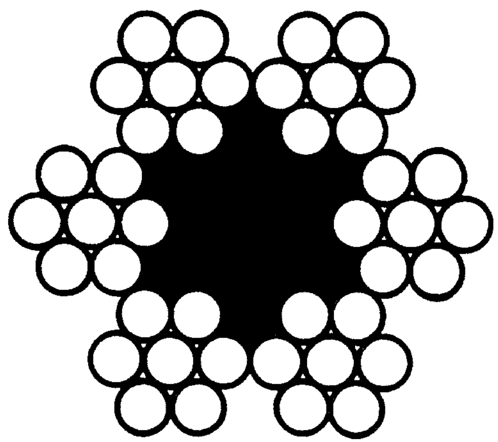
API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE

Class 6 × 7. Fiber Core (FC)

(API Spec 9A, 24th edition, June 1, 1995)

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	45.7	4.6	11 720	53	5.3
7/16	14.5	0.29	0.43	13 800	61.9	6.3	15 860	71	7.2
1/2	12.7	0.38	0.57	17 920	80.3	8.1	20 600	92	9.3
9/16	14.3	0.48	0.71	22 600	101.3	10.3	26 000	117	11.8
5/8	15.9	0.59	0.88	27 800	124.6	12.6	31 800	143	14.4
3/4	19.1	0.84	1.25	39 600	177.5	18.0	45 400	203	20.6
7/8	22.2	1.15	1.71	53 400	239.3	24.2	61 400	275	27.9
1	25.4	1.50	2.23	69 000	309.3	31.3	79 400	356	36.0

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.



Rope configuration 6 x 7

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Classes 6 × 19 and 6 × 37. Fiber Core (FC)

(API Spec 9A, 24th edition, June 1, 1995)

Nominal diameter		Approximate weight		Breaking strength								
				Plow Steel (PS)			Improved Plow Steel (IPS)			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.42	0.63	18 700	84	8.5	21 400	96	9.7	23 600	105	10.7
9/16	14.5	0.53	0.79	23 600	106	10.7	27 000	121	12.2	29 800	132	13.5
5/8	15.9	0.66	0.98	29 000	130	13.2	33 400	150	15.2	36 600	163	16.6
3/4	19.1	0.95	1.41	41 400	186	18.8	47 600	213	21.6	52 400	233	23.8
7/8	22.2	1.29	1.92	56 000	251	25.4	64 400	289	29.2	70 800	315	32.1
1	25.4	1.68	2.50	72 800	326	33.0	83 600	375	37.9	92 000	409	41.7
1 1/8	28.6	2.13	3.17	91 400	410	41.5	105 200	472	47.7	115 600	514	52.4
1 1/4	31.8	2.63	3.91	112 400	504	51.0	129 200	579	58.6	142 200	632	64.5
1 3/8	34.9	3.18	4.73				155 400	697	70.5	171 000	760	77.6
1 1/2	38.1	3.78	5.63				184 000	825	83.5	202 000	898	91.6
1 5/8	41.3	4.44	6.61				214 000	959	97.1	236 000	1050	107.0
1 3/4	44.5	5.15	7.66				248 000	1112	112.5	274 000	1220	124.0
1 7/8	47.6	5.91	8.80				282 000	1264	127.9	312 000	1390	142.0
2	50.8	6.72	10.00				320 000	1434	145.2	352 000	1560	160.0

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 Rope Core (IWRC) (API Spec 9A, 24th edition, June 1, 1995)

Nominal diameter		Approximate weight		Breaking strength								
				Improved Plow Steel			Extra Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.46	0.68	23 000	103	10.4	26 600	119	12.1	29 200	131	13.2
9/16	14.3	0.59	0.88	29 000	130	13.2	33 600	151	15.2	37 000	166	16.8
5/8	15.9	0.72	1.07	35 800	160	16.2	41 200	185	18.7	45 400	203	20.6
3/4	19.1	1.04	1.55	51 200	229	23.2	58 800	264	26.7	64 800	290	29.4
7/8	22.2	1.42	2.11	69 200	310	31.4	79 600	357	36.1	87 600	393	39.7
1	25.4	1.85	2.75	89 800	403	40.7	103 400	463	46.9	113 800	510	51.6
1 1/8	28.6	2.34	3.48	113 000	506	51.3	130 000	583	59.0	143 000	641	64.9
1 1/4	31.8	2.89	4.30	138 800	622	63.0	159 800	716	72.5	175 800	788	79.7
1 3/8	34.9	3.50	5.21	167 000	749	75.8	192 000	861	87.1	212 000	950	96.2
1 1/2	38.1	4.16	6.19	197 800	887	89.7	228 000	1 022	103.0	250 000	1 121	113.0
1 5/8	41.3	4.88	7.26	230 000	1 031	104.0	264 000	1 183	120.0	292 000	1 309	132.0
1 3/4	44.5	5.67	8.44	266 000	1 192	121.0	306 000	1 372	139.0	338 000	1 515	153.0
1 7/8	47.6	6.50	9.67	304 000	1 363	138.0	348 000	1 560	158.0	384 000	1 721	174.0
2	50.8	7.39	11.00	344 000	1 542	156.0	396 000	1 775	180.0	434 000	1 945	197.0

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.

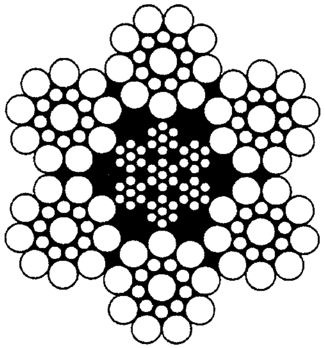
API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)
Class 6 × 37. Independent Wire Rope Core (IWRC) (API Spec 9A, 24th edition, June 1, 1995)

Nominal diameter		Approximate weight		Breaking strength								
				Improved Plow Steel			Extra Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.46	0.68	23 000	103	10.4	26 000	117	11.8	29 200	131	13.2
9/16	14.3	0.59	0.88	29 000	130	13.2	33 600	151	15.2	37 000	166	16.8
5/8	15.9	0.72	1.07	35 800	160	16.2	41 200	185	18.7	45 400	203	20.6
3/4	19.1	1.04	1.55	51 200	229	23.2	58 800	264	26.7	64 800	290	29.4
7/8	22.2	1.42	2.11	69 200	310	31.4	79 600	357	36.1	87 600	393	39.7
1	25.4	1.85	2.75	89 800	403	40.7	103 400	463	46.9	113 800	510	51.6
1 1/8	28.6	2.34	3.48	113 000	506	51.3	130 000	583	59.0	143 000	641	64.9
1 1/4	31.8	2.89	4.30	138 800	622	63.0	159 800	716	72.5	175 800	788	79.7
1 3/8	34.9	3.50	5.21	167 000	749	75.8	192 000	861	87.1	212 000	950	96.2
1 1/2	38.1	4.16	6.19	197 800	887	89.7	228 000	1 022	103.0	250 000	1 121	113.0
1 5/8	41.3	4.88	7.26	230 000	1 031	104.0	264 000	1 183	120.0	292 000	1 309	132.0
1 3/4	44.5	5.67	8.44	266 000	1 192	121.0	306 000	1 372	139.0	338 000	1 515	153.0
1 7/8	47.6	6.50	9.67	304 000	1 363	138.0	348 000	1 560	158.0	384 000	1 721	174.0
2	50.8	7.39	11.00	344 000	1 542	156.0	396 000	1 775	180.0	434 000	1 945	197.0
2 1/8	54.0	8.35	12.43	384 000	1 721	174.0	442 000	1 981	200.0	488 000	2 187	221.0
2 1/4	57.2	9.36	13.93	430 000	1 927	195.0	494 000	2 214	224.0	544 000	2 438	247.0
2 3/8	60.3	10.40	15.48	478 000	2 142	217.0	548 000	2 456	249.0	604 000	2 707	274.0
2 1/2	63.5	11.60	17.26	524 000	2 349	238.0	604 000	2 707	274.0	664 000	2 976	301.0
2 5/8	66.7	12.80	19.05	576 000	2 582	261.0	658 000	2 949	298.0	728 000	3 263	330.0
2 3/4	69.9	14.00	20.83	628 000	2 815	285.0	736 000	3 299	334.0	794 000	3 559	360.0
2 7/8	73.0	15.30	22.77	682 000	3 057	309.0	796 000	3 568	361.0	864 000	3 873	392.0
3	76.2	16.60	24.70	740 000	3 317	336.0	856 000	3 837	388.0	936 000	4 195	425.0
3 1/8	79.4	18.00	26.79	798 000	3 577	362.0	920 000	4 124	417.0	1 010 000	4 527	458.0
3 1/4	82.6	19.50	29.02	858 000	3 846	389.0	984 000	4 410	446.0	1 086 000	4 868	493.0
3 3/8	85.7	21.00	31.25	918 000	4 115	416.0	1 074 000	4 814	487.0	1 164 000	5 217	528.0
3 1/2	88.9	22.70	33.78	982 000	4 402	445.0	1 144 000	5 128	519.0	1 242 000	5 567	563.0
3 3/4	95.3	26.00	38.69	1 114 000	4 993	505.0	1 290 000	5 782	585.0	1 410 000	6 320	640.0
4	101.6	29.60	44.05	1 254 000	5 621	569.0	1 466 000	6 571	665.0	1 586 000	7 109	719.0

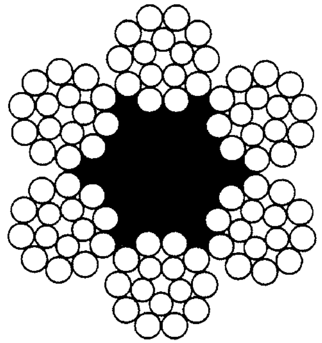
Note: The strength of galvanized wire rope is 10% less than the figures given in this table.

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

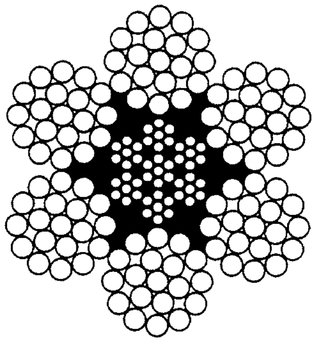
Configurations (API Spec 9A, 24th edition, June 1, 1995)



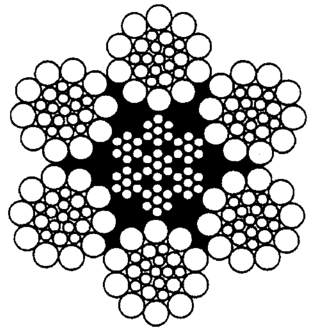
6 x 19 Seale IWRC



6 x 21 Filler Wire FC



6 x 25 Filler Wire IWRC

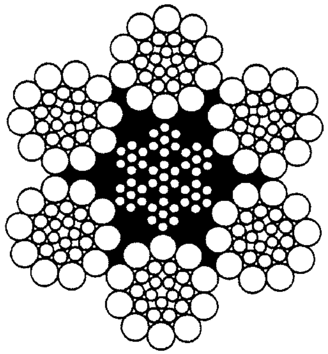


6 x 26 Warrington Seale IWRC

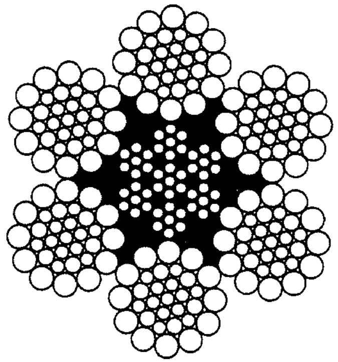
Classification 6 × 19

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

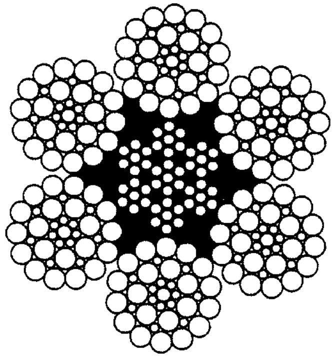
Configurations (API Spec 9A, 24th edition, June 1, 1995)



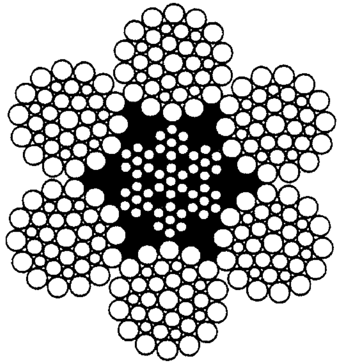
6 x 31 Filler
Wire Seale IWRC



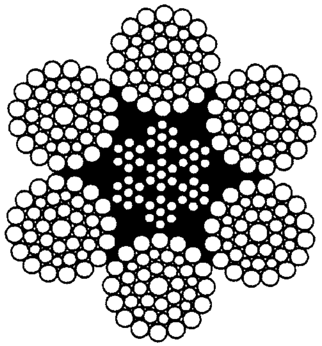
6 x 31
Warrington Seale IWRC



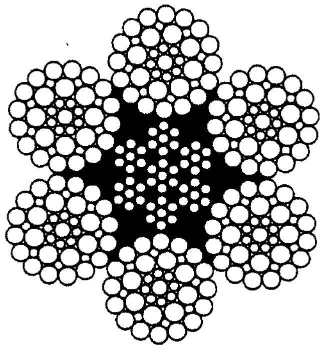
6 x 36 Seale
Filler Wire IWRC



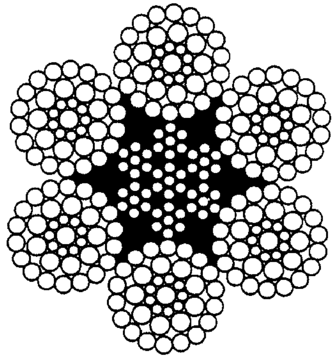
6 x 36
Warrington Seale IWRC



6 x 41
Warrington Seale IWRC



6 x 41 Seale
Filler Wire IWRC



6 x 46 Seale
Filler Wire IWRC

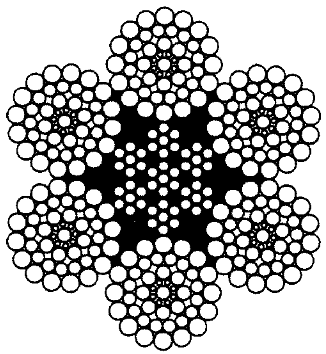
Classification 6 × 37

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

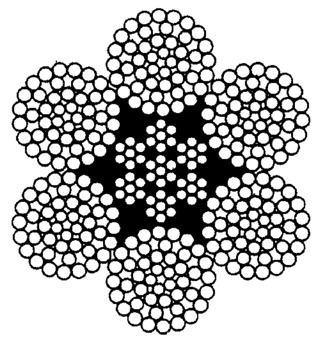
Class 6 × 61. Independent Wire Rope Core (IWRC) (API Spec 9A, 24th edition, June 1, 1995)

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	22.70	33.78	966	4 330	438	1 110	4 975	503
3 3/4	95.3	26.00	38.69	1 098	4 921	498	1 264	5 666	573
4	101.6	29.60	44.05	1 240	5 558	562	1 426	6 392	647
4 1/4	108.0	33.30	49.56	1 388	6 221	630	1 598	7 163	725
4 1/2	114.3	37.40	55.66	1 544	6 921	700	1 776	7 960	806
4 3/4	120.7	41.70	62.06	1 706	7 647	774	1 962	8 794	890
5	127.0	46.20	68.75	1 874	8 400	850	2 156	9 664	978

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.



6 x 57
Seale Filler Wire IWRC



6 x 61
Filler Wire Warrington Seale IWRC

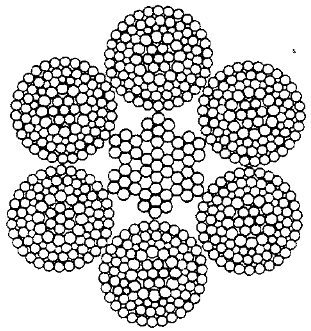
Classification 6 × 61

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

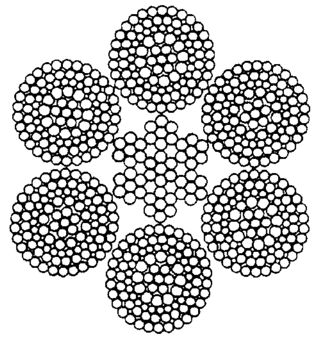
Class 6 × 91. Independent Wire Rope Core (IWRC) (API Spec 9A, 24th edition, June 1, 1995)

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	44.0	1 178	5 280	534	1 354	6 069	614
4 1/4	108.0	33.3	49.6	1 320	5 917	599	1 518	6 804	689
4 1/2	114.3	37.4	55.7	1 468	6 580	666	1 688	7 566	766
4 3/4	120.7	41.7	62.1	1 620	7 261	735	1 864	8 355	846
5	127.0	46.2	68.8	1 782	7 987	808	2 048	9 180	929
5 1/4	133.4	49.8	74.1	1 948	8 731	884	2 240	10 040	1 016
5 1/2	139.7	54.5	81.1	2 120	9 502	962	2 438	10 928	1 106
5 3/4	146.1	59.6	88.7	2 296	10 291	1 041	2 640	11 833	1 198
6	152.4	65.0	96.7	2 480	11 116	1 125	2 852	12 783	1 294

Note: The strength of galvanized wire rope is 10% less than the figures given in this table.



6 x 91
independant wire-rope core



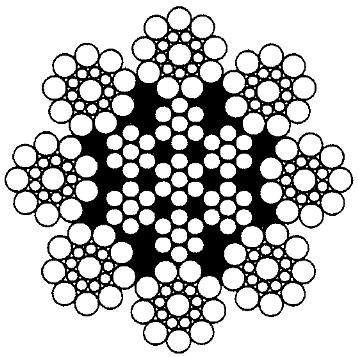
6 x 103
independant wire-rope core

Classification 6 × 91

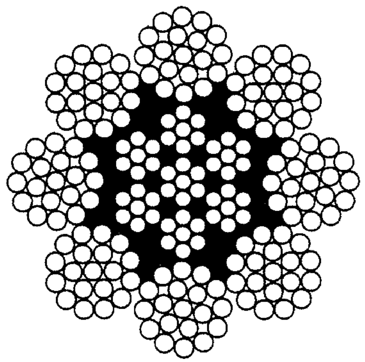
API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Class 8 × 19. Independent Wire Rope Core (IWRC) (API Spec 9A, 24th edition, June 1, 1995)

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	91	9.2	23 400	105	10.6
9/16	14.3	0.60	0.89	25 600	115	11.6	29 400	132	13.3
5/8	15.9	0.73	1.09	31 400	141	14.2	36 200	162	16.4
3/4	19.1	1.06	1.58	45 000	202	20.4	51 800	232	23.5
7/8	22.2	1.44	2.14	61 000	273	27.7	70 000	314	31.8
1	25.4	1.88	2.80	79 200	355	35.9	91 000	408	41.3
1 1/8	28.6	2.39	3.56	99 600	446	45.2	114 600	514	52.0



8 x 19
Seale IWRC



8 x 25
Filler Wire IWRC

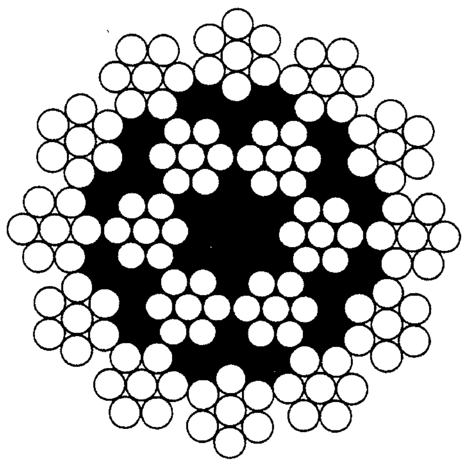
Classification 8 × 19

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)

Class 18 × 7. Fiber Core (FC)

(API Spec 9A, 24th edition, June 1, 1995)

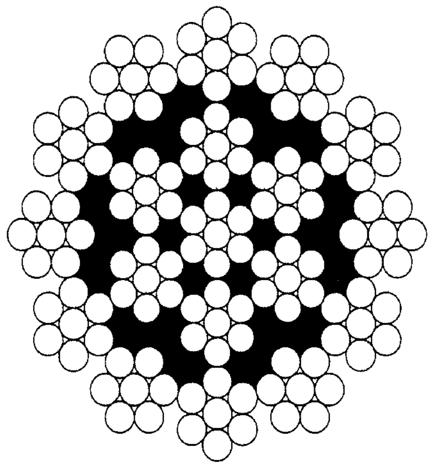
Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.43	0.64	19 700	88	8.9	21 600	97	9.8
9/16	14.3	0.55	0.82	24 800	111	11.2	27 200	122	12.3
5/8	15.9	0.68	1.01	30 600	137	13.9	33 600	151	15.2
3/4	19.1	0.97	1.44	43 600	195	19.8	48 000	215	21.8
7/8	22.2	1.32	1.96	59 000	264	26.8	65 000	291	29.5
1	25.4	1.73	2.57	76 600	343	34.7	84 400	378	38.3
1 1/8	28.6	2.19	3.26	96 400	432	43.7	106 200	476	48.2
1 1/4	31.8	2.70	4.02	118 400	531	53.7	130 200	584	59.1
1 3/8	34.9	3.27	4.87	142 600	639	64.7	156 800	703	71.1
1 1/2	38.1	3.89	5.79	168 800	757	76.6	185 600	832	84.2



18 x 7 Fiber Core

API CLASSIFICATION OF BRIGHT (UNCOATED) OR DRAWN GALVANIZED WIRE ROPE (continued)
Class 19 × 7. Metal Core
(API Spec 9A, 24th edition, June 1, 1995)

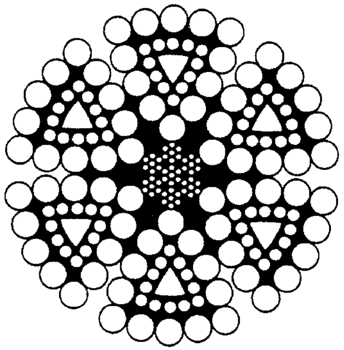
Nominal diameter		Approximate weight		Breaking strength					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t)	(lb)	(kN)	(t)
1/2	12.7	0.45	0.67	19 700	88	8.9	21 600	97	9.8
9/16	14.3	0.58	0.86	24 800	111	11.2	27 200	122	12.3
5/8	15.9	0.71	1.06	30 600	137	13.9	33 600	151	15.2
3/4	19.1	1.02	1.52	43 600	195	19.8	48 000	215	21.8
7/8	22.2	1.39	2.07	59 000	264	26.8	65 000	291	29.5
1	25.4	1.82	2.71	76 600	343	34.7	84 400	378	38.3
1 1/8	28.6	2.30	3.42	96 400	432	43.7	106 200	476	48.2
1 1/4	31.8	2.84	4.23	118 400	531	53.7	130 200	584	59.1
1 3/8	34.9	3.43	5.10	142 600	639	64.7	156 800	703	71.1
1 1/2	38.1	4.08	6.07	168 800	757	76.6	185 600	832	84.2



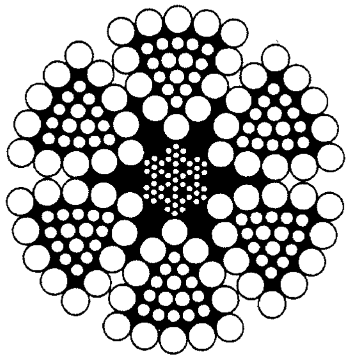
19× 7

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"
(API Spec 9A, 24th edition, June 1, 1995)

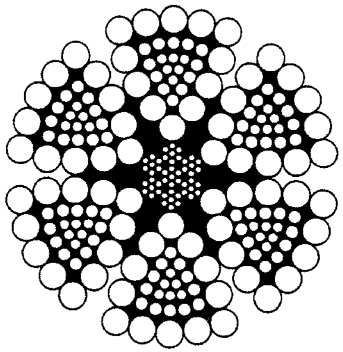
Nominal diameter		Approximate weight		Typical nominal strength*					
				Improved Plow Steel			Extra Improved Plow Steel		
(in)	(mm)	(lb/ft)	(kg/m)	(lb)	(kN)	(t^3)	(lb)	(kN)	(t^3)
1/2	13.0	0.47	0.70	25 400	113	11.5	28 000	125	12.7
9/16	14.3	0.60	0.89	32 000	142	14.5	35 200	157	16.0
5/8	16.0	0.74	1.10	39 400	175	17.9	43 400	193	19.7
3/4	19.0	1.06	1.58	56 400	251	25.6	62 000	276	28.1
7/8	22.0	1.46	2.17	76 000	330	34.5	83 800	373	38.0
1	25.0	1.89	2.81	98 800	439	44.8	108 800	484	49.3
1 1/8	29.0	2.39	3.56	124 400	553	56.4	137 000	609	62.1
1 1/4	32.0	2.95	4.39	152 600	679	69.2	168 000	747	76.2
1 3/8	35.0	3.57	5.31	183 600	817	83.3	202 000	898	91.6
1 1/2	38.0	4.25	6.32	216 000	961	98.0	238 000	1 060	108.0
1 5/8	41.0	4.99	7.43	254 000	1 130	115.0	280 000	1 250	127.0
1 3/4	44.0	5.74	8.54	292 000	1 300	132.0	322 000	1 430	146.0
1 7/8	48.0	6.65	9.90	334 000	1 490	151.0	368 000	1 640	167.0
2	51.0	7.56	11.25	378 000	1 680	172.0	414 000	1 840	188.0



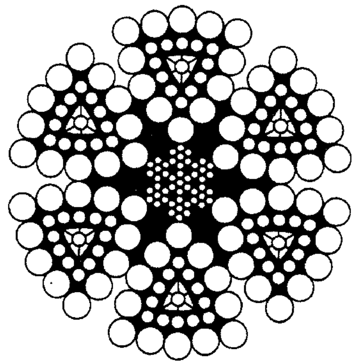
6 x 25 Style B
Flattened Strand IWRC



6 x 27 Style H
Flattened Strand IWRC



6 x 30 Style G
Flattened Strand IWRC



6 x 31 Style V
Flattened Strand IWRC

Flattened strand constructions

API WIRE ROPE
Sheave sizes (API RP 9B, May 30, 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	Service factor F Conditions B
6 × 17	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.

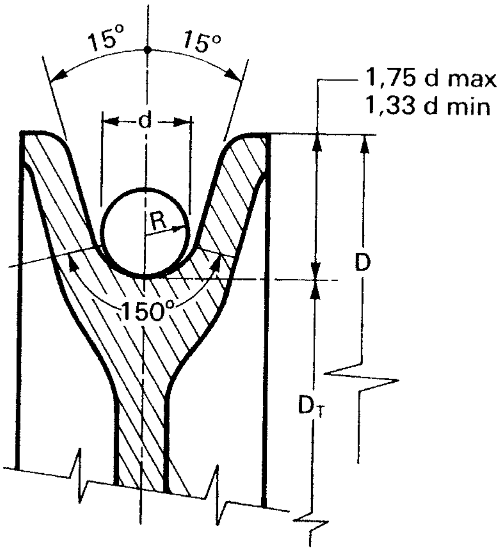
Example: with a 6 × 19 wire rope, diameter 1 1/4 inches, in condition A:

$D_T = 1.25 \times 51 = 63.75$ in
$= 1620$ mm

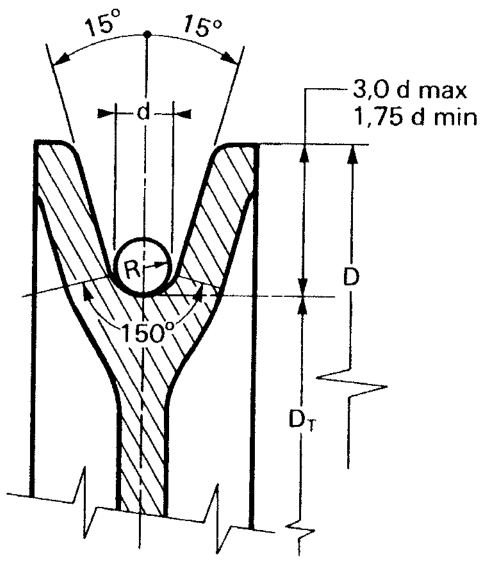
In condition B: $D_T = 953$ mm
$= 37.50$ in

SHEAVE GROOVES
(API Spec 8A, 12th edition, June 1, 1992)

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:

$$T_m = 0.981\left[pL(L+\ell)+4L\left(P+\frac{d}{2}\right)\right]10^{-6}$$

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 drill pipes 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:

$$T_f = 3\ T_{m1}$$

To drill from depth L_1 to depth L_2:

$$T_{f1-2} = 3\ [T_{m2} - T_{m1}]$$

III CORING OPERATION

Between depth L_1 and depth L_2:

$$T_{c1-2} = 2\ [T_{m2} - T_{m1}]$$

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 drill pipes 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 = 15 432 kg.

$$T_m = 0.981\left[25.53\times 400(400+27)+4\times 400\left(8000+\frac{15\,432}{2}\right)\right]10^{-6}$$

$$T_m = 28.9\ \ 10^3\ \text{daN.km}$$

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, 9th edition, May 30, 1986)

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, 9th edition, May 30, 1986)

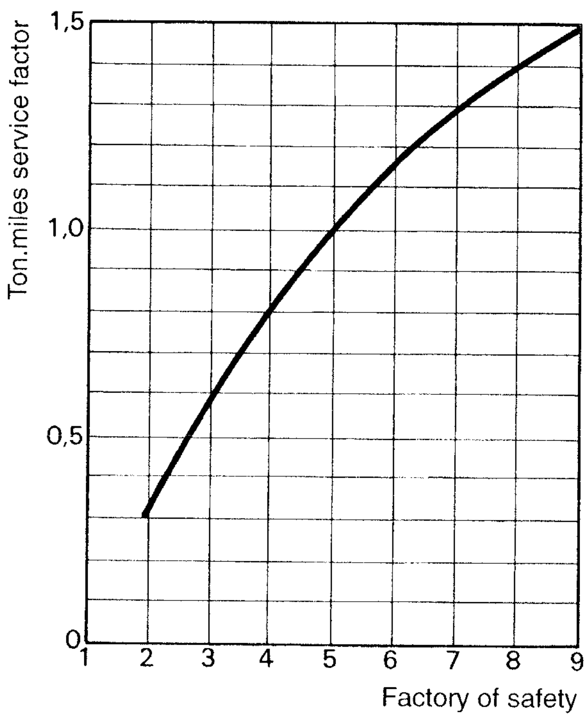
Derrick or mast height (ft)	Drilling difficulties	Total work of drilling line before first cutoff, fonction of line diameter									
		1″		1 1/8″		1 1/4″		1 3/8″		1 1/2″	
		10^3 daN.km	ton. mile	10^3 daN.km	ton. mile	10^3 daN.km	ton. mile	10^3 daN.km	ton. mile	10^3 daN.km	ton. mile
80 to 87	Very hard Hard Medium Low	716 716 716 859	500 500 500 600								
94 to 100	Very hard Hard Medium Low	716 716 716 859	500 500 500 600	859 1003 1146 1289	600 700 800 900						
126 to 131	Very hard Hard Medium Low			859 1003 1146 1289	600 700 800 900	1432 1575 1719 1862	1000 1100 1200 1300				
133 to 138	Very hard Hard Medium Low			859 1003 1146 1289	600 700 800 900	1432 1575 1719 1862	1000 1100 1200 1300				
142 to 147	Very hard Hard Medium Low					1432 1575 1719 1862	1000 1100 1200 1300	2292 2578 2864 3008	1600 1800 2000 2100		
187 to 189	Very hard Hard Medium Low							2292 2578 2864 3008	1600 1800 2000 2100	2864 3150 3437 3724	2000 2200 2400 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 F 23 *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 a drum or reel is:

$$(A + D) \times A \times B \times K$$

where:

$$A = \frac{H - D}{2} \text{ (cm)}$$

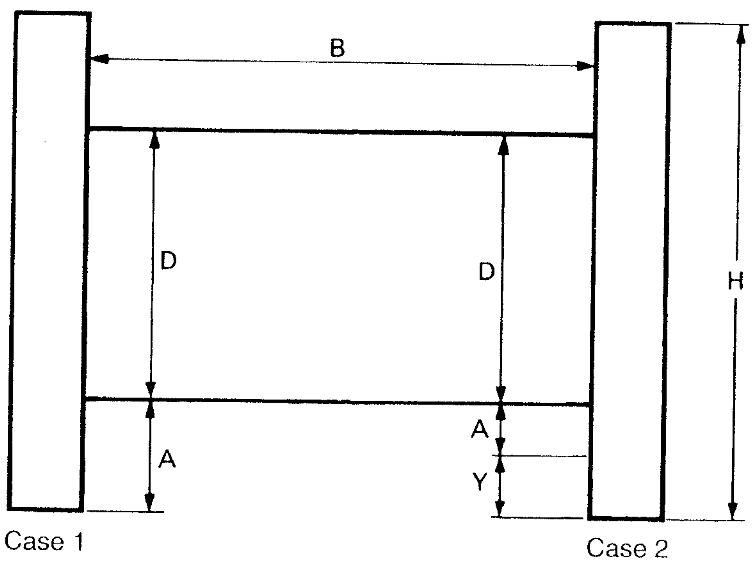
D = diameter of drum barrel (cm)
H = diameter of drum flanges (cm)
K = factor depending on the wire rope diameter selected
B = distance between flanges (cm)

- 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

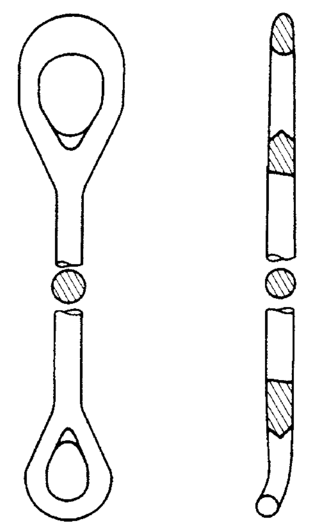
Nominal rope diameter (in)	Factor K	Nominal rope diameter (in)	Factor K	Nominal rope diameter (in)	Factor K
3/8	0.02939	13/16	0.00658	1 5/8	0.00165
7/16	0.02214	7/8	0.00573	1 3/4	0.00143
1/2	0.01721	1	0.00445	1 7/8	0.00126
9/16	0.01378	1 1/8	0.00355	2	0.00111
5/8	0.01129	1 1/4	0.00283	2 1/8	0.00099
11/16	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

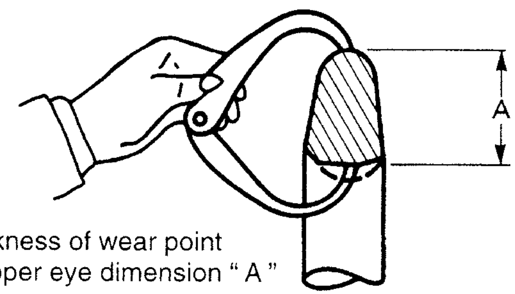


ELEVATOR LINK ARMS
Remaining capacities of worn link arms

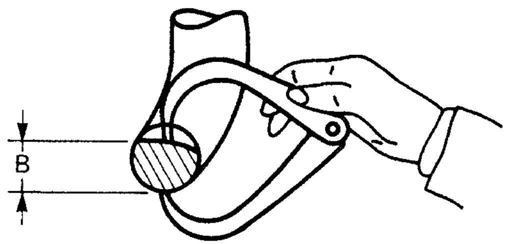
Dimensions and nominal capacity of link arms (per set)

		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	53/16
	(mm)	88.9	85.7	82.6	79.4	127.0	120.7	117.5	114.3	127.0	120.7	117.5	114.3	152.4	142.9	133.4	131.8
Dimension B	(in)	1 3/4	1 5/8	19/16	1 1/2	2 1/4	2 1/8	21/16	2	2 3/4	2 5/8	2 1/2	27/16	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 "



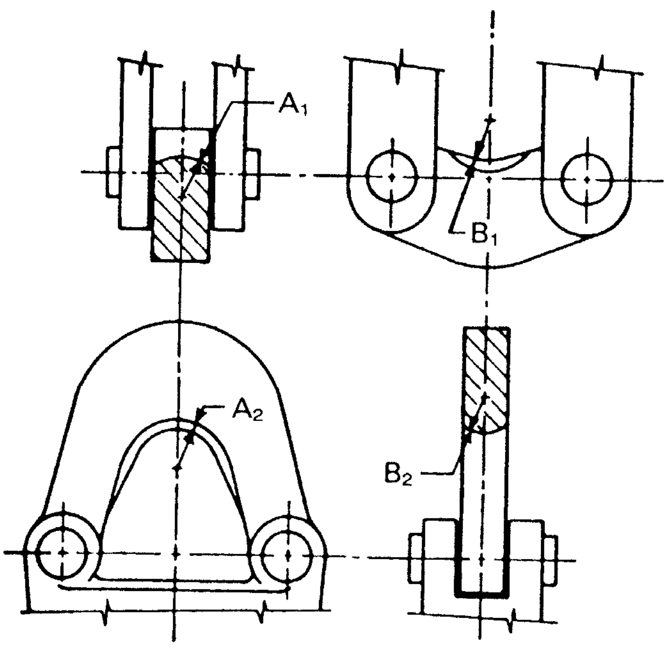
Thickness of wear point
in lower eye dimension " B "

Note: The nominal size of elevator link arms is the thickness at point B.
Capacity of set is that of weakest eye.

RECOMMENDED HOISTING TOOL CONTACT SURFACE RADII (API Spec 8A, 12th edition, June 1, 1992)

Capacity		Travelling block and hook bail							
		A_1 max.		A_2 min.		B_1 min.		B_2 max.	
(short tons)	(10^3 daN)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
25–40	22–36	2 3/4	69.9	2 3/4	69.9	3 1/4	82.6	3	76.2
41–65	36–57	2 3/4	69.9	2 3/4	69.9	3 1/4	82.6	3	76.2
66–100	57–89	2 3/4	69.9	2 3/4	69.9	3 1/4	82.6	3	76.2
101–150	89–133	2 3/4	69.9	2 3/4	69.9	3 1/4	82.6	3	76.2
151–250	133–222	4	101.6	4	101.6	3 1/4	82.6	3	76.2
251–350	222–312	4	101.6	4	101.6	3 1/4	82.6	3	76.2
351–500	312–445	4	101.6	4	101.6	3 1/2	88.9	3 1/4	82.6
501–650	445–578	4	101.6	4	101.6	3 1/2	88.9	3 1/4	82.6
651–750	578–667	6	152.4	6	152.4	3 1/2	88.9	3 1/4	82.6
751–1000	667–890	6	152.4	6	152.4	6 1/4	158.8	6	152.4

Travelling block

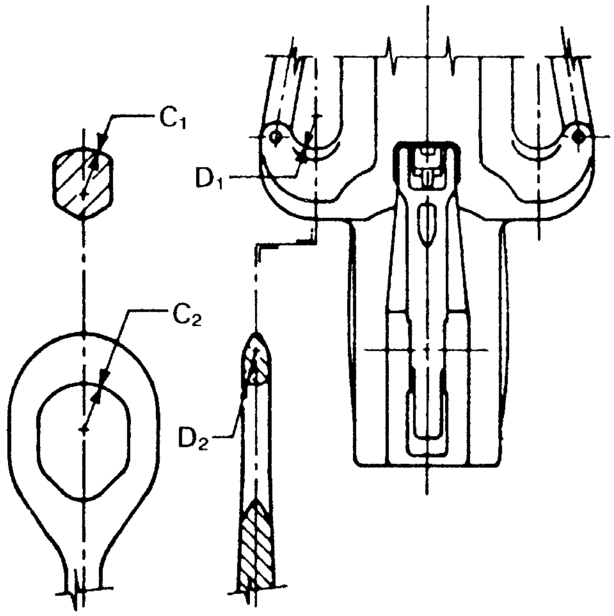


Hook bail

RECOMMENDED HOISTING TOOL CONTACT SURFACE RADII (continued) (API Spec 8A, 12th edition, June 1, 1992)

Capacity		Elevator link and hook link ear							
		C_1 max.		C_2 min.		D_1 min.		D_2 max.	
(short 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

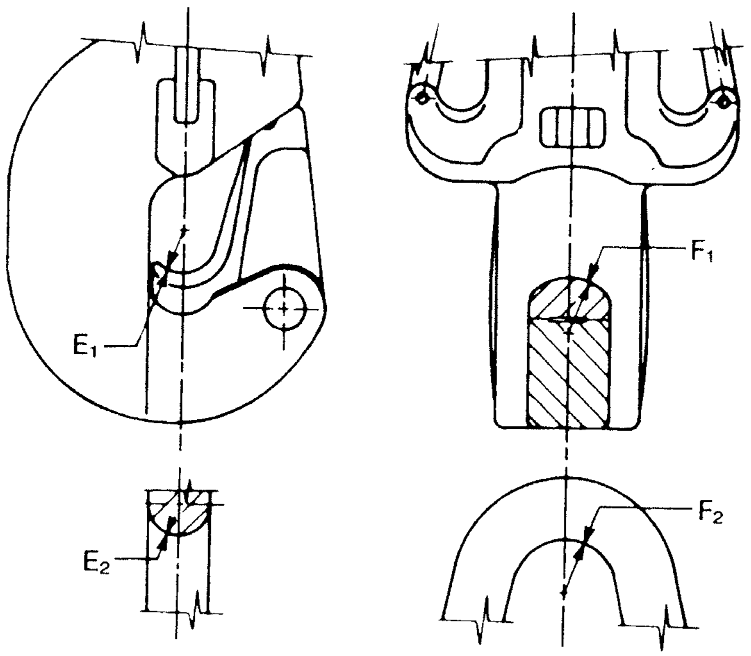


Elevator links

RECOMMENDED HOISTING TOOL CONTACT SURFACE RADII (continued) (API Spec 8A, 12th edition, June 1, 1992)

Capacity		Hook and swivel bail							
		E_1 max.		E_2 min.		F_1 min.		F_2 max.	
(short 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	44.5	3 1/2	88.9	3 1/2	88.9
66–100	57–89	2 1/4	57.2	2	50.8	4	101.6	4	101.6
101–150	89–133	2 1/2	63.5	2 1/4	57.2	4 1/2	114.3	4 1/2	114.3
151–250	133–222	2 3/4	69.9	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	69.9	4 1/2	114.3	4 1/2	114.3
351–500	312–445	3 1/2	88.9	3 1/4	82.6	4 1/2	114.3	4 1/2	114.3
501–650	445–578	3 1/2	88.9	3 1/4	82.6	4 1/2	114.3	4 1/2	114.3
651–750	578–667	4 1/4	108.0	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

DRILL PIPE ELEVATOR BORES
(API Spec 8A, 12th edition, June 1, 1992)

Tool joint designation reference	Drill pipe size and style (all weights and grades)	Weld-on tool joints								Elev. marking
		Taper shoulder				Square shoulder				
		Neck diam. max.		Elev. bore		Neck diam. max.		Elev. bore		
		(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	
NC26 (2 3/8 IF)	2 3/8 EU	2 9/16	65.09	2 21/32	67.47	*		*		2 3/8 EU
NC31 (2 7/8 IF)	2 7/8 EU	3 3/16	80.96	3 9/32	83.34	3 3/16	80.96	3 3/8	85.73	2 7/8 EU
NC38 (3 1/2 IF) NC40 (4 FH)	3 1/2 EU 3 1/2 EU	3 7/8 3 7/8	98.43 98.43	3 31/32 3 31/32	100.81 100.81	3 7/8 3 7/8	98.43 98.43	4 1/16 4 1/16	103.19 103.19	3 1/2 EU
NC40 (4 FH)	4 IU	4 3/16	106.36	4 9/32	101.86	4 1/8	104.78	4 5/16	109.54	4 IU
NC46 (4 IF) 4 1/2 FH**	4 EU 4 1/2 IU 4 1/2 IEU 4 1/2 IU 4 1/2 IEU	4 1/2 4 11/16 4 11/16 4 11/16 4 11/16	114.30 119.06 119.06 119.06 119.06	4 23/32 4 25/32 4 25/32 4 25/32 4 25/32	119.86 121.44 121.44 121.44 121.44	4 1/2 4 5/8 4 5/8 4 5/8 4 5/8	114.30 117.48 117.48 117.48 117.48	4 13/16 4 13/16 4 13/16 4 13/16 4 13/16	122.24 122.24 122.24 122.24 122.24	4 EU 4 1/2 IU 4 1/2 IEU
NC50 (4 1/2 IF) 5 1/2 FH**	4 1/2 EU 5 IEU 5 IEU	5 5 1/4 5 1/8	127.00 130.18 130.18	5 1/4 5 1/4 5 1/4	133.35 133.35 133.35	5 5 1/8 5 1/8	127.00 130.18 130.18	5 5/16 5 5/16 5 5/16	134.94 134.94 134.94	4 1/2 EU 5 IEU
5 1/2 FH**	5 IEU	5 11/16	144.46	5 13/16	147.64	5 11/16	144.46	5 7/8	149.23	5 1/2 IEU
6 5/8 FH	6 5/8 IEU	6 57/64	175.02	7 1/32	178.59					6 5/8

Note: Elevators with the same bores are the same elevators.

* Not manufactured.

** Obsolescent connection.

BRAKE BLOCKS

6 hole API brake block

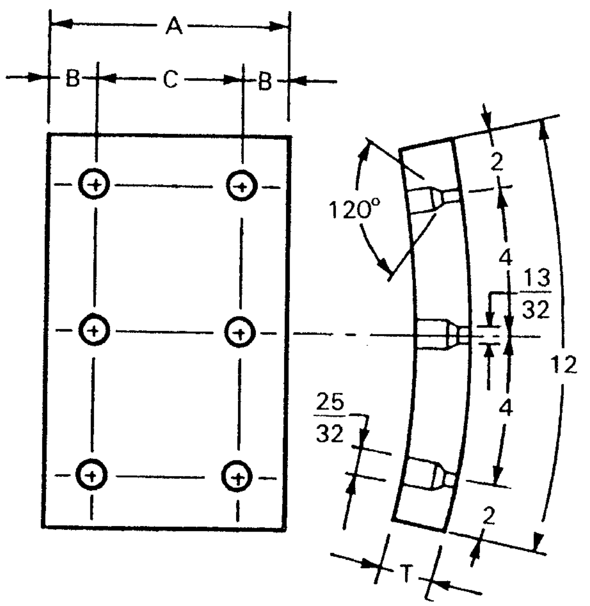
API block No.	A (in)	B (in)	C (in)
1	6	1 1/4	3 1/2
2	7	1 1/2	4
3	8	1 3/4	4 1/2
4	9	2	5
5	10	2 1/4	5 1/2
6	11	2 1/2	6
7	12	2 3/4	6

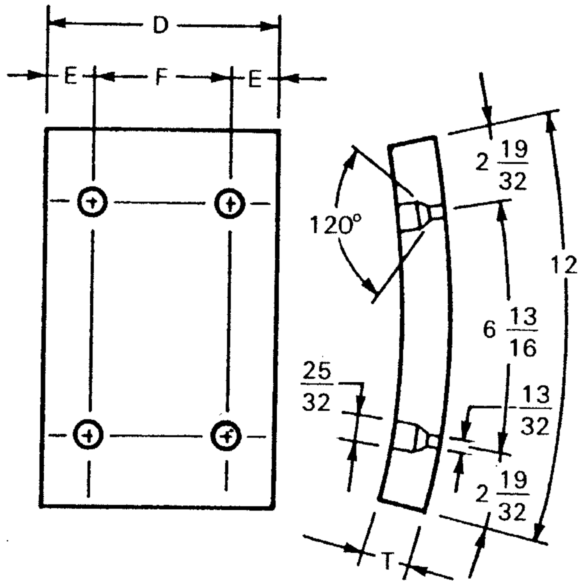
4 hole API brake block

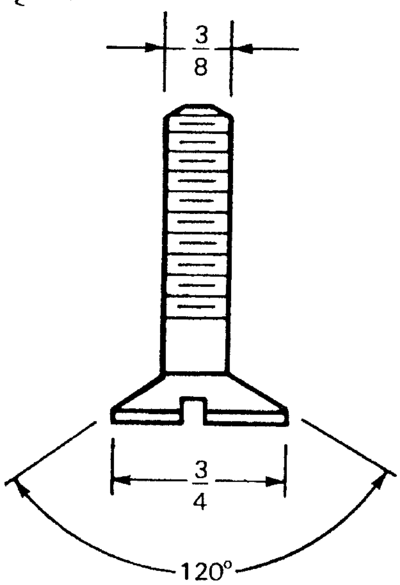
API block No.	D (in)	E (in)	F (in)
10	6	1 1/4	3 1/2
11	7	1 1/2	4
12	8	1 1/2	5
13	9	1 1/2	6
14	10	1 1/2	7

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 7K, 2nd edition, February, 1996)

Inside diameter *D*		Standard length (1) *L*		Line pipe thread size *T* (in)	Grade
(in)	(mm)	(ft)	(m)		
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 (continued) (API Spec 7K, 2nd edition, February, 1996)

Grade	Working pressure		Test pressure	
	(psi)	(kPa)	(psi)	(kPa)
Grade A	1 500	10 300	3 000	20 600
Grade B	2 000	13 800	4 000	27 600
Grade C	4 000	27 600	8 000	55 200
Grade D	5 000	34 500	10 000	69 000
Grade E	7 500	51 700	15 000	103 400

Hose length

$$L = \frac{L_r}{2} + \pi R + S$$

with:

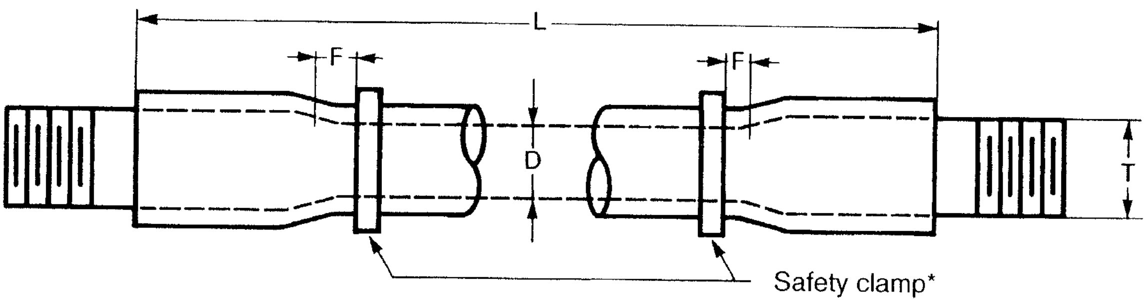
- L = length of hose in feet or meters
- L_r = length of hose travel in feet or meters
- R = minimum bending radius of hose in feet or meters:
  - R = 0.9 m (3 ft) for 2″ hose
  - R = 1.2 m (4 ft) for 2 1/2 cm and 3″ hose
  - R = 1.4 m (4 1/2 ft) for 3 1/2″ hose
- S = allowance for contraction in L due 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 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, 5th edition, October 1, 1993)

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.

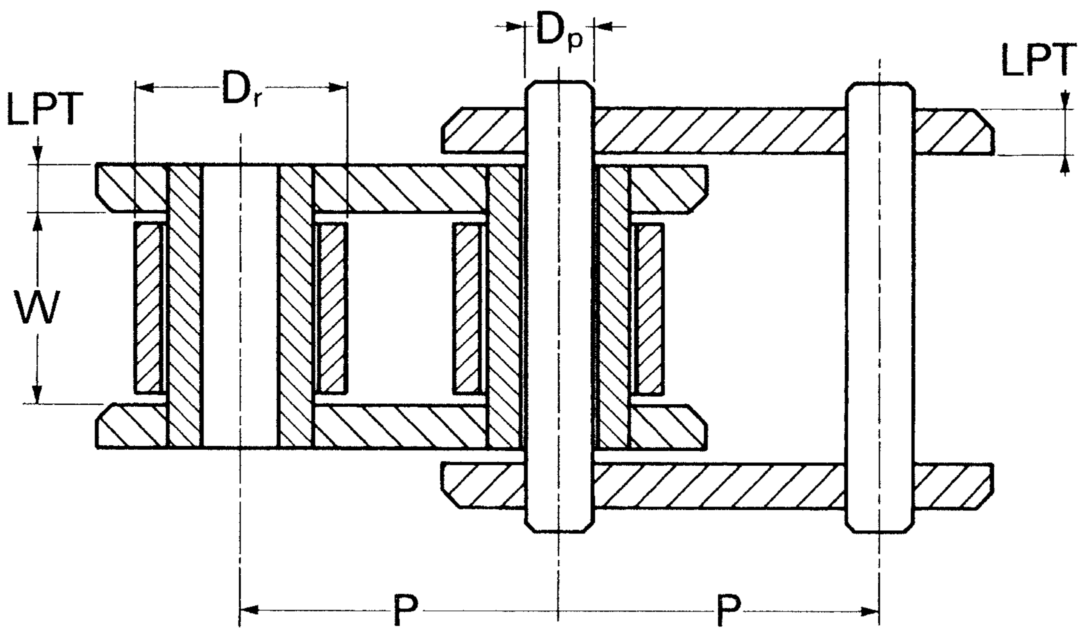
b) A number representing the number of chain strands

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.



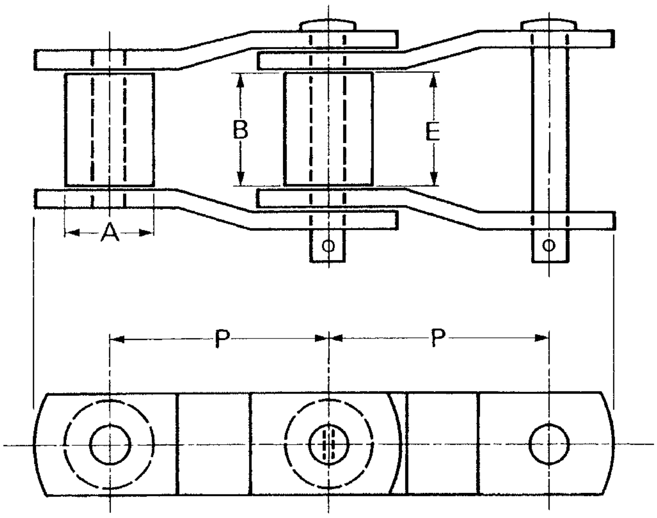
CHAINS (continued)
Standard chain dimensions (ANSI Standard, B29.1)

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	8.2	0.030	0.8	–	–
*35	3/8	9.5	0.200	5.1	3/16	4.8	0.1410	3.6	18	8.2	0.050	1.3	–	–
41	1/2	12.7	0.306	7.8	1/4	6.4	0.1410	3.6	18	8.2	0.050	1.3	–	–
40	1/2	12.7	0.312	7.9	5/16	7.9	0.1560	4.0	31	14.1	0.060	1.5	–	–
50	5/8	15.9	0.400	10.2	3/8	9.5	0.2000	5.1	49	22.2	0.080	2.0	–	–
60	3/4	19.1	0.469	11.9	1/2	12.7	0.2340	5.9	70	31.8	0.094	2.4	–	–
80	1	25.4	0.625	15.9	5/8	15.9	0.3120	7.9	125	56.7	0.125	3.2	0.125	3.2
100	1 1/4	31.8	0.750	19.1	3/4	19.1	0.3750	9.5	195	88.5	0.156	4.0	0.156	4.0
120	1 1/2	38.1	0.875	22.2	1	25.4	0.4370	11.1	281	127.5	0.187	4.7	0.187	4.7
140	1 3/4	44.5	1.000	25.4	1	25.4	0.5000	12.7	383	173.7	0.219	5.6	0.219	5.6
160	2	50.8	1.125	28.6	1 1/4	31.8	0.5620	14.3	500	226.8	0.250	6.4	0.250	6.4
180	2 1/4	57.2	1.406	35.7	1 13/32	35.7	0.6870	17.4	633	287.1	0.281	7.1	0.281	7.1
200	2 1/2	63.5	1.562	39.7	1 1/2	38.1	0.7810	19.8	781	354.3	0.312	7.9	0.312	7.9
240	3	76.2	1.875	47.6	7/8	22.2	0.9370	23.8	1125	510.3	0.375	9.5	0.375	9.5

(*) Without roller.

CHAINS (continued)

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

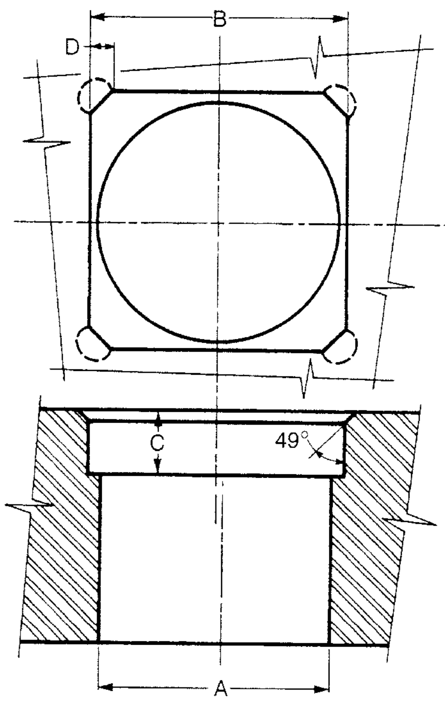
For a check of a chain tension, turn one sprocket to tighten the lower strand of chain; then measure the sag of upper strand. This sag measured at midpoint should be approximately two to three per cent of the length of the tangent to the sprockets.

Example: If the length of the tangent between the sprockets is 200 cm, the sag shall be between 4 and 6 cm.

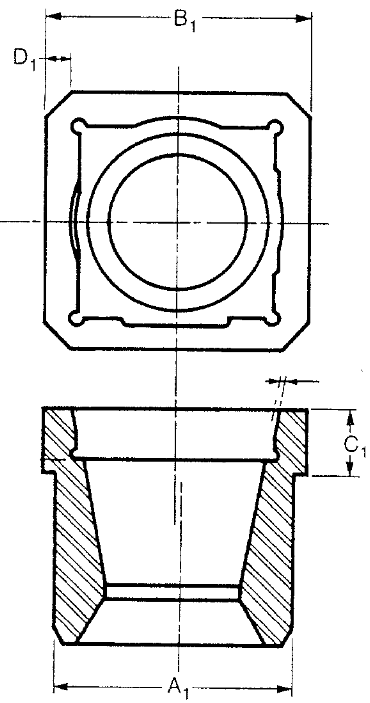
ROTARY TABLE OPENING AND SQUARE DRIVE MASTER BUSHING (API Spec 8C, 2nd edition, June 1, 1992)

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	125.73	49 1/2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

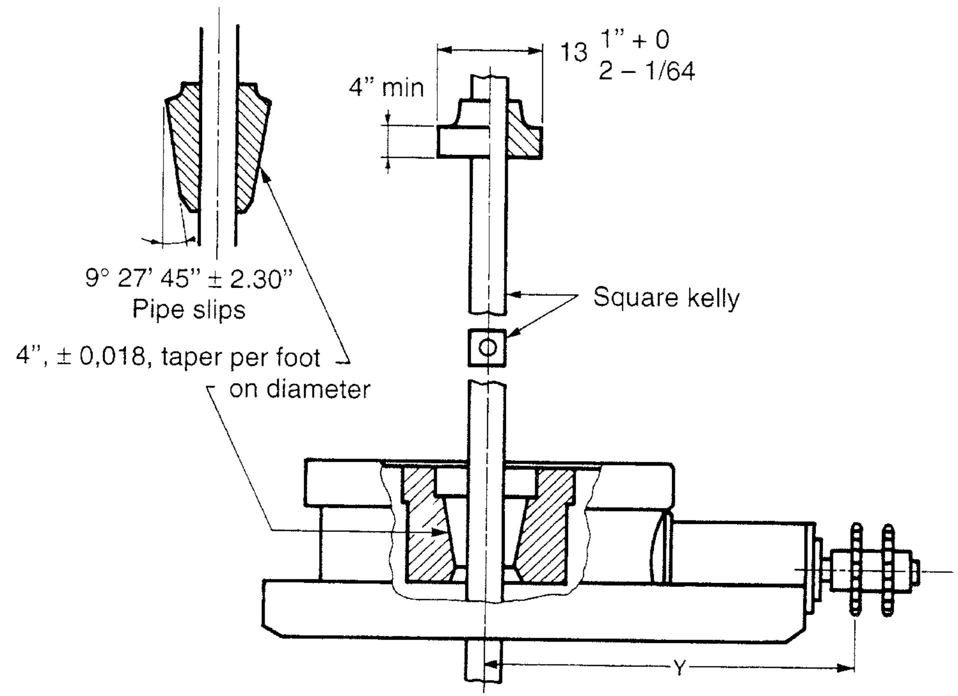
Note: Pipe slips and master bushing must have a taper of 4 in per foot on diameter (33.33%), that is an angle of 9°27′45″.



Rotary-table opening



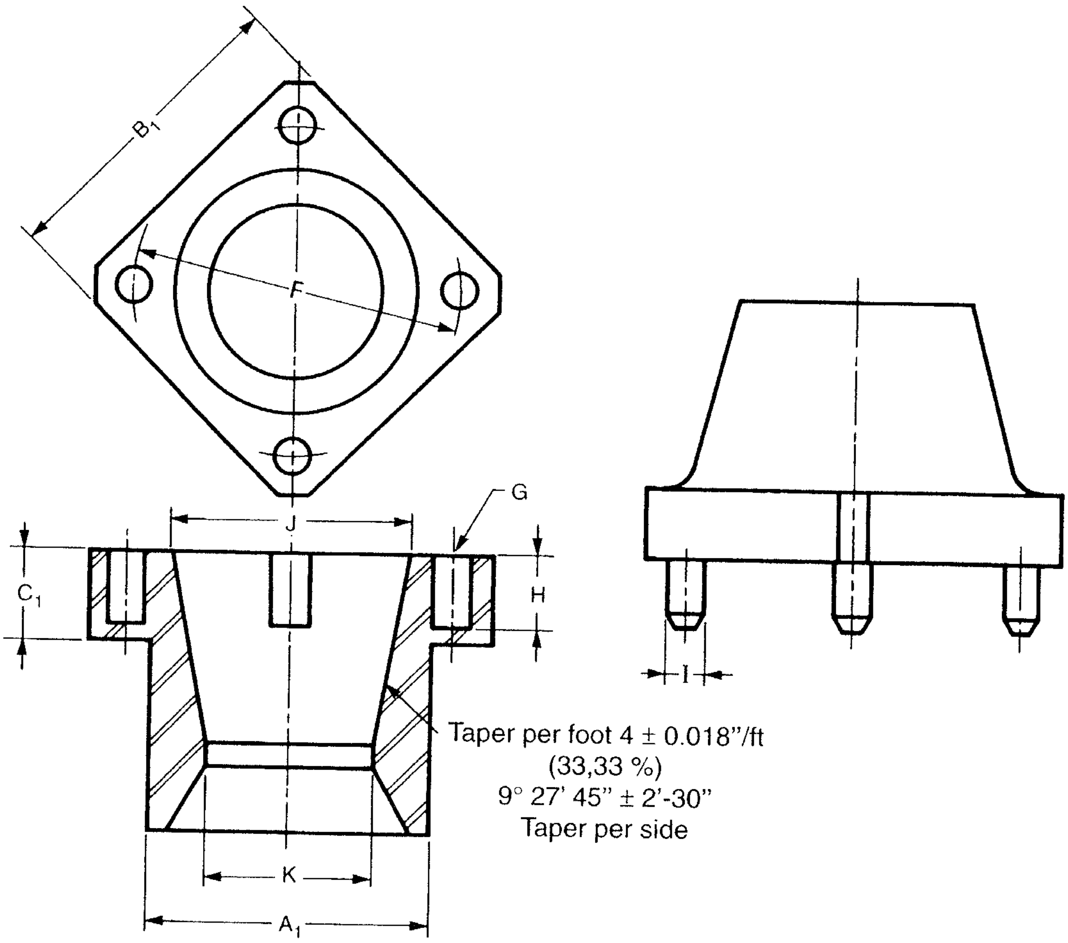
Square drive master bushing



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.

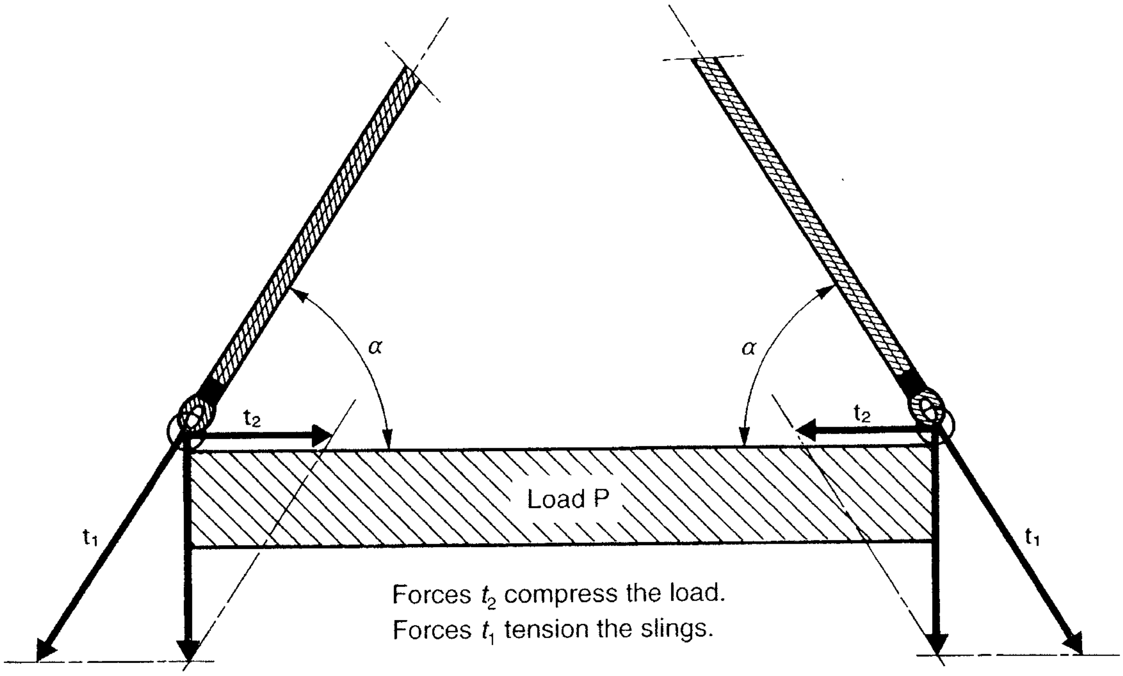
FOUR-PIN DRIVE KELLY BUSHING AND MASTER BUSHING (API Spec 8C, 2nd edition, June 1, 1992)

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	365.1	14 3/8	257.2	10 1/8
27 1/2	654.2	25 3/4	86.2	3.395	107.9	4 1/4	82.9	3.265	365.1	14 3/8	257.2	10 1/8
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



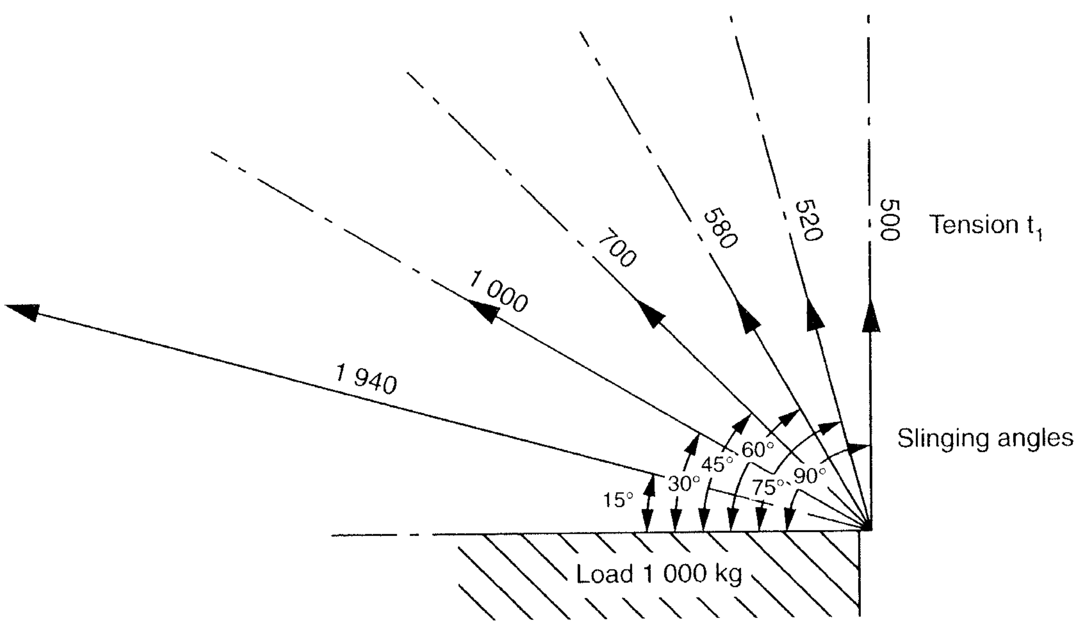
Forces t_2 compress the load.
Forces t_1 tension the slings.

$$t_1 = \frac{P}{2 \sin\alpha}$$

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 FLOW RATE

a. Duplex pump

$$Q_t = 0.0515\ nL\left(D^2 - \frac{d^2}{2}\right)$$

b. Single-acting Triplex pump

$$Q_t = 0.0386\ nLD^2$$

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

$$\eta_v = \frac{Q_r}{Q_t}$$

Q_r = true measured flow rate (l/min)

III HYDRAULIC POWER P_h

$$P_h\,(\text{kW}) = \frac{pQ_t}{60\,000}$$

$$P_h\,(\text{hp}) = \frac{pQ_t}{44\,750}$$

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}

$$P_{hr}(\text{kW}) = \frac{pQ_r}{60\,000} \quad \text{or} \quad P_{hr}(\text{kW}) = \frac{pQ_t\eta_v}{60\,000}$$

$$P_{hr}(\text{hp}) = \frac{pQ_r}{44\,750} \quad \text{or} \quad P_{hr}(\text{hp}) = \frac{pQ_t\eta_v}{44\,750}$$

II ENGINE POWER REQUIRED TO PRODUCE p AND Q_r

η_m = mechanical efficiency of pump
η_t = compound efficiency

$$P_m(\text{kW}) = \frac{pQ_r}{60\,000\ \eta_m\ \eta_t}$$

$$P_m(\text{hp}) = \frac{pQ_r}{44\,750\ \eta_m\ \eta_t}$$

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 p_{max} pressure (cm^2)

$$S = 5.067\left(D^2 - \frac{d^2}{2}\right) \quad \text{Duplex pump}$$

$$S = 5.067\ D^2 \quad \text{Triplex pump}$$

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 η_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 Rod (in) \ Ø Piston (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	24.54	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 Rod (in) \ Ø Piston (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	13.88	12.37	10.94	9.59	8.32				

Length of stroke 14″

Ø Rod (in) \ Ø Piston (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 Rod (in) \ Ø Piston (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
2 1/4		44.43	41.48	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 Rod (in) \ Ø Piston (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	21.8	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	25.95	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 1/4	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 Rod (in) \ Ø Piston (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	43.05	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	53.13	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 Rod (in) \ Ø Piston (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	30.92	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	228.6	9	38 510	30 440	27 370	24 750	22 480	20 440	18 720	17 170	15 820					
F1000	**746**	140	254.0	10		36 820	33 030	29 850	27 030	24 650	22 550	20 750	19 100					
F1300	**969**	120	304.8	12						31 140	28 450	26 140	24 090	22 480	20 660	19 230		
F1600	**1193**	120	304.8	12						38 320	35 010	32 160	29 640	27 660	25 430	23 600		
Gardner-Denver																		
PZ7	**410**	165	177.8	7		24 520		19 860		16 410		13 790		11 760		10 130		
PZ8	**559**	165	203.2	8	37 100	29 220		23 670		19 600		16 440	15 170					
PZ9	**746**	150	228.6	9		38 130		30 920		25 580		21 440	19 820	18 270		15 750		
PZ10	**1006**	130	254.0	10						35 790		30 070		25 620		22 090		
PZ11	**1193**	130	279.4	11						38 580		32 420		27 620		23 810		
Ideco																		
T800	**597**	150	228.6	9		27 460		22 220		18 380		15 440		13 170		11 350		
T1000	**746**	140	254.0	10		36 810		29 800		24 680		20 700		17 640		15 200		
T1300	**1048**	130	304.8	12				37 660		31 120		26 150		22 280		19 220		16 740
T1600	**1292**	130	304.8	12						38 300		32 190		27 430		23 650		20 600
National																		
8P80	**597**	160	215.9	8 1/2		30 300		24 550		20 270		17 030	15 720					
9P100	**746**	150	234.9	9 1/4		37 130		30 060		24 860		20 890	19 240					
10P130	**969**	140	254.0	10				38 750		32 030		26 890	24 790					
12P160	**1193**	120	304.8	12						38 300		32 200		27 440	25 440	23 650	22 060	
Wirth																		
TPK1000	**746**	160	234.9	9 1/4		34 810	31 230	28 190	25 570	23 300	21 310	19 570	18 040					
TPK1300	**969**	150	254.0	10				36 150	32 790	29 880	27 370	25 120	23 160	21 400	19 840	18 460		
TPK1600	**1193**	120	304.8	12						38 330	35 020	32 160	29 670	27 430	25 440	23 640		

From *SI Drilling Manual*, First Edition, Canadian Association of Oilwell Drilling Contractors, Gulf.

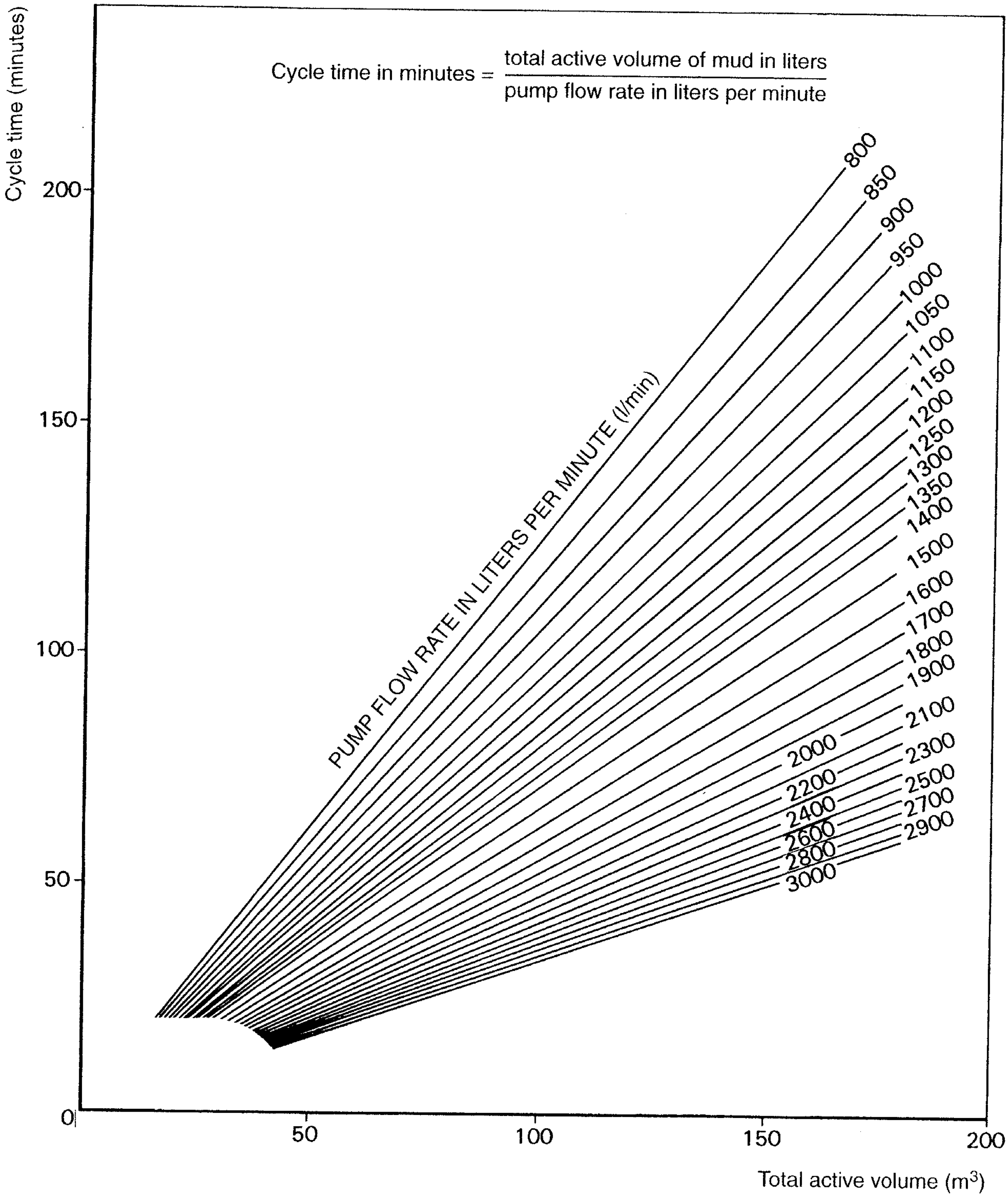
kW × 1.34 = hp   kPa × 0.145 = psi

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 m^3 × 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**	**13.3**	**11.28**	**13.95**	**12.03**	**15.6**	**13.58**	**27.23**	**25.21**	**21.16**	**30.4**	**26.35**	**23.94**	**43.2**	**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	1459	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

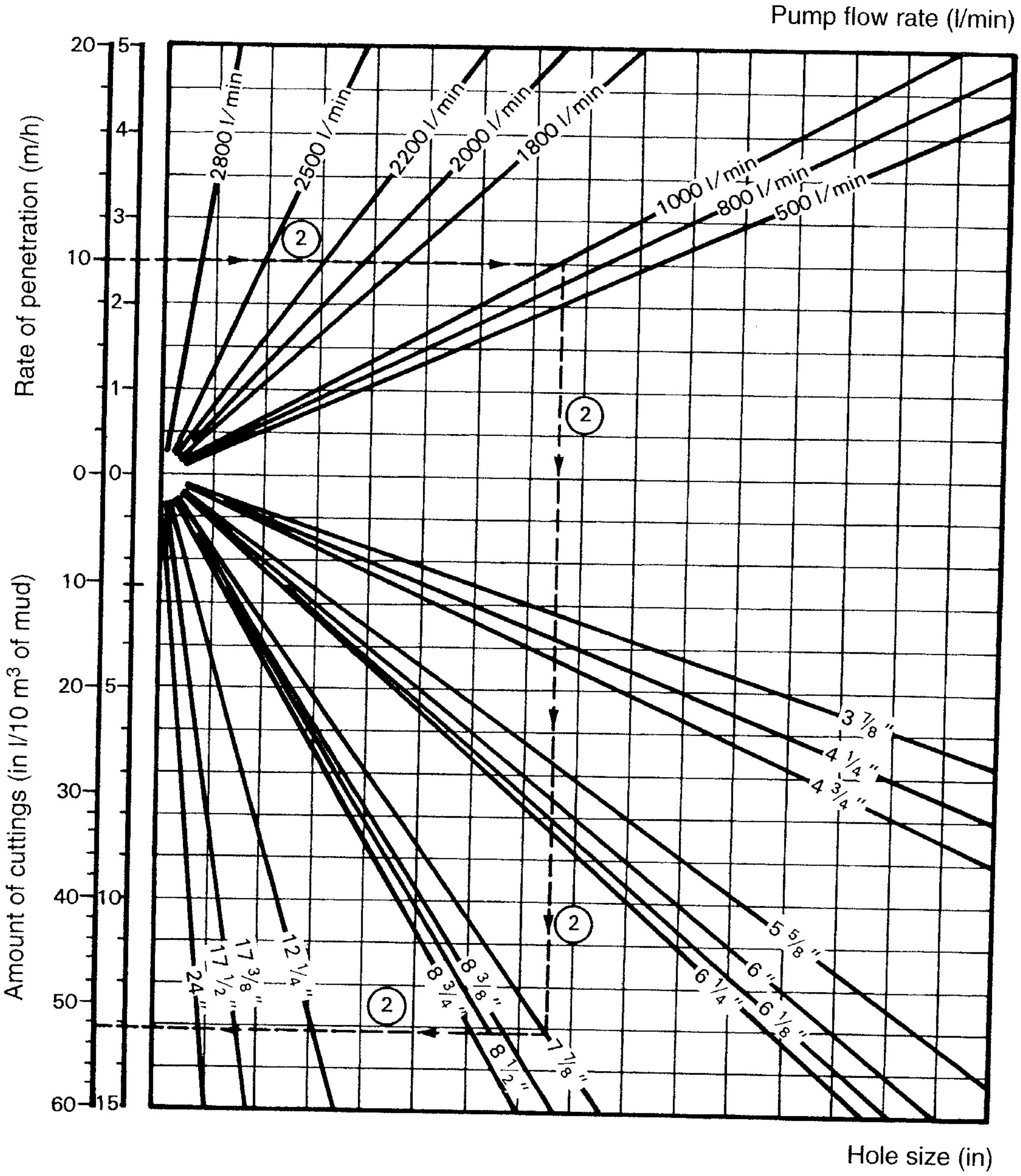
CIRCULATION FLOW RATE (l/min)
as a function of mud rising velocity opposite drill pipes (V_r in meters per minute) and hole/pipe annulus (V_a in liters per meter) (continued)

$$Q = V_r V_a$$

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**	**13.3**	**11.28**	**13.95**	**12.03**	**15.6**	**13.58**	**27.23**	**25.21**	**21.16**	**30.4**	**26.35**	**23.94**	**43.2**	**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		2997	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 = 2000 l/min
   Hole size = 12.25 in
   Amount of cuttings = 38.0 l in 10 m^3 of mud
2. Rate of penetration = 10 m/h
   Pump flow rate = 1000 l/m
   Hole size = 7 7/8 in
   Amount of cuttings = 52.2 l in 10 m^3 of mud

$$V = \frac{84.45\, D^2 A_v}{Q}$$

where:
V = amount of cuttings (l/10 m^3)
D = hole size (in)
A_v = rate of penetration (m/h)
Q = pump flow rate (l/m)

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)

$$d_{ann} = d_{init} + \frac{D_f^2 A_v (2.5 - d_{init})}{118.41\,Q - 60(D_f^2 - D_t^2)\,V_s}$$

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

$$d_{ann} = d_{init} + 0.05 = 1.20$$

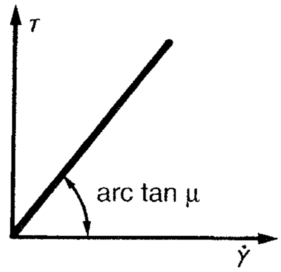
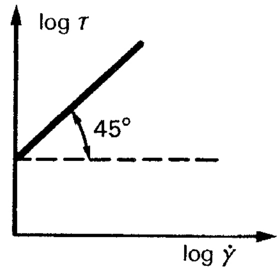
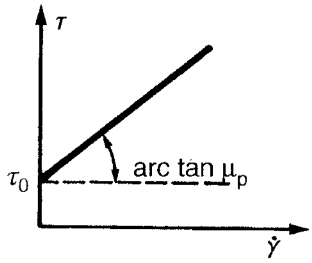
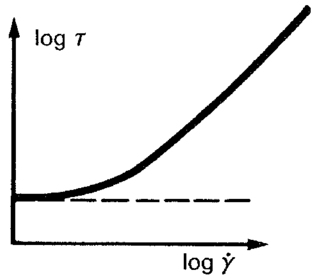
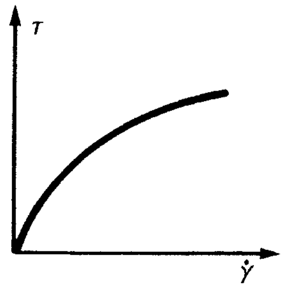
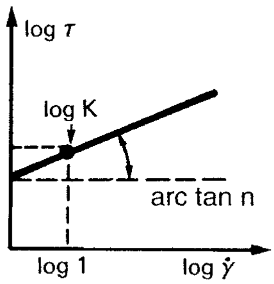
HYDRAULICS

(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 Éditions 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_o	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

<table>
<tr><th>RHEOLOGICAL SYSTEM</th><th>RHEOLOGICAL EQUATION</th><th>FLOW CURVE CARTESIAN COORDINATES</th><th>FLOW CURVE LOGARITHMIC COORDINATES</th></tr>
<tr><td>Newtonian</td><td>$\tau = \mu\gamma$</td><td>
</td><td>
</td></tr>
<tr><td>Bingham
or plastic</td><td>$\tau = \tau_0 + \mu_p\gamma$</td><td>
</td><td>
</td></tr>
<tr><td>" Power "
or pseudoplastic
or Ostwald</td><td>$\tau = K\gamma^n$</td><td>
</td><td>
</td></tr>
</table>

Rheological formulas for the Fann viscometer:

Apparent viscosity .... $\mu_a = \dfrac{\Theta_{600}}{2}$ (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 .... $n = 3.32 \log\left(\dfrac{\Theta_{600}}{\Theta_{300}}\right)$

Consistency index .... $K = \dfrac{\Theta_{600}}{(1020)^n} = \dfrac{\Theta_{300}}{(510)^n}$ (lb.s^n/100 ft^2)

CRITICAL VELOCITY BASED ON RHEOLOGICAL PARAMETERS (Practical units)

BINGHAM FLUIDS

Circulation in drill pipes and drill collars:

$$V_c = \frac{2.48}{Dd}\left(\mu_p + \sqrt{\mu_p^2 + 73.57\ \tau_0 D^2 d}\right)$$

Circulation in the annulus:

$$V_c = \frac{3.04}{(D_0 - D_I)d}\left(\mu_p + \sqrt{\mu_p^2 + 40.05\ \tau_0 (D_0 - D_I)^2 d}\right)$$

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:

$$p = \frac{KL}{13.26D}\left[\frac{2.59Q}{D^3}\frac{(3n+1)}{n}\right]^n$$

- Turbulent flow:

$$p = \frac{(\log n + 2.5)dQ^2L}{586.94D^5}\left[\frac{D^4K\left(\frac{2.59Q}{D^3}\frac{(3n+1)}{n}\right)^n}{18.07Q^2d}\right]^{\frac{1.4+\log n}{7}}$$

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:

$$p = \frac{(\log n + 2.5)dQ^2L}{479.23(D_0+D_i)^2(D_0-D_i)^3}\left[\frac{[(D_0+D_i)^2(D_0-D_i)^2K]\left[\frac{5.18Q}{(D_0+D_i)(D_0-D_i)^2}\left(\frac{2n+1}{n}\right)\right]^n}{22.13Q^2d}\right]^{\frac{1.4+\log n}{7}}$$

PRESSURE DROP IN ORIFICES

$$p = \frac{dQ^2}{2959.41\,C^2A^2}$$

where:

p = pressure drop (kPa)
d = specific gravity (kg/l)
Q = flow rate (l/min)
A = total nozzle area (in^2)
C = orifice coefficient
C: 0.80 for non-jet bit
C: 0.95 for jet bit

Example:

d = 1.15 kg/l
Q = 1500 l/min

2 nozzles size 12/32 in
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 48: at 1500 l/min

p_d = 6857 kPa   for d = 1

p = 6857 × 1.15 = 7885 kPa

CALCULATION OF THE BIT NOZZLE VELOCITY

$$V = \frac{Q}{38.71A}$$

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

$$P_h\,(\text{kW}) = \frac{p_d Q}{60\,000}$$

$$P_h\,(\text{hp}) = \frac{p_d Q}{44\,750}$$

p_d = pressure drop in nozzles (kPa)
Q = flow rate (l/min)

HYDRAULIC PRESSURE AT BIT IN RELATION TO BIT AREA: P_{hHSI}

$$P_{hHSI} = \frac{P_d Q}{35\,140 D^2}$$

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 G 17 of the Drilling Data Handbook. The pressure losses have the form:

$$p = NB$$

with:

$$N = \frac{LQ^{1.8}}{901.63 D^{4.8}} \quad \text{(in drill string)}$$

$$N = \frac{LQ^{1.8}}{706.96(D_0 + D_i)^{1.8}(D_0 - D_i)^3} \quad \text{(annulus)}$$

(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 G 23 to G 29 the **coefficient *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 G 30 to G 67, the corresponding **coefficients N_1, N_2, N_3, N_4 and N_5**.

d) **Calculate** the **pressure drops** in the nozzles.

$$\boxed{p_{\text{total}} = (N_1 + L_2N_2 + L_3N_3 + L_4N_4 + L_5N_5)B + p_d d}$$

where:

$L_2, L_3, \ldots L_5$ = lengths of the different sections (100 m)
p_d = pressure drop in nozzles for $d = 1$ kg/l (kPa), G 47 to G 55
d = specific gravity (kg/liter)
N_1 = pressure loss coefficient in the surface equipment, G 30
N_2 = pressure loss coefficient in the drill pipes (kPa/100 m), G 31 to G 44
N_3 = pressure loss coefficient in the drill collars (kPa/100 m), G 45 to G 46
N_4 = pressure loss coefficient in hole/drill collar annulus (kPa/100 m), G 59 to G 63
N_5 = pressure loss coefficient in hole/drill pipe annulus (kPa/100 m), G 64 to G 67

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) 2130 m of 5 inch, 19.50 – E – NC50 drill pipes.

The bit is equipped with a combination of nozzles: 11/11/12.

I. Coefficient $\boldsymbol{B = 2.08}$ G 23

II.	1) Surface equipment	G 30	$\boldsymbol{N_1 = 95}$
	2) In drill pipes	G 40	$\boldsymbol{N_2 = 57}$
	3) In drill collars	G 45	$\boldsymbol{N_3 = 404}$
	4) In nozzles	G 47	$\boldsymbol{p_d = 9608}$ **kPa**
	5) Hole/DC	G 60	$\boldsymbol{N_4 = 102}$
	6) Hole/pipe	G 66	$\boldsymbol{N_5 = 19}$

III. Discharge pressure in normal circulation p_r:

$$p_r = (N_1 + 21.3\ N_2 + 1.7\ N_3 + 1.7\ N_4 + 21.3\ N_5)B + p_d d$$
$$= (95 + 21.3 \times 57 + 1.7 \times 404 + 1.7 \times 102 + 21.3 \times 19)2.08 + 9608 \times 1.15$$
$$\mathbf{= 16\,403\ kPa}$$

TABLE OF COEFFICIENTS B

Viscosity \ Specific gravity	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	2.48	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	2.41	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)

Viscosity \ Specific gravity	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)

Viscosity \ Specific gravity	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)

Viscosity \ Specific gravity	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	2.65	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)

Viscosity \ Specific gravity	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	3.53	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	3.78	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)

Viscosity \ Specific gravity	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	4.15
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)

Viscosity \ Specific gravity	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

$$P_{\text{surface equipment}} = N_1 B \text{ (kPa)}$$

	Case 1			Case 2			Case 3			Case 4		
	ID (in)	Length (ft)	Length (m)	ID (in)	Length (ft)	Length (m)	ID (in)	Length (ft)	Length (m)	ID (in)	Length (ft)	Length (m)
Stand pipe	3	40	12.19	3 1/2	40	12.19	4	45	13.72	4	45	13.72
Drilling hose	2	45	13.72	2 1/2	55	16.76	3	55	16.76	3	55	16.76
Kelly	2 1/4	40	12.19	3 1/4	40	12.19	3 1/4	40	12.19	4	40	12.19
Swivel	2	4	1.22	2 1/2	5	1.52	2 1/2	5	1.52	3	6	1.83

Débit (l/min)	Case 1	Case 2	Case 3	Case 4	Débit (l/min)	Case 1	Case 2	Case 3	Case 4
500	68	24	13	10	**2 800**	1 506	529	293	229
550	80	28	16	12	**2 850**	1 555	546	303	236
600	94	33	18	14	**2 900**	1 604	563	312	244
650	109	38	21	17	**2 950**	1 655	581	322	251
700	124	44	24	19	**3 000**	1 705	598	332	259
750	141	49	27	21	**3 050**	1 757	617	342	267
800	158	55	31	24	**3 100**	1 809	635	352	275
850	176	62	34	27	**3 150**	1 862	653	362	283
900	195	69	38	30	**3 200**	1 915	672	373	291
950	215	76	42	33	**3 250**	1 970	691	383	299
1 000	236	83	46	36	**3 300**	2 025	710	394	308
1 050	258	90	50	39	**3 350**	2 080	730	405	316
1 100	280	98	55	43	**3 400**	2 136	750	416	324
1 150	304	107	59	46	**3 450**	2 193	770	427	333
1 200	328	115	64	50	**3 500**	2 251	790	438	342
1 250	353	124	69	54	**3 550**	2 309	810	449	351
1 300	379	133	74	57	**3 600**	2 368	831	461	360
1 350	405	142	79	62	**3 650**	2 427	852	472	369
1 400	433	152	84	66	**3 700**	2 488	873	484	378
1 450	461	162	90	70	**3 750**	2 548	894	496	387
1 500	490	172	95	74	**3 800**	2 610	916	508	396
1 550	520	182	101	79	**3 850**	2 672	938	520	406
1 600	550	193	107	84	**3 900**	2 735	960	532	415
1 650	581	204	113	88	**3 950**	2 798	982	545	425
1 700	613	215	119	93	**4 000**	2 862	1 004	557	435
1 750	646	227	126	98	**4 050**	2 927	1 027	570	445
1 800	680	239	132	103	**4 100**	2 992	1 050	582	455
1 850	714	251	139	109	**4 150**	3 058	1 073	595	465
1 900	749	263	146	114	**4 200**	3 125	1 097	608	475
1 950	785	276	153	119	**4 250**	3 192	1 120	621	485
2 000	822	288	160	125	**4 300**	3 260	1 144	635	495
2 050	859	302	167	131	**4 350**	3 329	1 168	648	506
2 100	897	315	175	136	**4 400**	3 398	1 192	661	516
2 150	936	329	182	142	**4 450**	3 468	1 217	675	527
2 200	976	342	190	148	**4 500**	3 538	1 242	689	537
2 250	1 016	357	198	154	**4 550**	3 609	1 267	703	548
2 300	1 057	371	206	161	**4 600**	3 681	1 292	716	559
2 350	1 099	386	214	167	**4 650**	3 753	1 317	731	570
2 400	1 141	400	222	173	**4 700**	3 826	1 343	745	581
2 450	1 184	416	231	180	**4 750**	3 900	1 368	759	592
2 500	1 228	431	239	187	**4 800**	3 974	1 395	774	604
2 550	1 273	447	248	193	**4 850**	4 049	1 421	788	615
2 600	1 318	463	257	200	**4 900**	4 124	1 447	803	626
2 650	1 364	479	266	207	**4 950**	4 200	1 474	818	638
2 700	1 411	495	275	214	**5 000**	4 277	1 501	833	650
2 750	1 458	512	284	221					

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2

Calculation of pressure losses in drill pipes $p_{int} = N_2B$ (kPa/100 m)

Nominal pipe size (in)	2 3/8			2 7/8						
Nominal weight (lb/ft)	6.65			10.4						
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	216	81	81	83	86	90	96	106
350	241	244	286	106	107	110	113	119	127	140
400	306	310	363	135	136	139	144	151	161	177
450	379	383	449	167	168	172	178	186	199	219
500	458	463	543	202	203	208	215	225	241	265
550	544	550	644	240	241	247	255	268	286	315
600	636	643	754	281	282	289	299	313	334	368
650	734	743	870	324	326	334	345	361	386	425
700	839	849	995	371	373	381	394	413	441	486
750	950	962	1 126	420	422	432	446	468	500	550
800	1 067	1 080	1 265	472	474	485	501	525	561	618
850	1 190	1 205	1 411	526	528	541	559	586	626	689
900	1 319	1 335	1 564	583	586	600	620	649	694	764
950	1 454	1 472	1 723	642	646	661	683	716	765	842
1 000	1 594	1 614	1 890	705	708	725	749	785	839	923
1 050	1 741	1 762	2 064	769	773	791	818	857	916	1 008
1 100	1 893	1 916	2 244	837	841	860	889	932	996	1 096
1 150	2 050	2 076	2 431	906	911	932	963	1 009	1 079	1 188
1 200	2 214	2 241	2 624	978	983	1 006	1 040	1 090	1 165	1 282
1 250	2 382	2 412	2 824	1 053	1 058	1 083	1 119	1 173	1 253	1 380
1 300	2 557	2 588	3 031	1 130	1 135	1 162	1 201	1 258	1 345	1 481
1 350	2 736	2 770	3 244	1 209	1 215	1 244	1 286	1 347	1 440	1 585
1 400	2 921	2 957	3 463	1 291	1 297	1 328	1 373	1 438	1 537	1 692
1 450	3 112	3 150	3 689	1 375	1 382	1 415	1 462	1 532	1 637	1 802
1 500	3 308	3 348	3 921	1 462	1 469	1 504	1 554	1 628	1 740	1 916
1 550	3 509	3 552	4 160	1 551	1 558	1 595	1 649	1 727	1 846	2 032
1 600	3 715	3 761	4 404	1 642	1 650	1 689	1 746	1 829	1 955	2 152
1 650	3 927	3 975	4 655	1 736	1 744	1 785	1 845	1 933	2 066	2 274
1 700	4 143	4 194	4 912	1 831	1 840	1 884	1 947	2 040	2 180	2 400
1 750	4 365	4 419	5 175	1 929	1 939	1 985	2 051	2 149	2 297	2 528
1 800	4 592	4 649	5 445	2 030	2 040	2 088	2 158	2 261	2 416	2 660
1 850	4 825	4 884	5 720	2 132	2 143	2 194	2 267	2 375	2 538	2 794
1 900	5 062	5 124	6 001	2 237	2 248	2 301	2 378	2 492	2 663	2 932
1 950	5 304	5 369	6 288	2 344	2 356	2 412	2 492	2 611	2 791	3 072
2 000	5 551	5 620	6 582	2 454	2 465	2 524	2 608	2 733	2 921	3 215

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_2 (continued)
Calculation of pressure losses in drill pipes $p_{int} = N_2 B$ (kPa/100 m)

Nominal pipe size (in)		3 1/2									
Nominal weight (lb/ft)		9.5		13.3				15.5			
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	152	159	165
	750	86	90	127	130	133	147	169	173	180	187
	800	97	101	143	146	149	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
	1 000	145	151	214	218	223	247	284	290	302	314
	1 050	158	165	233	238	244	270	310	316	330	343
	1 100	172	179	254	259	265	294	337	344	358	373
	1 150	186	194	275	280	287	318	366	373	388	404
	1 200	201	210	297	302	310	343	395	402	419	436
	1 250	216	226	319	325	334	370	425	433	451	469
	1 300	232	242	343	349	358	397	456	465	484	503
	1 350	248	259	367	374	383	425	488	497	518	539
	1 400	265	277	392	399	409	453	521	531	553	575
	1 450	282	295	417	425	436	483	555	566	589	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)	9.5		13.3				15.5			
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)										
1 500	300	314	443	452	463	513	590	601	626	651
1 550	318	333	470	479	492	544	626	638	664	691
1 600	337	352	498	508	520	576	662	675	703	731
1 650	356	372	526	536	550	609	700	714	743	773
1 700	376	393	555	566	580	643	739	753	784	816
1 750	396	414	585	596	612	677	778	793	826	859
1 800	416	435	616	627	643	713	819	835	869	904
1 850	437	457	647	659	676	749	860	877	913	950
1 900	459	480	678	692	709	785	903	920	958	996
1 950	481	503	711	725	743	823	946	964	1 004	1 044
2 000	503	526	744	758	778	861	990	1 009	1 051	1 093
2 050	526	550	778	793	813	901	1 035	1 055	1 099	1 142
2 100	550	575	812	828	849	940	1 081	1 102	1 148	1 193
2 150	573	600	847	864	886	981	1 127	1 149	1 197	1 245
2 200	598	625	883	900	923	1 023	1 175	1 198	1 248	1 297
2 250	622	651	920	938	961	1 065	1 224	1 247	1 299	1 351
2 300	647	677	957	975	1 000	1 108	1 273	1 298	1 352	1 405
2 350	673	704	995	1 014	1 040	1 151	1 323	1 349	1 405	1 461
2 400	699	731	1 033	1 053	1 080	1 196	1 374	1 401	1 459	1 517
2 450	725	758	1 072	1 093	1 121	1 241	1 426	1 454	1 515	1 575
2 500	752	787	1 112	1 133	1 162	1 287	1 479	1 508	1 571	1 633
2 550	779	815	1 152	1 175	1 204	1 334	1 533	1 562	1 628	1 692
2 600	807	844	1 193	1 216	1 247	1 381	1 587	1 618	1 685	1 752
2 650	835	874	1 235	1 259	1 291	1 429	1 643	1 674	1 744	1 813
2 700	864	903	1 277	1 302	1 335	1 478	1 699	1 732	1 804	1 875
2 750	893	934	1 320	1 346	1 380	1 528	1 756	1 790	1 865	1 938
2 800	922	965	1 363	1 390	1 425	1 578	1 814	1 849	1 926	2 002
2 850	952	996	1 408	1 435	1 471	1 630	1 872	1 909	1 988	2 067

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)		3.34						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	55	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	71	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
	1 000	86	89	93	96	100	105	38	38	39	42
	1 050	94	97	101	105	109	115	41	42	42	46
	1 100	102	106	110	114	119	125	45	45	46	50
	1 150	111	115	119	123	128	136	49	49	50	54
	1 200	120	124	129	133	139	146	52	53	53	58
	1 250	129	133	138	143	149	158	56	57	58	62
	1 300	138	143	148	154	160	169	61	61	62	67
	1 350	148	153	159	164	171	181	65	65	66	72
	1 400	158	163	170	175	183	193	69	70	71	76
	1 450	168	174	181	187	195	206	74	74	75	81

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)	3.34						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)										
1 500	179	185	192	199	207	219	78	79	80	87
1 550	190	196	204	211	220	232	83	84	85	92
1 600	201	208	216	223	233	246	88	89	90	97
1 650	212	220	228	236	246	260	93	94	95	103
1 700	224	232	241	249	260	274	98	99	100	108
1 750	236	244	254	262	274	289	103	104	105	114
1 800	248	257	267	276	288	304	109	110	111	120
1 850	261	270	280	290	302	319	114	115	117	126
1 900	273	283	294	304	317	335	120	121	122	133
1 950	286	297	308	319	332	351	126	127	128	139
2 000	300	310	322	333	348	367	131	132	134	145
2 050	313	325	337	349	364	384	137	138	140	152
2 100	327	339	352	364	380	401	143	145	146	159
2 150	342	354	367	380	396	418	150	151	153	166
2 200	356	369	383	396	413	436	156	157	159	173
2 250	371	384	399	412	430	454	162	164	166	180
2 300	386	399	415	429	447	472	169	170	172	187
2 350	401	415	431	446	465	491	176	177	179	194
2 400	416	431	448	463	483	510	182	184	186	202
2 450	432	447	465	481	501	529	189	191	193	209
2 500	448	464	482	498	520	549	196	198	200	217
2 550	464	481	499	516	539	568	203	205	208	225
2 600	481	498	517	535	558	589	211	212	215	233
2 650	498	515	535	553	577	609	218	220	223	241
2 700	515	533	553	572	597	630	226	227	230	249
2 750	532	551	572	592	617	651	233	235	238	258
2 800	549	569	591	611	638	673	241	243	246	266
2 850	567	587	610	631	658	694	249	251	254	275

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)		3.34						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)	**2 900**	585	606	629	651	679	717	256	259	262	284
	2 950	604	625	649	671	700	739	264	267	270	293
	3 000	622	644	669	692	722	762	273	275	278	301
	3 050	641	663	689	713	744	785	281	283	287	311
	3 100	660	683	710	734	766	808	289	291	295	320
	3 150	679	703	730	755	788	832	298	300	304	329
	3 200	699	723	751	777	811	855	306	309	312	339
	3 250	718	744	773	799	834	880	315	317	321	348
	3 300	739	765	794	821	857	904	324	326	330	358
	3 350	759	786	816	844	880	929	333	335	339	368
	3 400	779	807	838	867	904	954	341	344	349	378
	3 450	800	828	860	890	928	979	351	353	358	388
	3 500	821	850	883	913	953	1 005	360	363	367	398
	3 550	842	872	906	937	977	1 031	369	372	377	408
	3 600	864	894	929	961	1 002	1 057	378	382	386	419
	3 650	885	917	952	985	1 027	1 084	388	391	396	429
	3 700	907	939	976	1 009	1 053	1 111	398	401	406	440
	3 750	930	962	1 000	1 034	1 079	1 138	407	411	416	451
	3 800	952	986	1 024	1 059	1 105	1 166	417	421	426	461
	3 850	975	1 009	1 048	1 084	1 131	1 193	427	431	436	472
	3 900	998	1 033	1 073	1 109	1 158	1 221	437	441	446	483
	3 950	1 021	1 057	1 098	1 135	1 184	1 250	447	451	457	495
	4 000	1 044	1 081	1 123	1 161	1 211	1 278	458	461	467	506
	4 050	1 068	1 105	1 148	1 187	1 239	1 307	468	472	478	517
	4 100	1 092	1 130	1 174	1 214	1 267	1 336	478	482	488	529
	4 150	1 116	1 155	1 200	1 241	1 294	1 366	489	493	499	541
	4 200	1 140	1 180	1 226	1 268	1 323	1 396	500	504	510	552
	4 250	1 164	1 206	1 252	1 295	1 351	1 426	510	514	521	564

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)	16.6							20			
Pipe inside diameter (in)	3.826							3.64			
Tool joint inside diameter (in)	3 3/4	3 1/2	3 1/4	3	2 3/4	2 11/16	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	6	7	7	6	7	7	7
350	7	7	7	8	8	9	10	9	9	9	9
400	9	9	9	10	11	11	12	11	11	11	12
450	11	11	11	12	13	14	15	13	14	14	15
500	13	13	14	15	16	17	18	16	16	17	18
550	15	16	16	17	19	20	22	19	20	20	21
600	18	18	19	20	22	23	26	23	23	24	25
650	21	21	22	23	26	27	30	26	26	27	29
700	24	24	25	27	29	30	34	30	30	31	33
750	27	27	29	30	33	34	38	34	34	35	37
800	30	31	32	34	37	39	43	38	38	40	42
850	33	34	36	38	42	43	48	42	43	44	46
900	37	38	40	42	46	48	53	47	47	49	51
950	41	42	44	47	51	53	59	52	52	54	57
1 000	45	46	48	51	56	58	64	57	57	59	62
1 050	49	50	52	56	61	63	70	62	62	65	68
1 100	53	55	57	61	66	68	76	67	68	70	74
1 150	58	59	62	66	72	74	83	73	74	76	80
1 200	62	64	67	71	78	80	89	78	79	82	86
1 250	67	69	72	76	84	86	96	84	86	88	93
1 300	72	74	77	82	90	92	103	91	92	95	100
1 350	77	79	82	88	96	99	110	97	98	102	107
1 400	82	84	88	93	103	106	118	104	105	108	114
1 450	87	90	94	100	109	112	126	110	112	116	121

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)		16.6							20			
Pipe inside diameter (in)		3.826							3.64			
Tool joint inside diameter (in)		3 3/4	3 1/2	3 1/4	3	2 3/4	2 11/16	2 1/2	3 5/8	3 1/2	3 1/4	3
Flow rate Q (l/min)	**1 500**	93	95	100	106	116	120	133	117	119	123	129
	1 550	98	101	106	112	123	127	142	124	126	130	137
	1 600	104	107	112	119	130	134	150	132	133	138	145
	1 650	110	113	118	126	138	142	158	139	141	146	153
	1 700	116	120	125	133	145	150	167	147	149	154	162
	1 750	123	126	131	140	153	158	176	155	157	162	170
	1 800	129	133	138	147	161	166	185	163	165	170	179
	1 850	135	139	145	154	169	174	195	171	173	179	188
	1 900	142	146	152	162	178	183	204	179	182	188	198
	1 950	149	153	160	170	186	192	214	188	190	197	207
	2 000	156	160	167	178	195	201	224	197	199	206	217
	2 050	163	168	175	186	204	210	234	206	208	215	226
	2 100	170	175	182	194	213	219	245	215	218	225	237
	2 150	177	183	190	202	222	229	255	224	227	235	247
	2 200	185	190	198	211	231	238	266	234	237	245	257
	2 250	193	198	206	220	241	248	277	243	246	255	268
	2 300	200	206	215	228	250	258	288	253	256	265	279
	2 350	208	214	223	237	260	268	299	263	266	275	290
	2 400	216	223	232	247	270	279	311	273	277	286	301
	2 450	224	231	241	256	281	289	323	284	287	297	312
	2 500	233	239	250	265	291	300	335	294	298	308	324
	2 550	241	248	259	275	302	311	347	305	309	319	335
	2 600	250	257	268	285	312	322	359	316	320	330	347
	2 650	259	266	277	295	323	333	372	327	331	342	360
	2 700	267	275	287	305	334	344	384	338	342	354	372
	2 750	276	284	296	315	346	356	397	349	354	366	384
	2 800	285	294	306	325	357	368	410	361	365	378	397
	2 850	295	303	316	336	368	380	424	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)		16.6							20			
Pipe inside diameter (in)		3.826							3.64			
Tool joint inside diameter (in)		3 3/4	3 1/2	3 1/4	3	2 3/4	2 11/16	2 1/2	3 5/8	3 1/2	3 1/4	3
Flow rate Q (l/min)	**2 900**	304	313	326	347	380	392	437	384	389	402	423
	2 950	314	323	336	357	392	404	451	396	401	415	436
	3 000	323	332	347	368	404	416	465	408	413	428	449
	3 050	333	343	357	380	416	429	479	421	426	440	463
	3 100	343	353	368	391	429	442	493	433	439	453	477
	3 150	353	363	378	402	441	455	507	446	451	467	491
	3 200	363	373	389	414	454	468	522	459	464	480	505
	3 250	373	384	400	426	467	481	537	472	478	494	519
	3 300	384	395	411	437	480	494	552	485	491	508	534
	3 350	394	406	423	449	493	508	567	498	504	521	548
	3 400	405	417	434	462	506	522	582	512	518	536	563
	3 450	416	428	446	474	520	535	598	525	532	550	578
	3 500	427	439	457	486	533	549	613	539	546	564	593
	3 550	438	450	469	499	547	564	629	553	560	579	609
	3 600	449	462	481	512	561	578	645	567	574	594	624
	3 650	460	473	493	524	575	593	661	581	589	608	640
	3 700	471	485	505	537	589	607	678	596	603	624	656
	3 750	483	497	518	551	604	622	694	610	618	639	672
	3 800	495	509	530	564	618	637	711	625	633	654	688
	3 850	506	521	543	577	633	652	728	640	648	670	704
	3 900	518	533	556	591	648	668	745	655	663	686	721
	3 950	530	546	569	605	663	683	763	670	678	701	737
	4 000	543	558	582	618	678	699	780	685	694	718	754
	4 050	555	571	595	632	694	715	798	701	710	734	771
	4 100	567	583	608	647	709	730	815	717	726	750	789
	4 150	580	596	621	661	725	747	833	732	742	767	806
	4 200	592	609	635	675	741	763	852	748	758	783	824
	4 250	605	622	649	690	756	779	870	764	774	800	841

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)		19.5				25.5			
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	15	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	25	32	31	33	36	40
	950	25	26	28	35	35	36	39	44
	1 000	28	29	31	39	38	40	43	48
	1 050	30	32	34	42	42	44	47	52
	1 100	33	34	37	46	45	47	51	57
	1 150	35	37	40	50	49	51	55	62
	1 200	38	40	43	54	53	56	60	67
	1 250	41	43	46	58	57	60	64	72
	1 300	44	46	49	62	61	64	69	77
	1 350	47	50	53	67	65	69	74	82
	1 400	51	53	56	71	70	73	79	88
	1 450	54	56	60	76	74	78	84	94
	1 500	57	60	64	80	79	83	89	100
	1 550	61	64	68	85	84	88	95	106
	1 600	64	67	72	90	89	93	100	112
	1 650	68	71	76	96	94	98	106	118
	1 700	72	75	80	101	99	104	112	125
	1 750	76	79	84	106	104	110	118	131
	1 800	79	83	89	112	110	115	124	138
	1 850	83	87	93	117	115	121	130	145
	1 900	88	92	98	123	121	127	137	152
	1 950	92	96	102	129	127	133	143	160
	2 000	96	101	107	135	132	139	150	167
	2 050	100	105	112	141	139	146	157	175
	2 100	105	110	117	147	145	152	164	182
	2 150	109	114	122	154	151	159	171	190
	2 200	114	119	127	160	157	165	178	198

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)		19.5				25.5			
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)	**2 250**	119	124	133	167	164	172	185	206
	2 300	124	129	138	174	170	179	193	215
	2 350	128	134	143	181	177	186	200	223
	2 400	133	140	149	187	184	193	208	232
	2 450	138	145	155	195	191	201	216	241
	2 500	144	150	160	202	198	208	224	250
	2 550	149	156	166	209	205	216	232	259
	2 600	154	161	172	217	212	223	240	268
	2 650	159	167	178	224	220	231	249	277
	2 700	165	173	184	232	227	239	257	287
	2 750	170	178	190	240	235	247	266	296
	2 800	176	184	197	247	243	255	275	306
	2 850	182	190	203	255	251	263	283	316
	2 900	188	196	209	264	259	272	292	326
	2 950	193	202	216	272	267	280	302	336
	3 000	199	209	223	280	275	289	311	347
	3 050	205	215	229	289	283	298	320	357
	3 100	211	221	236	297	292	306	330	368
	3 150	218	228	243	306	300	315	339	378
	3 200	224	234	250	315	309	325	349	389
	3 250	230	241	257	324	317	334	359	400
	3 300	237	248	264	333	326	343	369	411
	3 350	243	254	271	342	335	352	379	423
	3 400	250	261	279	351	344	362	389	434
	3 450	256	268	286	360	354	372	400	446
	3 500	263	275	294	370	363	381	410	457
	3 550	270	282	301	379	372	391	421	469
	3 600	277	290	309	389	382	401	432	481
	3 650	284	297	317	399	391	411	442	493
	3 700	291	304	325	409	401	421	453	505
	3 750	298	312	333	419	411	432	465	518
	3 800	305	319	341	429	421	442	476	530
	3 850	312	327	349	439	431	453	487	543
	3 900	320	334	357	449	441	463	498	556
	3 950	327	342	365	460	451	474	510	569
	4 000	334	350	374	470	461	485	522	582

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)	21.9				24.7			25.2			27.72		
Pipe inside diameter (in)	4.778				4.67			5.965			5.901		
Tool joint inside diameter (in)	4	3 3/4	3 1/2	3	4	3 1/2	3	5	4 3/4	4 1/4	5	4 3/4	4 1/4
Flow rate *Q* (l/min)													
1 000	17	18	19	24	18	20	25	6	6	7	6	6	7
1 050	18	19	21	26	20	22	28	6	7	7	7	7	8
1 100	20	21	22	28	22	24	30	7	7	8	7	7	8
1 150	21	23	24	31	24	26	33	7	8	9	8	8	9
1 200	23	24	26	33	25	28	35	8	8	9	8	9	10
1 250	25	26	28	36	27	31	38	9	9	10	9	9	10
1 300	27	28	30	38	29	33	41	9	10	11	10	10	11
1 350	29	30	32	41	31	35	44	10	10	12	10	11	12
1 400	31	32	34	44	34	38	47	11	11	12	11	11	13
1 450	33	34	37	46	36	40	50	11	12	13	12	12	14
1 500	35	36	39	49	38	42	53	12	12	14	12	13	14
1 550	37	39	41	52	40	45	56	13	13	15	13	14	15
1 600	39	41	44	55	43	48	59	13	14	16	14	15	16
1 650	41	43	46	59	45	50	63	14	15	17	15	15	17
1 700	43	46	49	62	48	53	66	15	16	17	16	16	18
1 750	46	48	52	65	50	56	70	16	16	18	16	17	19
1 800	48	51	54	69	53	59	73	17	17	19	17	18	20
1 850	50	53	57	72	55	62	77	17	18	20	18	19	21
1 900	53	56	60	76	58	65	81	18	19	21	19	20	22
1 950	55	58	63	79	61	68	85	19	20	22	20	21	23
2 000	58	61	66	83	64	71	89	20	21	23	21	22	24
2 050	61	64	69	87	67	75	93	21	22	24	22	23	25
2 100	63	67	72	90	70	78	97	22	23	26	23	24	27
2 150	66	70	75	94	73	81	101	23	24	27	24	25	28
2 200	69	73	78	98	76	85	105	24	25	28	25	26	29
2 250	72	75	81	102	79	88	110	25	26	29	26	27	30
2 300	75	79	84	107	82	92	114	26	27	30	27	28	31
2 350	78	82	88	111	85	95	118	27	28	31	28	29	32
2 400	81	85	91	115	89	99	123	28	29	32	29	30	34
2 450	84	88	94	119	92	103	128	29	30	34	30	31	35
2 500	87	91	98	124	95	107	132	30	31	35	31	32	36
2 550	90	95	101	128	99	110	137	31	32	36	32	34	38
2 600	93	98	105	133	102	114	142	32	33	37	34	35	39
2 650	96	101	109	138	106	118	147	33	35	39	35	36	40
2 700	100	105	112	142	110	122	152	34	36	40	36	37	42
2 750	103	108	116	147	113	126	157	35	37	41	37	38	43

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)	21.9				24.7			25.2			27.72		
Pipe inside diameter (in)	4.778				4.67			5.965			5.901		
Tool joint inside diameter (in)	4	3 3/4	3 1/2	3	4	3 1/2	3	5	4 3/4	4 1/4	5	4 3/4	4 1/4
Flow rate Q (l/min)													
2 800	106	112	120	152	117	131	162	37	38	43	38	40	44
2 850	110	116	124	157	121	135	168	38	39	44	40	41	46
2 900	113	119	128	162	125	139	173	39	41	46	41	42	47
2 950	117	123	132	167	128	144	178	40	42	47	42	44	49
3 000	120	127	136	172	132	148	184	41	43	48	43	45	50
3 050	124	131	140	177	136	152	189	43	44	50	45	46	52
3 100	128	134	144	182	140	157	195	44	46	51	46	48	53
3 150	131	138	148	188	145	162	201	45	47	53	47	49	55
3 200	135	142	153	193	149	166	207	47	48	54	49	51	57
3 250	139	146	157	199	153	171	212	48	50	56	50	52	58
3 300	143	150	161	204	157	176	218	49	51	58	51	53	60
3 350	147	155	166	210	161	180	224	51	53	59	53	55	61
3 400	151	159	170	215	166	185	230	52	54	61	54	56	63
3 450	155	163	175	221	170	190	236	53	55	62	56	58	65
3 500	159	167	179	227	175	195	243	55	57	64	57	59	66
3 550	163	172	184	233	179	200	249	56	58	66	59	61	68
3 600	167	176	189	239	184	205	255	58	60	67	60	63	70
3 650	171	180	194	245	188	211	262	59	61	69	62	64	72
3 700	176	185	198	251	193	216	268	61	63	71	63	66	73
3 750	180	189	203	257	198	221	275	62	64	72	65	67	75
3 800	184	194	208	263	203	226	281	63	66	74	66	69	77
3 850	189	199	213	269	207	232	288	65	68	76	68	71	79
3 900	193	203	218	276	212	237	295	67	69	78	70	72	81
3 950	198	208	223	282	217	243	302	68	71	80	71	74	83
4 000	202	213	228	289	222	248	309	70	72	81	73	76	85
4 050	207	217	233	295	227	254	316	71	74	83	74	77	86
4 100	211	222	239	302	232	260	323	73	76	85	76	79	88
4 150	216	227	244	308	237	265	330	74	77	87	78	81	90
4 200	221	232	249	315	243	271	337	76	79	89	79	83	92
4 250	225	237	255	322	248	277	344	78	81	91	81	84	94
4 300	230	242	260	329	253	283	352	79	82	93	83	86	96
4 350	235	247	265	336	258	289	359	81	84	95	85	88	98
4 400	240	252	271	343	264	295	366	83	86	97	86	90	100
4 450	245	258	276	350	269	301	374	84	88	99	88	92	102
4 500	250	263	282	357	275	307	382	86	89	101	90	93	105
4 550	255	268	288	364	280	313	389	88	91	103	92	95	107

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)	21.9				24.7			25.2			27.72		
Pipe inside diameter (in)	4.778				4.67			5.965			5.901		
Tool joint inside diameter (in)	4	3 3/4	3 1/2	3	4	3 1/2	3	5	4 3/4	4 1/4	5	4 3/4	4 1/4
Flow rate *Q* (l/min)													
4 600	260	274	293	371	286	319	397	90	93	105	94	97	109
4 650	265	279	299	378	291	326	405	91	95	107	95	99	111
4 700	270	284	305	386	297	332	413	93	97	109	97	101	113
4 750	275	290	311	393	303	338	421	95	99	111	99	103	115
4 800	281	295	317	401	309	345	429	97	101	113	101	105	117
4 850	286	301	323	408	314	351	437	98	102	115	103	107	120
4 900	291	306	329	416	320	358	445	100	104	117	105	109	122
4 950	297	312	335	423	326	364	453	102	106	119	107	111	124
5 000	302	318	341	431	332	371	461	104	108	122	109	113	126
5 050	308	324	347	439	338	378	470	106	110	124	111	115	129
5 100	313	329	353	447	344	384	478	108	112	126	113	117	131
5 150	319	335	360	455	350	391	486	110	114	128	115	119	133
5 200	324	341	366	463	356	398	495	112	116	130	117	121	136
5 250	330	347	372	471	363	405	504	114	118	133	119	123	138
5 300	335	353	379	479	369	412	512	116	120	135	121	125	140
5 350	341	359	385	487	375	419	521	118	122	137	123	128	143
5 400	347	365	392	495	381	426	530	119	124	140	125	130	145
5 450	353	371	398	504	388	433	539	121	126	142	127	132	148
5 500	359	377	405	512	394	440	548	123	128	144	129	134	150
5 550	364	383	411	520	401	448	557	126	131	147	131	136	152
5 600	370	390	418	529	407	455	566	128	133	149	133	138	155
5 650	376	396	425	537	414	462	575	130	135	152	136	141	157
5 700	382	402	432	546	420	470	584	132	137	154	138	143	160
5 750	388	409	439	555	427	477	593	134	139	156	140	145	162
5 800	395	415	445	563	434	485	602	136	141	159	142	147	165
5 850	401	422	452	572	440	492	612	138	144	161	144	150	168
5 900	407	428	459	581	447	500	621	140	146	164	147	152	170
5 950	413	435	466	590	454	507	631	142	148	166	149	154	173
6 000	419	441	473	599	461	515	640	144	150	169	151	157	175
6 050	426	448	481	608	468	523	650	147	152	171	153	159	178
6 100	432	455	488	617	475	531	660	149	155	174	156	162	181
6 150	438	461	495	626	482	539	669	151	157	176	158	164	183
6 200	445	468	502	635	489	546	679	153	159	179	160	166	186
6 250	451	475	510	644	496	554	689	155	162	182	163	169	189
6 300	458	482	517	654	503	562	699	158	164	184	165	171	191
6 350	464	489	524	663	511	570	709	160	166	187	167	174	194

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_3

Calculation of pressure losses in drill collars $p_{int} = N_3 B$ (kPa/100 m)

Drill collar ID	(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	1 143	545	287	163	98	62	56	41	28	20
	550	1 356	647	341	194	117	74	66	49	33	23
	600	1 586	757	399	227	137	86	78	57	39	27
	650	1 832	874	461	262	158	100	90	66	45	31
	700	2 094	999	526	299	180	114	102	75	51	36
	750	2 371	1 131	596	339	204	129	116	85	58	41
	800	2 663	1 270	669	380	229	145	130	96	65	46
	850	2 970	1 417	746	424	256	162	145	107	73	51
	900	3 291	1 570	827	470	283	179	161	118	80	56
	950	3 628	1 731	912	518	312	198	178	130	89	62
	1 000	3 979	1 898	1 000	568	343	217	195	143	97	68
	1 050	4 344	2 073	1 092	620	374	237	213	156	106	74
	1 100	4 723	2 254	1 187	675	407	257	231	170	115	81
	1 150	5 117	2 441	1 286	731	441	279	250	184	125	88
	1 200	5 524	2 636	1 389	789	476	301	270	198	135	95
	1 250	5 945	2 837	1 494	849	512	324	291	213	145	102
	1 300	6 380	3 044	1 604	911	549	348	312	229	156	109
	1 350	6 829	3 258	1 716	975	588	372	334	245	167	117
	1 400	7 291	3 479	1 833	1 041	628	397	357	262	178	125
	1 450	7 766	3 706	1 952	1 109	669	423	380	279	190	133
	1 500	8 255	3 939	2 075	1 179	711	450	404	296	202	141
	1 550	8 757	4 178	2 201	1 251	754	477	428	314	214	150
	1 600	9 271	4 424	2 330	1 324	799	505	454	333	227	159
	1 650	9 800	4 676	2 463	1 399	844	534	480	352	240	168
	1 700	10 341	4 934	2 599	1 477	891	564	506	371	253	177
	1 750	10 894	5 198	2 738	1 556	938	594	533	391	266	187
	1 800	11 461	5 469	2 881	1 637	987	625	561	411	280	196
	1 850	12 040	5 745	3 026	1 720	1 037	656	589	432	294	206
	1 900	12 633	6 028	3 175	1 804	1 088	689	618	453	309	216
	1 950	13 237	6 316	3 327	1 890	1 140	722	648	475	324	227
	2 000	13 854	6 611	3 482	1 979	1 193	755	678	497	339	237
	2 050	14 484	6 911	3 641	2 068	1 247	789	709	520	354	248
	2 100	15 126	7 217	3 802	2 160	1 303	824	740	543	370	259

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_3 (continued)
Calculation of pressure losses in drill collars $p_{int} = N_3B$ (kPa/100 m)

Drill collar ID	(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)	**2 150**	15 781	7 530	3 967	2 254	1 359	860	772	566	386	270
	2 200	16 447	7 848	4 134	2 349	1 417	896	805	590	402	282
	2 250	17 126	8 172	4 305	2 446	1 475	933	838	615	419	293
	2 300	17 817	8 502	4 479	2 545	1 535	971	872	640	436	305
	2 350	18 521	8 837	4 655	2 645	1 595	1 009	906	665	453	317
	2 400	19 236	9 178	4 835	2 747	1 657	1 048	941	691	470	329
	2 450	19 963	9 526	5 018	2 851	1 719	1 088	977	717	488	342
	2 500	20 703	9 878	5 204	2 957	1 783	1 128	1 013	743	506	355
	2 550	21 454	10 237	5 393	3 064	1 848	1 169	1 050	770	524	367
	2 600	22 217	10 601	5 584	3 173	1 913	1 211	1 087	798	543	381
	2 650	22 992	10 971	5 779	3 284	1 980	1 253	1 125	825	562	394
	2 700	23 779	11 346	5 977	3 396	2 048	1 296	1 164	854	581	407
	2 750	24 577	11 727	6 178	3 510	2 117	1 340	1 203	882	601	421
	2 800	25 387	12 114	6 381	3 626	2 186	1 384	1 242	911	621	435
	2 850	26 209	12 506	6 588	3 743	2 257	1 429	1 282	941	641	449
	2 900	27 043	12 903	6 797	3 862	2 329	1 474	1 323	971	661	463
	2 950	27 888	13 307	7 010	3 983	2 402	1 520	1 365	1 001	682	478
	3 000	28 744	13 715	7 225	4 105	2 476	1 567	1 407	1 032	703	492
	3 050	29 612	14 130	7 443	4 229	2 550	1 614	1 449	1 063	724	507
	3 100	30 492	14 549	7 664	4 355	2 626	1 662	1 492	1 095	745	522
	3 150	31 383	14 974	7 888	4 482	2 703	1 711	1 536	1 127	767	538
	3 200	32 285	15 405	8 115	4 611	2 781	1 760	1 580	1 159	789	553
	3 250	33 199	15 841	8 345	4 741	2 859	1 810	1 624	1 192	812	569
	3 300	34 124	16 282	8 577	4 873	2 939	1 860	1 670	1 225	834	584
	3 350	35 060	16 729	8 813	5 007	3 020	1 911	1 716	1 259	857	601
	3 400	36 008	17 181	9 051	5 142	3 101	1 963	1 762	1 293	880	617
	3 450	36 966	17 639	9 292	5 279	3 184	2 015	1 809	1 327	904	633
	3 500	37 936	18 101	9 536	5 418	3 267	2 068	1 856	1 362	927	650
	3 550	38 917	18 569	9 782	5 558	3 352	2 121	1 904	1 397	951	667
	3 600	39 910	19 043	10 032	5 700	3 437	2 175	1 953	1 433	976	684
	3 650	40 913	19 522	10 284	5 843	3 524	2 230	2 002	1 469	1 000	701
	3 700	41 927	20 006	10 539	5 988	3 611	2 285	2 052	1 505	1 025	718
	3 750	42 953	20 495	10 797	6 134	3 699	2 341	2 102	1 542	1 050	736
	3 800	43 989	20 989	11 057	6 282	3 789	2 398	2 152	1 579	1 075	753
	3 850	45 036	21 489	11 320	6 432	3 879	2 455	2 204	1 617	1 101	771
	3 900	46 095	21 994	11 586	6 583	3 970	2 512	2 256	1 655	1 127	790
	3 950	47 164	22 504	11 855	6 736	4 062	2 571	2 308	1 693	1 153	808
	4 000	48 244	23 020	12 127	6 890	4 155	2 630	2 361	1 732	1 179	826
	4 050	49 335	23 540	12 401	7 046	4 249	2 689	2 414	1 771	1 206	845
	4 100	50 436	24 066	12 678	7 203	4 344	2 749	2 468	1 811	1 233	864
	4 150	51 549	24 597	12 957	7 362	4 440	2 810	2 522	1 850	1 260	883

l/min × 0.264 = gal/min

CALCULATIONS OF PRESSURE DROP IN NOZZLES
Combination of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\, A^2} \text{ (kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)	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
A (in²)	0.1473	0.1603	0.1733	0.1864	0.201	0.2155	0.2301	0.2462	0.2623	0.2784	0.2961	0.3137
Flow rate Q (l/min)												
200	690	583	499	431	371	322	283	247	218	193	171	152
250	1 079	911	779	673	579	504	442	386	340	302	267	238
300	1 553	1 311	1 122	970	834	726	636	556	490	435	384	342
350	2 114	1 785	1 527	1 320	1 135	988	866	757	667	592	523	466
400	2 761	2 331	1 995	1 724	1 483	1 290	1 131	988	871	773	683	609
450	3 494	2 951	2 525	2 182	1 877	1 633	1 432	1 251	1 102	978	865	770
500	4 314	3 643	3 117	2 694	2 317	2 016	1 768	1 544	1 360	1 208	1 068	951
550	5 220	4 408	3 771	3 260	2 803	2 439	2 139	1 869	1 646	1 461	1 292	1 151
600	6 212	5 245	4 488	3 879	3 336	2 902	2 546	2 224	1 959	1 739	1 537	1 370
650	7 291	6 156	5 267	4 553	3 915	3 406	2 988	2 610	2 299	2 041	1 804	1 607
700	8 455	7 140	6 109	5 280	4 541	3 950	3 465	3 027	2 667	2 367	2 093	1 864
750	9 707	8 196	7 013	6 061	5 213	4 535	3 978	3 475	3 061	2 717	2 402	2 140
800	11 044	9 325	7 979	6 897	5 931	5 160	4 526	3 953	3 483	3 092	2 733	2 435
850	12 468	10 527	9 007	7 786	6 696	5 825	5 109	4 463	3 932	3 490	3 085	2 749
900	13 977	11 802	10 098	8 729	7 507	6 530	5 728	5 003	4 408	3 913	3 459	3 082
950	15 574	13 150	11 251	9 725	8 364	7 276	6 382	5 575	4 911	4 360	3 854	3 434
1 000		14 571	12 467	10 776	9 267	8 062	7 072	6 177	5 442	4 831	4 270	3 805
1 050		16 064	13 745	11 880	10 217	8 889	7 796	6 810	6 000	5 326	4 708	4 195
1 100			15 085	13 039	11 213	9 755	8 557	7 474	6 585	5 845	5 167	4 604
1 150				14 251	12 256	10 662	9 352	8 169	7 197	6 389	5 648	5 032
1 200				15 517	13 345	11 610	10 183	8 895	7 836	6 956	6 149	5 479
1 250					14 480	12 597	11 049	9 651	8 503	7 548	6 673	5 945
1 300					15 662	13 625	11 951	10 439	9 197	8 164	7 217	6 430
1 350						14 693	12 888	11 257	9 918	8 804	7 783	6 934
1 400						15 802	13 860	12 107	10 666	9 468	8 370	7 457
1 450							14 868	12 987	11 442	10 157	8 979	7 999
1 500							15 911	13 898	12 244	10 869	9 608	8 561
1 550								14 840	13 074	11 606	10 260	9 141
1 600								15 813	13 931	12 367	10 932	9 740
1 650									14 816	13 152	11 626	10 358
1 700									15 727	13 961	12 342	10 996
1 750										14 794	13 078	11 652
1 800										15 651	13 836	12 327
1 850											14 616	13 022
1 900											15 416	13 735
1 950												14 467
2 000												15 219

l/min × 0.264 = gal/min kPa × 0.125 = psi kg/l = sp.gr kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES (continued)

Combination of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\,A^2} \text{ (kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)		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
A (in²)		0.3313	0.3505	0.3697	0.3889	0.4096	0.4303	0.451	0.4732	0.4955	0.5177	0.5415
Flow rate Q (l/min)	200	136	122	110	99	89	81	74	67	61	56	51
	250	213	190	171	155	139	126	115	105	95	87	80
	300	307	274	247	223	201	182	166	150	137	126	115
	350	418	373	336	303	273	248	225	205	187	171	156
	400	546	488	438	396	357	324	295	268	244	224	204
	450	691	617	555	501	452	409	373	339	309	283	259
	500	853	762	685	619	558	506	460	418	381	349	319
	550	1 032	922	829	749	675	612	557	506	461	423	386
	600	1 228	1 097	986	891	803	728	663	602	549	503	460
	650	1 441	1 288	1 157	1 046	943	854	778	706	644	590	539
	700	1 671	1 493	1 342	1 213	1 094	991	902	819	747	685	626
	750	1 919	1 714	1 541	1 392	1 255	1 137	1 035	941	858	786	718
	800	2 183	1 951	1 753	1 584	1 428	1 294	1 178	1 070	976	894	817
	850	2 465	2 202	1 979	1 789	1 612	1 461	1 330	1 208	1 102	1 009	923
	900	2 763	2 469	2 219	2 005	1 808	1 638	1 491	1 354	1 235	1 132	1 034
	950	3 079	2 751	2 472	2 234	2 014	1 825	1 661	1 509	1 376	1 261	1 152
	1 000	3 411	3 048	2 739	2 476	2 232	2 022	1 841	1 672	1 525	1 397	1 277
	1 050	3 761	3 360	3 020	2 729	2 460	2 229	2 029	1 843	1 681	1 540	1 408
	1 100	4 128	3 688	3 315	2 995	2 700	2 447	2 227	2 023	1 845	1 690	1 545
	1 150	4 511	4 031	3 623	3 274	2 951	2 674	2 434	2 211	2 017	1 848	1 689
	1 200	4 912	4 389	3 945	3 565	3 214	2 912	2 651	2 408	2 196	2 012	1 839
	1 250	5 330	4 762	4 280	3 868	3 487	3 160	2 876	2 613	2 383	2 183	1 995
	1 300	5 765	5 151	4 630	4 184	3 772	3 417	3 111	2 826	2 577	2 361	2 158
	1 350	6 217	5 554	4 992	4 512	4 067	3 685	3 355	3 047	2 779	2 546	2 327
	1 400	6 686	5 973	5 369	4 852	4 374	3 963	3 608	3 277	2 989	2 738	2 503
	1 450	7 172	6 408	5 759	5 205	4 692	4 251	3 870	3 516	3 206	2 937	2 685
	1 500	7 675	6 857	6 164	5 570	5 021	4 550	4 142	3 762	3 431	3 143	2 873
	1 550	8 195	7 322	6 581	5 948	5 362	4 858	4 422	4 017	3 664	3 356	3 068
	1 600	8 733	7 802	7 013	6 337	5 713	5 177	4 712	4 281	3 904	3 576	3 269
	1 650	9 287	8 297	7 458	6 740	6 076	5 505	5 011	4 552	4 152	3 803	3 476
	1 700	9 858	8 808	7 917	7 154	6 449	5 844	5 320	4 832	4 407	4 037	3 690
	1 750	10 447	9 334	8 389	7 581	6 834	6 193	5 637	5 121	4 670	4 278	3 910
	1 800	11 052	9 875	8 876	8 021	7 231	6 552	5 964	5 418	4 941	4 526	4 137
	1 850	11 675	10 431	9 375	8 473	7 638	6 921	6 300	5 723	5 219	4 781	4 370
	1 900	12 314	11 002	9 889	8 937	8 056	7 300	6 645	6 036	5 505	5 043	4 610
	1 950	12 971	11 589	10 416	9 413	8 486	7 689	6 999	6 358	5 799	5 312	4 855
	2 000	13 645	12 191	10 957	9 902	8 927	8 088	7 363	6 688	6 100	5 588	5 108

l/min × 0.264 = gal/min   kPa × 0.125 = psi   kg/l = sp.gr   kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES (continued)

Combination of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\, A^2} \text{ (kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)	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
A (in^2)	0.3313	0.3505	0.3697	0.3889	0.4096	0.4303	0.451	0.4732	0.4955	0.5177	0.5415
Flow rate Q (l/min)											
2 050	14 335	12 808	11 512	10 404	9 379	8 498	7 736	7 027	6 409	5 871	5 366
2 150	15 768	14 088	12 663	11 443	10 316	9 347	8 509	7 729	7 049	6 458	5 902
2 200	16 510	14 751	13 258	11 982	10 801	9 787	8 909	8 093	7 381	6 761	6 180
2 250	17 269	15 429	13 868	12 532	11 298	10 237	9 319	8 465	7 720	7 072	6 464
2 300	18 045	16 122	14 491	13 096	11 805	10 697	9 738	8 845	8 067	7 390	6 755
2 350	18 838	16 831	15 128	13 671	12 324	11 167	10 166	9 234	8 422	7 715	7 052
2 400	19 648	17 555	15 779	14 259	12 854	11 647	10 603	9 631	8 784	8 047	7 355
2 450	20 476	18 294	16 443	14 859	13 396	12 138	11 049	10 037	9 154	8 385	7 664
2 500	21 320	19 048	17 121	15 472	13 948	12 638	11 505	10 451	9 531	8 731	7 981
2 550		19 818	17 813	16 097	14 511	13 149	11 969	10 873	9 916	9 084	8 303
2 600		20 602	18 518	16 735	15 086	13 669	12 443	11 303	10 309	9 444	8 632
2 650		21 402	19 237	17 385	15 672	14 200	12 927	11 742	10 709	9 810	8 967
2 700			19 970	18 047	16 269	14 741	13 419	12 189	11 117	10 184	9 308
2 750			20 716	18 721	16 877	15 292	13 921	12 645	11 533	10 565	9 656
2 800			21 477	19 408	17 496	15 853	14 431	13 109	11 956	10 952	10 011
2 850				20 108	18 127	16 425	14 951	13 582	12 387	11 347	10 371
2 900				20 819	18 768	17 006	15 481	14 062	12 825	11 749	10 739
2 950				21 543	19 421	17 597	16 019	14 551	13 271	12 157	11 112
3 000					20 085	18 199	16 567	15 049	13 725	12 573	11 492
3 050					20 760	18 811	17 124	15 555	14 186	12 995	11 878
3 100					21 446	19 432	17 690	16 069	14 655	13 425	12 271
3 150						20 064	18 265	16 591	15 131	13 862	12 670
3 200						20 706	18 849	17 122	15 616	14 305	13 075
3 250						21 359	19 443	17 661	16 107	14 756	13 487
3 300							20 046	18 209	16 607	15 213	13 905
3 350							20 658	18 765	17 114	15 678	14 330
3 400							21 279	19 329	17 629	16 149	14 761
3 450							21 910	19 902	18 151	16 628	15 198
3 500								20 483	18 681	17 113	15 642
3 550								21 072	19 218	17 605	16 092
3 600									19 764	18 105	16 548
3 650									20 316	18 611	17 011
3 700									20 877	19 125	17 481
3 750										19 645	17 956
3 800										20 172	18 438
3 850											18 927
3 900											19 421
3 950											19 923

l/min × 0.264 = gal/min   kPa × 0.125 = psi   kg/l = sp.gr   kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES (continued)

Combination of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2 A^2} \text{ (kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)		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
A (in²)		0.5653	0.589	0.6412	0.6934	0.7455	0.9204	0.9848	1.0492	1.1137	1.3254	2.3562
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	389	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	1 057	974	822	703	608	399	348	307	272	192	61
	1 000	1 172	1 079	911	779	674	442	386	340	302	213	67
	1 050	1 292	1 190	1 004	859	743	487	426	375	333	235	74
	1 100	1 418	1 306	1 102	942	815	535	467	412	365	258	82
	1 150	1 549	1 427	1 204	1 030	891	585	511	450	399	282	89
	1 200	1 687	1 554	1 311	1 121	970	636	556	490	435	307	97
	1 250	1 831	1 686	1 423	1 217	1 053	691	603	531	472	333	105
	1 300	1 980	1 824	1 539	1 316	1 139	747	652	575	510	360	114
	1 350	2 135	1 967	1 660	1 419	1 228	805	704	620	550	388	123
	1 400	2 296	2 115	1 785	1 526	1 320	866	757	667	592	418	132
	1 450	2 463	2 269	1 915	1 637	1 416	929	812	715	635	448	142
	1 500	2 636	2 428	2 049	1 752	1 516	994	869	765	679	480	152
	1 550	2 815	2 593	2 188	1 871	1 619	1 062	928	817	725	512	162
	1 600	2 999	2 763	2 331	1 994	1 725	1 131	988	871	773	546	173
	1 650	3 190	2 938	2 479	2 120	1 834	1 203	1 051	926	822	580	184
	1 700	3 386	3 119	2 632	2 250	1 947	1 277	1 116	983	872	616	195
	1 750	3 588	3 305	2 789	2 385	2 063	1 354	1 182	1 042	924	653	207
	1 800	3 796	3 497	2 951	2 523	2 183	1 432	1 251	1 102	978	691	219

l/min × 0.264 = gal/min kPa × 0.125 = psi kg/l = sp.gr kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES (continued)

Combination of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\, A^2} \text{ (kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)		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
A (in²)		0.5653	0.589	0.6412	0.6934	0.7455	0.9204	0.9848	1.0492	1.1137	1.3254	2.3562
Flow rate Q (l/min)	**1 850**	4 010	3 694	3 117	2 665	2 306	1 513	1 321	1 164	1 033	729	231
	1 900	4 230	3 896	3 288	2 811	2 432	1 596	1 394	1 228	1 090	769	243
	1 950	4 455	4 104	3 463	2 961	2 562	1 681	1 468	1 293	1 148	810	256
	2 000	4 687	4 317	3 643	3 115	2 695	1 768	1 544	1 360	1 207	853	270
	2 050	4 924	4 535	3 827	3 273	2 831	1 857	1 622	1 429	1 269	896	283
	2 100	5 167	4 759	4 016	3 434	2 971	1 949	1 703	1 500	1 331	940	297
	2 150	5 416	4 989	4 210	3 600	3 114	2 043	1 785	1 572	1 395	985	312
	2 200	5 671	5 224	4 408	3 769	3 261	2 139	1 869	1 646	1 461	1 032	326
	2 250	5 931	5 464	4 610	3 942	3 410	2 237	1 954	1 722	1 528	1 079	341
	2 300	6 198	5 709	4 817	4 119	3 564	2 338	2 042	1 799	1 597	1 127	357
	2 350	6 470	5 960	5 029	4 300	3 720	2 441	2 132	1 878	1 667	1 177	372
	2 400	6 749	6 216	5 245	4 485	3 880	2 546	2 224	1 959	1 739	1 228	388
	2 450	7 033	6 478	5 466	4 674	4 044	2 653	2 317	2 042	1 812	1 279	405
	2 500	7 323	6 745	5 692	4 867	4 210	2 762	2 413	2 126	1 887	1 332	422
	2 550	7 619	7 018	5 922	5 064	4 381	2 874	2 510	2 212	1 963	1 386	439
	2 600	7 920	7 296	6 156	5 264	4 554	2 988	2 610	2 299	2 041	1 441	456
	2 650	8 228	7 579	6 395	5 469	4 731	3 104	2 711	2 388	2 120	1 497	474
	2 700	8 541	7 868	6 639	5 677	4 911	3 222	2 814	2 479	2 201	1 554	492
	2 750	8 860	8 162	6 887	5 889	5 095	3 342	2 920	2 572	2 283	1 612	510
	2 800	9 186	8 461	7 140	6 105	5 282	3 465	3 027	2 667	2 367	1 671	529
	2 850	9 517	8 766	7 397	6 325	5 472	3 590	3 136	2 763	2 452	1 731	548
	2 900	9 853	9 076	7 659	6 549	5 666	3 717	3 247	2 860	2 539	1 792	567
	2 950	10 196	9 392	7 925	6 777	5 863	3 846	3 360	2 960	2 627	1 855	587
	3 000	10 545	9 713	8 196	7 008	6 063	3 978	3 475	3 061	2 717	1 918	607
	3 050	10 899	10 040	8 471	7 244	6 267	4 111	3 591	3 164	2 808	1 983	627
	3 100	11 259	10 371	8 752	7 483	6 474	4 247	3 710	3 269	2 901	2 048	648
	3 150	11 625	10 709	9 036	7 727	6 685	4 385	3 831	3 375	2 995	2 115	669

l/min × 0.264 = gal/min kPa × 0.125 = psi kg/l = sp.gr kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES (continued)

Combination of three nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\, A^2} \text{ (kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)		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
A (in²)		0.5653	0.589	0.6412	0.6934	0.7455	0.9204	0.9848	1.0492	1.1137	1.3254	2.3562
Flow rate Q (l/min)	**3 200**	11 997	11 051	9 325	7 974	6 898	4 526	3 953	3 483	3 091	2 182	691
	3 250	12 375	11 399	9 619	8 225	7 116	4 668	4 078	3 593	3 188	2 251	712
	3 300	12 759	11 753	9 917	8 480	7 336	4 813	4 204	3 704	3 287	2 321	734
	3 350	13 149	12 112	10 220	8 739	7 560	4 960	4 333	3 817	3 388	2 392	757
	3 400	13 544	12 476	10 527	9 002	7 788	5 109	4 463	3 932	3 490	2 464	780
	3 450	13 945	12 846	10 839	9 269	8 018	5 261	4 595	4 048	3 593	2 537	803
	3 500	14 352	13 221	11 156	9 539	8 253	5 414	4 729	4 166	3 698	2 611	826
	3 550	14 765	13 601	11 477	9 814	8 490	5 570	4 865	4 286	3 804	2 686	850
	3 600	15 184	13 987	11 802	10 092	8 731	5 728	5 003	4 408	3 912	2 762	874
	3 650	15 609	14 378	12 132	10 374	8 975	5 888	5 143	4 531	4 022	2 839	898
	3 700	16 040	14 775	12 467	10 661	9 223	6 051	5 285	4 656	4 133	2 918	923
	3 750	16 476	15 177	12 806	10 951	9 474	6 215	5 429	4 783	4 245	2 997	948
	3 800	16 918	15 584	13 150	11 245	9 728	6 382	5 575	4 911	4 359	3 078	974
	3 850	17 366	15 997	13 498	11 543	9 986	6 551	5722	5 041	4 474	3 159	1 000
	3 900	17 820	16 415	13 851	11 844	10 247	6 722	5 872	5 173	4 591	3 242	1 026
	3 950	18 280	16 839	14 209	12 150	10 511	6 896	6 023	5 307	4 710	3 325	1 052
	4 000	18 746	17 268	14 571	12 459	10 779	7 072	6 177	5 442	4 830	3 410	1 079
	4 050	19 218	17 702	14 937	12 773	11 050	7 249	6 332	5 579	4 951	3 496	1 106
	4 100	19 695	18 142	15 308	13 090	11 325	7 430	6 490	5 717	5 074	3 583	1 134
	4 150		18 587	15 684	13 411	11 602	7 612	6 649	5 858	5 199	3 671	1 162
	4 200		19 038	16 064	13 737	11 884	7 796	6 810	6 000	5 325	3 760	1 190
	4 250		19 494	16 449	14 066	12 168	7 983	6 973	6 143	5 452	3 850	1 218
	4 300		19 955	16 838	14 398	12 456	8 172	7 138	6 289	5 581	3 941	1 247
	4 350			17 232	14 735	12 748	8 363	7 305	6 436	5 712	4 033	1 276
	4 400			17 631	15 076	13 042	8 557	7 474	6 585	5 844	4 126	1 306
	4 450			18 034	15 421	13 341	8 752	7 645	6 735	5 978	4 221	1 335
	4 500			18 441	15 769	13 642	8 950	7 818	6 887	6 113	4 316	1 366

l/min × 0.264 = gal/min   kPa × 0.125 = psi   kg/l = sp.gr   kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES
Combination of two nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\,A^2}\ \text{(kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)		11-11	12-12	13-13	14-14	15-15	16-16	18-18	20-20	22-22	24-24	32-32
A (in²)		0.1856	0.2209	0.2592	0.3007	0.3451	0.3927	0.497	0.6136	0.7424	0.8836	1.5708
Flow rate Q (l/min)	**500**	2 717	1 918	1 393	1 035	786	607	379	249	170	120	38
	550	3 288	2 321	1 686	1 253	951	734	459	301	205	145	46
	600	3 913	2 762	2 006	1 491	1 132	874	546	358	245	173	55
	650	4 592	3 242	2 355	1 749	1 328	1 026	640	420	287	203	64
	700	5 326	3 760	2 731	2 029	1 540	1 190	743	487	333	235	74
	750	6 114	4 316	3 135	2 329	1 768	1 366	853	559	382	270	85
	800	6 956	4 911	3 567	2 650	2 012	1 554	970	636	435	307	97
	850	7 853	5 544	4 026	2 992	2 271	1 754	1 095	718	491	346	110
	900	8 804	6 215	4 514	3 354	2 546	1 967	1 228	805	550	388	123
	950	9 809	6 925	5 030	3 737	2 837	2 191	1 368	897	613	433	137
	1 000	10 869	7 673	5 573	4 141	3 144	2 428	1 516	994	679	480	152
	1 050	11 983	8 459	6 144	4 565	3 466	2 677	1 671	1 096	749	529	167
	1 100	13 152	9 284	6 743	5 010	3 804	2 938	1 834	1 203	822	580	184
	1 150	14 374	10 147	7 370	5 476	4 158	3 211	2 005	1 315	898	634	201
	1 200	15 651	11 049	8 025	5 963	4 527	3 496	2 183	1 432	978	691	219
	1 250	16 983	11 989	8 708	6 470	4 912	3 794	2 368	1 554	1 061	749	237
	1 300	18 369	12 967	9 418	6 998	5 313	4 103	2 562	1 681	1 148	810	256
	1 350	19 809	13 984	10 157	7 547	5 730	4 425	2 763	1 812	1 238	874	277
	1 400	21 303	15 039	10 923	8 116	6 162	4 759	2 971	1 949	1 331	940	297
	1 450		16 132	11 717	8.706	6 610	5 105	3 187	2 091	1 428	1 008	319
	1 500		17 264	12 539	9 317	7 074	5 463	3 410	2 237	1 528	1 079	341
	1 550		18 434	13 389	9 948	7 553	5 833	3 642	2 389	1 632	1 152	365
	1 600		19 642	14 267	10 600	8 048	6 215	3 880	2 546	1 739	1 228	388
	1 650			15 172	11 273	8 559	6 610	4 127	2 707	1 849	1 306	413
	1 700			16 106	11 967	9 086	7 017	4 381	2 874	1 963	1 386	439
	1 750			17 067	12 681	9 628	7 435	4 642	3 045	2 080	1 469	465
	1 800			18 056	13 416	10 186	7 866	4 911	3 222	2 201	1 554	492

l/min × 0.264 = gal/min   kPa × 0.125 = psi   kg/l = sp.gr   kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES (continued)

Combination of two nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\, A^2} \text{ (kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)		11-11	12-12	13-13	14-14	15-15	16-16	18-18	20-20	22-22	24-24	32-32
A (in^2)		0.1856	0.2209	0.2592	0.3007	0.3451	0.3927	0.497	0.6136	0.7424	0.8836	1.5708
Flow rate Q (l/min)	1 850			19 073	14 172	10 760	8 309	5 188	3 403	2 325	1 641	519
	1 900			20 118	14 948	11 349	8 765	5 472	3 590	2 452	1 731	548
	1 950				15 745	11 954	9 232	5 764	3 781	2 583	1 823	577
	2 000				16 563	12 575	9 711	6 063	3 978	2 717	1 918	607
	2 050				17 402	13 212	10 203	6 370	4 179	2 855	2 015	638
	2 100				18 261	13 864	10 707	6 685	4 385	2 996	2 115	669
	2 150				19 141	14 532	11 223	7 007	4 597	3 140	2 217	701
	2 200				20 041	15 216	11 751	7 336	4 813	3 288	2 321	734
	2 250					15 916	12 291	7 674	5 034	3 439	2 428	768
	2 300					16 631	12 843	8 018	5 261	3 594	2 537	803
	2 350					17 362	13 408	8 371	5 492	3 752	2 648	838
	2 400					18 108	13 985	8 731	5 728	3 913	2 762	874
	2 450					18 871	14 573	9 098	5 969	4 078	2 879	911
	2 500					19 649	15 174	9 474	6 215	4 246	2 997	948
	2 550					20 443	15 787	9 856	6 466	4 417	3 118	987
	2 600						16 412	10 247	6 722	4 592	3 242	1 026
	2 650						17 050	10 645	6 983	4 770	3 368	1 066
	2 700						17 699	11 050	7 249	4 952	3 496	1 106
	2 750						18 361	11 463	7 520	5 137	3 627	1 148
	2 800						19 035	11 884	7 796	5 326	3 760	1 190
	2 850						19 720	12 312	8 077	5 518	3 895	1 233
	2 900						20 418	12 748	8 363	5 713	4 033	1 276
	2 950							13 191	8 654	5 912	4 173	1 321
	3 000							13 642	8 950	6 114	4 316	1 366
	3 050							14 101	9 251	6 319	4 461	1 412
	3 100							14 567	9 557	6 528	4 609	1 458
	3 150							15 040	9 867	6 741	4 758	1 506

l/min × 0.264 = gal/min kPa × 0.125 = psi kg/l = sp.gr kg/l × 8.35 = lb/gal

CALCULATIONS OF PRESSURE DROP IN NOZZLES (continued)

Combination of two nozzles

$$p_d = \frac{dQ^2}{2\,959.41 \times (0.95)^2\,A^2}\ \text{(kPa)} \qquad d = 1, \quad A = \text{nozzle area (in}^2\text{)}$$

Nozzles (1/32)		11-11	12-12	13-13	14-14	15-15	16-16	18-18	20-20	22-22	24-24	32-32
A (in²)		0.1856	0.2209	0.2592	0.3007	0.3451	0.3927	0.497	0.6136	0.7424	0.8836	1.5708
Flow rate Q (l/min)	3 200							15 522	10 183	6 956	4 911	1 554
	3 250							16 010	10 504	7 175	5 065	1 603
	3 300							16 507	10 829	7 398	5 222	1 652
	3 350							17 011	11 160	7 624	5 382	1 703
	3 400							17 522	11 496	7 853	5 544	1 754
	3 450							18 042	11 836	8 086	5 708	1 806
	3 500							18 568	12 182	8 322	5 875	1 859
	3 550							19 103	12 532	8 561	6 044	1 912
	3 600							19 644	12 888	8 804	6 215	1 967
	3 650							20 194	13 248	9 050	6 389	2 022
	3 700							20 751	13 614	9 300	6 565	2 077
	3 750								13 984	9 553	6 744	2 134
	3 800								14 360	9 809	6 925	2 191
	3 850								14 740	10 069	7 108	2 249
	3 900								15 125	10 332	7 294	2 308
	3 950								15 516	10 599	7 482	2 368
	4 000								15 911	10 869	7 673	2 428
	4 050								16 311	11 142	7 866	2 489
	4 100								16 716	11 419	8 061	2 551
	4 150								17 127	11 700	8 259	2 613
	4 200								17 542	11 983	8 459	2 677
	4 250								17 962	12 270	8 662	2 741
	4 300								18 387	12 561	8 867	2 806
	4 350								18 817	12 854	9 074	2 871
	4 400								19 252	13 152	9 284	2 938
	4 450								19 692	13 452	9 496	3 005
	4 500								20 137	13 756	9 711	3 073

l/min × 0.264 = gal/min   kPa × 0.125 = 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 (1/32 in)	A (in^2)	S (cm^2)	Nozzles (1/32 in)	A (in^2)	S (cm^2)	Nozzles (1/32 in)	A (in^2)	S (cm^2)
8-8-8	0.1473	0.9501	**16-16-17**	0.6144	3.9636	**24-24-25**	1.3629	8.7932
8-8-9	0.1603	1.0342	**16-17-17**	0.6397	4.1269	**24-25-25**	1.4005	9.0356
8-9-9	0.1733	1.1183	**17-17-17**	0.6650	4.2902	**25-25-25**	1.4381	9.2781
9-9-9	0.1864	1.2024	**17-17-18**	0.6918	4.4634	**25-25-26**	1.4772	9.5305
9-9-10	0.2010	1.2965	**17-18-18**	0.7187	4.6366	**25-26-26**	1.5163	9.7828
9-10-10	0.2155	1.3905	**18-18-18**	0.7455	4.8098	**26-26-26**	1.5555	10.0352
10-10-10	0.2301	1.4845	**18-18-19**	0.7739	4.9929	**26-26-27**	1.5961	10.2974
10-10-11	0.2462	1.5884	**18-19-19**	0.8023	5.1759	**26-27-27**	1.6368	10.5597
10-11-11	0.2623	1.6923	**19-19-19**	0.8307	5.3590	**27-27-27**	1.6774	10.8220
11-11-11	0.2784	1.7962	**19-19-20**	0.8606	5.5520	**27-27-28**	1.7196	11.0941
11-11-12	0.2961	1.9100	**19-20-20**	0.8905	5.7450	**27-28-28**	1.7618	11.3663
11-12-12	0.3137	2.0239	**20-20-20**	0.9204	5.9380	**28-28-28**	1.8040	11.6384
12-12-12	0.3313	2.1377	**20-20-21**	0.9518	6.1409	**28-28-29**	1.8477	11.9205
12-12-13	0.3505	2.2614	**20-21-21**	0.9833	6.3437	**28-29-29**	1.8914	12.2025
12-13-13	0.3697	2.3851	**21-21-21**	1.0147	6.5466	**29-29-29**	1.9351	12.4846
13-13-13	0.3889	2.5088	**21-21-22**	1.0477	6.7594	**29-29-30**	1.9804	12.7765
13-13-14	0.4096	2.6424	**21-22-22**	1.0807	6.9722	**29-30-30**	2.0256	13.0685
13-14-14	0.4303	2.7760	**22-22-22**	1.1137	7.1850	**30-30-30**	2.0709	13.3605
14-14-14	0.4510	2.9096	**22-22-23**	1.1482	7.4076	**30-30-31**	2.1177	13.6623
14-14-15	0.4732	3.0531	**22-23-23**	1.1827	7.6303	**30-31-31**	2.1644	13.9641
14-15-15	0.4955	3.1966	**23-23-23**	1.2172	7.8530	**31-31-31**	2.2112	14.2660
15-15-15	0.5177	3.3401	**23-23-24**	1.2533	8.0855	**31-31-32**	2.2596	14.5777
15-15-16	0.5415	3.4935	**23-24-24**	1.2893	8.3181	**31-32-32**	2.3079	14.8895
15-16-16	0.5653	3.6469	**24-24-24**	1.3254	8.5507	**32-32-32**	2.3562	15.2012
16-16-16	0.5890	3.8003						

TABLE OF NOZZLE AREAS
Combinations of two nozzles

***A* = total area of nozzle combination (in^2)**
***S* = total area of nozzle combination (cm^2)**

Nozzles (1/32 in)	*A* (in^2)	*S* (cm^2)
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

Nozzles (1/32 in)	*A* (in^2)	*S* (cm^2)
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

Nozzles (1/32 in)	*A* (in^2)	*S* (cm^2)
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 (1/32 in)	A (in^2)	S (cm^2)	Nozzles (1/32 in)	A (in^2)	S (cm^2)	Nozzles (1/32 in)	A (in^2)	S (cm^2)
8	0.0491	0.3167	**17**	0.2217	1.4301	**25**	0.4794	3.0927
9	0.0621	0.4008	**18**	0.2485	1.6033	**26**	0.5185	3.3451
10	0.0767	0.4948	**19**	0.2769	1.7863	**27**	0.5591	3.6073
11	0.0928	0.5987	**20**	0.3068	1.9793	**28**	0.6013	3.8795
12	0.1104	0.7126	**21**	0.3382	2.1822	**29**	0.6450	4.1615
13	0.1296	0.8363	**22**	0.3712	2.3950	**30**	0.6903	4.4535
14	0.1503	0.9699	**23**	0.4057	2.6177	**31**	0.7371	4.7553
15	0.1726	1.1134	**24**	0.4418	2.8502	**32**	0.7854	5.0671
16	0.1963	1.2668						

TABLE OF COEFFICIENTS N_4
Calculation of pressure loss in hole/drill collar annulus
$p_{ann} = N_4 B$ (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
	1 000	787	175	516	134	355	105	253	84	186	67	141	55
	1 050	859	191	563	147	387	115	276	91	203	74	153	60
	1 100	934	207	612	159	421	125	301	99	221	80	167	65
	1 150	1 012	225	663	173	456	135	326	107	240	87	181	71
	1 200	1 092	242	716	186	492	146	351	116	259	93	195	76
	1 250	1 176	261	771	201	530	157	378	125	278	101	210	82
	1 300	1 262	280	827	215	569	168	406	134	299	108	225	88
	1 350	1 350	300	885	230	609	180	434	143	320	116	241	94
	1 400	1 442	320	945	246	650	193	464	153	341	123	258	101
	1 450	1 536	341	1 007	262	692	205	494	163	364	131	274	107
	1 500	1 632	362	1 070	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 $p_{ann} = N_4 B$ (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	0	0	1	1	2	0	0	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
1 000	55	200	47	70	200	22	30	42	62	100	18	25	34	49	76
1 050	60	218	52	77	218	24	32	46	68	109	20	27	37	54	83
1 100	65	238	56	84	237	26	35	50	74	119	22	29	40	58	90
1 150	70	257	61	91	257	28	38	54	80	128	24	32	44	63	97
1 200	76	278	66	98	277	30	41	58	87	139	26	34	47	68	105
1 250	82	299	71	105	298	33	44	62	93	149	28	37	51	73	113
1 300	88	321	76	113	320	35	47	67	100	160	30	39	54	79	122
1 350	94	343	81	121	342	38	51	72	107	171	32	42	58	84	130
1 400	100	367	87	129	366	40	54	77	114	183	34	45	62	90	139
1 450	107	391	92	138	389	43	58	82	122	195	36	48	66	96	148
1 500	114	415	98	146	414	45	61	87	129	207	38	51	70	102	157
1 550	120	440	104	155	439	48	65	92	137	220	41	54	75	108	167
1 600	128	466	110	164	465	51	69	97	145	233	43	57	79	115	177
1 650	135	493	117	174	491	54	73	103	153	246	45	60	84	121	187
1 700	142	520	123	183	519	57	77	109	162	260	48	64	88	128	197
1 750	150	548	130	193	546	60	81	114	171	273	51	67	93	135	208
1 800	158	576	136	203	575	63	85	120	180	288	53	71	98	142	218
1 850	166	606	143	213	604	66	90	126	189	302	56	74	103	149	229
1 900	174	635	150	224	633	69	94	133	198	317	59	78	108	156	241
1 950	182	666	158	234	664	73	98	139	207	332	61	82	113	164	252
2 000	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**	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	2
	150	1	1	1	2	3	1	1	1	2	2	0	0	1	1	0	0	0	0	4
	200	1	2	2	3	5	1	1	2	3	4	0	0	1	2	0	0	0	1	7
	250	2	2	3	5	8	1	2	3	4	6	0	1	2	2	0	0	1	1	10
	300	2	3	5	7	11	2	3	4	5	8	1	1	2	3	0	0	1	1	14
	350	3	4	6	9	14	3	3	5	7	11	1	1	3	5	0	0	1	2	18
	400	4	5	8	11	18	3	4	6	9	14	1	1	4	6	0	0	1	2	23
	450	5	7	9	14	22	4	5	8	11	17	1	2	5	7	0	0	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
	1 000	21	28	39	59	94	17	23	32	46	72	6	7	21	30	2	2	7	12	121
	1 050	22	30	43	64	103	19	25	35	51	78	7	8	23	33	2	2	7	13	132
	1 100	24	33	47	70	112	21	27	38	55	85	7	9	25	36	2	2	8	14	144
	1 150	26	36	51	76	121	22	30	41	60	92	8	10	27	39	2	3	9	15	156
	1 200	29	39	55	82	131	24	32	44	64	99	8	10	29	42	2	3	9	16	168
	1 250	31	42	59	88	141	26	35	48	69	107	9	11	32	45	3	3	10	18	181
	1 300	33	45	63	94	151	28	37	51	74	115	10	12	34	48	3	3	11	19	194
	1 350	35	48	68	101	162	30	40	55	80	123	10	13	36	52	3	4	11	20	208
	1 400	38	51	72	108	173	32	42	59	85	131	11	14	39	55	3	4	12	21	222
	1 450	40	54	77	115	184	34	45	62	91	140	12	14	41	59	3	4	13	23	236
	1 500	43	58	82	122	196	36	48	66	96	149	13	15	44	62	4	4	14	24	251
	1 550	45	61	87	129	207	38	51	70	102	158	13	16	47	66	4	5	15	26	266
	1 600	48	65	92	137	220	40	54	75	108	167	14	17	49	70	4	5	16	27	282
	1 650	51	69	97	145	232	43	57	79	114	176	15	18	52	74	4	5	16	29	298
	1 700	53	72	102	153	245	45	60	83	121	186	16	19	55	78	5	5	17	30	314
	1 750	56	76	108	161	258	48	63	88	127	196	17	20	58	82	5	6	18	32	331
	1 800	59	80	113	169	272	50	67	92	134	206	17	21	61	87	5	6	19	34	348
	1 850	62	84	119	178	285	53	70	97	140	217	18	22	64	91	5	6	20	35	366
	1 900	65	88	125	187	299	55	73	102	147	227	19	23	67	95	6	7	21	37	384
	1 950	68	93	131	196	314	58	77	106	154	238	20	25	70	100	6	7	22	39	402
	2 000	72	97	137	205	328	60	81	111	162	249	21	26	74	105	6	7	23	41	421

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_4 (continued)
Calculation of pressure loss in hole/drill collar annulus $p_{ann} = N_4 B$ (kPa/100 m)

Hole size (in)	8 5/8					8 3/4					9 7/8				12 1/4				
Drill collar outside diameter (in) / Flow rate Q (l/min)	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
2 050	75	101	143	214	343	63	84	116	169	261	22	27	77	109	6	7	24	43	440
2 100	78	106	150	223	358	66	88	122	176	272	23	28	80	114	7	8	25	45	460
2 150	82	111	156	233	374	69	92	127	184	284	24	29	84	119	7	8	27	46	480
2 200	85	115	163	243	390	72	96	132	192	296	25	31	87	124	7	9	28	48	500
2 250	89	120	170	253	406	75	100	138	200	308	26	32	91	129	8	9	29	50	521
2 300	92	125	176	263	422	78	104	143	208	321	27	33	95	134	8	9	30	52	542
2 350	96	130	183	274	439	81	108	149	216	333	28	34	98	140	8	10	31	55	563
2 400	99	135	190	284	456	84	112	155	224	346	29	36	102	145	9	10	32	57	585
2 450	103	140	198	295	473	87	116	160	233	359	30	37	106	151	9	10	34	59	607
2 500	107	145	205	306	491	90	120	166	241	373	31	38	110	156	9	11	35	61	629
2 550	111	150	212	317	508	94	125	172	250	386	33	40	114	162	10	11	36	63	652
2 600	115	156	220	328	526	97	129	179	259	400	34	41	118	168	10	12	37	65	676
2 650	119	161	228	340	545	100	134	185	268	414	35	43	122	174	10	12	39	68	699
2 700	123	167	235	351	563	104	138	191	277	428	36	44	126	179	11	12	40	70	723
2 750	127	172	243	363	582	107	143	198	287	442	37	46	131	186	11	13	41	72	747
2 800	131	178	251	375	602	111	148	204	296	457	38	47	135	192	11	13	43	75	772
2 850	135	184	259	387	621	114	152	211	306	472	40	49	139	198	12	14	44	77	797
2 900	140	189	268	399	641	118	157	217	315	487	41	50	144	204	12	14	45	80	822
2 950	144	195	276	412	661	122	162	224	325	502	42	52	148	210	12	14	47	82	848
3 000	149	201	285	425	681	125	167	231	335	517	44	53	153	217	13	15	48	85	874
3 050	153	207	293	437	702	129	172	238	345	533	45	55	157	224	13	15	50	87	900
3 100	158	214	302	450	723	133	177	245	355	549	46	57	162	230	14	16	51	90	927
3 150	162	220	311	464	744	137	182	252	366	565	48	58	167	237	14	16	53	92	954
3 200	167	226	320	477	765	141	188	260	376	581	49	60	172	244	14	17	54	95	982
3 250	172	233	329	490	787	145	193	267	387	597	50	62	177	251	15	17	56	98	1 009
3 300	176	239	338	504	809	149	198	274	398	614	52	63	181	258	15	18	57	101	1 038
3 350	181	246	347	518	831	153	204	282	409	631	53	65	186	265	16	18	59	103	1 066
3 400	186	252	356	532	853	157	209	289	420	648	55	67	191	272	16	19	61	106	1 095
3 450	191	259	366	546	876	161	215	297	431	665	56	69	197	279	16	19	62	109	1 124
3 500	196	266	376	560	899	166	221	305	442	683	57	70	202	286	17	20	64	112	1 153
3 550	201	273	385	575	922	170	226	313	454	700	59	72	207	294	17	20	65	115	1 183
3 600	206	280	395	590	946	174	232	321	465	718	60	74	212	301	18	21	67	118	1 213
3 650	212	287	405	604	969	179	238	329	477	736	62	76	218	309	18	21	69	121	1 244
3 700	217	294	415	619	994	183	244	337	489	755	64	78	223	316	19	22	70	123	1 275
3 750	222	301	425	634	1 018	188	250	345	501	773	65	80	228	324	19	22	72	127	1 306
3 800	227	308	435	650	1 042	192	256	354	513	792	67	82	234	332	20	23	74	130	1 337
3 850	233	315	446	665	1 067	197	262	362	525	810	68	84	240	340	20	23	76	133	1 369
3 900	238	323	456	681	1 092	201	268	371	537	830	70	86	245	348	21	24	77	136	1 402
3 950	244	330	467	697	1 118	206	274	379	550	849	71	88	251	356	21	24	79	139	1 434

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)	15						17 1/2						
Drill collar outside diameter (in) / **Flow rate Q (l/min)**	**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**
2 000	1	1	2	3	5	7	0	0	1	1	1	1	6
2 100	1	1	3	3	6	7	0	0	1	1	1	1	6
2 200	1	2	3	4	7	8	0	1	1	1	1	1	7
2 300	2	2	3	4	7	8	1	1	1	1	1	2	7
2 400	2	2	3	4	8	9	1	1	1	1	2	2	8
2 500	2	2	4	5	8	10	1	1	1	1	2	2	9
2 600	2	2	4	5	9	10	1	1	1	1	2	2	9
2 700	2	2	4	5	9	11	1	1	1	1	2	2	10
2 800	2	2	4	6	10	12	1	1	1	1	2	2	11
2 900	2	2	5	6	11	13	1	1	1	1	2	2	11
3 000	2	3	5	6	11	14	1	1	1	2	2	2	12
3 100	3	3	5	7	12	14	1	1	1	2	2	3	13
3 200	3	3	5	7	13	15	1	1	1	2	3	3	14
3 300	3	3	6	7	14	16	1	1	2	2	3	3	14
3 400	3	3	6	8	14	17	1	1	2	2	3	3	15
3 500	3	3	6	8	15	18	1	1	2	2	3	3	16
3 600	3	4	7	9	16	19	1	1	2	2	3	3	17
3 700	4	4	7	9	17	20	1	1	2	2	3	4	18
3 800	4	4	7	10	17	21	1	1	2	2	3	4	18
3 900	4	4	8	10	18	22	1	1	2	3	4	4	19
4 000	4	4	8	10	19	23	1	1	2	3	4	4	20
4 100	4	5	9	11	20	24	1	2	2	3	4	4	21
4 200	4	5	9	11	21	25	2	2	2	3	4	5	22
4 300	5	5	9	12	22	26	2	2	3	3	4	5	23
4 400	5	5	10	12	23	27	2	2	3	3	4	5	24
4 500	5	5	10	13	24	28	2	2	3	3	5	5	25
4 600	5	6	11	14	25	29	2	2	3	3	5	5	26
4 700	5	6	11	14	26	30	2	2	3	4	5	6	27
4 800	6	6	11	15	27	32	2	2	3	4	5	6	28
4 900	6	6	12	15	28	33	2	2	3	4	5	6	29
5 000	6	7	12	16	29	34	2	2	3	4	6	6	30
5 100	6	7	13	16	30	35	2	2	3	4	6	6	31
5 200	7	7	13	17	31	37	2	2	4	4	6	7	32
5 300	7	7	14	17	32	38	2	2	4	4	6	7	34
5 400	7	8	14	18	33	39	2	3	4	4	6	7	35
5 500	7	8	15	19	34	40	2	3	4	5	7	7	36
5 600	7	8	15	19	35	42	3	3	4	5	7	8	37
5 700	8	8	15	20	36	43	3	3	4	5	7	8	38
5 800	8	9	16	20	37	44	3	3	4	5	7	8	39

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_5

Calculation of pressure loss in hole/pipe annulus $p_{ann} = N_5 B$ (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)	3 3/8	3 7/8	4 1/2	4 3/4	5	3 3/8	3 7/8	4 3/8	4 1/2	4 3/4	5	3 3/8	3 7/8	4 3/8	4 1/2	4 3/4	5
Flow rate Q (l/min)																	
100	0	1	1	2	3	0	1	1	1	1	2	0	0	1	1	1	1
150	1	1	3	3	6	1	1	1	2	3	4	1	1	1	2	2	3
200	1	2	5	6	9	1	2	2	4	4	6	1	2	2	3	3	4
250	2	3	7	9	14	2	3	3	6	7	9	2	2	3	5	5	7
300	3	5	10	12	19	3	4	5	8	9	13	2	3	4	6	7	9
350	4	6	13	16	26	3	5	6	10	12	17	3	4	5	8	9	12
400	5	8	16	20	33	4	7	8	13	15	22	4	6	6	11	12	16
450	6	10	20	25	40	5	8	9	16	19	27	5	7	8	13	15	19
500	8	12	24	30	49	7	10	11	19	23	32	6	8	10	16	18	23
550	9	14	29	36	58	8	12	14	23	27	38	7	10	11	19	21	28
600	10	16	34	42	67	9	14	16	27	32	45	8	12	13	22	25	32
650	12	19	39	48	78	10	16	18	31	37	52	9	13	15	25	29	37
700	14	21	45	55	89	12	18	21	36	42	59	10	15	17	29	33	43
750	16	24	51	63	101	14	20	24	40	48	67	12	17	20	33	37	48
800	18	27	57	70	113	15	23	27	45	53	75	13	19	22	37	42	54
850	20	30	63	78	126	17	25	30	51	60	84	15	22	25	41	47	60
900	22	33	70	87	140	19	28	33	56	66	93	16	24	27	45	52	67
950	24	37	78	96	154	21	31	36	62	73	103	18	26	30	50	57	74
1 000	26	40	85	105	169	23	34	40	68	80	113	20	29	33	55	63	81
1 050	29	44	93	115	185	25	37	44	74	87	123	22	32	36	60	68	88
1 100	31	48	101	125	201	27	40	47	81	95	134	23	34	39	65	74	96
1 150	34	52	109	135	218	29	44	51	87	103	145	25	37	43	71	80	104
1 200	36	56	118	146	235	32	47	55	94	111	156	27	40	46	76	87	112
1 250	39	60	127	157	253	34	51	60	101	119	168	29	43	50	82	94	121
1 300	42	65	136	168	271	36	54	64	109	128	181	32	46	53	88	100	130
1 350	45	69	146	180	290	39	58	69	116	137	193	34	50	57	94	107	139
1 400	48	74	156	193	310	42	62	73	124	146	206	36	53	61	101	115	148
1 450	51	79	166	205	330	44	66	78	132	156	220	38	56	65	107	122	158
1 500	55	83	177	218	351	47	70	83	141	166	234	41	60	69	114	130	168
1 550	58	89	187	231	372	50	75	88	149	176	248	43	64	73	121	138	178
1 600	61	94	198	245	394	53	79	93	158	186	262	46	67	77	128	146	189
1 650	65	99	210	259	417	56	84	98	167	197	277	49	71	82	135	154	199
1 700	68	105	221	273	440	59	88	104	176	207	293	51	75	86	143	163	210
1 750	72	110	233	288	463	62	93	109	186	219	308	54	79	91	151	171	222
1 800	76	116	245	303	487	65	98	115	195	230	324	57	83	96	158	180	233
1 850	80	122	257	318	512	69	103	121	205	242	341	60	87	100	166	189	245
1 900	83	128	270	334	537	72	108	127	215	253	358	63	92	105	175	199	257
1 950	87	134	283	350	563	76	113	133	226	266	375	66	96	110	183	208	269
2 000	91	140	296	366	589	79	118	139	236	278	392	69	101	116	191	218	282

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_5 (continued)
Calculation of pressure loss in hole/pipe annulus $p_{ann} = N_5 B$ (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
1 000	45	50	61	121	38	41	48	88	142	32	34	39	67	95	17	18	19	29	33	66
1 050	49	55	67	132	41	45	52	96	156	34	37	42	73	104	18	19	21	31	36	72
1 100	54	60	73	143	45	49	57	104	169	37	40	46	79	113	20	21	22	34	39	78
1 150	58	65	79	155	48	53	62	113	183	41	44	50	86	122	22	23	24	37	42	84
1 200	63	70	85	168	52	57	67	122	198	44	47	54	93	132	23	24	26	40	45	91
1 250	68	75	92	181	56	61	72	131	213	47	51	58	100	142	25	26	28	43	49	98
1 300	72	81	98	194	60	66	77	141	228	51	54	62	107	152	27	28	30	46	52	105
1 350	78	86	105	207	64	70	82	151	245	54	58	66	115	163	29	30	32	49	56	113
1 400	83	92	112	221	69	75	88	161	261	58	62	71	122	174	31	32	35	52	60	120
1 450	88	98	120	236	73	80	94	171	278	62	66	75	130	185	33	34	37	56	64	128
1 500	94	104	127	251	78	85	100	182	296	65	70	80	139	197	35	37	39	59	68	136
1 550	99	110	135	266	83	90	106	193	314	69	75	85	147	209	37	39	41	63	72	145
1 600	105	117	143	282	88	96	112	205	332	73	79	90	156	221	39	41	44	67	76	153
1 650	111	124	151	298	93	101	118	216	351	78	84	95	165	234	42	43	46	70	80	162
1 700	117	130	159	314	98	107	125	228	370	82	88	100	174	247	44	46	49	74	85	171
1 750	124	137	168	331	103	112	131	241	390	86	93	106	183	260	46	48	52	78	89	180
1 800	130	145	176	348	108	118	138	253	410	91	98	111	192	273	49	51	54	82	94	189
1 850	137	152	185	366	114	124	145	266	431	95	103	117	202	287	51	53	57	87	99	199
1 900	143	159	195	384	119	130	152	279	452	100	108	123	212	301	54	56	60	91	103	209
1 950	150	167	204	402	125	136	160	292	474	105	113	128	222	316	56	59	63	95	108	219
2 000	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 $p_{ann} = N_5 B$ (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 1/2-5	5 1/4-6	6- 6 3/8	4 1/2-5	5 1/4-6	6-6 3/8	6 3/8-7	4 1/2-5	5 1/4-6	6-6 3/8	6 3/8-7	4 1/2-5	5 1/4-6	6-6 3/8	6 3/8-7	4 1/2-5	5 1/4-6	6-6 3/8	6 3/8-7
Average outside diameter (in)	4 3/4	5 1/2	6 1/4	4 3/4	5 3/8	6 3/16	6 1/2	4 3/4	5 1/2	6 3/16	6 1/2	5	5 1/2	6 1/16	6 5/16	4 3/4	5 3/8	6	6 3/8
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	2	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	9	3	3	5	7	2	3	4	6	2	3	4	5	2	2	3	5
850	4	6	10	3	4	5	8	3	3	5	7	2	3	4	6	2	3	4	5
900	5	7	11	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	7
1 000	6	8	13	4	5	7	10	3	4	6	9	3	4	6	8	3	4	5	7
1 050	6	9	14	4	5	8	11	4	5	7	10	3	5	6	8	3	4	6	8
1 100	7	9	15	4	6	9	12	4	5	8	11	4	5	7	9	3	4	6	8
1 150	7	10	17	5	6	9	13	4	6	8	12	4	5	7	10	4	5	7	9
1 200	8	11	18	5	7	10	14	5	6	9	12	4	6	8	11	4	5	7	10
1 250	8	12	19	6	7	11	15	5	7	9	13	5	6	8	12	4	6	8	11
1 300	9	13	21	6	8	12	17	5	7	10	14	5	7	9	12	5	6	8	11
1 350	10	14	22	6	8	12	18	6	8	11	15	5	7	10	13	5	6	9	12
1 400	10	15	24	7	9	13	19	6	8	12	16	6	8	10	14	5	7	9	13
1 450	11	16	25	7	10	14	20	7	9	12	18	6	8	11	15	6	7	10	14
1 500	12	17	27	8	10	15	21	7	9	13	19	7	9	12	16	6	8	11	15
1 550	12	18	29	8	11	16	23	7	10	14	20	7	9	12	17	6	8	11	16
1 600	13	19	30	9	12	17	24	8	10	15	21	7	10	13	18	7	9	12	17
1 650	14	20	32	9	12	18	25	8	11	16	22	8	10	14	19	7	9	13	18
1 700	15	21	34	10	13	19	27	9	12	17	23	8	11	15	20	8	10	13	19
1 750	16	22	36	10	14	20	28	9	12	17	25	9	11	15	21	8	10	14	20
1 800	16	23	37	11	14	21	30	10	13	18	26	9	12	16	22	8	11	15	21
1 850	17	24	39	11	15	22	31	10	14	19	27	10	12	17	23	9	11	16	22
1 900	18	25	41	12	16	23	33	11	14	20	28	10	13	18	25	9	12	16	23
1 950	19	27	43	12	16	24	34	11	15	21	30	11	14	19	26	10	12	17	24
2 000	20	28	45	13	17	25	36	12	16	22	31	11	14	20	27	10	13	18	25
2 050	21	29	47	14	18	26	38	12	16	23	33	12	15	21	28	11	14	19	26
2 100	22	30	49	14	19	27	39	13	17	24	34	12	16	22	30	11	14	19	27
2 150	22	32	52	15	20	29	41	14	18	25	36	13	16	22	31	11	15	20	28
2 200	23	33	54	16	20	30	43	14	19	26	37	13	17	23	32	12	15	21	30

l/min × 0.264 = gal/min

TABLE OF COEFFICIENTS N_5 (continued)

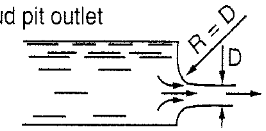
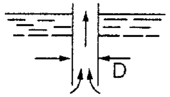
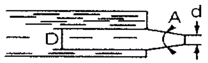
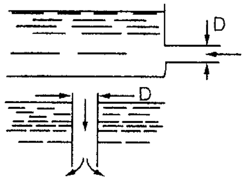
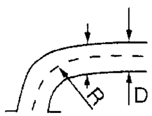
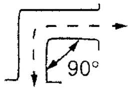
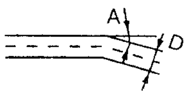
Calculation of pressure loss in hole/pipe annulus $p_{ann} = N_5 B$ (kPa/100 m)

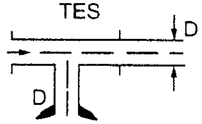
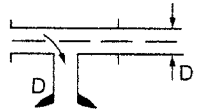
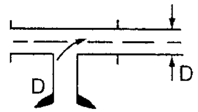
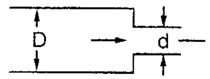
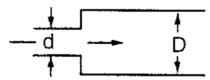
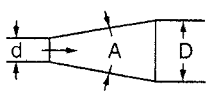
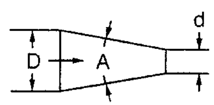
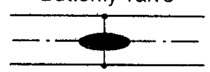
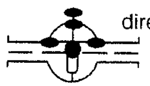
Hole size (in)	9 7/8			12 1/4			15			17 1/2		
Nominal pipe size (in)	**4 1/2**	**5**	**5 1/2**	**4 1/2**	**5**	**5 1/2**	**4 1/2**	**5**	**5 1/2**	**4 1/2**	**5**	**5 1/2**
Tool joint outside diameter (in)	**6-6 3/8**	**6 3/8-7**	**7-7 1/2**	**6-6 3/8**	**6 3/8-7**	**7-7 1/2**	**6-6 3/8**	**6 3/8-7**	**7-7 1/2**	**6-6 3/8**	**6 3/8-7**	**7-7 1/2**
Average outside diameter (in)	6	6 1/2	7 1/4	6	6 1/2	7 1/4	6	6 1/2	7 1/4	6	6 1/2	7 1/4
Flow rate *Q* (l/min)												
1 500	4	5	7	1	1	1	0	0	0	0	0	0
1 600	5	6	8	1	1	2	0	0	0	0	0	0
1 700	5	7	9	1	1	2	0	0	0	0	0	0
1 800	6	7	10	1	2	2	0	0	1	0	0	0
1 900	6	8	11	2	2	2	0	1	1	0	0	0
2 000	7	9	12	2	2	2	1	1	1	0	0	0
2 100	8	10	13	2	2	3	1	1	1	0	0	0
2 200	8	11	15	2	2	3	1	1	1	0	0	0
2 300	9	11	16	2	3	3	1	1	1	0	0	0
2 400	10	12	17	2	3	3	1	1	1	0	0	0
2 500	10	13	18	3	3	4	1	1	1	0	0	0
2 600	11	14	20	3	3	4	1	1	1	0	0	0
2 700	12	15	21	3	3	4	1	1	1	0	0	0
2 800	13	16	23	3	4	4	1	1	1	0	0	0
2 900	14	17	24	3	4	5	1	1	1	0	0	0
3 000	14	19	26	4	4	5	1	1	1	0	0	1
3 100	15	20	27	4	4	5	1	1	1	0	1	1
3 200	16	21	29	4	5	6	1	1	2	1	1	1
3 300	17	22	30	4	5	6	1	1	2	1	1	1
3 400	18	23	32	4	5	6	1	1	2	1	1	1
3 500	19	24	34	5	5	7	1	2	2	1	1	1
3 600	20	26	35	5	6	7	1	2	2	1	1	1
3 700	21	27	37	5	6	7	2	2	2	1	1	1
3 800	22	28	39	5	6	8	2	2	2	1	1	1
3 900	23	30	41	6	7	8	2	2	2	1	1	1
4 000	24	31	43	6	7	8	2	2	2	1	1	1
4 100	25	32	45	6	7	9	2	2	2	1	1	1
4 200	27	34	47	7	8	9	2	2	2	1	1	1
4 300	28	35	49	7	8	9	2	2	3	1	1	1
4 400	29	37	51	7	8	10	2	2	3	1	1	1
4 500	30	38	53	7	9	10	2	2	3	1	1	1
4 600	31	40	55	8	9	11	2	3	3	1	1	1
4 700	32	42	57	8	9	11	2	3	3	1	1	1
4 800	34	43	60	8	10	12	3	3	3	1	1	1
4 900	35	45	62	9	10	12	3	3	3	1	1	1
5 000	36	46	64	9	10	12	3	3	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).

Connection	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  $\frac{d}{D} = 0.5$ 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
 90°	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

Connection	Equivalent length for pipe size 3″	4″	6″	8″	10″
TES 	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)  $\frac{d}{D}$ = 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)  $\frac{d}{D}$ = 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
 A = 10° $\frac{d}{D}$ = 0.6 = 0.4 A = 20° $\frac{d}{D}$ = 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
 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	56.20	0.39	8.83
0.92	7.68	57.40	0.40	9.03
0.94	7.84	58.70	0.41	9.22
0.96	8.01	59.90	0.42	9.42
0.98	8.18	61.20	0.42	9.61
1.00	8.35	62.40	0.43	9.81
1.02	8.51	63.70	0.44	10.01
1.04	8.68	64.90	0.45	10.20
1.06	8.85	66.20	0.46	10.40
1.08	9.01	67.40	0.47	10.59
1.10	9.18	68.70	0.48	10.79
1.12	9.35	69.90	0.49	10.99
1.14	9.51	71.20	0.49	11.18
1.16	9.68	72.40	0.50	11.38
1.18	9.85	73.70	0.51	11.58
1.20	10.01	74.90	0.52	11.77
1.22	10.18	76.20	0.53	11.97
1.24	10.35	77.40	0.54	12.16
1.26	10.51	78.70	0.55	12.36
1.28	10.68	79.90	0.55	12.56
1.30	10.85	81.20	0.56	12.75
1.34	11.18	83.70	0.58	13.15
1.38	11.52	86.10	0.60	13.54
1.42	11.85	88.60	0.62	13.93
1.46	12.18	91.10	0.63	14.32
1.50	12.52	93.60	0.65	14.72
1.54	12.85	96.10	0.67	15.11
1.58	13.19	98.60	0.69	15.50
1.62	13.52	101.10	0.70	15.89
1.66	13.85	103.60	0.72	16.28
1.70	14.19	106.10	0.74	16.68
1.74	14.52	108.60	0.75	17.07
1.78	14.85	111.10	0.77	17.46
1.82	15.19	113.60	0.79	17.85
1.86	15.52	116.10	0.81	18.25
1.90	15.86	118.60	0.82	18.64
1.94	16.19	121.10	0.84	19.03
1.98	16.52	123.60	0.86	19.42
2.02	16.86	126.10	0.88	19.82
2.06	17.19	128.60	0.89	20.21
2.10	17.52	131.10	0.91	20.60
2.14	17.86	133.60	0.93	20.99
2.18	18.19	136.10	0.95	21.39
2.22	18.53	138.60	0.96	21.78
2.26	18.86	141.10	0.98	22.17
2.30	19.19	143.60	1.00	22.56

Hydrostatic pressure

$$P_H = 9.81\ Zd$$

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 m^3 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	1286	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	1438	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   m^3 × 6.29 = bbl   kg/m^3 × 0.3505 = lb/bbl

$$M = 4200\,\frac{(d_2 - d_1)}{(4.2 - d_2)} \quad (\text{kg/m}^3)$$

INCREASE OF MUD SPECIFIC GRAVITY WITH CALCIUM CARBONATE ($d = 2.65$)
Weight (in kg) of calcium carbonate to add to 1 m^3 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 × 6.29 = bbl   kg/m^3 × 0.3505 = lb/bbl

$$M = 2650 \frac{(d_2 - d_1)}{(2.65 - d_2)} \quad (\text{kg/m}^3)$$

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	1 000																								
1.15	2 000	500																							
1.20	3 000	1 000	333																						
1.25	4 000	1 500	667	250																					
1.30	5 000	2 000	1000	500	200																				
1.35	6 000	2 500	1333	750	400	167																			
1.40	7 000	3 000	1667	1000	600	333	143																		
1.45	8 000	3 500	2000	1250	800	500	286	125																	
1.50	9 000	4 000	2333	1500	1000	667	429	250	111																
1.55	10 000	4 500	2667	1750	1200	833	571	375	222	100															
1.60	11 000	5 000	3000	2000	1400	1000	714	500	333	200	91														
1.65	12 000	5 500	3333	2250	1600	1167	857	625	444	300	182	83													
1.70	13 000	6 000	3667	2500	1800	1333	1000	750	556	400	273	167	77												
1.75	14 000	6 500	4000	2750	2000	1500	1143	875	667	500	364	250	154	71											
1.80	15 000	7 000	4333	3000	2200	1667	1286	1000	778	600	455	333	231	143	67										
1.85	16 000	7 500	4667	3250	2400	1833	1429	1125	889	700	545	417	308	214	133	63									
1.90	17 000	8 000	5000	3500	2600	2000	1571	1250	1000	800	636	500	385	286	200	125	59								
1.95	18 000	8 500	5333	3750	2800	2167	1714	1375	1111	900	727	583	462	357	267	188	118	56							
2.00	19 000	9 000	5667	4000	3000	2333	1857	1500	1222	1000	818	667	538	429	333	250	176	111	53						
2.05	20 000	9 500	6000	4250	3200	2500	2000	1625	1333	1100	909	750	615	500	400	313	235	167	105	50					
2.10	21 000	10 000	6333	4500	3400	2667	2143	1750	1444	1200	1000	833	692	571	467	375	294	222	158	100	48				
2.15	22 000	10 500	6667	4750	3600	2833	2286	1875	1556	1300	1091	917	769	643	533	438	353	278	211	150	95	45			
2.20	23 000	11 000	7000	5000	3800	3000	2429	2000	1667	1400	1182	1000	846	714	600	500	412	333	263	200	143	91	43		
2.25	24 000	11 500	7333	5250	4000	3167	2571	2125	1778	1500	1273	1083	923	786	667	563	471	389	316	250	190	136	87	42	
2.30	25 000	12 000	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 $m^3 \times 6.29$ = bbl $l/m^3 \times 0.042$ = gal/bbl

$$M = 1000 \frac{(d_2 - d_1)}{(d_2 - 1)} \quad (\text{liters}/m^3)$$

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	1883	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

$$M = 1000\,\frac{(d_2 - d_1)}{(d_2 - 0.85)} \quad \text{(liters/m}^3\text{)}$$

FINAL VOLUME V_F (IN LITERS) AFTER ADDING WEIGHTING MATERIAL OF SPECIFIC GRAVITY d_a TO 1 m^3 OF MUD

M_a weight of weighting material added (kg/m^3)

M_a \ d_a	2.75	2.70	2.65	2.60	2.55	2.50	M_a \ d_a	4.40	4.35	4.30	4.25	4.20	4.15
50	1018	1019	1019	1019	1020	1020	50	1011	1011	1012	1012	1012	1012
100	1036	1037	1038	1038	1039	1040	100	1023	1023	1023	1024	1024	1024
150	1055	1056	1057	1058	1059	1060	150	1034	1034	1035	1035	1036	1036
200	1073	1074	1075	1077	1078	1080	200	1045	1046	1047	1047	1048	1048
250	1091	1093	1094	1096	1098	1100	250	1057	1057	1058	1059	1060	1060
300	1109	1111	1113	1115	1118	1120	300	1068	1069	1070	1071	1071	1072
350	1127	1130	1132	1135	1137	1140	350	1080	1080	1081	1082	1083	1084
400	1145	1148	1151	1154	1157	1160	400	1091	1092	1093	1094	1095	1096
450	1164	1167	1170	1173	1176	1180	450	1102	1103	1105	1106	1107	1108
500	1182	1185	1189	1192	1196	1200	500	1114	1115	1116	1118	1119	1120
550	1200	1204	1208	1212	1216	1220	550	1125	1126	1128	1129	1131	1133
600	1218	1222	1226	1231	1235	1240	600	1136	1138	1140	1141	1143	1145
650	1236	1241	1245	1250	1255	1260	650	1148	1149	1151	1153	1155	1157
700	1255	1259	1264	1269	1275	1280	700	1159	1161	1163	1165	1167	1169
750	1273	1278	1283	1288	1294	1300	750	1170	1172	1174	1176	1179	1181
800	1291	1296	1302	1308	1314	1320	800	1182	1184	1186	1188	1190	1193
850	1309	1315	1321	1327	1333	1340	850	1193	1195	1198	1200	1202	1205
900	1327	1333	1340	1346	1353	1360	900	1205	1207	1209	1212	1214	1217
950	1345	1352	1358	1365	1373	1380	950	1216	1218	1221	1224	1226	1229
1000	1364	1370	1377	1385	1392	1400	1000	1227	1230	1233	1235	1238	1241
1050	1382	1389	1396	1404	1412	1420	1050	1239	1241	1244	1247	1250	1253
1100	1400	1407	1415	1423	1431	1440	1100	1250	1253	1256	1259	1262	1265
1150	1418	1426	1434	1442	1451	1460	1150	1261	1264	1267	1271	1274	1277
1200	1436	1444	1453	1462	1471	1480	1200	1273	1276	1279	1282	1286	1289
1250	1455	1463	1472	1481	1490	1500	1250	1284	1287	1291	1294	1298	1301
1300	1473	1481	1491	1500	1510	1520	1300	1295	1299	1302	1306	1310	1313
1350	1491	1500	1509	1519	1529	1540	1350	1307	1310	1314	1318	1321	1325
1400	1509	1519	1528	1538	1549	1560	1400	1318	1322	1326	1329	1333	1337
1450	1527	1537	1547	1558	1569	1580	1450	1330	1333	1337	1341	1345	1349
1500	1545	1556	1566	1577	1588	1600	1500	1341	1345	1349	1353	1357	1361
1550	1564	1574	1585	1596	1608	1620	1550	1352	1356	1360	1365	1369	1373
1600	1582	1593	1604	1615	1627	1640	1600	1364	1368	1372	1376	1381	1386
1650	1600	1611	1623	1635	1647	1660	1650	1375	1379	1384	1388	1393	1398
1700	1618	1630	1642	1654	1667	1680	1700	1386	1391	1395	1400	1405	1410
1750	1636	1648	1660	1673	1686	1700	1750	1398	1402	1407	1412	1417	1422
1800	1655	1667	1679	1692	1706	1720	1800	1409	1414	1419	1424	1429	1434
1850	1673	1685	1698	1712	1725	1740	1850	1420	1425	1430	1435	1440	1446
1900	1691	1704	1717	1731	1745	1760	1900	1432	1437	1442	1447	1452	1458
1950	1709	1722	1736	1750	1765	1780	1950	1443	1448	1453	1459	1464	1470
2000	1727	1741	1755	1769	1784	1800	2000	1455	1460	1465	1471	1476	1482

l × 0.00629 = bbl   kg × 2.20 = lb

$$V_F = \left(V_I + \frac{M_a}{d_a}\right)$$

V_F = final volume (l)
V_I = initial volume = 1000 l
M_a = weight of weighting material (kg)
d_a = specific gravity of weighting material

MUD VOLUME (IN LITERS) REQUIRED TO PREPARE 1 m³ OF MUD WEIGHTED WITH BARITE ($d = 4.2$)

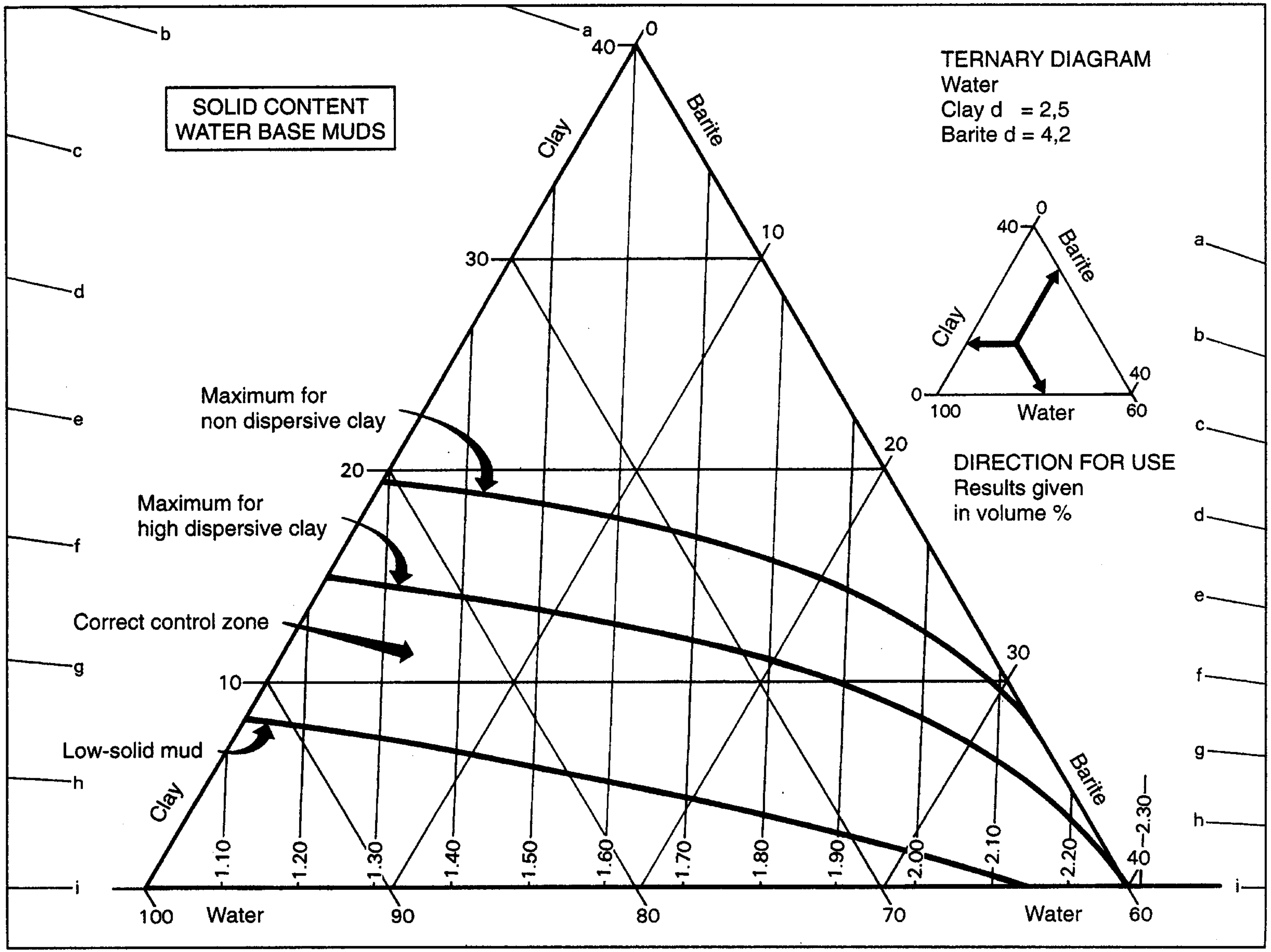
Initial mud specific gravity d_1	Desired mud specific gravity d_2																								
	1.05	**1.10**	**1.15**	**1.20**	**1.25**	**1.30**	**1.35**	**1.40**	**1.45**	**1.50**	**1.55**	**1.60**	**1.65**	**1.70**	**1.75**	**1.80**	**1.85**	**1.90**	**1.95**	**2.00**	**2.05**	**2.10**	**2.15**	**2.20**	**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	833	813
1.85																		979	957	936	915	894	872	851	830
1.90																			978	957	935	913	891	870	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

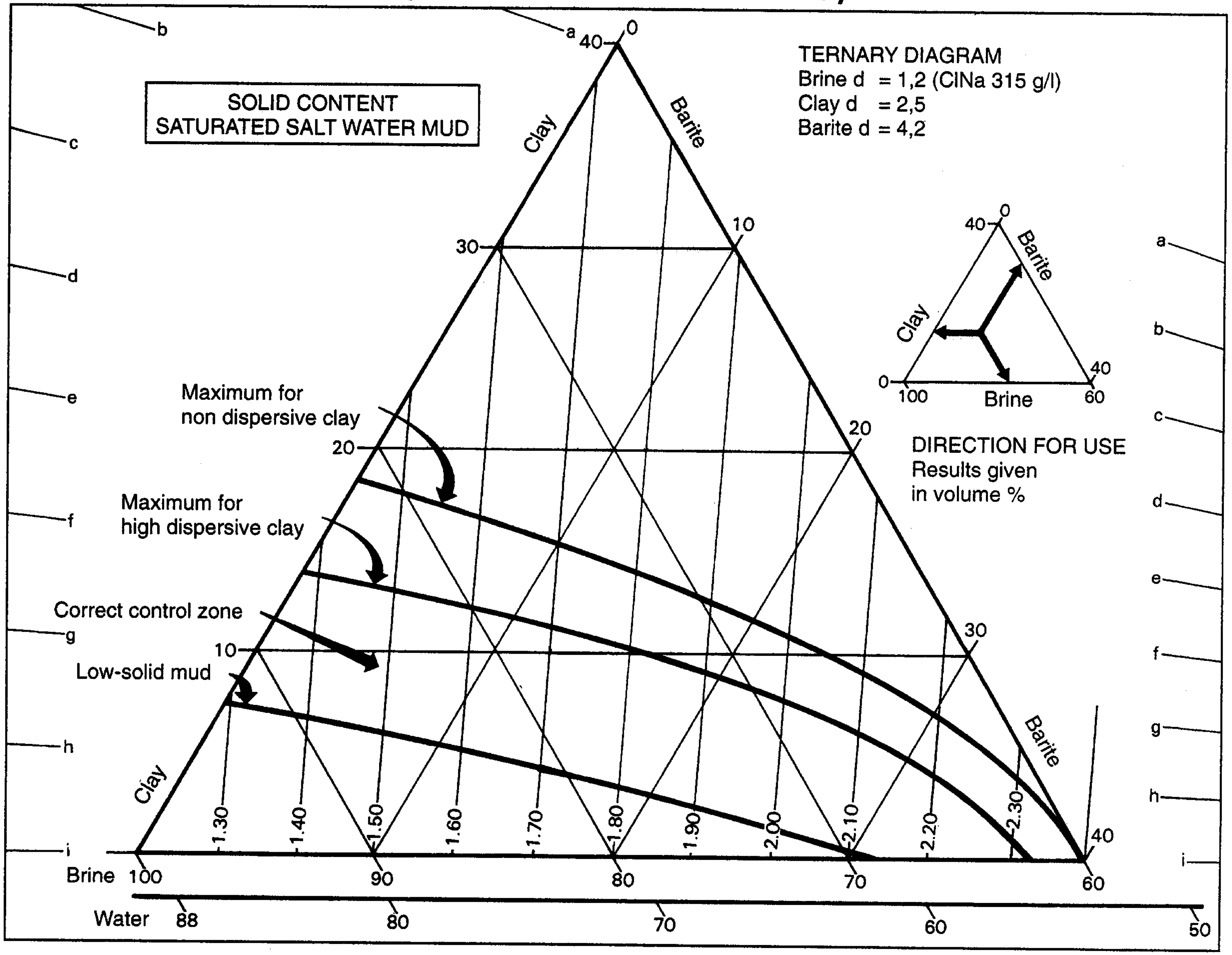
$$V_I = V_F \frac{(4.2 - d_2)}{(4.2 - d_1)}$$

V_I = initial volume of specific gravity d_1
V_F = final volume of mud d_2
here V_F = 1000 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	− 0.50	1
1.019	1018.3	25.68	0.993	− 1.70	3
1.031	1030.3	45.65	0.986	− 2.80	4
1.043	1042.3	62.77	0.981	− 3.30	6
1.055	1054.2	79.89	0.976	− 4.40	7
1.067	1066.2	99.86	0.969	− 5.60	9
1.079	1078.2	116.98	0.962	− 7.20	11
1.091	1090.2	134.10	0.952	− 8.30	12
1.103	1102.2	154.07	0.948	− 10.00	14
1.115	1114.1	174.04	0.940	− 11.70	15
1.127	1126.1	194.02	0.933	− 12.80	17
1.139	1138.1	211.14	0.926	− 14.40	18
1.151	1150.1	231.11	0.919	− 16.10	20
1.163	1162.1	251.08	0.909	− 18.30	21
1.175	1174.0	271.05	0.902	− 20.60	23
1.187	1186.0	291.03	0.895	− 15.00	24
1.199	1198.0	311.00	0.888	− 3.90	26

$kg/m^3 \times 0.00835 = lb/gal$ $kg \times 2.20 = lb$ $m^3 \times 6.29 = bbl$

PROPERTIES OF CALCIUM CHLORIDE SOLUTIONS

Sp. Gr. at 15.6°C	Solution weight at 15.6°C (kg/m³)	Materials to prepare 1 m³ 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 (m³)	$CaCl_2$ (kg)	Freshwater (m³)		
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	− 2.20	3
1.055	1054.2	68.48	0.988	85.60	0.967	− 3.90	7
1.079	1078.2	99.86	0.979	122.69	0.950	− 6.10	9
1.103	1102.2	131.25	0.971	162.63	0.933	− 8.30	11
1.127	1126.1	165.48	0.962	205.43	0.914	− 11.10	14
1.151	1150.1	199.72	0.950	245.37	0.895	− 14.40	16
1.175	1174.0	231.11	0.943	285.32	0.879	− 17.80	19
1.199	1198.0	268.20	0.931	330.97	0.855	− 22.20	21
1.223	1222.0	302.44	0.919	373.77	0.833	− 27.80	23
1.247	1245.9	336.68	0.912	416.57	0.817	− 33.90	26
1.271	1269.9	370.91	0.900	456.51	0.795	− 41.70	28
1.295	1293.8	405.15	0.893	499.31	0.779	− 50.60	30
1.319	1317.8	439.39	0.879	542.11	0.755	− 30.00	32
1.343	1341.8	476.48	0.864	587.76	0.729	− 17.80	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	15.60	40
1.439*	1437.6*	630.55	0.809	778.92	0.629	21.10	42

* Calculated values, since at 15.6°C, these are not liquids.

kg/m³ × 0.00835 = lb/gal   kg × 2.20 = lb   m³ × 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

$kg/m^3 \times 0.00835$ = lb/gal kg × 2.20 = lb $m^3 \times 6.29$ = bbl

PROPERTIES OF SODIUM CARBONATE (Na_2CO_3) SOLUTIONS

Relative density at 20°C	Specific gravity at 20°C	Solution weight (kg/m^3)	Concentration g/l or kg/m^3	Materials to prepare 1 m^3 of solution				Freezing point (°C)	Approximate % Anhydrous Na_2CO_3
				With anhydrous salt		With hydrated salt			
ρ or D_4^{20}	D_{20}^{20}		C_s	Na_2CO_3 (kg)	Freshwater (m^3)	Na_2CO_3 10 H_2O (kg)	Freshwater (m^3)	Δ	A%
1.009	1.010	1008.6	10.09	10.09	0.999	27.228	0.981	− 0.4	1
1.019	1.021	1019.0	20.38	20.38	0.999	55.018	0.964	− 0.8	2
1.029	1.031	1029.4	30.88	30.88	0.999	83.370	0.946	− 1.1	3
1.040	1.042	1039.8	41.59	41.59	0.998	112.283	0.928	− 1.4	4
1.050	1.052	1050.2	52.51	52.51	0.998	141.757	0.908	− 1.8	5
1.061	1.063	1060.6	63.64	63.64	0.997	171.793	0.889	− 2.1	6
1.071	1.073	1071.1	74.98	74.98	0.996	202.410	0.869		7
1.082	1.084	1081.6	86.53	86.53	0.995	233.593	0.848		8
1.092	1.094	1092.2	98.30	98.30	0.994	265.368	0.827		9
1.103	1.105	1102.9	110.29	110.29	0.993	297.741	0.805		10
1.114	1.116	1113.6	122.50	122.50	0.991	330.693	0.783		11
1.124	1.126	1124.4	134.93	134.93	0.989	364.255	0.760		12
1.135	1.137	1135.3	147.59	147.59	0.988	398.435	0.737		13
1.146	1.148	1146.3	160.48	160.48	0.986	433.241	0.713		14
1.157	1.160	1157.4	173.61	173.61	0.984	468.681	0.689		15

PROPERTIES OF POTASSIUM CARBONATE (K_2CO_3) SOLUTIONS

Relative density at 20°C	Specific gravity at 20°C	Solution weight (kg/m³)	Concentration g/l or kg/m³	Materials to prepare 1 m³ of solution with anhydrous salt		Freezing point (°C)	Approximate % Anhydrous K_2CO_3
ρ or D_4^{20}	D_{20}^{20}		C_s	K_2CO_3 (kg)	Freshwater (m³)	Δ	A%
1.007	1.009	1007	10.1	10.07	0.997	−0.3	1
1.016	1.018	1016	20.3	20.33	0.996	−0.7	2
1.025	10.27	1025	30.8	30.76	0.995	−1.0	3
1.035	1.036	1035	41.4	41.38	0.993	−1.3	4
1.044	1.046	1044	52.2	52.19	0.992	−1.7	5
1.053	1.055	1053	63.2	63.17	0.990	−2.0	6
1.062	1.064	1062	74.4	74.35	0.988	−2.4	7
1.072	1.073	1072	85.7	85.72	0.986	−2.8	8
1.081	1.083	1081	97.3	97.28	0.984	−3.2	9
1.090	1.092	1090	109.0	109.04	0.981	−3.6	10
1.110	1.112	1110	133.1	133.14	0.976	−4.4	12
1.129	1.131	1129	158.1	158.07	0.971	−5.4	14
1.149	1.151	1149	183.8	183.84	0.965	−6.4	16
1.169	1.171	1169	210.5	210.46	0.959	−7.6	18
1.190	1.192	1190	238.0	237.96	0.952	−8.8	20
1.211	1.213	1211	266.4	266.40	0.945		22
1.232	1.234	1232	295.7	295.68	0.936	−12.0	24
1.254	1.241	1254	326.0	325.98	0.928		26
1.276	1.278	1276	357.1	357.14	0.918	−16.0	28
1.298	1.301	1298	389.4	389.39	0.909		30
1.320	1.323	1320	422.5	422.53	0.898	−21.5	32
1.343	1.347	1343	456.8	456.77	0.887		34
1.367	1.369	1367	491.9	491.94	0.875	−28.6	36
1.390	1.393	1390	528.3	528.33	0.862		38
1.414	1.417	1414	565.7	565.68	0.849	−37.6	40
1.439	1.440	1439	604.3	604.28	0.834		42
1.463	1.466	1463	643.9	643.85	0.819		44
1.489	1.491	1489	684.8	684.83	0.804		46
1.514	1.517	1514	726.8	726.82	0.787		48
1.540	1.543	1540	770.2	770.20	0.770		50
1.566	1.569	1566	814.5	814.53	0.752		52

PROPERTIES OF SODIUM BROMIDE (NaBr) SOLUTIONS

Relative density at 20°C	Specific gravity at 20°C	Solution weight (kg/m^3)	Concentration g/l or kg/m^3	Materials to prepare 1 m^3 of solution		Freezing point (°C)	Approximate % NaBr
ρ or D_4^{20}	D_{20}^{20}		C_s	NaBr (kg)	Freshwater (m^3)	Δ	A%
1.006	1.008	1006	10.1	10.06	0.996	− 0.3	1
1.014	1.016	1014	20.3	20.28	0.994	− 0.7	2
1.022	1.024	1022	30.7	30.65	0.991	− 1.0	3
1.030	1.032	1030	41.2	41.19	0.989	− 1.4	4
1.038	1.040	1038	51.9	51.90	0.986	− 1.8	5
1.046	1.048	1046	62.8	62.77	0.983	− 2.1	6
1.055	1.056	1055	73.8	73.82	0.981	− 2.5	7
1.063	1.065	1063	85.0	85.04	0.978	− 2.9	8
1.072	1.074	1072	96.4	96.44	0.975	− 3.3	9
1.080	1.082	1080	108.0	108.03	0.972	− 3.8	10
1.089	1.091	1089	119.8	119.81	0.969	− 4.2	11
1.098	1.100	1098	131.8	131.77	0.966	− 4.7	12
1.107	1.109	1107	143.9	143.94	0.963	− 5.2	13
1.116	1.118	1116	156.3	153.30	0.960	− 5.7	14
1.126	1.128	1126	168.9	168.86	0.957	− 6.2	15
1.135	1.137	1135	181.6	181.63	0.954	− 6.7	16
1.145	1.147	1145	194.6	194.62	0.950	− 7.3	17
1.155	1.157	1155	207.8	207.83	0.947		18
1.165	1.167	1165	221.3	221.26	0.943		19
1.175	1.177	1175	234.9	234.90	0.940		20
1.185	1.187	1185	248.8	248.81	0.936		21
1.195	1.197	1195	262.9	262.92	0.932		22

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:

$$\textbf{Density change} = 0.647\,(T_1 - T_2) \qquad (\text{kg/m}^3)$$

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 1300 kg/m^3 is required at 15°C.

$$\text{Density change (kg/m}^3) = 0.647\,(80 - 15) = 42.06 \text{ kg/m}^3$$

$$\text{Required solution density at 15°C} = 1300 + 42.06 = 1342.06 \text{ kg/m}^3 \text{ at 15°C}$$

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
Silt	200
Coarse clay	10 to 20
Fine clay	2 to 10
Colloidal clay	0.2 to 2
	< 0.2

American definition in API 13C:

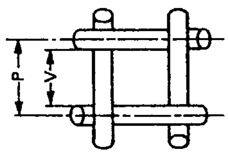
	(μ)
Coarse	> 2000
Intermediate	2000 to 250
Medium	250 to 74
Fine	74 to 44
Ultra fine	44 to 2
Colloidal	< 2

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. 36.0)
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	Russian		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 4100 1957	BS-410 1943		UNI 2332 1943	COST-3584-53 1953		The TYLER Standard Screen Scale Sieves		ASTM E 11-61 1961		Wenworth and J. Boucart scale
Opening (mm)	Module	Opening (mm)	Opening (mm)	Designation number (No.)	Opening (mm)	Opening (mm)	Designation number (No.)	Opening (mm)	Designation number (mesh)	Opening (mm)	Designation number (No.)	
								0.038	400 +	0.037	400	
0.04	17	0.04			0.04	0.04	4					
		0.045	0.044	350		0.045	45	0.043	325	0.044	325	
0.05	18	0.05			0.05	0.05	5					Silt. loess 4 to 62.5 μ
						0.056	56	0.053	270	0.053	270 +	
								0.061	250			
0.063	19	0.063	0.064	240	0.063	0.063	63			0.063	230	
		0.071	0.076	200	0.075	0.071	71	0.074	200 +	0.074	200 +	
0.08	20	0.08			0.08	0.08	8					
			0.089	170				0.088	170 +	0.088	170	
		0.09			0.09	0.09	9					
0.1	21	0.1			0.1	0.1	1					Very fine sand 62.5 to 125 μ
			0.104	150	0.106			0.104	150 +	0.105	140 +	
						0.112	112					
0.125	22	0.125	0.124	120	0.125	0.125	125	0.124	115	0.125	120	
						0.14	14					
			0.152	100	0.15			0.147	100 +	0.149	100 +	
0.16	23	0.16			0.16	0.16	16					
			0.178	85	0.18	0.18	18	0.175	80 +	0.177	80	
					0.2	0.2	2					
			0.211	72	0.212			0.208	65 +	0.21	70	Fine sand 125 to 250 μ
						0.224	224					
0.25	25	0.25	0.251	60	0.25	0.25	25	0.246	60	0.25	60 +	
						0.28	28					
			0.295	52	0.3			0.295	48 +	0.297	50 +	
0.315	26	0.315			0.315							
			0.353	44	0.355	0.355	355	0.351	42	0.354	45	
					0.4	0.4	4					Medium sand 0.25 to 0.5 mm
			0.422	36	0.425	0.45	45	0.417	35 +	0.42	40 +	
0.5	28	0.5	0.5	30	0.5	0.5	5	0.495	32	0.5	35	
			0.599	25	0.6	0.56	56	0.589	28 +	0.595	30 +	
0.63	29	0.63			0.63	0.63	63					
			0.699	22	0.71	0.7	7	0.701	24	0.707	25	
					0.75							
0.8	30	0.8			0.8	0.8	8					Coarse sand 0.5 to 1 mm
			0.853	18	0.85			0.833	20 +	0.841	20 +	
						0.9	9	0.991	16			
1	31	1	1.003	16	1	1	1			100	18	
			1.204	14	1.18			1.168	14 +	1.19	16	
1.25	32	1.25			1.25	1.25	1.25					
			1.405	12	14.4			1.397	12	1.41	14	
1.6	33	1.6			1.6	1.6	1.6					Very coarse sand 1 to 2 mm
			1.676	10	1.7			1.651	10 +	1.68	12 +	
2	34	2	2.057	8	2	2	2	1.981	9	2	10	
			2.411	7	2.36			2.362	8 +	2.38	8	
2.5	35	2.5			2.5	2.5	2.5					
					2.8			2.794	7			
			2.812	6						2.83	7	
3.15	36	3.15			3.15							Granulated material 2 to 4 mm
			3.353	5	3.35			3.327	6 +	3.36	6 +	
4	37	4			4			3.962	5	4	5	
								4.699	4 +	4.76	4	
5	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)

$$Q = Q_o + (NH)$$

Q = flow rate required (m^3/min)
Q_o = 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				
				Q_o	Values of N ROP Rate of penetration (m/h)				Q_o	Values of N ROP 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	0.94	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	**76.00**	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	1.348
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	**6.48**	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 = ft^3/min   m/h × 3.28 = ft/h

Example : 8 3/4 in hole, 5 in drill pipes, depth 7900 ft

ROP = 10 m/h

Q = 23.43 + 24 × 0.696 = 40.13 m^3/min

Sources : R.R. Angel, Phillips Petroleum Co., AIME Paper 873 – G, *AIME Petroleum Transactions*, vol. 210, 1957.

I

cementing

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* cu ft contains *x* sacks)	
Net weight of one 50 kg sack of cement	49.5 kg 109 lb
Cement volume in one 50 kg sack	32.89 liters 1.16 cu ft

Weight

1 short ton	=	2000 lb 907 kg 21.28 sacks of 94 lb 18.33 sacks of 50 kg
1 metric ton	=	2205 lb 23.45 sacks of 94 lb 1.10 short ton 0.984 long ton
1 short ton	=	2240 lb 1016 kg 23.83 sacks of 94 lb 20.53 sacks of 50 kg

Volume

1 cubic foot	=	28.32 liters	1 barrel	=	0.159 m^3
1 US gallon	=	3.785 liters	1 barrel	=	5.61 cu ft

Density

1 kg/l	=	8.345 lb/gal	1 lb/gal	=	7.48 lb/ft^3
1 kg/l	=	62.428 lb/ft^3	1 lb/ft^3	=	0.01602 kg/l
1 lb/gal	=	0.1198 kg/l	1 lb/ft^3	=	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 tons 2205 lb 1000 kg	Short tons 2000 lb 907 kg	Long tons 2240 lb 1016 kg
100	4.26	4.70	4.20
120	5.12	5.64	5.04
140	5.97	6.58	5.87
160	6.82	7.52	6.71
180	7.68	8.46	7.55
200	8.53	9.40	8.39
220	9.38	10.34	9.23
240	10.23	11.28	10.07
260	11.09	12.22	10.91
280	11.94	13.16	11.75
300	12.79	14.10	12.59
320	13.64	15.04	13.43
340	14.50	15.98	14.27
360	15.35	16.92	15.11
380	16.20	17.86	15.95
400	17.06	18.80	16.79
420	17.91	19.74	17.62
440	18.76	20.68	18.46
460	19.61	21.62	19.30
480	20.47	22.56	20.14
500	21.32	23.50	20.98
520	22.17	24.44	21.82
540	23.03	25.38	22.66
560	23.88	26.32	23.50
580	24.73	27.26	24.34
600	25.58	28.20	25.18
620	26.44	29.14	26.02
640	27.29	30.08	26.86
660	28.14	31.02	27.70
680	29.00	31.95	28.54
700	29.85	32.89	29.37
720	30.70	33.83	30.21
740	31.55	34.77	31.05
760	32.41	35.71	31.89
780	33.26	36.65	32.73
800	34.11	37.59	33.57
820	34.96	38.53	34.41
840	35.82	39.47	35.25
860	36.67	40.41	36.09
880	37.52	41.35	36.93
900	38.38	42.29	37.77
920	39.23	43.23	38.61
940	40.08	44.17	39.45
960	40.93	45.11	40.29
980	41.79	46.05	41.12

50 kg sacks

Sacks	Metric tons 2205 lb 1000 kg	Short tons 2000 lb 907 kg	Long tons 2240 lb 1016 kg
100	4.95	5.46	4.87
120	5.94	6.55	5.85
140	6.93	7.63	6.82
160	7.92	8.72	7.79
180	8.91	9.81	8.77
200	9.90	10.90	9.74
220	10.89	11.99	10.72
240	11.88	13.08	11.69
260	12.87	14.17	12.67
280	13.86	15.26	13.64
300	14.85	16.35	14.62
320	15.84	17.44	15.59
340	16.83	18.53	16.56
360	17.82	19.62	17.54
380	18.81	20.71	18.51
400	19.80	21.80	19.49
420	20.79	22.89	20.46
440	21.78	23.98	21.44
460	22.77	25.07	22.41
480	23.76	26.16	23.38
500	24.75	27.25	24.36
520	25.74	28.34	25.33
540	26.73	29.43	26.31
560	27.72	30.52	27.28
580	28.71	31.61	28.26
600	29.70	32.70	29.23
620	30.69	33.79	30.21
640	31.68	34.88	31.18
660	32.67	35.97	32.15
680	33.66	37.06	33.13
700	34.65	38.15	34.10
720	35.64	39.24	35.08
740	36.63	40.33	36.05
760	37.62	41.42	37.03
780	38.61	42.51	38.00
800	39.60	43.60	38.97
820	40.59	44.69	39.95
840	41.58	45.78	40.92
860	42.57	46.87	41.90
880	43.56	47.96	42.87
900	44.55	49.05	43.85
920	45.54	50.14	44.82
940	46.53	51.23	45.80
960	47.52	52.32	46.77
980	48.51	53.41	47.74

API CEMENT CLASSES AND TYPES
(API Spec 10, 5th edition, July 1, 1990)

Class	Type
A	For use from surface to 1830 m (6000 ft) depth, when special properties are not required. Available only in ordinary type.
B	For use from surface to 1830 m (6000 ft) depth, when conditions require moderate to high sulfate-resistance. Available in both moderate and high sulfate-resistant types.
C	For use from surface to 1830 m (6000 ft) depth, when conditions require high early strength. Available in ordinary and moderate and high sulfate-resistant types.
D	For use from 1830 m (6000 ft) to 3050 m (10 000 ft) depth, under conditions of moderately high temperatures and pressures. Available in both 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 temperature sand pressures. Available in both 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 both moderate and high sulfate-resistant types.
G	For use as a basic well cement 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. No additions other than calcium sulfate or water, or both, shall be interground or blended with the clinker during manufacture of Class G well cement. Available in moderate and high sulfate-resistant types.
H	For use as a basic well cement 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. No additions other than calcium sulfate or water, or both, shall be interground or blended with the clinker during manufacture of Class H well cement. Available in moderate and high sulfate-resistant types.

Notes: 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, 5th edition, July 1, 1990)

Class	Maximum depth		Minimum thickening time (min) according to API 10 tests	Compressive strength (kPa and psi) according to API Spec 10 tests Table 7.2						Mixing water				
				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	
	(m)	(ft)		T (°C)	P (kPa)	(kPa)	(psi)	(kPa)	(psi)		(liters)	(gal)	(liters)	(gal)
A	0–1 830	0–6 000	at 305 m: 90 at 1 830 m: 90	38	atm	1 700	250	12 400	1 800	46	19.6	5.19	23	6.07
B	0–1 830	0–6 000	at 305 m: 90 at 1 830 m: 90	38	atm	1 400	200	10 300	1 500	46	19.6	5.19	23	6.07
C	0–1 830	0–6 000	at 305 m: 90 at 1 830 m: 90	38	atm	2 100	300	13 800	2 000	56	23.9	6.32	28	7.39
D	1 830–3 050	60 000–10 000	at 1 830 m: 90 at 3 050 m: 100	77 110	20 700 20 700	3 500	500	6 900 13 800	1 000 2 000	38	16.2	4.29	19	5.02
E	3 050–4 270	10 000–14 000	at 3 050 m: 100 at 4 270 m: 154	77 143	20 700 20 700	3 500	500	6 900 13 800	1 000 2 000	38	16.2	4.29	19	5.02
F	3 050–4 880	10 000–16 000	at 3 050 m: 100 at 4 880m: 190	110 160	20 700 20 700	3 500	500	6 900 6 900	1 000 1 000	38	16.2	4.29	19	5.02
G	0–2 440	0–8 000	at 2 440: 90 max 120	38 60	atm atm	2 100 10 300	300 1 500			44	18.8	4.97	22	5.81
H	0–2 440	0–8 000	at 2 440: 90 max 120	38 60	atm atm	2 100 10 300	300 1 500			38	16.2	4.29	19	5.02

Remarks:
The addition of bentonite to cement requires an increase in the amount of water. For testing purpose, 5.3% water should be added for each 1% of bentonite in all API cement classes. For example, for 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.

PREPARATION OF FRESHWATER SLURRY

Rule of the thumb:

$$1 \text{ sack} \begin{cases} 94 \text{ lb} \\ 1 \text{ cu ft} \end{cases} + 5 \text{ gal water} \Rightarrow \text{cement with } d = 1.90$$

$$\text{Slurry density} = \frac{\text{Cement mass} + \text{Water mass}}{\text{Cement volume} + \text{Water volume}} = \frac{\text{Total mass}}{\text{Slurry volume}}$$

For 100 kg of cement:

- Slurry specific gravity:

$$d = \frac{100 + e}{\frac{100}{3.15} + e}$$

- Water volume (in liters):

$$e = \frac{100\left(1 - \frac{d}{3.15}\right)}{d - 1}$$

Class of cement	Volume of water (liters) for 100 kg of cement	Specific gravity 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
H	38	1.98

- Slurry yield (in liters):

$$v = \frac{100}{3.15} + e$$

$$v = \frac{68.3}{d - 1}$$

Example: 100 kg of cement + 44 liters of water gives:

slurry specific gravity: $d = \frac{100 + 44}{\frac{100}{3.15} + 44} = \frac{144}{31.8 + 44} = \frac{144}{75.8} = 1.90$

and slurry yield: $v = 75.9$ liters

CEMENT SLURRY (FRESHWATER)

	Slurry density			Freshwater volume							Slurry volume				
	(kg/l)	(lb/gal)	(lb/ft³)	(l/100 kg)	(gal/94 lb sack)	(ft³/94 lb sack)	(l/94 lb sack)	(l/sh ton)	(gal/ sh ton)	(ft³/ sh ton)	(l/100 kg)	(l/94 lb sack)	(ft³/94 lb sack)	(l/sh ton)	(ft³/ sh ton)
	1.74	14.5	108.6	60.5	6.81	0.91	25.8	549	145.0	19.38	92.2	39.3	1.39	837	29.55
	1.75	14.6	109.2	59.3	6.67	0.89	25.3	538	142.0	18.98	91.0	38.8	1.37	826	29.16
	1.76	14.7	109.9	58.1	6.54	0.87	24.8	527	139.1	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	136.4	18.23	88.6	37.8	1.33	804	28.40
Class C	**1.78**	**14.9**	**111.1**	**55.8**	**6.28**	**0.84**	**23.8**	**506**	**133.6**	**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	131.0	17.51	86.4	36.8	1.30	784	27.68
	1.80	15.0	112.4	53.6	6.03	0.81	22.8	486	128.4	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	125.9	16.83	84.3	35.9	1.27	764	27.00
	1.82	15.2	113.6	51.5	5.80	0.78	22.0	467	123.4	16.50	83.2	35.5	1.25	755	26.67
	1.83	15.3	114.2	50.5	5.69	0.76	21.5	458	121.0	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	118.7	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	116.4	15.55	80.3	34.2	1.21	728	25.73
	1.86	15.5	116.1	47.6	5.36	0.72	20.3	432	114.1	15.26	79.4	33.8	1.20	720	25.43
	1.87	15.6	116.7	46.7	5.26	0.70	19.9	424	111.9	14.96	78.5	33.5	1.18	712	25.13
Class A, B	**1.88**	**15.7**	**117.4**	**45.8**	**5.16**	**0.69**	**19.5**	**416**	**109.8**	**14.68**	**77.6**	**33.1**	**1.17**	**704**	**24.85**
	1.89	15.8	118.0	44.9	5.06	0.68	19.2	408	107.7	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**	**105.7**	**14.13**	**75.8**	**32.3**	**1.14**	**688**	**24.30**
	1.91	15.9	119.2	43.3	4.87	0.65	18.4	392	103.7	13.86	75.0	32.0	1.13	680	24.03
	1.92	16.0	119.9	42.4	4.78	0.64	18.1	385	101.7	13.60	74.2	31.6	1.12	673	23.77
	1.93	16.1	120.5	41.6	4.69	0.63	17.8	378	99.8	13.34	73.4	31.3	1.11	666	23.51
	1.94	16.2	121.1	40.9	4.60	0.62	17.4	371	97.9	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	96.1	12.85	71.8	30.6	1.08	652	23.02
	1.96	16.4	122.4	39.4	4.43	0.59	16.8	357	94.3	12.61	71.1	30.3	1.07	645	22.78
	1.97	16.4	123.0	38.6	4.35	0.58	16.5	350	92.6	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**	**90.8**	**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	89.1	11.92	68.9	29.4	1.04	625	22.09
	2.00	16.7	124.9	36.5	4.11	0.55	15.6	331	87.5	11.70	68.3	29.1	1.03	619	21.87
	2.01	16.8	125.5	35.8	4.04	0.54	15.3	325	85.9	11.48	67.6	28.8	1.02	613	21.65
	2.02	16.9	126.1	35.2	3.96	0.53	15.0	319	84.3	11.27	66.9	28.5	1.01	607	21.44
	2.03	16.9	126.7	34.5	3.89	0.52	14.7	313	82.7	11.06	66.3	28.3	1.00	601	21.23
	2.04	17.0	127.4	33.9	3.82	0.51	14.4	307	81.2	10.86	65.6	28.0	0.99	595	21.03
	2.05	17.1	128.0	33.3	3.75	0.50	14.2	302	79.7	10.65	65.0	27.7	0.98	590	20.83
	2.06	17.2	128.6	32.6	3.68	0.49	13.9	296	78.2	10.46	64.4	27.5	0.97	584	20.63
	2.07	17.3	129.2	32.0	3.61	0.48	13.7	291	76.8	10.27	63.8	27.2	0.96	579	20.44
	2.08	17.4	129.9	31.5	3.54	0.47	13.4	285	75.4	10.08	63.2	26.9	0.95	573	20.25
	2.09	17.4	130.5	30.9	3.48	0.46	13.2	280	74.0	9.89	62.6	26.7	0.94	568	20.06
	2.10	17.5	131.1	30.3	3.41	0.46	12.9	275	72.6	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 liters/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 specific 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	29.5	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
	2.01	1480	34.7	530
	2.02	1494	35.0	526
	2.03	1509	35.4	521
	2.04	1524	35.7	516
	2.05	1538	36.1	512
	2.06	1553	36.4	507
	2.07	1568	36.8	502
	2.08	1582	37.1	498
	2.09	1597	37.5	493
	2.10	1612	37.8	488

$m^3 \times 264$ = gal $m^3 \times 35.3$ = cu ft l × 0.264 = gal l × 0.0353 = cu ft

PREPARATION OF 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:

$$d = \frac{100 + 1.20\,e}{\dfrac{100}{3.15} + e}$$

where:

d = slurry specific gravity

e = brine volume in liters

- Water volume (in liters):

$$e = \frac{100\left(1 - \dfrac{d}{3.15}\right)}{d - 1.20}$$

- Slurry yield (in liters):

$$v = \frac{100}{3.15} + e$$

$$v = \frac{61.9}{d - 1.20}$$

Example: 100 kg of cement + 46 liters of water gives:

slurry specific gravity: $d = \dfrac{100 + 1.20 \times 46}{\dfrac{100}{3.15} + 46} = \dfrac{155.2}{31.8 + 46} = \dfrac{155.2}{77.8} = 2.00$

and slurry yield: $v = 77.4$ liters

CEMENT SLURRY (SATURATED SALT-WATER)
(Brine 315 g/l, *d* = 1.20)

Slurry density			Brine volume							Slurry volume				
(kg/l)	(lb/gal)	(lb/ft³)	(l/100 kg)	(gal/ 94 lb sack)	(ft³/ 94 lb sack)	(l/ 94 lb sack)	(l/sh ton)	(gal/ sh ton)	(ft³/ sh ton)	(l/100 kg)	(l/ 94 lb sack)	(ft³/ 94 lb sack	(l/sh ton)	(ft³/ sh ton)
1.80	15.0	112.4	71.4	8.05	1.08	30.5	648	171.2	22.88	103.2	44.0	1.55	936	33.05
1.81	15.1	113.0	69.7	7.86	1.05	29.7	633	167.1	22.34	101.5	43.3	1.53	921	32.51
1.82	15.2	113.6	68.1	7.67	1.03	29.0	618	163.2	21.82	99.8	42.6	1.50	906	31.99
1.83	15.3	114.2	66.5	7.49	1.00	28.4	603	159.4	21.31	98.3	41.9	1.48	891	31.48
1.84	15.4	114.9	65.0	7.32	0.98	27.7	589	155.7	20.82	96.7	41.2	1.46	877	30.99
1.85	15.4	115.5	63.5	7.15	0.96	27.1	576	152.2	20.34	95.2	40.6	1.43	864	30.51
1.86	15.5	116.1	62.0	6.99	0.93	26.5	563	148.7	19.88	93.8	40.0	1.41	851	30.05
1.87	15.6	116.7	60.6	6.83	0.91	25.9	550	145.4	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	142.1	18.99	91.0	38.8	1.37	826	29.17
1.89	15.8	118.0	58.0	6.53	0.87	24.7	526	138.9	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	135.9	18.16	88.4	37.7	1.33	802	28.33
1.91	15.9	119.2	55.4	6.25	0.83	23.6	503	132.9	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	130.0	17.37	86.0	36.7	1.29	780	27.55
1.93	16.1	120.5	53.1	5.98	0.80	22.6	481	127.2	17.00	84.8	36.2	1.28	769	27.17
1.94	16.2	121.1	51.9	5.85	0.78	22.1	471	124.4	16.63	83.7	35.7	1.26	759	26.80
1.95	16.3	121.7	50.8	5.72	0.76	21.7	461	121.7	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	119.1	15.92	81.5	34.7	1.23	739	26.10
1.97	16.4	123.0	48.6	5.48	0.73	20.7	441	116.6	15.59	80.4	34.3	1.21	729	25.76
1.98	16.5	123.6	47.6	5.36	0.72	20.3	432	114.1	15.26	79.4	33.8	1.20	720	25.43
1.99	16.6	124.2	46.6	5.25	0.70	19.9	423	111.7	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	109.4	14.62	77.4	33.0	1.17	702	24.79
2.01	16.8	125.5	44.7	5.03	0.67	19.1	405	107.1	14.31	76.4	32.6	1.15	693	24.48
2.02	16.9	126.1	43.7	4.93	0.66	18.7	397	104.8	14.02	75.5	32.2	1.14	685	24.19
2.03	16.9	126.7	42.8	4.83	0.65	18.3	389	102.7	13.72	74.6	31.8	1.12	677	23.89
2.04	17.0	127.4	42.0	4.73	0.63	17.9	381	100.5	13.44	73.7	31.4	1.11	669	23.61
2.05	17.1	128.0	41.1	4.63	0.62	17.5	373	98.5	13.16	72.8	31.1	1.10	661	23.33
2.06	17.2	128.6	40.2	4.53	0.61	17.2	365	96.4	12.89	72.0	30.7	1.08	653	23.06
2.07	17.3	129.2	39.4	4.44	0.59	16.8	358	94.4	12.63	71.2	30.3	1.07	646	22.80
2.08	17.4	129.9	38.6	4.35	0.58	16.5	350	92.5	12.37	70.3	30.0	1.06	638	22.54
2.09	17.4	130.5	37.8	4.26	0.57	16.1	343	90.6	12.11	69.6	29.7	1.05	631	22.28
2.10	17.5	131.1	37.0	4.17	0.56	15.8	336	88.8	11.87	68.8	29.3	1.04	624	22.04
2.11	17.6	131.7	36.3	4.09	0.55	15.5	329	87.0	11.62	68.0	29.0	1.02	617	21.79
2.12	17.7	132.3	35.5	4.00	0.54	15.2	322	85.2	11.39	67.3	28.7	1.01	610	21.56
2.13	17.8	133.0	34.8	3.92	0.52	14.8	316	83.4	11.15	66.6	28.4	1.00	604	21.33
2.14	17.9	133.6	34.1	3.84	0.51	14.5	309	81.7	10.93	65.9	28.1	0.99	597	21.10
2.15	17.9	134.2	33.4	3.76	0.50	14.2	303	80.1	10.71	65.2	27.8	0.98	591	20.88
2.16	18.0	134.8	32.7	3.69	0.49	14.0	297	78.5	10.49	64.5	27.5	0.97	585	20.66

PREPARATION OF ONE CUBIC METER OF SATURATED SALT-WATER SLURRY

Slurry specific gravity	Cement weight		Water volume (liters)
	(kg)	(94 lb sacks)	
1.75	888	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	1098	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	29.5	600
1.99	1276	29.9	595
2.00	1292	30.3	590
2.01	1308	30.7	585
2.02	1325	31.1	579
2.03	1341	31.4	574
2.04	1357	31.8	569
2.05	1373	32.2	564
2.06	1389	32.6	559
2.07	1405	33.0	554
2.08	1422	33.3	549
2.09	1438	33.7	544
2.10	1454	34.1	538
2.11	1470	34.5	533
2.12	1486	34.9	528
2.13	1502	35.2	523
2.14	1518	35.6	518
2.15	1535	36.0	513
2.16	1551	36.4	508

$m^3 \times 264$ = gal $m^3 \times 35.3$ = cu ft l × 0.264 = gal l × 0.0353 = cu ft

PREPARATION OF 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 a slurry specific gravity between 1.85 and 1.42 (for Class G)

(b) Or **prehydrated** in proportions ranging between 0.25 and 5% to obtain a slurry specific gravity 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:

$$d = \frac{100 + e + (Z+1)b}{\frac{100}{3.15} + e + \left(Z + \frac{1}{2.65}\right)b}$$

where:

d = bentonite slurry specific gravity

b = percentage of bentonite in relation to cement (or weight of bentonite per 100 kg of cement)
In general $0 < b < 20$ if **dry mixture**
$0 < b < 5$ if **prehydrated mixture**

e = volume of cement hydration water in relation to cement:

Class of cement	Volume of water (liters) for 100 kg of cement
A	46
B	46
C	56
D	38
E	38
F	38
G	44
H	38

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 prehydrated bentonite

The specific gravity of bentonite is taken as 2.65.

(1) Attapulgite ($d = 2.89$) is used with sea-water.

PREPARATION OF BENTONITE CEMENTS
(continued)

- Bentonite weight (in kg):

$$b = \frac{100\left(1 - \frac{d}{3.15}\right) - (d-1)e}{d\left(\frac{1}{2.65} + Z\right) - (Z+1)}$$

- Water volume (in liters):

$$E = e + Zb$$

- Slurry volume (in liters):

$$v = \frac{100}{3.15} + \frac{b}{2.65} + e + Zb$$

Example: to prepare a slurry with prehydrated bentonite and Class G cement, with specific gravity $d = 1.50$:

$d = 1.50$
$e = 44$ liters
$Z = 21.2$

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

(21.2 liters of water/kg bentonite)

% of bentonite	Volume water (l)	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

Dry mixture

(5.3 liters of water/kg bentonite)

% of bentonite	Volume water (l)	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

(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 (l)	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 (l)	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

PREPARATION OF WEIGHTED CEMENTS

For 100 kg of cement:

- Slurry specific gravity:

$$d = \frac{100 + e + a}{\frac{100}{3.15} + e + \frac{a}{d_a}}$$

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 – 4.33
Ilmenite: 4.45
Hematite: 4.95

- Specific gravity obtained:

Specific gravity	2.10	2.20	2.30	2.40	2.50	2.60	2.70
Barite (% BWOC) Water (% BWOC)* Dispersant (% BWOC)	40 48	87 60	110 58 1				
Ilmenite (% BWOC) Water (% BWOC)		30 38	55 41				
Hematite (% BWOC) Water (% BWOC) Dispersant (% BWOC)		40 44	60 46	80 46 0.3	110 50 0.5	150 55 0.8	175 55 1.0

* 44% BWOC water + 0.20 l water /kg barite
Dispersant: CD-31 (BJ Services), 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

Application	Description	BJ Services	Dowell	Halliburton
Accelerators	Sodium chloride	A5	D44	Salt
	Calcium chloride	A7 (A7L)	S1 (D77)	$Cacl_2$ ($Cacl_2$ liq)
	Sodium silicate	A2/Diacel A (A3L)	D79/D75	Econolite
	Gypsum	A10	D53	Cal-seat/EA2
	Potassium chloride	A9	M117	Kcl
Extenders and density-reducing agents	Bentonite	Bentonite	D20	Gel
	Attapulgite	Attapulgite	D128	Attapulgite
	Type F flyash	Flyash	D35	Pozmix A
	Type C flyash	Flyash	D132	Class C flyash
	Natural pozzolan	Pozzolan	D61	
	Diatomaceous earth	Diacel D	D56	Diacel D
	Perlite	Perlite	D72	Perlite
	Fumed silica	BA58 (BA58L - LW8L)	D154 (D155)	Silicate (Microblock)
	Glass microspheres	LW7-2/LW7-4		Glass spheres
	Pozzolan microspheres	LW-6	D124	Spherelite
	Proprietary extender	T40/FWC47 (BJ BLUE)	(D111)	VersaSet (verSaset L)
Retarders	Temperature <180°F	R3 (R21L)	D13 (D81)	HR4/HR7 (HR4L/HR7L)
	Temperature 125°F to 225°F	R3 (R10L/R12L/R21L)	D800 (D801)	HR5 (HR6L)
	Temperature 175°F to 300°F	R6/Diacel LWL	D8 (D110)	Diacel LWL
	Temperature > 225°F	R8 (R8L)	D28 (D150)	HR12/HR15 (HR12L/HR15L)
	Temperature > 300°F			HR20
	Aid for lignosulfonates	R9	D93/D121	Comp R/HR25
	Synthetic < 250°F	SR30 (R14/R15LS/R20L)		SCR100 (SCR100L)
	Synthetic < 425°F			HR25 (HR25L)
	For improved comp. strength	SR30 (R14/R15LS/R20L)	D161 (D110)	SCR100 (SCR100L)
	For thixotropic cement	R18/SR30	D74	
	Permafrost non lignosulfonate	R7		Sodium citrate
	Permafrost lignosulfonate		D13 (D81)	HR4 (HR4L)

( ) liquid additive.

CEMENTING ADDITIVES (continued)

Application	Description	BJ Services	Dowell	Halliburton
Fluid loss additive	Fresh water 60°F to 120°F	FL62 (BA10L)	D127/D156	LAP1 (LA2)
	Salt (<10%) 60°F to 120°F			
	Salt (<18%) 60°F to 120°F	FL33/FL63 (FL33L/FL63L)	D146	Halad 322/344/413 (L)
	Fresh water 80°F to 200°F	FL62 (BA10L)		LAP1/Halad 447 (LA2)
	Salt (<10%) 80°F to 200°F		(D300)	(Halad 10L)
	Salt (<18%) 80°F to 200°F		D60	Halad 9/322 (9L/322L)
	Salt (>18%) 80°F to 200°F		D59	
	Fresh water <250°F	FL62 (FL62L)		
	Salt (<10%) <250°F			
	Salt (<18%) <250°F		D160 (D603/D159)	Halad 22A/344 (22AL)
	Salt (>18%) <250°F		D65A (D80A/D604AM)	
	Fresh water <300°F			
	Salt (<10%) <300°F			
	Salt (<18%) <300°F			Halad 14 (14LXP/600LE+)
	Salt (>18%) <300°F	FL25/FL52		
	Fresh water >300°F			
	Salt (<10%) >300°F			
	Salt (<18%) >300°F		(D73/D73.1/D158)	
	Salt (>18%) >300°F	FL33/FL63 (FL33L/FL63L)	D8/D143 (D158)	Halad 413/100A (413L/361A)
Cement dispersant	General application	CD31/CD32 (CD31L/CD32L)	D65/D121 (D80/D145A)	CFR2/CFR3 (CFR2L/CFR3L)
	Salt-satured sluries	XR2	D45/D65A (D80A/D604AM)	FE2/CFR2 (CFR2L)
	Dispersant with anti-settling	CD32 (CD32L)	(D604AM)	CFR2 (CFR2L)
Loss circulation additives	Gilsonite	Gilsonite	D24	Gilsonite
	Cellophane flake	Celloflake	D29	Flocele
	Ground coal	Kol Seal	D42	
	Walnut plug	Nut Plug		Tuf Plug
	Polyester, thermoplastic	Flex Seal/Mud Save	D130	Granulite TR1/4
	Graded particule sizes	Kwik Seal		Kwik Seal

( ) liquid additive.

CEMENTING ADDITIVES (continued)

Application	Description	BJ Services	Dowell	Halliburton
Heavy weight additives	Sand 100 mesh Silica flour Barite Hematite Ilmenite Manganese Oxides Calcium carbonate	S8C S8 Barite Hematite Ilmenite W10	D30 D66 D31 D76 D18 D157 D151	SSA2 SSA1 Barite Hi-dense 3/Hi-dense 4 Micromax
Anti-foam agents	Decrease foaming	FP 11 (FP 6L/9L/10L/12L)	D46 (D47/M45/D144)	D-Air1 (D-Air2/3 /NF1/2/3)
Free water control	Polymers, sodium silicates	A2 /Diacel A/T40 (A3L/T40L)	D79/Diacel A/D153 (D75/D162)	Econolite/Diacel A/VersaSet
Bond improving expanding additives and anti-gas migration	Latex Fumed silica Expanding agent Gas-generating agents	BA10/BA58 (BA10L/BA86L) BA58/CSE (BA58L) A10/EC1 BA29/BA61	(D600/D134) D154 (D155) D53	Latex 2000 (LA2) Silicalite (Microblock) Cal-Seal/EA2/Microbond Super CBL (Gas-Chek)
Spacer and washes	No weighted chemical washes OBM chemical washes Spacer aqueous Spacer emulsion Spacer OBM Spacer high salt concentration	Flowcheck/Flo Guard Mud Clean/MRS2 Mud Sweep/Ultraflush II MCS 2/3/4/5 Ultraflush II APS1/OB1/RSB MCS 3/4/RSB	Zonelock/Zonelock SC CW7/CW8/CW8ES CW100/CW101 CW8/CW8ES/CW101 MUDPUSH XT/XTO/XS/XSO/XL MUDPUSH XEO MUDPUSH XLO/XTO/XEO MUDPUSH XS	Superflush Mud Flush Aqua Preflush N-Ver-Sperse/Alpha Preflush Dual Spacer/SD Spacer Dual/Alpha Spacer Dual Spacer/Dual Spacer E
Specialty cement blends	Thixotropic cements Silica flume and pozzolan Lightweight pozzolan micros. Permafrost	Sure Fill Cenolite Cold Set	RFC HILITE LITEFIL ARTICSET	Thix Set 31 My-T-Lite 2000 PERMAFROST

( ) liquid additive.

EFFECTS OF SOME ADDITIVES ON CEMENT PROPERTIES (1)

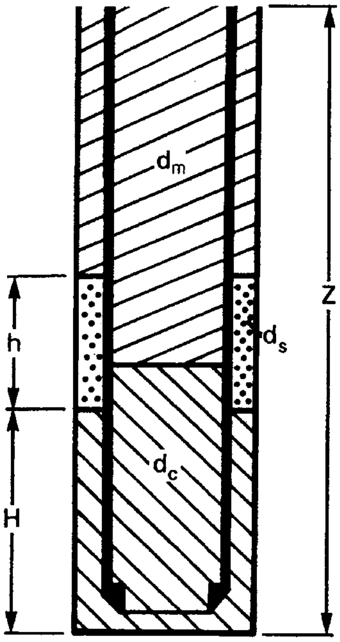
		Bentonite	Perlite	Diatomaceous earth	Pozzolan	Sand	Barite	Hematite	Calcium chloride	Sodium chloride	Lignosulfonate	CMHEC (2)	Diesel oil	Water loss additives	Lost circulation material
Density	Decreased	●	●	●	●										
	Increased					●	●	●	X	X	X				
Water required	Decreased										●				
	Increased	●	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) Carboxylmethyl hydroxyethyl cellulose

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 specific gravity d_s
V_c = cement volume at specific gravity d_c
V = displacement volume at specific gravity d_m at time of equilibrium
a = volume per meter in casing
b = volume per meter in annulus
h = spacer height in annulus in meters
H = cement height in annulus at equilibrium in meters
Z = casing setting depth in meters

$$h = \frac{V_s}{b} \tag{1}$$

$$H = \frac{V_c}{b+a} - \frac{a}{b(b+a)} V_s \frac{d_s - d_m}{d_c - d_m} \tag{2}$$

$$\boxed{V = \left(Z - \frac{V_c}{b+a} - \frac{V_s}{b+a}\frac{d_s - d_m}{d_c - d_m}\right) a} \tag{3}$$

SLURRY DISPLACEMENT (continued)

Specific case without spacer:

$$V = \left(Z - \frac{V_c}{b + a}\right) a$$

Cementing with two slurries: Formula (1), (2) and (3) can be used for a cement gel instead of a 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 in

Casing 9 5/8 in 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_m = 1.10
Results:	h = 173 m
	H = 696 m
	V = 85 m^3

The displacement volume corresponding to the time when the fluids in the annulus and the fluids in the casing reach hydrostatic equilibrium is 85 m^3.

BOTTOMHOLE CEMENTING TEMPERATURE BY DEPTH (API RP 10B, 22nd edition, December, 1997)

Well depth		Temp	Temperature gradient °C/100 m					
(m)	(ft)	(°C)	1.6	2.0	2.4	2.7	3.1	3.5
300	1 000	BHCT BHLT	27 32	27 33	27 34	27 35	27 36	27 37
610	2 000	BHCT BHLT	32 37	32 39	32 41	32 43	33 46	33 48
1 220	4 000	BHCT BHLT	37 47	38 51	38 56	39 60	39 64	40 69
1 830	6 000	BHCT BHLT	44 57	46 63	47 70	48 77	49 83	52 90
2 440	8 000	BHCT BHLT	52 67	54 76	57 84	60 93	63 102	71 111
3 050	10 000	BHCT BHLT	61 77	63 88	70 99	75 110	82 121	93 132
3 660	12 000	BHCT BHLT	64 87	74 100	84 113	94 127	104 140	113 153
4 270	14 000	BHCT BHLT	73 97	85 112	97 128	109 143	121 159	133 174
4 880	16 000	BHCT BHLT	83 107	97 124	112 142	126 160	140 178	154 196
5 490	18 000	BHCT BHLT	94 117	111 137	127 157	144 177	161 197	177 217
6 100	20 000	BHCT BHLT	106 127	124 149	144 171	163 193	182 216	202 238
6 710	22 000	BHCT BHLT	118 137	140 161	162 186	184 210	207 234	229 259

BHCT = Bottom Hole Circulating Temperature
BHLT = Bottom Hole Log Temperature after 24 hours

°F = 1.8°C + 32

J

directional drilling

REFERENCE COORDINATES

AZIMUTH

Azimuths measured in holes refer to one of the following:

(a) **True geographic North** (meridian direction): this is the direction of the geographic North Pole. The direction is shown on maps by the meridians of longitude.

(b) **Magnetic North** (compass direction): the compass initially gives a reading referenced to magnetic North. The position of this point is subject to time variation.

(c) **Grid North** (Lambert or UTM North): the surface of the Earth is a curved surface but the maps are flat surfaces.

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

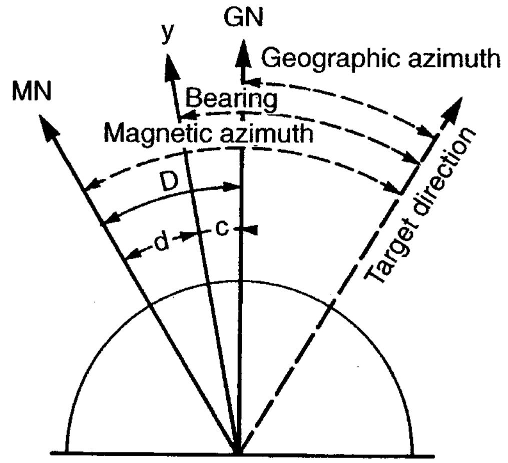
The declination is the angle between local magnetic North and geographic North (local meridian) measured positively eastward.

CONVERGENCE

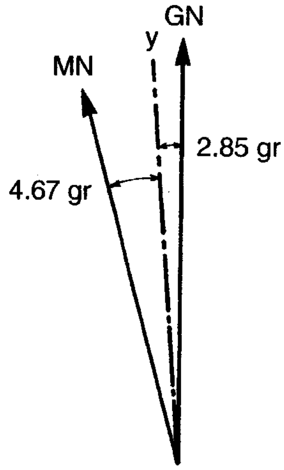
Convergence is the angle between the local meridian (True North) and Lambert or UTM North (Grid North – central meridian of the projection).

The values of declination related to the grid, and the value of convergence are normally indicated by a diagram on the right-hand margin of topographic maps.

REFERENCE COORDINATES (continued)



Magnetic declination corresponds to the center of the sheet and to 1 January 1967



Magnetic declination decreases each year by 11 centesimal minutes

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)

According to the diagram of the specific case, the declination *d* related to the grid in 1968 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

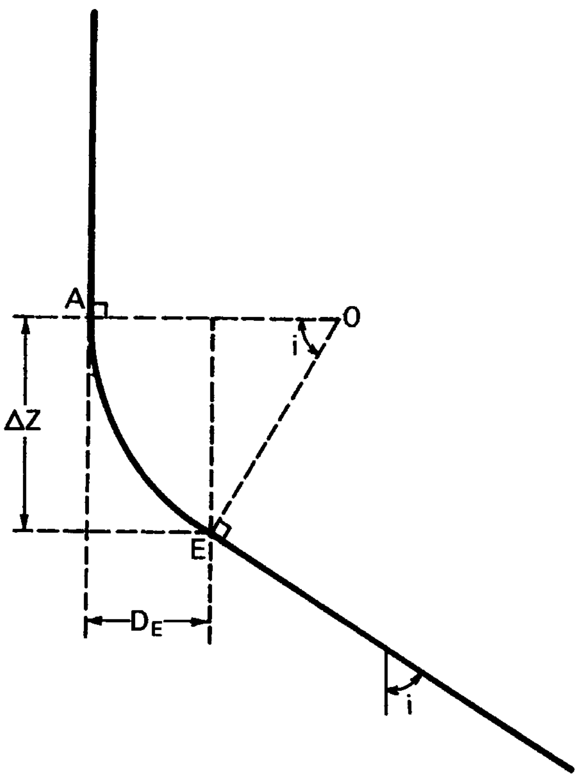
$AE = L$		Length drilled from A to E
$R = \frac{360}{2\Pi} \frac{\Delta L}{\Delta i}$		Radius of curvature (m)
$gbu = \frac{\Delta i}{\Delta L}$		Rate of buildup (°/10 m)

in general $\frac{\Delta i}{\Delta L}$ is kept as constant as possible during kickoff (constant radius of curvature).

Hence:

$$R = \frac{573}{gbu}$$

$$D_E = R(1 - \cos i) \quad \text{(m)}$$
$$\Delta Z = R \sin i \quad \text{(m)}$$



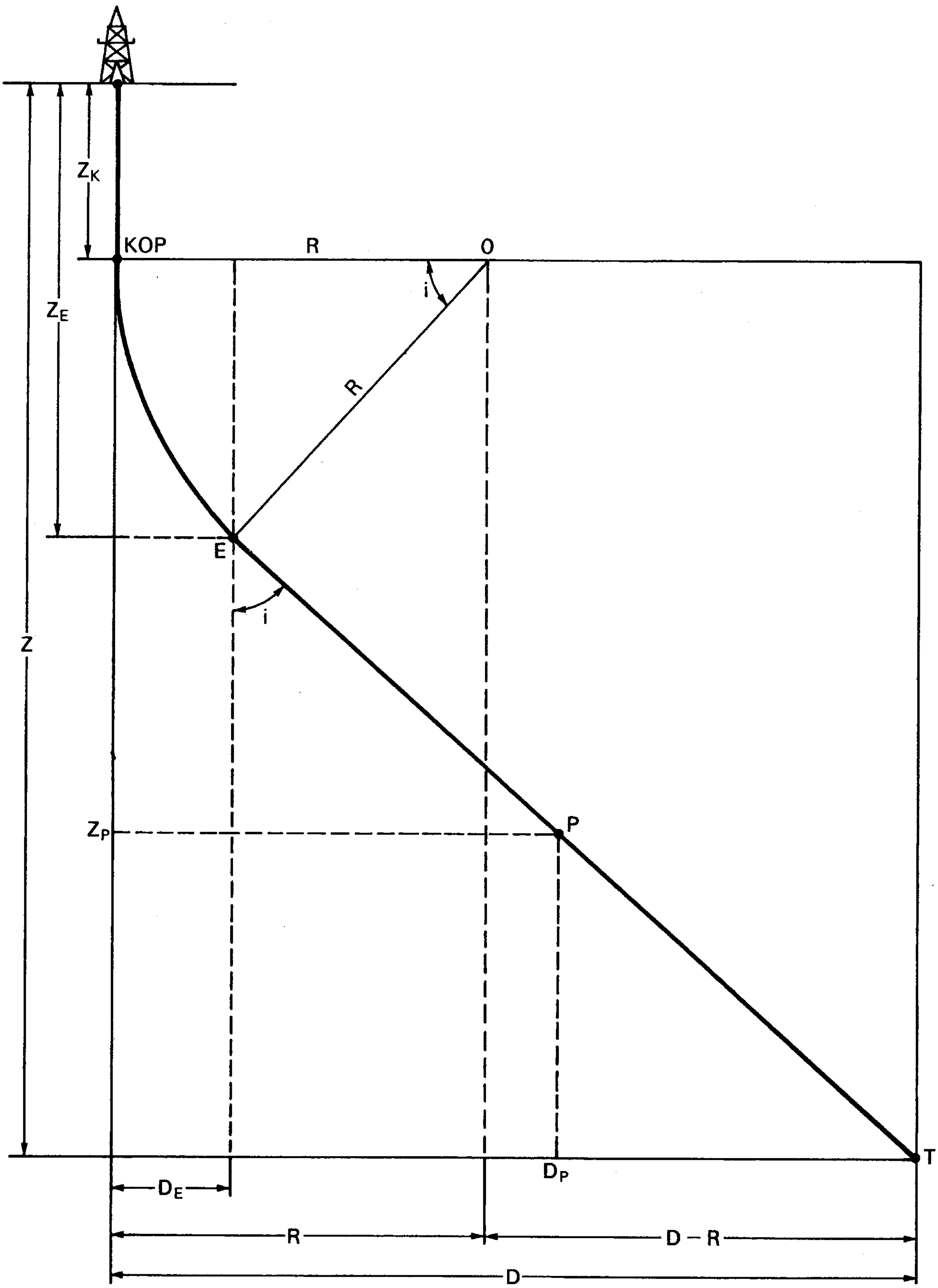
Radius of curvature for different rates of buildup:

gbu (°/10 m)	0.5	1.0	1.5	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
R (m)	1146	573	382	286	191	143	115	95	82	72	64	57

m × 3.28 = ft   °/10 m × 3.048 = °/100 ft

CALCULATION OF CHARACTERISTIC POINTS OF THE THEORETICAL VERTICAL PROFILE

J hole: *D* > *R*



CALCULATION OF CHARACTERISTIC 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
Vertical depth of target	Z	=	2350 m
Rate of buildup	gbu	=	1°/10 m (R = 573 m)

$$i = 180 - \tan^{-1}\left[\frac{2000}{700-573}\right] - \cos^{-1}\left[\frac{573}{2000}\sin\tan^{-1}\frac{2000}{700-573}\right]$$

$$i = 20°$$

(see graphic method in J 13)

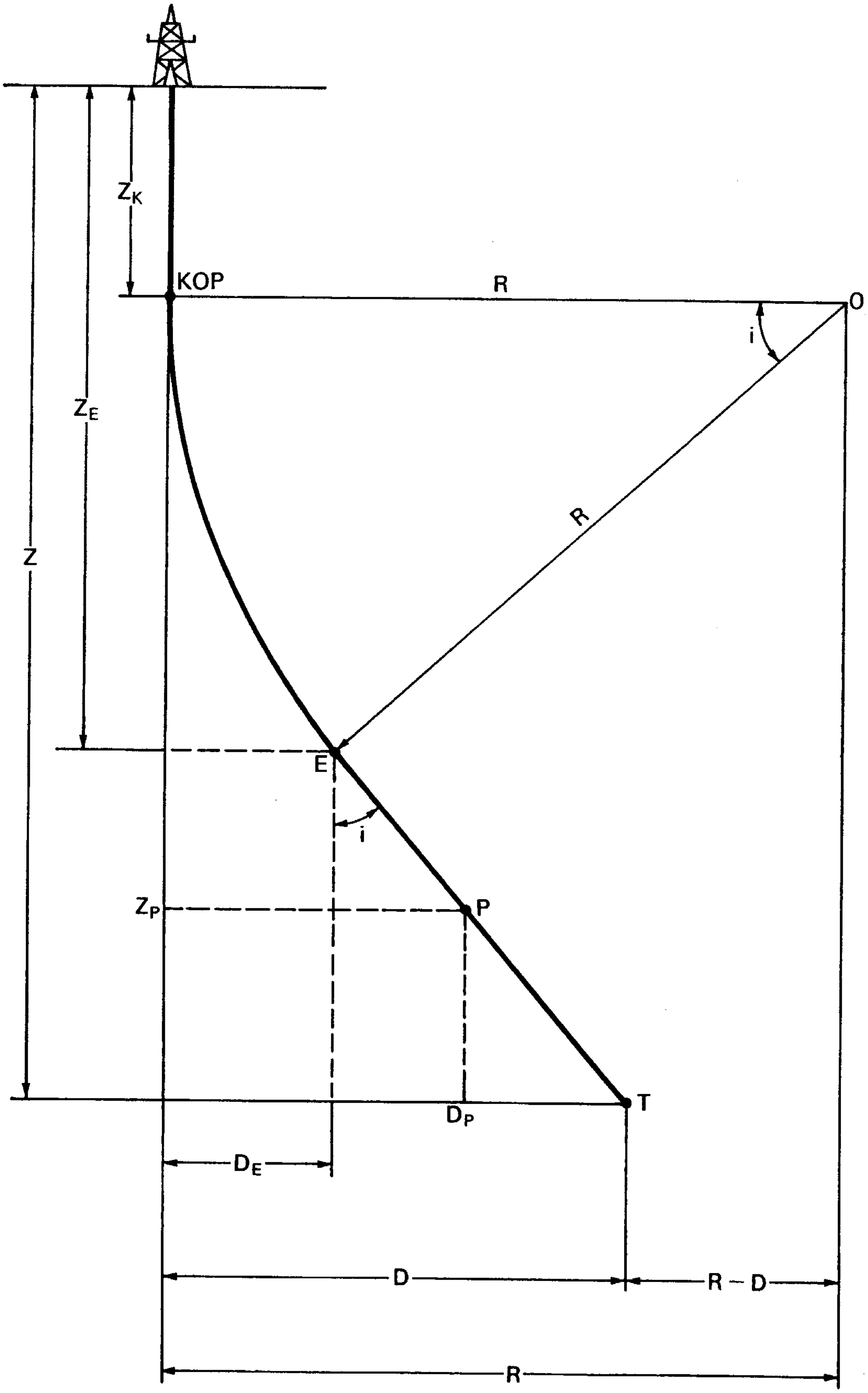
	Measured depth L (TMD)	Vertical depth Z (TVD)	Inclination	Displacement
Kickoff point (K)	Z_K	Z_K	0	0
End of deviation (E)	$L_E = Z_K + \frac{\Pi i R}{180}$	$Z_E = Z_K + R\sin i$	i	$D_E = R(1 - \cos i)$
Target (T)	$L_T = Z_K + \frac{\Pi i R}{180} + \frac{Z - Z_K - R\sin i}{\cos i}$	Z	i	D

Vertical depth Z_P as a function of drilled depth L_P at point P:

$$Z_P = Z_K + \frac{573}{gbu}\sin i + \left(L_P - Z_K - \frac{10i}{gbu}\right)\cos i$$

CALCULATION OF CHARACTERISTIC POINTS OF THE THEORETICAL VERTICAL PROFILE

J hole: *D* < *R*



CALCULATION OF CHARACTERISTIC 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
Vertical depth of target	Z	= 1800 m
Rate of buildup	gbu	= 1°/10 m (R = 573 m)

$$i = \tan^{-1}\left[\frac{1200}{573 - 300}\right] - \cos^{-1}\left[\frac{573}{1200}\sin\tan^{-1}\frac{1200}{573 - 300}\right]$$

$i = 15°$

(see graphic method in J 13)

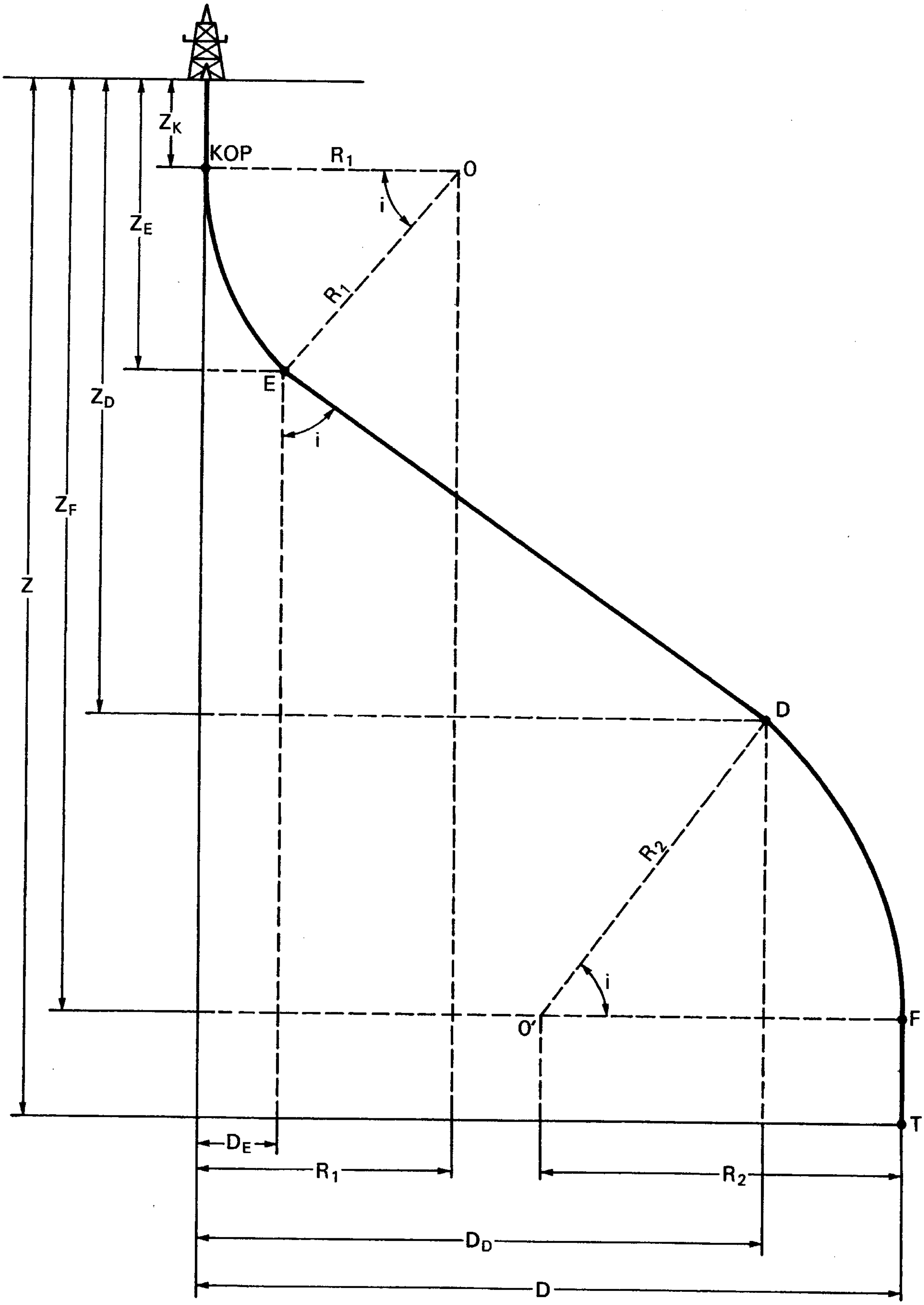
	Measured depth L (TMD)	Vertical depth Z (TVD)	Inclination	Displacement
Kickoff point (K)	Z_K	Z_K	0	0
End of deviation (E)	$L_E = Z_K + \frac{\Pi i R}{180}$	$Z_E = Z_K + R\sin i$	i	$D_E = R(1 - \cos i)$
Target (T)	$L_T = Z_K + \frac{\Pi i R}{180} + \frac{Z - Z_K - R\sin i}{\cos i}$	Z	i	D

Vertical depth Z_P as a function of drilled depth L_P at point P:

$$Z_P = Z_K + \frac{573}{gbu}\sin i + \left(L_P - Z_K - \frac{10i}{gbu}\right)\cos i$$

CALCULATION OF CHARACTERISTIC POINTS OF THE THEORETICAL VERTICAL PROFILE

S hole: $R_1 + R_2 < D$



CALCULATION OF CHARACTERISTIC 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 J 5 and J 7 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*:

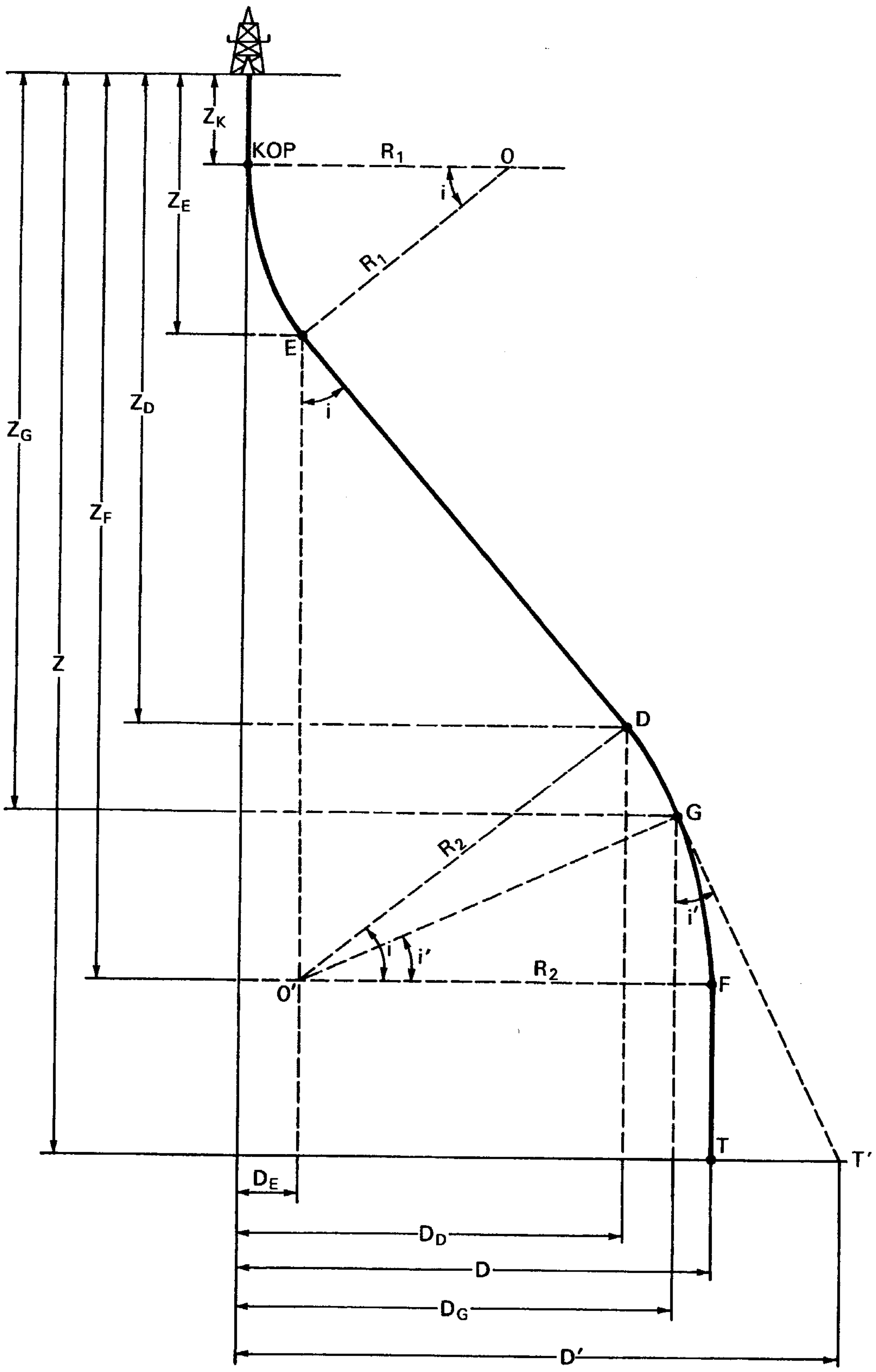
$$L_F = L_D + \frac{\Pi i R_2}{180}$$

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 CHARACTERISTIC POINTS OF THE THEORETICAL VERTICAL PROFILE

S hole: $R_1 + R_2 > D$



CALCULATION OF CHARACTERISTIC 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*:

$$i = \tan^{-1}\left[\frac{Z_F - Z_K}{R_1 + R_2 - D}\right] - \cos^{-1}\left[\frac{R_1 + R_2}{Z_F - Z_K}\sin\tan^{-1}\frac{Z_F - Z_K}{R_1 + R_2 - D}\right]$$

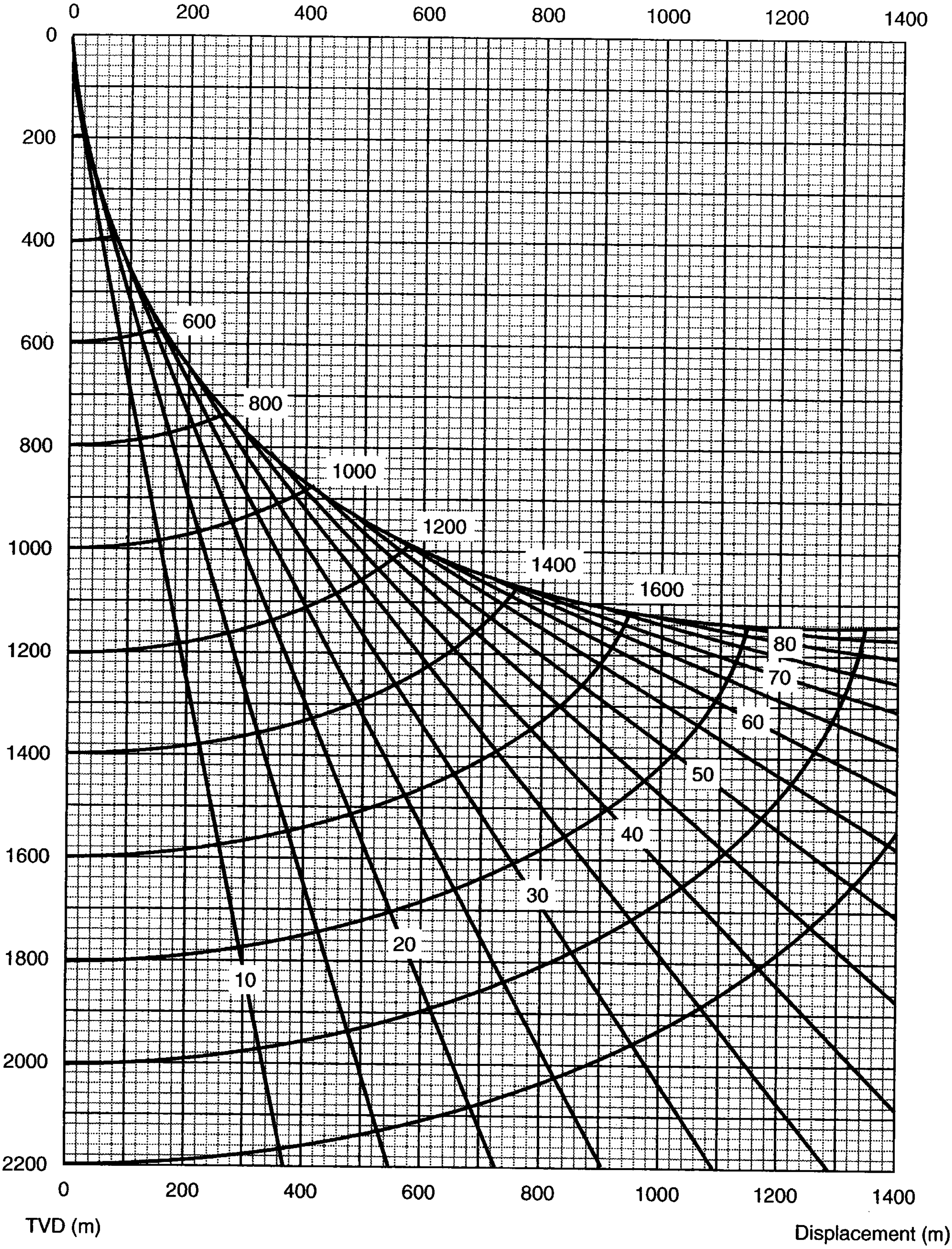
The remaining calculations are unchanged (see J 9).

If the well does not return to the vertical, the displacement at *T'* from point *G* becomes:

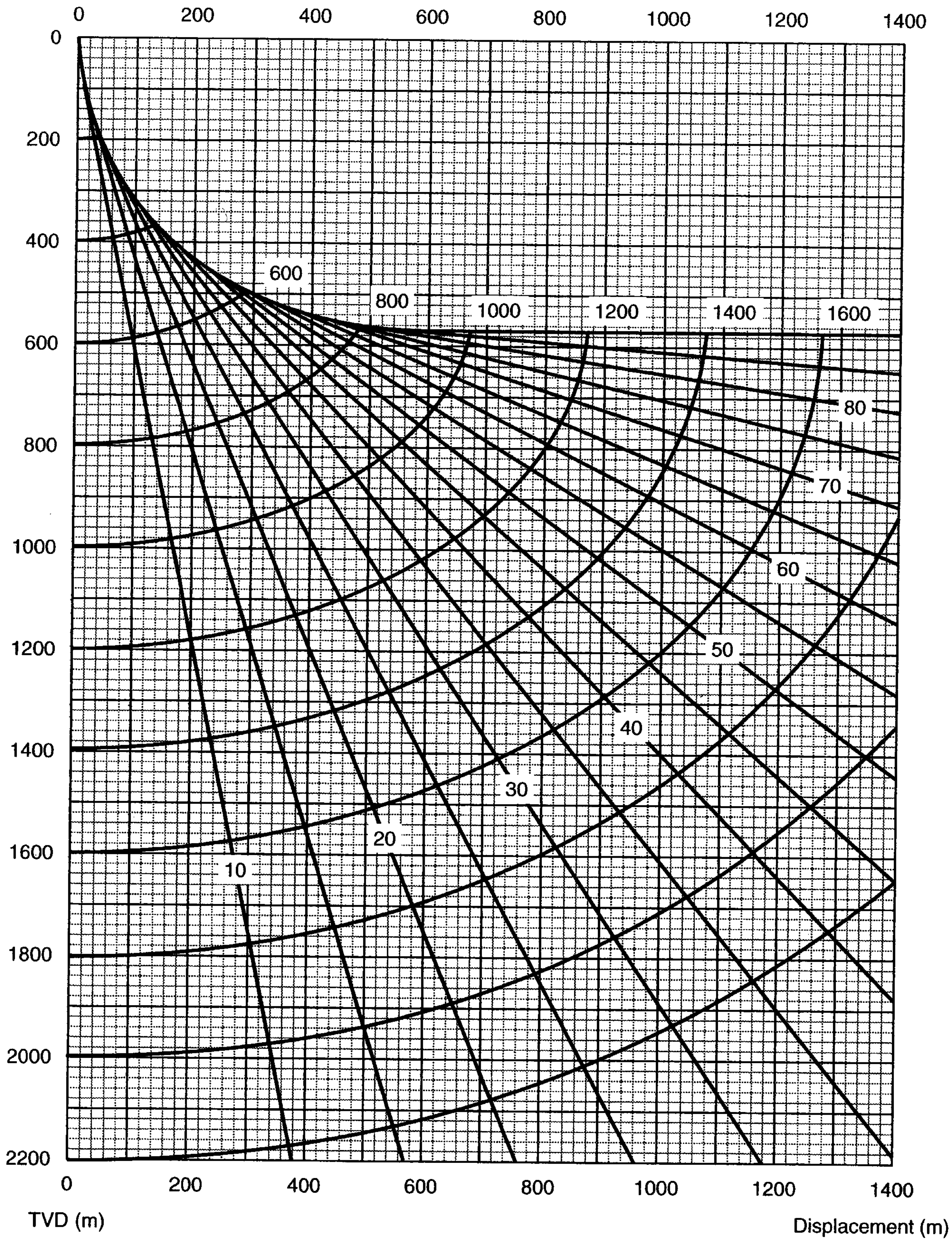
$$D' = D_G + (Z - Z_G)\tan i'$$

$$L_{T'} = L_G + \frac{(Z - Z_G)}{\cos i'}$$

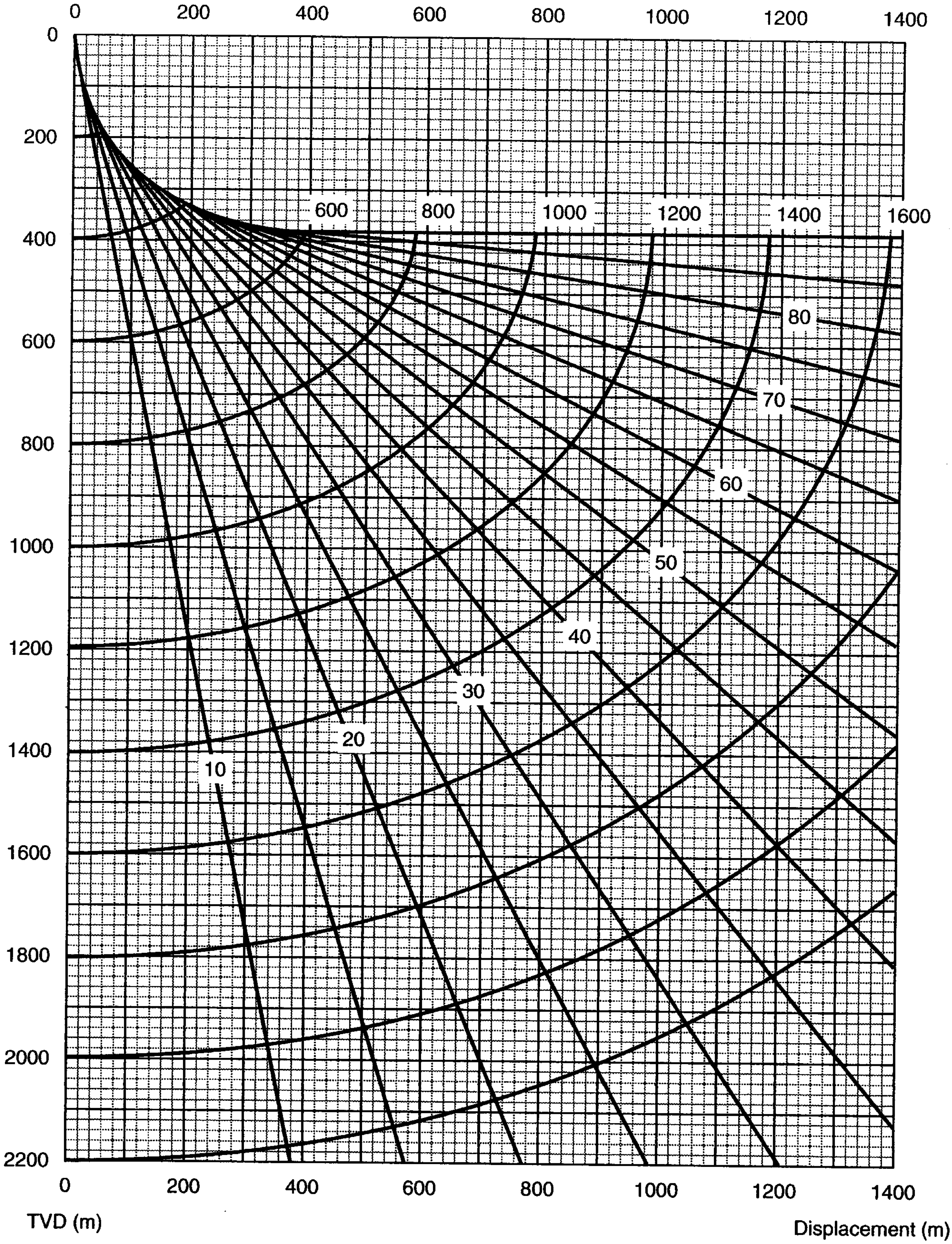
THEORETICAL VERTICAL PROFILE
RATE OF BUILDUP: 0.50 deg/10 m



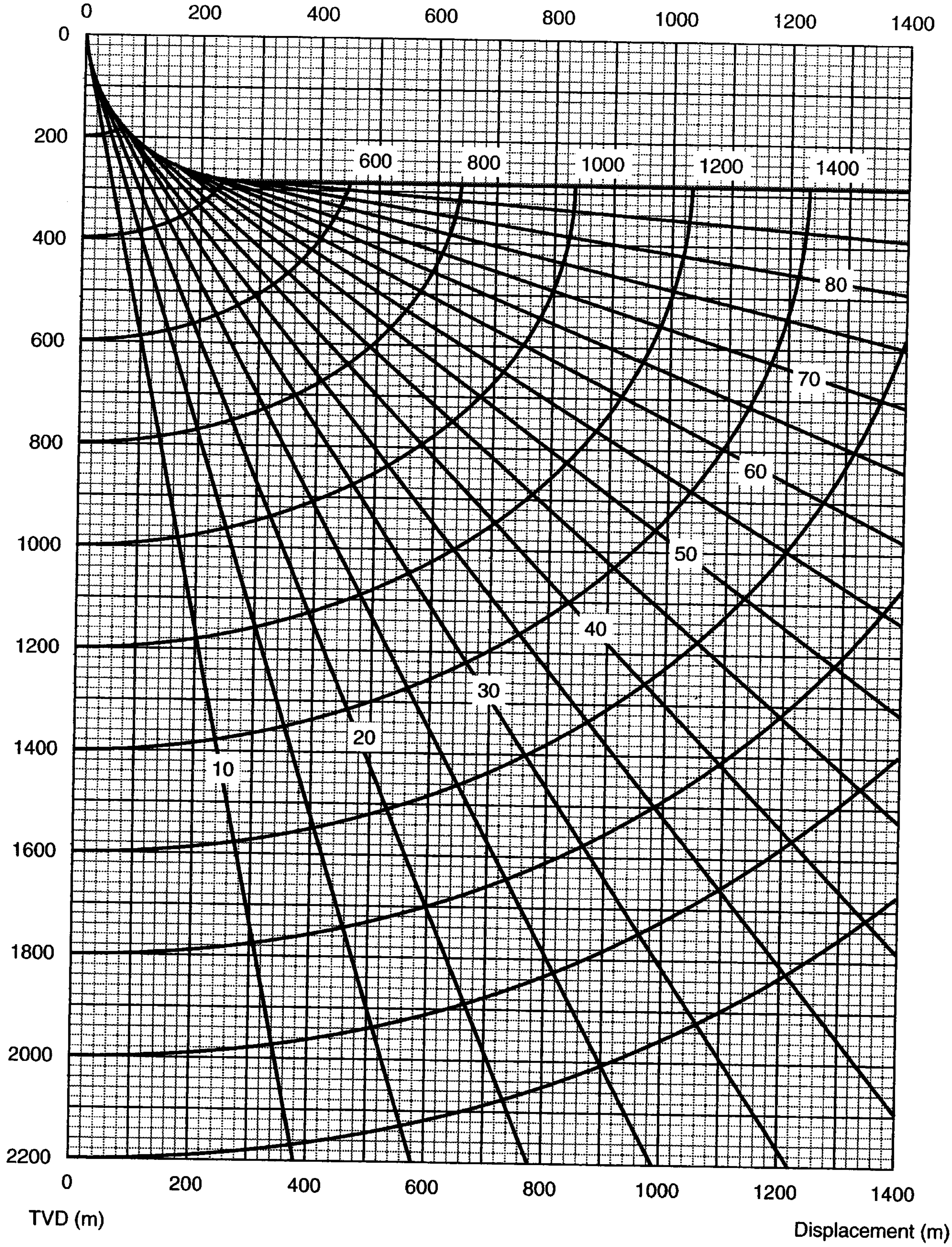
THEORETICAL VERTICAL PROFILE (continued)
RATE OF BUILDUP: 1.00 deg/10 m



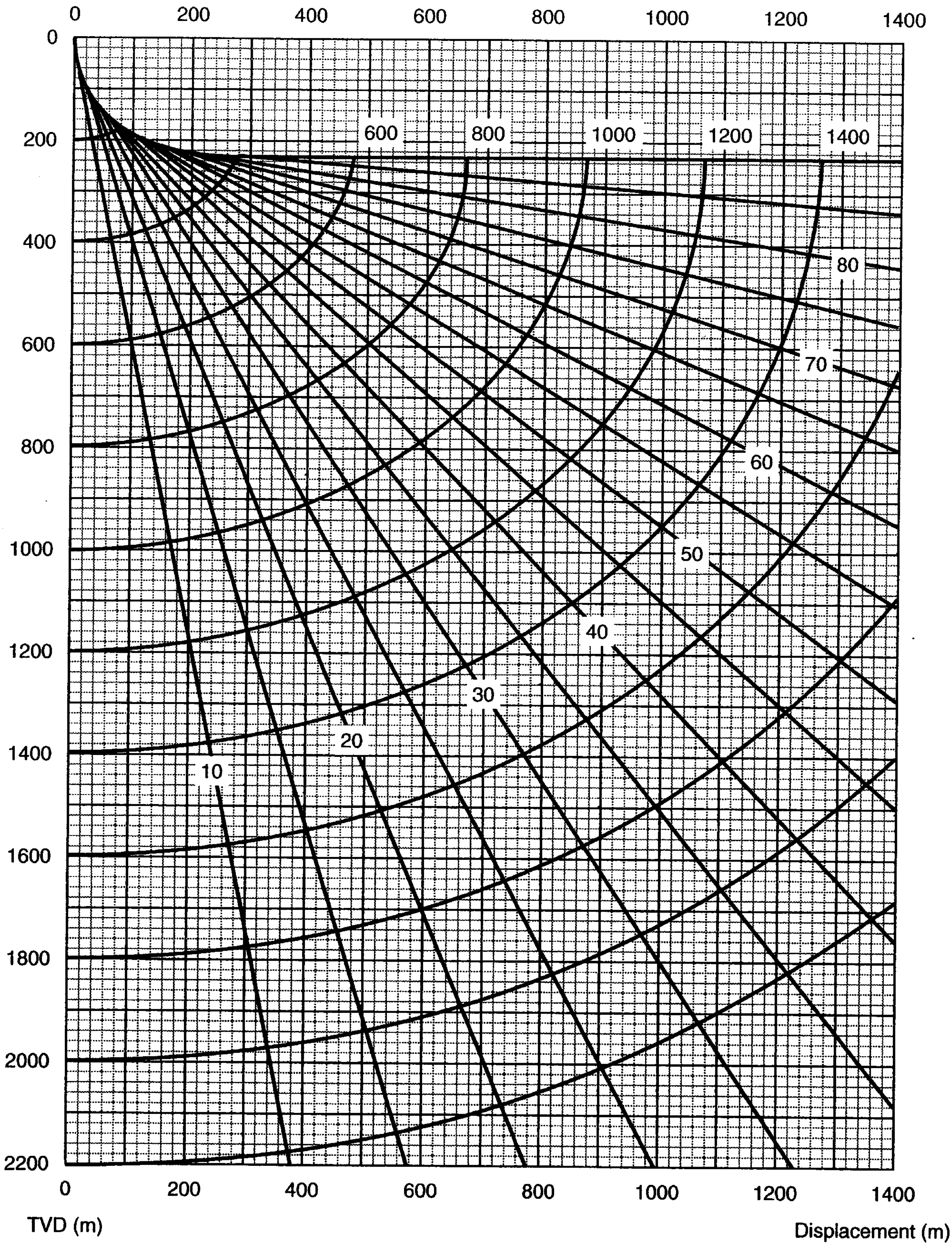
THEORETICAL VERTICAL PROFILE (continued)
RATE OF BUILDUP: 1.50 deg/10 m



THEORETICAL VERTICAL PROFILE (continued)
RATE OF BUILDUP: 2.00 deg/10 m



THEORETICAL VERTICAL PROFILE (continued)
RATE OF BUILDUP: 2.50 deg/10 m



RAGLAND DIAGRAM

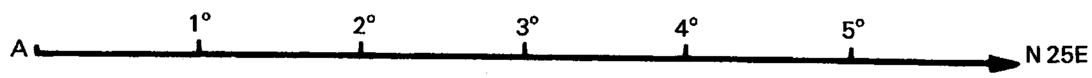
The Ragland diagram serves to determine the parameters used to calculate the orientation of the deflecting tool.

The diagram has four lines representing the characteristics of the hole and the deflecting tools.

These lines are the following:

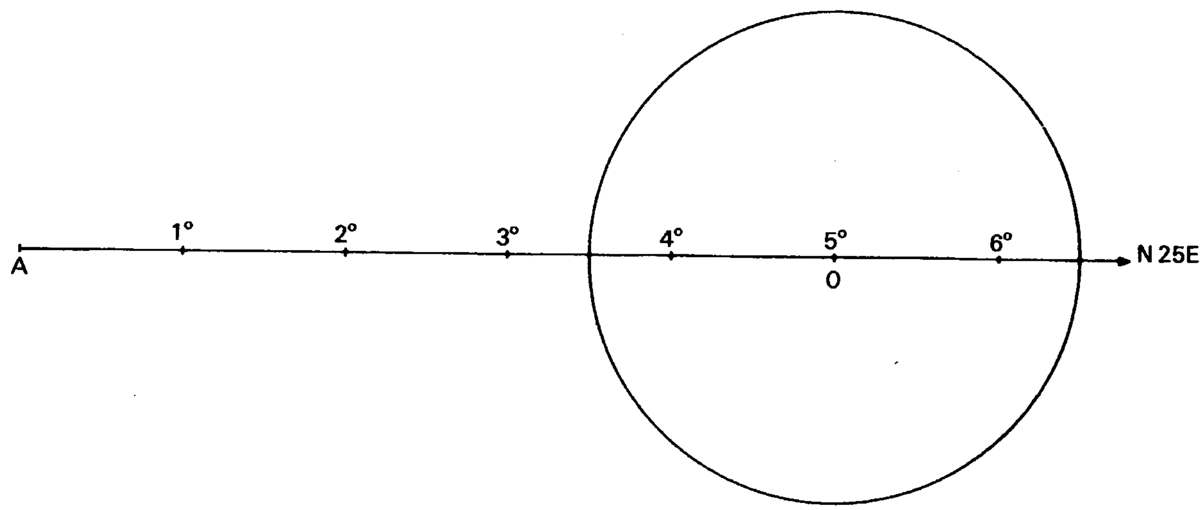
1) Original direction and inclination of a part of the hole.

Example: 5° and N25E



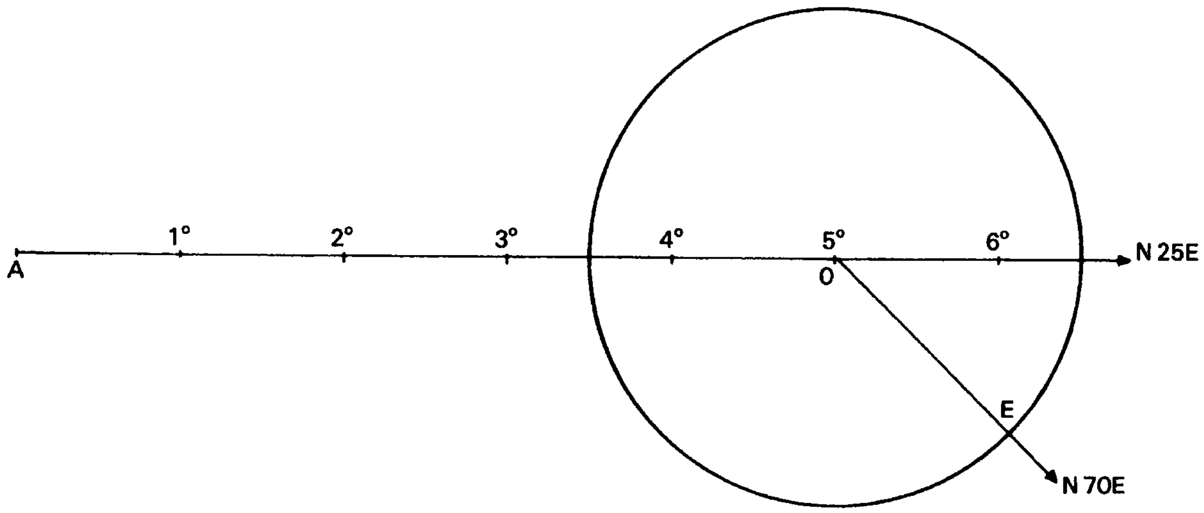
2) Dogleg circle (see dogleg formula in J 21).

Example: 1.5° dogleg



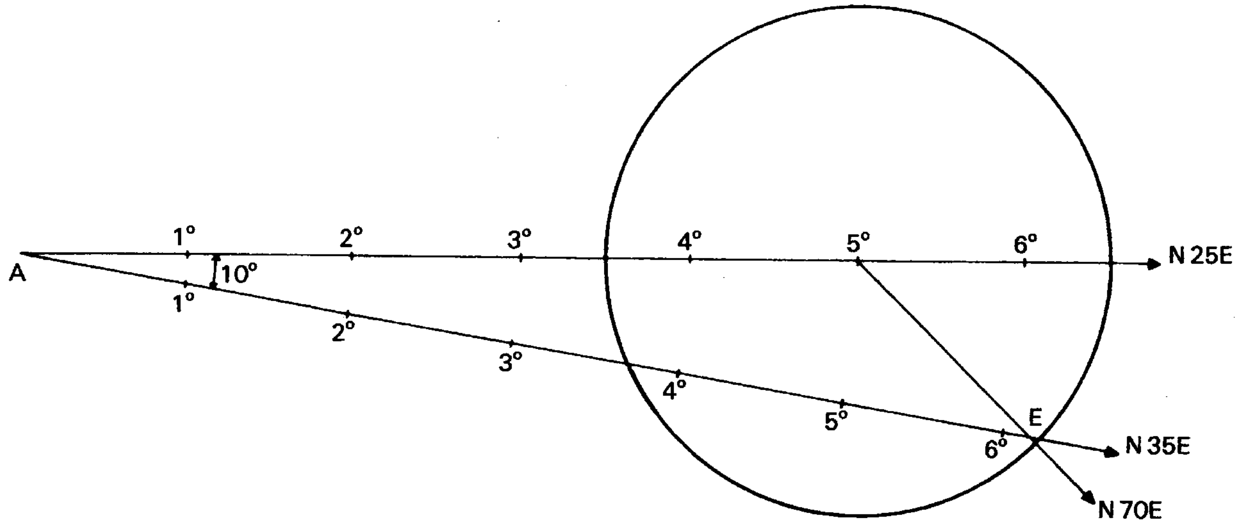
3) Orientation of deflecting tool in relation to the original direction, taking roll-off into account.

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:

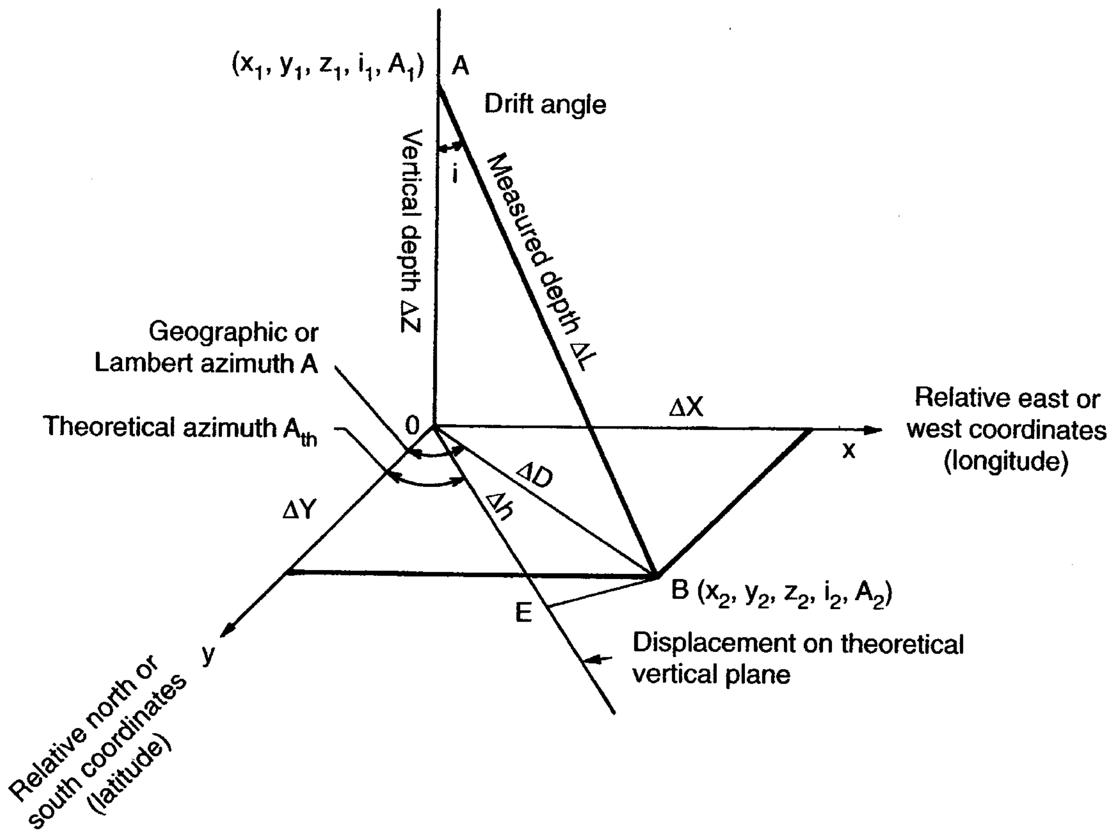


The angle between the two directions is 10 degrees.
The new direction is N35E.

Point *E* is common to the three lines:
(a) Orientation of deflecting tool
(b) Dogleg circle
(c) Direction obtained.

The third point 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 coordinates.
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 of survey and target $(A - A_{th})$	$\Delta h = \Delta D \cos(A - A_{th})$

CONTROL OF ACTUAL HOLE SHAPE
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

$$\Delta Z = \Delta L \cos i_2$$

$$\Delta D = \Delta L \sin i_2$$

$$\Delta Y = \Delta D \cos A_2$$

$$\Delta X = \Delta D \sin i_2$$

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
Different calculation formulas (continued)

d. Radius of curvature method

$$\Delta Z = \frac{180}{\Pi}\frac{\Delta L}{i_2 - i_1}(\sin i_2 - \sin i_1)$$

$$\Delta D = \frac{180}{\Pi}\frac{\Delta L}{i_2 - i_1}(\cos i_1 - \cos i_2)$$

$$\Delta Y = \frac{180}{\Pi}\frac{\Delta D}{A_2 - A_1}(\sin A_2 - \sin A_1)$$

$$\Delta X = \frac{180}{\Pi}\frac{\Delta D}{A_2 - A_1}(\cos A_1 - \cos A_2)$$

e. Minimum curvature method

The drilled section is assimilated to a spherical arc with a minimum curvature (maximum radius):

if:

$$\mathbf{DLG = \cos^{-1}[\cos i_1 \cos i_2 + \sin i_1 \sin i_2 \cos(A_2 - A_1)]}$$

and:

$$K = \frac{\Delta L}{\text{DLG}} \sin\frac{\text{DLG}}{2}$$

$$\Delta Z = K(\cos i_1 + \cos i_2)$$

$$\Delta D = K(\sin i_1 + \sin i_2)$$

$$\Delta Y = K(\sin i_1 \cos A_1 + \sin i_2 \cos A_2)$$

$$\Delta X = K(\sin i_1 \sin A_1 + \sin i_2 \sin A_2)$$

f. Dogleg

The formula for dogleg (DL) is the following:

$$\text{DL} = \cos^{-1}[\cos i_1 \cos i_2 + \sin i_1 \sin i_2 \cos(A_2 - A_1)]$$

g. Dogleg severity

The API formula for Dogleg severity is the following:

$$\text{DLS} = \frac{100}{\Delta L}(\cos)^{-1}[\cos i_1 \cos i_2 + \sin i_1 \sin i_2 \cos(A_2 - A_1)]$$

The values are expressed in degrees/100 ft if DL is in feet.

Other DLS formulas are available according to the calculation method employed.

COURSE CORRECTION

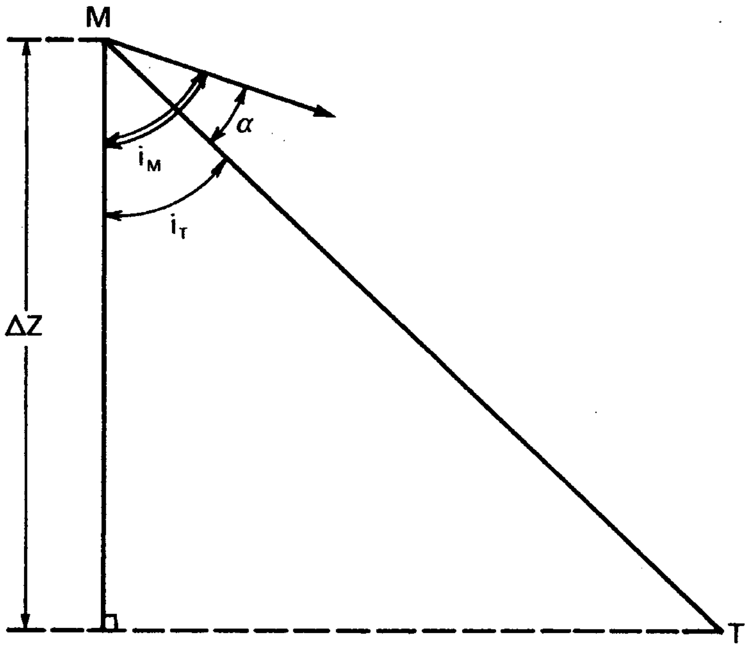
Let us assume that the last survey was made at point M:

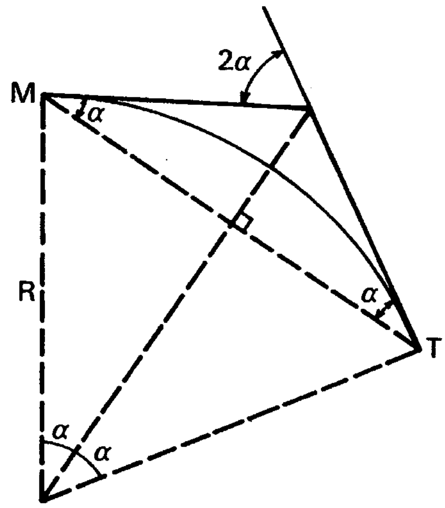
$$M \begin{cases} \text{Drift angle} = i_M \\ \text{Azimuth} = A_M \\ \text{Coordinates} = X_M, Y_M, Z_M \end{cases}$$

The target is at point T:

$$T \text{ coordinates} = X_T,\ Y_T,\ Z_T$$

Drift angle correction





Change in drift angle : 2α

$$MT = \sqrt{(X_T - X_M)^2 + (Y_T - Y_M)^2 + (Z_T - Z_M)^2}$$

$$\Delta Z = Z_T - Z_M$$

$$i_T = \cos^{-1}\left[\frac{\Delta Z}{MT}\right]$$

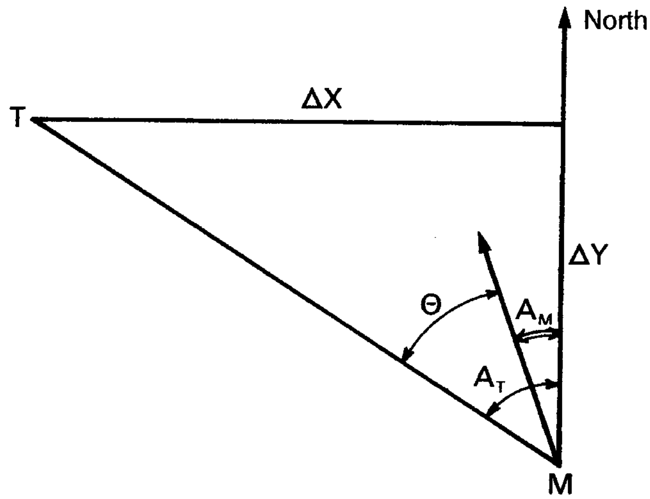
$$\alpha = i_T - i_M$$

rate of build up:

$$\boxed{ROB = \frac{2\alpha}{MT}}$$

COURSE CORRECTION (continued)

Azimuth correction



$$\Delta X = X_T - X_M$$

$$\Delta Y = Y_T - Y_M$$

$$A_T = \tan^{-1}\left[\frac{\Delta X}{\Delta Y}\right]$$

$$\theta = A_T - A_M$$

rate of azimuth change:

$$\boxed{ROW = \frac{2\theta}{MT}}$$

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 inclination i.

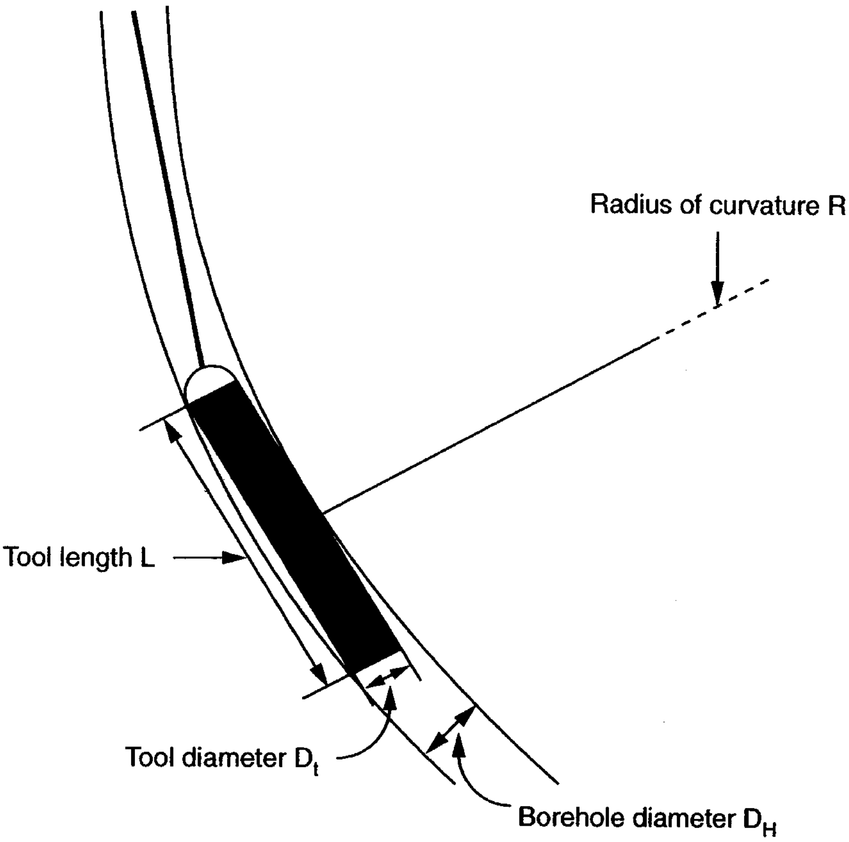
RADIUS OF BOREHOLE CURVATURE LIMITATION ON DOWNHOLE TOOLS

The length of a rigid downhole tool that can be run in a deviated well is given by:

$$L = 2\sqrt{(R + 0.0254 D_H)^2 - (R + 0.0254 D_t)^2}$$

where:

L = Maximum length of the downhole tool in meters
R = Radius of borehole curvature in meters (see page J 3)
D_H = Borehole diameter in inches
D_t = Tool diameter in inches



Conversely, the minimum radius of curvature of a well in which a specific rigid tool can be run is given by:

$$R = \frac{L^2 - 0.00258(D_H^2 - D_t^2)}{0.2032\,(D_H - D_t)}$$

RADIUS OF BOREHOLE CURVATURE LIMITATION ON DOWNHOLE TOOLS (continued)

Example 1:

Borehole diameter: 5 3/4 in

Radius of curvature: 143 m (4°/10 m)

Tool diameter: 3 1/2 in

$$L = 2\sqrt{(143 + 0.0254 \times 5.75)^2 - (143 + 0.0254 \times 3.5)^2} = 8.09 \text{ m}$$

Example 2:

Borehole diameter: 6 in

Tool length: 6.40 m (21 ft)

Tool diameter: 2 3/4 in

$$R = \frac{6.40^2 - 0.00258(6^2 - 2.75^2)}{0.2032(6 - 2.75)} = 61.91 \text{ m}$$

The equivalent *gbu* is: $gbu = \frac{573}{61.91} = 9.25°/10 \text{ m}$

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 of the mud (at shut-in)
d_2	intermediate specific gravity in case of multi-step weighting
d_e	specific gravity of the mud balancing formation pressure
d_{frac}	specific gravity of the mud corresponding to formation fracture
d_g	specific gravity (or density in kg/l) of gas measured with respect to water
d_r	specific gravity of the mud required to kill the well
FCP	Final Circulating Pressure at kill rate with mud at 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 influx (m)
HP	Hydrostatic Pressure (kPa)
ICP	Initial Circulating Pressure at kill rate with mud at specific gravity d_1 (kPa)
ICP_2	Initial Circulating Pressure at kill rate with mud at specific gravity d_2 (kPa)
K	ratio $\frac{T_s Z_s}{Z_b T_b}$ of $ZT\left(\frac{PV}{ZT} = \text{constant}\right)$ between surface and bottom hole
MAASP	Maximum Allowable Annulus Surface Pressure, well shut-in, corresponding to fracturing at weak zone (or shoe) (kPa)
N	pump speed (strokes) corresponding to drilling flow rate (strokes/min)
N_r	pump speed (strokes) corresponding to kill flow rate (strokes/min)
P_a	annulus surface pressure during kick control (kPa)
P_{afg}	static surface annulus pressure, well full of gas (kPa)
$P_{a\,max}$	annulus surface pressure when gas reaches surface (kPa)
P_{dp}	drill pipe pressure (kPa)
ΔP_{cl}	pressure losses in choke line (kPa)
P_f	formation pressure (kPa)
P_{frac}	fracturing pressure at weak zone (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 (or shoe) (kPa)
P_{sr_1}	pressure losses at kill (slow) rate with mud specific gravity d_1, measured by the normal drilling circuit (shale shakers or riser) (kPa)

MAIN SYMBOLS USED (continued)

P_{sr_2}	pressure losses at kill (slow) rate with mud specific gravity d_2, measured by the normal drilling circuit (shale shakers or riser) (kPa)
P_{sr_r}	pressure losses at kill (slow) rate with mud specific gravity d_r, measured by the normal drilling circuit (shale shakers or riser) (kPa)
Q	flow rate during drilling operation (l/min)
Q_r	flow rate (reduced) during kill operation (l/min)
S	downhole pressure increase (safety margin) during kill operation (kPa)
SICP	stabilized annulus (casing) pressure, well shut-in, after kick (kPa)
SIDPP	stabilized drill pipe pressure, well shut-in, after kick, with mud at specific gravity d_1 (kPa)
$SIDPP_2$	stabilized drill pipe pressure, well shut-in, after kick, with mud at 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 A 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_{sr_1})

These pressure losses can be determined as drilling proceeds:
(a) At fixed times, at crew changes for example
(b) After running 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, K 11).

K 4

COMPANY

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DRILLER'S PROCEDURES
for well control
(DRILLING FROM LAND OR FIXED SUPPORT)

WELL :	Phase :	Depth of week 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 No. 1 / 2	Liner size	Volume per stroke	Strokes per minute	P_{sr_1}

					--------

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 annular BOP.*
- *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* — *SIDPP =*
- *add the pressure loss at reduced flow rate* — S_{sr_1} =
- *add the trip margin* — *S =*

TOTAL *(2)* — *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 annular BOP*
- *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. Éditions Technip, Paris, 1981.

K 5

CALCULATION AFTER WELL SHUT-IN

Basic calculations

$$P_f = \text{SIDDP} + 9.81\, Z d_1$$

$$d_e = \frac{P_f}{9.81\, Z}$$

$$\text{ICP} = \text{SIDDP} + P_{sr_1} + S$$

$$d_r = d_1 + \frac{\text{SIDDP} + S}{9.81\, Z}$$

$$\text{FCP} = P_{sr_r} = P_{sr_1} \frac{d_r}{d_1}$$

Circulation of an intermediate mud weight d_2

From the time when mud d_2 reaches the bit, the casing pressure becomes:

$$\text{ICP}_2 = \text{SIDDP}_2 + P_{sr_2} + S$$

with:

$$\text{SIDPP}_2 = P_f - 9.81\, Z d_2$$

$$P_{sr_2} = P_{sr_1} \frac{d_2}{d_1}$$

Special case, if:

$$d_2 = \frac{d_1 + d_r}{2}$$

then:

$$\text{ICP}_2 = \frac{\text{ICP} + \text{FCP}}{2}$$

Barite addition

Barite weight to be added to V m^3 of mud to raise the specific gravity from d_1 to d_2:

$$B = 4.2\, V \frac{d_2 - d_1}{4.2 - d_2} \quad \text{(in metric tons)}$$

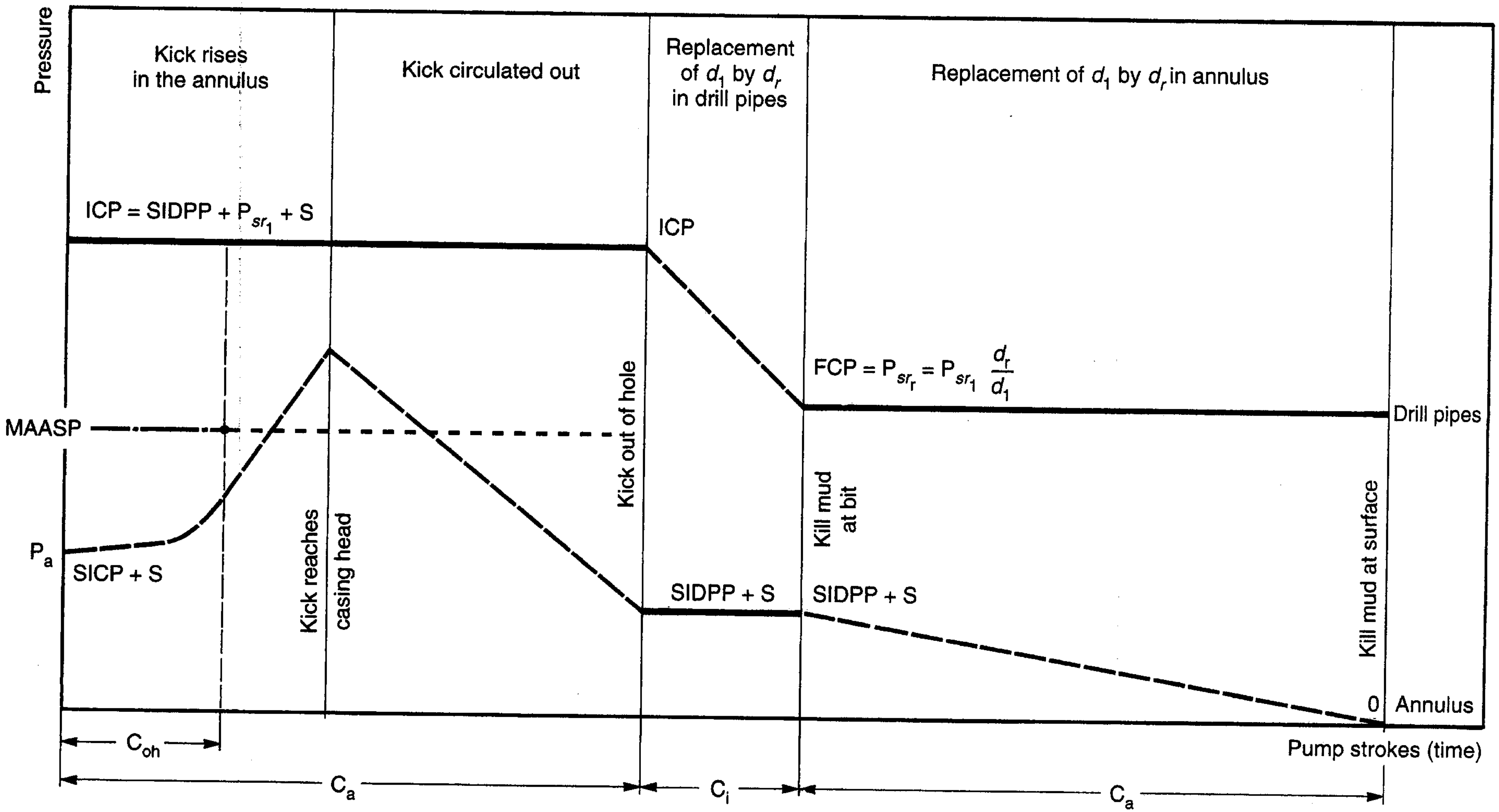
rate of barite addition at flow rate Q_r to raise the specific gravity from d_1 to d_2:

$$B = 4.2\, Q_r \frac{d_2 - d_1}{4.2 - d_2} \quad \text{(in kg/min)}$$

Volume increase due to barite addition:

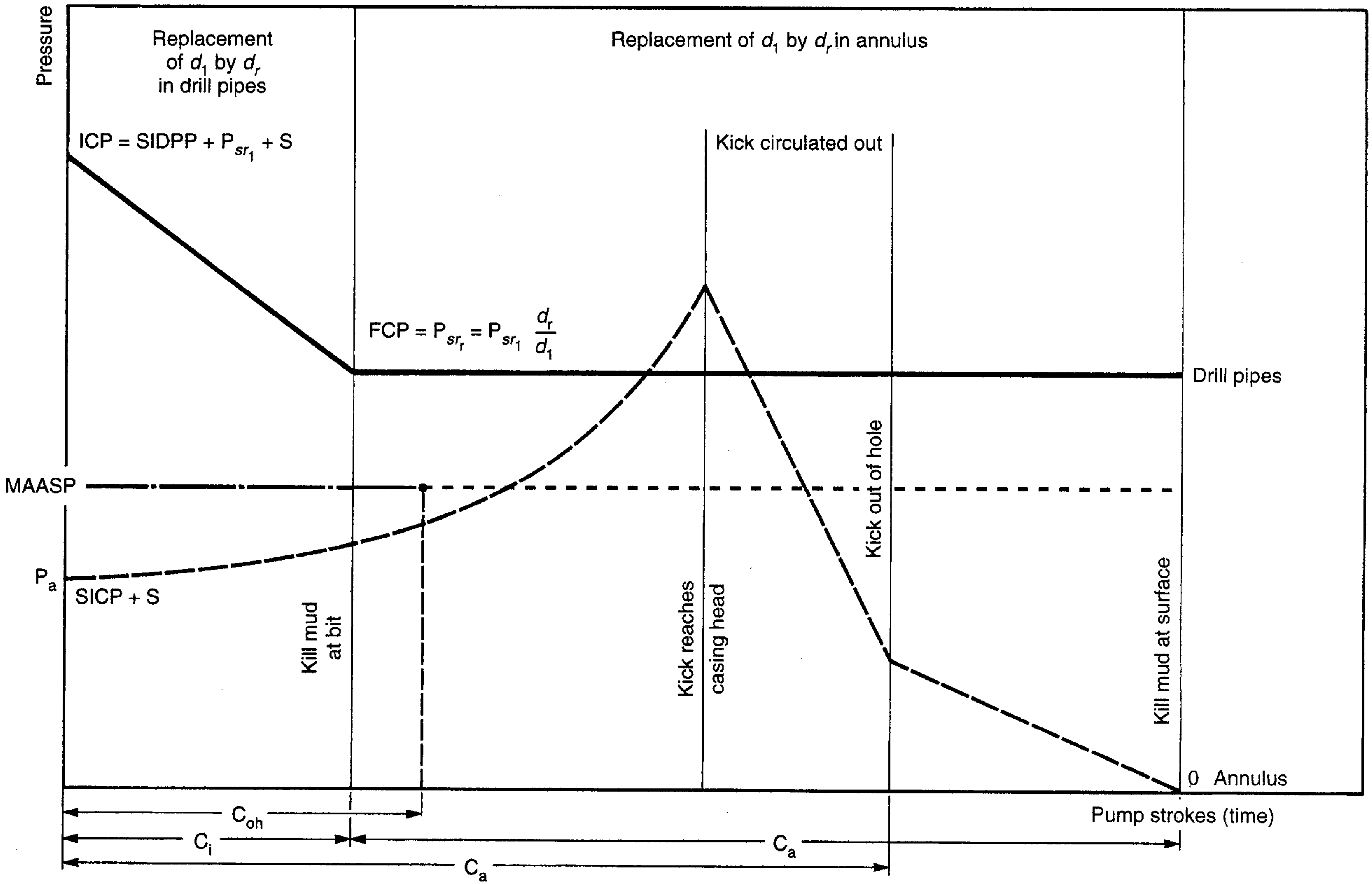
$$V_B = \frac{B}{4.2} \quad (\text{in m}^3)$$

DRILLER'S METHOD ON LAND OR ON FIXED SUPPORT



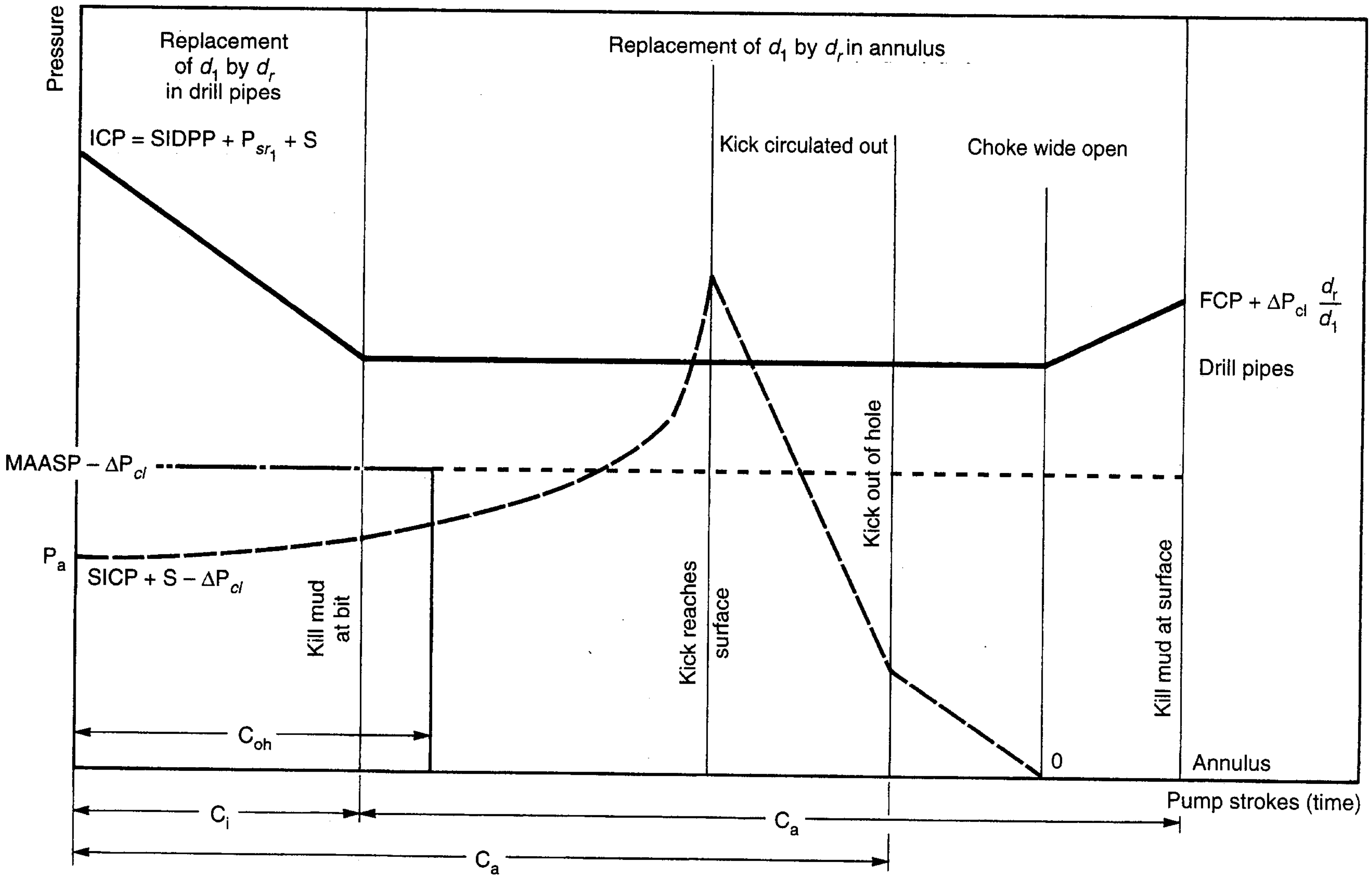
Choke must be adjusted to follow the solid line

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 A FLOATING RIG

Control is started with a drill pipe pressure of:

$$\text{ICP} = P_{\text{sr}_1} + \Delta P_{\text{ka}} + \text{SIDPP} + S$$

To avoid fracturing at the shoe, the starting annular surface pressure must be:

$$P_{\text{a}} < \text{MAASP} - \Delta P_{\text{cl}}$$

When the mud of the required weight reaches the bit, the drill pipe pressure is:

$$\text{FCP} = (P_{\text{sr}_1} + \Delta P_{\text{ka}}) \frac{d_{\text{r}}}{d_1}$$

In very deep water, the choke 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 circulationg pressure exceeds FCP. To limit this excess, which corresponds to a downhole overpressure of:

$$\Delta P_{\text{cl}} \frac{d_{\text{r}}}{d_1}$$

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 fluid circulates through the kelly instead of a kick assembly $\Delta P_{\text{ka}} = 0$.

WELL STRENGTH

MAASP

The maximum allowable pressure MAASP at the top of the annulus, well closed, without any risk of fracturing the formation at the weak zone, is related to the specific gravity of the fluid in the annulus between the weak zone and the surface.

The MAASP changes as the fluid specific gravity changes:

$$\text{MAASP} = P_{\text{frac}} - 9.81\, Z_s d_1$$

Fracturing specific gravity

$$d_{\text{frac}} = \frac{P_{\text{frac}}}{9.81\, Z_s}$$

Maximum allowable gain at shut-in to avoid fracturing at the weak zone

Gas height:

$$h = \frac{\text{MAASP} - (P_f - 9.81\, Z d_1)}{9.81\,(d_1 - d_g)}$$

d_g is given by the chart on page K 13.

$$G_{\max} = \frac{\text{MAASP} - (P_f - 9.81\, Z d_1)}{9.81\,(d_1 - d_g)}\, V_{ab}$$

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:

$$G_{\max} = \frac{P_{\max}[9.81\, Z d_1 - (P_f - P_{\max})]}{9.81\, K d_1 P_f}\, V_{ab}$$

K is given by the chart on page K 13.

Maximum annulus pressure, well shut-in and filled with gas

$$P_{afg} = P_f - 9.81\, Z d_g$$

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

$$P_{a\,max} = \frac{SIDPP}{2} + \sqrt{\frac{SIDPP^2}{4} + 9.81\,\frac{KGd_1 P_f}{V_a}}$$

K is given by the chart on page K 13.

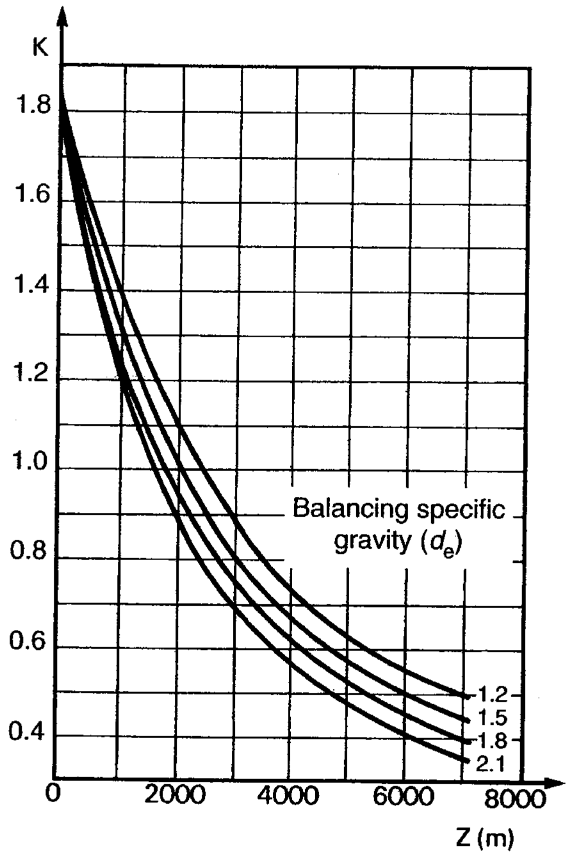
Note: this pressure is calculated when the gas arrives below the BOP. The geometry of the annulus is considered constant.

Maximum pressure at weak zone during circulation of a gas kick with mud of the original weight

$$P_{s\,max} = \frac{SIDPP + 9.81\,Z_s d_1}{2} + \sqrt{\frac{(SIDPP + 9.81\,Z_s d_1)^2}{4} + 9.81\,\frac{Gd_1 P_f}{V_a}}$$

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

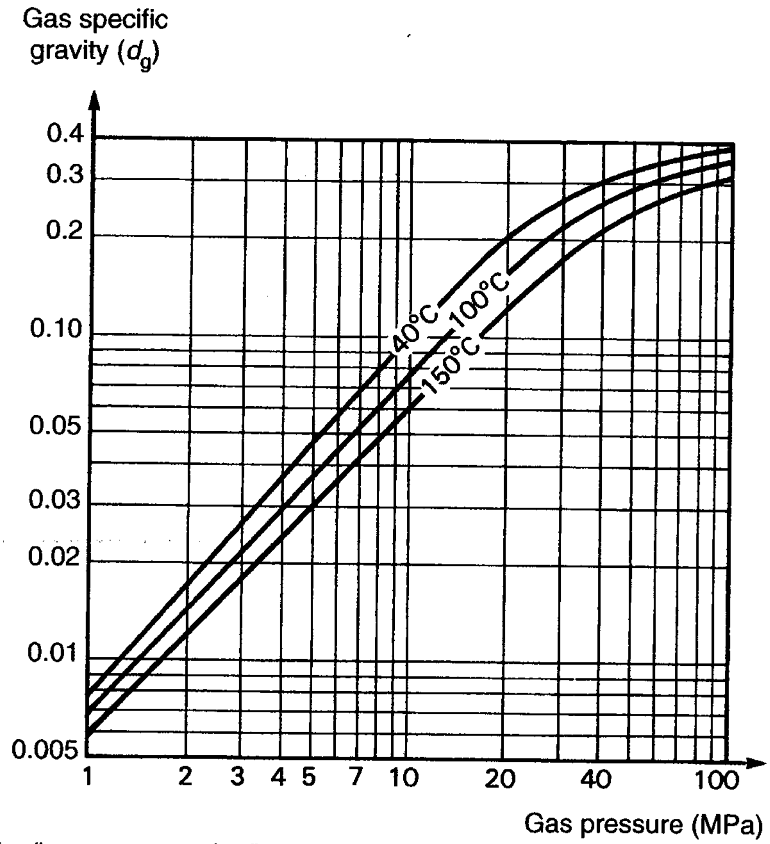


Value of the coefficient *K* as a function of depth and balancing mud weight for a given formation (coefficient used to calculate maximum circulating casing pressure $P_{a\,max}$ when taking a kick).

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	= 2500 m
Casing size 9 5/8 in (N80-47 lb/ft)	Z_s	= 1750 m
BOP serie 10 000		
Bit size 8 1/2 in with:		
. 5 in drill pipes, 19.5 lb/ft		= 2320 m
. 6 3/4 in - 2 1/4 in drill collars		= 180 m
. mud weight	d_1	= 1.15
. drilling mud flow rate	Q	= 1300 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}	= 3500 kPa
Leak Off Test at shoe with mud at d_1	MAASP	= 7700 kPa

II PRELIMINARY CALCULATIONS

Inside volume of drill pipes (9.15 l/m)	21 228	liters
Inside volume of drill collars (2.565 l/m)	462	liters
Inside volume of drill string V_i	21 690	liters **(1335 strokes)**
Annulus casing (38.18 l/m) - drill pipe (13.11 l/m) volume	43 872	liters
Annulus hole (36.61 l/m) - drill pipe (13.11 l/m) volume	13 395	liters
Annulus hole (36.61 l/m) - drill collar (23.09 l/m) volume	2 434	liters
Total annulus volume V_a	59 701	liters **(3673 strokes)**
Open-hole annulus volume V_{oh}	15 829	liters **(974 strokes)**

Fracture pressure:

$$P_{frac} = \text{MAASP} + 9.81\ Z_s d_1 = 7700 + 9.81 \times 1750 \times 1.15$$

$$P_{frac} = 27\ 440 \text{ kPa}$$

Fracture mud weight :

$$d_{frac} = \frac{P_{frac}}{9.81\ Z_s} = \frac{27\ 440}{9.81 \times 1750}$$

$$d_{frac} = 1.60$$

III WELL SHUT-IN

After waiting about 15 min for stabilization of the pressures, the readings are:

$$\text{SIDPP} = 2300 \text{ kPa}$$

$$\text{SICP} = 4500 \text{ kPa}$$

$$G = 4000 \text{ liters}$$

EXAMPLE OF KICK CONTROL (continued)

IV CALCULATIONS AFTER SHUT-IN

$$P_f = 2300 + 9.81 \times 2500 \times 1.15 = 30\,500 \text{ kPa}$$

Given the difference between MAASP (7700 kPa) and SICP (4500 kPa), the following safety margin is used:

$$S = 1000 \text{ kPa}$$

$$\text{ICP} = 2300 + 3500 + 1000 = 6800 \text{ kPa}$$

$$d_r = 1.15 + \frac{2300 + 1000}{9.81 \times 2500} = 1.29$$

$$\text{FCP} = 3500 \times \frac{1.29}{1.15} = 3925 \text{ kPa}$$

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 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 strokes 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:

$$P_a = \text{SICP} + S = 4500 + 1000 = 5500 \text{ kPa}$$

b) After a few moments, the drill pipe pressure should stabilize at:

$$\text{ICP} = 6800 \text{ kPa}$$

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.

c) When the drill pipe pressure is stabilized at ICP, continue to maintain ICP for at least 3673 strokes.

EXAMPLE OF KICK CONTROL (continued)

d) After 974 strokes, the entire influx 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 influx 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:

$$P_{dp} = \text{SIDPP} = 2300 \text{ kPa}$$
$$P_a = \text{SIDPP} = 2300 \text{ kPa}$$

f) Reset the stroke 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 drill pipes.

g) Control the choke to have the following casing pressure:

$$P_a = \text{SIDPP} + S = 2300 + 1000 = 3300 \text{ kPa}$$

The drill pipe pressure should drop from:

$$\text{ICP} = 6800 \text{ kPa} \quad \text{to} \quad \text{FCP} = 3925 \text{ kPa in 1335 strokes.}$$

h) After 1335 strokes, maintain the drill pipe pressure at:

$$\text{FCP} = 3925 \text{ kPa}$$

until the kill mud d_r reaches the surface.

VI WELL STRENGTH

a. Maximum allowable gain at shut-in to avoid fracturing at weak zone

$$h = \frac{\text{MAASP} - (P_f - 9.81\,Z d_1)}{9.81\,(d_1 - d_g)}$$

With P_f = 30 500 kPa = 30.5 MPa and a downhole temperature of about 80°C, we can take (chart page K 13):

$$d_g = 0.25$$

$$h = \frac{7700 - (30\,000 - 9.81 \times 2500 \times 1.15)}{9.81 \times (1.15 - 0.25)}$$

$$h = 612 \text{ m}$$

or: 180 m opposite the drill collars:	180 × 13.52	=	2 424 liters
432 m opposite the drill pipes:	432 × 23.5	=	10 152 liters
	Gain	=	12 586 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 (or shoe) during gas circulation

$$P_{s\,max} = \frac{SIDPP + 9.81\,Z_s d_1}{2} + \sqrt{\frac{(SIDPP + 9.81\,Z_s d_1)^2}{4} + 9.81\,\frac{G d_1 P_f}{V_a}}$$

$$P_{s\,max} = \frac{2300 + 9.81 \times 1750 \times 1.15}{2}$$

$$+ \sqrt{\frac{(2300 + 9.81 \times 1750 \times 1.15)^2}{4} + 9.81\,\frac{4000 \times 1.15 \times 30\,500}{23.5}}$$

$P_{s\,max} = 24\,439$ kPa $< P_{frac}$

At shut-in, the pressure at the weak zone (or shoe):

$$P_s = SICP + 9.81\,Z_s d_1 = 4500 + 9.81 \times 1750 \times 1.15 = 24\,242 \text{ kPa}$$

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 $Z = 2500$ m and $d_e = 1.24$, we obtain $K = 0.95$ on the chart on page K 13.

$$P_{a\,max} = \frac{SIDPP}{2} + \sqrt{\frac{SIDPP^2}{4} + 9.81\,\frac{K G d_1 P_f}{V_a}}$$

$$P_{a\,max} = \frac{2300}{2} + \sqrt{\frac{2300^2}{4} + 9.81\,\frac{0.95 \times 4000 \times 1.15 \times 30\,500}{23.5}}$$

$$P_{a\,max} = 8697 \text{ kPa}$$

Value lower than :

(a) The BOP working pressure = 68 950 kPa

(b) The casing bursting pressure = 47 300 kPa

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 in hole with a mud weight 1.40 (SG). The drill string consists of 2000 m of 5 in, 19.50 lb/ft (NC50) grade X95, class Premium drill pipes, 31.83 kg/m and 247 m of 6 3/4 in by 2 13/16 in drill collars, 149.8 kg/m.

First step. Calculate the maximum pull on drill pipe:

(a) Tension load at minimum yield strength = 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 = 2000 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 bushing level. Apply 110 10^3 daN and return to 105 10^3 daN. Draw a second mark at the kelly bushing level. This second mark should be distinct from the first (difference caused by friction of drill pipes 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 mark. Draw a datum line midway between these two marks. Measure the distance ℓ in mm between the two datum lines.

Assume $\ell = 700$ mm.

Fifth step. Apply the formula with:

$P_{dp} = 31.8$ kg/m
$\ell = 700$ 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 1000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION
(Grade E drill pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1000 m of drill pipe under a tension of (1000 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	4.85	18 3/4	18 1/4	16 3/4	13 1/2																		
2 3/8	6.65	18 3/4	18 1/2	17 3/4	16 1/4	14 1/4																	
2 7/8	6.85	15 1/2	15 1/4	14 1/2	13 1/2	11 1/2	8 3/4																
2 7/8	10.40	15 1/2	15 1/2	15 1/4	14 3/4	14	13 1/4	12	10 1/2	8 1/2													
3 1/2	9.50	12 3/4	12 3/4	12 1/4	12	11 1/4	10 1/4	9 1/4	7 1/2	4 3/4													
3 1/2	13.30	12 3/4	12 3/4	12 1/2	12 1/4	12	11 1/2	11	10 1/4	9 1/2	8 1/2	7 1/4	5 1/4										
3 1/2	15.50	12 3/4	12 3/4	12 1/2	12 1/2	12 1/4	12	11 1/2	11	10 1/2	10	9	8 1/4	7	5 1/2	2 3/4							
4	11.85	11 1/4	11	11	10 3/4	10 1/4	9 3/4	9	8 1/4	7	5 1/4	2 1/2											
4	14.00	11 1/4	11	11	10 3/4	10 1/2	10 1/4	9 3/4	9 1/4	8 3/4	7 3/4	6 3/4	5 1/2	3 1/2									
4 1/2	13.75	10	9 3/4	9 3/4	9 1/2	9 1/4	9	8 1/2	8	7 1/2	6 1/2	5 1/2	4										
4 1/2	16.60	10	9 3/4	9 3/4	9 3/4	9 1/2	9 1/4	9	8 3/4	8 1/4	7 3/4	7 1/4	6 1/2	5 3/4	4 1/2	3							
4 1/2	20.00	10	10	9 3/4	9 3/4	9 3/4	9 1/2	9 1/4	9 1/4	9	8 1/2	8 1/4	8	7 1/2	7	6 1/2	5 3/4	4 3/4	3 3/4	1 3/4			
5	19.50	9	9	8 3/4	8 3/4	8 3/4	8 1/2	8 1/4	8 1/4	8	7 3/4	7 1/4	7	6 1/2	6	5 1/2	4 3/4	3 3/4	2 1/4				
5	25.60	9	9	8 3/4	8 3/4	8 3/4	8 3/4	8 1/2	8 1/2	8 1/4	8 1/4	8	7 3/4	7 3/4	7 1/2	7 1/4	6 /4	6 1/2	6 1/4	5 3/4	5 1/4	4 3/4	4
5 1/2	21.90	8	8	8	8	8	7 3/4	7 3/4	7 1/2	7 1/2	7 1/4	7	6 3/4	6 1/4	6	5 1/2	5 1/4	4 1/2	4	3			
5 1/2	24.70	8	8	8	8	8	8	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	4 1/4	3 1/2	2 1/2
6 5/8	25.20	6 3/4	6 3/4	6 3/4	6 3/4	6 1/2	6 1/2	6 1/2	6 1/4	6 1/4	6	6	5 3/4	5 1/2	5 1/2	5 1/4	4 3/4	4 1/2	4 1/4	3 3/4	3 1/4	2 3/4	1 3/4
6 5/8	27.70	6 3/4	6 3/4	6 3/4	6 3/4	6 1/2	6 1/2	6 1/2	6 1/2	6 1/4	6 1/4	6	6	5 3/4	5 1/2	5 1/2	5 1/4	5	4 3/4	4 1/2	4	3 1/2	3 1/4

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 tensile load T (daN)
- L = length of drill pipe string (m)
- S = maximum shear strength (MPa). S is 57.7% of the minimum yield strength (grade)
- D = outside diameter of drill pipe (cm)
- G = modulus of elasticity in shear: 84 000 MPa
- T = total tensile load (daN)
- A = pipe cross-sectional area (mm^2).

MAXIMUM ALLOWABLE NUMBER OF TURNS WHICH CAN BE GIVEN TO 1000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION
(Grade X95 drill pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1000 m of drill pipe under a tension of (1000 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	4.85	23 3/4	23 1/4	22	20	16 1/4	10																
2 3/8	6.65	23 3/4	23 1/2	23	22	20 1/4	18 1/4	15 1/4	10 1/2														
2 7/8	6.85	19 1/2	19 1/2	19	18	16 3/4	14 3/4	12 1/4	8														
2 7/8	10.40	19 1/2	19 1/2	19 1/4	19	18 1/2	17 3/4	17	16	14 3/4	13	11	8	2 1/4									
3 1/2	9.50	16	16	15 3/4	15 1/2	15	14 1/4	13 1/2	12 1/2	11	9 1/4	6 1/2											
3 1/2	13.30	16	16	16	15 3/4	15 1/2	15 1/4	14 3/4	14 1/4	13 3/4	13	12 1/4	11 1/4	10	8 1/2	6 1/2	3 1/4						
3 1/2	15.50	16	16	16	16	15 3/4	15 1/2	15 1/4	14 3/4	14 1/2	14	13 1/2	12 3/4	12	11 1/4	10 1/4	9	7 3/4	5 3/4	2 1/4			
4	11.85	14	14	14	13 1/2	13 1/2	13	12 1/2	12	11	10	9	7 1/2	5 1/2									
4	14.00	14	14	14	13 3/4	13 3/4	13 1/2	13	12 3/4	12 1/4	11 3/4	11	10 1/4	9 1/4	8 1/4	7	5	1 1/4					
4 1/2	13.75	12 1/2	12 1/2	12 1/2	12 1/4	12	11 3/4	11 1/2	11	10 3/4	10	9 1/2	8 3/4	7 3/4	6 1/2	5	2						
4 1/2	16.60	12 1/2	12 1/2	12 1/2	12 1/4	12 1/4	12	11 3/4	11 1/2	11 1/4	11	10 1/2	10	9 1/2	9	8 1/4	7 1/2	6 1/2	5	3 1/4			
4 1/2	20.00	12 1/2	12 1/2	12 1/2	12 1/2	12 1/4	12 1/4	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	8	7 1/4	6 1/4	5 1/4
5	19.50	11 1/4	11 1/4	11 1/4	11 1/4	11	11	10 3/4	10 3/4	10 1/2	10 1/4	10	9 3/4	9 1/2	9 1/4	8 3/4	8 1/4	7 3/4	7 1/4	6 3/4	6	5	3 3/4
5	25.60	11 1/4	11 1/4	11 1/4	11 1/4	11 1/4	11	11	11	10 3/4	10 3/4	10 3/4	10 1/2	10 1/4	10 1/4	10	9 3/4	9 1/2	9 1/4	9	8 3/4	8 1/4	8
5 1/2	21.90	10 1/4	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 1/4	9	8 3/4	8 1/2	8 1/4	7 3/4	7 1/2	7	6 1/2	6	5 1/4
5 1/2	24.70	10 1/4	10 1/4	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	9	8 3/4	8 1/2	8 1/4	7 3/4	7 1/2	7 1/4	6 3/4
6 5/8	25.20	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 1/4	8	8	7 3/4	7 3/4	7 1/2	7 1/4	7 1/4	7	6 3/4	6 1/2	6 1/4	5 3/4	5 1/2
6 5/8	27.70	8 1/2	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	8	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

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 tensile load T (daN)
L = length of drill pipe string (m)
S = maximum shear strength (MPa). S is 57.7% of the minimum yield strength (grade)
D = outside diameter of drill pipe (cm)
G = modulus of elasticity in shear: 84 000 MPa
T = total tensile load (daN)
A = pipe cross-sectional area (mm^2).

MAXIMUM ALLOWABLE NUMBER OF TURNS WHICH CAN BE GIVEN TO 1000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION
(Grade G105 drill pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1000 m of drill pipe under a tension of (1000 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	4.85	26 1/4	26	24 3/4	22 3/4	19 3/4	15	4 1/2															
2 3/8	6.65	26 1/4	26	25 1/2	24 1/2	23 1/4	21 1/4	18 3/4	15 1/4	9 3/4													
2 7/8	6.85	21 3/4	21 1/2	21	20 1/4	19	17 1/2	15 1/4	12 1/4	7													
2 7/8	10.40	21 3/4	21 1/2	21 1/2	21	20 3/4	20	19 1/4	18 1/2	17 1/4	16	14 1/4	12 1/4	9 1/2	5								
3 1/2	9.50	17 3/4	17 3/4	17 1/2	17 1/4	16 3/4	16 1/4	15 1/2	14 1/2	13 1/4	12	10	7 1/2	2 1/4									
3 1/2	13.30	17 3/4	17 3/4	17 3/4	17 1/2	17 1/4	17	16 3/4	16 1/4	15 3/4	15	14 1/4	13 1/2	12 1/2	11 1/2	10	8 1/4	5 3/4					
3 1/2	15.50	17 3/4	17 3/4	17 3/4	17 1/2	17 1/2	17 1/4	17	16 3/4	16 1/4	16	15 1/2	15	14 1/4	13 1/2	12 3/4	11 3/4	10 3/4	9 1/2	8	5 3/4	1 1/2	
4	11.85	15 1/2	15 1/2	15 1/2	15 1/4	15	14 1/2	14 1/4	13 1/2	13	12 1/4	11 1/4	10	8 1/2	6 1/2	3 1/2							
4	14.00	15 1/2	15 1/2	15 1/2	15 1/4	15 1/4	15	14 3/4	14 1/4	14	13 1/2	12 3/4	12 1/4	11 1/2	10 1/2	9 1/2	8 1/4	6 3/4	4 1/2				
4 1/2	13.75	13 3/4	13 3/4	13 3/4	13 3/4	13 1/2	13 1/4	13	12 1/2	12 1/4	11 3/4	11 1/4	10 1/2	9 3/4	8 3/4	7 3/4	6 1/4	4 1/4					
4 1/2	16.60	13 3/4	13 3/4	13 3/4	13 3/4	13 1/2	13 1/2	13 1/4	13	12 3/4	12 1/2	12	11 3/4	11 1/4	10 3/4	10 1/4	9 1/2	8 3/4	7 3/4	6 3/4	5 1/4	3 1/4	
4 1/2	20.00	13 3/4	13 3/4	13 3/4	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 1/4	12	11 1/2	11 1/4	10 3/4	10 1/4	9 3/4	9 1/4	8 3/4	8
5	19.50	12 1/2	12 1/2	12 1/2	12 1/4	12 1/4	12 1/4	12	12	11 3/4	11 1/2	11 1/2	11 1/4	11	10 1/2	10 1/4	10	9 1/2	9	8 1/2	8	7 1/4	6 1/2
5	25.60	12 1/2	12 1/2	12 1/2	12 1/2	12 1/4	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	10	9 1/2
5 1/2	21.90	11 1/4	11 1/4	11 1/4	11 1/4	11 1/4	11 1/4	11	11	10 3/4	10 3/4	10 1/2	10 1/4	10 1/4	10	9 3/4	9 1/2	9 1/4	8 3/4	8 1/2	8	7 3/4	7 1/4
5 1/2	24.70	11 1/4	11 1/4	11 1/4	11 1/4	11 1/4	11 1/4	11	11	11	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 3/4	8 1/4
6 5/8	25.20	9 1/2	9 1/2	9 1/2	9 1/4	9 1/4	9 1/4	9 1/4	9 1/4	9	9	9	8 3/4	8 3/4	8 1/2	8 1/4	8 1/4	8	7 3/4	7 1/2	7 1/4	7	6 3/4
6 5/8	25.20	9 1/2	9 1/2	9 1/2	9 1/4	9 1/4	9 1/4	9 1/4	9 1/4	9 1/4	9	9	9	8 3/4	8 3/4	8 1/2	8 1/2	8 1/4	8	8	7 3/4	7 1/2	7 1/4

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 tensile load T (daN)
L = length of drill pipe string (m)
S = maximum shear strength (MPa). S is 57.7% of the minimum yield strength (grade)
D = outside diameter of drill pipe (cm)
G = modulus of elasticity in shear: 84 000 MPa
T = total tensile load (daN)
A = pipe cross-sectional area (mm^2).

MAXIMUM ALLOWABLE NUMBER OF TURNS WHICH CAN BE GIVEN TO 1000 m OF NEW DRILL PIPE UNDER A GIVEN AXIAL TENSION
(Grade S135 drill pipe)

Nominal weight and diameter of drill pipe		Number of turns for 1000 m of drill pipe under a tension of (1000 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	4.85	33 3/4	33 1/2	32 1/2	31 1/4	29	26	21 3/4	15														
2 3/8	6.65	33 3/4	33 1/2	33 1/4	32 1/2	31 1/2	30	28 1/4	26	23 1/4	19 1/2	14 1/2											
2 7/8	6.85	27 3/4	27 3/4	27 1/2	26 3/4	26	24 3/4	23 1/4	21 1/4	18 3/4	15 1/2	11											
2 7/8	10.40	27 3/4	27 3/4	27 3/4	27 1/2	27	26 3/4	26	25 1/2	24 3/4	23 3/4	22 3/4	21 1/2	20	18 1/4	16	13 1/2	10	3 3/4				
3 1/2	9.50	23	22 3/4	22 3/4	22 1/2	22	21 3/4	21	20 1/2	19 3/4	18 3/4	17 1/2	16 1/4	14 1/2	12 1/2	10	6						
3 1/2	13.30	23	22 3/4	22 3/4	22 3/4	22 1/2	22 1/4	22	21 3/4	21 1/4	20 3/4	20 1/4	19 3/4	19	18 1/4	17 1/2	16 1/2	15 1/2	14 1/4	12 3/4	11	9	6
3 1/2	15.50	23	23	22 3/4	22 3/4	22 1/2	22 1/2	22 1/4	22	21 3/4	21 1/2	21	20 3/4	20 1/4	19 3/4	19 1/4	18 3/4	18	17 1/4	16 1/2	15 1/2	14 1/2	13 1/4
4	11.85	20	20	20	19 3/4	19 1/2	19 1/4	19	18 1/2	18	17 1/2	16 3/4	16	15 1/4	14 1/4	13	11 3/4	10	7 3/4	4 1/2			
4	14.00	20	20	20	19 3/4	19 3/4	19 1/2	19 1/4	19	18 3/4	18 1/2	18	17 1/2	17	16 1/2	15 3/4	15	14 1/4	13 1/4	12 1/4	11	9 3/4	7 3/4
4 1/2	13.75	17 3/4	17 3/4	17 3/4	17 3/4	17 1/2	17 1/4	17	16 3/4	16 1/2	16 1/4	15 3/4	15 1/4	14 3/4	14 1/4	13 1/2	12 3/4	12	11	9 3/4	8 1/2	6 3/4	4 1/4
4 1/2	16.60	17 3/4	17 3/4	17 3/4	17 3/4	17 1/2	17 1/2	17 1/4	17 1/4	17	16 3/4	16 1/2	16 1/4	15 3/4	15 1/2	15	14 3/4	14 1/4	13 3/4	13	12 1/2	11 3/4	10 3/4
4 1/2	20.00	17 3/4	17 3/4	17 3/4	17 3/4	17 3/4	17 1/2	17 1/2	17 1/2	17 1/4	17 1/4	17	16 3/4	16 1/2	16 1/4	16	15 3/4	15 1/2	15 1/4	15	14 1/2	14 1/4	13 3/4
5	19.50	16	16	16	16	16	15 3/4	15 3/4	15 3/4	15 1/2	15 1/4	15 1/4	15	14 3/4	14 1/2	14 1/4	14	13 3/4	13 1/2	13 1/4	12 3/4	12 1/2	12
5	25.60	16	16	16	16	16	16	15 3/4	15 3/4	15 3/4	15 3/4	15 1/2	15 1/2	15 1/4	15 1/4	15 1/4	15	14 3/4	14 3/4	14 1/2	14 1/4	14 1/4	14
5 1/2	21.90	14 1/2	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	13 3/4	13 3/4	13 1/2	13 1/4	13 1/4	13	12 3/4	12 1/2	12 1/4	12	11 3/4
5 1/2	24.70	14 1/2	14 1/2	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 3/4	13 1/2	13 1/4	13 1/4	13	12 3/4	12 1/2	12 1/4
6 5/8	25.20	12	12	12	12	12	12	12	12	11 3/4	11 3/4	11 3/4	11 1/2	11 1/2	11 1/2	11 1/4	11 1/4	11	11	10 3/4	10 1/2	10 1/2	10 1/4
6 5/8	27.70	12	12	12	12	12	12	12	12	12	11 3/4	11 3/4	11 3/4	11 1/2	11 1/2	11 1/2	11 1/4	11 1/4	11	11	10 3/4	10 3/4	10 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 tensile load T (daN)
- L = length of drill pipe string (m)
- S = maximum shear strength (MPa). S is 57.7% of the minimum yield strength (grade)
- D = outside diameter of drill pipe (cm)
- G = modulus of elasticity in shear: 84 000 MPa
- T = total tensile load (daN)
- A = pipe cross-sectional area (mm^2).

BACK-OFF

1) Before any back-off, determine the depth of the stuck point using an extensometer or by the stretch test (see K 18).

2) Make-up the drill string to a maximum of 80% of the torsional limit (see K 20 to K 23).

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 (10^3 daN)
P = weight in mud of free length of drill pipe plus travelling block, hook, etc. (10^3 daN)
HP = hydrostatic pressure at back-off point (kPa)
S = area of matting surface of tool joint (cm^2) (see K 25)

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 5 in string, 19.50 lb/ft (NC50), class Premium, grade X95 drill pipe, in a hole containing mud with SG = 1.40. Weight of travelling block and accessories: 8 10^3 daN (see K 18).

Calculations:

Weight per meter of drill pipe = 31.83 kg/m

Buoyancy factor = 0.822

Weight per meter of drill pipe in mud = $31.83 \times 0.822 = 26.16$ kg/m

Weight of 2000 m of drill pipe in mud = $2000 \times 26.16 \simeq 52\ 10^3$ daN

Hydrostatic pressure at 2000 m HP = $9.81 \times 2000 \times 1.4 \simeq 28\,000$ kPa

Area of matting surface of tool-joint (see K 25) 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 90 10^3 daN on the weight indicator, or 90 – 8 = 82 10^3 daN for the drill string only. For 80 10^3 daN, page K 21 indicates a maximum number of turns of 10 1/2 per 1000 m of drill pipe, or 21 turns for 2000 m. Make-up the drill string with 80% of 21 turns, or 16 turns of the right.

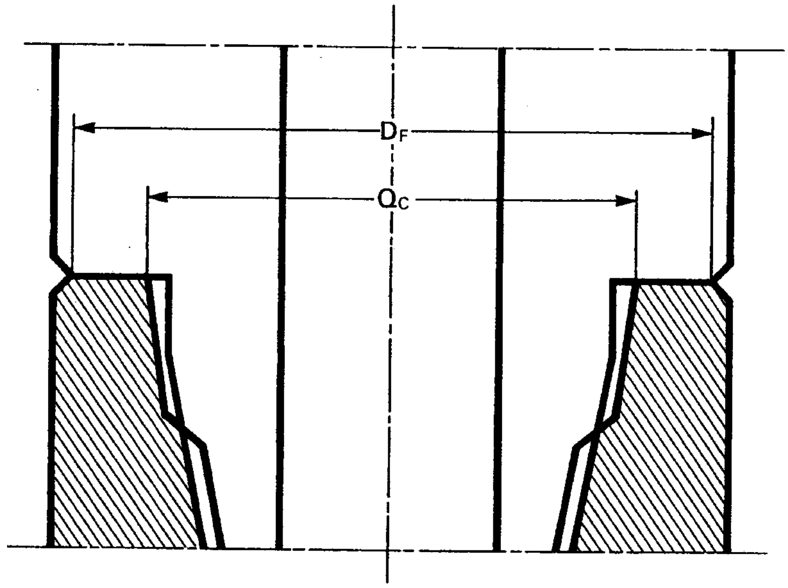
Second step. Set the neutral point at 2000 m. The weight indicator should show:

$$T = P + \frac{HP \times S}{100\,000} \quad \text{with: } P = 52 + 8 = 60 \quad \text{and: } \frac{HP \times S}{100\,000} = \frac{28\,000 \times 34.73}{100\,000} = 10$$

$$T = 60 + 10 = 70\ 10^3 \text{ daN}$$

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, April 1, 1994)



Type of connection	Bevel diameter D_F		Inside diameter Q_c		Matting surface area	
	(mm)	(in)	(mm)	(in)	(mm²)	(in²)
NC23	76.2	3	66.7	2 5/8	1 066	1.653
NC26	82.9	3 17/64	74.6	2 15/16	1 027	1.591
NC31	100.4	3 61/64	87.7	3 29/64	1 876	2.908
NC35	114.7	4 33/64	96.8	3 13/16	2 973	4.609
NC38	116.3	4 37/64	103.6	4 5/64	2 193	3.400
NC40	127.4	5 1/64	110.3	4 11/32	3 192	4.948
NC44	144.5	5 11/16	119.1	4 11/16	5 259	8.151
NC46	145.3	5 23/32	124.6	4 29/32	4 388	6.801
NC50	150.4	5 59/64	134.9	5 5/16	3 473	5.383
NC50 (1)	154.0	6 1/16	134.9	5 5/16	4 334	6.717
NC56	185.3	7 19/64	150.8	5 15/16	9 107	14.116
NC61	212.7	8 3/8	165.1	6 1/2	14 124	21.892
NC70	232.6	9 5/32	187.3	7 3/8	14 939	23.156
NC77	260.7	9 11/32	204.8	8 1/16	20 437	31.678
2 3/8 REG	76.6	3 1/64	68.3	2 11/16	945	1.464
2 7/8 REG	91.7	3 39/64	77.8	3 1/16	1 850	2.868
3 1/2 REG	104.4	4 7/64	90.5	3 9/16	2 128	3.298
4 1/2 REG	135.3	5 21/64	119.1	4 11/16	3 237	5.017
5 1/2 REG	165.1	6 1/2	141.7	5 37/64	5 638	8.740
6 5/8 REG	186.9	7 23/64	154.0	6 1/16	8 809	13.654
7 5/8 REG	215.1	8 15/32	180.2	7 3/32	10 835	16.795
8 5/8 REG	242.5	9 35/64	204.4	8 3/64	13 373	20.728
5 1/2 FH	170.7	6 23/32	150.0	5 29/32	5 214	8.081
6 5/8 FH	195.7	7 45/64	173.8	6 27/32	6 355	9.851

(1) Standard for all NC50 connections manufactured after June 1986.

L

wellheads

API FLANGES

Working pressure as a function of nominal size (API Spec 6A, 17th edition, February 1, 1996)

Working pressure		Nominal size (in)			
		Type 6B		Type 6BX	
(psi)	(MPa)	(in)	(mm)	(in)	(mm)
2 000	13.8	2 1/16 to 21 1/4	52 to 540	26 3/4 to 30	680 to 762
3 000	20.7	2 1/16 to 20 3/4	52 to 527	26 3/4 to 30	680 to 762
5 000	34.5	2 1/16 to 11	52 to 279	13 5/8 to 21 1/4	346 to 540
10 000	69.0			1 13/16 to 21 1/4	46 to 540
15 000	103.4			1 13/16 to 18 3/4	46 to 476
20 000	138.0			1 13/16 to 13 5/8	46 to 346

PHYSICAL PROPERTIES OF STEEL FOR WELLHEADS (PSL 1 to 4) (API Spec 6A, 17th edition, February 1, 1996)

API material property requirements for bodies, bonnets and end and outlet connections

API material designation	0.2% yield strength Minimum, psi (MPa)	Tensile strength, Minimum, psi (MPa)	Elongation in 2 in (50 mm), Minimum (%)	Reduction in area, Minimum (%)
36K	36 000 (248)	70 000 (483)	21	No Requirement
45K	45 000 (310)	70 000 (483)	19	32
60K	60 000 (414)	85 000 (586)	18	35
75K	75 000 (517)	95 000 (655)	17	35

API material applications for bodies, bonnets, and end and outlet connections

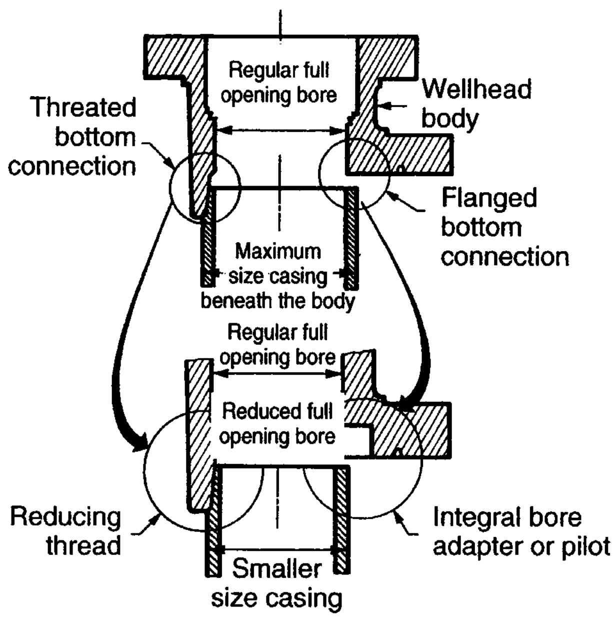
Part	Pressure ratings, psi (MPa)					
	2 000 (13.8)	3 000 (20.7)	5 000 (34.5)	10 000 (69.0)	15 000 (103.4)	20 000 (138.0)
	API material designation					
Body*, Bonnet	36K, 45K 60K, 75K	36K, 45K 60K, 75K	36K, 45K 60K, 75K	36K, 45K 60K, 75K	45K, 60K 75K	60K, 75K
Integral end connection						
Flanged	60K, 75K	60K, 75K	60K, 75K	60K, 75K	75K	75K
Threaded	60K, 75K	60K, 75K	60K, 75K	NA	NA	NA
Other	(See note)	(See note)	(See note)	(See note)	(See note)	(See note)
Loose connectors						
Weld neck	45K	45K	45K	60K, 75K	75K	75K
Blind	60K, 75K	60K, 75K	60K, 75K	60K, 75K	75K	75K
Threaded	60K, 75K	60K, 75K	60K, 75K	NA	NA	NA
Other	(See note)	(See note)	(See note)	(See note)	(See note)	(See note)

Note: As specified by the manufacturer.

* Provided end connections are of the API material designation indicated, welding is done in accordance with Section 6 and design is performed in accordance with Section 4.

MINIMUM VERTICAL FULL-OPENING BODY BORES AND MAXIMUM CASING SIZES
(API Spec 6A, 17th edition, February 1, 1996)

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	17.0	6.413	162.9	6.45	163.8
		3 000	20.7	7	177.80	20.0	6.331	160.8	6.36	161.5
		5 000	34.5	7	177.80	23.0	6.241	158.5	6.28	159.5
7 1/16	179.39	10 000	68.9	7	177.80	29.0	6.059	153.9	6.09	154.7
		15 000	103.4	7	177.80	38.0	5.795	147.2	5.83	148.1
		20 000	137.9	7	177.80	38.0	5.795	147.2	5.83	148.1
9	228.60	2 000	13.8	8 5/8	219.08	24.0	7.972	202.5	8.00	203.2
		3 000	20.7	8 5/8	219.08	32.0	7.796	198.0	7.83	198.9
		5 000	34.5	8 5/8	219.08	36.0	7.700	195.6	7.73	196.3
9	228.60	10 000	68.9	8 5/8	219.08	40.0	7.600	193.0	7.62	193.5
		15 000	103.4	8 5/8	219.08	49.0	7.386	187.6	7.41	188.2
		2 000	13.8	10 3/4	273.05	40.5	9.894	251.3	9.92	252.0
11	279.40	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	51.0	9.694	246.2	9.73	247.1
11	279.40	10 000	68.9	9 5/8	244.48	53.5	8.379	212.8	8.41	213.6
		15 000	103.4	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	61.0	12.359	313.9	12.39	314.7
13 5/8	346.08	5 000	34.5	13 3/8	339.73	72.0	12.191	309.7	12.22	310.4
13 5/8	346.08	10 000	68.9	11 3/4	298.45	60.0	10.616	269.6	10.66	270.8
16 3/4	425.45	2 000	13.8	16	406.40	65.0	15.062	382.6	15.09	383.3
		3 000	20.7	16	406.40	84.0	14.822	376.5	14.86	377.4
16 3/4	425.45	5 000	34.5	16	406.40	84.0	14.822	376.5	14.86	377.4
		10 000	68.9	16	406.40	84.0	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	68.9	18 5/8	473.08	87.5	17.567	446.2	17.59	446.8
20 3/4	527.05	3 000	20.7	20	508.00	94.0	18.936	481.0	18.97	481.8
21 1/4	539.75	2 000	13.8	20	508.00	94.0	18.936	481.0	18.97	481.8
21 1/4	539.75	5 000	34.5	20	508.00	94.0	18.936	481.0	18.97	481.8
		10 000	68.9	20	508.00	94.0	18.936	481.0	18.97	481.8

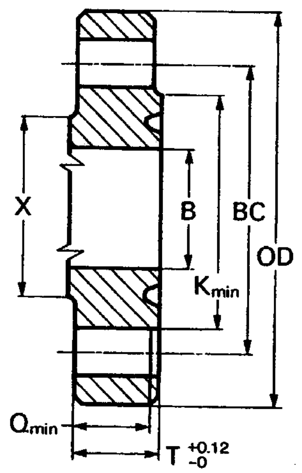


API TYPE 6B FLANGES
Working pressure 2000 psi (13.8 MPa)
(API Spec 6A, 17th edition, February 1, 1996)

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	488.95	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

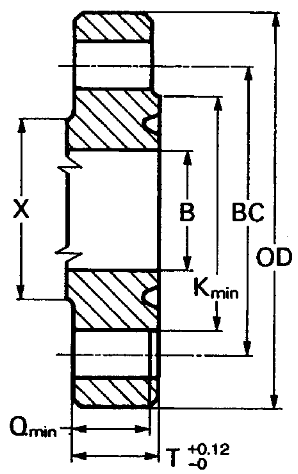


API TYPE 6B FLANGES
Working pressure 3000 psi (20.7 MPa)
(API Spec 6A, 17th edition, February 1, 1996)

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

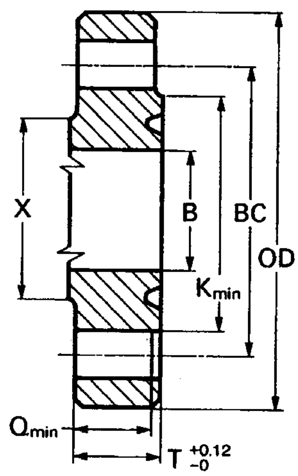


API TYPE 6B FLANGES
Working pressure 5000 psi (34.5 MPa)
(API Spec 6A, 17th edition, February 1, 1996)

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

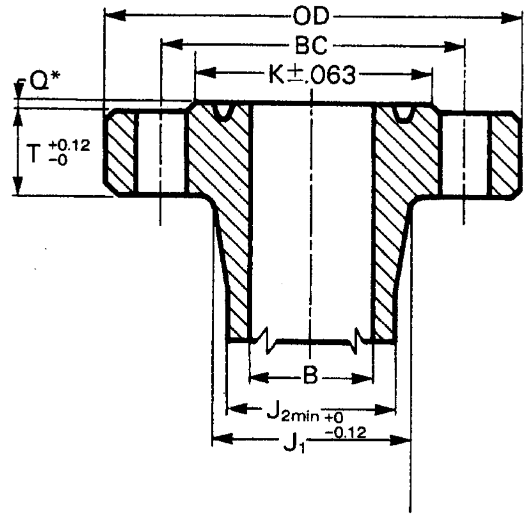
Bolt sizes

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	16	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 10 000 psi (69 MPa)
(API Spec 6A, 17th edition, February 1, 1996)

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
30.00	30.03	762.76	44.19	1122.43	35.75	908.05	5.28	134.11	36.69	931.93	32.80	833.12
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
30.00	30.03	762.76	46.68	1185.67	36.31	922.27	6.58	167.13	38.19	970.03	34.30	871.22
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
10 000 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



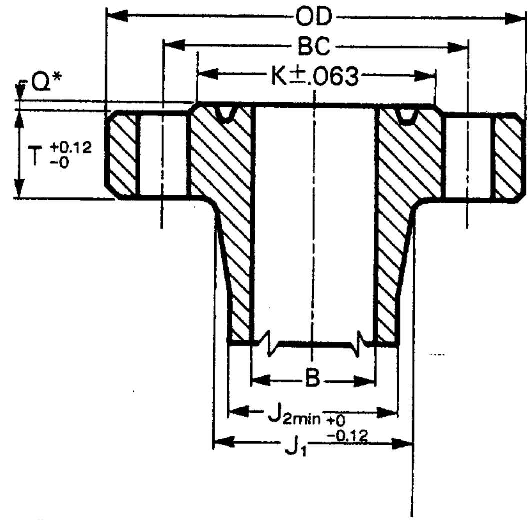
Q^*_{max} = E (Table X D3 – API 6A)

Q^*_{min} = 0.12″

API TYPE 6BX FLANGES
Working pressures: 2000 psi (13.8 MPa), 3000 psi (20.7 MPa), 5000 psi (34.5 MPa) and 10 000 psi (69 MPa) (API Spec 6A, 17th edition, February 1, 1996)

Bolt sizes

Nominal size	Diameter of bolt circle BC		Number of bolts	Diameter of bolts		Length of bolts L		Ring-point type
(in)	(in)	(mm)		(in)	(mm)	(in)	(mm)	BX
2000 psi (13.8 MPa)								
26.75	37.50	952.50	20	1.750	44.45	13.75	349.25	167
30.00	40.94	1039.88	32	1.625	41.28	14.25	361.95	303
3000 psi (20.7 MPa)								
26.75	39.38	1000.25	24	2.000	50.80	17.00	431.80	168
30.00	42.94	1090.68	32	1.875	47.63	17.75	450.85	303
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
10 000 psi (69 MPa)								
1.8125	5.75	146.05	8	0.750	19.05	5.00	127.00	151
2.0625	6.25	158.75	8	0.750	19.05	5.20	132.08	152
2.5625	7.25	184.15	8	0.875	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)

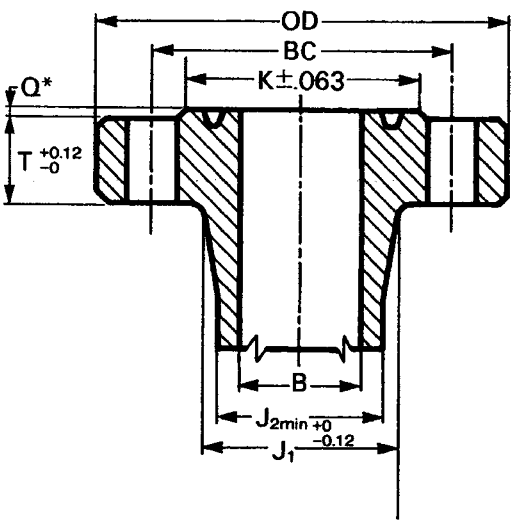
Q^*_{min} = 0.12″

API TYPE 6BX FLANGES
Working pressure: 15 000 psi (103.5 MPa)
(API Spec 6A, 17th edition, February 1, 1996)

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	153.92	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)

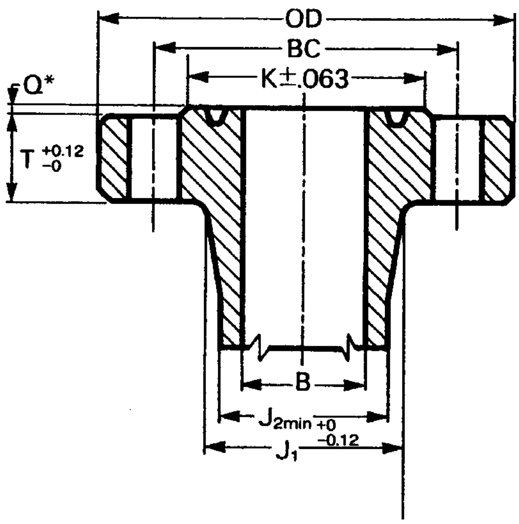
Q^*_{min} = 0.12″

API TYPE 6BX FLANGES
Working pressure 20 000 psi (138 MPa)
(API Spec 6A, 17th edition, February 1, 1996)

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)	B
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

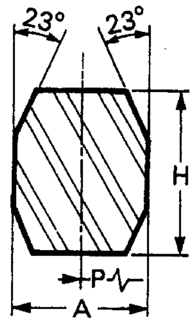


Q^{*}_{max} = E (Table X D3 – API 6A)

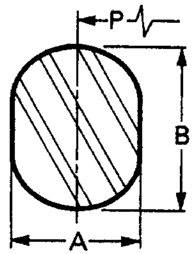
Q^{*}_{min} = 0.12″

API TYPE R RING-JOINT GASKETS
(API Spec 6A, 17^{th} edition, February 1, 1996)

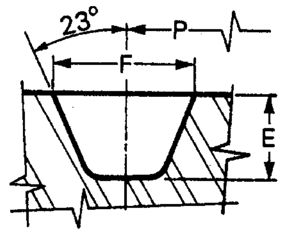
Ring No.	Pitch diameter of ring and groove P		Width of ring A		Height of oval ring B		Height of octogonal ring H		Depth of groove E		Width of groove F		Approximate distance between make-up flanges S	
R	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
20	2.688	68.28	0.313	7.95	0.56	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



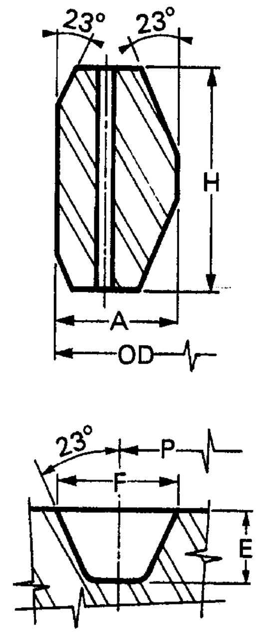
Oval



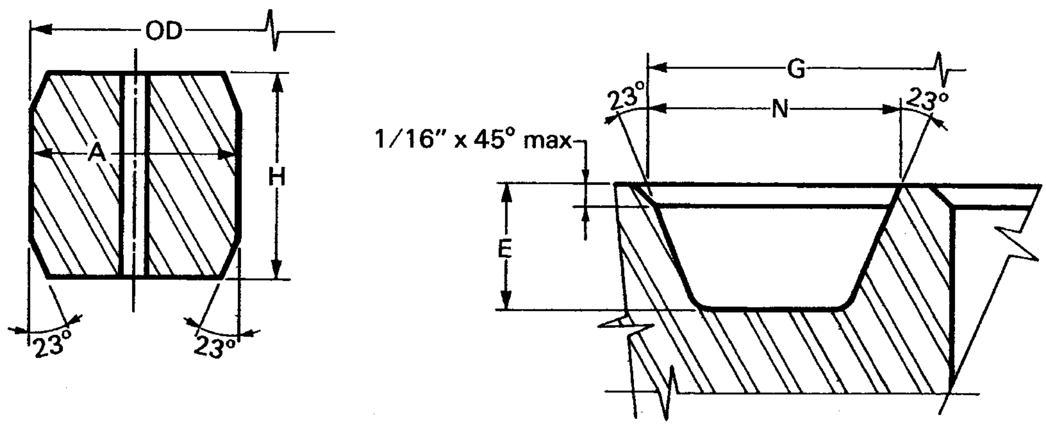
Groove

API TYPE RX RING-JOINT GASKETS
(API Spec 6A, 17th edition, February 1, 1996)

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
(API Spec 6A, 17th edition, February 1, 1996)



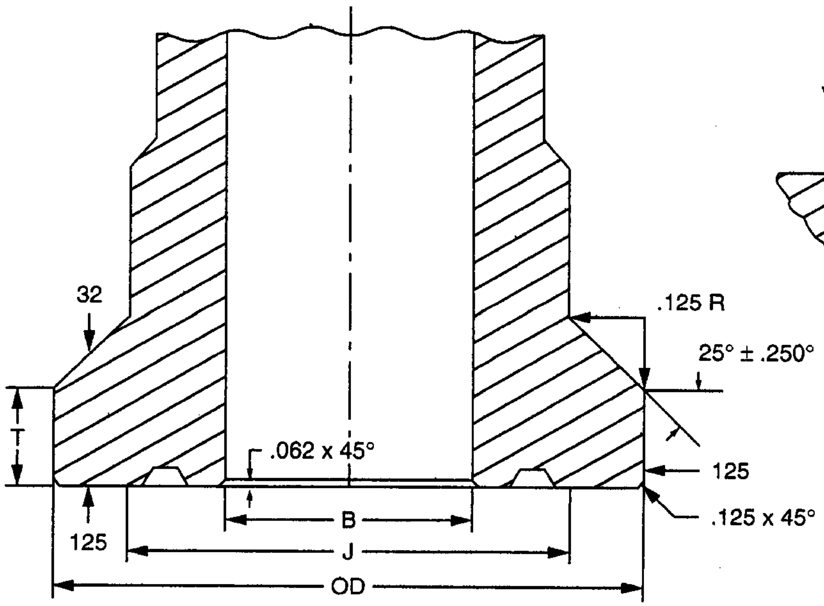
Ring No.	Outside diameter of ring OD		Height H		Width of ring A		Depth of groove E		Outside diameter of groove G		Width of groove N	
BX	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
150	2.842	72.19	0.366	9.30	0.366	9.30	0.220	5.59	2.893	73.48	0.450	11.43
151	3.008	76.40	0.379	9.63	0.379	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
303	33.573	852.75	1.494	37.95	0.668	16.97	0.890	22.61	33.949	862.30	1.078	27.38

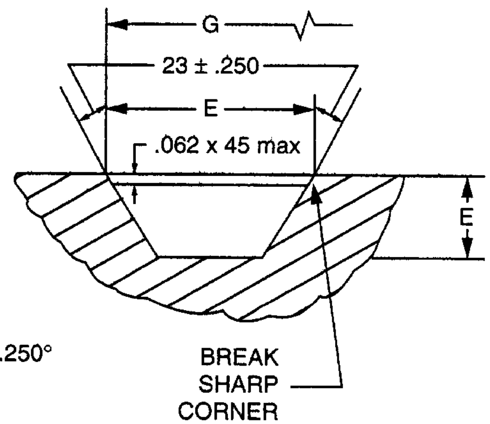
RECOMMENDED FLANGE BOLT TORQUE

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	2 524	45	6	7 448	3 313	59	8
5/8 — 11 UNC	9 026	4 015	86	12	11 846	5 269	113	15
3/4 — 10 UNC	13 355	5 941	150	20	17 528	7 797	196	27
7/8 — 9 UNC	18 482	8 221	239	32	24 257	10 790	313	42
1 — 8 UN	24 229	10 778	361	49	31 800	14 145	474	64
1 1/8 — 8 UN	31 617	14 064	522	71	41 497	18 459	686	93
1 1/4 — 8 UN	39 987	17 787	726	98	52 483	23 346	953	129
1 3/8 — 8 UN	49 339	21 947	976	132	64 757	28 805	1 281	174
1 1/2 — 8 UN	59 672	26 543	1 277	173	78 320	34 838	1 676	227
1 5/8 — 8 UN	70 988	31 577	1 635	222	93 171	41 445	2 146	291
1 3/4 — 8 UN	83 284	37 047	2 054	279	109 311	48 624	2 695	365
1 7/8 — 8 UN	96 563	42 953	2 538	344	126 739	56 376	3 331	452
2 — 8 UN	110 824	49 297	3 093	419	145 456	64 702	4 060	551
2 1/4 — 8 UN	142 290	63 294	4 435	601	186 755	83 073	5 821	789
2 1/2 — 8 UN	177 683	79 037	6 116	829	233 209	103 736	8 028	1 089
2 5/8 — 8 UN	196 852	87 564	7 097	962	258 368	114 928	9 314	1 263
2 3/4 — 8 UN	217 003	96 528	8 176	1 109	284 817	126 693	10 731	1 455
3 — 8 UN	260 250	115 765	10 653	1 445	341 578	151 941	13 982	1 896
3 1/4 — 8 UN	307 424	136 749	13 585	1 842	403 495	179 483	17 830	2 418
3 3/4 — 8 UN	413 554	183 958	20 967	2 843	542 790	241 445	27 519	3 732
3 7/8 — 8 UN	442 541	196 852	23 157	3 140	580 834	258 368	30 393	4 121
4 — 8 UN	472 509	210 182	25 494	3 457	620 168	275 864	33 461	4 537
4 1/2 — 8 UN	602 200	267 872	36 412	4 937	790 388	351 582	47 790	6 480
4 3/4 — 8 UN	672 936	299 337	42 879	5 814	883 229	392 880	56 289	7 633

API TYPE 16B INTEGRAL HUB CONNECTIONS
(API Spec 16A, 1st edition, November 1, 1986)

Nominal size B		Outside diameter OD		Total thickness T		Large diameter of neck J		Groove OD G		Width of groove N		Depth of groove E		Ring gasket number	*Cameron* clamp number
(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)		
2000 psi. Maximum working pressure = 13.8 MPa															
7 1/16	179.39	10.375	263.525	1.443	36.6522	8.875	225.425	8.987	228.2698	0.668	16.9672	0.562	14.275	RX-45	25
16 3/4	425.45	20.375	517.525	1.269	32.2326	19	482.6	19.14	486.0290	0.668	16.9672	0.562	14.275	RX-65	12
21 1/4	539.75	26.375	669.925	1.872	47.5488	24.5	622.3	23.75	603.3262	0.784	19.9136	0.688	17.475	RX-73	18
3000 psi. Maximum working pressure = 20.7 MPa															
11	279.40	15.625	396.875	1.399	35.5346	14	355.6	13.41	340.487	0.668	16.9672	0.562	14.275	RX-53	9
13 5/8	346.08	18.375	466.725	1.336	33.9344	16.75	425.45	15.64	397.129	0.668	16.9672	0.562	14.275	RX-57	11
16 3/4	425.45	21.250	539.750	1.459	37.0586	19.625	498.475	19.14	486.029	0.668	16.9672	0.562	14.275	RX-65	14





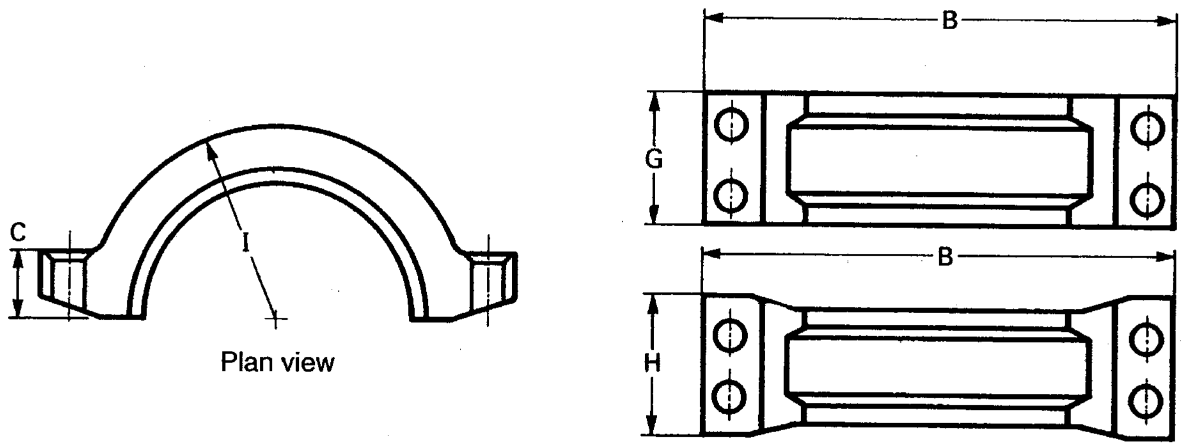
API TYPE 16B INTEGRAL HUB CONNECTIONS (continued)
(API Spec 16A, 1st edition, November 1, 1986)

Nominal size B		Outside diameter OD		Total thickness T		Large diameter of neck J		Groove OD G		Width of groove N		Depth of groove E		Ring gasket number	*Cameron* clamp number
(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)		
5000 psi. Maximum working pressure = 34.5 MPa															
2 1/16	52.3875	5.031	127.7874	1.166	29.616	3.656	92.8624	3.395	86.233	0.498	12.6492	0.234	5.9436	BX-152	1
2 9/16	65.0875	5.781	146.8374	1.166	29.616	4.406	111.9124	4.046	102.768	0.554	14.0716	0.226	5.7404	BX-153	2
3 1/8	79.375	6.312	160.3248	1.166	29.616	4.938	125.4252	4.685	118.999	0.606	15.3924	0.297	7.5438	BX-154	4
4 1/16	103.188	7.625	193.6750	1.197	30.404	6.250	158.7500	5.930	150.622	0.698	17.7292	0.328	8.3312	BX-155	5
7 1/16	179.390	13.25	336.5500	1.622	41.199	11.625	295.2750	9.521	241.833	0.921	23.3934	0.438	11.1252	BX-156	8
9	228.600	13.25	336.5500	1.622	41.199	11.625	295.2750	11.774	299.06	1.039	26.3906	0.5	12.7000	BX-157	8
11	279.400	16.25	412.7500	1.654	42.012	14.625	371.4750	14.064	357.226	1.149	29.1846	0.562	14.2748	BX-158	10
13 5/8	346.075	20.625	523.8750	1.871	47.523	19.000	482.6000	16.063	408	0.786	19.9644	0.562	14.2748	BX-160	13
16 3/4	425.450	25.625	650.8750	1.778	45.161	24.000	609.6000	18.832	478.333	0.705	17.907	0.328	8.3312	BX-162	19
21 1/4	539.750	31.250	793.7500	3.63	92.202	27.875	708.0250	24.904	632.562	1.071	27.2034	0.75	19.0500	BX-165	27
10 000 psi. Maximum working pressure = 69 MPa															
1 13/16	46.0375	5.031	127.7874	1.166	29.616	3.656	92.8624	3.062	77.7748	0.466	11.8364	0.219	5.5626	BX-151	1
2 1/16	52.3875	5.781	146.8374	1.166	29.616	4.406	111.9124	3.395	86.2330	0.498	12.6492	0.234	5.9436	BX-152	2
2 9/16	65.0875	6.312	160.3248	1.166	29.616	4.938	125.4252	4.046	102.7680	0.554	14.0716	0.266	6.7564	BX-153	4
3 1/16	77.7875	7.625	193.6750	1.197	30.404	6.250	158.7500	4.685	118.9990	0.606	15.3924	0.297	7.5438	BX-154	5
4 1/16	103.188	8.437	214.2998	1.31	33.274	6.812	173.0248	5.930	150.6220	0.698	17.7292	0.328	8.3312	BX-155	6
7 1/16	179.388	16.250	412.7500	1.653	41.986	14.625	371.4750	9.521	241.8330	0.921	23.3934	0.438	11.1252	BX-156	10
9	228.600	16.250	412.7500	1.653	41.986	14.625	371.4750	11.774	299.0600	1.039	26.3906	0.5	12.7000	BX-157	10
11	279.400	20.625	523.8750	2.035	51.689	18.625	473.0750	14.064	357.2260	1.149	29.1846	0.562	14.2748	BX-158	22
13 5/8	346.075	22.250	565.1500	2.309	58.649	20.625	523.8750	17.033	432.6380	1.279	32.4866	0.625	15.8750	BX-159	15
16 3/4	425.450	28.000	711.2000	3.005	76.327	25.000	635.0000	18.832	478.3330	0.705	17.907	0.328	8.3312	BX-162	28
18 3/4	476.250	31.250	793.7500	3.63	92.202	27.875	708.0250	22.752	577.9010	1.29	32.766	0.719	18.2626	BX-164	27
21 1/4	539.750	34.000	863.6000	4.005	101.730	30.500	774.7000	25.507	647.8780	1.373	34.8742	0.75	19.0500	BX-166	26

API TYPE 16B INTEGRAL HUB CONNECTIONS (continued)
(API Spec 16A, 1st edition, November 1, 1986)

Nominal size B		Outside diameter OD		Total thickness T		Large diameter of neck J		Groove OD G		Width of groove N		Depth of groove E		Ring gasket number	*Cameron* clamp number
(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)		
15 000 psi. Maximum working pressure = 103.5 MPa															
1 13/16	46.0375	5.781	146.8374	1.166	29.616	4.406	111.9124	3.062	77.7748	0.466	11.8364	0.219	5.5626	BX-151	2
2 1/16	52.3875	6.125	155.5750	1.622	41.199	4.500	114.3000	3.395	86.2330	0.498	12.6492	0.234	5.9436	BX-152	3
2 9/16	65.0875	6.125	155.5750	1.622	41.199	4.500	114.3000	4.046	102.7680	0.554	14.0716	0.266	6.7564	BX-153	3
3 1/16	77.7875	8.437	214.2998	1.31	33.274	6.812	173.0248	4.685	118.9990	0.606	15.3924	0.297	7.5438	BX-154	6
4 1/16	103.1880	13.250	336.5500	1.622	41.199	11.625	295.2750	5.930	150.6220	0.698	17.7292	0.328	8.3312	BX-155	8
7 1/16	179.3900	20.626	523.9004	2.035	51.689	18.625	473.0750	9.521	241.8330	0.921	23.3934	0.438	11.1252	BX-156	22
11	279.4000	22.250	565.1500	2.309	58.649	20.625	523.8750	14.064	357.2260	1.149	29.1846	0.562	14.2748	BX-158	15
13 5/8	346.0750	28.000	711.2000	3.005	76.327	25.000	635.0000	17.033	432.6380	1.279	32.4866	0.625	15.8750	BX-159	28
18 3/4	476.2500	34.000	863.6000	4.005	101.730	30.500	774.7000	22.752	577.9010	1.290	32.7660	0.719	18.2626	BX-164	26
20 000 psi. Maximum working pressure = 138 MPa															
1 13/16	46.0375	5.031	127.7874	1.622	41.199	4.500	114.3000	3.062	77.7748	0.466	11.8364	0.219	5.5626	BX-151	3
2 1/16	52.3875	5.781	146.8374	1.622	41.199	4.500	114.3000	3.395	86.2330	0.498	12.6492	0.234	5.9436	BX-152	3
2 9/16	65.0875	6.312	160.3248	1.31	33.274	6.812	173.0248	4.046	102.7680	0.554	14.0716	0.226	5.7404	BX-153	6
3 1/16	77.7875	7.625	193.6750	1.622	41.199	11.625	295.2750	4.685	118.9990	0.606	15.3924	0.297	7.5438	BX-154	8
4 1/16	103.1880	8.437	214.2998	1.653	41.986	14.625	371.4750	5.930	150.6220	0.698	17.7292	0.328	8.3312	BX-155	10
7 1/16	179.3880	16.250	412.7500	2.309	58.649	20.625	523.8750	9.521	241.8330	0.921	23.3934	0.438	11.1252	BX-156	15
11	279.4000	20.625	523.8750	3.005	76.327	25.000	635.0000	14.064	357.2260	1.149	29.1846	0.562	14.2748	BX-158	

CLAMP FOR FLANGES
Clamp dimensions (cameron)



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	266.70	50.80	0.875-9 UN	177.80	106.43	–	97.54
2	304.80	63.50	0.875-9 UN	203.20	108.71	–	108.71
3	355.60	69.85	1.000-8 UN	228.60	157.23	–	127.76
4	317.50	63.50	1.000-8 UN	215.90	113.54	–	119.13
5	349.25	63.50	1.000-8 UN	215.90	114.30	–	134.11
6	419.10	76.20	1.125-8 UN	247.69	136.65	–	153.92
7	508.00	95.25	1.375-8 UN	304.80	149.35	–	187.45
8	603.25	107.95	1.500-8 UN	342.90	165.10	–	223.01
9	654.05	107.95	1.375-8 UN	330.20	139.70	146.05	245.36
10	723.90	139.70	1.625-8 UN	412.75	171.45	–	264.41
11	771.65	141.22	1.375-8 UN	381.00	139.70	149.39	292.10
12	771.65	133.35	1.375-8 UN	381.00	117.35	146.05	305.56
13	838.20	153.16	2.250-8 UN	508.00	195.07	234.95	331.22
14	793.75	165.10	1.625-8 UN	463.55	146.05	146.05	328.68
15	990.60	133.35	2.500-8 UN	488.95	263.65	–	371.35
16	889.00	171.45	1.625-8 UN	476.25	139.70	172.97	373.13
17	968.25	162.05	2.250-8 UN	501.65	172.97	234.95	393.70
18	990.60	165.10	2.250-8 UN	508.00	184.15	241.3	412.75
19	1028.70	200.15	2.500-8 UN	596.90	225.30	266.7	406.40
20	1216.20	152.40	1.500-8 UN	431.80	193.55	–	505.71
21	1025.70	139.70	1.250-8 UN	381.00	165.10	–	421.39
22	853.95	139.70	2.250-8 UN	457.20	222.25	234.95	338.07
23	1397.00	184.15	2.250-8 UN	546.10	234.95	–	607.31
24	1295.40	162.05	1.625-8 UN	457.20	193.55	–	546.10
25	425.45	66.55	0.875-9 UN	215.90	120.65	–	169.93
26	1384.30	290.58	4.000-8 UN	939.80	401.57	–	552.20
27	1231.90	169.67	3.250-8 UN	622.30	333.25	–	496.82
28	1136.90	152.40	3.000-8 UN	660.40	304.80	–	450.85

mm × 0.0394 = in

CIW CLAMP FOR FLANGES
Make-up torque on bolts of CIW clamps

Clamp No.	Nominal size of studs		Torque API 5A lubricant		Torque molybdenum lubricant	
	(in)	(mm)	(daN.m)	(lb.ft)	(daN.m)	(lb.ft)
1	7/8	22.23	18.6	137.27	12.7	93.73
2	7/8	22.23	37.2	274.54	24.5	180.81
3	1	25.40	54.9	405.16	37.2	274.54
4	1	25.40	54.9	405.16	37.2	274.54
5	1	25.40	54.9	405.16	37.2	274.54
6	1 1/8	28.58	81.4	600.73	54.9	405.16
7	1 3/8	34.93	149.0	1 099.62	95.0	701.10
8	1 1/2	38.10	197.0	1 453.86	129.4	954.97
9	1 3/8	34.93	149.0	1 099.62	95.0	701.10
10	1 5/8	41.28	251.0	1 852.38	162.8	1 201.46
11	1 3/8	34.93	149.0	1 099.62	95.0	701.10
12	1 3/8	34.93	149.0	1 099.62	95.0	701.10
13	2 1/4	57.15	678.8	5 009.54	434.5	3 206.61
14	1 5/8	41.28	251.0	1 852.38	162.8	1 201.46
15	2 1/2	63.50	949.6	7 008.05	597.4	4 408.81
16	1 5/8	41.28	251.0	1 852.38	162.8	1 201.46
17	2 1/4	57.15	678.8	5 009.54	434.5	3 206.61
18	2 1/4	57.15	678.8	5 009.54	434.5	3 206.61
19	2 1/2	63.50	949.6	7 008.05	597.4	4 408.81
20	1 1/2	38.10	197.0	1 453.86	129.4	954.97
21	1 1/4	31.75	108.8	802.94	74.5	549.81
22	2 1/4	57.15	678.8	5 009.54	434.5	3 206.61
23	2 1/4	57.15	678.8	5 009.54	434.5	3 206.61
24	1 5/8	41.28	251.0	1 852.38	162.8	1 201.46
25	7/8	22.23	36.2	267.16	24.5	180.81
26	4	101.60	3866.0	28 531.08	2427.0	17 911.26
27	3 1/4	82.55	2062.0	15 217.56	1302.0	9 608.76
28	3	76.20	1628.0	12 014.64	1031.0	7 608.78

daN.m × 7.38 = lb.ft

CAMERON RAM-TYPE BLOW-OUT PREVENTERS
Operating data

Model	Nominal size	Working pressure	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
	(in)	(psi)	(gal)	(liters)	(gal)	(liters)		
Type U	7 1/16	3 000 to 15 000	1.3	4.9	1.3	4.9	6.9	2.2
	11	3 000 to 10 000	3.4	12.9	3.5	13.2	7.3	2.5
	11	15 000	6.1	23.1	6.2	23.5	9.8	2.2
	13 5/8	3 000 to 10 000	5.4	20.4	5.8	22.0	7.0	2.3
	13 5/8	15 000	10.4	39.4	10.6	40.1	10.6	3.6
	16 3/4	3 000 and 5 000	9.8	37.1	10.6	40.1	6.8	2.3
	16 3/4	10 000	11.6	43.9	12.4	46.9	6.8	2.3
	18 3/4	10 000	21.2	80.2	23.1	87.4	7.4	3.7
	20 3/4	3 000	7.9	29.9	8.4	31.8	7.0	1.3
	21 1/4	2 000						
	21 1/4	5 000	27.2	103.0	29.9	113.2	6.2	4.0
	21 1/4	10 000	24.5	92.7	26.9	101.8	7.2	4.0
	26 3/4	3 000	10.1	38.2	10.8	40.9	7.0	1.0
Type U special cavity (shear ram)	11	3 000 to 10 000	7.4	28.0	7.6	28.8	12.0	4.8
	11	15 000	8.9	33.7	9.0	34.1	15.2	3.7
	13 5/8	3 000 to 10 000	10.5	39.7	10.9	41.3	10.8	4.5
	13 5/8	15 000	16.0	60.6	16.2	61.3	16.2	6.0
	16 3/4	3 000 and 5 000	18.1	68.5	19.0	71.9	10.4	4.4
	16 3/4	10 000	18.2	68.9	19.1	72.3	10.4	4.4
	20 3/4	3 000	14.3	54.1	14.9	56.4	10.8	1.7
	21 1/4	2 000						
Type UII	18 3/4	10 000	22.3	84.4	24.7	93.5	6.7	2.5
	18 3/4	15 000	32.3	122.3	34.7	131.4	9.3	3.5
Type T	18 3/4	15 000	22.2	84.0	24.2	91.6	6.7	3.1

HYDRIL RAM-TYPE BLOW-OUT PREVENTERS
Operating data

Model	Nominal size	Working pressure	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
	(in)	(psi)	(gal)	(liters)	(gal)	(liters)		
Manual-Lock	7 1/16	3 000 and 5 000	0.93	3.5	1.0	3.8	4.8	1.5
	7 1/16	10 000	1.80	6.8	1.9	7.2	7.7	1.7
	7 1/16	15 000	3.40	12.9	3.7	14.0	7.1	6.6
	9	3 000 and 5 000	1.90	7.2	1.9	7.2	4.5	2.6
	11	3 000 and 5 000	3.20	12.1	3.3	12.5	6.0	2.0
	11	10 000	5.00	18.9	5.2	19.7	6.9	2.4
	11	15 000	8.10	30.7	8.8	33.3	7.2	3.24
	13 5/8	3 000 and 5 000	4.90	18.5	5.4	20.4	4.8	2.1
	13 5/8	10 000	11.80	44.7	11.8	44.7	10.2	3.8
	20 3/4	3 000	7.20	27.3	8.1	30.7	4.75	0.98
	21 1/4	2 000						
	21 1/4	5 000	16.60	62.8	17.5	66.2	10.2	1.9
Manual-Lock Shear rams	11	3 000 and 5 000	5.00	18.9	5.5	20.8	5.6	4.2
	11	10 000	8.20	31.0	8.8	33.3	11.7	4.0
	11	15 000	8.10	30.7	8.8	33.3	7.2	3.24
	13 5/8	3 000 and 5 000	11.20	42.4	11.5	43.5	10.1	4.7
	20 3/4	3 000	16.30	61.7	17.2	65.1	10.14	2.2
	21 1/4	2 000						
	21 1/4	5 000	16.60	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	1.80	6.8	2.0	7.6	8.2	1.7
	7 1/16	15 000	3.40	12.9	3.9	14.8	7.6	6.6
	9	3 000 and 5 000	1.90	7.2	2.2	8.3	5.3	2.6

HYDRIL RAM-TYPE BLOW-OUT PREVENTERS (continued)
Operating data

Model	Nominal size	Working pressure	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
	(in)	(psi)	(gal)	(liters)	(gal)	(liters)		
MPL	11	3 000 and 5 000	3.20	12.1	3.7	14.0	6.80	2.00
	11	10 000	5.00	18.9	5.7	21.6	7.60	2.40
	11	15 000	8.10	30.7	9.3	35.2	7.60	3.24
	13 5/8	3 000	4.90	18.5	5.9	22.3	5.20	2.10
	13 5/8	5 000	5.20	19.7	5.9	22.3	5.20	2.10
	13 5/8	10 000	11.80	44.7	12.9	48.8	10.60	3.80
	13 5/8	15 000	11.00	41.6	12.6	47.7	7.74	3.56
	16 3/4	10 000	14.10	53.4	15.6	59.1	10.60	2.41
	18 3/4	10 000	15.60	59.1	17.1	64.7	10.60	1.90
	18 3/4	15 000	16.70	63.2	19.4	73.4	7.27	2.15
	20 3/4	3 000	7.20	27.3	8.9	33.7	5.20	0.98
	21 1/4	2 000						
	21 1/4	5 000	16.60	62.8	19.3	73.1	10.60	1.90
Manual-Lock Shear rams	11	3 000 and 5 000	5.00	18.9	6.0	22.7	6.00	4.20
	11	10 000	8.20	31.0	9.3	35.2	12.40	4.00
	11	15 000	8.10	30.7	9.3	35.2	7.60	3.24
	13 5/8	3 000 and 5 000	11.20	42.4	12.0	45.4	10.60	4.70
	13 5/8	10 000	11.80	44.7	12.9	48.8	10.60	3.80
	13 5/8	15 000	11.00	41.6	12.6	47.7	7.74	3.56
	16 3/4	10 000	14.10	53.4	15.6	59.1	10.60	2.40
	18 3/4	10 000	15.60	59.1	17.1	64.7	10.60	1.90
	18 3/4	15 000	16.70	63.2	19.4	73.4	7.27	2.15
	20 3/4	3 000	16.30	61.7	18.0	68.1	10.60	2.20
	21 1/4	2 000						
	21 1/4	5 000	16.60	62.8	19.3	73.1	10.60	1.90

NL SHAFFER BLOW-OUT PREVENTERS
Operating data

Model	Nominal size	Working pressure	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio	Ram size
	(in)	(psi)	(gal)	(liters)	(gal)	(liters)			(in)
Sentinel	7 1/4	3 000	0.28	1.1	0.29	1.1	4.00	2.50	–
LWP	7 1/16	3 000	0.51	1.9	0.55	2.1	4.49	2.50	5
	9	3 000	0.68	2.6	0.77	2.9	4.49	1.81	5
SL Poslock and Manual-Lock	7 1/16	10 000	2.34	8.9	2.72	10.3	7.11	3.37	10
	7 1/16	10 000	5.57	21.1	6.00	22.7	13.94	7.14	14
	7 1/16	15 000	2.34	8.9	2.72	10.3	7.11	3.37	10
	7 1/16	15 000	5.57	21.1	6.00	22.7	13.94	7.14	14
	11	10 000	7.00	26.5	9.45	35.8	7.11	4.62	14
	11	15 000	8.10	30.7	9.40	35.6	7.11	2.80	14
	13 5/8	3 000	4.46	16.9	5.44	20.6	5.54	3.00	10
	13 5/8	5 000	4.46	16.9	5.44	20.6	5.54	3.00	10
	13 5/8	5 000	10.52	39.8	11.00	41.6	10.85	10.02	14
	13 5/8	10 000	10.52	39.8	10.58	40.0	7.11	4.29	14
	13 5/8	15 000	10.52	39.8	11.56	43.8	7.11	2.14	14
	16 3/4	5 000	4.97	18.8	6.07	23.0	5.54	2.03	10
	16 3/4	5 000	10.67	40.4	11.76	44.5	10.85	5.77	14
	16 3/4	10 000	12.50	47.3	14.47	54.8	7.11	2.06	14
	18 3/4	10 000	13.21	50.0	14.55	55.1	7.11	1.83	14
	18 3/4	15 000	13.33	50.5	14.62	55.3	10.85	1.68	14
	21 1/4	10 000	13.86	52.5	16.05	60.8	7.11	1.63	14
LWS Poslock and Manual-Lock	4 1/16	5 000 and 10 000	0.52	2.0	0.59	2.2	8.45	4.74	6
	7 1/16	5 000	1.18	4.5	1.45	5.5	5.45	1.93	6 1/2
	7 1/16*	10 000	5.25	19.9	5.18	19.6	10.63	15.22	14
	9	5 000	2.27	8.6	2.58	9.8	5.57	3.00	8 1/2
	11	3 000	1.45	5.5	1.74	6.6	5.45	1.16	6 1/2
	11	5 000	2.62	9.9	2.98	11.3	5.57	2.09	8 1/2
	11	5 000	8.9	33.7	9.50	36.0	16	3.41	14
	20 3/4	3 000	4.46	16.9	5.07	19.2	5.57	0.78	8 1/2
	20 3/4	3 000	6.86	26.0	7.80	29.5	8.16	1.15	10
	20 3/4	3 000	13.59	51.4	14.50	54.9	16	2.21	14
	21 1/4	2 000	4.46	16.9	5.07	19.2	5.57	0.78	8 1/2
	21 1/4	2 000	6.86	26.0	7.80	29.5	8.16	1.15	10
	21 1/4	2 000	13.59	51.4	14.50	54.9	16	2.21	14

* Replaced by 7 1/16 inch, 10 000 psi type SL.

KOOMEY RAM-TYPE BLOW-OUT PREVENTERS
Operating data

Model	Nominal size	Working pressure	Fluid volume to open rams		Fluid volume to close rams		Closing ratio	Opening ratio
	(in)	(psi)	(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	3.30	12.5	3.60	13.6	4.44	1.50
	11	5 000	3.30	12.5	3.60	13.6	7.41	2.50
	11	10 000	3.30	12.5	3.60	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	30.00	18.99
	11	15 000	2.66	10.1	2.66	10.1	42.86	16.72
	13 5/8	10 000	2.80	10.6	2.80	10.6	28.57	20.75
	13 5/8	15 000	3.54	13.4	3.54	13.4	42.86	25.00
	18 3/4	10 000	11.50	43.5	11.50	43.5	30.00	25.00
	18 3/4	15 000	11.50	43.5	11.50	43.5	30.00	25.00
	20 3/4	3 000	12.18	46.1	12.65	47.9	1.48	0.75
	21 1/4	2 000	9.20	34.8	9.20	34.8	4.00	2.00
	21 1/4	5 000	9.70	36.7	9.70	36.7	4.94	1.60
	21 1/4	10 000	4.40	16.7	4.40	16.7	18.32	13.30

CAMERON RAM-TYPE BLOW-OUT PREVENTERS
Dimensions and weights

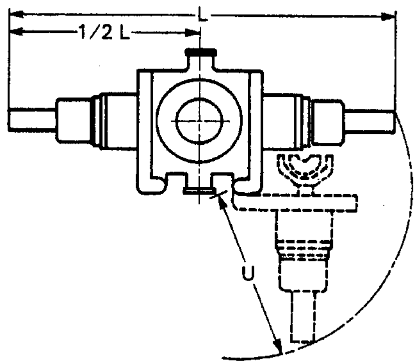
Model	Nominal size	Working pressure	Width bonnets closed locking rams screwed		Width bonnets open locking rams unscrewed		Single BOP				Double BOP			
							Height between flanges		Approximate weight		Height between flanges		Approximate weight	
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
Type U	7 1/16	3 000	74.000	188.0	109.500	278.1	24.062	61.1	2 600	1 179	41.000	104.1	5 000	2 268
	7 1/16	5 000	74.000	188.0	109.500	278.1	27.500	69.9	2 800	1 270	44.188	112.2	5 200	2 359
	7 1/16	10 000	74.000	188.0	109.500	278.1	30.562	77.6	3 550	1 610	48.625	123.5	6 400	2 903
	7 1/16	15 000	74.000	188.0	109.500	278.1	31.812	80.8	3 800	1 724	49.875	126.7	6 750	3 062
	11	3 000	96.250	244.5	146.875	373.1	29.062	73.8	5 300	2 404	49.250	125.1	9 900	4 491
	11	5 000	96.250	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	96.250	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	124.000	315.0	175.312	445.3	44.812	113.8	10 300	4 672	69.750	177.2	18 400	8 346
	13 5/8	3 000	112.125	284.8	171.500	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	171.500	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	172.750	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	139.000	353.1	214.375	544.5	53.688	136.4	23 700	10 750	81.750	207.6	43 250	19 618
	16 3/4 (Mod B)	3 000	127.250	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	129.250	328.3	202.125	513.4	43.062	109.4	13 750	6 237	68.875	174.9	26 940	12 220
	16 3/4	10 000	139.000	353.1	218.375	554.7	46.688	118.6	23 300	10 569	77.750	197.5	43 500	19 732
	18 3/4	10 000	156.375	397.2	242.125	615.0	56.000	142.2	28 900	13 109	87.125	221.3	56 950	25 833
	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	164.250	417.2	247.250	628.0	50.938	129.4	30 000	13 608	82.375	209.2	58 000	26 309
	21 1/4	10 000	163.375	415.0	250.375	636.0	66.000	167.6	34 650	15 717	100.062	254.2	65 500	29 711
	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	147.000 (1)	373.4	185.500 (1)	471.2	43.125 (2)	109.5			87.125	221.3	51 809	23 501
							64.750	164.5			74.000 (2)	188.0	50 706	23 000
	18 3/4	15 000	148.375 (1)	376.9	186.875 (1)	474.7	53.125 (2)	134.9			98.875	251.1	71 209	32 300
											87.250 (2)	221.6	69 446	31 501
Type T	18 3/4	15 000	177.000 (1)	449.6	217.000 (1)	551.2	64.200	163.1			98.100	249.2	87 744	39 801
							53.000 (2)	134.6			87.000 (2)	221.0	85 980	39 001

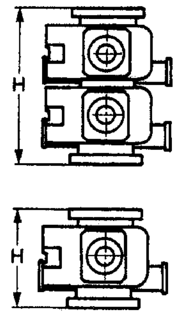
(1) With Wedge Lock system.
(2) Clamped upper and lower connections.

HYDRIL RAM-TYPE BLOW-OUT PREVENTERS
Dimensions and weights

Nominal size	Working pressure	Width bonnets closed L		Bonnets radius U		Single BOP				Double BOP			
						Height between flanges H		Approximate weight		Height between flanges H		Approximate weight	
(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
7 1/16	3 000	77 1/16	195.7	36 3/16	91.9	22 9/16	57.3	2 350	1 066	35 9/16	90.3	4 910	2 227
7 1/16	5 000	77 1/16	195.7	36 3/16	91.9	24 1/4	61.6	2 465	1 118	37 3/8	94.9	4 930	2 236
7 1/16	10 000	79	200.7	37 3/16	94.5	29 1/4	74.3	5 600	2 540	46	116.8	10 600	4 808
7 1/16	15 000	86 3/16	218.9	42 3/8	107.6	34 3/16	86.8	5 370	2 436	54 5/8	138.7	10 200	4 627
9	3 000	82 1/2	209.6			28 3/16	71.6	5 200	2 359	48 9/16	123.3	10 200	4 627
9	5 000	82 1/2	209.6			31 11/16	80.5	5 400	2 449	52 1/16	132.2	10 400	4 717
11	3 000	95	241.3	44 5/8	113.3	30 1/4	76.8	5 600	2 540	49 3/4	126.4	10 800	4 899
11	5 000	95	241.3	44 5/8	113.3	35 1/2	90.2	6 000	2 722	55	139.7	12 000	5 443
11	10 000	106 1/4	269.9	62 1/2	158.8	36 1/4	92.1	9 750	4 423	56 7/8	144.5	18 100	8 210
11	15 000	114 13/16	291.6	44 5/8	113.3	47 1/8	119.7	15 900	7 212	74 9/16	189.4	28 200	12 792
13 5/8	3 000	116 3/4	296.5	52 1/4	132.7	33 1/4	84.5	8 450	3 833	55 1/8	140.0	16 300	7 394
13 5/8	5 000	116 3/4	296.5	52 1/4	132.7	36 1/4	92.1	8 850	4 014	58 1/8	147.6	16 700	7 575
13 5/8	10 000	124 3/4	316.9	58 1/4	148.0	41 3/4	106.0	17 000	7 711	66 3/4	169.5	37 000	16 783
13 5/8	15 000	*119 1/8	302.6	45 3/8	115.3	51 3/8	130.5	21 150	9 594	80 5/8	204.8	41 150	18 666
16 3/4	10 000	143	363.2	61 5/16	155.7	44 7/8	114.0	21 000	9 526	73	185.4	43 000	19 505
18 3/4	10 000	*138 1/4	351.2	62	157.5	54 1/4	137.8	28 500	12 928	85 3/4	217.8	52 000	23 587
18 3/4	15 000	*150 3/4	382.9	**65 15/16	167.5	65 1/2	166.4	31 900	14 470	103 1/2	262.9	62 750	28 463
20 3/4	3 000	151 1/2	384.8	59 3/4	151.8	38 1/2	97.8	14 500	6 577	83 1/2	212.1	28 000	12 701
21 1/4	2 000	151 1/2	384.8	59 3/4	151.8	35 1/4	89.5	14 000	6 350	60 1/4	153.0	27 000	12 247
21 1/4	5 000	148	375.9	66	167.6	47	119.4	18 000	8 165	75 1/4	191.1	32 000	14 515

Note: L dimensions correspond to Manual-Lock types unless marked by an asterisk *.
**: Dimension U of type MPL.

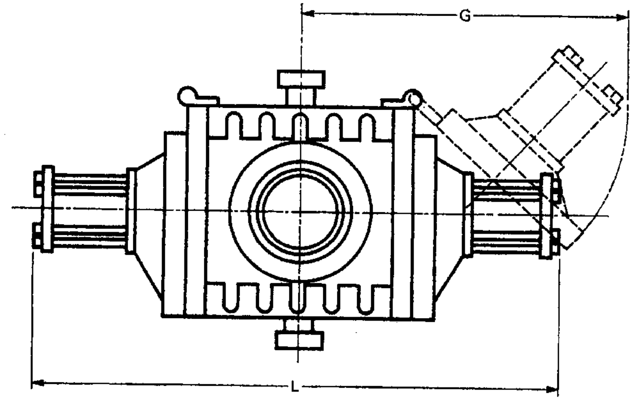




NL SHAFFER RAM-TYPE BLOW-OUT PREVENTERS
Dimensions and weights

Model	Nominal size	Working pressure	Width bonnets closed L		Overall dimensions bonnets open G		Single BOP				Double BOP				Piston size
							Height between flanges		Approximate weight		Height between flanges		Approximate weight		
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)	(in)
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	–	39 1/4	99.7	7 550	3 425	–	–	–	–	14
	7 1/16	15 000	79	200.7	46	–	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	Working pressure	Width bonnets closed L		Overall dimensions bonnets open G		Single BOP				Double BOP				Piston size
							Height between flanges		Approximate weight		Height between flanges		Approximate weight		
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)	(in)
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	11 184	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	11 506	
	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	12 088	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	13 926	78	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	Working pressure	Width bonnets closed L		Overall dimensions bonnets open G		Single BOP				Double BOP				Piston size
							Height between flanges		Approximate weight		Height between flanges		Approximate weight		
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)	(in)
SL POSLOCK and Manual-Lock	4 1/16	5 000 and 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	5 641	
	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	120.5	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	94.0	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	94.0	6 670	3 026	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	20 995	9 523	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

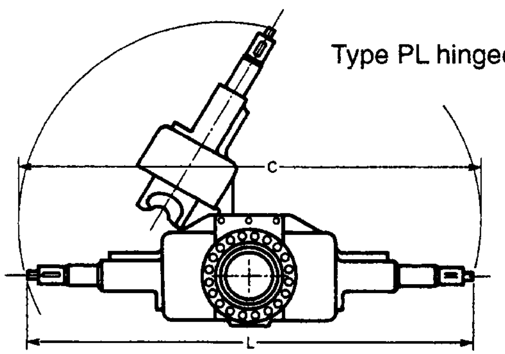
* Poslock type. All others: Manual-Lock type.

KOOMEY RAM-TYPE BLOW-OUT PREVENTERS
Dimensions and weights

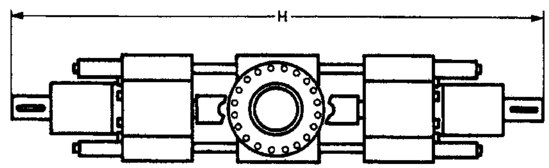
Model	Nominal size	Working pressure	Width bonnets closed L		Overall dimensions bonnets open C or H		Single BOP				Double BOP			
							Height between flanges		Approximate weight		Height between flanges		Approximate weight	
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
PL hinged	7 1/16	3 000	69.625	176.8	73.375	186.4	20.250	51.4	1 205	547	30.250	76.8	2 146	973
	7 1/16	5 000	69.625	176.8	73.375	186.4	24.000	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	143.500	364.5	27.125	68.9	7 246	3 287	44.250	112.4	13 714	6 221
	13 5/8	5 000	136.625	347.0	143.500	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	143.500	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	68.940	175.1	86.940	220.8	19.500	49.5	1 816	824	31.000	78.7	3 692	1 675
	7 1/16	5 000	68.940	175.1	86.940	220.8	22.750	57.8	1 700	771	34.250	87.0	3 230	1 465
	7 1/16	10 000	68.940	175.1	86.940	220.8	25.125	63.8	2 325	1 055	36.625	93.0	4 201	1 906
	11	3 000	102.580	260.6	126.875	322.3	26.500	67.3	5 120	2 322	40.875	103.8	9 610	4 359
	11	5 000	102.580	260.6	126.875	322.3	31.750	80.6	5 582	2 532	46.125	117.2	10 072	4 569
	11	10 000	102.580	260.6	126.875	322.3	33.630	85.4	6 313	2 864	48.000	121.9	10 804	4 901
	13 5/8	5 000	126.750	321.9	157.500	400.1	35.000	88.9	7 033	3 190	52.125	132.4	12 612	5 721
	13 5/8	10 000	126.750	321.9	157.500	400.1	36.750	93.3	–	–	53.880	136.9	–	–

KOOMEY RAM-TYPE BLOW-OUT PREVENTERS (continued)
Dimensions and weights

Model	Nominal size	Working pressure	Width bonnets closed L		Width bonnets open C or H		Single BOP				Double BOP			
							Height between flanges H		Approximate weight		Height between flanges H		Approximate weight	
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(in)	(cm)	(lb)	(kg)
PB-PRC (Power Ram Change)	7 1/16	15 000	91.750	233.0	111.000	281.9	28.375	72.1	3 200	1 452	40.875	103.8	5 825	2 642
	11	15 000	143.500	364.5	172.500	438.2	42.250	107.3	14 500	6 577	61.370	155.9	25 000	11 340
	13 5/8	10 000	136.000	345.4	166.500	422.9	39.375	100.0	11 678	5 297	56.500	143.5	20 520	9 308
	13 5/8	15 000	149.000	378.5	184.500	468.6	49.250	125.1	19 698	8 935	73.750	187.3	35 699	16 193
	18 3/4	10 000	199.125	505.8	249.125	632.8	54.560	138.6	37 274	16 907	84.250	214.0	69 524	31 536
	18 3/4	15 000	199.125	505.8	249.125	632.8	64.375	163.5	50 258	22 797	96.000	243.8	94 070	42 670
	20 3/4	3 000	212.000	538.5	260.000	660.4	36.000	91.4	18 826	8 539	55.130	140.0	35 657	16 174
	21 3/4	2 000	212.000	538.5	260.000	660.4	33.000	83.8	14 530	6 591	51.880	131.8	27 401	12 429
	21 1/4	5 000	198.000	502.9	246.000	624.8	54.500	138.4	33 698	15 285	81.750	207.6	62 418	28 313
	21 1/4	10 000	214.000	543.6	264.000	670.6	56.000	142.2	37 930	17 205	85.000	215.9	66 650	30 232



Type PL hinged



Type PL-PRC or PB-PRC

CAMERON TYPE D ANNULAR BLOW-OUT PREVENTERS
Dimensions and operating data

Model	Nominal size	Working pressure	Overall height flanged		Diameter		Weight		Closing fluid volume		Opening fluid volume	
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(gal)	(liters)	(gal)	(liters)
D	7 1/16	3 000	23 15/16	60.8	27 7/8	70.8	2 738	1 242	1.69	6.4	1.30	4.9
	7 1/16	5 000	25 1/2	64.8	27 7/8	70.8	2 778	1 260	1.69	6.4	1.69	6.4
	7 1/16	10 000	34 7/32	86.9	37 3/8	94.9	7 255	3 291	2.94	11.1	2.55	9.7
	7 1/16	15 000	44 3/4	113.7	43 1/4	109.9	12 000	5 443	6.94	26.3	6.12	23.2
	7 1/16	20 000	50 3/4	128.9	48	121.9	17 716	8 036	8.38	31.7	7.56	28.6
	11	3 000	32 1/2	82.6	41 1/4	104.8	8 255	3 744	5.65	21.4	4.69	17.8
	11	5 000	34 15/16	88.7	41 1/4	104.8	8 447	3 832	5.65	21.4	4.69	17.8
	11	10 000	41 1/16	104.3	48 1/2	123.2	13 954	6 330	10.15	38.4	9.06	34.3
	11	15 000	62 1/2	158.8	61	154.9	35 500	16 103	23.50	88.9	21.30	80.6
	13 5/8	3 000	36 11/16	93.2	50	127.0	12 885	5 845	12.12	45.9	10.34	39.1
	13 5/8	5 000	40 3/16	102.1	52 3/8	133.0	16 215	7 355	12.12	45.9	10.34	39.1
	13 5/8	10 000	49 3/32	124.7	61	154.9	27 262	12 366	18.10	68.5	16.15	61.1
	13 5/8	15 000	67 1/4	170.8	65 3/4	167.0	36 000	16 330	26.00	98.4	22.50	85.2
	16 3/4	3 000	47	119.4	60 1/2	153.7	25 950	11 771	22.32	84.5	19.00	71.9
	16 3/4	5 000	49	124.5	60 1/2	153.7	26 300	11 930	22.32	84.5	19.00	71.9
	16 3/4	10 000	65 1/2	166.4	63	160.0	35 300	16 012	40.75	154.2	35.42	134.1
	18 3/4	5 000	60 13/16	154.5	62	157.5	17 716	8 036	35.60	134.7	29.00	109.8
	18 3/4	10 000	70 1/2	179.1	67	170.2	40 940	18 570	51.00	193.0	45.10	170.7
	20 3/4	3 000	54 3/4	139.1	66	167.6	20 000	9 072	39.70	150.3	24.10	91.2
	21 1/4	2 000	53 5/16	135.4	66	167.6	19 800	8 981	39.70	150.3	24.10	91.2

HYDRIL ANNULAR BLOW-OUT PREVENTERS
Dimensions and operating data

Model	Nominal size	Working pressure	Overall height flanged		Diameter		Weight		Closing fluid volume		Opening fluid volume		Secondary chamber	
	(in)	(psi)	(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	67.7		
	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	84.00	213.4	52 250	23 701	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	14 266	35.30	133.6	35.30	133.6	16.60	62.8
	16 3/4	5 000	110 1/8 (1)	279.7	70 3/4	179.7	55 000	24 948	35.30	133.6	35.30	133.6	16.60	62.8
	Dual 18 3/4	5 000	65 1/4	165.7	76 1/4	193.7	35 000	15 876	44.00	166.5	44.00	166.5	20.00	75.7
	18 3/4	5 000	112	284.5	76 1/4	193.7	63 100	28 622	44.00	166.5	44.00	166.5	20.00	75.7
	Dual 21 1/4	5 000	77 1/2	196.9	78 1/4	198.8	45 000	20 412	58.00	219.5	58.00	219.5	29.50	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	11.20	42.4	7.50	28.4		
	7 1/16	20 000	59	149.9	58	147.3	23 000	10 433	10.90	41.3	7.20	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	3 720	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	138.4	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	Working pressure	Overall height flanged		Overall diameter		Weight		Closing fluid volume		Opening fluid volume	
	(in)	(psi)	(in)	(cm)	(in)	(cm)	(lb)	(kg)	(gal)	(liters)	(gal)	(liters)
MSP	7 1/16	2 000	25 3/4	65.41	29 7/8	75.88	1 850	839	2.85	10.8	1.98	7.5
	9	2 000	30 1/4	76.84	32	81.28	2 450	1 111	4.57	17.3	2.95	11.2
	11	2 000	31 1/4	79.38	37 1/4	94.62	3 520	1 597	7.43	28.1	5.23	19.8
	20 3/4 (1)	2 000	54 1/4	137.80	58 3/4	149.23	–	–	31.05	117.5	18.93	71.7
	21 1/4	2 000	52 1/2	133.35	58 3/4	149.23	15 100	6 849	31.05	117.5	18.93	71.7
	21 1/4 (2)	2 000	52 1/2	133.35	58 3/4	149.23	16 320	7 403	31.05	117.5	18.93	71.7
	21 1/4 (3)	2 000	48	121.92	61 1/4	155.58	12 700	5 761	31.75	120.2	19.25	72.9
	29 1/2	500	67 13/16	172.24	82 1/2	209.55	24 500	11 113	60.00	227.1	–	–
	30 (2)	1 000	58 1/8	147.64	90 1/2	229.87	32 500	14 742	87.60	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	800	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 3000	7 1/16 5000	7 1/16 10 000	7 1/16 15 000	7 1/16 20 000	9 3000	9 5000	9 10 000	11 3000	11 5000	11 10 000	13 5/8 3000	13 5/8 5000	13 5/8 10 000	16 3/4 2000	16 3/4 3000	16 3/4 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	1000

***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		Overall 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	9.0	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	12.1
B	7 1/16	5 000	30 7/8	78.4	29	73.7	3 175	1 440	4.57	17.3	3.21	12.1
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	115.7	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	88.9	14.67	55.5
B	13 5/8	5 000	44 15/16	114.1	50	127.0	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	7 825	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	14 731	40.16	152.0	32.64	123.5
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	25 878	85.00	321.7	66.00	249.8
B	21 1/4	2 000	46 1/8	117.2	49	124.5	10 850	4 922	32.59	123.4	19.92	75.4
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	55.00	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	1175	975	790	640	480			
13 5/8	3 000/5 000	1 500	1 265	8 90	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.

BOP CONTROL SYSTEM
Example of calculations for fluid capacity
(IADC Drilling Manual, 11th edition, 1992)

I APPLICATION OF BOYLE'S LAW FOR CALCULATING STORED USABLE FLUID IN A SURFACE ACCUMULATOR BOTTLES

$$P_1 \times V_1 = P_2 \times V_2$$

P_1 = initial pressure (nitrogen pre-charge)
V_1 = initial gas volume
P_2 = pressure at a later time
V_2 = gas volume at a later time

Application:

Accumulator bottle pre-charge:	1000	psi	(P_1)
Accumulator capacity:	10	gallons	(V_1)
Minimum pressure required to operate BOP:	1200	psi	(P_2)
Maximum pressure in the bottle:	3000	psi	(P_3)

Usable fluid forced out of the bottle from 3000 psi to 1200 psi: $V_2 - V_3$

$V_2 = P_1 \times V_1/P_2$ $V_3 = P_1 \times V_1/P_3$

$V_2 = 1000 \times 10/1200$ $V_3 = 1000 \times 10/3000$

$V_2 = 8.3$ gallons. $V_3 = 3.3$ gallons.

Usable fluid : 5.0 gallons

II SIZING ACCUMULATOR SYSTEM FOR SURFACE BOP

Example of BOP stack:

Hydril GK 13 5/8-5 000 (L 33)
Three U-13 5/8-10 000 (two rams and one shear ram) (L 20)

Annular gallons to close:		17.98
Two rams @ 5.8 gal each to close:		11.6
One shear ram to close:		10.9
	Total:	40.48
Plus 50% Safety Factor:		20.24
Stored Usable Fluid Required:		**60.72 gallons**

Accumulator Bottles = 60.72/5.0 =12.15   **Required bottles = 13**

Nota: Regulations of various countries and some oil companies may have specific requirements. These calculations are for example only.

BOP CONTROL SYSTEM
Example of calculations for fluid capacity
(IADC Drilling Manual, 11th edition, 1992) (continued)

III APPLICATION OF BOYLE'S LAW FOR CALCULATING STORED USABLE FLUID IN A SUBSEA ACCUMULATOR BOTTLES

$$P_1 \times V_1 = P_2 \times V_2$$

In subsea, the pre-charge pressure must be added with the seawater hydrostatic pressure : seawater hydrostatic gradient = 0.445 psi per foot

Application in 3000 feet of water:

Accumulator capacity: 10 gallons (V_1)

Accumulator bottle pre-charge in 3000 feet of water:

$1000 + 3000 \times 0.445 = 2335$ psi (P_1)

Minimum pressure required to operate BOP in 3000 feet of water:

$2335 + 200 = 2535$ psi (P_2)

Maximum pressure in the bottle in 3000 feet of water:

$2335 + 2000 = 4335$ psi (P_3)

Usable fluid forced out of the bottle from 4535 psi to 2535 psi: $V_2 - V_3$

$V_2 = P_1 \times V_1/P_2$	$V_3 = P_1 \times V_1/P_3$
$V_2 = 2335 \times 10/2535$	$V_3 = 2335 \times 10/4335$
$V_2 = 9.2$ gallons	$V_3 = 5.4$ gallons.

Usable fluid: 3.8 gallons

IV SIZING ACCUMULATOR SYSTEM FOR SUBSEA BOP

Example of BOP stack:

Hydril GK 13 5/8-5000 (L 33)

Three U-13 5/8-10000 (two rams and one shear ram) (L 20)

Annular gallons to close:	17.98
Annular gallons to open:	14.16
Two rams @ 5.8 gal. each to close:	11.6
Two rams @ 5.4 gal. each to open:	10.8
One shear ram to close:	10.9
One shear ram to open:	10.5
Total:	75.94
Plus 50% Safety Factor:	37.97
Stored Usable Fluid Required:	**113.91 gallons**

BOP CONTROL SYSTEM
Example of calculations for fluid capacity
(IADC Drilling Manual, 11th edition, 1992) (continued)

At least the capacity to close the annular and one ram will be mounted **subsea**:

Subsea capacity	=	17.98 + 11.6	=	29.58 gallons
Subsea bottles	=	29.58/3.8	=	7.78 or **8** bottles
Surface capacity	=	113.91 - 29.58	=	84.33 gallons
Surface bottles	=	84.33/5.0	=	16.87 or **17** bottles

Nota: These subsea bottles must be of 5000 psi Working Pressure. Regulations of various countries and some oil companies may have specific requirements. These calculations are for example only.

SCHEMATIC SYMBOLS FOR FLUID POWER DIAGRAMS
(Based on ANSI Y. 32.10)
(API Spec 16D, 1st edition, March 1, 1993)

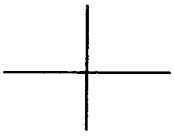
: Main lines

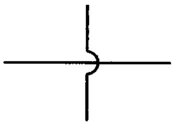

: Hydraulic lines

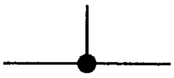

: Pneumatic lines

: Pilot lines (dashes)

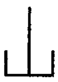
: Drain lines (dotted)

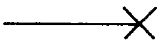

: Lines crossing (not connected)

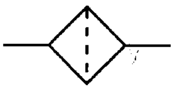

: Lines crossing (alternate)

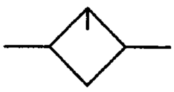

: Lines connected

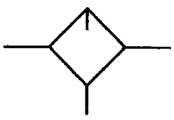

: Connected to reservoir (above fluid level)

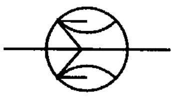

: Connected to reservoir (below fluid level)

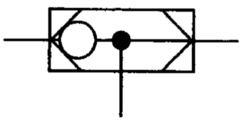

: Plugged port

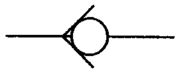

: Filter or strainer

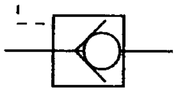

: Lubricator without drain

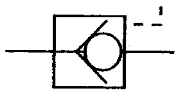

: Lubricator with drain

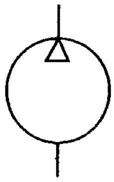

: Totalizing flow meter

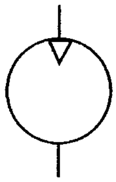

: Shuttle valve

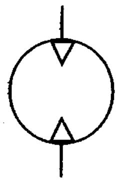

: Check valve (free flow is from left to right)

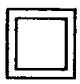

: Pilot operated check valve (pilot to open)

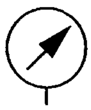

: Pilot operated check valve (pilot to close)

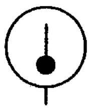

: Compressor, fixed displacement, pneumatic

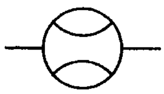

: Motor, uni-directional, pneumatic

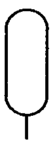

: Motor, bi-directional, pneumatic


: Internal combustion engine

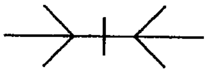

: Pressure gauge

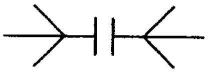

: Temperature gauge

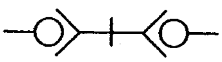

: Flow rate flowmeter

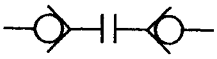

: Receiver, air or gas

SCHEMATIC SYMBOLS FOR FLUID POWER DIAGRAMS
(Based on ANSI Y. 32.10)
(API Spec 16D, 1st edition, March 1, 1993)
(continued)


: Quick disconnect, connected

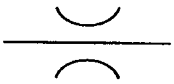

: Quick disconnect, disconnected

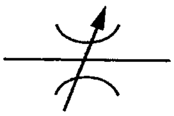

: Quick disconnect, with check valve, vonnected


: Quick disconnect, with check valve, disconnected


: Manual shut off valve, normally open

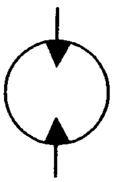

: Manual shut off valve, normally closed

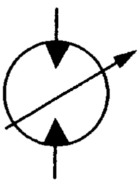

: Orifice, fixed

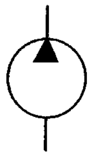

: Adjustable orifice

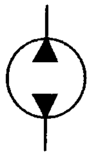

: Accumulator, spring loaded

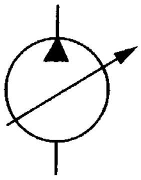

: Accumulator, gas charged

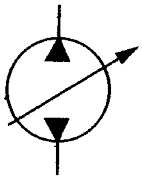

: Hydraulic motor, fixed displacement bi-directional


: Hydraulic motor, variable displacement uni-directional

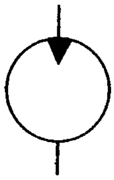

: Pump, hydraulic, uni-directional, fixed displacement

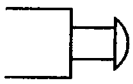

: Pump, hydraulic, bi-directional, fixed displacement

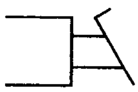

: Variable displacement hydraulic pump, uni-directional

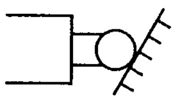

: Variable displacement bi-directional hydraulic pump

: Electric motor

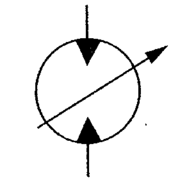

: Hydraulic motor fixed displacement, uni-directional


: Push button operator

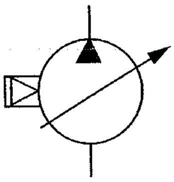

: Foot pedal operator


: Mechanical operator

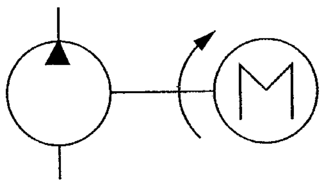
SCHEMATIC SYMBOLS FOR FLUID POWER DIAGRAMS
(Based on ANSI Y. 32.10)
(API Spec 16D, 1st edition, March 1, 1993)
(continued)



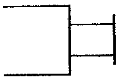
: Hydraulic motor, variable displacement, bi-directional



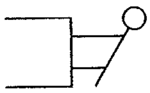
: Air operated variable displacement uni-directional hydraulic pump



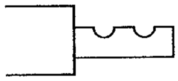
: Electric motor driven, fixed displacement uni-directional hydraulic pump



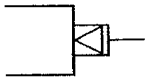
: Manual operator



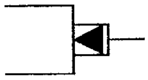
: Lever operator



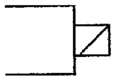
: Two position detent



: Pneumatic pilot

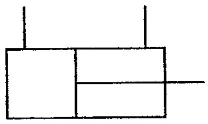


: Hydraulic pilot

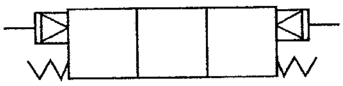


: Solenoid operator

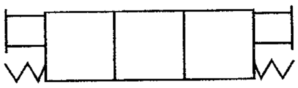
: Spring



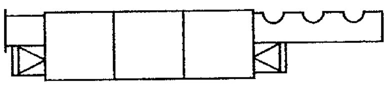
: Cylinder, double acting



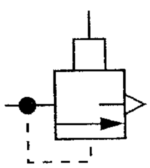
: 3 Position, double air pilot operated, spring centered



: 3 Position, manual operated, spring centered

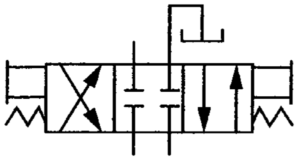


: 3 Position, double air pilot operated, with manual overside, detented, valve

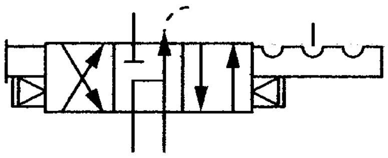


: Relief valve, remote pilot set, vented to atmosphere

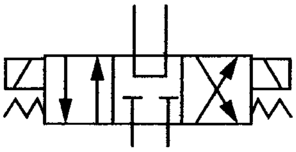
SCHEMATIC SYMBOLS FOR FLUID POWER DIAGRAMS
(Based on ANSI Y. 32.10)
(API Spec 16D, 1st edition, March 1, 1993)
(continued)



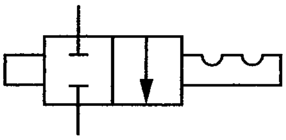
: 4 way, 3 position, manual operated, spring centered, center position, all ports blocked



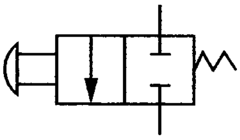
: 4 way, 3 position, pilot cylinder operated with manual override, detented, pressure blocked, cylinders vented to ambient in the center position, valve



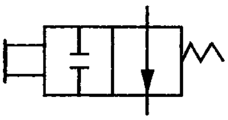
: 4 way, 3 position, solenoid operated, spring centered, pressure connected to return, cylinder ports blocked, valve



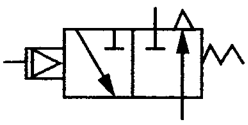
: 2 way manual operated, detented valve (shown in the closed position)



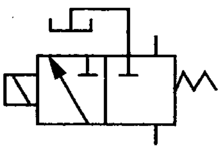
: 2 way, push button operated, spring return, normally close valve



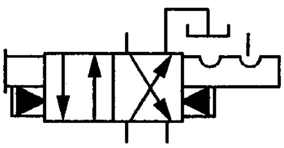
: 2 way, manual operated, spring return, normally open valve



: 3 way, pneumatic pilot operated, spring return, normally closed valve (fluid vents to ambient)

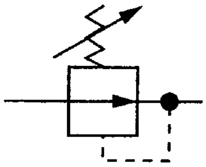


: 3 way solenoid operated, spring return, normally open valve (fluid vent is connected to reservoir)

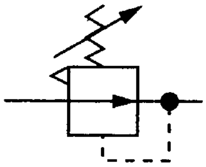


: 4 way, two position, hydraulic pilot operated with manual override, detented valve (fluid vent is connected to reservoir)

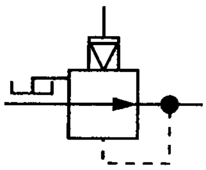
SCHEMATIC SYMBOLS FOR FLUID POWER DIAGRAMS
(Based on ANSI Y. 32.10)
(API Spec 16D, 1st edition, March 1, 1993)
(continued)



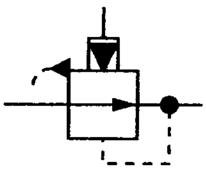
: Regulator, manual set, non-relieving



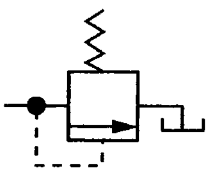
: Regulator, manual set, relieving type (fluid vented to ambient)



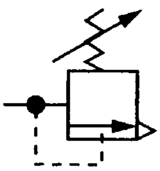
: Regulator, air pilot operated, relieving (fluid vent connected to reservoir)



: Regulator, hydraulic pilot operated, relieving (fluid vented to ambient)



: Relief valve, non adjustable (vent connected to reservoir)



: Relief valve, adjustable (vented to ambient)

M

geology

TERTIARY AND QUATERNARY CENOZOIC ERAS

Age (Ma) Cosuna	Age (Ma) Odin	Systems / Period	Series / Epoch		STAGES – AGES: Standard classification	Sub-stages and/or local equivalents		Orogenic phases
0.01		QUATERNARY	Holocene		Versilian	Flandrian		
		QUATERNARY	PLEISTOCENE	Upper	Tyrrhenian Milazzian Sicilian			Pasadenian
		QUATERNARY	PLEISTOCENE	Lr.	Emilian Calabrian	Villafranchian		
5.3		NEOGENE (Nummulitic)	Pliocene		Astian Plaisancian Zanclean Tabianian	Villafranchian	Dacian	Walachian Rhodanian Attic
		NEOGENE (Nummulitic)	MIOCENE	Upper	Messinian Tortonian		Pontian Meotian Sarmatian	
		NEOGENE (Nummulitic)	MIOCENE	Mid	Serravallian Langhian	Helvetian		
25	23	NEOGENE (Nummulitic)	MIOCENE	Lower	Burdigalian Aquitanian	Vindobodian		
38	38	PALEOGENE	Oligocene		Chattian Rupelian Stampian	Sannoisian		Lepontine
		PALEOGENE	EOCENE	Upper	Bartonian Priabonian	Ludian Marinesian Auversian	Lattorfian Tongrian	Pyrenean
		PALEOGENE	EOCENE	Mid	Lutetian	Ledian	Biarritzian	
55	55	PALEOGENE	EOCENE	Lr.	Ypresian	Cuisian Sparnacian	Ilerdian	
67	65	PALEOGENE	Paleocene		Thanetian Montian Danian	Landenian		Laramide

ALPINE

From J. Guillemot, *Elements of Geology*, Éditions Technip, Paris 1991.

SECONDARY MESOZOIC ERA

Cosuna	Odin	Systems / Period	Series / Epoch		STAGES – AGES: Standard classification	Sub-stages and/or local equivalents			Orogenic phases
Age (Ma)									
		CRETACEOUS	Upper	Senonian	Maestrichtian	Aturian	Rognacian Begudian Fuvelian Valdonian		
					Campanian				
					Santonian Coniacian	Emscherian			
					Turonian	Provencian Ligerian	Angoumian Salmurian		eo-Alpine
100	95				Cenomanian				
			Lower		Albanian	Vraconian Clansayesian Gargasian Bedoulian	Gault	Urgonian	
					Aptian				
					Barremian		Wealden		
					Hauterivian Valanginian	Neocomian			
140	130				Berriasian		Purbeckian		Late Cimmerian
		JURASSIC	Upper	Malm	Portlandian Kimmeridgian	Tithonian	Volgian		
160	158				Oxfordian		Sequanian Rauracian Argovian		
180	178			Dogger	Callovian Bathonian Bajocian Aalenian				ALPINE
			Lower	Lias	Toarcian				
					Pliensbachian	Charmoutian	Domerian Carixian		
					Sinemurian	Lotharingian			
200	204				Hettangian				
			Trias		Rhaetic Norian Carnian		Keuper		Early Cimmerian
					Ladinian		Muschelkalk		
250	245				Anisian Scythian	Wirglorian Werfenian	Bundsandstein		Palatinian

From J. Guillemot, *Elements of Geology*, Éditions Technip, Paris 1991.

PRIMARY PALEOZOIC ERA

Age (Ma) Cosuna	Age (Ma) Odin	Systems / Period	Series / Epoch	STAGES — AGES: Standard classification	Sub-stages and/or local equivalents		Orogenic phases	
		PERMIAN	Upper	Tatarian Kazanian	Thuringian	Zechstein	Saalian	VARISCAN
290	290		Lower	Kungurian Artinskian Sakmarian	Saxonian Autunian	Rotliegende		
330		CARBONI-FEROUS	Upper	Stephanian Westphalian Namurian	Ouralian Moscovian Bashkirian	Pennsylvanian	Asturian Sudetic	
365	360		Lower	Dinantian	Visean Tournaisian	Mississippian	Bretonic	
		DEVONIAN	Upper	Famennian	Strunian	Old Red Sandstones		
				Frasnian				
			Middle	Givetian Couvinian	Eifelian		eo-Hercinian	
405	400		Lower	Emsian Siegenian Gedinnian	Coblenzian		Ardennes	
		SILURIAN	Upper	Pridoli Ludlow Wenlock				CALEDONIAN
425	418		Lower	Llandoverey			Taconic	
		ORDO-VICIAN	Upper	Ashgill Caradoc				
			Middle	Llandeilo Llanvirn			Sardinian	
500	495		Lower	Arenig Tremadoc				
570	530	CAMBRIAN		Postdamian Acadian Georgian			Cadomian	
	1000	PRECAMBRIAN	Protero-zoic	Brioverian	Algonkian	Infracambrian	Grenvillian	
2500	2000			Pentevrian		Vendian Riphaean		
	3000 4000			ARCHAEAN				

From J. Guillemot, *Elements of Geology*, Éditions Technip, Paris 1991.

TABLE OF GRAIN SIZE CLASSES

Φ scale	10	9	8	7	6	5	4	3	2	1	0	−1	−2	−3	−4
Fractions of mm			$\frac{1}{256}$	$\frac{1}{128}$	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$					
	1 µm	2	4	8	16	31	62.5	125	250	500	1 mm	2	4	8	16

	Lutites		Arenites					Rudites		
			Sands							
Loose	Clay	Silt	Very fine	Fine	Medium	Coarse	Very coarse	Granules	Gravel	Pebbles
Consolidated	Mudstones	Siltstones	Sandstones					Conglomerates		

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, *Elements of Geology*, Éditions Technip, Paris 1991.

REPRESENTATION OF SEDIMENTS (1)

1 PREDOMINANTLY SHALE ROCKS

1.1 One-component rocks

Clay, shale

1.2 Two-component rocks

ALS Slightly sandy shale

ASB Sandy shale

ASL Silicified claystone

ACL Calcareous shale

ADL Dolomitic shale

2 PREDOMINANTLY SILICA ROCKS

2.1 One-component rocks

Slt SLT Silt

SFN Fine to very fine sand

SMN Medium sand

SGR Coarse to very coarse sand

Sti STI Siltstone

GFN Fine to very fine sandstone

GMN Medium sandstone

GGR Coarse to very coarse sandstone

QTZ Quartzite

SLX Chert

2.2 Two-component rocks

STA Argillaceous silt

GAR Argillaceous sandstone

GCL Calcareous sandstone

GDL Dolomitic sandstone

GMO Asphaltic or bituminous sandstone

GCQ Shelly sandstone

3 PREDOMINANTLY CARBONATE ROCKS

3.1 Predominantly limestone rocks

3.1.1 One-component rocks

CLC Limestone

CRA Chalk

Coo COO Oolitic limestone

CCN Reefal limestone

CCQ Coquina

(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

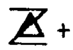
× Glauconite

■ Pyrite

EXPLORATION SYMBOLS IN DRILLING

SHOWS

A. Shows from cuttings and cores

Oil in mass	●
Oil in fractures	
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	● M
Direct fluorescence (pale +, bright + +, very bright + + +)	$▲^{M}{}_{+}$
Gas (y, z,...)[2]	$☼^{M}_{y}$
Gasoline, condensate	
Sulfides dissolved in mud	$S^{--}M$
Losses	
Gains	

(1) x = hydrocarbons, H_2S, etc.
(2) y, z, ... = hydrocarbons, CO_2, N_2, H_2S, 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	– 78.2 (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} (i-C_4)	– 11.8	2.075
n-butane	C_4H_{10} (n-C_4)	– 0.5	2.081
Isopentane	C_5H_{12} (i-C_5)	27.8	2.626
n-pentane	C_5H_{12} (n-C_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 depends 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, etc.) and the extrapolated value based on the normal trend.

One of the most widely used parameter is the rate of penetration.

The "*d* exponent" method of Jordan and Shirley

The *d* exponent is only significant in shale and with milled tooth bits (rock bits).

The interpretation is based on the assumption of undercompacted shales:

$$v_a = KN\left(\frac{WOB}{D}\right)^d$$

where:

- v_a = rate of penetration (**m/h** or ft/h)
- WOB = weight on bit (**t** or lb)
- N = speed of rotation of the bit (**rpm**)
- D = bit diameter (**in**)
- K = proportionality factor
- d = *d* exponent

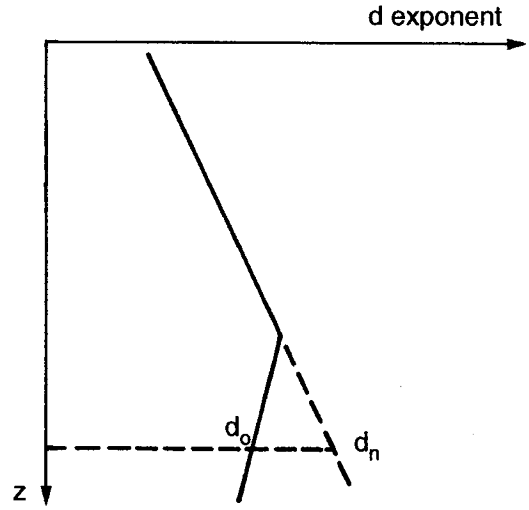
$$\boxed{d = \frac{\log \frac{v_a}{N}}{\log \frac{WOB}{D}}}$$

$$d = \frac{\log \frac{v_a}{60N}}{\log \frac{12WOB}{10^6 D}} \quad \text{or} \quad d = \frac{1.26 - \log \frac{v_a}{N}}{1.58 - \log \frac{WOB}{D}}$$

American units — Combined units (in bold above)

$$P_f = P_{fn}\frac{d_n}{d_o}$$

- P_f = observed pore pressure
- P_{fn} = normal pore pressure at depth Z
- d_n = *d* exponent extrapolated on the normal curve
- d_o = *d* exponent calculated at the same depth



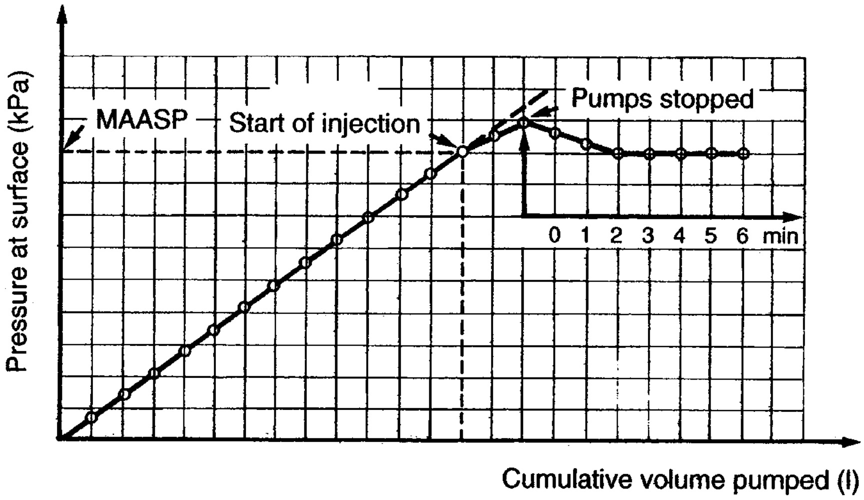
FRACTURING GRADIENT AND LEAK OFF TEST

EATON FORMULA

$$P_{frac} = P_f + \frac{\mu}{1-\mu}(S - P_f)$$

P_{frac} = fracturing pressure
P_f = pore pressure
S = overburden pressure (weight of formations)
μ = Poisson's ratio (0.25 to 0.50)

LEAK OFF TEST



$$P_{frac} = \text{MAASP} + 9.81\,Z_s d \qquad d_{frac} = \frac{P_{frac}}{9.81\,Z_s}$$

where:

P_{frac} = fracturing pressure (kPa)
MAASP = pressure at start of injection point (kPa)
d_{frac} = fracture density (kg/l)
d = mud density in the well during leak off test (kg/l)
Z_s = depth of weak point (or shoe) (m)

MUD COMPRESSIBILITY

Water Base Mud (WBM)	Oil Base Mud (OBM)	Base Oil
0.45 10^{-6} kPa^{-1} 0.30 10^{-5} psi^{-1} 0.45 10^{-2} liters/bar per m^3 4.5 liters per bar for 100 m^3 4.5 liters per m^3 for 100 bar 4.5 liters per MPa for 10 m^3 4.5 liters per m^3 for 10 MPa 3 liters per m^3 for 1000 psi 0.125 gal per bbl for 1000 psi	0.80 10^{-6} kPa^{-1} 0.55 10^{-5} psi^{-1} 0.80 10^{-2} liters/bar per m^3 8 liters per bar for 100 m^3 8 liters per m^3 for 100 bar 8 liters per MPa for 100 m^3 8 liters per m^3 for 100 MPa 5.5 liters per m^3 for 1000 psi 0.229 gal per bbl for 1000 psi	0.70 10^{-6} kPa^{-1} 0.47 10^{-5} psi^{-1} 0.70 10^{-2} liters/bar per m^3 7 liters per bar for 100 m^3 7 liters per m^3 for 100 bar 7 liters per MPa for 10 m^3 7 liters per m^3 for 10 MPa 4.7 liters per m^3 for 1000 psi 0.192 gal per bbl for 1000 psi

ABBREVIATIONS USED IN WIRELINE LOGGING

Halliburton

Resistivity	
DIL	Go Dual Induction
DIND	Dits Dual Induction
DLL	Standard Dual Laterolog
HDIL	Hostile Dual Induction
HEDL	Hostile Env. Dual Laterolog
LL3	Laterolog 3
MICLOG	Microlog
MSFL	Micro-Spherically Focused

Radioactivity	
CDL	Compensated Density Log
CNT	Conpensated Neutron Log
DSEN	Dual Spacing Epithermal Neutron
EVRSDL	Spectral Density (EVR)
GAMMA	Gamma Ray Tool
GR_xyz	Natural Gamma + xyz
HDSN	Hostile Dual Spaced Neutron
HGNC	Hostile CCL/Gamma/Neutron
HSDL	Hostile Spectral Density Inst.
RMT	Reservoir Monitor Tool
SDL	Spectral Density
SGR	Spectral Gamma Ray
SLD	Spectral Litho-Density
TMD	Thermal Multigate Decay
TMDL	Thermal Multigate Decay Lith.
TRAC_x	Tracer Scan - x

Acoustic	
BCS	Compensated Sonic
CAST	Acoustic Scanning Tool
CBL	Cement Bond Log
FWS	Full Wave Sonic
HFWSA	Hostile Sonic - Full Wave (A)

Diplog and Caliper	
CAL_x	Caliper x
FEDOLD	Four Arm Dipmeter
FIAC	Four Independant Arm Caliper
HECT	Hostile Four Arm caliper
MACT	Multi-Arm Caliper Tool
MSFCAL	MSFL Caliper
SED	Six Electrode Dipmeter (DITS)
XYCA	Analog XY Caliper

Formation Sampling	
PQ_PL	Pressure -[Petro-Quartz]
SFT	Sequential Formation Tester
SFT4	SFT4 Petro Quartz

Production Logging	
BATS	Borehole Audio Tracer Survey
CEN_x	Production Logging Centralizer
CENT	Bottom Centralizer in FWST
CQP_MP	Pressure [Petro-Quartz]
FDF_TT	Flow Diverter - TTTC
FLD_PL	Fluid Density
FLTT	Fluid travel Tool
FMS_MP	High Sensitive Flowmeter
GHT	Gas Holdup Mux
H_CENT	Hostile Centralizer
HMR_MC	HMR Quartz Pressure Tool
HYD_xy	Center Sample Hydrometer
M_FLOW	Sondex Fullbore Flowmeter
M_GRAD	Sondex Gradiometer
QPG_MP	Quartz Pressure Tool
SPIN	DC Spinner
TEMPDC	Temperature
TPH_PL	Temperature High Resolution

ABBREVIATIONS USED IN WIRELINE LOGGING

Halliburton (continued)

Pipe Evaluation

Plug Setting and Mechanical

Auxiliary

BRID	Cable Electrode Bridle
DTD	Downhole Tension Device
DTEN	Differential Tension
FLEX	Flex joint
HDTD	Hostile Downhole Tension Sub

Pipe Recovery

CIC	Casing Inspection Caliper
CIT	Casing Inspection Tool
PIT	DITS Pipe Inspection Tool
PIT8	Pipe Inspection Tool (8 pad)

Perforating

CCL	Casing Collar Locator
M157	M157 Gamma Perforator
M187	M187 Gamma Perforator

ABBREVIATIONS USED IN WIRELINE LOGGING

Schlumberger

Resistivity

AIT	Array Induction Imager Tool
ALAT	Azimuthal Laterolog
ARC	Array Resistivity Compensed Tool (Anadrill)
CDR	Compensated Dual Resistivity Tool (Anadrill)
DIT	Dual Induction Tool (SFL or LL8)
DLT	Dual Laterolog Tool
DST	Dual Laterolog Tool with SRT (MSFL)
ES	Electrical Survey Tool
HALS	HILT Azimuthal Laterolog Sonde
IRT	Induction Logging Tool (w/o SN)
ISF	Induction Spherical Focused Log
LL3	Laterolog 3 Sonde
LL7	Laterolog 7 Sonde
MCFL	HILT Micro-Cylindrical Focused Log Device
MLL	Microlaterolog Tool
MLT	Microlog Tool
MPT	Microlog Proximity Tool (PL)
RAB	Azimuthal Resistivity At the Bit Tool (Anadrill)
SRT	Micro Spherical Focused Resistivity Tool

Radioactivity

AACT	Aluminium Activation Clay Tool
ADN	Azimuthal Density Neutron Tool (Anadrill)
AGS	Aluminium Gamma Ray Spectroscopy Sonde
APS	Accelerator Porosity Sonde
CDN	Neutron Density Sonde (Anadrill)
CGRS	Compact Gamma Ray Sonde
CNT	Compensated Neutron Tool
ECS	Elemental Capture Spectroscopy Cartridge
FGT	Formation Gamma Ray Tool
FSMT	Formation Subsidence Monitoring Tool
GFT	Formation Tester Gamma Ray Tool
GNT	Gamma Neutron tool
GPT	Gamma Ray Perforating Tool
GRA	Geochemical Reservoir Analyzer
GRT	Gamma Ray Tool
GST	Gamma Spectroscopy Tool
HLDT	Hostile Environment Litho Density Tool
HNGT	Hostile Natural Gamma Ray Spectroscopy Tool
HSGT	Hostile Environment Gamma Ray Tool
LDS	Litho Density Tool (IPLT)
LDT	Litho Density Tool
MIST	Multiple Isotope Spectroscopy Tool
MSGT	Scintillation Gamma Ray Tool
NDT	Neutron Depth Tool
NFD	Nuclear Fluid Density Tool
NGT	Natural Gamma Ray Spectroscopy Tool
NPLT	Nuclear Porosity Lithology Tool (IPLT)
PGGT	Powered Gun Gamma Ray Tool

Radioactivity

PGT	Compensated Density Tool
PNT	Sidewall Neutron Tool (SNP)
RST	Reservoir Saturation Tool
SGT	Scintillation Gamma Ray Tool
SLDT	Slimhole Litho-Density Tool
SSGT	Scintillation Gama Ray Tool
SWT	Water Saturation Tool
TDT	Thermal Decay Time Tool

Acoustic

ASMT	Acoustic Sonde Measuring Tool
AST	Acoustic Scanner Tool
BHTV	Borehole Televiewer
CBT	Cement Bond Tool
CET	Cement Evaluation Tool
CMT	Circumferential Microsonic Tool
CSAT	Combined Seismic Acquisition Tool
CWRT	Cross Well Receiver Tool
DSA	Downhole Seismic Array
DSLT	Digitizing Sonic Logging Tool
DSST	Dipole shear Sonic Imager Tool
DWST	Digital Waveform Sonic Tool
ISONIC	Sonic Tool (Anadrill)
QSST	Quick Shot Seismic Tool
SAT	Seismic Acquisition Tool
SDT	Sonic Digital Tool (AS, BHC, DDBHC, CBL)
SLT	Sonic Logging Tool (BHC, DDBHC, CBL)
SSLT	Slim Sonic Logging Tool
UBI	Ultrasonic Borehole Imager
UCI	Ultrasonic Corrosion Imager
USIT	Ultrasonic Imaging Tool
WST	Seismic Acquisition Tool

Diplog and Caliper

CALI	Generalized Caliper
ECD	Eccentred Caliper Device
EDAC	Eccentred Dual Axis Caliper
HDT	High Resolution Dipmeter Tool
FBST	Full Bore Scanner Tool (FMI)
MCD	Mechanical Caliper Device
MEST	Micro-Electrical Scanner Tool (FMS)
OBDT	Oil Base Mud Dipmeter Tool
PCD	Powered Caliper Device
SHDT	Stratigraphic High Res. Dipmeter Tool
SPCS	Slim Powered Caliper Sonde
TCS	Through Tubing Caliper Sonde
VCD	Caliper Device

ABBREVIATIONS USED IN WIRELINE LOGGING

Schlumberger (continued)

Formation Sampling

CST	Core Sidewall Takeri
FIT	Formation Interval Tester
MDT	Modular Formation Dynamics Tester
MSCT	Mechanical Sidewall Coring Tool
PST	Production Fluid Sampler Tool
RFT	Repeat Formation Tester

Production Logging

CFS	Continuous Flowmeter Sonde
DEFT	Digital Entry and Fluid Imager Tool
EFM	Electrical Flowmeter Tool (Flopetrol-John.)
FBDS	Full Bore Directional Spinner Flowmeter Sonde
FBS	Full Bore Spinner Flowmeter Sonde
GMS	Gradiomanometer Sonde
HCFT	Flowmeter Sonde
HTT	High Resolution Thermometer Tool
HUM	Hold Up Meter
LEE_FM	Flowmeter manufactured by Lee Tools
LIFT	Local Impedance Flowmeter Tool
PBFT	Petal Basket Flowmeter Tool
RCT	Flowmeter Transmitter (Rotron type)
SCTT	Sidewall Contact Temperature Tool
SVFS	Slim Hole Vortex Flowmeter Sonde
TEMP	Temperature
TMT	Temperature Manometer Tool

Pipe evaluation

CIT	Casing inspection Tool
CPET	Corrosion Protection Evaluation Tool
ETT	Electromagnetic Thickness Tool
FTGT	Tubing Geometry Tool
MFCT	Multi-Finger Caliper Tool
PAT	Pipe Analysis Tool
PHAT	Pit and Hole Analysis Tool

Plug Setting and Mechanical

BO	Back-off Tool
CCL	Casing Anomaly Locator
CERT	Correlatable Electromagnetic Recovery Tool
	Free Point Indicator Tool
FPIT	Mechanical Plugback Tool
MPBT	Production Packer Tool
SPPT	

Auxiliary

ACTS	Auxiliary Compression Tension Sub
AMS	Auxiliary Measurement Sonde
EMS	Environment Measurement Sonde
MPD	Magnetic Positioning Device
NOSE	Nose Orienting Scanning Equipment
TTG	Through Tubing Guide

Perforating

GUN	Perforating Gun
PGGT	Powered Gun Gamma Ray Tool

ABBREVIATIONS USED IN WIRELINE LOGGING

Western Atlas

Resistivity

DEL2	Dielectric Log 200MHz
DIFL	Dual Induction-Focused Log
DLL	Dual Laterolog
DPIL℠	Dual Phase Induction Log
IEL	Induction Electrolog
ML	Minilog®
MLL	Micro Laterolog
TBRT®	Thin-Bed Resistivity

Radioactivity

CDL	Compensated Densilog℠
CN	Compensated Neutron Log
GR	Gamma Ray Log
HYDL	Hydrolog℠
MRIL®	Magnetic Resonance Imaging Log
MSI	Multiparameter Spectroscopy Instrument
PDK	PDK-100®
PFC	Perforation-Formation-Collar Log
PRSM	PRISM® Log
SL	Spectralog®
ZDL	Compensated Z-Densilog℠

Acoustic

AC	BHC Acoustilog
ACL	Long-Spaced BHC Acoustilog℠
BAL®	Bond Attenuation Log
CBIL℠	Circumferential Borehole Imaging Log
CBL	Acoustic Cement Bond Log
DAC℠	Digital Array Acoustilog℠
DAL	Digital Acoustilog
DRB℠	Dual Receiver Bond Log
MAC℠	Multiple Array Acoustilog℠
SBT℠	Segmented Bond Tool
SRB	Single Receiver Bond Log

Diplog® and Caliper

2CAL	2-Arm Caliper Log
3CAL	3-Arm Caliper Log
4CAL	4-Arm Caliper Log
DIP	High Resolution 4-Arm Diplog
HDIP℠	Hexagonal Diplog℠

Formation Sampling

CHFT	Cased Hole Formation Tester
FMT	Formation Multi-Tester
FQPG	Fast Response Quartz Pressure Gauge
QPG	Quartz Pressure Gauge
RCI℠	Reservoir Characterization Instrument
RCOR℠	Rotary Sidewall Coring Tool
SWC	Sidewall Corgun
VPC	VPC Formation Multi-Tester

Production Logging

CCL	Casing Collar Locator
DWP	Downhole Wireline Packoff
FCON	Fluid Conductivity Log
FDDP	Differential Pressure Fluid Density
FDN	Nuclear Fluid Density
FMBK	Basket Flowmeter
FMCS	Continuous Spinner Flowmeter
FMFI	Folding Impeller Flowmeter
FQPG	Fast Response Quartz Pressure Gauge
NFL	Nuclear Flolog℠
PHT	Photon Log
QPG	Quartz Pressure Gauge
SON	Sonar
SPG	Strain Pressure Gauge
SRPL	Surface Recorded Pressure Log
SWAT	Swing-Arm Tracerlog
TBFS	Through-Tubing Borehole Fluid Sampler
TCAL	Through-Tubing (X-Y) Caliper
TEMP	Differential Temperature
TRL	Tracerlog
VIBR	Vibrator
WHI	Water Holdup Indicator

ABBREVIATIONS USED IN WIRELINE LOGGING

Western Atlas (continued)

Pipe Evaluation

CPP	Casing Potential Profile
DMAG	Digital Magnelog^{SM}
DVRT	Digital Vertilog^{SM}
MAG	Magnelog^{SM}
MFC	Multi-Finger Caliper
MVRT	Multichannel Vertilog^{SM}
VRT	Vertilog®
VTLN	Vertiline^{SM}

Plug Setting and Mechanical

BP	Bridge Plug
CRET	Cement Retainer
DB	Dump Bailer
JCGR	Junk Catcher Gauge Ring
PDB	Positive Displacement Dump Bailer
PPKR	Production Packer
SB	Sinker Bar
TTBP	Through-Tubing Bridge Plug

Auxiliary

BHVC	Borehole Video Camera
CHTS	Cablehead Tension Sub
DIRO	Photoinclinometer
EMT	Electromagnetic Fishing Tool
ORIT	Instrument Orienting Log
PSM	Precision Subsidence Monitoring
TFLR	Fluid Resistivity
TTEM	Temperature
TTEN	Tension
TTRM^{SM}	TTRM Sub

Pipe Recovery

BHJ	Bottomhole Junk Shot
BO	String Shot-Back Off
CC	Chemical Cutters
FG	Feeler Gauge
FPST	Spring-Tector^{SM} Freepoint Indicator
FPTM	Tri-Mag Freepoint Indicator
HCS	Hydraulic Cleanout Service
JCS	Jet Cutters
MST	Metal Severing Tool
PRL	Pipe Recovery Log
SSH	Surface Shot

Perforating

AJ	Alpha Jet™
EBC	Expendable Bar Carrier
EGUN	Bullet Guns
EHC	Expendable Hollow Carrier
EMO^{SM}	Electromagnetic Orientation Tool
JJ	Jumbo Jet®
PHC	Ported Hollow Carrier
POL	Perforating Orientation Log
SJ	Silver Jet®
TCP	Tubing-Conveyed Perforating

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