Appendix D

D-1
Alphabetical Conversion Factors

A

Acre	$\times 10$	= Square chain (Gunters)
Acre	$\times 160$	= Rods
Acre	$\times 1 \times 10^5$	= Square links (Gunters)
Acre	$\times 0.4047$	= Hectare or square hectometer
Acres	$\times 43{,}560$	= Square feet
Acres	$\times 4{,}047$	= Square meters
Acres	$\times 1.562 \times 10^{-3}$	= Square miles
Acres	$\times 4{,}840$	= Square yards
Acre-feet	$\times 43{,}560$	= Cubic feet
Acre-feet	$\times 3.259 \times 10^5$	= Gallons
Amperes/square centimeters	$\times 6.452$	= Amperes/square inch
Amperes/square centimeters	$\times 10^4$	= Amperes/square meter
Amperes/square inch	$\times 0.1550$	= Amperes/square centimeters
Amperes/square inches	$\times 1{,}550$	= Amperes/square meter
Amperes/square meter	$\times 10^{-4}$	= Amperes/square centimeter
Amperes/square meter	$\times 6.452 \times 10^{-4}$	= Amperes/square inch
Ares	$\times 0.02471$	= Acre (USA)
Ares	$\times 119.60$	= Square yards
Ares	$\times 100$	= Square meters
Atmospheres	$\times 14.7$	= Pounds/square inch
Atmospheres	$\times 1.058$	= Tonnes/square foot
Atmospheres	$\times 29.92$	= Inches of mercury at 0° C
Atmospheres	$\times 76$	= Centimeters of mercury
Atmospheres	$\times 33.90$	= Feet of water at 4° C
Atmospheres	$\times 1.0333$	= Kilograms/square centimeter
Atmospheres	$\times 10{,}332$	= Kilograms/square meter
Atmospheres	$\times 1{,}013.2$	= Millibar
Atmospheres	$\times 760$	= Millimeters of mercury
Atmospheres	$\times 10.332$	= Meters of water at 4° C

B

Barrels (USA, dry)	$\times 7{,}056$	= Cubic inches
Barrels (USA, dry)	$\times 105$	= Quarts (dry)
Barrels (USA, liquid)	$\times 31.5$	= Gallons
Barrels (oil)	$\times 42$	= Gallons (oil)
Barrels (oil)	$\times 0.159$	= Cubic meters
Barrels (oil)	$\times 159$	= Liters
Barrels/day	$\times 6.6245 \times 10^{-3}$	= Cubic meters/hour
Barrels (oil)	$\times 5.6154$	= Cubic feet
Barrels/day	$\times 29.167 \times 10^{-3}$	= Gallons per minute
Bars	$\times 0.9869$	= Atmospheres
Bars	$\times 10^6$	= Dynes/square centimeter
Bars	$\times 1.020 \times 10^4$	= Kilograms/square meter
Bars	$\times 2{,}089$	= Pounds/square foot
Bars	$\times 14.50$	= Pounds/square inch
Board feet $\times$ 144 sq.in.	$\times 1$ in.	= Cubic inches
Board feet	$\times 0.0833$	= Cubic feet
Btu	$\times 1.055 \times 10^{10}$	= Ergs
Btu	$\times 778.3$	= Foot-pounds
Btu	$\times 252$	= Gram-calories
Btu	$\times 3.931 \times 10^{-4}$	= Horsepower-hours
Btu	$\times 1{,}054.8$	= Joules
Btu	$\times 0.252$	= Kilogram-calories
Btu	$\times 107.5$	= Kilogram-meters
Btu	$\times 2.928 \times 10^{-4}$	= Kilowatt-hours
Btu/hour	$\times 0.2162$	= Foot-pounds/second
Btu/hour	$\times 0.070$	= Gram-calorie/second

Btu/hour	$\times 3.929 \times 10^{-4}$	= Horsepower-hours (British)
Btu/hour	$\times 0.2931$	= Watts
Btu/hour foot °F	$\times 1.4882$	= Kilocalorie/meter hour °C
Btu/hour foot^2	$\times 2.7125$	= Kilocalorie/meter^2 hour
Btu/pound	$\times 0.5556$	= Kilocalorie/kilogram
Btu/pound °F	$\times 1$	= Kilocalorie/kilogram °C
Btu inches/hour foot^2 °F	$\times 0.12402$	= Kilocalorie/meter hour °C
Btu/minute	$\times 12.96$	= Foot-pounds/second
Btu/minute	$\times 0.02356$	= Horsepower
Btu/minute	$\times 0.01757$	= Kilowatts
Btu/minute	$\times 17.57$	= Watts
Btu/square foot/minute	$\times 0.1221$	= Watts/square inch
Bucket (British-dry)	$\times 1.818 \times 10^4$	= Cubic centimeters
Bushels	$\times 1.2445$	= Cubic feet
Bushels	$\times 2,150.4$	= Cubic inches
Bushels	$\times 0.03524$	= Cubic meters
Bushels	$\times 35.24$	= Liters
Bushels	$\times 4$	= Pecks
Bushels	$\times 64$	= Pints (dry)
Bushels	$\times 32$	= Quarts (dry)

C

Calories, gram (mean)	$\times 3.9685 \times 10^{-3}$	= Btu (mean)
Calories/gram	$\times 1.8$	= Btu/pound
Calories/gram-mol-°C	$\times 1.0$	= Btu/pound-mol-°F
Candle/square centimeter	$\times 3.142$	= Lamberts
Candle/square inch	$\times 0.487$	= Lamberts
Centares	$\times 1.0$	= Square meters
Centigrade	$\times 9/5 + 32$	= Fahrenheit
Centiliter	$\times 0.3382$	= Fluid ounce (USA)
Centiliter	$\times 0.6103$	= Cubic inch
Centiliter	$\times 2.705$	= Drams
Centimeters	$\times 3.281 \times 10^{-2}$	= Feet
Centimeters	$\times 0.3937$	= Inches
Centimeters	$\times 1.094 \times 10^{-2}$	= Yards
Centimeters	$\times 393.7$	= mils
Centimeters of mercury	$\times 0.1934$	= Pounds/square inch
Centimeters of mercury	$\times 0.01316$	= Atmospheres
Centimeters of mercury	$\times 0.4461$	= Feet of water
Centimeters of mercury	$\times 136$	= Kilograms/square meter
Centimeters of mercury	$\times 27.85$	= Pounds/square foot
Centimeters of mercury	$\times 0.1934$	= Pounds/square inch
Centimeters/second	$\times 1.1969$	= Feet/minute
Centimeters/second	$\times 0.03281$	= Feet/second
Centimeters/second	$\times 0.036$	= Kilometers/hour
Centimeters/second	$\times 0.1943$	= Knots
Centimeters/second	$\times 0.6$	= Meters/minute
Centimeters/second	$\times 0.02237$	= Miles/hour
Chain	$\times 792$	= Inches
Chain	$\times 20.12$	= Meters
Circumference	$\times 6.283$	= Radians
Cords	$\times 8$	= Cord feet
Cord feet	$\times 16$	= Cubic feet
Coulomb	$\times 2.998 \times 10^9$	= Statcoulombs
Coulombs	$\times 1.036 \times 10^{-5}$	= Faradays
Coulombs/square centimeter	$\times 64.52$	= Coulombs/square inch
Coulombs/square centimeter	$\times 10^4$	= Coulombs/square meter
Coulombs/square inch	$\times 0.155$	= Coulombs/square centimeter
Coulombs/square inch	$\times 1,550$	= Coulombs/square meter
Cubic centimeters	$\times 3.531 \times 10^{-5}$	= Cubic feet
Cubic centimeters	$\times 0.06102$	= Cubic inches
Cubic centimeters	$\times 10^{-6}$	= Cubic meters
Cubic centimeters	$\times 1.308 \times 10^{-6}$	= Cubic yards
Cubic centimeters	$\times 2.624 \times 10^{-4}$	= Gallons (USA liquid)
Cubic centimeters	$\times 0.001$	= Liters
Cubic centimeters	$\times 2.113 \times 10^{-3}$	= Pints (USA liquid)
Cubic centimeters	$\times 1.057 \times 10^{-3}$	= Quarts (USA liquid)
Cubic feet	$\times 0.8036$	= Bushels (dry)
Cubic feet	$\times 28,320$	= Cubic centimeters

Cubic feet	$\times 1{,}728$	= Cubic inches
Cubic feet	$\times 0.02832$	= Cubic meters
Cubic feet	$\times 0.03704$	= Cubic yards
Cubic feet	$\times 7.48052$	= Gallons (USA liquid)
Cubic feet	$\times 6.232$	= Gallons (imperial)
Cubic feet	$\times 6.428$	= Gallons (USA dry)
Cubic feet	$\times 62.425$	= Pounds (water)
Cubic feet	$\times 28.32$	= Liters
Cubic feet	$\times 59.84$	= Pints (USA liquid)
Cubic feet	$\times 29.92$	= Quarts (USA liquid)
Cubic feet	$\times 0.1781$	= Barrels (oil, USA)
Cubic feet/minute	$\times 472$	= Cubic centimeters/second
Cubic feet/minute	$\times 0.1247$	= Gallons/second
Cubic feet/minute	$\times 0.4720$	= Liters/second
Cubic feet/minute	$\times 62.43$	= Pounds of water/minute
Cubic feet/minute	$\times 1.6989$	= Cubic meters/hour
Cubic feet/minute	$\times 4.719 \times 10^{-4}$	= Cubic meters/second
Cubic feet/second	$\times 0.646317$	= Million gallons/day
Cubic feet/second	$\times 448.831$	= Gallons/minute
Cubic feet/second	$\times 101.94$	= Cubic meters/hour
Cubic inches	$\times 16.39$	= Cubic centimeters
Cubic inches	$\times 5.787 \times 10^{-4}$	= Cubic feet
Cubic inches	$\times 1.639 \times 10^{-5}$	= Cubic meters
Cubic inches	$\times 2.143 \times 10^{-5}$	= cubic yards
Cubic inches	$\times 4.329 \times 10^{-3}$	= Gallons (U.S)
Cubic inches	$\times 0.01639$	= Liters
Cubic inches	$\times 1.061 \times 10^{5}$	= Mil-feet
Cubic inches	$\times 0.03463$	= Pints (USA liquid)
Cubic inches	$\times 0.01732$	= Quarts (USA liquid)
Cubic meters	$\times 6.290$	= Barrels(USA oil)
Cubic meters	$\times 28.38$	= Bushes(dry)
Cubic meters	$\times 10^{6}$	= Cubic centimeters
Cubic meters	$\times 35.314$	= Cubic feet
Cubic meters	$\times 61{,}023$	= Cubic inches
Cubic meters	$\times 1.308$	= Cubic yards
Cubic meters	$\times 264.17$	= Gallons (USA liquid)
Cubic meters	$\times 220$	= Gallons (imperial)
Cubic meters	$\times 1{,}000$	= Liters
Cubic meters	$\times 2{,}113$	= Prints (USA liquid)
Cubic meters	$\times 1.057$	= Quarts (USA liquid)
Cubic meters/hour	$\times 9.810 \times 10^{-3}$	= Cubic feet/second
Cubic meters/hour	$\times 0.5886$	= Cubic feet/minute
Cubic meters/hour	$\times 4.4033$	= Gallons/minute (USA)
Cubic meters/hour	$\times 150.95$	= Barrels/day
Cubic meters/hour	$\times 3.6651$	= Imperial gallons/minute
Cubic meters/hour	$\times 35.31$	= Cubic feet/hour
Cubic meters/hour	$\times 277.8$	= Cubic centimeters/second
Cubic yards	$\times 7.646 \times 10^{5}$	= Cubic centimeters
Cubic yards	$\times 27$	= Cubic feet
Cubic yards	$\times 46{,}656$	= Cubic inches
Cubic yards	$\times 0.7646$	= Cubic meters
Cubic yards	$\times 202$	= Gallons (USA liquid)
Cubic yards	$\times 764.6$	= Liters
Cubic yards	$\times 1{,}615.9$	= Pints (USA liquid)
Cubic yards	$\times 807.9$	= Quarts (USA liquid)
Cubic yards/minute	$\times 0.45$	= Cubic feet/second
Cubic yards/minute	$\times 3.367$	= Gallons/second
Cubic yards/minute	$\times 12.74$	= Liters/second
Cubit (from The Bible)	$\times 21.8$	= Inch
Cup	$\times 0.5$	= Pint
Cup	$\times 16$	= Tablespoon

D

Dalton	$\times 1.650 \times 10^{-24}$	= Gram
Days	$\times 1{,}440$	= Minutes
Days	$\times 86{,}400$	= Seconds
Decigrams	$\times 0.1$	= Grams
Deciliters	$\times 0.1$	= Liters
Decimeters	$\times 0.1$	= Meters

Degrees (Angle)	$\times 60$	= Minutes
Degrees (Angle)	$\times 3600$	= Seconds
Degrees (Angle)	$\times 0.01745$	= Radians
Degrees (Angle)	$\times 0.01111$	= Quadrants
Degrees/second	$\times 0.1667$	= Revolutions/minute
Degrees/second	$\times 2.778 \times 10^{-3}$	= Revolutions/second
Dekagrams	$\times 10$	= Grams
Dekaliters	$\times 10$	= Liters
Dekameters	$\times 10$	= Meters
Drams (apothecaries or troy)	$\times 0.1371429$	= Ounces (avoirdupois)
Drams (apothecaries or troy)	$\times 0.125$	= Ounces (troy)
Drams	$\times 27.34375$	= Grains
Drams	$\times 1.771845$	= Grams
Drams	$\times 0.0625$	= Ounces
Dyne/centimeter	$\times 0.01$	= Erg/square millimeters
Dyne/square centimeters	$\times 9.869 \times 10^{-7}$	= Atmospheres
Dyne/square centimeters	$\times 2.953 \times 10^{-5}$	= Inch of mercury at 0° C
Dyne/square centimeters	$\times 4.015 \times 10^{-4}$	= Inch of water at 4° C
Dynes/square centimeters	$\times 10^{-6}$	= Bars
Dynes	$\times 1.020 \times 10^{-3}$	= Grams
Dynes	$\times 10^{-7}$	= Joules/centimeters
Dynes	$\times 10^{-5}$	= Joules/meters (newtons)
Dynes	$\times 1.020 \times 10^{-6}$	= Kilograms
Dynes	$\times 7.233 \times 10^{-5}$	= Poundals
Dynes	$\times 2.248 \times 10^{-6}$	= Pounds

E

Ell	$\times 114.30$	= Centimeters
Ell	$\times 45$	= Inches
Em, pica	$\times 0.167$	= Inch
Em, pica	$\times 0.4233$	= Centimeter
Erg/second	$\times 1$	= Dyne-centimeter/second
Erg/second	$\times 1.0 \times 10^{-7}$	= Watt
Erg	$\times 9.480 \times 10^{-11}$	= Btu
Erg	$\times 1$	= Dyne-centimeter
Erg	$\times 7.367 \times 10^{-8}$	= Foot-pounds
Erg	$\times 1.0 \times 10^{-7}$	= Joules
Expansion coefficient, ° F	$\times 1.8$	= Expansion coefficient, ° C

F

Fahrenheit minus 32° F	$\times 0.5556$	= Centigrade
Famm	$\times 5.8455$	= Foot, USA
Famm	$\times 1.7814$	= Meter
Faradays	$\times 26.8$	= Ampere-hour
Fathom, British	$\times 6.08$	= Feet
Fathom, British	$\times 1.8532$	= Meter
Fathom, USA	$\times 6$	= Feet
Fathom, USA	$\times 1.8288$	= Meter
Fathom, USA	$\times 2$	= Yard
Feet	$\times 30.48$	= Centimeters
Feet	$\times 1.645 \times 10^{-4}$	= Miles (nautical)
Feet, USA	$\times 0.3048$	= Meters
Feet, USA	$\times 0.3333$	= Yards
Feet, USA	$\times 0.18939 \times 10^{-3}$	= Miles, USA statute
Feet, USA	$\times 12$	= Inches
Feet, USA	$\times 1.2 \times 10^{4}$	= Mils
Feet, USA	$\times 0.0606$	= Rod
Feet of water	$\times 0.0295$	= Atmospheres
Feet of water	$\times 0.8826$	= Inches of mercury
Feet of water	$\times 0.03048$	= Kilograms/square centimeters
Feet of water	$\times 304.8$	= Kilograms/square meter
Feet of water	$\times 62.43$	= Pounds/square foot
Feet of water	$\times 0.4335$	= Pounds/square inch
Feet/hour	$\times 0.01666$	= Feet/minute
Feet/hour	$\times 0.2777 \times 10^{-3}$	= Feet/second

Feet/hour	$\times 0.1894 \times 10^{-3}$	= Miles/hour
Feet/minute	$\times 0.5080$	= Centimeter/second
Feet/minute	$\times 0.01666$	= Feet/second
Feet/minute	$\times 0.18288$	= Kilometer/hour
Feet/minute	$\times 0.009868$	= Knot
Feet/minute	$\times 0.3048$	= Meter/minute
Feet/minute	$\times 0.00508$	= Meter/second
Feet/minute	$\times 0.01136$	= Mile/hour
Feet/minute	$\times 0.1894 \times 10^{-3}$	= Mile/minute
Feet/second	$\times 30.48$	= Centimeters/second
Feet/second	$\times 1.097$	= Kilometers/hour
Feet/second	$\times 0.5921$	= Knots
Feet/second	$\times 18.29$	= Meters/minute
Feet/second	$\times 0.681818$	= Miles/hour
Feet/second	$\times 0.0113636$	= Miles/minute
Feet/second	$\times 3600$	= Feet/hour
Feet/second	$\times 60$	= Feet/minute
Feet/second/second	$\times 30.48$	=Centimeters/second/second
Feet/second/second	$\times 1.097$	= Kilometers/hour/second
Feet/second/second	$\times 0.3048$	= Meters/second/second
Feet/second/second	$\times 0.6818$	= Miles/hour/second
Feet/100 feet	$\times 1$	= Percent grade
Firkin	$\times 9$	= Gallon, liquid, USA
Firkin	$\times 34.06798$	= Liter
Foot-candle	$\times 10.764$	= Lumen/square meter
Foot-candle	$\times 1$	= Lumen/square foot
Foot-candle	$\times 10.764$	= Lux
Foot-candle	$\times 1.076$	= Milliphot
Foot-candle	$\times 0.001076$	= Phot
Foot-candle	$\times$ distance in feet^2	= Candlepower
Foot-Lambert	$\times 0.3425 \times 10^{-3}$	= Candle/square centimeters
Foot-Lambert	$\times 0.3183$	= Candle/square foot
Foot-Lambert	$\times 0.00221$	= Candle/square inch
Foot-Lambert	$\times 0.001076$	= Lambert
Foot-Lambert	$\times$ square foot Area	= Lumen
Foot-Lambert	$\times 1.076$	= Millilambert
Foot-Lambert	$\times 0.342 \times 10^{-3}$	= Stilb
Foot-pound	$\times 1.2853 \times 10^{-3}$	= Btu
Foot-pound	$\times 1.356 \times 10^{7}$	= Ergs
Foot-pound	$\times 0.32389$	= Gram-calorie
Foot-pound	$\times 5.0505 \times 10^{-7}$	= Horsepower-hours, USA
Foot-pound	$\times 5.12 \times 10^{-7}$	= Horsepower-hours, metric
Foot-pound	$\times 12$	= Inch-pound
Foot-pound	$\times 1.35582$	= Joule absolute
Foot-pound	$\times 1.3554$	= Joule international
Foot-pound	$\times 3.238 \times 10^{-4}$	= Kilogram-calories
Foot-pound	$\times 0.1383$	= Kilogram-meters
Foot-pound	$\times 3.766 \times 10^{-7}$	= Kilowatt-hours
Foot-pound	$\times 0.001356$	= Kilowatt-second
Foot-pound	$\times 0.01338$	= Liter-atmosphere
Foot-pound	$\times 0.3766 \times 10^{-3}$	= Watt-hour
Foot-pound	$\times 1.356$	= Watt-second
Foot-pound/minute	$\times 0.077118$	= Btu/hour
Foot-pound/minute	$\times 1.286 \times 10^{-3}$	= Btu/minute
Foot-pound/minute	$\times 2.259 \times 10^{5}$	= Erg/second
Foot-pound/minute	$\times 0.01666$	= Foot-pound/second
Foot-pound/minute	$\times 3.066 \times 10^{-5}$	= Horsepower, metric
Foot-pound/minute	$\times 3.0303 \times 10^{-5}$	= Horsepower, USA
Foot-pound/minute	$\times 2.2597 \times 10^{-5}$	= Kilowatt
Foot-pound/minute	$\times 0.022597$	= Watt
Foot-pound/second	$\times 0.0771$	= Btu/minute
Foot-pound/second	$\times 4.6263$	= Btu/hour
Foot-pound/second	$\times 1.843 \times 10^{-3}$	= Horsepower, metric
Foot-pound/second	$\times 1.818 \times 10^{-3}$	= Horsepower, USA
Foot-pound/second	$\times 1.356$	= Joule
Foot-pound/second	$\times 1.3558 \times 10^{-3}$	= Kilowatts
Foot-pound/second	$\times 1.3558$	= Watt
Fot	$\times 0.974$	= Foot, USA
Fot	$\times 100$	= Lines
Fot	$\times 0.2969$	= Meter

Fot	×10	= Turn
Foute	×1	= Foot, USA
Furlong	×6.6	= Chain, engineer
Furlong	×10	= Chain, Gunter
Furlong	×660	= Feet
Furlong	×201.168	= Meters
Furlong	×0.125	= Mile, statue, USA
Furlong	×220	= Yards
Furlong	×40	= Rods
Fuss	×0.9842	= Foot, USA
Fuss	×0.300	= Meter

G

Gallon, British, Imperial Liquid	×0.125	= Bushel, dry, British
Gallon, British, Imperial Liquid	×4546	= Cubic centimeter
Gallon, British, Imperial Liquid	×0.16046	= Cubic foot
Gallon, British, Imperial Liquid	×0.0045	= Cubic meter
Gallon, British, Imperial Liquid	×1.032	= Gallon, dry, USA
Gallon, British, Imperial Liquid	×1.20095	= Gallon, liquid, USA
Gallon, British, Imperial Liquid	×4.54596	= Kilogram
Gallon, British, Imperial Liquid	×10	= Pound, water, 62° F
Gallon, dry, USA	×0.125	= Bushel, USA
Gallon, dry, USA	×4404.92	= Cubic centimeter
Gallon, dry, USA	×0.155555	= Cubic foot
Gallon, dry, USA	×268.803	= Cubic inch
Gallon, dry, USA	×1.16365	= Gallon, liquid, USA
Gallon, dry, USA	×4.4049	= Liter
Gallon, dry, USA	×0.05	= Peck
Gallon, dry, USA	×8	= Pint
Gallon, dry, USA	×4.6546	= Quart, liquid, USA
Gallon, liquid, USA	×0.0238	= Barrel, oil
Gallon, liquid, USA	×3785.434	= Cubic centimeter
Gallon, liquid, USA	×3.785434	= Cubic decimeter
Gallon, liquid, USA	×0.13368	= Cubic foot
Gallon, liquid, USA	×231	= Cubic inch, water, 62° F
Gallon, liquid, USA	$\times 3.7854 \times 10^{-3}$	= Cubic moter
Gallon, liquid, USA	$\times 4.951 \times 10^{-3}$	= Cubic yard
Gallon, liquid, USA	×0.859365	= Gallon, dry, USA
Gallon, liquid, USA	×0.832673	= Gallon, liquid, British
Gallon, liquid, USA	×3.7853	= Liter
Gallon, liquid, USA	×8	= Pint, liquid, USA
Gallon, liquid, USA	×4	= Quart, liquid, USA
Gallon, liquid, USA	×8.3453	= Pounds, water
Gallon/hour, USA	×0.1337	= Cubic feet/hour
Gallon/hour, USA	$\times 2.228 \times 10^{-3}$	= Cubic feet/minute
Gallon/hour, USA	×0.01666	= Gallons/minute
Gallon/hour, USA	$\times 2.777 \times 10^{-4}$	= Gallons/second
Gallon/minute, USA	×34.2857	= Barrels/day, oil
Gallon/minute, USA	×1.42857	= Barrels/hour, oil
Gallon/minute, USA	×0.023809	= Barrels/minute, oil
Gallon/minute, USA	×192.49999	= Cubic feet/day
Gallon/minute, USA	×8.021	= Cubic feet/hour
Gallon/minute, USA	×0.13368	= Cubic feet/minute
Gallon/minute, USA	$\times 2.228 \times 10^{-3}$	= Cubic feet/second
Gallon/minute, USA	×0.2271	= Cubic meters/hour
Gallon/minute, USA	×1440	= Gallons/day
Gallon/minute, USA	×60	= Gallons/hour
Gallon/minute, USA	×0.01666	= Gallons/second
Gallon/minute, USA	×5.35565	= Tonnes, long, water, 62° F/day
Gallon/minute, USA	×5.99839	= Tonnes, short, water, 62° F/day
Gallon/minute, USA	×0.06308	= Liters/second
Gallon/second, USA	×481	= Cubic feet/hour
Gallon/second, USA	×8.02	= Cubic feet/minute
Gallon/second, USA	×0.1337	= Cubic feet/second
Gallon/second, USA	×60	= Gallons/minute, USA
Gills, British	×142.07	= Cubic centimeter
Gills, British	×0.1183	= Liters
Gills, British	×0.25	= Pints, liquid
Grade	×0.0025	= Circle

Grade	$\times 9{,}000$	= Degree
Grade	$\times 54$	= Minute
Grade	$\times 0.01571$	= Radian
Grain	$\times 0.01666$	= Dram, apothecary
Grain	$\times 0.03657$	= Dram, avoirdupois
Grain (troy)	$\times 1$	= Grain (avdp)
Grain (troy)	$\times 0.0648$	= Grams
Grain (troy)	$\times 2.0833 \times 10^{-3}$	= Ounces (troy)
Grain (troy)	$\times 2.286 \times 10^{-3}$	= Ounces (avdp)
Grain/U.S. gallon	$\times 17.118$	= Parts/million
Grain/U.S. gallon	$\times 142.86$	= Pounds/million gallon
Grain/Imperial gallon	$\times 14.286$	= Parts/million
Gram	$\times 5$	= Carat
Gram	$\times 3.858$	= Carat, metric
Gram	$\times 100$	= Centigram
Gram	$\times 0.2572$	= Dram, apothecary
Gram	$\times 0.56438$	= Dram, avoirdupois
Gram	$\times 980.665$	= Dyne
Gram	$\times 15.4324$	= Grain
Gram	$\times 9.807 \times 10^{-5}$	= Joules/centimeters
Gram	$\times 9.807 \times 10^{-3}$	= Joules/meter (newtons)
Gram	$\times 0.001$	= Kilograms
Gram	$\times 1000$	= Milligrams
Gram	$\times 0.03527$	= Ounces, avoirdupois
Gram	$\times 0.03215$	= Ounces, troy
Gram	$\times 0.07093$	= Poundals
Gram	$\times 2.205 \times 10^{-3}$	= Pounds
Grams	$\times 1/MW$	= Gram-mols
Grams/centimeter	$\times 5.6 \times 10^{-3}$	= Pounds/inch
Grams/cubic centimeter	$\times 62.43$	= Pounds/cubic foot
Grams/cubic centimeter	$\times 0.03613$	= Pounds/cubic foot
Grams/liter	$\times 58.417$	= Grains/gallon, USA
Grams/liter	$\times 8.345$	= Pounds/1,000 gallons
Grams/liter	$\times 0.062427$	= Pounds/cubic foot
Grams/liter	$\times 1{,}000$	= Parts/million
Grams/square centimeter	$\times 2.0481$	= Pounds/square foot
Gram-calories	$\times 3.968 \times 10^{-3}$	= Btu
Gram-calories	$\times 4.1868 \times 10^{7}$	= Ergs
Gram-calories	$\times 3.088$	= Foot-pounds
Gram-calories	$\times 1.55856 \times 10^{-6}$	= Horsepower/hours
Gram-calories	$\times 1.163 \times 10^{-6}$	= Kilowatt-hours
Gram-calories	$\times 1.163 \times 10^{-3}$	= Watt-hours
Gram/calories/second	$\times 14.286$	= Btu/hour
Gram-centimeters	$\times 9.29658 \times 10^{-8}$	= Btu
Gram-centimeters	$\times 980.7$	= Ergs
Gram-centimeters	$\times 9.807 \times 10^{-5}$	= Joules
Gram-mol	$\times 22.414$	= Liters at 0° C and 1 atm
Gross	$\times 12$	= Dozen
Gross, great	$\times 144$	= Dozen
Gross, great	$\times 12$	= Gross

H

Hand	$\times 10.16$	= Centimeter
Hand	$\times 4$	= Inch
Hand	$\times 48$	= Foot
Hand	$\times 1{,}016$	= Meter
Head, feet elevation, water	$\times 0.433$	= Pounds/square inch
Hectare	$\times 2.471$	= Acre
Hectare	$\times 100$	= Are
Hectare	$\times 1.07639 \times 10^{5}$	= Square feet
Hectare	$\times 0.01$	= Square kilometer
Hectare	$\times 10{,}000$	= Square meters
Hectare	$\times 3.861 \times 10^{-3}$	= Square miles
Hectare	$\times 11{,}960$	= Square yard
Hectogram	$\times 100$	= Gram
Hectoliter	$\times 3.532$	= Cubic feet
Hectoliter	$\times 0.1$	= Cubic meter
Hectoliter	$\times 0.1308$	= Cubic yard

Hectoliter	$\times 26.42$	= Gallon, USA
Hectoliter	$\times 100$	= Liter
Hectometer	$\times 328.089$	= Feet
Hectometer	$\times 100$	= Meter
Hectometer	$\times 0.06214$	= Mile, statute, USA
Hectometer	$\times 109.36$	= Yard
Hectowatts	$\times 100$	= Watts
Henries	$\times 1{,}000$	= Millihenries
Hogsheads, British	$\times 10.114$	= Cubic feet
Hogsheads, USA	$\times 8.42184$	= Cubic feet
Hogsheads, USA	$\times 63$	= Gallons, USA
Hogsheads, USA	$\times 238.476$	= Liter
Hogsheads, USA	$\times 504$	= Pint
Hogsheads, USA	$\times 252$	= Quart
Horsepower, USA	$\times 42.44$	= Btu/minute
Horsepower, USA	$\times 33{,}000$	= Foot-pounds/minute
Horsepower, USA	$\times 550$	= Foot-pounds/second
Horsepower, USA	$\times 0.7457$	= Kilowatts
Horsepower, USA	$\times 1.014$	= Horsepower (metric)
Horsepower, boiler	$\times 33{,}479$	= Btu/hour
Horsepower, boiler	$\times 34.5$	= Pounds water/hour
Horsepower, boiler	$\times 9.803$	= Kilowatts
Horsepower, electric	$\times 0.7072$	= Btu/second
Horsepower, electric	$\times 746$	= Joule/second
Horsepower, electric	$\times 0.746$	= Kilowatts
Horsepower, electric	$\times 746$	= Watts
Horsepower (metric)	$\times 0.98632$	= Horsepower (USA)
Horsepower (metric)	$\times 542.5$	= Foot-pounds/second
Horsepower, hours, USA	$\times 2{,}547$	= Btu
Horsepower, hours, USA	$\times 2.6845 \times 10^{13}$	= Ergs
Horsepower, hours, USA	$\times 1.98 \times 10^{6}$	= Foot-pounds
Horsepower, hours, USA	$\times 641{,}190$	= Gram-calories
Horsepower, hours, USA	$\times 1.01387$	= Horsepower-hour, metric
Horsepower, hours, USA	$\times 2{,}376 \times 10^{4}$	= Inch-pounds
Horsepower, hours, USA	$\times 26.8453 \times 10^{5}$	= Joule
Horsepower, hours, USA	$\times 0.7457$	= Kilowatt-hour
Horsepower-hours, metric	$\times 2509.83$	= Btu
Horsepower-hours, metric	$\times 1.9529 \times 10^{6}$	= Foot-pounds
Horsepower-hours, metric	$\times 0.98632$	= Horsepower-hour, USA
Horsepower-hours, metric	$\times 632{,}467$	= Gram-calories
Horsepower-hours, metric	$\times 26.4761$	= Joule
Horsepower-hours, metric	$\times 0.73545$	= Kilowatt-hour
Hours	$\times 0.0417$	= Day
Hours	$\times 60$	= Minute
Hours	$\times 0.00137$	= Month
Hours	$\times 0.1142 \times 10^{-3}$	= Year
Hours	$\times 5.952 \times 10^{-3}$	= Week
Hundredweight (long)	$\times 112$	= Pounds
Hundredweight (long)	$\times 0.05$	= Tonnes, long
Hundredweight (short)	$\times 1.8$	= Cubic foot
Hundredweight (short)	$\times 45.36$	= Kilograms
Hundredweight (short)	$\times 100$	= Pounds
Hundredweight (short)	$\times 0.05$	= Ton, short
Hundredweight (short)	$\times 0.04536$	= Tonnes, metric
Hundredweight (short)	$\times 0.044643$	= Tonnes, long

I

Inch	$\times 254 \times 10^{6}$	= Angstrom
Inch	$\times 2.54$	= Centimeter
Inch	$\times 0.833 \times 10^{-3}$	= Chain, engineer
Inch	$\times 1.2626 \times 10^{-3}$	= Chain, Gunter
Inch	$\times 0.254$	= Decemeter
Inch	$\times 0.08333$	= Foot, USA
Inch	$\times 0.0254$	= Meter
Inch	$\times 1.578 \times 10^{-5}$	= Mile, statute, USA
Inch	$\times 25.4$	= Millimeters
Inch	$\times 1{,}000$	= Mils
Inch	$\times 5.05 \times 10^{-3}$	= Rods
Inch	$\times 0.02778$	= Yards

Inch, mercury	$\times 0.03342$	= Atmospheres
Inch, mercury	$\times 1.133$	= Feet of water
Inch, mercury	$\times 13.61$	= Inch height, water
Inch, mercury	$\times 70.73$	= Pound/square foot
Inch, mercury	$\times 0.49116$	= Pound/square inch
Inch, mercury	$\times 0.03453$	= Kilograms/square centimeter
Inches of mercury	$\times 345.3$	= Kilograms/square meter
Inch-pound	$\times 1.07 \times 10^{-4}$	= Btu
Inch-pound	$\times 0.0833$	= Foot-pound
Inch, water, 4° C	$\times 2.458 \times 10^{-3}$	= Atmospheres
Inch, water, 4° C	$\times 0.07355$	= Inches of mercury
Inch, water, 4° C	$\times 2.54 \times 10^{-3}$	= Kilograms/square centimeter
Inch, water, 4° C	$\times 0.5781$	= Ounces/square inch
Inch, water, 4° C	$\times 5.204$	= Pounds/square foot
Inch, water, 4° C	$\times 0.03613$	=Pounds/square inch

J

Joule	$\times 9.48 \times 10^{-4}$	= Btu
Joule	$\times 10^{7}$	= Erg
Joule	$\times 0.7376$	= Foot-pound
Joule	$\times 2.389 \times 10^{-4}$	= Kilogram-calorie
Joule	$\times 1.0197 \times 10^{4}$	= Gram-centimeter
Joule	$\times 2.778 \times 10^{-4}$	= Watt-hours

K

Kilogram	$\times 1{,}000$	= Grams
Kilogram	$\times 70.93$	= Poundals
Kilogram	$\times 2.205$	= Pounds (avdp)
Kilogram	$\times 9.842 \times 10^{-4}$	= Tonnes, long
Kilogram	$\times 1.102 \times 10^{-3}$	= Tonnes, short
Kilogram	$\times 0.001$	= Tonnes, metric
Kilocalories	$\times 3.968$	= Btu
Kilocalories	$\times 3,088$	= Foot-lbs.
Kilocalories	$\times 1.56 \times 10^{-3}$	= Hp.-hrs.
Kilocalories	$\times 1.163 \times 10^{-3}$	= Kilowatt-hrs.
Kilocalories/square meter/hr/° C	$\times 0.205$	= Btu/square foot/hr/° F
Kilogram-meters	$\times 9.294 \times 10^{-3}$	= Btu
Kilograms/cubic meter	$\times 0.001$	= Grams/cubic centimeter
Kilograms/cubic meter	$\times 0.06243$	= Pounds/cubic foot
Kilograms/cubic meter	$\times 3.613 \times 10^{-5}$	= Pounds/cubic inch
Kilograms/cubic meter	$\times 3.405 \times 10^{-10}$	= Pounds/mil-foot
Kilograms/cubic meter	$\times 8.428 \times 10^{-3}$	= Ton, short/cubic yard
Kilograms/meter	$\times 10$	= Gram/centimeter
Kilograms/meter	$\times 391.983$	= Gram/inch
Kilograms/meter	$\times 0.672$	= Pounds/foot
Kilograms/meter	$\times 0.056$	= Pounds/inch
Kilograms/square centimeter	$\times 0.9678$	= Atmospheres
Kilograms/square centimeter	$\times 32.81$	= Feet of water
Kilograms/square centimeter	$\times 28.96$	= Inch of mercury
Kilograms/square centimeter	$\times 2{,}048$	= Pounds/square foot
Kilograms/square centimeter	$\times 14.223$	= Pounds/square inch
Kilograms/square meter	$\times 9.678 \times 10^{-5}$	= Atmospheres
Kilograms/square meter	$\times 3.281 \times 10^{-3}$	= Feet of water
Kilograms/square meter	$\times 2.896 \times 10^{-3}$	= Inches of mercury
Kilograms/square meter	$\times 0.03937$	= Inches of water
Kilograms/square meter	$\times 0.2048$	= Pounds/square foot
Kilograms/square meter	$\times 1.422 \times 10^{-3}$	= Pounds/square inch
Kilometers	$\times 3281$	= Feet
Kilometers	$\times 3.937 \times 10^{4}$	= Inches
Kilometers	$\times 1{,}000$	= Meters
Kilometers	$\times 0.6214$	= Miles (statute)
Kilometers	$\times 0.5295$	= Miles (nautical)
Kilometers	$\times 1{,}094$	= Yards
Kilometers/hour	$\times 27.78$	= Centimeters/second
Kilometers/hour	$\times 54.68$	= Feet/minute
Kilometers/hour	$\times 0.9113$	= Feet/second

Kilometers/hour	$\times 0.5396$	= Knots
Kilometers/hour	$\times 16.67$	= Meters/minute
Kilometers/hour	$\times 0.6214$	= Miles/hour
Kilowatts	$\times 56.92$	= Btu/minute
Kilowatts	$\times 1.35972$	= Horsepower, metric
Kilowatts	$\times 1.341$	= Horsepower, USA
Kilowatts	$\times 1{,}000$	= Watts
Kilowatts	$\times 4.426 \times 10^4$	= Foot-lbs./minute
Kilowatts	$\times 737.6$	= Foot-lbs./second
Kilowatt-hrs.	$\times 2.655 \times 10^6$	= Foot-lbs.
Kilowatt-hours	$\times 1000$	= Watt hours
Kilowatt-hours	$\times 3{,}413$	= Btu
Kilowatt-hours	$\times 3.6 \times 10^{13}$	= Ergs
Kilowatt-hours	$\times 1.36$	= Horsepower-hour, metric
Kilowatt-hours	$\times 1.341$	= Horsepower-hour, USA
Kilowatt-hours	$\times 3.6 \times 10^6$	= Joules
Kilowatt-hours	$\times 860.5$	= Kilogram-calories
Kilowatt-hours	$\times 3.671 \times 10^5$	= Kilogram-meters
Kilowatt-hours	$\times 3.53$	= Pounds of water*
Kilowatt-hours	$\times 22.75$	= Pounds of water†
Kip	$\times 1$	= Kilopound
Kip	$\times 1{,}000$	= Pound
Knott, USA	$\times 51.48$	= Centimeter/second
Knott, USA	$\times 6080.2$	= Feet/hour
Knott, USA	$\times 1.8532$	= Kilometer/hour
Knott, USA	$\times 30.887$	= Meter/minute
Knott, USA	$\times 1.15155$	= Mile/hour (statute)
Knott, USA	$\times 2027$	= Yards/hour

L

League, land	$\times 24$	= Furlong
League, land	$\times 4.828$	= Kilometer
League, land	$\times 3$	= Mile
League, marine	$\times 5.56$	= Kilometer
League, marine	$\times 3$	= Mile, nautical
League, marine	$\times 3.45$	= Mile, statute
Light year	$\times 5.9 \times 10^{12}$	= Miles
Light year	$\times 9.46091 \times 10^{12}$	= Kilometers
Links, engineers'	$\times 12$	= Inches
Links, surveyors'	$\times 7.92$	= Inches
Links, surveyors'	$\times 0.66$	= Feet
Links, surveyors'	$\times 0.22$	= Yard
Liters	$\times 0.02838$	= Bushels, USA, dry
Liters	$\times 100$	= Centiliters
Liters	$\times 1{,}000$	= Cubic centimeters
Liters	$\times 0.035316$	= Cubic feet
Liters	$\times 61.02$	= Cubic inches
Liters	$\times 6.291 \times 10^{-3}$	= Barrels, oil, USA
Liters	$\times 61.027$	= Cubic inches
Liters	$\times 0.001$	= Cubic meter
Liters	$\times 1.308 \times 10^{-3}$	= Cubic yard
Liters	$\times 0.2642$	= Gallon, USA, liquid
Liters	$\times 0.2199$	= Gallons (Imperial)
Liters	$\times 1.7598$	= Pint, USA, dry
Liters	$\times 2.1134$	= Pint, USA, liquid
Liters	$\times 2.202$	= Pounds of water
Liters/minute	$\times 5.886 \times 10^{-4}$	= Cubic foot/second
Liters/minute	$\times 4.403 \times 10^{-3}$	= Gallons/second
Liters/second	$\times 2.1186$	= Cubic feet/minute
Lumen	$\times 0.07958$	= Candlepower
Lumen	$\times 1.47 \times 10^{-3}$	= Watt
Lumens/square foot	$\times 1$	= Foot-candles
Lux	$\times 0.0929$	= Foot-candles

* Evaporated from and at 212° F
† Raised from 62° to 212° F

M

Maas	$\times 1.5$	= Liter
Meter	$\times 10^{10}$	= Angstrom units
Meter	$\times 100$	= Centimeter
Meter	$\times 3.2808$	= Feet, USA
Meter	$\times 0.01$	= Hectometer
Meter	$\times 39.37$	= Inches
Meter	$\times 0.001$	= Kilometer
Meter	$\times 5.396 \times 10^{-4}$	= Miles, nautical
Meter	$\times 6.214 \times 10^{-4}$	= Miles, statute
Meter	$\times 1000$	= Millimeters
Meter	$\times 1.094$	= Yards
Meter	$\times 1.179$	= Vara
Meters/minute	$\times 1.667$	= Centimeters/second
Meters/minute	$\times 3.281$	= Feet/minute
Meters/minute	0.05468	= Feet/second
Meters/minute	$\times 0.06$	= Kilometers/hour
Meters/minute	$\times 0.03238$	= Knots
Meters/minute	$\times 0.03728$	= Miles/hour
Meters/second	$\times 196.8$	= Feet/minute
Meters/second	$\times 3.281$	= Feet/second
Meters/second	$\times 3.6$	= Kilometers/hour
Meters/second	$\times 0.06$	= Kilometers/minute
Meters/second	$\times 2.237$	= Miles/hour
Meters/second	$\times 0.03728$	= Miles/minute
Microns	$\times 39.37 \times 10^{-6}$	= Inches
Microns	$\times 1 \times 10^{-6}$	= Meters
Micron	$\times 0.0001$	= Centimeter
Micron	$\times 1000$	= Millimicron
Mile, USA, nautical	$\times 6,080.2$	= Feet, USA
Mile, USA, nautical	$\times 6,080$	= Feet, British
Mile, USA, nautical	$\times 72,962.5$	= Inches
Mile, USA, nautical	$\times 1.853$	= Kilometer
Mile, USA, nautical	$\times 0.333$	= League
Mile, USA, nautical	$\times 1,853.248$	= Meter
Mile, USA, nautical	$\times 1.15155$	= Mile, USA, statute
Mile, USA, nautical	$\times 2,026.73$	= Yard
Mile, USA, statute	$\times 5,280$	= Feet, USA
Miles, USA, statute	$\times 8$	= Furlongs
Miles, USA, statute	$\times 63,360$	= Inches
Miles, USA, statute	$\times 1.60935$	= Kilometer
Miles, USA, statute	$\times 8,000$	= Link
Miles, USA, statute	$\times 1,609.35$	= Meters
Miles, USA, statute	$\times 0.8684$	= Mile, USA, nautical
Miles, USA, statute	$\times 1,900.8$	= Vara
Miles, USA, statute	$\times 1,706$	= Yard
Miles/hour	$\times 44.7$	= Centimeters/second
Miles/hour	$\times 88$	= Feet/minute
Miles/hour	$\times 1.467$	= Feet/second
Miles/hour	$\times 1.609$	= Kilometers/hour
Miles/hour	$\times 0.02682$	= Kilometers/minute
Miles/hour	$\times 0.8684$	= Knots
Miles/hour	$\times 26.82$	= Meters/minute
Miles/hour	$\times 0.4470$	= Meters/second
Miles/hour	$\times 0.01667$	= Miles/minute
Miles/minute	$\times 5,280$	= Feet/minute
Miles/minute	$\times 316,800$	= Feet/hour
Miles/minute	$\times 88$	= Feet/second
Miles/minute	$\times 60$	= Miles/hour
Miles/minute	$\times 1.609$	= Kilometers/minute
Miles/minute	$\times 0.8684$	= Knots/minute
Millimeter	$\times 0.1$	= Centimeter
Millimeter	$\times 3.281 \times 10^{-3}$	= Feet
Millimeter	$\times 0.03937 \times 10^{-2}$	= Inches
Millimeter	$\times 10^{-6}$	= Kilometers
Millimeter	$\times 0.001$	= Meters
Millimeter	$\times 6.214 \times 10^{-7}$	= Miles
Millimeter	$\times 39.37$	= Mils
Millimeter	$\times 1.094 \times 10^{-3}$	= Yards
Million gallons/day	$\times 1.54723$	= Cubic feet/second

Mils	$\times 2.540 \times 10^{-3}$	= Centimeters
Mils	$\times 8.333 \times 10^{-5}$	= Feet
Mils	$\times 0.001$	= Inches
Mils	$\times 2.540 \times 10^{-8}$	= Kilometers
Mils	$\times 2.778 \times 10^{-5}$	= Yards

N

Nail	$\times 2.5$	= Inch
Nepers	$\times 8.686$	= Decibels
Newton	$\times 1 \times 10^{5}$	= Dynes

O

Ounces (avdp)	$\times 16$	= Drams
Ounces (avdp)	$\times 437.5$	= Grains
Ounces (avdp)	$\times 28.349527$	= Grams
Ounces (avdp)	$\times 0.0625$	= Pounds
Ounces (avdp)	$\times 0.9115$	= Ounces, troy
Ounces	$\times 2.79 \times 10^{-5}$	= Tonnes, long
Ounces	$\times 2.835 \times 10^{-5}$	= Tonnes, metric
Ounces, fluid	$\times 1.805$	= Cubic inches
Ounces, fluid	$\times 0.02957$	= Liters
Ounces, troy	$\times 480$	= Grains
Ounces, troy	$\times 31.103481$	= Grams
Ounces, troy	$\times 1.09714$	= Ounces, avoirdupois
Ounces, troy	$\times 0.08333$	= Pounds, troy
Ounces/square inch	$\times 0.0625$	= Pounds/square inch

P

Parsec	$\times 19 \times 10^{12}$	= Miles, USA, statute
Parsec	$\times 3.084 \times 10^{13}$	= Kilometers
Parts/million	$\times 0.05833$	= Grains/gallon, USA
Parts/million	$\times 0.07016$	= Grains/gallon, British
Parts/million	$\times 8.345$	= Pounds/million gallons, USA
Peck, British	$\times 554.6$	= Cubic inches
Peck, British	$\times 2$	= Gallons, British
Peck, British	$\times 9.0919$	= Liters
Peck, USA	$\times 0.25$	= Bushels
Peck, USA	$\times 537.605$	= Cubic inches
Peck, USA	$\times 8.809582$	= Liters
Peck, USA	$\times 8$	= Quarts, dry
Peck, USA	$\times 9.3092$	= Quarts, liquid
Pennyweights, troy	$\times 24$	= Grains
Pennyweights, troy	$\times 0.05$	= Ounces, troy
Pennyweights, troy	$\times 1.55517$	= Grams
Pennyweights, troy	$\times 4.1667 \times 10^{-3}$	= Pounds, troy
Percent	$\times 10^{4}$	= Parts/million
Pfund, Germany	$\times 500$	= Gram
Pint, USA, dry	$\times 0.015625$	= Bushel
Pint, USA, dry	$\times 550.6136$	= Cubic centimeter
Pint, USA, dry	$\times 0.01945$	= Cubic feet
Pint, USA, dry	$\times 33.6$	= Cubic inches
Pint, USA, dry	$\times 2$	= Cup
Pint, USA, dry	$\times 0.125$	= Gallon, USA, dry
Pint, USA, dry	$\times 0.145545$	= Gallon, USA, liquid
Pint, USA, dry	$\times 0.5506$	= Liter
Pint, USA, dry	$\times 0.0625$	= Peck
Pint, USA, dry	$\times 0.5$	= Quart, USA, dry
Pint, USA, dry	$\times 0.58182$	= Quart, USA, liquid
Pint, USA, liquid	$\times 437.2$	= Cubic centimeters
Pint, USA, liquid	$\times 0.01671$	= Cubic feet
Pint, USA, liquid	$\times 28.875$	= Cubic inch
Pint, USA, liquid	$\times 2$	= Cup
Pint, USA, liquid	$\times 0.1074$	= Gallon, USA, dry
Pint, USA, liquid	$\times 0.125$	= Gallon, USA, liquid

Pint, USA, liquid	$\times 4$	= Gill
Pint, USA, liquid	$\times 0.4732$	= Liters
Pint, USA, liquid	$\times 16$	= Ounces
Pint, USA, liquid	$\times 0.5$	= Quarts, USA, liquid
Pint, USA, liquid	$\times 0.42968$	= Quarts, USA, dry
Pint, USA, liquid	$\times 128$	= Dram, fluid
Poise	$\times 100$	= Centipoise
Pole	$\times 16.5$	= Feet
Pole	$\times 5.0292$	= Meter
Pole	$\times 1$	= Rod
Pole	$\times 5.5$	= Yard
Ponce	$\times 2.71$	= Centimeter
Pood	$\times 1{,}000$	= Cubic inch
Pood	$\times 40$	= Funt
Pood	$\times 4.32$	= Gallon, USA
Pood	$\times 16.3805$	= Kilogram
Poundals	$\times 13{,}826$	= Dynes
Poundals	$\times 14.098$	= Grams
Poundals	$\times 1.383 \times 10^{-3}$	= Joules/centimeter
Poundals	$\times 0.1383$	= Joules/meter
Poundals	$\times 0.0141$	= Kilograms
Poundals	$\times 0.1383$	= Newton
Poundals	$\times 0.03108$	= Pound-force
Pound-mol	$\times 359.05$	= Cubic feet at 32° F and 1 atm
Pounds	$\times$ 1/Mol. Wt.	= Pound-mols
Pounds	$\times 2267.9616$	= Carats
Pounds (avdp)	$\times 256$	= Drams
Pounds (avdp)	$\times 7{,}000$	= Grains
Pounds (avdp)	$\times 453.5924$	= Grams (metric)
Pounds	$\times 0.04448$	= Joules/centimeters
Pounds (avdp)	$\times 0.4536$	= Kilograms
Pounds (avdp)	$\times 16$	= Ounces
Pounds (avdp)	$\times 14.5833$	= Ounces, troy
Pounds	$\times 32.174$	= Poundals
Pounds (avdp)	$\times 1.21528$	= Pounds, troy
Pounds	$\times 4.464 \times 10^{-4}$	= Tons, long
Pounds	$\times 4.536 \times 10^{-4}$	= Tonnes, metric
Pounds	$\times 5 \times 10^{-4}$	= Tonnes, short
Pounds, troy	$\times 5{,}760$	= Grains
Pounds, troy	$\times 373.24177$	= Grams
Pounds, troy	$\times 13.1657$	= Ounces, avoirdupois
Pounds, troy	$\times 12$	= Ounces, troy
Pounds, troy	$\times 240$	= Pennyweights, troy
Pounds, troy	$\times 0.822857$	= Pounds, avoirdupois
Pounds, troy	$\times 3.6735 \times 10^{-4}$	= Tonnes, long
Pounds, troy	$\times 3.7324 \times 10^{-4}$	= Tonnes, metric
Pounds, troy	$\times 4.1143 \times 10^{-4}$	= Tonnes, short
Pounds of water	$\times 0.01602$	= Cubic feet
Pounds of water	$\times 27.68$	= Cubic inches
Pounds of water	$\times 0.1198$	= Gallons
Pounds of water/minute	$\times 2.67 \times 10^{-4}$	= Cubic feet/second
Pounds/cubic foot	$\times 0.01602$	= Grams/cubic centimeters
Pounds/cubic foot	$\times 16.02$	= Kilograms/cubic meter
Pounds/cubic foot	$\times 5.787 \times 10^{-4}$	= Pounds/cubic inch
Pounds/cubic foot	$\times 27$	= Pounds/cubic yard
Pounds/cubic inch	$\times 27.68$	= Grams/cubic centimeter
Pounds/cubic inch	$\times 2.768 \times 10^{4}$	= Kilograms/cubic meter
Pounds/cubic inch	$\times 1{,}728$	= Pounds/cubic foot
Pounds/cubic inch	$\times 46{,}656$	= Pounds/cubic yard
Pounds/hour	$\times 10.714 \times 10^{-3}$	= Tonnes/day, long
Pounds/hour	$\times 12 \times 10^{-3}$	= Tonnes/day, short
Pounds/hour	$\times 10.886 \times 10^{-3}$	= Tonnes/day, metric
Pounds/hour	$\times 0.45359$	= Kilograms/hour
Pounds/square foot	$\times 4.725 \times 10^{-4}$	= Atmospheres
Pounds/square foot	$\times 0.01602$	= Feet of water
Pounds/square foot	$\times 0.01414$	= Inches of mercury
Pounds/square foot	$\times 4.8824$	= Kilograms/square meter
Pounds/square foot	$\times 0.1111$	= Ounce/square inch
Pounds/square foot	$\times 0.107638$	= Pound/square centimeter
Pounds/square foot	$\times 6.944 \times 10^{-3}$	= Pound/square inch
Pounds/square foot	$\times 10.76387$	= Pound/square meter

Pounds/square inch	$\times 0.068046$	= Atmospheres
Pounds/square inch	$\times 2.307$	= Feet of water
Pounds/square inch	$\times 27.7$	= Inch of water
Pounds/square inch	$\times 2.036$	= Inch of mercury
Pounds/square inch	$\times 0.0703$	= Kilogram/square centimeter
Pounds/square inch	$\times 703.1$	= Kilogram/square meter
Pounds/square inch	$\times 51.714$	= Millimeters of mercury
Pounds/square inch	$\times 2,304$	= Ounce/square foot
Pounds/square inch	$\times 144$	= Pound/square foot

Q

Quadrant	$\times 0.25$	= Circumference
Quadrant	$\times 90$	= Degrees
Quadrant	$\times 5,400$	= Minutes
Quadrant	$\times 1.571$	= Radians
Quarts, USA, dry	$\times 0.03125$	= Bushel
Quarts, USA, dry	$\times 1,101.2$	= Cubic centimeter
Quarts, USA, dry	$\times 0.03889$	= Cubic foot
Quarts, USA, dry	$\times 67.20$	= Cubic inches
Quarts, USA, dry	$\times 1.1012$	= Liter
Quarts, USA, dry	$\times 1.16365$	= Quart, USA, liquid
Quarts, USA, liquid	$\times 946.331$	= Cubic centimeter
Quarts, USA, liquid	$\times 0.03342$	= Cubic foot
Quarts, USA, liquid	$\times 57.75$	= Cubic inches
Quarts, USA, liquid	$\times 9.464 \times 10^{-4}$	= Cubic meters
Quarts, USA, liquid	$\times 1.238 \times 10^{-3}$	= Cubic yard
Quarts, USA, liquid	$\times 4$	= Cup
Quarts, USA, liquid	$\times 256$	= Dram fluid
Quarts, USA, liquid	$\times 0.25$	= Gallons
Quarts, USA, liquid	$\times 0.946331$	= Liter
Quarts, USA, liquid	$\times 5.9523 \times 10^{-3}$	= Oil, barrel
Quarts, USA, liquid	$\times 32$	= Ounces
Quarts, USA, liquid	$\times 2$	= Pint
Quarts, USA, liquid	$\times 0.8594$	= Quart, USA, dry

R

Radians	$\times 57.3$	= Degrees
Radians	$\times 3,438$	= Minutes
Radians	$\times 0.6366$	= Quadrants
Radians	$\times 2.063 \times 10^{5}$	= Seconds
Revolutions/minute	$\times 6.0$	= Degrees/second
Revolutions/minute	$\times 0.1047$	= Radians/second
Revolutions/minute	$\times 0.01667$	= Revolutions/second
Rod	$\times 0.165$	= Chain, engineer
Rod	$\times 0.25$	= Chain, Gunters
Rod	$\times 16.5$	= Foot
Rod	$\times 0.025$	= Furlong
Rod	$\times 198$	= Inch
Rod	$\times 25$	= Link
Rod	$\times 5.029$	= Meter
Rod	$\times 5.5$	= Yard

S

Seconds, angle	$\times 2.778 \times 10^{-4}$	= Degrees
Seconds, angle	$\times 16.67 \times 10^{-3}$	= Minutes
Seconds, time	$\times 2.777 \times 10^{-4}$	= Hour
Seconds, time	$\times 0.166$	= Minutes
Slugs	$\times 14.59$	= Kilograms
Slugs	$\times 32.17$	= Pounds
Slugs/cubic foot	$\times 0.5154$	= Gm/cubic centimeter
Snow, cubic foot	$\times 7.2$	= Pounds, 32° F
Snow, inch deep	$\times 0.1$	= Inch, water
Square centimeter	$\times 1.076 \times 10^{-3}$	= Square foot
Square centimeter	$\times 0.155$	= Square inch

Square centimeter	$\times 0.0001$	= Square meter
Square centimeter	$\times 3.861 \times 10^{-11}$	= Square miles
Square centimeter	$\times 100$	= Square millimeters
Square centimeter	$\times 1.196 \times 10^{-4}$	= Square yards
Square feet, USA	$\times 2.296 \times 10^{-5}$	= Acre
Square feet, USA	$\times 9.29 \times 10^{-4}$	= Are
Square feet, USA	$\times 929.034$	= Square centimeters
Square feet, USA	$\times 144$	= Square inches
Square feet, USA	$\times 0.0929$	= Square meter
Square feet, USA	$\times 3.587 \times 10^{-8}$	= Square miles
Square feet, USA	$\times 9.29 \times 10^{4}$	= Square millimeters
Square feet, USA	$\times 0.1111$	= Square yards
Square inches	$\times 6.452$	= Square centimeters
Square inches	$\times 6.944 \times 10^{-3}$	= Square feet
Square inches	$\times 645.2$	= Square millimeters
Square inches	$\times 7.716 \times 10^{-4}$	= Square yard
Square kilometer	$\times 247.1$	= Acre
Square kilometer	$\times 100$	= Hectare
Square kilometer	$\times 10.76 \times 10^{6}$	= Square feet
Square kilometer	$\times 1.55 \times 10^{9}$	= Square inches
Square kilometer	$\times 10^{6}$	= Square meters
Square kilometer	$\times 0.3861$	= Square mile, USA
Square kilometer	$\times 1.196 \times 10^{6}$	= Square yards
Square meters	$\times 2.471 \times 10^{-4}$	= Acre
Square meters	$\times 0.01$	= Are
Square meters	$\times 0.0001$	= Hectare
Square meters	$\times 10{,}000$	= Square centimeters
Square meters	$\times 10.764$	= Square feet
Square meters	$\times 1{,}550$	= Square inches
Square meters	$\times 3.861 \times 10^{-7}$	= Square miles
Square meters	$\times 1.196$	= Square yards
Square miles	$\times 640$	= Acre
Square miles	$\times 259$	= Hectare
Square miles	$\times 27.88 \times 10^{6}$	= Square feet
Square miles	$\times 2.59$	= Square kilometers
Square miles	$\times 2.59 \times 10^{6}$	= Square meters
Square miles	$\times 3.098 \times 10^{6}$	= Square yards
Square millimeters	$\times 0.01$	= Square centimeters
Square millimeters	$\times 1.076 \times 10^{-5}$	= Square feet
Square millimeters	$\times 1.55 \times 10^{-3}$	= Square inches
Square rods	$\times 0.00625$	= Acre
Square rods	$\times 272.25$	= Square feet
Square rods	$\times 25.293$	= Square meter
Square rods	$\times 30.25$	= Square yard
Square vara	$\times 7.716$	= Square feet
Square yard	$\times 2.066 \times 10^{-4}$	= Acres
Square yard	$\times 8361$	= Square centimeter
Square yard	$\times 9$	= Square feet
Square yard	$\times 1{,}296$	= Square inches
Square yard	$\times 0.8361$	= Square meters
Square yard	$\times 3.228 \times 10^{-7}$	= Square miles
Square yard	$\times 8.361 \times 10^{5}$	= Square millimeters
Square yard	$\times 0.03306$	= Square rods
Stone	$\times 14$	= Pound
Stone	$\times 6.35$	= Kilogram

T

Tablespoon	$\times 0.0625$	= Cup
Tablespoon	$\times 3$	= Teaspoon
Teaspoon	$\times 0.0208$	= Cup
Teaspoon	$\times 0.333$	= Tablespoon
Temperature, $^\circ C + 17.78$	$\times 1.8$	$=^\circ F$
Temperature, $^\circ F - 32$	$\times 0.5556$	$=^\circ C$
Ton, long	$\times 1{,}016$	= Kilogram
Ton, long	$\times 2{,}240$	= Pounds
Ton, long	$\times 1.016$	= Metric tonnes
Ton, long	$\times 1.12$	= Short tonnes
Ton, metric	$\times 7.454$	= Barrel, oil, 36 API

Ton, metric	×1,000	= Kilograms
Ton, metric	×2,205	= Pounds
Ton, metric	×0.9842	= Ton, long
Ton, metric	×1.1023	= Ton, short
Ton, shipping, USA	×40	= Cubic feet
Ton, shipping, USA	×2.8317	= Cubic meter
Ton, shipping, USA	×1.050	= Ton, shipping, British
Ton, short	×40	= Cubic feet
Ton, short	×268.8	= Gallons, USA, liquid
Ton, short	×4	= Hogshead
Ton, short	×907.18486	= Kilograms
Ton, short	×1,000	= Liter
Ton, short	×32,000	= Ounces
Ton, short	×2,000	= Pounds
Ton, short	×0.89286	= Tonnes, long
Ton, short	×0.907	= Tonnes, metric
Tonnes, short/square foot	×9,765	= Kilograms/square meter
Tonnes, short/square foot	×2,000	= Pounds/square inch
Tonnes, short/day	×83.333	= Pounds/hour
Tonnes, short/day	×0.16643	= Gallons/minute
Tonnes, short/day	×0.9072	= Tonnes, metric/day
Tonnes, short/day	×0.8929	= Tonnes, long/day
Tonnes, short/day	×37.8	= Kilograms/hour
Tonnes, metric/day	×91.859	= Pounds/hour
Tonnes, metric/day	×41.667	= Kilograms/hour
Tonnes, metric/day	×0.9843	= Tonnes, long/day
Tonnes, metric/day	×1.1023	= Tonnes, short/day
Tonnes, long/day	×1.12	= Tonnes, short/day
Tonnes, long/day	×1.016	= Tonnes, metric/day
Tonnes, long/day	×93.333	= Pounds/hour
Tonnes, long/day	×42.335	= Kilograms/hour

V

Vara	×2.7777	= Feet
Vara	×33.3333	= Inch
Vara	×0.9259	= Yard
Volt/inch	×0.3937	= Volt/centimeter

W

Water, 62° F, Gallon	×8.3311	= Pound
Water height in feet	×0.4335	= Pound/square inch
Water height in feet	×0.03048	= Kilograms/square centimeters
Water height in inches	×0.03613	= Pound/square inch
Water height in inches	×0.00254	= Kilograms/square centimeter
Water height in meters	×1.42067	= Pound/square inch
Water height in meters	×0.100	= Kilograms/square centimeters
Watts	×3.4128	= Btu/hour
Watts	×0.05688	= Btu/minute
Watts	×107	= Ergs/second
Watts	×44.27	= Foot-pounds/minute
Watts	×0.7378	= Foot-pounds/second
Watts	$\times 1.341 \times 10^{-3}$	= Horsepower, USA
Watts	$\times 1.36 \times 10^{-3}$	= Horsepower, metric
Watts	×0.001	= Kilowatt
Watts	×1	= Joules/second
Watts (abs.)	×0.056884	= Btu (mean)/minute
Watt-hours	×3.4128	= Btu
Watt-hours	$\times 3.60 \times 10^{10}$	= Ergs
Watt-hours	×2,656	= Foot-pounds
Watt-hours	×858.85	= Gram-calories
Watt-hours	$\times 1.341 \times 10^{-3}$	= Horsepower-hours, USA
Watt-hours	$\times 1.3596 \times 10^{-3}$	= Horsepower-hours, metric
Watt-hours	×0.8605	= Kilogram-calories
Watt-hours	×367.2	= Kilogram-meters
Watt-hours	×0.001	= Kilowatt-hours

Y

Yard, USA	$\times 91.4402$	= Centimeter
Yard, USA	$\times 3$	= Feet
Yard, USA	$\times 36$	= Inch
Yard, USA	$\times 9.144 \times 10^{-4}$	= Kilometer
Yard, USA	$\times 0.9144$	= Meter
Yard, USA	$\times 4.934 \times 10^{-4}$	= Mile, nautical, USA
Yard, USA	$\times 5.682 \times 10^{-4}$	= Mile, Statute, USA
Yard, USA	$\times 914.402$	= Millimeters
Yard, USA	$\times 0.1818$	= Rod
Year	$\times 8,765$	= Hours
Year	$\times 525,948$	= Minutes

D-2
Physical Property Conversion Factors

Acceleration of gravity = 32.172 ft./sec./sec.
= 980.6 cm./sec./sec.

Electrical conductance;
1 mho = 1 ohm^{-1}
= 10^{-6} megamho
= 10^{6} micromho

Heat Value of Fuel

Lower heating value
= Higher heating value − 10.3 ($9H_2 + H_2O$), Btu/lb.
where: H_2 = weight % hydrogen in fuel
H_2O = weight % water vapor in fuel
GPM = (pounds/hour) / (500 × Sp.Gr.)

$$\text{Velocity, feet/sec.} = \frac{0.321\ (\text{GPM})}{(\text{Flow Area, sq.in.})}$$

Head, feet = 2.31 (Pressure or head, psi) / Sp.Gr.

$$\text{Brake horsepower, BHP} = \frac{(\text{GPM})\ (\text{Sp.Gr.})\ (\text{Head, feet})}{3960\ (\text{Efficiency, fraction})}$$

Weight/Volume (avoirdupois unless otherwise stated)

Density of sea water = 1.025 grams/cc.
1 gram-molecular volume of a gas at 760 mm Hg and 0° C. = 22.4 liters
1 U. S. gallon = (8.34 × Sp.Gr. of fluid), pounds
Weight of one cu.ft. liquid = (62.32 pounds × Sp.Gr. of fluid), pounds/cu.ft.
1 pound avoirdupois = 1.2153 pound apothecaries'
1 grain avoirdupois = 1 grain troy = 1 grain apothecaries' weight

Air Analysis*

	By Weight %	By Volume %
Nitrogen	75.47	78.2
Oxygen	23.19	21.0

* Neglects trace gases such as argon, xenon, helium, krypton and assumes dry basis.

Gas Constants, (R), Universal

R = 0.0821 (atm) (liter) / (g-mol) (°K)
= 1.987 (g-cal.) / (g-mol) (°K)
= 1.987 Btu/(lb.-mol) (°R)
= 1.987 (Chu) / (lb.-mol) (°K)
= 8.314 joules/(g-mol) (°K)
= 1,546 (ft.) (lb.force) / (lb.-mol) (°R)
= 10.73 (lb.-force/sq. in abs.) (cu.ft.) / (lb.-mol) (°R)
= 18,510 (lb.-force/sq.in.) (cu.in.) / (lb.-mol) (°R)
= 0.7302 (Atm) (cu.ft.) / (lb.-mol) (°R)

R_i = R/mol.wt. gas
where: R_i = individual gas constant
Avogadro Constant, N_a = 6.02252 × 10^{23} molecules/mol

Density Vapor or Gases (Ideal), ρ

$$\rho = \left(\frac{\text{mol. wt., vapor}}{359}\right)\left(\frac{14.7 + p}{14.7}\right)\left(\frac{460 + 32}{460 + {}^\circ F}\right), \text{ lbs./cu.ft.}$$

where: p = gage pressure at actual condition, psig
°F = fahrenheit temperature at actual condition

$$\rho = \frac{144\ P}{R_i\ T}, \text{ pounds/cu.ft.}$$

where: P = absolute pressure, pounds/sq. in. abs.
T = absolute temperature, °Rankine, °R
o = standard conditions (0°C & 760 mm Hg)

$V = V_o\ (P_o/P'')\ (T/T_o)$

$P''V = 1543\ nT$; P'' = PSF abs.; V = cu. ft.

T = °R; n = Lb. moles

$$\text{cu.ft.} = \frac{\text{lb}}{MW}\ (359)\left(\frac{273 + {}^\circ C}{273}\right)\left(\frac{14.7}{p + 14.7}\right) \text{ at p, °C}$$

Specific Volume, Gas or Vapor

$$\overline{V} = 1/\rho, \text{ cu.ft./pound}$$

Velocity of sound in dry air @ 0° C. and 1 atm. = 1,089 ft./sec.
Density of dry air @ 0° C. and 1 atm.
= 0.001293 gm/cu.cm.
= 0.0808 lb./cu.ft.

Viscosity (Dynamic)

1 Poise = 1 gram/cm.-sec. = 1 dyne-sec./sq:cm.
= 0.1 kg/meter-sec.
1 Poise × 100 = Centipoise (μ)
Poise × 2.09 × 10^{-3} = slugs/ft.-sec.
= pounds (force)-sec./sq.ft.
Poise × 0.10 = pascal-sec.

D-2
Physical Property Conversion Factors

Poise × 0.0672 = pounds (mass)/(ft.-sec.)
= poundal-sec./sq.ft.
Poise × 0.10 = Newton-sec./sq. meter
Centipoise × 0.01 = gm./cm.-sec.
Centpoise × 6.72 × 10^{-4} = pound/ft.-sec .
Centipoise × 2.4 = pound/ft.-hr.
Millipoise × 1000 = poise
Micropoise × 1,000,000 = poise
Slugs/ft.-sec. × 47,900 = centipoise
1 centistoke = 1.076 × 10^{-5} $ft.^2/sec.$
1 centipoise (cp) = 0.01 gm./cm. sec.
Slugs/ft.-sec. × 32.2 = pounds (mass)/ft.-sec.
Pounds/ft.-sec. × 3600 = lb./ft.-hr.
Pounds (mass)/ft.-sec. × 1487 = centipoise
Pounds (mass)/ft.-sec. × 0.0311 = slugs/ft.-sec.
= pounds (force)-sec./sq.ft.
Viscosity of air @ 68° F. = 180.8 × 10^{-6} poise
Viscosity of water @ 66° F = 0.010087 poise

Viscosity (Kinematic)

Kinematic viscosity,
centistokes × 1.076 × 10^{-5} = $ft.^2/sec.$

$$\text{Kinematic viscosity, centistokes } (\nu) = \frac{\text{Dynamic viscosity, centipoise}}{\text{Fluid density, gm./cu.cm.}} = \frac{\text{Centipoise}}{\text{Sp.Gr. of liquid relative to water at 39.2° F. (4° C.)}}$$

Centistokes × 0.01 = stokes, sq.cm./sec.
Centistokes × 1.076 × 10^{-5} = sq.ft./sec.
Centistokes × 0.01 = Stokes, sq.cm./sec.

Thermal Conductivity (through a homogeneous material)

$$\frac{\text{Btu (ft.)}}{\text{(sq.ft.) (°F.) (hr.)}} \times 4.134 \times 10^{-3} = \frac{\text{(g.-cal.) (cm.)}}{\text{(sq.cm.) (°C.) (sec.)}}$$

$$\times 1.200 \times 10 = \frac{\text{(Btu) (in.)}}{\text{(sq.ft.) (°F.) (hr.)}}$$

$$\times 3.518 \times 10^{-3} = \frac{\text{(kilowatt hrs.) (in.)}}{\text{(sq.ft.) (°F.) (hr.)}}$$

$$\frac{\text{(g.-cal.) (cm.)}}{\text{(sq.cm.) (°C.) (hr.)}} \times 8.063 \times 10^{-1} = \frac{\text{Btu (in.)}}{\text{(sq.ft.) (°F.) (hr.)}}$$

$$\times 6.719 \times 10^{-2} = \frac{\text{Btu (ft.)}}{\text{(sq.ft.) (°F.) (hr.)}}$$

$$\frac{\text{(g.-cal.) (cm.)}}{\text{(sq.cm.) (°C.) (sec.)}} \times 2.903 \times 10^{3} = \frac{\text{Btu (in.)}}{\text{(sq.ft.) (°F.) (hr.)}}$$

$$\times 8.063 \times 10^{-1} = \frac{\text{Btu (in.)}}{\text{(sq.ft.) (°F.) (sec.)}}$$

$$\times 8.506 \times 10^{2} = \frac{\text{(joules) (in.)}}{\text{(sq.ft.) (°F.) (sec.)}}$$

Specific Gravity (Liquid)

$$s = \frac{\rho \text{ of liquid @ 60° F.*}}{\rho \text{ of water @ 60° F.*}}$$

* or at other specified temperature

Oil

$$s \text{ at } 60° \text{ F.}/60° \text{ F.} = \frac{141.5}{131.5 + \text{degrees API}}$$

Liquids Lighter Than Water

$$s \text{ @ } 60° \text{ F.}/60° \text{ F.} = \frac{140}{130 + \text{degrees Baume'}}$$

Liquids Heavier Than Water

$$s \text{ @ } 60° \text{ F.}/60° \text{ F.} = \frac{145}{145 - \text{degrees Baume'}}$$

Specific Gravity (Gases)

$$S_g = \frac{\text{R of air}}{\text{R of gas}} = \frac{53.3}{\text{R of gas}}, \text{ where R = gas constant}$$

$$S_g = \frac{\text{mol. wt. (gas)}}{\text{mol. wt. (air)}} = \frac{\text{mol. wt. (gas)}}{29}$$

Density, Liquid ρ

Density liquid, ρ = (62.3 lb./cu. ft. water) (Sp. Gr. liquid), pounds /cu. ft.

Metric

1 gram = 10 decigrams
= 100 centigrams
= 1,000 milligrams
= 1,000,000 microgram
= 0.001 kilogram
= 10^{-6} megagram
1 liter = 10 deciliters = 1.0567 liquid quarts
10 liters = 1 dekaliter = 2.6417 liquid gallons
10 dekaliters = 1 hectoliter = 2.8375 U. S. bushels

D-2
Physical Property Conversion Factors

1 meter = 10 decimeters = 39.37 inches
= 100 centimeters
= 1,000 millimeters
= 1,000,000 miscrons = 1,000,000 micrometers
= 1/1,000 kilometer
= 10^{10} Angstrom units

10 millimeters = 1 centimeter = 0.3937 inches
10 centimeters = 1 decimeter = 3.937 inches
25.4 millimeters = 1 inch

Specific Heat

$$\frac{\text{(gram-cal.)}}{\text{(gram)(°C.)}} \times 1.8 = \frac{\text{Btu}}{\text{(pound)(°C.)}}$$

$$\times 1.0 = \frac{\text{Btu}}{\text{(pound)(°F.)}}$$

$$\times 4.186 = \frac{\text{joules}}{\text{(gram)(°C.)}}$$

$$\times 1055 = \frac{\text{joules}}{\text{(pound)(°F.)}}$$

$$\times 1.163 \times 10^{-3} = \frac{\text{kilowatt-hours}}{\text{(kilogram)(°C.)}}$$

$$\times 2.930 \times 10^{-4} = \frac{\text{kilowatt-hours}}{\text{(pound)(°F.)}}$$

Specific heat of water at 1 atm. = 0.238 cal./gm-°C.
Btu/lb. − ° F. × 0.2390 = Btu/lb. − ° R

Heat Transfer Coefficient

PCU/(hr.)(sq. ft.)(°C.) × 1.0
= Btu/(hr.)(sq.ft.)(°F)

Kg-cal./(hr.)(sq. m.)(°C.) × 0.2048
= Btu/(hr.)(sq.ft.)(°F)
G-cal./(sec.)(sq. cm.)(°C.) × 7,380
= Btu/(hr.)(sq.ft.)(°F)
Watts/(sq. in.)(°F.) × 490 = Btu/(hr.)(sq. ft.)(°F.)

Energy Units

Pound-Centigrade-Unit(PCU)	× 1.8 = Btu
	× 0.45359 = calorie
	× 1400.4 = ft.-lb.
	× 0.0005276 = kilowatt-hr.
	× 1899.36 = joules

Calories	× 3.9683 = Btu
	× 3091.36 = ft.-lb.
	× 0.001559 = horsepower-hr.
	× 0.001163 = kilowatt-hr.
	× 4187.37 = joules

Pressure

1 mm Hg = 1,333 dynes/sq. cm.
750 mm Hg = 10 dynes/sq. cm. = 1 megabar @ °C. and g = 980.6

D-3
Synchronous Speeds

$$\text{Synchronous Speed} = \frac{\text{Frequency} \times 120}{\text{No. of Poles}}$$

	FREQUENCY				FREQUENCY	
Poles	60 cycle	50 cycle	25 cycle	Poles	60 cycle	50 cycle
2	3600	3000	1500	42	171.4	142.9
4	1800	1500	750	44	163.6	136.4
6	1200	1000	500	46	156.5	130.4
8	900	750	375	48	150	125
10	720	600	300	50	144	120
12	600	500	250	52	138.5	115.4
14	514.3	428.6	214.3	54	133.3	111.1
16	450	375	187.5	56	128.6	107.1
18	400	333.3	166.7	58	124.1	103.5
20	360	300	150	60	120	100
22	327.2	272.7	136.4	62	116.1	96.8
24	300	250	125	64	112.5	93.7
26	276.9	230.8	115.4	66	109.1	90.9
28	257.1	214.3	107.1	68	105.9	88.2
30	240	200	100	70	102.9	85.7
32	225	187.5	93.7	72	100	83.3
34	211.8	176.5	88.2	74	97.3	81.1
36	200	166.7	83.3	76	94.7	78.9
38	189.5	157.9	78.9	78	92.3	76.9
40	180	150	75	80	90	75

Courtesy Ingersoll-Rand Co.

Conversion Factors

Units of Length	Multiply units in left column by proper factor below							
	in.	ft.	yd.	mile	mm.	cm.	m.	km.
1 inch	1	0.0833	0.0278	—	25.40	2.540	0.0254	—
1 foot	12	1	0.3333	—	304.8	30.48	0.3048	—
1 yard	36	3	1	—	914.4	91.44	0.9144	—
1 mile	—	5280	1760	1	—	—	1609.3	1.609
1 millimeter	0.0394	0.0033	—	—	1	0.100	0.001	—
1 centimeter	0.3937	0.0328	0.0109	—	10	1	0.01	—
1 meter	39.37	3.281	1.094	—	1000	100	1	0.001
1 kilometer	—	3281	1094	0.6214	—	—	1000	1

(1 micron = 0.001 millimeter)

Courtesy Ingersoll-Rand Co.

D-4
(Continued). Conversion Factors

Units of Weight	Multiply units in left column by proper factor below						
	grain	oz.	lb.	ton	gram	kg.	metric ton
1 grain	1	—	—	—	0.0648	—	—
1 ounce	437.5	1	0.0625	—	28.35	0.0283	—
1 pound	7000	16	1	0.0005	453.6	0.4536	—
1 ton	—	32,000	2000	1	—	907.2	0.9072
1 gram	15.43	0.0353	—	—	1	0.001	—
1 kilogram	—	35.27	2.205	—	1000	1	0.001
1 metric ton	—	35,274	2205	1.1023	—	1000	1

Units of Density	Multiply units in left column by proper factor below				
	lb/cu. in.	lb/cu. ft.	lb/gal.	g/cu. cm.	g/liter
1 pound/cu. in.	1	1728	231.0	27.68	27,680
1 pound/cu. ft.	—	1	0.1337	0.0160	16.019
1 pound/gal.	0.00433	7.481	1	0.1198	119.83
1 gram/cu. cm.	0.0361	62.43	8.345	1	1000.0
1 gram/liter	—	0.0624	0.00835	0.001	1

Units of Area	Multiply units in left column by proper factor below						
	sq. in.	sq. ft.	acre	sq. mile	sq. cm.	sq. m.	hectare
1 sq. inch	1	0.0069	—	—	6.452	—	—
1 sq. foot	144	1	—	—	929.0	0.0929	—
1 acre	—	43,560	1	0.0016	—	4047	0.4047
1 sq. mile	—	—	640	1	—	—	259.0
1 sq. centimeter	0.1550	—	—	—	1	0.0001	—
1 sq. meter	1550	10.76	—	—	10,000	1	—
1 hectare	—	—	2.471	—	—	10,000	1

Units of Volume	Multiply units in left column by proper factor below							
	cu. in.	cu. ft.	cu. yd.	cu. cm.	cu. meter	liter	U.S. gal.	Imp. gal.
1 cu. inch	1	—	—	16.387	—	0.0164	—	—
1 cu. foot	1728	1	0.0370	28,317	0.0283	28.32	7.481	6.229
1 cu. yard	46,656	27	1	—	0.7646	764.5	202.0	168.2
1 cu. centimeter	0.0610	—	—	1	—	0.0010	—	—
1 cu. meter	61,023	35.31	1.308	1,000,000	1	999.97	264.2	220.0
1 liter	61.025	0.0353	—	1000.028	0.0010	1	0.2642	0.2200
1 U.S. gallon	231	0.1337	—	3785.4	—	3.785	1	0.8327
1 Imperial gallon	277.4	0.1605	—	4546.1	—	4.546	1.201	1

D-4
(Continued). Conversion Factors

Units of Pressure	Multiply units in left column by proper factor below						
	lb/sq. in.	lb/sq. ft.	Int. atm.	kg/cm²	mm Hg at 32°F	in. Hg at 32°F	ft. water at 39.2°F
1 pound/sq. in.	1	144	—	0.0703	51.713	2.0359	2.307
1 pound/sq. ft.	0.00694	1	—	—	0.3591	0.01414	0.01602
1 intern. atmosphere	14.696	2116.2	1	1.0333	760	29.921	33.90
1 kilogram/sq. cm.	14.223	2048.1	0.9678	1	735.56	28.958	32.81
1 millimeter-mercury— 1 torr (torricelli)—	0.0193	2.785	—	—	1	0.0394	0.0446
1 inch mercury	0.4912	70.73	0.0334	0.0345	25.400	1	1.133
1 foot water	0.4335	62.42	—	0.0305	22.418	0.8826	1

Units of Energy	Multiply units in left column by proper factor below					
	ft.-lb.	Btu	g. cal.	Joule	kw-hr.	hp-hr.
1 foot-pound	1	0.001285	0.3240	1.3556	—	—
1 Btu	778.2	1	252.16	1054.9	—	—
1 gram calorie	3.0860	0.003966	1	4.1833	—	—
1 int. Joule	0.7377	0.000948	0.2390	1	—	—
1 int. kilowatt-hour	2,655,656	3412.8	860,563	—	1	1.3412
1 horsepower-hour	1,980,000	2544.5	641,617	—	0.7456	1

Units of Specific Energy	Multiply units in left column by proper factor below				
	absolute Joule/g	Int. Joule/g	cal/g	Int. cal/g	Btu/lb.
1 absolute Joule/gram	1	0.99984	0.23901	0.23885	0.42993
1 int. Joule/gram	1.000165	1	0.23904	0.23892	0.43000
1 calorie/gram	4.1840	4.1833	1	0.99935	1.7988
1 int. calorie/gram	4.1867	4.1860	1.00065	1	1.8000
1 Btu/lb	2.3260	2.3256	0.55592	0.55556	1

Units of Power (rates of energy use)	Multiply units in left column by proper factor below								
	hp	watt	kw	Btu/min.	Btu/hr.	ft-lb/sec.	ft-lb/min.	g. cal/sec.	metric hp
1 horsepower	1	745.7	0.7475	42.41	2544.5	550	33.000	178.2	1.014
1 watt	—	1	0.001	0.0569	3.413	0.7376	44.25	0.2390	0.00136
1 kilowatt	1.3410	1000	1	56.88	3412.8	737.6	44,254	239.0	1.360
1 Btu per minute	—	—	—	1	60	12.97	778.2	4.203	0.0239
1 metric hp	0.9863	735.5	0.7355	41.83	2509.6	542.5	32.550	175.7	1

Units of Refrigeration	Multiply units in left column by factor below					
	Btu(IT)/min.	Btu(IT)/hr.	kg cal/hr.	ton (U.S.) comm	ton (BRIT.) comm	frigorie/hr.
1 ton (U.S.) comm	200	12,000	3025.9	1	0.8965	3025.9
1 ton (Brit) comm	223.08	13,385	3375.2	1.1154	1	3375.2
1 frigorie/hr.	0.06609	3.9657	1	0.0003305	0.0002963	1

Note:—Btu is International Steam Table Btu(IT). 1 frigorie = 1 kg cal (Not IT).

D-5
Temperature Conversion

NOTE: The center column of numbers in boldface refers to the temperature in degrees, either Centigrade or Fahrenheit, which it is desired to convert into the other scale. If converting from Fahrenheit to Centigrade degrees, the equivalent temperature will be found in the left column; while if converting from degrees Centigrade to degrees Fahrenhiet, the answer will be found in the column on the right.

Centigrade		Fahrenheit	Centigrade		Fahrenheit	Centigrade		Fahrenheit	Centigrade		Fahrenheit
−273.17	**−459.7**		−20.6	**−5**	23.0	11.1	**52**	125.6	54.4	**130**	266
−268	**−450**		−17.8	**0**	32.0	11.7	**53**	127.4	57.2	**135**	275
−262	**−440**					12.2	**54**	129.2	60.0	**140**	284
−257	**−430**		−17.2	**1**	33.8	12.8	**55**	131.0	62.8	**145**	293
−251	**−420**		−16.7	**2**	35.6	13.3	**56**	132.8	65.6	**150**	302
−246	**−410**		−16.1	**3**	37.4				68.3	**155**	311
−240	**−400**		−15.6	**4**	39.2	13.9	**57**	134.6	71.1	**160**	320
−234	**−390**		−15.0	**5**	41.0	14.4	**58**	136.4			
			−14.4	**6**	42.8	15.0	**59**	138.2	73.9	**165**	329
−229	**−380**		−13.9	**7**	44.6	15.6	**60**	140.0	76.7	**170**	338
−223	**−370**		−13.3	**8**	46.4	16.1	**61**	141.8	79.4	**175**	347
−218	**−360**					16.7	**62**	143.6	82.2	**180**	356
−212	**−350**		−12.8	**9**	48.2	17.2	**63**	145.4	85.0	**185**	365
−207	**−340**		−12.2	**10**	50.0	17.8	**64**	147.2	87.8	**190**	374
−201	**−330**		−11.7	**11**	51.8				90.6	**195**	383
−196	**−320**		−11.1	**12**	53.6	18.3	**65**	149.0	93.3	**200**	392
−190	**−310**		−10.6	**13**	55.4	18.9	**66**	150.8	96.1	**205**	401
			−10.0	**14**	57.2	19.4	**67**	152.6	98.9	**210**	410
−184	**−300**		−9.4	**15**	59.0	20.0	**68**	154.4	100.0	**212**	414
−179	**−290**		−8.9	**16**	60.8	20.6	**69**	156.2	102	**215**	419
−173	**−280**					21.1	**70**	158.0	104	**220**	428
−169	**−273**	**−459.4**	−8.3	**17**	62.6	21.7	**71**	159.8	107	**225**	437
−168	**−270**	**−454**	−7.8	**18**	64.4	22.2	**72**	161.6	110	**230**	446
−162	**−260**	**−436**	−7.2	**19**	66.2				113	**235**	455
−157	**−250**	**−418**	−6.7	**20**	68.0	22.8	**73**	163.4	116	**240**	464
−151	**−240**	**−400**	−6.1	**21**	69.8	23.3	**74**	165.2			
			−5.6	**22**	71.6	23.9	**75**	167.0	118	**245**	473
−146	**−230**	**−382**	−5.0	**23**	73.4	24.4	**76**	168.8	121	**250**	482
−140	**−220**	**−364**	−4.4	**24**	75.2	25.0	**77**	170.6	124	**255**	491
−134	**−210**	**−346**				25.6	**78**	172.4	127	**260**	500
−129	**−200**	**−328**	−3.9	**25**	77.0	26.1	**79**	174.2	129	**265**	509
−123	**−190**	**−310**	−3.3	**26**	78.8	26.7	**80**	176.0	132	**270**	518
−118	**−180**	**−292**	−2.8	**27**	80.6				135	**275**	527
−112	**−170**	**−274**	−2.2	**28**	82.4	27.2	**81**	177.8	138	**280**	536
−107	**−160**	**−256**	−1.7	**29**	84.2	27.8	**82**	179.6	141	**285**	545
			−1.1	**30**	86.0	28.3	**83**	181.4	143	**290**	554
−101	**−150**	**−238**	−0.6	**31**	87.8	28.9	**84**	183.2	146	**295**	563
−96	**−140**	**−220**	0.0	**32**	89.6	29.4	**85**	185.0	149	**300**	572
−90	**−130**	**−202**				30.0	**86**	186.8	154	**310**	590
−84	**−120**	**−184**	0.6	**33**	91.4	30.6	**87**	188.6	160	**320**	608
−79	**−110**	**−166**	1.1	**34**	93.2	31.1	**88**	190.4	166	**330**	626
−73.3	**−100**	**−148.0**	1.7	**35**	95.0				171	**340**	644
−67.8	**−90**	**−130.0**	2.2	**36**	96.8	31.7	**89**	192.2	177	**350**	662
−62.2	**−80**	**−112.0**	2.8	**37**	98.6	32.2	**90**	194.0			
			3.3	**38**	100.4	32.8	**91**	195.8	182	**360**	680
−59.4	**−75**	**−103.0**	3.9	**39**	102.2	33.3	**92**	197.6	188	**370**	698
−56.7	**−70**	**−94.0**	4.4	**40**	104.0	33.9	**93**	199.4	193	**380**	716
−53.9	**−65**	**−85.0**				34.4	**94**	201.2	199	**390**	734
−51.1	**−60**	**−76.0**	5.0	**41**	105.8	35.0	**95**	203.0	204	**400**	752
−48.3	**−55**	**−67.0**	5.6	**42**	107.6	35.6	**96**	204.8	210	**410**	770
−45.6	**−50**	**−58.0**	6.1	**43**	109.4				216	**420**	788
−42.8	**−45**	**−49.0**	6.7	**44**	111.2	36.1	**97**	206.6	221	**430**	806
−40.0	**−40**	**−40.0**	7.2	**45**	113.0	36.7	**98**	208.4			
			7.8	**46**	114.8	37.2	**99**	210.2	227	**440**	824
−37.2	**−35**	**−31.0**	8.3	**47**	116.6	37.8	**100**	212.0	232	**450**	842
−34.4	**−30**	**−22.0**	8.9	**48**	118.4	40.6	**105**	221	238	**460**	860
−31.7	**−25**	**−13.0**				43.3	**110**	230	243	**470**	878
−28.9	**−20**	**−4.0**	9.4	**49**	120.2	46.1	**115**	239	249	**480**	896
−26.1	**−15**	**5.0**	10.0	**50**	122.0	48.9	**120**	248	254	**490**	914
−23.3	**−10**	**.4.0**	10.6	**51**	123.8	51.7	**125**	257	260	**500**	932

The formulas at the right may also be used for converting Centigrade or Fahrenheit degrees into the other scales.

Degrees Cent., $°C = \frac{5}{9}(°F + 40) - 40$

$= \frac{5}{9}(°F - 32)$

Degrees Fahr., $°F = \frac{9}{5}(°C + 40) - 40$

$= \frac{9}{5}\ C + 32$

Degrees Kelvin, $°K = °C + 273.2$

Degrees Rankine, $°R = °F + 459.7$

D-6
Altitude and Atmospheric Pressures

Altitude above Sea Level			Temperature**		Barometer*		Atmospheric Pressure	
Feet*	Miles	Meters*	°F	°C	Inches Hg Abs.	mm Hg Abs.	PSIA	Kg/sq cm Abs.
−5000	———	−1526	77	25	35.58	903.7	17.48	1.229
−4500	———	−1373	75	24	35.00	889.0	17.19	1.209
−4000	———	−1220	73	23	34.42	874.3	16.90	1.188
−3500	———	−1068	71	22	33.84	859.5	16.62	1.169
−3000	———	−915	70	21	33.27	845.1	16.34	1.149
−2500	———	−763	68	20	32.70	830.6	16.06	1.129
−2000	———	−610	66	19	32.14	816.4	15.78	1.109
−1500	———	−458	64	18	31.58	802.1	15.51	1.091
−1000	———	−305	63	17	31.02	787.9	15.23	1.071
−500	———	−153	61	16	30.47	773.9	14.96	1.052
0	———	0	59	15	29.92	760.0	14.696	1.0333
500	———	153	57	14	29.38	746.3	14.43	1.015
1000	———	305	55	13	28.86	733.0	14.16	.956
1500	———	458	54	12	28.33	719.6	13.91	.978
2000	———	610	52	11	27.82	706.6	13.66	.960
2500	———	763	50	10	27.32	693.9	13.41	.943
3000	———	915	48	9	26.82	681.2	13.17	.926
3500	———	1068	47	8	26.33	668.8	12.93	.909
4000	———	1220	45	7	25.84	656.3	12.69	.892
4500	———	1373	43	6	25.37	644.4	12.46	.876
5000	0.95	1526	41	5	24.90	632.5	12.23	.860
6000	1.1	1831	38	3	23.99	609.3	11.78	.828
7000	1.3	2136	34	1	23.10	586.7	11.34	.797
8000	1.5	2441	31	−1	22.23	564.6	10.91	.767
9000	1.7	2746	27	−3	21.39	543.3	10.50	.738
10,000	1.9	3050	23	−5	20.58	522.7	10.10	.710
15,000	2.8	4577	6	−14	16.89	429.0	8.29	.583
20,000	3.8	6102	−12	−24	13.76	349.5	6.76	.475
25,000	4.7	7628	−30	−34	11.12	282.4	5.46	.384
30,000	5.7	9153	−48	−44	8.903	226.1	4.37	.307
35,000	6.6	10,679	−66		7.060	179.3	3.47	.244
40,000	7.6	12,204	−70	−57	5.558	141.2	2.73	.192
45,000	8.5	13,730	−70	−57	4.375	111.1	2.15	.151
50,000	9.5	15,255	−70	−57	3.444	87.5	1.69	.119
55,000	10.4	16,781	−70	−57	2.712	68.9	1.33	.0935
60,000	11.4	18,306	−70	−57	2.135	54.2	1.05	.0738
70,000	13.3	21,357	−67	−55	1.325	33.7	.651	.0458
80,000	15.2	24,408	−62	−52	†8.273^{-1}	21.0	.406	.0285
90,000	17.1	27,459	−57	−59	5.200^{-1}	13.2	.255	.0179
100,000	18.9	30,510	−51	−46	3.290^{-1}	8.36	.162	.0114
120,000	22.8	36,612	−26	−48	1.358^{-1}	3.45	———	———
140,000	26.6	42,714	4	−16	5.947^{-2}	1.51	———	———
160,000	30.4	48,816	28	−2	2.746^{-2}	†6.97^{-1}	———	———
180,000	34.2	54,918	19	−7	1.284^{-2}	3.26^{-1}	———	———
200,000	37.9	61,020	−3	−19	5.846^{-3}	1.48^{-1}	———	———
220,000	41.7	67,122	−44	−42	2.523^{-3}	6.41^{-2}	———	———
240,000	45.5	73,224	−86	−66	9.955^{-4}	2.53^{-2}	———	———
260,000	49.3	79,326	−129	−90	3.513^{-4}	8.92^{-3}	———	———
280,000	53.1	85,428	−135	−93	1.143^{-4}	3.67^{-3}	———	———
300,000	56.9	91,530	−127	−88	3.737^{-5}	9.49^{-4}	———	———
400,000	75.9	122,040	———	———	6.3^{-7}	1.60^{-5}	———	———
500,000	94.8	152,550	———	———	1.4^{-7}	3.56^{-6}	———	———
600,000	114	183,060	———	———	5.9^{-8}	1.50^{-6}	———	———
800,000	152	244,080	———	———	1.6^{-8}	4.06^{-7}	———	———
1,000,000	189	305,100	———	———	5.1^{-9}	1.30^{-7}	———	———
1,200,000	228	366,120	———	———	2.0^{-9}	5.08^{-8}	———	———
1,400,000	266	427,140	———	———	8.2^{-10}	2.08^{-8}	———	———
1,600,000	304	488,160	———	———	3.8^{-10}	9.65^{-9}	———	———
1,800,000	342	549,180	———	———	1.8^{-10}	4.57^{-9}	———	———
2,000,000	379	610,200	———	———	9.2^{-11}	2.34^{-9}	———	———

Data from NASA Standard Atmosphere (1962).

*Temperature and barometer are approximate for negative altitudes.

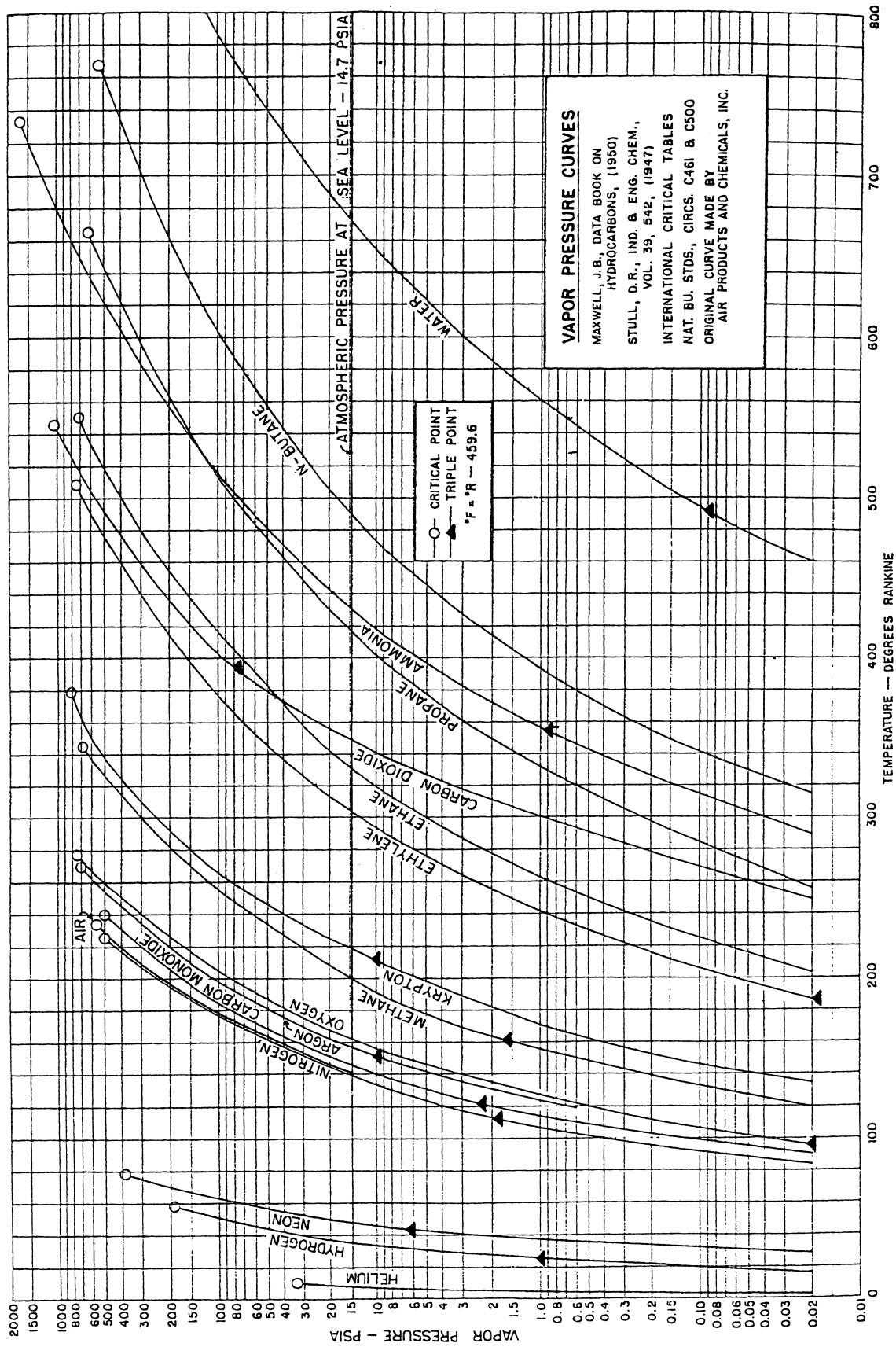
**Temperatures are average existing at 40° latitude and are rounded to even numbers.

†Negative exponent shows number of spaces the decimal point must be moved to the left.

Courtesy Ingersoll-Rand Co.

D-7

Vapor Pressure Curves. (Courtesy Ingersoll-Rand Co.)



D-8
Pressure Conversion Chart

MULTIPLY GIVEN NUMBER OF — BY FACTOR TO OBTAIN →

GIVEN	lb/in^2	in H_2O (at +39.2°F)	cm H_2O (at +4°C)	in Hg (at +32°F)	mm Hg (Torr) (at 0°C)	dyne/cm^2 (1μ bar)	newton/m^2 (PASCAL)	kgm/cm^2	bar	atm. (A_n)	lb/ft^2	ft H_2O (at +39.2°F)
lb/in^2	1.0000	2.7680×10^{1}	7.0308×10^{1}	2.0360	5.1715×10^{1}	6.8948×10^{4}	6.8948×10^{3}	7.0306×10^{-2}	6.8947×10^{-2}	6.8045×10^{-2}	1.4400×10^{2}	2.3067
in H_2O (at +39.2°F)	3.6127×10^{-2}	1.0000	2.5400	7.3554×10^{-2}	1.8683	2.4908×10^{3}	2.4908×10^{2}	2.5399×10^{-3}	2.4908×10^{-3}	2.4582×10^{-3}	5.2022	8.3333x10
cm H_2O (at +4°C)	1.4223×10^{-2}	0.3937	1.0000	2.8958×10^{-2}	0.7355	9.8064×10^{2}	9.8064×10^{1}	9.9997×10^{-4}	9.8064×10^{-4}	9.6781×10^{-4}	2.0481	3.2808×10^{-2}
in Hg (at +32°F)	4.9116×10^{-1}	1.3596×10^{1}	3.4532×10^{1}	1.0000	2.5400×10^{1}	3.3864×10^{4}	3.3864×10^{3}	3.4532×10^{-2}	3.3864×10^{-2}	3.3421×10^{-2}	7.0727×10^{1}	1.1330
mm Hg (Torr) (at 0°C)	1.9337×10^{-2}	5.3525×10^{-1}	1.3595	3.9370×10^{-2}	1.0000	1.3332×10^{3}	1.3332×10^{2}	1.3595×10^{-3}	1.3332×10^{-3}	1.3158×10^{-3}	2.7845	4.4605×10^{-2}
dyne/cm^2 (1μ bar)	1.4504×10^{-5}	4.0147×10^{-4}	1.0197×10^{-3}	2.9530×10^{-5}	7.5006×10^{-4}	1.0000	1.0000×10^{-1}	1.0197×10^{-6}	1.0000×10^{-6}	9.8692×10^{-7}	2.0886×10^{-3}	3.3456×10^{-5}
newton/m^2 (PASCAL)	1.4504×10^{-4}	4.0147×10^{-3}	1.0197×10^{-2}	2.9530×10^{-4}	7.5006×10^{-3}	1.0000×10^{1}	1.0000	1.0197×10^{-5}	1.0000×10^{-5}	9.8692×10^{-6}	2.0885×10^{-2}	3.3456×10^{-4}
kgm/cm^2	1.4224×10^{1}	3.9371×10^{2}	1.00003×10^{3}	2.8959×10^{1}	7.3556×10^{2}	9.8060×10^{5}	9.8060×10^{4}	1.0000	9.8060×10^{-1}	9.678×10^{-1}	2.0482×10^{3}	3.2809×10^{1}
bar	1.4504×10^{1}	4.0147×10^{2}	1.0197×10^{3}	2.9530×10^{1}	7.5006×10^{2}	1.0000×10^{6}	1.0000×10^{5}	1.0197	1.0000	9.8692×10^{-1}	2.0885×10^{3}	3.3456×10^{1}
atm. (A_n)	1.4696×10^{1}	4.0679×10^{2}	1.0333×10^{3}	2.9921×10^{1}	7.6000×10^{2}	1.0133×10^{6}	1.0133×10^{5}	1.0332	1.0133	1.0000	2.1162×10^{3}	3.3900×10^{1}
lb/ft^2	6.9445×10^{-3}	1.9223×10^{-1}	4.882×10^{-1}	1.4139×10^{-2}	3.591×10^{-1}	4.7880×10^{2}	4.7880×10^{1}	4.8824×10^{-4}	4.7880×10^{-4}	4.7254×10^{-4}	1.0000	1.6019×10^{-2}
ft H_2O (at +39.2°F)	4.3352×10^{-1}	1.2000×10^{1}	3.0480×10^{1}	8.826×10^{-1}	2.2419×10^{1}	2.9890×10^{4}	2.9890×10^{3}	3.0479×10^{-2}	2.9890×10^{-2}	2.9499×10^{-2}	6.2427×10^{1}	1.0000

D-9
Vacuum Conversion

Torr	Absolute Pressure		Inches Hg (Abs.)	Psia	Vacuum* Inches Hg
	Microns Hg	Mm Hg			
		762	30.00	14.74	—
		750	29.53	14.50	0.47
		700	27.56	13.54	2.44
		650	25.59	12.57	4.41
		600	23.62	11.60	6.38
		550	21.65	10.64	8.35
		500	19.68	9.67	10.32
		450	17.72	8.70	12.28
		400	15.75	7.74	14.25
		350	13.78	6.77	16.22
		300	11.81	5.80	18.19
		250	9.84	4.84	20.16
		200	7.84	3.87	22.13
		150	5.91	2.900	24.09
		100	3.94	1.934	26.06
		50	1.97	0.967	28.03
		40	1.57	0.774	28.43
		30	1.181	0.580	28.82
		20	0.787	0.3868	
		10	0.394	0.1934	
		5	0.197	0.0967	
		4	0.158	0.0774	
		3	0.1181	0.0580	
		2	0.0787	0.0387	
1.0	1000	1	0.0392	0.0193	
0.5	500	0.50	0.0197		Low Vacuum
1×10^{-1}	100	0.10	0.0039		
5×10^{-2}	50	0.050			
1×10^{-2}	10	0.010			
5×10^{-3}	5	0.005			
1×10^{-3}	1	0.001			
1×10^{-4} to 1×10^{-6}					High Vacuum
1×10^{-6} to 1×10^{-9}					Very High Vac.
1×10^{-9} and beyond					Ultra High Vac.

*Refers to 30" Barometer

Conversion Factors:

1 millimeter = 1000 microns
1 Torr = 1 mm Hg Abs.
1 inch Hg = 25.4 mm Hg
1 atmosphere = 14.7 pounds per sq. in. = 760 mm Hg = 29.92 in. Hg

Courtesy Pfaudler Co., Div. of Sybron Corp.

D-10
Decimal and Millimeter Equivalent of Fractions

Inches		Millimeters	Inches		Millimeters
Fractions	Decimals		Fractions	Decimals	
1/64	.015625	0.397	33/64	.515625	13.097
1/32	.03125	0.794	17/32	.53125	13.494
3/64	.046875	1.191	35/64	.546875	13.891
1/16	.0625	1.588	9/16	.5625	14.288
5/64	.078125	1.984	37/64	.578125	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.109375	2.778	39/64	.609375	15.478
1/8	.125	3.175	5/8	.625	15.875
9/64	.140625	3.572	41/64	.640625	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.171875	4.366	43/64	.671875	17.066
3/16	.1875	4.763	11/16	.6875	17.463
13/64	.203125	5.159	45/64	.703125	17.859
7/32	.21875	5.556	23/32	.71875	18.256
15/64	.234375	5.953	47/64	.734375	18.653
1/4	.250	6.350	3/4	.750	19.050
17/64	.265625	6.747	49/64	.765625	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64	.296875	7.541	51/64	.796875	20.241
5/16	.3125	7.938	13/16	.8125	20.638
21/64	.328125	8.334	53/64	.828125	21.034
11/32	.34375	8.731	27/32	.83475	21.431
23/64	.359375	9.128	55/64	.859375	21.828
3/8	.375	9.525	7/8	.875	22.225
25/64	.390625	9.922	57/64	.890625	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.421875	10.716	59/64	.921875	23.416
7/16	.4375	11.113	15/16	.9375	23.813
29/64	.453125	11.509	61/64	.953125	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.484375	12.303	63/64	.984375	25.003
1/2	.500	12.700		1.000	25.400

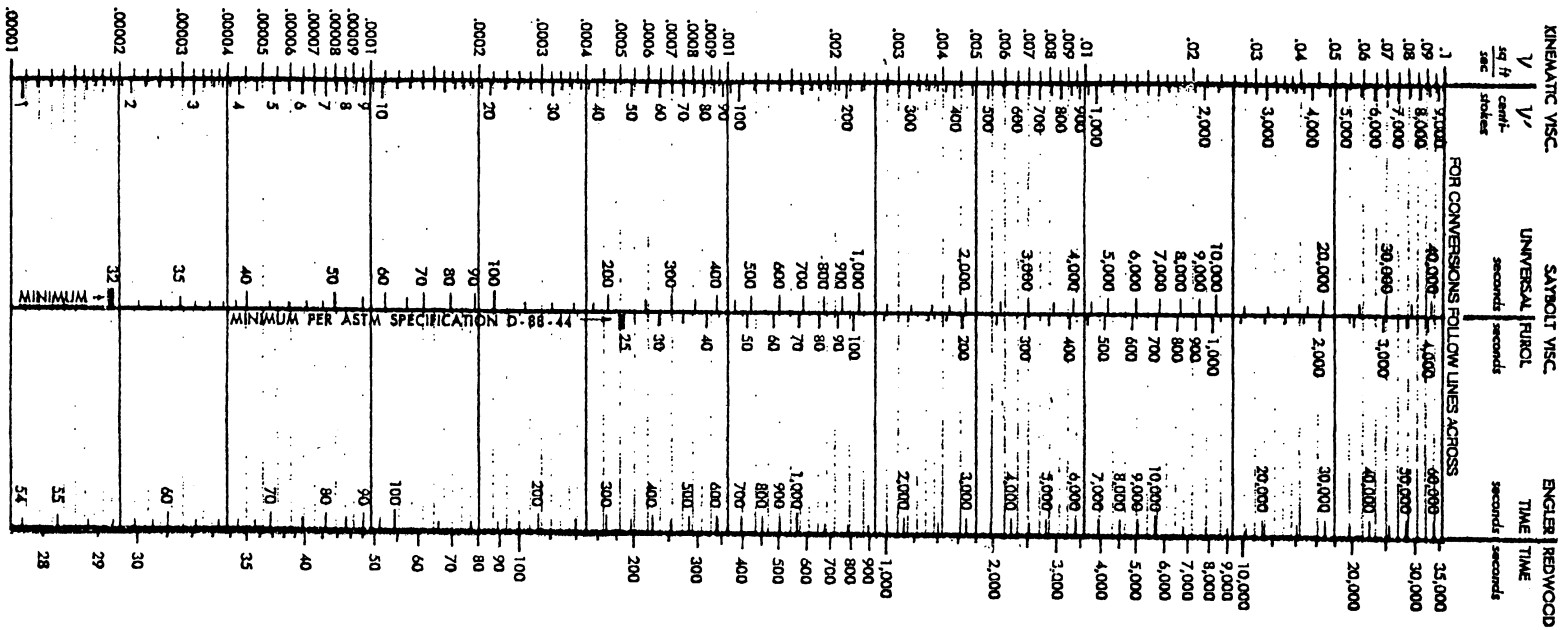
D-11
Particle Size Measurement

Meshes/Lineal Inch US and ASTM Std. Sieve No.	Actual Opening		Meshes/Lineal Inch US and ASTM Std. Sieve No.	Actual Opening	
	Inches	Microns		Inches	Microns
10	.0787	2000	170	.0035	88
12	.0661 1/6	1680	200	.0029	74
14	.0555	1410		.0026	65
16	.0469 3/64	1190	230	.0024	62
18	.0394	1000	270	.0021	53
20	.0331 1/32	840		.0020	50
25	.0280	710	325	.0017	44
30	.0232	590		.0016	40
35	.0197 1/64	500	400	.00142	36
40	.0165	420		.00118	30
45	.0138	350	550	.00099	25
50	.0117	297	625	.00079	20
60	.0098	250		.00059	15
70	.0083	210	1,250	.000394	10
80	.0070	177	1,750	.000315	8
100	.0059	149	2,500	.000197	5
120	.0049	125	5,000	.000099	2.5
140	.0041	105	12,000	.0000394	1

* 1 micron (μ) = 1 micrometer (μm), new National Bureau of Standards terminology
1 micron = one-millionth of a meter
Inches × 25,400 = microns or micrometers
Reference ASTM E 11-70

D-12

Viscosity Conversions. (By permission, Tube Turns Div., Chemetron Corp., Bull. TT 725.)



To convert other units into kinematic viscosity in English units ν (sq ft per sec) or in Metric units ν' (centistokes), use the chart or the formulas to the right:

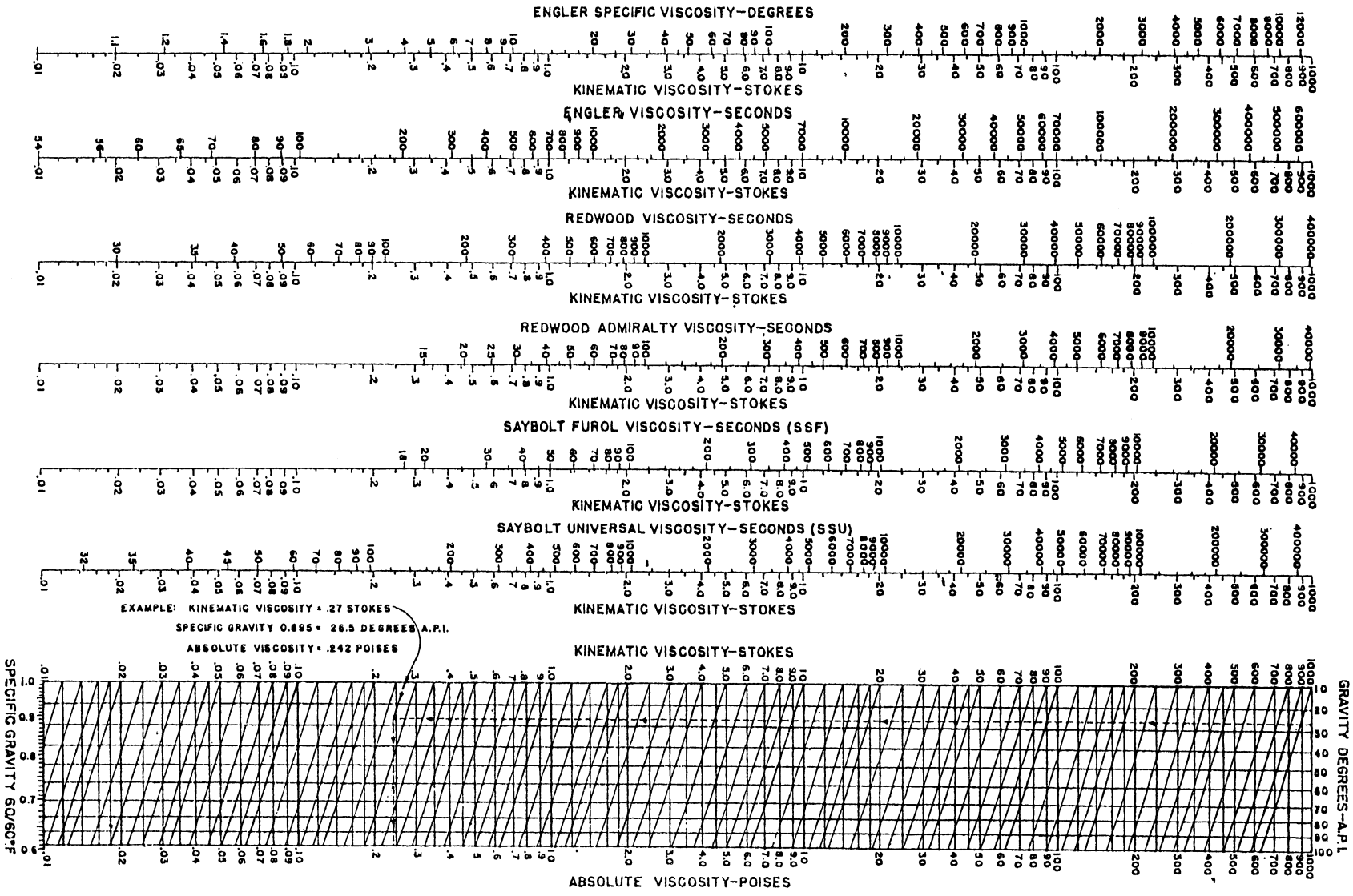
To convert:	into centistokes (ν')	into sq ft per sec (ν)
from Metric units (centistokes)	.....	$\nu = 0.000\ 010\ 76\ \nu'$
from English units (sq ft per sec)	$\nu' = 92\ 900\ \nu$	.....
from Saybolt Universal (seconds)	see Table I in ASTM Spec. D-446-39 (plotted for basic temperature 100 F)	converted from ASTM Spec. D-446-39
from Saybolt Furol (seconds)	see Table I in ASTM Spec. D-666-44 (plotted for std temp of 122 F)	converted from ASTM Spec. D-666-44
from Engler (seconds)	$\nu' = 0.147\ \text{Engler} - \frac{374}{\text{Engler}}$	$\nu = 0.000\ 001\ 88\ \text{Engler} - \frac{0.00403}{\text{Engler}}$
from Redwood standard (seconds)	$\nu' = 0.260\ \text{Redwood} - \frac{171.5}{\text{Redwood}}$	$\nu = 0.000\ 002\ 80\ \text{Redwood} - \frac{0.00188}{\text{Redwood}}$
from absolute viscosity	$\nu' = \frac{\text{centipoises}}{\text{density}}$	$\nu = 32.2\ \mu \frac{(\text{lb sec per sq ft})}{\rho\ (\text{lb per cu ft})}$

To convert degrees API and Baumé into Specific Gravity, use the formulas to right:

Liquids lighter than water (API Formula)	Liquids heavier than water (U.S. Bureau of Stds.)
Specific gravity 60/60F $= \frac{141.5}{131.5 + \text{Degrees API}}$	Specific gravity $= \frac{145}{145 - \text{Degrees Baumé}}$

D-13

Viscosity Conversions. (Courtesy Kinney Vacuum Div., The New York Air Brake Co.)



1 CENTISTOKE = (STOKE/100) 1 STOKE = 100 CENTISTOKES

1 CENTIPOISE = (POISE/100) 1 POISE = 100 CENTIPOISES

$$\text{KINEMATIC VISCOSITY (STOKES)} = \frac{\text{ABSOLUTE VISCOSITY (POISES)}}{\text{DENSITY AT GIVEN TEMPERATURE}}$$

D-14
Commercial Wrought Steel Pipe Data
(Based on ANSI B36.10 wall thicknesses)

	Nominal Pipe Size	Outside Diameter	Thickness	Inside Diameter		Inside Diameter Functions (In Inches)				Transverse Internal Area	
				d	D	d^2	d^3	d^4	d^5	a	A
	Inches	Inches	Inches	Inches	Feet					Sq. In.	Sq. Ft.
Schedule 10	14	14	0.250	13.5	1.125	182.25	2460.4	33215.	448400.	143.14	0.994
	16	16	0.250	15.5	1.291	240.25	3723.9	57720.	894660.	188.69	1.310
	18	18	0.250	17.5	1.4583	306.25	5359.4	93789.	1641309.	240.53	1.670
	20	20	0.250	19.5	1.625	380.25	7414.9	144590.	2819500.	298.65	2.074
	24	24	0.250	23.5	1.958	552.25	12977.	304980.	7167030.	433.74	3.012
	30	30	0.312	29.376	2.448	862.95	25350.	744288.	21864218.	677.76	4.707
Schedule 20	8	8.625	0.250	8.125	0.6771	66.02	536.38	4359.3	35409.	51.85	0.3601
	10	10.75	0.250	10.25	0.8542	105.06	1076.9	11038.	113141.	82.52	0.5731
	12	12.75	0.250	12.25	1.021	150.06	1838.3	22518.	275855.	117.86	0.8185
	14	14	0.312	13.376	1.111	178.92	2393.2	32012.	428185.	140.52	0.9758
	16	16	0.312	15.376	1.281	236.42	3635.2	55894.	859442.	185.69	1.290
	18	18	0.312	17.376	1.448	301.92	5246.3	91156.	1583978.	237.13	1.647
	20	20	0.375	19.250	1.604	370.56	7133.3	137317.	2643352.	291.04	2.021
	24	24	0.375	23.25	1.937	540.56	12568.	292205.	6793832.	424.56	2.948
	30	30	0.500	29.00	2.417	841.0	24389.	707281.	20511149.	660.52	4.587
Schedule 30	8	8.625	0.277	8.071	0.6726	65.14	525.75	4243.2	34248.	51.16	0.3553
	10	10.75	0.307	10.136	0.8447	102.74	1041.4	10555.	106987.	80.69	0.5603
	12	12.75	0.330	12.09	1.0075	146.17	1767.2	21366.	258304.	114.80	0.7972
	14	14	0.375	13.25	1.1042	175.56	2326.2	30821.	408394.	137.88	0.9575
	16	16	0.375	15.25	1.2708	232.56	3546.6	54084.	824801.	182.65	1.268
	18	18	0.438	17.124	1.4270	293.23	5021.3	85984.	1472397.	230.30	1.599
	20	20	0.500	19.00	1.5833	361.00	6859.0	130321.	2476099.	283.53	1.969
	24	24	0.562	22.876	1.9063	523.31	11971.	273853.	6264703.	411.00	2.854
	30	30	0.625	28.75	2.3958	826.56	23764.	683201.	19642160.	649.18	4.508
Schedule 40	⅛	0.405	0.068	0.269	0.0224	0.0724	0.0195	0.005242	0.00141	0.057	0.00040
	¼	0.540	0.088	0.364	0.0303	0.1325	0.0482	0.01756	0.00639	0.104	0.00072
	⅜	0.675	0.091	0.493	0.0411	0.2430	0.1198	0.05905	0.02912	0.191	0.00133
	½	0.840	0.109	0.622	0.0518	0.3869	0.2406	0.1497	0.09310	0.304	0.00211
	¾	1.050	0.113	0.824	0.0687	0.679	0.5595	0.4610	0.3799	0.533	0.00371
	1	1.315	0.133	1.049	0.0874	1.100	1.154	1.210	1.270	0.864	0.00600
	1¼	1.660	0.140	1.380	0.1150	1.904	2.628	3.625	5.005	1.495	0.01040
	1½	1.900	0.145	1.610	0.1342	2.592	4.173	6.718	10.82	2.036	0.01414
	2	2.375	0.154	2.067	0.1722	4.272	8.831	18.250	37.72	3.355	0.02330
	2½	2.875	0.203	2.469	0.2057	6.096	15.051	37.161	91.75	4.788	0.03322
	3	3.500	0.216	3.068	0.2557	9.413	28.878	88.605	271.8	7.393	0.05130
	3½	4.000	0.226	3.548	0.2957	12.59	44.663	158.51	562.2	9.886	0.06870
	4	4.500	0.237	4.026	0.3355	16.21	65.256	262.76	1058.	12.730	0.08840
	5	5.563	0.258	5.047	0.4206	25.47	128.56	648.72	3275.	20.006	0.1390
	6	6.625	0.280	6.065	0.5054	36.78	223.10	1352.8	8206.	28.891	0.2006
	8	8.625	0.322	7.981	0.6651	63.70	508.36	4057.7	32380.	50.027	0.3474
	10	10.75	0.365	10.02	0.8350	100.4	1006.0	10080.	101000.	78.855	0.5475
	12	12.75	0.406	11.938	0.9965	142.5	1701.3	20306.	242470.	111.93	0.7773
	14	14.0	0.438	13.124	1.0937	172.24	2260.5	29666.	389340.	135.28	0.9394
	16	16.0	0.500	15.000	1.250	225.0	3375.0	50625.	759375.	176.72	1.2272
	18	18.0	0.562	16.876	1.4063	284.8	4806.3	81111.	1368820.	223.68	1.5533
	20	20.0	0.593	18.814	1.5678	354.0	6659.5	125320.	2357244.	278.00	1.9305
	24	24.0	0.687	22.626	1.8855	511.9	11583.	262040.	5929784.	402.07	2.7921
Schedule 60	8	8.625	0.406	7.813	0.6511	61.04	476.93	3725.9	29113.	47.94	0.3329
	10	10.75	0.500	9.750	0.8125	95.06	926.86	9036.4	88110.	74.66	0.5185
	12	12.75	0.562	11.626	0.9688	135.16	1571.4	18268.	212399.	106.16	0.7372
	14	14.0	0.593	12.814	1.0678	164.20	2104.0	26962.	345480.	128.96	0.8956
	16	16.0	0.656	14.688	1.2240	215.74	3168.8	46544.	683618.	169.44	1.1766
	18	18.0	0.750	16.500	1.3750	272.25	4492.1	74120.	1222982.	213.83	1.4849
	20	20.0	0.812	18.376	1.5313	337.68	6205.2	114028.	2095342.	265.21	1.8417
	24	24.0	0.968	22.064	1.8387	486.82	10741.	236994.	5229036.	382.35	2.6552
Schedule 80	⅛	0.405	0.095	0.215	0.0179	0.0462	0.00994	0.002134	0.000459	0.036	0.00025
	¼	0.540	0.119	0.302	0.0252	0.0912	0.0275	0.008317	0.002513	0.072	0.00050
	⅜	0.675	0.126	0.423	0.0353	0.1789	0.0757	0.03200	0.01354	0.141	0.00098
	½	0.840	0.147	0.546	0.0455	0.2981	0.1628	0.08886	0.04852	0.234	0.00163
	¾	1.050	0.154	0.742	0.0618	0.5506	0.4085	0.3032	0.2249	0.433	0.00300
	1	1.315	0.179	0.957	0.0797	0.9158	0.8765	0.8387	0.8027	0.719	0.00499
	1¼	1.660	0.191	1.278	0.1065	1.633	2.087	2.6667	3.409	1.283	0.00891

Courtesy Crane Co., Technical Manual 410, Flow of Fluids.

D-14
(Continued). Commercial Wrought Steel Pipe Data
(Based on ANSI B36.10 wall thicknesses)

	Nominal Pipe Size	Outside Diameter	Thickness	Inside Diameter		Inside Diameter Functions (In Inches)				Transverse Internal Area	
				d	D	d^2	d^3	d^4	d^8	a	A
	Inches	Inches	Inches	Inches	Feet					Sq. In.	Sq. Ft.
Schedule 80—cont.	1½	1.900	0.200	1.500	0.1250	2.250	3.375	5.062	7.594	1.767	0.01225
	2	2.375	0.218	1.939	0.1616	3.760	7.290	14.136	27.41	2.953	0.02050
	2½	2.875	0.276	2.323	0.1936	5.396	12.536	29.117	67.64	4.238	0.02942
	3	3.5	0.300	2.900	0.2417	8.410	24.389	70.728	205.1	6.605	0.04587
	3½	4.0	0.318	3.364	0.2803	11.32	38.069	128.14	430.8	8.888	0.06170
	4	4.5	0.337	3.826	0.3188	14.64	56.006	214.33	819.8	11.497	0.07986
	5	5.563	0.375	4.813	0.4011	23.16	111.49	536.38	2583.	18.194	0.1263
	6	6.625	0.432	5.761	0.4801	33.19	191.20	1101.6	6346.	26.067	0.1810
	8	8.625	0.500	7.625	0.6354	58.14	443.32	3380.3	25775.	45.663	0.3171
	10	10.75	0.593	9.564	0.7970	91.47	874.82	8366.8	80020.	71.84	0.4989
	12	12.75	0.687	11.376	0.9480	129.41	1472.2	16747.	190523.	101.64	0.7058
	14	14.0	0.750	12.500	1.0417	156.25	1953.1	24414.	305176.	122.72	0.8522
	16	16.0	0.843	14.314	1.1928	204.89	2932.8	41980.	600904.	160.92	1.1175
	18	18.0	0.937	16.126	1.3438	260.05	4193.5	67626.	1090518.	204.24	1.4183
	20	20.0	1.031	17.938	1.4948	321.77	5771.9	103536.	1857248.	252.72	1.7550
	24	24.0	1.218	21.564	1.7970	465.01	10027.	216234.	4662798.	365.22	2.5362
Schedule 100	8	8.625	0.593	7.439	0.6199	55.34	411.66	3062.	22781.	43.46	0.3018
	10	10.75	0.718	9.314	0.7762	86.75	807.99	7526.	69357.	68.13	0.4732
	12	12.75	0.843	11.064	0.9220	122.41	1354.4	14985.	165791.	96.14	0.6677
	14	14.0	0.937	12.126	1.0105	147.04	1783.0	21621.	262173.	115.49	0.8020
	16	16.0	1.031	13.938	1.1615	194.27	2707.7	37740.	526020.	152.58	1.0596
	18	18.0	1.156	15.688	1.3057	246.11	3861.0	60572.	950250.	193.30	1.3423
	20	20.0	1.281	17.438	1.4532	304.08	5302.6	92467.	1612438.	238.83	1.6585
	24	24.0	1.531	20.938	1.7448	438.40	9179.2	192195.	4024179.	344.32	2.3911
Schedule 120	4	4.50	0.438	3.624	0.302	13.133	47.595	172.49	625.1	10.315	0.07163
	5	5.563	0.500	4.563	0.3802	20.82	95.006	433.5	1978.	16.35	0.1136
	6	6.625	0.562	5.501	0.4584	30.26	166.47	915.7	5037.	23.77	0.1650
	8	8.625	0.718	7.189	0.5991	51.68	371.54	2671.	19202.	40.59	0.2819
	10	10.75	0.843	9.064	0.7553	82.16	744.66	6750.	61179.	64.53	0.4481
	12	12.75	1.000	10.750	0.8959	115.56	1242.3	13355.	143563.	90.76	0.6303
	14	14.0	1.093	11.814	0.9845	139.57	1648.9	19480.	230137.	109.62	0.7612
	16	16.0	1.218	13.564	1.1303	183.98	2495.5	33849.	459133.	144.50	1.0035
	18	18.0	1.375	15.250	1.2708	232.56	3546.6	54086.	824804.	182.66	1.2684
	20	20.0	1.500	17.000	1.4166	289.00	4913.0	83521.	1419857.	226.98	1.5762
	24	24.0	1.812	20.376	1.6980	415.18	8459.7	172375.	3512313.	326.08	2.2645
Schedule 140	8	8.625	0.812	7.001	0.5834	49.01	343.15	2402.	16819.	38.50	0.2673
	10	10.75	1.000	8.750	0.7292	76.56	669.92	5862.	51291.	60.13	0.4176
	12	12.75	1.125	10.500	0.8750	110.25	1157.6	12155.	127628.	86.59	0.6013
	14	14.0	1.250	11.500	0.9583	132.25	1520.9	17490.	201136.	103.87	0.7213
	16	16.0	1.438	13.124	1.0937	172.24	2260.5	29666.	389340.	135.28	0.9394
	18	18.0	1.562	14.876	1.2396	221.30	3292.0	48972.	728502.	173.80	1.2070
	20	20.0	1.750	16.5	1.3750	272.25	4492.1	74120.	1222981.	213.82	1.4849
	24	24.0	2.062	19.876	1.6563	395.06	7852.1	156069.	3102022.	310.28	2.1547
Schedule 160	½	0.840	0.187	0.466	0.0388	0.2172	0.1012	0.04716	0.02197	0.1706	0.00118
	¾	1.050	0.218	0.614	0.0512	0.3770	0.2315	0.1421	0.08726	0.2961	0.00206
	1	1.315	0.250	0.815	0.0679	0.6642	0.5413	0.4412	0.3596	0.5217	0.00362
	1¼	1.660	0.250	1.160	0.0966	1.346	1.561	1.811	2.100	1.057	0.00734
	1½	1.900	0.281	1.338	0.1115	1.790	2.395	3.205	4.288	1.406	0.00976
	2	2.375	0.343	1.689	0.1407	2.853	4.818	8.138	13.74	2.241	0.01556
	2½	2.875	0.375	2.125	0.1771	4.516	9.596	20.39	43.33	3.546	0.02463
	3	3.50	0.438	2.624	0.2187	6.885	18.067	47.41	124.4	5.408	0.03755
	4	4.50	0.531	3.438	0.2865	11.82	40.637	139.7	480.3	9.283	0.06447
	5	5.563	0.625	4.313	0.3594	18.60	80.230	346.0	1492.	14.61	0.1015
	6	6.625	0.718	5.189	0.4324	26.93	139.72	725.0	3762.	21.15	0.1469
	8	8.625	0.906	6.813	0.5677	46.42	316.24	2155.	14679.	36.46	0.2532
	10	10.75	1.125	8.500	0.7083	72.25	614.12	5220.	44371.	56.75	0.3941
	12	12.75	1.312	10.126	0.8438	102.54	1038.3	10514.	106461.	80.53	0.5592
	14	14.0	1.406	11.188	0.9323	125.17	1400.4	15668.	175292.	98.31	0.6827
	16	16.0	1.593	12.814	1.0678	164.20	2104.0	26961.	345482.	128.96	0.8956
	18	18.0	1.781	14.438	1.2032	208.45	3009.7	43454.	627387.	163.72	1.1369
	20	20.0	1.968	16.064	1.3387	258.05	4145.3	66590.	1069715.	202.67	1.4074
	24	24.0	2.343	19.314	1.6095	373.03	7204.7	139152.	2687582.	292.98	2.0346

D-14
(Continued). Commercial Wrought Steel Pipe Data
(Based on ANSI B36.10 wall thicknesses)

Nominal Pipe Size	Outside Diameter	Thickness	Inside Diameter		Inside Diameter Functions (In Inches)				Transverse Internal Area	
			d	D	d^2	d^3	d^4	d^5	a	A
Inches	Inches	Inches	Inches	Feet					Sq. In.	Sq. Ft.
Standard Wall Pipe										
⅛	0.405	0.068	0.269	0.0224	0.0724	0.0195	0.00524	0.00141	0.057	0.00040
¼	0.540	0.088	0.364	0.0303	0.1325	0.0482	0.01756	0.00639	0.104	0.00072
⅜	0.675	0.091	0.493	0.0411	0.2430	0.1198	0.05905	0.02912	0.191	0.00133
½	0.840	0.109	0.622	0.0518	0.3869	0.2406	0.1497	0.0931	0.304	0.00211
¾	1.050	0.113	0.824	0.0687	0.679	0.5595	0.4610	0.3799	0.533	0.00371
1	1.315	0.133	1.049	0.0874	1.100	1.154	1.210	1.270	0.864	0.00600
1¼	1.660	0.140	1.380	0.1150	1.904	2.628	3.625	5.005	1.495	0.01040
1½	1.900	0.145	1.610	0.1342	2.592	4.173	6.718	10.82	2.036	0.01414
2	2.375	0.154	2.067	0.1722	4.272	8.831	18.250	37.72	3.355	0.02330
2½	2.875	0.203	2.469	0.2057	6.096	15.051	37.161	91.75	4.788	0.03322
3	3.500	0.216	3.068	0.2557	9.413	28.878	88.605	271.8	7.393	0.05130
3½	4.000	0.226	3.548	0.2957	12.59	44.663	158.51	562.2	9.886	0.06870
4	4.500	0.237	4.026	0.3355	16.21	65.256	262.76	1058.	12.730	0.08840
5	5.563	0.258	5.047	0.4206	25.47	128.56	648.72	3275.	20.006	0.1390
6	6.625	0.280	6.065	0.5054	36.78	223.10	1352.8	8206.	28.891	0.2006
8	8.625	0.277	8.071	0.6725	65.14	525.75	4243.0	34248.	51.161	0.3553
	8.625S	0.322	7.981	0.6651	63.70	508.36	4057.7	32380.	50.027	0.3474
	10.75	0.279	10.192	0.8493	103.88	1058.7	10789.	109876.	81.585	0.5666
10	10.75	0.307	10.136	0.8446	102.74	1041.4	10555.	106987.	80.691	0.5604
	10.75S	0.365	10.020	0.8350	100.4	1006.0	10080.	101000.	78.855	0.5475
12	12.75	0.330	12.090	1.0075	146.17	1767.2	21366.	258300.	114.80	0.7972
	12.75S	0.375	12.000	1.000	144.0	1728.0	20736.	248800.	113.10	0.7854
Extra Strong Pipe										
⅛	0.405	0.095	0.215	0.0179	0.0462	0.00994	0.002134	0.000459	0.036	0.00025
¼	0.540	0.119	0.302	0.0252	0.0912	0.0275	0.008317	0.002513	0.072	0.00050
⅜	0.675	0.126	0.423	0.0353	0.1789	0.0757	0.03201	0.01354	0.141	0.00098
½	0.840	0.147	0.546	0.0455	0.2981	0.1628	0.08886	0.04852	0.234	0.00163
¾	1.050	0.154	0.742	0.0618	0.5506	0.4085	0.3032	0.2249	0.433	0.00300
1	1.315	0.179	0.957	0.0797	0.9158	0.8765	0.8387	0.8027	0.719	0.00499
1¼	1.660	0.191	1.278	0.1065	1.633	2.087	2.6667	3.409	1.283	0.00891
1½	1.900	0.200	1.500	0.1250	2.250	3.375	5.062	7.594	1.767	0.01225
2	2.375	0.218	1.939	0.1616	3.760	7.290	14.136	27.41	2.953	0.02050
2½	2.875	0.276	2.323	0.1936	5.396	12.536	29.117	67.64	4.238	0.02942
3	3.500	0.300	2.900	0.2417	8.410	24.389	70.728	205.1	6.605	0.04587
3½	4.000	0.318	3.364	0.2803	11.32	38.069	128.14	430.8	8.888	0.06170
4	4.500	0.337	3.826	0.3188	14.64	56.006	214.33	819.8	11.497	0.07986
5	5.563	0.375	4.813	0.4011	23.16	111.49	536.6	2583.	18.194	0.1263
6	6.625	0.432	5.761	0.4801	33.19	191.20	1101.6	6346.	26.067	0.1810
8	8.625	0.500	7.625	0.6354	58.14	443.32	3380.3	25775.	45.663	0.3171
10	10.75	0.500	9.750	0.8125	95.06	926.86	9036.4	88110.	74.662	0.5185
12	12.75	0.500	11.750	0.9792	138.1	1622.2	19072.	223970.	108.434	0.7528
Double Extra Strong Pipe										
½	0.840	0.294	0.252	0.0210	0.0635	0.0160	0.004032	0.00102	0.050	0.00035
¾	1.050	0.308	0.434	0.0362	0.1884	0.0817	0.03549	0.01540	0.148	0.00103
1	1.315	0.358	0.599	0.0499	0.3588	0.2149	0.1287	0.07711	0.282	0.00196
1¼	1.660	0.382	0.896	0.0747	0.8028	0.7193	0.6445	0.5775	0.630	0.00438
1½	1.900	0.400	1.100	0.0917	1.210	1.331	1.4641	1.611	0.950	0.00660
2	2.375	0.436	1.503	0.1252	2.259	3.395	5.1031	7.670	1.774	0.01232
2½	2.875	0.552	1.771	0.1476	3.136	5.554	9.8345	17.42	2.464	0.01710
3	3.500	0.600	2.300	0.1917	5.290	12.167	27.984	64.36	4.155	0.02885
3½	4.000	0.636	2.728	0.2273	7.442	20.302	55.383	151.1	5.845	0.04059
4	4.500	0.674	3.152	0.2627	9.935	31.315	98.704	311.1	7.803	0.05419
5	5.563	0.750	4.063	0.3386	16.51	67.072	272.58	1107.	12.966	0.09006
6	6.625	0.864	4.897	0.4081	23.98	117.43	575.04	2816.	18.835	0.1308
8	8.625	0.875	6.875	0.5729	47.27	324.95	2234.4	15360.	37.122	0.2578

D-15
Stainless Steel Pipe Data
(Based on ANSI B36.19 wall thicknesses)

Nominal Pipe Size	Outside Diameter	Thickness	Inside Diameter		Inside Diameter Functions (In Inches)				Transverse Internal Area	
			d	D	d^2	d^3	d^4	d^5	a	A
Inches	Inches	Inches	Inches	Feet					Sq. In.	Sq. Ft.
Schedule 5 S										
½	0.840	0.065	0.710	0.0592	0.504	0.358	0.254	0.1804	0.396	0.00275
¾	1.050	0.065	0.920	0.0767	0.846	0.779	0.716	0.659	0.664	0.00461
1	1.315	0.065	1.185	0.0988	1.404	1.664	1.972	2.337	1.103	0.00766
1¼	1.660	0.065	1.530	0.1275	2.341	3.582	5.480	8.384	1.839	0.01277
1½	1.900	0.065	1.770	0.1475	3.133	5.545	9.815	17.37	2.461	0.01709
2	2.375	0.065	2.245	0.1871	5.040	11.31	25.40	57.03	3.958	0.02749
2½	2.875	0.083	2.709	0.2258	7.339	19.88	53.86	145.9	5.764	0.04003
3	3.500	0.083	3.334	0.2778	11.12	37.06	123.6	411.9	8.733	0.06065
3½	4.000	0.083	3.834	0.3195	14.70	56.36	216.1	828.4	11.545	0.08017
4	4.500	0.083	4.334	0.3612	18.78	81.41	352.8	1529.	14.750	0.1024
5	5.563	0.109	5.345	0.4454	28.57	152.7	816.2	4363.	22.439	0.1558
6	6.625	0.109	6.407	0.5339	41.05	263.0	1685.	10796.	32.241	0.2239
8	8.625	0.109	8.407	0.7006	70.68	594.2	4995.	41996.	55.512	0.3855
10	10.750	0.134	10.482	0.8375	109.9	1152.	12072.	126538.	86.315	0.5994
12	12.750	0.156	12.438	1.0365	154.7	1924.	23933.	297682.	121.50	0.8438
Schedule 10 S										
⅛	0.405	0.049	0.307	0.0256	0.0942	0.0289	0.00888	0.00273	0.074	0.00051
¼	0.540	0.065	0.410	0.0342	0.1681	0.0689	0.02826	0.01159	0.132	0.00092
⅜	0.675	0.065	0.545	0.0454	0.2970	0.1619	0.08822	0.04808	0.233	0.00162
½	0.840	0.083	0.674	0.0562	0.4543	0.3062	0.2064	0.1391	0.357	0.00248
¾	1.050	0.083	0.884	0.0737	0.7815	0.6908	0.6107	0.5398	0.614	0.00426
1	1.315	0.109	1.097	0.0914	1.203	1.320	1.448	1.589	0.945	0.00656
1¼	1.660	0.109	1.442	0.1202	2.079	2.998	4.324	6.235	1.633	0.01134
1½	1.900	0.109	1.682	0.1402	2.829	4.759	8.004	13.46	2.222	0.01543
2	2.375	0.109	2.157	0.1798	4.653	10.04	21.65	46.69	3.654	0.02538
2½	2.875	0.120	2.635	0.2196	6.943	18.30	48.21	127.0	5.453	0.03787
3	3.500	0.120	3.260	0.2717	10.63	34.65	112.9	368.2	8.347	0.05796
3½	4.000	0.120	3.760	0.3133	14.14	53.16	199.9	751.5	11.11	0.07712
4	4.500	0.120	4.260	0.3550	18.15	77.31	329.3	1403.	14.26	0.09899
5	5.563	0.134	5.295	0.4413	28.04	148.5	786.1	4162.	22.02	0.1529
6	6.625	0.134	6.357	0.5298	40.41	256.9	1633.	10382.	31.74	0.2204
8	8.625	0.148	8.329	0.6941	69.37	577.8	4813.	40083.	54.48	0.3784
10	10.750	0.165	10.420	0.8683	108.6	1131.	11789.	122840.	85.29	0.5923
12	12.750	0.180	12.390	1.0325	153.5	1902.	23566.	291982.	120.6	0.8372
Schedule 40 S										
⅛ to 12	Values are the same, size for size, as those shown on the facing page for Standard Wall Pipe (heaviest weight on 8, 10, and 12-inch sizes).									
Schedule 80 S										
⅛ to 12	Values are the same, size for size, as those shown on the facing page for Extra Strong Pipe.									

Courtesy Crane Co., Technical Manual 410, Flow of Fluids.

D-16
Properties of Pipe

Tabulated below are the most generally required data used in piping design. This table is believed to be the most comprehensive published up to this time. Many thicknesses traditionally included in such tables have been omitted because of their having become obsolete through disuse and lack of coverage by any Standard.

Sizes and thicknesses listed herein are covered by the following Standards:—

1) American National Standard Institute B36.10
2) American National Standard Institute B36.19
3) American Petroleum Institute Standard API 5L
4) American Petroleum Institute Standard API 5LX
5) New United States Legal Standard for Steel Plate Gauges.

ANSI American National Standards Institute

Sizes and thicknesses to which no Standard designation applies are largely the more commonly used dimensions to which Taylor Forge Electric Fusion Welded Pipe is produced for a wide variety of applications including river crossings, penstocks, power plant and other piping.

All data is computed from the *nominal* dimensions listed and the effect of tolerances is not taken into account. Values are computed by application of the following formulas:

Radius of Gyration: $R = \frac{\sqrt{D^2 + d^2}}{4}$

Moment of Inertia: $I = R^2 A$

Section Modulus: $Z = \frac{I}{0.5\,D}$

Nominal Pipe Size	Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area in.² a	Area of Metal in.² A	Moment of Inertia in.⁴ I	Section Modulus in.³ Z	Radius of Gyration in. R
⅛	.405	10S	.049	.307	.186	.0320	.106	.0804	.0740	.0548	.00090	.00440	.1270
		Std.	.068	.269	.244	.0246	.106	.0705	.0568	.0720	.00106	.00530	.1215
		X-Stg.	.095	.215	.314	.0157	.106	.0563	.0364	.0925	.00122	.00600	.1146
¼	.540	10S	.065	.410	.330	.0570	.141	.1073	.1320	.0970	.00280	.01030	.1695
		Std.	.088	.364	.424	.0451	.141	.0955	.1041	.1250	.00331	.01230	.1628
		X-Stg.	.119	.302	.535	.0310	.141	.0794	.0716	.1574	.00378	.01395	.1547
⅜	.675	10S	.065	.545	.423	.1010	.177	.1427	.2333	.1245	.00590	.01740	.2160
		Std.	.091	.493	.567	.0827	.177	.1295	.1910	.1670	.00730	.02160	.2090
		X-Stg.	.126	.423	.738	.0609	.177	.1106	.1405	.2173	.00862	.02554	.1991
½	.840	10S	.083	.670	.671	.1550	.220	.1764	.3568	.1974	.01430	.03410	.2692
		Std.	.109	.622	.850	.1316	.220	.1637	.3040	.2503	.01710	.04070	.2613
		X-Stg.	.147	.546	1.087	.1013	.220	.1433	.2340	.3200	.02010	.04780	.2505
		160	.138	.464	1.310	.0740	.220	.1220	.1706	.3836	.02213	.05269	.2402
		XX-Stg.	.294	.252	1.714	.0216	.220	.0660	.0499	.5043	.02424	.05772	.2192
¾	1.050	10S	.083	.884	.857	.2660	.275	.2314	.6138	.2522	.02970	.05660	.3430
		Std.	.113	.824	1.130	.2301	.275	.2168	.5330	.3326	.03704	.07055	.3337
		X-Stg.	.154	.742	1.473	.1875	.275	.1948	.4330	.4335	.04479	.08531	.3214
		160	.219	.612	1.940	.1280	.275	.1607	.2961	.5698	.05270	.10038	.3041
		XX-Stg.	.308	.434	2.440	.0633	.275	.1137	.1479	.7180	.05792	.11030	.2840
1	1.315	10S	.109	1.097	1.404	.4090	.344	.2872	.9448	.4129	.07560	.1150	.4282
		Std.	.133	1.049	1.678	.3740	.344	.2740	.8640	.4939	.08734	.1328	.4205
		X-Stg.	.179	.957	2.171	.3112	.344	.2520	.7190	.6388	.10560	.1606	.4066
		160	.250	.815	2.850	.2261	.344	.2134	.5217	.8364	.12516	.1903	.3868
		XX-Stg.	.358	.599	3.659	.1221	.344	.1570	.2818	1.0760	.14050	.2136	.3613
1¼	1.660	10S	.109	1.442	1.806	.7080	.434	.3775	1.633	.5314	.1606	.1934	.5499
		Std.	.140	1.380	2.272	.6471	.434	.3620	1.495	.6685	.1947	.2346	.5397
			.191	1.278	2.996	.5553	.434	.3356	1.283	.8815	.2418	.2913	.5237
			.250	1.160	3.764	.4575	.434	.3029	1.057	1.1070	.2833	.3421	.5063
			.382	.896	5.214	.2732	.434	.2331	.6305	1.5340	.3411	.4110	.4716

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D-16
(Continued). Properties of Pipe

Nominal Pipe Size	Nominal Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area in.^{2} a	Area of Metal in.^{2} A	Moment of Inertia in.^{4} I	Section Modulus in.^{3} Z	Radius of Gyration in. R
1½	1.900	10S	.109	1.682	2.085	.9630	.497	.4403	2.221	.613	.2469	.2599	.6344
		Std.	.145	1.610	2.717	.8820	.497	.4213	2.036	.800	.3099	.3262	.6226
		X-Stg.	.200	1.500	3.631	.7648	.497	.3927	1.767	1.068	.3912	.4118	.6052
		160	.281	1.337	4.862	.6082	.497	.3519	1.405	1.430	.4826	.5080	.5809
		XX-Stg.	.400	1.100	6.408	.4117	.497	.2903	.950	1.885	.5678	.5977	.5489
2	2.375	10S	.109	2.157	2.638	1.563	.622	.5647	3.654	.775	.5003	.4213	.8034
		Std.	.154	2.067	3.652	1.452	.622	.5401	3.355	1.075	.6657	.5606	.7871
		X-Stg.	.218	1.939	5.022	1.279	.622	.5074	2.953	1.477	.8679	.7309	.7665
		- -	.250	1.875	5.673	1.196	.622	.4920	2.761	1.669	.9555	.8046	.7565
		160	.344	1.687	7.450	.970	.622	.4422	2.240	2.190	1.162	.9790	.7286
		XX-Stg.	.436	1.503	9.029	.769	.622	.3929	1.774	2.656	1.311	1.1040	.7027
2½	2.875	10S	.120	2.635	3.53	2.360	.753	.6900	5.453	1.038	.9878	.6872	.9755
		Std.	.203	2.469	5.79	2.072	.753	.6462	4.788	1.704	1.530	1.064	.9474
		X-Stg.	.276	2.323	7.66	1.834	.753	.6095	4.238	2.254	1.924	1.339	.9241
		160	.375	2.125	10.01	1.535	.753	.5564	3.547	2.945	2.353	1.638	.8938
		XX-Stg.	.552	1.771	13.69	1.067	.753	.4627	2.464	4.028	2.871	1.997	.8442
3	3.500	10S	.120	3.260	4.33	3.62	.916	.853	8.346	1.272	1.821	1.041	1.196
		API	.125	3.250	4.52	3.60	.916	.851	8.300	1.329	1.900	1.086	1.195
		API	.156	3.188	5.58	3.46	.916	.835	7.982	1.639	2.298	1.313	1.184
		API	.188	3.125	6.65	3.34	.916	.819	7.700	1.958	2.700	1.545	1.175
		Std.	.216	3.068	7.57	3.20	.916	.802	7.393	2.228	3.017	1.724	1.164
		API	.250	3.000	8.68	3.06	.916	.785	7.184	2.553	3.388	1.936	1.152
		API	.281	2.938	9.65	2.94	.916	.769	6.780	2.842	3.819	2.182	1.142
		X-Stg.	.300	2.900	10.25	2.86	.916	.761	6.605	3.016	3.892	2.225	1.136
		160	.438	2.624	14.32	2.34	.916	.687	5.407	4.214	5.044	2.882	1.094
		XX-Stg.	.600	2.300	18.58	1.80	.916	.601	4.155	5.466	5.993	3.424	1.047
3½	4.000	10S	.120	3.760	4.97	4.81	1.047	.984	11.10	1.46	2.754	1.377	1.372
		API	.125	3.750	5.18	4.79	1.047	.982	11.04	1.52	2.859	1.430	1.371
		API	.156	3.688	6.41	4.63	1.047	.966	10.68	1.88	3.485	1.743	1.360
		API	.188	3.624	7.71	4.48	1.047	.950	10.32	2.27	4.130	2.065	1.350
		Std.	.226	3.548	9.11	4.28	1.047	.929	9.89	2.68	4.788	2.394	1.337
		API	.250	3.500	10.02	4.17	1.047	.916	9.62	2.94	5.201	2.601	1.329
		API	.281	3.438	11.17	4.02	1.047	.900	9.28	3.29	5.715	2.858	1.319
		X-Stg.	.318	3.364	12.51	3.85	1.047	.880	8.89	3.68	6.280	3.140	1.307
		XX-Stg.	.636	2.728	22.85	2.53	1.047	.716	5.84	6.72	9.848	4.924	1.210
4	4.500	10S	.120	4.260	5.61	6.18	1.178	1.115	14.25	1.65	3.97	1.761	1.550
		API	.125	4.250	5.84	6.15	1.178	1.113	14.19	1.72	4.12	1.829	1.548
		API	.156	4.188	7.24	5.97	1.178	1.096	13.77	2.13	5.03	2.235	1.537
		API	.188	4.124	8.56	5.80	1.178	1.082	13.39	2.52	5.86	2.600	1.525
		API	.219	4.062	10.02	5.62	1.178	1.063	12.96	2.94	6.77	3.867	1.516
		Std.	.237	4.026	10.79	5.51	1.178	1.055	12.73	3.17	7.23	3.214	1.510
		API	.250	4.000	11.35	5.45	1.178	1.049	12.57	3.34	7.56	3.360	1.505
		API	.281	3.938	12.67	5.27	1.178	1.031	12.17	3.73	8.33	3.703	1.495
		API	.312	3.876	14.00	5.12	1.178	1.013	11.80	4.11	9.05	4.020	1.482
		X-Stg.	.337	3.826	14.98	4.98	1.178	1.002	11.50	4.41	9.61	4.271	1.477
		120	.438	3.624	19.00	4.47	1.178	.949	10.32	5.59	11.65	5.177	1.444
		- -	.500	3.500	21.36	4.16	1.178	.916	9.62	6.28	12.77	5.676	1.425
		160	.531	3.438	22.60	4.02	1.178	.900	9.28	6.62	13.27	5.900	1.416
		XX-Stg.	.674	3.152	27.54	3.38	1.178	.826	7.80	8.10	15.28	6.793	1.374

D-16
(Continued). Properties of Pipe

Nominal Pipe Size	Nominal Outside Diam. D	Designation	Wall Thickness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Transverse Area in.² a	Area of Metal in.² A	Moment of Inertia in.⁴ I	Section Modulus in.³ Z	Radius of Gyration in. R
5	5.563	10S	.134	5.295	7.77	9.54	1.456	1.386	22.02	2.29	8.42	3.028	1.920
		API	.156	5.251	9.02	9.39	1.456	1.375	21.66	2.65	9.70	3.487	1.913
		API	.188	5.187	10.80	9.16	1.456	1.358	21.13	3.17	11.49	4.129	1.902
		API	.219	5.125	12.51	8.94	1.456	1.342	20.63	3.68	13.14	4.726	1.891
		Std.	.258	5.047	14.62	8.66	1.456	1.321	20.01	4.30	15.16	5.451	1.878
		API	.281	5.001	15.86	8.52	1.456	1.309	19.64	4.66	16.31	5.862	1.870
		API	.312	4.939	17.51	8.31	1.456	1.293	19.16	5.15	17 81	6.402	1.860
		API	.344	4.875	19.19	8.09	1.456	1.276	18.67	5.64	19.28	6.932	1.849
		X-Stg.	.375	4.813	20.78	7.87	1.456	1.260	18.19	6.11	20.67	7.431	1.839
		120	.500	4.563	27.10	7.08	1.456	1.195	16.35	7.95	25.74	9.253	1.799
		160	.625	4.313	32.96	6.32	1.456	1.129	14.61	9.70	30.03	10.800	1.760
		XX-Stg.	.750	4.063	38.55	5.62	1.456	1.064	12.97	11.34	33.63	12.090	1.722
6	6.625	12 Ga.	.104	6.417	7.25	14.02	1.734	1.680	32.34	2.13	11.33	3.42	2.31
		10S	.134	6.357	9.29	13.70	1.734	1.660	31.75	2.73	14.38	4.34	2.29
		8 Ga.	.164	6.297	11.33	13.50	1.734	1.649	31.14	3.33	17.38	5.25	2.28
		API	.188	6.249	12.93	13.31	1.734	1.639	30.70	3.80	19.71	5.95	2.28
		6 Ga.	.194	6.237	13.34	13.25	1.734	1.633	30.55	3.92	20.29	6.12	2.27
		API	.219	6.187	15.02	13.05	1.734	1.620	30.10	4.41	22.66	6.84	2.27
		API	.250	6.125	17.02	12.80	1.734	1.606	29.50	5.01	25.55	7.71	2.26
		API	.277	6.071	18.86	12.55	1.734	1.591	28.95	5.54	28.00	8.46	2.25
		Std.	.280	6.065	18.97	12.51	1.734	1.587	28.90	5.58	28.14	8.50	2.24
		API	.312	6.001	21.05	12.26	1.734	1.571	28.28	6.19	30.91	9.33	2.23
		API	.344	5.937	23.09	12.00	1.734	1.554	27.68	6.79	33.51	10.14	2.22
		API	.375	5.875	25.10	11.75	1.734	1.540	27.10	7.37	36.20	10.90	2.21
		X-Stg.	.432	5.761	28.57	11.29	1.734	1.510	26.07	8.40	40.49	12.22	2.19
		- -	.500	5.625	32.79	10.85	1.734	1.475	24.85	9.63	45.60	13.78	2.16
		120	.562	5.501	36.40	10.30	1.734	1.470	23.77	10.74	49.91	15.07	2.15
		160	.719	5.187	45.30	9.16	1.734	1.359	21.15	13.36	58.99	17.81	2.10
		XX-Stg.	.864	4.897	53.16	8.14	1.734	1.280	18.83	15.64	66.33	20.02	2.06
8	8.625	12 Ga.	.104	8.417	9.47	24.1	2.26	2.204	55.6	2.78	25.3	5.86	3.01
		10 Ga.	.134	8.357	12.16	23.8	2.26	2.188	54.8	3.57	32.2	7.46	3.00
		10S	.148	8.329	13.40	23.6	2.26	2.180	54.5	3.94	35.4	8.22	3.00
		8 Ga.	.164	8.297	14.83	23.4	2.26	2.172	54.1	4.36	39.1	9.06	2.99
		API	.188	8.249	16.90	23.2	2.26	2.161	53.5	5.00	44.5	10.30	2.98
		6 Ga.	.194	8.237	17.48	23.1	2.26	2.156	53.3	5.14	45.7	10.60	2.98
		API	.203	8.219	18.30	23.1	2.26	2.152	53.1	5.38	47.7	11.05	2.98
		API	.219	8.187	19.64	22.9	2.26	2.148	52.7	5.80	51.3	11.90	2.97
		3 Ga.	.239	8.147	21.42	22.6	2.26	2.133	52.1	6.30	55.4	12.84	2.96
		20	.250	8.125	22.40	22.5	2.26	2.127	51.8	6.58	57.7	13.39	2.96
		30	.277	8.071	24.70	22.2	2.26	2.115	51.2	7.26	63.3	14.69	2.95
		API	.312	8.001	27.72	21.8	2.26	2.095	50.3	8.15	70.6	16.37	2.94
		Std.	.322	7.981	28.55	21.6	2.26	2.090	50.0	8.40	72.5	16.81	2.94
		API	.344	7.937	30.40	21.4	2.26	2.078	49.5	8.94	76.8	17.81	2.93
		API	.375	7.875	33.10	21.1	2.26	2.062	48.7	9.74	83.1	19.27	2.92
		60	.406	7.813	35.70	20.8	2.26	2.045	47.9	10.48	88.8	20.58	2.91
		API	.438	7.749	38.33	20.4	2.26	2.029	47.2	11.27	94.7	21.97	2.90
		X-Stg.	.500	7.625	43.39	19.8	2.26	2.006	45.6	12.76	105.7	24.51	2.88
		100	.594	7.437	50.90	18.8	2.26	1.947	43.5	14.96	121.4	28.14	2.85
		- -	.625	7.375	53.40	18.5	2.26	1.931	42.7	15.71	126.5	29.33	2.84
		120	.719	7.187	60.70	17.6	2.26	1.882	40.6	17.84	140.6	32.61	2.81
		140	.812	7.001	67.80	16.7	2.26	1.833	38.5	19.93	153.8	35.65	2.78
		XX-Stg.	.875	6.875	72.42	16.1	2.26	1.800	37.1	21.30	162.0	37.56	2.76
		160	.906	6.813	74.70	15.8	2.26	1.784	36.4	21.97	165.9	38.48	2.76

D-16
(Continued). Properties of Pipe

Nominal Pipe Size	Nominal Outside Diam. D	Desig-nation	Wall Thick-ness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Trans-verse Area in.² a	Area of Metal in.² A	Moment of Inertia in.⁴ I	Section Modulus in.³ Z	Radius of Gyration in. R
		12 Ga.	.104	10.542	11.83	37.8	2.81	2.76	87.3	3.48	49.3	9.16	3.76
		10 Ga.	.134	10.482	15.21	37.4	2.81	2.74	86.3	4.47	63.0	11.71	3.75
		8 Ga.	.164	10.422	18.56	37.0	2.81	2.73	85.3	5.45	76.4	14.22	3.74
		10S	.165	10.420	18.65	36.9	2.81	2.73	85.3	5.50	76.8	14.29	3.74
		API	.188	10.374	21.12	36.7	2.81	2.72	84.5	6.20	86.5	16.10	3.74
		6 Ga.	.194	10.362	21.89	36.6	2.81	2.71	84.3	6.43	89.7	16.68	3.73
		API	.203	10.344	22.86	36.5	2.81	2.71	84.0	6.71	93.3	17.35	3.73
		API	.219	10.310	24.60	36.2	2.81	2.70	83.4	7.24	100.5	18.70	3.72
		3 Ga.	.239	10.272	28.05	35.9	2.81	2.69	82.9	7.89	109.2	20.32	3.72
		20	.250	10.250	28.03	35.9	2.81	2.68	82.6	8.26	113.6	21.12	3.71
		API	.279	10.192	31.20	35.3	2.81	2.66	81.6	9.18	125.9	23.42	3.70
10	10.750	30	.307	10.136	34.24	35.0	2.81	2.65	80.7	10.07	137.4	25.57	3.69
		API	.344	10.062	38.26	34.5	2.81	2.63	79.5	11.25	152.3	28.33	3.68
		Std.	.365	10.020	40.48	34.1	2.81	2.62	78.9	11.91	160.7	29.90	3.67
		API	.438	9.874	48.28	33.2	2.81	2.58	76.6	14.19	188.8	35.13	3.65
		X-Stg.	.500	9.750	54.74	32.3	2.81	2.55	74.7	16.10	212.0	39.43	3.63
		80	.594	9.562	64.40	31.1	2.81	2.50	71.8	18.91	244.9	45.56	3.60
		100	.719	9.312	77.00	29.5	2.81	2.44	68.1	22.62	286.2	53.25	3.56
		- -	.750	9.250	80.10	29.1	2.81	2.42	67.2	23.56	296.2	55.10	3.54
		120	.844	9.062	89.20	27.9	2.81	2.37	64.5	26.23	324.3	60.34	3.51
		140	1.000	8.750	104.20	26.1	2.81	2.29	60.1	30.63	367.8	68.43	3.46
		160	1.125	8.500	116.00	24.6	2.81	2.22	56.7	34.01	399.4	74.31	3.43
		12 Ga.	.104	12.542	14.1	53.6	3.34	3.28	123.5	4.13	82.6	12.9	4.47
		10 Ga.	.134	12.482	18.1	53.0	3.34	3.27	122.4	5.31	105.7	16.6	4.46
		8 Ga.	.164	12.422	22.1	52.5	3.34	3.25	121.2	6.48	128.4	20.1	4.45
		10S	.180	12.390	24.2	52.2	3.34	3.24	120.6	7.11	140.4	22.0	4.44
		6 Ga.	.194	12.362	26.0	52.0	3.34	3.23	120.0	7.65	150.9	23.7	4.44
		API	.203	12.344	27.2	52.0	3.34	3.23	119.9	7.99	157.2	24.7	4.43
		API	.219	12.312	29.3	51.7	3.34	3.22	119.1	8.52	167.6	26.3	4.43
		3 Ga.	.239	12.272	32.0	51.3	3.34	3.21	118.3	9.39	183.8	28.8	4.42
		20	.250	12.250	33.4	51.3	3.34	3.12	118.0	9.84	192.3	30.2	4.42
		API	.281	12.188	37.4	50.6	3.34	3.19	116.7	11.01	214.1	33.6	4.41
		API	.312	12.126	41.5	50.1	3.34	3.17	115.5	12.19	236.0	37.0	4.40
		30	.330	12.090	43.8	49.7	3.34	3.16	114.8	12.88	248.5	39.0	4.39
		API	.344	12.062	45.5	49.7	3.34	3.16	114.5	13.46	259.0	40.7	4.38
		Std.	.375	12.000	49.6	48.9	3.34	3.14	113.1	14.58	279.3	43.8	4.37
		40	.406	11.938	53.6	48.5	3.34	3.13	111.9	15.74	300.3	47.1	4.37
12	12.750	API	.438	11.874	57.5	48.2	3.34	3.11	111.0	16.95	321.0	50.4	4.35
		X-Stg.	.500	11.750	65.4	46.9	3.34	3.08	108.4	19.24	361.5	56.7	4.33
		60	.562	11.626	73.2	46.0	3.34	3.04	106.2	21.52	400.5	62.8	4.31
		- -	.625	11.500	80.9	44.9	3.34	3.01	103.8	23.81	438.7	68.8	4.29
		80	.688	11.374	88.6	44.0	3.34	2.98	101.6	26.03	475.2	74.6	4.27
		- -	.750	11.250	96.2	43.1	3.34	2.94	99.4	28.27	510.7	80.1	4.25
		100	.844	11.062	108.0	41.6	3.34	2.90	96.1	31.53	561.8	88.1	4.22
		- -	.875	11.000	110.9	41.1	3.34	2.88	95.0	32.64	578.5	90.7	4.21
		120	1.000	10.750	125.5	39.3	3.34	2.81	90.8	36.91	641.7	100.7	4.17
		140	1.125	10.500	140.0	37.5	3.34	2.75	86.6	41.08	700.7	109.9	4.13
		- -	1.250	10.250	153.6	35.8	3.34	2.68	82.5	45.16	755.5	118.5	4.09
		160	1.312	10.126	161.0	34.9	3.34	2.65	80.5	47.14	781.3	122.6	4.07
		- -	1.375	10.000	167.2	34.0	3.34	2.62	78.5	49.14	807.2	126.6	4.05
		- -	1.500	9.750	180.4	32.4	3.34	2.55	74.7	53.01	853.8	133.9	4.01

D-16
(Continued). Properties of Pipe

Nominal Pipe Size	Nominal Outside Diam. D	Desig-nation	Wall Thick-ness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Trans-verse Area in.^{2} a	Area of Metal in.^{2} A	Moment of Inertia in.^{4} I	Section Modulus in.^{3} Z	Radius of Gyra-tion in. R
14	14.000	10 Ga.	.134	13.732	20	64.2	3.67	3.59	148.1	5.84	140.4	20.1	4.90
		8 Ga.	.164	13.672	24	63.6	3.67	3.58	146.8	7.13	170.7	24.4	4.89
		6 Ga.	.194	13.612	29	63.1	3.67	3.56	145.5	8.41	200.6	28.7	4.88
		API	.210	13.580	31	62.8	3.67	3.55	144.8	9.10	216.2	30.9	4.87
		API	.219	13.562	32	62.6	3.67	3.55	144.5	9.48	225.1	32.2	4.87
		3 Ga.	.239	13.522	35	62.3	3.67	3.54	143.6	10.33	244.9	35.0	4.87
		10	.250	13.500	37	62.1	3.67	3.54	143.0	10.82	256.0	36.6	4.86
		API	.281	13.438	41	61.5	3.67	3.52	141.8	12.11	285.2	40.7	4.85
		20	.312	13.375	46	60.8	3.67	3.50	140.5	13.44	314.9	45.0	4.84
		API	.344	13.312	50	60.3	3.67	3.48	139.2	14.76	344.3	49.2	4.83
		Std.	.375	13.250	55	59.7	3.67	3.47	137.9	16.05	372.8	53.2	4.82
		40	.438	13.124	63	58.5	3.67	3.44	135.3	18.66	429.6	61.4	4.80
		X-Stg.	.500	13.000	72	57.4	3.67	3.40	132.7	21.21	483.8	69.1	4.78
		60	.594	12.812	85	55.9	3.67	3.35	129.0	24.98	562.4	80.3	4.74
		- -	.625	12.750	89	55.3	3.67	3.34	127.7	26.26	588.5	84.1	4.73
		80	.750	12.500	107	51.2	3.67	3.27	122.7	31.22	687.5	98.2	4.69
		- -	.875	12.250	123	51.1	3.67	3.21	117.9	36.08	780.1	111.4	4.65
		100	.938	12.124	131	50.0	3.67	3.17	115.5	38.47	820.5	117.2	4.63
		- -	1.000	12.000	139	49.0	3.67	3.14	113.1	40.84	868.0	124.0	4.61
		120	1.094	11.812	151	47.5	3.67	3.09	109.6	44.32	929.8	132.8	4.58
		- -	1.125	11.750	155	47.0	3.67	3.08	108.4	45.50	950.3	135.8	4.57
		140	1.250	11.500	171	45.0	3.67	3.01	103.9	50.07	1027.5	146.8	4.53
		- -	1.375	11.250	186	43.1	3.67	2.94	99.4	54.54	1099.5	157.1	4.49
		160	1.406	11.188	190	42.6	3.67	2.93	98.3	55.63	1116.9	159.6	4.48
		- -	1.500	11.000	200	41.2	3.67	2.88	95.0	58.90	1166.5	166.6	4.45
16	16.000	10 Ga.	.134	15.732	23	84.3	4.19	4.12	194.4	6.68	210	26.3	5.61
		8 Ga.	.164	15.672	28	83.6	4.19	4.10	192.9	8.16	256	32.0	5.60
		- -	.188	15.624	32	83.3	4.19	4.09	192.0	9.39	294	36.7	5.59
		6 Ga.	.194	15.612	33	83.0	4.19	4.09	191.4	9.63	301	37.6	5.59
		API	.219	15.562	37	82.5	4.19	4.07	190.2	10.86	338	42.3	5.58
		3 Ga.	.239	15.522	40	82.0	4.19	4.06	189.2	11.83	368	45.9	5.57
		10	.250	15.500	42	82.1	4.19	4.06	189.0	12.40	385	48.1	5.57
		API	.281	15.438	47	81.2	4.19	4.04	187.0	13.90	430	53.8	5.56
		20	.312	15.375	52	80.1	4.19	4.03	185.6	15.40	474	59.2	5.55
		API	.344	15.312	57	80.0	4.19	4.01	184.1	16.94	519	64.9	5.54
		Std.	.375	15.250	63	79.1	4.19	4.00	182.6	18.41	562	70.3	5.53
		API	.438	15.124	73	78.2	4.19	3.96	180.0	21.42	650	81.2	5.51
		X-Stg.	.500	15.000	83	76.5	4.19	3.93	176.7	24.35	732	91.5	5.48
		- -	.625	14.750	103	74.1	4.19	3.86	170.9	30.19	893	111.7	5.44
		60	.656	14.688	108	73.4	4.19	3.85	169.4	31.62	933	116.6	5.43
		- -	.750	14.500	122	71.5	4.19	3.80	165.1	35.93	1047	130.9	5.40
		80	.844	14.312	137	69.7	4.19	3.75	160.9	40.14	1157	144.6	5.37
		- -	.875	14.250	141	69.1	4.19	3.73	159.5	41.58	1192	149.0	5.35
		- -	1.000	14.000	160	66.7	4.19	3.66	153.9	47.12	1331	166.4	5.31
		100	1.031	13.938	165	66.0	4.19	3.65	152.6	48.49	1366	170.7	5.30
		- -	1.125	13.750	179	64.4	4.19	3.60	148.5	52.57	1463	182.9	5.27
		120	1.219	13.562	193	62.6	4.19	3.55	144.5	56.56	1556	194.5	5.24
		- -	1.250	13.500	197	62.1	4.19	3.53	143.1	57.92	1586	198.3	5.23
		- -	1.375	13.250	215	59.8	4.19	3.47	137.9	63.17	1704	213.0	5.19
		140	1.438	13.124	224	58.6	4.19	3.44	135.3	65.79	1761	220.1	5.17
		- -	1.500	13.000	232	57.4	4.19	3.40	132.7	68.33	1816	227.0	5.15
		160	1.594	12.812	245	55.9	4.19	3.35	129.0	72.10	1893	236.6	5.12

D-16
(Continued). Properties of Pipe

Nominal													
Pipe Size	Outside Diam.	Desig-nation	Wall Thick-ness	Inside Diam.	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Trans-verse Area in.^{2}	Area of Metal in.^{2}	Moment of Inertia in.^{4}	Section Modulus in.^{3}	Radius of Gyra-tion in.
	D			d					a	A	I	Z	R
		10 Ga.	.134	17.732	26	107.1	4.71	4.64	246.9	7.52	300	33.4	6.32
		8 Ga.	.164	17.672	31	106.3	4.71	4.63	245.3	9.19	366	40.6	6.31
		6 Ga.	.194	17.612	37	105.6	4.71	4.61	243.6	10.85	430	47.8	6.29
		3 Ga.	.239	17.522	45	104.5	4.71	4.59	241.1	13.34	526	58.4	6.28
		10	.250	17.500	47	104.6	4.71	4.58	241.0	13.96	550	61.1	6.28
		API	.281	17.438	49	104.0	4.71	4.56	240.0	14.49	570	63.4	6.27
		20	.312	17.375	59	102.5	4.71	4.55	237.1	17.36	679	75.5	6.25
		API	.344	17.312	65	102.0	4.71	4.53	235.4	19.08	744	82.6	6.24
		Std.	.375	17.250	71	101.2	4.71	4.51	233.7	20.76	807	89.6	6.23
		API	.406	17.188	76	100.6	4.71	4.50	232.0	22.44	869	96.6	6.22
		30	.438	17.124	82	99.5	4.71	4.48	229.5	24.95	963	107.0	6.21
		X-Stg.	.500	17.000	93	98.2	4.71	4.45	227.0	27.49	1053	117.0	6.19
18	18.000	40	.562	16.876	105	97.2	4.71	4.42	224.0	30.85	1177	130.9	6.17
		- -	.625	16.750	116	95.8	4.71	4.39	220.5	34.15	1290	143.2	6.14
		60	.750	16.500	138	92.5	4.71	4.32	213.8	40.64	1515	168.3	6.10
		- -	.875	16.250	160	89.9	4.71	4.25	207.4	47.07	1730	192.3	6.06
		80	.938	16.124	171	88.5	4.71	4.22	204.2	50.23	1834	203.8	6.04
		- -	1.000	16.000	182	87.2	4.71	4.19	201.1	53.41	1935	215.0	6.02
		- -	1.125	15.750	203	84.5	4.71	4.12	194.8	59.64	2133	237.0	5.98
		100	1.156	15.688	208	83.7	4.71	4.11	193.3	61.18	2182	242.3	5.97
		- -	1.250	15.500	224	81.8	4.71	4.06	188.7	65.78	2319	257.7	5.94
		120	1.375	15.250	244	79.2	4.71	3.99	182.7	71.82	2498	277.5	5.90
		- -	1.500	15.000	265	76.6	4.71	3.93	176.7	77.75	2668	296.5	5.86
		140	1.562	14.876	275	75.3	4.71	3.89	173.8	80.66	2750	305.5	5.84
		160	1.781	14.438	309	71.0	4.71	3.78	163.7	90.75	3020	335.5	5.77
		10 Ga.	.134	19.732	28	132.6	5.24	5.17	305.8	8.36	413	41.3	7.02
		8 Ga.	.164	19.672	35	131.8	5.24	5.15	303.9	10.22	503	50.3	7.01
		6 Ga.	.194	19.612	41	131.0	5.24	5.13	302.1	12.07	592	59.2	7.00
		3 Ga.	.239	19.522	50	129.8	5.24	5.11	299.3	14.84	725	72.5	6.99
		10	.250	19.500	53	130.0	5.24	5.11	299.0	15.52	759	75.9	6.98
		API	.281	19.438	59	128.6	5.24	5.09	296.8	17.41	846	84.6	6.97
		API	.312	19.374	66	128.1	5.24	5.08	295.0	19.36	937	93.7	6.95
		API	.344	19.312	72	127.0	5.24	5.06	292.9	21.24	1026	102.6	6.95
		Std.	.375	19.250	79	126.0	5.24	5.04	291.1	23.12	1113	111.3	6.94
		API	.406	19.188	85	125.4	5.24	5.02	289.2	24.99	1200	120.0	6.93
		API	.438	19.124	92	125.1	5.24	5.01	288.0	26.95	1290	129.0	6.92
		X-Stg.	.500	19.000	105	122.8	5.24	4.97	283.5	30.63	1457	145.7	6.90
20	20.000	40	.594	18.812	123	120.4	5.24	4.93	278.0	36.15	1704	170.4	6.86
		- -	.625	18.750	129	119.5	5.24	4.91	276.1	38.04	1787	178.7	6.85
		60	.812	18.376	167	114.9	5.24	4.81	265.2	48.95	2257	225.7	6.79
		- -	.875	18.250	179	113.2	5.24	4.78	261.6	52.57	2409	240.9	6.77
		- -	1.000	18.000	203	110.3	5.24	4.71	254.5	59.69	2702	270.2	6.73
		80	1.031	17.938	209	109.4	5.24	4.80	252.7	61.44	2771	277.1	6.72
		- -	1.125	17.750	227	107.3	5.24	4.65	247.4	66.71	2981	298.1	6.68
		- -	1.250	17.500	250	104.3	5.24	4.58	240.5	73.63	3249	324.9	6.64
		100	1.281	17.438	256	103.4	5.24	4.56	238.8	75.34	3317	331.7	6.63
		- -	1.375	17.250	274	101.3	5.24	4.52	233.7	80.45	3508	350.8	6.60
		120	1.500	17.000	297	98.3	5.24	4.45	227.0	87.18	3755	375.5	6.56
		140	1.750	16.500	342	92.6	5.24	4.32	213.8	100.33	4217	421.7	6.48
		160	1.969	16.062	379	87.9	5.24	4.21	202.7	111.49	4586	458.6	6.41

D-16
(Continued). Properties of Pipe

Nominal Pipe Size	Nominal Outside Diam. D	Design-nation	Wall Thick-ness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Trans-verse Area in.² a	Area of Metal in.² A	Moment of Inertia in.⁴ I	Section Modulus in.³ Z	Radius of Gyra-tion in. R
22	22.000	8 Ga.	.164	21.672	38	159.9	5.76	5.67	368.9	11.25	671	61.0	7.72
		6 Ga.	.194	21.612	45	159.0	5.76	5.66	366.8	13.29	790	71.8	7.71
		3 Ga.	.239	21.522	56	157.7	5.76	5.63	363.8	16.34	967	87.9	7.69
		API	.250	21.500	58	157.4	5.76	5.63	363.1	17.18	1010	91.8	7.69
		API	.281	21.438	65	156.5	5.76	5.61	361.0	19.17	1131	102.8	7.68
		API	.312	21.376	72	155.6	5.76	5.60	358.9	21.26	1250	113.6	7.67
		API	.344	21.312	80	154.7	5.76	5.58	356.7	23.40	1373	124.8	7.66
		API	.375	21.250	87	153.7	5.76	5.56	354.7	25.48	1490	135.4	7.65
		API	.406	21.188	94	152.9	5.76	5.55	352.6	27.54	1607	146.1	7.64
		API	.438	21.124	101	151.9	5.76	5.53	350.5	29.67	1725	156.8	7.62
		API	.500	21.000	115	150.2	5.76	5.50	346.4	33.77	1953	177.5	7.61
		- -	.625	20.750	143	146.6	5.76	5.43	338.2	41.97	2400	218.2	7.56
		- -	.750	20.500	170	143.1	5.76	5.37	330.1	50.07	2829	257.2	7.52
		- -	.875	20.250	198	139.6	5.76	5.30	322.1	58.07	3245	295.0	7.47
		- -	1.000	20.000	224	136.2	5.76	5.24	314.2	65.97	3645	331.4	7.43
		- -	1.125	19.750	251	132.8	5.76	5.17	306.4	73.78	4029	366.3	7.39
		- -	1.250	19.500	277	129.5	5.76	5.10	298.6	81.48	4400	400.0	7.35
		- -	1.375	19.250	303	126.2	5.76	5.04	291.0	89.09	4758	432.6	7.31
		- -	1.500	19.000	329	122.9	5.76	4.97	283.5	96.60	5103	463.9	7.27
24	24.000	8 Ga.	.164	23.672	42	190.8	6.28	6.20	440.1	12.28	872	72.7	8.43
		6 Ga.	.194	23.612	49	189.8	6.28	6.18	437.9	14.51	1028	85.7	8.42
		3 Ga.	.239	23.522	61	188.4	6.28	6.16	434.5	17.84	1260	105.0	8.40
		10	.250	23.500	63	189.0	6.28	6.15	435.0	18.67	1320	110.0	8.40
		API	.281	23.438	71	187.0	6.28	6.14	431.5	20.94	1472	122.7	8.38
		API	.312	23.376	79	186.9	6.28	6.12	430.0	23.20	1630	136.0	8.38
		API	.344	23.312	87	185.0	6.28	6.10	426.8	25.57	1789	149.1	8.36
		Std.	.375	23.250	95	183.8	6.28	6.09	424.6	27.83	1942	161.9	8.35
		API	.406	23.188	102	183.1	6.28	6.07	422.3	30.09	2095	174.6	8.34
		API	.438	23.124	110	182.1	6.28	6.05	420.0	32.42	2252	187.7	8.33
		X-Stg.	.500	23.000	125	181.0	6.28	6.02	416.0	36.90	2550	213.0	8.31
		30	.562	22.876	141	178.5	6.28	5.99	411.0	41.40	2840	237.0	8.28
		- -	.625	22.750	156	175.9	6.28	5.96	406.5	45.90	3137	261.4	8.27
		40	.688	22.624	171	174.2	6.28	5.92	402.1	50.30	3422	285.2	8.25
		- -	.750	22.500	186	172.1	6.28	5.89	397.6	54.78	3705	308.8	8.22
		- -	.875	22.250	216	168.6	6.28	5.82	388.8	63.57	4257	354.7	8.18
		60	.969	22.062	238	165.8	6.28	5.78	382.3	70.04	4652	387.7	8.15
		- -	1.000	22.000	246	164.8	6.28	5.76	380.1	72.26	4788	399.0	8.14
		- -	1.125	21.750	275	161.1	6.28	5.69	371.5	80.85	5302	441.8	8.10
		80	1.219	21.562	297	158.2	6.28	5.65	365.2	87.17	5673	472.8	8.07
		- -	1.250	21.500	304	157.4	6.28	5.63	363.1	89.34	5797	483.0	8.05
		- -	1.375	21.250	332	153.8	6.28	5.56	354.7	97.73	6275	522.9	8.01
		- -	1.500	21.000	361	150.2	6.28	5.50	346.4	106.03	6740	561.7	7.97
		100	1.531	20.938	367	149.3	6.28	5.48	344.3	108.07	6847	570.6	7.96
		120	1.812	20.376	429	141.4	6.28	5.33	326.1	126.30	7823	651.9	7.87
		140	2.062	19.876	484	134.4	6.28	5.20	310.3	142.10	8627	718.9	7.79
		160	2.344	19.312	542	127.0	6.28	5.06	293.1	159.40	9457	788.1	7.70
26	26.000	8 Ga.	.164	25.672	45	224.4	6.81	6.72	517.6	13.31	1111	85.4	9.13
		6 Ga.	.194	25.612	54	223.4	6.81	6.70	515.2	15.73	1310	100.7	9.12
		3 Ga.	.239	25.522	66	221.8	6.81	6.68	511.6	19.34	1605	123.4	9.11
		API	.250	25.500	67	221.4	6.81	6.68	510.7	19.85	1646	126.6	9.10
		API	.281	25.438	77	220.3	6.81	6.66	508.2	22.70	1877	144.4	9.09
		API	.312	25.376	84	219.2	6.81	6.64	505.8	25.18	2076	159.7	9.08

D-16
(Continued). Properties of Pipe

Nominal Pipe Size	Nominal Outside Diam. D	Desig-nation	Wall Thick-ness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Trans-verse Area in.² a	Area of Metal in.² A	Moment of Inertia in.⁴ I	Section Modulus in.³ Z	Radius of Gyra-tion in. R
26 cont.	26.000	API	.344	25.312	94	218.2	6.81	6.63	503.2	27.73	2280	175.4	9.07
		API	.375	25.250	103	217.1	6.81	6.61	500.7	30.19	2478	190.6	9.06
		API	.406	25.188	111	216.0	6.81	6.59	498.3	32.64	2673	205.6	9.05
		API	.438	25.124	120	214.9	6.81	6.58	495.8	35.17	2874	221.1	9.04
		API	.500	25.000	136	212.8	6.81	6.54	490.9	40.06	3259	250.7	9.02
		- -	.625	24.750	169	208.6	6.81	6.48	481.1	49.82	4013	308.7	8.98
		- -	.750	24.500	202	204.4	6.81	6.41	471.4	59.49	4744	364.9	8.93
		- -	.875	24.250	235	200.2	6.81	6.35	461.9	69.07	5458	419.9	8.89
		- -	1.000	24.000	267	196.1	6.81	6.28	452.4	78.54	6149	473.0	8.85
		- -	1.125	23.750	299	192.1	6.81	6.22	443.0	87.91	6813	524.1	8.80
		- -	1.375	23.250	362	184.1	6.81	6.09	424.6	106.37	8088	622.2	8.72
		- -	1.500	23.000	393	180.1	6.81	6.02	415.5	115.45	8695	668.8	8.68
30	30.000	8 Ga.	.164	29.672	52	299.9	7.85	7.77	691.4	15.37	1711	114.0	10.55
		6 Ga.	.194	29.612	62	298.6	7.85	7.75	688.6	18.17	2017	134.4	10.53
		3 Ga.	.239	29.522	76	296.7	7.85	7.73	684.4	22.35	2474	165.0	10.52
		API	.250	29.500	79	296.3	7.85	7.72	683.4	23.37	2585	172.3	10.52
		API	.281	29.438	89	295.1	7.85	7.70	680.5	26.24	2897	193.1	10.51
		10	.312	29.376	99	293.7	7.85	7.69	677.8	29.19	3201	213.4	10.50
		API	.344	29.312	109	292.6	7.85	7.67	674.8	32.04	3524	235.0	10.49
		API	.375	29.250	119	291.2	7.85	7.66	672.0	34.90	3823	254.8	10.48
		API	.406	29.188	130	290.7	7.85	7.64	669.0	37.75	4132	275.5	10.46
		API	.438	29.124	138	288.8	7.85	7.62	666.1	40.68	4442	296.2	10.45
		20	.500	29.000	158	286.2	7.85	7.59	660.5	46.34	5033	335.5	10.43
		30	.625	28.750	196	281.3	7.85	7.53	649.2	57.68	6213	414.2	10.39
		- -	.750	28.500	234	276.6	7.85	7.46	637.9	68.92	7371	491.4	10.34
		- -	.875	28.250	272	271.8	7.85	7.39	620.7	80.06	8494	566.2	10.30
		- -	1.000	28.000	310	267.0	7.85	7.33	615.7	91.11	9591	639.4	10.26
		- -	1.125	27.750	347	262.2	7.85	7.26	604.7	102.05	10653	710.2	10.22
		- -	1.250	27.500	384	257.5	7.85	7.20	593.9	112.90	11682	778.8	10.17
		- -	1.375	27.250	421	252.9	7.85	7.13	583.1	123.65	12694	846.2	10.13
		- -	1.500	27.000	457	248.2	7.85	7.07	572.5	134.30	13673	911.5	10.09
32	32.000	API	.250	31.500	85	337.8	8.38	8.25	779.2	24.93	3141	196.3	11.22
		API	.281	31.438	95	336.5	8.38	8.23	776.2	28.04	3525	220.3	11.21
		API	.312	31.376	106	335.2	8.38	8.21	773.2	31.02	3891	243.2	11.20
		API	.344	31.312	116	333.8	8.38	8.20	770.0	34.24	4287	268.0	11.19
		API	.375	31.250	127	332.5	8.38	8.18	766.9	37.25	4656	291.0	11.18
		API	.406	31.188	137	331.2	8.38	8.16	764.0	40.29	5025	314.1	11.17
		API	.438	31.124	148	329.8	8.38	8.15	760.8	43.43	5407	337.9	11.16
		API	.500	31.000	168	327.2	8.38	8.11	754.7	49.48	6140	383.8	11.14
		- -	.625	30.750	209	321.9	8.38	8.05	742.5	61.59	7578	473.6	11.09
		- -	.750	30.500	250	316.7	8.38	7.98	730.5	73.63	8990	561.9	11.05
		- -	.875	30.250	291	311.5	8.38	7.92	718.6	85.53	10368	648.0	11.01
		- -	1.000	30.000	331	306.4	8.38	7.85	706.8	97.38	11680	730.0	10.95
		- -	1.125	29.750	371	301.3	8.38	7.79	695.0	109.0	13003	812.7	10.92
		- -	1.250	29.500	410	296.3	8.38	7.72	680.5	120.7	14398	899.9	10.88
		- -	1.375	29.250	450	291.2	8.38	7.66	671.9	132.2	15526	970.4	10.84
		- -	1.500	29.000	489	286.3	8.38	7.59	660.5	143.7	16752	1047.0	10.80

D-16
(Continued). Properties of Pipe

Nominal Pipe Size	Nominal Outside Diam. D	Design-nation	Wall Thick-ness	Inside Diam. d	Weight per Foot	Wt. of Water per Ft. of Pipe	Sq. Ft. Outside Surface per Ft.	Sq. Ft. Inside Surface per Ft.	Trans-verse Area in.² a	Area of Metal in.² A	Moment of Inertia in.⁴ I	Section Modulus in.³ Z	Radius of Gyra-tion in. R
34	34.000	API	.250	33.500	90	382.0	8.90	8.77	881.2	26.50	3773	221.9	11.93
		API	.281	33.438	101	380.7	8.90	8.75	878.2	29.77	4230	248.8	11.92
		API	.312	33.376	112	379.3	8.90	8.74	874.9	32.99	4680	275.3	11.91
		API	.344	33.312	124	377.8	8.90	8.72	871.6	36.36	5147	302.8	11.90
		API	.375	33.250	135	376.2	8.90	8.70	867.8	39.61	5597	329.2	11.89
		API	.406	33.188	146	375.0	8.90	8.69	865.0	42.88	6047	355.7	11.87
		API	.438	33.124	157	373.6	8.90	8.67	861.7	46.18	6501	382.4	11.86
		API	.500	33.000	179	370.8	8.90	8.64	856.3	52.62	7385	434.4	11.85
		--	.625	32.750	223	365.0	8.90	8.57	841.9	65.53	9124	536.7	11.80
		--	.750	32.500	266	359.5	8.90	8.51	829.3	78.34	10829	637.0	11.76
		--	.875	32.250	308	354.1	8.90	8.44	816.8	90.66	12442	731.9	11.71
		--	1.000	32.000	353	348.6	8.90	8.38	804.2	103.6	14114	830.2	11.67
		--	1.125	31.750	395	343.2	8.90	8.31	791.6	116.1	15703	923.7	11.63
		--	1.250	31.500	437	337.8	8.90	8.25	779.2	128.5	17246	1014.5	11.58
		--	1.375	31.250	479	332.4	8.90	8.18	766.9	140.9	18770	1104.1	11.54
		--	1.500	31.000	521	327.2	8.90	8.11	754.7	153.1	20247	1191.0	11.50
36	36.000	--	.164	35.672	63	433.2	9.42	9.34	999.3	18.53	2975	165.3	12.67
		--	.194	35.612	74	431.8	9.42	9.32	996.0	21.83	3499	194.4	12.66
		--	.239	35.522	91	429.6	9.42	9.30	991.0	26.86	4293	238.5	12.64
		API	.250	35.500	96	429.1	9.42	9.29	989.7	28.11	4491	249.5	12.64
		API	.281	35.438	107	427.6	9.42	9.28	986.4	31.49	5023	279.1	12.63
		API	.312	35.376	119	426.1	9.42	9.26	982.9	34.95	5565	309.1	12.62
		API	.344	35.312	131	424.6	9.42	9.24	979.3	38.56	6127	340.4	12.60
		API	.375	35.250	143	423.1	9.42	9.23	975.8	42.01	6664	370.2	12.59
		API	.406	35.188	154	421.6	9.42	9.21	972.5	45.40	7191	399.5	12.58
		API	.438	35.124	166	420.1	9.42	9.19	968.9	48.93	7737	429.9	12.57
		API	.500	35.000	190	417.1	9.42	9.16	962.1	55.76	8785	488.1	12.55
		--	.625	34.750	236	411.1	9.42	9.10	948.3	69.50	10872	604.0	12.51
		--	.750	34.500	282	405.3	9.42	9.03	934.7	83.01	12898	716.5	12.46
		--	.875	34.250	329	399.4	9.42	8.97	921.2	96.60	14906	828.1	12.42
		--	1.000	34.000	374	393.6	9.42	8.90	907.9	109.9	16851	936.2	12.38
		--	1.125	33.750	419	387.8	9.42	8.83	894.5	123.3	18766	1042.6	12.34
		--	1.250	33.500	464	382.1	9.42	8.77	881.3	136.5	20624	1145.8	12.29
		--	1.375	33.250	509	376.4	9.42	8.70	868.2	149.6	22451	1247.3	12.25
		--	1.500	33.000	553	370.8	9.42	8.64	855.3	162.6	24237	1346.5	12.21
42	42.000	--	.250	41.500	112	586.4	10.99	10.86	1352.6	32.82	7126	339.3	14.73
		--	.375	41.250	167	579.3	10.99	10.80	1336.3	49.08	10627	506.1	14.71
		--	.500	41.000	222	572.3	10.99	10.73	1320.2	65.18	14037	668.4	14.67
		--	.625	40.750	276	565.4	10.99	10.67	1304.1	81.28	17373	827.3	14.62
		--	.750	40.500	331	558.4	10.99	10.60	1288.2	97.23	20689	985.2	14.59
		--	.875	40.250	385	551.6	10.99	10.54	1272.3	113.0	23896	1137.9	14.54
		--	1.000	40.000	438	544.8	10.99	10.47	1256.6	128.8	27080	1289.5	14.50
		--	1.125	39.750	492	537.9	10.99	10.41	1240.9	144.5	30193	1437.8	14.45
		--	1.250	39.500	544	531.2	10.99	10.34	1225.3	160.0	33233	1582.5	14.41
		--	1.375	39.250	597	524.4	10.99	10.27	1209.9	175.5	36240	1725.7	14.37
		--	1.500	39.000	649	517.9	10.99	10.21	1194.5	190.8	39181	1865.7	14.33

D-16
Equation of Pipes

The table below gives the number of pipes of one size required to equal in delivery other larger pipes of same length and under same conditions. The upper portion above the diagonal line of stars pertains to "standard" steam and gas pipes, while the lower portion is for pipes of the ACTUAL internal diameters given. The figures given in the table opposite the intersection of any two sizes is the number of the smaller-sized pipes required to equal one of the larger. Thus, it requires 29 standard 2-inch pipes to equal one standard 7-inch pipe.

STANDARD STEAM AND GAS PIPES

Dia.	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Dia.
½	* * *	2.27	4.88	15.8	31.7	52.9	96.9	205	377	620	918	1292	1767	2488	3014	3786	4904	5927	7321	8535	9717	½
¾	2.60	* * *	2.05	6.97	14.0	23.3	42.5	90.4	166	273	405	569	779	1096	1328	1668	2161	2615	3226	3761	4282	¾
1	7.55	2.90	* * *	3.45	6.82	11.4	20.9	44.1	81.1	133	198	278	380	536	649	815	1070	1263	1576	1837	2092	1
1½	24.2	9.30	3.20	* * *	1.26	3.34	6.13	13.0	23.8	39.2	58.1	81.7	112	157	190	239	310	375	463	539	614	1½
2	54.8	21.0	7.25	2.26	* * *	1.67	3.06	6.47	11.9	19.6	29.0	40.8	55.8	78.5	95.1	119	155	187	231	269	307	2
2½	102	39.4	13.6	4.23	1.87	* * *	1.83	3.87	7.12	11.7	17.4	24.4	33.4	47.0	56.9	71.5	92.6	112	138	161	184	2½
3	170	65.4	22.6	7.03	3.11	1.66	* * *	2.12	3.89	6.39	9.48	13.3	20.9	23.7	31.2	39.1	50.6	61.1	75.5	88.0	100	3
4	376	144	49.8	15.5	6.87	3.67	2.21	* * *	1.84	3.02	4.48	6.30	8.61	12.1	14.7	18.5	23.9	28.9	35.7	41.6	47.4	4
5	686	263	90.9	28.3	12.5	6.70	4.03	1.83	* * *	1.65	2.44	3.43	4.69	6.60	8.00	10.0	13.0	15.7	19.4	22.6	25.8	5
6	1116	429	148	46.0	20.4	10.9	6.56	2.97	1.63	* * *	1.48	2.09	2.85	4.02	4.86	6.11	7.91	9.56	11.8	13.8	15.6	6
7	1707	656	226	70.5	31.2	16.6	10.0	4.54	2.49	1.51	* * *	1.41	1.93	2.71	3.28	4.12	5.34	6.45	7.97	9.31	10.6	7
8	2435	936	322	101	44.5	23.8	14.3	6.48	3.54	2.18	1.43	* * *	1.35	1.93	2.33	2.92	3.79	4.57	5.67	6.60	7.52	8
9	3335	1281	440	137	60.8	32.5	19.5	8.85	4.85	2.98	1.95	1.37	* * *	1.41	1.71	2.14	2.77	3.35	4.14	4.83	5.50	9
10	4393	1688	582	181	80.4	42.9	25.8	11.7	6.40	3.93	2.57	1.80	1.32	* * *	1.21	1.52	1.97	2.38	2.94	3.43	3.91	10
11	5642	2168	747	233	103	55.1	33.1	15.0	8.22	5.05	3.31	2.32	1.70	1.28	* * *	1.26	1.63	1.88	2.43	2.83	3.22	11
12	7087	2723	938	293	129	69.2	41.6	18.8	10.3	6.34	4.15	2.91	2.13	1.61	1.26	* * *	1.30	1.57	1.93	2.26	2.58	12
13	8657	3326	1146	358	158	84.5	50.7	23.0	12.6	7.75	5.07	3.56	2.60	1.98	1.53	1.22	* * *	1.21	1.49	1.74	1.98	13
14	10600	4070	1403	438	193	103	62.2	28.2	15.4	9.48	6.21	4.35	3.18	2.41	1.88	1.50	1.22	* * *	1.24	1.44	1.64	14
15	12824	4927	1698	530	234	125	75.3	34.1	18.7	11.5	7.52	5.27	3.85	2.92	2.27	1.81	1.48	1.21	* * *	1.17	1.35	15
16	14978	5758	1984	619	274	146	88.0	39.9	21.8	13.4	8.78	6.15	4.51	3.41	2.66	2.12	1.73	1.42	1.18	* * *	1.14	16
17	17537	6738	2322	724	320	171	103	46.6	25.6	15.7	10.3	7.20	5.27	3.99	3.11	2.47	2.03	1.66	1.37	1.17	* * *	17
18	20327	7810	2691	840	317	198	119	54.1	29.6	18.2	11.9	8.35	6.11	4.63	3.60	2.87	2.35	1.92	1.59	1.36	1.16	18
20	26676	10249	3532	1102	487	260	157	70.9	38.9	23.9	15.6	10.9	8.02	6.07	4.73	3.76	3.08	2.52	2.08	1.78	1.52	20
24	42624	16376	5644	1761	778	416	250	113	62.1	38.2	25.0	17.5	12.8	9.70	7.55	6.01	4.92	4.02	3.32	2.84	2.43	24
30	75453	28990	9990	3117	1378	736	443	201	110	67.6	44.2	31.0	22.7	17.2	13.4	10.7	8.72	7.14	5.88	5.03	4.30	30
36	120100	46143	15902	4961	2193	1172	705	319	175	108	70.4	49.3	36.1	27.3	21.3	16.9	13.9	11.3	9.37	8.01	6.85	36
42	177724	68282	23541	7341	3245	1734	1044	473	259	159	104	73.0	53.4	40.5	31.5	25.1	20.5	16.8	13.9	11.9	10.1	42
48	249351	95818	33020	10301	4554	2434	1465	663	363	223	146	102	75.0	56.8	44.2	35.2	28.8	23.5	19.4	16.6	14.2	48
Dia.	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	

By permission, Buffalo Tank Div., Bethlehem Steel Corp.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
29	93.070	689 30	36.	113.097	1017.9	42¼	132.732	1402.0
⅜	93.462	695.13	⅛	113.490	1025.0	⅜	133.125	1410.3
⅞	93.855	700.98	¼	113.883	1032.1	½	133.518	1418.6
30.	94.248	706.86	⅜	114.275	1039.2	⅝	133.910	1427.0
⅛	94.640	712.76	½	114.668	1046.3	¾	134.303	1435.4
¼	95.033	718.69	⅝	115.061	1053.5	⅞	134.696	1443.8
⅜	95.426	724.64	¾	115.454	1060.7			
½	95.819	730.62	⅞	115.846	1068.0	43.	135.088	1452.2
⅝	96.211	736.62	37.	116.239	1075.2	⅛	135.481	1460.7
¾	96.604	742.64	⅛	116.632	1082.5	¼	135.874	1469.1
⅞	96.997	748.69	¼	117.024	1089.8	⅜	136.267	1477.6
31.	97.389	754.77	⅜	117.417	1097.1	½	136.659	1486.2
⅛	97.782	760.87	½	117.810	1104.5	⅝	137.052	1494.7
¼	98.175	766.99	⅝	118.202	1111.8	¾	137.445	1503.3
⅜	98.567	773.14	¾	118.596	1119.2	⅞	137.837	1511.9
½	98.960	779.31	⅞	118.988	1126.7	44.	138.230	1520.5
⅝	99.353	785.51	38.	119.381	1134.1	⅛	138.623	1529.2
¾	99.746	791.73	⅛	119.773	1141.6	¼	139.015	1537.9
⅞	100.138	797.98	¼	120.166	1149.1	⅜	139.408	1546.6
32.	100.531	804.25	⅜	120.559	1156.6	½	139.801	1555.3
⅛	100.924	810.54	½	120.951	1164.2	⅝	140.194	1564.0
¼	101.316	816.86	⅝	121.344	1171.7	¾	140.586	1572.8
⅜	101.709	823.21	¾	121.737	1179.3	⅞	140.979	1581.6
½	102.102	829.58	⅞	122.129	1186.9	45.	141.372	1590.4
⅝	102.494	835.97	39.	122.522	1194.6	⅛	141.764	1599.3
¾	102.887	842.39	⅛	122.915	1202.3	¼	142.157	1608.2
⅞	103.280	848.83	¼	123.308	1210.6	⅜	142.550	1617.0
33.	103.673	855.30	⅜	123.700	1217.7	½	142.942	1626.0
⅛	104.065	861.79	½	124.093	1225.4	⅝	143.335	1634.9
¼	104.458	868.31	⅝	124.486	1233.2	¾	143.728	1643.9
⅜	104.851	874.85	¾	124.878	1241.0	⅞	144.121	1652.9
½	105.243	881.41	⅞	125.271	1248.8	46.	144.513	1661.9
⅝	105.636	888.00				⅛	144.906	1670.9
¾	106.029	894.62	40.	125.664	1256.6	¼	145.299	1680.0
⅞	106.421	901.26	⅛	126.056	1264.5	⅜	145.691	1689.1
34.	106.814	907.92	¼	126.449	1272.4	½	146.084	1698.2
⅛	107.207	914.61	⅜	126.842	1280.3	⅝	146.477	1707.4
¼	107.600	921.32	½	127.235	1288.2	¾	146.869	1716.5
⅜	107.992	928.06	⅝	127.627	1296.2	⅞	147.262	1725.7
½	108.385	934.82	¾	128.020	1304.2	47.	147.655	1734.9
⅝	108.778	941.61	⅞	128.413	1312.2	⅛	148.048	1744.2
¾	109.170	948.42	41.	128.805	1320.3	¼	148.440	1753.5
⅞	109.563	955.25	⅛	129.198	1328.3	⅜	148.833	1762.7
35.	109.956	962.11	¼	129.591	1336.4	½	149.226	1772.1
⅛	110.348	969.00	⅜	129.983	1344.5	⅝	149.618	1781.4
¼	110.741	975.91	½	130.376	1352.7	¾	150.011	1790.8
⅜	111.134	982.84	⅝	130.769	1360.8	⅞	150.404	1800.1
½	111.527	989.80	¾	131.161	1369.0	48.	150.796	1809 6
⅝	111.919	996.78	⅞	131.554	1377.2	⅛	151.189	1819.0
¾	112.312	1003.8	42.	131.947	1385.4	¼	151.582	1828.5
⅞	112.705	1010.8	⅛	132.340	1393.7	⅜	151.975	1837.9
						½	152.367	1847.5

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
48⅝	152.760	1857.0	55.	172.788	2375.8	61¼	192.423	2946.5
¾	153.153	1866.5	⅛	173.180	2386.6	⅜	192.815	2958.5
⅞	153.545	1876.1	¼	173.573	2397.5	½	193.208	2970.6
49.	153.938	1885.7	⅜	173.966	2408.3	⅝	193.601	2982.7
⅛	154.331	1895.4	½	174.358	2419.2	¾	193.993	2994.8
¼	154.723	1905.0	⅝	174.751	2430.1	⅞	194.386	3006.9
⅜	155.116	1914.7	¾	175.144	2441.1			
½	155.509	1924.4	⅞	175.536	2452.0	62.	194.779	3019.1
⅝	155.902	1934.2	56.	175.929	2463.0	⅛	195.171	3031.3
¾	156.294	1943.9	⅛	176.322	2474.0	¼	195.564	3043.5
⅞	156.687	1953.7	¼	176.715	2485.0	⅜	195.957	3055.7
50.	157.080	1963.5	⅜	177.107	2496.1	½	196.350	3068.0
⅛	157.472	1973.3	½	177.500	2507.2	⅝	196.742	3080.3
¼	157.865	1983.2	⅝	177.893	2518.3	¾	197.135	3092.6
⅜	158.258	1993.1	¾	178.285	2529.4	⅞	197.528	3104.9
½	158.650	2003.0	⅞	178.678	2540.6	63.	197.920	3117.2
⅝	159.043	2012.9	57.	179.071	2551.8	⅛	198.313	3129.6
¾	159.436	2022.8	⅛	179.463	2563.0	¼	198.706	3142.0
⅞	159.829	2032.8	¼	179.856	2574.2	⅜	199.098	3154.5
51.	160.221	2042.8	⅜	180.249	2585.4	½	199.491	3166.9
⅛	160.614	2052.8	½	180.642	2596.7	⅝	199.884	3179.4
¼	161.007	2062.9	⅝	181.034	2608.0	¾	200.277	3191.9
⅜	161.399	2073.0	¾	181.427	2619.4	⅞	200.669	3204.4
½	161.792	2083.1	⅞	181.820	2630.7	64.	201.062	3217.0
⅝	162.185	2093.2	58.	182.212	2642.1	⅛	201.455	3229.6
¾	162.577	2103.3	⅛	182.605	2653.5	¼	201.847	3242.2
⅞	162.970	2113.5	¼	182.998	2664.9	⅜	202.240	3254.8
52.	163.363	2123.7	⅜	183.390	2676.4	½	202.633	3267.5
⅛	163.756	2133.9	½	183.783	2687.8	⅝	203.025	3280.1
¼	164.148	2144.2	⅝	184.176	2699.3	¾	203.418	3292.8
⅜	164.541	2154.5	¾	184.569	2710.9	⅞	203.811	3305.6
½	164.934	2164.8	⅞	184.961	2722.4	65.	204.204	3318.3
⅝	165.326	2175.1				⅛	204.596	3331.1
¾	165.719	2185.4	59.	185.354	2734.0	¼	204.989	3343.9
⅞	166.112	2195.8	⅛	185.747	2745.6	⅜	205.382	3356.7
53.	166.504	2206.2	¼	186.139	2757.2	½	205.774	3369.6
⅛	166.897	2216.6	⅜	186.532	2768.8	⅝	206.167	3382.4
¼	167.290	2227.0	½	186.925	2780.5	¾	206.560	3395.3
⅜	167.683	2237.5	⅝	187.317	2792.2	⅞	206.952	3408.2
½	168.075	2248.0	¾	187.710	2803.9			
⅝	168.468	2258.5	⅞	188.103	2815.7	66.	207.345	3421.2
¾	168.861	2269.1				⅛	207.738	3434.2
⅞	169.253	2279.6	60.	188.496	2827.4	¼	208.131	3447.2
			⅛	188.888	2839.2	⅜	208.523	3460.2
54.	169.646	2290.2	¼	189.281	2851.0	½	208.916	3473.2
⅛	170.039	2300.8	⅜	189.674	2862.9	⅝	209.309	3486.3
¼	170.431	2311.5	½	190.066	2874.8	¾	209.701	3499.4
⅜	170.824	2322.1	⅝	190.459	2886.6	⅞	210.094	3512.5
½	171.217	2332.8	¾	190.852	2898.6			
⅝	171.609	2343.5	⅞	191.244	2910.5	67.	210.487	3525.7
¾	172.002	2354.3	61.	191.637	2922.5	⅛	210.879	3538.8
⅞	172.395	2365.0	⅛	192.030	2934.5	¼	211.272	3552.0
						⅜	211.665	3565.2

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles (Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
1/16	.04909	.00019	2 1/8	6.6759	3.5466	5 3/8	16.886	22.691
1/8	.09818	.00077	3/16	6.8722	3.7583	7/16	17.082	23.221
3/16	.14726	.00173	1/4	7.0686	3.9761	1/2	17.279	23.758
1/4	.19635	.00307	5/16	7.2649	4.2000	9/16	17.475	24.301
5/16	.29452	.00690	3/8	7.4613	4.4301	5/8	17.671	24.850
3/8	.39270	.01227	7/16	7.6576	4.6664	11/16	17.868	25.406
7/16	.49087	.01917	1/2	7.8540	4.9087	3/4	18.064	25.967
1/2	.58905	.02761	9/16	8.0503	5.1572	13/16	18.261	26.535
9/16	.68722	.03758	5/8	8.2467	5.4119	7/8	18.457	27.109
			11/16	8.4430	5.6727	15/16	18.653	27.688
1/4	.78540	.04909	3/4	8.6394	5.9396			
9/16	.88357	.06213	13/16	8.8357	6.2126	6.	18.850	28.274
5/8	.98175	.07670	7/8	9.0321	6.4918	1/8	19.242	29.465
11/16	1.0799	.09281	15/16	9.2284	6.7771	1/4	19.635	30.680
3/4	1.1781	.11045				3/8	20.028	31.919
13/16	1.2763	.12962	3.	9.4248	7.0686	1/2	20.420	33.183
7/8	1.3744	.15033	1/16	9.6211	7.3662	5/8	20.813	34.472
15/16	1.4726	.17257	1/8	9.8175	7.6699	3/4	21.206	35.785
			3/16	10.014	7.9798	7/8	21.598	37.122
1/2	1.5708	.19635	1/4	10.210	8.2958			
1/16	1.6690	.22166	5/16	10.407	8.6179	7.	21.991	38.485
1/8	1.7671	.24850	3/8	10.603	8.9462	1/8	22.384	39.871
3/16	1.8653	.27688	7/16	10.799	9.2806	1/4	22.776	41.282
1/4	1.9635	.30680	1/2	10.996	9.6211	3/8	23.169	42.718
5/16	2.0617	.33824	9/16	11.192	9.9678	1/2	23.562	44.179
3/8	2.1598	.37122	5/8	11.388	10.321	5/8	23.955	45.664
7/16	2.2580	.40574	11/16	11.585	10.680	3/4	24.347	47.173
			3/4	11.781	11.045	7/8	24.740	48.707
9/16	2.3562	.44179	13/16	11.977	11.416			
5/8	2.4544	.47937	7/8	12.174	11.793	8.	25.133	50.265
11/16	2.5525	.51849	15/16	12.370	12.177	1/8	25.525	51.849
3/4	2.6507	.55914				1/4	25.918	53.456
13/16	2.7489	.60132	4.	12.566	12.566	3/8	26.311	55.088
7/8	2.8471	.64504	1/16	12.763	12.962	1/2	26.704	56.745
15/16	2.9452	.69029	1/8	12.959	13.364	5/8	27.096	58.426
			3/16	13.155	13.772	3/4	27.489	60.132
1.	3.1416	.7854	1/4	13.352	14.186	7/8	27.882	61.862
1/16	3.3379	.8866	5/16	13.548	14.607			
1/8	3.5343	.9940	3/8	13.744	15.033	9.	28.274	63.617
3/16	3.7306	1.1075	7/16	13.941	15.466	1/8	28.667	65.397
1/4	3.9270	1.2272	1/2	14.137	15.904	1/4	29.060	67.201
5/16	4.1233	1.3530	9/16	14.334	16.349	3/8	29.452	69.029
3/8	4.3197	1.4849	5/8	14.530	16.800	1/2	29.845	70.882
7/16	4.5160	1.6230	11/16	14.726	17.257	5/8	30.238	72.760
1/2	4.7124	1.7671	3/4	14.923	17.728	3/4	30.631	74.662
9/16	4.9087	1.9175	13/16	15.119	18 190	7/8	31.023	76.589
5/8	5.1051	2.0739	7/8	15 315	18.665			
11/16	5.3014	2.2365	15/16	15.512	19.147	10.	31.416	78.540
3/4	5.4978	2.4053				1/8	31.809	80.516
13/16	5.6941	2.5802	5.	15.708	19.635	1/4	32.201	82.516
7/8	5.8905	2.7612	1/16	15.90	20.129	3/8	32.594	84.541
15/16	6.0868	2.9483	1/8	16.101	20.629	1/2	32.987	86.590
			3/16	16.297	21.135	5/8	33.379	88.664
2.	6.2832	3.1416	1/4	16.493	21.648	3/4	33.772	90.763
1/16	6.4795	3.3410	5/16	16.690	22.166	7/8	34.165	92.886

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles (Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
11.	34.558	95.033	17 1/4	54.192	233.71	23 1/2	73.827	433.74
1/8	34.950	97.205	3/8	54.585	237.10	5/8	74.220	438.36
1/4	35.343	99.402	1/2	54.978	240.53	3/4	74.613	443.01
3/8	35.736	101.62	5/8	55.371	243.98	7/8	75.006	447.69
1/2	36.128	103.87	3/4	55.763	247.45			
5/8	36.521	106.14	7/8	56.156	250.95	24.	75.398	452.39
3/4	36.914	108.43				1/8	75.791	457.11
7/8	37.306	110.75	18.	56.549	254.47	1/4	76.184	461.86
			1/8	56.941	258.02	3/8	76.576	466.64
12.	37.699	113.10	1/4	57.334	261.59	1/2	76.969	471.44
1/8	38.092	115.47	3/8	57.727	265.18	5/8	77.362	476.26
1/4	38.485	117.86	1/2	58.119	268.80	3/4	77.754	481.11
3/8	38.877	120.28	5/8	58.512	272.45	7/8	78.147	485.98
1/2	39.270	122.72	3/4	58.905	276.12			
5/8	39.663	125.19	7/8	59.298	279.81	25.	78.540	490.87
3/4	40.055	127.68				1/8	78.933	495.79
7/8	40.448	130.19	19.	59.690	283.53	1/4	79.325	500.74
			1/8	60.083	287.27	3/8	79.718	505.71
13.	40.841	132.73	1/4	60.476	291.04	1/2	80.111	510.71
1/8	41.233	135.30	3/8	60.868	294.83	5/8	80.503	515.72
1/4	41.626	137.89	1/2	61.261	298.65	3/4	80.896	520.77
3/8	42.019	140.50	5/8	61.654	302.49	7/8	81.289	525.84
1/2	42.412	143.14	3/4	62.046	306.35			
5/8	42.804	145.80	7/8	62.439	310.24	26.	81.681	530.93
3/4	43.197	148.49				1/8	82.074	536.05
7/8	43.590	151.20	20.	62.832	314.16	1/4	82.467	541.19
			1/8	63.225	318.10	3/8	82.860	546.35
14.	43.982	153.94	1/4	63.617	322.06	1/2	83.252	551.55
1/8	44.375	156.70	3/8	64.010	326.05	5/8	83.645	556.76
1/4	44.768	159.48	1/2	64.403	330.06	3/4	84.038	562.00
3/8	45.160	162.30	5/8	64.795	334.10	7/8	84.430	567.27
1/2	45.553	165.13	3/4	65.188	338.16			
5/8	45.946	167.99	7/8	65.581	342.25	27.	84.823	572.56
3/4	46.338	170.87				1/8	85.216	577.87
7/8	46.731	173.78	21.	65.973	346.36	1/4	85.608	583.21
			1/8	66.366	350.50	3/8	86.001	588.57
15.	47.124	176.71	1/4	66.759	354.66	1/2	86.394	593.96
1/8	47.517	179.67	3/8	67.152	358.84	5/8	86.786	599.37
1/4	47.909	182.65	1/2	67.544	363.05	3/4	87.179	604.81
3/8	48.302	185.66	5/8	67.937	367.28	7/8	87.572	610.27
1/2	48.695	188.69	3/4	68.330	371.54			
5/8	49.087	191.75	7/8	68.722	375.83	28.	87.965	615.75
3/4	49.480	194.83				1/8	88.357	621.26
7/8	49.873	197.93	22.	69.115	380.13	1/4	88.750	626.80
			1/8	69.508	384.46	3/8	89.143	632.36
16.	50.265	201.06	1/4	69.900	388.82	1/2	89.535	637.94
1/8	50.658	204.22	3/8	70.293	393.20	5/8	89.928	643.55
1/4	51.051	207.39	1/2	70.686	397.61	3/4	90.321	649.18
3/8	51.444	210.60	5/8	71.079	402.04	7/8	90.713	654.84
1/2	51.836	213.82	3/4	71.471	406.49			
5/8	52.229	217.08	7/8	71.864	410.97	29.	91.106	660.52
3/4	52.622	220.35				1/8	91.499	666.23
7/8	53.014	223.65	23.	72.257	415.48	1/4	91.892	671.96
			1/8	72.649	420.00	3/8	92.284	677.71
17.	53.407	226.98	1/4	73.042	424.56			
1/8	53.800	230.33	3/8	73.435	429.13			

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
67½	212.058	3578.5	73¾	231.692	4271.8	80.	251.327	5026.5
⅝	212.450	3591.7	⅛	232.085	4286.3	⅛	251.720	5042.3
¾	212.843	3605.0				¼	252.113	5058.0
⅞	213.236	3618.3	74.	232.478	4300.8	⅜	252.506	5073.8
			⅛	232.871	4315.4	½	252.898	5089.6
68.	213.628	3631.7	¼	233.263	4329.9	⅝	253.291	5105.4
⅛	214.021	3645.0	⅜	233.656	4344.5	¾	253.684	5121.2
¼	214.414	3658.4	½	234.049	4359.2	⅞	254.076	5137.1
⅜	214.806	3671.8	⅝	234.441	4373.8			
½	215.199	3685.3	¾	234.834	4388.5	81.	254.469	5153.0
⅝	215.592	3698.7	⅞	235.227	4403.1	⅛	254.862	5168.9
¾	215.984	3712.2				¼	255.254	5184.9
⅞	216.377	3725.7	75.	235.619	4417.9	⅜	255.647	5200.8
			⅛	236.012	4432.6	½	256.040	5216.8
69.	216.770	3739.3	¼	236.405	4447.4	⅝	256.433	5232.8
⅛	217.163	3752.8	⅜	236.798	4462.2	¾	256.825	5248.9
¼	217.555	3766.4	½	237.190	4477.0	⅞	257.218	5264.9
⅜	217.948	3780.0	⅝	237.583	4491.8			
½	218.341	3793.7	¾	237.976	4506.7	82.	257.611	5281.0
⅝	218.733	3807.3	⅞	238.368	4521.5	⅛	258.003	5297.1
¾	219.126	3821.0				¼	258.396	5313.3
⅞	219.519	3834.7	76.	238.761	4536.5	⅜	258.789	5329.4
			⅛	239.154	4551.4	½	259.181	5345.6
70.	219.911	3848.5	¼	239.546	4566.4	⅝	259.574	5361.8
⅛	220.304	3862.2	⅜	239.939	4581.3	¾	259.967	5378.1
¼	220.697	3876.0	½	240.332	4596.3	⅞	260.359	5394.3
⅜	221.090	3889.8	⅝	240.725	4611.4			
½	221.482	3903.6	¾	241.117	4626.4	83.	260.752	5410.6
⅝	221.875	3917.5	⅞	241.510	4641.5	⅛	261.145	5426.9
¾	222.268	3931.4				¼	261.538	5443.3
⅞	222.660	3945.3	77.	241.903	4656.6	⅜	261.930	5459.6
			⅛	242.295	4671.8	½	262.323	5476.0
71.	223.053	3959.2	¼	242.688	4686.9	⅝	262.716	5492.4
⅛	223.446	3973.1	⅜	243.081	4702.1	¾	263.108	5508.8
¼	223.838	3987.1	½	243.473	4717.3	⅞	263.501	5525.3
⅜	224.231	4001.1	⅝	243.866	4732.5			
½	224.624	4015.2	¾	244.259	4747.8	84.	263.894	5541.8
⅝	225.017	4029.2	⅞	244.652	4763.1	⅛	264.286	5558.3
¾	225.409	4043.3				¼	264.679	5574.8
⅞	225.802	4057.4	78.	245.044	4778.4	⅜	265.072	5591.4
			⅛	245.437	4793.7	½	265.465	5607.9
72.	226.195	4071.5	¼	245.830	4809.0	⅝	265.857	5624.5
⅛	226.587	4085.7	⅜	246.222	4824.4	¾	266.250	5641.2
¼	226.980	4099.8	½	246.615	4839.8	⅞	266.643	5657.8
⅜	227.373	4114.0	⅝	247.008	4855 2			
½	227.765	4128.2	¾	247.400	4870.7	85.	267.035	5674.5
⅝	228.158	4142.5	⅞	247.793	4886.2	⅛	267.428	5691.2
¾	228.551	4156.8				¼	267.821	5707.9
⅞	228.944	4171.1	79.	248.186	4901.7	⅜	268.213	5724.7
			⅛	248.579	4917.2	½	268.606	5741.5
73.	229.336	4185.4	¼	248.971	4932.7	⅝	268.999	5758.3
⅛	229.729	4199.7	⅜	249.364	4948.3	¾	269.392	5775.1
¼	230.122	4214.1	½	249.757	4963.9	⅞	269.784	5791.9
⅜	230.514	4228.5	⅝	250.149	4979.5			
½	230.907	4242.9	¾	250.542	4995.2	86.	270.177	5808.8
⅝	231.300	4257.4	⅞	250.935	5010.9	⅛	270.570	5825.7

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
86¼	270.962	5842.6	92½	290.597	6720.1	98¾	310.232	7658.9
⅜	271.355	5859.6	⅝	290.990	6738.2	⅞	310.625	7678.3
½	271.748	5876.5	¾	291.383	6756.4			
⅝	272.140	5893.5	⅞	291.775	6774.7	99.	311.018	7697.7
¾	272.533	5910.6				⅛	311.410	7717.1
⅞	272.926	5927.6	93.	292.168	6792.9	¼	311.803	7736.6
			⅛	292.561	6811.2	⅜	312.196	7756.1
87.	273.319	5944.7	¼	292.954	6829.5	½	312.588	7775.6
⅛	273.711	5961.8	⅜	293.346	6847.8	⅝	312.981	7795.2
¼	274.104	5978.9	½	293.739	6866.1	¾	313.374	7814.8
⅜	274.497	5996.0	⅝	294.132	6884.5	⅞	313.767	7834.4
½	274.889	6013.2	¾	294.524	6902.9			
⅝	275.282	6030.4	⅞	294.917	6921.3	100.	314.16	7854
¾	275.675	6047.6				⅛	314.55	7873
⅞	276.067	6064.9	94.	295.310	6939.8	¼	314.95	7893
			⅛	295.702	6958.2	⅜	315.34	7913
88.	276.460	6082.1	¼	296.095	6976.7	½	315.73	7933
⅛	276.853	6099.4	⅜	296.488	6995.3	⅝	316.12	7952
¼	277.246	6116.7	½	296.881	7013.8	¾	316.52	7972
⅜	277.638	6134.1	⅝	297.273	7032.4	⅞	316.91	7992
½	278.031	6151.4	¾	297.666	7051.0			
⅝	278.424	6168.8	⅞	298.059	7069.6	101.	317.30	8012
¾	278.816	6186.2				⅛	317.69	8032
⅞	279.209	6203.7	95.	298.451	7088.2	¼	318.09	8052
			⅛	298.844	7106.9	⅜	318.48	8071
89.	279.602	6221.1	¼	299.237	7125.6	½	318.87	8091
⅛	279.994	6238.6	⅜	299.629	7144.3	⅝	319.27	8111
¼	280.387	6256.1	½	300.022	7163.0	¾	319.66	8131
⅜	280.780	6273.7	⅝	300.415	7181.8	⅞	320.05	8151
½	281.173	6291.2	¾	300.807	7200.6			
⅝	281.565	6308.8	⅞	301.200	7219.4	102.	320.44	8171
¾	281.958	6326.4				⅛	320.84	8191
⅞	282.351	6344.1	96.	301.593	7238.2	¼	321.23	8211
			⅛	301.986	7257.1	⅜	321.62	8231
90.	282.743	6361.7	¼	302.378	7276.0	½	322.01	8252
⅛	283.136	6379.4	⅜	302.771	7294.9	⅝	322.41	8272
¼	283.529	6397.1	½	303.164	7313.8	¾	322.80	8292
⅜	283.921	6414.9	⅝	303.556	7332.8	⅞	323.19	8312
½	284.314	6432.6	¾	303.949	7351.8			
⅝	284.707	6450.4	⅞	304.342	7370.8	103.	323.59	8332
¾	285.100	6468.2				⅛	323.98	8352
⅞	285.492	6486.0	97.	304.734	7389.8	¼	324.37	8372
			⅛	305.127	7408.9	⅜	324.76	8393
91.	285.885	6503.9	¼	305.520	7428.0	½	325.16	8413
⅛	286.278	6521.8	⅜	305.913	7447.1	⅝	325.55	8434
¼	286.670	6539.7	½	306.305	7466.2	¾	325.94	8454
⅜	287.063	6557.6	⅝	306.698	7485 3	⅞	326.33	8474
½	287.456	6575.5	¾	307.091	7504 5			
⅝	287.848	6593.5	⅞	307.483	7523.7	104.	326.73	8495
¾	288.241	6611.5				⅛	327.12	8515
⅞	288.634	6629.6	98.	307.876	7543.0	¼	327.51	8536
			⅛	308.269	7562.2	⅜	327.91	8556
92.	289.027	6647.6	¼	308.661	7581.5	½	328.30	8577
⅛	289.419	6665.7	⅜	309.054	7600.8	⅝	328.69	8597
¼	289.812	6683.8	½	309.447	7620.1	¾	329.08	8618
⅜	290.205	6701.9	⅝	309.840	7639.5	⅞	329.48	8638

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
105.	329.87	8659	111¼	349.50	9720	117½	369.14	10844
⅛	330.26	8679	⅜	349.90	9742	⅝	369.53	10867
¼	330.65	8700	½	350.29	9764	¾	369.92	10890
⅜	331.05	8721	⅝	350.68	9786	⅞	370.32	10913
½	331.44	8741	¾	351.07	9808			
⅝	331.83	8762	⅞	351.47	9830	118.	370.71	10936
¾	332.22	8783				⅛	371.11	10960
⅞	332.62	8804	112.	351.86	9852	¼	371.49	10983
106.	333.01	8825	⅛	352.25	9874	⅜	371.89	11007
⅛	333.40	8845	¼	352.65	9897	½	372.28	11030
¼	333.80	8866	⅜	353.04	9919	⅝	372.67	11053
⅜	334.19	8887	½	353.43	9941	¾	373.07	11076
½	334.58	8908	⅝	353.82	9963	⅞	373.46	11099
⅝	334.97	8929	¾	354.22	9985			
¾	335.37	8950	⅞	354.61	10007	119.	373.85	11122
⅞	335.76	8971	113.	355.00	10029	⅛	374.24	11146
107.	336.15	8992	⅛	355.39	10052	¼	374.64	11169
⅛	336.54	9014	¼	355.79	10074	⅜	375.03	11193
¼	336.94	9035	⅜	356.18	10097	½	375.42	11216
⅜	337.33	9056	½	356.57	10119	⅝	375.81	11240
½	337.72	9077	⅝	356.96	10141	¾	376.21	11263
⅝	338.12	9098	¾	357.36	10163	⅞	376.60	11287
¾	338.51	9119	⅞	357.75	10185			
⅞	338.90	9140	114.	358.14	10207	120.	376.99	11310
108.	339.29	9161	⅛	358.54	10230	⅛	377.39	11334
⅛	339.69	9183	¼	358.93	10252	¼	377.78	11357
¼	340.08	9204	⅜	359.32	10275	⅜	378.17	11381
⅜	340.47	9225	½	359.71	10297	½	378.56	11404
½	340.86	9246	⅝	360.11	10320	⅝	378.96	11428
⅝	341.26	9268	¾	360.50	10342	¾	379.35	11451
¾	341.65	9289	⅞	360.89	10365	⅞	379.74	11475
⅞	342.04	9310	115.	361.28	10387	121.	380.13	11499
109.	342.43	9331	⅛	361.68	10410	⅛	380.53	11522
⅛	342.83	9353	¼	362.07	10432	¼	380.92	11546
¼	343.22	9374	⅜	362.46	10455	⅜	381.31	11570
⅜	343.61	9396	½	362.86	10477	½	381.70	11594
½	344.01	9417	⅝	363.25	10500	⅝	382.10	11618
⅝	344.40	9439	¾	363.64	10522	¾	382.49	11642
¾	344.79	9460	⅞	364.03	10545	⅞	382.88	11666
⅞	345.18	9481	116.	364.43	10568	122.	383.28	11690
110.	345.58	9503	⅛	364.82	10590	⅛	383.67	11714
⅛	345.97	9525	¼	365.21	10613	¼	384.06	11738
¼	346.36	9546	⅜	365.60	10636	⅜	384.45	11762
⅜	346.75	9568	½	366.00	10659	½	384.85	11786
½	347.15	9589	⅝	366.39	10682	⅝	385.24	11810
⅝	347.54	9611	¾	366.78	10705	¾	385.63	11834
¾	347.93	9633	⅞	367.18	10728	⅞	386.02	11858
⅞	348.33	9655	117.	367.57	10751	123.	386.42	11882
111.	348.72	9677	⅛	367.96	10774	⅛	386.81	11907
⅛	349.11	9698	¼	368.35	10798	¼	387.20	11931
			⅜	368.75	10821	⅜	387.60	11956
						½	387.99	11980

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
123⅝	388.38	12004	130.	408.41	13273	136¼	428.04	14580
¾	388.77	12028	⅛	408.80	13299	⅜	428.44	14607
⅞	389.17	12052	¼	409.19	13324	½	428.83	14633
			⅜	409.59	13350	⅝	429.22	14660
124.	389.56	12076	½	409.98	13375	¾	429.61	14687
⅛	389.95	12101	⅝	410.37	13401	⅞	430.01	14714
¼	390.34	12125	¾	410.76	13426			
⅜	390.74	12150	⅞	411.16	13452	137.	430.40	14741
½	391.13	12174				⅛	430.79	14768
⅝	391.52	12199	131.	411.55	13478	¼	431.19	14795
¾	391.92	12223	⅛	411.94	13504	⅜	431.58	14822
⅞	392.31	12248	¼	412.34	13529	½	431.97	14849
			⅜	412.73	13555	⅝	432.36	14876
125.	392.70	12272	½	413.12	13581	¾	432.76	14903
⅛	393.09	12297	⅝	413.51	13607	⅞	433.15	14930
¼	393.49	12321	¾	413.91	13633			
⅜	393.88	12346	⅞	414.30	13659	138.	433.54	14957
½	394.27	12370				⅛	433.93	14984
⅝	394.66	12395	132.	414.69	13685	¼	434.33	15012
¾	395.06	12419	⅛	415.08	13711	⅜	434.72	15039
⅞	395.45	12444	¼	415.48	13737	½	435.11	15067
			⅜	415.87	13763	⅝	435.50	15094
126.	395.84	12469	½	416.26	13789	¾	435.90	15121
⅛	396.23	12494	⅝	416.66	13815	⅞	436.29	15148
¼	396.63	12518	¾	417.05	13841			
⅜	397.02	12543	⅞	417.44	13867	139.	436.68	15175
½	397.41	12568				⅛	437.08	15203
⅝	397.81	12593	133.	417.83	13893	¼	437.47	15230
¾	398.20	12618	⅛	418.23	13919	⅜	437.86	15258
⅞	398.59	12643	¼	418.62	13946	½	438.25	15285
			⅜	419.01	13972	⅝	438.65	15313
127.	398.98	12668	½	419.40	13999	¾	439.04	15340
⅛	399.38	12693	⅝	419.80	14025	⅞	439.43	15367
¼	399.77	12718	¾	420.19	14051			
⅜	400.16	12743	⅞	420.58	14077	140.	439.82	15394
½	400.55	12768				⅛	440.22	15422
⅝	400.95	12793	134.	420.97	14103	¼	440.61	15449
¾	401.34	12818	⅛	421.37	14130	⅜	441.00	15477
⅞	401.73	12843	¼	421.76	14156	½	441.40	15504
			⅜	422.15	14183	⅝	441.79	15532
128.	402.13	12868	½	422.55	14209	¾	442.18	15559
⅛	402.52	12893	⅝	422.94	14236	⅞	442.57	15587
¼	402.91	12919	¾	423.33	14262			
⅜	403.30	12944	⅞	423.72	14288	141.	442.97	15615
½	403.70	12970				⅛	443.36	15642
⅝	404.09	12995	135.	424.12	14314	¼	443.75	15670
¾	404.48	13020	⅛	424.51	14341	⅜	444.14	15697
⅞	404.87	13045	¼	424.90	14367	½	444.54	15725
			⅜	425.29	14394	⅝	444.93	15753
129.	405.27	13070	½	425.69	14420	¾	445.32	15781
⅛	405.66	13096	⅝	426.08	14447	⅞	445.72	15809
¼	406.05	13121	¾	426.47	14473			
⅜	406.44	13147	⅞	426.87	14500	142.	446.11	15837
½	406.84	13172				⅛	446.50	15865
⅝	407.23	13198				¼	446.89	15893
¾	407.62	13223	136.	427.26	14527	⅜	447.29	15921
⅞	408.02	13248	⅛	427.65	14553			

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles (Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
142½	447.68	15949	148¾	467.31	17379	155.	486.95	18869
⅝	448.07	15977	⅞	467.71	17408	⅛	487.34	18900
¾	448.46	16005				¼	487.73	18930
⅞	448.86	16033	149.	468.10	17437	⅜	488.13	18961
			⅛	468.49	17466	½	488.52	18991
143.	449.25	16061	¼	468.88	17496	⅝	488.91	19022
⅛	449.64	16089	⅜	469.28	17525	¾	489.30	19052
¼	450.03	16117	½	469.67	17555	⅞	489.70	19083
⅜	450.43	16145	⅝	470.06	17584			
½	450.82	16173	¾	470.46	17614	156.	490.09	19113
⅝	451.21	16201	⅞	470.85	17643	⅛	490.48	19144
¾	451.61	16229				¼	490.88	19174
⅞	452.00	16258	150.	471.24	17672	⅜	491.27	19205
			⅛	471.63	17702	½	491.66	19235
144.	452.39	16286	¼	472.03	17731	⅝	492.05	19266
⅛	452.78	16314	⅜	472.42	17761	¾	492.45	19297
¼	453.18	16342	½	472.81	17790	⅞	492.84	19328
⅜	453.57	16371	⅝	473.20	17820			
½	453.96	16399	¾	473.60	17849	157.	493.23	19359
⅝	454.35	16428	⅞	473.99	17879	⅛	493.62	19390
¾	454.75	16456				¼	494.02	19421
⅞	455.14	16485	151.	474.38	17908	⅜	494.41	19452
			⅛	474.77	17938	½	494.80	19483
145.	455.53	16513	¼	475.17	17967	⅝	495.20	19514
⅛	455.93	16542	⅜	475.56	17997	¾	495.59	19545
¼	456.32	16570	½	475.95	18026	⅞	495.98	19576
⅜	456.71	16599	⅝	476.35	18056			
½	457.10	16627	¾	476.74	18086	158.	496.37	19607
⅝	457.50	16656	⅞	477.13	18116	⅛	496.77	19638
¾	457.89	16684				¼	497.16	19669
⅞	458.28	16713	152.	477.52	18146	⅜	497.55	19701
			⅛	477.92	18175	½	497.94	19732
146.	458.67	16742	¼	478.31	18205	⅝	498.34	19766
⅛	459.07	16770	⅜	478.70	18235	¾	498.73	19794
¼	459.46	16799	½	479.09	18265	⅞	499.12	19825
⅜	459.85	16827	⅝	479.49	18295			
½	460.24	16856	¾	479.88	18325	159.	499.51	19856
⅝	460.64	16885	⅞	480.27	18355	⅛	499.91	19887
¾	461.03	16914				¼	500.30	19919
⅞	461.42	16943	153.	480.67	18385	⅜	500.69	19950
			⅛	481.06	18415	½	501.09	19982
147.	461.82	16972	¼	481.45	18446	⅝	501.48	20013
⅛	462.21	17000	⅜	481.84	18476	¾	501.87	20044
¼	462.60	17029	½	482.24	18507	⅞	502.26	20075
⅜	462.99	17058	⅝	482.63	18537			
½	463.39	17087	¾	483.02	18567	160.	502.66	20106
⅝	463.78	17116	⅞	483.41	18597	⅛	503.05	20138
¾	464.17	17145				¼	503.44	20169
⅞	464.56	17174	154.	483.81	18627	⅜	503.83	20201
			⅛	484.20	18658	½	504.23	20232
148.	464.96	17203	¼	484.59	18688	⅝	504.62	20264
⅛	465.35	17232	⅜	484.99	18719	¾	505.01	20295
¼	465.74	17262	½	485.38	18749	⅞	505.41	20327
⅜	466.14	17291	⅝	485.77	18779			
½	466.53	17321	¾	486.16	18809	161.	505.80	20358
⅝	466.92	17350	⅞	486.56	18839	⅛	506.19	20390

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles (Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
161¼	506.58	20421	167½	526.22	22035	173¾	545.85	23711
⅜	506.98	20453	⅝	526.61	22068	⅞	546.25	23745
½	507.37	20484	¾	527.00	22101			
⅝	507.76	20516	⅞	527.40	22134	174.	546.64	23779
¾	508.15	20548				⅛	547.03	23813
⅞	508.55	20580	168.	527.79	22167	¼	547.42	23848
			⅛	528.18	22200	⅜	547.82	23882
162.	508.94	20612	¼	528.57	22233	½	548.21	23917
⅛	509.33	20644	⅜	528.97	22266	⅝	548.60	23951
¼	509.73	20675	½	529.36	22299	¾	549.00	23985
⅜	510.12	20707	⅝	529.75	22332	⅞	549.39	24019
½	510.51	20739	¾	530.15	22366			
⅝	510.90	20771	⅞	530.54	22399	175.	549.78	24053
¾	511.30	20803				⅛	550.17	24087
⅞	511.69	20835	169.	530.93	22432	¼	550.57	24122
			⅛	531.32	22465	⅜	550.96	24156
163.	512.08	20867	¼	531.72	22499	½	551.35	24191
⅛	512.47	20899	⅜	532.11	22532	⅝	551.74	24225
¼	512.87	20931	½	532.50	22566	¾	552.14	24260
⅜	513.26	20964	⅝	532.89	22599	⅞	552.53	24294
½	513.65	20996	¾	533.29	22632			
⅝	514.04	21028	⅞	533.68	22665	176.	552.92	24329
¾	514.44	21060				⅛	553.31	24363
⅞	514.83	21092	170.	534.07	22698	¼	553.71	24398
			⅛	534.47	22731	⅜	554.10	24432
164.	515.22	21124	¼	534.86	22765	½	554.49	24467
⅛	515.62	21157	⅜	535.25	22798	⅝	554.89	24501
¼	516.01	21189	½	535.64	22832	¾	555.28	24536
⅜	516.40	21222	⅝	536.04	22865	⅞	555.67	24571
½	516.7[illegible]	21254	¾	536.43	22899			
⅝	517.[illegible]	21287	⅞	536.82	22932	177.	556.06	24606
¾	517.58	21319				⅛	556.46	24640
⅞	517.97	21351	171.	537.21	22966	¼	556.85	24675
			⅜	537.61	22999	⅜	557.24	24710
165.	518.36	21383	¼	538.00	23033	½	557.63	24745
⅛	518.76	21416	⅜	538.39	23066	⅝	558.03	24780
¼	519.15	21448	½	538.78	23100	¾	558.42	24815
⅜	519.54	21481	⅝	539.18	23133	⅞	558.81	24850
½	519.94	21513	¾	539.57	23167			
⅝	520.33	21546	⅞	539.96	23201	178.	559.21	24885
¾	520.72	21578				⅛	559.60	24920
⅞	521.11	21610	172.	540.36	23235	¼	559.99	24955
			⅛	540.75	23268	⅜	560.38	24990
166.	521.51	21642	¼	541.14	23302	½	560.78	25025
⅛	521.90	21675	⅜	541.53	23336	⅝	561.17	25060
¼	522.29	21707	½	541.93	23370	¾	561.56	25095
⅜	522.68	21740	⅝	542.32	23404	⅞	561.95	25130
½	523.08	21772	¾	542.71	23438			
⅝	523.47	21805	⅞	543.10	23472	179.	562.35	25165
¾	523.86	21838				⅛	562.74	25200
⅞	524.26	21871	173.	543.50	23506	¼	563.13	25236
			⅛	543.89	23540	⅜	563.53	25271
167.	524.65	21904	¼	544.28	23575	½	563.92	25307
⅛	525.04	21937	⅜	544.68	23609	⅝	564.31	25342
¼	525.43	21969	½	545.07	23643	¾	564.70	25377
⅜	525.83	22002	⅝	545.46	23677	⅞	565.10	25412

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
180.	565.49	25447	186¼	585.12	27245	192½	604.76	29103
⅛	565.88	25482	⅜	585.52	27281	⅝	605.15	29141
¼	566.27	25518	½	585.91	27318	¾	605.54	29179
⅜	566.67	25553	⅝	586.30	27354	⅞	605.94	29217
½	567.06	25589	¾	586.59	27391			
⅝	567.45	25624	⅞	587.09	27428	193.	606.33	29255
¾	567.84	25660				⅛	606.72	29293
⅞	568.24	25695	187.	587.48	27465	¼	607.11	29331
			⅛	587.87	27501	⅜	607.51	29369
181.	568.63	25730	¼	588.27	27538	½	607.90	29407
⅛	569.02	25765	⅜	588.66	27574	⅝	608.29	29445
¼	569.42	25801	½	589.05	27611	¾	608.58	29483
⅜	569.81	25836	⅝	589.44	27648	⅞	609.08	29521
½	570.20	25872	¾	589.84	27685			
⅝	570.59	25908	⅞	590.23	27722	194.	609.47	29559
¾	570.99	25944				⅛	609.86	29597
⅞	571.38	25980	188.	590.62	27759	¼	610.26	29636
			⅛	591.01	27796	⅜	610.65	29674
182.	571.77	26016	¼	591.41	27833	½	611.05	29713
⅛	572.16	26051	⅜	591.80	27870	⅝	611.43	29751
¼	572.56	26087	½	592.19	27907	¾	611.83	29789
⅜	572.95	26122	⅝	592.58	27944	⅞	612.29	29827
½	573.34	26158	¾	592.98	27981			
⅝	573.74	26194	⅞	593.37	28018	195.	612.61	29865
¾	574.13	26230				⅛	613.00	29903
⅞	574.52	26266	189.	593.76	28055	¼	613.40	29942
			⅛	594.16	28092	⅜	613.79	29980
183.	574.91	26302	¼	594.55	28130	½	614.18	30019
⅛	575.31	26338	⅜	594.94	28167	⅝	614.57	30057
¼	575.70	26374	½	595.33	28205	¾	614.97	30096
⅜	576.09	26410	⅝	595.73	28242	⅞	615.36	30134
½	576.48	26446	¾	596.12	28279			
⅝	576.88	26482	⅞	596.51	28316	196.	615.75	30172
¾	577.27	26518				⅛	616.15	30210
⅞	577.66	26554	190.	596.90	28353	¼	616.54	30249
			⅛	597.29	28390	⅜	616.93	30287
184.	578.05	26590	¼	597.68	28428	½	617.32	30326
⅛	578.45	26626	⅜	598.08	28465	⅝	617.72	30364
¼	578.84	26663	½	598.47	28503	¾	618.11	30403
⅜	579.23	26699	⅝	598.86	28540	⅞	618.50	30442
½	579.63	26736	¾	599.25	28578			
⅝	580.02	26772	⅞	599.64	28615	197.	618.89	30481
¾	580.41	26808				⅛	619.29	30519
⅞	580.80	26844	191.	600.04	28652	¼	619.68	30558
			⅛	600.44	28689	⅜	620.08	30596
185.	581.20	26880	¼	600.83	28727	½	620.47	30635
⅛	581.59	26916	⅜	601.22	28764	⅝	620.86	30674
¼	581.98	26953	½	601.62	28802	¾	621.25	30713
⅜	582.37	26989	⅝	602.01	28839	⅞	621.64	30752
½	582.77	27026	¾	602.40	28877			
⅝	583.16	27062	⅞	602.79	28915	198.	622.04	30791
¾	583.55	27099				⅛	622.44	30830
⅞	583.95	27135	192.	603.19	28953	¼	622.83	30869
			⅛	603.58	28990	⅜	623.22	30908
186.	584.34	27172	¼	603.97	29028	½	623.62	30947
⅛	584.73	27208	⅜	604.36	29065	⅝	624.01	30986

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-18
(Continued). Circumferences and Areas of Circles
(Advancing of eighths)

Dia.	Circum.	Area*	Dia.	Circum.	Area*	Dia.	Circum.	Area*
198¾	624.40	31025	204⅞	643.63	32966	211.	662.88	34967
⅞	624.79	31064				⅛	663.28	35008
			205.	644.03	33006	¼	663.67	35050
199.	625.18	31103	⅛	644.43	33046	⅜	664.07	35091
⅛	625.58	31142	¼	644.82	33087	½	664.46	35133
¼	625.97	31181	⅜	645.21	33127	⅝	664.85	35174
⅜	626.36	31220	½	645.61	33168	¾	665.24	35216
½	626.76	31260	⅝	646.00	33208	⅞	665.63	35257
⅝	627.15	31299	¾	646.39	33249			
¾	627.54	31338	⅞	646.78	33289	212.	666.02	35299
⅞	627.94	31377				⅛	666.43	35340
			206.	647.17	33329	¼	666.82	35382
200.	628.32	31416	⅛	647.57	33369	⅜	667.21	35423
⅛	628.72	31455	¼	647.96	33410	½	667.61	35465
¼	629.11	31495	⅜	648.35	33450	⅝	668.00	35507
⅜	629.51	31534	½	648.75	33491	¾	668.39	35549
½	629.90	31574	⅝	649.14	33531	⅞	668.78	35591
⅝	630.29	31613	¾	649.53	33572			
¾	630.58	31653	⅞	649.93	33613	213.	669.16	35633
⅞	631.08	31692				⅛	669.57	35674
			207.	650.31	33654	¼	669.96	35716
201.	631.46	31731	⅛	650.71	33694	⅜	670.35	35758
⅛	631.86	31770	¼	651.10	33735	½	670.75	35800
¼	632.26	31810	⅜	651.50	33775	⅝	671.14	35842
⅜	632.65	31849	½	651.89	33816	¾	671.53	35884
½	633.05	31889	⅝	652.28	33857	⅞	671.93	35926
⅝	633.43	31928	¾	652.57	33898			
¾	633.83	31968	⅞	653 07	33939	214.	672.30	35968
⅞	634.29	32007				⅛	672.71	36010
			208.	653.45	33980	¼	673.10	36052
202.	634.60	32047	⅛	653.85	34020	⅜	673.50	36094
⅛	635.00	32086	¼	654.25	34061	½	673.89	36137
¼	635.40	32126	⅜	654.64	34102	⅝	674.28	36179
⅜	635.79	32166	½	655.04	34143	¾	674.57	36221
½	636.18	32206	⅝	655.42	34184	⅞	675.07	36263
⅝	636.57	32246	¾	655.82	34225			
¾	636.97	32286	⅞	656.28	34266	215.	675.44	36305
⅞	637.36	32326				⅛	675.85	36347
			209.	656.59	34307	¼	676.25	36390
203.	637.74	32366	⅛	656.99	34348	⅜	676.64	36432
⅛	638.15	32405	¼	657.39	34389	½	677.04	36475
¼	638.54	32445	⅜	657.78	34431	⅝	677.42	36517
⅜	638.93	32485	½	658.17	34472	¾	677.82	36560
½	639.32	32525	⅝	658.56	34513	⅞	678.28	36602
⅝	639.72	32565	¾	658.96	34554			
¾	640.11	32605	⅞	659.35	34595			
⅞	640.50	32645						
			210.	659.73	34636	216.	678.58	36644
204.	640.88	32685	⅛	660.14	34677	⅛	678.99	36686
⅛	641.28	32725	¼	660.53	34719	¼	679.39	36729
¼	641.67	32766	⅜	660.92	34760	⅜	679.78	36771
⅜	642.07	32806	½	661.31	34802	½	680.17	36814
½	642.46	32846	⅝	661.71	34843	⅝	680.56	36856
⅝	642.85	32886	¾	662.10	34885	¾	680.96	36899
¾	643.24	32926	⅞	662.49	34926	⅞	681.36	36941

*Approximate area, sufficiently accurate for practical purposes, including estimating.

D-19
Capacities of Cylinders and Spheres

Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.
1/64	.0002	.00143	.000034	.00077	.000002
1/32	.0008	.00574	.000137	.00307	.000016
1/16	.0031	.02295	.000546	.01227	.000128
3/32	.0069	.05164	.00123	.02761	.000431
1/8	.0123	.09180	.00219	.04909	.00102
5/32	.0192	.14344	.00342	.07670	.00200
3/16	.0276	.20655	.00492	.11045	.00345
7/32	.0376	.28114	.00669	.15033	.00548
1/4	.0491	.36720	.00874	.19635	.00818
9/32	.0621	.46474	.01107	.24850	.01165
5/16	.0767	.57375	.01366	.30680	.01598
11/32	.0928	.69424	.01653	.37122	.02127
3/8	.1104	.82620	.01967	.44179	.02761
13/32	.1296	.96964	.02309	.51849	.03511
7/16	.1503	1.1245	.02677	.60132	.04385
15/32	.1726	1.2909	.03074	.69029	.05393
1/2	.1963	1.4688	.03497	.78540	.06545
17/32	.2217	1.6581	.03948	.88664	.07850
9/16	.2485	1.8589	.04426	.99402	.09319
19/32	.2769	2.0712	.04932	1.1075	.10960
5/8	.3068	2.2950	.05464	1.2272	.12783
21/32	.3382	2.5302	.06024	1.3530	.14798
11/16	.3712	2.7769	.06612	1.4849	.17014
23/32	.4057	3.0351	.07227	1.6230	.19442
3/4	.4418	3.3048	.07869	1.7671	.22089
25/32	.4794	3.5859	.08538	1.9175	.24967
13/16	.5185	3.8785	.09235	2.0739	.28085
27/32	.5591	4.1826	.09959	2.2365	.31451
7/8	.6013	4.4982	.10710	2.4053	.35077
29/32	.6450	4.8252	.11489	2.5802	.38971
15/16	.6903	5.1637	.12295	2.7612	.43143
31/32	.7371	5.5137	.13128	2.9483	.47603
1	.7854	5.8752	.13989	3.1416	.52360
1 1/16	.8866	6.6325	.15792	3.5466	.62804
1 1/8	.9940	7.4358	.17704	3.9761	.74551
1 3/16	1.1075	8.2849	.19726	4.4301	.87680
1 1/4	1.2272	9.1800	.21857	4.9087	1.0227
1 5/16	1.3530	10.121	.24097	5.4119	1.1838
1 3/8	1.4849	11.108	.26447	5.9396	1.3612
1 7/16	1.6230	12.141	.28906	6.4918	1.5553
1 1/2	1.7671	13.219	.31474	7.0686	1.7671
1 9/16	1.9175	14.344	.34152	7.6699	1.9974
1 5/8	2.0739	15.514	.36938	8.2958	2.2468
1 11/16	2.2365	16.731	.39835	8.9462	2.5161
1 3/4	2.4053	17.993	.42840	9.6211	2.8062
1 13/16	2.5802	19.301	.45955	10.321	3.1177
1 7/8	2.7612	20.655	.49178	11.045	3.4515
1 15/16	2.9483	22.055	.52512	11.793	3.8082
2	3.1416	23.501	.55954	12.566	4.1888
2 1/16	3.3410	24.992	.59506	13.364	4.5939
2 1/8	3.5466	26.530	.63167	14.186	5.0243
2 3/16	3.7583	28.114	.66937	15.033	5.4808
2 1/4	3.9761	29.743	.70817	15.904	5.9641
2 5/16	4.2000	31.418	.74806	16.800	6.4751
2 3/8	4.4301	33.140	.78904	17.721	7.0144
2 7/16	4.6664	34.907	.83112	18.665	7.5829
2 1/2	4.9087	36.720	.87428	19.635	8.1812
2 9/16	5.1572	38.579	.91854	20.629	8.8103
2 5/8	5.4119	40.484	.96390	21.648	9.4708
2 11/16	5.6727	42.434	1.0103	22.691	10.164
2 3/4	5.9396	44.431	1.0578	23.758	10.889
2 13/16	6.2126	46.474	1.1065	24.850	11.649
2 7/8	6.4918	48.562	1.1562	25.967	12.443
2 15/16	6.7771	50.696	1.2071	27.109	13.272
3	7.0686	52.877	1.2590	28.274	14.137
3 1/16	7.3662	55.103	1.3120	29.465	15.039
3 1/8	7.6699	57.375	1.3661	30.680	15.979
3 3/16	7.9798	59.693	1.4213	31.919	16.957
3 1/4	8.2958	62.057	1.4775	33.183	17.974
3 5/16	8.6179	64.466	1.5349	34.472	19.031
3 3/8	8.9462	66.922	1.5934	35.785	20.129
3 7/16	9.2806	69.424	1.6529	37.122	21.268
3 1/2	9.6211	71.971	1.7136	38.485	22.449
3 9/16	10.321	77.204	1.8382	41.282	24.942
3 5/8	11.045	82.620	1.9671	44.179	27.612
3 3/4	11.793	88.220	2.1005	47.173	30.466
4	12.566	94.003	2.2382	50.265	33.510
4 1/8	13.364	99.970	2.3802	53.456	36.751
4 1/4	14.186	106.12	2.5267	56.745	40.194
4 3/8	15.033	112.45	2.6775	60.132	43.846
4 1/2	15.904	118.97	2.8327	63.617	47.713
4 5/8	16.800	125.67	2.9922	67.201	51.800
4 3/4	17.721	132.56	3.1562	70.882	56.115
4 7/8	18.665	139.63	3.3245	74.662	60.663
5	19.635	146.88	3.4971	78.540	65.450
5 1/8	20.629	154.32	3.6742	82.516	70.482
5 1/4	21.648	161.93	3.8556	86.590	75.766
5 3/8	22.691	169.74	4.0414	90.763	81.308
5 1/2	23.758	177.72	4.2315	95.033	87.114
5 5/8	24.850	185.89	4.4261	99.402	93.189
5 3/4	25.967	194.25	4.6250	103.87	99.541
5 7/8	27.109	202.79	4.8282	108.43	106.17
6	28.274	211.51	5.0359	113.10	113.10
6 1/8	29.465	220.41	5.2479	117.86	120.31
6 1/4	30.680	229.50	5.4643	122.72	127.83
6 3/8	31.919	238.77	5.6850	127.68	135.66
6 1/2	33.183	248.23	5.9102	132.73	143.79
6 5/8	34.472	257.87	6.1397	137.89	152.25
6 3/4	35.785	267.69	6.3735	143.14	161.03
6 7/8	37.122	277.69	6.6118	148.49	170.14
7	38.485	287.88	6.8544	153.94	179.59
7 1/8	39.871	298.26	7.1014	159.48	189.39
7 1/4	41.282	308.81	7.3527	165.13	199.53
7 3/8	42.718	319.56	7.6085	170.87	210.03
7 1/2	44.179	330.48	7.8686	176.71	220.89
7 5/8	45.664	341.59	8.1330	182.65	232.12
7 3/4	47.173	352.88	8.4019	188.69	243.73
7 7/8	48.707	364.35	8.6751	194.83	255.71

By permission, Buffalo Tank Div., Bethlehem Steel Corp.

D-19
(Continued). Capacities of Cylinders and Spheres

Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.
8	50.265	376.01	8.9527	201.06	268.08
8 1/8	51.849	387.85	9.2346	207.39	280.85
8 1/4	53.456	399.88	9.5209	213.82	294.01
8 3/8	55.088	412.09	9.8116	220.35	307.58
8 1/2	56.745	424.48	10.107	226.98	321.56
8 5/8	58.426	437.06	10.406	233.71	335.95
8 3/4	60.132	449.82	10.710	240.53	350.77
8 7/8	61.862	462.76	11.018	247.45	366.02
9	63.617	475.89	11.331	254.47	381.70
9 1/8	65.397	489.20	11.648	261.59	397.83
9 1/4	67.201	502.70	11.969	268.80	414.40
9 3/8	69.029	516.37	12.295	276.12	431.43
9 1/2	70.882	530.24	12.625	283.53	448.92
9 5/8	72.760	544.28	12.959	291.04	466.88
9 3/4	74.662	558.51	13.298	298.65	485.30
9 7/8	76.589	572.92	13.641	306.35	504.21
10	78.540	587.52	13.989	314.16	523.60
10 1/4	82.516	617.26	14.697	330.06	563.86
10 1/2	86.590	647.74	15.422	346.36	606.13
10 3/4	90.763	678.95	16.166	363.05	650.47
11	95.033	710.90	16.926	380.13	696.91
11 1/4	99.402	743.58	17.704	397.61	745.51
11 1/2	103.87	776.99	18.500	415.48	796.33
11 3/4	108.43	811.14	19.313	433.74	849.40
12	113.10	846.03	20.143	452.39	904.78
12 1/4	117.86	881.65	20.992	471.44	962.51
12 1/2	122.72	918.00	21.857	490.87	1022.7
12 3/4	127.68	955.08	22.740	510.71	1085.2
13	132.73	992.91	23.641	530.93	1150.3
13 1/4	137.89	1031.5	24.559	551.55	1218.0
13 1/2	143.14	1070.8	25.494	572.56	1288.2
13 3/4	148.49	1110.8	26.447	593.96	1361.2
14	153.94	1151.5	27.418	615.75	1436.8
14 1/4	159.48	1193.0	28.405	637.94	1515.1
14 1/2	165.13	1235.3	29.411	660.52	1596.3
14 3/4	170.87	1278.2	30.434	683.49	1680.3
15	176.71	1321.9	31.474	706.86	1767.1
15 1/4	182.65	1366.3	32.532	730.62	1857.0
15 1/2	188.69	1411.5	33.607	754.77	1949.8
15 3/4	194.83	1457.4	34.700	779.31	2045.7
16	201.06	1504.0	35.811	804.25	2144.7
16 1/4	207.39	1551.4	36.938	829.58	2246.8
16 1/2	213.82	1599.5	38.084	855.30	2352.1
16 3/4	220.35	1648.4	39.247	881.41	2460.6
17	226.98	1697.9	40.427	907.92	2572.4
17 1/4	233.71	1748.2	41.625	934.82	2687.6
17 1/2	240.53	1799.3	42.840	962.11	2806.2
17 3/4	247.45	1851.1	44.073	989.80	2928.2
18	254.47	1903.6	45.323	1017.9	3053.6
18 1/4	261.59	1956.8	46.591	1046.3	3182.6
18 1/2	268.80	2010.8	47.876	1075.2	3315.2
18 3/4	276.12	2065.5	49.178	1104.5	3451.5
19	283.53	2120.9	50.499	1134.1	3591.4
19 1/4	291.04	2177.1	51.836	1164.2	3735.0
19 1/2	298.65	2234.0	53.191	1194.6	3882.4
19 3/4	306.35	2291.7	54.564	1225.4	4033.7
20	314.16	2350.1	55.954	1256.6	4188.8
20 1/4	322.06	2409.2	57.362	1288.2	4347.8
20 1/2	330.06	2469.0	58.787	1320.3	4510.9
20 3/4	338.16	2529.6	60.229	1352.7	4677.9
21	346.36	2591.0	61.689	1385.4	4849.0
21 1/4	354.66	2653.0	63.167	1418.6	5024.3
21 1/2	363.05	2715.8	64.662	1452.2	5203.7
21 3/4	371.54	2779.3	66.175	1486.2	5387.4
22	380.13	2843.6	67.705	1520.5	5575.3
22 1/4	388.82	2908.6	69.252	1555.3	5767.5
22 1/2	397.61	2974.3	70.817	1590.4	5964.1
22 3/4	406.49	3040.8	72.399	1626.0	6165.1
23	415.48	3108.0	73.999	1661.9	6370.6
23 1/4	424.56	3175.9	75.617	1698.2	6580.6
23 1/2	433.74	3244.6	77.252	1734.9	6795.2
23 3/4	443.01	3314.0	78.904	1772.1	7014.4
24	452.39	3384.1	80.574	1809.6	7238.2
24 1/4	461.86	3455.0	82.261	1847.5	7466.8
24 1/2	471.44	3526.6	83.966	1885.7	7700.1
24 3/4	481.11	3598.9	85.689	1924.4	7938.2
25	490.87	3672.0	87.428	1963.5	8181.2
25 1/4	500.74	3745.8	89.186	2003.0	8429.1
25 1/2	510.71	3820.3	90.960	2042.8	8682.0
25 3/4	520.77	3895.6	92.753	2083.1	8939.9
26	530.93	3971.6	94.563	2123.7	9202.8
26 1/4	541.19	4048.4	96.390	2164.8	9470.8
26 1/2	551.55	4125.8	98.235	2206.2	9744.0
26 3/4	562.00	4204.1	100.10	2248.0	10022
27	572.56	4283.0	101.98	2290.2	10306
27 1/4	583.21	4362.7	103.87	2332.8	10595
27 1/2	593.96	4443.1	105.79	2375.8	10889
27 3/4	604.81	4524.3	107.72	2419.2	11189
28	615.75	4606.1	109.67	2463.0	11494
28 1/4	626.80	4688.8	111.64	2507.2	11805
28 1/2	637.94	4772.1	113.62	2551.8	12121
28 3/4	649.18	4856.2	115.62	2596.7	12443
29	660.52	4941.0	117.64	2642.1	12770
29 1/4	671.96	5026.6	119.68	2687.8	13103
29 1/2	683.49	5112.9	121.74	2734.0	13442
29 3/4	695.13	5199.9	123.81	2780.5	13787

Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.	Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.
30	706.86	5287.7	125.90	2827.4	14137	42	1385.4	10364	246.76	5541.8	38792
30¼	718.69	5376.2	128.00	2874.8	14494	42¼	1402.0	10488	249.70	5607.9	39489
30½	730.62	5465.4	130.13	2922.5	14856	42½	1418.6	10612	252.67	5674.5	40194
30¾	742.64	5555.4	132.27	2970.6	15224	42¾	1435.4	10737	255.65	5714.5	40908
31	754.77	5646.1	134.43	3019.1	15599	43	1452.2	10863	258.65	5808.8	41630
31¼	766.99	5737.5	136.61	3068.0	15979	43¼	1469.1	10990	261.66	5876.5	42360
31½	779.31	5829.7	138.80	3117.2	16366	43½	1486.2	11117	264.70	5944.7	43099
31¾	791.73	5922.6	141.01	3166.9	16758	43¾	1503.3	11245	267.75	6013.2	43846
32	804.25	6016.2	143.24	3217.0	17157	44	1520.5	11374	270.82	6082.1	44602
32¼	816.86	6110.6	145.49	3267.5	17563	44¼	1537.9	11504	273.90	6151.4	45367
32½	829.58	6205.7	147.75	3318.3	17974	44½	1555.3	11634	277.01	6221.1	46140
32¾	842.39	6301.5	150.04	3369.6	18392	44¾	1572.8	11765	280.13	6291.2	46922
33	855.30	6398.1	152.34	3421.2	18817	45	1590.4	11897	283.27	6361.7	47713
33¼	868.31	6495.4	154.65	3473.2	19247	45¼	1608.2	12030	286.42	6432.6	48513
33½	881.41	6593.4	156.99	3525.7	19685	45½	1626.0	12163	289.60	6503.9	49321
33¾	894.62	6692.2	159.34	3578.5	20129	45¾	1643.9	12297	292.79	6575.5	50139
34	907.92	6791.7	161.71	3631.7	20580	46	1661.9	12432	296.00	6647.6	50965
34¼	921.32	6892.0	164.09	3685.3	21037	46¼	1680.0	12567	299.22	6720.1	51800
34½	934.82	6992.9	166.50	3739.3	21501	46½	1698.2	12704	302.47	6792.9	52645
34¾	948.42	7094.7	168.92	3793.7	21972	46¾	1716.5	12841	305.73	6866.1	53499
35	962.11	7197.1	171.36	3848.5	22449	47	1734.9	12978	309.01	6939.8	54362
35¼	975.91	7300.3	173.82	3903.6	22934	47¼	1753.5	13117	312.30	7013.8	55234
35½	989.80	7404.2	176.29	3959.2	23425	47½	1772.1	13256	315.62	7088.2	56115
35¾	1003.8	7508.9	178.78	4015.2	23924	47¾	1790.8	13396	318.95	7163.0	57006
36	1017.9	7614.2	181.29	4071.5	24429	48	1809.6	13536	322.30	7238.2	57906
36¼	1032.1	7720.4	183.82	4128.2	24942	48¼	1828.5	13678	325.66	7313.8	58815
36½	1046.3	7827.2	186.36	4185.4	25461	48½	1847.5	13820	329.05	7389.8	59734
36¾	1060.7	7934.8	188.92	4242.9	25988	48¾	1866.5	13963	332.45	7466.2	60663
37	1075.2	8043.1	191.50	4300.8	26522	49	1885.7	14106	335.86	7543.0	61601
37¼	1089.8	8152.2	194.10	4359.2	27063	49¼	1905.0	14251	339.30	7620.1	62549
37½	1104.5	8262.0	196.71	4417.9	27612	49½	1924.4	14396	342.75	7697.7	63506
37¾	1119.2	8372.5	199.35	4477.0	28168	49¾	1943.9	14541	346.23	7775.6	64473
38	1134.1	8483.8	201.99	4536.5	28731	50	1963.5	14688	349.71	7854.0	65450
38¼	1149.1	8595.8	204.66	4596.3	29302	50¼	1983.2	14835	353.22	7932.7	66437
38½	1164.2	8708.5	207.35	4656.6	29880	50½	2003.0	14983	356.74	8011.8	67433
38¾	1179.3	8822.0	210.05	4717.3	30466	50¾	2022.8	15132	360.28	8091.4	68439
39	1194.6	8936.2	212.77	4778.4	31059	51	2042.8	15281	363.84	8171.3	69456
39¼	1210.0	9051.1	215.50	4839.8	31660	51¼	2062.9	15432	367.42	8251.6	70482
39½	1225.4	9166.8	218.26	4901.7	32269	51½	2083.1	15582	371.01	8332.3	71519
39¾	1241.0	9283.2	221.03	4963.9	32886	51¾	2103.3	15734	374.62	8413.4	72565
40	1256.6	9400.3	223.82	5026.5	33510	52	2123.7	15887	378.25	8494.9	73622
40¼	1272.4	9518.2	226.62	5089.6	34143	52¼	2144.2	16040	381.90	8576.7	74689
40½	1288.2	9636.8	229.45	5153.0	34783	52½	2164.8	16193	385.56	8659.0	75766
40¾	1304.2	9756.1	232.29	5216.8	35431	52¾	2185.4	16348	389.24	8741.7	76854
41	1320.3	9876.2	235.15	5281.0	36087	53	2206.2	16503	392.94	8824.7	77952
41¼	1336.4	9997.0	238.02	5345.6	36751	53¼	2227.0	16659	396.65	8908.2	79060
41½	1352.7	10119.	240.92	5410.6	37423	53½	2248.0	16816	400.39	8992.0	80179
41¾	1369.0	10241.	243.83	5476.0	38104	53¾	2269.1	16974	404.14	9076.3	81308

D-19
(Continued). Capacities of Cylinders and Spheres

Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.	Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.
54	2290.2	17132	407.91	9160.9	82448	66	3421.2	25592	609.34	13685	150533
54¼	2311.5	17291	411.69	9245.9	83598	66¼	3447.2	25787	613.97	13789	152250
54½	2332.8	17451	415.49	9331.3	84759	66½	3473.2	25982	618.61	13893	153980
54¾	2354.3	17611	419.32	9417.1	85931	66¾	3499.4	26177	623.27	13998	155723
55	2375.8	17772	423.15	9503.3	87114	67	3525.7	26374	627.95	14103	157479
55¼	2397.5	17934	427.01	9589.9	88307	67¼	3552.0	26571	632.64	14208	159249
55½	2419.2	18097	430.88	9676.9	89511	67½	3578.5	26769	637.35	14314	161031
55¾	2441.1	18260	434.77	9764.3	90726	67¾	3605.0	26967	642.08	14420	162827
56	2463.0	18245	438.68	9852.0	91952	68	3631.7	27167	646.83	14527	164636
56¼	2485.0	18589	442.61	9940.2	93189	68¼	3658.4	27367	651.59	14634	166459
56½	2507.2	18755	446.55	10029	94437	68½	3685.3	27568	656.38	14741	168295
56¾	2529.4	18921	450.51	10118	95697	68¾	3712.2	27769	661.18	14849	170144
57	2551.8	19088	454.49	10207	96967	69	3739.3	27972	665.99	14957	172007
57¼	2574.2	19256	458.48	10297	98248	69¼	3766.4	28175	670.83	15066	173883
57½	2596.7	19425	462.50	10387	99541	69½	3793.7	28379	675.68	15175	175773
57¾	2619.4	19594	466.53	10477	100845	69¾	3821.0	28583	680.55	15284	177677
58	2642.1	19764	470.57	10568	102160	70	3848.5	28788	685.44	15394	179594
58¼	2664.9	19935	474.64	10660	103487	70¼	3876.0	28994	690.34	15504	181525
58½	2687.8	20106	478.72	10751	104825	70½	3903.6	29201	695.27	15615	183470
58¾	2710.9	20279	482.82	10843	106175	70¾	3931.4	29409	700.21	15725	185429
59	2734.0	20452	486.94	10936	107536	71	3959.2	29617	705.16	15837	187402
59¼	2757.2	20625	491.08	11029	108909	71¼	3987.1	29826	710.14	15948	189388
59½	2780.5	20800	495.23	11122	110293	71½	4015.2	30035	715.13	16061	191389
59¾	2803.9	20975	499.40	11216	111690	71¾	4043.3	30246	720.14	16173	193404
60	2827.4	21151	503.59	11310	113097	72	4071.5	30457	725.17	16286	195432
60¼	2851.0	21327	507.79	11404	114517	72¼	4099.8	30669	730.21	16399	197475
60½	2874.8	21505	512.02	11499	115948	72½	4128.2	30881	735.27	16513	199532
60¾	2898.6	21683	516.26	11594	117392	72¾	4156.8	31095	740.35	16627	201603
61	2922.5	21862	520.51	11690	118847	73	4185.4	31309	745.45	16742	203689
61¼	2946.5	22041	524.79	11786	120314	73¼	4214.1	31524	750.56	16856	205789
61½	2970.6	22221	529.08	11882	121793	73½	4242.9	31739	755.70	16972	207903
61¾	2994.8	22402	533.39	11979	123285	73¾	4271.8	31956	760.85	17087	210032
62	3019.1	22584	537.72	12076	124788	74	4300.8	32173	766.01	17203	212175
62¼	3043.5	22767	542.06	12174	126304	74¼	4329.9	32390	771.20	17320	214332
62½	3068.0	22950	546.43	12272	127832	74½	4359.2	32609	776.40	17437	216505
62¾	3092.6	23134	550.81	12370	129372	74¾	4388.5	32828	781.62	17554	218692
63	3117.2	23319	555.21	12469	130924	75	4417.9	33048	786.86	17671	220893
63¼	3142.0	23504	559.62	12568	132489	75¼	4447.4	33269	792.11	17789	223110
63½	3166.9	23690	564.05	12668	134066	75½	4477.0	33490	797.38	17908	225341
63¾	3191.9	23877	568.50	12768	135656	75¾	4506.7	33712	802.67	18027	227587
64	3217.0	24065	572.97	12868	137258	76	4536.5	33935	807.98	18146	229847
64¼	3242.2	24253	577.46	12969	138873	76¼	4566.4	34159	813.30	18265	232123
64½	3267.5	24442	581.96	13070	140500	76½	4596.3	34383	818.64	18385	234414
64¾	3292.8	24632	586.48	13171	142141	76¾	4626.4	34608	824.00	18506	236719
65	3318.3	24823	591.02	13273	143793	77	4656.6	34834	829.38	18627	239040
65¼	3343.9	25014	595.57	13376	145459	77¼	4686.9	35061	834.77	18748	241376
65½	3369.6	25206	600.14	13478	147137	77½	4717.3	35288	840.19	18869	243727
65¾	3395.3	25399	604.73	13581	148828	77¾	4747.8	35516	845.62	18991	246093

Diam. in Feet	Cu Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot o. Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.	Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.
78	4778.4	35745	851.06	19113	248475	90	6361.7	47589	1133.1	25447	381704
78¼	4809.0	35974	856.53	19236	250872	90¼	6397.1	47854	1139.4	25588	384893
78½	4839.8	36204	862.01	19359	253284	90½	6432.6	48119	1145.7	25730	388101
78¾	4870.7	36435	867.51	19483	255712	90¾	6468.2	48385	1152.0	25873	391326
79	4901.7	36667	873.02	19607	258155	91	6503.9	48652	1158.4	26016	394569
79¼	4932.7	36899	878.56	19731	260613	91¼	6539.7	48920	1164.8	26159	397830
79½	4963.9	37133	884.11	19856	263087	91½	6575.5	49189	1171.2	26302	401109
79¾	4995.2	37367	889.68	19981	265577	91¾	6611.5	49458	1177.6	26446	404405
80	5026.5	37601	895.27	20106	268083	92	6647.6	49728	1184.0	26590	407720
80¼	5058.0	37837	900.87	20232	270604	92¼	6683.8	49998	1190.4	26735	411053
80½	5089.6	38073	906.49	20358	273141	92½	6720.1	50270	1196.9	26880	414404
80¾	5121.2	38310	912.13	20485	275693	92¾	6756.4	50542	1203.4	27026	417773
81	5153.0	38547	917.79	20612	278262	93	6792.9	50814	1209.9	27172	421160
81¼	5184.9	38785	923.46	20739	280846	93¼	6829.5	51088	1216.4	27318	424566
81½	5216.8	39024	929.15	20867	283447	93½	6866.1	51362	1222.9	27465	427990
81¾	5248.9	39264	934.86	20995	286063	93¾	6902.9	51637	1229.5	27612	431432
82	5281.0	39505	940.59	21124	288696	94	6939.8	51913	1236.0	27759	434893
82¼	5313.3	39746	946.33	21253	291344	94¼	6976.7	52190	1242.6	27907	438372
82½	5345.6	39988	952.09	21382	294009	94½	7013.8	52467	1249.2	28055	441870
82¾	5378.1	40231	957.87	21512	296690	94¾	7051.0	52745	1255.8	28204	445386
83	5410.6	40474	963.67	21642	299387	95	7088.2	53024	1262.5	28353	448920
83¼	5443.3	40718	969.48	21773	302100	95¼	7125.6	53303	1269.1	28502	452474
83½	5476.0	40963	975.32	21904	304830	95½	7163.0	53583	1275.8	28652	456046
83¾	5508.8	41209	981.16	22035	307576	95¾	7200.6	53864	1282.5	28802	459637
84	5541.8	41455	987.03	22167	310339	96	7238.2	54146	1289.2	28953	463247
84¼	5574.8	41702	992.92	22299	313118	96¼	7276.0	54428	1295.9	29104	466875
84½	5607.9	41950	998.82	22432	315914	96½	7313.8	54711	1302.6	29255	470523
84¾	5641.2	42199	1004.7	22565	318726	96¾	7351.8	54995	1309.4	29407	474189
85	5674.5	42448	1010.7	22698	321555	97	7389.8	55280	1316.2	29559	477874
85¼	5707.9	42698	1016.6	22832	324401	97¼	7428.0	55565	1323.0	29712	481579
85½	5741.5	42949	1022.6	22966	327263	97½	7466.2	55851	1329.8	29865	485302
85¾	5775.1	43201	1028.6	23100	330142	97¾	7504.5	56138	1336.6	30018	489045
86	5808.8	43453	1034.6	23235	333038	98	7543.0	56425	1343.5	30172	492807
86¼	5842.6	43706	1040.6	23371	335951	98¼	7581.5	56714	1350.3	30326	496588
86½	5876.5	43960	1046.7	23506	338881	98½	7620.1	57003	1357.2	30481	500388
86¾	5910.6	44214	1052.7	23642	341828	98¾	7658.9	57292	1364.1	30635	504208
87	5944.7	44469	1058.8	23779	344791	99	7697.7	57583	1371.0	30791	508047
87¼	5978.9	44725	1064.9	23916	347772	99¼	7736.6	57874	1377.9	30946	511906
87½	6013.2	44982	1071.0	24053	350770	99½	7775.6	58166	1384.9	31103	515784
87¾	6047.6	45239	1077.1	24190	353785	99¾	7814.8	58458	1391.9	31259	519682
88	6082.1	45497	1083.3	24328	356818	100	7854.0	58752	1398.9	31416	523599
88¼	6116.7	45756	1089.4	24467	359868	100¼	7893.3	59046	1405.9	31573	527536
88½	6151.4	46016	1095.6	24606	362935	100½	7932.7	59341	1412.9	31731	531492
88¾	6186.2	46276	1101.8	24745	366019	100¾	7972.2	59636	1419.9	31889	535468
89	6221.1	46537	1108.0	24885	369121	101	8011.8	59933	1427.0	32047	539464
89¼	6256.1	46799	1114.3	25025	372240	101¼	8051.6	60230	1434.0	32206	543480
89½	6291.2	47062	1120.5	25165	375377	101½	8091.4	60528	1441.1	32365	547516
89¾	6326.4	47325	1126.8	25306	378531	101¾	8131.3	60826	1448.2	32525	551572

D-19
(Continued). Capacities of Cylinders and Spheres

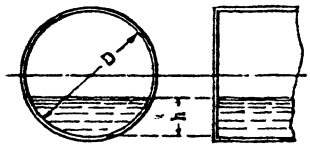
Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.	Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.
102	8171.3	61125	1455.4	32685	555647	114	10207	76354	1818.0	40828	775735
102¼	8211.4	61425	1462.5	32846	559743	114¼	10252	76689	1825.9	41007	780849
102½	8251.6	61726	1469.7	33006	563859	114½	10297	77025	1833.9	41187	785986
102¾	8291.9	62028	1476.8	33168	567994	114¾	10342	77362	1841.9	41367	791146
103	8332.3	62330	1484.0	33329	572151	115	10387	77699	1850.0	41548	796328
103¼	8372.8	62633	1491.3	33491	576327	115¼	10432	78038	1858.0	41728	801533
103½	8413.4	62936	1498.5	33654	580523	115½	10477	78376	1866.1	41910	806760
103¾	8454.1	63241	1505.7	33816	584740	115¾	10523	78716	1874.2	42091	812010
104	8494.9	63546	1513.0	33979	588977	116	10568	79057	1882.3	42273	817283
104¼	8535.8	63852	1520.3	34143	593235	116¼	10614	79398	1890.4	42456	822579
104½	8576.7	64159	1527.6	34307	597513	116½	10660	79739	1898.6	42638	827897
104¾	8617.8	64466	1534.9	34471	601812	116¾	10705	80082	1906.7	42822	833238
105	8659.0	64774	1542.2	34636	606131	117	10751	80425	1914.9	43005	838603
105¼	8700.3	65083	1549.6	34801	610471	117¼	10797	80769	1923.1	43189	843990
105½	8741.7	65392	1557.0	34967	614831	117½	10843	81114	1931.3	43374	849400
105¾	8783.2	65703	1564.3	35133	619213	117¾	10890	81460	1939.5	43558	854833
106	8824.7	66014	1571.8	35299	623615	118	10936	81806	1947.8	43744	860290
106¼	8866.4	66325	1579.2	35466	628037	118¼	10982	82153	1956.0	43929	865769
106½	8908.2	66638	1586.6	35633	632481	118½	11029	82501	1964.3	44115	871272
106¾	8950.1	66951	1594.1	35800	636945	118¾	11075	82849	1972.6	44301	876798
107	8992.0	67265	1601.5	35968	641431	119	11122	83199	1980.9	44488	882347
107¼	9034.1	67580	1609.0	36136	645938	119¼	11169	83548	1989.2	44675	887920
107½	9076.3	67895	1616.6	36305	650465	119½	11216	83899	1997.6	44863	893516
107¾	9118.5	68211	1624.1	36474	655014	119¾	11263	84251	2006.0	45051	899136
108	9160.9	68528	1631.6	36644	659584	120	11310	84603	2014.3	45239	904779
108¼	9203.3	68846	1639.2	36813	664175	120¼	11357	84956	2022.8	45428	910445
108½	9245.9	69164	1646.8	36984	668787	120½	11404	85309	2031.2	45617	916136
108¾	9288.6	69483	1654.4	37154	673421	120¾	11452	85664	2039.6	45806	921850
109	9331.3	69803	1662.0	37325	678076	121	11499	86019	2048.1	45996	927587
109¼	9374.2	70124	1669.6	37497	682752	121¼	11547	86374	2056.5	46186	933349
109½	9417.1	70445	1677.3	37668	687450	121½	11594	86731	2065.0	46377	939134
109¾	9460.2	70767	1684.9	37841	692169	121¾	11642	87088	2073.5	46568	944943
110	9503.3	71090	1692.6	38013	696910	122	11690	87446	2082.1	46759	950776
110¼	9546.6	71413	1700.3	38186	701672	122¼	11738	87805	2090.6	46951	956633
110½	9589.9	71737	1708.0	38360	706457	122½	11786	88165	2099.2	47144	962514
110¾	9633.4	72062	1715.8	38533	711262	122¾	11834	88525	2107.7	47336	968419
111	9676.9	72388	1723.5	38708	716090	123	11882	88886	2116.3	47529	974348
111¼	9720.5	72715	1731.3	38882	720939	123¼	11931	89247	2124.9	47723	980301
111½	9764.3	73042	1739.1	39057	725810	123½	11979	89610	2133.6	47916	986278
111¾	9808.1	73370	1746.9	39232	730704	123¾	12028	89973	2142.2	48111	992280
112	9852.0	73698	1754.7	39408	735619	124	12076	90337	2150.9	48305	998306
112¼	9896.1	74028	1762.6	39584	740556	124¼	12125	90701	2159.6	48500	1004356
112½	9940.2	74358	1770.4	39761	745515	124½	12174	91067	2168.3	48695	1010431
112¾	9984.4	74689	1778.3	39938	750496	124¾	12223	91433	2177.0	48891	1016530
113	10029	75020	1786.2	40115	755499	125	12272	91800	2185.7	49087	1022654
113¼	10073	75353	1794.1	40293	760525	125¼	12321	92167	2194.5	49284	1028802
113½	10118	75686	1802.0	40471	765572	125½	12370	92536	2203.2	49481	1034975
113¾	10162	76019	1810.0	40649	770642	125¾	12420	92905	2212.0	49678	1041172

D-19
(Concluded). Capacities of Cylinders and Spheres

Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.	Diam. in Feet	Cu. Ft. per Foot of Cylinder	Gallons per Foot of Cylinder	42 Gallon Barrels per Foot of Cylinder	Sphere Surface in Sq. Ft.	Sphere Volume in Cu. Ft.
126	12469	93274	2220.8	49876	1047394	138	14957	111887	2664.0	59828	1376055
126¼	12519	93645	2229.6	50074	1053641	138¼	15011	112293	2673.6	60045	1383547
126½	12568	94016	2238.5	50273	1059913	138½	15066	112699	2683.3	60263	1391067
126¾	12618	94388	2247.3	50471	1066209	138¾	15120	113107	2693.0	60481	1398613
127	12668	94761	2256.2	50671	1072531	139	15175	113514	2702.7	60699	1406187
127¼	12718	95134	2265.1	50870	1078877	139¼	15229	113923	2712.5	60917	1413788
127½	12768	95508	2274.0	51071	1085248	139½	15284	114333	2722.2	61136	1421416
127¾	12818	95883	2282.9	51271	1091645	139¾	15339	114743	2732.0	61356	1429072
128	12868	96259	2291.9	51472	1098066	140	15394	115154	2741.8	61575	1436755
128¼	12918	96635	2300.8	51673	1104513	140¼	15449	115565	2751.6	61795	1444466
128½	12969	97013	2309.8	51875	1110985	140½	15504	115978	2761.4	62016	1452204
128¾	13019	97390	2318.8	52077	1117481	140¾	15559	116391	2771.2	62237	1459970
129	13070	97769	2327.8	52279	1124004	141	15615	116805	2781.1	62458	1467763
129¼	13121	98148	2336.9	52482	1130551	141¼	15670	117219	2790.9	62680	1475584
129½	13171	98528	2345.9	52685	1137124	141½	15725	117634	2800.8	62902	1483433
129¾	13222	98909	2355.0	52889	1143723	141¾	15781	118050	2810.7	63124	1491310
130	13273	99291	2364.1	53093	1150347	142	15837	118467	2820.6	63347	1499214
130¼	13324	99673	2373.2	53297	1156996	142¼	15893	118885	2830.6	63570	1507146
130½	13376	100056	2382.3	53502	1163671	142½	15948	119303	2840.5	63794	1515107
130¾	13427	100440	2391.4	53707	1170371	142¾	16005	119722	2850.5	64018	1523095
131	13478	100824	2400.6	53913	1177098	143	16061	120142	2860.5	64242	1531111
131¼	13530	101209	2409.7	54119	1183850	143¼	16117	120562	2870.5	64467	1539156
131½	13581	101595	2418.9	54325	1190627	143½	16173	120983	2880.6	64692	1547228
131¾	13633	101982	2428.1	54532	1197431	143¾	16230	121405	2890.6	64918	1555329
132	13685	102369	2437.4	54739	1204260	144	16286	121828	2900.7	65144	1563458
132¼	13737	102757	2446.6	54947	1211116	144¼	16343	122251	2910.7	65370	1571615
132½	13789	103146	2455.9	55155	1217997	144½	16399	122675	2920.8	65597	1579800
132¾	13841	103536	2465.1	55363	1224904	144¾	16456	123100	2931.0	65824	1588014
133	13893	103926	2474.4	55572	1231838	145	16513	123526	2941.1	66052	1596256
133¼	13945	104317	2483.7	55781	1238797	145¼	16570	123952	2951.2	66280	1604527
133½	13998	104709	2493.1	55990	1245783	145½	16627	124379	2961.4	66508	1612826
133¾	14050	105102	2502.4	56200	1252795	145¾	16684	124807	2971.6	66737	1621154
134	14103	105495	2511.8	56410	1259833	146	16742	125235	2981.8	66966	1629511
134¼	14155	105889	2521.2	56621	1266898	146¼	16799	125665	2992.0	67196	1637896
134½	14208	106284	2530.6	56832	1273988	146½	16856	126095	3002.3	67426	1646310
134¾	14261	106679	2540.0	57044	1281106	146¾	16914	126525	3012.5	67656	1654752
135	14314	107075	2549.4	57256	1288249	147	16972	126957	3022.8	67887	1663224
135¼	14367	107472	2558.9	57468	1295420	147¼	17029	127389	3033.1	68118	1671724
135½	14420	107870	2568.3	57680	1302616	147½	17087	127822	3043.4	68349	1680253
135¾	14473	108268	2577.8	57893	1309840	147¾	17145	128256	3053.7	68581	1688811
136	14527	108667	2587.3	58107	1317090	148	17203	128690	3064.0	68813	1697398
136¼	14580	109067	2596.8	58321	1324366	148¼	17262	129125	3074.4	69046	1706015
136½	14634	109468	2606.4	58535	1331670	148½	17320	129561	3084.8	69279	1714660
136¾	14687	109869	2615.9	58750	1339000	148¾	17378	129998	3095.2	69513	1723334
137	14741	110271	2625.5	58965	1346357	149	17437	130435	3105.6	69746	1732038
137¼	14795	110674	2635.1	59180	1353741	149¼	17495	130873	3116.0	69981	1740771
137½	14849	111078	2644.7	59396	1361152	149½	17554	131312	3126.5	70215	1749533
137¾	14903	111482	2654.3	59612	1368590	149¾	17613	131751	3136.9	70450	1758325
						150	17671	132192	3147.4	70686	1767146

D-20
Tank Capacities, Horizontal Cylindrical
Contents of Tanks with Flat Ends
When Filled to Various Depths

Diameter of tank inches	Full tank	Depth of liquid, in inches = h																							
		3"	6"	9"	12"	15"	18"	21"	24"	27"	30"	33"	36"	39"	42"	45"	48"	51"	54"	57"	60"
12"	5.88	1.15	2.94	.....	.....																
18"	13.22	1.45	3.86	6.61	.....																
24"	23.50	1.70	4.60	8.05	11.75	15"	18"	21"													
30"	36.72	1.91	5.23	9.27	13.72	18.36	.....	.....													
36"	52.88	2.12	5.79	10.34	15.43	20.85	26.44	.....													
42"	71.97	2.28	6.31	11.31	16.97	23.07	29.47	35.99	24"	27"	30"										
48"	94.01	2.45	6.78	12.20	18.38	25.10	32.20	39.54	47.60	.....	.....										
54"	118.98	2.60	7.22	13.04	19.68	26.97	34.72	42.80	51.08	59.49	.....										
60"	146.89	2.75	7.64	13.82	20.91	28.72	37.06	45.82	54.87	64.11	73.44	33"	36"	39"							
66"	177.73	2.89	8.04	14.56	22.07	30.37	39.28	48.65	58.39	68.41	78.59	88.86	.....	.....							
72"	211.52	3.02	8.42	15.26	23.17	31.92	41.36	51.32	61.71	72.45	83.41	94.54	105.76	.....							
78"	248.24	3.15	8.78	15.94	24.21	33.41	43.34	53.86	64.87	76.27	87.97	99.90	111.97	124.13	42"	45"	48"				
84"	287.90	3.26	9.12	16.57	25.24	34.85	45.24	56.29	67.87	79.91	92.30	104.98	117.85	130.87	143.95	.....	.....				
90"	330.49	3.43	9.46	17.20	26.20	36.21	47.05	58.61	70.75	83.39	96.43	109.81	123.45	137.28	151.23	165.25	.....				
96"	376.02	3.50	9.79	17.80	27.13	37.52	48.81	60.84	73.52	86.73	100.39	114.44	128.79	143.40	158.17	173.06	188.01	51"	54"	57"	60"
102"	424.50	3.61	10.10	18.37	28.01	39.00	50.49	62.99	76.18	89.94	104.20	118.89	133.92	149.25	164.81	180.53	196.37	212.25	.....	.....	.....
108"	476.10	3.71	10.39	18.94	28.90	40.03	52.14	65.09	78.74	93.04	107.87	123.17	138.87	154.89	171.19	187.71	204.37	221.14	238.05	.....	.....
114"	530.25	3.78	10.74	19.49	29.75	41.22	53.73	67.10	81.24	96.05	111.43	127.31	143.63	160.33	177.33	194.60	212.05	229.65	247.37	265.13	.....
120"	587.54	3.94	10.98	20.02	30.57	42.39	55.25	69.06	83.65	98.95	114.87	131.32	148.25	165.58	183.27	201.24	219.46	237.87	256.43	275.08	293.77



To ascertain the contents of a tank over one-half full: Let h = depth of unfilled portion. Find from the table the quantity corresponding to a depth h. Subtract this quantity from the contents of a full tank.

Contents in U.S. gallons per 1 foot of length.
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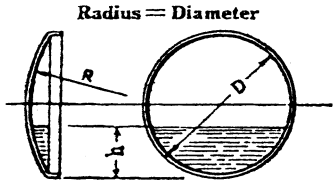
D-21
Tank Capacities, Horizontal Cylindrical
Contents of Standards Dished Heads
When Filled to Various Depths

Diameter of head inches	Full head	Depth of liquid, in inches = h																							
		3"	6"	9"	12"	15"	18"	21"	24"	27"	30"	33"	36"	39"	42"	45"	48"	51"	54"	57"	60"
12"	0.40	0.05	0.20	.....	.....																
18"	1.36	0.07	0.32	0.68	.....																
24"	3.22	0.08	0.41	0.95	1.61	15"	18"	21"													
30"	6.30	0.10	0.49	1.18	2.10	3.15	.....	.....													
36"	10.88	0.11	0.56	1.39	2.54	3.92	5.44	.....													
42"	17.28	0.12	0.63	1.59	2.94	4.64	6.57	8.64	24"	27"	30"										
48"	25.79	0.13	0.68	1.75	3.31	5.29	7.62	10.19	12.89	.....	.....										
54"	36.72	0.14	0.74	1.90	3.64	5.91	8.60	11.65	14.95	18.36	.....										
60"	50.37	0.14	0.82	2.07	3.98	6.49	9.54	13.03	16.87	20.96	25.18	33"	36"	39"							
66"	67.04	0.15	0.83	2.19	4.25	6.98	10.35	14.30	18.68	23.43	28.42	33.52	.....	.....							
72"	87.04	0.16	0.88	2.32	4.52	7.47	11.15	15.48	20.38	25.74	31.46	37.43	43.52	.....							
78"	110.66	0.17	0.93	2.44	4.79	7.97	11.94	16.65	22.02	27.97	34.39	41.16	48.20	55.33	42"	45"	48"				
84"	138.22	0.18	0.98	2.59	5.07	8.44	12.69	17.78	23.60	30.11	37.19	44.75	52.67	60.83	69.11	.....	.....				
90"	170.01	0.18	1.00	2.68	5.33	8.91	13.44	18.86	25.12	32.18	39.90	48.22	56.99	66.14	75.52	85.00	.....				
96"	206.32	0.20	1.07	2.83	5.59	9.36	14.14	19.90	26.60	34.17	42.52	51.53	61.13	71.22	81.66	92.34	103.16	51"	54"	57"	60"
102"	247.48	0.22	1.14	3.01	5.89	9.87	14.92	21.01	28.11	36.18	45.19	54.91	65.31	76.29	87.73	99.56	111.59	123.74	.....	.....	.....
108"	293.77	0.20	1.13	3.03	6.04	10.21	15.50	21.93	29.47	38.03	47.56	57.97	69.14	81.05	93.53	106.47	119.76	133.26	146.88	.....	.....
114"	345.51	0.21	1.16	3.12	6.25	10.55	16.06	22.80	30.70	39.73	49.81	60.88	72.85	85.61	99.05	113.07	127.56	142.41	157.51	172.75	.....
120"	402.27	0.21	1.19	3.23	6.47	10.93	16.68	23.70	31.96	41.43	52.04	63.73	76.40	89.95	104.32	119.39	135.04	151.15	167.62	184.32	201.13



To ascertain the contents of a head over one-half full: Let h = depth of unfilled portion. Find from the table the quantity corresponding to a depth h. Subtract this quantity from the contents of a full head.

Contents in U.S. gallons for one head only. This table is only approximate, but close enough for practical use.
By permission, The Permutit Co., Inc., Data Book, 1953.

D-22

Miscellaneous Formulas

(Courtesy of Chicago Bridge and iron Co.)

1. Area of Roofs.

Umbrella Roofs:

D = diameter of tank in feet.

Surface area in square feet { = 0.842 D^2 (when radius = diameter); = 0.882 D^2 (when radius = 0.8 diameter)

Conical Roofs:

Surface area in square feet { = 0.787 D^2 (when pitch is ¾ in 12); = 0.792 D^2 (when pitch is 1½ in 12)

2. Average weights.

Steel —490 pounds per cubic foot—specific gravity 7.85

Wrought iron —485 pounds per cubic foot—specific gravity 7.77

Cast iron —450 pounds per cubic foot—specific gravity 7.21

1 cubic foot air or gas at 32° F., 760 m.m. barometer = molecular weight x 0.0027855 pounds.

3. Expansion in steel pipe = 0.78 inch per 100 lineal feet per 100 degrees Fahr. change in temperature = 0.412 inch per mile per degree Fahr. temperature change.

4. Linear coefficients of expansion per degree increase in temperature:

	Per Degree Fahrenheit	Per Degree Centigrade
STRUCTURAL STEEL—A-7		
70° to 200° F	0.0000067	—
21.1° to 93° C	—	0.0000121
STAINLESS STEEL—TYPE 304		
32° to 932° F	0.0000102	—
0° to 500° C	—	0.0000184
ALUMINUM		
−76° to 68° F	0.0000120	—
−60° to 20° C	—	0.0000216

5. To determine the net thickness of shells for horizontal cylindrical pressure tanks:

$$T = \frac{6PD}{S}$$

P = working pressure in pounds per square inch

D = diameter of cylinder in feet

S = allowable unit working stress in pounds per square inch

T = Net thickness in inches

Resulting net thickness must be corrected to gross or actual thickness by dividing by joint efficiency.

6. To determine the net thickness of heads for cylindrical pressure tanks:

(6a) Ellipsoidal or Bumped Heads:

$$T = \frac{6PD}{S}$$

T, P and D as in formula 5

(6b) Dished or Basket Heads:

$$T = \frac{10.6P(MR)}{S}$$

T, S and P as in formula 5

MR = principal radius of head in feet

Resulting net thickness of heads is both net and gross thickness if one piece seamless heads are used, otherwise net thickness must be corrected to gross thickness as above.

Formulas 5 and 6 must often be modified to comply with various engineering codes, and state and municipal regulations. Calculated gross plate thicknesses are sometimes arbitrarily increased to provide an additional allowance for corrosion.

7. Heads for Horizontal Cylindrical Tanks:

Hemi-ellipsoidal Heads have an ellipsoidal cross section, usually with minor axis equal to one half the major axis—that is, depth = ¼ D, or more.

Dished or Basket Heads consist of a spherical segment normally dished to a radius equal to the inside diameter of the tank cylinder (or within a range of 6 inches plus or minus) and connected to the straight cylindrical flange by a "knuckle" whose inside radius is usually not less than 6 per cent of the inside diameter of the cylinder nor less than 3 times the thickness of the head plate. Basket heads closely approximate hemi-ellipsoidal heads.

Bumped Heads consist of a spherical segment joining the tank cylinder directly without the transition "knuckle." The radius = D, or less. This type of head is used only for pressures of 10 pounds per square inch or less, excepting where a compression ring is placed at the junction of head and shell.

Surface Area of Heads:

(7a) Hemi-ellipsoidal Heads:

$$S = \pi R^2 [1 + K^2(2-K)]$$

S = surface area in square feet

R = radius of cylinder in feet

K = ratio of the depth of the head (not including the straight flange) to the radius of the cylinder

The above formula is not exact but is within limits of practical accuracy.

(7b) Dished or Basket Heads:
Formula (7a) gives surface area within practical limits.

(7c) Bumped Heads:

$$S = \pi R^2 (1 + K^2)$$

S, R, and K as in formula (7a)

Volume of Heads:

(7d) Hemi-ellipsoidal Heads:

$$V = \tfrac{2}{3} \pi K R^3$$

R = radius of cylinder in feet

K = ratio of the depth of the head (not including the straight flange) to the radius of the cylinder

(7e) Dished or Basket Heads:
Formula (7d) gives volume within practical limits.

(7f) Bumped Heads:

$$V = \tfrac{1}{2} \pi K R^3 (1 + \tfrac{1}{3} K^2)$$

V, K and R as in formula (7d)

Note: K in above formulas may be determined as follows:
Hemi-ellipsoidal heads—K is known

Dished Heads—$K = M - \sqrt{(M-1)(M+1-2m)}$

Bumped Heads— $K = [M - \sqrt{M^2-1}]$

MR = principal radius of head in feet

mR = radius of knuckle in feet

R = radius of cylinder in feet

$$M = \frac{MR}{R} \qquad m = \frac{mR}{R}$$

For bumped heads m = o

8. Total volume or length of shell in cylindrical tank with ellipsiodal or hemispherical heads:

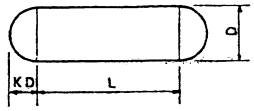
V = Total volume

L = Length of cylindrical shell

KD = Depth of head

$$V = \frac{\pi D^2}{4} (L + 1\tfrac{1}{3} KD)$$

$$L = (V \div \frac{\pi D^2}{4}) - 1\tfrac{1}{3} KD$$

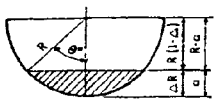


D-22
(Continued). Miscellaneous Formulas

9. Volume or contents of partially filled horizontal cylindrical tanks:

(9a) Tank cylinder or shell (straight portion only)

$$Q = R^2L\left[\left(\frac{\pi\ \Theta^\circ}{180}\right) - \sin\Theta\cos\Theta\right]$$



Q = partially filled volume or contents in cubic feet

R = radius of cylinder in feet

L = length of straight portion of cylinder in feet

The straight portion or flange of the heads must be considered a part of the cylinder. The length of flange depends upon the diameter of tank and thickness of head but ranges usually between 2 and 4 inches.

$a = \Delta R$ = depth of liquid in feet

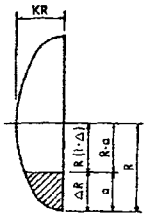
$\Delta = \frac{a}{R}$ = a ratio

$\text{Cos}\ \Theta = 1 - \Delta$, or $\frac{R-a}{R}$

Θ = degrees

(9b) Hemi-ellipsoidal Heads:

$Q = \frac{3}{4}\ V\ \Delta^2\ (1 - \frac{1}{3}\ \Delta)$



Q = partially filled volume or contents in cubic feet

V = total volume of one head per formula (7d)

$\Delta = \frac{a}{R}$ = a ratio

$a = \Delta R$ = depth of liquid in feet

R = radius of cylinder in feet

(9c) Dished or Basket Heads:
Formula (9b) gives partially filled volume within practical limits, and formula (7d) gives V within practical limits.

(9d) Bumped Heads:
Formula (9b) gives partially filled volume within practical limits, and formula (7f) gives V.

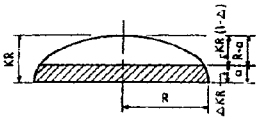
Note: To obtain the volume or quantity of liquid in partially filled tanks, add the volume per formula (9a) for the cylinder or straight portion to twice (for 2 heads) the volume per formula (9b), (9c) or (9d) for the type of head concerned.

10. Volume or contents of partially filled hemi-ellipsoidal heads with major axis vertical:

Q = Partially filled volume or contents in cubic feet

V = Total volume of one head per formula (7d)

R = Radius of cylinder in feet

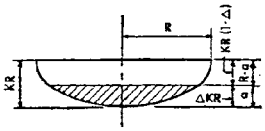


(10a) Upper Head:

$Q = 1\frac{1}{2}\ V\ \Delta\ (1 - \frac{1}{3}\Delta^2)$

$\Delta = \frac{a}{KR}$ = a ratio

$a = \Delta\ KR$ = depth of liquid in feet



(10b) Lower Head:

$Q = 1\frac{1}{2}\ V\ \Delta^2(1 - \frac{1}{3}\Delta)$

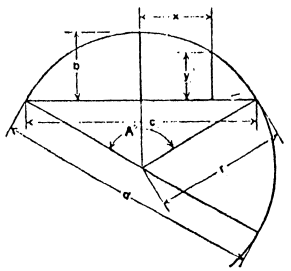
$\Delta = \frac{a}{KR}$ = a ratio

$a = \Delta\ KR$ = depth of liquid in feet

D-23
Decimal Equivalent in Inches, Feet and Millimeters

In. Equiv. for Decimal of In.	*Decimals*	*Millimeter Equiv. for Decimal of In.*	*In. Equiv. for Decimal of Ft.*
1/64	.0156	0.397	3/16
1/32	.0313	0.794	3/8
3/64	.0469	1.191	9/16
1/16	.0625	1.588	3/4
5/64	.0781	1.984	15/16
3/32	.0938	2.381	1 1/8
7/64	.1094	2.778	1 5/16
1/8	.1250	3.175	1 1/2
9/64	.1406	3.572	1 11/16
5/32	.1563	3.969	1 7/8
11/64	.1719	4.366	2 1/16
3/16	.1875	4.763	2 1/4
13/64	.2031	5.159	2 7/16
7/32	.2188	5.556	2 5/8
15/64	.2344	5.953	2 13/16
1/4	.2500	6.350	3
17/64	.2656	6.747	3 3/16
9/32	.2813	7.144	3 3/8
19/64	.2969	7.541	3 9/16
5/16	.3125	7.938	3 3/4
21/64	.3281	8.334	3 15/16
11/32	.3438	8.731	4 1/8
23/64	.3594	9.128	4 5/16
3/8	.3750	9.525	4 1/2
25/64	.3906	9.922	4 11/16
13/32	.4063	10.319	4 7/8
27/64	.4219	10.716	5 1/16
7/16	.4375	11.113	5 1/4
29/64	.4531	11.509	5 7/16
15/32	.4688	11.906	5 5/8
31/64	.4844	12.303	5 13/16
1/2	.5000	12.700	6
33/64	.5156	13.097	6 3/16
17/32	.5313	13.494	6 3/8
35/64	.5469	13.891	6 9/16
9/16	.5625	14.288	6 3/4
37/64	.5781	14.684	6 15/16
19/32	.5938	15.081	7 1/8
39/64	.6094	15.478	7 5/16
5/8	.6250	15.875	7 1/2
41/64	.6406	16.272	7 11/16
21/32	.6563	16.669	7 7/8
43/64	.6719	17.066	8 1/16
11/16	.6875	17.463	8 1/4
45/64	.7031	17.859	8 7/16
23/32	.7188	18.256	8 5/8
47/64	.7344	18.653	8 13/16
3/4	.7500	19.050	9
49/64	.7656	19.447	9 3/16
25/32	.7813	19.844	9 3/8
51/64	.7969	20.241	9 9/16
13/16	.8125	20.638	9 3/4
53/64	.8281	21.034	9 15/16
27/32	.8438	21.431	10 1/8
55/64	.8594	21.828	10 5/16
7/8	.8750	22.225	10 1/2
57/64	.8906	22.622	10 11/16
29/32	.9063	23.019	10 7/8
59/64	.9219	23.416	11 1/16
15/16	.9375	23.813	11 1/4
61/64	.9531	24.209	11 7/16
31/32	.9688	24.606	11 5/8
63/64	.9844	25.003	11 13/16
1	1.0000	25.400	12

PROPERTIES OF THE CIRCLE



Circumference = 6.28318 r = 3.14159 d
Diameter = 0.31831 circumference
Area = 3.14159 r^2

Arc $a = \frac{\pi r A^\circ}{180^\circ} = 0.017453\ r A^\circ$

Angle $A^\circ = \frac{180^\circ a}{\pi r} = 57.29578 \frac{a}{r}$

Radius $r = \frac{4b^2 + c^2}{8b}$

Chord $c = 2\sqrt{2br - b^2} = 2r \sin \frac{A}{2}$

Rise $b = r - \frac{1}{2}\sqrt{4r^2 - c^2} = \frac{c}{2} \tan \frac{A}{4}$

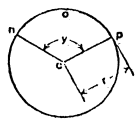
$= 2r \sin^2 \frac{A}{4} = r + y - \sqrt{r^2 - x^2}$

$y = b - r + \sqrt{r^2 - x^2}$

$x = \sqrt{r^2 - (r + y - b)^2}$

Diameter of circle of equal periphery as square = 1.27324 side of square
Side of square of equal periphery as circle = 0.78540 diameter of circle
Diameter of circle circumscribed about square = 1.41421 side of square
Side of square inscribed in circle = 0.70711 diameter of circle

CIRCULAR SECTOR



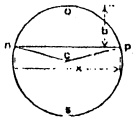
r = radius of circle y = angle ncp in degrees

Area of Sector ncpo = ½ (length of arc nop × r)

= Area of Circle × $\frac{y}{360}$

= 0.0087266 × r^2 × y

CIRCULAR SEGMENT



r = radius of circle x = chord b = rise

Area of Segment nop = Area of Sector ncpo — Area of triangle ncp

$= \frac{\text{(Length of arc nop} \times r) - x\,(r - b)}{2}$

Area of Segment nsp = Area of Circle — Area of Segment nop

VALUES FOR FUNCTIONS OF π

π = 3.14159265359, log = 0.4971499

π^2 = 9.8696044, log = 0.9942998 $\frac{1}{\pi}$ = 0.3183099, log = $\bar{1}$.5028501 $\sqrt{\frac{1}{\pi}}$ = 0.5641896, log = $\bar{1}$.7514251

π^3 = 31.0062767, log = 1.4914497 $\frac{1}{\pi^2}$ = 0.1013212, log = $\bar{1}$.0057002 $\frac{\pi}{180}$ = 0.0174533, log = $\bar{2}$.2418774

$\sqrt{\pi}$ = 1.7724539, log = 0.2485749 $\frac{1}{\pi^3}$ = 0.0322515, log = $\bar{2}$.5085503 $\frac{180}{\pi}$ = 57.2957795, log = 1.7581226

AREA OF PLANE FIGURES

Triangle: Base x ½ perpendicular height.
$\sqrt{s(s-a)(s-b)(s-c)}$,
s = ½ sum of the three sides a, b and c.

Trapezium: Sum of area of the two triangles.

Trapezoid: ½ sum of parallel sides x perpendicular height.

Parallelogram: Base x perpendicular height.

Regular Polygon: ½ sum of sides x inside radius.

Circle: πr^2 = 0.78540 x dia.^{2} = 0.07958 x circumference^2

Sector of Circle: $\frac{\pi r^2 A^\circ}{360}$ = 0.0087266$r^2 A^\circ$ = arc x ½ radius.

Segment of Circle: $\frac{r^2}{2}\left(\frac{\pi A^\circ}{180} - \sin A^\circ\right)$

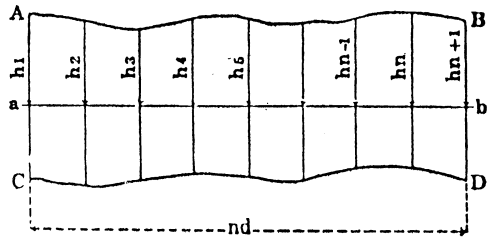
Circle of same area as square: diameter = side x 1.12838

Square of same area as circle: side = diameter x 0.88623

Ellipse: Long diameter x short diameter x 0.78540

Parabola: Base x ⅔ perpendicular height.

Irregular plane surface

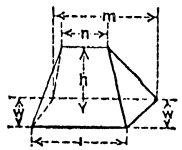


Divide any plane surface A, B, C, D, along a line a-b into an even number, n, of parallel and sufficiently small strips, d, whose ordinates are $h_1, h_2, h_3, h_4, h_5 \ldots h_{n-1}, h_n, h_{n+1}$, and considering contours between three ordinates as parabolic curves, then for section ABCD,

$$\text{Area} = \frac{d}{3}\left[h_1 + h_{n+1} + 4(h_2 + h_4 + h_6 \ldots + h_n) + 2(h_3 + h_5 + h_7 \ldots + h_{n-1})\right]$$

or, approximately, Area = Sum of ordinates x width, d.

VOLUME OF A WEDGE



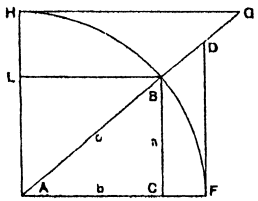
This formula is useful in obtaining the contents of special, wedge-shaped, tank bottoms.

$$\text{Volume} = \frac{wh}{6}(l + m + n)$$

D-24
(Continued).

TRIGONOMETRIC FORMULAS

TRIGONOMETRIC FUNCTIONS



Radius AF = 1
$= \sin^2 A + \cos^2 A = \sin A \operatorname{cosec} A$
$= \cos A \sec A = \tan A \cot A$

Sine A $= \frac{\cos A}{\cot A} = \frac{1}{\operatorname{cosec} A} = \cos A \tan A = \sqrt{1-\cos^2 A} =$ BC

Cosine A $= \frac{\sin A}{\tan A} = \frac{1}{\sec A} = \sin A \cot A = \sqrt{1-\sin^2 A} =$ AC

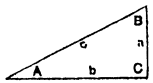
Tangent A $= \frac{\sin A}{\cos A} = \frac{1}{\cot A} = \sin A \sec A =$ FD

Cotangent A $= \frac{\cos A}{\sin A} = \frac{1}{\tan A} = \cos A \operatorname{cosec} A =$ HG

Secant A $= \frac{\tan A}{\sin A} = \frac{1}{\cos A} =$ AD

Cosecant A $= \frac{\cot A}{\cos A} = \frac{1}{\sin A} =$ AG

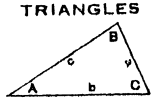
RIGHT ANGLED TRIANGLES



$a^2 = c^2 - b^2$
$b^2 = c^2 - a^2$
$c^2 = a^2 + b^2$

Known	Required					
	A	B	a	b	c	Area
a, b	$\tan A = \frac{a}{b}$	$\tan B = \frac{b}{a}$			$\sqrt{a^2+b^2}$	$\frac{ab}{2}$
a, c	$\sin A = \frac{a}{c}$	$\cos B = \frac{a}{c}$		$\sqrt{c^2-a^2}$		$\frac{a\sqrt{c^2-a^2}}{2}$
A, a		$90° - A$		$a \cot A$	$\frac{a}{\sin A}$	$\frac{a^2 \cot A}{2}$
A, b		$90° - A$	$b \tan A$		$\frac{b}{\cos A}$	$\frac{b^2 \tan A}{2}$
A, c		$90° - A$	$c \sin A$	$c \cos A$		$\frac{c^2 \sin 2A}{4}$

OBLIQUE ANGLED TRIANGLES



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

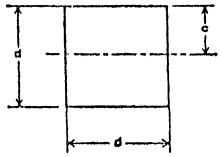
$a^2 = b^2 + c^2 - 2bc \cos A$
$b^2 = a^2 + c^2 - 2ac \cos B$
$c^2 = a^2 + b^2 - 2ab \cos C$

Known	Required					
	A	B	C	b	c	Area
a, b, c	$\cos \frac{1}{2} A = \sqrt{\frac{s(s-a)}{bc}}$	$\cos \frac{1}{2} B = \sqrt{\frac{s(s-b)}{ac}}$	$\cos \frac{1}{2} C = \sqrt{\frac{s(s-c)}{ab}}$			$\sqrt{s(s-a)(s-b)(s-c)}$
a, A, B			$180° - (A+B)$	$\frac{a \sin B}{\sin A}$	$\frac{a \sin C}{\sin A}$	
a, b, A		$\sin B = \frac{b \sin A}{a}$			$\frac{b \sin C}{\sin B}$	
a, b, C	$\tan A = \frac{a \sin C}{b - a \cos C}$				$\sqrt{a^2+b^2-2ab\cos C}$	$\frac{ab \sin C}{2}$

PROPERTIES OF SECTIONS

SQUARE

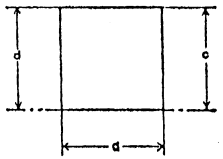
Axis of moments through center



$A = d^2$
$c = \frac{d}{2}$
$I = \frac{d^4}{12}$
$S = \frac{d^3}{6}$
$r = \frac{d}{\sqrt{12}} = .288675\ d$

SQUARE

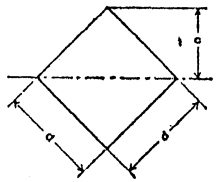
Axis of moments on base



$A = d^2$
$c = d$
$I = \frac{d^4}{3}$
$S = \frac{d^3}{3}$
$r = \frac{d}{\sqrt{3}} = .577350\ d$

SQUARE

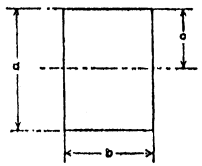
Axis of moments on diagonal



$A = d^2$
$c = \frac{d}{\sqrt{2}} = .707107\ d$
$I = \frac{d^4}{12}$
$S = \frac{d^3}{6\sqrt{2}} = .117851\ d^3$
$r = \frac{d}{\sqrt{12}} = .288675\ d$

RECTANGLE

Axis of moments through center



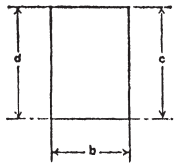
$A = bd$
$c = \frac{d}{2}$
$I = \frac{bd^3}{12}$
$S = \frac{bd^2}{6}$
$r = \frac{d}{\sqrt{12}} = .288675\ d$

D-24
(Continued).

PROPERTIES OF SECTIONS

RECTANGLE

Axis of moments on base



$A = bd$

$c = d$

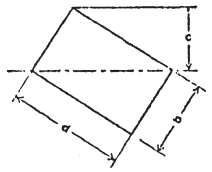
$I = \frac{bd^3}{3}$

$S = \frac{bd^2}{3}$

$r = \frac{d}{\sqrt{3}} = .577350\,d$

RECTANGLE

Axis of moments on diagonal



$A = bd$

$c = \frac{bd}{\sqrt{b^2 + d^2}}$

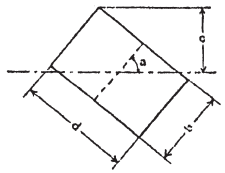
$I = \frac{b^3d^3}{6(b^2 + d^2)}$

$S = \frac{b^3d^2}{6\sqrt{b^2 + d^2}}$

$r = \frac{bd}{\sqrt{6(b^2 + d^2)}}$

RECTANGLE

Axis of moments any line through center of gravity



$A = bd$

$c = \frac{b \sin a + d \cos a}{2}$

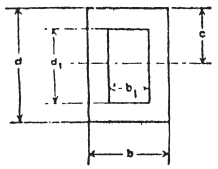
$I = \frac{bd(b^2 \sin^2 a + d^2 \cos^2 a)}{12}$

$S = \frac{bd(b^2 \sin^2 a + d^2 \cos^2 a)}{6(b \sin a + d \cos a)}$

$r = \sqrt{\frac{b^2 \sin^2 a + d^2 \cos^2 a}{12}}$

HOLLOW RECTANGLE

Axis of moments through center



$A = bd - b_1d_1$

$c = \frac{d}{2}$

$I = \frac{bd^3 - b_1d_1^3}{12}$

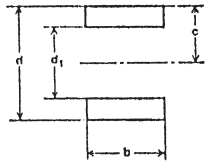
$S = \frac{bd^3 - b_1d_1^3}{6d}$

$r = \sqrt{\frac{bd^3 - b_1d_1^3}{12A}}$

PROPERTIES OF SECTIONS

EQUAL RECTANGLES

Axis of moments through center of gravity



$A = b(d - d_1)$

$c = \frac{d}{2}$

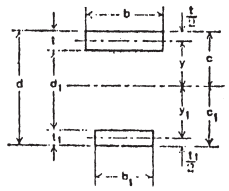
$I = \frac{b(d^3 - d_1^3)}{12}$

$S = \frac{b(d^3 - d_1^3)}{6d}$

$r = \sqrt{\frac{d^3 - d_1^3}{12(d - d_1)}}$

UNEQUAL RECTANGLES

Axis of moments through center of gravity



$A = bt + b_1t_1$

$c = \frac{\frac{1}{2}bt^2 + b_1t_1(d - \frac{1}{2}t_1)}{A}$

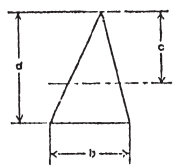
$I = \frac{bt^3}{12} + bty^2 + \frac{b_1t_1^3}{12} + b_1t_1y_1^2$

$S = \frac{I}{c} \qquad S_1 = \frac{I}{c_1}$

$r = \sqrt{\frac{I}{A}}$

TRIANGLE

Axis of moments through center of gravity



$A = \frac{bd}{2}$

$c = \frac{2d}{3}$

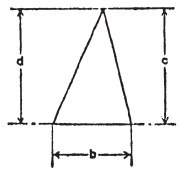
$I = \frac{bd^3}{36}$

$S = \frac{bd^2}{24}$

$r = \frac{d}{\sqrt{18}} = .235702\,d$

TRIANGLE

Axis of moments on base



$A = \frac{bd}{2}$

$c = d$

$I = \frac{bd^3}{12}$

$S = \frac{bd^2}{12}$

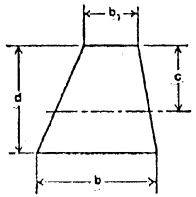
$r = \frac{d}{\sqrt{6}} = .408248\,d$

D-24
(Continued).

PROPERTIES OF SECTIONS

TRAPEZOID

Axis of moments through center of gravity



$$A = \frac{d(b + b_1)}{2}$$

$$c = \frac{d(2b + b_1)}{3(b + b_1)}$$

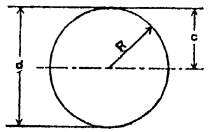
$$I = \frac{d^3 (b^2 + 4bb_1 + b_1^2)}{36 (b + b_1)}$$

$$S = \frac{d^2 (b^2 + 4bb_1 + b_1^2)}{12 (2b + b_1)}$$

$$r = \frac{d}{6(b + b_1)} \sqrt{2 (b^2 + 4bb_1 + b_1^2)}$$

CIRCLE

Axis of moments through center



$$A = \frac{\pi d^2}{4} = \pi R^2 = .785398\, d^2 = 3.141593\, R^2$$

$$c = \frac{d}{2} = R$$

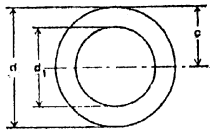
$$I = \frac{\pi d^4}{64} = \frac{\pi R^4}{4} = .049087\, d^4 = .785398\, R^4$$

$$S = \frac{\pi d^3}{32} = \frac{\pi R^3}{4} = .098175\, d^3 = .785398\, R^3$$

$$r = \frac{d}{4} = \frac{R}{2}$$

HOLLOW CIRCLE

Axis of moments through center



$$A = \frac{\pi(d^2 - d_1^2)}{4} = .785398\, (d^2 - d_1^2)$$

$$c = \frac{d}{2}$$

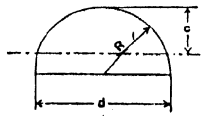
$$I = \frac{\pi(d^4 - d_1^4)}{64} = .049087\, (d^4 - d_1^4)$$

$$S = \frac{\pi(d^4 - d_1^4)}{32d} = .098175\, \frac{d^4 - d_1^4}{d}$$

$$r = \frac{\sqrt{d^2 + d_1^2}}{4}$$

HALF CIRCLE

Axis of moments through center of gravity



$$A = \frac{\pi R^2}{2} = 1.570796\, R^2$$

$$c = R\left(1 - \frac{4}{3\pi}\right) = .575587\, R$$

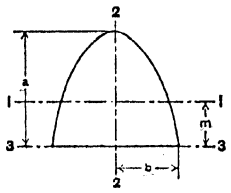
$$I = R^4\left(\frac{\pi}{8} - \frac{8}{9\pi}\right) = .109757\, R^4$$

$$S = \frac{R^3}{24}\,\frac{(9\pi^2 - 64)}{(3\pi - 4)} = .190687\, R^3$$

$$r = R\,\frac{\sqrt{9\pi^2 - 64}}{6\pi} = .264336\, R$$

PROPERTIES OF SECTIONS

PARABOLA



$$A = \frac{4}{3}ab$$

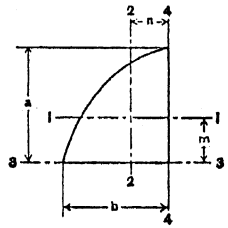
$$m = \frac{2}{5}a$$

$$I_1 = \frac{16}{175}a^3b$$

$$I_2 = \frac{4}{15}ab^3$$

$$I_3 = \frac{32}{105}a^3b$$

HALF PARABOLA



$$A = \frac{2}{3}ab$$

$$m = \frac{2}{5}a$$

$$n = \frac{3}{8}b$$

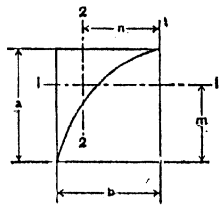
$$I_1 = \frac{8}{175}a^3b$$

$$I_2 = \frac{19}{480}ab^3$$

$$I_3 = \frac{16}{105}a^3b$$

$$I_4 = \frac{2}{15}ab^3$$

COMPLEMENT OF HALF PARABOLA



$$A = \frac{1}{3}ab$$

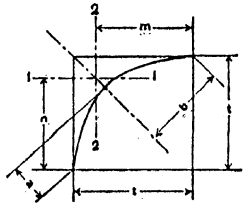
$$m = \frac{7}{10}a$$

$$n = \frac{3}{4}b$$

$$I_1 = \frac{37}{2100}a^3b$$

$$I_2 = \frac{1}{80}ab^3$$

PARABOLIC FILLET IN RIGHT ANGLE



$$a = \frac{t}{2\sqrt{2}}$$

$$b = \frac{t}{\sqrt{2}}$$

$$A = \frac{1}{6}t^2$$

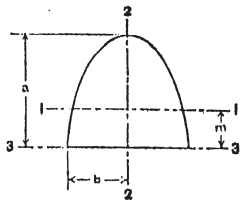
$$m = n = \frac{4}{5}t$$

$$I_1 = I_2 = \frac{11}{525}t^4$$

D-24
(Continued).

PROPERTIES OF SECTIONS

HALF ELLIPSE



$A = \frac{1}{2}\pi ab$

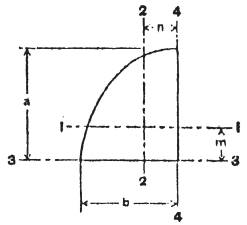
$m = \frac{4a}{3\pi}$

$I_1 = a^3b\left(\frac{\pi}{8} - \frac{8}{9\pi}\right)$

$I_2 = \frac{1}{8}\pi ab^3$

$I_3 = \frac{1}{8}\pi a^3b$

QUARTER ELLIPSE



$A = \frac{1}{4}\pi ab$

$m = \frac{4a}{3\pi}$

$n = \frac{4b}{3\pi}$

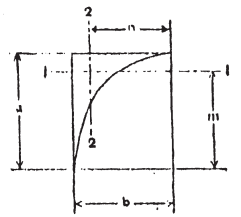
$I_1 = a^3b\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)$

$I_2 = ab^3\left(\frac{\pi}{16} - \frac{4}{9\pi}\right)$

$I_3 = \frac{1}{16}\pi a^3b$

$I_4 = \frac{1}{16}\pi ab^3$

ELLIPTIC COMPLEMENT



$A = ab\left(1 - \frac{\pi}{4}\right)$

$m = \frac{a}{6\left(1 - \frac{\pi}{4}\right)}$

$n = \frac{b}{6\left(1 - \frac{\pi}{4}\right)}$

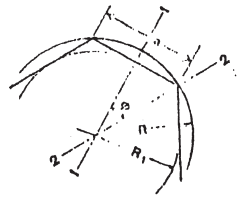
$I_1 = a^3b\left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36\left(1 - \frac{\pi}{4}\right)}\right)$

$I_2 = ab^3\left(\frac{1}{3} - \frac{\pi}{16} - \frac{1}{36\left(1 - \frac{\pi}{4}\right)}\right)$

PROPERTIES OF SECTIONS

REGULAR POLYGON

Axis of moments through center



n = Number of sides

$\phi = \frac{180°}{n}$

$a = 2\sqrt{R^2 - R_1^2}$

$R = \frac{a}{2\sin\phi}$

$R_1 = \frac{a}{2\tan\phi}$

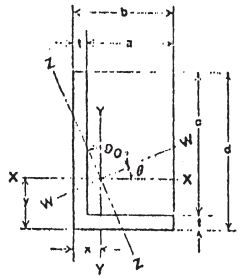
$A = \frac{1}{4}na^2\cot\phi = \frac{1}{2}nR^2\sin 2\phi = nR_1^2\tan\phi$

$I_1 = I_2 = \frac{A(6R^2 - a^2)}{24} = \frac{A(12R_1^2 + a^2)}{48}$

$r_1 = r_2 = \sqrt{\frac{6R^2 - a^2}{24}} = \sqrt{\frac{12R_1^2 + a^2}{48}}$

ANGLE

Axis of moments through center of gravity



Z-Z is axis of minimum I

$\tan 2\theta = \frac{2K}{I_Y - I_X}$

$A = t(b + c) \quad x = \frac{b^2 + ct}{2(b + c)} \quad y = \frac{d^2 + at}{2(b + c)}$

K = Product of Inertia about X-X & Y-Y

$= \frac{abcdt}{+\ 4(b + c)}$

$I_X = \frac{1}{3}\left(t(d - y)^3 + by^3 - a(y - t)^3\right)$

$I_Y = \frac{1}{3}\left(t(b - x)^3 + dx^3 - c(x - t)^3\right)$

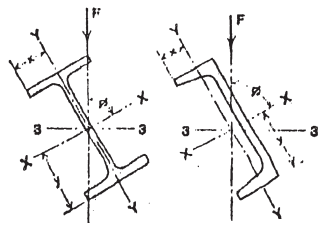
$I_Z = I_X\sin^2\theta + I_Y\cos^2\theta + K\sin 2\theta$

$I_W = I_X\cos^2\theta + I_Y\sin^2\theta - K\sin 2\theta$

K is negative when heel of angle, with respect to C_0, g_0, is in 1st or 3rd quadrant, positive when in 2nd or 4th quadrant.

BEAMS AND CHANNELS

Transverse force oblique through center of gravity



$I_3 = I_X\sin^2\phi + I_Y\cos^2\phi$

$I_4 = I_X\cos^2\phi + I_Y\sin^2\phi$

$= M\left(\frac{y}{I_X}\sin\phi + \frac{x}{I_Y}\cos\phi\right)$

where M is bending moment due to force F. Extreme fiber assumed same as for case $\phi = 0$. If not, locate extreme fiber and find f by usual method.

D-25
Wind Chill Equivalent Temperatures on Exposed Flesh at Varying Velocity

Temperature, F	WIND VELOCITY (MILES PER HOUR)										
	45	35	25	20	15	10	5	3	2	1	0
	90	89.5	89	88.5	88	88.75	87.5	87	86	84.5	83
	82	81	80.5	80	79.5	78	76	74	72.5	70	60
	72	71	69.5	68	67	65	60	57	53.5	47.5	23
	63	61	59	57	55	52	44.5	39	34.5	20	−11
	51	49	47	45	42.5	38	28	18.5	11	0	−27
	41	39	36	34	30.5	25	11	0	−9	−23.5	−38
	30	28	25	23	18	11	−5	−16.5	−40	Below −40	Below −40
	20	18	14	11	6	−2	−19	−40	Below −40	do	do
	10	7.5	3	0	−6	−15	−35	Below −40	do	do	do
	0	−2.5	−8	−12	−18	−29	Below −40	do	do	do	do
	−11	−14	−18	−23	−30	Below −40	do	do	do	do	do
	−21	−24	−30	−35	Below −40	do	do	do	do	do	do
	−32	−35	−40	−40				do	do	do	

Instructions for use of the table:

(1) First obtain the temperature and wind velocity forecast data.
(2) Locate the number at the top corresponding to the expected wind speed (or the number closest to this).
(3) Read down this column until the number corresponding to the expected temperature (or the number closest to this) is reached.
(4) From this point follow across to the right on the same line until the last number is reached under the column marked zero (0) wind speed.
(5) This is the equivalent temperature reading. Example: weather information gives the expected temperature (at a given time, such as midnight) to be 35°F, and the expected wind speed (at the same time, midnight) to be 20 miles per hour (mph). Locate the 20 mph column at the top, follow down this column to the number nearest to 35°F. The nearest number is 34°F. From this point, move all the way to the right on the same line and find the last number, which is −38°F. This means that with a temperature of 35°F, and a windspeed of 20 mph the rate of cooling of all exposed flesh is the same as −38°F, with no wind.

do means ditto.

D-26
Impurities in Water

U. S. Systems of Expressing Impurities

1 grain per gallon ..... = 1 grain calcium carbonate ($CaCO_3$) per U. S. gallon of water
1 part per million ..... = 1 part calcium carbonate ($CaCO_3$) per 1,000,000 parts of water
1 part per hundred thousand.. = 1 part calcium carbonate ($CaCO_3$) per 100,000 parts of water

Foreign Systems of Expressing Impurities

1 English degree (or °Clark).. = 1 grain calcium carbonate ($CaCO_3$) per British Imperial gal. of water
1 French degree ..... = 1 part calcium carbonate ($CaCO_3$) per 100,000 parts of water
1 German degree ..... = 1 part calcium oxide (CaO) per 100,000 parts of water

Conversions

CONVERSION TABLE (Expressed to 3 Significant Figures)	Parts $CaCO_3$ per Million (ppm)	Parts $CaCO_3$ per Hundred Thousand (Pts./100,000)	Grains $CaCO_3$ per U.S. Gallon (gpg)	English Degrees or °Clark	French Degrees — °French	German Degrees — °German	Milli-equivalents per Liter or Equivalents per Million
1 Part per Million	1.	.1	.0583	.07	.1	.0560	.020
1 Part per Hundred Thousand	10.0	1.	.583	.7	1.	.560	.20
1 Grain per U. S. Gallon	17.1	1.71	1.	1.2	1.71	.958	.343
1 English or Clark Degree	14.3	1.43	.833	1.	1.43	.800	.286
1 French Degree	10.	1.	.583	.7	1.	.560	.20
1 German Degree	17.9	1.79	1.04	1.24	1.79	1.	.357
1 Milli-equivalent per Liter 1 Equivalent per Million	50.	5.	2.92	3.50		2.80	1.

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D-27
Water Analysis Conversions for Units Employed : Equivalents

WATER ANALYSIS UNITS CONVERSION TABLE (Expressed to 3 Significant Figures)	Parts per Million (ppm)	Milligrams per Liter (mgm/L)	Grams per Liter (grms/L)	Parts per Hundred Thousand (Pts./100,000)	Grains U.S. Gallon (grs/U.S. gal)	Grains per British Imp. Gallon	Kilograins per Cubic Foot (Kgr/cu. ft.)
1 Part per Million	1.	1.	.001	.1	.0583	.07	.0004
1 Milligram per Liter	1.	1.	.001	.1	.0583	.07	.0004
1 Gram per Liter	1000.	1000.	1.	100.	58.3	70.	.436
1 Part per Hundred Thousand	10.	10.	.01	1.	.583	.7	.00436
1 Grain per U.S. Gallon	17.1	17.1	.017	1.71	1.	1.2	.0075
1 Grain per British Imp. Gallon	14.3	14.3	.014	1.43	.833	1.	.0062
1 Kilograin per Cubic Foot	2294.	2294.	2.294	229.4	134.	161.	1.

NOTE: In practice, water analysis samples are measured by volume, not by weight and corrections for variations in specific gravity are practically never made. Therefore, parts per million are assumed to be the same as milligrams per liter and hence the above relationships are, for practical purposes, true.

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D-28
Parts Per Million to Grains Per U.S. Gallon

A. To convert parts per million of hardness to grains per U. S. gallon, divide by the factor 17.1.

B. To convert grains per U. S. gallons to parts per million of hardness, multiply by the factor 17.1.

Example:

1. $\frac{242 \text{ parts/million}}{17.1} = 14.1$ grains/U. S. gallon

2. 24.3 grains/U. S. gallon $\times$ 17.1 = 416 parts/million

Equivalents

Water analyses may also be expressed as:

(1) Equivalents per million (epm) ..... $= \frac{\text{No. of ppm of substance present}}{\text{Equivalent weight of substance}}$

(2) Milli equivalents per liter (meq/l) ..... = Equivalents per million

(3) Parts per million expressed as $CaCO_3$ ..... = No. of ppm $CaCO_3$ equivalent to No. of ppm of substance present

(4) Fiftieths of equivalents per million (epm/50) $= \frac{\text{No. of ppm of substance present} \times 50}{\text{Equivalent weight of substance}}$

NOTES: Numerically (1) and (2) are equal.
Numerically (3) and (4) are equal.

Section xxii contains equivalent weights of a number of substances.
Section xxiii contains factors for converting various substances to $CaCO_3$.
Section xxiii contains factors for various chemical conversions.

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D-29
Formulas, Molecular and Equivalent Weights, and Conversion Factors to $CaCO_3$ of Substances Frequently Appearing in the Chemistry of Water Softening

Substance	Formula	Molecular weight	Equivalent weight	Multiplying Factor (Considering molecular wt. of $CaCO_3$ as 100.) Substance to $CaCO_3$ equivalent	$CaCO_3$ equivalent to substance
Aluminum	Al	27.0	9.0	5.56	0.18
Aluminum Chloride	$AlCl_3$	133.	44.4	1.13	0.89
Aluminum Chloride	$AlCl_3.6H_2O$	241.	80.5	0.62	1.61
Aluminum Sulfate	$Al_2(SO_4)_3.18H_2O$	666.4	111.1	0.45	2.22
Aluminum Sulfate	$Al_2(SO_4)_3$ (anhydrous)	342.1	57.0	0.88	1.14
Aluminum Hydrate	$Al(OH)_3$	78.0	26.0	1.92	0.52
Alumina	Al_2O_3	101.9	17.0	2.94	0.34
Sodium Aluminate	$Na_2Al_2O_4$	163.9	27.3	1.83	0.55
Ammonium Alum	$Al_2(SO_4)_3.(NH_4)_2SO_4.24H_2O$	906.6	151.1	0.33	3.02
Potassium Alum	$Al_2(SO_4)_3K_2SO_4.24H_2O$	948.8	156.1	0.32	3.12
Ammonia	NH_3	17.0	17.0	2.94	0.34
Ammonium (Ion)	NH_4	18.0	18.0	2.78	0.36
Ammonium Chloride	NH_4Cl	53.5	53.5	0.94	1.07
Ammonium Hydroxide	NH_4OH	35.1	35.1	1.43	0.70
Ammonium Sulfate	$(NH_4)_2SO_4$	132.	66.1	0.76	1.32
Barium	Ba	137.4	68.7	0.73	1.37
Barium Carbonate	$BaCO_3$	197.4	98.7	0.51	1.97
Barium Chloride	$BaCl_2.2H_2O$	244.3	122.2	0.41	2.44
Barium Hydroxide	$Ba(OH)_2$	171.	85.7	0.59	1.71
Barium Oxide	BaO	153.	76.7	0.65	1.53
Barium Sulfate	$BaSO_4$	233.4	116.7	0.43	2.33
Calcium	Ca	40.1	20.0	2.50	0.40
Calcium Bicarbonate	$Ca(HCO_3)_2$	162.1	81.1	0.62	1.62
Calcium Carbonate	$CaCO_3$	100.08	50.1	1.00	1.00
Calcium Chloride	$CaCl_2$	111.0	55.5	0.90	1.11
Calcium Hydrate	$Ca(OH)_2$	74.1	37.1	1.35	0.74
Calcium Hypochlorite	$Ca(ClO)_2$	143.1	35.8	0.70	1.43
Calcium Oxide	CaO	56.1	28.0	1.79	0.56
Calcium Sulfate	$CaSO_4$ (anhydrous)	136.1	68.1	0.74	1.36
Calcium Sulfate	$CaSO_4.2H_2O$ (gypsum)	172.2	86.1	0.58	1.72
Calcium Nitrate	$Ca(NO_3)_2$	164.1	82.1	0.61	1.64
Calcium Phosphate	$Ca_3(PO_4)_2$	310.3	51.7	0.97	1.03
Carbon	C	12.0	3.00	16.67	0.06
Chlorine (Ion)	Cl	35.5	35.5	1.41	0.71
Copper (Cupric)	Cu	63.6	31.8	1.57	0.64
Copper Sulfate (Cupric)	$CuSO_4$	160.	80.0	0.63	1.60
Copper Sulfate (Cupric)	$CuSO_4.5H_2O$	250.	125.	0.40	2.50
Iron (Ferrous)	$Fe^{''}$	55.8	27.9	1.79	0.56
Iron (Ferric)	$Fe^{'''}$	55.8	18.6	2.69	0.37
Ferrous Carbonate	$FeCO_3$	116.	57.9	0.86	1.16
Ferrous Hydroxide	$Fe(OH)_2$	89.9	44.9	1.11	0.90
Ferrous Oxide	FeO	71.8	35.9	1.39	0.72
Ferrous Sulfate	$FeSO_4$ (anhydrous)	151.9	76.0	0.66	1.52
Ferrous Sulfate	$FeSO_4.7H_2O$	278.0	139.0	0.36	2.78
Ferrous Sulfate	$FeSO_4$ (anhydrous)	151.9	151.9	oxidation	
Ferric Chloride	$FeCl_3$	162.	54.1	0.93	1.08
Ferric Chloride	$FeCl_3.6H_2O$	270.	90.1	0.56	1.80
Ferric Hydroxide	$Fe(OH)_3$	107.	35.8	1.41	0.71
Ferric Oxide	Fe_2O_3	160.	26.6	1.88	0.53
Ferric Sulfate (Ferrisul)	$Fe_2(SO_4)_3$	399.9	66.7	0.75	1.33
Ferrous or Ferric	Fe or Fe	55.8	55.8	oxidation	
Ferrous Sulfate	$FeSO_4$	151.9	151.9	oxidation	
Fluorine	F	19.0	19.0	2.66	0.38
Hydrogen (Ion)	H	1.01	1.01	50.0	0.02
Iodine	I	127.	127.	0.40	2.54
Lead	Pb	207.	104.	0.48	2.08
Magnesium	Mg	24.3	12.2	4.10	0.24
Magnesium Oxide	MgO	40.3	20.2	2.48	0.40
Magnesium Bicarbonate	$Mg(HCO_3)_2$	146.3	73.2	0.68	1.46
Magnesium Carbonate	$MgCO_3$	84.3	42.2	1.19	0.84
Magnesium Chloride	$MgCl_2$	95.2	47.6	1.05	0.95
Magnesium Hydrate	$Mg(OH)_2$	58.3	29.2	1.71	0.58
Magnesium Nitrate	$Mg(NO_3)_2$	148.3	74.2	0.67	1.48
Magnesium Phosphate	$Mg_3(PO_4)_2$	262.9	43.8	1.14	0.88
Magnesium Sulfate	$MgSO_4$	120.4	60.2	0.83	1.20
Manganese (Manganous)	$Mn^{''}$	54.9	27.5	1.82	0.55
Manganese (Manganic)	$Mn^{'''}$	54.9	18.3	2.73	0.37
Manganese Chloride	$MnCl_2$	125.8	62.9	0.80	1.26
Manganese Dioxide	MnO_2	86.9	21.7	2.30	0.43
Manganese Hydrate	$Mn(OH)_2$	89.0	44.4	1.13	0.89
Manganic Oxide	Mn_2O_3	158.	26.3	1.90	0.53
Manganous Oxide	MnO	70.9	35.5	1.41	0.71

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(continued on next page)

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(Continued). Formulas, Molecular and Equivalent Weights, and Conversion Factors to $CaCO_3$ of Substances Frequently Appearing in the Chemistry of Water Softening

Substance	Formula	Molecular weight	Equivalent weight	Multiplying Factor Considering molecular wt. of $CaCO_3$ as 100.	
				Substance to $CaCO_3$ equivalent	$CaCO_3$ equivalent to substance
Nitrate (Ion)	NO_3	62.0	62.0	0.81	1.24
Nitric Acid	HNO_3	63.0	63.0	0.79	1.26
Nitrogen (Valence 3)	N'''	14.0	4.67	10.8	0.093
Nitrogen (Valence 5)	N'''''	14.0	2.80	17.9	0.056
Oxygen	O	16.0	8.00	6.25	0.16
Phosphorus (Valence 3)	P'''	31.0	10.3	4.76	0.21
Phosphorus (Valence 5)	P'''''	31.0	6.20	8.33	0.12
Potassium	K	39.1	39.1	1.28	0.78
Potassium Carbonate	K_2CO_3	138.	69.1	0.72	1.38
Potassium Chloride	KCl	74.6	74.6	0.67	1.49
Potassium Hydroxide	KOH	56.1	56.1	0.88	1.12
Silver Chloride	AgCl	143.3	143.3	0.35	2.87
Silver Nitrate	$AgNO_3$	169.9	169.9	0.29	3.40
Silica	SiO_2	60.1	30.0	1.67	0.60
Silicon	Si	28.1	7.03	7.14	0.14
Sodium	Na	23.0	23.0	2.18	0.46
Sodium Bicarbonate	$NaHCO_3$	84.0	84.0	0.60	1.68
Sodium Bisulfate	$NaHSO_4$	120.			
Sodium Bisulfite	$NaHSO_3$	104.			
Sodium Carbonate	Na_2CO_3	106.	53.0	0.94	1.06
Sodium Carbonate	$Na_2CO_3 \cdot 10H_2O$	286.	143.	0.35	2.86
Sodium Chloride	NaCl	58.5	58.5	0.85	1.17
Sodium Hypochlorite	NaClO	74.5	37.3	0.67	1.49
Sodium Hydrate	NaOH	40.0	40.0	1.25	0.80
Sodium Nitrate	$NaNO_3$	85.0	85.0	0.59	1.70
Sodium Nitrite	$NaNO_2$	69.0	34.5	0.73	1.38
Sodium Oxide	Na_2O	62.0	31.0	1.61	0.62
Tri-sodium Phosphate	$Na_3PO_4 \cdot 12H_2O$ (18.7% P_2O_5)	380.2	126.7	0.40	2.53
Tri-sodium Phos. (anhydrous)	Na_3PO_4(43.2% P_2O_5)	164.0	54.7	0.91	1.09
Di-sodium Phosphate	$Na_2HPO_4 \cdot 12H_2O$ (19.8% P_2O_5)	358.2	119.4	0.42	2.39
Di-sodium Phos. (anhydrous)	Na_2HPO_4 (50% P_2O_5)	142.0	47.3	1.06	0.95
Mono-sodium Phosphate	$NaH_2PO_4 \cdot H_2O$ (51.4% P_2O_5)	138.1	46.0	1.09	0.92
Mono-sod. phos. (anhydrous)	NaH_2PO_4 (59.1% P_2O_5)	120.0	40.0	1.25	0.80
Meta-Phosphate (Hagan)	$NaPO_3$ (69% P_2O_5)	102.0	34.0	1.47	0.68
Sodium Sulfate	$Na_2SO_4 \cdot 10H_2O$	322.1	161.1	0.31	3.22
Sodium Sulfate	Na_2SO_4	142.1	71.0	0.70	1.42
Sodium Thiosulfate	$Na_2S_2O_3$	158.1	158.1	0.63	1.59
Sodium Tetrathionate	$Na_2S_4O_6$	270.2	135.1	0.37	2.71
Sodium Sulfite	Na_2SO_3	126.1	63.0	0.79	1.27
Sulfur (Valence 2)	S''	32.1	16.0	3.13	0.32
Sulfur (Valence 4)	S''''	32.1	8.02	6.25	0.16
Sulfur (Valence 6)	S''''''	32.1	5.34	9.10	0.11
Sulfur Dioxide	SO_2	64.1	32.0		
Tin	Sn	119.			
Water	H_2O	18.0	9.00	5.56	0.18
Zinc	Zn	65.4	32.7	1.54	0.65
ACID RADICALS					
Bicarbonate	HCO_3	61.0	61.0	0.82	1.22
Carbonate	CO_3	60.0	30.0	1.67	.60
Carbon Dioxide	CO_2	44.0	22.0	2.27	.44
Chloride	Cl	35.5	35.5	1.41	.71
Iodide	I	126.9	126.9	0.40	2.54
Nitrate	NO_3	62.0	62.0	0.81	1.24
Hydrate	OH	17.0	17.0	2.94	0.34
Phosphate	PO_4	95.0	31.7	1.58	0.63
Phosphorous Oxide	P_2O_5	142.0	23.7	2.11	0.47
Sulfide	S	32.1	16.0	3.11	0.32
Sulfate	SO_4	96.1	48.0	1.04	0.96
Sulfur Trioxide	SO_3	80.1	40.0	1.25	0.80
ACIDS					
Hydrogen	H	1.0	1.0	50.00	0.02
Acetic Acid	$HC_2H_3O_2$	60.1	60.1	0.83	1.20
Carbonic Acid	H_2CO_3	62.0	31.0	1.61	0.62
Hydrochloric Acid	HCl	36.5	36.5	1.37	0.73
Phosphoric Acid	H_3PO_4	98.0	32.7	1.53	0.65
Sulfurous Acid	H_2SO_3	82.1	41.1	1.22	0.82
Sulfuric Acid	H_2SO_4	98.1	49.0	1.02	0.98
Hydrogen Sulfide	H_2S	—	—	—	—
Manganous Acid	H_2MnO_3	104.9	52.5	0.95	1.05

D-30
Grains Per U.S. Gallons – Pounds Per 1000 Gallons

A. To convert grains per U. S. gallons to pounds per 1000 gallons multiply by the factor 0.143.

B. To convert pounds per 1000 gallons to grains per U. S. gallons multiply by the factor 7.0.

Example:

1. 4.5 grains/U. S. gallon × 0.143 = 0.644 lbs./1000 gals.
2. 0.5 lbs./1000 gallons × 7.0 = 3.5 grains/U. S. gal.

D-31
Parts Per Million – Pounds Per 1000 Gallons

A. To convert parts per million to pounds per 1000 gallons divide by the factor 120.

B. To convert pounds per 1000 gallons to parts per million multiply by the factor 120.

Example:

1. $\frac{39 \text{ parts/million}}{120} = 0.325$ lbs./1000 gals.
2. 0.167 lbs./1000 gals. × 120 = 20 parts/million

D-32
Coagulant, Acid, and Sulfate—1 ppm Equivalents

1 Ppm Name of Chemical	1 Ppm. Formula of Chemical	ppm Alkalinity Reduction	ppm SO_3 as $CaCO_3$ Increase	ppm Na_2SO_4 Increase	ppm CO_2 Increase	ppm Total Solids Increase
Filter Alum	$Al_2(SO_4)_3 \cdot 18H_2O$	0.45	0.45	0.64	0.40	0.16
Ammonia Alum	$Al_2(SO_4)_3 \cdot (NH_4)_2SO_4 \cdot 24H_2O$	0.33	0.44	0.63	0.29	0.27
Potash Alum	$Al_2(SO_4)_3 \cdot K_2SO_4 \cdot 24H_2O$	0.32	0.43	0.60	0.28	0.30
Copperas (ferrous sulfate)	$FeSO_4 \cdot 7H_2O$	0.36	0.36	0.51	0.31	0.13
Chlorinated Copperas	$FeSO_4 \cdot 7H_2O + (\frac{1}{2}Cl_2)$	0.54	0.36	0.51	0.48	0.18
Ferric Sulfate (100% $Fe_2(SO_4)_3$)	$Fe_2(SO_4)_3$	0.75	0.75	1.07	0.66	0.27
Sulfuric Acid—98%	H_2SO_4	1.00	1.00	1.42	0.88	0.36
Sulfuric Acid—93.2% (66° Be)	H_2SO_4	0.95	0.95	1.35	0.84	0.34
Sulfuric Acid—77.7% (60° Be)	H_2SO_4	0.79	0.79	1.13	0.70	0.28
Salt Cake—96%	Na_2SO_4	—	0.66	0.95	—	1.00

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D-33
Alkali and Lime – 1 ppm Equivalents

Name 1 Ppm	Formula 1 Ppm	Alkalinity A Increase ppm	Free CO_2 Reduction ppm	T.H. as $CaCO_3$ Increase ppm
Sodium Bicarbonate	$NaHCO_3$	0.60	—	—
Soda Ash (56% Na_2O = 99.16% Na_2CO_3)	Na_2CO_3	0.94	0.41	—
Caustic Soda (76% Na_2O = 98.06% NaOH)	NaOH	1.23	1.08	—
Chemical Lime (Quicklime—Usually 90% CaO)	CaO	1.61	1.41	1.61
Hydrated Lime (Usually 93% $Ca(OH)_2$)	$Ca(OH)_2$	1.26	1.11	1.26

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D-34
Sulfuric, Hydrochloric Acid Equivalent

Name		Formula	Specific Gravity 60°/60°F.	Concentration	Grams/Liter	$CaCO_3$ Equivalent to one lb. Acid	
						Lbs.	Grains
Sulfuric Acid	60° Be	H_2SO_4	1.7059	77.67%	1325	.7926	5548
Sulfuric Acid	66° Be	H_2SO_4	1.8354	93.19%	1710	.9509	6657
Sulfuric Acid	98%	H_2SO_4	1.8407	98.00%	1804	1.0000	7000
Hydrochloric Acid	18% Be	HCl	1.1417	27.92%	319	.3831	2682

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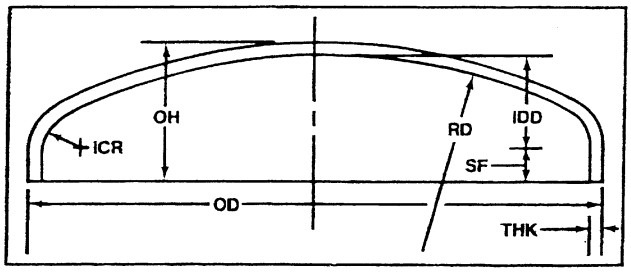

ASME FLANGED AND DISHED HEADS IDD CHART

OD – Outside Diameter
THK – Thickness
OH – Overall Height
SF – Straight Flange
RD – Radius of Dish
ICR – Inside Corner Radius
IDD – Inside Depth of Dish

For "Overall Height" add length of straight flange to IDD given, plus thickness of material.

Use when **RD EQUALS DIAMETER**

OD \ THK / ICR	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	7/8"	1"
12	1/8	1.95	1.92	2.00	2.09							
14	1/8	2.29	2.26	2.27	2.35							
16	1	2.63	2.60	2.57	2.62							
18	1 1/8	2.97	2.94	2.91	2.88							
20	1 1/4	3.31	3.28	3.25	3.22							
22	1 1/8	3.73	3.75	3.67	3.64							
24	1 1/2	4.00	3.97	3.93	3.90							
26	2 1/4	4.72	4.69	4.66	4.63							
28	2 1/4	4.99	4.96	4.92	4.89							
30	2 1/4	5.25	5.22	5.19	5.16							
32	2 1/4	5.52	5.48	5.45	5.42							
34	2 1/4	5.78	5.75	5.72	5.69							
36	2 1/4	6.05	6.02	5.98	5.95							
38	3	6.78	6.74	6.71	6.68	6.65	6.62	6.59	6.56	6.53	6.50	6.44	6.38
40	3	7.04	7.01	6.98	6.95	6.91	6.88	6.85	6.82	6.79	6.76	6.70	6.64
42	3	7.31	7.27	7.24	7.21	7.18	7.15	7.12	7.08	7.05	7.02	6.96	6.90
44	3	7.57	7.54	7.51	7.47	7.44	7.41	7.38	7.35	7.32	7.29	7.22	7.16
46	3	7.84	7.80	7.77	7.74	7.71	7.68	7.64	7.61	7.58	7.55	7.49	7.43
48	3	8.10	8.07	8.04	8.00	7.97	7.94	7.91	7.88	7.85	7.81	7.75	7.69
50	3	8.37	8.34	8.30	8.27	8.24	8.21	8.17	8.14	8.11	8.08	8.02	7.95
52	3 1/4	9.09	9.06	9.03	8.99	8.96	8.93	8.90	8.87	8.84	8.80	8.74	8.68
54	3 1/4	9.35	9.32	9.29	9.26	9.23	9.19	9.16	9.13	9.10	9.07	9.01	8.94
56	3 1/4	9.62	9.59	9.56	9.52	9.49	9.46	9.43	9.40	9.36	9.33	9.27	9.21
58	3 1/4	9.89	9.85	9.82	9.79	9.76	9.72	9.69	9.66	9.63	9.60	9.53	9.47
60	3 1/4	10.15	10.12	10.09	10.05	10.02	9.99	9.96	9.93	9.89	9.86	9.80	9.74
62	3 1/4	10.42	10.39	10.35	10.32	10.29	10.26	10.22	10.19	10.16	10.13	10.06	10.00
64	4 1/4	10.99	10.95	10.92	10.89	10.86	10.83	10.79	10.76	10.73	10.70	10.64	10.57
66	4 1/4	11.25	11.22	11.19	11.16	11.12	11.09	11.06	11.03	10.99	10.96	10.90	10.84
68	4 1/4	11.52	11.49	11.45	11.42	11.39	11.36	11.32	11.29	11.26	11.23	11.16	11.10
70	4 1/4	11.78	11.75	11.72	11.69	11.65	11.62	11.59	11.56	11.53	11.49	11.43	11.37
72	4 1/4	12.35	12.32	12.29	12.26	12.22	12.19	12.16	12.13	12.10	12.06	12.00	11.94
74	4 1/4	12.62	12.59	12.55	12.52	12.49	12.46	12.43	12.39	12.36	12.33	12.27	12.20
76	4 1/4	12.89	12.85	12.82	12.79	12.76	12.72	12.69	12.66	12.63	12.59	12.53	12.47
78	4 1/4	13.15	13.12	13.09	13.05	13.02	12.99	12.96	12.92	12.89	12.86	12.80	12.73
80	5	13.57	13.54	13.50	13.47	13.44	13.41	13.37	13.34	13.31	13.28	13.21	13.15
82	5	13.84	13.80	13.77	13.74	13.70	13.67	13.64	13.61	13.57	13.54	13.48	13.41
84	5 1/4	14.56	14.52	14.49	14.46	14.43	14.39	14.36	14.33	14.30	14.27	14.20	14.14
86	5 1/4	14.82	14.79	14.76	14.72	14.69	14.66	14.63	14.60	14.56	14.53	14.47	14.40
88	5 1/4	15.09	15.05	15.02	14.99	14.96	14.92	14.89	14.86	14.83	14.80	14.73	14.67
90	5 1/4	15.35	15.32	15.29	15.26	15.22	15.19	15.16	15.13	15.09	15.06	15.00	14.93
92	5 1/4	15.62	15.59	15.55	15.52	15.49	15.46	15.42	15.39	15.36	15.33	15.26	15.20
94	5 1/4	15.89	15.85	15.82	15.79	15.75	15.72	15.69	15.66	15.62	15.59	15.53	15.46
96	6 1/2	16.61	16.57	16.54	16.51	16.48	16.44	16.41	16.38	16.35	16.32	16.25	16.19
98	6 1/2	16.87	16.84	16.81	16.77	16.74	16.71	16.68	16.64	16.61	16.58	16.52	16.45
100	6 1/2	17.14	17.10	17.07	17.04	17.01	16.97	16.94	16.91	16.88	16.85	16.78	16.72
102	6 1/2	17.40	17.37	17.34	17.31	17.27	17.24	17.21	17.18	17.14	17.11	17.05	16.98
104	6 1/2	17.67	17.64	17.60	17.57	17.54	17.51	17.47	17.44	17.41	17.38	17.31	17.25
106	6 1/2	17.94	17.90	17.87	17.84	17.80	17.77	17.74	17.71	17.67	17.64	17.58	17.51
108	6 1/2	18.20	18.17	18.14	18.10	18.07	18.04	18.00	17.97	17.94	17.91	17.84	17.78
110	7 1/4	18.92	18.89	18.86	18.82	18.79	18.76	18.73	18.69	18.66	18.63	18.57	18.50
112	7 1/4	19.19	19.15	19.12	19.09	19.06	19.02	18.99	18.96	18.93	18.89	18.83	18.77
114	7 1/4	19.45	19.42	19.39	19.36	19.32	19.29	19.26	19.23	19.19	19.16	19.10	19.03
116	7 1/4	19.72	19.69	19.65	19.62	19.59	19.56	19.52	19.49	19.46	19.43	19.36	19.30
118	7 1/4	19.99	19.95	19.92	19.89	19.85	19.82	19.79	19.76	19.72	19.69	19.63	19.56
120	7 1/4	20.25	20.22	20.19	20.15	20.12	20.09	20.05	20.02	19.99	19.96	19.89	19.83

On Application

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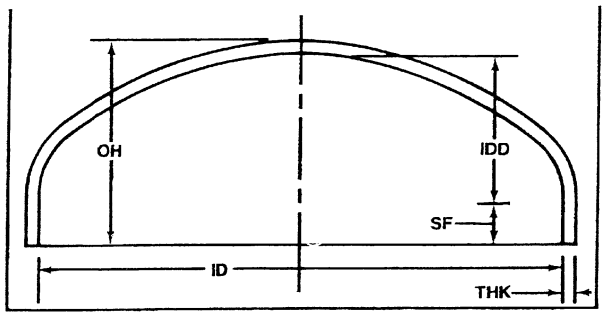

ELLIPTICAL HEADS (2:1 RATIO)

ID – Inside Diameter
THK – Thickness
OH – Overall Height
SF – Straight Flange
IDD – Inside Depth of Dish

X – STANDARD
I – INQUIRE

SIZES AND THICKNESSES OF HEADS

ID \ THK	3/16	1/4	5/16	3/8, 7/16	1/2, 9/16, 5/8	11/16, 3/4, 13/16	7/8, 1	1 1/8, 1 1/4	1 3/8	1 1/2, 1 5/8, 1 3/4	1 7/8	2	2 1/4, 2 1/2, 2 3/4	3	3 1/4	3 1/2	3 3/4	4, 4 1/4, 4 1/2	4 3/4	5, 5 1/4	5 1/2	5 3/4	6	6 1/2	7	8	THK \ ID
6	X	X	X	X	X	X	X	I	I	I																	6
8	X	X	X	X	X	X	X	X	X	I																	8
10	X	X	X	X	X	X	X	X	X	X	X	X															10
12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I												12
14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I												14
16	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I												16
18	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I												18
20	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I												20
22	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												22
24	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I										24
30	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I										30
36	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X									36
42	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							42
48	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I						48
54	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I					54
60	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		60
66		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		66
72		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		72
78			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		78
84				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		84
90				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		90
96				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		96
102				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		102
108				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		108
114				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		114
120				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	I		120

Elliptical (2:1 Ratio)

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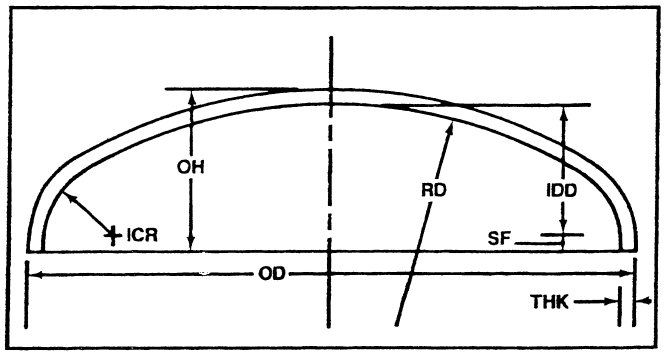


80-10® HEADS

OD — Outside Diameter
THK — Thickness
OH — Overall Height
SF — Straight Flange
RD — Radius of Dish
ICR — Inside Corner Radius
IDD — Inside Depth of Dish

Meeting all A.S.M.E. Unfired Pressure Vessel Code requirements, the 80-10® Head permits significantly higher pressures than other configurations selected for the same service. The 80-10® Head is named for its unique dimensions—the dish radius equals 80% of the head diameter and the inside corner radius equals 10% of the head diameter. These dimensions compare to 100% and 6% respectively for A.S.M.E. F&D Heads.

Figure 1.

INTERNAL PRESSURE COMPARISON

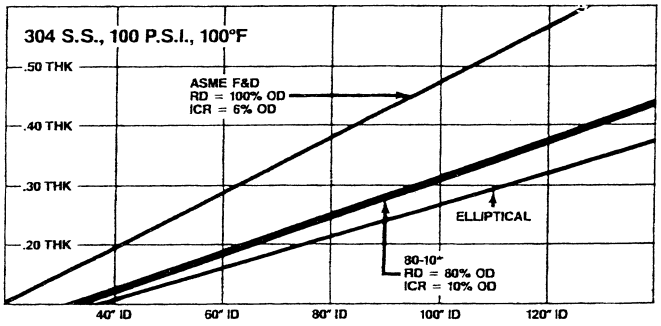
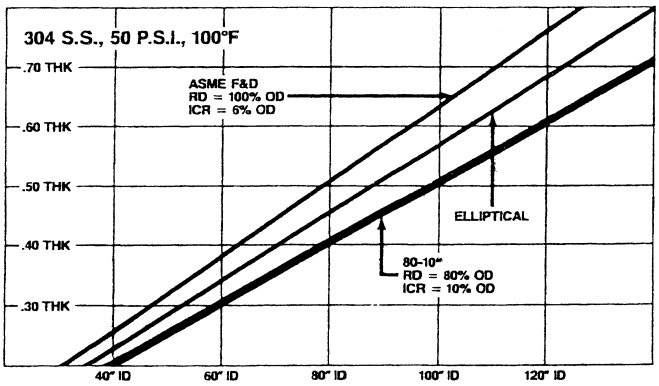


Figure 2.

EXTERNAL PRESSURE COMPARISON



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