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SHIVAJI UNIVERSITY

B.E.CHEMICAL ENGG. – I / II

CHEMICAL PROCESSES AND PLANT DESIGN

DATA – BOOK

Instructions – **Do not write or mark anything on data book.**

APPENDIX OF CALCULATION DATA

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APPENDIX OF CALCULATION DATA

Table 1. Conversion Factors and Constants

Energy and power:

Btu = 0.252 kg-cal
Btu = 0.293 watt-hr
Btu = 0.555 pcu (pound centigrade unit)
Btu = 778 ft-lb
Btu/min = 0.236 hp
Hp = 42.4 Btu/min
Hp = 33,000 ft-lb/min
Hp = 0.7457 kw
Hp-hr = 2543 Btu
Kw = 1.3415 hp
Watt-hr = 3.415 Btu

Fluid flow:

Bbl/hr = 0.0936 cfm
Bbl/hr = 0.700 gpm
Bbl/day = 0.0292 gpm
Bbl/day = 0.0039 cfm
Cfm = 10.686 bbl/hr
Gpm = 1.429 bbl/hr
Gpm = 34.3 bbl/day
Gpm × s (specific gravity) = 500 × s lb/hr

Heat-transfer coefficients:

Btu/(hr)(ft^2)(°F) = 1.0 pcu/(hr)(ft^2)(°C)
Btu/(hr)(ft^2)(°F) = 4.88 kg-cal/(hr)(m^2)(°C)
Btu/(hr)(ft^2)(°F) = 0.00204 watts/(in.^{2})(°F)

Length, area, and volume:

Bbl = 42 gal
Bbl = 5.615 ft^3
Cm = 0.3937 in.
Ft^3 = 0.1781 bbl
Ft^3 = 7.48 gal
Ft^3 = 0.0283 m^3
M^3 = 6.290 bbl
M^3 = 35.314 ft^3
Ft = 30.48 cm
Ft = 0.3048 m
Gal = 0.02381 bbl
Gal = 0.1337 ft^3
Gal = 3.785 liter
Gal = 0.8327 gal (Imperial)
In. = 2.54 cm
Liter = 0.2642 gal
Liter = 1.0567 qt
M = 3.281 ft
Ft^2 = 0.0929 m^2
M^2 = 10.76 ft^2

Pressure:

Atm = 33.93 ft of water at 60°F
Atm = 29.92 in. Hg at 32°F
Atm = 760 mm Hg at 32°F
Atm = 14.696 psi
Atm = 2116.8 lb/ft²
Atm = 1.033 kg/cm²
Ft of water at 60°F = 0.4331 psi
In. of water at 60°F = 0.0361 psi
Kg/cm² = 14.223 psi
Psi = 2.309 Ft of water at 60°F

Temperature:

Temperature °C = $\frac{5}{9}$(°F − 32)
Temperature °F = $\frac{9}{5}$(°C + 32)
Temperature °F absolute (°R) = °F + 460
Temperature °C absolute (°K) = °C + 273

Thermal conductivity:

Btu/(hr)(ft²)(°F/ft) = 12 Btu/(hr)(ft²)(°F/in.)
Btu/(hr)(ft²)(°F/ft) = 1.49 kg-cal/(hr)(m²)(°C/m)
Btu/(hr)(ft²)(°F/ft) = 0.0173 watts/(cm²)(°C/cm)

Viscosity (additional factors are contained in Fig. 13):

Poise = 1 g/(cm)(sec)
Centipoise = 0.01 poise
Centipoise = 2.42 lb/(ft)(hr)

Weight:

Lb = 0.4536 kg
Lb = 7000 grains
Ton (short or net) = 2000 lb
Ton (long) = 2240 lb
Ton (metric) = 2205 lb
Ton (metric) = 1000 kg

Constants:

Acceleration of gravity = 32.2 ft/sec²
Acceleration of gravity = 4.18 × 10⁸ ft/hr²
Density of a cubic foot of water = 62.5 lb/ft³

②

TABLE 2. THERMAL CONDUCTIVITIES OF SOME BUILDING AND INSULATING MATERIALS*

k = Btu/(hr)(ft²)(°F/ft)

Material	Apparent density ρ, lb/ft³ at room temperature	°F	k
Aerogel, silica, opacified	8.5	248	0.013
		554	0.026
Asbestos-cement boards	120	68	0.43
Asbestos sheets	55.5	124	0.096
Asbestos slate	112	32	0.087
	112	140	0.114
Asbestos	29.3	−328	0.043
	29.3	32	0.090
	36	32	0.087
	36	212	0.111
	36	392	0.120
	36	752	0.129
	43.5	−328	0.090
	43.5	32	0.135
Aluminum foil, 7 air spaces per 2.5 in.	0.2	100	0.025
		351	0.038
Ashes, wood	......	32–212	0.041
Asphalt	132	68	0.43
Boiler scale (ref. 364)			
Bricks			
Alumina (92–99% Al_2O_3 by weight) fused	......	801	1.8
Alumina (64–65% Al_2O_3 by weight)	......	2399	2.7
(See also Bricks, fire clay)	115	1472	0.62
	115	2012	0.63
Building brickwork	......	68	0.4
Chrome brick (32% Cr_2O_3 by weight)	200	392	0.67
	200	1202	0.85
	200	2399	1.0
Diatomaceous earth, natural, across strata	27.7	399	0.051
	27.7	1600	0.077
Diatomaceous, natural, parallel to strata	27.7	399	0.081
	27 7	1600	0.106
Diatomaceous earth, molded and fired	38	399	0.14
	38	1600	0.18
Diatomaceous earth and clay, molded and fired	42.3	399	0.14
	42.3	1600	0.19
Diatomaceous earth, high burn, large pores	37	392	0.13
	37	1832	0.34

TABLE 2. THERMAL CONDUCTIVITIES OF SOME BUILDING AND INSULATING MATERIALS.*—(*Continued*)

Material	Apparent density ρ, lb/ft^3 at room temperature	°F	k
Bricks: (*Continued*)			
Fire clay, Missouri	......	392	0.58
		1112	0.85
		1832	0.95
		2552	1.02
Kaolin insulating brick	27	932	0.15
	27	2102	0.26
Kaolin insulating firebrick	19	392	0.050
	19	1400	0.113
Magnesite (86.8% MgO, 6.3% Fe_2O_3, 3% CaO, 2.6% SiO_2 by weight)	158	399	2.2
	158	1202	1.6
	158	2192	1.1
Silicon carbide brick, recrystallized	129	1112	10.7
	129	1472	9.2
	129	1832	8.0
	129	2192	7.0
	129	2552	6.3
Calcium carbonate, natural	162	86	1.3
White marble	......	......	1.7
Chalk	96	......	0.4
Calcium sulphate ($4H_2O$), artificial	84.6	104	0.22
Plaster, artificial	132	167	0.43
Building	77.9	77	0.25
Cambric, varnished	......	100	0.09
Carbon, gas	......	32–212	2.0
Cardboard, corrugated	......	......	0.037
Celluloid	87.3	86	0.12
Charcoal flakes	11.9	176	0.043
	15	176	0.051
Clinker, granular	......	32–1292	0.27
Coke, petroleum	......	212	3.4
		932	2.9
Coke, powdered	......	32–212	0.11
Concrete, cinder	......	......	0.20
1:4 dry	......	......	0.44
Stone	......	......	0.54
Cotton wool	5	86	0.024
Cork board	10	86	0.025
Cork, ground	9.4	86	0.025
Regranulated	8.1	86	0.026

(3)

TABLE 2. THERMAL CONDUCTIVITIES OF SOME BUILDING AND INSULATING MATERIALS.*—(*Continued*)

Material	Apparent density ρ, lb/ft^3 at room temperature	°F	k
Diatomaceous earth powder, coarse	20.0	100	0.036
	20.0	1600	0.082
Fine	17.2	399	0.040
	17.2	1600	0.074
Molded pipe covering	26.0	399	0.051
	26.0	1600	0.088
4 vol. calcined earth and 1 vol. cement, poured and fired	61.8	399	0.16
	61.8	1600	0.23
Dolomite	167	122	1.0
Ebonite	......	......	0.10
Enamel, silicate	38	......	0.5–0.75
Felt, wool	20.6	86	0.03
Fiber insulating board	14.8	70	0.028
Fiber, red	80.5	68	0.27
With binder, baked	......	68–207	0.097
Gas carbon	......	32–212	2.0
Glass	......	......	0.2–0.73
Boro-silicate type	139	86–167	0.63
Soda glass	......	......	0.3–0.44
Window glass	......	......	0.3–0.61
Granite	......	......	1.0–2.3
Graphite, dense, commercial	......	32	86.7
Powdered, through 100 mesh	30	104	0.104
Gypsum, molded and dry	78	68	0.25
Hair, felt, perpendicular to fibers	17	86	0.021
Ice	57.5	32	1.3
Infusorial earth (see Diatomaceous earth)			
Kapok	0.88	68	0.020
Lampblack	10	104	0.038
Lava	......	......	0.49
Leather, sole	62.4	......	0.092
Limestone (15.3 vol % H_2O)	103	75	0.54
Linen	......	86	0.05
Magnesia, powdered	49.7	117	0.35
Magnesia, light carbonate	19	70	0.04
Magnesium oxide, compressed	49.9	68	0.32
Marble	......	......	1.2–1.7

TABLE 2. THERMAL CONDUCTIVITIES OF SOME BUILDING AND INSULATING MATERIALS.*—(*Continued*)

Material	Apparent density ρ, lb/ft³ at room temperature	°F	k
Mica, perpendicular to planes	......	122	0.25
Mill shavings	......	......	0.033–0.05
Mineral wool	9.4	86	0.0225
	19.7	86	0.024
Paper	......	......	0.075
Paraffin wax	......	32	0.14
Petroleum coke	......	212	3.4
	......	932	2.9
Porcelain	......	392	0.88
Portland cement (see Concrete)	......	194	0.17
Pumice stone	......	70–151	0.14
Pyroxylin plastics	......	......	0.075
Rubber, hard	74.8	32	0.087
Para	......	70	0.109
Soft	......	70	0.075–0.092
Sand, dry	94.6	68	0.19
Sandstone	140	104	1.06
Sawdust	12	70	0.03
Scale (ref. 364)			
Silk	6.3	......	0.026
Varnished	......	100	0.096
Slag, blast furnace	......	75–261	0.064
Slag wool	12	86	0.022
Slate	......	201	0.86
Snow	34.7	32	0.27
Sulphur, monoclinic	......	212	0.09–0.097
Rhombic	......	70	0.16
Wallboard, insulating type	14.8	70	0.028
Wallboard, stiff pasteboard	43	86	0.04
Wood shavings	8.8	86	0.034
Wood, across grain			
Balsa	7–8	86	0.025–0.03
Oak	51.5	59	0.12
Maple	44.7	122	0.11
Pine, white	34.0	59	0.087
Teak	40.0	59	0.10
White fir	28.1	140	0.062
Wood, parallel to grain			
Pine	34.4	70	0.20
Wool, animal	6.9	86	0.021

* From L. S. Marks, "Mechanical Engineers' Handbook," McGraw-Hill Book Company, Inc., New York, 1941.

TABLE 3. THERMAL CONDUCTIVITIES, SPECIFIC HEATS, SPECIFIC GRAVITIES OF METALS AND ALLOYS

k = Btu/(hr)(ft²)(°F/ft)

Substance	Temp, °F	k*	Specific heat,† Btu/(lb)(°F)	Specific gravity
Aluminum	32	117	0.183	2.55–7.8
Aluminum	212	119	0.1824	
Aluminum	932	155	0.1872	
Antimony	32	10.6	0.0493	
Antimony	212	9.7	0.0508	
Bismuth	64	4.7	0.0294	9.8
Bismuth	212	3.9	0.0304	
Brass (70-30)	32	56	0.1315‡	8.4–8.7
Brass	212	60	0.1488‡	
Brass	752	67	0.2015‡	
Copper	32	224	0.1487	8.8–8.95
Copper	212	218	0.1712	
Copper	932	207	0.2634	
Cadmium	64	53.7	0.0550	8.65
Cadmium	212	52.2	0.0567	
Gold	64	169.0	0.030	19.25–19.35
Gold	212	170.8	0.031	
Iron, cast	32	32	0.1064	7.03–7.13
Iron, cast	212	30	0.1178	
Iron, cast	752	25	0.1519	
Iron, wrought	64	34.6	See Iron	7.6–7.9
Iron, wrought	212	27.6	See Iron	
Lead	32	20	0.0306	11.34
Lead	212	19	0.0315	
Lead	572	18	0.0335	
Magnesium	32–212	92	0.255	1.74
Mercury	32	4.8	0.0329	13.6
Nickel	32	36	0.1050	8.9
Nickel	212	34	0.1170	
Nickel	572	32	0.1408	
Silver	32	242	0.0557	10.4–10.6
Silver	212	238	0.0571	
Steel	32	26	See Iron	7.83
Steel	212	26	See Iron	
Steel	1112	21	See Iron	
Tantalum	64	32	0.0342	16.6
Zinc	32	65	0.0917	6.9–7.2
Zinc	212	64	0.0958	
Zinc	752	54	0.1082	

* From L. S. Marks, "Mechanical Engineers' Handbook," McGraw-Hill Book Company, Inc., New York, 1941.

† From K. K. Kelley, *U.S. Bur. Mines Bull.* 371 (1939).

‡ Weighted value for copper and zinc.

TABLE 4. THERMAL CONDUCTIVITIES OF LIQUIDS*

k = Btu/(hr)(ft²)(°F/ft)

A linear variation with temperature may be assumed. The extreme values given constitute also the temperature limits over which the data are recommended.

Liquid	°F	k
Acetic acid 100%	68	0.099
50%	68	0.20
Acetone	86	0.102
	167	0.095
Allyl alcohol	77–86	0.104
Ammonia	5–86	0.29
Ammonia, aqueous 26%	68	0.261
	140	0.29
Amyl acetate	50	0.083
Alcohol (n-)	86	0.094
	212	0.089
	86	0.088
	167	0.087
Aniline	32–68	0.100
Benzene	86	0.092
	140	0.087
Bromobenzene	86	0.074
	212	0.070
Butyl acetate (n-)	77–86	0.085
Alcohol (n-)	86	0.097
	167	0.095
(iso-)	50	0.091
Calcium chloride brine 30%	86	0.32
15%	86	0.34
Carbon disulphide	86	0.093
	167	0.088
Tetrachloride	32	0.107
	154	0.094
Chlorobenzene	50	0.083
Chloroform	86	0.080
Cymene (para)	86	0.078
	140	0.079
Decane (n-)	86	0.085
	140	0.083
Dichlorodifluoromethane	20	0.057
	60	0.053
	100	0.048
	140	0.043
	180	0.038
Dichloroethane	122	0.082
Dichloromethane	5	0.111
	86	0.096
Ethyl acetate	68	0.101
Alcohol 100%	68	0.105
80%	68	0.137
60%	68	0.176
40%	68	0.224
20%	68	0.281
100%	122	0.087
Benzene	86	0.086
	140	0.082
Bromide	68	0.070
Ether	86	0.080
	167	0.078
Iodide	104	0.064
	167	0.063
Ethylene glycol	32	0.153
Gasoline	86	0.078
Glycerol 100%	68	0.164
80%	68	0.189
60%	68	0.220
40%	68	0.259
20%	68	0.278
100%	212	0.164
Heptane (n-)	86	0.081
	140	0.079
Hexane (n-)	86	0.080
	140	0.078
Heptyl alcohol (n-)	86	0.094
	167	0.091
Hexyl alcohol (n-)	86	0.093
	167	0.090
Kerosene	68	0.086
	167	0.081
Lauric acid	212	0.102
Mercury	82	4.83
Methyl aclohol 100%	68	0.124
80%	68	0.154
60%	68	0.190
40%	68	0.234
20%	68	0.284
100%	122	0.114
Chloride	5	0.111
	86	0.089
Nitrobenzene	86	0.095
	212	0.088
Nitromethane	86	0.125
	140	0.120
Nonane (n-)	86	0.084
	140	0.082
Octane (n-)	86	0.083
	140	0.081
Oils		
Castor	68	0.104
	212	0.100
Olive	68	0.097
	212	0.095
Oleic acid	212	0.0925
Palmitic acid	212	0.0835
Paraldehyde	86	0.084
	212	0.078
Pentane (n-)	86	0.078
	167	0.074
Perchloroethylene	122	0.092
Petroleum ether	86	0.075
	167	0.073
Propyl alcohol (n-)	86	0.099
	167	0.095
Alcohol (iso-)	86	0.091
	140	0.090
Sodium	212	49
	410	46
Sodium chloride brine 25.0%	86	0.33
12.5%	86	0.34
Stearic acid	212	0.0786
Sulfuric acid 90%	86	0.21
60%	86	0.25
30%	86	0.30
Sulfur dioxide	5	0.128
	86	0.111
Toluene	86	0.086
	167	0.084
β-trichloroethane	122	0.077
Trichloroethylene	122	0.080
Turpentine	59	0.074
Vaseline	59	0.106
Water	32	0.330
	86	0.356
	140	0.381
	176	0.398
Xylene (ortho-)	68	0.090
(meta-)	68	0.090

* From Perry, J. H., "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York, 1950.

TABLE 5. THERMAL CONDUCTIVITIES OF GASES AND VAPORS*

k = Btu/(hr)(ft²)(°F/ft)

The extreme temperature values given constitute the experimental range. For extrapolation to other temperatures, it is suggested that the data given be plotted as log k vs. log T or that use be made of the assumption that the ratio $c\mu/k$ is practically independent of temperature (or of pressure, within moderate limits).

Substance	°F	k
Acetone	32	0.0057
	115	0.0074
	212	0.0099
	363	0.0147
Acetylene	−103	0.0068
	32	0.0108
	122	0.0140
	212	0.0172
Air	−148	0.0095
	32	0.0140
	212	0.0183
	392	0.0226
	572	0.0265
Ammonia	−76	0.0095
	32	0.0128
	122	0.0157
	212	0.0185
Benzene	32	0.0052
	115	0.0073
	212	0.0103
	363	0.0152
	413	0.0176
Butane (n-)	32	0.0078
	212	0.0135
(iso-)	32	0.0080
	212	0.0139
Carbon dioxide	−58	0.0068
	32	0.0085
	212	0.0133
	392	0.0181
	572	0.0228
Disulpnide	32	0.0040
	45	0.0042
Monoxide	−312	0.0041
	−294	0.0046
	32	0.0135
Tetrachloride	115	0.0041
	212	0.0052
	363	0.0065
Chlorine	32	0.0043
Chloroform	32	0.0038
	115	0.0046
	212	0 0058
	363	0.0077
Cyclohexane	216	0.0095
Dichlorodifluoromethane	32	0.0048
	122	0.0064
	212	0.0080
	302	0.0097
Ethane	−94	0.0066
	−29	0.0086
	32	0.0106
	212	0.0175
Ethyl acetate	115	0.0072
	212	0.0096
	363	0.0141
Alcohol	68	0.0089
	212	0.0124
Chloride	32	0.0055
	212	0.0095
	363	0.0135
	413	0.0152
Ether	32	0.0077
	115	0.0099
	212	0.0131
	363	0.0189
	413	0.0209
Ethylene	−96	0.0064
	32	0.0101
	122	0.0131
	212	0.0161
Heptane (n-)	392	0.0112
	212	0.0103
Hexane (n-)	32	0.0072
	68	0.0080
Hexene	32	0.0061
	212	0.0109
Hydrogen	−148	0.065
	−58	0.083
	32	0.100
	122	0.115
	212	0.129
	572	0.178
Hydrogen and carbon dioxide	32	
0% H_2	....	0.0083
20%	....	0.0165
40%	....	0.0270
60%	....	0.0410
80%	....	0.0620
100%	....	0.10

TABLE 5. THERMAL CONDUCTIVITIES OF GASES AND VAPORS.*—(*Continued*)

Substance	°F	k
Hydrogen and nitrogen	32	
0 % H_2	.....	0.0133
20 %	.....	0.0212
40 %	.....	0.0313
60 %	.....	0.0438
80 %	.....	0.0635
Hydrogen and nitrous oxide	32	
0 % H_2	.....	0.0002
20 %	.....	0.0170
40 %	.....	0.0270
60 %	.....	0.0410
80 %	.....	0.0650
Hydrogen sulphide	32	0.0076
Mercury	392	0.0197
Methane	−148	0.0100
	−58	0.0145
	32	0.0175
	122	0.0215
Methyl alcohol	32	0.0083
	212	0.0128
Acetate	32	0.0059
	68	0.0068
Methyl chloride	32	0.0053
	115	0.0072
	212	0.0094
	363	0.0130
	413	0.0148
Methylene chloride	32	0.0039
	115	0.0049
	212	0.0063
	413	0.0095

Substance	°F	k
Nitric oxide	−94	0.0103
	32	0.0138
Nitrogen	−148	0.0095
	32	0.0140
	122	0.0160
	212	0.0180
Nitrous oxide	−98	0.0067
	32	0.0087
	212	0.0128
Oxygen	−148	0.0095
	−58	0.0119
	32	0.0142
	122	0.0164
	212	0.0185
Pentane (n-)	32	0.0074
	68	0.0083
(iso-)	32	0.0072
	212	0.0127
Propane	32	0.0087
	212	0.0151
Sulphur dioxide	32	0.0050
	212	0.0069
Water vapor	115	0.0120
	212	0.0137
	392	0.0187
	572	0.0248
	752	0.0315
	932	0.0441

* From Perry, J. H., "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York, 1950.

115 - 6.007
100 -

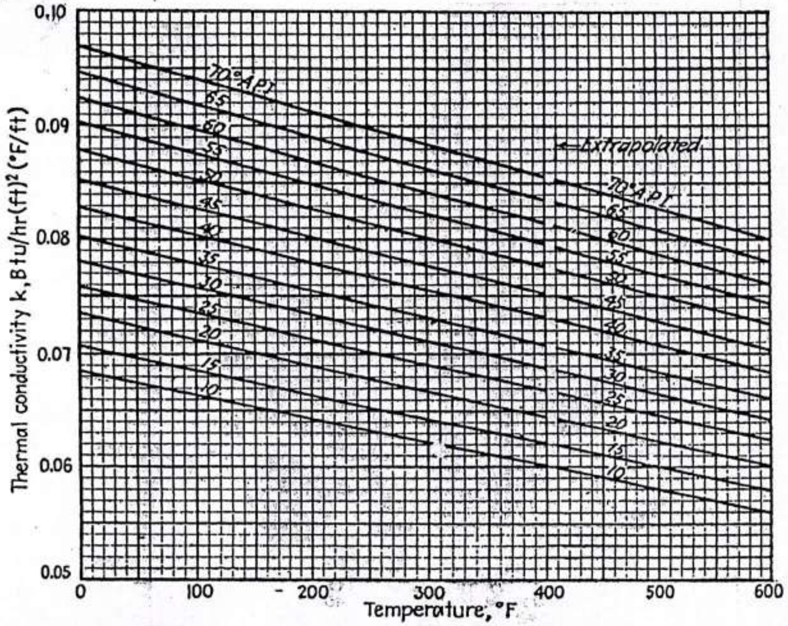
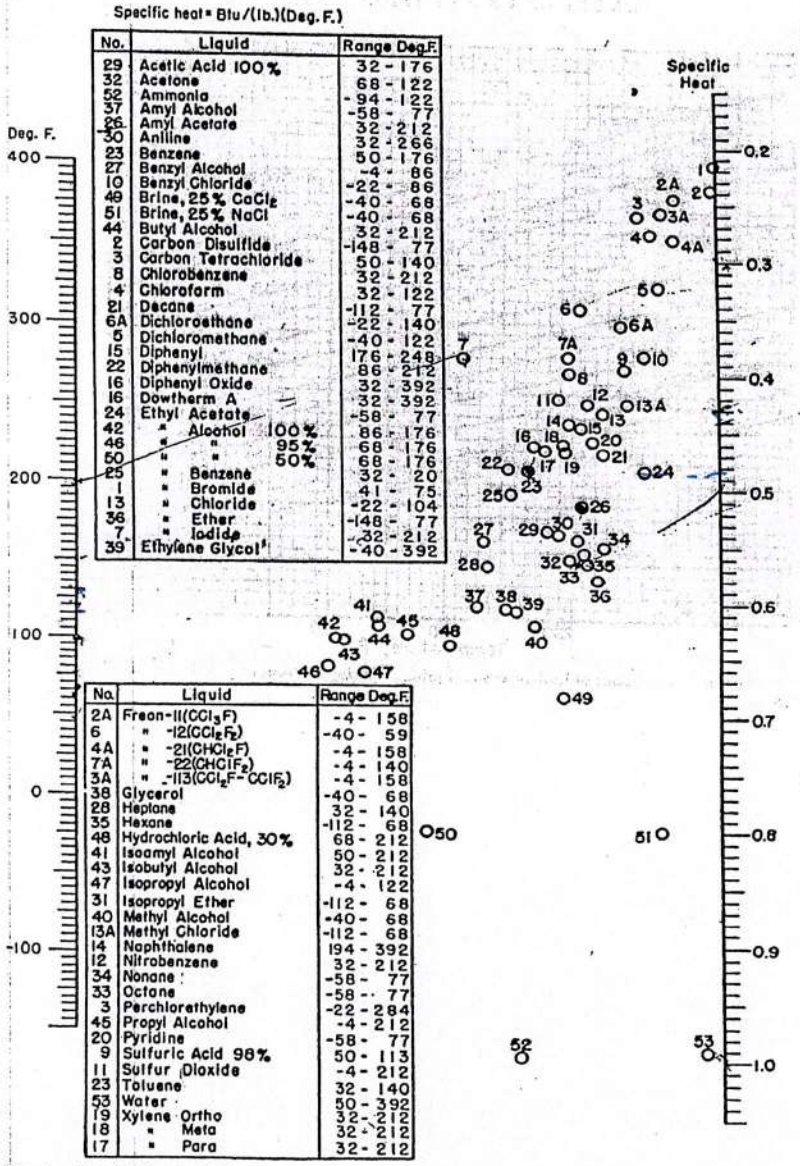


FIG. 1. Thermal conductivities of hydrocarbon liquids. (*Adapted from Natl. Bur. Standards Misc. Pub. 97.*)



Specific heat = Btu/(lb.)(Deg. F.)

No.	Liquid	Range Deg.F.
29	Acetic Acid 100%	32 - 176
32	Acetone	68 - 122
52	Ammonia	-94 - 122
37	Amyl Alcohol	-58 - 77
26	Amyl Acetate	32 - 212
30	Aniline	32 - 266
23	Benzene	50 - 176
27	Benzyl Alcohol	-4 - 86
10	Benzyl Chloride	-22 - 86
49	Brine, 25% $CaCl_2$	-40 - 68
51	Brine, 25% NaCl	-40 - 68
44	Butyl Alcohol	32 - 212
2	Carbon Disulfide	-148 - 77
3	Carbon Tetrachloride	50 - 140
8	Chlorobenzene	32 - 212
4	Chloroform	32 - 122
21	Decane	-112 - 77
6A	Dichloroethane	-22 - 140
5	Dichloromethane	-40 - 122
15	Diphenyl	176 - 248
22	Diphenylmethane	86 - 212
16	Diphenyl Oxide	32 - 392
16	Dowtherm A	32 - 392
24	Ethyl Acetate	-58 - 77
42	" Alcohol 100%	86 - 176
46	" " 95%	68 - 176
50	" " 50%	68 - 176
25	" Benzene	32 - 20
1	" Bromide	41 - 75
13	" Chloride	-22 - 104
36	" Ether	-148 - 77
7	" Iodide	-32 - 212
39	Ethylene Glycol	-40 - 392

No.	Liquid	Range Deg.F.
2A	Freon-11(CCl_3F)	-4 - 158
6	" -12(CCl_2F_2)	-40 - 59
4A	" -21($CHCl_2F$)	-4 - 158
7A	" -22($CHClF_2$)	-4 - 140
3A	" -113($CCl_2F-CClF_2$)	-4 - 158
38	Glycerol	-40 - 68
28	Heptane	32 - 140
35	Hexane	-112 - 68
48	Hydrochloric Acid, 30%	68 - 212
41	Isoamyl Alcohol	50 - 212
43	Isobutyl Alcohol	32 - 212
47	Isopropyl Alcohol	-4 - 122
31	Isopropyl Ether	-112 - 68
40	Methyl Alcohol	-40 - 68
13A	Methyl Chloride	-112 - 68
14	Naphthalene	194 - 392
12	Nitrobenzene	32 - 212
34	Nonane	-58 - 77
33	Octane	-58 - 77
3	Perchlorethylene	-22 - 284
45	Propyl Alcohol	-4 - 212
20	Pyridine	-58 - 77
9	Sulfuric Acid 98%	50 - 113
11	Sulfur Dioxide	-4 - 212
23	Toluene	32 - 140
53	Water	50 - 392
19	Xylene Ortho	32 - 212
18	" Meta	32 - 212
17	" Para	32 - 212

FIG. 2. Specific heats of liquids. (*Chilton, Colburn, and Vernon, based mainly on data from International Critical Tables. Perry, "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York,* 1950.)

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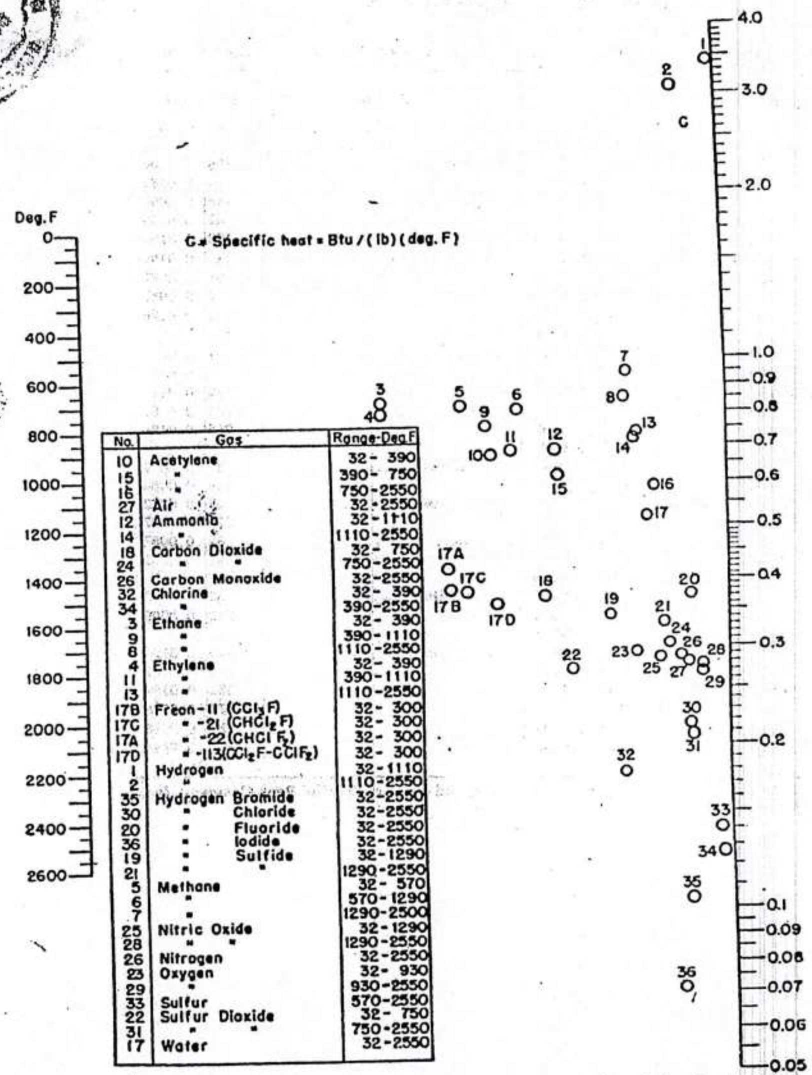
(7)



No.	Gas	Range-Deg F
10	Acetylene	32 - 390
15	"	390 - 750
16	"	750 - 2550
27	Air	32 - 2550
12	Ammonia	32 - 1110
14	"	1110 - 2550
18	Carbon Dioxide	32 - 750
24	" "	750 - 2550
26	Carbon Monoxide	32 - 2550
32	Chlorine	32 - 390
34	"	390 - 2550
3	Ethane	32 - 390
9	"	390 - 1110
8	"	1110 - 2550
4	Ethylene	32 - 390
11	"	390 - 1110
13	"	1110 - 2550
17B	Freon-11 (CCl_3F)	32 - 300
17C	" -21 ($CHCl_2F$)	32 - 300
17A	" -22 ($CHClF_2$)	32 - 300
17D	" -113($CCl_2F-CClF_2$)	32 - 300
1	Hydrogen	32 - 1110
2	"	1110 - 2550
35	Hydrogen Bromide	32 - 2550
30	" Chloride	32 - 2550
20	" Fluoride	32 - 2550
36	" Iodide	32 - 2550
19	" Sulfide	32 - 1290
21	" "	1290 - 2550
5	Methane	32 - 570
6	"	570 - 1290
7	"	1290 - 2500
25	Nitric Oxide	32 - 1290
28	" "	1290 - 2550
26	Nitrogen	32 - 2550
23	Oxygen	32 - 930
29	"	930 - 2550
33	Sulfur	570 - 2550
22	Sulfur Dioxide	32 - 750
31	" "	750 - 2550
17	Water	32 - 2550

FIG. 3. Specific heats of gases at 1 atm. (*Perry, "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York,* 1950.)

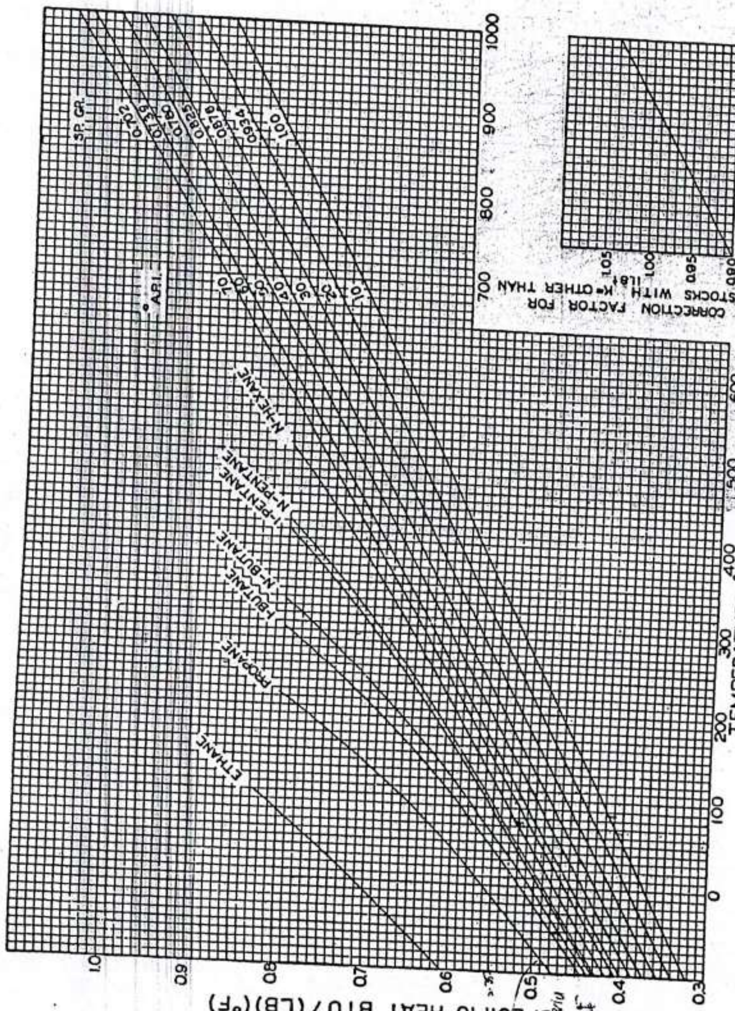


FIG. 4. Specific heats of hydrocarbon liquids. [*Holcomb and Brown, Ind. Eng. Chem.*, **34**, 595 (1942).]

† K = characterization factor.

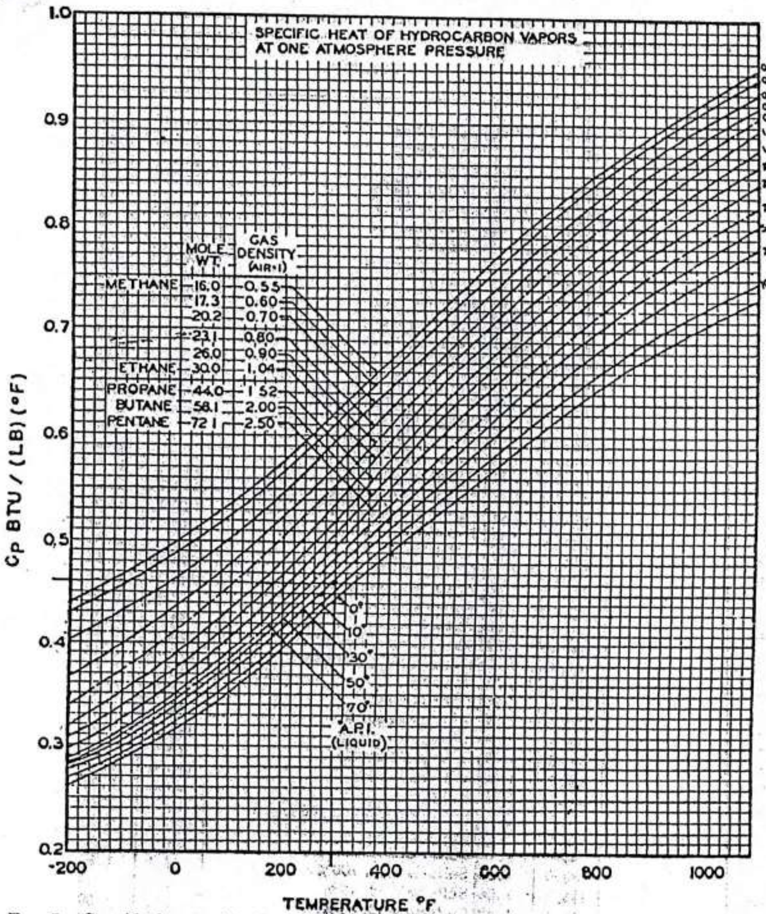


FIG. 5. Specific heats of hydrocarbon vapors at 1 atm. [*Holcomb and Brown, Ind. Eng. Chem.*, **34**, 595 (1942).]

TABLE 6. SPECIFIC GRAVITIES AND MOLECULAR WEIGHTS OF LIQUIDS

Compound	Mol. wt.	s*	Compound	Mol. wt.	s*
Acetaldehyde	44.1	0.78	Ethyl iodide	155.9	1.93
Acetic acid, 100%	60.1	1.05	Ethyl glycol	88.1	1.04
Acetic acid, 70%	......	1.07	Formic acid	46.0	1.22
Acetic anhydride	102.1	1.08	Glycerol, 100%	92.1	1.26
Acetone	58.1	0.79	Glycerol, 50%	......	1.13
Allyl alcohol	58.1	0.86	*n*-Heptane	100.2	0.68
Ammonia, 100%	17.0	0.61	*n*-Hexane	86.1	0.66
Ammonia, 26%	......	0.91	Isopropyl alcohol	60.1	0.79
Amyl acetate	130.2	0.88	Mercury	200.6	13.55
Amyl alcohol	88.2	0.81	Methanol, 100%	32.5	0.79
Aniline	93.1	1.02	Methanol, 90%	......	0.82
Anisole	108.1	0.99	Methanol, 40%	......	0.94
Arsenic trichloride	181.3	2.16	Methyl acetate	74.9	0.93
Benzene	78.1	0.88	Methyl chloride	50.5	0.92
Brine, $CaCl_2$ 25%	......	1.23	Methyl ethyl ketone	72.1	0.81
Brine, NaCl 25%	......	1.19	Naphthalene	128.1	1.14
Bromotoluene, ortho	171.0	1.42	Nitric acid, 95%	......	1.50
Bromotoluene, meta	171.0	1.41	Nitric acid, 60%	......	1.38
Bromotoluene, para	171.0	1.39	Nitrobenzene	123.1	1.20
n-Butane	58.1	0.60	Nitrotoluene, ortho	137.1	1.16
i-Butane	58.1	0.60	Nitrotoluene, meta	137.1	1.16
Butyl acetate	116.2	0.88	Nitrotoluene, para	137.1	1.29
n-Butyl alcohol	74.1	0.81	*n*-Octane	114.2	0.70
i-Butyl alcohol	74.1	0.82	Octyl alcohol	130.23	0.82
n-Butyric acid	88.1	0.96	Pentachloroethane	202.3	1.67
i-Butyric acid	88.1	0.96	*n*-Pentane	72.1	0.63
Carbon dioxide	44.0	1.29	Phenol	94.1	1.07
Carbon disulfide	76.1	1.26	Phosphorus tribromide	270.8	2.85
Carbon tetrachloride	153.8	1.60	Phosphorus trichloride	137.4	1.57
Chlorobenzene	112.6	1.11	Propane	44.1	0.59
Chloroform	119.4	1.49	Propionic acid	74.1	0.99
Chlorosulfonic acid	116.5	1.77	*n*-Propyl alcohol	60.1	0.80
Chlorotoluene, ortho	126.6	1.08	*n*-Propyl bromide	123.0	1.35
Chlorotoluene, meta	126.6	1.07	*n*-Propyl chloride	78.5	0.89
Chlorotoluene, para	126.6	1.07	*n*-Propyl iodide	170.0	1.75
Cresol, meta	108.1	1.03	Sodium	23.0	0.97
Cyclohexanol	100.2	0.96	Sodium hydroxide, 50%	......	1.53
Dibromo methane	187.9	2.09	Stannic chloride	260.5	2.23
Dichloro ethane	99.0	1.17	Sulfur dioxide	64.1	1.38
Dichloro methane	88.9	1.34	Sulfuric acid, 100%	98.1	1.83
Diethyl oxalate	146.1	1.08	Sulfuric acid, 98%	......	1.84
Dimethyl oxalate	118.1	1.42	Sulfuric acid, 60%	......	1.50
Diphenyl	154.2	0.99	Sulfuryl chloride	135.0	1.67
Dipropyl oxalate	174.1	1.02	Tetra chloroethane	167.9	1.60
Ethyl acetate	88.1	0.90	Tetra chloroethylene	165.9	1.63
Ethyl alcohol, 100%	46.1	0.79	Titanium tetrachloride	189.7	1.73
Ethyl alcohol, 95%	......	0.81	Toluene	92.1	0.87
Ethyl alcohol, 40%	......	0.94	Trichloroethylene	131.4	1.46
Ethyl benzene	106.1	0.87	Vinyl acetate	86.1	0.93
Ethyl bromide	108.9	1.43	Water	18.0	1.0
Ethyl chloride	64.5	0.92	Xylene, ortho	106.1	0.87
Ethyl ether	74.1	0.71	Xylene, meta	106.1	0.86
Ethyl formate	74.1	0.92	Xylene, para	106.1	0.86

* At approximately 68°F. These values will be satisfactory, without extrapolation, for most engineering problems.

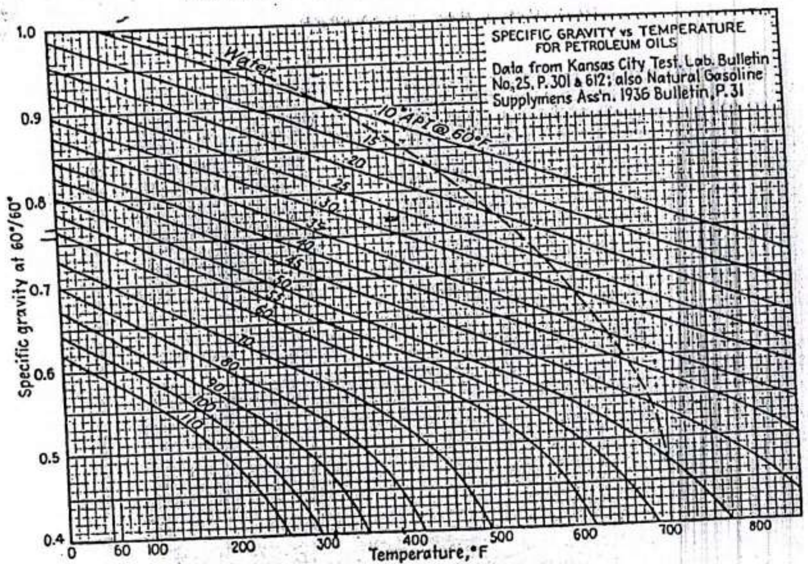


FIG. 6. Specific gravities of hydrocarbons.

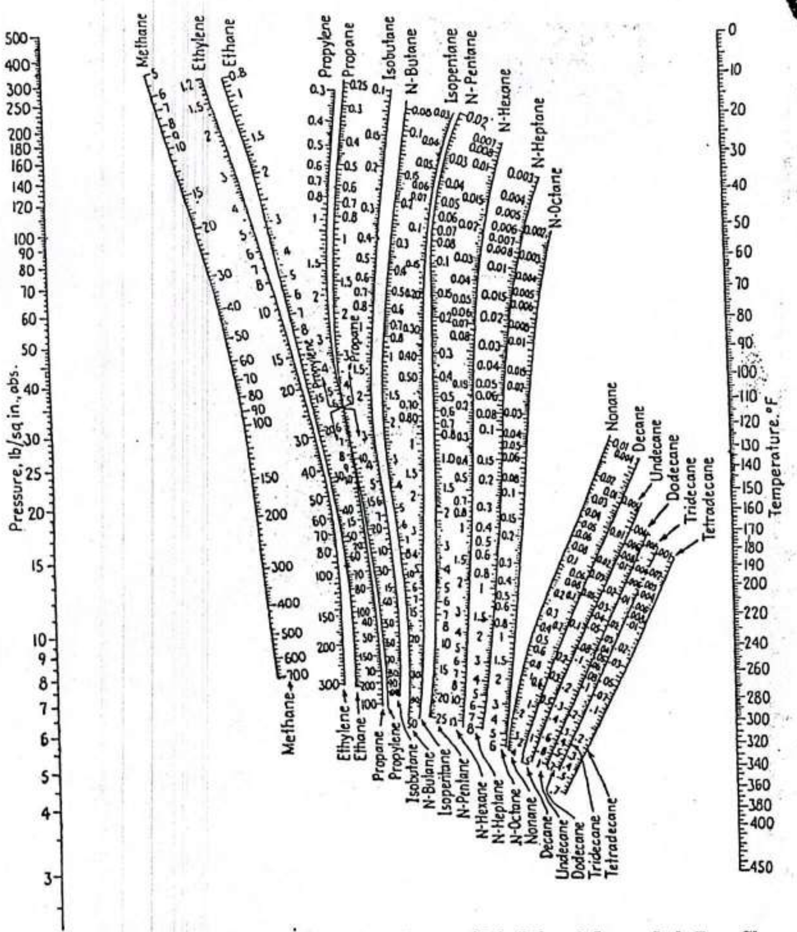


FIG. 7. Equilibrium constants for hydrocarbons. [*Scheibel and Jenny, Ind. Eng. Chem.*, **37**, 81 (1945).]

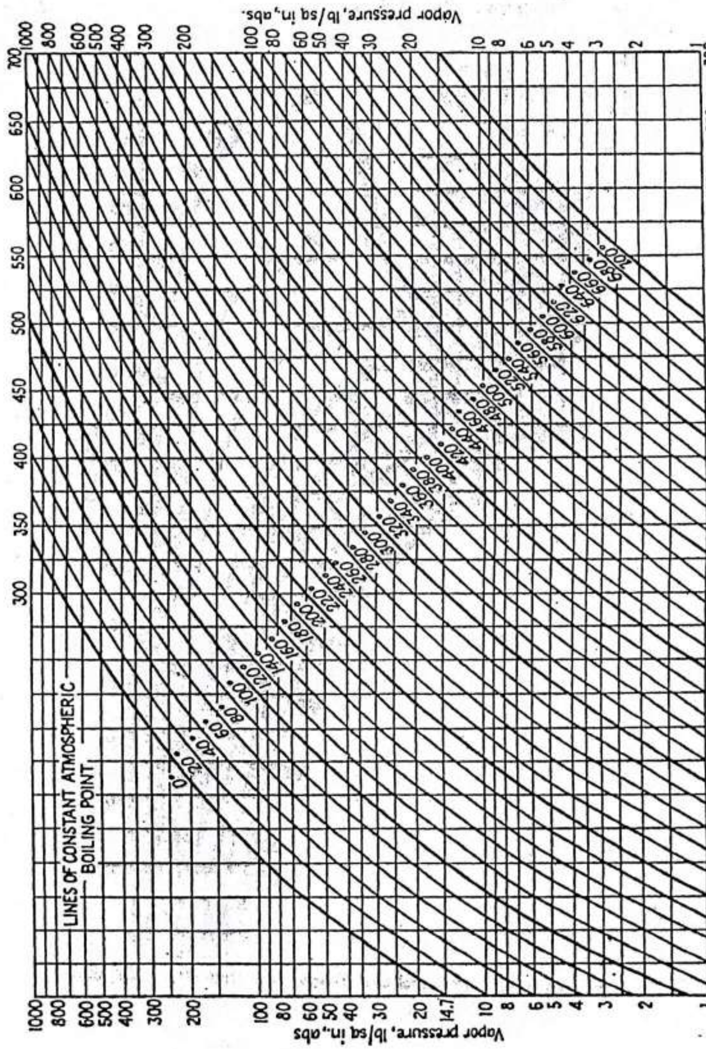


FIG. 8. Vapor pressures of hydrocarbons.

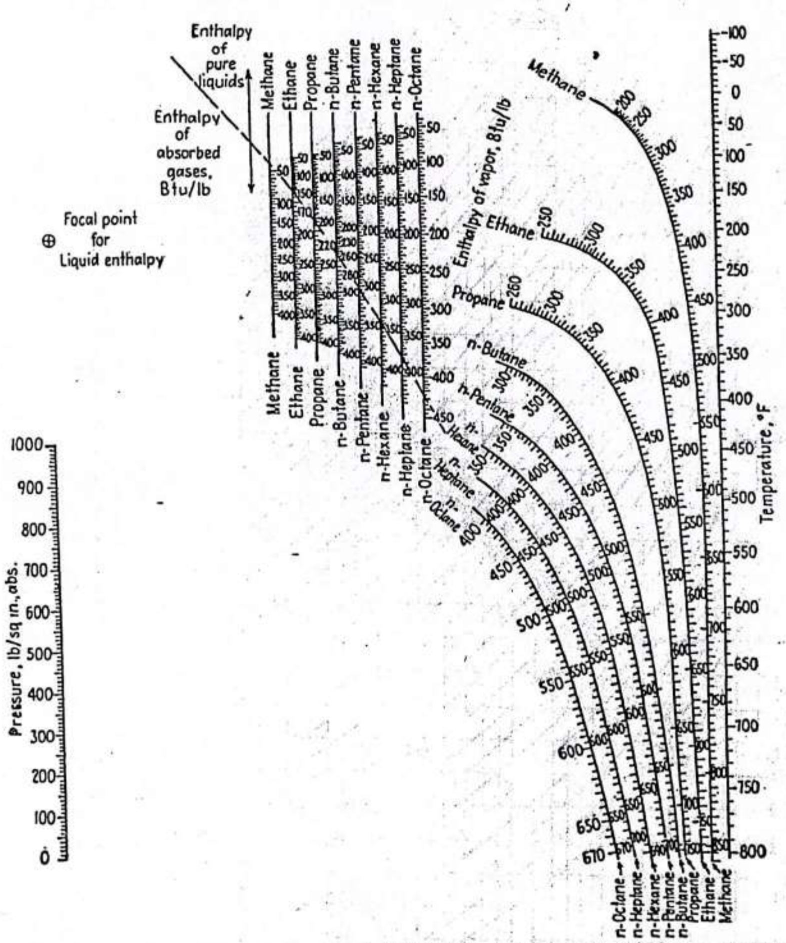


Fig. 9. Enthalpies of pure hydrocarbons. [*Scheibel and Jenny, Ind. Eng. Chem.*, **37**, 992 (1945).]

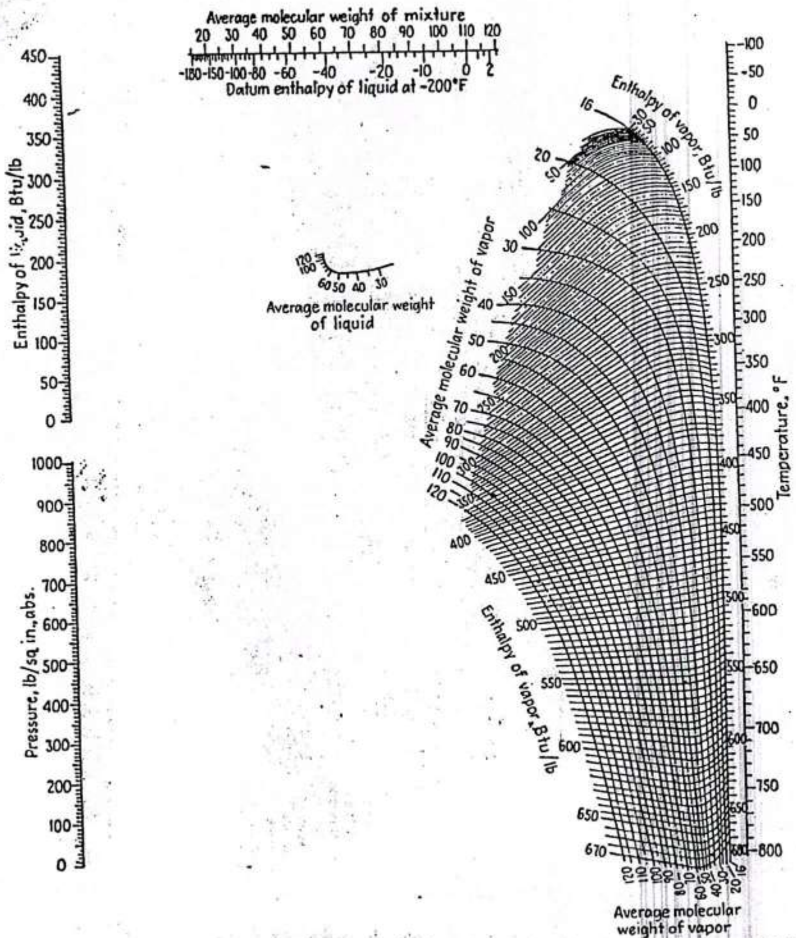


Fig. 10. Enthalpies of light hydrocarbons. [*Scheibel and Jenny, Ind. Eng. Chem.*, **37**, 993 (1945).]

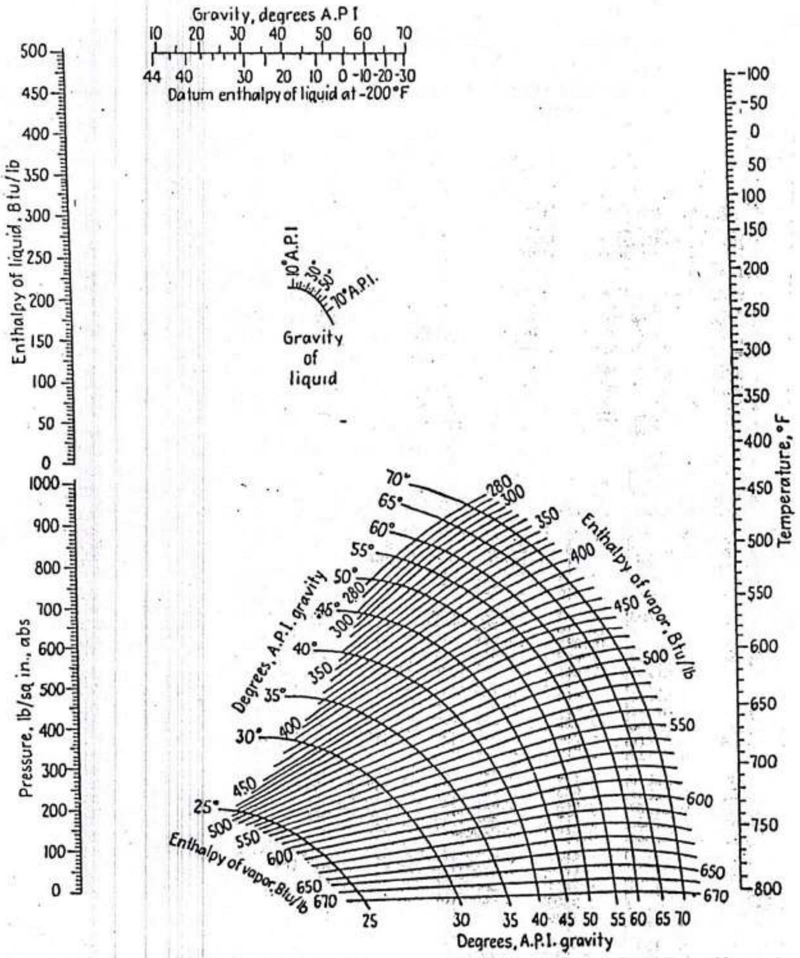
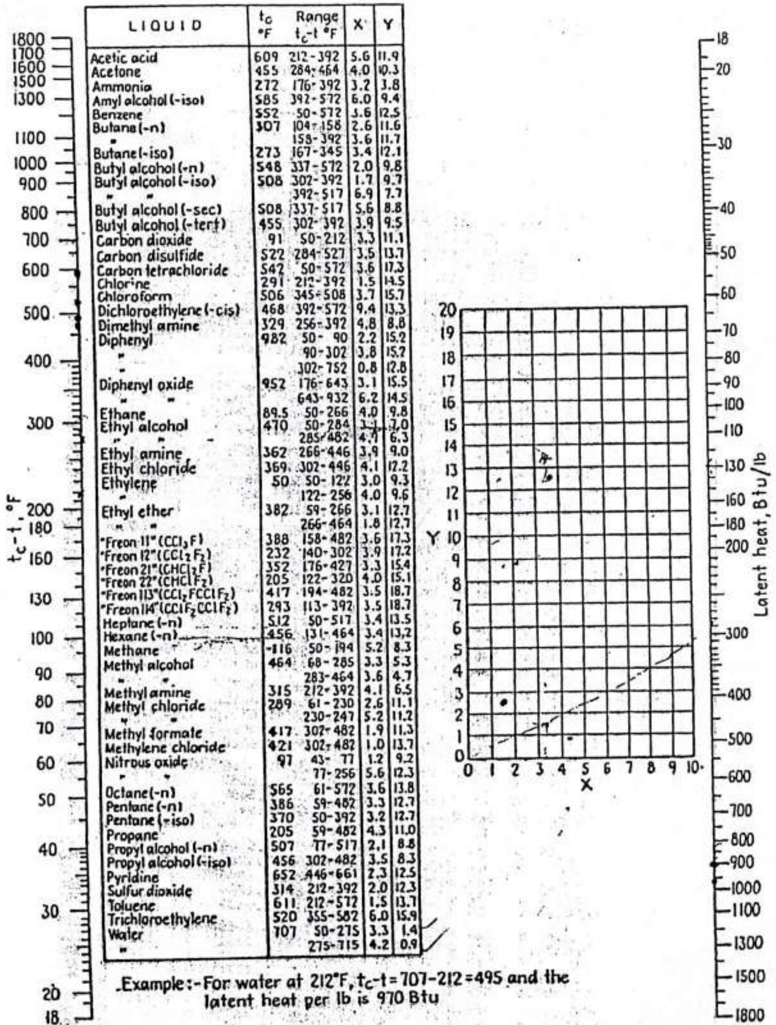


Fig. 11. Enthalpies of petroleum fractions. [*Scheibel and Jenny, Ind. Eng. Chem.*, **37**, 994 (1945).]



LIQUID	t_c °F	Range $t_c - t$ °F	X	Y
Acetic acid	609	212-392	5.6	11.9
Acetone	455	284-464	4.0	10.3
Ammonia	272	176-392	3.2	3.8
Amyl alcohol (-iso)	585	392-572	6.0	9.4
Benzene	552	50-572	3.6	12.5
Butane (-n)	307	104-158	2.6	11.6
"		158-392	3.6	11.7
Butane (-iso)	273	167-345	3.4	12.1
Butyl alcohol (-n)	548	337-572	2.0	9.8
Butyl alcohol (-iso)	508	302-392	1.7	9.7
" "		392-517	6.9	7.7
Butyl alcohol (-sec)	508	337-517	5.6	8.8
Butyl alcohol (-tert)	455	302-392	3.9	9.5
Carbon dioxide	91	50-212	3.3	11.1
Carbon disulfide	522	284-527	3.5	13.7
Carbon tetrachloride	542	50-572	3.6	17.3
Chlorine	291	212-392	1.5	14.5
Chloroform	506	345-508	3.7	15.7
Dichloroethylene (-cis)	468	392-572	9.4	13.3
Dimethyl amine	329	256-392	4.8	8.8
Diphenyl	982	50-90	2.2	15.2
"		90-302	3.8	15.2
"		302-752	0.8	12.8
Diphenyl oxide	952	176-643	3.1	15.5
" "		643-932	6.2	14.5
Ethane	89.5	50-266	4.0	9.8
Ethyl alcohol	470	50-284	3.1	7.0
" "		285-482	4.7	6.3
Ethyl amine	362	266-446	3.9	9.0
Ethyl chloride	369	302-446	4.1	12.2
Ethylene	50	50-122	3.0	9.3
"		122-256	4.0	9.6
Ethyl ether	382	59-266	3.1	12.7
" "		266-464	1.8	12.7
"Freon 11" (CCl_3F)	388	158-482	3.6	17.3
"Freon 12" (CCl_2F_2)	232	140-302	3.9	17.2
"Freon 21" ($CHCl_2F$)	352	176-427	3.3	15.4
"Freon 22" ($CHClF_2$)	205	122-320	4.0	15.1
"Freon 113" (CCl_2FCClF_2)	417	194-482	3.5	18.7
"Freon 114" ($CClF_2CClF_2$)	293	113-392	3.5	18.7
Heptane (-n)	512	50-517	3.4	13.5
Hexane (-n)	456	131-464	3.4	13.2
Methane	-116	50-194	5.2	8.3
Methyl alcohol	464	68-285	3.3	5.3
" "		283-464	3.6	4.7
Methyl amine	315	212-392	4.1	6.5
Methyl chloride	289	61-230	2.6	11.1
" "		230-247	5.2	11.2
Methyl formate	417	302-482	1.9	11.3
Methylene chloride	421	302-482	1.0	13.7
Nitrous oxide	97	43-77	1.2	9.2
" "		77-256	5.6	12.3
Octane (-n)	565	61-572	3.6	13.8
Pentane (-n)	386	59-482	3.3	12.7
Pentane (-iso)	370	50-392	3.2	12.7
Propane	205	59-482	4.3	11.0
Propyl alcohol (-n)	507	77-517	2.1	8.8
Propyl alcohol (-iso)	456	302-482	3.5	8.3
Pyridine	652	446-661	2.3	12.5
Sulfur dioxide	314	212-392	2.0	12.3
Toluene	611	212-572	1.5	13.7
Trichloroethylene	520	355-582	6.0	15.9
Water	707	50-275	3.3	1.4
"		275-715	4.2	0.9

Example:- For water at 212°F, $t_c - t = 707 - 212 = 495$ and the latent heat per lb is 970 Btu

Fig. 12. Latent heats of vaporization. [*Reproduced by permission of Chilton, Colburn, and Vernon, personal communication (revised)* 1947.]

TABLE 7. THERMODYNAMIC PROPERTIES OF STEAM

Dry saturated steam: pressure table*

Abs press., psi	Temp., °F	Specific volume		Enthalpy			Entropy			Internal energy		Abs press., psi
		Sat. liquid	Sat. vapor	Sat. liquid	Evap	Sat. vapor	Sat. liquid	Evap	Sat. vapor	Sat. liquid	Sat. vapor	
p	t	v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	u_f	u_g	p
1.0	101.74	0.01614	333.6	69.70	1036.3	1106.0	0.1326	1.8456	1.9782	69.70	1044.3	1.0
2.0	126.08	0.01623	173.73	93.99	1022.2	1116.2	0.1749	1.7451	1.9200	93.98	1051.9	2.0
3.0	141.48	0.01630	118.71	109.37	1013.2	1122.6	0.2008	1.6855	1.8863	109.36	1056.7	3.0
4.0	152.97	0.01636	90.63	120.86	1006.4	1127.3	0.2198	1.6427	1.8625	120.85	1060.2	4.0
5.0	162.24	0.01640	73.52	130.13	1001.0	1131.1	0.2347	1.6094	1.8441	130.12	1063.1	5.0
6.0	170.06	0.01645	61.98	137.96	996.2	1134.2	0.2472	1.5820	1.8292	137.94	1065.4	6.0
7.0	176.85	0.01649	53.64	144.76	992.1	1136.9	0.2581	1.5586	1.8167	144.74	1067.4	7.0
8.0	182.86	0.01653	47.34	150.79	988.5	1139.3	0.2674	1.5383	1.8057	150.77	1069.2	8.0
9.0	188.28	0.01656	42.40	156.22	985.2	1141.4	0.2759	1.5203	1.7962	156.19	1070.8	9.0
10	193.21	0.01659	38.42	161.17	982.1	1143.3	0.2835	1.5041	1.7876	161.14	1072.2	10
14.696	212.00	0.01672	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566	180.02	1077.5	14.696
15	213.03	0.01672	26.29	181.11	969.7	1150.8	0.3135	1.4415	1.7549	181.06	1077.8	15
20	227.96	0.01683	20.089	196.16	960.1	1156.3	0.3356	1.3962	1.7319	196.10	1081.9	20
25	240.07	0.01692	16.303	208.42	952.1	1160.6	0.3533	1.3606	1.7139	208.34	1085.1	25
30	250.33	0.01701	13.746	218.82	945.3	1164.1	0.3680	1.3313	1.6993	218.73	1087.8	30
35	259.28	0.01708	11.898	227.91	939.2	1167.1	0.3807	1.3063	1.6870	227.80	1090.1	35
40	267.25	0.01715	10.498	236.03	933.7	1169.7	0.3919	1.2844	1.6763	235.90	1092.0	40
45	274.44	0.01721	9.401	243.36	928.6	1172.0	0.4019	1.2650	1.6669	243.22	1093.7	45
50	281.01	0.01727	8.515	250.09	924.0	1174.1	0.4110	1.2474	1.6585	249.93	1095.3	50
55	287.07	0.01732	7.787	256.30	919.6	1175.9	0.4193	1.2316	1.6509	256.12	1096.7	55
60	292.71	0.01738	7.175	262.09	915.5	1177.6	0.4270	1.2168	1.6438	261.90	1097.9	60
65	297.97	0.01743	6.655	267.50	911.6	1179.1	0.4342	1.2032	1.6374	267.29	1099.1	65
70	302.92	0.01748	6.206	272.61	907.9	1180.6	0.4409	1.1906	1.6315	272.38	1100.2	70
75	307.60	0.01753	5.816	277.43	904.5	1181.9	0.4472	1.1787	1.6259	277.19	1101.2	75
80	312.03	0.01757	5.472	282.02	901.1	1183.1	0.4531	1.1676	1.6207	281.76	1102.1	80
85	316.25	0.01761	5.168	286.39	807.8	1184.2	0.4587	1.1571	1.6158	286.11	1102.9	85
90	320.27	0.01766	4.896	290.56	804.7	1185.3	0.4641	1.1471	1.6112	290.27	1103.7	90
95	324.12	0.01770	4.652	294.56	891.7	1186.2	0.4692	1.1376	1.6068	294.25	1104.5	95
100	327.81	0.01774	4.432	298.40	888.8	1187.2	0.4740	1.1286	1.6026	298.08	1105.2	100
110	334.77	0.01782	4.049	305.66	883.2	1188.9	0.4832	1.1117	1.5948	305.30	1106.5	110
120	341.25	0.01789	3.728	312.44	877.9	1190.4	0.4916	1.0962	1.5878	312.05	1107.6	120
130	347.32	0.01796	3.455	318.81	879.9	1191.7	0.4995	1.0817	1.5812	318.38	1108.6	130
140	353.02	0.01802	3.220	324.82	868.2	1193.0	0.5069	1.0682	1.5751	324.35	1109.6	140
150	358.42	0.01809	3.015	330.51	863.6	1194.1	0.5138	1.0556	1.5694	330.01	1110.5	150
160	363.53	0.01815	2.834	335.93	859.2	1195.1	0.5204	1.0436	1.5640	335.39	1111.2	160
170	368.41	0.01822	2.675	341.09	854.9	1196.0	0.5266	1.0324	1.5590	340.52	1111.9	170
180	373.06	0.01827	2.532	346.03	850.8	1196.9	0.5325	1.0217	1.5542	345.42	1112.5	180
190	377.51	0.01833	2.404	350.79	846.8	1197.6	0.5381	1.0116	1.5497	350.15	1113.1	190
200	381.79	0.01839	2.288	355.36	843.0	1198.4	0.5435	1.0018	1.5453	354.68	1113.7	200
250	400.95	0.01865	1.8438	376.00	825.1	1201.1	0.5675	0.9588	1.5263	375.14	1115.8	250
300	417.33	0.01890	1.5433	393.84	809.0	1202.8	0.5879	0.9225	1.5104	392.79	1117.1	300
350	431.72	0.01913	1.3260	409.69	794.2	1203.9	0.6056	0.8910	1.4966	408.45	1118.0	350
400	444.59	0.0193	1.1613	424.0	780.5	1204.5	0.6214	0.8630	1.4844	422.6	1118.5	400
450	456.28	0.0195	1.0320	437.2	767.4	1204.6	0.6356	0.8378	1.4734	435.5	1118.7	450
500	467.01	0.0197	0.9278	449.4	755.0	1204.4	0.6487	0.8147	1.4634	447.6	1118.6	500
550	476.94	0.0199	0.8424	460.8	743.1	1203.9	0.6608	0.7934	1.4542	458.8	1118.2	550
600	486.21	0.0201	0.7698	471.6	731.6	1203.2	0.6720	0.7734	1.4454	469.4	1117.7	600
650	494.90	0.0203	0.7083	481.8	720.5	1202.3	0.6826	0.7548	1.4374	479.4	1117.1	650
700	503.10	0.0205	0.6554	491.5	709.7	1201.2	0.6925	0.7371	1.4296	488.8	1116.3	700
750	510.86	0.0207	0.6092	500.8	699.2	1200.0	0.7019	0.7204	1.4223	598.0	1115.4	750
800	518.23	0.0209	0.5687	509.7	688.9	1198.6	0.7108	0.7045	1.4153	506.6	1114.4	800
850	525.26	0.0210	0.5327	518.3	678.8	1197.1	0.7194	0.6891	1.4085	515.0	1113.3	850
900	531.98	0.0212	0.5006	526.6	668.8	1195.4	0.7275	0.6744	1.4020	523.1	1112.1	900
950	538.43	0.0214	0.4717	534.6	659.1	1193.7	0.7355	0.6602	1.3957	530.9	1110.8	950
1000	544.61	0.0216	0.4456	542.4	649.4	1191.8	0.7430	0.6467	1.3897	538.4	1109.4	1000
1100	556.31	0.0220	0.4001	557.4	630.4	1187.8	0.7575	0.6205	1.3780	552.9	1106.4	1100
1200	567.22	0.0223	0.3619	571.7	611.7	1183.4	0.7711	0.5956	1.3667	566.7	1103.0	1200
1300	577.46	0.0227	0.3293	585.4	593.2	1178.6	0.7840	0.5719	1.3559	580.0	1099.4	1300
1400	587.10	0.0231	0.3012	598.7	574.7	1173.4	0.7963	0.5491	1.3454	592.7	1095.4	1400
1500	596.23	0.0235	0.2765	611.6	556.3	1167.9	0.8082	0.5269	1.3351	605.1	1091.2	1500
2000	635.82	0.0257	0.1878	671.7	463.4	1135.1	0.8619	0.4230	1.2849	662.2	1065.6	2000
2500	668.13	0.0287	0.1307	730.6	360.5	1091.1	0.9126	0.3197	1.2322	717.3	1030.6	2500
3000	695.36	0.0346	0.0858	802.5	217.8	1020.3	0.9731	0.1885	1.1615	783.4	972.7	3000
3206.2	705.40	0.0503	0.0503	902.7	0	902.7	1.0580	0	1.0580	872.9	872.9	3206.2

* Abridged "Thermodynamic Properties of Steam" by Joseph H. Keenan and Frederick G. Keyes. John Wiley & Sons, Inc., New York, 1937.

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TABLE 7. THERMODYNAMIC PROPERTIES OF STEAM.—(*Continued*)

Dry saturated steam: temperature table*

Temp., °F	Abs press., psi	Specific volume			Enthalpy			Entropy			Temp., °F
		Sat. liquid	Evap.	Sat. vapor	Sat. liquid	Evap.	Sat. vapor	Sat. liquid	Evap.	Sat. vapor	
t	p	v_f	v_{fg}	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g	t
32	0.08854	0.01602	3306	3306	0.00	1075.8	1075.8	0.0000	2.1877	2.1877	32
35	0.09995	0.01602	2947	2947	3.02	1074.1	1077.1	0.0061	2.1709	2.1770	35
40	0.12170	0.01602	2444	2444	8.05	1071.3	1079.3	0.0162	2.1435	2.1597	40
45	0.14752	0.01602	2036.4	2036.4	13.06	1068.4	1081.5	0.0262	2.1167	2.1429	45
50	0.17811	0.01603	1703.2	1703.2	18.07	1065.6	1083.7	0.0361	2.0903	2.1264	50
60	0.2563	0.01604	1206.6	1206.7	28.06	1059.9	1088.0	0.0555	2.0393	2.0948	60
70	0.3631	0.01606	867.8	867.9	38.04	1054.3	1092.3	0.0745	1.9902	2.0647	70
80	0.5069	0.01608	633.1	633.1	48.02	1048.6	1096.6	0.0932	1.9428	2.0360	80
90	0.6982	0.01610	468.0	468.0	57.99	1042.9	1100.9	0.1115	1.8972	2.0087	90
100	0.9492	0.01613	350.3	350.4	67.97	1037.2	1105.2	0.1295	1.8531	1.9826	100
110	1.2748	0.01617	265.3	265.4	77.94	1031.6	1109.5	0.1471	1.8106	1.9577	110
120	1.6924	0.01620	203.25	203.27	87.92	1025.8	1113.7	0.1645	1.7694	1.9339	120
130	2.2225	0.01625	157.32	157.34	97.90	1020.0	1117.9	0.1816	1.7296	1.9112	130
140	2.8886	0.01629	122.99	123.01	107.89	1014.1	1122.0	0.1984	1.6910	1.8894	140
150	3.718	0.01634	98.06	97.07	117.89	1008.2	1126.1	0.2149	1.6537	1.8685	150
160	4.741	0.01639	77.27	77.29	127.89	1002.3	1130.2	0.2311	1.6174	1.8485	160
170	5.992	0.01645	62.04	62.06	137.90	996.3	1134.2	0.2472	1.5822	1.8293	170
180	7.510	0.01651	50.21	50.23	147.92	990.2	1138.1	0.2630	1.5480	1.8109	180
190	9.339	0.01657	40.94	40.96	157.95	984.1	1142.0	0.2785	1.5147	1.7932	190
200	11.526	0.01663	33.62	33.64	167.99	977.9	1145.9	0.2938	1.4824	1.7762	200
210	14.123	0.01670	27.80	27.82	178.05	971.6	1149.7	0.3090	1.4508	1.7598	210
212	14.696	0.01672	26.78	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566	212
220	17.186	0.01677	23.13	23.15	188.13	965.2	1153.4	0.3239	1.4201	1.7440	220
230	20.780	0.01684	19.365	19.382	198.23	958.8	1157.0	0.3387	1.3901	1.7288	230
240	24.969	0.01692	16.306	16.323	208.34	952.2	1160.5	0.3531	1.3609	1.7140	240
250	29.825	0.01700	13.804	13.821	216.48	945.5	1164.0	0.3675	1.3323	1.6998	250
260	35.429	0.01709	11.746	11.763	228.64	938.7	1167.3	0.3817	1.3043	1.6860	260
270	41.858	0.01717	10.044	10.061	238.84	931.8	1170.6	0.3958	1.2769	1.6727	270
280	49.203	0.01726	8.628	8.645	249.06	924.7	1173.8	0.4096	1.2501	1.6597	280
290	57.556	0.01735	7.444	7.461	259.31	917.5	1176.8	0.4234	1.2238	1.6472	290
300	67.013	0.01745	6.449	6.466	269.59	910.1	1179.7	0.4369	1.1980	1.6350	300
310	77.68	0.01755	5.609	5.626	279.92	902.6	1182.5	0.4504	1.1727	1.6231	310
320	89.66	0.01765	4.896	4.914	290.28	894.9	1185.2	0.4637	1.1478	1.6115	320
330	103.06	0.01776	4.289	4.307	300.68	887.0	1187.7	0.4769	1.1233	1.6002	330
340	118.01	0.01787	3.770	3.788	311.13	879.0	1190.1	0.4900	1.0992	1.5891	340
350	134.63	0.01799	3.324	3.342	321.63	870.7	1192.3	0.5029	1.0754	1.5783	350
360	153.04	0.01811	2.939	2.957	332.18	862.2	1194.4	0.5158	1.0519	1.5677	360
370	173.37	0.01823	2.606	2.625	342.79	853.5	1196.3	0.5286	1.0287	1.5573	370
380	195.77	0.01836	2.317	2.335	353.45	844.6	1198.1	0.5413	1.0059	1.5471	380
390	220.37	0.01850	2.0651	2.0836	364.17	835.4	1199.6	0.5539	0.9832	1.5371	390
400	247.31	0.01864	1.8447	1.8633	374.97	826.0	1201.0	0.5664	0.9608	1.5272	400
410	276.75	0.01878	1.6512	1.6700	385.83	816.3	1202.1	0.5788	0.9386	1.5174	410
420	308.83	0.01894	1.4811	1.5000	396.77	806.3	1203.1	0.5912	0.9166	1.5078	420
430	343.72	0.01910	1.3308	1.3499	407.79	796.0	1203.8	0.6035	0.8947	1.4982	430
440	381.59	0.01926	1.1979	1.2171	418.90	785.4	1204.3	0.6158	0.8730	1.4887	440
450	422.6	0.0194	1.0799	1.0993	430.1	774.5	1204.6	0.6280	0.8513	1.4793	450
460	466.9	0.0196	0.9748	0.9944	441.4	763.2	1204.6	0.6402	0.8298	1.4700	460
470	514.7	0.0198	0.8811	0.9009	452.8	751.5	1204.3	0.6523	0.8083	1.4606	470
480	566.1	0.0200	0.7972	0.8172	464.4	739.4	1203.7	0.6645	0.7868	1.4513	480
490	621.4	0.0202	0.7221	0.7423	476.0	726.8	1202.8	0.6766	0.7653	1.4419	490
500	680.8	0.0204	0.6545	0.6749	487.8	713.9	1201.7	0.6887	0.7438	1.4325	500
520	812.4	0.0209	0.5385	0.5594	511.9	686.4	1198.2	0.7130	0.7006	1.4136	520
540	962.5	0.0215	0.4434	0.4649	536.6	656.6	1193.2	0.7374	0.6568	1.3942	540
560	1133.1	0.0221	0.3647	0.3868	562.2	624.2	1186.4	0.7621	0.6121	1.3742	560
580	1325.8	0.0228	0.2989	0.3217	588.9	588.4	1177.3	0.7872	0.5659	1.3532	580
600	1542.9	0.0236	0.2432	0.2668	617.0	548.5	1165.5	0.8131	0.5176	1.3307	600
620	1786.6	0.0247	0.1955	0.2201	646.7	503.6	1150.3	0.8398	0.4664	1.3062	620
640	2059.7	0.0260	0.1538	0.1798	678.6	452.0	1130.5	0.8679	0.4110	1.2789	640
660	2365.4	0.0278	0.1165	0.1442	714.2	390.2	1104.4	0.8987	0.3485	1.2472	660
680	2708.1	0.0305	0.0810	0.1115	757.3	309.9	1067.2	0.9351	0.2719	1.2071	680
700	3093.7	0.0369	0.0392	0.0761	823.3	172.1	995.4	0.9905	0.1484	1.1389	700
705.4	3206.2	0.0503	0	0.0503	902.7	0	902.7	1.0580	0	1.0580	705.4

* Abridged from "Thermodynamic Properties of Steam" by Joseph H. Keenan and Frederick G. Keyes, John Wiley & Sons, Inc., New York.

TABLE 7. THERMODYNAMIC PROPERTIES OF STEAM.—(*Continued*)
Properties of superheated steam*

Abs press., psi (sat temp)		Temp, °F 200	300	400	500	600	700	800	900	1000	1100	1200	1400	1600
1	v	392.6	452.3	512.0	571.6	631.2	690.8	750.4	809.9	869.5	929.1	988.7	1107.8	1227.0
	h	1150.4	1195.8	1241.7	1288.3	1335.7	1383.8	1432.8	1482.7	1533.5	1585.2	1637.7	1745.7	1857.5
(101.74)	s	2.0512	2.1153	2.1720	2.2233	2.2702	2.3137	2.3542	2.3923	2.4283	2.4625	2.4952	2.5566	2.6137
5	v	78.16	90.25	102.26	114.22	126.16	138.10	150.03	161.95	173.87	185.79	197.71	221.6	245.4
	h	1148.8	1195.0	1241.2	1288.0	1335.4	1383.6	1432.7	1482.6	1533.4	1585.1	1637.7	1745.7	1857.4
(162.24)	s	1.8718	1.9370	1.9942	2.0456	2.0927	2.1361	2.1767	2.2148	2.2500	2.2851	2.3178	2.3792	2.4363
10	v	38.85	45.00	51.04	57.05	63.03	69.01	74.98	80.95	86.92	92.88	98.84	110.77	122.69
	h	1146.6	1193.9	1240.6	1287.5	1335.1	1383.4	1432.5	1482.4	1533.2	1585.0	1637.6	1745.6	1857.3
(193.21)	s	1.7927	1.8595	1.9172	1.9689	2.0160	2.0596	2.1002	2.1383	2.1744	2.2086	2.2413	2.3028	2.3598
14.696	v	....	30.53	34.68	38.78	42.86	46.94	51.00	55.07	59.13	63.19	67.25	75.37	83.48
	h	....	1192.8	1239.9	1287.1	1334.8	1383.2	1432.3	1482.3	1533.1	1584.8	1637.5	1745.5	1857.3
(212.00)	s	....	1.8160	1.8743	1.9261	1.9734	2.0170	2.0576	2.0958	2.1319	2.1662	2.1989	2.2603	2.3174
20	v	....	22.36	25.43	28.46	31.47	34.47	37.46	40.45	43.44	46.42	49.41	55.37	61.34
	h	....	1191.6	1239.2	1286.6	1334.4	1382.9	1432.1	1482.1	1533.0	1584.7	1637.4	1745.4	1857.2
(227.96)	s	....	1.7808	1.8396	1.8918	1.9392	1.9829	2.0235	2.0618	2.0978	2.1321	2.1648	2.2263	2.2834
40	v	....	11.040	12.628	14.168	15.688	17.198	18.702	20.20	21.70	23.20	24.69	27.68	30.66
	h	....	1186.8	1236.5	1284.8	1333.1	1381.9	1431.3	1481.4	1532.4	1584.3	1637.0	1745.1	1857.0
(267.25)	s	....	1.6994	1.7608	1.8140	1.8619	1.9058	1.9467	1.9850	2.0212	2.0555	2.0883	2.1498	2.2069
60	v	....	7.259	8.357	9.403	10.427	11.441	12.449	13.452	14.454	15.453	16.451	18.446	20.44
	h	....	1181.6	1233.6	1283.0	1331.8	1380.9	1430.5	1480.8	1531.9	1583.8	1636.6	1744.8	1856.7
(292.71)	s	....	1.6492	1.7135	1.7678	1.8162	1.8605	1.9015	1.9400	1.9762	2.0106	2.0434	2.1049	2.1621
80	v	....	....	6.220	7.020	7.797	8.562	9.322	10.077	10.830	11.582	12.332	13.830	15.325
	h	....	....	1230.7	1281.1	1330.5	1379.9	1429.7	1480.1	1531.3	1583.4	1636.2	1744.5	1856.5
(312.03)	s	....	....	1.6791	1.7346	1.7836	1.8281	1.8694	1.9079	1.9442	1.9787	2.0115	2.0731	2.1303
100	v	....	....	4.937	5.589	6.218	6.835	7.446	8.052	8.656	9.259	9.860	11.060	12.258
	h	....	....	1227.6	1279.1	1329.1	1378.9	1428.9	1479.5	1530.8	1582.9	1635.7	1744.2	1856.2
(327.81)	s	....	....	1.6518	1.7085	1.7581	1.8029	1.8443	1.8829	1.9193	1.9538	1.9867	2.0484	2.1056
120	v	....	....	4.081	4.636	5.165	5.683	6.195	6.702	7.207	7.710	8.212	9.214	10.213
	h	....	....	1224.4	1277.2	1327.7	1377.8	1428.1	1478.8	1530.2	1582.4	1635.3	1743.9	1856.0
(341.25)	s	....	....	1.6287	1.6869	1.7370	1.7822	1.8237	1.8625	1.8990	1.9335	1.9664	2.0281	2.0854
140	v	....	....	3.468	3.954	4.413	4.861	5.301	5.738	6.172	6.604	7.035	7.895	8.752
	h	....	....	1221.1	1275.2	1326.4	1376.8	1427.3	1478.2	1529.7	1581.9	1634.9	1743.5	1855.7
(353.02)	s	....	....	1.6087	1.6683	1.7190	1.7645	1.8063	1.8451	1.8817	1.9163	1.9493	2.0110	2.0683
160	v	....	....	3.008	3.443	3.849	4.244	4.631	5.015	5.396	5.775	6.152	6.906	7.656
	h	....	....	1217.6	1273.1	1325.0	1375.7	1426.4	1477.5	1529.1	1581.4	1634.5	1743.2	1855.5
(363.53)	s	....	....	1.5908	1.6519	1.7033	1.7491	1.7911	1.8301	1.8667	1.9014	1.9344	1.9962	2.0535
180	v	....	....	2.649	3.044	3.411	3.764	4.110	4.452	4.792	5.129	5.466	6.136	6.804
	h	....	....	1214.0	1271.0	1323.5	1374.7	1425.6	1476.8	1528.6	1581.0	1634.1	1742.9	1855.2
(373.06)	s	....	....	1.5745	1.6373	1.6894	1.7355	1.7776	1.8167	1.8534	1.8882	1.9212	1.9831	2.0404
200	v	....	....	2.361	2.726	3.060	3.380	3.693	4.002	4.309	4.613	4.917	5.521	6.123
	h	....	....	1210.3	1268.9	1322.1	1373.6	1424.8	1476.2	1528.0	1580.5	1633.7	1742.6	1855.0
(381.79)	s	....	....	1.5594	1.6240	1.6767	1.7232	1.7655	1.8048	1.8415	1.8763	1.9094	1.9713	2.0287
220	v	....	....	2.125	2.465	2.772	3.066	3.352	3.634	3.913	4.191	4.467	5.017	5.565
	h	....	....	1206.5	1266.7	1320.7	1372.0	1424.0	1475.5	1527.5	1580.0	1633.3	1742.3	1854.7
(389.86)	s	....	....	1.5453	1.6117	1.6652	1.7120	1.7545	1.7939	1.8308	1.8656	1.8987	1.9607	2.0181
240	v	....	....	1.9276	2.247	2.533	2.804	3.068	3.327	3.584	3.839	4.093	4.597	5.100
	h	....	....	1202.5	1264.5	1319.2	1371.5	1423.2	1474.8	1526.9	1579.6	1632.9	1742.0	1854.5
(397.37)	s	....	....	1.5219	1.6003	1.6546	1.7017	1.7444	1.7830	1.8209	1.8558	1.8889	1.9510	2.0084
260	v	....	....	....	2.063	2.330	2.582	2.827	3.067	3.305	3.541	3.776	4.242	4.707
	h	....	....	....	1262.3	1317.7	1370.4	1422.3	1474.2	1526.3	1579.1	1632.5	1741.7	1854.2
(404.42)	s	....	....	....	1.5897	1.6447	1.6922	1.7352	1.7748	1.8118	1.8467	1.8799	1.9420	1.9995
280	v	....	....	....	1.9047	2.156	2.392	2.621	2.845	3.066	3.286	3.504	3.938	4.370
	h	....	....	....	1260.0	1316.2	1369.4	1421.5	1473.5	1525.8	1578.6	1632.1	1741.4	1854.0
(411.05)	s	....	....	....	1.5796	1.6354	1.6834	1.7265	1.7662	1.8033	1.8383	1.8716	1.9337	1.9912
300	v	....	....	....	1.7675	2.005	2.227	2.442	2.652	2.859	3.065	3.269	3.674	4.078
	h	....	....	....	1257.6	1314.7	1368.3	1420.6	1472.8	1525.2	1578.1	1631.7	1741.0	1853.7
(417.33)	s	....	....	....	1.5701	1.6268	1.6751	1.7184	1.7582	1.7954	1.8305	1.8638	1.9260	1.9835
350	v	....	....	....	1.4923	1.7036	1.8980	2.084	2.266	2.445	2.622	2.798	3.147	3.493
	h	....	....	....	1251.5	1310.9	1365.5	1418.5	1471.1	1523.8	1577.0	1630.7	1740.3	1853.1
(431.72)	s	....	....	....	1.5481	1.6070	1.6563	1.7002	1.7403	1.7777	1.8130	1.8463	1.9086	1.9663
400	v	....	....	....	1.2851	1.4770	1.6508	1.8161	1.9767	2.134	2.290	2.445	2.751	3.055
	h	....	....	....	1245.1	1306.9	1362.7	1416.4	1469.4	1522.4	1575.8	1629.6	1739.5	1852.5
(444.59)	s	....	....	....	1.5281	1.5894	1.6398	1.6842	1.7247	1.7623	1.7977	1.8311	1.8936	1.9513

* Abridged from "Thermodynamic Properties of Steam," by Joseph H. Keenan and Frederick G. Keyes, John Wiley & Sons, Inc., New York, 1937.

TABLE 7. THERMODYNAMIC PROPERTIES OF STEAM.—(*Continued*)
Properties of superheated steam*

Abs Press., psi (sat temp)		Temp, °F 500	550	600	620	640	660	680	700	800	900	1000	1200	1400	1600
450	v	1.1231	1.2155	1.3005	1.3332	1.3652	1.3967	1.4278	1.4584	1.6074	1.7516	1.8928	2.170	2.443	2.714
	h	1238.4	1272.0	1302.8	1314.6	1326.2	1337.5	1348.8	1359.9	1414.3	1467.7	1521.0	1628.6	1738.7	1851.9
(456.28)	s	1.5095	1.5437	1.5735	1.5845	1.5951	1.6054	1.6153	1.6250	1.6699	1.7108	1.7486	1.8177	1.8803	1.9381
500	v	0.9927	1.0800	1.1591	1.1893	1.2188	1.2478	1.2763	1.3044	1.4405	1.5715	1.6996	1.9504	2.197	2.442
	h	1231.3	1266.8	1298.6	1310.7	1322.6	1334.2	1345.7	1357.0	1412.1	1466.0	1519.6	1627.6	1737.9	1851.3
(467.01)	s	1.4919	1.5280	1.5588	1.5701	1.5810	1.5915	1.6016	1.6115	1.6571	1.6982	1.7363	1.8056	1.8683	1.9262
550	v	0.8852	0.9686	1.0431	1.0714	1.0989	1.1259	1.1523	1.1783	1.3038	1.4241	1.5414	1.7706	1.9957	2.219
	h	1223.7	1261.2	1294.3	1306.8	1318.9	1330.8	1342.5	1354.0	1409.9	1464.3	1518.2	1626.6	1737.1	1850.6
(476.94)	s	1.4751	1.5131	1.5451	1.5568	1.5680	1.5787	1.5890	1.5991	1.6452	1.6868	1.7250	1.7946	1.8575	1.9155
600	v	0.7947	0.8753	0.9463	0.9729	0.9988	1.0241	1.0489	1.0732	1.1899	1.3013	1.4096	1.6208	1.8279	2.033
	h	1215.7	1255.5	1289.9	1302.7	1315.2	1327.4	1339.3	1351.1	1407.7	1462.5	1516.7	1625.5	1730.3	1850.0
(486.21)	s	1.4586	1.4990	1.5323	1.5443	1.5558	1.5667	1.5773	1.5875	1.6343	1.6762	1.7147	1.7846	1.8476	1.9056
700	v	....	0.7277	0.7934	0.8177	0.8411	0.8639	0.8860	0.9077	1.0108	1.1082	1.2024	1.3853	1.5641	1.7405
	h	....	1243.2	1280.6	1294.3	1307.5	1320.3	1332.8	1345.0	1403.2	1459.0	1515.9	1623.5	1734.8	1848.8
(503.10)	s	....	1.4722	1.5084	1.5212	1.5333	1.5449	1.5559	1.5665	1.6147	1.6573	1.6963	1.7666	1.8299	1.8881
800	v	....	0.6154	0.6779	0.7006	0.7223	0.7433	0.7635	0.7833	0.8763	0.9633	1.0470	1.2088	1.3662	1.5214
	h	....	1229.8	1270.7	1285.4	1299.4	1312.9	1325.9	1338.6	1398.6	1455.4	1511.0	1621.4	1733.2	1847.5
(518.23)	s	....	1.4467	1.4863	1.5000	1.5129	1.5250	1.5366	1.5476	1.5972	1.6407	1.6801	1.7510	1.8146	1.8729
900	v	....	0.5264	0.5873	0.6089	0.6294	0.6491	0.6680	0.6863	0.7716	0.8506	0.9262	1.0714	1.2124	1.3509
	h	....	1215.0	1260.1	1275.9	1290.9	1305.1	1318.8	1332.1	1393.9	1451.8	1508.1	1619.3	1731.6	1846.3
(531.98)	s	....	1.4216	1.4653	1.4800	1.4938	1.5066	1.5187	1.5303	1.5814	1.6257	1.6656	1.7371	1.8009	1.8595
1000	v	....	0.4533	0.5140	0.5350	0.5546	0.5733	0.5912	0.6084	0.6878	0.7604	0.8294	0.9615	1.0893	1.2146
	h	....	1198.3	1248.8	1265.9	1281.9	1297.0	1311.4	1325.3	1389.2	1448.2	1505.1	1617.3	1730.0	1845.0
(544.61)	s	....	1.3961	1.4450	1.4610	1.4757	1.4893	1.5021	1.5141	1.5670	1.6121	1.6525	1.7245	1.7886	1.8474
1100	v	....	....	0.4532	0.4738	0.4929	0.5110	0.5281	0.5445	0.6191	0.6866	0.7503	0.8716	0.9885	1.1031
	h	....	....	1236.7	1255.3	1272.4	1288.5	1303.7	1318.3	1384.3	1444.5	1502.2	1615.2	1728.4	1843.8
(556.31)	s	....	....	1.4251	1.4425	1.4583	1.4728	1.4862	1.4989	1.5535	1.5995	1.6405	1.7130	1.7775	1.8363
1200	v	....	....	0.4016	0.4222	0.4410	0.4586	0.4752	0.4909	0.5617	0.6250	0.6843	0.7967	0.9046	1.0101
	h	....	....	1223.5	1243.9	1262.4	1279.6	1295.7	1311.0	1379.3	1440.7	1499.2	1613.1	1726.9	1842.5
(567.22)	s	....	....	1.4052	1.4243	1.4413	1.4568	1.4710	1.4843	1.5409	1.5879	1.6293	1.7025	1.7672	1.8263
1400	v	....	....	0.3174	0.3390	0.3580	0.3753	0.3912	0.4062	0.4714	0.5281	0.5805	0.6789	0.7727	0.8640
	h	....	....	1193.0	1218.4	1240.4	1260.3	1278.5	1295.5	1369.1	1433.1	1493.2	1608.9	1723.7	1840.0
(587.10)	s	....	....	1.3639	1.3877	1.4079	1.4258	1.4419	1.4567	1.5177	1.5666	1.6093	1.6836	1.7489	1.8083
1600	v	....	....	....	0.2733	0.2936	0.3112	0.3271	0.3417	0.4034	0.4553	0.5027	0.5906	0.6738	0.7545
	h	....	....	....	1187.8	1215.2	1238.7	1259.6	1278.7	1358.4	1425.3	1487.0	1604.6	1720.5	1837.5
(604.90)	s	....	....	....	1.3489	1.3741	1.3952	1.4137	1.4303	1.4964	1.5476	1.5914	1.6669	1.7328	1.7926
1800	v	....	....	....	....	0.2407	0.2597	0.2760	0.2907	0.3502	0.3986	0.4421	0.5218	0.5968	0.6693
	h	....	....	....	....	1185.1	1214.0	1238.5	1260.3	1347.2	1417.4	1480.8	1600.4	1717.3	1835.0
(621.03)	s	....	....	....	....	1.3377	1.3638	1.3855	1.4044	1.4765	1.5301	1.5752	1.6520	1.7185	1.7786
2000	v	....	....	....	....	0.1936	0.2161	0.2337	0.2489	0.3074	0.3532	0.3935	0.4668	0.5352	0.6011
	h	....	....	....	....	1145.6	1184.9	1214.8	1240.0	1335.5	1409.2	1474.5	1596.1	1714.1	1832.5
(635.82)	s	....	....	....	....	1.2945	1.3300	1.3564	1.3783	1.4576	1.5139	1.5603	1.6384	1.7065	1.7660
2500	v	....	....	....	....	....	....	0.1484	0.1686	0.2294	0.2710	0.3061	0.3678	0.4244	0.4784
	h	....	....	....	....	....	....	1132.3	1176.8	1303.6	1387.8	1458.4	1585.3	1706.1	1826.2
(668.13)	s	....	....	....	....	....	....	1.2687	1.3073	1.4127	1.4772	1.5273	1.6088	1.6775	1.7389
3000	v	....	....	....	....	....	....	....	0.0984	0.1760	0.2159	0.2476	0.3018	0.3505	0.3966
	h	....	....	....	....	....	....	....	1060.7	1267.2	1365.0	1441.8	1574.3	1698.0	1819.9
(695.36)	s	....	....	....	....	....	....	....	1.1966	1.3690	1.4439	1.4984	1.5837	1.6540	1.7163
3206.2	v	....	....	....	....	....	....	....	....	0.1583	0.1981	0.2288	0.2806	0.3267	0.3703
	h	....	....	....	....	....	....	....	....	1250.5	1356.2	1434.7	1569.8	1694.6	1817.2
(705.40)	s	....	....	....	....	....	....	....	....	1.3508	1.4309	1.4874	1.5742	1.6452	1.7080
3500	v	....	....	....	....	....	....	....	0.0306	0.1364	0.1762	0.2058	0.2546	0.2977	0.3381
	h	....	....	....	....	....	....	....	780.5	1224.9	1340.7	1424.5	1563.3	1689.8	1813.6
	s	....	....	....	....	....	....	....	0.9515	1.3241	1.4127	1.4723	1.5615	1.6336	1.6968
4000	v	....	....	....	....	....	....	....	0.0287	0.1052	0.1462	0.1743	0.2192	0.2581	0.2943
	h	....	....	....	....	....	....	....	763.8	1174.8	1314.4	1406.8	1552.1	1681.7	1807.2
	s	....	....	....	....	....	....	....	0.9347	1.2757	1.3827	1.4482	1.5417	1.6154	1.6795
4500	v	....	....	....	....	....	....	....	0.0276	0.0798	0.1226	0.1500	0.1917	0.2273	0.2602
	h	....	....	....	....	....	....	....	753.5	1113.9	1286.5	1388.4	1540.8	1673.5	1800.9
	s	....	....	....	....	....	....	....	0.9235	1.2204	1.3529	1.4253	1.5235	1.5990	1.6640
5000	v	....	....	....	....	....	....	....	0.0268	0.0593	0.1036	0.1303	0.1696	0.2027	0.2329
	h	....	....	....	....	....	....	....	746.4	1047.1	1256.5	1369.5	1529.5	1665.3	1704.5
	s	....	....	....	....	....	....	....	0.9152	1.1622	1.3231	1.4034	1.5066	1.5839	1.6499
5500	v	....	....	....	....	....	....	....	0.0262	0.0463	0.0880	0.1143	0.1516	0.1825	0.2106
	h	....	....	....	....	....	....	....	741.3	985.0	1224.1	1349.3	1518.2	1657.0	1788.1
	s	....	....	....	....	....	....	....	0.9090	1.1093	1.2930	1.3821	1.4908	1.5699	1.6360

* Abridged from "Thermodynamic Properties of Steam," by Joseph H. Keenan and Frederick G. Keyes, John Wiley & Sons, Inc., New York, 1937.

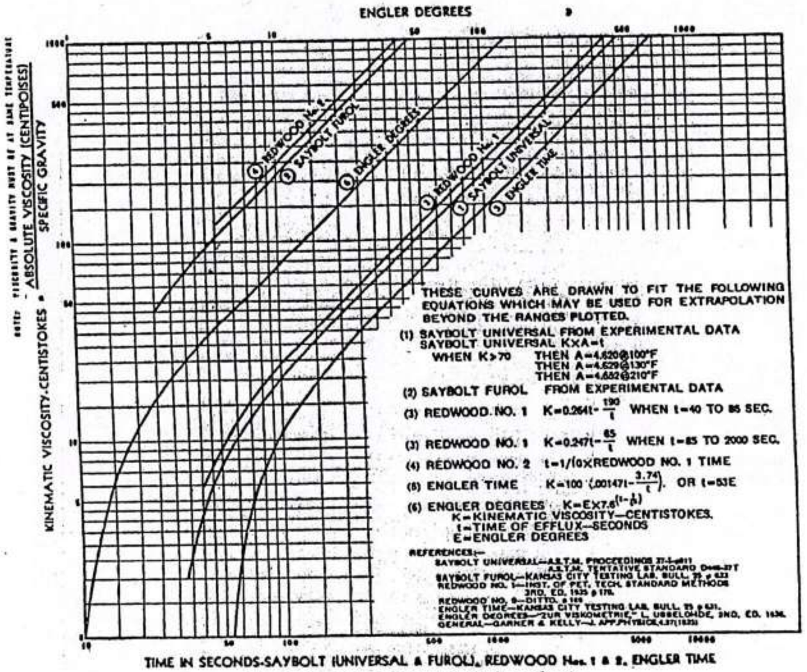

FIG. 13*a*. Viscosity conversion chart.

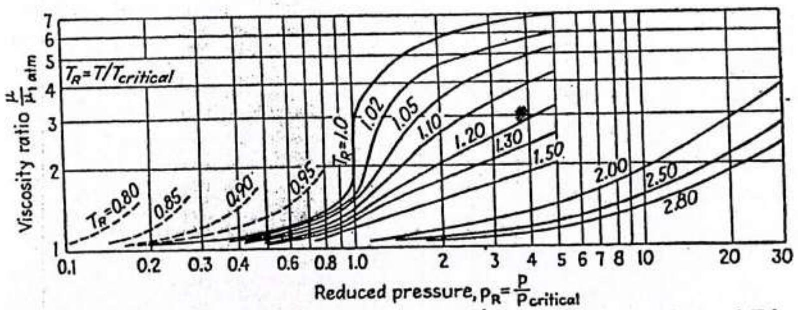

FIG. 13*b*. Viscosity correction chart for gases at different pressures. [*Comings and Egly*, *Ind. Eng. Chem.*, **32**, 715 (1940).]

VISCOSITIES OF PETROLEUM FRACTIONS
For temperature ranges employed in the text
Coordinates to be used with Fig. 14

	X	*Y*
76°API natural gasoline	14.4	6.4
56°API gasoline	14.0	10.5
42°API kerosene	11.6	16.0
35°API distillate	10.0	20.0
34°API mid-continent crude	10.3	21.3
28°API gas oil	10.0	23.6

VISCOSITIES OF ANIMAL AND VEGETABLE OILS*

	Acid No.	Sp gr, 20/4°C	*X*	*Y*
Almond	2.85	0.9188	6.9	28.2
Coconut	0.01	0.9226	6.9	26.9
Cod liver	.....	0.9138	7.7	27.7
Cottonseed	14.24	0.9187	7.0	28.0
Lard	3.39	0.9138	7.0	28.2
Linseed	3.42	0.9297	6.8	27.5
Mustard	.....	0.9237	7.0	28.5
Neatsfoot	13.35	0.9158	6.5	28.0
Olive	.....	0.9158	6.6	28.3
Palm kernel	9.0	0.9190	7.0	26.9
Perilla, raw	1.36	0.9297	8.1	27.2
Rapeseed	0.34	0.9114	7.0	28.8
Sardine	0.57	0.9384	7.7	27.3
Soybean	3.50	0.9228	8.3	27.5
Sperm	0.80	0.8829	7.7	26.3
Sunflower	2.76	0.9207	7.5	27.6
Whale, refined	0.73	0.9227	7.5	27.5

* Based on data at 100 and 210°F of A. R. Rescorla and F. L. Carnahan, *Ind. Eng. Chem.*, **28**, 1212-1213 (1936).

VISCOSITIES OF COMMERCIAL FATTY ACIDS*
250 to 400°F

	Sp gr at 300°F	*X*	*Y*
Lauric	0.792	10.1	23.1
Oleic	0.799	10.0	25.2
Palmitic	0.786	9.2	25.9
Stearic	0.789	10.5	25.5

* From data of D. Q. Kern and W. Van Nostrand, *Ind. Eng. Chem.*, **41**, 2209 (1949).

Viscosities of Liquids*

Coordinates to be used with Fig. 14

Liquid	X	Y	Liquid	X	Y
Acetaldehyde	15.2	4.8	Freon-21	15.7	7.5
Acetic acid, 100%	12.1	14.2	Freon-22	17.2	4.7
Acetic acid, 70%	9.5	17.0	Freon-113	12.5	11.4
Acetic anhydride	12.7	12.8	Freon-114	14.6	8.3
Acetone, 100%	14.5	7.2	Glycerol, 100%	2.0	30.0
Acetone, 35%	7.9	15.0	Glycerol, 50%	6.9	19.6
Allyl alcohol	10.2	14.3	Heptane	14.1	8.4
Ammonia, 100%	12.6	2.0	Hexane	14.7	7.0
Ammonia, 26%	10.1	13.9	Hydrochloric acid, 31.5%	13.0	16.6
Amyl acetate	11.8	12.5	Isobutyl alcohol	7.1	18.0
Amyl alcohol	7.5	18.4	Isobutyric acid	12.2	14.4
Aniline	8.1	18.7	Isopropyl alcohol	8.2	16.0
Anisole	12.3	13.5	Mercury	18.4	16.4
Arsenic trichloride	13.9	14.5	Methanol, 100%	12.4	10.5
Benzene	12.5	10.9	Methanol, 90%	12.3	11.8
Brine, $CaCl_2$, 25%	6.6	15.9	Methanol, 40%	7.8	15.5
Brine, NaCl, 25%	10.2	16.6	Methyl acetate	14.2	8.2
Bromine	14.2	13.2	Methyl chloride	15.0	3.8
Bromotoluene	20.0	15.9	Methyl ethyl ketone	13.9	8.6
n-Butane	15.3	3.3	Naphthalene	7.9	18.1
Isobutane	14.5	3.7	Nitric acid, 95%	12.8	13.8
Butyl acetate	12.3	11.0	Nitric acid, 60%	10.8	17.0
Butyl alcohol	8.6	17.2	Nitrobenzene	10.6	16.2
Butyric acid	12.1	15.3	Nitrotoluene	11.0	17.0
Carbon dioxide	11.6	0.3	Octane	13.7	10.0
Carbon disulfide	16.1	7.5	Octyl alcohol	6.6	21.1
Carbon tetrachloride	12.7	13.1	Pentachloroethane	10.9	17.3
Chlorobenzene	12.3	12.4	Pentane	14.9	5.2
Chloroform	14.4	10.2	Phenol	6.9	20.8
Chlorosulfonic acid	11.2	18.1	Phosphorus tribromide	13.8	16.7
Chlorotoluene, ortho	13.0	13.3	Phosphorus trichloride	16.2	10.9
Chlorotoluene, meta	13.3	12.5	Propane	15.3	1.0
Chlorotoluene, para	13.3	12.5	Propionic acid	12.8	13.8
Cresol, meta	2.5	20.8	Propyl alcohol	9.1	16.5
Cyclohexanol	2.9	24.3	Propyl bromide	14.5	9.6
Dibromoethane	12.7	15.8	Propyl chloride	14.4	7.5
Dichloroethane	13.2	12.2	Propyl iodide	14.1	11.6
Dichloromethane	14.6	8.9	Sodium	16.4	13.9
Diethyl oxalate	11.0	16.4	Sodium hydroxide, 50%	3.2	25.8
Dimethyl oxalate	12.3	15.8	Stannic chloride	13.5	12.8
Diphenyl	12.0	18.3	Sulfur dioxide	15.2	7.1
Dipropyl oxalate	10.3	17.7	Sulfuric acid, 110%	7.2	27.4
Ethyl acetate	13.7	9.1	Sulfuric acid, 98%	7.0	24.8
Ethyl alcohol, 100%	10.5	13.8	Sulfuric acid, 60%	10.2	21.3
Ethyl alcohol, 95%	9.8	14.3	Sulfuryl chloride	15.2	12.4
Ethyl alcohol, 40%	6.5	16.6	Tetrachloroethane	11.9	15.7
Ethyl benzene	13.2	11.5	Tetrachloroethylene	14.2	12.7
Ethyl bromide	14.5	8.1	Titanium tetrachloride	14.4	12.3
Ethyl chloride	14.8	6.0	Toluene	13.7	10.4
Ethyl ether	14.5	5.3	Trichloroethylene	14.8	10.5
Ethyl formate	14.2	8.4	Turpentine	11.5	14.9
Ethyl iodide	14.7	10.3	Vinyl acetate	14.0	8.8
Ethylene glycol	6.0	23.6	Water	10.2	13.0
Formic acid	10.7	15.8	Xylene, ortho	13.5	12.1
Freon-11	14.4	9.0	Xylene, meta	13.9	10.6
Freon-12	16.8	5.6	Xylene, para	13.9	10.9

* From Perry, J. H., "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York, 1950.

(16)

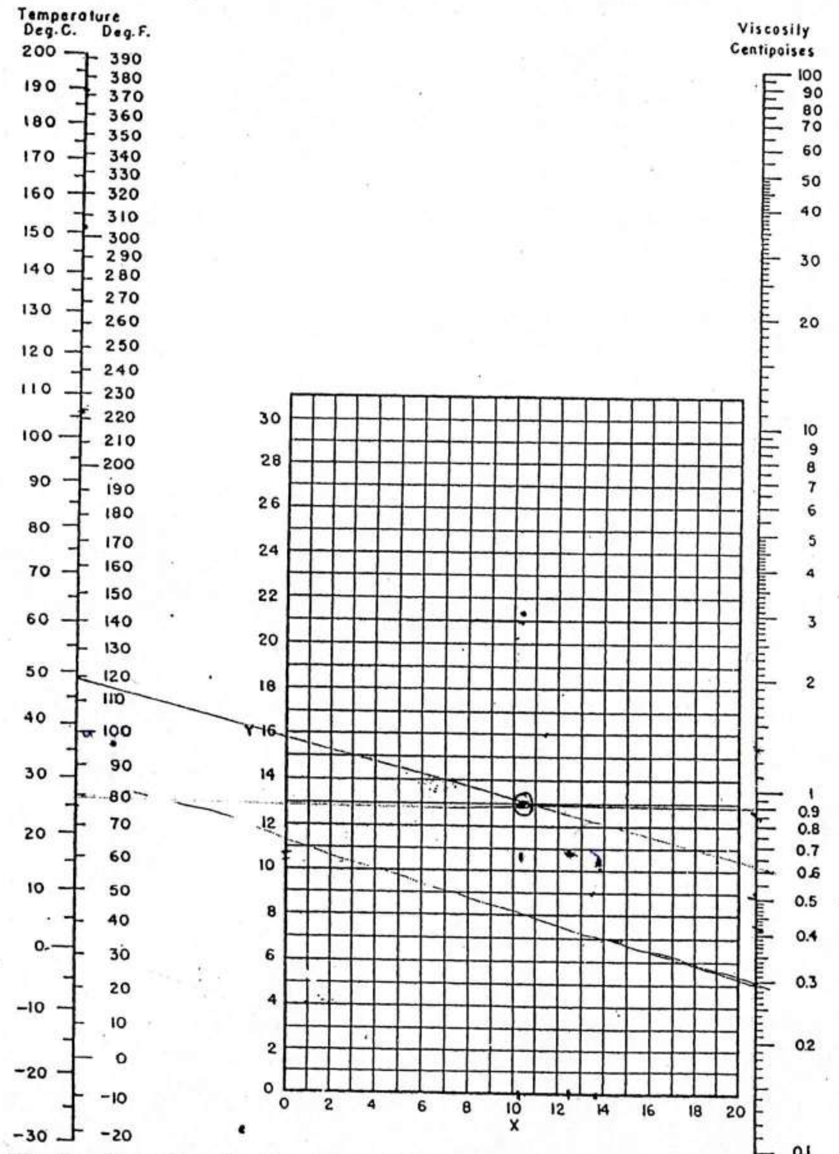

FIG. 14. Viscosities of liquids. (*Perry, "Chemical Engineers' Handbook," 3d ed., McGraw Hill Book Company, Inc., New York,* 1950.)

0-3

VISCOSITIES OF GASES*
Coordinates to be used with Fig. 15

Gas	X	Y
Acetic acid	7.7	14.3
Acetone	8.9	13.0
Acetylene	9.8	14.9
Air	11.0	20.0
Ammonia	8.4	16.0
Argon	10.5	22.4
Benzene	8.5	13.2
Bromine	8.9	19.2
Butene	9.2	13.7
Butylene	8.9	13.0
Carbon dioxide	9.5	18.7
Carbon disulfide	8.0	16.0
Carbon monoxide	11.0	20.0
Chlorine	9.0	18.4
Chloroform	8.9	15.7
Cyanogen	9.2	15.2
Cyclohexane	9.2	12.0
Ethane	9.1	14.5
Ethyl acetate	8.5	13.2
Ethyl alcohol	9.2	14.2
Ethyl chloride	8.5	15.6
Ethyl ether	8.9	13.0
Ethylene	9.5	15.1
Fluorine	7.3	23.8
Freon-11	10.6	15.1
Freon-12	11.1	16.0
Freon-21	10.8	15.3
Freon-22	10.1	17.0
Freon-113	11.3	14.0
Helium	10.9	20.5
Hexane	8.6	11.8
Hydrogen	11.2	12.4
$3H_2 + 1N_2$	11.2	17.2
Hydrogen bromide	8.8	20.9
Hydrogen chloride	8.8	18.7
Hydrogen cyanide	9.8	14.9
Hydrogen iodide	9.0	21.3
Hydrogen sulfide	8.6	18.0
Iodine	9.0	18.4
Mercury	5.3	22.9
Methane	9.9	15.5
Methyl alcohol	8.5	15.6
Nitric oxide	10.9	20.5
Nitrogen	10.6	20.0
Nitrosyl chloride	8.0	17.6
Nitrous oxide	8.8	19.0
Oxygen	11.0	21.3
Pentane	7.0	12.8
Propane	9.7	12.9
Propyl alcohol	8.4	13.4
Propylene	9.0	13.8
Sulfur dioxide	9.6	17.0
Toluene	8.6	12.4
2, 3, 3-Trimethylbutane	9.5	10.5
Water	8.0	16.0
Xenon	9.3	23.0

* From Perry, J. H., "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York, 1950.

(17)

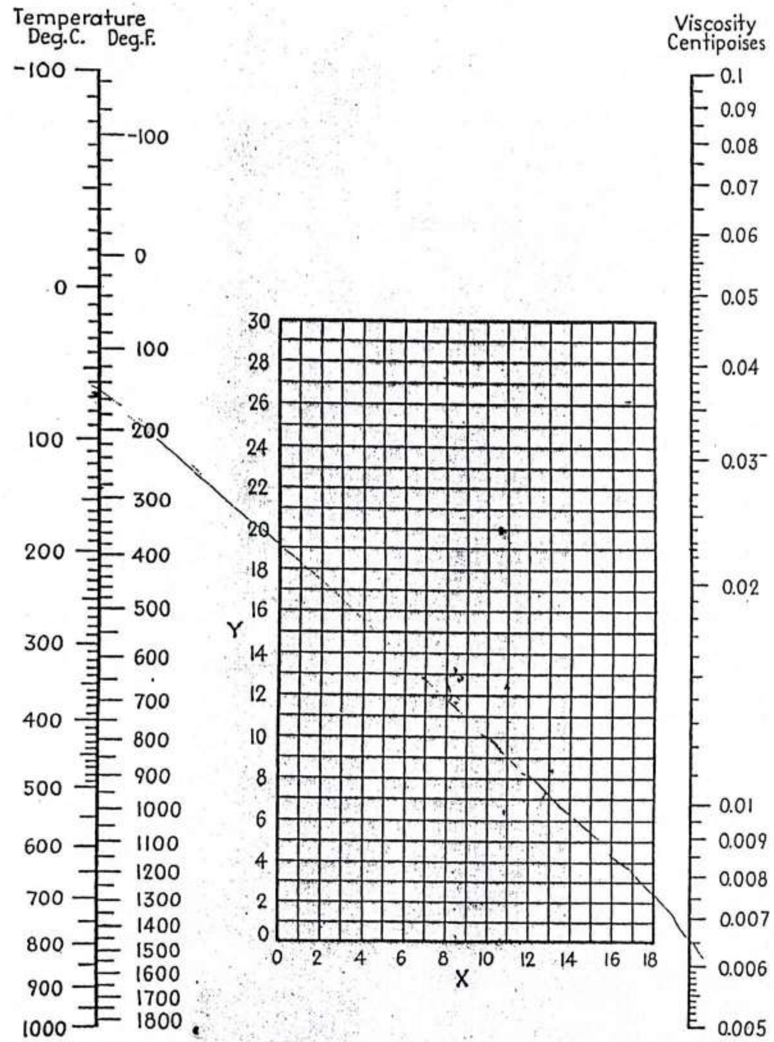

FIG. 15. Viscosities of gases. (*Perry, "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Book Company, Inc., New York, 1950.*)

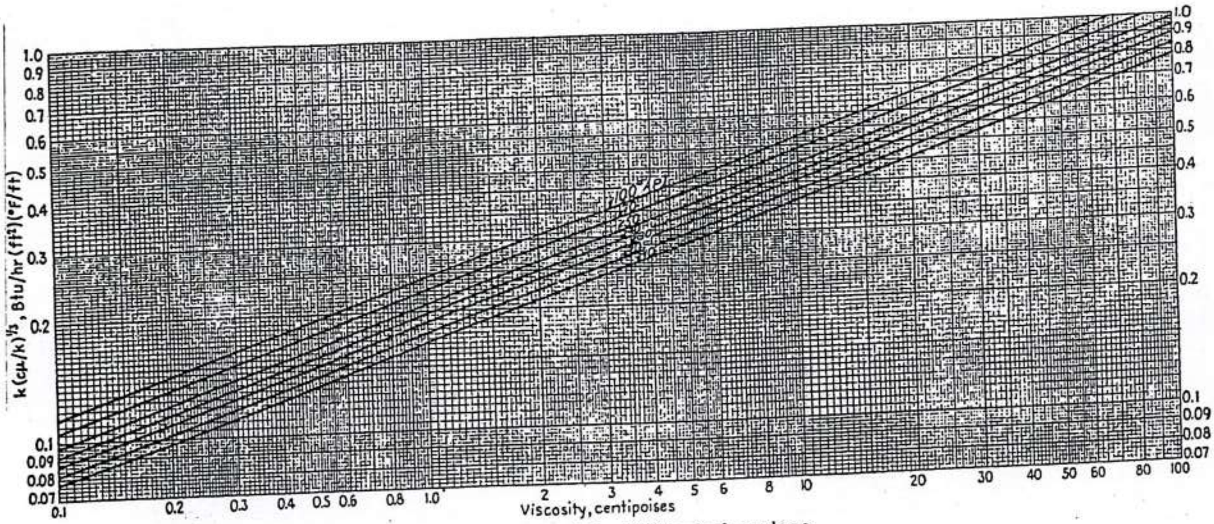

FIG. 16. Values of $k(c\mu/k)^{1/3}$ for hydrocarbons.

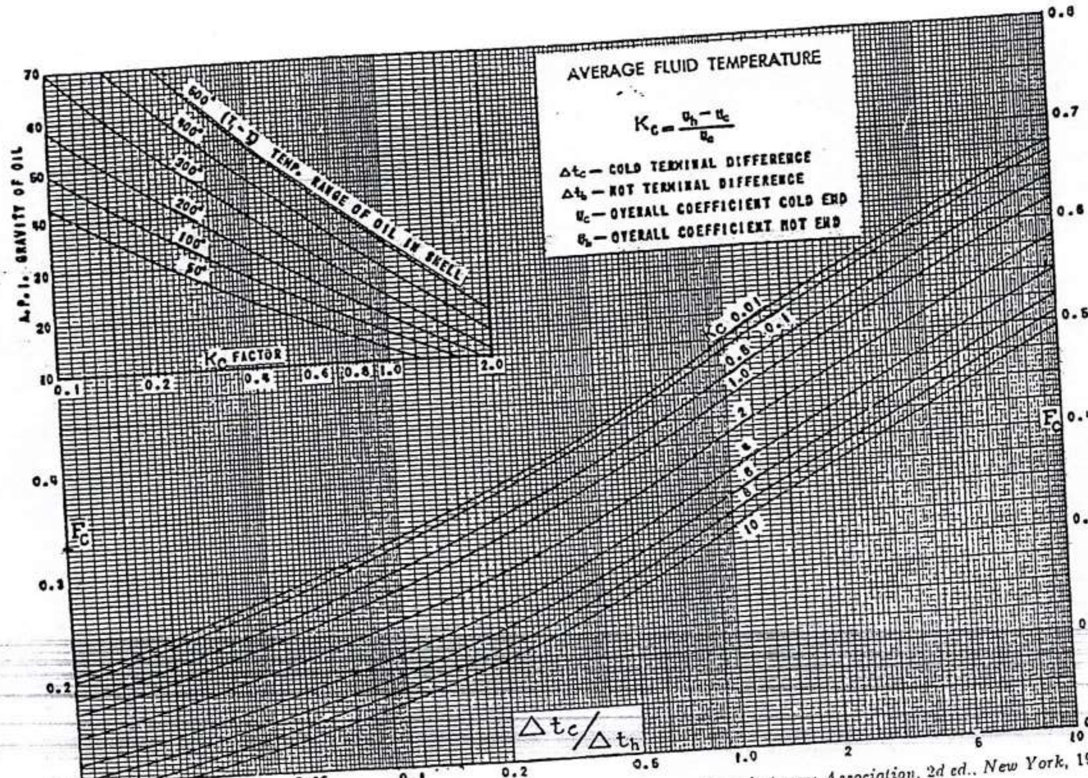

FIG. 17. The caloric temperature factor F_c. (*Standards of Tubular Exchanger Manufacturers Association*, 2d ed., New York, 1949.)

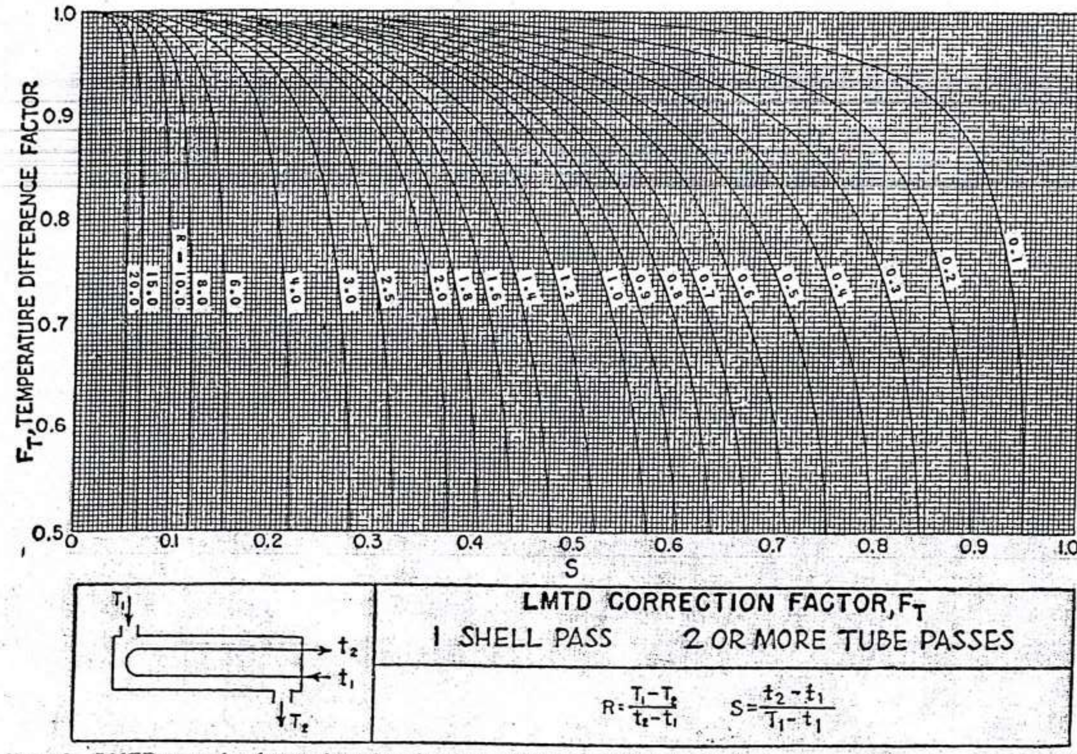

FIG. 18. LMTD correction factors for 1-2 exchangers. (*Standards of Tubular Exchanger Manufacturers Association, 2d ed., New York*, 1949.)

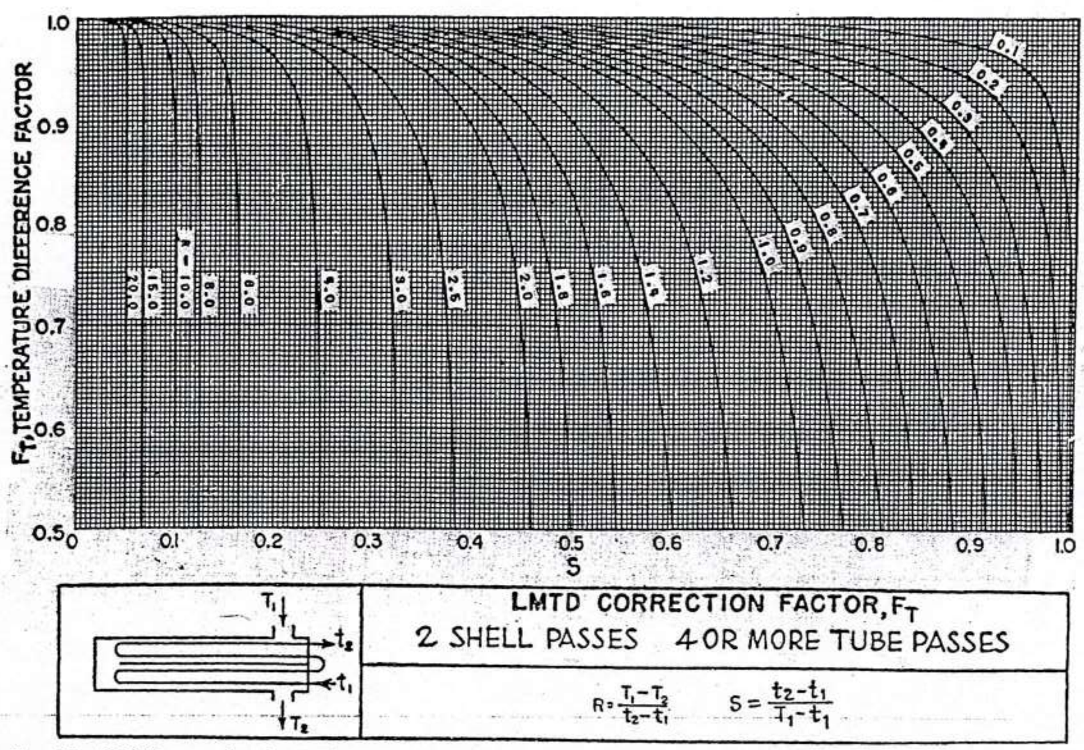

FIG. 19. LMTD correction factors for 2-4 exchangers. (*Standards of Tubular Exchanger Manufacturers Association 2d ed., New York*, 1949.)

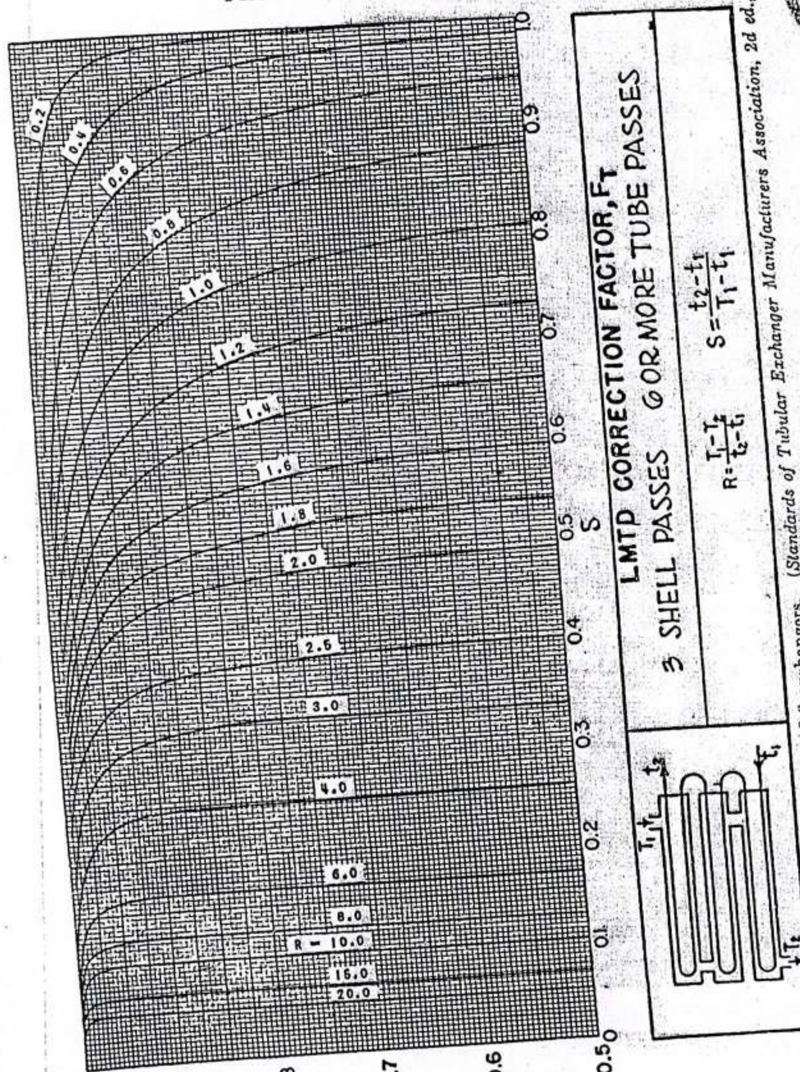

FIG. 20. LMTD correction factors for 3-6 exchangers. (*Standards of Tubular Exchanger Manufacturers Association*, 2d ed., New York, 1949.)

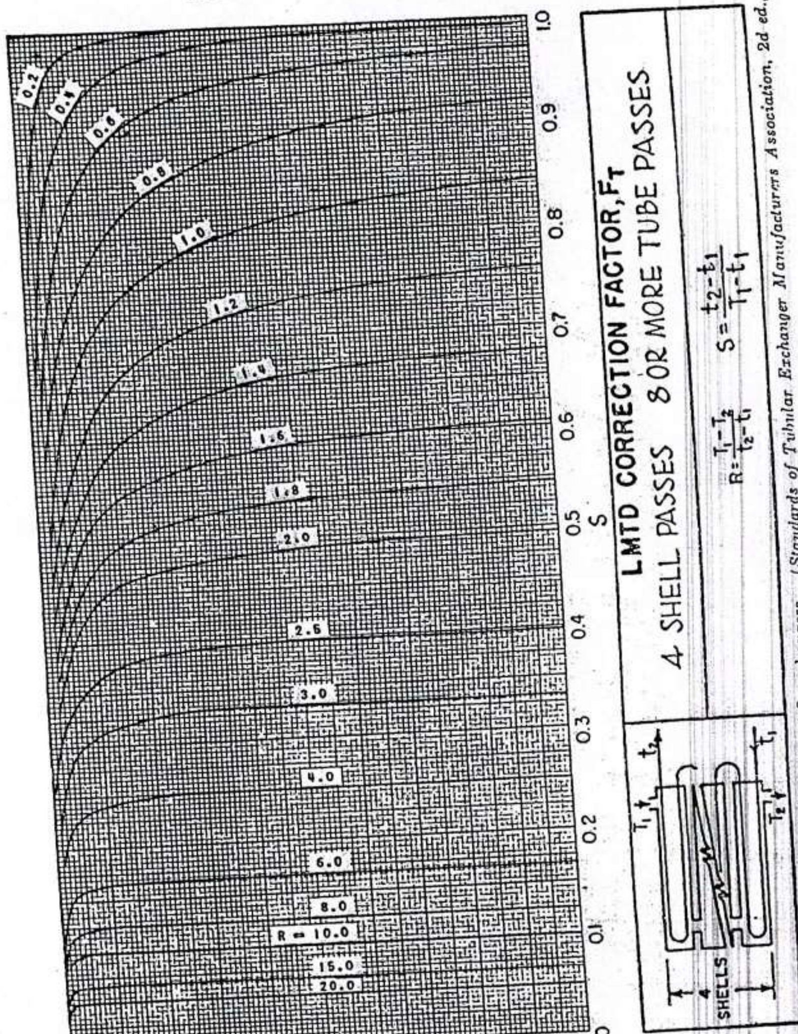

FIG. 21. LMTD correction factors for 4-8 exchangers. (*Standards of Tubular Exchanger Manufacturers Association*, 2d ed., New York, 1949.)

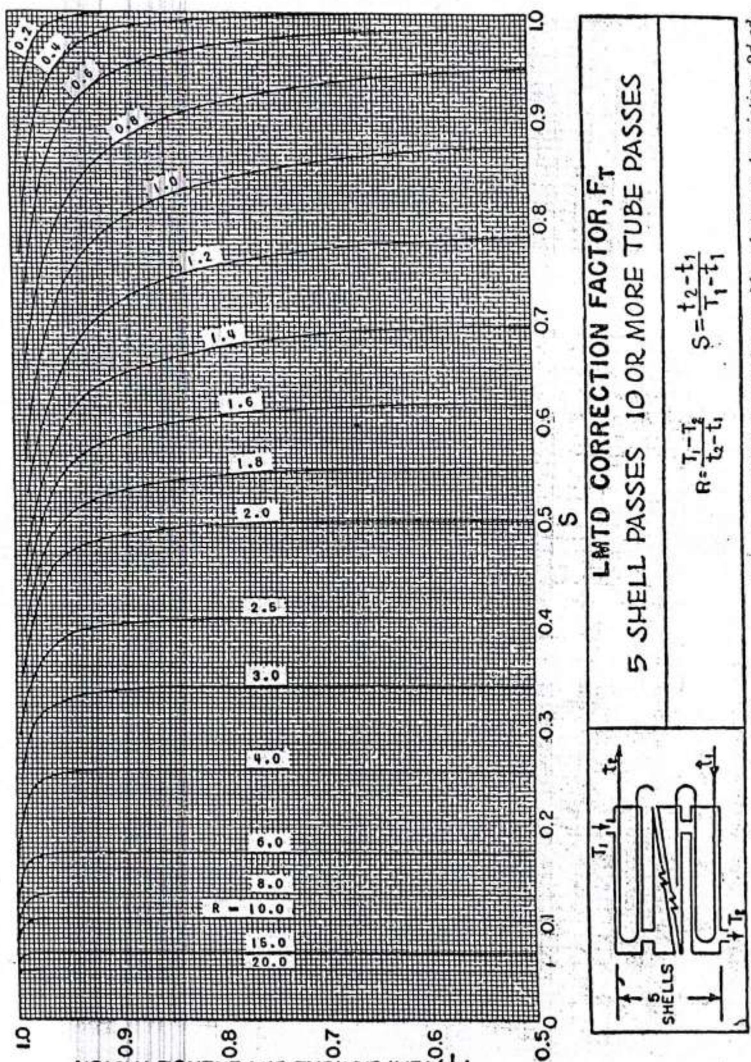

FIG. 22. LMTD correction factors for 5-10 exchangers. (*Standards of Tubular Exchanger Manufacturers Association*, 2d ed., New York, 1949.)

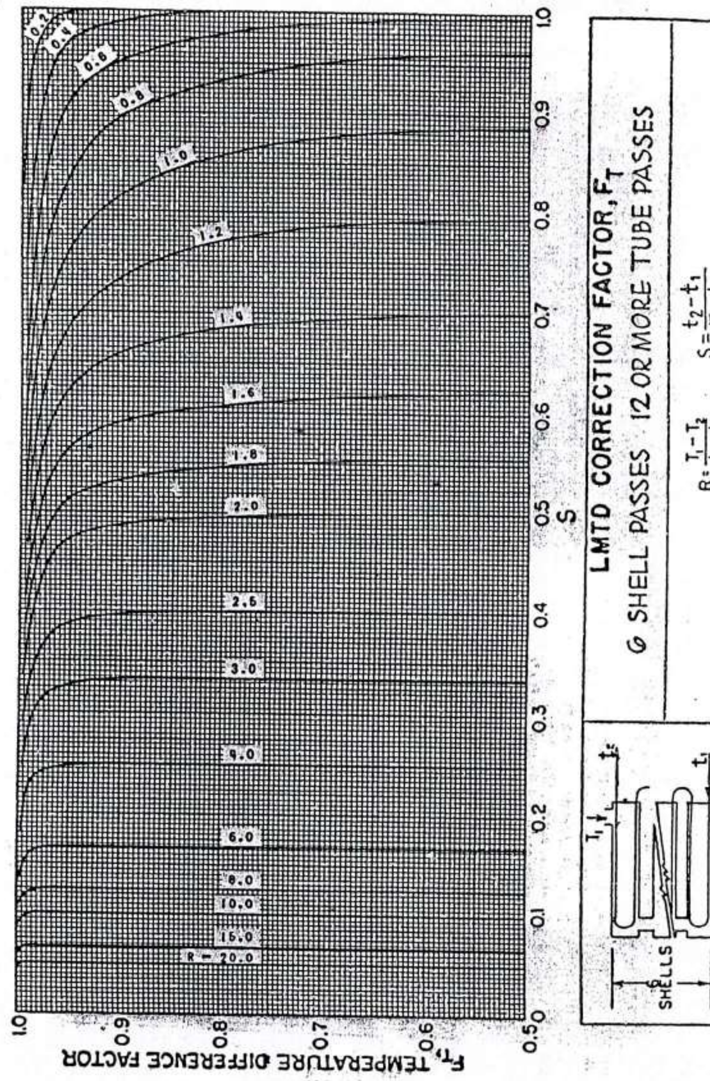

FIG. 23. LMTD correction factors for 6-12 exchangers. (*Standards of Tubular Exchanger Manufacturers Association*, 2d ed., New York, 1949.)

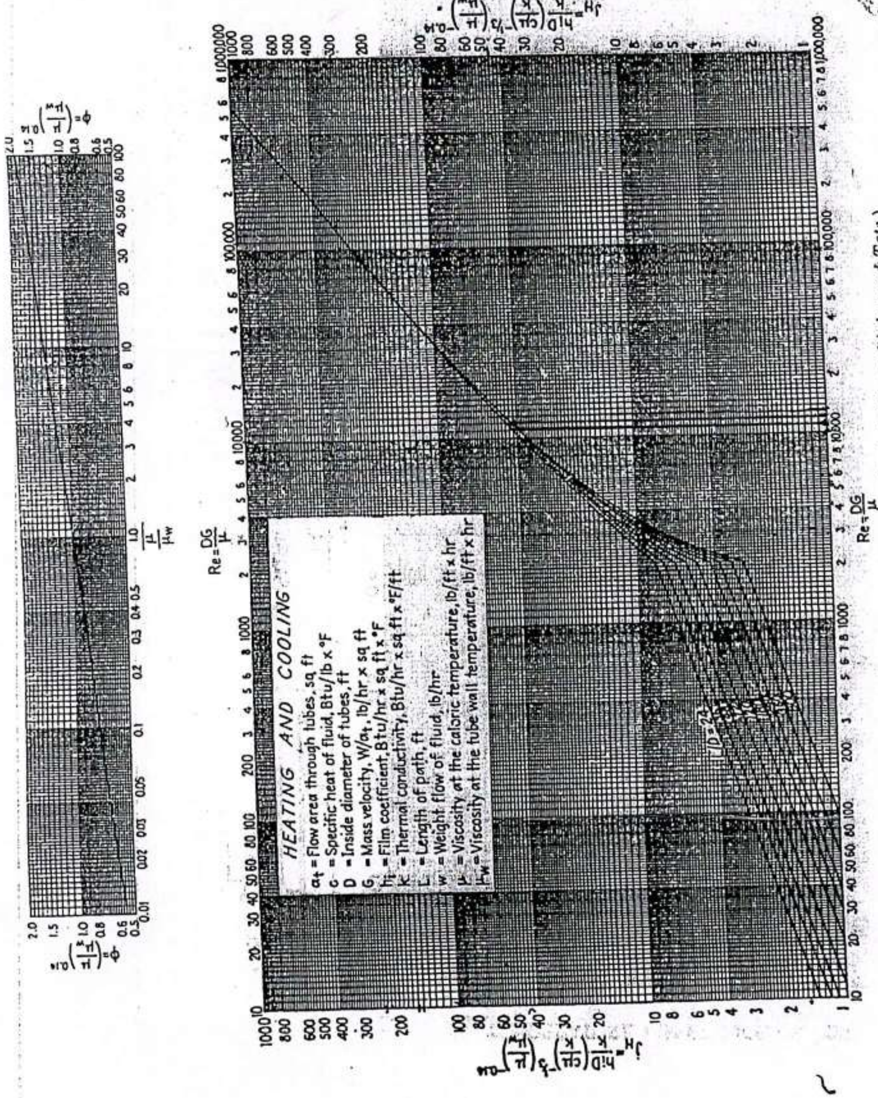

FIG. 24. Tube-side heat-transfer curve. (*Adapted from Sieder and Tate.*)

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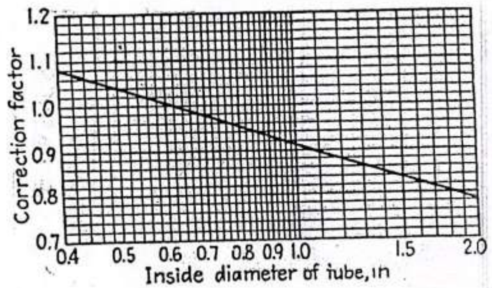

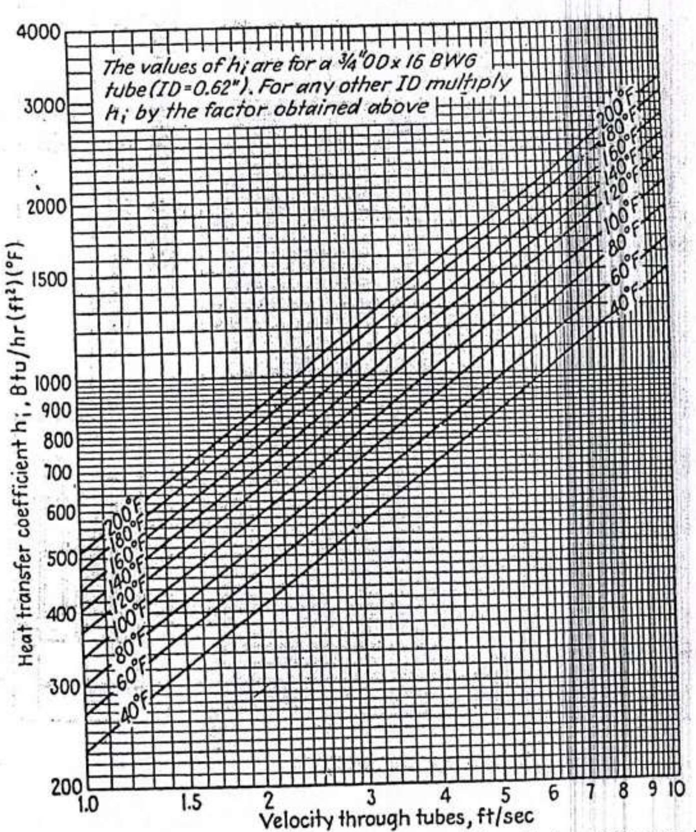

FIG. 25. Tube-side water-heat-transfer curve. [*Adapted from Eagle and Ferguson, Proc. Roy. Soc.*, **A127**, 540 (1930).]

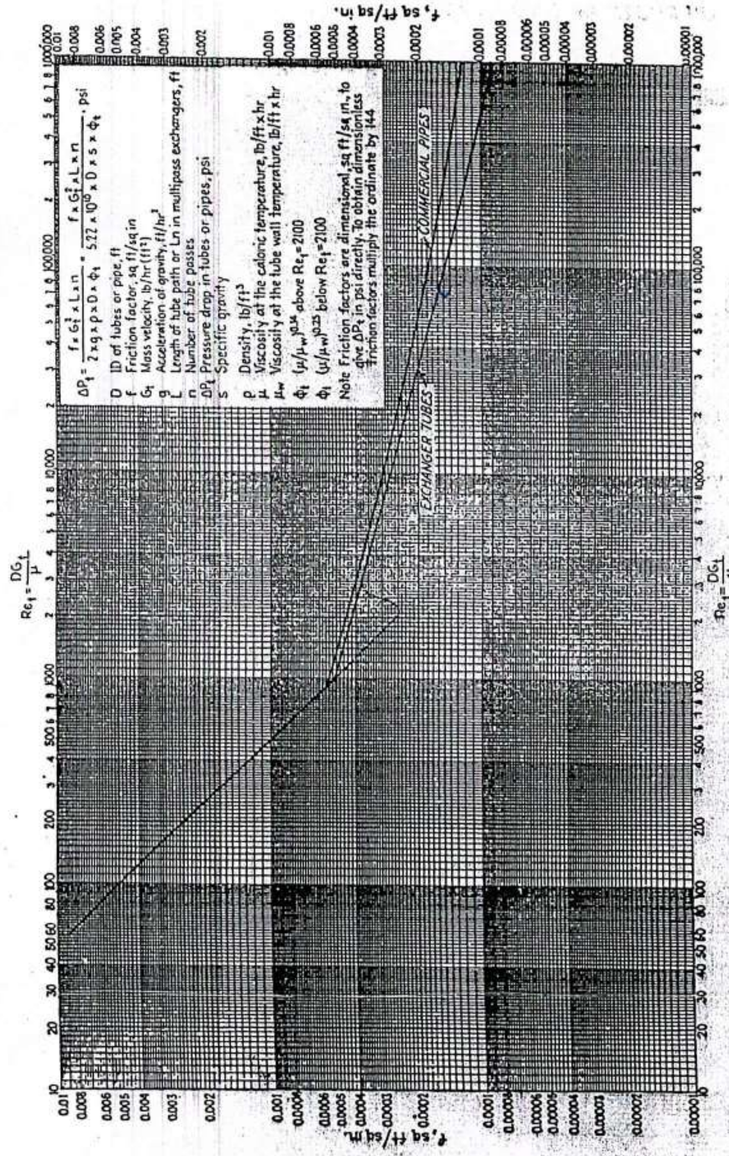

FIG. 26. Tube-side friction factors. *(Standards of Tubular Exchanger Manufacturers Association, 2d ed., New York, 1949.)*

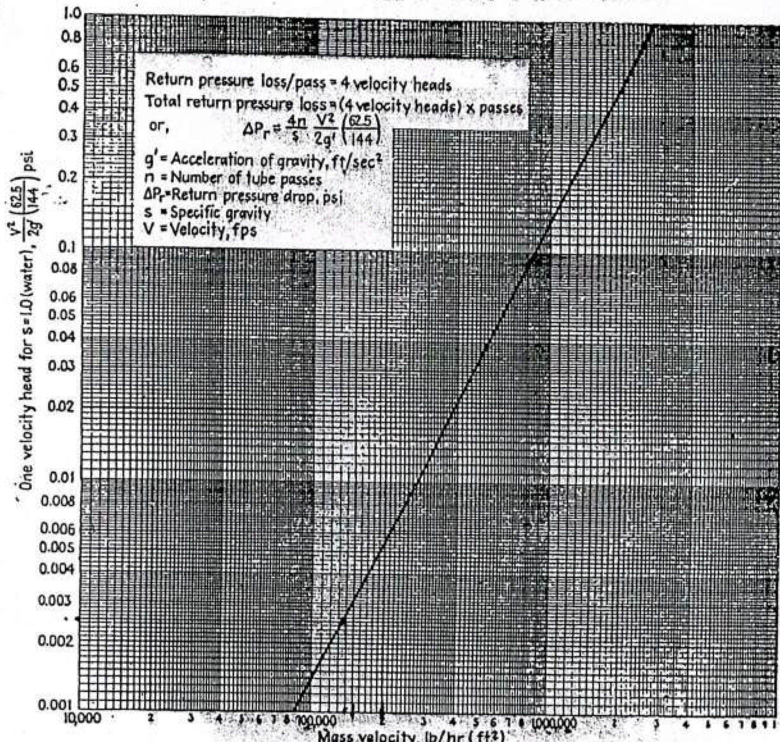

FIG. 27. Tube-side return pressure loss.

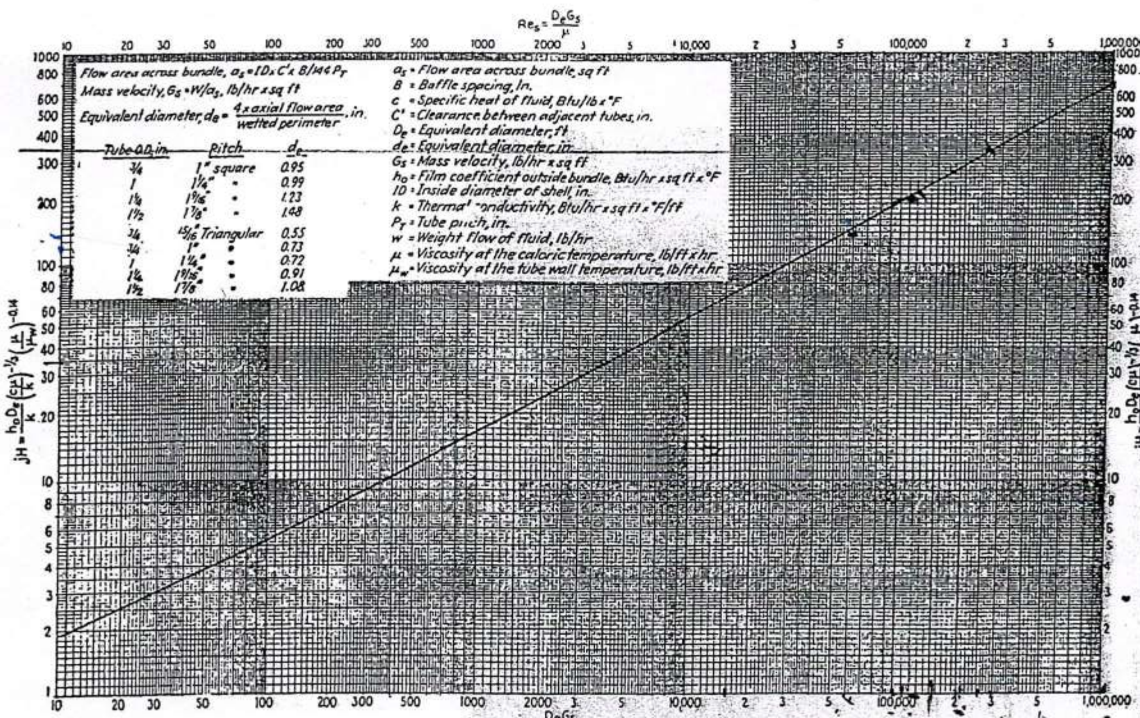

FIG. 28. Shell-side heat-transfer curve for bundles with 25% cut segmental baffles.

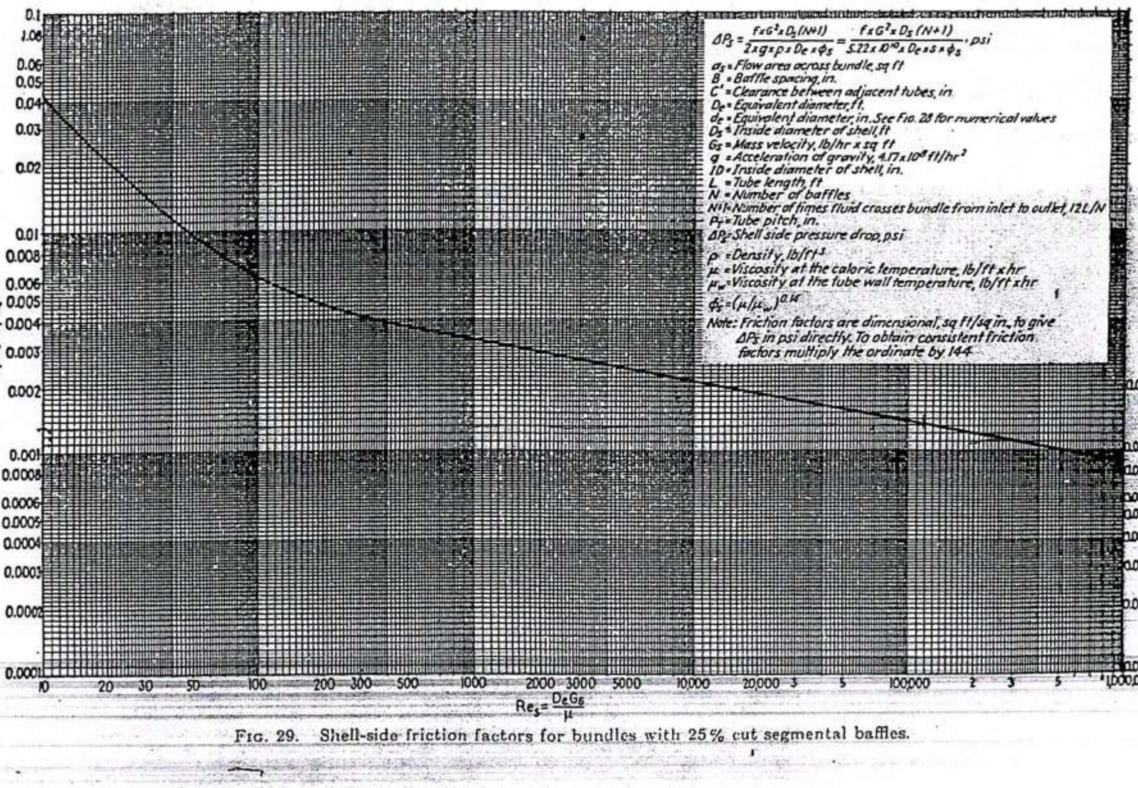

FIG. 29. Shell-side friction factors for bundles with 25% cut segmental baffles.

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TABLE 8. APPROXIMATE OVERALL DESIGN COEFFICIENTS

Values include total dirt factors of 0.003 and allowable pressure drops of 5 to 10 psi on the controlling stream

Coolers

Hot fluid	Cold fluid	Overall U_D
Water	Water	250–500§
Methanol	Water	250–500§
Ammonia	Water	250–500§
Aqueous solutions	Water	250–500§
Light organics*	Water	75–150
Medium organics†	Water	50–125
Heavy organics‡	Water	5–75‖
Gases	Water	2–50¶
Water	Brine	100–200
Light organics	Brine	40–100

Heaters

Hot fluid	Cold fluid	Overall U_D
Steam	Water	200–700§
Steam	Methanol	200–700§
Steam	Ammonia	200–700§
Steam	Aqueous solutions:	
Steam	Less than 2.0 cp	200–700
Steam	More than 2.0 cp	100–500§
Steam	Light organics	100–200
Steam	Medium organics	50–100
Steam	Heavy organics	6–60
Steam	Gases	5–50¶

Exchangers

Hot fluid	Cold fluid	Overall U_D
Water	Water	250–500§
Aqueous solutions	Aqueous solutions	250–500§
Light organics	Light organics	40–75
Medium organics	Medium organics	20–60
Heavy organics	Heavy organics	10–40
Heavy organics	Light organics	30–60
Light organics	Heavy organics	10–40

* *Light organics* are fluids with viscosities of less than 0.5 centipoise and include benzene, toluene, acetone, ethanol, methyl ethyl ketone, gasoline, light kerosene, and naphtha.

† *Medium organics* have viscosities of 0.5 to 1.0 centipoise and include kerosene, straw oil, hot gas oil, hot absorber oil, and some crudes.

‡ *Heavy organics* have viscosities above 1.0 centipose and include cold gas oil, lube oils, fuel oils, reduced crude oils, tars, and asphalts.

§ Dirt factor 0.001.

‖ Pressure drop 20 to 30 psi.

¶ These rates are greatly influenced by the operating pressure.

TABLE 9. TUBE-SHEET LAYOUTS (TUBE COUNTS)

Square Pitch

¾ in. OD tubes on 1-in. square pitch						1 in. OD tubes on 1¼-in. square pitch					
Shell ID, in.	1-P	2-P	4-P	6-P	8-P	Shell ID, in.	1-P	2-P	4-P	6-P	8-P
8	32	26	20	20		8	21	16	14		
10	52	52	40	36		10	32	32	26	24	
12	81	76	68	68	60	12	48	45	40	38	36
13¼	97	90	82	76	70	13¼	61	56	52	48	44
15¼	137	124	116	108	108	15¼	81	76	68	68	64
17¼	177	166	158	150	142	17¼	112	112	96	90	82
19¼	224	220	204	192	188	19¼	138	132	128	122	116
21¼	277	270	246	240	234	21¼	177	166	158	152	148
23¼	341	324	308	302	292	23¼	213	208	192	184	184
25	413	394	370	356	346	25	260	252	238	226	222
27	481	460	432	420	408	27	300	288	278	268	260
29	553	526	480	468	456	29	341	326	300	294	286
31	657	640	600	580	560	31	406	398	380	368	358
33	749	718	688	676	648	33	465	460	432	420	414
35	845	824	780	766	748	35	522	518	488	484	472
37	934	914	886	866	838	37	596	574	562	544	532
39	1049	1024	982	968	948	39	665	644	624	612	600

1¼ in. OD tubes on 1$\frac{9}{16}$-in. square pitch						1½ in. OD tubes on 1⅞-in. square pitch					
10	16	12	10								
12	30	24	22	16	16	12	16	16	12	12	
13¼	32	30	30	22	22	13¼	22	22	16	16	
15¼	44	40	37	35	31	15¼	29	29	25	24	22
17¼	56	53	51	48	44	17¼	39	39	34	32	29
19¼	78	73	71	64	56	19¼	50	48	45	43	39
21¼	96	90	86	82	78	21¼	62	60	57	54	50
23¼	127	112	106	102	96	23¼	78	74	70	66	62
25	140	135	127	123	115	25	94	90	86	84	78
27	166	160	151	146	140	27	112	108	102	98	94
29	193	188	178	174	166	29	131	127	120	116	112
31	226	220	209	202	193	31	151	146	141	138	131
33	258	252	244	238	226	33	176	170	164	160	151
35	293	287	275	268	258	35	202	196	188	182	176
37	334	322	311	304	293	37	224	220	217	210	202
39	370	362	348	342	336	39	252	246	237	230	224

TABLE 9. TUBE-SHEET LAYOUTS (TUBE COUNTS).—(*Continued*)
Triangular Pitch

¾ in. OD tubes on $\frac{15}{16}$-in. triangular pitch

Shell ID, in.	1-P	2-P	4-P	6-P	8-P
8	36	32	26	24	18
10	62	56	47	42	36
12	109	98	86	82	78
13¼	127	114	96	90	86
15¼	170	160	140	136	128
17¼	239	224	194	188	178
19¼	301	282	252	244	234
21¼	361	342	314	306	290
23¼	442	420	386	378	364
25	532	506	468	446	434
27	637	602	550	536	524
29	721	692	640	620	594
31	847	822	766	722	720
33	974	938	878	852	826
35	1102	1068	1004	988	958
37	1240	1200	1144	1104	1072
39	1377	1330	1258	1248	1212

¾ in. OD tubes on 1-in. triangular pitch

Shell ID, in.	1-P	2-P	4-P	6-P	8-P
8	37	30	24	24	
10	61	52	40	36	
12	92	82	76	74	70
13¼	109	106	86	82	74
15¼	151	138	122	118	110
17¼	203	196	178	172	166
19¼	262	250	226	216	210
21¼	316	302	278	272	260
23¼	384	376	352	342	328
25	470	452	422	394	382
27	559	534	488	474	464
29	630	604	556	538	508
31	745	728	678	666	640
33	856	830	774	760	732
35	970	938	882	864	848
37	1074	1044	1012	986	870
39	1206	1176	1128	1100	1078

1 in. OD tubes on 1¼-in. triangular pitch

Shell ID, in.	1-P	2-P	4-P	6-P	8-P
8	21	16	16	14	
10	32	32	26	24	
12	55	52	48	46	44
13¼	68	66	58	54	50
15¼	91	86	80	74	72
17¼	131	118	106	104	94
19¼	163	152	140	136	128
21¼	199	188	170	164	160
23¼	241	232	212	212	202
25	294	282	256	252	242
27	349	334	302	296	286
29	397	376	338	334	316
31	472	454	430	424	400
33	538	522	486	470	454
35	608	592	562	546	532
37	674	664	632	614	598
39	766	736	700	688	672

1¼ in. OD tubes on $1\frac{9}{16}$-in. triangular pitch

Shell ID, in.	1-P	2-P	4-P	6-P	8-P
10	20	18	14		
12	32	30	26	22	20
13¼	38	36	32	28	26
15¼	54	51	45	42	38
17¼	69	66	62	58	54
19¼	95	91	86	78	69
21¼	117	112	105	101	95
23¼	140	136	130	123	117
25	170	164	155	150	140
27	202	196	185	179	170
29	235	228	217	212	202
31	275	270	255	245	235
33	315	305	297	288	275
35	357	348	335	327	315
37	407	390	380	374	357
39	449	436	425	419	407

1½ in. OD tubes on 1⅞-in. triangular pitch

Shell ID, in.	1-P	2-P	4-P	6-P	8-P
12	18	14	14	12	12
13¼	27	22	18	16	14
15¼	36	34	32	30	27
17¼	48	44	42	38	36
19¼	61	58	55	51	48
21¼	76	72	70	66	61
23¼	95	91	86	80	76
25	115	110	105	98	95
27	136	131	125	118	115
29	160	154	147	141	136
31	184	177	172	165	160
33	215	206	200	190	184
35	246	238	230	220	215
37	275	268	260	252	246
39	307	299	290	284	275

TABLE 10. HEAT EXCHANGER AND CONDENSER TUBE DATA

Tube OD, in.	BWG	Wall thickness, in.	ID, in.	Flow area per tube, in.²	Surface per lin ft, ft²: Outside	Surface per lin ft, ft²: Inside	Weight per lin ft, lb steel
½	12	0.109	0.282	0.0625	0.1309	0.0748	0.493
	14	0.083	0.334	0.0876		0.0874	0.403
	16	0.065	0.370	0.1076		0.0969	0.329
	18	0.049	0.402	0.127		0.1052	0.258
	20	0.035	0.430	0.145		0.1125	0.190
¾	10	0.134	0.482	0.182	0.1963	0.1263	0.965
	11	0.120	0.510	0.204		0.1335	0.884
	12	0.109	0.532	0.223		0.1393	0.817
	13	0.095	0.560	0.247		0.1466	0.727
	14	0.083	0.584	0.268		0.1529	0.647
	15	0.072	0.606	0.289		0.1587	0.571
	16	0.065	0.620	0.302		0.1623	0.520
	17	0.058	0.634	0.314		0.1660	0.469
	18	0.049	0.652	0.334		0.1707	0.401
1	8	0.165	0.670	0.355	0.2618	0.1754	1.61
	9	0.148	0.704	0.389		0.1843	1.47
	10	0.134	0.732	0.421		0.1916	1.36
	11	0.120	0.760	0.455		0.1990	1.23
	12	0.109	0.782	0.479		0.2048	1.14
	13	0.095	0.810	0.515		0.2121	1.00
	14	0.083	0.834	0.546		0.2183	0.890
	15	0.072	0.856	0.576		0.2241	0.781
	16	0.065	0.870	0.594		0.2277	0.710
	17	0.058	0.884	0.613		0.2314	0.639
	18	0.049	0.902	0.639		0.2361	0.545
1¼	8	0.165	0.920	0.665	0.3271	0.2409	2.09
	9	0.148	0.954	0.714		0.2498	1.91
	10	0.134	0.982	0.757		0.2572	1.75
	11	0.120	1.01	0.800		0.2644	1.58
	12	0.109	1.03	0.836		0.2701	1.45
	13	0.095	1.06	0.884		0.2775	1.28
	14	0.083	1.08	0.923		0.2839	1.13
	15	0.072	1.11	0.960		0.2896	0.991
	16	0.065	1.12	0.985		0.2932	0.900
	17	0.058	1.13	1.01		0.2969	0.808
	18	0.049	1.15	1.04		0.3015	0.688
1½	8	0.165	1.17	1.075	0.3925	0.3063	2.57
	9	0.148	1.20	1.14		0.3152	2.34
	10	0.134	1.23	1.19		0.3225	2.14
	11	0.120	1.26	1.25		0.3299	1.98
	12	0.109	1.28	1.29		0.3356	1.77
	13	0.095	1.31	1.35		0.3430	1.56
	14	0.083	1.33	1.40		0.3492	1.37
	15	0.072	1.36	1.44		0.3555	1.20
	16	0.065	1.37	1.47		0.3587	1.09
	17	0.058	1.38	1.50		0.3623	0.978
	18	0.049	1.40	1.54		0.3670	0.831

Table 11. Dimensions of Steel Pipe (IPS)

Nominal pipe size, IPS, in.	OD, in.	Schedule No.	ID, in.	Flow area per pipe, in.^{2}	Surface per lin ft, ft.^{2}/ft. Outside	Surface per lin ft, ft.^{2}/ft. Inside	Weight per lin ft, lb steel
1/8	0.405	40*	0.269	0.058	0.106	0.070	0.25
		80†	0.215	0.036		0.056	0.32
1/4	0.540	40*	0.364	0.104	0.141	0.095	0.43
		80†	0.302	0.072		0.079	0.54
3/8	0.675	40*	0.493	0.192	0.177	0.129	0.57
		80†	0.423	0.141		0.111	0.74
1/2	0.840	40*	0.622	0.304	0.220	0.163	0.85
		80†	0.546	0.235		0.143	1.09
3/4	1.05	40*	0.824	0.534	0.275	0.216	1.13
		80†	0.742	0.432		0.194	1.48
1	1.32	40*	1.049	0.864	0.344	0.274	1.68
		80†	0.957	0.718		0.250	2.17
1 1/4	1.66	40*	1.380	1.50	0.435	0.362	2.28
		80†	1.278	1.28		0.335	3.00
1 1/2	1.90	40*	1.610	2.04	0.498	0.422	2.72
		80†	1.500	1.76		0.393	3.64
2	2.38	40*	2.067	3.35	0.622	0.542	3.66
		80†	1.939	2.95		0.508	5.03
2 1/2	2.88	40*	2.469	4.79	0.753	0.647	5.80
		80†	2.323	4.23		0.609	7.67
3	3.50	40*	3.068	7.38	0.917	0.804	7.58
		80†	2.900	6.61		0.760	10.3
4	4.50	40*	4.026	12.7	1.178	1.055	10.8
		80†	3.826	11.5		1.002	15.0
6	6.625	40*	6.065	28.9	1.734	1.590	19.0
		80†	5.761	26.1		1.510	28.6
8	8.625	40*	7.981	50.0	2.258	2.090	28.6
		80†	7.625	45.7		2.000	43.4
10	10.75	40*	10.02	78.8	2.814	2.62	40.5
		60	9.75	74.6		2.55	54.8
12	12.75	30	12.09	115	3.338	3.17	43.8
14	14.0	30	13.25	138	3.665	3.47	54.6
16	16.0	30	15.25	183	4.189	4.00	62.6
18	18.0	20‡	17.25	234	4.712	4.52	72.7
20	20.0	20	19.25	291	5.236	5.05	78.6
22	22.0	20‡	21.25	355	5.747	5.56	84.0
24	24.0	20	23.25	425	6.283	6.09	94.7

* Commonly known as standard.
† Commonly known as extra heavy.
‡ Approximately.

Table 12. Fouling Factors*

Temperature of heating medium	Up to 240°F		240–400°F†	
Temperature of water	125°F or less		Over 125°F	
Water	Water velocity, fps		Water velocity, fps	
	3 ft and less	Over 3 ft	3 ft and less	Over 3 ft
Sea water	0.0005	0.0005	0.001	0.001
Brackish water	0.002	0.001	0.003	0.002
Cooling tower and artificial spray pond:				
Treated make-up	0.001	0.001	0.002	0.002
Untreated	0.003	0.003	0.005	0.004
City or well water (such as Great Lakes)	0.001	0.001	0.002	0.002
Great Lakes	0.001	0.001	0.002	0.002
River water:				
Minimum	0.002	0.001	0.003	0.022
Mississippi	0.003	0.002	0.004	0.003
Delaware, Schuylkill	0.003	0.002	0.004	0.003
East River and New York Bay	0.003	0.002	0.004	0.003
Chicago sanitary canal	0.008	0.006	0.010	0.008
Muddy or silty	0.003	0.002	0.004	0.003
Hard (over 15 grains/gal)	0.003	0.003	0.005	0.005
Engine jacket	0.001	0.001	0.001	0.001
Distilled	0.0005	0.0005	0.0005	0.0005
Treated boiler feedwater	0.001	0.0005	0.001	0.001
Boiler blowdown	0.002	0.002	0.002	0.002

† Ratings in the last two columns are based on a temperature of the heating medium of 240 to 400°F. If the heating medium temperature is over 400°F, and the cooling medium is known to scale these ratings should be modified accordingly.

Petroleum Fractions

Oils (industrial):
- Fuel oil 0.005
- Clean recirculating oil 0.001
- Machinery and transformer oils 0.001
- Quenching oil 0.004
- Vegetable oils 0.003

Gases, vapors (industrial):
- Coke-oven gas, manufactured gas 0.01
- Diesel-engine exhaust gas 0.01
- Organic vapors 0.0005
- Steam (non-oil bearing) 0.0
- Alcohol vapors 0.0
- Steam, exhaust (oil bearing from reciprocating engines) 0.001
- Refrigerating vapors (condensing from reciprocating compressors) 0.002
- Air 0.002

Liquids (industrial):
- Organic 0.001
- Refrigerating liquids, heating, cooling, or evaporating 0.001
- Brine (cooling) 0.001

Atmospheric distillation units:
- Residual bottoms, less than 25°API 0.005
- Distillate bottoms, 25°API or above 0.002

Atmospheric distillation units:
- Overhead untreated vapors 0.0013
- Overhead treated vapors 0.003
- Side-stream cuts 0.0013

Vacuum distillation units:
- Overhead vapors to oil:
  - From bubble tower (partial condenser) 0.001
  - From flash pot (no appreciable reflux) 0.003

* *Standards of Tubular Exchanger Manufacturers Association*, 2d ed., New York, 1949.

TABLE 12. FOULING FACTORS.*—(*Continued*)

Overhead vapors in water-cooled condensers:	
From bubble tower (final condenser)	0.001
From flash pot	0.04
Side stream:	
To oil	0.001
To water	0.002
Residual bottoms, less than 20°API	0.005
Distillate bottoms, over 20°API	0.002
Natural gasoline stabilizer units:	
Feed	0.0005
O.H. vapors	0.0005
Product coolers and exchangers	0.0005
Product reboilers	0.001
H_2S Removal Units:	
For overhead vapors	0.001
Solution exchanger coolers	0.0016
Reboiler	0.0016
Cracking units:	
Gas oil feed:	
Under 500°F	0.002
500°F and over	0.003
Naphtha feed:	
Under 500°F	0.002
500°F and over	0.004
Separator vapors (vapors from separator, flash pot, and vaporizer)	0.006
Bubble-tower vapors	0.002
Residuum	0.010
Absorption units:	
Gas	0.002
Fat oil	0.002
Lean oil	0.002
Overhead vapors	0.001
Gasoline	0.0005
Debutanizer, Depropanizer, Depentanizer, and Alkylation Units:	
Feed	0.001
Overhead vapors	0.001
Product coolers	0.001
Product reboilers	0.002
Reactor feed	0.002
Lube treating units:	
Solvent oil mixed feed	0.002
Overhead vapors	0.001
Refined oil	0.001
Refined oil heat exchangers water cooled‡	0.003
Gums and tars:	
Oil-cooled and steam generators	0.005
Water-cooled	0.003
Solvent	0.001
Deasphaltizing units:	
Feed oil	0.002
Solvent	0.001
Asphalt and resin:	
Oil-cooled and steam generators	0.005
Water-cooled	0.003
Solvent vapors	0.001
Refined oil	0.001
Refined oil water cooled	0.003
Dewaxing units:	
Lube oil	0.001
Solvent	0.001
Oil wax mix heating	0.001
Oil wax mix cooling‡	0.003

‡ Precautions must be taken against deposition of wax.

Crude Oil Streams

	0–199°F			200–299°F			300–499°F			500°F and over		
	Velocity, fps											
	Under 2 ft	2–4 ft	4 ft and over	Under 2 ft	2–4 ft.	4 ft and over	Under 2 ft	2–4 ft	4 ft and over	Under 2 ft	2–4 ft	4 ft and over
Dry	.0.003	0.002	0.002	0.003	0.002	0.002	0.004	0.003	0.002	0.005	0.004	0.003
Salt§	.0.003	0.002	0.002	0.005	0.004	0.004	0.006	0.005	0.004	0.007	0.006	0.005

§ Refers to a wet crude—any crude that has not been dehydrated.

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APPENDIX D

Physical Property Data Bank

norganic compounds are listed in alphabetical order of the principal element in the pirical formula.

Organic compounds with the same number of carbon atoms are grouped together, and nged in order of the number of hydrogen atoms, with other atoms in alphabetical order.

)	= Number in list
OLWT	= Molecular weight
FP	= Normal freezing point, deg C
BP	= Normal boiling point, deg C
C	= Critical temperature, deg K
C	= Critical pressure, bar
C	= Critical volume, cubic metre/mol
DEN	= Liquid density, kg/cubic metre
DEN	= Reference temperature for liquid density, deg C
IVAP	= Heat of vaporisation at normal boiling point, J/mol
VISA, VISB	= Constants in the liquid viscosity equation:

LOG[viscosity] = [VISA] * [(1/T) − (1/VISB)], viscosity mNs/sq.m, T deg K.

DELHF = Standard enthalpy of formation of vapour at 298 K, kJ/mol.

DELGF = Standard Gibbs energy of formation of vapour at 298 K, kJ/mol.

CPVAPA, CPVAPB, CPVAPC, CPVAPD = Constants in the ideal gas heat capacity equation:

Cp = CPVAPA + (CPVAPB) *T + (CPVAPC) *T **2 + (CPVAPD) *T **3,
Cp J/mol K, T deg K.

ANTA, ANTB, ANTC = Constants in the Antione equation:
Ln (vapour pressure) = ANTA − ANTB/ (T + ANTC), vap. press. mmHg, T deg K

To convert mmHg to N/sq.m multiply by 133.32.
To convert degrees Celsius to Kelvin add 273.15.

TMN = Minimum temperature for Antoine constant, deg C
TMX = Maximum temperature for Antoine constant, deg C

Most of the values in this data bank were taken, with the permission of the publishe from: The Properties of Gases and Liquids, by Reid, R. C., Sherwood, T. K. a Prausnitz, J. M., 3rd edn, McGraw-Hill.

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
1	AR	ARGON	39.948	−189.9	−185.9	150.8	48.7	0.075	1373	−183	6531	1
2	BCL3	BORON TRICHLORIDE	117.169	−107.3	12.5	452.0	38.7		1350	11		2
3	BF3	BORON TRIFLUORIDE	67.805	−126.7	−99.9	260.8	49.9					3
4	BR2	BROMINE	159.808	−7.2	58.7	584.0	103.4	0.127	3119	20	30,187	4
5	CLNO	NITROSYL CHLORIDE	65.459	−59.7	−5.5	440.0	91.2	0.139	1420	−12	25,707	5
6	CL2	CHLORINE	70.906	−101.0	−34.5	417.0	77.0	0.124	1563	−34	20,432	6
7	CL3P	PHOSPHORUS TRICHLORIDE	137.333	−112.2	75.8	563.0		0.260	1574	21		7
8	CL4SI	SILICON TETRACHLORIDE	169.898	−68.9	57.2	507.0	37.5	0.326	1480	20	27,549	8
9	D2	DEUTERIUM	4.032	−254.5	−249.5	38.4	16.6	0.060	165	−250	1223	9
10	D2O	DEUTERIUM OXIDE	20.031	3.8	101.4	644.0	216.6	0.056	1105	20	41,366	10
11	F2	FLUORINE	37.997	−219.7	−188.2	144.3	52.2	0.066	1510	−188	6531	11
12	F3N	NITROGEN TRIFLUORIDE	71.002	−206.8	−129.1	234.0	45.3		1537	−129		12
13	F4SI	SILICON TETRAFLUORIDE	104.080	−90.2	−86.2	259.0	37.2		1660	−95		13
14	F6S	SULPHUR HEXAFLUORIDE	146.050	−50.7	−63.9	318.7	37.6	0.198	1830	−50		14
15	HBR	HYDROGEN BROMIDE	80.912	−86.1	−67.1	363.2	85.5	0.100	2160	−57	17,668	15
16	HCL	HYDROGEN CHLORIDE	36.461	−114.2	−85.1	324.6	83.1	0.081	1193	−85	16,161	16
17	HF	HYDROGEN FLUORIDE	20.006	−83.2	19.5	461.0	64.8	0.069	967	20	6699	17
18	HI	HYDROGEN IODIDE	127.912	−50.8	−35.6	424.0	83.1	0.131	2803	−36	19,778	18
19	H2	HYDROGEN	2.016	−259.2	−252.8	33.2	13.0	0.065	71	−253	904	19
20	H2O	WATER	18.015	0.0	100.0	647.3	220.5	0.056	998	20	40,683	20
21	H2S	HYDROGEN SULPHIDE	34.080	−85.6	−60.4	373.2	89.4	0.099	993	−60	18,673	21
22	H3N	AMMONIA	17.031	−77.8	−33.5	405.6	112.8	0.073	639	0	23,362	22
23	H3P	PHOSPHINE	33.998	−133.8	−87.5	324.8	62.7	0.113			14,725	23
24	H4N2	HYDRAZINE	32.045	1.5	113.5	653.0	146.9	0.096	1008	20	44,799	24
25	H4SI	SILANE	32.112	−185.0	−112.2	269.7	48.4		680	88		25
26	HE(4)	HELIUM−4	4.003		−269.0	5.2	2.3	0.057	123	−269	92	26
27	I2	IODINE	253.808	113.6	184.3	819.0	116.5	0.155	3740	180	41,868	27
28	KR	KRYPTON	83.800	−157.4	−153.4	209.4	55.0	0.091	2420	−153	9667	28
29	NO	NITRIC OXIDE	30.006	−163.7	−151.8	180.0	64.8	0.058	1280	−152	13,816	29
30	NO2	NITROGEN DIOXIDE	46.006	−11.3	21.1	431.4	101.3	0.170	1447	20	19,071	30
31	N2	NITROGEN	28.013	−209.9	−195.8	126.2	33.9	0.090	805	−195	5581	31
32	N2O	NITROUS OXIDE	44.013	−90.9	−88.5	309.6	72.4	0.097	1226	−90	16,559	32
33	NE	NEON	20.183	−248.7	−246.2	44.4	27.6	0.042	1204	−246	1842	33
34	O2	OXYGEN	31.999	−218.8	−183.0	154.6	50.5	0.073	1149	−183	6824	34
35	O2S	SULPHUR DIOXIDE	64.063	−75.5	−10.2	430.8	78.8	0.122	1455	−10	24,932	35
36	O3	OZONE	47.998	−192.7	−111.9	261.0	55.7	0.089	1356	−112	11,179	36
37	O3S	SULPHUR TRIOXIDE	80.058	16.8	44.8	491.0	82.1	0.130	1780	45	40,679	37
38	XE	XENON	131.300	−111.9	−108.2	289.7	58.4	0.118	3060	−108	13,013	38
39	CBRF3	TRIFLUOROBROMOMETHANE	148.910		−59.2	340.2	39.7	0.200				39
40	CCLF3	CHLOROTRIFLUOROMETHANE	104.459	−181.2	−81.5	302.0	39.2	0.180			15,516	40
41	CCL2F2	DICHLORODIFLUOROMETHANE	120.914	−157.8	−29.8	385.0	41.2	0.217	1750	−115	19,979	41
42	CCL2O	PHOSGENE	98.916	−128.2	7.6	455.0	56.7	0.190	1361	20	24,409	42
43	CCL3F	TRICHLOROFLUOROMETHANE	137.368	−111.2	23.8	471.2	44.1	0.248			24,786	43
44	CCL4	CARBON TETRACHLORIDE	153.823	−23.2	76.5	556.4	45.6	0.276	1584	25	30,019	44
45	CF4	CARBON TETRAFLUORIDE	88.005	−186.8	−128.0	227.6	37.4	0.140			11,974	45
46	CO	CARBON MONOXIDE	28.010	−205.1	−191.5	132.9	35.0	0.093	803	−192	6046	46
47	COS	CARBONYL SULPHIDE	60.070	−138.9	−50.3	375.0	58.8	0.140	1274	−99		47
48	CO2	CARBON DIOXIDE	44.010	−56.6	−78.5	304.2	73.8	0.094	777	20	17,166	48
49	CS2	CARBON DISULPHIDE	76.131	−111.9	46.2	552.0	79.0	0.170	1293	0	26,754	49
50	CHBR3	BROMOFORM	94.940	−178.3	3.5	464.0	66.1	0.162	1733	0	24,241	50

NO	VISA	VISB	DELHF	DELGF	CPVAPA	CPVAPB	CPVAPC	CPVAPD	ANTA	ANTB	ANTC	TMN	TMX	NO
1	107.57	58.76			20.804	−3.211E-05	51.665E-09		15.2330	700.51	−5.84	−192	−179	1
2														2
3														3
4	387.82	292.79			33.859	11.254E-03	−1.192E-05	45.343E-10	15.8441	2582.32	−51.56	−14	81	4
5			52.63	66.99	34.097	44.715E-03	−3.340E-05	10.149E-09	16.9505	2520.70	−23.46	−63	12	5
6	191.96	172.35			26.929	33.838E-03	−3.869E-05	15.470E-09	15.9610	1978.32	−27.01	−101	−9	6
7														7
8									15.8019	2634.16	−43.15	−35	91	8
9	19.67	8.38			30.250	−6.406E-03	11.698E-06	−3.684E-09	13.2954	157.89		−254	−248	9
10	757.92	304.58	−249.41	−234.80										10
11	84.20	52.52			23.216	36.568E-03	−3.462E-05	12.041E-09	15.6700	714.10	−6.00	−214	−182	11
12			−124.68	−127.19					15.6107	1155.69	−15.37	−170	−118	12
13														13
14	251.29	180.75	−1221.71	−1117.88					19.3785	2524.78	−11.16	−114	−53	14
15	88.08	166.32	−36.26	−53.30	30.647	−9.462E-03	17.224E-06	−6.238E-09	14.4687	1242.53	−47.86	−89	−52	15
16	372.78	277.74	−92.36	−95.33	30.291	−7.201E-03	12.460E-06	−3.898E-09	16.5040	1714.25	−14.45	−136	−73	16
17	438.74	199.62	−271.30	−273.40	29.061	66.110E-05	−2.032E-06	25.037E-10	17.6958	3404.49	15.06	−67	40	17
18	155.15	285.43	26.38	1.59	31.158	−1.428E-02	29.722E-06	−1.353E-08	12.9149	957.96	−85.06	−58	−17	18
19	13.82	5.39			27.143	92.738E-04	−1.381E-05	76.451E-10	13.6333	164.90	3.19	−259	−248	19
20	658.25	283.16	−242.00	−228.77	32.243	19.238E-04	10.555E-06	−3.596E-09	18.3036	3816.44	−46.13	11	168	20
21	342.79	165.54	−20.18	−33.08	31.941	14.365E-04	24.321E-06	−1.176E-08	16.1040	1768.69	−26.06	−83	−43	21
22	349.02	169.63	−45.72	−16.16	27.315	23.831E-03	17.074E-06	−1.185E-08	16.9481	2132.50	−32.98	−94	−12	22
23			229.44		23.228	44.003E-03	13.029E-06	−1.593E-08						23
24	524.98	290.88	95.25	158.64	9.768	18.945E-02	−1.657E-04	60.248E-09	17.9899	3877.65	−45.15	15	70	24
25			32.66	54.93	11.179	12.200E-02	−5.548E-05	68.412E-10	16.3424	1629.99	5.35	−111	−179	25
26									12.2514	33.73	1.79	−269	−269	26
27	559.62	520.55			35.592	65.147E-04	−6.988E-06	28.345E-10	16.1597	3709.23	−68.16	110	214	27
28									15.2677	958.75	−8.71	−160	−144	28
29			90.43	86.75	29.345	−9.378E-04	97.469E-07	−4.187E-09	20.1314	1572.52	−4.88	−178	−133	29
30	406.20	230.21	33.87	52.00	24.233	48.358E-03	−2.081E-05	29.308E-11	20.5324	4141.29	3.65	−43	47	30
31	90.30	46.14			31.150	−1.357E-02	26.796E-06	−1.168E-08	14.9542	588.72	−6.60	−219	−183	31
32			81.60	103.71	21.621	72.808E-03	−5.778E-05	18.301E-09	16.1271	1506.49	−25.99	−129	−73	32
33					20.786				14.0099	180.47	−2.61	−249	−244	33
34	85.68	51.50			28.106	−3.680E-06	17.459E-06	−1.065E-08	15.4075	734.55	−6.45	−210	−173	34
35	397.85	208.42	−297.05	−300.36	23.852	66.989E-03	−4.961E-05	13.281E-09	16.7680	2302.35	−35.97	−78	7	35
36	313.79	120.34	142.77	162.91	20.545	80.093E-03	−6.243E-05	16.973E-09	15.7427	1272.18	−22.16	−164	−99	36
37	1372.80	315.99	−395.53	−370.62	16.370	14.591E-02	−1.120E-04	32.423E-09	20.8403	3995.70	−36.66	17	59	37
38									15.2958	1303.92	−14.50	−115	−95	38
39			−649.37	−623.00										39
40			−695.01	−654.40	22.814	19.113E-02	−1.576E-04	44.589E-09						40
41	215.09	165.55	−481.48	−442.54	31.598	17.823E-02	−1.509E-04	43.417E-09						41
42			−221.06	−206.91	28.089	13.607E-02	−1.374E-04	50.702E-09	15.7565	2167.31	−43.15	−60	68	42
43			−284.70	−245.51	40.985	16.308E-02	−1.416E-04	41.462E-09	15.8516	2401.61	−36.30	−33	27	43
44	540.15	290.84	−100.48	−58.28	40.717	20.486E-02	−2.270E-04	88.425E-09	15.8742	2808.19	−45.99	−20	101	44
45			−933.66	−889.03	13.980	20.256E-02	−1.625E-04	45.134E-09	16.0543	1244.55	−13.06	−180	−125	45
46	94.06	48.90	−110.62	−137.37	30.869	−1.285E-02	27.892E-06	−1.272E-08	14.3686	530.22	−13.15	−210	−165	46
47			−138.50	−165.76	23.567	79.842E-03	−7.017E-05	24.535E-09						47
48	578.08	185.24	−393.77	−394.65	19.795	73.436E-03	−5.602E-05	17.153E-09	22.5898	3103.39	−0.16	−119	−69	48
49	274.08	200.22	117.15	66.95	27.444	81.266E-03	−7.666E-05	26.729E-09	15.9844	2690.85	−31.62	−45	69	49
50			−36.34						15.7078	3163.17	−72.18	101	30	50

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
51	CHCLF2	CHLORODIFLUOROMETHANE	86.469	−160.2	−40.8	369.2	49.8	0.165	1230	16	20,205	51
52	CHCL2F	DICHLOROFLUOROMETHANE	102.923	−135.2	8.8	451.6	51.7	0.197	1380	9	24,953	52
53	CHCL3	CHLOROFORM	119.378	−63.6	61.1	536.4	54.7	0.239	1489	20	29,726	53
54	CHN	HYDROGEN CYANIDE	27.026	−13.3	25.7	456.8	53.9	0.139	688	20	25,234	54
55	CH2BR2	DIBROMOMETHANE	173.835	−52.6	96.8	583.0	71.9		2500	20		55
56	CH2CL2	DICHLOROMETHANE	84.993	−95.1	39.8	510.0	60.8	0.193	1317	25	28,010	56
57	CH2O	FORMALDEHYDE	30.026	−117.2	−19.2	408.0	65.9		815	−20	23,027	57
58	CH2O2	FORMIC ACID	46.025	8.3	100.6	580.0			1226	15	21,939	58
59	CH3BR	METHYL BROMIDE	94.939	−93.7	3.5	464.0	86.1		1737	−5	23,928	59
60	CH3CL	METHYL CHLORIDE	50.488	−97.8	−24.3	416.3	66.8	0.139	915	20	21,436	60
61	CH3F	METHYL FLUORIDE	34.033	−141.8	−78.4	317.8	58.8	0.124	843	−60		61
62	CH3I	METHYL IODIDE	141.939	−66.5	42.4	528.0	65.9	0.190	2279	20	27,214	62
63	CH3NO2	NITROMETHANE	61.041	−28.6	101.2	588.0	63.1	0.173	1138	20	34,436	63
64	CH4	METHANE	16.043	−182.5	−161.5	190.6	46.0	0.099	425	−161	8185	64
65	CH4O	METHANOL	32.042	−97.7	64.6	512.6	81.0	0.118	791	20	35,278	65
66	CH4S	METHYL MERCAPTAN	48.107	−123.2	5.9	470.0	72.3	0.145	866	20	24,577	66
67	CH5N	METHYL AMINE	31.058	−93.5	−6.4	430.0	74.6	0.140	703	−14	26,000	67
68	CH6N2	METHYL HYDRAZINE	46.072		90.8	567.0	80.4	0.271				68
69	CH6SI	METHYL SILANE	46.145	−156.5	−57.6	352.5						69
70	C2CLF5	CHLOROPENTAFLUOROETHANE	154.467	−106.2	−39.2	353.2	31.6	0.252			19,469	70
71	C2CL2F4	1:1-DICHLORO-1:2:2:2-TETRAFLUOROETHANE	170.992	−94.2	3.8	418.6	33.0	0.294	1455	25		71
72	C2CL2F4	1:2-DICHLORO-1:1:2:2-TETRAFLUOROETHANE	170.922	−93.9	3.7	418.9	32.6	0.293	1480	4	23,279	72
73	C2CL3F3	1:2-DICHLORO-1:1:2:2-TETRAFLUOROETHANE	187.380	−35.0	47.5	487.2	34.1	0.304	1580	16	27,507	73
74	C2CL4	TETRACHLOROETHYLENE	165.834	−22.2	121.1	620.0	44.6	0.290	1620	20	34,750	74
75	C2CL4F2	1:1:2:2-TETRACHLORO-1:2-DIFLUOROETHANE	203.831	24.8	91.5	551.0			1645	25		75
76	C2F4	TETRAFLUOROETHYLENE	100.016	−142.5	−75.7	306.4	39.4	0.175	1519	−76		76
77	C2F6	HEXAFLUOROETHANE	138.012	−100.8	−78.3	292.8		0.224	1590	−78	16,161	77
78	C2N2	CYANOGEN	52.035	−27.9	−20.7	400.0	59.8					78
79	C2HCL3	TRICHLOROETHYLENE	131.389	−116.4	87.2	571.0	49.1	0.256	1462	20	31,401	79
80	C2HF3O2	TRIFLURORQACETIC ACID	114.024	−15.3	72.4	491.3	32.6		1535	0		80
81	C2H2	ACETYLENE	26.038	−80.8	−84.0	308.3	61.4	0.113	615	−84	16,957	81
82	C2H2F2	1:1-DIFLUOROETHYLENE	64.035			302.8	44.6	0.154				82
83	C2H2O	KETENE	42.038	−135.2	−41.2	380.0	64.8	0.145			20,641	83
84	C2H3CL	VINYL CHLORIDE	62.499	−153.8	−13.4	429.7	56.0	0.169	969	−14	20,641	84
85	C2H3CLF2	1-CHLORO-1:1-DIFLUOROETHANE	100.490	−131.2	−9.8	410.2	41.2	0.231	1100	30		85
86	C2H3CLO	ACETYL CHLORIDE	78.498	−113.0	50.7	508.0	58.8	0.204	1104	20	28,680	86
87	C2H3CL3	1:1:2-TRICHLOROETHANE	133.400	−36.7	113.7	602.0	41.5	0.294	1441	20	33,327	87
88	C2H3F	VINYL FLUORIDE	46.044	−143.2	−37.7	327.8	52.4	0.144				88
89	C2H3F3	1:1:1-TRIFLUOROETHANE	84.041	−111.3	−47.7	346.2	37.6	0.221			19,176	89
90	C2H3N	ACETONITRILE	41.053	−43.9	81.6	548.0	48.3	0.173	782	20	31,401	90
91	C2H3NO	METHYL ISOCYANATE	57.052		38.8	491.0	55.7		958	20	29,601	91
92	C2H4	ETHYLENE	28.054	−169.2	−103.8	282.4	50.4	0.129	577	−110	13,553	92
93	C2H4CL2	1:1-DICHLOROETHANE	98.960	−97.0	57.2	523.0	50.7	0.240	1168	25	28,721	93
94	C2H4CL2	1:2-DICHLOROETHANE	98.960	−35.7	83.4	561.0	53.7	0.220	1250	16	32,029	94
95	C2H4F2	1:1-DIFLUOROETHANE	66.051	−117.0	−24.8	386.6	45.0	0.181			21,353	95
96	C2H4O	ACETALDEHYDE	44.054	−123.0	20.4	461.0	55.7	0.154	778	20	25,749	96
97	C2H4O	ETHYLENE OXIDE	44.054	−112.2	10.3	469.0	71.9	0.140	899	0	25,623	97
98	C2H4O2	ACETIC ACID	60.052	16.6	117.9	594.4	57.9	0.171	1049	20	23,697	98
99	C2H4O2	METHYL FORMATE	60.052	−99.0	31.7	487.2	60.0	0.172	974	20	28,219	99
100	C2H5BR	ETHYL BROMIDE	108.966	−118.6	38.3	503.8	62.3	0.215	1451	[illegible]	[illegible]	100

NO	VISA	VISB	DELHF	DELGF	CPVAPA	CPVAPB	CPVAPC	CPVAPD	ANTA	ANTB	ANTC			NO
51			−502.00	−470.89	17.300	16.182E-02	−1.170E-04	30.585E-09	15.5602	1704.80	−41.30	−48	−33	51
52			−298.94	−268.37	23.664	15.814E-02	−1.200E-04	32.636E-09						52
53	394.81	246.50	−101.32	−68.58	24.003	18.933E-02	−1.841E-04	66.570E-09	15.9732	2696.79	−46.16	−13	97	53
54	194.70	145.31	130.63	120.20	21.863	60.625E-03	−4.961E-05	18.154E-09	16.5138	2585.80	−37.15	−39	57	54
55	428.91	294.57	−4.19	−5.61										55
56	359.55	225.13	−95.46	−68.91	12.954	16.232E-02	−1.302E-04	42.077E-09	16.3029	2622.44	−41.70	−44	59	56
57	319.83	171.35	−115.97	−109.99	23.475	31.568E-03	29.852E-06	−2.300E-08	16.4775	2204.13	−30.15	−88	−2	57
58	729.35	325.72	−378.86	−351.23	11.715	13.578E-02	−8.411E-05	20.168E-09	16.9882	3599.58	−26.09	−2	136	58
59	298.15	211.15	−37.68	−28.18	14.428	10.911E-02	−5.401E-05	95.836E-10	16.0252	2271.71	−34.83	−58	53	59
60	426.45	193.56	−86.37	−62.93	13.875	10.140E-02	−3.889E-05	25.665E-10	16.1052	2077.97	−29.55	−93	−7	60
61			−234.04	−210.14	13.825	86.164E-03	−2.071E-05	−1.985E-09	16.3428	1704.41	−19.27	−132	−64	61
62	336.19	229.95	13.98	15.66	10.806	13.892E-02	−1.041E-04	34.855E-09	16.0905	2629.55	−36.50	−13	52	62
63	452.80	261.21	−74.78	−6.95	7.423	19.778E-02	−1.081E-04	20.850E-09	16.2193	2972.64	−64.15	5	136	63
64	114.14	57.60	−74.86	−50.87	19.251	52.126E-03	11.974E-06	−1.132E-08	15.2243	597.84	−7.16	−180	−153	64
65	555.30	260.64	−201.30	−162.62	21.152	70.924E-03	25.870E-06	−2.852E-08	18.5875	3626.55	−34.29	−16	91	65
66			−22.99	−9.92	13.268	14.566E-02	−8.545E-05	20.750E-09	16.1909	2338.38	−34.44	−73	27	66
67	311.80	176.30	−23.03	32.28	11.476	14.273E-02	−5.334E-05	47.520E-10	17.2622	2484.83	−32.92	−61	38	67
68			85.41	177.98					15.1424	2319.84	−91.70	−3	127	68
69														69
70					27.834	34.918E-02	−2.891E-04	81.391E-09	15.7343	1848.90	−30.88	−98	−43	70
71					40.453	32.783E-02	−2.752E-04	78.209E-09						71
72			−898.49		38.778	34.399E-02	−2.950E-04	85.076E-09						72
73			−745.67		61.140	28.742E-02	−2.420E-04	69.040E-09	15.8424	2532.61	−45.67	−23	87	73
74	392.58	281.82	−12.14	22.61	45.971	22.554E-02	−2.294E-04	83.820E-09	16.1642	3259.29	−52.15	34	187	74
75														75
76			−659.00	−624.13	29.010	22.772E-02	−2.037E-04	67.784E-09	15.8800	1574.60	−27.22	−133	−63	76
77			−1343.96	−1258.22	26.816	34.579E-02	−2.869E-04	81.350E-09	15.6422	1512.94	−26.94	−103	−73	77
78			309.15	297.39	35.935	92.528E-03	−8.223E-05	29.496E-09						78
79	145.67	196.60	−5.86	19.89	30.174	22.868E-02	−2.229E-04	82.438E-09	16.1827	3028.13	−43.15	−13	127	79
80														80
81			226.88	209.34	26.821	75.781E-03	−5.007E-05	14.122E-09	16.3481	1637.14	−19.77	−79	−71	81
82			−345.41	−321.71	3.073	24.447E-02	−2.099E-04	70.213E-09						82
83			−61.13	−60.33	6.385	16.383E-02	−1.084E-04	26.984E-09	16.0197	1849.21	−35.15	−103	−18	83
84	276.90	167.04	35.17	51.54	5.949	20.193E-02	−1.536E-04	47.730E-09	14.9601	1803.84	−43.15	−88	17	84
85					16.818	27.566E-02	−1.992E-04	53.047E-09						85
86			−244.09	−206.37	25.020	17.107E-02	−9.856E-05	22.190E-09	15.7514	2447.33	−55.53	−36	82	86
87	346.72	304.43	−138.58	−77.54	6.322	34.307E-02	−2.958E-04	97.929E-09	16.0381	3110.79	−56.16	29	155	87
88														88
89			−746.09	−679.22	5.744	31.409E-02	−2.597E-04	84.155E-09	15.8965	1814.91	−29.92	−3	27	89
90	334.91	210.05	87.92	105.67	20.482	10.831E-02	−4.492E-05	32.029E-10	16.2874	2945.47	−49.15	−13	117	90
91	616.78	227.47	−90.02		35.764	10.396E-02	−5.820E-06	−1.687E-08	16.3258	2480.37	−56.31	−43	67	91
92	168.98	93.94	52.33	68.16	3.806	15.659E-02	−8.348E-05	17.551E-09	15.5368	1347.01	−18.15	−153	−91	92
93	412.27	239.10	−130.00	−73.14	12.472	26.959E-02	−2.050E-04	63.011E-09	16.0842	2697.29	−45.03	−31	79	93
94	473.95	277.98	−129.79	−73.90	20.486	23.103E-02	−1.438E-04	33.888E-09	16.1764	2927.17	−50.22	−33	100	94
95	319.27	186.56	−494.04	−436.52	8.675	23.957E-02	−1.457E-04	33.942E-09	16.1871	2095.35	−29.16	−35	0	95
96	368.70	192.82	−166.47	−133.39	7.716	18.225E-02	−1.007E-04	23.802E-09	16.2418	2465.15	−37.15	−63	47	96
97	341.88	194.22	−52.67	−13.10	−7.519	22.224E-02	−1.256E-04	25.916E-09	16.7400	2567.61	−29.01	−73	37	97
98	600.94	306.21	−435.13	−376.94	4.840	25.485E-02	−1.753E-04	49.488E-09	16.8080	3405.57	−56.34	17	157	98
99	363.19	212.70	−350.02	−297.39	1.432	27.001E-02	−1.949E-04	57.024E-09	16.5104	2590.87	−42.60	−48	51	99
100	369.80	220.68	−64.06	−26.33	6.657	23.480E-02	−1.472E-04	38.041E-09	15.9338	2511.68	−41.44	−47	60	100

(31)

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
101	C2H5CL	ETHYL CHLORIDE	64.515	−136.4	12.2	460.4	52.7	0.199	896	20	24,702	101
102	C2H5F	ETHYL FLUORIDE	48.060	−143.3	−37.8	375.3	50.3	0.169				102
103	C2H5N	ETHYLENE IMIDE	43.069	−78.2	56.6				833	25	32,071	103
104	C2H5NO2	NITROETHANE	75.068	−89.2	114.0	595.0	48.5	0.228	1047	20	35,994	104
105	C2H6	ETHANE	30.070	−183.3	−88.7	305.4	48.8	0.148	548	−90	14,717	105
106	C2H6O	DIMETHYL ETHER	46.069	−141.5	−24.9	400.0	53.7	0.178	667	20	21,520	106
107	C2H6O	ETHANOL	46.069	−114.1	78.3	516.2	63.8	0.167	789	20	38,770	107
108	C2H6O2	ETHYLENE GLYCOL	62.069	−13.0	197.2	645.0	77.0	0.186	1114	20	52,544	108
109	C2H6S	ETHYL MERCAPTAN	62.134	−147.9	35.0	499.0	54.9	0.207	839	20	26,796	109
110	C2H6S	DIMETHYL SULPHIDE	62.130	−98.3	37.3	503.0	55.3	0.201	848	20	26,963	110
111	C2H7N	ETHYL AMINE	45.085	−81.2	16.5	456.0	56.2	0.178	683	20	28,052	111
112	C2H7N	DIMETHYL AMIDE	45.085	−92.2	6.8	437.6	53.1	0.187	656	20	26,502	112
113	C2H7NO	MONOETHANOLAMINE	61.084	10.3	170.3	614.0	44.6	0.196	1016	20	50,242	113
114	C2H8N2	ETHYLENEDIAMINE	60.099	10.8	117.2	593.0	62.8	0.206	896	20	41,868	114
115	C3H3N	ACRYLONITRILE	53.064	−83.7	77.3	536.0	35.5	0.210	806	20	32,657	115
116	C3H4	PROPADIENE	40.065	−136.3	−34.5	393.0	54.7	0.162	658	−35	18,631	116
117	C3H4	METHYL ACETYLENE	40.065	−102.7	−23.2	402.4	56.2	0.164	706	−50	22,148	117
118	C3H4O	ACROLEIN	56.064	−87.2	52.8	506.0	51.7		839	20	28,345	118
119	C3H4O2	ACRYLIC ACID	72.064	11.8	140.8	615.0	56.7	0.210	1051	20	46,055	119
120	C3H4O2	VINYL FORMATE	72.064	−57.7	46.4	475.0	57.8	0.210	963	20	32,155	120
121	C3H5CL	ALLYL CHLORIDE	76.526	−134.5	45.1	514.0	47.6	0.234	937	20	27,110	121
122	C3H5CL3	1;2;3-TRICHLOROPROPANE	147.432	−14.7	155.8	651.0	39.5	0.348	1389	20	38,435	122
123	C3H5N	PROPIONITRILE	55.080	−92.7	97.3	564.4	41.8	0.230	782	20	32,280	123
124	C3H6	CYCLOPROPANE	42.081	−127.5	−32.8	397.8	54.9	0.170	563	15	20,055	124
125	C3H6	PROPYLENE	42.081	−185.3	−47.8	365.0	46.2	0.181	612	−50	18,422	125
126	C3H6CL2	1;2-DICHLOROPROPANE	112.987	−100.5	96.3	577.0	44.6	0.226	1150	20	31,401	126
127	C3H6O	ACETONE	58.080	−95.0	56.2	508.1	47.0	0.209	790	20	29,140	127
128	C3H6O	ALLYL ALCOHOL	58.080	−129.2	96.8	545.0	57.1	0.203	855	15	39,984	128
129	C3H6O	PROPIONALDEHYDE	58.080	−80.2	47.8	496.0	47.6	0.223	797	20	28,303	129
130	C3H6O	PROPYLENE OXIDE	58.080	−112.2	34.3	482.2	49.2	0.186	829	20	27,005	130
131	C3H6O	VINYL METHYL ETHER	58.080	−121.7	4.8	436.0	47.6	0.205	750	20	19,050	131
132	C3H6O2	PROPIONIC ACID	74.080	−20.7	140.8	612.0	53.7	0.230	993	20	32,238	132
133	C3H6O2	ETHYL FORMATE	74.080	−79.4	54.2	508.4	47.4	0.229	927	16	30,145	133
134	C3H6O2	METHYL ACETATE	74.080	−98.2	56.9	506.8	46.9	0.228	934	20	30,145	134
135	C3H7CL	PROPYL CHLORIDE	78.542	−122.8	46.4	503.0	45.8	0.254	891	20	27,256	135
136	C3H7CL	ISOPROPYL CHLORIDE	78.452	−117.2	35.7	485.0	47.2	0.230	862	20	26,293	136
137	C3H8	PROPANE	44.097	−187.7	−42.1	369.8	42.5	0.203	582	−42	18,786	137
138	C3H8O	N-PROPYL ALCOHOL	60.096	−126.3	97.2	536.7	51.7	0.219	804	20	41,784	138
139	C3H8O	ISOPROPYL ALCOHOL	60.096	−88.5	82.2	508.3	47.6	0.220	786	20	39,858	139
140	C3H8O	METHYL ETHYL ETHER	60.096	−139.2	7.3	437.8	44.0	0.221	700	20	24,702	140
141	C3H8O2	METHYLAL	76.096	−105.2	41.8	497.0			888	18		141
142	C3H8O2	1;2-PROPANEDIOL	76.096	−60.2	187.3	625.0	60.8	0.237	1036	20	54,177	142
143	C3H8O2	1;3-PROPANEDIOL	76.096	−26.8	214.4	658.0	59.8	0.241	1053	20	56,522	143
144	C3H8O3	GLYCEROL	92.095	17.8	289.8	726.0	66.9	0.255	1261	20	61,127	144
145	C3H8S	METHYL ETHYL SULPHIDE	76.157	−106.0	66.6	533.0	42.6		837	20	29,517	145
146	C3H9N	N-PROPYL AMINE	59.112	−83.2	48.6	497.0	47.4	0.233	717	20	29,726	146
147	C3H9N	ISOPROPYL AMINE	59.112	−95.3	32.4	476.0	50.7	0.229	688	20	27,214	147
148	C3H9N	TRIMETHYL AMINE	59.112	−117.2	2.9	433.2	40.7	0.254	633	20	24,116	148
149	C4H2O3	MALEIC ANHYDRIDE	98.058	52.8	199.6				1310	60		149
150	C4H4	VINYL ACETYLENE	52.076	−45.6	4.9	455.0	49.6	0.202	710	0	24,493	150

NO	VISA	VISB	DELHF	DELGF	CPVAPA	CPVAPB	CPVAPC	CPVAPD	ANTA	ANTB	ANTC	TMN	TMX	NO
101	320.94	190.83	−111.79	−60.04	−0.553	26.063E-02	−1.840E-04	55.475E-09	15.9800	2332.01	−36.48	−73	37	101
102			−261.67	−209.67	4.346	21.801E-02	−1.166E-04	24.103E-09	16.0686	1966.89	−27.00	−103	−21	102
103			123.51	178.11	−20.771	30.225E-02	−2.063E-04	56.480E-09	16.4227	2610.44	−63.15	−25	86	103
104			−101.32						17.4716	3848.24	−31.96	114	−21	104
105	156.60	95.57	−84.74	−32.95	5.409	17.811E-02	−6.938E-05	87.127E-10	15.6637	1511.42	−17.16	−143	−74	105
106			−184.18	−113.00	17.015	17.907E-02	−5.233E-05	−1.918E-09	16.8467	2361.44	−17.10	−94	−8	106
107	686.64	300.88	−234.96	−168.39	9.014	21.407E-02	−8.390E-05	13.733E-10	18.9119	3803.98	−41.68	−3	96	107
108	1365.00	402.41	−389.58	−304.67	35.697	24.832E-02	−1.497E-04	30.103E-09	20.2501	6022.18	−28.25	91	221	108
109	419.60	206.21	−46.14	−4.69	14.922	23.509E-02	−1.369E-04	31.619E-09	16.0077	2497.23	−41.77	−49	57	109
110	267.34	184.24	−37.56	6.95	24.304	18.748E-02	−6.875E-05	40.989E-10	16.0001	2511.56	−42.35	−47	58	110
111	340.54	192.44	−46.05	37.30	3.693	27.516E-02	−1.583E-04	38.083E-09	17.0073	2616.73	−37.30	−58	43	111
112			−18.84	68.04	−0.172	26.955E-02	−1.329E-04	23.392E-09	16.2653	2358.77	−35.15	−55	37	112
113	1984.10	367.03	−201.72		9.311	30.095E-02	−1.818E-04	46.557E-09	17.8174	3988.33	−86.93	71	204	113
114	839.76	316.41			38.297	24.070E-02	−4.338E-05	−3.948E-08	16.4082	3108.49	−72.15	19	152	114
115	343.31	210.42	185.06	195.44	10.693	22.077E-02	−1.565E-04	46.013E-09	15.9253	2782.21	−51.15	−18	112	115
116			192.26	202.52	9.906	19.774E-02	−1.182E-04	27.821E-09	13.1563	1054.72	−77.08	−99	−16	116
117			185.56	194.56	14.708	18.644E-02	−1.174E-04	32.243E-09	15.6227	1850.66	−44.07	−90	−6	117
118	388.17	217.14	−70.92	−65.19	11.970	21.055E-02	−1.071E-04	19.058E-09	15.9057	2606.53	−45.15	−38	87	118
119	733.02	307.15	−336.45	−286.25	1.742	31.908E-02	−2.352E-04	69.752E-09	16.5617	3319.18	−80.15	42	177	119
120	428.40	224.83			27.813	18.388E-02	−3.560E-05	−2.335E-07	16.6531	2569.68	−63.15	−33	77	120
121	368.27	210.61	−0.63	43.63	2.529	30.467E-02	−2.278E-04	72.934E-09	15.9772	2531.92	−47.15	−43	77	121
122	818.63	342.88	−185.89	−97.85	26.883	36.220E-02	−2.787E-04	87.881E-09	16.1246	3417.27	−69.15	42	197	122
123	366.77	225.86	50.66	96.21	15.403	22.454E-02	−1.100E-04	19.540E-09	15.9571	2940.86	−55.15	−3	132	123
124			53.34	104.46	−35.240	38.133E-02	−2.881E-04	90.351E-09	15.8599	1971.04	−26.65	−93	−28	124
125	273.84	131.63	20.43	62.76	3.710	23.454E-02	−1.160E-04	22.048E-09	15.7027	1807.53	−26.15	−113	−33	125
126	514.36	281.03	−165.80	−83.15	10.450	36.547E-02	−2.604E-04	77.414E-09	16.0385	2985.07	−52.16	15	135	126
127	367.25	209.68	−217.71	−153.15	6.301	26.059E-02	−1.253E-04	20.377E-09	16.6513	2940.46	−35.93	−32	77	127
128	793.52	307.26	−132.09	−71.30	−1.105	31.464E-02	−2.032E-04	53.214E-09	16.9066	2928.20	−85.15	13	127	128
129	343.44	219.33	−192.17	−130.54	11.723	26.142E-02	−1.300E-04	21.261E-09	16.2315	2659.02	−44.15	−38	77	129
130	377.43	213.36	−92.82	−25.79	−8.457	32.569E-02	−1.989E-04	48.232E-09	15.3227	2107.58	−64.87	−48	67	130
131	318.41	180.98			15.629	23.413E-02	−9.697E-05	10.622E-09	14.4602	1980.22	−25.15	−83	42	131
132	535.04	299.32	−455.44	−369.57	5.669	36.890E-02	−2.865E-04	98.767E-09	17.3789	3723.42	−67.48	42	177	132
133	400.91	226.23	−371.54		24.673	23.161E-02	−2.120E-05	−5.359E-08	16.1611	2603.30	−54.15	−33	87	133
134	408.62	224.03	−409.72		16.550	22.454E-02	−4.342E-05	29.144E-09	16.1295	2601.92	−56.15	−28	87	134
135	374.77	215.00	−130.21	−50.70	−3.345	36.258E-02	−2.508E-04	74.483E-09	15.9594	2581.48	−42.95	−43	77	135
136	306.25	212.24	−146.54	−62.55	1.842	34.876E-02	−2.244E-04	58.615E-09	16.0384	2490.48	−43.15	−48	67	136
137	222.67	133.41	−103.92	−23.49	−4.224	30.626E-02	−1.586E-04	32.146E-09	15.7260	1872.46	−25.16	−109	−24	137
138	951.04	327.83	−256.57	−161.90	2.470	33.252E-02	−1.855E-04	42.957E-09	17.5439	3166.38	−80.15	12	127	138
139	1139.70	323.44	−272.60	−173.50	32.427	18.862E-02	64.058E-06	−9.261E-08	18.6929	3640.20	−53.54	0	111	139
140	303.82	171.66	−216.58	−117.73	18.669	26.854E-02	−1.025E-04	89.514E-10	13.5435	1161.63	−112.40	−68	37	140
141									15.8237	2415.92	−52.58	−3	42	141
142	1404.20	426.74	−424.25		0.632	42.119E-02	−2.981E-04	89.514E-09	20.5324	6091.95	−22.46	84	210	142
143	1813.00	406.96	−409.09		8.269	36.756E-02	−2.162E-04	50.535E-09	17.2917	3888.84	−123.20	107	252	143
144	3337.10	406.00	−585.31		8.424	44.422E-02	−3.159E-04	93.784E-09	17.2392	4487.04	−140.20	167	327	144
145			−59.66	11.43	19.527	28.906E-02	−1.209E-04	12.866E-09	15.9765	2722.95	−48.37	−23	87	145
146			−72.43	39.82	6.691	34.985E-02	−1.822E-04	35.864E-09	15.9957	2551.72	−49.15	−38	77	146
147			−83.82		−7.486	41.755E-02	−2.826E-04	83.485E-09	16.3637	2582.35	−40.15	−34	64	147
148	433.64	228.46	−23.86	98.98	−8.206	39.716E-02	−2.189E-04	46.222E-09	16.0499	2230.51	−39.15	−58	32	148
149	952.48	365.81			−13.075	34.847E-02	−2.184E-04	48.399E-09	16.2747	3765.65	−82.15	79	243	149
150			304.80	306.18	6.757	28.407E-02	−2.265E-04	74.609E-09	16.0100	2203.57	−43.15	−73	32	150

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
151	C4H4O	FURAN	68.075	−85.7	31.3	490.2	55.0	0.218	938	20	27.105	151
152	C4H4S	THIOPHENE	84.136	−38.3	84.1	579.4	56.9	0.219	1071	16	31.485	152
153	C4H5CL	CHLOROPRENE	88.537		59.4	511.2	42.5	0.266	958	20	29.658	153
154	C4H5CL	CHLOROBUTADIENE	88.537	−60.0	67.8	527.2	39.5	0.265	963	20	29.038	154
155	C4H5N	ALLYL CYANIDE	67.091	−86.5	118.8	585.0	39.5	0.265	835	20	34.332	155
156	C4H5N	PYRROLE	67.091		129.8	640.0			967	21		156
157	C4H6	ETHYLACETYLENE	54.092	−125.8	8.0	463.7	47.1	0.220	650	16	24.995	157
158	C4H6	DIMETHYL ACETYLENE	54.092	−32.3	27.0	488.6	50.9	0.221	691	20	26.670	158
159	C4H6	1:2-BUTADIENE	54.092	−136.2	10.8	443.7	45.0	0.219	652	20	24.283	159
160	C4H6	1:3-BUTADIENE	54.092	−108.9	−4.5	425.0	43.3	0.221	621	20	22.483	160
161	C4H6O2	VINYL ACETATE	86.091	−100.2	72.8	525.0	43.6	0.265	932	20		161
162	C4H6O3	ACETIC ANHYDRIDE	102.089	−74.2	138.8	569.0	46.8	0.290	1087	20	41.240	162
163	C4H6O4	DIMETHYL OXALATE	118.090	53.8	163.4	628.0	39.8		1150	15		163
164	C4H6O4	SUCCINIC ACID	118.090	182.8	234.8							164
165	C4H7N	BUTYRONITRILE	69.107	−112.2	117.8	582.2	37.9	0.285	792	20	34.415	165
166	C4H7O2	METHYL ACRYLATE	86.091	−76.5	80.3	536.0	42.6	0.265	956	20	32.029	166
167	C4H8	1-BUTENE	56.108	−185.4	−6.3	419.6	37.2	0.240	595	20	21.930	167
168	C4H8	CIS-2-BUTENE	56.108	−138.9	3.7	435.6	42.0	0.234	621	20	23.362	168
169	C4H8	TRANS-2-BUTENE	56.108	−105.6	0.8	428.6	41.0	0.238	604	20	22.772	169
170	C4H8	CYCLOBUTANE	56.108	−90.8	12.5	459.9	49.9	0.210	694	20	24.200	170
171	C4H8	ISOBUTYLENE	56.108	−140.4	−6.9	417.9	40.0	0.239	594	20	22.131	171
172	C4H8O	N-BUTYRALDEHYDE	72.107	−96.4	74.8	524.0	40.5	0.278	802	20	31.527	172
173	C4H8O	ISOBUTYRALDEHYDE	72.107	−65.0	63.8	513.0	41.5	0.274	789	20	31.401	173
174	C4H8O	MERTYL ETHYL KETONE	72.107	−86.7	79.6	535.6	41.5	0.267	805	20	31.234	174
175	C4H8O	TETRAHYDROFURAN	72.107	−108.5	65.9	540.2	51.9	0.224	889	20	29.601	175
176	C4H8O	VINYL ETHYL ETHER	72.107	−115.3	35.6	475.0	40.7	0.260	793	20	26.502	176
177	C4H8O2	N-BUTYRIC ACID	88.107	−5.3	163.2	628.0	52.7	0.292	958	20	42.035	177
178	C4H8O2	1:4-DIOXANE	88.107	11.8	101.3	587.0	52.1	0.238	1033	20	36.383	178
179	C4H8O2	ETHYL ACETATE	88.107	−83.6	77.1	523.2	38.3	0.286	901	20	32.238	179
180	C4H8O2	ISOBUTYRIC ACID	88.107	−46.0	154.7	609.0	40.5	0.292	968	20	41.156	180
181	C4H8O2	METYL PROPIONATE	88.107	−87.5	79.8	530.6	40.0	0.282	915	20	32.573	181
182	C4H8O2	N-PROPYL FORMATE	88.107	−92.9	80.5	538.0	40.6	0.285	911	16	32.490	182
183	C4H9CL	1-CHLOROBUTANE	92.569	−123.1	78.4	542.0	36.9	0.312	886	20	30.019	183
184	C4H9CL	2-CHLOROBUTANE	92.569	−131.4	68.2	520.6	39.5	0.305	873	20	29.224	184
185	C4H9CL	2-CHLORO-2-METHYL PROPANE	92.569	−25.4	50.8	507.0	39.5	0.295	842	20	27.424	185
186	C4H9N	PYRROLIDINE	71.123		86.5	568.6	56.1	0.249	852	22		186
187	C4H9NO	MORPHOLINE	87.122	−4.8	128.2	618.0	54.7	0.253	1000	20	37.681	187
188	C4H10	N-BUTANE	58.124	−138.4	−0.5	425.2	38.0	0.255	579	20	22.408	188
189	C4H10	ISOBUTANE	58.124	−159.6	−11.9	408.1	36.5	0.263	557	20	21.311	189
190	C4H10O	N-BUTANOL	74.123	−89.3	117.7	562.9	44.2	0.274	810	20	43.124	190
191	C4H10O	2-BUTANOL	74.123	−114.7	99.5	536.0	41.9	0.268	807	20	40.821	191
192	C4H10O	ISOBUTANOL	74.123	−108.0	107.8	547.7	43.0	0.273	802	20	42.077	192
193	C4H10O	2-METHYL-2-PROPANOL	74.123	25.6	82.4	506.2	39.7	0.275	787	20	39.063	193
194	C4H10O	ETHYL ETHER	74.123	−116.3	34.5	466.7	36.4	0.280	713	20	26.712	194
195	C4H10O2	1:2-DIMETHIOXYETHANE	90.123	−71.2	85.4	536.0	38.7	0.271	867	20	31.443	195
196	C4H10O3	DIETHYLENE GLYCOL	106.122	−8.2	245.8	681.0	46.6	0.316	1116	20	57.234	196
197	C4H10S	DIMETHYL SULPHIDE	90.184	−104.0	92.1	557.0	39.6	0.318	837	20	31.778	197
198	C4H10S2	DIETHYL DISULPHIDE	122.244	−101.5	154.0	642.0			998	20	37.723	198
199	C4H11N	N-BUTYL AMINE	73.139	−49.1	77.4	524.0	41.5	0.288	739	20	32.113	199
200	C4H11N	ISOBUTYL AMINE	73.139	[illegible]	67.4	516.0	42.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NO	VISA	VISB	DELHF											NO
151	389.40	222.70	−34.71	0.88	−35.529	43.208E-02	−3.455E-04	10.743E-08	16.0612	244.70	−45.41	−35	90	151
152	498.60	264.90	115.81	126.86	−30.606	44.799E-02	−3.772E-04	12.527E-08	16.0243	2869.07	−51.80	−13	107	152
153			65.86						14.4844	1938.59	−85.36	27	−84	153
154			79.97											154
155	521.30	252.03			21.700	25.715E-02	−1.192E-04	12.292E-09	16.0019	3128.75	−58.15	127	157	155
156			108.35						16.7966	3457.47	−62.73	57	167	156
157			165.29	202.22	12.548	27.436E-02	−1.545E-04	34.499E-09	16.0605	2271.42	−40.30	−73	27	157
158			146.41	185.56	15.927	23.815E-02	−1.070E-04	17.534E-09	16.2821	2536.78	−37.34	−33	47	158
159			162.32	198.58	11.200	27.235E-02	−1.468E-04	30.890E-09	16.1039	2397.26	−30.88	−28	32	159
160	300.59	163.12	110.24	150.77	−1.687	34.185E-02	−2.340E-04	63.346E-09	15.7727	2142.66	−34.30	−58	17	160
161	457.89	235.35	−316.10		15.160	27.951E-02	−8.805E-05	−1.660E-08	16.1003	2744.68	−56.15	−18	106	161
162	502.33	286.04	−576.10	−477.00	−23.128	50.870E-02	−3.580E-04	98.348E-09	16.3982	3287.56	−75.11	35	164	162
163														163
164	0.00					15.072E+00	46.892E-03	−3.143E-04						164
165	438.04	256.84	34.08	108.73	15.211	32.058E-02	−1.638E-04	29.823E-09	16.2092	3202.21	−56.16	34	160	165
166	451.02	245.30			15.165	27.959E-02	−8.805E-05	−1.660E-08	16.1088	2788.43	−59.15	−13	117	166
167	256.30	151.86	−0.13	71.34	−2.994	35.320E-02	−1.982E-04	44.631E-09	15.7564	2132.42	−33.15	−83	22	167
168	268.94	155.34	−6.99	65.90	0.440	29.534E-02	−1.018E-04	−6.155E-10	15.8171	2210.71	−36.15	−73	32	168
169	259.04	153.30	−11.18	63.01	18.317	25.636E-02	−7.013E-05	−8.989E-09	15.8177	2212.32	−33.15	−73	27	169
170			26.67	110.11	−50.254	50.242E-02	−3.558E-04	10.471E-08	15.9254	2359.09	−31.78	−73	17	170
171			−16.91	58.11	16.052	28.043E-02	−1.091E-04	90.979E-10	15.7528	2125.75	−33.15	−83	17	171
172	472.31	233.42	−205.15	−114.84	14.080	34.570E-02	−1.723E-04	28.872E-09	16.1668	2839.09	−50.15	−18	107	172
173	464.06	253.64	−215.87	−121.42	24.463	33.557E-02	−2.057E-04	63.681E-09	15.9888	2676.98	−51.15	−26	97	173
174	423.84	231.67	−238.52	−146.16	10.944	35.592E-02	−1.900E-04	39.197E-09	16.5986	3150.42	−36.65	−16	103	174
175	419.79	244.46	−184.34		−19.104	51.623E-02	−4.132E-04	14.541E-08	16.1069	2768.38	−46.90	−3	97	175
176	349.95	189.02	−140.26		17.279	32.360E-02	−1.471E-04	21.495E-09	15.8911	2449.26	−44.15	−48	67	176
177	640.42	321.13	−476.16		11.740	41.370E-02	−2.430E-04	55.308E-09	17.9240	4130.93	−70.55	62	197	177
178	660.36	308.77	−315.27	−180.91	−53.574	59.871E-02	−4.085E-04	10.622E-08	16.1327	2966.88	−62.15	2	137	178
179	427.38	235.98	−443.21	−327.62	7.235	40.717E-02	−2.092E-04	28.546E-09	16.1516	2790.50	−57.15	−13	112	179
180	588.65	311.24	−484.25		9.814	46.683E-02	−3.720E-04	13.502E-08	16.7792	3385.49	−94.15	57	192	180
181	442.88	238.39			18.204	31.397E-02	−9.353E-05	−1.828E-08	16.1693	2804.06	−58.92	−13	112	181
182	452.97	246.09							15.7671	2593.95	−69.69	7	87	182
183	783.72	260.03	−147.38	−38.81	−2.613	44.966E-02	−2.937E-04	80.805E-09	15.9750	2826.26	−49.05	−18	112	183
184	480.77	237.30	−161.61	−53.51	−3.433	45.594E-02	−2.981E-04	82.564E-09	15.9907	2753.43	−47.15	−23	102	184
185	543.41	253.35	−183.38	−64.14	−3.931	46.515E-02	−2.886E-04	78.712E-09	15.8121	2567.15	−44.15	−38	87	185
186			−3.60	114.76	−51.531	53.382E-02	−3.240E-04	75.279E-09	15.9444	2717.03	−67.90	27	127	186
187	914.14	332.75			−42.802	53.884E-02	−2.666E-04	41.994E-09	16.2364	3171.35	−71.15	27	167	187
188	265.84	160.20	−126.23	−17.17	9.487	33.130E-02	−1.108E-04	−2.822E-09	15.6782	2154.90	−34.42	−78	17	188
189	302.51	170.20	−134.61	20.89	−1.390	38.473E-02	−1.846E-04	28.952E-09	15.5381	2032.73	−33.15	−86	7	189
190	984.54	341.12	−274.86	−150.89	3.266	41.801E-02	−2.242E-04	46.850E-09	17.2160	3137.02	−94.43	15	131	190
191	1441.70	331.50	−292.82	−167.72	5.753	42.454E-02	−2.328E-04	47.730E-09	17.2102	3026.03	−86.65	25	120	191
192	1199.10	343.85	−283.40	−167.43	−7.708	46.892E-02	−2.884E-04	72.306E-09	16.8712	2874.73	−100.30	20	115	192
193	972.10	363.38	−312.63	−177.77	−48.613	71.720E-02	−7.084E-04	29.199E-08	16.8548	2658.29	−95.50	20	103	193
194	353.14	190.58	−252.38	−122.42	21.424	33.587E-02	−1.035E-04	−9.357E-09	16.0828	2511.29	−41.95	−48	67	194
195					32.234	35.672E-02	−1.336E-04	83.987E-10	16.0241	2869.79	−53.15	−11	120	195
196	1943.00	385.24	−571.50		73.060	34.441E-02	−1.468E-04	18.464E-09	17.0326	4122.52	−122.50	129	287	196
197	407.59	233.32	−83.53	17.79	13.595	39.595E-02	−1.780E-04	26.490E-09	15.9531	2896.27	−54.49	−13	117	197
198			−74.69	22.27	26.896	46.013E-02	−2.710E-04	59.704E-09	16.0607	3421.57	−64.19	39	182	198
199	472.06	243.98	−92.11	49.24	5.079	44.757E-02	−2.407E-04	75.990E-09	16.6085	3012.70	−48.96	−14	100	199
200					9.491	44.296E-02	−2.110E-04	23.329E-09	16.1419	2704.16	−56.15	−22	100	200

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NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
01	C4H11N	DIETHYL AMINE	73.139	-49.8	55.4	496.6	37.1	0.301	707	20	27,842	201
02	C4H12SI	TETRAMETHYLSILANE	88.225	-102.2	27.6	448.6	28.2	0.362	646	20	24,685	202
03	C5H4O2	FURFURAL	96.085	-31.0	161.7	657.1	49.2	0.270	1156	25		203
04	C5H5N	PYRIDINE	79.102	-41.7	115.3	620.0	56.3	0.254	983	20	35,169	204
05	C5H8	CYCLOPENTENE	68.119	-135.1	44.2	506.0			772	20	27,005	205
06	C5H8	1:2-PENTADIENE	68.119	-137.3	44.8	503.0	40.7	0.276	693	20	27,591	206
07	C5H8	1-TRANS-3-PENTADIENE	68.119	-87.5	42.0	496.0	39.9	0.275	676	20	27,047	207
08	C5H8	1:4-PENTADIENE	68.119	-148.3	25.9	478.0	37.9	0.276	661	20	25,163	208
09	C5H8	1-PENTYNE	68.119	-105.7	40.1	493.4	40.5	0.278	690	20		209
10	C5H8	2-METHYL-1:3-BUTADIENE	68.119	-146.0	34.0	484.0	38.5	0.276	681	20	26,084	210
11	C5H8	3-METHYL-1:2-BUTADIENE	68.119	-113.7	40.8	496.0	41.1	0.267	686	20	27,256	211
12	C5H8O	CYCLOPENTONE	84.118	-50.7	130.7	626.0	53.7	0.268	950	20	36,593	212
13	C5H8O2	ETHYL ACRYLATE	100.118	-72.2	99.8	552.0	37.5	0.320	921	20	33,285	213
14	C5H10	CYCLOPENTANE	70.135	-93.9	49.2	511.6	45.1	0.260	745	20	27,315	214
15	C5H10	1-PENTENE	70.135	-165.3	29.9	464.7	40.5	0.300	640	20	25,213	215
16	C5H10	CIS-2-PENTENE	70.135	-151.4	36.9	476.0	36.5	0.300	656	20	26,126	216
17	C5H10	TRANS-2-PENTENE	70.135	-140.3	36.3	475.0	36.6	0.300	649	20	26,084	217
18	C5H10	2-METHYL-1-BUTENE	70.135	-137.6	31.1	465.0	34.5	0.294	650	20	25,514	218
19	C5H10	2-METHYL-2-BUTENE	70.135	-133.8	38.5	470.0	34.5	0.318	662	20	26,322	219
20	C5H10	3-METHYL-1-BUTENE	70.135	-168.5	20.1	450.0	35.2	0.300	627	20	24,116	220
21	C5H10O	VALERALDEHYDE	86.134	-91.2	102.8	554.0	35.5	0.333	810	20	33,662	221
22	C5H10O	METHYL N-PROPYL KETONE	86.134	-77.2	102.3	564.0	38.9	0.301	806	20	33,494	222
23	C5H10O	METHYL ISOPROPYL KETONE	86.134	-92.2	94.2	553.4	38.5	0.310	803	20	30,647	223
24	C5H10O	DIETHYL KETONE	86.134	-39.0	101.9	561.0	37.4	0.336	814	20	33,746	224
25	C5H10O2	N-VALERIC ACID	102.134	-34.2	185.5	651.0	38.5	0.340	939	20	49,823	225
26	C5H10O2	ISOBUTYL FORMATE	102.134	-95.2	98.4	551.0	38.8	0.350	885	20	34,206	226
27	C5H10O2	N-PROPYL ACETATE	102.134	-95.2	101.6	549.4	33.3	0.345	887	20	34,206	227
28	C5H10O2	ETHYL PROPIONATE	102.134	-73.9	98.8	546.0	33.6	0.345	895	16	34,248	228
29	C5H10O2	METHYL BUTYRATE	102.134	-84.8	102.6	554.4	34.8	0.340	898	20	34,101	229
30	C5H10O2	METHYL ISOBUTYRATE	102.134	-87.8	92.2	540.8	34.3	0.339	891	20	33,386	230
31	C5H11N	PIPERIDINE	85.150	-10.5	106.5	594.0	47.6	0.289	862	20	34,248	231
32	C5H12	N-PENTANE	72.151	-129.8	36.0	469.6	33.7	0.304	626	20	25,791	232
33	C5H12	2-METHYL BUTANE	72.151	-159.3	27.8	460.4	33.8	0.306	620	20	24,702	233
34	C5H12	2:2-DIMETHYL PROPANE	72.151	-16.6	9.4	433.8	32.0	0.303	591	20	22,768	234
35	C5H12O	1-PENTANOL	88.150	-78.2	137.8	586.0	38.5	0.326	815	20	44,380	235
36	C5H12O	2-METHYL-1-BUTANOL	88.150	-70.2	128.7	571.0	38.5	0.322	819	20	45,217	236
37	C5H12O	3-METHYL-1-BUTANOL	88.150	-117.2	131.2	579.5	38.5	0.329	810	20	44,129	237
38	C5H12O	2-METHYL-2-BUTANOL	88.150	-8.8	102.0	545.0	39.5	0.319	809	20	40,612	238
39	C5H12O	2:2-DIMETHYL-1-PROPANOL	88.150	53.8	113.1	549.0	39.5	0.319	783	54	43,124	239
40	C5H12O	ETHYL PROPYL ETHER	88.150	-126.8	63.6	500.6	32.5		733	20	30,522	240
41	C5H12O	METHYL-T-BUTYL ETHER	88.150	-108.2	55.1	407.1	34.3	0.339	741	20	27,646	241
42	C5H12O	BUTYLMETHYL ETHER	88.150	-115.5	70.1	512.8	34.3	0.329				242
43	C6F6	PERFLUOROBENZENE	186.056		80.2	516.7	33.0					243
44	C6F12	PERFLUOROCYCLOHEXANE	300.047		52.5	457.2	24.3					244
45	C6F14	PERFLUORO-N-HEXANE	338.044	-87.2	57.1	451.7	19.0	0.442				245
46	C6H3CL3	1:2:4-TRICHLOROBENZENE	181.449	16.8	213.0	734.9	39.8	0.401				246
47	C6H4CL2	O-DICHLOROBENZENE	147.004	-17.1	180.4	697.3	41.0	0.360	1306	20	39,691	247
48	C6H4CL2	M-DICHLOROBENZENE	147.004	-24.8	172.8	684.0	38.5	0.359	[illegible]	[illegible]	[illegible]	[illegible]
49	C6H4CL2	P-DICHLOROBENZENE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NO													NO
201	473.89	229.29	-72.43	72.14	2.039	44.296E-02	-2.183E-04	36.530E-09	16.0545	2595.01	[illegible]	[illegible]	[illegible]
202			-232.41						16.0999	2570.24	-28.73	27	-84	202
203					18.196	28.198E-02	-6.523E-05	-5.476E-08	18.7949	5365.88	5.40	77	277	203
204	618.50	291.58	140.26	190.33	39.791	49.279E-02	-3.558E-04	10.044E-08	16.0910	3095.13	-61.15	12	152	204
205	396.83	218.66	32.95	110.66	-41.512	46.306E-02	-2.579E-04	54.345E-09	15.9356	2583.07	-39.70	-29	105	205
206			145.70	210.55	8.826	38.799E-02	-2.280E-04	52.461E-09	15.9297	2544.34	-44.30	-23	67	206
207			77.87	146.83	30.689	28.110E-02	-6.711E-05	-2.352E-08	15.9182	2541.69	-41.43	-23	67	207
208			105.51	170.36	6.996	39.515E-02	-2.374E-04	55.998E-09	15.7392	2344.02	-41.69	-33	47	208
209			144.44	210.39	18.066	35.035E-02	-1.913E-04	40.976E-09	16.0429	2515.62	-45.97	-43	62	209
210	328.49	182.48	75.78	145.95	-34.122	45.845E-02	-3.337E-04	10.002E-08	15.8548	2467.40	-39.64	-23	57	210
211			129.79	198.75	14.687	35.977E-02	-1.976E-04	42.622E-09	15.9880	2541.83	-42.26	-23	62	211
212	574.71	303.44	-192.76		-40.641	52.251E-02	-3.035E-04	71.301E-09	16.0897	3193.92	-66.15	27	167	212
213	438.08	256.84			16.810	36.898E-01	-1.382E-04	-5.732E-09	16.0890	2974.94	-58.15	1	136	213
214	406.69	231.67	-77.29	38.64	-53.625	54.261E-02	-3.031E-04	64.854E-09	15.8574	2588.48	-41.79	-43	72	214
215	305.25	174.70	-20.93	79.17	-0.134	43.292E-02	-2.317E-04	46.808E-09	15.7646	2405.96	-39.63	-53	52	215
216	305.31	175.72	-28.09	71.89	-13.151	46.013E-02	-2.541E-04	54.554E-09	15.8251	2459.05	-42.56	-53	57	216
217	349.33	176.62	-31.78	69.96	1.947	41.818E-02	-2.178E-04	44.045E-09	15.9011	2495.97	-40.18	-53	57	217
218	369.27	193.39	-36.34	65.65	10.572	39.971E-02	-1.946E-04	33.139E-09	15.8260	2426.42	-40.36	-53	52	218
219	322.47	180.43	-42.58	59.70	11.803	35.090E-02	-1.117E-04	-5.807E-09	15.9238	2521.53	-40.31	-47	62	219
220			-28.97	74.82	21.742	38.895E-02	-2.007E-04	40.105E-09	15.7179	2333.61	-36.33	-63	42	220
221	521.30	252.03	-227.97	-108.35	14.239	43.292E-02	-2.107E-04	31.623E-09	16.1623	3030.20	-58.15	-46	139	221
222	437.94	243.03	-258.83	-137.16	1.147	48.023E-02	-2.818E-04	66.612E-09	16.0031	2934.87	-62.25	2	137	222
223					-2.914	49.907E-02	-2.935E-04	66.654E-09	14.1779	1993.12	-103.20	-2	133	223
224	409.17	236.65	-258.83	135.36	30.011	39.394E-02	-1.907E-04	33.976E-09	16.8138	3410.51	-40.15	2	127	224
225	729.09	341.13	-490.69	-357.43	13.389	50.325E-02	-2.931E-04	66.193E-09	17.6306	4092.15	-86.55	77	222	225
226					19.850	40.336E-02	-1.436E-04	-7.402E-09	16.2292	2980.47	-64.15	5	136	226
227	489.53	255.83	-466.03		15.420	45.008E-02	-1.686E-04	-1.439E-08	16.2291	2980.47	-64.15	7	137	227
228	463.31	248.72	-470.18	-323.72	19.854	40.344E-02	-1.437E-04	-7.402E-09	16.1620	2935.11	-64.16	3	123	228
229	479.35	254.66												229
230	451.21	246.09												230
231	772.79	313.49	-49.03		-53.068	62.886E-02	-3.358E-04	64.267E-09	16.1004	3015.46	-61.15	7	143	231
232	313.66	182.48	-146.54	-8.37	-3.626	48.734E-02	-2.580E-04	53.047E-09	15.8333	2477.07	-39.94	-53	57	232
233	367.32	191.58	-154.58	-14.82	-9.525	50.660E-02	-2.729E-04	57.234E-09	15.6338	2348.67	-40.05	-57	49	233
234	355.54	196.35	-166.09	-15.24	-16.592	55.517E-02	-3.306E-04	76.325E-09	15.2069	2034.15	-45.37	-13	32	234
235	1151.10	349.62	-298.94	-146.12	3.869	50.451E-02	-2.639E-04	51.205E-09	16.5270	3026.89	-105.00	37	138	235
236	1259.40	349.85	-302.71	-165.71	-9.483	56.773E-02	-3.481E-04	86.374E-09	16.2708	2752.19	-116.30	34	129	236
237	1148.80	349.51	-302.29		-9.542	56.815E-02	-3.485E-04	86.499E-09	16.7127	3026.43	-104.10	25	153	237
238	1502.00	336.75	-329.92	-165.38	-12.087	60.960E-02	-4.204E-04	12.284E-08	15.0113	1988.08	-137.80	25	102	238
239			-293.08	-125.52	12.154	53.968E-02	-3.160E-04	71.217E-09	18.1336	3694.96	-65.00	55	133	239
240	399.87	213.39							15.3549	2423.41	-62.28	-27	87	240
241			-292.99	-125.52	2.533	51.372E-02	-2.596E-04	43.040E-09	16.4174	2913.70	-30.63	-88	88	241
242									15.8830	2666.26	-53.70	69	23	242
243			-957.27	-879.98	36.283	52.670E-02	-4.547E-04	14.558E-08	16.1940	2827.53	-57.66	-3	117	243
244									13.9087	1374.07	-136.80	7	127	244
245									15.8307	2488.59	-59.73	-3	57	245
246					-14.361	60.876E-02	-5.623E-04	20.725E-08	16.8979	4452.50	-53.00	127	327	246
247	554.35	319.07	29.98	82.73	-14.302	55.056E-02	-4.513E-04	14.294E-08	16.2799	3798.23	-59.84	58	210	247
248	402.20	300.89	26.46	78.63	-13.590	54.931E-02	-4.505E-04	14.269E-08	16.8173	4104.13	-43.15	53	202	248
249	483.82	312.03	23.03	77.20	-14.344	55.349E-02	-4.559E-04	14.478E-08	16.1135	3626.83	-64.64	54	204	249
250	508.18	302.42	105.09	138.62	-28.805	53.507E-02	-4.080E-04	12.117E-08	15.7972	3313.00	-67.71	47	177	250

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
251	C6H5CL	CHLOROBENZENE	112.559	−45.6	131.7	632.4	45.2	0.308	1106	20	36,572	251
252	C6H5F	FLUOROBENZENE	96.104	−39.2	85.3	560.1	45.5	0.271	1024	20		252
253	C6H5I	IODOBENZENE	204.011	−31.4	188.2	721.0	45.2	0.351	1855	4	39,523	253
254	C6H5NO2	NITROBENZENE	123.112	4.8	210.6	712.0	35.0	0.337	1203	20	44,031	254
255	C6H6	BENZENE	78.114	5.5	80.1	562.1	48.9	0.259	885	16	30,781	255
256	C6H6O	PHENOL	94.113	40.8	181.8	694.2	61.3	0.229	1059	40	45,636	256
257	C6H7N	ANILINE	93.129	−6.2	184.3	699.0	53.1	0.270	1022	20	41,868	257
258	C6H7N	4-METHYL PYRIDINE	93.129	3.7	145.3	646.0	44.6	0.311	955	20	37,472	258
259	C6H10	1,5-HEXADIENE	82.146	−141.2	59.4	507.0	34.5	0.328	692	20	27,470	259
260	C6H10	CYCLOHEXENE	82.146	−103.5	82.9	560.4	43.5	0.292	816	16	30,480	260
261	C6H10O	CYCLOHEXANONE	98.145	−31.2	155.6	629.0	38.5	0.312	951	15	39,775	261
262	C6H12	CYCLOHEXANE	84.162	6.5	80.7	553.4	40.7	0.308	779	20	29,977	262
263	C6H12	METHYLCYCLOPENTANE	84.162	−142.5	71.8	532.7	37.9	0.319	754	16	29,098	263
264	C6H12	1-HEXENE	84.162	−139.9	63.4	504.0	31.7	0.350	673	20	28,303	264
265	C6H12	CIS-2-HEXENE	84.162	−141.2	68.8	518.0	32.8	0.351	687	20	29,140	265
266	C6H12	TRANS-2-HEXENE	84.162	−133.2	67.8	516.0	32.7	0.351	678	20	28,931	266
267	C6H12	CIS-3-HEXENE	84.162	−137.9	66.4	517.0	32.8	0.350	680	20	28,721	267
268	C6H12	TRANS-3-HEXENE	84.162	−113.5	67.1	519.9	32.5	0.350	677	20	28,973	268
269	C6H12	2-METHYL-2-PENTENE	84.162	−135.1	67.3	518.0	32.8	0.351	691	16	29,015	269
270	C6H12	3-METHYL-CIS-2-PENTENE	84.162	−134.9	67.7	518.0	32.8	0.351	694	20	28,847	270
271	C6H12	3-METHYL-TRANS-2-PENTENE	84.162	−138.5	70.4	521.0	32.9	0.350	698	20	29,308	271
272	C6H12	4-METHYL-CIS-2-PENTENE	84.162	−134.2	56.4	490.0	30.4	0.360	669	20	27,591	272
273	C6H12	4-METHYL-TRANS-2-PENTENE	84.162	−141.2	58.5	493.0	30.4	0.360	669	20	27,968	273
274	C6H12	2,3-DIMETHYL-1-BUTENE	84.162	−157.3	55.6	501.0	32.4	0.343	678	20	27,424	274
275	C6H12	2,3-DIMETHYL-2-BUTENE	84.162	−74.3	73.2	524.0	33.6	0.351	708	20	29,655	275
276	C6H12	3,3-DIMETHYL-1-BUTENE	84.162	−115.2	41.2	490.0	32.5	0.340	653	20	25,665	276
277	C6H12O	CYCLOHEXANOL	100.161	24.8	161.1	625.0	37.5	0.327	942	30	45,511	277
278	C6H12O	METHYL ISOBUTYL KETONE	100.161	−84.2	116.4	571.0	32.7	0.371	801	20	35,588	278
279	C6H12O2	N-BUTYL ACETATE	116.160	−73.5	126.0	579.0	31.4	0.400	898	0	36,006	279
280	C6H12O2	ISOBUTYL ACETATE	116.160	−98.9	116.8	561.0	30.4	0.414	875	20	35,873	280
281	C6H12O2	ETHYL BUTYRATE	116.160	−93.2	120.8	566.0	31.4	0.395	879	20	34,332	281
282	C6H12O2	ETHYL ISOBUTYRATE	116.160	−88.2	111.0	553.0	30.4	0.410	869	20	35,023	282
283	C6H12O2	N-PROPYL PROPIONATE	116.160	−75.9	122.5	578.0			881	20	36,383	283
284	C6H14	N-HEXANE	86.178	−95.4	68.7	507.4	29.7	0.370	659	20	28,872	284
285	C6H14	2-METHYL PENTANE	86.178	−153.7	60.2	497.5	30.1	0.367	653	20	27,800	285
286	C6H14	3-METHYL PENTANE	86.178	−118.2	63.2	504.4	31.2	0.367	664	20	28,093	286
287	C6H14	2,2-DIMETHYL BUTANE	86.178	−99.9	49.7	488.7	30.8	0.359	649	20	26,322	287
288	C6H14	2,3-DIMETHYL BUTANE	86.178	−128.6	58.0	499.9	31.3	0.358	662	20	27,298	288
289	C6H14O	1-HEXANOL	102.177	−44.0	157.0	610.0	40.5	0.381	819	20	48,567	289
290	C6H14O	ETHYL BUTYL ETHER	102.177	−103.2	92.2	531.0	30.4	0.390	749	20	31,820	290
291	C6H14O	DIISOPROPYL ETHER	102.177	−85.5	68.3	500.0	28.8	0.386	724	20	29,349	291
292	C6H15N	DIPROPYLAMINE	101.193	−63.2	109.2	550.0	31.4	0.407	738	20	37,011	292
293	C6H15N	TRIETHYLAMINE	101.193	−114.8	89.5	535.0	30.4	0.390	728	20	31,401	293
294	C7F14	PERFLUOROMETHYLCYCLOHEXANE	350.055		76.3	486.8	23.3					294
295	C7F16	PERFLUORO-N-HEPTANE	388.051	−78.2	82.5	474.8	16.2	0.664	1733	20		295
296	C7H5N	BENZONITRILE	103.124	−13.2	190.8	699.4	42.2		1010	15		296
297	C7H6O	BENZALDEHYDE	106.124	−57.2	178.8	695.0	46.6		1045	20	42,705	297
298	C7H6O2	BENZOIC ACID	122.124	122.4	249.8	752.0	45.6	0.341	1075	130	50,660	298
299	C7H7NO2	O-NITROTOLUENE	137.139	−9.2	222.1	720.0	34.0	0.371	1167	20	[illegible]	299
300	C7H7NO2	M-NITROTOLUENE	137.139	16.0	233.1	725.0	30.5	0.371	[illegible]	[illegible]	[illegible]	[illegible]

251	477.76	276.22	51.87	99.23	−33.888	56.312E-02	−4.522E-04	14.264E-08	16.0676	3295.12	−55.60	47	147	251
252	452.06	252.89	−116.64	−69.08	−38.728	56.689E-02	−4.434E-04	13.553E-08	16.5487	3181.78	−37.59	−23	97	252
253	565.72	331.21	162.66	187.90	−29.274	55.643E-02	−4.509E-04	14.432E-08	16.1454	3776.53	−64.38	17	197	253
254			−67.49						16.1484	4032.66	−71.81	44	211	254
255	545.64	265.34	82.98	129.75	−33.917	47.436E-02	−3.017E-04	71.301E-09	15.9008	2788.51	−52.36	7	104	255
256	1405.50	370.07	−96.67	−32.91	−35.843	59.829E-02	−4.827E-04	15.269E-08	16.4279	3490.89	−98.59	72	208	256
257	1074.60	357.21	86.92	166.80	−40.516	63.849E-02	−5.133E-04	16.333E-08	16.6748	3857.52	−73.15	67	227	257
258	500.97	285.50	102.28		−17.430	48.818E-02	−2.798E-04	54.512E-09	16.2143	3409.40	−62.65	27	187	258
259			83.74						16.1351	2728.54	−45.45	9	77	259
260	506.92	264.54	−5.36	106.93	−68.651	72.515E-02	−5.414E-04	16.442E-08	15.8243	2813.53	−49.98	27	87	260
261	787.38	336.47	−230.27	−90.81	−37.807	55.391E-02	−1.953E-04	−1.534E-08						261
262	653.62	290.84	−123.22	31.78	−54.541	61.127E-02	−2.523E-04	13.214E-09	15.7527	2766.63	−50.50	7	107	262
263	440.52	243.24	−105.93	35.80	−50.108	63.807E-02	−3.642E-04	80.135E-09	15.8023	2731.00	−47.11	−23	102	263
264	357.43	197.74	−41.70	87.50	−1.746	53.089E-02	−2.903E-04	60.541E-09	15.8089	2654.81	−47.30	−33	87	264
265	344.33	197.95	−52.38	76.28	−9.810	53.089E-02	−2.717E-04	48.274E-09	16.2057	2897.97	−39.30	−28	97	265
266	344.33	197.95	−53.93	76.49	−32.925	69.292E-02	−5.619E-04	20.046E-08	15.8727	2701.72	−48.62	−28	92	266
267	344.33	197.95	−47.65	83.07	−21.729	58.113E-02	−3.362E-04	74.567E-09	15.8384	2680.52	−48.40	−28	92	267
268	344.33	197.95	−54.47	77.67	−4.338	55.098E-02	−3.282E-04	80.470E-09	15.9288	2718.68	−47.77	−28	92	268
269			−59.79	71.26	−14.750	56.689E-02	−3.341E-04	79.633E-09	15.9423	2725.89	−47.64	−28	97	269
270			−57.78	73.27	−14.750	56.689E-02	−3.341E-04	79.633E-09	15.9124	2731.79	−46.76	−25	91	270
271			−58.70	71.34	−14.750	56.689E-02	−3.341E-04	79.633E-09	15.9484	2750.50	−48.33	−23	93	271
272			−50.37	82.19	−1.675	53.759E-02	−3.044E-04	67.533E-09	15.7527	2580.52	−46.56	−35	79	272
273			−54.39	79.67	12.627	51.540E-02	−3.007E-04	73.269E-09	15.8425	2631.57	−46.00	−33	81	273
274			−55.77	79.09	7.025	55.852E-02	−3.696E-04	10.630E-08	15.8012	2612.69	−43.78	−38	87	274
275			−59.24	75.91	2.294	48.274E-02	−2.199E-04	30.417E-09	16.0043	2798.63	−47.71	−23	102	275
276			−43.17	98.22	−12.556	54.847E-02	−2.915E-04	52.084E-09	15.3755	2326.80	−48.24	−48	67	276
277			−294.75	−117.98	−55.534	72.139E-02	−4.086E-04	82.354E-09						277
278	473.65	259.03	−284.03		3.894	56.564E-02	−3.318E-04	82.312E-09	15.7165	2893.66	−70.75	12	152	278
279	537.58	272.30	−486.76		13.620	54.889E-02	−2.278E-04	−7.913E-10	16.1836	3151.09	−69.15	22	162	279
280	533.99	270.49	−495.47		7.310	57.401E-02	−2.576E-04	11.011E-09	16.1714	3092.83	−66.15	16	154	280
281	489.95	264.22			21.508	49.279E-02	−1.938E-04	35.588E-10	15.9987	3127.60	−60.15	15	159	281
282														282
283									16.8641	3558.18	−47.86	19	147	283
284	362.79	207.09	−167.30	−0.25	−4.413	58.197E-02	−3.119E-04	64.937E-09	15.8366	2697.55	−48.78	−28	97	284
285	384.13	208.27	−174.42	−5.02	−10.567	61.839E-02	−3.573E-04	80.847E-09	15.7476	2614.38	−46.58	−33	97	285
286	372.11	207.55	−171.74	−2.14	−2.386	56.899E-02	−2.870E-04	50.325E-09	15.7701	2653.43	−46.02	−33	92	286
287	438.44	226.67	−185.68	−9.63	−16.634	62.928E-02	−3.481E-04	68.496E-09	15.5536	2489.50	−43.81	−43	77	287
288	444.19	228.86	−177.90	−4.10	−14.608	61.504E-02	−3.376E-04	68.203E-09	15.6802	2595.44	−44.25	−38	81	288
289	1179.40	354.94	−317.78	−135.65	4.811	58.908E-02	−3.010E-04	54.261E-09	18.0994	4055.45	−76.49	35	157	289
290	443.32	234.68			23.626	53.675E-02	−2.528E-04	41.567E-09	16.0477	2921.52	−55.15	−8	127	290
291	410.58	219.67	−319.03	−121.96	7.503	58.490E-02	−3.027E-04	58.448E-09	16.3417	2895.73	−43.15	−24	91	291
292	561.11	257.39			6.460	52.928E-02	−3.390E-04	70.715E-09	16.5939	3259.08	−55.15	29	149	292
293	355.52	214.48	−99.65	110.36	−18.430	71.552E-02	−4.392E-04	10.923E-08	15.8853	2882.38	−51.15	−13	127	293
294			−2898.10						15.7130	2610.57	−61.93	17	112	294
295			−3386.70	−3089.31					15.9747	2719.68	−64.50	−3	117	295
296			218.97	261.05	−26.004	57.317E-02	−4.430E-04	13.490E-08						296
297	686.84	314.66	−36.80	22.40	−12.142	49.614E-02	−2.845E-04	51.665E-09	16.3501	3748.62	−66.12	27	187	297
298	2617.60	407.88	−290.40	−210.55	−51.292	62.928E-02	−4.237E-04	10.622E-08	17.1634	4190.70	−125.20	132	287	298
299			−265.86						14.2028	2603.49	−151.52	222	129	299
300			−265.86											300

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
301	C7H7NO2	P-NITROTOLUENE	137.139	54.8	238.0	735.0	30.1	0.371	1164	20	46.875	301
302	C7H8	TOLUENE	92.141	−95.2	110.6	591.7	41.1	0.316	867	20	33.201	302
303	C7H8O	METHYL PHENYL ETHER	108.140	−37.5	153.6	641.0	41.7		996	20		303
304	C7H8O	BENZYL ALCOHOL	108.140	−15.4	205.4	677.0	46.6	0.334	1041	25	50,535	304
305	C7H8O	O-CRESOL	108.140	30.9	191.0	697.6	50.1	0.282	1028	40	45,217	305
306	C7H8O	M-CRESOL	108.140	12.2	202.2	705.8	45.6	0.310	1034	20	47,436	306
307	C7H8O	P-CRESOL	108.140	34.7	201.9	704.6	51.5		1019	40	47,478	307
308	C7H9N	2;3-DIMETHYLPYRIDINE	107.156		160.8	655.4			942	25		308
309	C7H9N	2;5-DIMETHYLPYRIDINE	107.156		157.0	644.2			938	0		309
310	C7H9N	3;4-DIMETHYLPYRIDINE	107.156		179.1	683.8			954	25		310
311	C7H9N	3;5-DIMETHYLPYRIDINE	107.156		171.9	667.2			939	25		311
312	C7H9N	METHYLPHENYLAMINE	107.156	−57.2	195.9	701.0	52.0		989	20		312
313	C7H9N	O-TOLUIDINE	107.156	−14.8	200.1	694.0	37.5	0.343	998	20	45,364	313
314	C7H9N	M-TOLUIDINE	107.156	−30.4	203.3	709.0	41.5	0.343	989	20	45,636	314
315	C7H9N	P-TOLUIDINE	107.156	43.7	200.1	667.0			964	50	44,799	315
316	C7H14	CYCLOHEPTANE	98.189	−8.2	118.7	589.0	37.2	0.390	810	20	33,076	316
317	C7H14	1;1-DIMETHYLCYCLOPENTANE	98.189	−69.8	87.8	547.0	34.5	0.360	759	16	30,312	317
318	C7H14	CIS-1;2-DIMETHYLCYCLOPENTANE	98.189	−53.9	99.5	564.8	34.5	0.368	777	16	31,719	318
319	C7H14	TRANS-1;2-DIMETHYLCYCLOPENTANE	98.189	−117.6	91.8	553.2	34.5	0.362	756	16	30,878	319
320	C7H14	ETHYLCYCLOPENTANE	98.189	−138.5	103.4	569.5	33.9	0.375	771	16	32,301	320
321	C7H14	METHYLCYCLOHEXANE	98.189	−126.6	100.9	572.1	34.8	0.368	774	16	31,150	321
322	C7H14	1-HEPTENE	98.189	−118.9	93.6	537.2	28.4	0.440	679	20	31,108	322
323	C7H14	2;3;3-TRIMETHYL-1-BUTENE	98.189	−109.9	77.8	533.0	29.0	0.400	705	20	28,889	323
324	C7H16	N-HEPTANE	100.250	−90.6	98.4	540.2	27.4	0.432	684	20	31,719	324
325	C7H16	2-METHYLHEXANE	100.205	−118.3	90.0	530.3	27.4	0.421	679	20	30,689	325
326	C7H16	3-METHYLHEXANE	100.205	−173.2	91.8	535.2	28.2	0.404	687	20	30,815	326
327	C7H16	2;2-DIMETHYLPENTANE	100.205	−123.8	79.2	520.4	27.8	0.416	674	20	29,182	327
328	C7H16	2;3-DIMETHYLPENTANE	100.205		89.7	537.3	29.1	0.393	965	20	30,409	328
329	C7H16	2;4-DIMETHYLPENTANE	100.205	−119.2	80.5	519.7	27.4	0.418	673	20	29,517	329
330	C7H16	3;3-DIMETHYLPENTANE	100.205	−134.5	86.0	536.3	29.5	0.414	693	20	29,668	330
331	C7H16	3-ETHYLPENTANE	100.205	−118.6	93.4	540.6	28.9	0.416	698	20	30,978	331
332	C7H16	2;2;3-TRIMETHYLBUTANE	100.205	−24.9	80.8	531.1	29.6	0.398	690	20	28,968	332
333	C7H16O	1-HEPTANOL	116.204	−34.0	176.3	633.0	30.4	0.435	822	20	48,148	333
334	C8H4O3	PHTHALIC ANHYDRIDE	148.118	130.8	286.8	810.0	47.6	0.368			47,614	334
335	C8H8	STYRENE	104.152	−30.7	145.1	647.0	39.9		906	20	36,844	335
336	C8H8O	METHYL PHENYL KETONE	120.151	19.6	201.7	701.0	38.5	0.376	1032	15		336
337	C8H8O2	METHYL BENZOATE	136.151	−12.4	199.0	692.0	36.5	0.396	1083	20	43,124	337
338	C8H10	O-XYLENE	106.168	−25.2	144.4	630.2	37.3	0.369	880	20	36,844	338
339	C8H10	M-XYLENE	106.168	−47.9	139.1	617.0	35.5	0.376	864	20	36,383	339
340	C8H10	P-XYLENE	106.168	13.2	138.3	616.2	35.2	0.379	861	20	36,006	340
341	C8H10	ETHYL BENZENE	106.168	−95.0	136.1	617.1	36.1	0.374	867	20	35,588	341
342	C8H10O	O-ETHYLPHENOL	122.167	−3.4	204.5	703.0			1037	0	48,106	342
343	C8H10O	M-ETHYLPHENOL	122.167	−4.2	218.4	716.4			1025	0	50,828	343
344	C8H10O	P-ETHYLPHENOL	122.167	44.8	217.8	716.4					50,660	344
345	C8H10O	ETHYL PHENYL ETHER	122.167	−30.2	169.8	647.0	34.2		979	4		345
346	C8H10O	2;3-XYLENOL	122.167	74.8	216.9	722.8					47,311	346
347	C8H10O	2;4-XYLENOL	122.167	24.8	210.8	707.6					47,143	347

[redacted]

302	467.33	255.24	50.03	122.09	−24.355	51.246E-02	−2.765E-04	49.111E-09	16.0137	3096.52	−53.67	7	137	302
303	388.84	325.85							16.2394	3430.82	−69.58	97	167	303
304	1088.00	367.21	−94.08		−7.398	54.805E-02	−3.357E-04	77.707E-09	17.4582	4384.81	−73.15	112	330	304
305	1533.40	365.61	−128.70	−37.10	−32.276	70.045E-02	−5.924E-04	21.240E-08	15.9148	3305.37	−108.00	97	207	305
306	1785.60	370.75	−132.43	−40.57	−45.008	72.641E-02	−6.029E-04	20.775E-08	17.2878	4274.42	−74.09	97	207	306
307	1826.90	372.68	−125.48	−30.90	−40.633	70.548E-02	−5.757E-04	19.674E-08	16.1989	3479.39	−111.30	97	207	307
308			68.29						17.1492	4219.74	−33.04	147	167	308
309			66.44						16.3046	3545.14	−63.59	77	162	309
310			70.05						16.9517	4237.04	−41.65	127	187	310
311			72.81						16.8850	4106.95	−44.45	127	187	311
312	915.12	332.74	85.41	199.33	−15.989	56.815E-02	−3.033E-04	46.432E-09	16.3066	3756.28	−80.71	47	207	312
313	1085.10	356.46							16.7834	4072.58	−72.15	102	227	313
314	928.12	354.07							16.7498	4080.32	−73.15	82	227	314
315	738.90	356.02							16.6968	4041.04	−72.15	77	227	315
316			−119.41	63.05	−76.187	78.670E-02	−4.204E-04	75.614E-09	15.7818	3066.05	−56.80	57	162	316
317			−138.37	39.06	−57.891	76.702E-02	−4.501E-04	10.103E-08	15.6973	2807.94	−51.20	−13	117	317
318			−129.62	45.76	−55.643	76.158E-02	−4.484E-04	10.140E-08	15.7729	2922.30	−52.94	−3	127	318
319			−136.78	38.39	−54.521	75.907E-02	−4.480E-04	10.170E-08	15.7594	2861.53	−51.46	−13	117	319
320	433.81	249.72	−127.15	44.59	−55.312	75.111E-02	−4.396E-04	10.040E-08	15.8581	2990.13	−52.47	−3	129	320
321	528.41	271.58	−154.87	27.30	−61.919	78.419E-02	−4.438E-04	93.659E-09	15.7105	2926.04	−51.75	−3	127	321
322	368.69	214.32	−62.34	95.88	−3.303	62.969E-02	−3.512E-04	76.074E-09	15.8894	2895.51	−53.97	−8	127	322
323			−86.54						15.6536	2719.47	−49.56	−20	102	323
324	436.73	232.53	−187.90	8.00	−5.146	67.617E-02	−3.651E-04	76.577E-09	15.8737	2911.32	−56.51	−3	127	324
325	417.46	225.13	−195.06	3.22	−39.389	86.416E-02	−6.289E-04	18.363E-08	15.8261	2845.06	−53.60	−9	117	325
326			−192.43	4.61	−7.046	68.370E-02	−3.734E-04	78.335E-09	15.8133	2855.66	−53.93	−8	117	326
327	417.37	226.19	−206.28	0.08	−50.099	89.556E-02	−6.360E-04	17.358E-08	15.6917	2740.15	−49.85	−19	105	327
328			−199.38	0.67	−7.046	70.476E-02	−3.734E-04	78.335E-09	15.7815	2850.64	−51.33	−11	115	328
329			−202.14	3.10	−7.046	68.370E-02	−3.734E-04	78.335E-09	15.7179	2744.78	−51.52	−17	105	329
330			−201.68	2.64	−7.046	68.370E-02	−3.734E-04	78.335E-09	15.7190	2829.10	−47.83	−13	112	330
331			−189.79	11.01	−7.046	68.370E-02	−3.734E-04	78.335E-09	15.8317	2882.44	−53.26	−7	119	331
332			−204.94	4.27	−22.944	75.195E-02	−4.421E-04	10.048E-08	15.6398	2764.40	−47.10	−19	106	332
333	1287.00	361.83	−332.01	−121.00	4.907	67.784E-02	−3.447E-04	60.457E-09	15.3068	2626.42	−146.60	60	176	333
334			−371.79		−4.455	65.398E-02	−4.283E-04	10.094E-08	15.9984	4467.01	−83.15	136	342	334
335	528.64	276.71	147.46	213.95	−28.248	61.588E-02	−4.023E-04	99.353E-09	16.0193	3328.57	−63.72	32	187	335
336	1316.40	310.82	−86.92	1.84	−29.580	64.100E-02	−4.071E-04	97.217E-09	16.2384	3781.07	−81.15	77	247	336
337	768.94	332.33	−254.06		−21.210	55.015E-02	−1.799E-04	44.254E-09	16.2272	3751.83	−81.15	77	243	337
338	513.54	277.98	19.01	122.17	−15.851	59.620E-02	−3.443E-04	75.279E-09	16.1156	3395.57	−59.46	32	172	338
339	453.42	257.18	17.25	118.95	−29.165	62.969E-02	−3.747E-04	84.783E-09	16.1390	3366.99	−58.04	27	167	339
340	475.16	261.40	17.96	121.21	−25.091	60.416E-02	−3.374E-04	68.203E-09	16.0963	3346.65	−57.84	27	167	340
341	472.82	264.22	29.81	130.67	−43.099	70.715E-02	−4.811E-04	13.008E-08	16.0195	3272.47	−59.95	27	177	341
342			−145.78						17.9610	4928.36	−45.75	77	227	342
343			−146.58						17.1955	4272.77	−86.08	97	227	343
344			−144.65						19.0905	5579.62	−44.15	97	227	344
345	646.88	305.91							16.1673	3473.20	−78.66	112	187	345
346			−157.34						16.2424	3724.58	−102.40	147	227	346
347			−162.78						13.2456	3655.26	−103.80	137	227	347
348			−161.53						16.2328	3667.32	−102.40	137	217	348
349			−161.95						16.2809	3749.35	−85.55	127	207	349
350			−156.50						16.3004	3733.53	−113.90	157	247	350

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP	NO
351	C8H10O	3,5-XYLENOL	122.167	63.8	221.6	715.6					49,404	351
352	C8H11N	N,N-DIMETHYLANILINE	121.183	2.4	193.5	687.0	36.3		956	20		352
353	C8H16	1,1-DIMETHYLCYCLOHEXANE	112.216	−33.5	119.5	591.0	29.7	0.416	785	16	32,615	353
354	C8H16	CIS-1,2-DIMETHYLCYCLOHEXANE	112.216	−50.1	129.7	606.0	29.7		796	20	33,662	354
355	C8H16	TRANS-1,2-DIMETHYLCYCLOHEXANE	112.216	−88.2	123.4	596.0	29.7		776	20	32,908	355
356	C8H16	CIS-1,3-DIMETHYLCYCLOHEXANE	112.216	−75.6	120.1	591.0	29.7		766	20	32,825	356
357	C8H16	TRANS-1,3-DIMETHYLCYCLOHEXANE	112.216	−90.2	124.4	598.0	29.7		785	20	33,871	357
358	C8H16	CIS-1,4-DIMETHYLCYCLOHEXANE	112.216	−87.5	124.3	598.0	29.7		783	20	33,787	358
359	C8H16	TRANS-1,4-DIMETHYLCYCLOHEXANE	112.216	−37.0	119.3	590.0	29.7		763	20	32,615	359
360	C8H16	ETHYLCYCLOHEXANE	112.216	−111.4	131.7	609.0	30.3	0.450	788	20	34,332	360
361	C8H16	1,1,2-TRIMETHYLCYCLOPENTANE	112.216		113.7	579.5	29.4				32,615	361
362	C8H16	1,1,3-TRIMETHYLCYCLOPENTANE	112.216		104.8	569.5	28.3				31,694	362
363	C8H16	CIS,CIS,TRANS-1,2,4-TRIMETHYLCYCLOPENTANE	112.216		117.8	579.0	28.8				33,076	363
364	C8H16	CIS,TRANS,CIS-1,2,4-TRIMETHYLCYCLOPENTANE	112.216		109.2	571.0	28.1				33,076	364
365	C8H16	1-METHYL-1-ETHYLCYCLOPENTANE	112.216		121.5	592.0	29.9				33,662	365
366	C8H16	N-PROPYLCYCLOPENTANE	112.216	−117.4	130.9	603.0	30.0	0.425	781	16	34,131	366
367	C8H16	ISOPROPYLCYCLOPENTANE	112.216	−112.7	126.4	601.0	30.0		776	20	34,122	367
368	C8H16	1-OCTENE	112.216	−101.8	121.2	566.6	26.2	0.464	715	20	33,787	368
369	C8H16	TRANS-2-OCTENE	112.216	−87.8	124.9	580.0	27.7		720	20	34,332	369
370	C8H18	N-OCTANE	114.232	−56.8	125.6	568.8	24.8	0.492	703	20	34,436	370
371	C8H18	2-METHYLHEPTANE	114.232	−109.2	117.6	559.6	24.8	0.488	702	16	33,829	371
372	C8H18	3-METHYLHEPTANE	114.232	−120.5	118.9	563.6	25.4	0.464	706	20	33,913	372
373	C8H18	4-METHYLHEPTANE	114.232	−121.0	117.7	561.7	25.4	0.476	705	20	33,913	373
374	C8H18	2,2-DIMETHYLHEXANE	114.232	−121.2	108.8	549.8	25.3	0.478	695	20	32,280	374
375	C8H18	2,3-DIMETHYLHEXANE	114.232		115.6	563.4	26.2	0.468	712	20	33,226	375
376	C8H18	2,4-DIMETHYLHEXANE	114.232		109.4	553.5	25.5	0.472	700	20	32,615	376
377	C8H18	2,5-DIMETHYLHEXANE	114.232	−91.3	109.1	550.0	24.8	0.482	693	20	32,657	377
378	C8H18	3,3-DIMETHYLHEXANE	114.232	−126.2	111.9	562.0	26.5	0.443	710	20	32,490	378
379	C8H18	3,4-DIMETHYLHEXANE	114.232		117.7	568.8	27.0	0.466	719	20	33,298	379
380	C8H18	3-ETHYLHEXANE	114.232		118.5	565.4	26.0	0.455	718	16	33,633	380
381	C8H18	2,2,3-TRIMETHYLPENTANE	114.232	−112.3	109.8	563.4	27.3	0.436	716	20	32,029	381
382	C8H18	2,2,4-TRIMETHYLPENTANE	114.232	−107.4	99.2	543.9	25.6	0.468	692	20	31,028	382
383	C8H18	2,3,3-TRIMETHYLPENTANE	114.232	−100.7	114.7	573.5	28.2	0.455	726	20	32,364	383
384	C8H18	2,3,4-TRIMETHYLPENTANE	114.232	−109.3	113.4	566.3	27.3	0.461	719	20	32,753	384
385	C8H18	2-METHYL-3-ETHYLPENTANE	114.232	−115.0	115.6	567.0	27.1	0.443	719	20	32,988	385
386	C8H18	3-METHYL-3-ETHYLPENTANE	114.232	−90.9	118.2	576.5	28.1	0.455	727	20	32,816	386
387	C8H18O	1-OCTANOL	130.231	−15.5	195.2	658.0	34.5	0.490	826	20	50,660	387
388	C8H18O	2-OCTANOL	130.231	−32.0	179.7	637.0	27.4	0.494	821	20	44,380	388
389	C8H18O	2-ETHYLHEXANOL	130.231	−70.0	184.6	613.0	27.6	0.494	833	20	46,599	389
390	C8H18O	BUTYL ETHER	130.231	−97.9	142.4	580.0	25.3	0.500	768	20	37,263	390
391	C8H18O5	TETRAETHYLENE GLYCOL	194.229		318.9	795.8	21.0	0.646				391
392	C8H19N	DIBUTYLAMINE	129.247	−62.2	159.6	596.0	25.3	0.517	767	20	39,775	392
393	C8H20SI	TETRAETHYL SILANE	144.333	−82.5	153.4	603.7	26.0	0.582	766	20	36,473	393
394	C9H8	INDENE	116.163		181.9	691.9	38.2	0.377				394
395	C9H10	INDAN	118.179		177.0	681.1	36.3	0.392				395
396	C9H10	ALPHA-METHYL STYRENE	118.179		165.3	654.0	34.0	0.397	911	20	38,309	396
397	C9H10O2	ETHYL BENZOATE	150.178	−34.9	212.7	697.0	32.4	0.451	1046	20	44,799	397
398	C9H12	N-PROPYLBENZENE	120.195	−99.5	159.2	638.3	32.0	0.440	862	20	[illegible]	398
399	C9H12	ISOPROPYLBENZENE	120.195	−96.1	152.4	631.0	32.1	0.428	[illegible]	[illegible]	[illegible]	399
400	[illegible]	1-METHYL-2-ETHYLBEN[illegible]	120.19[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	400

NO	VISA	VISB	DELHF	DELGF	CPVAPA	CPVAPB	CPVAPC	CPVAPD	ANTA	ANTB	ANTC	[illegible]	[illegible]	NO
351			−161.48						16.4192	3775.91	−109.00	157	227	351
352	553.02	320.03	84.15	231.36					16.9647	4276.08	−52.80	72	207	352
353			−181.12	35.25	−72.105	89.974E-02	−5.020E-04	10.304E-08	15.6535	3043.34	−55.30	10	147	353
354			−172.29	41.24	−68.370	89.723E-02	−5.137E-04	10.986E-08	15.7438	3148.35	−57.31	17	157	354
355			−180.12	34.50	−68.479	91.230E-02	−5.355E-04	11.811E-08	15.7337	3117.43	−54.02	13	151	355
356			−184.89	29.85	−65.163	88.383E-02	−4.932E-04	10.199E-08	15.7470	3081.95	−55.08	11	147	356
357			−176.68	36.34	−64.154	88.258E-02	−5.016E-04	10.685E-08	15.7371	3093.95	−57.76	15	152	357
358			−176.77	37.97	−64.154	88.258E-02	−5.016E-04	10.685E-08	15.7333	3098.39	−57.00	14	152	358
359			184.72	31.74	−70.363	91.314E-02	−5.309E-04	11.547E-08	15.6984	3063.44	−54.57	10	147	359
360	506.43	280.76	−171.87	39.27	−63.891	88.928E-02	−5.108E-04	11.028E-08	15.8125	3183.25	−58.15	20	160	360
361									15.7084	3015.51	−54.59	6	141	361
362									15.6794	2938.09	−53.25	0	131	362
363									15.7543	3073.95	−54.20	10	145	363
364									15.7756	3009.70	−53.23	9	144	364
365									15.8222	3120.66	−55.06	13	149	365
366	454.23	264.22	−148.17	52.63	−55.973	84.490E-02	−4.924E-04	11.175E-08	15.8969	3187.67	−59.99	21	158	366
367									15.8561	3176.22	−55.18	16	154	367
368	418.82	237.63	−82.98	104.29	−4.099	72.390E-02	−4.036E-04	86.750E-09	15.9630	3116.52	−60.39	16	147	368
369	427.64	240.32	−94.58	92.74	−12.820	75.321E-02	−4.442E-04	10.505E-08	15.8554	3134.97	−58.00	16	152	369
370	473.70	251.71	−208.59	16.41	−6.096	77.121E-02	−4.195E-04	88.551E-09	15.9426	3120.29	−63.63	19	152	370
371	643.61	259.51	−215.62	12.77	−89.744	12.422E-01	−1.176E-03	46.180E-08	15.9278	3097.63	−59.46	12	144	371
372			−212.77	13.73	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.8865	3065.96	−60.74	13	145	372
373			−212.23	16.75	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.8893	3057.05	−60.59	12	144	373
374			−224.87	10.72	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.7431	2932.56	−58.08	3	132	374
375			−214.07	17.71	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.8189	3029.06	−58.99	10	142	375
376			−219.56	11.72	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.7797	2965.44	−58.36	5	135	376
377			−222.78	10.47	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.7954	2964.06	−58.74	5	135	377
378	446.20	244.67	−220.27	13.27	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.7755	3011.51	−55.71	6	138	378
379			−213.15	17.33	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.8415	3062.52	−58.29	11	144	379
380	437.60	238.33	−211.01	16.54	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.8671	3057.57	−60.55	13	145	380
381	474.57	257.61	−220.27	17.12	−7.461	77.791E-02	−4.287E-04	91.733E-09	15.7162	2981.56	−54.73	4	136	381
382	467.04	246.43	−224.29	13.69	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.6850	2896.28	−52.41	−4	125	382
383			−216.58	18.92	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.7578	3057.94	−52.77	7	142	383
384			−217.59	18.92	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.7818	3028.09	−55.62	7	140	384
385			211.35	21.27	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.8040	3035.08	−57.84	9	142	385
386			−215.12	19.83	−9.215	78.586E-02	−4.400E-04	96.966E-09	15.8126	3102.06	−53.47	10	145	386
387	1312.10	369.97	−360.06	−120.16	6.171	76.074E-02	−3.797E-04	62.635E-09	15.7428	3017.81	−137.10	70	195	387
388					25.879	76.409E-02	−4.224E-04	90.644E-09	14.7108	2441.66	−150.70	72	180	388
389	1798.00	351.17	−365.55		−14.993	86.541E-02	−5.280E-04	12.845E-08	15.3614	2773.46	−140.00	75	185	389
390	473.50	266.56	−334.11	−88.59	6.054	77.288E-02	−4.085E-04	80.847E-09	16.0778	3296.15	−66.15	32	182	390
391					7.164	86.164E-02	−2.904E-04	−9.115E-08	20.5564	8215.28	−11.50	227	427	391
392	581.42	286.54			9.764	80.805E-02	−4.392E-04	92.486E-09	16.7307	3721.90	−64.15	49	186	392
393			−314.93						16.6385	3873.18	−39.33	153	−1	393
394					−42.944	68.957E-02	−4.340E-04	91.482E-09	16.4380	3994.97	−49.40	77	277	394
395					−59.639	78.126E-02	−4.841E-04	98.474E-09	16.2601	3789.86	−57.00	77	277	395
396	354.34	270.80			−24.329	69.333E-02	−4.530E-04	11.807E-08	16.3308	3644.30	−67.15	75	220	396
397	746.50	338.47			20.670	68.873E-02	−3.608E-04	50.618E-09	16.2065	3845.09	−84.15	88	258	397
398	527.45	282.65	7.83	137.33	−31.288	74.860E-02	−4.601E-04	10.810E-08	16.0062	3433.84	−66.01	43	188	398
399	517.17	276.22	3.94	137.08	−39.364	78.419E-02	−5.087E-04	12.912E-08	15.9722	3363.60	−63.37	38	181	399
400			1.21	131.17	−16.446	69.961E-02	−4.120E-04	93.282E-09	16.1253	3535.33	−65.85	48	194	400

NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP
401	C9H12	1-METHYL-3-ETHYLBENZENE	120.195	−95.6	161.3	637.0	28.4	0.490	865	20	38,560
402	C9H12	1-METHYL-4-ETHYLBENZENE	120.195	−62.4	162.0	640.0	29.4	0.470	861	20	38,435
403	C9H12	1,2,3-TRIMETHYLBENZENE	120.195	−25.5	176.0	664.5	34.6	0.430	894	20	40,068
404	C9H12	1,2,4-TRIMETHYLBENZENE	120.195	−46.2	169.3	649.1	32.3	0.430	880	16	39,272
405	C9H12	1,3,5-TRIMETHYLBENZENE	120.195	−44.8	164.7	637.3	31.3	0.433	865	20	39,063
406	C9H18	N-PROPYLCYCLOHEXANE	126.243	−94.5	156.7	639.0	28.1		793	20	36,090
407	C9H18	ISOPROPYLCYCLOHEXANE	126.243	−89.8	154.5	640.0	28.4		802	20	
408	C9H18	1-NONENE	126.243	−81.4	146.8	592.0	23.4	0.580	745	0	36,341
409	C9H20	N-NONANE	128.259	−53.5	150.8	594.6	23.1	0.548	718	20	36,940
410	C9H20	2,2,3-TRIMETHYLHEXANE	128.259		133.6	588.0	24.9				34,792
411	C9H20	2,2,4-TRIMETHYLHEXANE	128.259	−120.2	126.5	573.7	23.7		720	16	34,039
412	C9H20	2,2,5-TRIMETHYLHEXANE	128.259	−105.8	124.1	568.0	23.3	0.519	717	16	33,787
413	C9H20	3,3-DIMETHYLPENTANE	128.259		146.1	610.0	26.7		752	20	36,006
414	C9H20	2,2,3,3-TETRAMETHYLPENTANE	128.259		140.2	607.6	27.4				35,295
415	C9H20	2,2,3,4-TETRAMETHYLPENTANE	128.259		133.0	592.7	26.0				34,290
416	C9H29	2,2,4,4-TETRAMETHYLPENTANE	128.259	−67.2	122.2	574.7	24.8		719	20	32,866
417	C9H20	2,3,3,4-TETRAMETHYLPENTANE	128.259		141.5	607.6	27.2				34,960
418	C10H8	NAPHTHALENE	128.174	80.3	217.9	748.4	40.5	0.410	971	90	43,292
419	C10H12	1,2,3,4-TETRAHYDRONAPHTHALENE	132.206	−31.2	207.5	719.0	35.2		973	20	39,733
420	C10H14	N-BUTYLBENZENE	134.222	−88.0	183.2	660.5	28.9	0.497	860	20	39,272
421	C10H14	ISOBUTYLBENZENE	134.222	−51.5	172.7	650.0	31.4	0.480	853	20	37,849
422	C10H14	SEC-BUTYLBENZENE	134.222	−75.5	173.3	664.0	29.5		862	20	37,974
423	C10H14	TERT-BUTYLBENZENE	134.222	−57.9	169.1	660.0	29.7		867	20	37,639
424	C10H14	1-METHYL-2-ISOPROPYLBENZENE	134.222		178.3	670.0	29.0		876	20	
425	C10H14	1-METHYL-3-ISOPROPYLBENZENE	134.222		175.1	666.0	29.4		861	20	38,142
426	C10H14	1-METHYL-4-ISOPROPYLBENZENE	134.222	−73.2	177.1	653.0	28.3		857	20	
427	C10H14	1,4-DIETHYLBENZENE	134.222	−42.2	183.7	657.9	28.1	0.480	862	20	39,398
428	C10H14	1,2,4,5-TETRAMETHYLBENZENE	134.222	78.8	196.8	675.0	29.4	0.480	838	81	45,552
429	C10H15N	N-BUTYLANILINE	149.236	−14.2	240.7	721.0	28.4	0.518	932	20	48,944
430	C10H18	CIS-DECALIN	138.254	−43.2	195.7	702.2	31.4		897	20	39,356
431	C10H18	TRANS-DECALIN	138.254	−30.4	187.2	690.0	31.4		870	20	38,519
432	C10H19N	CAPRYLONITRILE	153.269	−17.9	242.8	622.0	32.5		820	20	
433	C10H20	N-BUTYLCYCLOHEXANE	140.270	−74.8	180.9	667.0	31.5		799	20	38,519
434	C10H20	ISOBUTYLCYCLOHEXANE	140.270		171.3	659.0	31.2		795	20	
435	C10H20	SEC-BUTYLCYCLOHEXANE	140.270		179.3	669.0	26.7		813	20	
436	C10H20	TERT-BUTYLCYCLOHEXANE	140.270	−41.2	171.5	659.0	26.6		813	20	
437	C10H20	1-DECENE	140.270	−66.3	170.5	615.0	22.1	0.650	741	20	38,686
438	C10H20O	MENTHOL	156.269	42.8	216.3	694.0					
439	C10H22	N-DECANE	142.286	−29.7	174.1	617.6	21.1	0.603	730	20	39,306
440	C10H22	3,3,5-TRIMETHYLHEPTANE	142.286		155.6	609.6	23.2				36,676
441	C10H22	2,2,3,3-TETRAMETHYLHEXANE	142.286		160.3	623.1	25.1				36,383
442	C10H22	2,2,5,5-TETRAMETHYLHEXANE	142.286		137.4	581.5	21.9				35,295
443	C10H22O	1-DECANOL	158.285	6.9	230.2	700.0	22.3	0.600	830	20	50,242
444	C11H10	1-METHYLNAPHTHALENE	142.201	−30.5	244.6	772.0	35.7	0.445	1020	20	46,055
445	C11H10	2-METHYLNAPHTHALENE	142.201	34.5	241.0	761.0	35.1	0.462	990	40	46,055
446	C11H14O2	BUTYL BENZOATE	178.232	−22.2	249.8	723.0	26.3	0.561	1006	20	48,986
447	C11H22	N-HEXYLCYCLOPENTANE	154.297		203.1	660.1	21.4				41,198
448	C11H22	1-UNDECENE	154.297	−49.2	192.6	637.0	20.0		751	20	40,905
449	C11H24	N-UNDECANE	156.313	−25.6	195.9	638.8	19.7	0.660	740	20	41,533
450	C12H8	ACENAPHTHALENE	152.196	95.0	270.0	796.9	32.2	0.487			

NO	VISA	VISB	DELHF	DELGF	CPVAPA	CPVAPB	CPVAPC	CPVAPD	ANTA	ANTB	ANTC	TMN	TMX
401			−1.93	126.53	−28.998	72.934E-02	−4.363E-04	99.981E-09	16.1545	3521.08	−64.64	45	190
402	463.17	266.08	−2.05	126.78	−27.310	71.762E-02	−4.224E-04	95.417E-09	16.1135	3516.31	−64.23	45	190
403			−9.59	124.64	−6.942	63.346E-02	−3.326E-04	66.110E-09	16.2121	3670.22	−66.07	56	206
404	872.74	297.75	−13.94	117.02	−4.668	62.383E-02	−3.263E-04	63.765E-09	16.2190	3622.58	−64.59	51	198
405	437.52	268.27	−16.08	118.03	−19.590	67.240E-02	−3.692E-04	76.995E-09	16.2893	3614.19	−63.57	48	193
406	549.08	293.93	−193.43	47.35	−62.517	98.892E-02	−5.795E-04	12.912E-08	15.8567	3363.62	−65.21	40	186
407									15.8260	3346.12	−63.71	57	167
408	471.00	258.92	−103.58	112.75	−3.718	81.224E-02	−4.509E-04	97.050E-09	16.0118	3305.03	−67.61	35	175
409	525.56	272.12	−229.19	24.83	3.144	67.742E-02	−1.928E-04	−2.981E-08	15.9671	3291.45	−71.33	39	179
410			−241.37	24.53	−45.632	10.555E-01	−7.172E-04	19.866E-08	15.8017	3164.17	−61.66	24	163
411			−243.38	22.52	−60.311	11.045E-01	−7.712E-04	21.876E-08	15.7639	3084.08	−61.94	18	155
412			254.18	13.44	−54.106	10.948E-01	−7.746E-04	22.546E-08	15.7445	3052.17	−62.24	42	147
413			231.95	35.09	−67.269	11.262E-01	−7.988E-04	23.061E-08	15.8709	3341.62	−57.57	77	167
414			−237.39	34.33	−54.583	10.890E-01	−7.570E-04	21.420E-08	15.7280	3220.55	−59.31	55	167
415			−237.22	32.66	−54.583	10.890E-01	−7.570E-04	21.420E-08	15.7363	3167.42	−58.21	45	157
416			−242.12	34.04	−67.403	11.681E-01	−8.612E-04	25.736E-08	15.6488	3049.98	−57.13	40	140
417			−236.39	34.12	−54.918	10.911E-01	−7.603E-04	21.579E-08	15.8029	3269.07	−58.19	52	152
418	873.32	352.57	151.06	223.74	−68.802	84.992E-02	−6.506E-04	19.808E-08	16.1426	3992.01	−71.29	87	252
419			27.63	167.05					16.2805	4009.49	−64.98	92	227
420	563.84	296.01	−13.82	144.78	−22.990	79.340E-02	−4.396E-04	85.704E-09	16.0793	3633.40	−71.77	62	213
421			−21.56						15.9524	3512.47	−69.03	53	203
422	582.82	295.82	−17.46		−65.147	98.934E-02	−7.214E-04	21.520E-08	15.9999	3544.19	−68.10	52	203
423			−22.69		−86.001	11.020E-01	−8.746E-04	28.265E-08	15.9300	3462.28	−69.87	50	199
424									15.9809	3564.52	−70.00	57	208
425			−29.31		−48.759	90.644E-02	−6.054E-04	16.274E-08	15.9811	3543.79	−69.22	55	205
426									15.9424	3539.21	−70.10	56	207
427			−22.27	137.96	−37.417	86.709E-02	−5.560E-04	14.110E-08	16.1140	3657.22	−71.18	62	214
428			−45.30	119.53	15.265	65.188E-02	−2.879E-04	32.569E-09	16.3023	3850.91	−71.72	88	227
429	1111.10	341.28			−34.068	91.440E-02	−5.560E-04	12.874E-08	16.3994	4079.72	−96.15	112	287
430			−169.06	85.87	−112.457	11.183E-01	−6.607E-04	14.369E-08	15.8312	3671.61	−69.74	95	222
431	702.27	339.66	−182.42	73.48	−97.670	10.446E-01	−5.476E-04	89.807E-09	15.7989	3610.66	−66.49	90	197
432													
433	598.30	311.39	−213.32	56.48	−62.957	10.627E-01	−6.305E-04	14.001E-08	15.9116	3542.57	−72.32	59	212
434									15.8141	3437.99	−69.99	82	182
435									15.8670	3524.57	−70.78	87	197
436									15.7884	3457.85	−67.04	84	177
437	518.37	277.80	−124.22	121.12	−4.664	90.770E-02	−5.058E-04	10.953E-08	16.0129	3448.18	−76.09	83	187
438									19.0161	5539.90	−37.85	212	56
439	558.61	288.37	−249.83	33.24	−7.913	96.087E-02	−5.288E-04	11.309E-08	16.0114	3456.80	−78.67	57	203
440			−258.74	33.58	−70.372	12.322E-01	−8.646E-04	24.551E-08	15.7848	3305.20	−67.66	40	275
441					−58.833	12.313E-01	−8.834E-04	25.849E-08	15.7598	3371.05	−64.09	41	190
442					−62.341	12.447E-01	−8.956E-04	26.180E-08	15.8446	3172.92	−66.15	27	165
443	1481.80	380.00	−401.93	−104.25	14.570	89.472E-02	−3.921E-04	34.508E-09	15.9395	3389.43	−139.00	103	230
444	862.89	361.76	116.94	217.84	−64.820	93.868E-02	−6.942E-04	20.155E-08	16.2008	4206.70	−78.15	107	278
445	695.42	351.79	116.18	216.29	−56.518	89.974E-02	−6.469E-04	18.401E-08	16.2758	4237.37	−74.75	104	275
446	882.36	350.34			−17.367	86.751E-02	−4.610E-04	72.348E-09	16.3363	4158.47	−94.15	117	297
447	617.57	318.65	−209.63	78.25	−58.322	11.279E-01	−6.536E-04	14.729E-08	16.0140	3702.56	−81.55	78	234
448	566.26	294.89	−144.86	129.54	−5.585	10.027E-01	−5.602E-04	12.163E-08	16.0412	3597.72	−83.41	72	223
449	605.50	305.01	−270.47	41.62	−8.395	10.538E-01	−5.799E-04	12.368E-08	16.0541	3614.07	−85.45	75	225
450					−64.623	88.509E-02	−5.853E-04	13.054E-08	16.3091	4470.92	−81.40	177	377

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NO	FORMULA	COMPOUND NAME	MOLWT	TFP	TBP	TC	PC	VC	LDEN	TDEN	HVAP
451	C12H10	DIPHENYL	154.212	69.2	255.2	789.0	38.5	0.502	990	74	45,636
452	C12H10O	DIPHENYL ETHER	170.211	26.8	258.0	766.0	31.4		1066	30	47,143
453	C12H24	N-HEPTYLCYCLOPENTANE	168.324		224.1	679.0	19.5				43,375
454	C12H24	1-DODECENE	168.324	−35.2	213.3	657.0	18.5		758	20	42,998
455	C12H26	N-DODECANE	170.340	−9.6	216.3	658.3	18.2	0.713	748	20	43,668
456	C12H26O	DIHEXYL ETHER	186.339	−43.2	226.4	657.0	18.2	0.720	794	20	45,636
457	C12H26O	DODECANOL	186.339	23.9	259.9	679.0	19.3	0.718	835	20	
458	C12H27N	TRIBUTYLAMINE	185.355		213.4	643.0	18.2		779	20	44,380
459	C13H10	FLUORENE	166.223	114.0	297.9	822.3	29.9	0.534			
460	C13H12	DIPHENYLMETHANE	168.239	26.8	264.3	767.0	29.8		1006	20	
461	C13H26	N-OCTYLCYCLOPENTANE	182.351		243.7	694.0	17.9				45,427
462	C13H26	1-TRIDECENE	182.351	−23.1	232.7	674.0	17.0		766	20	45,008
463	C13H28	N-TRIDECANE	184.367	−5.4	235.4	675.8	17.2	0.780	756	20	45,678
464	C14H10	ANTHRACENE	178.234	216.5	341.2	883.0					56,522
465	C14H10	PHENANTHRENE	178.234	100.5	339.4	878.0					55,684
466	C14H28	N-NONYLCYCLOPENTANE	196.378		262.1	710.5	16.5				47,269
467	C14H28	1-TETRADECENE	196.378	−12.9	251.1	689.0	15.6		786	0	46,934
468	C14H30	N-TETRADECANE	198.394	5.8	253.5	694.0	16.2	0.830	763	20	47,646
469	C15H12	1-PHENYLINDENE	192.261		322.0	843.7	27.0	0.598			
470	C15H14	2-ETHYLFLUORENE	194.277		309.0	811.1	24.6	0.629			
471	C15H30	N-DECYLCYCLOPENTANE	210.405		279.3	723.8	15.2				49,027
472	C15H30	1-PENTADECENE	210.405	−3.8	268.3	704.0	14.6		791	0	48,692
473	C15H32	N-PENTADECANE	212.421	9.8	270.6	707.0	15.2	0.880	769	20	49,488
474	C16H10	FLUORANTHENE	202.256	110.0	393.0	936.6	26.0	0.660			
475	C16H10	PYRENE	202.256	151.0	362.0	892.1	26.0	0.637			
476	C16H12	N-PHENYLNAPHTHALENE	204.272		316.0	840.1	26.3	0.605			
477	C16H22O4	DIBUTYL-O-PHTHALATE	278.350	−35.2	334.8				1047	20	79,131
478	C16H32	N-DECYLCYCLOHEXANE	224.432		297.6	750.0	13.6				50,409
479	C16H32	1-HEXADECENE	224.432	4.1	284.8	717.0	13.4		788	10	50,451
480	C16H32O2	PALMIC ACID	256.431	63.0	348.5	791.0	19.0	0.946	828	102	66,992
481	C16H34	N-HEXADECANE	226.448	17.8	286.8	717.0	14.2		773	20	51,246
482	C17H34	N-DODECYLCYCLOPENTANE	238.459		310.9	750.0	13.0				52,628
483	C17H36O	HEPTADECANOL	256.474	53.8	323.8	736.0	14.2		848	54	60,709
484	C17H36	N-HEPTADECANE	240.475	21.8	302.0	733.0	13.2	1.000	778	20	52,921
485	C18H12	CHRYSENE	228.294	255.0	448.0	993.6	23.9	0.736			
486	C18H14	O-TERPHENYL	230.310	56.8	331.8	891.0	39.0	0.769			
487	C18H14	M-TERPHENYL	230.310	86.8	364.8	924.8	35.1	0.784			
488	C18H14	P-TERPHENYL	230.310	211.8	375.8	926.0	33.2	0.779			
489	C18H34O2	OLEIC ACID	282.469	13.3	362.3	797.0	17.0	1.035	893	20	68,131
490	C18H36	1-OCTADECENE	252.486	17.6	314.8	739.0	11.3		789	20	54,303
491	C18H36	N-TRIDECYLCYCLOPENTANE	252.486		325.4	761.0	12.1				54,345
492	C18H36O2	STEARIC ACID	284.485	70.0	371.9	810.0	16.5	1.054	844	70	70,049
493	C18H38	N-OCTADECANE	254.502	28.1	316.3	745.0	12.1		777	28	54,512
494	C18H38O	1-OCTADECANOL	270.501	57.8	334.8	747.0	14.2		812	59	
495	C19H38	N-TETRADECYLCYCLOPENTANE	266.513		325.8	772.0	11.2				56,019
496	C19H40	N-NONADECANE	268.529	31.8	329.9	756.0	11.1		789	32	56,061
497	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	10.2				[illegible]

NO												
451	[illegible]	369.58	[illegible]	[illegible]	−97.067	11.057E-01	−8.855E-04	27.901E-08	16.6832	4602.23	−70.42	70	272
452	1146.00	379.29	49.99		−60.730	92.821E-02	−5.870E-04	13.586E-08	16.3459	4310.25	−87.31	145	325
453	654.77	333.12	−230.27	86.67	−59.264	12.234E-01	−7.084E-04	15.964E-08	16.0589	3850.38	−88.75	95	256
454	615.67	310.07	−165.46	138.00	−6.544	10.978E-01	−6.155E-04	13.410E-08	16.0610	3729.87	−90.88	88	244
455	631.63	318.78	−291.07	50.07	−9.328	11.489E-01	−6.347E-04	13.590E-08	16.1134	3774.56	−91.31	91	247
456	723.43	323.35			33.536	10.735E-01	−5.535E-04	16.777E-08	16.3372	3982.78	−89.15	100	272
457	1417.80	398.89	−443.13	−87.13	9.224	11.032E-01	−5.338E-04	77.791E-09	15.2638	3242.04	−157.10	134	307
458	889.06	312.48			7.993	11.978E-01	−6.703E-04	14.486E-08	16.2878	3865.58	−86.15	89	258
459									18.2166	6462.60	−13.40	207	407
460					−54.491	90.351E-02	−5.388E-04	92.570E-09	14.4856	2902.44	−167.90	200	290
461	695.83	346.19	−250.87	95.12	−59.951	13.167E-01	−7.612E-04	17.082E-08	16.0941	3983.01	−95.85	112	276
462	658.16	323.71	−186.10	146.37	−7.118	11.911E-01	−6.674E-04	14.511E-08	16.0850	3856.23	−97.94	104	264
463	664.10	332.10	−311.71	58.49	−10.463	12.452E-01	−6.912E-04	14.897E-08	16.1355	3892.91	−98.93	107	267
464	513.28	405.81	224.83		−58.979	10.057E-01	−6.594E-04	16.056E-08	17.6701	6492.44	−26.13	217	382
465			202.64		−58.979	10.057E-01	−6.594E-04	16.056E-08	16.7187	5477.94	−69.39	177	382
466	735.19	357.74	−271.51	103.50	−60.809	14.118E-01	−8.156E-04	18.347E-08	16.1089	4096.30	−103.00	127	296
467	697.49	336.13	−206.66	154.87	−7.967	12.858E-01	−7.210E-04	15.692E-08	16.1643	4018.01	−102.70	119	284
468	689.85	344.21	−332.35	66.86	−10.982	13.377E-01	−7.423E-04	15.981E-08	16.1480	4008.52	−105.40	121	287
469					−96.154	11.865E-01	−7.786E-04	17.650E-08	16.4170	4872.90	−97.30	227	427
470					−107.036	12.611E-01	−8.156E-04	17.928E-08	16.5199	4789.44	−97.90	207	407
471	771.74	368.30	−292.15	111.91	−61.923	15.077E-01	−8.717E-04	19.590E-08	16.1261	4203.94	−109.70	140	313
472	739.13	347.46	−227.39	163.16	−9.203	13.825E-01	−7.783E-04	17.028E-08	16.1539	4103.15	−110.60	133	301
473	718.51	355.92	−352.99	75.28	−11.916	14.327E-01	−7.972E-04	17.199E-08	16.1724	4121.51	−111.80	135	304
474					−80.706	11.715E-01	−7.938E-04	18.600E-08	16.4523	5438.77	−112.40	287	487
475					−94.379	11.916E-01	−7.930E-04	17.559E-08	16.4842	5203.08	−107.20	257	477
476					−99.516	11.463E-01	−6.113E-04	60.612E-09	16.9691	5351.04	−81.70	227	427
477	2588.10	336.24			1.880	12.539E-01	−6.121E-04	69.710E-09	16.9539	4852.47	−138.10	196	384
478	925.84	378.69			−69.015	16.542E-01	−9.613E-04	21.428E-08	16.1627	4373.37	−111.80	190	300
479	767.48	357.85	−247.98	171.62	−9.705	14.750E-01	−8.298E-04	18.104E-08	16.2203	4245.00	−115.20	147	319
480			−723.06						18.9558	7049.18	−55.08	353	153
481	738.30	366.11	−373.59	83.74	−13.017	15.290E-01	−8.537E-04	18.497E-08	16.1841	4214.91	−118.70	150	321
482	853.53	385.53	−336.12	126.02	−63.263	16.952E-01	−9.768E-04	21.855E-08	16.1915	4395.87	−124.20	168	346
483			−546.25	−44.67	−7.792	16.529E-01	−9.345E-04	20.436E-08	15.6161	3672.62	−188.10	191	383
484	757.88	375.90	−394.19	92.15	−13.967	16.241E-01	−9.081E-04	19.720E-08	16.1510	4294.55	−124.00	161	337
485					−115.757	13.415E-01	−8.311E-04	15.412E-08	16.6038	5915.26	−128.10	377	577
486	1094.10	461.27											
487	940.58	460.94											
488	911.01	461.10											
489			−646.02						18.2445	5884.49	−127.26	360	176
490	816.19	376.93	−289.22	188.45	−11.329	16.643E-01	−9.374E-04	20.486E-08	16.2221	4416.13	−127.30	171	350
491	891.80	392.78	−353.99	137.08	−64.209	17.903E-01	−1.032E-03	23.094E-08	16.2270	4483.13	−131.30	180	361
492			−764.51						19.8034	7709.35	−57.83	370	174
493	777.40	385.00	−414.83	100.57	−14.470	17.170E-01	−9.592E-04	20.783E-08	16.1232	4361.79	−129.90	172	352
494			−566.85	−36.22	−8.704	17.476E-01	−8.524E-04	21.575E-08	15.6898	3757.82	−193.10	201	385
495	924.60	399.62	−374.63	145.58	−64.929	18.845E-01	−1.085E-03	24.258E-08	16.2632	4439.38	−138.10	192	375
496	793.62	393.54	−435.43	108.98	−15.491	18.125E-01	−1.015E-03	22.052E-08	16.1533	4450.44	−135.60	183	366
497	950.57	406.33	−395.28	153.99	−66.093	19.804E-01	−1.140E-03	25.498E-08	16.3092	4642.01	−145.10	203	388
498	811.29	401.67	−456.07	117.40	−22.383	19.393E-01	−1.117E-03	25.284E-08	16.4685	4680.46	−141.10	198	379
499			−608.13	−19.43	−12.581	19.498E-01	−1.118E-03	25.158E-08	15.8233	3912.10	−203.10	219	406
500	977.42	412.29	−415.87	162.41	−66.683	20.741E-01	−1.237E-03	26.682E-08	16.3553	4715.69	−152.10	215	401

APPENDIX E

Conversion Factors for Some Commo SI Units

An asterisk (*) denotes an exact relationship.

Length	*1 in.	:	25.4 mm
	*1 ft	:	0.3048 m
	*1 yd	:	0.9144 m
	1 mile	:	1.6093 km
	*1 Å(angstrom)	:	10^{-10} m
Time	*1 min	:	60 s
	*1 h	:	3.6 ks
	*1 day	:	86.4 ks
	1 year	:	31.5 Ms
Area	*1 $in.^2$	:	645.16 mm^2
	1 ft^2	:	0.092903 m^2
	1 yd^2	:	0.83613 m^2
	1 acre	:	4046.9 m^2
	1 $mile^2$	:	2.590 km^2
Volume	1 $in.^3$	:	16.387 cm^3
	1 ft^3	:	0.02832 m^3
	1 yd^3	:	0.76453 m^3
	1 UK gal	:	4546.1 cm^3
	1 US gal	:	3785.4 cm^3
Mass	1 oz	:	28.352 g
	*1 lb	:	0.45359237 kg
	1 cwt	:	50.8023 kg
	1 ton	:	1016.06 kg
Force	1 pdl	:	0.13826 N
	1 lbf	:	4.4482 N
	1 kgf	:	9.8067 N
	1 tonf	:	9.9640 kN
	*1 dyn	:	10^{-5} N
Temperature difference	*1 deg F (deg R)	:	$\frac{5}{9}$ deg C (deg K)
Energy (work, heat)	1 ft lbf	:	1.3558 J
	1 ft pdl	:	0.04214 J
	*1 cal (internat. table)	:	4.1868 J
	1 erg	:	10^{-7} J
	1 Btu	:	1.05506 kJ
	1 hp h	:	2.6845 MJ
	*1 kW h	:	3.6 MJ
	1 therm	:	105.51 MJ
	1 thermie	:	4.1855 MJ
Calorific value (volumetric)	1 Btu/ft^3	:	37.259 kJ/m^3
Velocity	1 ft/s	:	0.3048 m/s
	1 mile/h	:	0.44704 m/s
Volumetric flow	1 ft^3/s	:	0.028316 m^3/s
	1 ft^3/h	:	7.8658 cm^3/s
	1 UK gal/h	:	1.2628 cm^3/s
	1 US gal/h	:	1.0515 cm^3/s
Mass flow	1 lb/h	:	0.12600 g/s
	1 ton/h	:	0.28224 kg/s
Mass per unit area	1 $lb/in.^2$	:	703.07 kg/m^2
	1 lb/ft^2	:	4.8824 kg/m^2
	1 ton/sq mile	:	392.30 kg/km^2
Density	1 lb/in^3	:	27.680 g/cm^3
	1 lb/ft^3	:	16.019 kg/m^3
	1 lb/UK gal	:	99.776 kg/m^3
	1 lb/US gal	:	119.83 kg/m^3
Pressure	1 $lbf/in.^2$	:	6.8948 kN/m^2
	1 $tonf/in.^2$	:	15.444 MN/m^2
	1 lbf/ft^2	:	47.880 N/m^2
	*1 standard atm	:	101.325 kN/m^2
	*1 atm (1 kgf/cm^2)	:	98.0665 kN/m^2
	*1 bar	:	10^5 N/m^2
	1 ft water	:	2.9891 kN/m^2
	1 in. water	:	249.09 N/m^2
	1 in. Hg	:	3.3864 kN/m^2
	1 mmHg (1 torr)	:	133.32 N/m^2
Power (heat flow)	1 hp (British)	:	745.70 W
	1 hp (metric)	:	735.50 W
	1 erg/s	:	10^{-7} W
	1 ft lbf/s	:	1.3558 W
	1 Btu/h	:	0.29307 W
	1 ton of refrigeration	:	3516.9 W
Moment of inertia	1 lb ft^2	:	0.042140 kg m^2
Momentum	1 lb ft/s	:	0.13826 kg m/s
Angular momentum	1 lb ft^2/s	:	0.042140 kg m^2/s
Viscosity, dynamic	*1 P (Poise)	:	0.1 N* s/m^2
	1 lb/ft h	:	0.41338 mN s/m^2
	1 lb/ft s	:	1.4882 N s/m^2
Viscosity, kinematic	*1 S (Stokes)	:	10^{-4} m^2/s
	1 ft^2/h	:	0.25806 cm^2/s
Surface energy (surface tension)	1 erg/cm^2 (1 dyn/cm)	:	10^{-3} J/m^2 (10^{-3} N/m)
Mass flux density	1 lb/h ft^2	:	1.3562 g/s m^2
Heat flux density	1 Btu/h ft^2	:	3.1546 W/m^2
	*1 kcal/h m^2	:	1.163 W/m^2
Heat transfer coefficient	1 Btu/h ft^2 F	:	5.6783 W/m^2 K
Specific enthalpy (latent heat, etc.)	*1 Btu/lb	:	2.326 kJ/kg
Specific heat capacity	*1 Btu/lb °F	:	4.1868 kJ/kg K
Thermal conductivity	1 Btu/h ft °F	:	1.7307 W/m K
	1 kcal/h m °C	:	1.163 W/m K

en from MULLIN, J. W.: *The Chemical Engineer* No. 211 (Sept. 1967), 176. SI units in chemical engineering.)

*Where temperature difference is involved K = °C.

APPENDIX 1 (41)

Conversion Factors and Constants of Nature

To convert from	To	Multiply by[†]
acre	ft^2	43,560*
	m^2	4,046.85
atm	N/m^2	$1.01325^* \times 10^5$
	$lb_f/in.^2$	14.696
Avogadro's number	particles/g mol	6.022169×10^{23}
bbl (petroleum)	ft^3	5.6146
	gal (U.S.)	42*
	m^3	0.15899
bar	N/m^2	$1^* \times 10^5$
	$lb_f/in.^2$	14.504
Boltzmann's constant	J/K	1.380622×10^{-23}
Btu	cal_{IT}	251.996
	$ft \cdot lb_f$	778.17
	J	1,055.06
	kWh	2.9307×10^{-4}
Btu/lb	cal_{IT}/g	0.55556
Btu/lb·°F	$cal_{IT}/g \cdot °C$	1*
$Btu/ft^2 \cdot h$	W/m^2	3.1546
$Btu/ft^2 \cdot h \cdot °F$	$W/m^2 \cdot °C$	5.6783
	$kcal/m^2 \cdot h \cdot K$	4.882
$Btu \cdot ft/ft^2 \cdot h \cdot °F$	$W \cdot m/m^2 \cdot °C$	1.73073
	$kcal/m \cdot h \cdot K$	1.488
cal_{IT}	Btu	3.9683×10^{-3}
	$ft \cdot lb_f$	3.0873
	J	4.1868*
cal	J	4.184*
cm	in.	0.39370
	ft	0.0328084
cm^3	ft^3	$3.531467 \times 10^{-}$
	gal (U.S.)	2.64172×10^{-4}

(Continue

To convert from	To	Multiply by†
cP (centipoise)	kg/m·s	$1^* \times 10^{-3}$
	lb/ft·h	2.4191
	lb/ft·s	6.7197×10^{-4}
cSt (centistoke)	m^2/s	$1^* \times 10^{-6}$
faraday	C/g mol	9.648670×10^{4}
ft	m	0.3048*
ft·lb_f	Btu	1.2851×10^{-3}
	cal_{IT}	0.32383
	J	1.35582
ft·lb_f/s	Btu/h	4.6262
	hp	1.81818×10^{-3}
ft^2/h	m^2/s	2.581×10^{-5}
	cm^2/s	0.2581
ft^3	m^3	0.0283168
	gal (U.S.)	7.48052
	L	28.31684
ft^3·atm	Btu	2.71948
	cal_{IT}	685.29
	J	2.8692×10^{3}
ft^3/s	gal (U.S.)/min	448.83
gal (U.S.)	ft^3	0.13368
	$in.^3$	231*
gas law constant, R, see Table 1.2, p. 11		
gravitational constant	$N \cdot m^2/kg^2$	6.673×10^{-11}
gravity acceleration, standard	m/s^2	9.80665*
h	min	60*
	s	3,600*
hp	Btu/h	2,544.43
	kW	0.74624
hp/1,000 gal	kW/m^3	0.197
in.	cm	2.54*
$in.^3$	cm^3	16.3871
J	erg	$1^* \times 10^{7}$
	ft·lb_f	0.73756
kg	lb	2.20462
kWh	Btu	3,412.1
L	m^3	$1^* \times 10^{-3}$
lb	kg	0.45359237*
lb/ft^3	kg/m^3	16.018
	g/cm^3	0.016018
$lb_f/in.^2$	N/m^2	6.89473×10^{3}
lb mol/ft^2·h	kg mol/m^2·s	1.3562×10^{-3}
	g mol/cm^2·s	1.3562×10^{-4}
light, speed of	m/s	2.997925×10^{8}
m	ft	3.280840
	in.	39.3701
m^3	ft^3	35.3147
	gal (U.S.)	264.17
N	dyn	$1^* \times 10^{5}$
	lb_f	0.22481
N/m^2	$lb_f/in.^2$	1.4503×10^{-4}

(Continued)

To convert from	To	Multiply by†
Planck's constant	J·s	6.626196×10^{-34}
proof (U.S.)	percent alcohol by volume	0.5
ton (long)	kg	1,016
	lb	2,240*
ton (short)	lb	2,000*
t (metric)	kg	1,000*
	lb	2,204.6
yd	ft	3*
	m	0.9144*

†Values that end in an asterisk are exact, by definition.

Dimensions, Capacities, and Weights of Standard Steel Pipe†

Nominal pipe size, in.	Outside diameter, in.	Schedule no.	Wall thickness, in.	Inside diameter, in.	Cross-sectional area of metal, in.^{2}	Inside sectional area, ft^2	Circumference, ft or surface, ft^2/ft of length: Outside	Inside	Capacity at 1 ft/s velocity: U.S. gal/min	Water, lb/h	Pipe weight, lb/ft
$\frac{1}{8}$	0.405	40	0.068	0.269	0.072	0.00040	0.106	0.0705	0.179	89.5	0.24
		80	0.095	0.215	0.093	0.00025	0.106	0.0563	0.113	56.5	0.31
$\frac{1}{4}$	0.540	40	0.088	0.364	0.125	0.00072	0.141	0.095	0.323	161.5	0.42
		80	0.119	0.302	0.157	0.00050	0.141	0.079	0.224	112.0	0.54
$\frac{3}{8}$	0.675	40	0.091	0.493	0.167	0.00133	0.177	0.129	0.596	298.0	0.57
		80	0.126	0.423	0.217	0.00098	0.177	0.111	0.440	220.0	0.74
$\frac{1}{2}$	0.840	40	0.109	0.622	0.250	0.00211	0.220	0.163	0.945	472.0	0.85
		80	0.147	0.546	0.320	0.00163	0.220	0.143	0.730	365.0	1.09
$\frac{3}{4}$	1.050	40	0.113	0.824	0.333	0.00371	0.275	0.216	1.665	832.5	1.13
		80	0.154	0.742	0.433	0.00300	0.275	0.194	1.345	672.5	1.47
1	1.315	40	0.133	1.049	0.494	0.00600	0.344	0.275	2.690	1,345	1.68
		80	0.179	0.957	0.639	0.00499	0.344	0.250	2.240	1,120	2.17
$1\frac{1}{4}$	1.660	40	0.140	1.380	0.668	0.01040	0.435	0.361	4.57	2,285	2.27
		80	0.191	1.278	0.881	0.00891	0.435	0.335	3.99	1,995	3.00
$1\frac{1}{2}$	1.900	40	0.145	1.610	0.800	0.01414	0.497	0.421	6.34	3,170	2.72
		80	0.200	1.500	1.069	0.01225	0.497	0.393	5.49	2,745	3.63
2	2.375	40	0.154	2.067	1.075	0.02330	0.622	0.541	10.45	5,225	3.65
		80	0.218	1.939	1.477	0.02050	0.622	0.508	9.20	4,600	5.02
$2\frac{1}{2}$	2.875	40	0.203	2.469	1.704	0.03322	0.753	0.647	14.92	7,460	5.79
		80	0.276	2.323	2.254	0.02942	0.753	0.608	13.20	6,600	7.66
3	3.500	40	0.216	3.068	2.228	0.05130	0.916	0.803	23.00	11,500	7.58
		80	0.300	2.900	3.016	0.04587	0.916	0.759	20.55	10,275	10.25
$3\frac{1}{2}$	4.000	40	0.226	3.548	2.680	0.06870	1.047	0.929	30.80	15,400	9.11
		80	0.318	3.364	3.678	0.06170	1.047	0.881	27.70	13,850	12.51
4	4.500	40	0.237	4.026	3.17	0.08840	1.178	1.054	39.6	19,800	10.79
		80	0.337	3.826	4.41	0.07986	1.178	1.002	35.8	17,900	14.98
5	5.563	40	0.258	5.047	4.30	0.1390	1.456	1.321	62.3	31,150	14.62
		80	0.375	4.813	6.11	0.1263	1.456	1.260	57.7	28,850	20.78
6	6.625	40	0.280	6.065	5.58	0.2006	1.734	1.588	90.0	45,000	18.97
		80	0.432	5.761	8.40	0.1810	1.734	1.508	81.1	40,550	28.57
8	8.625	40	0.322	7.981	8.396	0.3474	2.258	2.089	155.7	77,850	28.55
		80	0.500	7.625	12.76	0.3171	2.258	1.996	142.3	71,150	43.39
10	10.75	40	0.365	10.020	11.91	0.5475	2.814	2.620	246.0	123,000	40.48
		80	0.594	9.562	18.95	0.4987	2.814	2.503	223.4	111,700	64.40
12	12.75	40	0.406	11.938	15.74	0.7773	3.338	3.13	349.0	174,500	53.56
		80	0.688	11.374	26.07	0.7056	3.338	2.98	316.7	158,350	88.57

†Based on ANSI B36.10-1959 by permission of ASME.

Condenser and Heat-Exchanger Tube Data†

Outside diameter, in.	Wall thickness: BWG no.	in.	Inside diameter, in.	Cross-sectional area metal, in.^{2}	Inside sectional area, ft^2	Circumference, ft or surface, ft^2/ft of length: Outside	Inside	Velocity, ft/s, for 1 U.S. gal/min	Capacity at 1 ft/s velocity: U.S. gal/min	Water, lb/h	Weight, lb/ft‡
$\frac{5}{8}$	12	0.109	0.407	0.177	0.000903	0.1636	0.1066	2.468	0.4053	202.7	0.602
	14	0.083	0.459	0.141	0.00115	0.1636	0.1202	1.938	0.5161	258.1	0.479
	16	0.065	0.495	0.114	0.00134	0.1636	0.1296	1.663	0.6014	300.7	0.388
	18	0.049	0.527	0.089	0.00151	0.1636	0.1380	1.476	0.6777	338.9	0.303
$\frac{3}{4}$	12	0.109	0.532	0.220	0.00154	0.1963	0.1393	1.447	0.6912	345.6	0.748
	14	0.083	0.584	0.174	0.00186	0.1963	0.1529	1.198	0.8348	417.4	0.592
	16	0.065	0.620	0.140	0.00210	0.1963	0.1623	1.061	0.9425	471.3	0.476
	18	0.049	0.652	0.108	0.00232	0.1963	0.1707	0.962	1.041	520.5	0.367
$\frac{7}{8}$	12	0.109	0.657	0.262	0.00235	0.2291	0.1720	0.948	1.055	527.5	0.891
	14	0.083	0.709	0.207	0.00274	0.2291	0.1856	0.813	1.230	615.0	0.704
	16	0.065	0.745	0.165	0.00303	0.2291	0.1950	0.735	1.350	680.0	0.561
	18	0.049	0.777	0.127	0.00329	0.2291	0.2034	0.678	1.477	738.5	0.432
1	10	0.134	0.732	0.364	0.00292	0.2618	0.1916	0.763	1.310	655.0	1.237
	12	0.109	0.782	0.305	0.00334	0.2618	0.2047	0.667	1.499	750.0	1.037
	14	0.083	0.834	0.239	0.00379	0.2618	0.2183	0.588	1.701	850.5	0.813
	16	0.065	0.870	0.191	0.00413	0.2618	0.2278	0.538	1.854	927.0	0.649
$1\frac{1}{4}$	10	0.134	0.982	0.470	0.00526	0.3272	0.2571	0.424	2.361	1,181	1.598
	12	0.109	1.032	0.391	0.00581	0.3272	0.2702	0.384	2.608	1,304	1.329
	14	0.083	1.084	0.304	0.00641	0.3272	0.2838	0.348	2.877	1,439	1.033
	16	0.065	1.120	0.242	0.00684	0.3272	0.2932	0.326	3.070	1,535	0.823
$1\frac{1}{2}$	10	0.134	1.232	0.575	0.00828	0.3927	0.3225	0.269	3.716	1,858	1.955
	12	0.109	1.282	0.476	0.00896	0.3927	0.3356	0.249	4.021	2,011	1.618
	14	0.083	1.334	0.370	0.00971	0.3927	0.3492	0.229	4.358	2,176	1.258
2	10	0.134	1.732	0.7855	0.0164	0.5236	0.4534	0.136	7.360	3,680	2.68
	12	0.109	1.782	0.6475	0.0173	0.5236	0.4665	0.129	7.764	3,882	2.22

†Condensed, by permission, from J. H. Perry (ed.), *Chemical Engineers' Handbook*, 5th ed., p. 11-12. Copyright © 1973, McGraw-Hill Book Company, New York.

‡For steel; for copper, multiply by 1.14; for brass, multiply by 1.06.

APPENDIX 2

Dimensionless Groups

Symbol	Name	Definition
Bi	Biot number	$\frac{hs}{k}$ for slab
		$\frac{hr_m}{k}$ for cylinder or sphere
C_D	Drag coefficient	$\frac{2F_{Dc}}{\rho u_0^2 A_p}$
Fo	Fourier number	$\frac{\alpha t}{r^2}$
Fr	Froude number	$\frac{u^2}{gL}$
f	Fanning friction factor	$\frac{\Delta p_{sc} D}{2L\rho \bar{V}^2}$
Gr	Grashof number	$\frac{L^3\rho^2\beta g\Delta T}{\mu^2}$
Gz	Graetz number	$\frac{\dot{m}c_p}{kL}$
Gz′	Graetz number for mass transfer	$\frac{\dot{m}}{\rho D_v L}$
j_H	Heat-transfer factor	$\frac{h}{c_p G}\left(\frac{c_p\mu}{k}\right)^{2/3}\left(\frac{\mu_w}{\mu}\right)^{0.14}$
j_M	Mass-transfer factor	$\frac{k\bar{M}}{G}\left(\frac{\mu}{D_v\rho}\right)^{2/3}$

(Continued)

Symbol	Name	Definition
Ma	Mach number	$\frac{u}{a}$
N_{Ae}	Aeration number	$\frac{q_g}{nD_a^3}$
N_P	Power number	$\frac{P_c}{\rho n^3 D^5}$
N_Q	Flow number	$\frac{q}{nD_a^3}$
Nu	Nusselt number	$\frac{hD}{k}$
Pe	Peclet number	$\frac{D\bar{V}}{\alpha}$ or $\frac{Du_o}{D_v}$
Pr	Prandtl number	$\frac{c_p\mu}{k}$
Re	Reynolds number	$\frac{DG}{\mu}$
N_s	Separation number	$\frac{u_t u_0}{gD_p}$
Sc	Schmidt number	$\frac{\mu}{D_v\rho}$
Sh	Sherwood number	$\frac{k_c D}{D_v}$
We	Weber number	$\frac{D\rho\bar{V}^2}{\sigma}$

(46)

Properties of Saturated Steam and Water†

Temperature T, °F	Vapor pressure p_A, $lb_f/in.^2$	Specific volume, ft³/lb: Liquid v_x	Specific volume, ft³/lb: Saturated vapor v_y	Enthalpy, Btu/lb: Liquid H_x	Enthalpy, Btu/lb: Vaporization λ	Enthalpy, Btu/lb: Saturated vapor H_y
32	0.08859	0.016022	3,305	0	1,075.4	1,075.4
35	0.09992	0.016021	2,948	3.00	1,073.7	1,076.7
40	0.12166	0.016020	2,445	8.02	1,070.9	1,078.9
45	0.14748	0.016021	2,037	13.04	1,068.1	1,081.1
50	0.17803	0.016024	1,704.2	18.06	1,065.2	1,083.3
55	0.2140	0.016029	1,431.4	23.07	1,062.4	1,085.5
60	0.2563	0.016035	1,206.9	28.08	1,059.6	1,087.7
65	0.3057	0.016042	1,021.5	33.09	1,056.8	1,089.9
70	0.3632	0.016051	867.7	38.09	1,054.0	1,092.0
75	0.4300	0.016061	739.7	43.09	1,051.1	1,094.2
80	0.5073	0.016073	632.8	48.09	1,048.3	1,096.4
85	0.5964	0.016085	543.1	53.08	1,045.5	1,098.6
90	0.6988	0.016099	467.7	58.07	1,042.7	1,100.7
95	0.8162	0.016114	404.0	63.06	1,039.8	1,102.9
100	0.9503	0.016130	350.0	68.05	1,037.0	1,105.0
110	1.2763	0.016166	265.1	78.02	1,031.4	1,109.3
120	1.6945	0.016205	203.0	88.00	1,025.5	1,113.5
130	2.225	0.016247	157.17	97.98	1,019.8	1,117.8
140	2.892	0.016293	122.88	107.96	1,014.0	1,121.9
150	3.722	0.016343	96.99	117.96	1,008.1	1,126.1
160	4.745	0.016395	77.23	127.96	1,002.2	1,130.1
170	5.996	0.016450	62.02	137.97	996.2	1,134.2
180	7.515	0.016509	50.20	147.99	990.2	1,138.2
190	9.343	0.016570	40.95	158.03	984.1	1,142.1
200	11.529	0.016634	33.63	168.07	977.9	1,145.9
210	14.125	0.016702	27.82	178.14	971.6	1,149.7
212	14.698	0.016716	26.80	180.16	970.3	1,150.5

(Continued)

Temperature T, °F	Vapor pressure p_A, $lb_f/in.^2$	Specific volume, ft³/lb: Liquid v_x	Specific volume, ft³/lb: Saturated vapor v_y	Enthalpy, Btu/lb: Liquid H_x	Enthalpy, Btu/lb: Vaporization λ	Enthalpy, Btu/lb: Saturated vapor H_y
220	17.188	0.016772	23.15	188.22	965.3	1,153.5
230	20.78	0.016845	19.386	198.32	958.8	1,157.1
240	24.97	0.016922	16.327	208.44	952.3	1,160.7
250	29.82	0.017001	13.826	218.59	945.6	1,164.2
260	35.42	0.017084	11.768	228.76	938.8	1,167.6
270	41.85	0.017170	10.066	238.95	932.0	1,170.9
280	49.18	0.017259	8.650	249.18	924.9	1,174.1
290	57.53	0.017352	7.467	259.44	917.8	1,177.2
300	66.98	0.017448	6.472	269.73	910.4	1,180.2
310	77.64	0.017548	5.632	280.06	903.0	1,183.0
320	89.60	0.017652	4.919	290.43	895.3	1,185.8
340	117.93	0.017872	3.792	311.30	879.5	1,190.8
350	134.53	0.017988	3.346	321.80	871.3	1,193.1
360	152.92	0.018108	2.961	332.35	862.9	1,195.2
370	173.23	0.018233	2.628	342.96	854.2	1,197.2
380	195.60	0.018363	2.339	353.62	845.4	1,199.0
390	220.2	0.018498	2.087	364.34	836.2	1,200.6
400	247.1	0.018638	1.8661	375.12	826.8	1,202.0
410	276.5	0.018784	1.6726	385.97	817.2	1,203.1
420	308.5	0.018936	1.5024	396.89	807.2	1,204.1
430	343.3	0.019094	1.3521	407.89	796.9	1,204.8
440	381.2	0.019260	1.2192	418.98	786.3	1,205.3
450	422.1	0.019433	1.1011	430.2	775.4	1,205.6

†Abstracted from *Steam Tables*, by Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and Joan G. Moore, John Wiley & Sons, New York, 1969, with the permission of the publisher.

Latent heat of vapn is defined as the difference in enthalpy between a fixed mass of vapor and same mass of liquid.

APPENDIX 5

Tyler Standard Screen Scale

This screen scale has as its base an opening of 0.0029 in., which is the opening in 200-mesh 0.0021-in. wire, the standard sieve, as adopted by the National Bureau of Standards.

Mesh	Clear opening, in.	Clear opening, mm	Approximate opening, in.	Wire diameter, in.
	1.050	26.67	1	0.148
†	0.883	22.43	$\frac{7}{8}$	0.135
	0.742	18.85	$\frac{3}{4}$	0.135
†	0.624	15.85	$\frac{5}{8}$	0.120
	0.525	13.33	$\frac{1}{2}$	0.105
†	0.441	11.20	$\frac{7}{16}$	0.105
	0.371	9.423	$\frac{3}{8}$	0.092
$2\frac{1}{2}$†	0.312	7.925	$\frac{5}{16}$	0.088
3	0.263	6.680	$\frac{1}{4}$	0.070
$3\frac{1}{2}$†	0.221	5.613	$\frac{7}{32}$	0.065
4	0.185	4.699	$\frac{3}{16}$	0.065
5†	0.156	3.962	$\frac{5}{32}$	0.044
6	0.131	3.327	$\frac{1}{8}$	0.036
7†	0.110	2.794	$\frac{7}{64}$	0.0328
8	0.093	2.362	$\frac{3}{32}$	0.032
9†	0.078	1.981	$\frac{5}{64}$	0.033
10	0.065	1.651	$\frac{1}{16}$	0.035
12†	0.055	1.397		0.028
14	0.046	1.168	$\frac{3}{64}$	0.025
16†	0.0390	0.991		0.0235
20	0.0328	0.833	$\frac{1}{32}$	0.0172
24†	0.0276	0.701		0.0141
28	0.0232	0.589		0.0125
32†	0.0195	0.495		0.0118
35	0.0164	0.417	$\frac{1}{64}$ <None>	0.0122
42†	0.0138	0.351		0.0100
48	0.0116	0.295		0.0092
60†	0.0097	0.246		0.0070
65	0.0082	0.208		0.0072
80†	0.0069	0.175		0.0056
100	0.0058	0.147		0.0042
115†	0.0049	0.124		0.0038
150	0.0041	0.104		0.0026
170†	0.0035	0.088		0.0024
200	0.0029	0.074		0.0021
270	0.0021	0.053		
325	0.0017	0.044		

†These screens, for closer sizing, are inserted between the sizes usually considered as the standard series. With the inclusion of these screens the ratio of diameters of openings in two successive screens is as 1 : $\sqrt[4]{2}$ instead of 1 : $\sqrt{2}$.

APPENDIX 6

Properties of Liquid Water

Temperature T, °F	Viscosity† μ, cP	Thermal conductivity‡ k, Btu/ft·h·°F	Density§ ρ, lb/ft^3	$\psi_f = \left(\frac{k^3 \rho^2 g}{\mu^2}\right)^{1/3}$
32	1.794	0.320	62.42	1,410
40	1.546	0.326	62.43	1,590
50	1.310	0.333	62.42	1,810
60	1.129	0.340	62.37	2,050
70	0.982	0.346	62.30	2,290
80	0.862	0.352	62.22	2,530
90	0.764	0.358	62.11	2,780
100	0.682	0.362	62.00	3,020
120	0.559	0.371	61.71	3,530
140	0.470	0.378	61.38	4,030
160	0.401	0.384	61.00	4,530
180	0.347	0.388	60.58	5,020
200	0.305	0.392	60.13	5,500
220	0.270	0.394	59.63	5,960
240	0.242	0.396	59.10	6,420
260	0.218	0.396	58.53	6,830
280	0.199	0.396	57.94	7,210
300	0.185	0.396	57.31	7,510

†From *International Critical Tables*, vol. 5, McGraw-Hill Book Company, New York, 1929, p. 10.

‡From E. Schmidt and W. Sellschopp, *Forsch. Geb. Ingenieurw.*, 3:277 (1932).

§Calculated from J. H. Keenan and F. G. Keyes, *Thermodynamic Properties of Steam*, John Wiley & Sons., Inc., New York, 1937.

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Viscosities of Liquids†

No.	Liquid	X	Y	No.	Liquid	X	Y
1	Acetaldehyde	15.2	4.8	32	Ethyl chloride	14.8	6.0
2	Acetic acid, 100%	12.1	14.2	33	Ethyl ether	14.5	5.3
3	Acetic anhydride	12.7	12.8	34	Ethyl formate	14.2	8.4
4	Acetone, 100%	14.5	7.2	35	Ethyl iodide	14.7	10.3
5	Ammonia, 100%	12.6	2.0	36	Ethylene glycol	6.0	23.6
6	Ammonia, 26%	10.1	13.9	37	Formic acid	10.7	15.8
7	Amyl acetate	11.8	12.5	38	Freon-12	16.8	5.6
8	Amyl alcohol	7.5	18.4	39	Glycerol, 100%	2.0	30.0
9	Aniline	8.1	18.7	40	Glycerol, 50%	6.9	19.6
10	Anisole	12.3	13.5	41	Heptane	14.1	8.4
11	Benzene	12.5	10.9	42	Hexane	14.7	7.0
12	Biphenyl	12.0	18.3	43	Hydrochloric acid, 31.5%	13.0	16.6
13	Brine, $CaCl_2$, 25%	6.6	15.9	44	Isobutyl alcohol	7.1	18.0
14	Brine, NaCl, 25%	10.2	16.6	45	Isopropyl alcohol	8.2	16.0
15	Bromine	14.2	13.2	46	Kerosene	10.2	16.9
16	Butyl acetate	12.3	11.0	47	Linseed oil, raw	7.5	27.2
17	Butyl alcohol	8.6	17.2	48	Mercury	18.4	16.4
18	Carbon dioxide	11.6	0.3	49	Methanol, 100%	12.4	10.5
19	Carbon disulfide	16.1	7.5	50	Methyl acetate	14.2	8.2
20	Carbon tetrachloride	12.7	13.1	51	Methyl chloride	15.0	3.8
21	Chlorobenzene	12.3	12.4	52	Methyl ethyl ketone	13.9	8.6
22	Chloroform	14.4	10.2	53	Napthalene	7.9	18.1
23	*m*-Cresol	2.5	20.8	54	Nitric acid, 95%	12.8	13.8
24	Cyclohexanol	2.9	24.3	55	Nitric acid, 60%	10.8	17.0
25	Dichloroethane	13.2	12.2	56	Nitrobenzene	10.6	16.2
26	Dichloromethane	14.6	8.9	57	Nitrotoluene	11.0	17.0
27	Ethyl acetate	13.7	9.1	58	Octane	13.7	10.0
28	Ethyl alcohol, 100%	10.5	13.8	59	Octyl alcohol	6.6	21.1
29	Ethyl alcohol, 95%	9.8	14.3	60	Pentane	14.9	5.2
30	Ethyl alcohol, 40%	6.5	16.6	61	Phenol	6.9	20.8
31	Ethyl benzene	13.2	11.5	62	Sodium	16.4	13.9

(*Continued*)

No.	Liquid	X	Y	No.	Liquid	X	Y
63	Sodium hydroxide, 50%	3.2	25.8	70	Toluene	13.7	10.4
64	Sulfur dioxide	15.2	7.1	71	Trichloroethylene	14.8	10.5
65	Sulfuric acid, 98%	7.0	24.8	72	Vinyl acetate	14.0	8.8
66	Sulfuric acid, 60%	10.2	21.3	73	Water	10.2	13.0
67	Tetrachloroethane	11.9	15.7	74	*o*-Xylene	13.5	12.1
68	Tetrachloroethylene	14.2	12.7	75	*m*-Xylene	13.9	10.6
69	Titanium tetrachloride	14.4	12.3	76	*p*-Xylene	13.9	10.9

Coordinates for use with figure on next page.

APPENDIX 8

Viscosities of Gases[†]

No.	Gas	X	Y	No.	Gas	X	Y
1	Acetic acid	7.7	14.3	29	Freon-113	11.3	14.0
2	Acetone	8.9	13.0	30	Helium	10.9	20.5
3	Acetylene	9.8	14.9	31	Hexane	8.6	11.8
4	Air	11.0	20.0	32	Hydrogen	11.2	12.4
5	Ammonia	8.4	16.0	33	$3H_2 + N_2$	11.2	17.2
6	Argon	10.5	22.4	34	Hydrogen bromide	8.8	20.9
7	Benzene	8.5	13.2	35	Hydrogen chloride	8.8	18.7
8	Bromine	8.9	19.2	36	Hydrogen cyanide	9.8	14.9
9	Butene	9.2	13.7	37	Hydrogen iodide	9.0	21.3
10	Butylene	8.9	13.0	38	Hydrogen sulfide	8.6	18.0
11	Carbon dioxide	9.5	18.7	39	Iodine	9.0	18.4
12	Carbon disulfide	8.0	16.0	40	Mercury	5.3	22.9
13	Carbon monoxide	11.0	20.0	41	Methane	9.9	15.5
14	Chlorine	9.0	18.4	42	Methyl alcohol	8.5	15.6
15	Chloroform	8.9	15.7	43	Nitric oxide	10.9	20.5
16	Cyanogen	9.2	15.2	44	Nitrogen	10.6	20.0
17	Cyclohexane	9.2	12.0	45	Nitrosyl chloride	8.0	17.6
18	Ethane	9.1	14.5	46	Nitrous oxide	8.8	19.0
19	Ethyl acetate	8.5	13.2	47	Oxygen	11.0	21.3
20	Ethyl alcohol	9.2	14.2	48	Pentane	7.0	12.8
21	Ethyl chloride	8.5	15.6	49	Propane	9.7	12.9
22	Ethyl ether	8.9	13.0	50	Propyl alcohol	8.4	13.4
23	Ethylene	9.5	15.1	51	Propylene	9.0	13.8
24	Fluorine	7.3	23.8	52	Sulfur dioxide	9.6	17.0
25	Freon-11	10.6	15.1	53	Toluene	8.6	12.4
26	Freon-12	11.1	16.0	54	2,3,3-Trimethylbutane	9.5	10.5
27	Freon-21	10.8	15.3	55	Water	8.0	16.0
28	Freon-22	10.1	17.0	56	Xenon	9.3	23.0

Coordinates for use with figure on next page.

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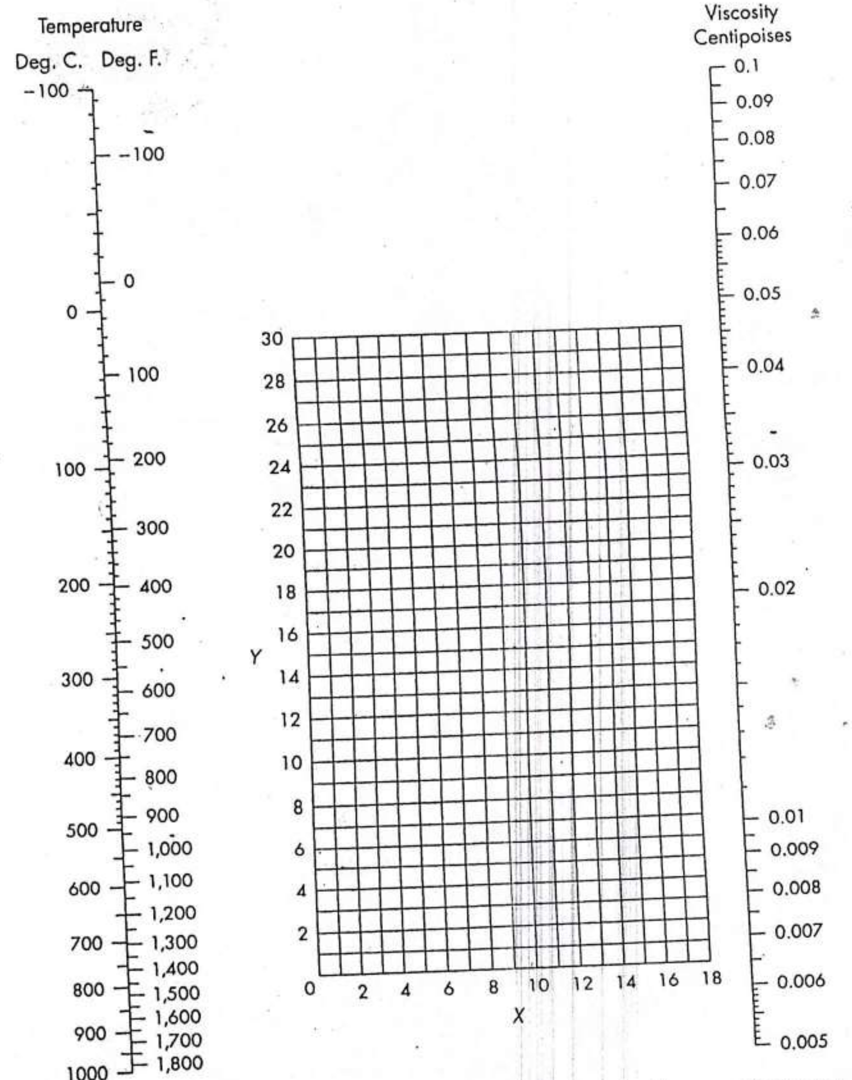


Viscosities of gases and vapors at 1 atm; for coordinates, see table on previous page.

APPENDIX 11

Thermal Conductivities of Various Solids and Insulating Materials†

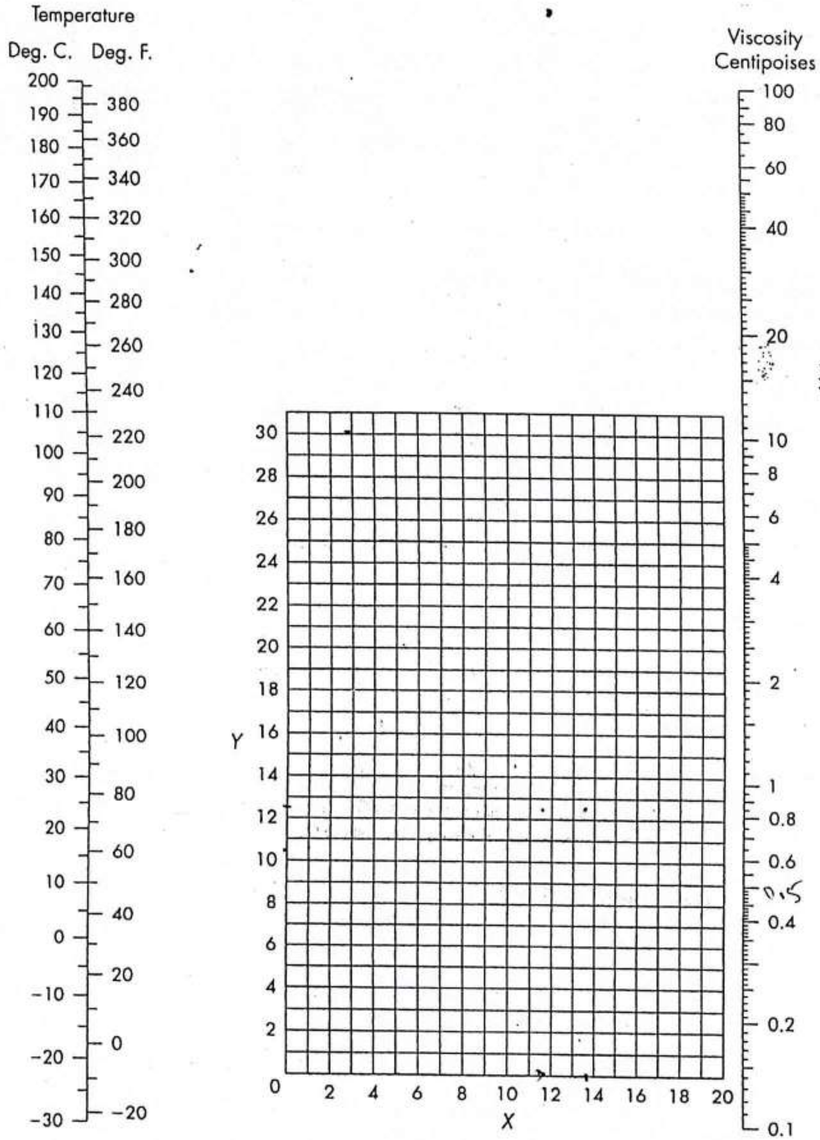
Material	Apparent density ρ, lb/ft^3	Temperature T, °C	Thermal conductivity k, Btu/h · ft^2 · (°F/ft)
Asbestos	29	−200	0.043
	36	0	0.087
	36	400	0.129
Bricks			
Alumina	—	1,315	2.7
Building brickwork	—	20	0.4
Carbon	96.7	—	3.0
Fire clay (Missouri)	—	200	0.58
	—	1,000	0.95
	—	1,400	1.02
Kaolin insulating firebrick	19	200	0.050
	19	760	0.113
Silicon carbide, recrystallized	129	600	10.7
	129	1,000	8.0
	129	1,400	6.3
Cardboard, corrugated	—	—	0.37
Concrete			
Clinker	—	—	0.20
Stone	—	—	0.54
1:4 dry	—	—	0.44
Cork, ground	9.4	30	0.025
Glass			
Borosilicate	139	30–75	0.63
Window	—	—	0.3–0.61
Granite	—	—	1.0–2.3
Ice	57.5	0	1.3
Insulating materials			
Fiberglass batts‡	6	20	0.019
	6	150	0.027
	6	200	0.035
	9	20	0.018
	9	150	0.023
Kapok	0.88	20	0.020
Polystyrene foam§	1	20	0.023
	2–5	20	0.020
Polyurethane foam§ (made with fluorocarbon gas)	1.3–3.0	—	0.014
	4–8	—	0.018
Polyurethane foam§ (made with CO_2)	1.3–3.0	—	0.018
Wall board	14.8	21	0.028
Magnesia, powdered	49.7	47	0.35
Paper	—	—	0.75
Porcelain	—	200	0.88
Rubber, soft	—	21	0.075–0.092
Snow	34.7	0	0.27
Wood (across grain)			
Oak	51.5	15	0.12
Maple	44.7	50	0.11
Pine, white	34.0	15	0.087
Wood (parallel to grain)			
Pine	34.4	21	0.20

(*Continued*)

†From J. H. Perry (ed.), *Chemical Engineers' Handbook*, 6th ed., McGraw-Hill, New York, p. 3-260, except as noted.

‡From *Heat Transfer and Fluid Data Book*, vol. 1, Genium Publishing Corp., Schenectady, NY, 1984, sect. 515.24, p. 1.

§From *Modern Plastics Encyclopedia*, vol. 65, no. 11, McGraw-Hill Book Co., New York, 1988, p. 657.



Viscosities of liquids at 1 atm. For coordinates, see table on previous page.

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Thermal Conductivities of Metals†

Metal	Thermal conductivity k‡ 32°F	64°F	212°F
Aluminum	117		119
Antimony	10.6		9.7
Brass (70 copper, 30 zinc)	56		60
Cadmium		53.7	52.2
Copper (pure)	224		218
Gold		169.0	170.0
Iron (cast)	32		30
Iron (wrought)		34.9	34.6
Lead	20		19
Magnesium	92	92	92
Mercury (liquid)	4.8		
Nickel	36		34
Platinum		40.2	41.9
Silver	242		238
Sodium (liquid)			49
Steel (mild)			26
Steel (1% carbon)		26.2	25.9
Steel (stainless, type 304)			9.4
Steel (stainless, type 316)			9.4
Steel (stainless, type 347)			9.3
Tantalum		32	
Tin	36		34
Zinc	65		64

†Based on W. H. McAdams, *Heat Transmission*, 3rd ed., McGraw-Hill Book Company, New York, 1954, pp. 445–447.

‡k = Btu/ft·h·°F. To convert to W/m·°C, multiply by 1.73073.

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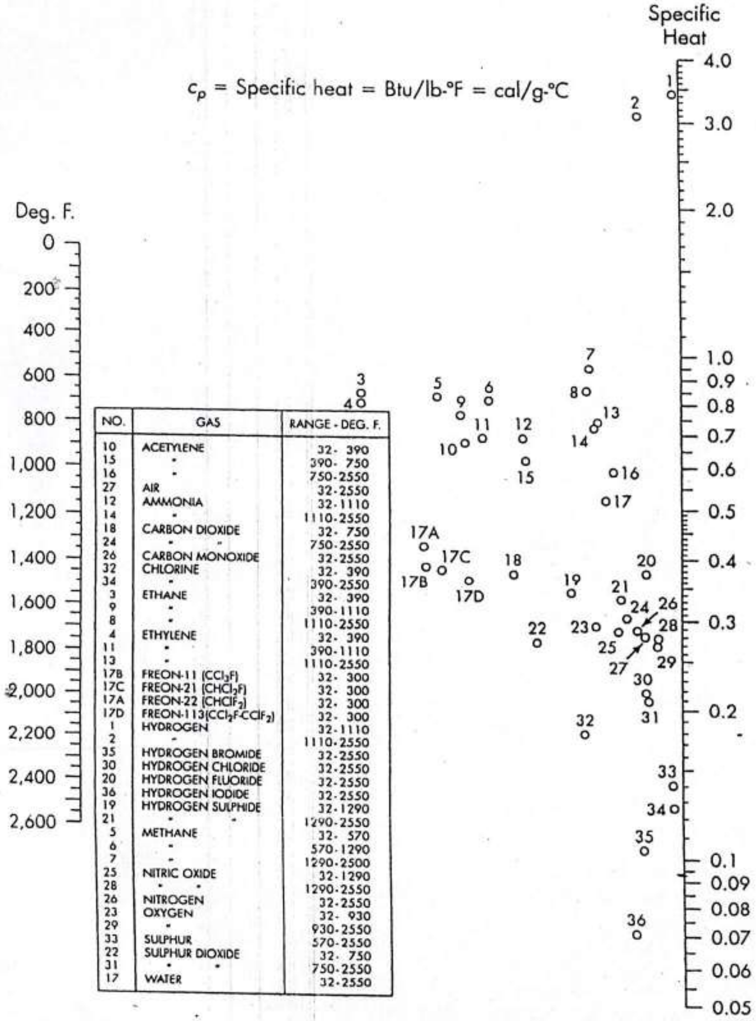
APPENDIX 14

Specific Heats of Gases†



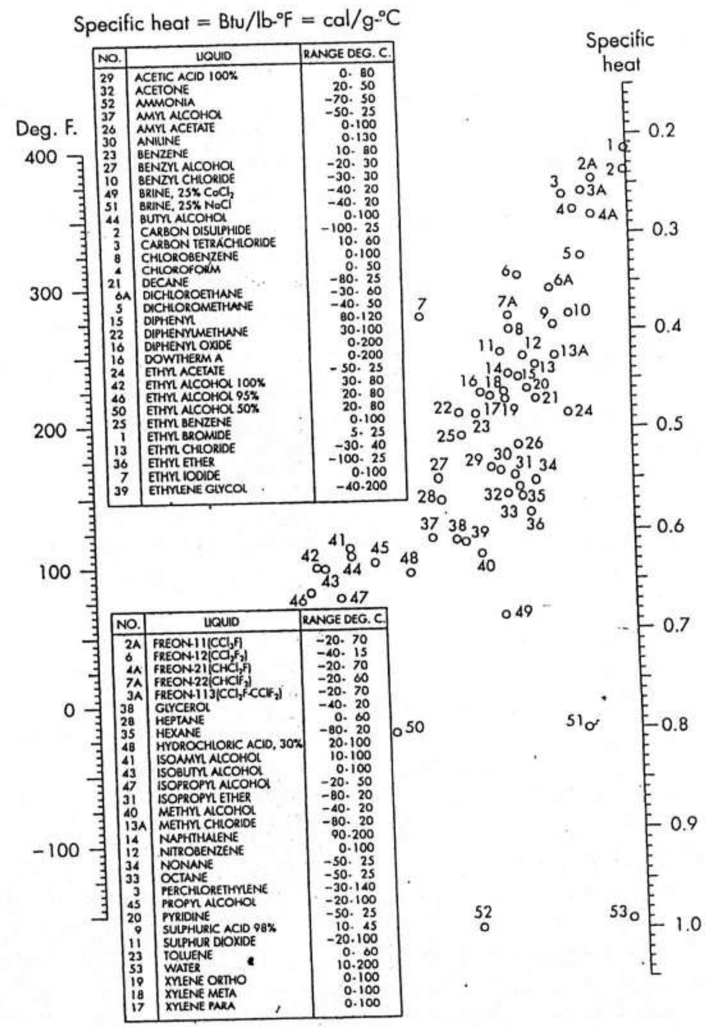
NO.	GAS	RANGE - DEG. F.
10	ACETYLENE	32- 390
15	"	390- 750
16	"	750-2550
27	AIR	32-2550
12	AMMONIA	32-1110
14	"	1110-2550
18	CARBON DIOXIDE	32- 750
24	" "	750-2550
26	CARBON MONOXIDE	32-2550
32	CHLORINE	32- 390
34	"	390-2550
3	ETHANE	32- 390
9	"	390-1110
8	"	1110-2550
4	ETHYLENE	32- 390
11	"	390-1110
13	"	1110-2550
17B	FREON-11 (CCl_3F)	32- 300
17C	FREON-21 ($CHCl_2F$)	32- 300
17A	FREON-22 ($CHClF_2$)	32- 300
17D	FREON-113 (CCl_2F-$CClF_2$)	32- 300
1	HYDROGEN	32-1110
2	"	1110-2550
35	HYDROGEN BROMIDE	32-2550
30	HYDROGEN CHLORIDE	32-2550
20	HYDROGEN FLUORIDE	32-2550
36	HYDROGEN IODIDE	32-2550
19	HYDROGEN SULPHIDE	32-1290
21	" "	1290-2550
5	METHANE	32- 570
6	"	570-1290
7	"	1290-2500
25	NITRIC OXIDE	32-1290
28	" "	1290-2550
26	NITROGEN	32-2550
23	OXYGEN	32- 930
29	"	930-2550
33	SULPHUR	570-2550
22	SULPHUR DIOXIDE	32- 750
31	" "	750-2550
17	WATER	32-2550

True specific heats c_p of gases and vapors at 1 atm pressure.

†*Courtesy of T. H. Chilton.*

APPENDIX 15

Specific Heats of Liquids†



NO.	LIQUID	RANGE DEG. C.
29	ACETIC ACID 100%	0- 80
32	ACETONE	20- 50
52	AMMONIA	−70- 50
37	AMYL ALCOHOL	−50- 25
26	AMYL ACETATE	0-100
30	ANILINE	0-130
23	BENZENE	10- 80
27	BENZYL ALCOHOL	−20- 30
10	BENZYL CHLORIDE	−30- 30
49	BRINE, 25% $CaCl_2$	−40- 20
51	BRINE, 25% NaCl	−40- 20
44	BUTYL ALCOHOL	0-100
2	CARBON DISULPHIDE	−100- 25
3	CARBON TETRACHLORIDE	10- 60
8	CHLOROBENZENE	0-100
4	CHLOROFORM	0- 50
21	DECANE	−80- 25
6A	DICHLOROETHANE	−30- 60
5	DICHLOROMETHANE	−40- 50
15	DIPHENYL	80-120
22	DIPHENYLMETHANE	30-100
16	DIPHENYL OXIDE	0-200
16	DOWTHERM A	0-200
24	ETHYL ACETATE	−50- 25
42	ETHYL ALCOHOL 100%	30- 80
46	ETHYL ALCOHOL 95%	20- 80
50	ETHYL ALCOHOL 50%	20- 80
25	ETHYL BENZENE	0-100
1	ETHYL BROMIDE	5- 25
13	ETHYL CHLORIDE	−30- 40
36	ETHYL ETHER	−100- 25
7	ETHYL IODIDE	0-100
39	ETHYLENE GLYCOL	−40-200

NO.	LIQUID	RANGE DEG. C.
2A	FREON-11 (CCl_3F)	−20- 70
6	FREON-12 (CCl_2F_2)	−40- 15
4A	FREON-21 ($CHCl_2F$)	−20- 70
7A	FREON-22 ($CHClF_2$)	−20- 60
3A	FREON-113 (CCl_2F-$CClF_2$)	−20- 70
38	GLYCEROL	−40- 20
28	HEPTANE	0- 60
35	HEXANE	−80- 20
48	HYDROCHLORIC ACID, 30%	20-100
41	ISOAMYL ALCOHOL	10-100
43	ISOBUTYL ALCOHOL	0-100
47	ISOPROPYL ALCOHOL	−20- 50
31	ISOPROPYL ETHER	−80- 20
40	METHYL ALCOHOL	−40- 20
13A	METHYL CHLORIDE	−80- 20
14	NAPHTHALENE	90-200
12	NITROBENZENE	0-100
34	NONANE	−50- 25
33	OCTANE	−50- 25
3	PERCHLORETHYLENE	−30-140
45	PROPYL ALCOHOL	−20-100
20	PYRIDINE	−50- 25
9	SULPHURIC ACID 98%	10- 45
11	SULPHUR DIOXIDE	−20-100
23	TOLUENE	0- 60
53	WATER	10-200
19	XYLENE ORTHO	0-100
18	XYLENE META	0-100
17	XYLENE PARA	0-100

†*Courtesy of T. H. Chilton.*

APPENDIX 12

Thermal Conductivities of Gases and Vapors†

Substance	Thermal conductivity k‡ 32°F	212°F
Acetone	0.0057	0.0099
Acetylene	0.0108	0.0172
Air	0.0140	0.0184
Ammonia	0.0126	0.0192
Benzene		0.0103
Carbon dioxide	0.0084	0.0128
Carbon monoxide	0.0134	0.0176
Carbon tetrachloride		0.0052
Chlorine	0.0043	
Ethane	0.0106	0.0175
Ethyl alcohol		0.0124
Ethyl ether	0.0077	0.0131
Ethylene	0.0101	0.0161
Helium	0.0818	0.0988
Hydrogen	0.0966	0.1240
Methane	0.0176	0.0255
Methyl alcohol	0.0083	0.0128
Nitrogen	0.0139	0.0181
Nitrous oxide	0.0088	0.0138
Oxygen	0.0142	0.0188
Propane	0.0087	0.0151
Sulfur dioxide	0.0050	0.0069
Water vapor (at 1 atm abs pressure)		0.0136

†Based on W. H. McAdams, *Heat Transmission*, 3rd ed., McGraw-Hill Book Company, New York, 1954, pp. 457–458.

‡k = Btu/ft·h·°F. To convert to W/m·°C, multiply by 1.73073.

APPENDIX 13

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Thermal Conductivities of Liquids Other Than Water†

Liquid	Temperature, °F	k‡
Acetic acid	68	0.099
Acetone	86	0.102
Ammonia (anhydrous)	5–86	0.29
Aniline	32–68	0.100
Benzene	86	0.092
n-Butyl alcohol	86	0.097
Carbon bisulfide	86	0.093
Carbon tetrachloride	32	0.107
Chlorobenzene	50	0.083
Ethyl acetate	68	0.101
Ethyl alcohol (absolute)	68	0.105
Ethyl ether	86	0.080
Ethylene glycol	32	0.153
Gasoline	86	0.078
Glycerine	68	0.164
n-Heptane	86	0.081
Kerosene	68	0.086
Methyl alcohol	68	0.124
Nitrobenzene	86	0.095
n-Octane	86	0.083
Sulfur dioxide	5	0.128
Sulfuric acid (90%)	86	0.21
Toluene	86	0.086
Trichloroethylene	122	0.080
o-Xylene	68	0.090

†Based on W. H. McAdams, *Heat Transmission*, 3rd ed., McGraw-Hill Book Company, New York, 1954, pp. 455–456.

‡k = Btu/ft·h·°F. To convert to W/m·°C, multiply by 1.73073.

Diffusivities and Schmidt Numbers for Gases in Air at 0°C and 1 atm[†]

Gas	Volumetric diffusivity D_v, ft^2/h[¶]	$Sc = \frac{\mu}{\rho D_v}$[‡]
Acetic acid	0.413	1.24
Acetone	0.32[§]	1.60
Ammonia	0.836	0.61
Benzene	0.299	1.71
n-Butyl alcohol	0.273	1.88
Carbon dioxide	0.535	0.96
Carbon tetrachloride	0.26[§]	1.97
Chlorine	0.43[§]	1.19
Chlorobenzene	0.24[§]	2.13
Ethane	0.49[§]	1.04
Ethyl acetate	0.278	1.84
Ethyl alcohol	0.396	1.30
Ethyl ether	0.302	1.70
Hydrogen	2.37	0.22
Methane	0.74[§]	0.69
Methyl alcohol	0.515	1.00
Naphthalene	0.199	2.57
Nitrogen	0.70[§]	0.73
n-Octane	0.196	2.62
Oxygen	0.690	0.74
Phosgene	0.31[§]	1.65
Propane	0.36[§]	1.42
Sulfur dioxide	0.44[§]	1.16
Toluene	0.275	1.86
Water vapor	0.853	0.60

[†]By permission, from T. K. Sherwood and R. L. Pigford, *Absorption and Extraction*, 2nd ed., p. 20. Copyright 1952, McGraw-Hill Book Company, New York.

[‡]The value of μ/ρ is that for pure air, 0.512 ft^2/h.

[§]Calculated by Eq. (17.28).

[¶]To convert ft^2/h to cm^2/s, multiply by 0.2581.

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Collision Integral and Lennard–Jones Force Constants[†]

Collision integral Ω_D

$\frac{kT}{\varepsilon_{12}}$	Ω_D	$\frac{kT}{\varepsilon_{12}}$	Ω_D	$\frac{kT}{\varepsilon_{12}}$	Ω_D
0.30	2.662	1.65	1.153	4.0	0.8836
0.35	2.476	1.70	1.140	4.1	0.8788
0.40	2.318	1.75	1.128	4.2	0.8740
0.45	2.184	1.80	1.116	4.3	0.8694
0.50	2.066	1.85	1.105	4.4	0.8652
0.55	1.966	1.90	1.094	4.5	0.8610
0.60	1.877	1.95	1.084	4.6	0.8568
0.65	1.798	2.00	1.075	4.7	0.8530
0.70	1.729	2.1	1.057	4.8	0.8492
0.75	1.667	2.2	1.041	4.9	0.8456
0.80	1.612	2.3	1.026	5.0	0.8422
0.85	1.562	2.4	1.012	6	0.8124
0.90	1.517	2.5	0.9996	7	0.7896
0.95	1.476	2.6	0.9878	8	0.7712
1.00	1.439	2.7	0.9770	9	0.7556
1.05	1.406	2.8	0.9672	10	0.7424
1.10	1.375	2.9	0.9576	20	0.6640
1.15	1.346	3.0	0.9490	30	0.6232
1.20	1.320	3.1	0.9406	40	0.5960
1.25	1.296	3.2	0.9328	50	0.5756
1.30	1.273	3.3	0.9256	60	0.5596
1.35	1.253	3.4	0.9186	70	0.5464
1.40	1.233	3.5	0.9120	80	0.5352
1.45	1.215	3.6	0.9058	90	0.5256
1.50	1.198	3.7	0.8998	100	0.5130
1.55	1.182	3.8	0.8942	200	0.4644
1.60	1.167	3.9	0.8888	400	0.4170

APPENDIX 16

Prandtl Numbers for Gases at 1 atm and 100°C†

Gas	$\Pr = \frac{c_p \mu}{k}$
Air	0.69
Ammonia	0.86
Argon	0.66
Carbon dioxide	0.75
Carbon monoxide	0.72
Helium	0.71
Hydrogen	0.69
Methane	0.75
Nitric oxide, nitrous oxide	0.72
Nitrogen	0.70
Oxygen	0.70
Water vapor	1.06

†Based on W. H. McAdams, *Heat Transmission*, 3rd ed., McGraw-Hill Book Company, New York, 1954, p. 471.

APPENDIX 17

Prandtl Numbers for Liquids†

	$\Pr = \frac{c_p \mu}{k}$	
Liquid	**61°F**	**212°F**
Acetic acid	14.5	10.5
Acetone	4.5	2.4
Aniline	69	9.3
Benzene	7.3	3.8
n-Butyl alcohol	43	11.5
Carbon tetrachloride	7.5	4.2
Chlorobenzene	9.3	7.0
Ethyl acetate	6.8	5.6
Ethyl alcohol	15.5	10.1
Ethyl ether	4.0	2.3
Ethylene glycol	350	125
n-Heptane	6.0	4.2
Methyl alcohol	7.2	3.4
Nitrobenzene	19.5	6.5
n-Octane	5.0	3.6
Sulfuric acid (98%)	149	15.0
Toluene	6.5	3.8
Water	7.7	1.5

†Based on W. H. McAdams, *Heat Transmission*, 3rd ed., McGraw-Hill Book Company, New York, 1954, p. 470.

Lennard–Jones force constants

(55)

Compound	ε/k (K)	σ (Å)
Acetone	560.2	4.600
Acetylene	231.8	4.033
Air	78.6	3.711
Ammonia	558.3	2.900
Argon	93.3	3.542
Benzene	412.3	5.349
Bromine	507.9	4.296
n-butane	310	5.339
i-butane	313	5.341
Carbon dioxide	195.2	3.941
Carbon disulfide	467	4.483
Carbon monoxide	91.7	3.690
Carbon tetrachloride	322.7	5.947
Carbonyl sulfide	336	4.130
Chlorine	316	4.217
Chloroform	340.2	5.389
Cyanogen	348.6	4.361
Cyclohexane	297.1	6.182
Cyclopropane	248.9	4.807
Ethane	215.7	4.443
Ethanol	362.6	4.530
Ethylene	224.7	4.163
Fluorine	112.6	3.357
Helium	10.22	2.551
n-Hexane	339.3	5.949
Hydrogen	59.7	2.827
Hydrogen cyanide	569.1	3.630
Hydrogen chloride	344.7	3.339
Hydrogen iodide	288.7	4.211
Hydrogen sulfide	301.1	3.623
Iodine	474.2	5.160
Krypton	178.9	3.655
Methane	148.6	3.758
Methanol	481.8	3.626
Methylene chloride	356.3	4.898
Methyl chloride	350	4.182
Mercury	750	2.969
Neon	32.8	2.820
Nitric oxide	116.7	3.492
Nitrogen	71.4	3.798
Nitrous oxide	232.4	3.828
Oxygen	106.7	3.467
n-Pentane	341.1	5.784
Propane	237.1	5.118
n-Propyl alcohol	576.7	4.549
Propylene	298.9	4.678
Sulfur dioxide	335.4	4.112
Water	809.1	2.641

[1]From J. O. Hirschfelder, C. F. Curtiss, and R. B. Bird, *Molecular Theory of Gases and Liquids*, New York: Wiley, 1954.

(56)

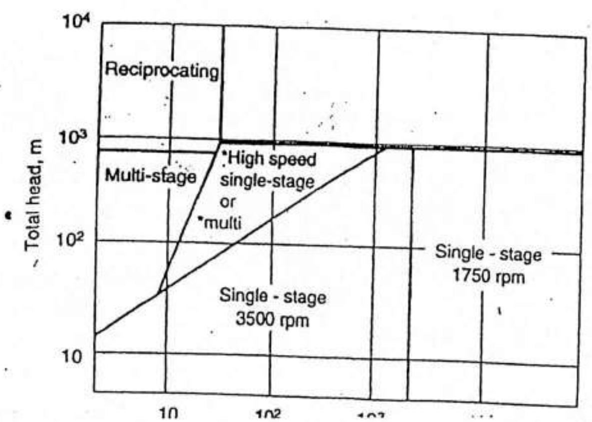
where ΔP_f = pressure drop, N/m²;

Table 13 Pressure loss in pipe fittings and valves (for turbulent flow)

Fitting or valve	K, number of velocity heads	number of equivalent pipe diameters
45° standard elbow	0.35	15
45° long radius elbow	0.2	10
90° standard radius elbow	0.6–0.8	30–40
90° standard long elbow	0.45	23
90° square elbow	1.5	75
Tee-entry from leg	1.2	60
Tee-entry into leg	1.8	90
Union and coupling	0.04	2
Sharp reduction (tank outlet)	0.5	25
Sudden expansion (tank inlet)	1.0	50
Gate valve		
fully open	0.15	7.5
1/4 open	16	800
1/2 open	4	200
3/4 open	1	40
Globe valve, bevel seat-		
fully open	6	300
1/2 open	8.5	450
Plug valve - open	0.4	18

Table 14 Pipe roughness

Material	Absolute roughness, mm
Drawn tubing	0.0015
Commercial steel pipe	0.046
Cast iron pipe	0.26
Concrete pipe	0.3 to 3.0



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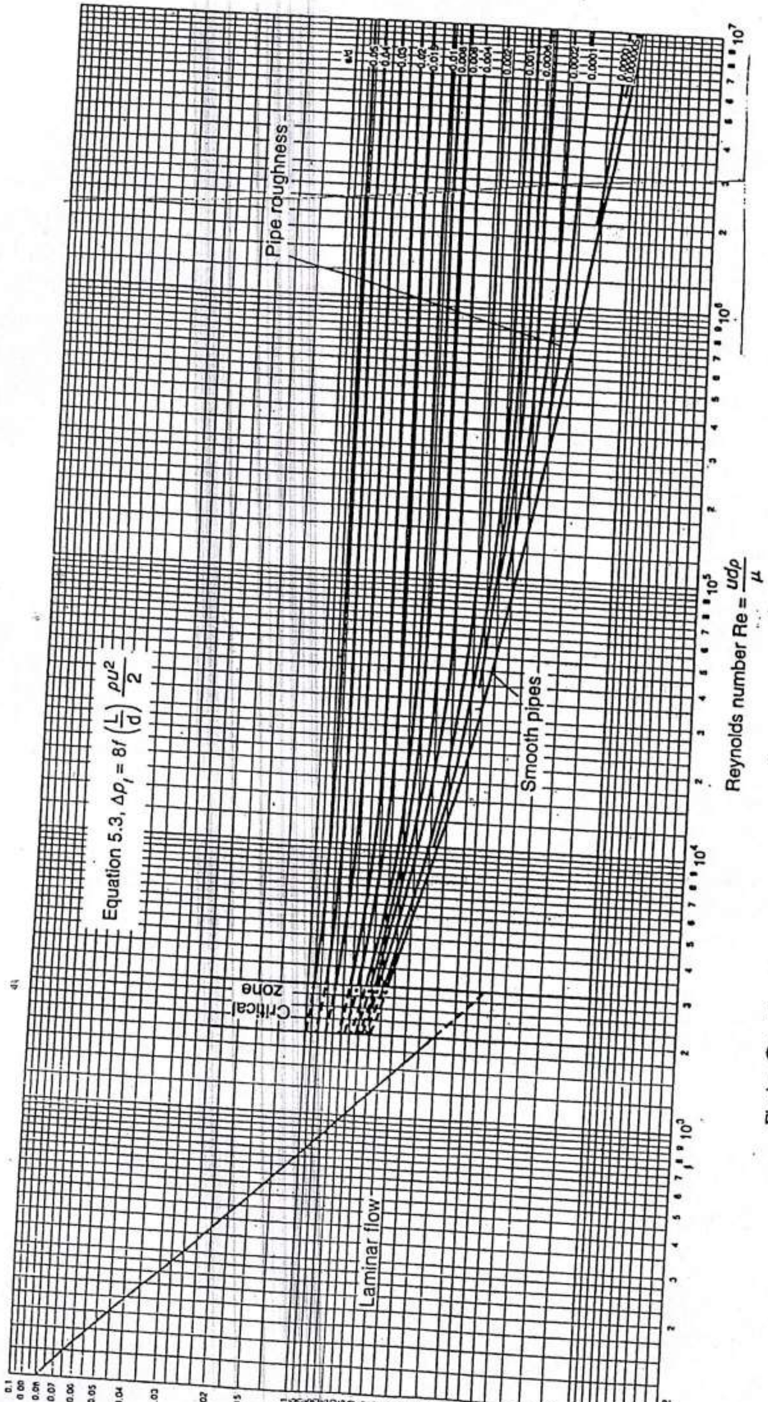

Figure 31 Pipe friction versus Reynolds number and relative roughness

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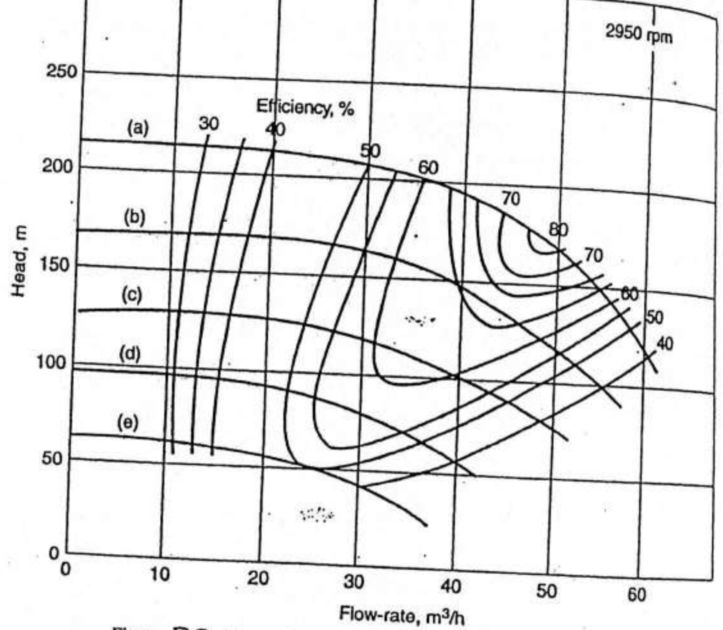


Figure 32 Pump characteristic for a range of impeller sizes (a) 250 mm (b) 225 mm (c) 200 (d) 175 mm (e) 150 mm.

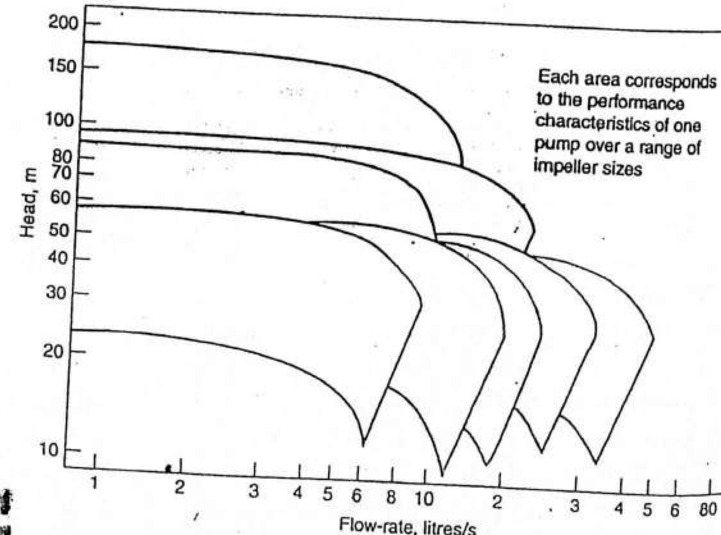


Figure 33 Family of pump curves

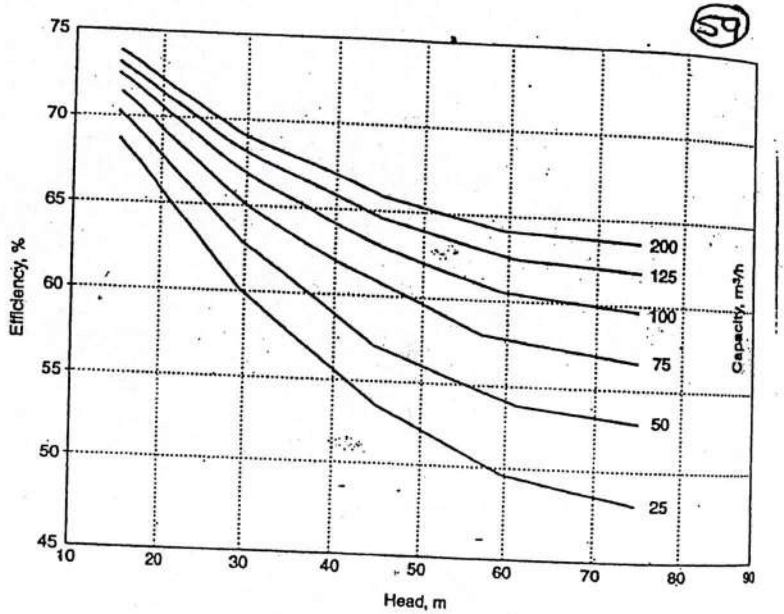


Figure 34 Centrifugal pump efficiency

MATERIALS OF CONSTRUCTION

Table 15 Mechanical properties of common metals and alloys (typical values at room temperature)

	Tensile strength (N/mm^2)	0.1 per cent proof stress (N/mm^2)	Modulus of elasticity (kN/mm^2)	Hardness Brinell	Specific gravity
Mild steel	430	220	210	100–200	7.9
Low alloy steel	420–660	230–460	210	130–200	7.9
Cast iron	140–170	—	140	150–250	7.2
Stainless steel (18Cr, 8Ni)	>540	200	210	160	8.0
Nickel (>99 per cent Ni)	500	130	210	80–150	8.9
Monel	650	170	170	120–250	8.8
Copper (deoxidised)	200	60	110	30–100	8.9
Brass (Admiralty)	400–600	130	115	100–200	8.6
Aluminium (>99 per cent)	80–150	—	70	30	2.7
Dural	400	150	70	100	2.7
Lead	30	—	15	5	11.3
Titanium	500	350	110	150	4.5

Table 16. PIPE SIZE SELECTION

Typical pipe velocities and allowable pressure drops, which can be used to estimate pipe sizes, are given below:

	Velocity m/s	ΔP kPa/m
Liquids, pumped (not viscous)	1–3	0.5
Liquids, gravity flow	—	0.05
Gases and vapours	15–30	0.02 per cent of line pressure
High-pressure steam, >8 bar	30–60	—

Rase (1953) gives expressions for design velocities in terms of the pipe diameter. His expressions, converted to SI units, are:

Pump discharge	$0.06d + 0.4$ m/s
Pump suction	$0.02d + 0.1$ m/s
Steam or vapour	$0.2d$ m/s

where d is the internal diameter in mm.

Simpson (1968) gives values for the optimum velocity in terms of the fluid density. His values, converted to SI units and rounded, are:

Fluid density kg/m^3	Velocity m/s
1600	2.4
800	3.0
160	4.9
16	9.4
0.16	18.0
0.016	34.0

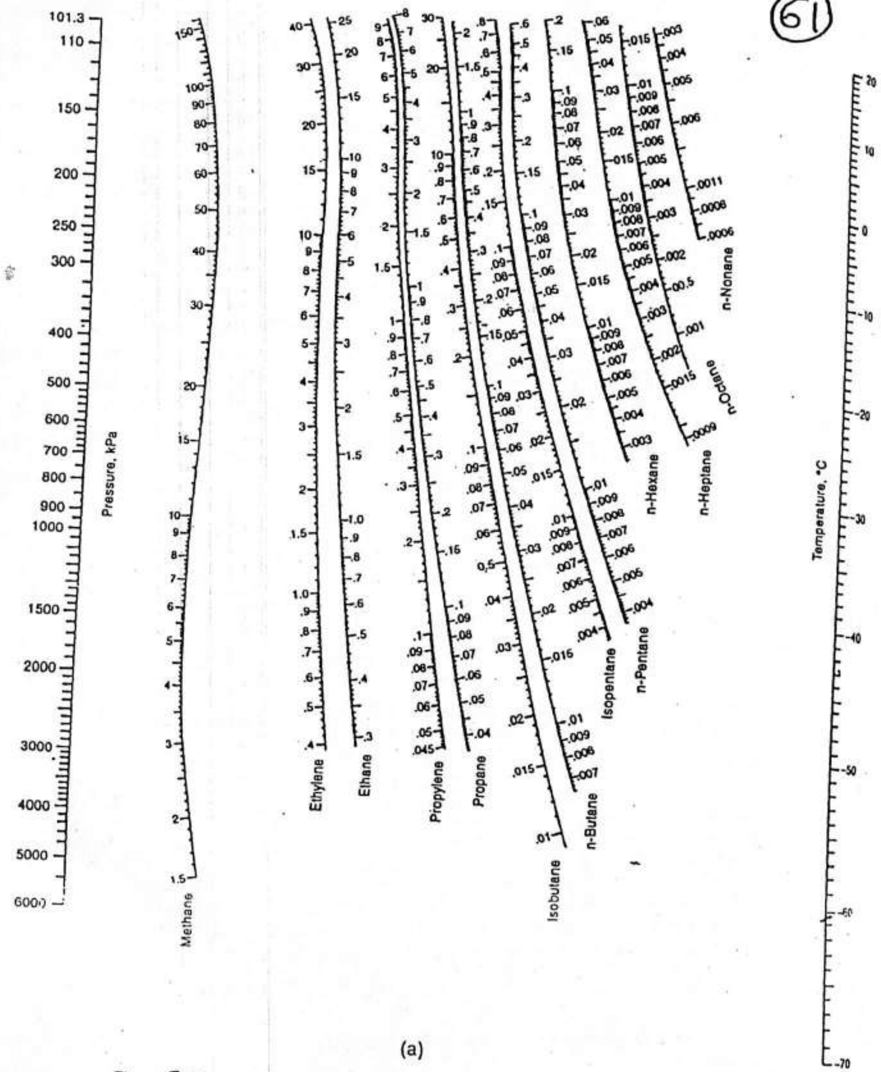


Figure 35 (*a*) De Priester chart — *K*-values for hydrocarbons, low temperature

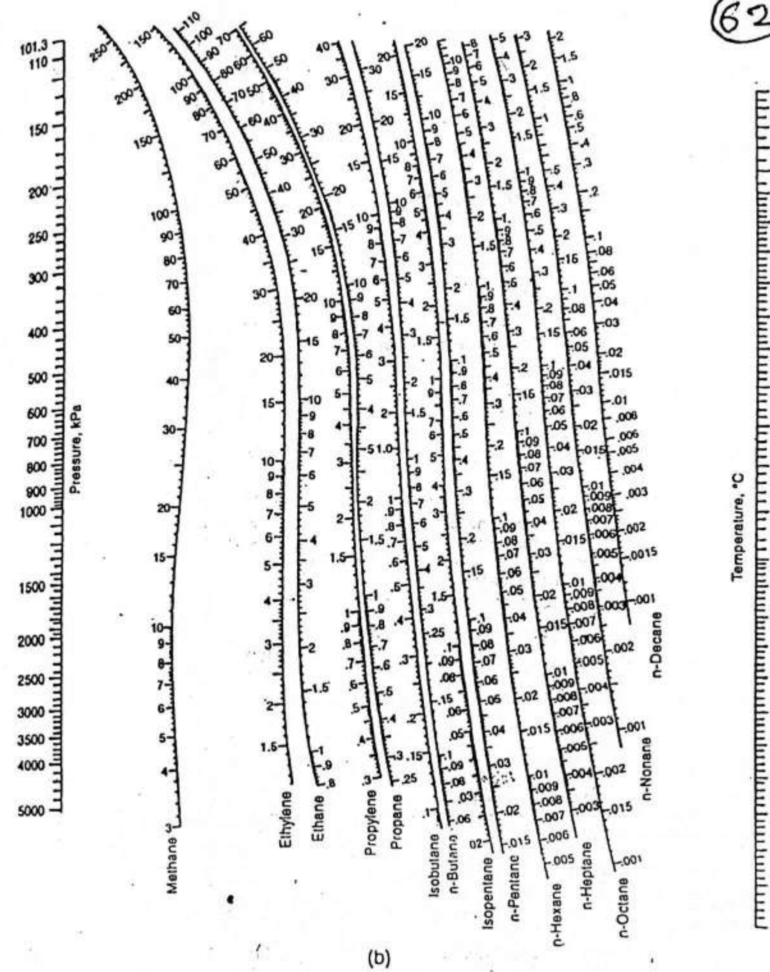


Figure 35 (*b*) De Priester chart — *K*-values for hydrocarbons, high temperature

Table 17 Typical overall coefficients

Hot fluid	Cold fluid	U (W/m^2°C)
Shell and tube exchangers		
Heat exchangers		
Water	Water	800–1500
Organic solvents	Organic solvents	100–300
Light oils	Light oils	100–400
Heavy oils	Heavy oils	50–300
Gases	Gases	10–50
Coolers		
Organic solvents	Water	250–750
Light oils	Water	350–900
Heavy oils	Water	60–300
Gases	Water	20–300
Organic solvents	Brine	150–500
Water	Brine	600–1200
Gases	Brine	15–250
Heaters		
Steam	Water	1500–4000
Steam	Organic solvents	500–1000
Steam	Light oils	300–900
Steam	Heavy oils	60–450
Steam	Gases	30–300
Dowtherm	Heavy oils	50–300
Dowtherm	Gases	20–200
Flue gases	Steam	30–100
Flue	Hydrocarbon vapours	30–100
Condensers		
Aqueous vapours	Water	1000–1500
Organic vapours	Water	700–1000
Organics (some non-condensables)	Water	500–700
Vacuum condensers	Water	200–500
Vaporisers		
Steam	Aqueous solutions	1000–1500
Steam	Light organics	900–1200
Steam	Heavy organics	600–900

Air-cooled exchangers

Process fluid	U (W/m^2°C)
Water	300–450
Light organics	300–700
Heavy organics	50–150
Gases, 5–10 bar	50–100
10–30 bar	100–300
Condensing hydrocarbons	300–600

Immersed coils

Coil	Pool	U (W/m^2°C)
Natural circulation		
Steam	Dilute aqueous solutions	500–1000
Steam	Light oils	200–300
Steam	Heavy oils	70–150
Water	Aqueous solutions	200–500
Water	Light oils	100–150

(*continued overleaf*)

Table 17 (*continued*)

Immersed coils

Coil	Pool	U (W/m^2°C)
Agitated		
Steam	Dilute aqueous solutions	800–1500
Steam	Light oils	300–500
Steam	Heavy oils	200–400
Water	Aqueous solutions	400–700
Water	Light oils	200–300

Jacketed vessels

Jacket	Vessel	U (W/m^2°C)
Steam	Dilute aqueous solutions	500–700
Steam	Light organics	250–500
Water	Dilute aqueous solutions	200–500
Water	Light organics	200–300

Gasketed-plate exchangers

Hot fluid	Cold fluid	U (W/m^2°C)
Light organic	Light organic	2500–5000
Light organic	Viscous organic	250–500
Viscous organic	Viscous organic	100–200
Light organic	Process water	2500–3500
Viscous organic	Process water	250–500
Light organic	Cooling water	2000–4500
Viscous organic	Cooling water	250–450
Condensing steam	Light organic	2500–3500
Condensing steam	Viscous organic	250–500
Process water	Process water	5000–7500
Process water	Cooling water	5000–7000
Dilute aqueous solutions	Cooling water	5000–7000
Condensing steam	Process water	3500–4500

TABLE 18 FLOW AREAS AND EQUIVALENT DIAMETERS IN DOUBLE PIPE EXCHANGERS

Exchanger, IPS	Flow area, in.^{2}		Annulus, in.	
	Annulus	Pipe	d_e	d_e'
2 × 1¼	1.19	1.50	0.915	0.40
2½ × 1¼	2.63	1.50	2.02	0.81
3 × 2	2.93	3.35	1.57	0.69
4 × 3	3.14	7.38	1.14	0.53

Table 19 Standard dimensions for steel tubes

Outside diameter (mm)	Wall thickness (mm)				
16	1.2	1.6	2.0	—	—
20	—	1.6	2.0	2.6	—
25	—	1.6	2.0	2.6	3.2
30	—	1.6	2.0	[illegible]	[illegible]

(65)

Gas	$\frac{c\mu}{k}$
Air	0.74
Ammonia	0.78
Carbon dioxide	0.80
Carbon monoxide	0.74
Ethylene	0.83
Hydrogen	0.74
Hydrogen sulfide	0.77
Methane	0.79
Nitrogen	0.74
Oxygen	0.74
Steam	0.78
Sulfur dioxide	0.80

Table 21 Fouling factors (coefficients), typical values

Fluid	Coefficient (W/m^2°C)	Factor (resistance) (m^2°C/W)
River water	3000–12,000	0.0003–0.0001
Sea water	1000–3000	0.001–0.0003
Cooling water (towers)	3000–6000	0.0003–0.00017
Towns water (soft)	3000–5000	0.0003–0.0002
Towns water (hard)	1000–2000	0.001–0.0005
Steam condensate	1500–5000	0.00067–0.0002
Steam (oil free)	4000–10,000	0.0025–0.0001
Steam (oil traces)	2000–5000	0.0005–0.0002
Refrigerated brine	3000–5000	0.0003–0.0002
Air and industrial gases	5000–10,000	0.0002–0.0001
Flue gases	2000–5000	0.0005–0.0002
Organic vapours	5000	0.0002
Organic liquids	5000	0.0002
Light hydrocarbons	5000	0.0002
Heavy hydrocarbons	2000	0.0005
Boiling organics	2500	0.0004
Condensing organics	5000	0.0002
Heat transfer fluids	5000	0.0002
Aqueous salt solutions	3000–5000	0.0003–0.0002

TABLE 22 TUBE COUNT ENTRY ALLOWANCES

Shell ID, in.	*Nozzle, in.*
Less than 12	2
12–17¼	3
19¼–21¼	4
23¼–29	6
31–37	8
Over 39	10

(66)

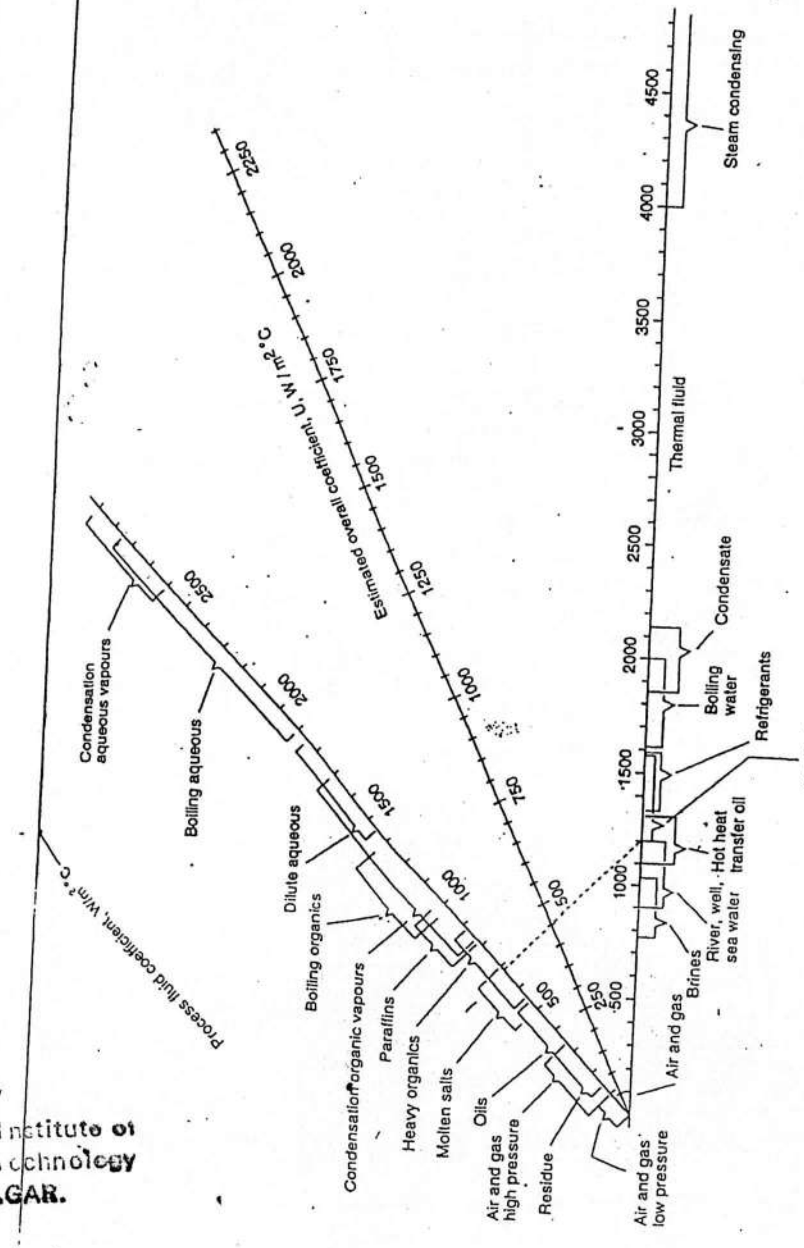


Figure 36 Overall coefficients (join process side duty to service side and read U from centre scale)

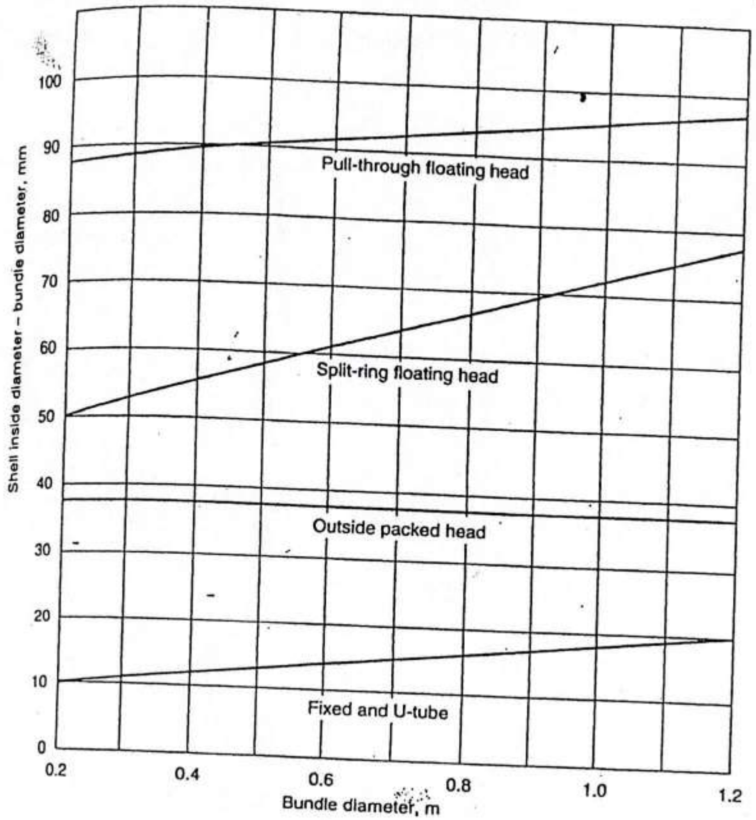


Figure 37 Shell-bundle clearance

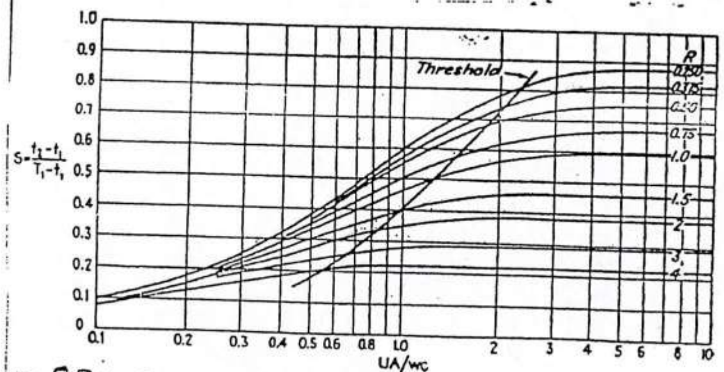


FIG. 38 Ten Broeck chart for determining t_2 when T_1 and t_1 are known in a 1-2 exchanger. (*Industrial & Engineering Chemistry.*)

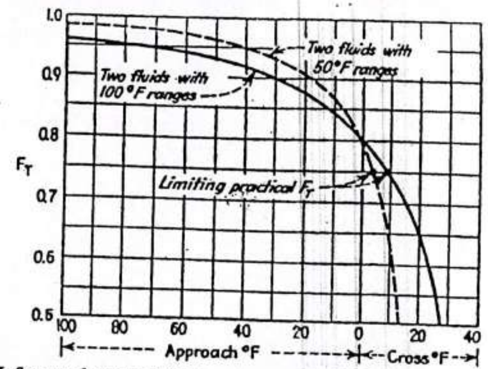


FIG. 39 Influence of approach temperature on F_T with fluids having equal ranges in a 1-2 exchanger.

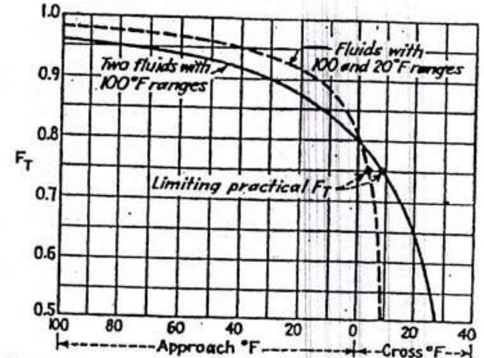


FIG. 40 Influence of approach temperature on F_T with fluids having unequal ranges in a 1-2 exchanger.

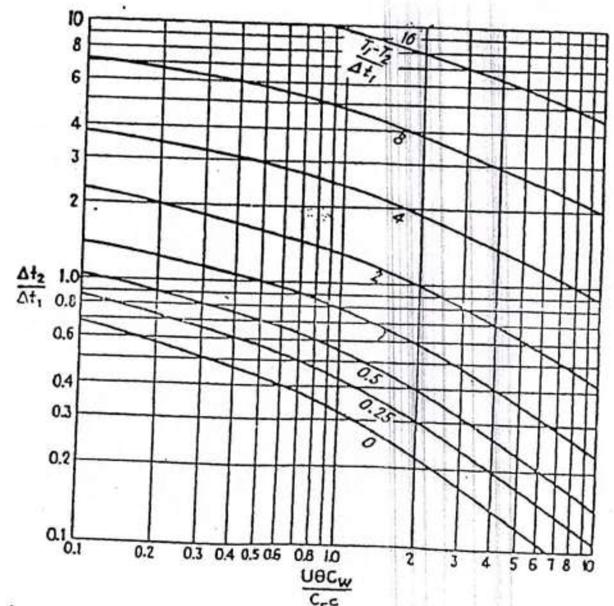


FIG. 41 Optimum outlet water temperature. (*Perry, Chemical Engineers' Handbook, McGraw-Hill Book Company, Inc., New York, 1950.*)

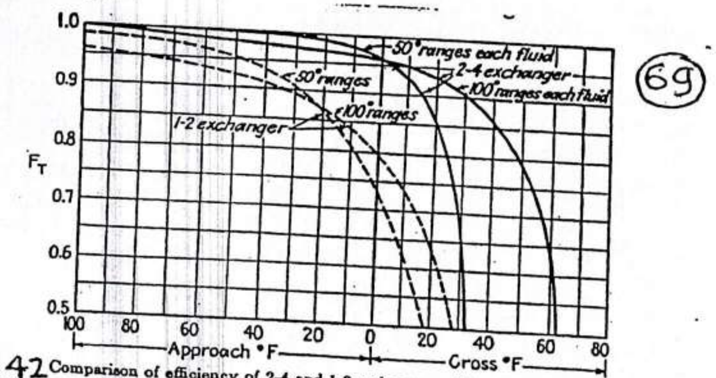


FIG. 42 Comparison of efficiency of 2-4 and 1-2 exchangers with equal fluid temperature ranges.

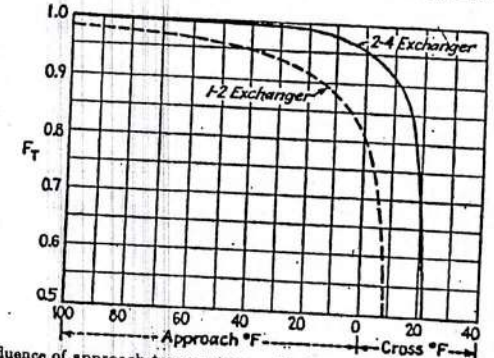


FIG. 43 Influence of approach temperature on F_T for unequal fluid temperature ranges.

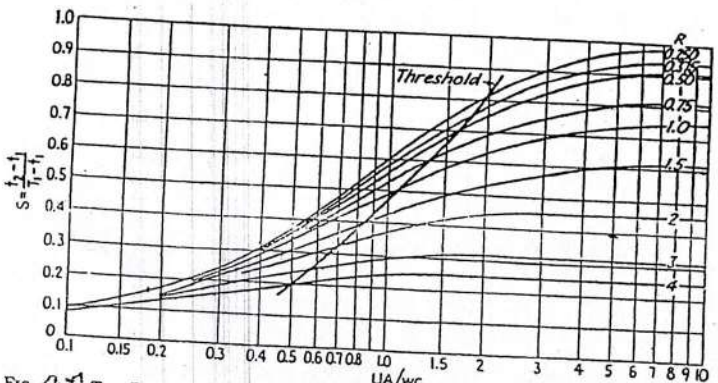


FIG. 44 Ten Broeck chart for determining t_2 in a 2-4 exchanger. (*Industrial and Engineering Chemistry.*)

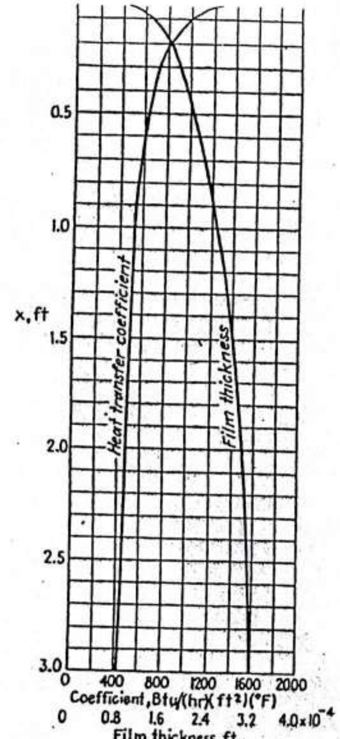
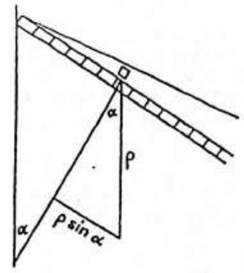
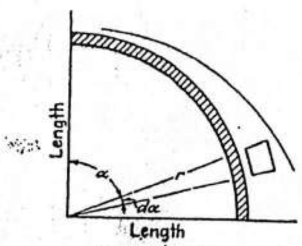


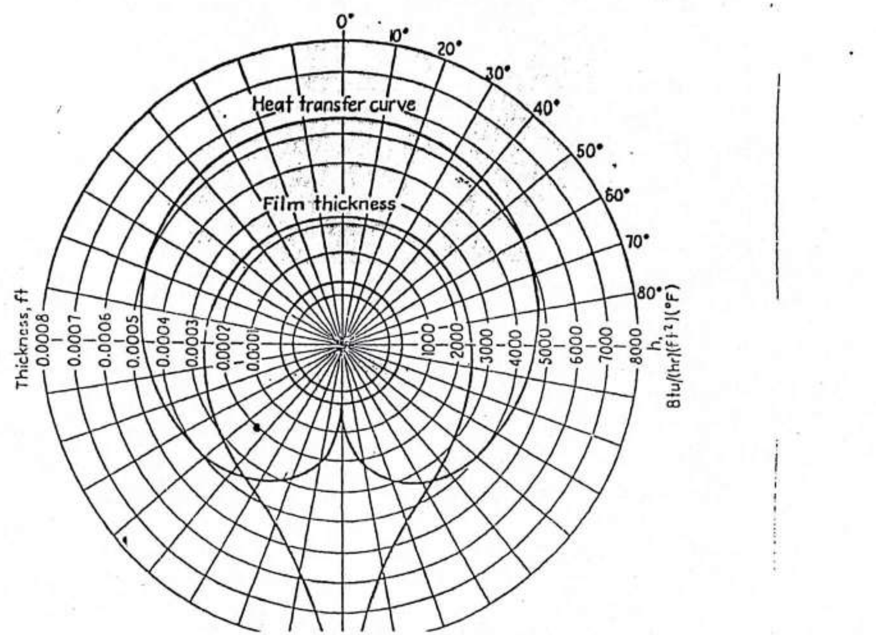
FIG. 45 Vertical film thickness and condensing coefficients for a descending film. (*After Nusselt.*)



Film on an inclined surface



Condensate film on a horizontal



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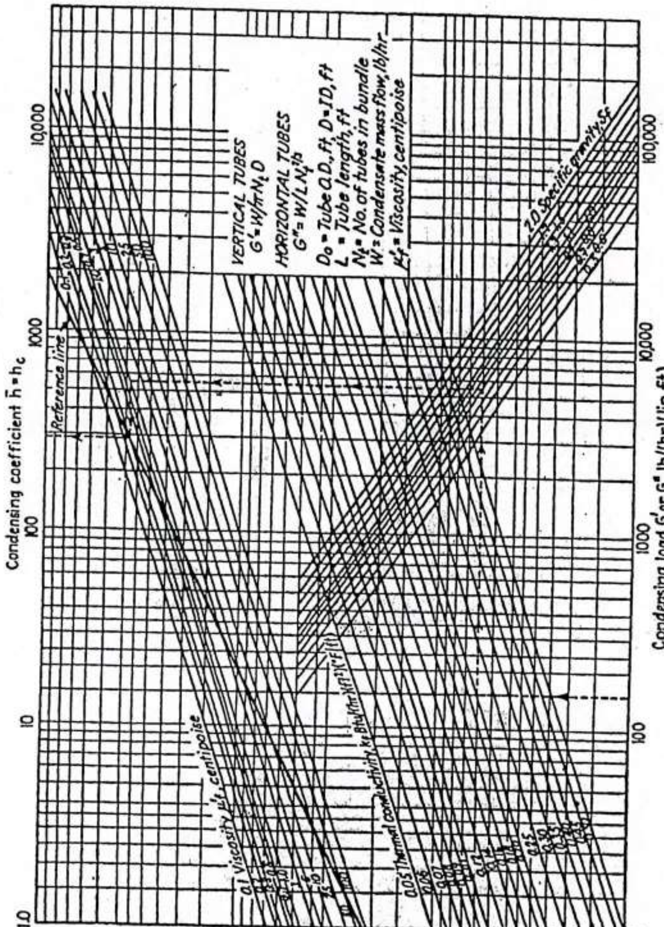


Fig. 47 Condensing coefficients.

72

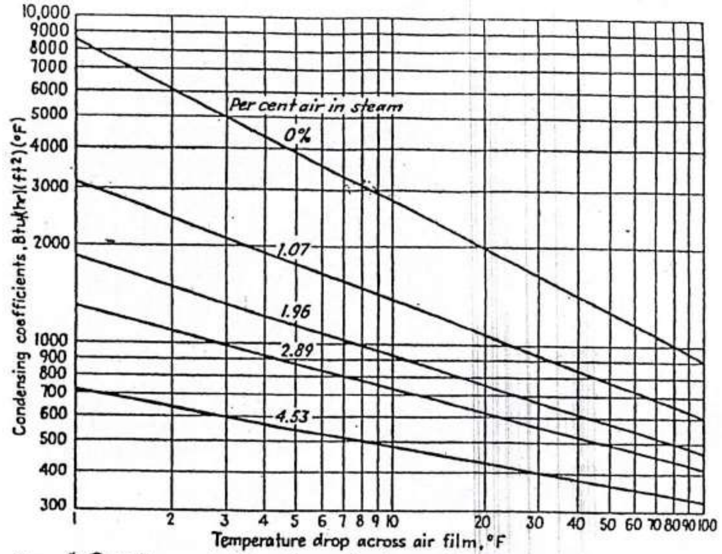


Fig. 48 Influence of air on the condensing coefficient of 230°F steam. (*Data of Othmer.*)

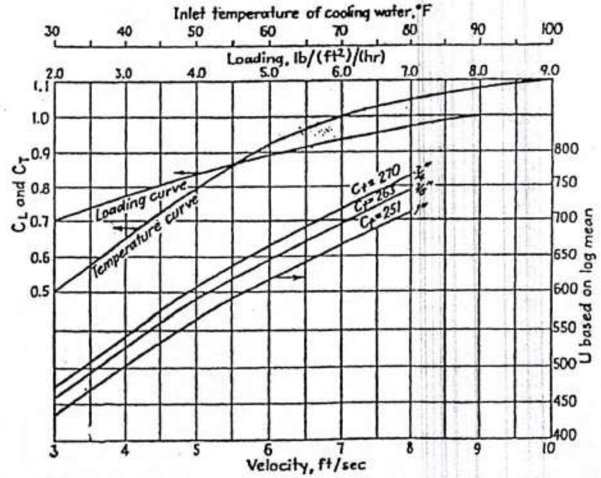
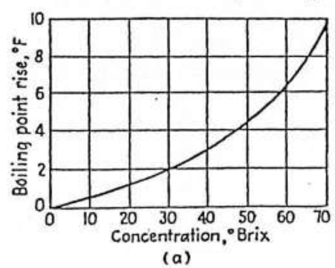
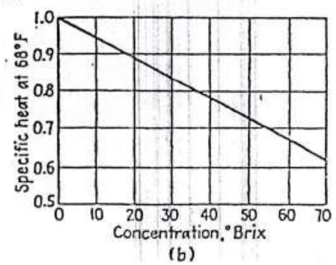


Fig. 49 Overall coefficients in surface condensers. (*Heat Exchange Institute.*)





(73)

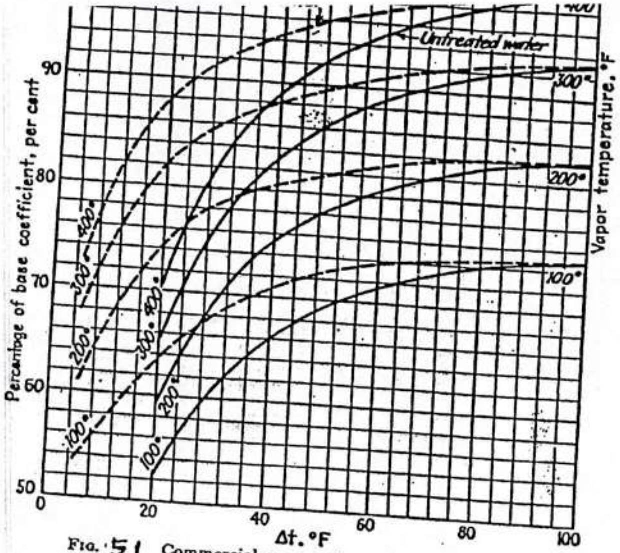


FIG. 51 Commercial evaporation coefficients for water.

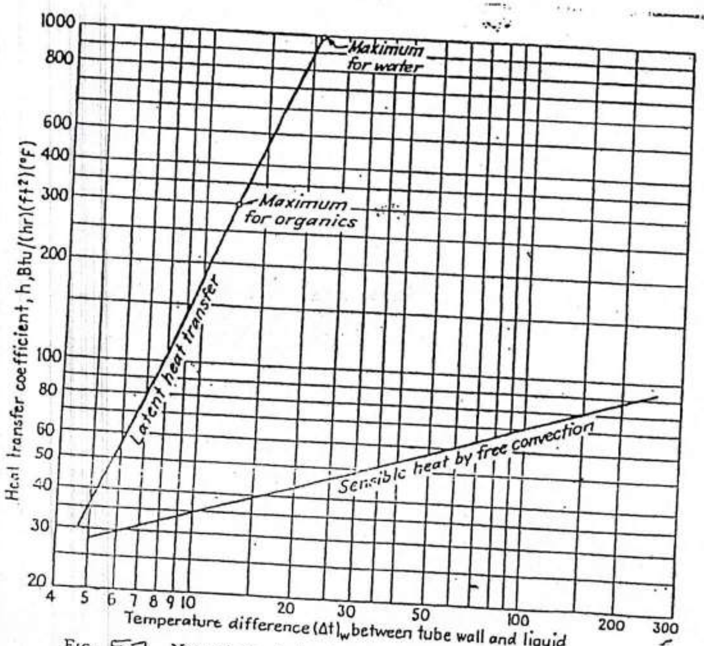


FIG. 52 Natural-circulation boiling and sensible film coefficients.

(74)

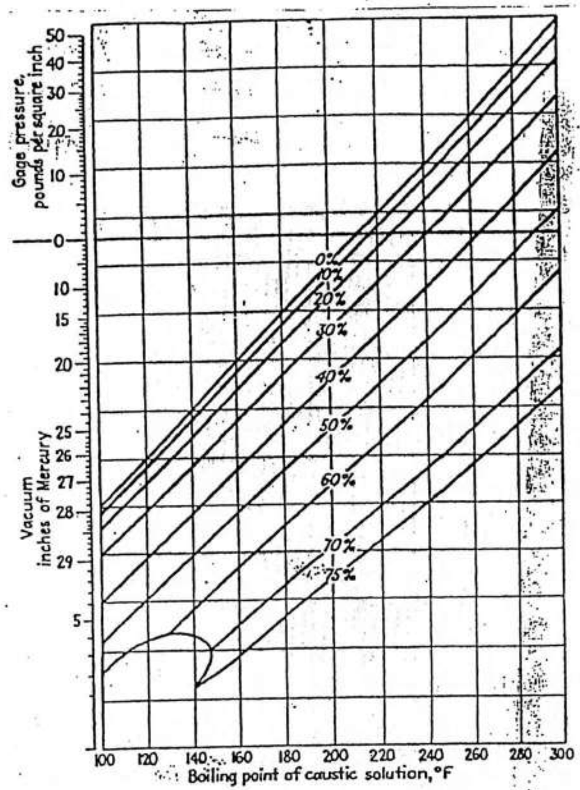
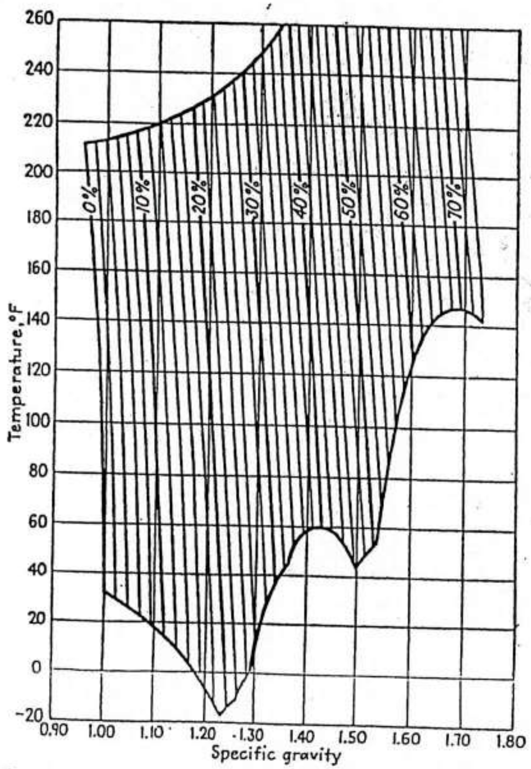


FIG. 53 Boiling-point–pressure relations of caustic soda solutions. (Columbia Alkali Corporation.)



54 Specific gravity of caustic soda solutions. (*Columbia Alkali Corporation.*)

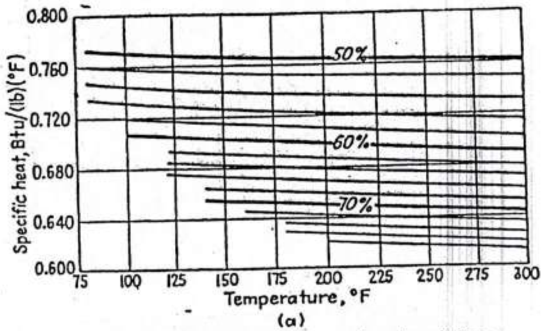


Fig. 55a. Specific heats of high-concentration caustic soda solutions.

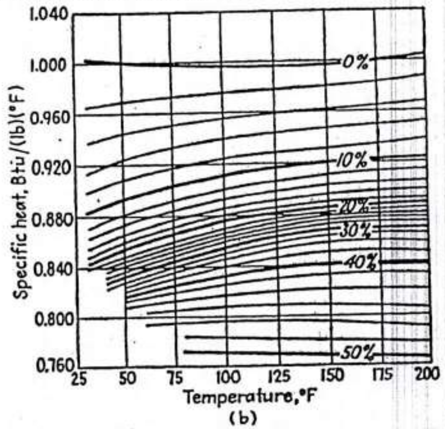


Fig. 55 b. Specific heats of low-concentration caustic soda solutions. (*Columbia Alkali Corporation.*)

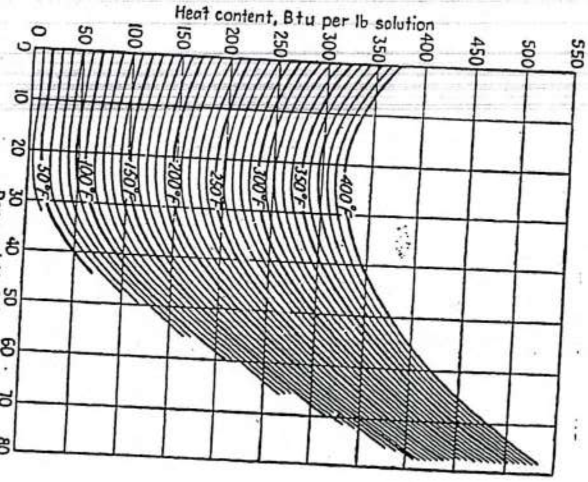


FIG. 56. Relative heat content of caustic soda solutions. (*Columbia Alkali Corporation.*)

Table 23 Gas-cleaning equipment

Type of equipment	Minimum particle size (μm)	Minimum loading (mg/m^3)	Approx. efficiency (%)	Typical gas velocity (m/s)	Maximum capacity (m^3/s)	Gas pressure drop ($mm\ H_2O$)	Liquid rate ($m^3/10^3\ m^3$ gas)	Space required (relative)
Dry collectors								
Settling chamber	50	12,000	50	1.5–3	none	5	—	Large
Baffle chamber	50	12,000	50	5–10	none	3–12	—	Medium
Louver	20	2500	80	10–20	15	10–50	—	Small
Cyclone	10	2500	85	10–20	25	10–70	—	Medium
Multiple cyclone	5	2500	95	10–20	100	50–150	—	Small
Impingement	10	2500	90	15–30	none	25–50	—	Small
Wet scrubbers								
Gravity spray	10	2500	70	0.5–1	50	25	0.05–0.3	Medium
Centrifugal	5	2500	90	10–20	50	50–150	0.1–1.0	Medium
Impingement	5	2500	95	15–30	50	50–200	0.1–0.7	Medium
Packed	5	250	90	0.5–1	25	25–250	0.7–2.0	Medium
Jet	0.5 to 5 (range)	250	90	10–100	50	none	7–14	Small
Venturi	0.5	250	99	50–200	50	250–750	0.4–1.4	Small
Others								
Fabric filters	0.2	250	99	0.01–0.1	100	50–150	—	Large
Electrostatic precipitators	2	250	99	5–30	1000	5–25	—	Large

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High Efficiency Cyclone

High Throughput Cyclone

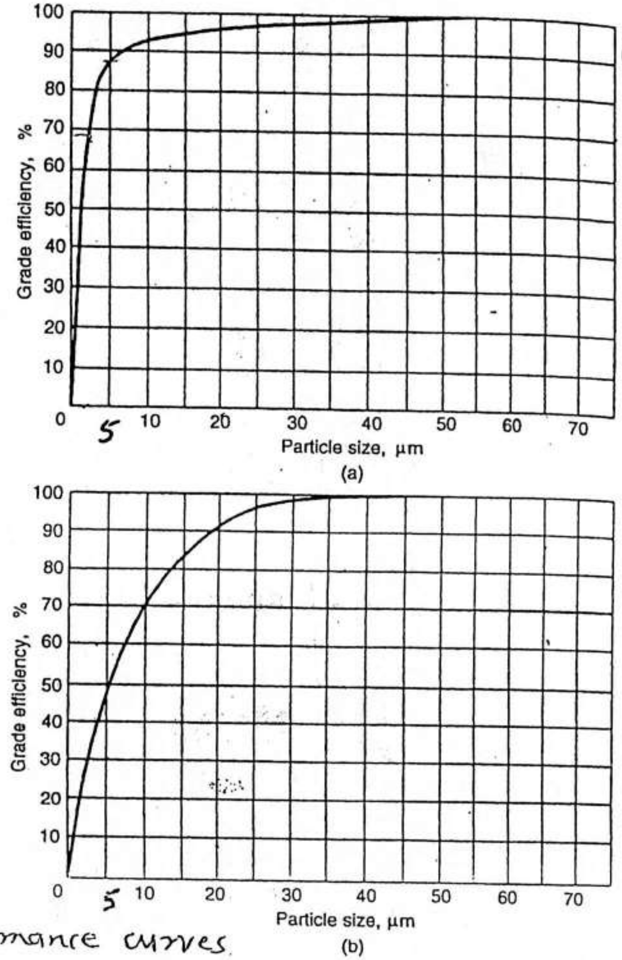

Fig. 57 Performance curves

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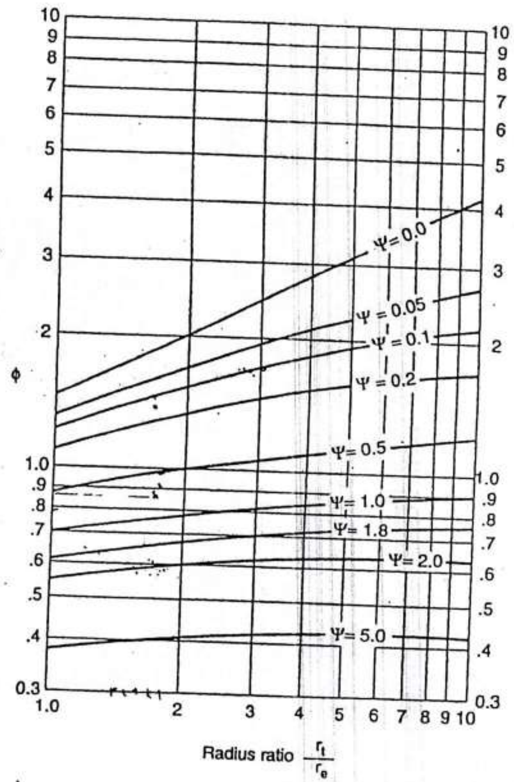


Figure 58 Cyclone pressure drop factor

(81)

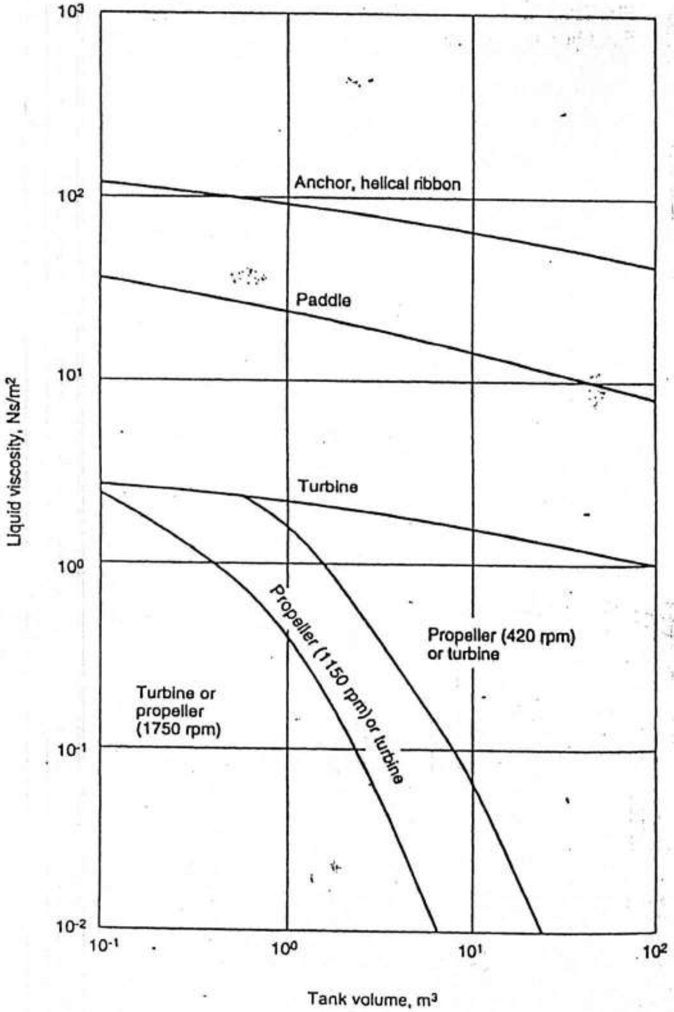


Figure 59 Agitator selection guide

(82)

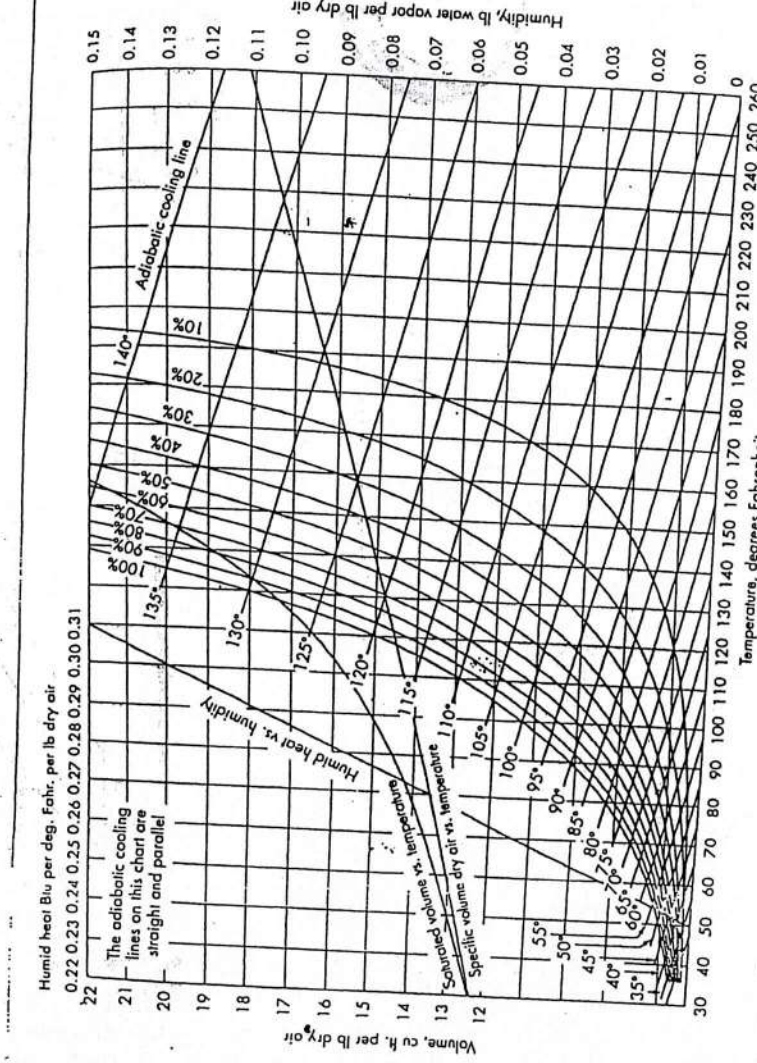


FIGURE 60
Humidity chart. Air-water at 1 atm.

(83)

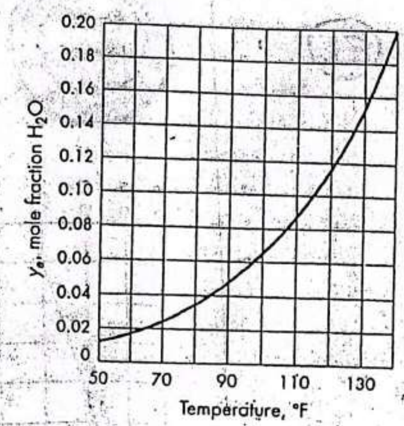
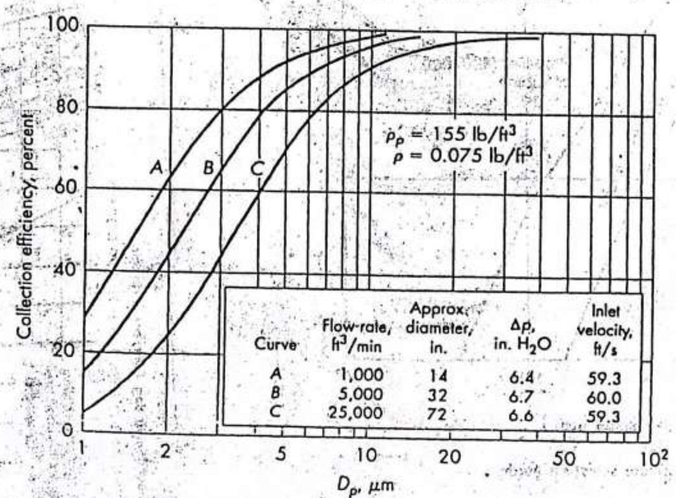


FIGURE 61
Equilibria for the system air-water at 1 atm.



Curve	Flow-rate, ft^3/min	Approx. diameter, in.	Δp, in. H_2O	Inlet velocity, ft/s
A	1,000	14	6.4	59.3
B	5,000	32	6.7	60.0
C	25,000	72	6.6	59.3

FIGURE 62
Collection efficiency of typical cyclones. (*By permission, Fisher-Klosterman Inc., Louisville, KY.*)