University of Mosul

College of Petroleum and Mining Engineering

Mining Engineering Department

“Enviromental and Safety of Mines Subject”

“Tables & Charts”

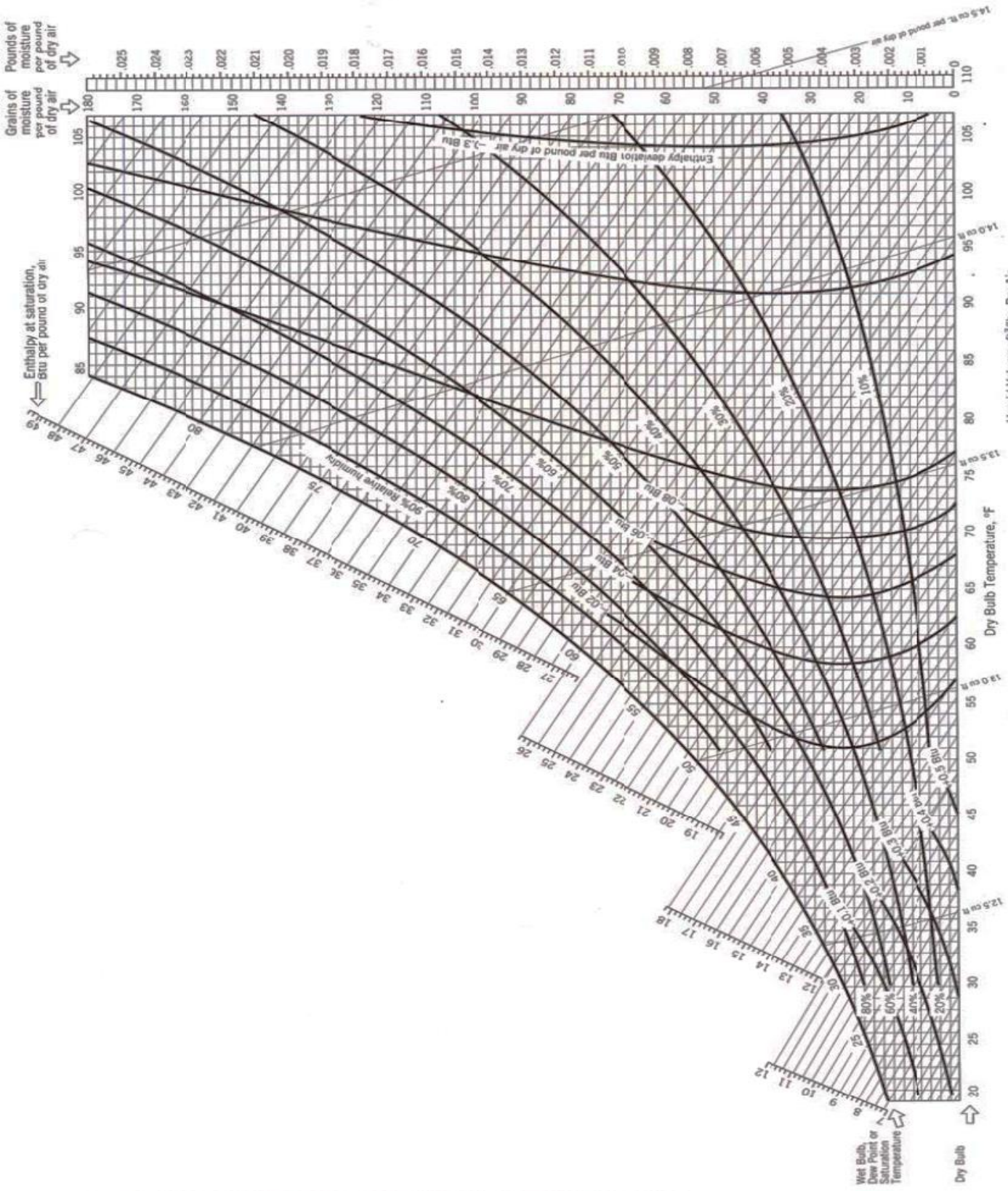

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Figure 8.4-2 Psychrometric chart—American Engineering units. Reference states: H_2O (L, 32°F, 1 atm), dry air (0°F, 1 atm). (Reprinted with permission of Carrier Corporation.)

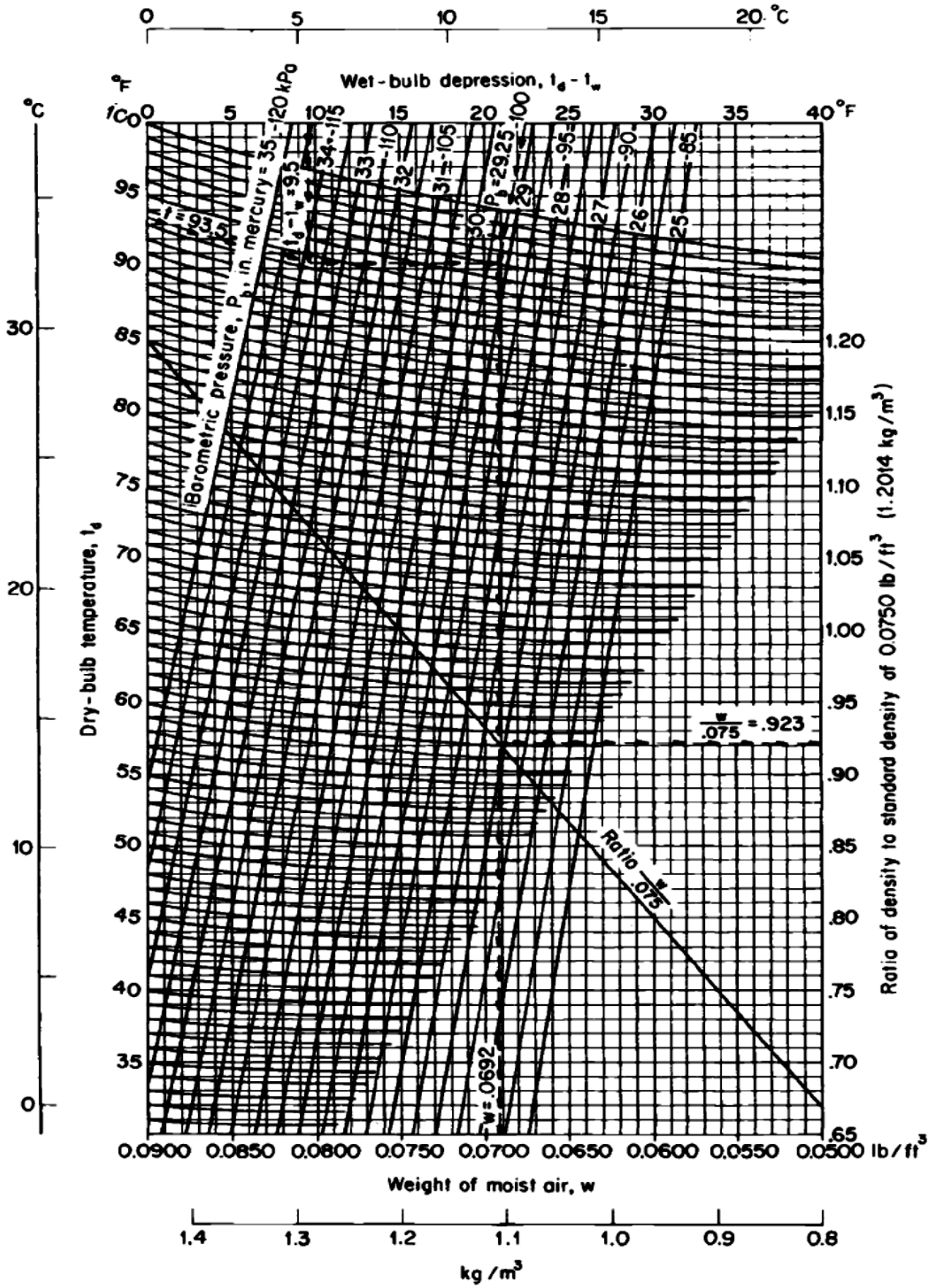

FIGURE 2.3 Chart to determine air specific weight and ratio to standard specific weight (w = 0.0750 lb/ft³ or 1.2014 kg/m³). (After McElroy, 1935.)

TABLE A.1 Barometric Pressure, Temperature, and Air Specific Weight at Different Altitudes

Altitude Above or Below Sea Level, Z ft	Barometric Pressure p_b		At Constant t = 70°F		At Varying t and Z	
	psi	in. mercury	Relative Air Specific Weight	Air Specific Weight, w lb/ft^3	Air Temperature, °F	Air Specific Weight, lb/ft^3
−1000	15.23	31.02	1.037	0.0778	73.8	0.0771
−500	14.94	30.47	1.018	0.0764	71.9	0.0761
0	14.70	29.92	1.000	0.0750	70.0	0.0750
500	14.42	29.38	0.981	0.0736	68.1	0.0740
1,000	14.16	28.86	0.964	0.0723	66.1	0.0730
1,500	13.91	28.33	0.947	0.0710	64.2	0.0719
2,000	13.66	27.82	0.930	0.0698	62.3	0.0709
2,500	13.41	27.31	0.913	0.0685	60.4	0.0698
3,000	13.16	26.81	0.896	0.0672	58.4	0.0687
3,500	12.92	26.32	0.880	0.0660	56.5	0.0676
4,000	12.68	25.84	0.864	0.0648	54.6	0.0666
4,500	12.45	25.36	0.848	0.0636	52.6	0.0657
5,000	12.22	24.89	0.832	0.0624	50.7	0.0648
5,500	11.99	24.43	0.816	0.0612	48.8	0.0638
6,000	11.77	23.98	0.799	0.0599	46.9	0.6628
6,500	11.55	23.53	0.786	0.0590	45.0	0.0619
7,000	11.33	23.09	0.774	0.0580	43.0	0.0610
7,500	11.12	22.65	0.758	0.0568	41.0	0.0600
8,000	10.91	22.22	0.739	0.0554	39.0	0.0590
8,500	10.70	21.80	0.728	0.0546	37.1	0.0581
9,000	10.50	21.38	0.715	0.0536	35.2	0.0573
9,500	10.30	20.98	0.701	0.0526	33.3	0.0564
10,000	10.10	20.58	0.687	0.0515	31.3	0.0555
10,500	9.90	20.18	0.674	0.0506	29.4	0.0546
11,000	9.71	19.75	0.661	0.0496	27.5	0.0538
11,500	9.52	19.40	0.648	0.0486	25.5	0.0529
12,000	9.34	19.03	0.636	0.0477	23.6	0.0521
12,500	9.15	18.65	0.624	0.0468	21.6	0.0513
13,000	8.97	18.29	0.611	0.0458	19.7	0.0505
13,500	8.80	17.93	0.599	0.0449	17.7	0.0496
14,000	8.62	17.57	0.587	0.0440	15.8	0.0488
14,500	8.45	17.22	0.576	0.0432	13.9	0.0480
15,000	8.28	16.88	0.564	0.0423	12.0	0.0473

Source: Madison (1949, pp. 28–29). By permission from Buffalo Forge Co., Buffalo, NY.

Conversion factors: 1 ft = 0.3048 m, 1 psi = 6.8948 kPa, 1 lb/ft^3 = 1.6018 kg/m^3, °F = $\frac{9}{5}$°C + 32.

TABLE A.2 Psychrometric Data for Air-Water-Vapor Mixtures

Temperature, °F t	Properties of Water[a] and Steam: Saturation Pressure of Water and Steam, in. Hg p_s	Enthalpy: Saturated Water,[a] Btu/lb h_f	Enthalpy: Saturated Steam, Btu/lb h_g	Specific Volume of Sat. Steam, ft³/lb v_g	Properties of Dry Air at a Pressure of 29.921 in. Hg abs.: True Specific Volume, ft³/lb v_a	Enthalpy, Btu/lb h_a	Properties of Mixture of Dry Air and Sat. Steam at a Total Pressure of 29.921 in. Hg abs.: Volume of Mixture per lb of Dry Air, ft³ v_s	Enthalpy of Mixture per lb of Dry Air, Btu h_s	Specific Humidity Grains per lb of Dry Air W_s
1	3.966 (10)$^{-2}$	−158.5	1061.5	14,080	11.604	0.24	11.62	1.12	5.777
2	4.178 (10)$^{-2}$	−158.0	1062.0	13,400	11.630	0.48	11.65	1.40	6.084
3	4.400 (10)$^{-2}$	−157.6	1062.4	12,750	11.655	0.72	11.56	1.68	6.348
4	4.633 (10)$^{-2}$	−157.1	1062.8	12,140	11.680	0.96	11.70	1.98	6.745
5	4.878 (10)$^{-2}$	−156.6	1063.3	11.550	11.706	1.20	11.72	2.28	7.106
6	5.134 (10)$^{-2}$	−156.1	1063.7	11.000	11.731	1.44	11.75	2.58	7.478
7	5.402 (10)$^{-2}$	−155.7	1064.2	10.480	11.756	1.68	11.78	2.88	7.867
8	5.683 (10)$^{-2}$	−155.2	1064.6	9979	11.782	1.92	11.80	3.18	8.280
9	5.977 (10)$^{-2}$	−154.7	1065.1	9507	11.807	2.16	11.83	3.49	8.711
10	6.286 (10)$^{-2}$	−154.2	1065.5	9060	11.832	2.40	11.86	3.80	9.161
11	6.608 (10)$^{-2}$	−153.7	1065.9	8636	11.857	2.64	11.88	4.11	9.633
12	6.946 (10)$^{-2}$	−153.3	1066.4	8234	11.883	2.88	11.91	4.43	10.13
13	7.300 (10)$^{-2}$	−152.8	1066.8	7851	11.918	3.12	11.94	4.75	10.64
14	7.669 (10)$^{-2}$	−152.3	1067.3	7489	11.933	3.36	11.96	5.07	11.18
15	8.056 (10)$^{-2}$	−151.8	1067.7	7144	11.959	3.60	11.99	5.40	11.73
16	8.461 (10)$^{-2}$	−151.3	1068.1	6817	11.984	3.84	12.02	5.73	12.34
17	8.884 (10)$^{-2}$	−150.8	1068.6	6505	12.009	4.08	12.05	6.06	12.96
18	9.326 (10)$^{-2}$	−150.3	1069.0	6210	12.035	4.32	12.07	6.40	13.51
19	9.789 (10)$^{-2}$	−149.8	1069.5	5929	12.060	4.56	12.10	6.75	14.28
20	0.1027	−149.4	1069.9	5662	12.085	4.81	12.13	7.10	14.99
21	0.1078	−148.9	1070.3	5408	12.110	5.05	12.15	7.45	15.73
22	0.1130	−148.4	1070.8	5166	12.136	5.29	12.18	7.81	16.51
23	0.1186	−147.9	1071.2	4936	12.161	5.53	12.21	8.18	17.32
24	0.1243	−147.4	1071.7	4717	12.186	5.77	12.24	8.55	18.16
25	0.1303	−146.9	1072.1	4509	12.211	6.01	12.27	8.92	19.04
26	0.1366	−146.4	1072.5	4311	12.237	6.25	12.29	9.31	19.96
27	0.1431	−145.9	1073.0	4122	12.262	6.49	12.32	9.70	20.92
28	0.1500	−145.4	1073.4	3943	12.287	6.73	12.35	10.09	21.92
29	0.1571	−144.9	1073.8	3771	12.313	6.97	12.38	10.49	22.98
30	0.1645	−144.4	1074.3	3608	12.338	7.21	12.41	10.90	24.07
31	0.1723	−143.9	1074.7	3453	12.363	7.45	12.43	11.32	25.21
32	0.1803	−143.4	1075.2	3305	12.389	7.69	12.46	11.75	26.40
33	0.1878	1.0	1075.6	3180	12.414	7.93	12.49	12.16	27.49
34	0.1955	2.0	1076.0	3062	12.439	8.17	12.52	12.57	28.63
35	0.2034	3.0	1076.5	2948	12.464	8.41	12.55	13.00	29.80
36	0.2117	4.0	1076.9	2839	12.490	8.65	12.58	13.42	31.02
37	0.2202	5.0	1077.4	2734	12.515	8.89	12.61	13.86	32.28
38	0.2290	6.0	1077.8	2634	12.540	9.13	12.64	14.30	33.58
39	0.2382	7.0	1078.2	2538	12.565	9.37	12.67	14.75	34.94
40	0.2477	8.0	1078.7	2445	12.591	9.61	12.70	15.21	36.34
41	0.2575	9.0	1079.1	2357	12.616	9.85	12.73	15.68	37.80
42	0.2676	10.1	1079.5	2272	12.641	10.09	12.76	16.16	39.30
43	0.2781	11.1	1080.0	2190	12.667	10.34	12.79	16.64	40.86
44	0.2890	12.1	1080.4	2112	12.692	10.58	12.82	17.13	42.47
45	0.3002	13.1	1080.9	2037	12.717	10.82	12.85	17.63	44.14
46	0.3119	14.1	1081.3	1965	12.742	11.06	12.88	18.13	45.86
47	0.3239	15.1	1081.7	1896	12.768	11.30	12.91	18.66	47.65
48	0.3363	16.1	1082.2	1829	12.793	11.54	12.94	19.19	49.51
49	0.3491	17.1	1082.6	1766	12.818	11.78	12.97	19.73	51.42
50	0.3624	18.1	1083.1	1704	12.844	12.02	13.00	20.28	53.40
51	0.3761	19.1	1083.5	1645	12.869	12.26	13.03	20.84	55.44
52	0.3903	20.1	1083.9	1589	12.894	12.50	13.06	21.41	57.56
53	0.4049	21.1	1084.4	1534	12.919	12.74	13.10	21.99	59.75
54	0.4200	22.1	1084.8	1482	12.945	12.98	13.13	22.59	62.01
55	0.4356	23.1	1085.2	1431	12.970	13.22	13.16	23.20	64.36
56	0.4518	24.1	1085.7	1383	12.995	13.46	13.19	23.82	66.78

(continued)

TABLE A.2—(*continued*)

Temperature, °F t	Properties of Water[a] and Steam: Saturation Pressure of Water and Steam, in. Hg p_s	Properties of Water[a] and Steam: Enthalpy: Saturated Water,[a] Btu/lb h_f	Properties of Water[a] and Steam: Enthalpy: Saturated Steam, Btu/lb h_g	Properties of Water[a] and Steam: Specific Volume of Sat. Steam, ft³/lb v_g	Properties of Dry Air at a Pressure of 29.921 in. Hg abs.: True Specific Volume, ft³/lb v_a	Properties of Dry Air at a Pressure of 29.921 in. Hg abs.: Enthalpy, Btu/lb h_a	Properties of Mixture of Dry Air and Sat. Steam at a Total Pressure of 29.921 in. Hg abs.: Volume of Mixture per lb of Dry Air, ft³ v_s	Properties of Mixture of Dry Air and Sat. Steam at a Total Pressure of 29.921 in. Hg abs.: Enthalpy of Mixture per lb of Dry Air, Btu h_s	Properties of Mixture of Dry Air and Sat. Steam at a Total Pressure of 29.921 in. Hg abs.: Specific Humidity Grains per lb of Dry Air W_s
57	0.4684	25.1	1086.1	1336	13.020	13.70	13.23	24.45	69.28
58	0.4856	26.1	1086.5	1292	13.046	13.94	13.26	25.10	71.86
59	0.5033	27.1	1087.0	1249	13.071	14.18	13.29	25.76	74.54
60	0.5216	28.1	1087.4	1207	13.096	14.42	13.33	26.43	77.29
61	0.5405	29.1	1087.9	1167	13.122	14.66	13.36	27.11	80.14
62	0.5599	30.1	1088.3	1129	13.147	14.90	13.40	27.82	83.09
63	0.5800	31.1	1088.7	1092	13.172	15.14	13.43	28.54	86.14
64	0.6007	32.1	1089.2	1056	13.197	15.38	13.47	29.27	89.27
65	0.6221	33.1	1089.6	1022	13.223	15.62	13.50	30.03	92.51
66	0.6441	34.1	1090.0	988.6	13.248	15.85	13.54	30.79	95.86
67	0.6668	35.1	1090.5	956.8	13.273	16.10	13.58	31.58	99.32
68	0.6902	36.1	1090.9	926.1	13.298	16.35	13.61	32.38	102.9
69	0.7143	37.1	1091.3	896.5	13.324	16.59	13.65	33.20	106.6
70	0.7392	38.1	1091.8	868.0	13.349	16.83	13.69	34.04	110.4
71	0.7648	39.1	1092.2	840.5	13.374	17.07	13.72	34.90	114.3
72	0.7911	40.1	1092.6	814.0	13.399	17.31	13.76	35.79	118.4
73	0.8183	41.1	1093.1	788.4	13.425	17.55	13.80	36.69	122.6
74	0.8463	42.1	1093.5	763.8	13.450	17.79	13.84	37.61	126.9
75	0.8751	43.1	1093.9	740.0	13.475	18.03	13.88	38.55	131.3
76	0.9047	44.1	1094.4	717.0	13.501	18.27	13.92	39.52	135.9
77	0.9352	45.1	1094.8	694.9	13.526	18.51	13.96	40.51	140.6
78	0.9667	46.1	1095.2	673.5	13.551	18.75	14.00	41.52	145.5
79	0.9990	47.1	1095.7	652.9	13.576	18.99	14.04	42.56	150.6
80	1.0323	48.1	1096.1	633.0	13.602	19.23	14.09	43.63	155.8
81	1.0665	49.1	1096.6	613.8	13.627	19.47	14.13	44.72	161.2
82	1.1017	50.1	1097.0	595.3	13.652	19.71	14.17	45.84	166.7
83	1.1380	51.1	1097.4	577.4	13.678	19.95	14.22	46.98	172.4
84	1.1752	52.1	1097.8	560.1	13.703	20.19	14.26	48.16	178.3
85	1.2136	53.1	1098.3	543.3	13.738	20.43	14.31	49.36	184.4
86	1.2530	54.0	1098.7	527.2	13.753	20.67	14.35	50.59	190.6
87	1.2935	55.0	1099.1	511.6	13.778	20.91	14.40	51.86	197.0
88	1.3351	56.0	1099.6	496.5	13.804	21.15	14.45	53.14	203.7
89	1.3779	57.0	1100.0	482.0	13.829	21.39	14.50	54.48	210.6
90	1.4219	58.0	1100.4	467.9	13.854	21.64	14.55	55.85	217.6
91	1.4671	59.0	1100.9	454.3	13.880	21.88	14.60	57.25	224.9
92	1.5136	60.0	1101.3	441.1	13.905	22.12	14.65	58.69	232.4
93	1.5613	61.0	1101.7	428.4	13.930	22.36	14.70	60.16	240.1
94	1.6103	62.0	1102.2	416.1	13.955	22.60	14.75	61.67	248.1
95	1.6607	63.0	1102.6	404.2	13.981	22.84	14.80	63.12	256.4
96	1.7124	64.0	1103.0	392.7	14.006	23.08	14.86	64.81	264.8
97	1.7655	65.0	1103.4	381.5	14.031	23.32	14.91	66.20	273.6
98	1.8200	66.0	1103.9	370.7	14.057	23.56	14.97	68.53	282.6
99	1.8759	67.0	1104.3	360.3	14.082	23.80	15.02	70.03	293.0
100	1.9334	68.0	1104.7	350.2	14.107	24.04	15.08	71.62	301.5
101	1.9923	69.0	1105.2	340.4	14.132	24.28	15.14	73.44	311.3
102	2.0529	70.0	1105.6	331.0	14.157	24.52	15.20	75.31	321.5
103	2.1149	71.0	1106.0	321.8	14.183	24.76	15.26	77.22	332.0
104	2.1786	72.0	1106.4	313.0	14.208	25.00	15.32	79.19	342.8
105	2.2440	73.0	1106.9	304.4	14.233	25.24	15.39	81.21	353.9
106	2.3110	74.0	1107.3	296.0	14.259	25.48	15.45	83.29	365.4
107	2.3798	75.0	1107.7	288.0	14.284	25.72	15.52	85.42	377.2
108	2.4503	76.0	1108.2	280.2	14.309	25.96	15.59	87.62	389.4
109	2.5226	77.0	1108.6	272.6	14.334	26.20	15.65	89.87	402.0
110	2.5968	78.0	1109.0	265.3	14.360	26.45	15.72	92.19	414.9
111	2.6728	79.0	1109.4	258.2	14.385	26.69	15.80	94.58	428.3

TABLE A.2—(*continued*)

Temperature, °F t	Properties of Water[a] and Steam: Saturation Pressure of Water and Steam, in. Hg p_s	Enthalpy: Saturated Water,[a] Btu/lb h_f	Enthalpy: Saturated Steam, Btu/lb h_g	Specific Volume of Sat. Steam, ft³/lb v_g	Properties of Dry Air at a Pressure of 29.921 in. Hg abs.: True Specific Volume, ft³/lb v_a	Enthalpy, Btu/lb h_a	Properties of Mixture of Dry Air and Sat. Steam at a Total Pressure of 29.921 in. Hg abs.: Volume of Mixture per lb of Dry Air, ft³ v_s	Enthalpy of Mixture per lb of Dry Air, Btu h_s	Specific Humidity Grains per lb of Dry Air W_s
112	2.7507	80.0	1109.9	251.3	14.410	26.93	15.87	97.03	442.1
113	2.8306	81.0	1110.3	244.6	14.435	27.17	15.94	99.55	456.3
114	2.9125	82.0	1110.7	238.1	14.461	27.41	16.02	102.16	471.0
115	2.9963	83.0	1111.1	231.8	14.486	27.65	16.10	104.81	486.1
116	3.0823	84.0	1111.6	225.8	14.511	27.89	16.18	107.55	501.6
117	3.1703	85.0	1112.0	219.9	14.537	28.13	16.26	110.38	517.7
118	3.2606	86.0	1112.4	214.1	14.562	28.37	16.34	113.29	534.3
119	3.3530	87.0	1112.8	208.6	14.587	28.61	16.43	116.28	551.4
120	3.4477	88.0	1113.3	203.2	14.612	28.85	16.51	119.36	569.0
121	3.5446	89.0	1113.7	197.9	14.637	29.09	16.60	122.52	587.2
122	3.6439	90.0	1114.1	192.9	14.663	29.33	16.70	125.79	606.0
123	3.7455	91.0	1114.5	188.0	14.688	29.57	16.79	129.15	625.3
124	3.8496	92.0	1114.9	183.2	14.713	29.82	16.89	132.61	645.3
125	3.9561	93.0	1115.4	178.5	14.739	30.06	16.98	136.17	665.9
126	4.0651	94.0	1115.8	174.0	14.764	30.30	17.08	139.88	687.2
127	4.1768	95.0	1116.2	169.6	14.789	30.54	17.19	143.64	709.2
128	4.2910	96.0	1116.6	165.4	14.814	30.78	17.29	147.54	731.9
129	4.4078	97.0	1117.0	161.3	14.839	31.02	17.40	151.57	755.4
130	4.5274	98.0	1117.5	157.3	14.865	31.26	17.52	155.72	779.6
131	4.6498	99.0	1117.9	153.4	14.890	31.50	17.63	160.00	804.6
132	4.7750	100.0	1118.3	149.6	14.915	31.74	17.75	164.43	830.5
133	4.9030	101.0	1118.7	145.9	14.941	31.98	17.87	168.98	857.2
134	5.0340	102.0	1119.2	142.4	14.966	32.22	17.99	173.69	884.8
135	5.1679	103.0	1119.6	138.9	14.991	32.46	18.12	178.54	913.3
136	5.3049	104.0	1120.0	135.5	15.016	32.70	18.25	183.57	942.8
137	5.4450	105.0	1120.4	132.2	15.043	32.94	18.39	188.75	973.4
138	5.5881	106.0	1120.8	129.1	15.067	33.18	18.53	194.09	1000.0
139	5.7345	107.0	1121.2	126.0	15.092	33.43	18.67	199.64	1038
140	5.8842	108.0	1121.7	123.0	15.117	33.67	18.82	205.34	1071
141	6.0371	109.0	1122.1	120.0	15.143	33.91	18.97	211.27	1106
142	6.1934	110.0	1122.5	117.2	15.168	34.15	19.13	217.39	1143
143	6.3532	111.0	1122.9	114.4	15.193	34.39	19.29	223.70	1180
144	6.5164	112.0	1123.3	111.7	15.218	34.63	19.45	230.28	1219
145	6.6832	113.0	1123.7	109.1	15.244	34.87	19.62	236.94	1259
146	6.8536	114.0	1124.1	106.6	15.269	35.11	19.81	244.06	1301
147	7.0277	115.0	1124.6	104.1	15.294	35.35	19.99	251.34	1344
148	7.2056	116.0	1125.0	101.7	15.319	35.59	20.18	258.88	1389
149	7.3872	117.0	1125.4	99.32	15.345	35.83	20.37	266.71	1436
150	7.5727	118.0	1125.8	97.04	15.370	36.07	20.58	274.34	1485

Source: Goff and Gratch (1946, p. 95). Reprinted by permission of the American Society of Heating, Refrigeration, & Air Conditioning, Inc., Atlanta, GA.

[a] For temperatures of 1 to 32°F, the data are for ice instead of water.

Conversion factors: °F = $\frac{9}{5}$ °C + 32, 1 in. Hg = 3.3768 kPa, 1 Btu/lb = 2.326 kJ/kg, 1 ft³/lb = 0.06243 m³/kg, 1 grain/lb = 1.429×10^{-4} kg

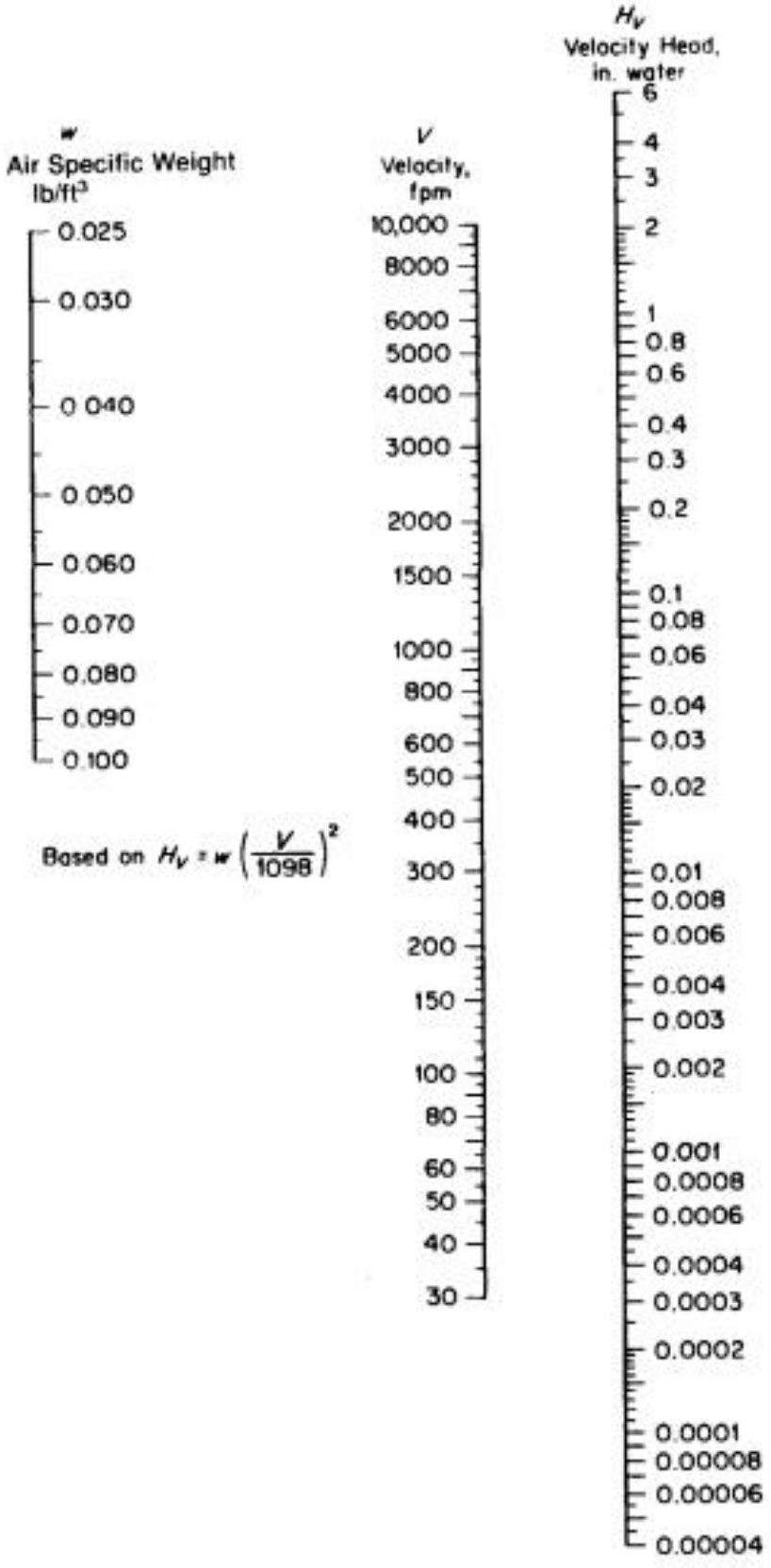

FIGURE A.1 Nomograph for conversion of velocity and velocity head. (*Conversion factors*: 1 lb/ft³ = 16.018 kg/m³, 1 fpm = 0.005080 m/s, 1 in. water = 248.84 Pa.) (After Baumeister, 1935.)

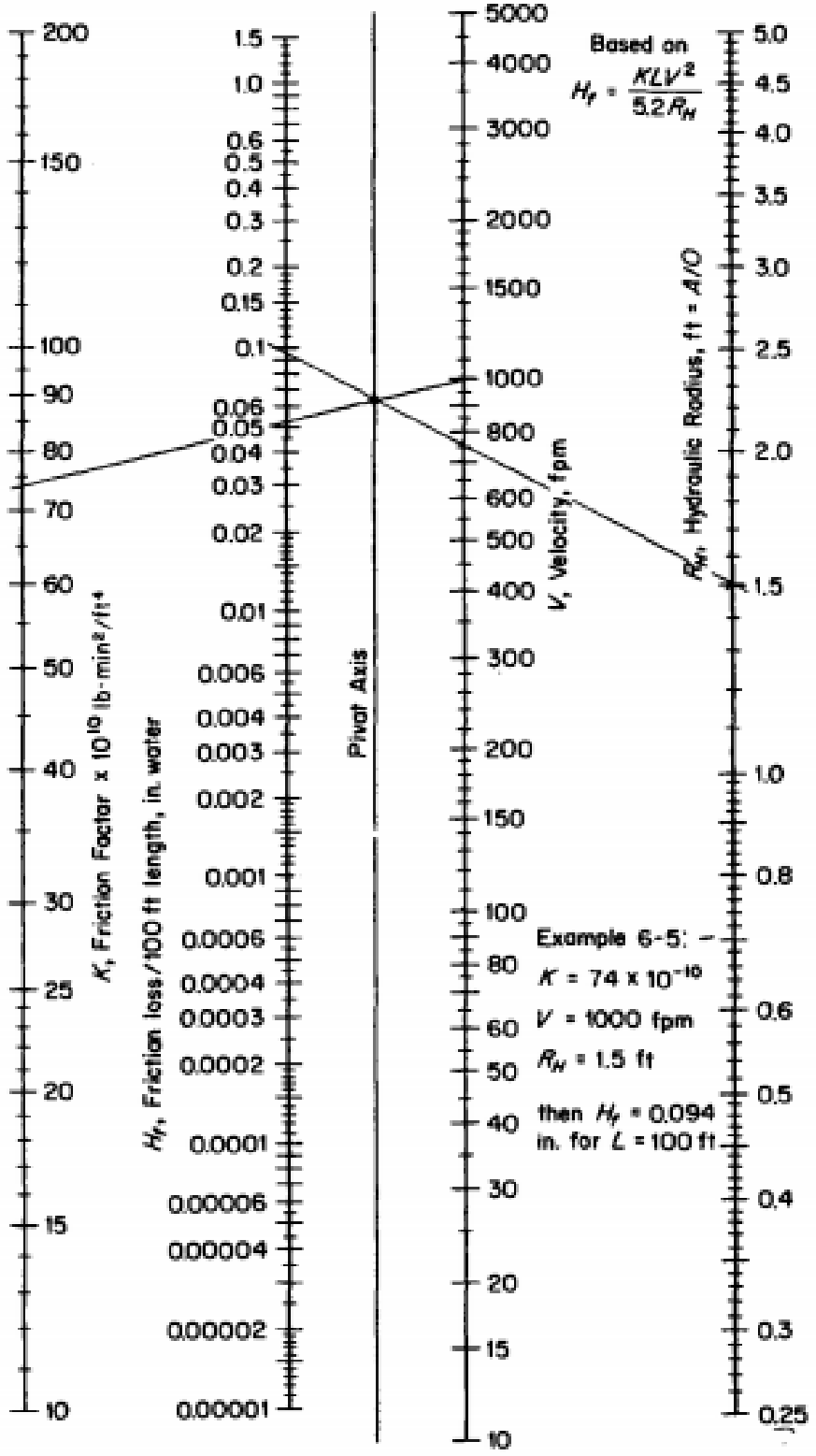

FIGURE A.2 Nomograph for determination of friction loss in mine airways. (*Conversion factors*: 1 lb·min²/ft⁴ = 1.855 × 10^6 kg/m³, 1 in. water = 248.84 Pa, 1 fpm = 0.005080 m/s, 1 ft = 0.3048 m.) (After Hartman, 1954. By permission from *Eng. Mng. J.*, Chicago, IL.)

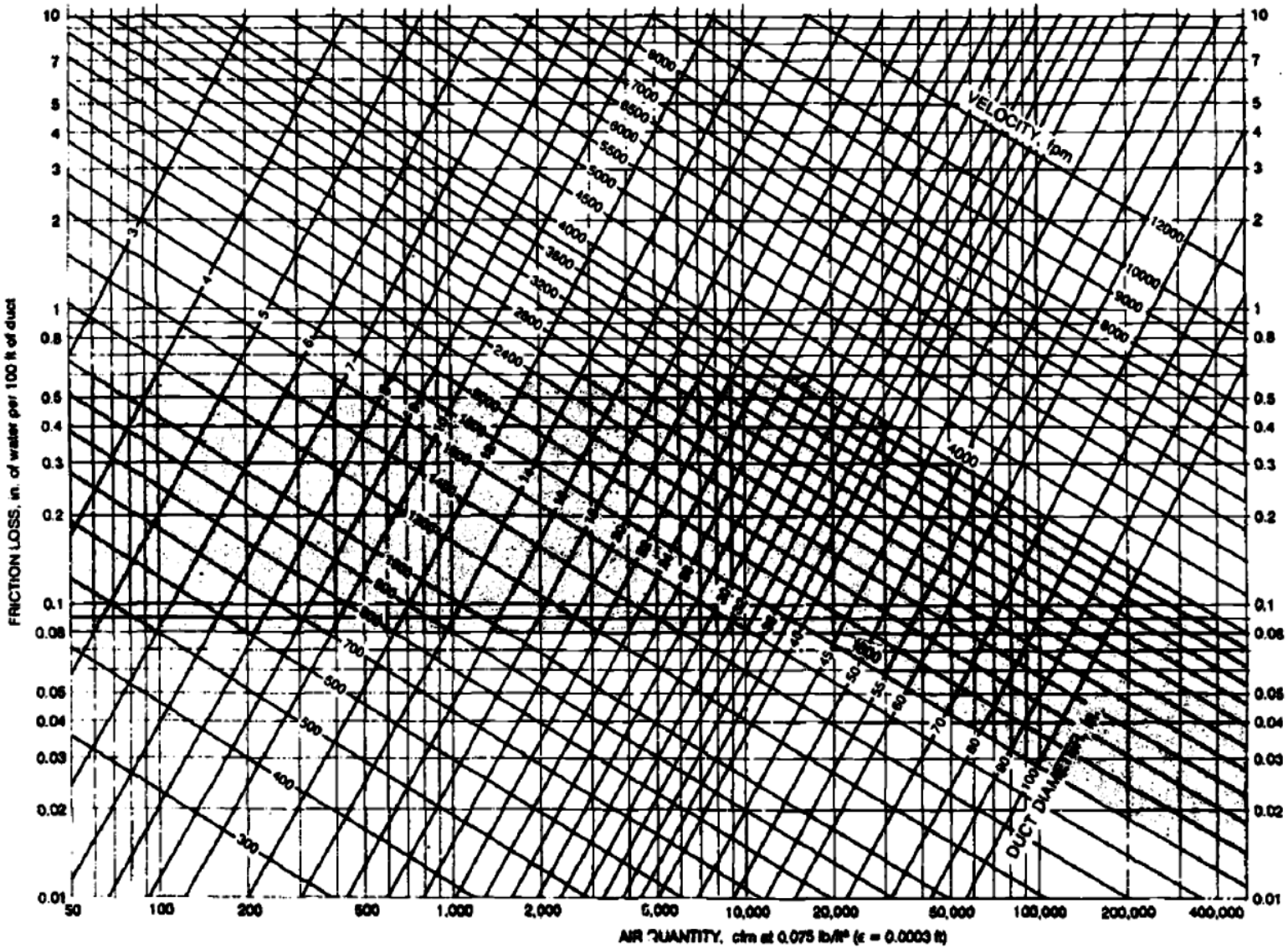

FIGURE A.3 Graph for determination of friction loss in ventilation pipe or tubing. Use without correction for new, steel pipe; see correction table, Section 5.5, for other pipe or tubing. Based on standard air specific weight. The shaded area of the graph contains the recommended velocities for efficient use of steel ventilation pipe. (*Conversion factors*: 1 cfm = 4.7195×10^{-4} m³/s, 1 fpm = 0.005080 m/s, 1 in. = 25.4 mm, 1 in. water = 248.84 Pa., 1 ft = 0.3048 m.) (After Anon., 1993. Reprinted with permission of the American Society of Heating, Refrigerating, & Air Conditioning, Inc., Atlanta, GA.)

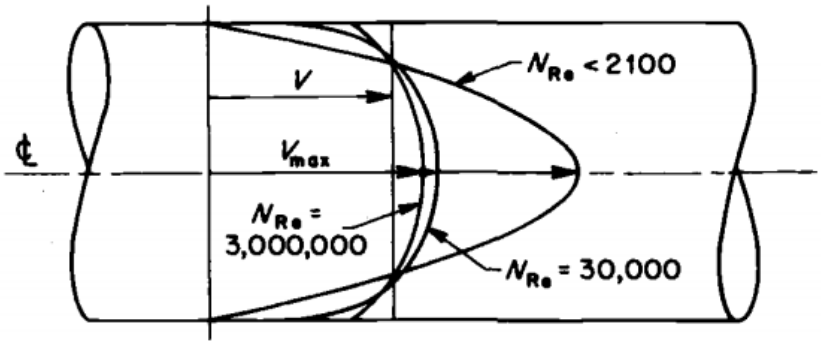

FIGURE 5.9 Velocity distributions in circular conduits, average velocity constant (After Rouse, 1937. Reprinted from *Trans. Amer. Soc. Civil Engl.*, Vol. 102, p. 16 with permission of the ASCE.)

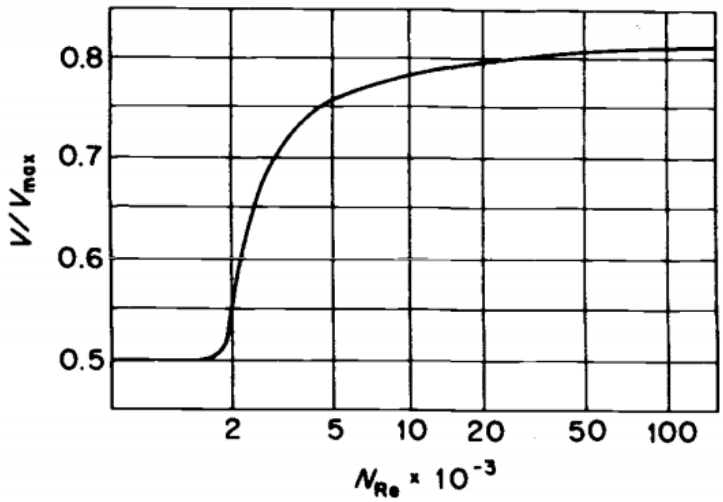

FIGURE 5.10 Relation of velocity ratio V/V_{max} and Reynolds number. (After Vennard, 1940. Reprinted by permission of John Wiley & Sons, Inc.)

TABLE 5.1 Friction Factor K for Noncoal Mine Airways and Openings

		Values of $K \times 10^{10}$ [a]											
		Straight			Sinuous or Curved								
					Slightly			Moderately			High Degree		
Type of Airway	Irregularities of Surfaces, Areas, and Alignment	Clean (Basic Values)	Slightly Obstructed	Moderately Obstructed	Clean	Slightly Obstructed	Moderately Obstructed	Clean	Slightly Obstructed	Moderately Obstructed	Clean	Slightly Obstructed	Moderately Obstructed
Smooth lined	Minimum	10	15	25	20	25	35	25	30	40	35	40	50
	Average	15	*20*	30	25	30	40	30	35	45	40	45	55
	Maximum	20	25	35	30	35	45	35	40	50	45	50	60
Sedimentary rock	Minimum	30	35	45	40	45	55	45	50	60	55	60	70
	Average	55	*60*	70	65	70	80	70	75	85	80	85	95
	Maximum	70	75	85	80	85	95	85	95	100	95	100	110
Timbered (5-ft centers)	Minimum	80	85	95	90	95	105	95	100	110	105	110	120
	Average	95	*100*	110	105	110	120	110	115	125	120	125	135
	Maximum	105	110	120	115	120	130	120	125	135	130	135	145
Igneous rock	Minimum	90	95	105	100	105	115	105	110	120	115	120	130
	Average	145	*150*	160	155	160	165	160	165	175	170	175	195
	Maximum	195	200	210	205	210	220	210	215	225	220	225	235

Source: McElroy (1935).

[a] To provide correct values of K, the numerical values obtained from the table are multiplied by 10^{-10} and units of lb·min^2/ft^4 attached. K is based on standard air specific weight (w = 0.0750 lb/ft^3). Recommended values are in italics. To convert K to SI units (kg/m^3), multiply table values by 1.855×10^6.

TABLE 5.2 Friction Factor K for Coal Mine Airways and Openings

	Value of $K \times 10^{10}$ [a]					
	Straight			Curved		
Type of Airway	Clean	Slightly Obstructed	Moderately Obstructed	Clean	Slightly Obstructed	Moderately Obstructed
Smooth lined	25	28	34	31	39	43
Unlined (rock-bolted)	43	49	61	62	68	74
Timbered	67	75	82	85	87	90

Source: Kharkar et al. (1974).

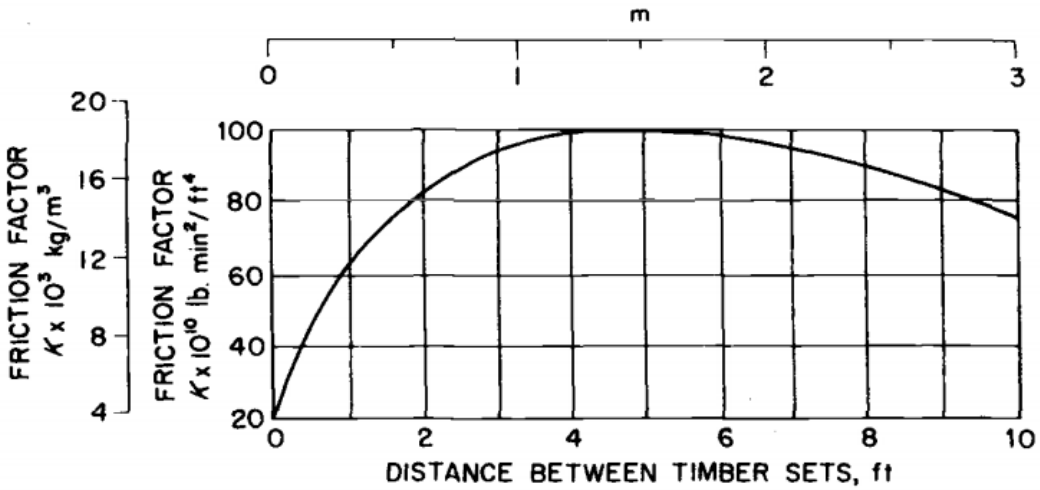

FIGURE 5.11 Effect of spacing of timber sets on friction factor K. (After McElroy, 1935.)

Pipe or Tubing	Friction Factor, $K \times 10^{10}$ lb·min^2/ft^4 (kg/m^3)	
	Good, New	Average, Used
Steel, wood, fiberglass (rigid)	15 (0.0028)	20 (0.0037)
Jute, canvas, plastic (flexible)	20 (0.0037)	25 (0.0046)
Spiral-type canvas	22.5 (0.0042)	27.5 (0.0051)

For vent pipes based on w=0.075

Pipe or Tubing	Correction Factor for Pipe Condition	
	Good, New	Average, Used
Steel, wood, fiberglass (rigid)	1.00	1.33
Jute, canvas, plastic (flexible)	1.33	1.67
Spiral-type canvas	1.50	1.83

TABLE 5.3 Equivalent Lengths for Various Sources of Shock Loss

Source	ft	(m)	Source	ft	(m)
Bend, acute, round	3	(1)	Contraction, gradual	1	(1)
Bend, acute, sharp	150	(45)	Contraction, abrupt	10	(3)
Bend, right, round	1	(1)	Expansion, gradual	1	(1)
Bend, right, sharp	70	(20)	Expansion, abrupt	20	(6)
Bend, obtuse, round	1	(1)	Splitting, straight branch	30	(10)
Bend, obtuse, sharp	15	(5)	Splitting, deflected branch (90°)	200	(60)
Doorway	70	(20)	Junction, straight branch	60	(20)
Overcast	65	(20)	Junction, deflected branch (90°)	30	(10)
Inlet	20	(6)	Mine car or skip (20% of airway area)	100	(30)
Discharge	65	(20)	Mine car or skip (40% of airway area)	500	(150)

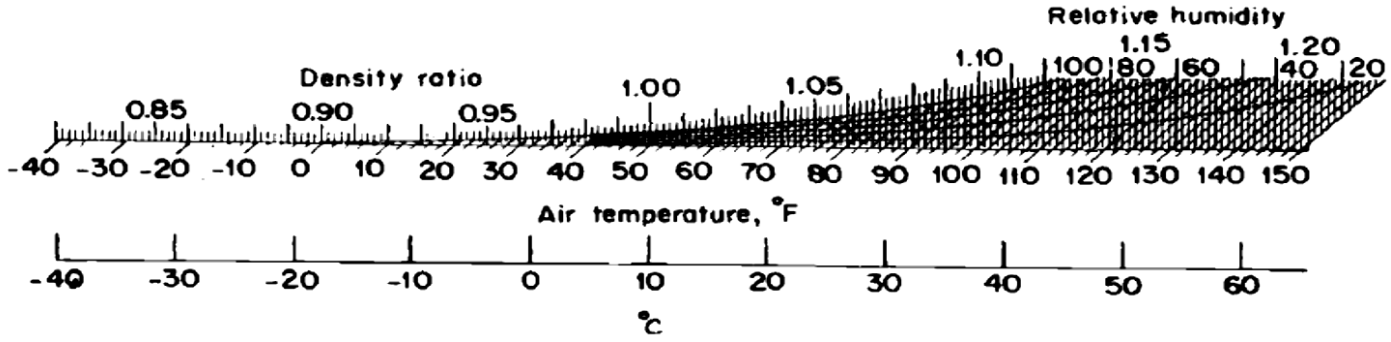

FIGURE 6.15 Ratio of altimeter-scale air specific weight to mine air specific weight. Correction factor for difference of elevation. (After McElroy and Kingery, 1957.)

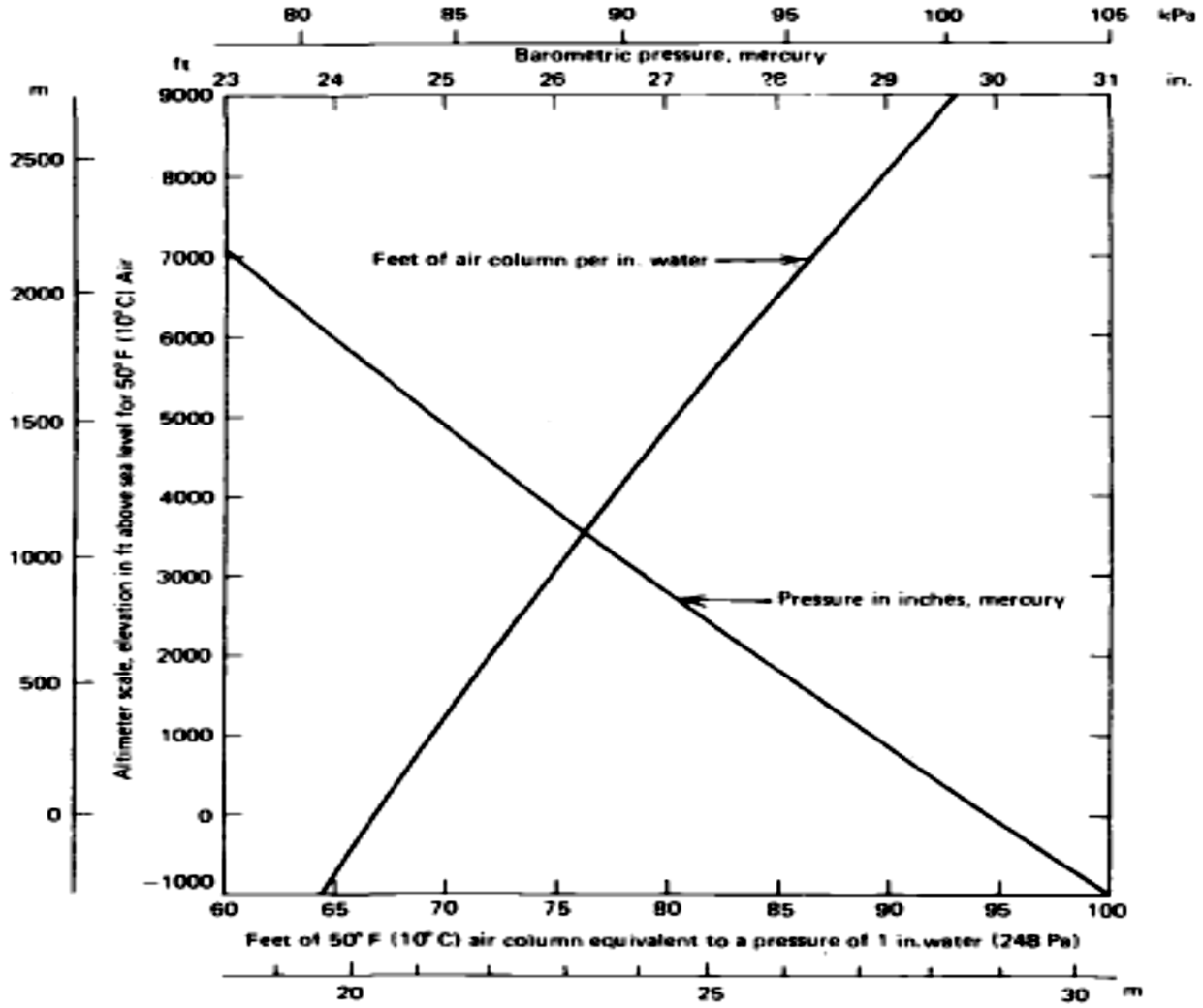

FIGURE 6.16 Chart for converting altimeter readings to heads, in in. mercury, and for converting altimeter differences to equivalent heads, in in. water. The curves are based on an altimeter with an offset of 1000 ft (304.8 m). If the altimeter reading is taken from an instrument without this offset, 1000 ft (304.8 m) must be subtracted from the reading before attempting to read the conversion factor CF from the graph. (After McElroy and Kingery, 1957. Based on Smithsonian Meteorological Table 51.)

TABLE 6.1 Relative Humidities for 30.0 in. Hg Barometric Pressure

Air temperature, t_d, °F	0.378 x p'_v	Depression of wet-bulb thermometer ($t_d - t_w$), °F																			
		0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0	6,5	7,0	7,5	8,0	8,5	9,0	9,5	10,0	10,5
20	0.039	92	85	77	70	62	55	48	40	33	26	19	12	5								
21	.041	92	85	78	71	63	56	49	42	35	28	21	15	8	1							
22	.043	93	86	78	71	65	58	51	44	37	31	24	17	11	4							
23	.045	93	86	79	72	66	59	52	46	39	33	26	20	14	7	1						
24	.047	93	87	80	73	67	60	54	47	41	35	29	22	16	10	4						
25	.049	94	87	81	74	68	62	55	49	43	37	31	25	19	13	7	1					
26	.051	94	87	81	75	69	63	57	51	45	39	33	27	21	16	10	4					
27	.054	94	88	82	76	70	64	58	52	47	41	35	29	24	18	13	7	2				
28	.057	94	88	82	76	71	65	59	54	48	43	37	32	26	21	15	10	5				
29	.059	94	88	83	77	72	66	60	55	50	44	39	34	28	23	18	13	8	3			
30	.062	94	89	83	78	73	67	62	56	51	46	41	36	31	26	21	16	11	6	1		
31	.065	94	89	84	78	73	68	63	58	52	47	42	37	33	28	23	18	13	8	4		
32	.068	95	89	84	79	74	69	64	59	54	49	44	39	35	30	25	20	16	11	7	2	
33	.071	95	90	85	80	75	70	65	60	56	51	46	41	37	32	27	23	18	14	9	5	0
34	.074	95	90	86	81	76	71	66	62	57	52	48	43	38	34	29	25	21	16	12	8	3
35	.077	95	91	86	81	77	72	67	63	58	54	49	45	40	36	32	27	23	19	14	10	6
36	.080	95	91	86	82	77	73	68	64	60	55	51	46	42	38	34	29	25	21	17	13	9
37	.083	95	91	87	83	78	74	69	65	61	57	53	48	44	40	36	31	27	23	19	15	11
38	.086	96	91	87	83	79	75	70	66	62	58	54	50	46	42	37	33	29	25	21	17	14
39	.090	96	92	87	83	79	75	71	67	63	59	55	51	47	43	39	35	31	27	24	20	16
40	.093	96	92	87	83	79	75	71	68	64	60	56	52	48	45	41	37	33	29	26	22	18
41	.097	96	92	88	84	80	76	72	69	65	61	57	54	50	46	42	39	35	31	28	24	20
42	.101	96	92	88	85	81	77	73	69	65	62	58	55	51	47	44	40	36	33	30	26	23
43	.105	96	92	88	85	81	77	73	70	66	63	59	55	52	48	45	42	38	35	31	28	25
44	.109	96	93	89	85	81	78	74	71	67	63	60	56	53	49	46	43	39	36	33	30	26
45	.113	96	93	89	86	82	78	74	71	67	64	61	57	54	51	47	44	41	38	34	31	28
46	.117	96	93	89	86	82	79	75	72	68	65	61	58	55	52	48	45	42	39	35	32	29
47	.122	96	93	89	86	82	79	75	72	69	66	62	59	56	53	49	46	43	40	37	34	31
48	.126	96	93	90	86	83	79	76	73	69	66	63	60	57	54	50	47	44	41	38	35	32
49	.131	96	93	90	86	83	80	76	73	70	67	64	61	57	54	51	48	45	42	39	36	34

50	.136	96	93	90	87	83	80	77	74	71	67	64	61	58	55	52	49	46	43	41	38	35
51	.141	97	94	90	87	84	81	78	75	71	68	65	62	59	56	53	50	47	45	42	39	36
52	.146	97	94	90	87	84	81	78	75	72	69	66	63	60	57	54	51	49	46	43	40	37
53	.152	97	94	90	87	84	81	78	75	72	69	66	63	61	58	55	52	50	47	44	41	39
54	.158	97	94	91	88	85	82	79	76	73	70	67	64	61	59	56	53	50	48	45	42	40
55	.163	97	94	91	88	85	82	79	76	73	70	68	65	62	59	57	54	51	49	46	43	41
56	.169	97	94	91	88	85	82	79	76	73	71	68	65	63	60	57	55	52	50	47	44	42
57	.176	97	94	91	88	85	82	80	77	74	71	69	66	63	61	58	55	53	50	48	45	43
58	.182	97	94	91	88	85	83	80	77	74	72	69	66	64	61	59	56	54	51	49	46	44
59	.189	97	94	91	89	86	83	80	78	75	72	70	67	65	62	59	57	55	52	49	47	45
60	.196	97	94	91	89	86	83	81	78	75	73	70	68	65	63	60	58	55	53	50	48	46
61	.203	97	94	92	89	86	84	81	78	76	73	71	68	65	63	61	58	56	54	51	49	47
62	.210	97	94	92	89	86	84	81	79	76	74	71	69	66	64	61	59	57	54	52	50	47
63	.217	97	95	92	89	87	84	82	79	77	74	71	69	67	64	62	60	57	55	53	50	48
64	.225	97	95	92	90	87	84	82	79	77	74	72	70	67	65	63	60	58	56	53	51	49
65	.233	97	95	92	90	87	85	82	80	77	75	72	70	68	66	63	61	59	56	54	52	50
66	.241	97	95	92	90	87	85	82	80	78	75	73	71	68	66	64	61	59	57	55	53	51
67	.250	97	95	92	90	87	85	83	80	78	75	73	71	69	66	64	62	60	58	56	53	51
68	.259	97	95	92	90	88	85	83	80	78	76	74	71	69	67	65	62	60	58	56	54	52
69	.263	97	95	93	90	88	85	83	81	79	76	74	72	70	67	65	63	61	59	57	55	53
70	.277	98	95	93	90	88	86	83	81	79	77	74	72	70	68	66	64	61	59	57	55	53
71	.286	98	95	93	90	88	86	84	81	79	77	75	72	70	68	66	64	62	60	58	56	54
72	.296	98	95	93	91	88	86	84	82	79	77	75	73	71	69	67	65	63	61	59	57	55
73	.306	98	95	93	91	88	86	84	82	80	78	75	73	71	69	67	65	63	61	59	57	55
74	.317	98	95	93	91	89	86	84	82	80	78	76	74	71	69	67	65	63	61	60	58	56
75	.328	98	96	93	91	89	86	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56
76	.339	98	96	93	91	89	87	84	82	80	78	76	74	72	70	68	66	64	62	61	59	57
77	.350	98	96	93	91	89	87	85	83	81	79	77	74	72	71	69	67	65	63	61	59	57
78	.362	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	62	60	58
79	.374	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	68	66	64	62	60	58
80	.387	98	96	94	91	89	87	85	83	81	79	77	75	74	72	70	68	66	64	62	61	59

Source: McElroy and Kingery (1957)