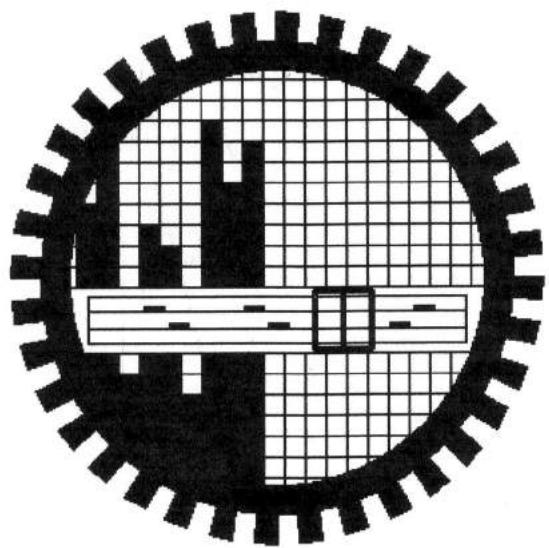


REFRIGERATION & AIR CONDITIONING DATA BOOK



**DEPARTMENT OF MECHANICAL ENGINEERING
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY**

1. Refrigerant 718 (Water/Steam) Properties of Saturated Liquid and Saturated Vapor

Temp., °C	Pres- sure, MPa	Density, kg/m³/kg		Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c_p , kJ/(kg·K)		Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, mN/m		Temp., °C	
		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	c_p/c_v	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	
0.01a	0.00061	999.8	205.99	0.00	2500.92	0.0000	9.1555	4.220	1.884	1.329	1402.	409.0	1791.2	9.22	561.0	17.07	75.65	0.01	
5.00	0.00087	999.9	147.01	21.02	2510.06	0.0763	9.0248	4.205	1.889	1.328	1426.	412.6	1518.3	9.34	570.5	17.34	74.94	5.00	
10.00	0.00123	999.7	106.30	42.02	2519.21	0.1511	8.8998	4.196	1.895	1.328	1447.	416.2	1306.0	9.46	580.0	17.62	74.22	10.00	
15.00	0.00171	999.1	77.875	62.98	2528.33	0.2245	8.7803	4.189	1.900	1.328	1466.	419.7	1137.6	9.59	589.3	17.92	73.49	15.00	
20.00	0.00234	998.2	57.757	83.91	2537.43	0.2965	8.6660	4.184	1.906	1.327	1482.	423.2	1001.6	9.73	598.4	18.23	72.74	20.00	
25.00	0.00317	997.0	43.337	104.83	2546.51	0.3672	8.5566	4.182	1.912	1.327	1497.	426.6	890.1	9.87	607.2	18.55	71.97	25.00	
30.00	0.00425	995.6	32.878	125.73	2555.55	0.4368	8.4520	4.180	1.918	1.327	1509.	430.0	797.4	10.01	615.5	18.89	71.19	30.00	
35.00	0.00563	994.0	25.205	146.63	2564.55	0.5051	8.3517	4.180	1.925	1.327	1520.	433.4	719.3	10.16	623.3	19.24	70.40	35.00	
40.00	0.00738	992.2	19.515	167.53	2573.51	0.5724	8.2555	4.180	1.931	1.327	1529.	436.7	653.0	10.31	630.6	19.60	69.60	40.00	
45.00	0.00959	990.2	15.252	188.43	2582.43	0.6386	8.1633	4.180	1.939	1.327	1536.	440.0	596.1	10.46	637.3	19.97	68.78	45.00	
50.00	0.01235	988.0	12.027	209.34	2591.29	0.7038	8.0748	4.182	1.947	1.328	1542.	443.2	546.8	10.62	643.6	20.36	67.94	50.00	
55.00	0.01576	985.7	9.5643	230.26	2600.09	0.7680	7.9898	4.183	1.955	1.328	1547.	446.4	504.0	10.77	649.2	20.77	67.10	55.00	
60.00	0.01995	983.2	7.6672	251.18	2608.83	0.8313	7.9081	4.185	1.965	1.328	1551.	449.5	466.4	10.93	654.3	21.19	66.24	60.00	
65.00	0.02504	980.5	6.1935	272.12	2617.50	0.8937	7.8296	4.187	1.975	1.329	1553.	452.6	433.2	11.10	659.0	21.62	65.37	65.00	
70.00	0.03120	977.7	5.0395	293.07	2626.10	0.9551	7.7540	4.190	1.986	1.330	1555.	455.6	403.9	11.26	663.1	22.07	64.48	70.00	
75.00	0.03860	974.8	4.1289	314.03	2634.60	1.0158	7.6812	4.193	1.999	1.331	1555.	458.5	377.7	11.43	666.8	22.53	63.58	75.00	
80.00	0.04741	971.8	3.4052	335.01	2643.02	1.0756	7.6111	4.197	2.012	1.332	1554.	461.4	354.3	11.59	670.0	23.01	62.67	80.00	
85.00	0.05787	968.6	2.8258	356.01	2651.33	1.1346	7.5434	4.201	2.027	1.333	1553.	464.2	333.3	11.76	672.8	23.51	61.75	85.00	
90.00	0.07018	965.3	2.3591	377.04	2659.53	1.1929	7.4781	4.205	2.043	1.334	1550.	466.9	314.4	11.93	675.3	24.02	60.82	90.00	
95.00	0.08461	961.9	1.9806	398.09	2667.61	1.2504	7.4151	4.210	2.061	1.335	1547.	469.6	297.3	12.10	677.3	24.55	59.87	95.00	
99.7b	-0.10133	958.4	1.6732	419.06	2675.53	1.3069	7.3544	4.216	2.080	1.337	1543.	472.2	281.8	12.27	679.1	25.09	58.92	99.97	
100.00	0.10142	958.3	1.6718	419.17	2675.57	1.3072	7.3541	4.216	2.080	1.337	1543.	472.2	281.7	12.27	679.1	25.10	58.91	100.00	
105.00	0.12090	954.7	1.4184	440.27	2683.39	1.3633	7.2952	4.222	2.101	1.339	1538.	474.7	267.6	12.44	680.5	25.66	57.94	105.00	
110.00	0.14338	950.9	1.2093	461.42	2691.06	1.4188	7.2381	4.228	2.124	1.341	1533.	477.1	254.7	12.61	681.7	26.24	56.96	110.00	
115.00	0.16918	947.1	1.0358	482.59	2698.58	1.4737	7.1828	4.236	2.150	1.343	1527.	479.5	242.9	12.78	682.6	26.85	55.97	115.00	
120.00	0.19867	943.1	0.89121	503.81	2705.93	1.5279	7.1291	4.244	2.177	1.346	1520.	481.7	232.1	12.96	683.2	27.47	54.97	120.00	
125.00	0.23224	939.0	0.77003	525.07	2713.10	1.5816	7.0770	4.252	2.207	1.349	1512.	483.9	222.1	13.13	683.6	28.11	53.96	125.00	
130.00	0.27028	934.8	0.66800	546.38	2720.08	1.6346	7.0264	4.261	2.239	1.352	1504.	486.0	212.9	13.30	683.7	28.76	52.93	130.00	
135.00	0.31323	930.5	0.58173	567.74	2726.87	1.6872	6.9772	4.272	2.274	1.355	1496.	487.9	204.4	13.47	683.6	29.44	51.90	135.00	
140.00	0.36154	926.1	0.50845	589.16	2733.44	1.7392	6.9293	4.283	2.311	1.359	1486.	489.8	196.5	13.65	683.3	30.14	50.86	140.00	
145.00	0.41568	921.6	0.44596	610.64	2739.80	1.7907	6.8826	4.294	2.351	1.363	1476.	491.6	189.2	13.82	682.8	30.86	49.80	145.00	
150.00	0.47616	917.0	0.39245	632.18	2745.93	1.8418	6.8371	4.307	2.394	1.368	1466.	493.3	182.5	13.99	682.0	31.60	48.74	150.00	
155.00	0.54350	912.3	0.34646	653.79	2751.81	1.8924	6.7926	4.321	2.440	1.373	1455.	494.8	176.1	14.16	681.1	32.35	47.67	155.00	
160.00	0.61823	907.4	0.30678	675.47	2757.44	1.9426	6.7491	4.335	2.488	1.379	1443.	496.3	170.2	14.34	680.0	33.13	46.59	160.00	
165.00	0.70093	902.5	0.27243	697.24	2762.81	1.9923	6.7066	4.351	2.540	1.385	1431.	497.6	164.7	14.51	678.6	33.93	45.50	165.00	
170.00	0.79219	897.5	0.24259	719.08	2767.90	2.0417	6.6650	4.368	2.594	1.392	1419.	498.9	159.6	14.68	677.0	34.75	44.41	170.00	
175.00	0.89260	892.3	0.21658	741.02	2772.71	2.0906	6.6241	4.386	2.652	1.399	1405.	500.0	154.7	14.85	675.3	35.59	43.30	175.00	
180.00	1.0028	887.0	0.19384	763.05	2777.21	2.1392	6.5840	4.405	2.713	1.407	1392.	501.0	150.1	15.03	673.3	36.45	42.19	180.00	
185.00	1.1235	881.6	0.17390	785.19	2781.41	2.1875	6.5447	4.425	2.777	1.416	1378.	501.9	145.8	15.20	671.1	37.33	41.07	185.00	
190.00	1.2552	876.1	0.15636	807.43	2785.28	2.2355	6.5059	4.447	2.844	1.425	1363.	502.7	141.8	15.37	668.8	38.24	39.95	190.00	
195.00	1.3988	870.4	0.14089	829.79	2788.82	2.2832	6.4678	4.471	2.915	1.436	1348.	503.4	137.9	15.54	666.1	39.16	38.81	195.00	
200.00	1.5549	864.7	0.12721	852.27	2792.01	2.3305	6.4302	4.496	2.990	1.447	1332.	503.9	134.3	15.71	663.3	40.11	37.67	200.00	
205.00	1.7243	858.8	0.11508	874.88	2794.83	2.3777	6.3930	4.523	3.068	1.459	1316.	504.3	130.9	15.89	660.3	41.09	36.53	205.00	
210.00	1.9077	852.7	0.10429	897.63	2797.27	2.4245	6.3563	4.551	3.150	1.472	1299.	504.6	127.6	16.06	657.0	42.09	35.38	210.00	
215.00	2.1058	846.5	0.09468	920.53	2799.32	2.4712	6.3200	4.582	3.237	1.486	1282.	504.8	124.5	16.24	653.4	43.11	34.23	215.00	
220.00	2.3196	840.2	0.08609	943.58	2800.95	2.5177	6.2840	4.615	3.329	1.501	1264.	504.8	121.5	16.41	649.7	44.17	33.07	220.00	
225.00	2.5497	833.7	0.07840	966.80	2802.15	2.5640	6.2483	4.650	3.426	1.518	1246.	504.6	118.7	16.59	645.6	45.26	31.90	225.00	
230.00	2.7971	827.1	0.07150	990.19	2802.90	2.6101	6.2128	4.688	3.528	1.536	1228.	504.4	116.0	16.76	641.3	46.38	30.74	230.00	
235.00	3.0625	820.3	0.06530	1013.77	2803.17	2.6561	6.1775	4.728	3.638	1.556	1209.	503.9	113.4	16.94	636.7	47.53	29.57	235.00	
240.00	3.3469	813.4	0.05970	1037.55	2802.96	2.7020	6.1423	4.772	3.754	1.578	1189.	503.3	110.9	17.12	631.8	48.73	28.39	240.00</	

Properties of Superheated Water Vapor

<i>T</i> °C	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 0.06 bar = 0.006 MPa								
(T _{sat} = 36.16°C)								
Sat.	23.739	2425.0	2567.4	8.3304	4.526	2473.0	2631.4	7.7158
80	27.132	2487.3	2650.1	8.5804	4.625	2483.7	2645.6	7.7564
120	30.219	2544.7	2726.0	8.7840	5.163	2542.4	2723.1	7.9644
160	33.302	2602.7	2802.5	8.9693	5.696	2601.2	2800.6	8.1519
200	36.383	2661.4	2879.7	9.1398	6.228	2660.4	2878.4	8.3237
240	39.462	2721.0	2957.8	9.2982	6.758	2720.3	2956.8	8.4828
280	42.540	2781.5	3036.8	9.4464	7.287	2780.9	3036.0	8.6314
320	45.618	2843.0	3116.7	9.5859	7.815	2842.5	3116.1	8.7712
360	48.696	2905.5	3197.7	9.7180	8.344	2905.1	3197.1	8.9034
400	51.774	2969.0	3279.6	9.8435	8.872	2968.6	3279.2	9.0291
440	54.851	3033.5	3362.6	9.9633	9.400	3033.2	3362.2	9.1490
500	59.467	3132.3	3489.1	10.1336	10.192	3132.1	3488.8	9.3194

<i>T</i> °C	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>T</i> °C	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 0.70 bar = 0.07 MPa									
(T _{sat} = 89.95°C)									
Sat.	2.365	2494.5	2660.0	7.4797	1.694	2506.1	2675.5	7.3594	
100	2.434	2509.7	2680.0	7.5341	1.696	2506.7	2676.2	7.3614	
120	2.571	2539.7	2719.6	7.6375	1.793	2537.3	2716.6	7.4668	
160	2.841	2599.4	2798.2	7.8279	1.984	2597.8	2796.2	7.6597	
200	3.108	2659.1	2876.7	8.0012	2.172	2658.1	2875.3	7.8343	
240	3.374	2719.3	2955.5	8.1611	2.359	2718.5	2954.5	7.9949	
280	3.640	2780.2	3035.0	8.3162	2.546	2779.6	3034.2	8.1445	
320	3.905	2842.0	3115.3	8.4504	2.732	2841.5	3114.6	8.2849	
360	4.170	2904.6	3196.5	8.5828	2.917	2904.2	3195.9	8.4175	
400	4.434	2968.2	3278.6	8.7086	3.103	2967.9	3278.2	8.5435	
440	4.698	3032.9	3361.8	8.8286	3.288	3032.6	3361.4	8.6636	
500	5.095	3131.8	3488.5	8.9991	3.565	3131.6	3488.1	8.8342	

<i>T</i> °C	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>T</i> °C	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 1.5 bar = 0.15 MPa									
(T _{sat} = 111.37°C)									
Sat.	1.159	2519.7	2693.6	7.2233	0.606	2543.6	2725.3	6.9919	
120	1.188	2533.3	2711.4	7.2693	0.651	2587.1	2782.3	7.1276	
160	1.317	2595.2	2792.8	7.4665	0.716	2650.7	2865.5	7.3115	
200	1.444	2656.2	2872.9	7.6433	0.781	2713.1	2947.3	7.4774	
240	1.570	2717.2	2952.7	7.8052	0.844	2775.4	3028.6	7.6299	
280	1.695	2778.6	3032.8	7.9555	0.907	2838.1	3110.1	7.7722	
320	1.819	2840.6	3113.5	8.0964	0.969	2901.4	3192.2	7.9061	
360	1.943	2903.5	3195.0	8.2293	1.032	2965.6	3275.0	8.0330	
400	2.067	2967.3	3277.4	8.3555	1.094	3030.6	3358.7	8.1538	
440	2.191	3032.1	3360.7	8.4757	1.187	3130.0	3486.0	8.3251	
500	2.376	3131.2	3487.6	8.6466	1.341	3300.8	3703.2	8.5892	
600	2.685	3301.7	3704.3	8.9101					

<i>T</i> °C	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 5.0 bar = 0.50 MPa (<i>T</i> _{sat} = 151.86°C)								
<i>p</i> = 7.0 bar = 0.70 MPa (<i>T</i> _{sat} = 164.97°C)								
Sat.	0.3749	2561.2	2748.7	6.8213	0.2729	2572.5	2763.5	6.7080
180	0.4045	2609.7	2812.0	6.9656	0.2847	2599.8	2799.1	6.7880
200	0.4249	2642.9	2855.4	7.0592	0.2999	2634.8	2844.8	6.8865
240	0.4646	2707.6	2939.9	7.2307	0.3292	2701.8	2932.2	7.0641
280	0.5034	2771.2	3022.9	7.3865	0.3574	2766.9	3017.1	7.2233
320	0.5416	2834.7	3105.6	7.5308	0.3852	2831.3	3100.9	7.3697
360	0.5796	2898.7	3188.4	7.6660	0.4126	2895.8	3184.7	7.5063
400	0.6173	2963.2	3271.9	7.7938	0.4397	2960.9	3268.7	7.6350
440	0.6548	3028.6	3356.0	7.9152	0.4667	3026.6	3353.3	7.7571
500	0.7109	3128.4	3483.9	8.0873	0.5070	3126.8	3481.7	7.9299
600	0.8041	3299.6	3701.7	8.3522	0.5738	3298.5	3700.2	8.1956
700	0.8969	3477.5	3925.9	8.5952	0.6403	3476.6	3924.8	8.4391

<i>T</i> °C	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>T</i> °C	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 10.0 bar = 1.0 MPa (<i>T</i> _{sat} = 179.91°C)									
<i>p</i> = 15.0 bar = 1.5 MPa (<i>T</i> _{sat} = 198.32°C)									
Sat.	0.1944	2583.6	2778.1	6.5865	0.1318	2594.5	2792.2	6.4448	
200	0.2060	2621.9	2827.9	6.6940	0.1325	2598.1	2796.8	6.4546	
240	0.2275	2692.9	2920.4	6.8817	0.1483	2676.9	2899.3	6.6628	
280	0.2480	2760.2	3008.2	7.0465	0.1627	2748.6	2992.7	6.8381	
320	0.2678	2826.1	3093.9	7.1962	0.1765	2817.1	3081.9	6.9938	
360	0.2873	2891.6	3178.9	7.3349	0.1899	2884.4	3169.2	7.1363	
400	0.3066	2957.3	3263.9	7.4651	0.2030	2951.3	3255.8	7.2690	
440	0.3257	3023.6	3349.3	7.5883	0.2160	3018.5	3342.5	7.3940	
500	0.3541	3124.4	3478.5	7.7622	0.2352	3120.3	3473.1	7.5698	
540	0.3729	3192.6	3565.6	7.8720	0.2478	3189.1	3560.9	7.6805	
600	0.4011	3296.8	3697.9	8.0290	0.2668	3293.9	3694.0	7.8385	
640	0.4198	3367.4	3787.2	8.1290	0.2793	3364.8	3783.8	7.9391	

<i>T</i> °C	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>T</i> °C	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 20.0 bar = 2.0 MPa (<i>T</i> _{sat} = 212.42°C)									
<i>p</i> = 30.0 bar = 3.0 MPa (<i>T</i> _{sat} = 233.90°C)									
Sat.	0.0996	2600.3	2799.5	6.3409	0.0667	2604.1	2804.2	6.1869	
240	0.1085	2659.6	2876.5	6.4952	0.0682	2619.7	2824.3	6.2265	
280	0.1200	2736.4	2976.4	6.6828	0.0771	2709.9	2941.3	6.4462	
320	0.1308	2807.9	3069.5	6.8452	0.0850	2788.4	3043.4	6.6245	
360	0.1411	2877.0	3159.3	6.9917	0.0923	2861.7	3138.7	6.7801	
400	0.1512	2945.2	3247.6	7.1271	0.0994	2932.8	3230.9	6.9212	
440	0.1611	3013.4	3335.5	7.2540	0.1062	3002.9	3321.5	7.0520	
500	0.1757	3116.2	3467.6	7.4317	0.1162	3108.0	3456.5	7.2338	
540	0.1853	3185.6	3556.1	7.5434	0.1227	3178.4	3546.6	7.3474	
600	0.1996	3290.9	3690.1	7.7024	0.1324	3285.0	3682.3	7.5085	
640	0.2091	3362.2	3780.4	7.8035	0.1388	3357.0	3773.5	7.6106	
700	0.2232	3470.9	3917.4	7.9487	0.1484	3466.5	3911.7	7.7571	

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
$p = 40 \text{ bar} = 4.0 \text{ MPa}$								
$(T_{\text{sat}} = 250.4^\circ\text{C})$								
Sat.	0.04978	2602.3	2801.4	6.0701	0.03244	2589.7	2784.3	5.8892
280	0.05546	2680.0	2901.8	6.2568	0.03317	2605.2	2804.2	5.9252
320	0.06199	2767.4	3015.4	6.4553	0.03876	2720.0	2952.6	6.1846
360	0.06788	2845.7	3117.2	6.6215	0.04331	2811.2	3071.1	6.3782
400	0.07341	2919.9	3213.6	6.7690	0.04739	2892.9	3177.2	6.5408
440	0.07872	2992.2	3307.1	6.9041	0.05122	2970.0	3277.3	6.6853
500	0.08643	3099.5	3445.3	7.0901	0.05665	3082.2	3422.2	6.8803
540	0.09145	3171.1	3536.9	7.2056	0.06015	3156.1	3517.0	6.9999
600	0.09885	3279.1	3674.4	7.3688	0.06525	3266.9	3658.4	7.1677
640	0.1037	3351.8	3766.6	7.4720	0.06859	3341.0	3752.6	7.2731
700	0.1110	3462.1	3905.9	7.6198	0.07352	3453.1	3894.1	7.4234
740	0.1157	3536.6	3999.6	7.7141	0.07677	3528.3	3989.2	7.5190

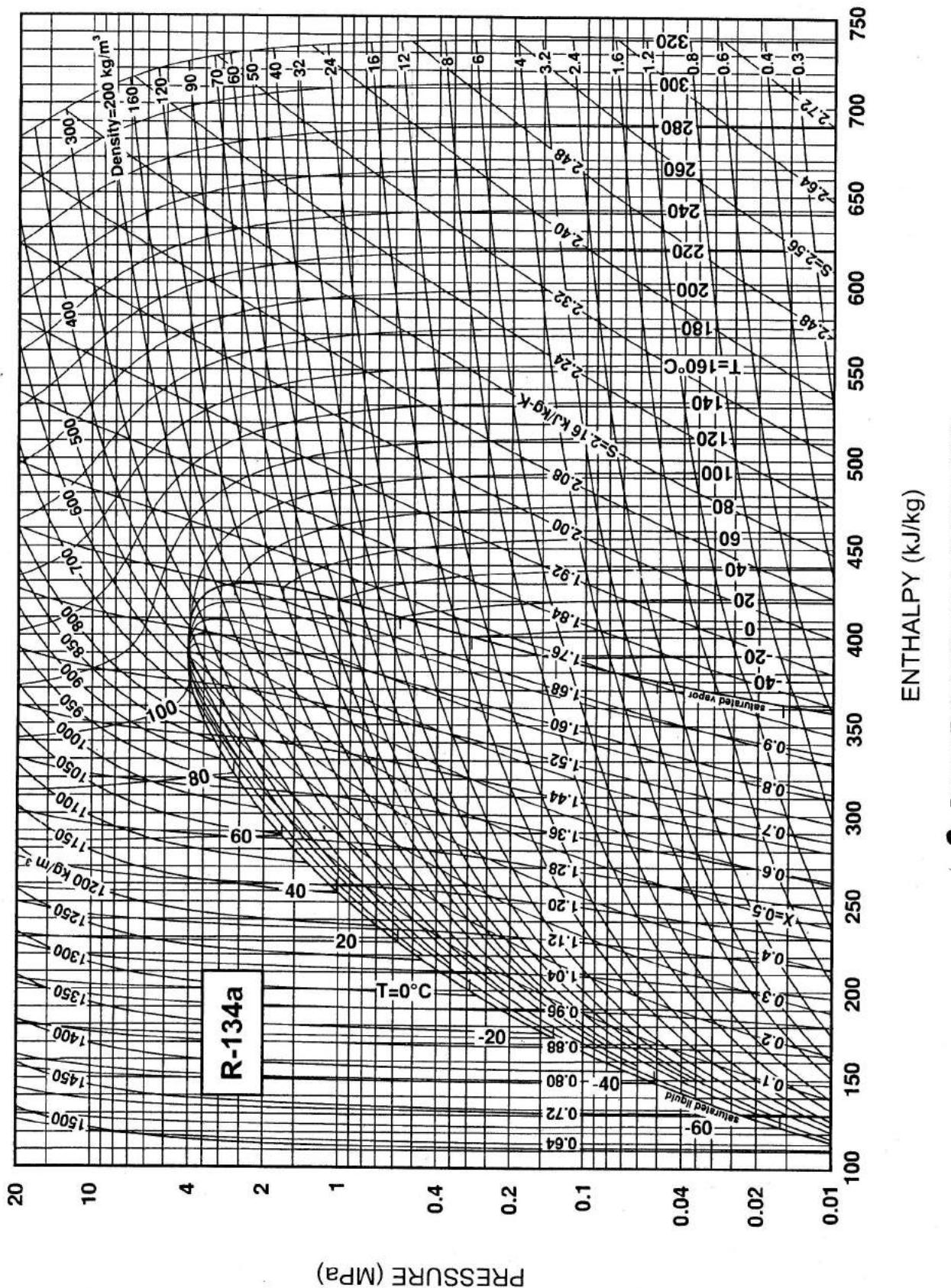
$p = 80 \text{ bar} = 8.0 \text{ MPa}$ ($T_{\text{sat}} = 295.06^\circ\text{C}$)				$p = 100 \text{ bar} = 10.0 \text{ MPa}$ ($T_{\text{sat}} = 311.06^\circ\text{C}$)			
0.02352	2569.8	2758.0	5.7432	0.01803	2544.4	2724.7	5.6141
0.02682	2662.7	2877.2	5.9489	0.01925	2588.8	2781.3	5.7103
0.03089	2772.7	3019.8	6.1819	0.02331	2729.1	2962.1	6.0060
0.03432	2863.8	3138.3	6.3634	0.02641	2832.4	3096.5	6.2120
0.03742	2946.7	3246.1	6.5190	0.02911	2922.1	3213.2	6.3805
0.04034	3025.7	3348.4	6.6586	0.03160	3005.4	3321.4	6.5282
0.04313	3102.7	3447.7	6.7871	0.03394	3085.6	3425.1	6.6622
0.04582	3178.7	3545.3	6.9072	0.03619	3164.1	3526.0	6.7864
0.04845	3254.4	3642.0	7.0206	0.03837	3241.7	3625.3	6.9029
0.05102	3330.1	3738.3	7.1283	0.04048	3318.9	3723.7	7.0131
0.05481	3443.9	3882.4	7.2812	0.04358	3434.7	3870.5	7.1687
0.05729	3520.4	3978.7	7.3782	0.04560	3512.1	3968.1	7.2670

$p = 120 \text{ bar} = 12.0 \text{ MPa}$ ($T_{\text{sat}} = 324.75^\circ\text{C}$)				$p = 140 \text{ bar} = 14.0 \text{ MPa}$ ($T_{\text{sat}} = 336.75^\circ\text{C}$)			
0.01426	2513.7	2684.9	5.4924	0.01149	2476.8	2637.6	5.3717
0.01811	2678.4	2895.7	5.8361	0.01422	2617.4	2816.5	5.6602
0.02108	2798.3	3051.3	6.0747	0.01722	2760.9	3001.9	5.9448
0.02355	2896.1	3178.7	6.2586	0.01954	2868.6	3142.2	6.1474
0.02576	2984.4	3293.5	6.4154	0.02157	2962.5	3264.5	6.3143
0.02781	3068.0	3401.8	6.5555	0.02343	3049.8	3377.8	6.4610
0.02977	3149.0	3506.2	6.6840	0.02517	3133.6	3486.0	6.5941
0.03164	3228.7	3608.3	6.8037	0.02683	3215.4	3591.1	6.7172
0.03345	3307.5	3709.0	6.9164	0.02843	3296.0	3694.1	6.8326
0.03610	3425.2	3858.4	7.0749	0.03075	3415.7	3846.2	6.9939
0.03781	3503.7	3957.4	7.1746	0.03225	3495.2	3946.7	7.0952

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg · K
$p = 160 \text{ bar} = 16.0 \text{ MPa}$ ($T_{\text{sat}} = 347.44^\circ\text{C}$)								
$p = 180 \text{ bar} = 18.0 \text{ MPa}$ ($T_{\text{sat}} = 357.06^\circ\text{C}$)								
Sat.	0.00931	2431.7	2580.6	5.2455	0.00749	2374.3	2509.1	5.1044
360	0.01105	2539.0	2715.8	5.4614	0.00809	2418.9	2564.5	5.1922
400	0.01426	2719.4	2947.6	5.8175	0.01190	2672.8	2887.0	5.6887
440	0.01652	2839.4	3103.7	6.0429	0.01414	2808.2	3062.8	5.9428
480	0.01842	2939.7	3234.4	6.2215	0.01596	2915.9	3203.2	6.1345
520	0.02013	3031.1	3353.3	6.3752	0.01757	3011.8	3378.0	6.2960
560	0.02172	3117.8	3465.4	6.5132	0.01904	3101.7	3444.4	6.4392
600	0.02323	3201.8	3573.5	6.6399	0.02042	3188.0	3555.6	6.5696
640	0.02467	3284.2	3678.9	6.7580	0.02174	3272.3	3663.6	6.6905
700	0.02674	3406.0	3833.9	6.9224	0.02362	3396.3	3821.5	6.8580
740	0.02808	3486.7	3935.9	7.0251	0.02483	3478.0	3925.0	6.9623

$p = 200 \text{ bar} = 20.0 \text{ MPa}$ ($T_{\text{sat}} = 365.81^\circ\text{C}$)				$p = 240 \text{ bar} = 24.0 \text{ MPa}$				
Sat.	0.00583	2293.0	2409.7	4.9269	0.00673	2477.8	2639.4	5.2393
400	0.00994	2619.3	2818.1	5.5540	0.00929	2700.6	2923.4	5.6506
440	0.01222	2774.9	3019.4	5.8450	0.01100	2838.3	3102.3	5.8950
480	0.01399	2891.2	3170.8	6.0518	0.01241	2950.5	3248.5	6.0842
520	0.01551	2992.0	3302.2	6.2218	0.01366	3051.1	3379.0	6.2448
560	0.01689	3085.2	3423.0	6.3705	0.01481	3145.2	3500.7	6.3875
600	0.01818	3174.0	3537.6	6.5048	0.01588	3235.5	3616.7	6.5174
640	0.01940	3260.2	3648.1	6.6286	0.01739	3366.4	3783.8	6.6947
700	0.02113	3386.4	3809.0	6.7993	0.01835	3451.7	3892.1	6.8038
740	0.02224	3469.3	3914.1	6.9052	0.01974	3578.0	4051.6	6.9567
800	0.02385	3592.7	4069.7	7.0544				

$p = 280 \text{ bar} = 28.0 \text{ MPa}$				$p = 320 \text{ bar} = 32.0 \text{ MPa}$				
400	0.00383	2223.5	2330.7	4.7494	0.00236	1980.4	2055.9	4.3239
440	0.00712	2613.2	2812.6	5.4494	0.00544	2509.0	2683.0	5.2327
480	0.00885	2780.8	3028.5	5.7446	0.00722	2718.1	2949.2	5.5968
520	0.01020	2906.8	3192.3	5.9566	0.00853	2860.7	3133.7	5.8357
560	0.01136	3015.7	3333.7	6.1307	0.00963	2979.0	3287.2	6.0246
600	0.01241	3115.6	3463.0	6.2823	0.01061	3085.3	3424.6	6.1858
640	0.01338	3210.3	3584.8	6.4187	0.01150	3184.5	3552.5	6.3290
700	0.01473	3346.1	3758.4	6.6029	0.01273	3325.4	3732.8	6.5203
740	0.01558	3433.9	3870.0	6.7153	0.01350	3415.9	3847.8	6.6361
800	0.01680	3563.1	4033.4	6.8720	0.01460	3548.0	4015.1	6.7966
900	0.01873	3774.3	4298.8	7.1084	0.01633	3762.7	4285.1	7.0372



2. Pressure-Enthalpy Diagram for Refrigerant 134a

B Refrigerant 134a (1,1,1,2-Tetrafluoroethane) Properties of Saturated Liquid and Saturated Vapor

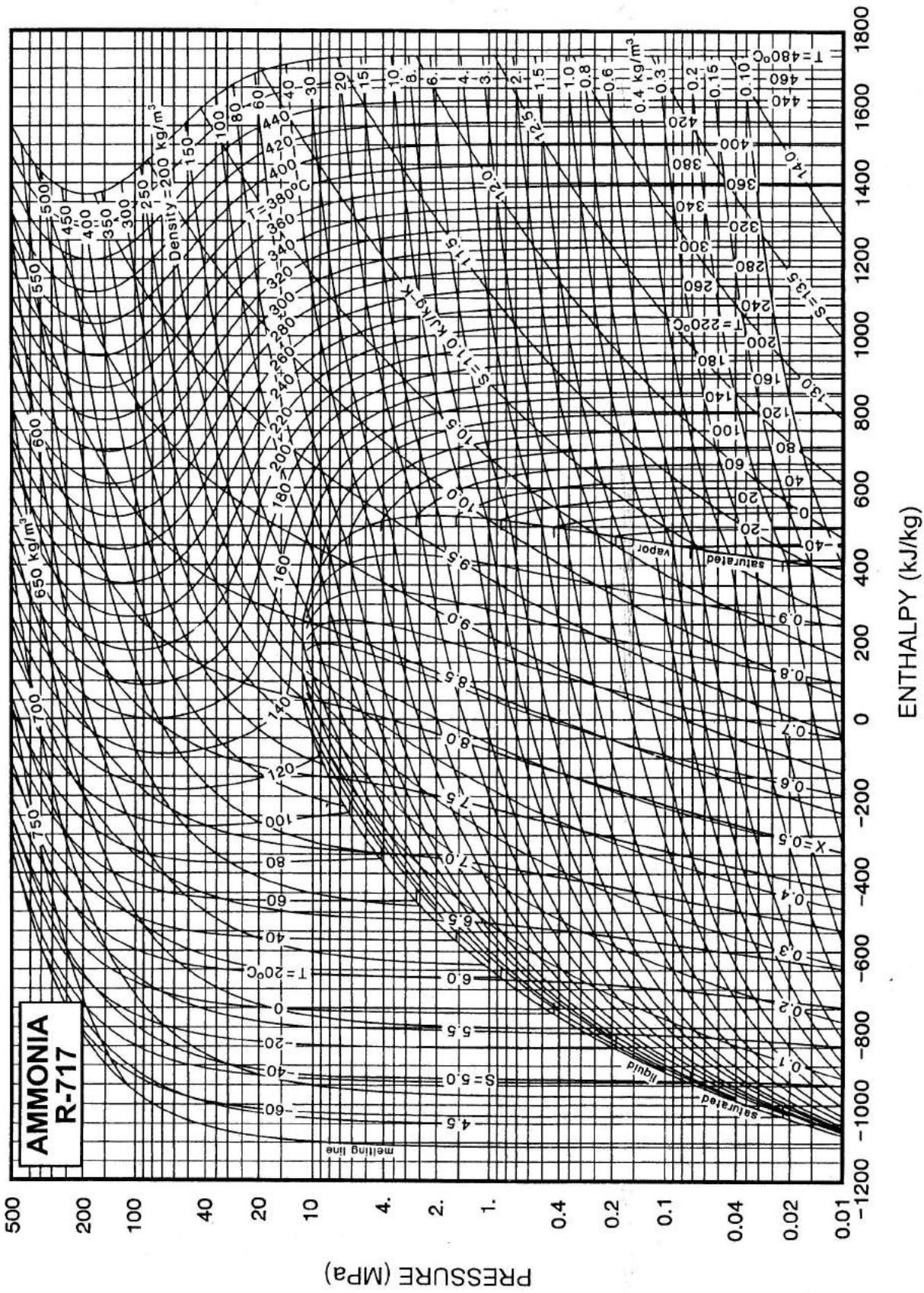
Temp., °C	Pres- sure, MPa	Density, Volume, kg/m ³ , m ³ /kg		Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat <i>c_p</i> , kJ/(kg·K)		Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, Temp., mN/m, °C		
		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	<i>c_p</i> / <i>c_v</i>	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	b	c	
-103.30a	0.00039	1591.1	35.496	71.46	334.94	0.4126	1.9639	1.184	0.585	1.164	1120.	126.8	2175.	6.46	145.2	3.08	28.07	-103.30
-100.00	0.00056	1582.4	25.193	75.36	336.85	0.4354	1.9456	1.184	0.593	1.162	1103.	127.9	1893.	6.60	143.2	3.34	27.50	-100.00
-90.00	0.00152	1555.8	9.7698	87.23	342.76	0.5020	1.8972	1.189	0.617	1.156	1052.	131.0	1339.	7.03	137.3	4.15	25.79	-90.00
-80.00	0.00367	1529.0	4.2682	99.16	348.83	0.5054	1.8580	1.198	0.642	1.151	1002.	134.0	1018.	7.46	131.5	4.95	24.10	-80.00
-70.00	0.00798	1501.9	2.0590	111.20	355.02	0.6262	1.8264	1.210	0.667	1.148	952.	136.8	809.2	7.89	126.0	5.75	22.44	-70.00
-60.00	0.01591	1474.3	1.0790	123.36	361.31	0.6846	1.8010	1.223	0.692	1.146	903.	139.4	663.1	8.30	120.7	6.56	20.80	-60.00
-50.00	0.02945	1446.3	0.60620	135.67	367.65	0.7410	1.7806	1.238	0.720	1.146	855.	141.7	555.1	8.72	115.6	7.36	19.18	-50.00
-40.00	0.05121	1417.7	0.36108	148.14	374.00	0.7956	1.7643	1.255	0.749	1.148	807.	143.6	472.2	9.12	110.6	8.17	17.60	-40.00
-30.00	0.08438	1388.4	0.22394	160.79	380.32	0.8486	1.7515	1.273	0.781	1.152	760.	145.2	406.4	9.52	105.8	8.99	16.04	-30.00
-28.00	0.09270	1382.4	0.20680	163.34	381.57	0.8591	1.7492	1.277	0.788	1.153	751.	145.4	394.9	9.60	104.8	9.15	15.73	-28.00
-26.07b	0.10133	1376.7	0.19018	165.81	382.78	0.8690	1.7472	1.281	0.794	1.154	742.	145.7	384.2	9.68	103.9	9.31	15.44	-26.07
-26.00	0.10167	1376.5	0.18958	165.90	382.82	0.8694	1.7471	1.281	0.794	1.154	742.	145.7	383.8	9.68	103.9	9.32	15.43	-26.00
-24.00	0.11130	1370.4	0.17407	168.47	384.07	0.8798	1.7451	1.285	0.801	1.155	732.	145.9	373.1	9.77	102.9	9.48	15.12	-24.00
-22.00	0.12165	1364.4	0.16006	171.05	385.32	0.8900	1.7432	1.289	0.809	1.156	723.	146.1	362.9	9.85	102.0	9.65	14.82	-22.00
-20.00	0.13273	1358.3	0.14739	173.64	386.55	0.9002	1.7413	1.293	0.816	1.158	714.	146.3	353.0	9.92	101.1	9.82	14.51	-20.00
-18.00	0.14460	1352.1	0.13592	176.23	387.79	0.9104	1.7396	1.297	0.823	1.159	705.	146.4	343.5	10.01	100.1	9.98	14.21	-18.00
-16.00	0.15728	1345.9	0.12551	178.83	389.02	0.9205	1.7379	1.302	0.831	1.161	695.	146.6	334.3	10.09	99.2	10.15	13.91	-16.00
-14.00	0.17082	1339.7	0.11605	181.44	390.24	0.9306	1.7363	1.306	0.838	1.163	686.	146.7	325.4	10.17	98.3	10.32	13.61	-14.00
-12.00	0.18524	1333.4	0.10744	184.07	391.46	0.9407	1.7348	1.311	0.846	1.165	677.	146.8	316.9	10.25	97.4	10.49	13.32	-12.00
-10.00	0.20060	1327.1	0.09959	186.70	392.66	0.9506	1.7334	1.316	0.854	1.167	668.	146.9	308.6	10.33	96.5	10.66	13.02	-10.00
-8.00	0.21693	1320.8	0.09242	189.34	393.87	0.9606	1.7320	1.320	0.863	1.169	658.	146.9	300.6	10.41	95.6	10.83	12.72	-8.00
-6.00	0.23428	1314.3	0.08587	191.99	395.06	0.9705	1.7307	1.325	0.871	1.171	649.	147.0	292.9	10.49	94.7	11.00	12.43	-6.00
-4.00	0.25268	1307.9	0.07987	194.65	396.25	0.9804	1.7294	1.330	0.880	1.174	640.	147.0	285.4	10.57	93.8	11.17	12.14	-4.00
-2.00	0.27217	1301.4	0.07436	197.32	397.43	0.9902	1.7282	1.336	0.888	1.176	631.	147.0	278.1	10.65	92.9	11.34	11.85	-2.00
0.00	0.29280	1294.8	0.06931	200.00	398.60	1.0000	1.7271	1.341	0.897	1.179	622.	146.9	271.1	10.73	92.0	11.51	11.56	0.00
2.00	0.31462	1288.1	0.06466	202.69	399.77	1.0098	1.7260	1.347	0.906	1.182	612.	146.9	264.3	10.81	91.1	11.69	11.27	2.00
4.00	0.33766	1281.4	0.06039	205.40	400.92	1.0195	1.7250	1.352	0.916	1.185	603.	146.8	257.6	10.90	90.2	11.86	10.99	4.00
6.00	0.36198	1274.7	0.05644	208.11	402.06	1.0292	1.7240	1.358	0.925	1.189	594.	146.7	251.2	10.98	89.4	12.04	10.70	6.00
8.00	0.38761	1267.9	0.05280	210.84	403.20	1.0388	1.7230	1.364	0.935	1.192	585.	146.5	244.9	11.06	88.5	12.22	10.42	8.00
10.00	0.41461	1261.0	0.04944	213.58	404.32	1.0485	1.7221	1.370	0.945	1.196	576.	146.4	238.8	11.15	87.6	12.40	10.14	10.00
12.00	0.44301	1254.0	0.04633	216.33	405.43	1.0581	1.7212	1.377	0.956	1.200	566.	146.2	232.9	11.23	86.7	12.58	9.86	12.00
14.00	0.47288	1246.9	0.04345	219.09	406.53	1.0677	1.7204	1.383	0.967	1.204	557.	146.0	227.1	11.32	85.9	12.77	9.58	14.00
16.00	0.50425	1239.8	0.04078	221.87	407.61	1.0772	1.7196	1.390	0.978	1.209	548.	145.7	221.5	11.40	85.0	12.95	9.30	16.00
18.00	0.53718	1232.6	0.03830	224.66	408.69	1.0867	1.7188	1.397	0.989	1.214	539.	145.5	216.0	11.49	84.1	13.14	9.03	18.00
20.00	0.57171	1225.3	0.03600	227.47	409.75	1.0962	1.7180	1.405	1.001	1.219	530.	145.1	210.7	11.58	83.3	13.33	8.76	20.00
22.00	0.60789	1218.0	0.03385	230.29	410.79	1.1057	1.7173	1.413	1.013	1.224	520.	144.8	205.5	11.67	82.4	13.53	8.48	22.00
24.00	0.64578	1210.5	0.03186	233.12	411.82	1.1152	1.7166	1.421	1.025	1.230	511.	144.5	200.4	11.76	81.6	13.72	8.21	24.00
26.00	0.68543	1202.9	0.03000	235.97	412.84	1.1246	1.7159	1.429	1.038	1.236	502.	144.1	195.4	11.85	80.7	13.92	7.95	26.00
28.00	0.72688	1195.2	0.02826	238.84	413.84	1.1341	1.7152	1.437	1.052	1.243	493.	143.6	190.5	11.95	79.8	14.13	7.68	28.00
30.00	0.77020	1187.5	0.02664	241.72	414.82	1.1435	1.7145	1.446	1.065	1.249	483.	143.2	185.8	12.04	79.0	14.33	7.42	30.00
32.00	0.81543	1179.6	0.02513	244.62	415.78	1.1529	1.7138	1.456	1.080	1.257	474.	142.7	181.1	12.14	78.1	14.54	7.15	32.00
34.00	0.86263	1171.6	0.02371	247.54	416.72	1.1623	1.7131	1.466	1.095	1.265	465.	142.1	176.6	12.24	77.3	14.76	6.89	34.00
36.00	0.91185	1163.4	0.02238	250.48	417.65	1.1717	1.7124	1.476	1.111	1.273	455.	141.6	172.1	12.34	76.4	14.98	6.64	36.00
38.00	0.96315	1155.1	0.02113	253.43	418.55	1.1811	1.7118	1.487	1.127	1.282	446.	141.0	167.7	12.44	75.6	15.21	6.38	38.00
40.00	1.0166	1146.7	0.01997	256.41	419.43	1.1905	1.7111	1.498	1.145	1.292	436.	140.3	163.4	12.55	74.7	15.44	6.13	40.00
42.00	1.0722	1138.2	0.01887	259.41	420.28	1.1999	1.7103	1.510	1.163	1.303	427.	139.7	159.2	12.65	73.9	15.68	5.88	42.00
44.00	1.1301	1129.5	0.01784	262.43	421.11	1.2092	1.7096	1.523	1.182	1.314	418.	138.9	155.1	12.76	73.0	15.93	5.63	44.00
46.00	1.1903	1120.6	0.01687	265.47	421.92	1.2186	1.7089	1.537	1.202	1.326	408.	138.2	151.0	12.88	72.1	16.18	5.38	46.00
48.00	1.2529	1111.5	0.01595	268.53	422.69	1.2280	1.7081	1.551	1.223	1.339	399.	137.4	147.0	13.00	71.3	16.45	5.13	48.00
50.00	1.3179	1102.3	0.01509	271.62	423.44	1.2375	1.7072	1.566	1.246	1.354	389.	136.6	143.1	13.12	70.4	16.72	4.89	50.00
52.00	1.3854	1092.9	0.01428	274.74	424.15	1.2469	1.7064	1.582	1.270	1.369	379.	135.7	139.2					

Refrigerant 134a Properties of Superheated Vapor

Pressure = 0.101325 MPa					Pressure = 0.200 MPa					Pressure = 0.400 MPa				
Saturation temperature = -26.07°C					Saturation temperature = -10.07°C					Saturation temperature = 8.94°C				
Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s
Saturated					Saturated					Saturated				
Liquid	1374.34	166.07	0.8701	747.1	Liquid	1325.78	186.69	0.9506	672.8	Liquid	1263.84	212.08	1.0432	583.8
Vapor	5.26	382.90	1.7476	145.7	Vapor	10.01	392.71	1.7337	146.9	Vapor	19.52	403.80	1.7229	146.6
-20.00	5.11	387.68	1.7667	147.8	-10.00	10.01	392.77	1.7339	147.0	10.00	19.41	404.78	1.7263	147.0
-10.00	4.89	395.65	1.7976	151.0	0.00	9.54	401.21	1.7654	150.6	20.00	18.45	414.00	1.7583	151.2
0.00	4.69	403.74	1.8278	154.2	10.00	9.13	409.73	1.7961	154.0	30.00	17.61	423.21	1.7892	155.0
10.00	4.50	411.97	1.8574	157.2	20.00	8.76	418.35	1.8260	157.3	40.00	16.87	432.46	1.8192	158.6
20.00	4.34	420.34	1.8864	160.1	30.00	8.42	427.07	1.8552	160.4	50.00	16.20	441.76	1.8485	162.0
30.00	4.18	428.85	1.9150	162.9	40.00	8.12	435.90	1.8839	163.4	60.00	15.60	451.15	1.8771	165.3
40.00	4.04	437.52	1.9431	165.7	50.00	7.83	444.87	1.9121	166.3	70.00	15.05	460.63	1.9051	168.4
50.00	3.91	446.33	1.9708	168.4	60.00	7.57	453.97	1.9398	169.2	80.00	14.54	470.21	1.9326	171.4
60.00	3.78	455.30	1.9981	171.0	70.00	7.33	463.20	1.9671	171.9	90.00	14.08	479.91	1.9597	174.3
70.00	3.67	464.43	2.0251	173.6	80.00	7.11	472.57	1.9940	174.6	100.00	13.65	489.72	1.9864	177.1
80.00	3.56	473.70	2.0518	176.1	90.00	6.89	482.08	2.0206	177.2	110.00	13.24	499.65	2.0126	179.8
90.00	3.46	483.13	2.0781	178.6	100.00	6.70	491.74	2.0468	179.7	120.00	12.87	509.71	2.0386	182.4
100.00	3.36	492.71	2.1041	181.0	110.00	6.51	501.53	2.0727	182.2	130.00	12.51	519.90	2.0641	185.0
110.00	3.27	502.44	2.1298	183.4	120.00	6.34	511.47	2.0983	184.7	140.00	12.18	530.21	2.0894	187.5
120.00	3.19	512.32	2.1553	185.7	130.00	6.17	521.55	2.1236	187.1	150.00	11.87	540.66	2.1144	190.0
130.00	3.11	522.35	2.1805	188.1	140.00	6.01	531.76	2.1486	189.4					
140.00	3.03	532.52	2.2054	190.3	150.00	5.87	542.12	2.1734	191.7					
Pressure = 0.600 MPa					Pressure = 0.800 MPa					Pressure = 1.000 MPa				
Saturation temperature = 21.58°C					Saturation temperature = 31.33°C					Saturation temperature = 39.39°C				
Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s
Saturated					Saturated					Saturated				
Liquid	1219.08	229.62	1.1035	524.0	Liquid	1181.92	243.58	1.1495	477.4	Liquid	1149.06	255.44	1.1874	438.6
Vapor	29.13	410.67	1.7178	145.0	Vapor	38.99	415.58	1.7144	142.9	Vapor	49.16	419.31	1.7117	140.6
-30.00	27.79	418.97	1.7455	149.0	40.00	36.98	424.61	1.7437	147.6	40.00	48.95	419.99	1.7139	141.0
-40.00	26.41	428.72	1.7772	153.4	50.00	35.03	434.85	1.7758	152.4	50.00	45.86	430.91	1.7482	146.9
-50.00	25.21	438.44	1.8077	157.4	60.00	33.36	444.98	1.8067	156.8	60.00	43.34	441.56	1.7807	152.0
-60.00	24.16	448.16	1.8374	161.2	70.00	31.90	455.08	1.8366	160.8	70.00	41.21	452.05	1.8117	156.7
-70.00	23.22	457.93	1.8662	164.7	80.00	30.62	465.17	1.8656	164.6	80.00	39.36	462.47	1.8416	160.9
-80.00	22.37	467.75	1.8944	168.0	90.00	29.46	475.30	1.8939	168.1	90.00	37.74	472.86	1.8706	164.9
-90.00	21.59	477.65	1.9221	171.2	100.00	28.41	485.49	1.9215	171.5	100.00	36.29	483.26	1.8989	168.6
-100.00	20.88	487.64	1.9492	174.3	110.00	27.46	495.74	1.9486	174.7	110.00	34.99	493.69	1.9265	172.1
-110.00	20.22	497.72	1.9759	177.3	120.00	26.58	506.07	1.9753	177.8	120.00	33.80	504.19	1.9535	175.4
-120.00	19.61	507.92	2.0022	180.1	130.00	25.77	516.50	2.0015	180.8	130.00	32.71	514.75	1.9800	178.6
-130.00	19.04	518.22	2.0280	182.9	140.00	25.01	527.03	2.0272	183.7	140.00	31.70	525.39	2.0061	181.7
-140.00	18.51	528.63	2.0536	185.6	150.00	24.31	537.66	2.0527	186.4	150.00	30.76	536.12	2.0318	184.6
-150.00	18.01	539.17	2.0787	188.2	160.00	23.65	548.40	2.0777	189.2	160.00	29.90	546.95	2.0571	187.5
-160.00	17.54	549.82	2.1036	190.8	170.00	23.03	559.24	2.1025	191.8	170.00	29.08	557.88	2.0820	190.3
-170.00	17.10	560.59	2.1282	193.3	180.00	22.45	570.20	2.1270	194.4	180.00	28.32	568.91	2.1066	193.0
-180.00	16.68	571.48	2.1525	195.8	190.00	21.89	581.28	2.1511	196.9	190.00	27.60	580.05	2.1309	195.6
-190.00	16.29	582.50	2.1766	198.2	200.00	21.37	592.46	2.1750	199.4	200.00	26.92	591.29	2.1550	198.2
Pressure = 1.200 MPa					Pressure = 1.400 MPa					Pressure = 1.600 MPa				
Saturation temperature = 46.32°C					Saturation temperature = 52.43°C					Saturation temperature = 57.91°C				
Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s
Saturated					Saturated					Saturated				
Liquid	1118.89	265.91	1.2200	405.0	Liquid	1090.50	275.38	1.2488	375.1	Liquid	1063.28	284.11	1.2748	348.1
Vapor	59.73	422.22	1.7092	138.2	Vapor	70.76	424.50	1.7068	135.6	Vapor	82.34	426.27	1.7042	132.9
-50.00	58.09	426.51	1.7226	140.7	60.00	66.61	433.69	1.7347	141.2	60.00	80.74	428.99	1.7124	134.7
-60.00	54.32	437.83	1.7571	146.9	70.00	62.25	445.31	1.7691	147.5	70.00	74.43	441.47	1.7493	142.3
-70.00	51.26	448.81	1.7896	152.3	80.00	58.74	456.56	1.8014	153.0	80.00	69.61	453.30	1.7833	148.7
-80.00	48.69	459.61	1.8206	157.1	90.00	55.79	467.60	1.8322	158.0	90.00	65.71	464.76	1.8153	154.2
-90.00	46.49	470.30	1.8504	161.5	100.00	53.24	478.53	1.8619	162.5	100.00	62.43	476.01	1.8458	159.2
-100.00	44.55	480.94	1.8794	165.6	110.00	51.03	489.39	1.8906	166.6	110.00	59.62	487.13	1.8753	163.8
-110.00	42.83	491.58	1.9075	169.4	120.00	49.05	500.25	1.9186	170.5	120.00	57.14	498.19	1.9038	168.0
-120.00	41.28	502.25	1.9350	173.0	130.00	47.28	511.11	1.9459	174.2	130.00	54.95	509.23	1.9315	171.9
-130.00	39.87	512.95	1.9619	176.4	140.00	45.67	522.02	1.9726	177.7	140.00	52.98	520.28	1.9586	175.6
-140.00	38.58	523.72	1.9882	179.7	150.00	44.19	532.97	1.9988	181.0	150.00	51.18	531.36	1.9851	179.1
-150.00	37.39	534.56	2.0142	182.8	160.00	42.83	544.00	2.0246	184.2	160.00	49.54	542.49	2.0111	182.5
-160.00	36.29	545.48	2.0397	185.8	170.00	41.57	555.10	2.0499	187.2	170.00	48.03	553.68	2.0366	185.7
-170.00	35.26	556.50	2.0648	188.8	180.00	40.41	566.28	2.0748	190.2	180.00	46.63	564.94	2.0617	188.8
-180.00	34.31	567.60	2.0896	191.6	190.00	39.31	577.55	2.0994	193.1	190.00	45.32	576.29	2.0865	191.8
-190.00	33.40	578.80	2.1141	194.4	200.00	38.28	588.92	2.1237	195.9	200.00	44.10	587.71	2.1109	194.7
-200.00	32.56	590.11	2.1382	197.1	210.00	37.32	600.38	2.1477						

Refrigerant 134a Properties of Superheated Vapor (Concluded)

Pressure = 1.800 MPa Saturation temperature = 62.90°C					Pressure = 2.000 MPa Saturation temperature = 67.49°C					Pressure = 2.200 MPa Saturation temperature = 71.74°C							
Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s			
Saturated					Saturated					Saturated							
Liquid	1036.81	292.26	1.2987	323.2	Liquid	1010.74	299.96	1.3209	300.1	Liquid	984.76	307.32	1.3417	278.4			
Vapor	94.53	427.59	1.7014	130.1	Vapor	107.46	428.52	1.6983	127.2	Vapor	121.25	429.08	1.6948	124.3			
70.00	88.23	437.17	1.7296	136.5	70.00	104.37	432.22	1.7091	129.9	80.00	110.03	441.49	1.7303	133.3			
	81.54	449.76	1.7657	144.0		80.00	94.85	445.86	1.7483	138.9		90.00	100.70	454.98	1.7680	141.8	
	90.00	76.38	461.74	1.7992	150.3		90.00	87.97	458.49	1.7835	146.2		100.00	93.78	467.61	1.8023	148.7
	100.00	72.17	473.36	1.8308	155.9		100.00	82.58	470.57	1.8164	152.4		110.00	88.25	479.75	1.8344	154.7
	110.00	68.64	484.78	1.8610	160.8		110.00	78.17	482.32	1.8474	157.8		120.00	83.70	491.59	1.8649	160.0
	120.00	65.60	496.06	1.8900	165.4		120.00	74.44	493.86	1.8772	162.7		130.00	79.79	503.25	1.8942	164.9
	130.00	62.91	507.29	1.9183	169.6		130.00	71.18	505.30	1.9059	167.2		140.00	76.41	514.81	1.9226	169.3
	140.00	60.53	518.50	1.9457	173.5		140.00	68.33	516.68	1.9338	171.4		150.00	72.40	526.32	1.9501	173.5
	150.00	58.37	529.71	1.9725	177.3		150.00	65.78	528.03	1.9609	175.4		160.00	70.71	537.81	1.9769	177.4
	160.00	56.42	540.95	1.9988	180.8		160.00	63.47	539.39	1.9875	179.1		170.00	68.28	549.31	2.0032	181.1
	170.00	54.62	552.24	2.0246	184.2		170.00	61.37	550.79	2.0135	182.6		180.00	66.06	560.84	2.0289	184.6
	180.00	52.97	563.59	2.0499	187.4		180.00	59.45	562.23	2.0390	186.0		190.00	64.02	572.42	2.0542	188.0
	190.00	51.44	575.01	2.0748	190.6		190.00	57.67	573.72	2.0641	189.3		200.00	62.13	584.06	2.0790	191.3
	200.00	50.01	586.50	2.0993	193.6		200.00	56.02	585.28	2.0888	192.4		210.00	60.38	595.76	2.1035	194.4
	210.00	48.68	598.08	2.1236	196.5		210.00	54.49	596.92	2.1131	195.5		220.00	58.74	607.53	2.1276	197.5
	220.00	47.43	609.74	2.1475	199.4		220.00	53.05	608.64	2.1371	198.4		230.00	57.21	619.38	2.1514	200.4
	230.00	46.25	621.50	2.1710	202.1		230.00	51.70	620.44	2.1608	201.3		240.00	55.77	631.31	2.1749	203.3
	240.00	45.14	633.34	2.1944	204.9		240.00	50.43	632.33	2.1842	204.1		250.00	54.42	643.33	2.1981	206.1
	250.00	44.09	645.28	2.2174	207.5		250.00	49.23	644.30	2.2073	206.8						
Pressure = 2.400 MPa Saturation temperature = 75.70°C					Pressure = 2.600 MPa Saturation temperature = 79.41°C					Pressure = 2.800 MPa Saturation temperature = 82.90°C							
Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s			
Saturated					Saturated					Saturated							
Liquid	958.58	314.40	1.3616	257.9	Liquid	931.88	321.29	1.3806	238.2	Liquid	904.29	328.05	1.3990	219.1			
Vapor	136.07	429.27	1.6908	121.4	Vapor	152.12	429.08	1.6863	118.3	Vapor	169.71	428.50	1.6812	115.3			
80.00	127.96	436.42	1.7112	126.9	80.00	150.48	430.22	1.6895	119.3	90.00	150.13	441.84	1.7183	125.9			
90.00	114.90	451.12	1.7523	137.0	90.00	131.08	446.81	1.7359	131.7	100.00	133.85	457.32	1.7603	136.4			
100.00	105.89	464.44	1.7885	144.8	100.00	119.15	461.03	1.7745	140.8	110.00	122.89	471.16	1.7970	144.6			
110.00	99.00	477.04	1.8218	151.5	110.00	110.50	474.19	1.8093	148.1	120.00	103.72	486.75	1.8417	154.4			
120.00	93.44	489.22	1.8532	157.2	120.00	130.00	486.75	1.8417	154.4	130.00	98.17	498.96	1.8724	160.0			
130.00	88.79	501.14	1.8831	162.4	140.00	93.46	510.94	1.9017	165.0	150.00	89.39	522.79	1.9301	169.7			
140.00	84.77	512.90	1.9119	167.2	150.00	100.00	510.94	1.9017	165.0	160.00	85.80	534.57	1.9576	174.0			
150.00	81.27	524.57	1.9398	171.6	160.00	107.00	524.57	1.9447	171.6	170.00	82.59	546.30	1.9844	178.1			
160.00	78.15	536.20	1.9670	175.7	170.00	110.00	546.30	1.9844	178.1	180.00	79.70	558.04	2.0106	181.9			
170.00	75.35	547.82	1.9935	179.6	180.00	117.00	556.97	2.0362	185.5	190.00	77.07	569.79	2.0614	189.0			
180.00	72.81	559.45	2.0195	183.3	190.00	120.00	564.65	2.0614	189.0	200.00	74.65	581.57	2.0861	192.4			
190.00	70.48	571.11	2.0449	186.8	200.00	123.00	572.43	2.0861	192.4	210.00	72.43	593.40	2.1105	195.6			
200.00	68.34	582.82	2.0699	190.2	210.00	126.00	590.29	2.1105	193.4	220.00	67.00	605.29	2.1345	198.8			
210.00	66.36	594.58	2.0945	193.4	220.00	129.00	617.24	2.1345	198.8	230.00	66.64	629.27	2.1581	201.8			
220.00	64.51	606.41	2.1188	196.6	230.00	132.00	630.29	2.1581	201.8	240.00	64.95	641.37	2.1815	204.8			
230.00	62.79	618.31	2.1427	199.6	240.00	135.00	652.33	2.1815	204.8	250.00	70.30	640.39	2.1740	204.1			
Pressure = 3.000 MPa Saturation temperature = 86.20°C					Pressure = 4.000 MPa Saturation temperature = 100.35°C					Pressure = 6.00 MPa Saturation temperature = n/a (supercritical)							
Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s	Temp., °C	Density, kg/m³	Enthalpy, kJ/kg	Entropy, kJ/(kg·K)	Vel. Sound, m/s			
Saturated					Saturated					Saturated							
Liquid	875.30	334.75	1.4171	200.4	Liquid	626.95	376.48	1.5272	101.3	Liquid	762.66	375.61	1.5174	173.6			
Vapor	189.25	427.47	1.6752	112.2	Vapor	396.29	404.57	1.6024	93.4	Vapor	591.77	405.75	1.5950	127.4			
90.00	173.82	435.84	1.6983	119.1	110.00	233.68	446.28	1.7131	119.8	120.00	179.83	465.29	1.7621	132.5			
100.00	150.47	453.20	1.7455	131.8	130.00	179.83	481.11	1.8018	142.0	140.00	165.73	495.51	1.8371	149.7			
110.00	136.36	467.93	1.7845	141.0	140.00	165.73	495.51	1.8697	156.4	150.00	154.59	509.13	1.8967	167.4			
120.00	126.23	481.47	1.8194	148.5	160.00	146.10	522.25	1.9004	162.4	170.00	137.84	535.07	1.9296	167.8			
130.00	118.34	494.36	1.8518	155.0	170.00	138.74	535.07	1.9296	167.8	180.00	132.41	547.69	1.9578	172.7			
140.00	111.89	506.86	1.8824	160.7	180.00	121.97	572.58	2.0115	181.7	190.00	126.88	560.17	1.9850	177.4			
150.00	106.45	519.11	1.9117	165.9	190.00	120.00	584.95	2.0374	185.8	200.00	117.55	597.30	2.0627	189.7			
160.00	101.75	531.21	1.9399	170.6	200.00	113.56	609.66	2.0875	193.4	210.00	109.90	609.66	2.1119	197.0			
170.00	97.62	543.21	1.9673	175.0	210.00	106.55	622.05	2.1119	197.0	220.00	102.00	620.70	2.1387	198.6			
180.00	93.94	555.16	1.9940	179.2	220.00	99.00	634.47	2.1359	200.5	230.00	97.87	659.45	2.1827	207.1			
190.00	90.62	567.10	2.0201	183.1	230.00	90.90	657.02	2.1827	207.1	240.00	90.75	679.38	2.2507	216.2			
200.00	87.61	579.05	2.0456	186.8	240.00	90.00	672.03	2.2057	210.2	250.00	90.75	697.38	2.2507	216.2			
210.00	84.84	591.02	2.0706	190.4	250.00	102.00	684.67	2.2283	213.3	260.00	102.00	707.39	2.2739	218.6			
220.00	82.30	603.03	2.0952	193.8	260.00	113.56	697.30	2.2627	218.1	270.00	113.56	723.90	2.3131	220.0			
230.00	79.94	615.10	2.1195	197.2	270.00	119.00	709.66	2.2875	218.1	280.00	117.00	740.66	2.3571	227.4			



3. Pressure-Enthalpy Diagram for Refrigerant 717 (Ammonia)
 Note: The reference states for enthalpy and entropy differ from those in the table.

3

Table A-13 Properties of Saturated Ammonia (Liquid-Vapor): Temperature Table

Temp. °C	Press. bar	Specific Volume m³/kg		Internal Energy kJ/kg		Enthalpy kJ/kg		Entropy kJ/kg · K		Temp. °C
		Sat. Liquid $v_l \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Sat. Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	
-50	0.4086	1.4245	2.6265	-43.94	1264.99	-43.88	1416.20	1372.32	-0.1922	6.1543
-45	0.5453	1.4367	2.0060	-22.03	1271.19	-21.95	1402.52	1380.57	-0.0951	6.0523
-40	0.7174	1.4493	1.5524	-0.10	1277.20	0.00	1388.56	1388.56	0.0000	5.9557
-36	0.8850	1.4597	1.2757	17.47	1281.87	17.60	1377.17	1394.77	0.0747	5.8819
-32	1.0832	1.4703	1.0561	35.09	1286.41	35.25	1365.55	1400.81	0.1484	5.8111
-30	1.1950	1.4757	0.9634	43.93	1288.63	44.10	1359.65	1403.75	0.1849	5.7767
-28	1.3159	1.4812	0.8803	52.78	1290.82	52.97	1353.68	1406.66	0.2212	5.7430
-26	1.4465	1.4867	0.8056	61.65	1292.97	61.86	1347.65	1409.51	0.2572	5.7100
-22	1.7390	1.4980	0.6780	79.46	1297.18	79.72	1335.36	1415.08	0.3287	5.6457
-20	1.9019	1.5038	0.6233	88.40	1299.23	88.68	1329.10	1417.79	0.3642	5.6144
-18	2.0769	1.5096	0.5739	97.36	1301.25	97.68	1322.77	1420.45	0.3994	5.5837
-16	2.2644	1.5155	0.5291	106.36	1303.23	106.70	1316.35	1423.05	0.4346	5.5536
-14	2.4652	1.5215	0.4885	115.37	1305.17	115.75	1309.86	1425.61	0.4695	5.5239
-12	2.6798	1.5276	0.4516	124.42	1307.08	124.83	1303.28	1428.11	0.5043	5.4948
-10	2.9089	1.5338	0.4180	133.50	1308.95	133.94	1296.61	1430.55	0.5389	5.4662
-8	3.1532	1.5400	0.3874	142.60	1310.78	143.09	1289.86	1432.95	0.5734	5.4380
-6	3.4134	1.5464	0.3595	151.74	1312.57	152.26	1283.02	1435.28	0.6077	5.4103
-4	3.6901	1.5528	0.3340	160.88	1314.32	161.46	1276.10	1437.56	0.6418	5.3831
-2	3.9842	1.5594	0.3106	170.07	1316.04	170.69	1269.08	1439.78	0.6759	5.3562
0	4.2962	1.5660	0.2892	179.29	1317.71	179.96	1261.97	1441.94	0.7097	5.3298
2	4.6270	1.5727	0.2695	188.53	1319.34	189.26	1254.77	1444.03	0.7435	5.3038
4	4.9773	1.5796	0.2514	197.80	1320.92	198.59	1247.48	1446.07	0.7770	5.2781
6	5.3479	1.5866	0.2348	207.10	1322.47	207.95	1240.09	1448.04	0.8105	5.2529
8	5.7395	1.5936	0.2195	216.42	1323.96	217.34	1232.61	1449.94	0.8438	5.2279
10	6.1529	1.6008	0.2054	225.77	1325.42	226.75	1225.03	1451.78	0.8769	5.2033
12	6.5890	1.6081	0.1923	235.14	1326.82	236.20	1217.35	1453.55	0.9099	5.1791
16	7.5324	1.6231	0.1691	253.95	1329.48	255.18	1201.70	1456.87	0.9755	5.1314
20	8.5762	1.6386	0.1492	272.86	1331.94	274.26	1185.64	1459.90	1.0404	5.0849
24	9.7274	1.6547	0.1320	291.84	1334.19	293.45	1169.16	1462.61	1.1048	5.0394
28	10.993	1.6714	0.1172	310.92	1336.20	312.75	1152.24	1465.00	1.1686	4.9948
32	12.380	1.6887	0.1043	330.07	1337.97	332.17	1134.87	1467.03	1.2319	4.9509
36	13.896	1.7068	0.0930	349.32	1339.47	351.69	1117.00	1468.70	1.2946	4.9078
40	15.549	1.7256	0.0831	368.67	1340.70	371.35	1098.62	1469.97	1.3569	4.8652
45	17.819	1.7503	0.0725	393.01	1341.81	396.13	1074.84	1470.96	1.4341	4.8125
50	20.331	1.7765	0.0634	417.56	1342.42	421.17	1050.09	1471.26	1.5109	4.7604

Source: Tables A-13 through A-15 are calculated based on equations from L. Haar and J. S. Gallagher, "Thermodynamic Properties of Ammonia," *J. Phys. Chem. Reference Data*, Vol. 7, 1978, pp. 535-792.

Properties of Superheated Ammonia Vapor

<i>T</i> °C	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 0.4 bar = 0.04 MPa (<i>T</i> _{sat} = -50.36°C)					<i>p</i> = 0.6 bar = 0.06 MPa (<i>T</i> _{sat} = -43.28°C)			
Sat.	2.6795	1264.54	1371.72	6.1618	1.8345	1273.27	1383.34	6.0186
-50	2.6841	1265.11	1372.48	6.1652				
-45	2.7481	1273.05	1382.98	6.2118				
-40	2.8118	1281.01	1393.48	6.2573	1.8630	1278.62	1390.40	6.0490
-35	2.8753	1288.96	1403.98	6.3018	1.9061	1286.75	1401.12	6.0946
-30	2.9385	1296.93	1414.47	6.3455	1.9491	1294.88	1411.83	6.1390
-25	3.0015	1304.90	1424.96	6.3882	1.9918	1303.01	1422.52	6.1826
-20	3.0644	1312.88	1435.46	6.4300	2.0343	1311.13	1433.19	6.2251
-15	3.1271	1320.87	1445.95	6.4711	2.0766	1319.25	1443.85	6.2668
-10	3.1896	1328.87	1456.45	6.5114	2.1188	1327.37	1454.50	6.3077
-5	3.2520	1336.88	1466.95	6.5509	2.1609	1335.49	1465.14	6.3478
0	3.3142	1344.90	1477.47	6.5898	2.2028	1343.61	1475.78	6.3871
5	3.3764	1352.95	1488.00	6.6280	2.2446	1351.75	1486.43	6.4257

<i>p</i> = 0.8 bar = 0.08 MPa (<i>T</i> _{sat} = -37.94°C)				<i>p</i> = 1.0 bar = 0.10 MPa (<i>T</i> _{sat} = -33.60°C)				
Sat.	1.4021	1279.61	1391.78	5.9174	1.1381	1284.61	1398.41	5.8391
-35	1.4215	1284.51	1398.23	5.9446	1.1573	1290.71	1406.44	5.8723
-30	1.4543	1292.81	1409.15	5.9900	1.1838	1299.15	1417.53	5.9175
-25	1.4868	1301.09	1420.04	6.0343	1.2101	1307.57	1428.58	5.9616
-20	1.5192	1309.36	1430.90	6.0777	1.2362	1315.96	1439.58	6.0046
-15	1.5514	1317.61	1441.72	6.1200	1.2621	1324.33	1450.54	6.0467
-10	1.5834	1325.85	1452.53	6.1615	1.2880	1332.67	1461.47	6.0878
-5	1.6153	1334.09	1463.31	6.2021	1.3136	1341.00	1472.37	6.1281
0	1.6471	1342.31	1474.08	6.2419	1.3392	1349.33	1483.25	6.1676
5	1.6788	1350.54	1484.84	6.2809	1.3647	1357.64	1494.11	6.2063
10	1.7103	1358.77	1495.60	6.3192	1.3900	1365.95	1504.96	6.2442
15	1.7418	1367.01	1506.35	6.3568	1.4153	1374.27	1515.80	6.2816
20	1.7732	1375.25	1517.10	6.3939				

<i>p</i> = 1.5 bar = 0.15 MPa (<i>T</i> _{sat} = -25.22°C)				<i>p</i> = 2.0 bar = 0.20 MPa (<i>T</i> _{sat} = -18.86°C)				
Sat.	0.7787	1293.80	1410.61	5.6973	0.59460	1300.39	1419.31	5.5969
-25	0.7795	1294.20	1411.13	5.6994	0.60542	1307.43	1428.51	5.6328
-20	0.7978	1303.00	1422.67	5.7454	0.61926	1316.46	1440.31	5.6781
-15	0.8158	1311.75	1434.12	5.7902	0.63294	1325.41	1452.00	5.7221
-10	0.8336	1320.44	1445.49	5.8338	0.64648	1334.29	1463.59	5.7649
-5	0.8514	1329.08	1456.79	5.8764	0.65989	1343.11	1475.09	5.8066
0	0.8689	1337.68	1468.02	5.9179	0.67320	1351.87	1486.51	5.8473
5	0.8864	1346.25	1479.20	5.9585	0.68640	1360.59	1497.87	5.8871
10	0.9037	1354.78	1490.34	5.9981	0.69952	1369.28	1509.18	5.9260
15	0.9210	1363.29	1501.44	6.0370	0.71256	1377.93	1520.44	5.9641
20	0.9382	1371.79	1512.51	6.0751	0.72553	1386.56	1531.67	6.0014
25	0.9553	1380.28	1523.56	6.1125				
30	0.9723	1388.76	1534.60	6.1492				

Table A-1S (Continued)

<i>T</i> °C	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>v</i> m³/kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg
<i>p</i> = 2.5 bar = 0.25 MPa (<i>T</i> _{sat} = -13.67°C)								
<i>p</i> = 3.0 bar = 0.30 MPa (<i>T</i> _{sat} = -9.24°C)								
Sat.	0.48213	1305.49	1426.03	5.5190	0.40607	1309.65	1431.47	5.455
-10	0.49051	1312.37	1435.00	5.5534				
-5	0.50180	1321.65	1447.10	5.5989	0.41428	1317.80	1442.08	5.495
0	0.51293	1330.83	1459.06	5.6431	0.42382	1327.28	1454.43	5.540
5	0.52393	1339.91	1470.89	5.6860	0.43323	1336.64	1466.61	5.585
10	0.53482	1348.91	1482.61	5.7278	0.44251	1345.89	1478.65	5.628
15	0.54560	1357.84	1494.25	5.7685	0.45169	1355.05	1490.56	5.669
20	0.55630	1366.72	1505.80	5.8083	0.46078	1364.13	1502.36	5.710
25	0.56691	1375.55	1517.28	5.8471	0.46978	1373.14	1514.07	5.749
30	0.57745	1384.34	1528.70	5.8851	0.47870	1382.09	1525.70	5.788
35	0.58793	1393.10	1540.08	5.9223	0.48756	1391.00	1537.26	5.826
40	0.59835	1401.84	1551.42	5.9589	0.49637	1399.86	1548.77	5.8635
45	0.60872	1410.56	1562.74	5.9947	0.50512	1408.70	1560.24	5.8998
<i>p</i> = 3.5 bar = 0.35 MPa (<i>T</i> _{sat} = -5.36°C)								
<i>p</i> = 4.0 bar = 0.40 MPa (<i>T</i> _{sat} = -1.90°C)								
Sat.	0.35108	1313.14	1436.01	5.4016	0.30942	1316.12	1439.89	5.3548
0	0.36011	1323.66	1449.70	5.4522	0.31227	1319.95	1444.86	5.3731
10	0.37654	1342.82	1474.61	5.5417	0.32701	1339.68	1470.49	5.4652
20	0.39251	1361.49	1498.87	5.6259	0.34129	1358.81	1495.33	5.5515
30	0.40814	1379.81	1522.66	5.7057	0.35520	1377.49	1519.57	5.6328
40	0.42350	1397.87	1546.09	5.7818	0.36884	1395.85	1543.38	5.7101
60	0.45363	1433.55	1592.32	5.9249	0.39550	1431.97	1590.17	5.8549
80	0.48320	1469.06	1638.18	6.0586	0.42160	1467.77	1636.41	5.9897
100	0.51240	1504.73	1684.07	6.1850	0.44733	1503.64	1682.58	6.1169
120	0.54136	1540.79	1730.26	6.3056	0.47280	1539.85	1728.97	6.2380
140	0.57013	1577.38	1776.92	6.4213	0.49808	1576.55	1775.79	6.3541
160	0.59876	1614.60	1824.16	6.5330	0.52323	1613.86	1823.16	6.4661
180	0.62728	1652.51	1872.06	6.6411	0.54827	1651.85	1871.16	6.5744
200	0.65572	1691.15	1920.65	6.7460	0.57322	1690.56	1919.85	6.6796
<i>p</i> = 4.5 bar = 0.45 MPa (<i>T</i> _{sat} = 1.25°C)								
<i>p</i> = 5.0 bar = 0.50 MPa (<i>T</i> _{sat} = 4.13°C)								
Sat.	0.27671	1318.73	1443.25	5.3135	0.25034	1321.02	1446.19	5.2765
10	0.28846	1336.48	1466.29	5.3962	0.25757	1333.22	1462.00	5.3330
20	0.30142	1356.09	1491.72	5.4845	0.26949	1353.32	1488.06	5.4234
30	0.31401	1375.15	1516.45	5.5674	0.28103	1372.76	1513.28	5.5080
40	0.32631	1393.80	1540.64	5.6460	0.29227	1391.74	1537.87	5.5878
60	0.35029	1430.37	1588.00	5.7926	0.31410	1428.76	1585.81	5.7362
80	0.37369	1466.47	1634.63	5.9285	0.33535	1465.16	1632.84	5.8733
100	0.39671	1502.55	1681.07	6.0564	0.35621	1501.46	1679.56	6.0020
120	0.41947	1538.91	1727.67	6.1781	0.37681	1537.97	1726.37	6.1242
140	0.44205	1575.73	1774.65	6.2946	0.39722	1574.90	1773.51	6.2412
160	0.46448	1613.13	1822.15	6.4069	0.41749	1612.40	1821.14	6.3537
180	0.48681	1651.20	1870.26	6.5155	0.43765	1650.54	1869.36	6.4626
200	0.50905	1689.97	1919.04	6.6208	0.45771	1689.38	1918.24	6.5681

(continued)

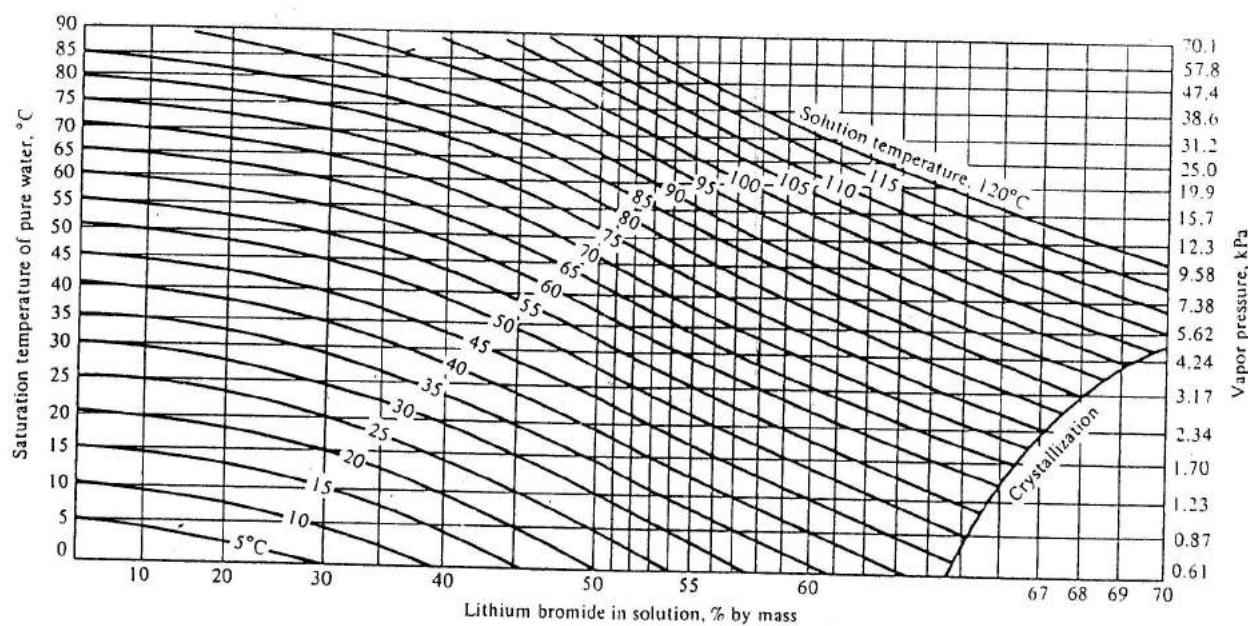
	<i>u</i> kg kJ/kg	<i>h</i> kg/kg kJ/kg · K	<i>s</i> kJ/kg · K	<i>v</i> m ³ /kg	<i>u</i> kg/kg kJ/kg	<i>h</i> kg/kg kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 5.5 bar = 0.55 MPa (<i>T</i> _{sat} = 6.79°C)							
<i>p</i> = 6.0 bar = 0.60 MPa (<i>T</i> _{sat} = 9.27°C)							
0.22861	1323.06	1448.80	5.2430	0.21038	1324.89	1451.12	5.2122
0.23227	1329.88	1457.63	5.2743	0.21115	1326.47	1453.16	5.2195
0.24335	1350.50	1484.34	5.3671	0.22155	1347.62	1480.55	5.3145
0.25403	1370.35	1510.07	5.4534	0.23152	1367.90	1506.81	5.4026
40 0.26441	1389.64	1535.07	5.5345	0.24118	1387.52	1532.23	5.4851
50 0.27454	1408.53	1559.53	5.6114	0.25059	1406.67	1557.03	5.5631
60 0.28449	1427.13	1583.60	5.6848	0.25981	1425.49	1581.38	5.6373
80 0.30398	1463.85	1631.04	5.8230	0.27783	1462.52	1629.22	5.7768
100 0.32307	1500.36	1678.05	5.9525	0.29546	1499.25	1676.52	5.9071
120 0.34190	1537.02	1725.07	6.0753	0.31281	1536.07	1723.76	6.0304
140 0.36054	1574.07	1772.37	6.1926	0.32997	1573.24	1771.22	6.1481
160 0.37903	1611.66	1820.13	6.3055	0.34699	1610.92	1819.12	6.2613
180 0.39742	1649.88	1868.46	6.4146	0.36390	1649.22	1867.56	6.3707
200 0.41571	1688.79	1917.43	6.5203	0.38071	1688.20	1916.63	6.4766

	<i>p</i> = 7.0 bar = 0.70 MPa (<i>T</i> _{sat} = 13.79°C)				<i>p</i> = 8.0 bar = 0.80 MPa (<i>T</i> _{sat} = 17.84°C)			
Sat.	0.18148	1328.04	1455.07	5.1576	0.15958	1330.64	1458.30	5.1099
20 0.18721	1341.72	1472.77	5.2186	0.16138	1335.59	1464.70	5.1318	
30 0.19610	1362.88	1500.15	5.3104	0.16948	1357.71	1493.29	5.2277	
40 0.20464	1383.20	1526.45	5.3958	0.17720	1378.77	1520.53	5.3161	
50 0.21293	1402.90	1551.95	5.4760	0.18465	1399.05	1546.77	5.3986	
60 0.22101	1422.16	1576.87	5.5519	0.19189	1418.77	1572.28	5.4763	
80 0.23674	1459.85	1625.56	5.6939	0.20590	1457.14	1621.86	5.6209	
100 0.25205	1497.02	1673.46	5.8258	0.21949	1494.77	1670.37	5.7545	
120 0.26709	1534.16	1721.12	5.9502	0.23280	1532.24	1718.48	5.8801	
140 0.28193	1571.57	1768.92	6.0688	0.24590	1569.89	1766.61	5.9995	
160 0.29663	1609.44	1817.08	6.1826	0.25886	1607.96	1815.04	6.1140	
180 0.31121	1647.90	1865.75	6.2925	0.27170	1646.57	1863.94	6.2243	
200 0.32571	1687.02	1915.01	6.3988	0.28445	1685.83	1913.39	6.3311	

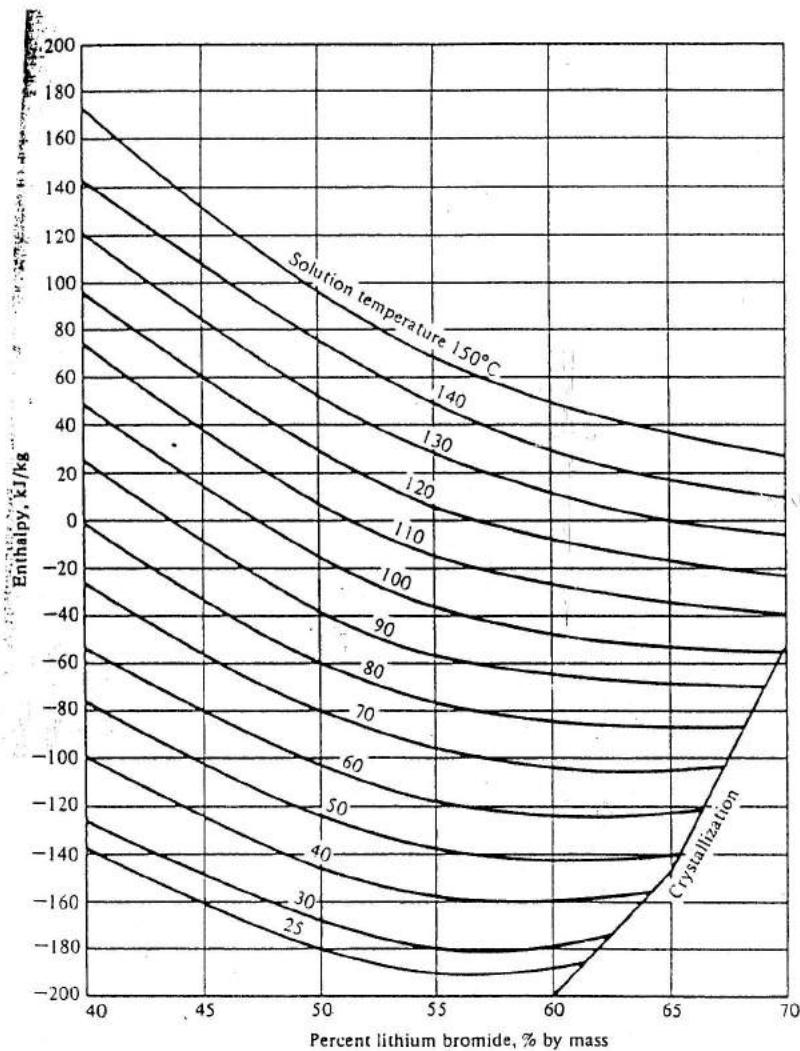
	<i>p</i> = 9.0 bar = 0.90 MPa (<i>T</i> _{sat} = 21.52°C)				<i>p</i> = 10.0 bar = 1.00 MPa (<i>T</i> _{sat} = 24.89°C)			
Sat.	0.14239	1332.82	1460.97	5.0675	0.12852	1334.66	1463.18	5.0294
30 0.14872	1352.36	1486.20	5.1520	0.13206	1346.82	1478.88	5.0816	
40 0.15582	1374.21	1514.45	5.2436	0.13868	1369.52	1508.20	5.1768	
50 0.16263	1395.11	1541.47	5.3286	0.14499	1391.07	1536.06	5.2644	
60 0.16922	1415.32	1567.61	5.4083	0.15106	1411.79	1562.86	5.3460	
80 0.18191	1454.39	1618.11	5.5555	0.16270	1451.60	1614.31	5.4960	
100 0.19416	1492.50	1667.24	5.6908	0.17389	1490.20	1664.10	5.6332	
120 0.20612	1530.30	1715.81	5.8176	0.18478	1528.35	1713.13	5.7612	
140 0.21788	1568.20	1764.29	5.9379	0.19545	1566.51	1761.96	5.8823	
160 0.22948	1606.46	1813.00	6.0530	0.20598	1604.97	1810.94	5.9981	
180 0.24097	1645.24	1862.12	6.1639	0.21638	1643.91	1860.29	6.1095	
200 0.25237	1684.64	1911.77	6.2711	0.22670	1683.44	1910.14	6.2171	

(Continued)

<i>T</i> °C	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K	<i>v</i> m ³ /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	<i>s</i> kJ/kg · K
<i>p</i> = 12.0 bar = 1.20 MPa (<i>T</i> _{sat} = 30.94°C)								
Sat. 40 60 80 100 120 140 160 180 200 220 240 260 280								
Sat.	0.10751	1337.52	1466.53	4.9625	0.09231	1339.56	1468.79	4.9050
40	0.11287	1359.73	1495.18	5.0553	0.09432	1349.29	1481.33	4.9453
60	0.12378	1404.54	1553.07	5.2347	0.10423	1396.97	1542.89	5.1360
80	0.13387	1445.91	1606.56	5.3906	0.11324	1440.06	1598.59	5.2984
100	0.14347	1485.55	1657.71	5.5315	0.12172	1480.79	1651.20	5.4433
120	0.15275	1524.41	1707.71	5.6620	0.12986	1520.41	1702.21	5.5765
140	0.16181	1563.09	1757.26	5.7850	0.13777	1559.63	1752.52	5.7013
160	0.17072	1601.95	1806.81	5.9021	0.14552	1598.92	1802.65	5.8198
180	0.17950	1641.23	1856.63	6.0145	0.15315	1638.53	1852.94	5.9333
200	0.18819	1681.05	1906.87	6.1230	0.16068	1678.64	1903.59	6.0427
220	0.19680	1721.50	1957.66	6.2282	0.16813	1719.35	1954.73	6.1485
240	0.20534	1762.63	2009.04	6.3303	0.17551	1760.72	2006.43	6.2513
260	0.21382	1804.48	2061.06	6.4297	0.18283	1802.78	2058.75	6.3513
280	0.22225	1847.04	2113.74	6.5267	0.19010	1845.55	2111.69	6.4488
<i>p</i> = 16.0 bar = 1.60 MPa (<i>T</i> _{sat} = 41.03°C)								
Sat. 60 80 100 120 140 160 180 200 220 240 260 280								
Sat.	0.08079	1340.97	1470.23	4.8542	0.07174	1341.88	1471.01	4.8086
60	0.08951	1389.06	1532.28	5.0461	0.07801	1380.77	1521.19	4.9627
80	0.09774	1434.02	1590.40	5.2156	0.08565	1427.79	1581.97	5.1399
100	0.10539	1475.93	1644.56	5.3648	0.09267	1470.97	1637.78	5.2937
120	0.11268	1516.34	1696.64	5.5008	0.09931	1512.22	1690.98	5.4326
140	0.11974	1556.14	1747.72	5.6276	0.10570	1552.61	1742.88	5.5614
160	0.12663	1595.85	1798.45	5.7475	0.11192	1592.76	1794.23	5.6828
180	0.13339	1635.81	1849.23	5.8621	0.11801	1633.08	1845.50	5.7985
200	0.14005	1676.21	1900.29	5.9723	0.12400	1673.78	1896.98	5.9096
220	0.14663	1717.18	1951.79	6.0789	0.12991	1715.00	1948.83	6.0170
240	0.15314	1758.79	2003.81	6.1823	0.13574	1756.85	2001.18	6.1210
260	0.15959	1801.07	2056.42	6.2829	0.14152	1799.35	2054.08	6.2222
280	0.16599	1844.05	2109.64	6.3809	0.14724	1842.55	2107.58	6.3207
<i>p</i> = 20.0 bar = 2.00 MPa (<i>T</i> _{sat} = 49.37°C)								
Sat. 60 80 100 120 140 160 180 200 220 240 260 280								
Sat.	0.06445	1342.37	1471.26	4.7670				
60	0.06875	1372.05	1509.54	4.8838				
80	0.07596	1421.36	1573.27	5.0696				
100	0.08248	1465.89	1630.86	5.2283				
120	0.08861	1508.03	1685.24	5.3703				
140	0.09447	1549.03	1737.98	5.5012				
160	0.10016	1589.65	1789.97	5.6241				
180	0.10571	1630.32	1841.74	5.7409				
200	0.11116	1671.33	1893.64	5.8530				
220	0.11652	1712.82	1945.87	5.9611				
240	0.12182	1754.90	1998.54	6.0658				
260	0.12706	1797.63	2051.74	6.1675				
280	0.13224	1841.03	2105.50	6.2665				

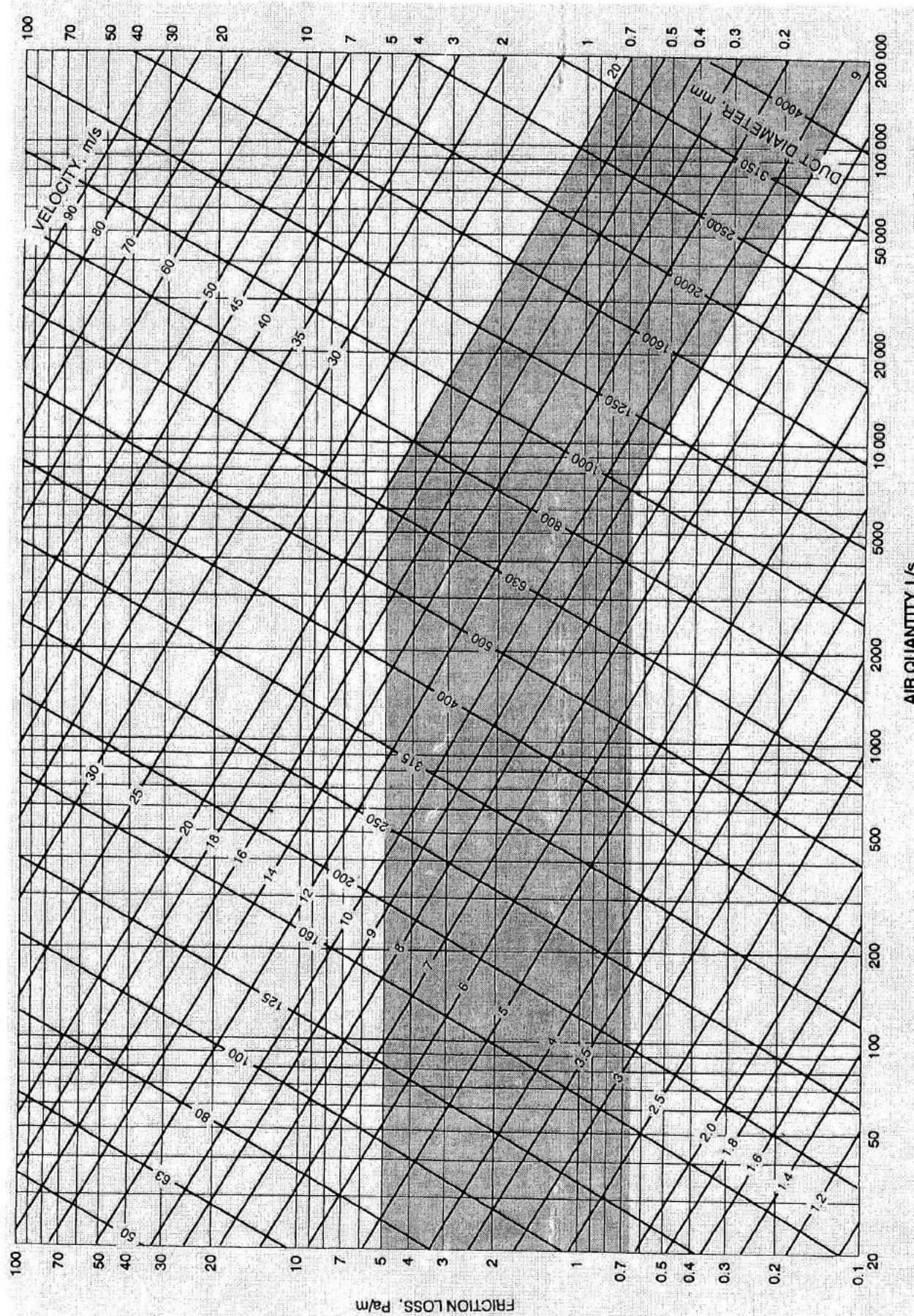


4. Temperature-pressure-concentration diagram of saturated LiBr-water solutions.



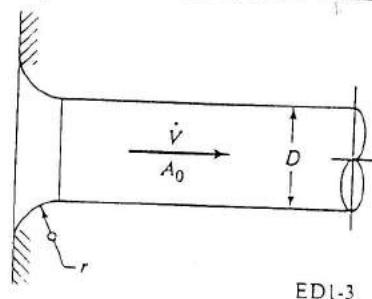
5. Enthalpy of LiBr-water solutions;

6. Friction Chart for Round Duct ($\rho = 1.20 \text{ kg/m}^3$ and $\varepsilon = 0.09 \text{ mm}$)



7. Total pressure coefficients of ducts.

Total Pressure-Loss Coefficients for Bell-Mouth Inlet to a Round Duct

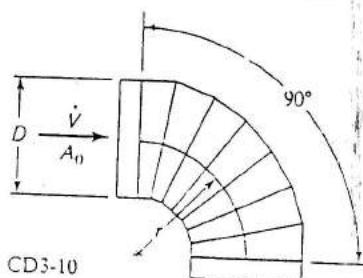


ED1-3

r/D	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.10	0.12	0.16	0.20	10.00
C_o	0.50	0.44	0.37	0.31	0.26	0.22	0.20	0.15	0.12	0.09	0.06	0.03	0.03

SOURCE: Reprinted by permission from ASHRAE Duct Fitting Database, 1994.

Total Pressure-Loss Coefficients for a 90-deg Pleated Elbow in a Round Duct,
7 Sections, $r/D = 2.5$

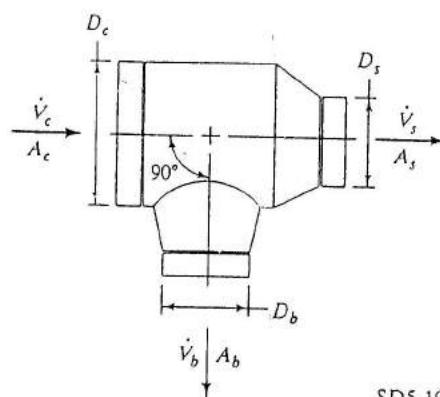


CD3-10

D , in. (mm)	3(75)	6(150)	9(230)	12(300)	15(380)	18(450)	27(690)	60(1500)
C_o	0.16	0.12	0.10	0.08	0.07	0.06	0.05	0.03

SOURCE: Reprinted by permission from ASHRAE Duct Fitting Database, 1994.

Total Pressure-Loss Coefficients for Diverging Tee in a Round Duct
with a Conical Branch Tapered into the Body



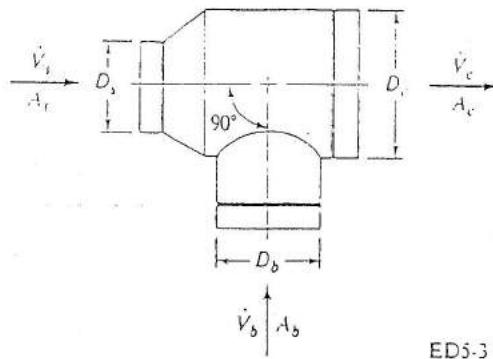
SDS-10

$\dot{V}_b/\dot{V}_c =$	C_b									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
A_b/A_c										
0.1	0.65	0.24								
0.2	2.98	0.65	0.33	0.24	0.18					
0.3	7.36	1.56	0.65	0.39	0.29	0.24	0.20			
0.4	13.78	2.98	1.20	0.65	0.43	0.33	0.27	0.24	0.21	
0.5	22.24	4.92	1.98	1.04	0.65	0.47	0.36	0.30	0.26	
0.6	32.73	7.36	2.98	1.56	0.96	0.65	0.49	0.39	0.33	
0.7	45.26	10.32	4.21	2.21	1.34	0.90	0.65	0.51	0.42	
0.8	59.82	13.78	5.67	2.98	1.80	1.20	0.86	0.65	0.52	
0.9	76.41	17.75	7.36	3.88	2.35	1.56	1.11	0.83	0.65	

$\dot{V}_s/\dot{V}_c =$	C_s									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
A_s/A_c										
0.1	0.13	0.16								
0.2	0.20	0.13	0.15	0.16	0.28					
0.3	0.90	0.13	0.13	0.14	0.15	0.16	0.20			
0.4	2.88	0.20	0.14	0.13	0.14	0.15	0.15	0.16	0.34	
0.5	6.25	0.37	0.17	0.14	0.13	0.14	0.14	0.15	0.15	
0.6	11.88	0.90	0.20	0.13	0.14	0.13	0.14	0.14	0.15	
0.7	18.62	1.71	0.33	0.18	0.16	0.14	0.13	0.14	0.15	
0.8	26.88	2.88	0.50	0.20	0.15	0.14	0.13	0.15	0.14	
0.9	36.45	4.46	0.90	0.30	0.19	0.16	0.15	0.14	0.13	

SOURCE: Reprinted by permission from ASHRAE Duct Fitting Database, 1994.

Total Pressure-Loss Coefficients for a Converging Tee In a Round Duct,
 $D_c \geq 10$ in. (25 cm)



ED5-3

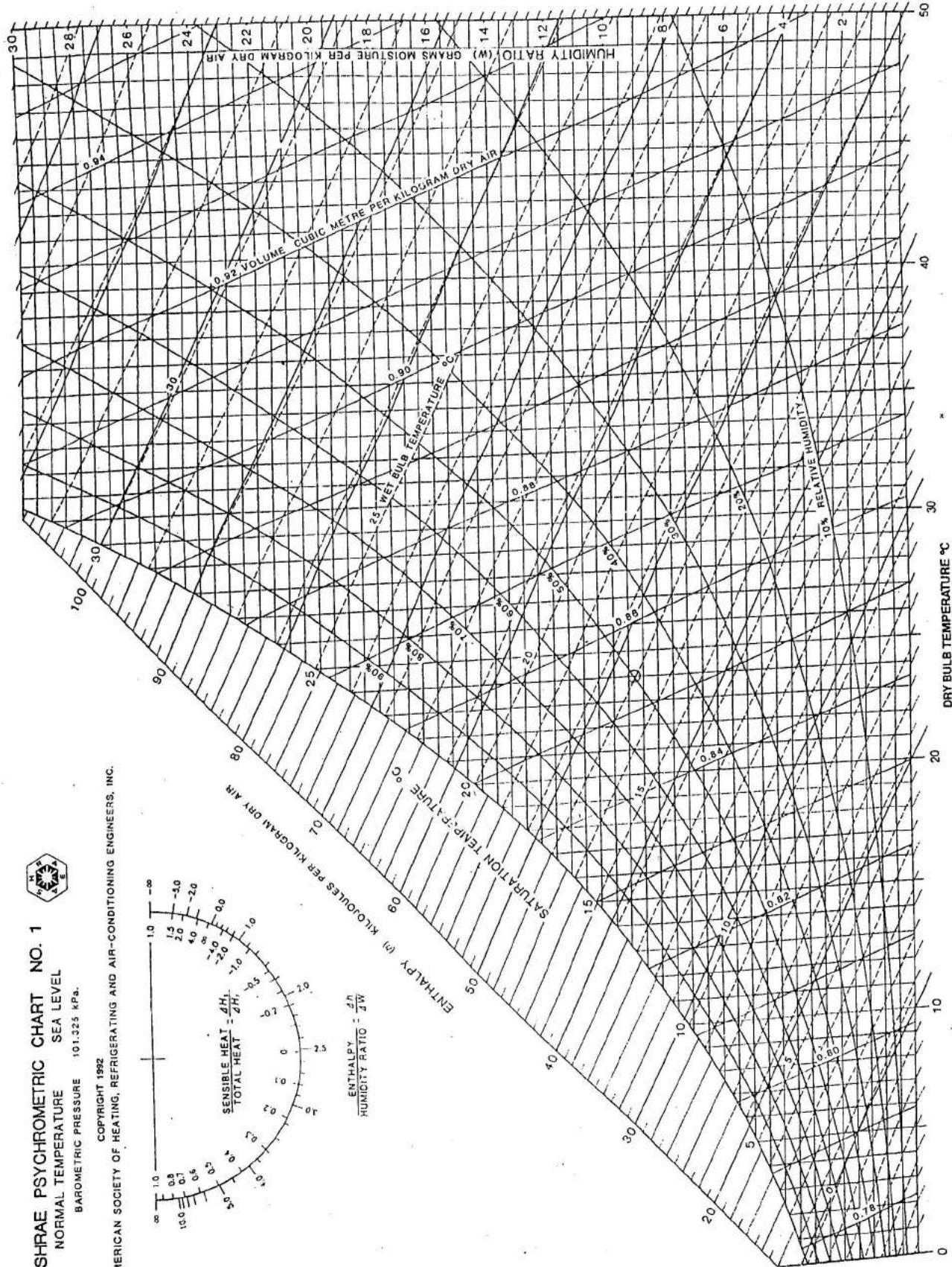
		C_d								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$\dot{V}_b/\dot{V}_c =$	A_s/A_c	A_b/A_c								
0.5	0.2	-7.26	-0.62	0.43	0.75	0.86	0.91	0.93	0.93	0.90
	0.3	-16.99	-2.35	-0.07	0.57	0.80	0.89	0.91	0.90	0.87
	0.4	-30.49	-4.67	-0.72	0.38	0.76	0.89	0.92	0.90	0.85
	0.5	-47.82	-7.61	-1.50	0.19	0.75	0.93	0.97	0.93	0.85
	0.6	-69.03	-11.17	-2.42	-0.03	0.76	1.01	1.05	0.98	0.88
	0.7	-94.17	-15.37	-3.49	-0.26	0.80	1.13	1.17	1.07	0.93
	0.8	-123.30	-20.22	-4.71	-0.50	0.87	1.29	1.33	1.20	1.02
	0.9	-156.48	-25.73	-6.09	-0.77	0.96	1.48	1.53	1.36	1.13
	1.0	-193.74	-31.92	-7.63	-1.07	1.06	1.71	1.77	1.56	1.28
1.0	0.2	-1.54	0.39	0.74	0.87	0.92	0.95	0.97	0.99	1.03
	0.3	-3.75	0.03	0.64	0.83	0.90	0.94	0.97	1.00	1.08
	0.4	-6.57	-0.32	0.61	0.85	0.93	0.97	0.99	1.03	1.16
	0.5	-10.05	-0.65	0.64	0.94	1.02	1.03	1.04	1.08	1.26
	0.6	-14.24	-0.98	0.74	1.10	1.16	1.15	1.13	1.16	1.40
	0.7	-19.20	-1.32	0.91	1.33	1.37	1.31	1.26	1.27	1.57
	0.8	-24.98	-1.69	1.14	1.63	1.63	1.53	1.43	1.41	1.78
	0.9	-31.62	-2.10	1.42	2.00	1.96	1.80	1.64	1.59	2.02
	1.0	-39.19	-2.55	1.76	2.43	2.35	2.12	1.90	1.81	2.30

		C_s								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$\dot{V}_s/\dot{V}_c =$	A_s/A_c	A_b/A_c								
0.5	0.2	126.36	16.99	5.39	2.42	1.32	0.81	0.54	0.38	0.28
	0.3	65.94	10.28	3.65	1.79	1.05	0.68	0.48	0.35	0.27
	0.4	38.84	7.27	2.87	1.51	0.93	0.63	0.45	0.34	0.27
	0.5	25.07	5.74	2.47	1.37	0.87	0.60	0.44	0.33	0.26
	0.6	17.98	4.95	2.27	1.29	0.84	0.58	0.43	0.33	0.26
	0.7	14.69	4.58	2.17	1.26	0.82	0.58	0.43	0.33	0.26
	0.8	13.78	4.48	2.15	1.25	0.82	0.57	0.43	0.33	0.26
	0.9	14.45	4.56	2.17	1.26	0.82	0.58	0.43	0.33	0.26
	1.0	16.24	4.76	2.22	1.28	0.83	0.58	0.43	0.33	0.26
1.0	0.2	-99.78	-0.17	3.15	2.40	1.58	0.98	0.56	0.25	0.02
	0.3	-75.42	2.54	3.85	2.65	1.69	1.03	0.58	0.26	0.03
	0.4	-38.31	6.66	4.92	3.34	1.86	1.11	0.62	0.28	0.03
	0.5	3.90	11.35	6.14	3.48	2.04	1.20	0.66	0.29	0.04
	0.6	48.66	16.32	7.43	3.34	2.24	1.29	0.70	0.31	0.04
	0.7	94.88	21.46	8.76	4.43	2.45	1.38	0.75	0.33	0.05
	0.8	142.01	26.70	10.12	4.72	2.66	1.48	0.79	0.35	0.06
	0.9	189.74	32.00	11.49	5.41	2.87	1.58	0.84	0.37	0.07
	1.0	237.90	37.35	12.88	5.92	3.08	1.68	0.88	0.39	0.07

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ASHRAE PSYCHROMETRIC CHART NO. 1
NORMAL TEMPERATURE SEA LEVEL
BAROMETRIC PRESSURE 101.325 kPa.

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8 ASHRAE Psychrometric Chart No. 1

TABLE 9 Climatic conditions for different countries

Country and station	Lat. °	Long. °	Col. 1 Col. 2	Col. 3 Eleva- tion, (m)	Winter, °C			Col. 5 Design dry-bulb			Col. 7 Design wet-bulb			Summer, °C			Prevailing winds		
					Col. 4			Col. 6 Mean daily			Col. 7 Mean daily			Col. 8 Summer range, °C			Col. 9 Winter range, °C		
					99%	97.5%	95%	1%	2.5%	5%	1%	2.5%	5%	1%	2.5%	5%	1%	2.5%	5%
AFGHANISTAN																			
Kabul	34	35N	69	12E	1816	-17	-14	-13	37	36	34	18	19	18	N	2	N		
ALGERIA																			
Algers	36	46N	3	03E	59	3	6	7	35	33	32	8	25	24	24				
ARGENTINA																			
Buenos Aires	34	35S	58	29W	27	-3	0	1	33	32	30	12	25	24	24				
Cordoba	31	22S	64	15W	423	-6	-2	0	38	36	34	15	24	24	23				
Tucuman	26	50S	65	10W	427	-4	0	2	39	37	36	13	24	24	23				
AUSTRALIA																			
Adelaide	34	56S	138	35E	43	2	3	4	37	34	33	14	22	21	20				
Alice Springs	23	48S	133	53E	547	-2	1	3	40	39	38	15	24	23	22				
Brisbane	27	28S	153	02E	42	4	7	8	33	31	30	10	25	24	24				
Darwin	12	28S	130	51E	27	16	18	19	34	34	33	9	28	27	27				
Melbourne	37	49S	144	58E	35	-1	2	3	35	33	30	12	22	21	20				
Perth	31	57S	115	51E	64	3	4	6	38	36	34	12	24	23	23				
Sydney	33	52S	151	12E	42	3	4	6	32	29	27	7	23	23	22				
AUSTRIA																			
Vienna	48	15N	16	22E	196	-19	-14	-12	31	30	28	9	22	21	19	W	7	SSE	
AZORES																			
Lajes (Terceira)	38	45N	27	05W	52	6	8	9	27	26	25	6	23	22	22	W	5	NW	
BAHAMAS																			
Nassau	25	05N	77	21W	3	13	16	17	32	32	31	7	27	27	27				
BANGLADESH																			
Chittagong	22	21N	91	50E	27	9	11	12	34	33	32	11	28	27	27				
BELGIUM																			
Brussels	50	48N	4	21E	100	-11	-9	-7	28	26	25	11	21	20	19	NE	4	ENE	
BERMUDA																			
Kindley AFB	33	22N	64	41W	9	8	12	13	31	30	29	7	26	26	26	NW	8	S	
BOLIVIA																			
La Paz	16	20S	68	09W	2659	-2	-1	1	22	21	20	13	14	14	13				
BRAZIL																			
Belem	1	27S	48	29W	13	19	21	22	32	32	31	11	27	26	26	SE	3	E	
Belo Horizonte	19	56S	43	57W	915	6	8	10	30	29	28	10	24	24	24				
Brasilia	5	52S	47	55W	1049	8	9	11	32	31	30	9	24	24	24				
Curitiba	25	25S	49	17W	949	-2	1	3	30	29	28	12	24	23	23				
Fonaleza	3	46S	38	33W	27	19	21	21	33	32	9	26	26	26	26				
Porto Alegre	30	02S	51	13W	10	0	3	4	35	33	32	11	24	24	24				
Recife	8	04S	34	53W	30	19	21	21	31	31	30	6	26	25	25				
Rio De Janeiro	22	55S	43	12W	61	13	14	16	34	33	32	6	27	26	26	N	3	S	
Salvador	13	00S	38	30W	47	18	19	20	31	31	30	7	26	26	26				
Sao Paulo	23	33S	46	38W	795	2	6	8	30	29	28	10	24	23	23	N	3	W	

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 3.

(Contd.)

TABLE 10 Surface conductance ($\text{W}/(\text{m}^2 \cdot ^\circ\text{C})$) and resistance ($\text{m}^2 \cdot ^\circ\text{C}/\text{W}$) for air

Position of surface	Direction of heat flow	Surface emittance, ε^e					
		Non-reflective $\varepsilon = 0.90$		$\varepsilon = 0.20$		Reflective $\varepsilon = 0.05$	
		h_l	R	h_l	R	h_l	R
STILL AIR							
Horizontal	Upward	9.26	0.11	5.17	0.19	4.32	0.23
Sloping 45°	Upward	9.09	0.11	5.00	0.20	4.15	0.24
Vertical	Horizontal	8.29	0.12	4.20	0.24	3.35	0.30
Sloping 45°	Downward	7.50	0.13	3.41	0.29	2.56	0.39
Horizontal	Downward	6.13	0.16	2.10	0.48	1.25	0.80
MOVING AIR (Any Position)							
Wind (for winter) 6.7 m/s (24 km/h)	Any	34.0	0.030	—	—	h_o	R
Wind (for summer) 3.4 m/s (12 km/h)	Any	22.7	0.044	—	—	—	—

*No surface has both an airspace resistance value and a surface resistance value. No airspace value exists for any surface facing an airspace of less than 13 mm.

^bFor ventilated attics or spaces above ceiling under summer conditions (heat flow down), see Table 5.

^cConductances are for surfaces of the stated emittance facing virtual black body surrounding at the same temperature as the ambient air. Values are based on a surface-air temperature difference of 5.5°C and for surface temperature of 21°C.

^dsee Chapter 3 for more detailed information, especially Tables 5 and 6, and see Figure 1 for additional data.

^eCondensate can have a significant impact on the surface emittance (see Table 3).

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 1.

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TABLE 11 Recommended indoor temperature and relative humidity for summer cooling

Type of premise	Dry bulb temperature (°C)	Minimum relative humidity
Offices	25.5	55%
Cafeterias	24.0	55%
Auditoriums	25.5	50%
Computer rooms	24.0	As needed
Department stores	26.5	55%
Supermarkets	25.5	55%
Factory	22	50%
Residence	25.5	55%

12(a) Roof Construction Code

Roof No.	Description	Code Numbers of Layers (see Table 8)
1	Steel Sheet with 25-mm insulation	A0, E2, E3, B5, A3, EO
2	25-mm wood with 25-mm insulation	A0, E2, E3, B5, B7, EO
3	100-mm l. w. concrete	A0, E2, E3, C14, EO
4	50-mm h. w. concrete with 25-mm insulation	A0, E2, E3, B5, C12, EO
5	25-mm wood with 50-mm insulation	A0, E2, E3, B6, B7, EO
5	25-mm wood with 50-mm insulation	A0, E2, E3, B5, C12, EO
6	150-mm l. w. concrete	A0, E2, E3, B6, B7, EO
7	63-mm wood with 25-mm insulation	A0, E2, E3, B5, B8, EO
8	200-mm l. w. concrete	A0, E2, E3, C16, EO
9	100-mm h. w. concrete with 25-mm insulation	A0, E2, E3, B5, C5, EO
10	63-mm wood with 50-mm insulation	A0, E2, E3, B6, B8, EO
11	Roof terrace system	A0, C12, B1, B6, E2, E3, C5, EO
12	150-mm h. w. concrete with 25-mm insulation	A0, E2, E3, B5, C13, EO
13	100-mm wood with 25-mm insulation	A0, E2, E3, B5, B9, EO

TABLE 12(b) Cooling load temperature differences (CLTD) for calculating cooling load from flat roofs

Roof no.	Description of construction	Mass, kg/m ²	U-value, W/m ² °C	Solar time												Hours of				Maxi-difference, min	Min-difference, min												
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
Without Suspended Ceiling																																	
1	Steel sheet with 25 mm (or 50 mm) insulation	34 (39)	1.209 (0.704)	0	-1	-2	-3	-2	-3	11	19	27	34	40	43	44	43	39	33	25	17	10	7	5	3	1	14	-3	44	47			
2	25 mm wood with 25 mm insulation	39	0.965	3	2	0	-1	-2	-2	-1	2	8	15	22	29	35	39	41	41	39	35	29	21	15	11	8	5	16	-2	41	43		
3	100 mm l.w. concrete	88	1.209 (0.693)	5	3	1	0	-1	-2	1	5	11	18	25	31	36	39	40	40	37	32	25	19	14	10	7	16	-2	40	42			
4	50 mm h.w. concrete with 25 mm (or 50 mm) ins.	142	1.170 (0.693)	7	5	3	2	0	-1	0	2	6	11	17	23	28	33	36	37	34	30	25	20	16	12	10	16	-1	37	38			
5	25 mm wood with 50 mm insulation	44	0.619	2	0	-2	-3	-4	-4	-1	-2	3	9	15	22	27	32	35	36	35	32	27	20	14	10	6	3	16	-4	36	40		
6	150 mm l.w. concrete	117	0.897	12	10	7	5	3	2	1	0	2	4	8	13	18	24	29	33	35	36	32	28	24	19	16	13	10	19	3	31	38	
7	60 mm wood with 25 mm insulation	63	0.738	16	13	11	9	7	6	4	3	4	5	8	11	15	19	23	27	29	31	31	30	27	25	22	20	19	4	30	26		
8	200 mm l.w. concrete with 25 mm (or 50 mm) ins.	151	0.715	20	17	14	12	10	8	6	5	4	4	5	7	11	14	18	22	25	28	30	30	29	27	24	21	19	16	18	4	30	26
9	100 mm h.w. concrete with 25 mm (or 50 mm) ins.	136 (254)	1.136 (0.681)	14	12	10	8	7	5	4	4	6	8	11	15	18	22	25	28	29	30	29	27	24	21	19	16	18	19	4	30	26	
10	60 mm wood with 50 mm insulation	63	0.528	18	15	13	11	9	8	6	5	5	5	7	10	13	17	21	24	27	28	29	27	25	22	20	19	17	19	8	25	17	
11	Roof terrace system	366	0.602	19	17	15	14	12	11	9	8	7	8	10	12	15	18	20	22	24	25	25	25	24	22	20	19	19	19	8	25	17	
12	150 mm h.w. concrete with 25 mm (or 50 mm) ins.	366 (0.664)	1.090 (0.664)	18	16	14	12	11	10	9	8	7	9	10	12	15	17	20	22	24	25	25	25	24	22	20	19	19	21	19	24	15	
13	100 mm wood with 25 mm (or 50 mm) insulation	83 (88)	0.602 (0.443)	21	20	18	17	15	14	13	11	10	9	9	10	12	14	16	18	20	22	23	24	23	22	22	22	22	9	24	15		
With Suspended Ceiling																																	
1	Steel Sheet with 25 mm (or 50 mm) insulation	44 (49)	0.761 (0.522)	1	0	-1	-2	-3	-3	0	5	13	20	28	35	40	43	43	41	37	31	23	15	10	7	5	3	15	-3	43	46		
2	25 mm wood with 25 mm insulation	49	0.653	11	8	6	5	3	2	1	2	4	7	12	17	22	27	31	33	35	34	32	28	24	20	17	14	17	1	35	34		
3	100 mm l.w. concrete	97	0.761	10	8	6	4	2	1	0	0	2	6	10	16	21	27	31	34	36	34	30	26	21	17	13	17	0	36	36			
4	50 mm h.w. concrete with 25 mm insulation	146	0.744	16	14	13	11	10	8	7	7	8	9	11	14	17	19	22	24	25	26	26	25	23	21	18	18	7	26	19			
5	25 mm wood with 50 mm insulation	49	0.471	14	11	9	7	5	4	3	3	4	6	10	14	18	23	27	30	31	32	31	29	26	22	19	16	18	3	32	30		
6	150 mm l.w. concrete	127	0.619	18	15	13	11	9	7	6	4	4	4	6	9	12	16	20	24	27	29	30	28	26	23	20	20	4	30	26			
7	60 mm wood with 25 mm insulation	73	0.545	19	18	16	14	13	12	10	9	8	8	9	10	12	14	17	19	21	23	24	25	24	23	22	21	20	8	25	17		
8	200 mm l.w. concrete	161	0.528	22	20	18	16	15	13	12	11	11	11	12	13	15	16	18	19	20	21	21	20	19	18	19	11	11	21	10	23	13	
9	100 mm h.w. concrete with 25 mm (or 50 mm) ins.	239 (264)	0.727 (0.511)	17	16	15	14	13	12	11	10	10	10	11	12	14	16	18	19	21	22	23	23	22	21	21	21	20	8	25	17		
10	60 mm wood with 50 mm insulation	73	0.409	19	18	17	16	14	13	12	11	10	10	10	11	12	14	15	16	17	18	18	19	19	19	18	18	18	19	11	21	10	
11	Roof terrace system	376	0.466	17	16	15	15	14	13	13	12	12	12	13	13	14	15	16	16	17	18	18	19	18	18	18	18	19	19	7	7	7	
12	150 mm h.w. concrete with 25 mm (or 50 mm) ins.	376 (376)	0.710	16	16	15	15	14	13	13	12	12	12	13	13	14	15	16	17	18	18	19	19	19	18	18	18	19	19	12	20	8	
13	100 mm wood with 25 mm (or 50 mm) insulation	93 (97)	0.465 (0.363)	20	19	19	18	17	16	15	14	14	13	12	12	12	13	14	15	16	16	17	18	19	20	20	20	23	12	20	8		

Adapted by permission from ASHRAE Fundamentals, 1989, Table 29.

TABLE B CLTD correction for latitude and month applied to walls and roofs, north latitudes

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	HOR
0	Dec	-1.6	-2.7	-2.7	-2.7	-1.1	0.0	1.6	3.3	5.0	-0.5
	Jan/Nov	-1.6	-2.7	-2.2	-2.2	-0.5	0.0	1.1	2.2	3.8	-0.5
	Feb/Oct	-1.6	-1.1	-1.1	-1.1	-0.5	-0.5	0.0	-0.5	-3.8	0.0
	Mar/Sept	-1.6	0.0	0.5	-0.5	-1.6	-1.6	-1.6	-2.7	-4.4	0.0
	Apr/Aug	2.7	2.2	1.6	0.0	-1.1	-2.7	-3.3	-4.4	-4.4	-1.1
	May/Jul	5.5	3.8	2.7	0.0	-1.6	-3.8	-4.4	-5.0	-4.4	-2.2
	Jun	6.6	5.0	2.7	0.0	-1.6	-3.8	-5.0	-5.5	-4.4	-2.7
	Dec	-2.2	-3.3	-3.3	-3.3	-1.6	0.0	2.2	4.4	6.6	-2.2
	Jan/Nov	-1.6	-2.7	-3.3	-2.7	-1.1	0.0	1.6	3.3	5.5	-2.2
	Feb/Oct	-1.6	-2.2	-1.6	-1.6	-0.5	-0.5	0.5	1.1	2.2	-0.5
8	Mar/Sept	-1.6	-1.1	-0.5	-0.5	-1.1	-1.1	-1.1	-1.6	-2.2	0.0
	Apr/Aug	1.1	1.1	1.1	0.0	-0.5	-0.5	-2.2	-2.7	-3.8	-0.5
	May/Jul	3.8	2.7	2.2	0.0	-1.1	-2.7	-3.8	-5.0	-3.8	-1.1
	Jun	5.0	3.3	2.2	0.0	-1.1	-3.3	-4.4	-5.0	-3.8	-1.1
	Dec	-2.2	-3.3	-3.8	-3.8	-2.2	-2.2	-0.5	2.2	5.0	-5.0
	Jan/Nov	-2.2	-3.3	-2.7	-2.7	-2.2	-1.1	0.0	1.1	2.7	-2.2
	Feb/Oct	-1.6	-2.7	-1.6	-1.1	-0.5	-0.5	0.0	0.0	0.0	-0.5
	Mar/Sept	-1.6	-1.6	-1.1	-1.1	-0.5	-0.5	-1.6	-2.7	-3.3	0.0
16	Apr/Aug	-0.5	0.0	-0.5	-0.5	-0.5	-0.5	-0.5	2.2	4.4	-3.8
	May/Jul	2.2	1.6	1.6	0.0	-0.5	-0.5	-2.2	-2.7	-3.8	0.0
	Jun	3.3	2.2	2.2	0.5	-0.5	-0.5	-2.2	-3.3	-4.4	-3.8
	Dec	-2.7	-3.8	-5.0	-5.5	-3.8	-1.6	1.6	5.0	7.2	-7.2
	Jan/Nov	-2.2	-3.3	-4.4	-5.0	-3.3	-1.6	1.6	3.8	5.5	-3.8
	Feb/Oct	-2.2	-2.7	-3.3	-3.3	-1.6	-0.5	0.0	0.0	0.0	-0.5
	Mar/Sept	-1.6	-2.2	-1.6	-1.6	-0.5	-0.5	-0.5	-0.5	-2.7	-3.3
	Apr/Aug	-1.1	-0.5	0.0	-0.5	-0.5	-0.5	-0.5	-0.5	-3.8	-3.8
24	May/Jul	2.2	1.6	1.6	0.0	-0.5	-0.5	-2.2	-3.3	-4.4	-3.8
	Jun	3.3	2.2	2.2	0.5	-0.5	-0.5	-2.2	-3.3	-4.4	-3.8
	Dec	-2.7	-3.8	-5.0	-5.5	-3.8	-1.6	1.6	5.0	7.2	-7.2
	Jan/Nov	-2.2	-3.3	-4.4	-5.0	-3.3	-1.6	1.6	3.8	5.5	-3.8
	Feb/Oct	-2.2	-2.7	-3.3	-3.3	-1.6	-0.5	0.0	0.0	0.0	-0.5
	Mar/Sept	-1.6	-2.2	-1.6	-1.6	-0.5	-0.5	-0.5	-0.5	-1.6	0.0
	Apr/Aug	-1.1	-0.5	0.0	-0.5	-0.5	-0.5	-0.5	-0.5	-2.7	-3.3
	May/Jul	0.5	1.1	1.1	0.0	0.0	0.0	-1.6	-1.6	-3.3	0.5
32	Jun	1.6	1.6	1.6	0.5	0.0	0.0	-1.6	-2.2	5.0	6.6
	Dec	-2.7	-3.8	-5.5	-6.1	-4.4	-2.7	1.1	5.0	6.6	-9.4
	Jan/Nov	-2.7	-3.8	-5.0	-6.1	-4.4	-2.2	1.1	5.0	6.6	-8.3
	Feb/Oct	-2.2	-3.3	-3.8	-4.4	-2.2	-1.1	2.2	4.4	6.1	-5.5
	Mar/Sept	-1.6	-2.2	-2.2	-2.2	1.1	-0.5	1.6	2.7	3.8	-2.7
	Apr/Aug	-1.1	-0.5	-0.5	-1.1	0.0	-0.5	0.0	0.5	0.5	-0.5
	May/Jul	0.5	0.5	0.5	0.0	0.0	-0.5	-1.6	-1.6	0.5	0.5
	Jun	0.5	1.1	1.1	0.5	0.0	-1.1	-1.1	-2.2	-2.2	1.1

(Contd.)

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 32.

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Table 13-14 Wall Construction Group Description

Mass (kg/m ²)	U-Value (W/m ² •°C)	Group No.	Description of Construction	Code Numbers of Layers (see Table 8)
405	2.033		101.6-mm Face Brick + (Brick)	
405	2.033	C	Air Space + 101.6-mm Face Brick	A0, A2, B1, A2, E0
439	2.356	D	101.6-mm Common Brick	A0, A2, C4, E1, E0
439	0.987-1.709	C	25.4-mm Insulation or Air Space + 101.6-mm Common Brick	A0, A2, C4, B1/B2, E1, E0
430	0.630	B	50.8-mm Insulation + 101.6-mm Common Brick	A0, A2, B3, C4, E1, E0
635	1.714	B	203.2-mm Common Brick	A0, A2, C9, E1, E0
635	0.874-1.379	A	Insulation or Air Space + 203.2-mm Common brick	A0, A2, C9, B1/B2, E1, E0
			101.6-mm Face Brick + (H. W. Concrete)	
459	1.987	C	Air Space + 50.8-mm Concrete	A0, A2, B1, C5, E1, E0
474	0.658	B	50.8-mm Insulation + 101.6-mm Concrete	A0, A2, B3, C5, E1, E0
698-928	0.625-0.636	A	Air Space or Insulation + 203.2-mm or more Concrete	A0, A2, B1, C10/11, E1, E0
			101.6-mm Face Brick + (L. W. or H. W. Concrete Block)	
303	1.811	E	101.6-mm Block	A0, A2, C2, E1, E0
303	0.868-1.397	D	Air Space or Insulation + 101.6-mm Block	A0, A2, C2, B1/B2, E1, E0
342	1.555	D	203.2-mm Block	A0, A2, C7, A6, E0
356-434	1.255-1.561	C	Air Space or 25.4-mm Insulation + 152.4-mm or 203.2-mm Block	A0, A2, B1, C7/C8, E1, E0
434	0.545-0.607	B	50.8-mm Insulation + 203.2-mm Block	A0, A2, B3, C7/C8, E1, E0
			101.6-mm Face Brick + (Clay Tile)	
347	2.163	D	101.6-mm Tile	A0, A2, C1, E1, E0
347	1.595	D	Air Space + 101.6-mm Tile	A0, A2, C1, B1, E1, E0
347	0.959	C	Insulation + 101.6-mm Tile	A0, A2, C1, B2, E1, E0
469	1.561	C	203.2-mm Tile	A0, A2, C6, E1, E0
469	0.806-1.255	B	Air Space or 25.4-mm Insulation + 203.2-mm Tile	A0, A2, C6, B1/B2, E1, E0
474	0.551	A	50.8-mm Insulation + 203.2-mm Tile	A0, A2, B3, C6, E1, E0
			H.W. Concrete Wall + (Finish)	
308	3.321	E	101.6-mm Concrete	A0, A1, C5, E1, E0
308	0.675-1.136	D	101.6-mm Concrete + 25.4-mm or 50.8-mm Insulation	A0, A1, C5, B2/B3, E1, E0
308	0.675	C	50.8-mm Insulation + 101.6-mm Concrete	A0, A1, B6, C5, E1, E0
532	2.782	C	203.2-mm Concrete	A0, A1, C10, E1, E0
537	0.653-1.061	B	203.2-mm Concrete + 25.4-mm or 50.8-mm Insulation	A0, A1, C10, B5/B6, E1, E0
537	0.653	A	50.8-mm Insulation + 203.2-mm Concrete	A0, A1, B3, C10, E1, E0
762	2.390	B	304.8-mm Concrete	A0, A1, C11, E1, E0
762	0.642	A	304.8-mm Concrete + Insulation	A0, C11, B6, A6, E0
			L. W. and H. W. Concrete Block + (Finish)	
142	0.914-1.493	F	101.6-mm Block + Air Space/Insulation	A0, A1, C2, B1/B2, E1, E0
142-181	0.596-0.647	E	50.8-mm Insulation + 101.6-mm Block	A0, A1, B3, C2/C3, E1, E0
229-249	1.669-2.282	E	203.2-mm Block	A0, A1, C7/C8, E1, E0
200-278	0.846-0.982	D	203.2-mm Block + Air Space/Insulation	A0, A1, C7/C8, B1/B2, E1, E0
			Clay Tile + (Finish)	
190	2.379	F	101.6-mm Tile	A0, A1, C1, E1, E0
190	1.720	F	101.6-mm Tile + Air Space	A0, A1, C1, B1, E1, E0
190	0.993	E	101.6-mm Tile + 25.4-mm Insulation	A0, A1, C1, B2, E1, E0
195	0.625	D	50.8-mm Insulation + 101.6-mm Tile	A0, A1, B3, C1, E1, E0
308	1.681	D	203.2-mm Tile	A0, A1, C6, B1/B2, E1, E0
308	0.857-1.312	C	203.2-mm Tile + Air Space/25.4-mm Insulation	A0, A1, C6, B1/B2, E1, E0
308	0.562	B	50.8-mm Insulation + 203.2-mm Tile	A0, A1, B3, C6, E1, E0
			Metal Curtain Wall	
24-29	0.516-1.306	G	With/without air Space + 25.4-mm/50.8-mm 76.2-mm Insulation	A0, A3, B5/B6/B12, A3, E0
			Frame Wall	
78	0.459-1.010	G	25.4-mm to 76.2-mm Insulation	A0, A1, B1, B2/B3/B4, E1, E0

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Table Cooling Load Temperature Differences for Calculating Cooling Load from Sunlit Walls

North Latitude	Wall Facing	Solar Time, h																								H of Maxi- mum CLTD	Mini- mum CLTD	Maxi- mum CLTD	Differ- ence CLTD	
		0100	0200	0300	0400	0500	0600	0	1	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400				
Group A Walls																														
N	8	8	8	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	8	2	6	8	2			
NE	11	11	10	10	10	9	9	8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	11	22	8	11	3			
E	14	13	13	13	12	12	11	11	10	10	10	11	11	12	12	13	13	14	14	14	14	14	14	22	10	14	4			
SE	13	13	13	13	12	12	11	11	10	10	10	10	11	11	12	12	13	13	13	13	13	13	13	22	10	13	3			
S	11	11	11	11	10	10	9	9	8	8	8	8	8	8	9	9	10	10	11	11	11	11	11	23	8	11	3			
SW	14	14	14	14	13	13	12	12	11	11	10	10	9	9	10	10	10	11	12	13	13	14	14	24	9	14	5			
W	15	15	15	14	14	13	13	12	12	11	11	10	10	10	11	11	12	13	14	14	15	15	1	10	15	5				
NW	12	12	11	11	11	10	10	10	9	9	8	8	8	8	8	9	9	10	11	11	11	11	1	8	12	4				
Group B Walls																														
N	8	8	8	7	7	6	6	6	5	5	5	5	5	5	5	6	6	6	7	7	8	8	8	8	24	5	8	3		
NE	11	10	10	9	9	8	7	7	7	7	8	8	9	9	10	10	11	11	11	12	12	12	12	11	21	7	12	5		
E	13	13	12	11	10	10	9	8	8	9	9	10	12	13	13	14	14	15	15	15	15	15	15	14	20	8	15	7		
SE	13	12	12	11	10	10	9	8	8	8	8	9	10	11	12	13	14	14	14	14	14	14	14	14	21	8	14	6		
S	12	11	11	10	9	9	8	7	7	6	6	6	6	7	8	9	10	11	11	12	12	12	12	12	23	6	12	6		
SW	15	15	14	13	13	12	11	10	9	9	8	8	8	7	8	9	10	11	13	14	15	15	16	16	24	7	16	9		
W	16	15	14	14	13	12	11	10	9	9	8	8	8	8	8	9	11	12	14	15	15	16	16	17	24	8	17	9		
NW	13	12	11	11	10	9	9	8	7	7	6	6	5	6	6	7	8	8	9	11	12	13	13	13	24	6	13	7		
Group C Walls																														
N	9	8	7	7	6	5	5	4	4	4	4	4	4	4	5	5	6	6	7	8	9	9	9	10	9	22	4	10	6	
NE	10	10	9	8	7	6	6	6	6	7	8	10	10	11	12	12	12	13	13	13	13	12	12	11	20	6	13	7		
E	13	12	11	10	9	8	7	7	8	9	11	13	14	15	16	16	17	17	16	16	16	15	14	13	18	7	17	10		
SE	13	12	11	10	9	8	7	6	7	7	9	10	12	14	15	16	16	16	16	16	15	15	14	13	19	6	16	10		
S	12	11	10	9	8	7	6	6	5	5	5	5	6	8	9	11	12	13	14	14	14	14	14	13	20	5	14	9		
SW	16	15	14	12	11	10	9	8	7	7	7	7	8	9	10	12	14	16	18	18	18	18	18	17	22	6	18	12		
W	17	16	15	14	12	11	10	9	8	7	7	7	7	7	8	9	11	13	15	15	15	15	15	15	22	7	20	13		
NW	14	13	12	11	10	9	8	7	6	6	5	4	4	4	5	6	7	8	10	12	15	17	18	17	16	15	22	5	15	10
Group D Walls																														
N	8	7	7	6	5	4	3	3	3	3	4	4	4	5	6	6	6	7	8	9	10	11	10	10	9	21	3	11	8	
NE	9	8	7	6	5	5	4	4	4	6	8	10	11	12	13	13	14	14	14	14	13	12	11	10	19	4	14	10		
E	11	10	8	7	6	5	5	5	7	10	13	15	17	18	18	18	18	18	17	17	16	15	15	13	12	16	5	18	13	
SE	11	10	9	8	7	6	5	5	5	7	10	12	14	16	17	18	18	18	17	17	16	15	14	12	17	5	18	13		
S	11	10	8	7	6	5	4	4	3	3	4	5	7	9	11	13	15	16	16	16	15	14	14	13	20	3	16	13		
SW	15	14	12	10	9	8	6	5	5	4	4	5	5	7	9	12	15	18	20	21	21	20	19	19	17	21	4	21	17	
W	17	15	13	12	10	9	7	6	5	5	5	6	6	6	8	10	13	17	20	22	23	22	21	19	21	5	23	18		
NW	14	12	11	9	8	7	6	5	4	4	4	5	6	7	8	10	12	15	17	18	17	16	15	22	4	18	14			
Group E Walls																														
N	7	6	5	4	3	2	2	2	3	3	4	5	6	7	8	10	10	11	12	12	11	10	9	8	20	2	12	10		
NE	7	6	5	4	3	2	2	3	5	8	11	13	14	14	14	14	14	14	14	13	12	11	9	8	16	2	15	13		
E	8	7	6	5	4	3	3	6	10	15	18	20	21	21	20	19	18	18	17	15	14	12	11	9	13	3	21	18		
SE	8	7	6	5	4	3	3	4	7	10	14	17	19	20	20	19	18	18	17	16	15	14	13	11	10	15	3	20	17	
S	8	7	6	5	4	3	2	2	2	3	5	7	10	14	16	18	19	18	17	16	14	13	11	10	17	2	19	17		
SW	12	10	8	7	6	4	4	3	3	3	4	5	7	10	14	18	21	24	25	24	22	19	17	14	19	3	25	22		
W	14	12	10	8	6	5	4	3	3	4	4	5	6	8	11	15	20	24	27	27	25	22	19	16	20	3	27	24		
NW	11	9	8	6	5	4	3	3	3	4	5	6	7	9	11	14	18	21	21	20	18	15	13	20	3	21	18			
Group F Walls																														
N	5	4	3	2	1	1	1	2	3	4	5	6	8	9	11	12	13	13	11	9	7	6	19	1	13	12				
NE	5	4	3	2	1	1	1	3	8	13	16	17	16	15	15	15	14	13	12	10	9	7	6	11	1	17	16			
E	5	4	3	2	2	1	4	9	16	21	24	25	24	22	20	19	18	17	15	13	11	10	8	7	12	1	25	24		
SE	5	4	3	2	2	1	2	6	10	15	20	23	24	23	22	20	19	17	16	14	12	10	8	7</						

TABLE 16 Thermal properties and code numbers of layers used in wall and roof descriptions

Code number	Description	<i>L</i>	<i>k</i>	Thickness and thermal properties			Mass
				<i>P</i>	<i>c_p</i>	<i>R</i>	
A0	Outside surface resistance	0	0.000	0	0.00	0.059	0.00
A1	25 mm stucco	25	0.692	1858	0.84	0.037	47.34
A2	100 mm facebrick	100	1.333	2002	0.92	0.076	203.50
A3	Steel siding	2	44.998	7689	0.42	0.000	11.71
A4	12 mm slag	13	0.190	1121	1.67	0.067	10.74
A5	Outside surface resistance	0	0.000	0	0.00	0.059	0.00
A6	Finish	13	0.415	1249	1.09	0.031	16.10
A7	100 mm facebrick	100	1.333	2002	0.92	0.076	203.50
B1	Air space resistance	0	0.000	0	0.00	0.160	0.00
B2	25 mm insulation	25	0.043	32	0.84	0.587	0.98
B3	50 mm insulation	51	0.043	32	0.84	1.173	1.46
B4	75 mm insulation	76	0.043	32	0.84	1.760	2.44
B5	25 mm insulation	25	0.043	91	0.84	0.587	2.44
B6	50 mm insulation	51	0.043	91	0.84	1.173	4.88
B7	25 mm wood	25	0.121	593	2.51	1.760	15.13
B8	62 mm wood	63	0.121	593	2.51	0.524	37.55
B9	100 mm wood	101	0.121	593	2.51	0.837	60.02
B10	50 mm wood	51	0.121	593	2.51	0.420	30.26
B11	75 mm wood	76	0.121	593	2.51	0.628	45.38
B12	75 mm insulation	76	0.043	91	0.84	1.760	6.83
B13	100 mm insulation	100	0.043	91	0.84	2.347	9.27
B14	125 mm insulation	125	0.043	91	0.84	2.933	11.71
B15	150 mm insulation	150	0.043	91	0.84	3.520	14.15
B16	4 mm insulation	4	0.043	91	0.84	0.088	0.49
B17	8 mm insulation	8	0.043	91	0.84	0.176	0.49
B18	12 mm insulation	12	0.043	91	0.84	0.264	0.98
B19	15 mm insulation	15	0.043	91	0.84	0.352	1.46
B20	20 mm insulation	20	0.043	91	0.84	0.440	1.95
B21	35 mm insulation	35	0.043	91	0.84	0.792	2.93
B22	42 mm insulation	42	0.043	91	0.84	0.968	3.90
B23	60 mm insulation	62	0.043	91	0.84	1.408	5.86
B24	70 mm insulation	70	0.043	91	0.84	1.584	6.34

(Contd.)

TABLE 1.2 Thermal properties and code numbers of layers used in wall and roof descriptions (Contd.)

Code number	Description	L	k	Thickness and thermal properties				Mass
				p	c_p	R		
B25	85 mm insulation	85	0.043	91	0.84	1.936	7.81	
B26	92 mm insulation	92	0.043	91	0.84	2.112	8.30	
B27	115 mm insulation	115	0.043	91	0.84	2.640	10.74	
C1	100 mm clay tile	100	0.571	1121	0.84	0.178	113.70	
C2	100 mm lightweight concrete block	100	0.381	609	0.84	0.266	61.98	
C3	100 mm heavy weight concrete block	100	0.813	977	0.84	0.125	99.06	
C4	100 mm common brick	100	0.727	1922	0.84	0.140	195.20	
C5	100 mm heavy weight concrete	100	1.731	2243	0.84	0.059	227.90	
C6	200 mm clay tile	200	0.571	1121	0.84	0.352	227.90	
C7	200 mm lightweight concrete block	200	0.571	609	0.84	0.352	123.46	
C8	200 mm heavy weight concrete block	200	1.038	977	0.84	0.196	198.62	
C9	200 mm common brick	200	1.731	2243	0.84	0.279	390.40	
C10	200 mm heavy weight concrete	300	1.731	2243	0.84	0.117	455.79	
C11	300 mm heavy weight concrete	50	1.731	2243	0.84	0.029	113.70	
C12	50 mm heavy weight concrete	150	1.731	2243	0.84	0.088	341.60	
C13	150 mm heavy weight concrete	100	0.173	641	0.84	0.587	64.90	
C14	100 mm lightweight concrete	150	0.173	641	0.84	0.880	97.60	
C15	150 mm lightweight concrete	200	0.173	641	0.84	1.173	130.30	
C16	200 mm lightweight concrete	200	0.138	288	0.84	1.467	58.56	
C17	200 mm lightweight conc blk. (filled)	200	0.588	849	0.84	0.345	172.75	
C18	200 mm heavy weight conc. blk. (filled)	300	0.138	304	0.84	2.200	92.72	
C19	300 mm lightweight conc. blk. (filled)	300	0.675	897	0.84	0.451	273.28	
C20	300 mm heavy weight conc. blk. (filled)	0	0.000	0	0.00	0.121	0.00	
E0	Inside surface resistance	20	0.7277	1602	0.84	0.026	30.74	
E1	20 mm plaster or gypsum	12	1.436	881	1.67	0.099	11.22	
E2	12 mm slag or stone	10	0.190	1121	1.67	0.050	10.74	
E3	10 mm felt and membrane	0	0.000	0	0.00	0.176	0.00	
E4	Ceiling air space	19	0.061	481	0.84	0.314	9.27	
E5	Acoustic tile							

L = thickness mm, K = thermal conductivity, W/(m·°C), p = density, kg/m³, c_p = specific heat, kg/(kg·°C), R = thermal resistance, (m²·°C)/W.

Mass = kg/m²

Adapted by permission from ASHRAE Fundamentals, 1989, Table 11.

TABLE 17 Typical thermal properties of common building and insulating materials—design values

Description	Density kg/m ³	Conduc- tivity (k) W/(m · K)	Conduc- tance (C) W(m ² · K)	Resistance (R)	
				For thickness listed (1/Ω) (m ² · K)/W	Specific heat, kJ/(kg · K)
Expanded polystyrene molded beads	16	0.03	—	26	—
	20	0.036	—	27.0	—
	24	0.035	—	28.9	—
	28	0.035	—	28.9	—
	32	0.033	—	30.2	—
	24	0.023–0.026	—	43.3–38.5	1.59
Cellular polyurethane polyisocyanurate (CFC-11 exp.) (unfaced)	24–40	0.023–0.026	—	43.3–38.5	—
Cellular polyisocyanurate (CFC-11 exp.) (gas permeable facer)	32	0.020	—	49.9	0.92
Cellular phenolic (closed cell) (CFC-11, CFC 113 exp.)	32	0.017	—	56.8	—
Cellular phenolic (open cell)	29–35	0.033	—	30.5	—
Mineral fiber with resin binder	240	0.042	—	23.9	0.71
Mineral fiberboard wet felted	260–270	0.049	—	20.4	—
Core or roof insulation	290	0.050	—	19.8	0.80
Acoustical tile	340	0.053	—	18.7	—
Mineral fiberboard, wet molded	370	0.060	—	16.5	—
Acoustical tile				0.59	
Wood or cane fiberboard	12.7 mm	—	—	0.80	1.25
Acoustical tile	19.0 mm	—	—	0.53	1.89
Acoustical tile					1.34
Interior finish (plank, tile)	240	0.050	—	19.8	—
Cement fiber slabs (shredded wood with Portland cement binder)	400–430	0.072–0.076	—	13.9–13.1	—
Cement fiber slabs (shredded wood with magnesia oxy sulfide binder)	350	0.082	—	12.1	—
					1.30

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 4.

(Contd.)

TABLE . . . Typical thermal properties of common building and insulating materials—design values (Contd.)

Description	Density kg/m ³	Conduc- tivity (k) W/(m · K)	Conduc- tance (C) W/(m ² · K)	Resistance (R)	
				For thickness listed (1/Ω) m ² · K/W	Specific heat, kJ/(kg · K)
<i>Loose Fill</i>					
Cellulosic insulation (milled paper or wood pulp)	37-51	0.039-0.046	—	25.6-21.7	—
Pperlite expanded	32-66	0.039-0.045	—	25.6-22.9	—
	66-120	0.045-0.052	—	22.9-1.4	—
	120-180	0.052-0.060	—	19.4-16.6	—
Mineral fiber (rock, slag, or glass)					
approx. 95-130 mm	9.6-32	—	—	—	1.38
approx. 170-220 mm	9.6-32	—	—	—	1.09
approx. 190-250 mm	9.6-32	—	—	—	—
approx. 260-350 mm	9.6-32	—	—	—	—
Mineral fiber (rock, slag, or glass) approx. 90 mm (closed sidewall application)	32-56	—	—	—	—
	110-130	0.068	—	14.8	—
Vermiculite expanded	64-96	0.063	—	15.7	—
—	—	—	—	—	—
<i>Spray Applied</i>					
Polyurethane foam	24-40	0.023-0.026	—	43.3-38.5	—
Urea formaldehyde foam	11-26	0.032-0.040	—	31.5-24.7	—
Cellulosic fiber	56-96	0.042-0.049	—	23.9-20.4	—
Glass fiber	56-72	0.038-0.039	—	26.7-25.6	—
PLASTERING MATERIALS					
Cement plaster, sand aggregate	1860	0.72	—	1.39	—
Sand aggregate	95 mm	—	75.5	—	0.84
Sand aggregate	19 mm	—	37.8	—	0.84
Gypsum plaster:					
Light weight aggregate	127 mm	720	—	17.7	—
Light weight aggregate	16 mm	720	—	15.2	—
Light weight agg. on metal lath	19 mm	—	—	12.1	—
Perlite aggregate					
Light weight aggregate	720	0.22	—	4.64	—
Light weight aggregate	1680	0.81	—	1.25	—
Sand aggregate	127 mm	1680	—	63.0	—
Sand aggregate	16 mm	1680	—	51.7	—
Sand aggregate on metal lath	19 mm	—	—	43.7	—
Vermiculite aggregate					
	720	0.24	—	4.09	—

(Contd.)

TABLE . Typical thermal properties of common building and insulating materials—design values (Contd.)

Description	Density kg/m ³	Conduc- tivity (k) W/(m · K)	Conduc- tance (C) W(m ² · K)	Conduc- tance (1/k) m·K/W	Resistance (R)					
					For thickness listed (1/Ω)	Specific heat, kJ/(kg · K)				
MASONRY MATERIALS										
<i>Concretes</i>										
Cement mortar	1680-2160	0.72-1.51	—	1.39-0.69	—	—				
Light weight aggregates including expanded shale, clay or slate; expanded slags; cinders, pumice, vermiculite also cellular concretes	1920 1600 1280 960 640 480 320 800 640 480 320	0.79-1.59 0.53-0.85 0.36-0.50 0.23-0.26 0.73-0.16 0.11-0.13 0.09-0.12 0.20-0.26 0.13 0.10 0.072	— — — — — — — — — — —	1.25-0.62 1.87-1.18 2.77-2.00 4.37-3.86 7.49-6.24 9.22-7.62 11.0-8.32 4.92-3.88 7.49 9.77 13.9	— — — — — — — — — — —	0.84 0.84 — — 0.84 — — — — — —				
Perlite expanded	2240	1.15-2.30	—	0.90-0.42	—	0.75-0.92				
Sand and gravel or stone aggregate (over dried)	2240 1860	1.44-2.88 0.72	— —	0.69-0.35 1.39	— —	0.79-1.00 —				
Sand and gravel or stone aggregate (not dried)										
Stucco										
<i>Masonry Units</i>										
Brick, common	1280 1440 1600 1760 1920 2080	0.32-0.46 0.39-0.53 0.48-0.62 0.50-0.80 0.63-0.92 0.78-1.30	— — — — — —	3.12-2.15 2.56-1.87 2.08-1.59 2.01-1.25 1.59-1.11 1.32-0.76	— — — — — —	— — — — — —				
Clay tile hollow	76 mm 102 mm 152 mm 203 mm 254 mm 305 mm	— — — — — —	— — — — — —	7.10 5.11 3.75 3.07 2.56 2.27	— — — — — —	0.14 0.20 0.27 0.33 0.39 0.44				

(Contd.)

TABLE 7 Typical thermal properties of common building and insulating materials—design values (Contd.)

Description	Density kg/m ³	Conduc- tivity (k) W/(m · K)	Conduc- tance (C) W(m ² · K)	Resistance (R)	
				(1/k) m·K/W	For thickness listed (1/Ω) (m ² · K)/W kJ/(kg · K)
Concrete blocks					
Limestone aggregate					
200 mm, 16.3 kg, 2210 kg/m ³ concrete, 2 cores	—	—	—	—	—
Same with perlite filled cores	—	—	2.73	—	0.37
300 mm, 25 kg, 2210 kg/m ³ concrete, 2 cores	—	—	—	—	—
Same with perlite filled cores	—	—	1.53	—	0.65
Normal weight aggregate (sand and gravel)					
200 mm, 15–16 kg, 2020–2180 kg/m ³ concrete	—	—	5.1–5.8	—	0.20–0.17
2 or 3 cores	—	—	3.0–4.1	—	0.34–0.24
Same with perlite filled cores	—	—	4.60	—	0.217
Same with vermiculite filled cores	—	—	2.84	—	0.35
300 mm, 22.7 kg, 2000 kg/m ³ concrete, 2 cores	—	—	—	—	—
Medium weight aggregate (combinations of normal weight and lightweight aggregate)					
200 mm, 12–13 kg, 1550–1790 kg/m ³ concrete	—	—	3.3–4.4	—	0.30–0.22
2 or 3 cores	—	—	1.5–2.5	—	0.65–0.41
Same with perlite filled cores	—	—	1.70	—	0.58
Same with vermiculite filled cores	—	—	1.82	—	0.56
Same with molded EPS (beads) filled cores	—	—	2.10	—	0.47
Same with molded EPS inserts in cores	—	—	—	—	—
Lightweight aggregate (expanded shale, clay, slate or slag, pumice)					
150 mm, 7.3–7.7 kg, 1360–1390 kg/m ³ concrete	—	—	3.0–3.5	—	0.34–0.29
2 or 3 cores	—	—	1.36	—	0.74
Same with perlite filled cores	—	—	1.87	—	0.53
Same with vermiculite filled cores	—	—	1.8–3.1	—	0.56–0.33
200 mm, 8.6–10.0 mm, 1150–1380 kg/m ³ concrete	—	—	0.9–1.3	—	1.20–0.77
Same with perlite filled cores	—	—	1.1–1.5	—	0.93–0.69
Same with vermi. filled cores	—	—	1.19	—	0.85
Same with molded EPS (beads) filled cores	—	—	1.25	—	0.79
Same with UF foam filled cores	—	—	1.65	—	0.62
Same with molded EPS inserts in cores	—	—	—	—	—
300 mm, 14.5–16.3 kg, 1280–1450 kg/m ³ concrete,	—	—	2.2–2.5	—	0.46–0.40
2 or 3 cores	—	—	0.6–0.9	—	1.6–1.1
Same with perlite filled cores	—	—	0.97	—	1.0
Same with vermiculite filled cores	—	—	—	—	(Contd.)

TABLE Typical thermal properties of common building and insulating materials—design values (Contd.)

Description	Density kg/m ³	Conduc- tivity (k) W/(m · K)	Conduc- tance (C) W(m ² · K)	Resistance (R)	
				(1/k) m · K/W	For thickness listed (1/Ω) (m ² · K)/W
Stone lime or sand	—	1.80	—	0.09	—
Gypsum partition tile	—	—	—	—	**
76 by 305 by 760, solid	—	—	4.50	—	0.222
76 by 305 by 760, 2 cells	—	—	4.20	—	0.236
102 by 305 by 760, 3 cells	—	—	3.40	—	0.294
METALS					
(See Chapter 39, Table 3)					
ROOFING					
Asbestos-cement shingles	1900	—	27.0	—	0.037
Asphalt roll roofing	1100	—	36.9	—	0.026
Asphalt shingles	1100	—	12.9	—	0.077
Built-up roofing	1100	—	17.0	—	0.058
Slate	—	—	1.14	—	0.009
Wood shingles, plain and plastic film faced	—	—	6.0	—	0.166
SIDING MATERIALS (on flat surface)					
<i>Shingles</i>					
Asbestos-cement	1900	—	27.0	—	—
Wood, 400 mm, 190 mm exposure	—	—	6.53	—	0.15
Wood, double, 400 mm, 300 mm exposure	—	—	4.77	—	0.21
Wood, plus insul. backer board, 8 mm	—	—	4.03	—	0.25
<i>Siding</i>					
Asbestos-cement, 6.4 mm, lapped	—	—	27.0	—	0.037
Asphalt roll siding	—	—	36.9	—	0.026
Asphalt insulating siding (12.7 mm bed)	—	—	3.92	—	0.26
Hardboard siding, 11 mm	—	—	8.46	—	0.12
Wood, drop, 20 by 200 mm	—	—	7.21	—	0.14
Wood, bevel, 13 by 200 mm, lapped	—	—	6.98	—	0.14
Wood, bevel, 19 by 250 mm, lapped	—	—	5.40	—	0.17
Wood, plywood, 9.5 mm, lapped	—	—	9.03	—	0.10
Aluminum or Steel, over sheathing	—	—	9.14	—	0.11
Hollow-backed	—	—	—	—	1.22
Insulating-board backed	—	—	—	—	—
9.5 mm nominal	—	—	3.12	—	0.32
9.5 mm nominal, foil backed	—	—	1.93	—	0.52
Architectural glass	—	—	56.8	—	0.018
(Contd.)					

TABLE Typical thermal properties of common building and insulating materials—design values (Contd.)

Description	WOODS (12% moisture content)	Conduc-	Conduc-	Resistance (R)	
				For thickness listed (1/ Ω) (m ² K)/W	Specific heat, kJ/(kg · K)
Hardwoods					
Oak	659-749	0.16-0.18	—	6.2-5.5	—
Birch	682-726	0.167-0.176	—	6.0-5.7	—
Maple	637-704	0.157-0.171	—	6.4-5.8	—
Ash	614-670	0.153-0.164	—	6.5-6.1	—
Softwoods					
Southern Pine	570-659	0.144-0.161	—	6.9-6.2	—
Douglas Fir-larch	536-581	0.137-0.145	—	7.3-6.9	—
Southern Cypress	502-514	0.130-0.132	—	7.7-7.6	—
Hem-Fir, Spruce-Pine-Fir	392-502	0.107-0.130	—	9.3-7.7	—
West Coast Woods, Cedars	347-502	0.098-0.130	—	10.3-7.7	—
California Redwood	392-448	0.107-0.118	—	9.4-8.5	—
BUILDING BOARD					
Asbestos-cement board	1900	0.58	—	1.73	1.00
Asbestos-cement board	3.2 mm	1900	—	182.4	—
Asbestos-cement board	6.4 mm	1900	—	93.3	0.005
Gypsum or plaster board	9.5 mm	800	—	17.6	0.011
Gypsum or plaster board	12.7 mm	800	—	12.6	0.056
Gypsum or plaster board	15.9 mm	800	—	10.1	0.079
Plywood (Douglas Fir)	540	0.12	—	8.66	—
Plywood (Douglas Fir)	6.4 mm	540	—	18.2	0.099
Plywood (Douglas Fir)	9.5 mm	540	—	12.1	0.11
Plywood (Douglas Fir)	12.7 mm	540	—	9.1	0.14
Plywood (Douglas Fir)	15.9 mm	540	—	7.3	0.16
Plywood or wood panels	19.0 mm	540	—	6.1	1.21

(Contd.)

TABLE Typical thermal properties of common building and insulating materials—design values (Contd.)

Description	Density kg/m ³	Conduc- tivity (k) W/(m · K)	Conduc- tance (C) W(m ² , K)	Resistance (R)	
				For listed (1/Ω) (m ² · K)/W	Specific heat, kJ/(kg · K)
Vegetable Fiber Board					
Sheathing regular density	12.7 mm	290	—	4.3	—
	19.8 mm	290	—	2.8	—
Sheathing intermediate density	12.7 mm	350	—	5.2	—
	12.7 mm	400	—	5.3	—
Nail-base sheathing	9.5 mm	290	—	6.0	—
Shingle backer	7.9 mm	290	—	7.3	—
Shingle backer	12.7 mm	240	—	4.2	—
Sound deadening board				17.3	—
Tile and lay-in panels, plain or acoustic	12.7 mm	290	0.058	—	—
	19.0 mm	290	—	4.5	—
	480	0.072	—	3.0	—
Laminated paperboard				13.9	—
Homogeneous board from repulped paper	480	0.072	—	13.9	—
Hardboard				9.50	—
Medium density	800	0.105	—	9.50	—
High density, service temp. service underlayment	880	0.82	—	8.46	—
High density, std. tempered	1010	0.144	—	6.93	—
Particleboard				9.77	—
Low density	590	0.102	—	9.77	—
Medium density	800	0.135	—	7.35	—
High density	1000	0.170	—	5.90	—
Underlayment	15.9 mm	640	—	6.9	—
Waferboard	590	0.01	—	11.0	0.14
Wood subfloor	19.0 mm	—	6.0	—	—
				0.17	1.38

(Contd.)

TABLE Typical thermal properties of common building and insulating materials—design values (Contd.)

Description	Density kg/m ³	Conduc- tivity (k) W/(m · K)	Conduc- tance (C) W(m ² · K)	Resistance (R)	
				(1/k) m · K/W	For thickness listed (1/Ω) (m ² · K)/W kJ/(kg · K)
BUILDING MEMBRANE					
Vapor-permeable felt	—	—	—	94.9	—
Vapor-seal, 2 layers of mopped 0.73 kg/m ² felt	—	—	—	47.4	—
Vapor-seal, plastic film	—	—	—	—	—
FINISH FLOORING MATERIALS					
Carpet and fibrous pad	—	—	—	2.73	—
Carpet and rubber pad	—	—	—	4.60	—
Cork tile	3.2 mm	—	—	20.4	—
Terrazzo	25 mm	—	—	71.0	—
Tile—asphalt, linoleum, vinyl, rubber vinyl asbestos	—	—	—	113.6	—
ceramic	—	—	—	—	—
Wood, hardwood finish	19 mm	—	—	8.35	—
INSULATING MATERIALS					
Blanket and Batt	—	—	—	—	—
Mineral Fiber, fibrous form processed from rock, slag, or glass approx. 75–100 mm	5–32	—	—	0.52	—
approx. 90 mm	5–32	—	—	0.44	—
approx. 140–165 mm	5–32	—	—	0.30	—
approx. 150–190 mm	5–32	—	—	0.26	—
approx. 230–250 mm	5–32	—	—	0.19	—
approx. 300–330 mm	5–32	—	—	0.15	—
Board and Slabs	136	0.050	—	19.8	—
Cellular glass	64–140	0.036	—	27.7	—
Glass fiber, organic bonded Expanded perlite organic bonded	16	0.052	—	19.3	—
Expanded rubber (rigid)	72	0.032	—	31.6	—
Expanded polystyrene extruded (smooth skin surface) (CFC-12 exp.)	29–56	0.029	—	34.7	—
<i>(Concluded)</i>					

TABLE 18(a) Maximum solar heat gain factor (W/m^2) for sunlit glass, north latitudes
(Contd.)

	24°N Lat									
	N	NNE/ NNW	NE/ NW	ENE/ WNW	E/ W	ESE/ WSW	SE/ SW	SSE/ SWW	S	HOR
Jan.	85	85	129	404	599	757	798	760	716	675
Feb.	95	95	252	521	694	770	767	672	606	786
Mar.	107	142	391	615	738	748	675	530	432	868
Apr.	117	278	502	659	719	669	533	338	237	893
May	136	369	562	675	688	599	416	211	145	890
June	174	401	581	675	669	565	369	174	136	880
July	142	366	555	663	672	584	407	205	145	877
Aug.	120	274	492	640	694	644	511	325	227	874
Sep.	110	133	375	584	700	710	650	514	423	839
Oct.	98	98	249	502	666	748	741	653	590	770
Nov.	85	85	133	398	590	745	786	748	707	672
Dec.	82	82	91	353	568	738	779	779	748	628

TABLE 18(b) Maximum solar heat gain factor (SHGF) for externally shaded glass (W/m^2)
(Based on ground reflectance of 0.2)

Use for latitudes 0 to 24 deg.

For latitudes greater than 24, use north orientation, Table A4(a).

For horizontal glass in shade, use the tabulated values for all latitudes.

	N	NNE/ NNW	NE/ NW	ENE/ WNW	E/ W	ESE/ WSW	SE/ SW	SSE/ SWW	S	(All Lat.)
									HOR	
Jan.	98	98	98	101	107	114	117	117	120	50
Feb.	107	107	107	110	114	117	120	120	123	50
Mar.	114	114	117	120	123	126	126	123	123	60
Apr.	126	126	130	133	133	133	129	126	126	76
May	137	139	142	145	142	136	129	126	126	88
June	142	145	148	148	145	139	129	126	126	98
July	142	142	145	148	148	142	133	129	129	98
Aug.	133	133	136	142	145	142	136	133	133	88
Sept.	117	117	120	126	129	133	133	129	129	73
Oct.	107	107	107	114	120	123	126	126	126	60
Nov.	101	101	101	101	107	114	120	120	123	54
Dec.	95	95	95	98	101	107	114	117	117	47

TABLE 19 Cooling load factors (CLF) for glass without interior shading, north latitudes, general

Fenes- tration Facing	Room Con- struction	Solar time (h)																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
N (Shaded)	L	0.17	0.14	0.11	0.09	0.08	0.33	0.42	0.48	0.56	0.63	0.71	0.76	0.80	0.82	0.79	0.75	0.84	0.61	0.48	0.38	0.31	0.25	0.20			
	M	0.23	0.20	0.18	0.16	0.14	0.34	0.41	0.46	0.53	0.59	0.65	0.70	0.73	0.75	0.74	0.75	0.79	0.61	0.50	0.42	0.36	0.31	0.27			
	H	0.25	0.23	0.21	0.20	0.19	0.38	0.45	0.49	0.55	0.60	0.65	0.69	0.72	0.72	0.70	0.70	0.75	0.57	0.46	0.39	0.34	0.21	0.28			
NNE	M	0.09	0.08	0.07	0.06	0.06	0.24	0.38	0.42	0.39	0.47	0.44	0.41	0.40	0.39	0.39	0.36	0.33	0.30	0.26	0.20	0.16	0.13	0.10	0.08		
NE	M	0.11	0.10	0.09	0.09	0.08	0.26	0.39	0.42	0.35	0.41	0.45	0.51	0.51	0.45	0.39	0.36	0.33	0.31	0.28	0.22	0.19	0.15	0.12	0.07		
NE	H	0.07	0.06	0.05	0.05	0.04	0.21	0.36	0.44	0.45	0.40	0.45	0.51	0.51	0.45	0.36	0.33	0.31	0.30	0.28	0.23	0.21	0.17	0.15	0.12	0.05	
E	M	0.09	0.08	0.08	0.08	0.07	0.20	0.34	0.45	0.46	0.42	0.47	0.51	0.57	0.57	0.50	0.42	0.37	0.32	0.29	0.25	0.22	0.19	0.15	0.12	0.08	
E	H	0.07	0.06	0.05	0.05	0.05	0.18	0.33	0.44	0.45	0.40	0.49	0.43	0.49	0.43	0.36	0.32	0.28	0.24	0.20	0.16	0.13	0.10	0.09	0.07	0.06	
ESE	M	0.08	0.07	0.06	0.05	0.05	0.16	0.31	0.43	0.43	0.46	0.51	0.54	0.51	0.44	0.39	0.35	0.32	0.29	0.26	0.22	0.19	0.16	0.14	0.12	0.09	
ESE	H	0.10	0.09	0.09	0.08	0.08	0.19	0.32	0.43	0.50	0.52	0.49	0.41	0.36	0.32	0.29	0.26	0.24	0.21	0.18	0.16	0.14	0.13	0.12	0.11	0.10	
SE	M	0.01	0.04	0.03	0.03	0.02	0.19	0.37	0.51	0.57	0.57	0.50	0.42	0.37	0.32	0.29	0.25	0.22	0.19	0.15	0.12	0.11	0.10	0.09	0.08	0.05	
SE	H	0.09	0.08	0.08	0.08	0.07	0.22	0.36	0.45	0.45	0.49	0.43	0.38	0.38	0.33	0.30	0.27	0.25	0.21	0.19	0.16	0.14	0.12	0.11	0.10	0.08	
SSE	M	0.05	0.04	0.04	0.03	0.02	0.17	0.34	0.49	0.58	0.61	0.57	0.48	0.41	0.36	0.32	0.28	0.24	0.20	0.16	0.13	0.10	0.09	0.07	0.06	0.05	
SSE	H	0.07	0.06	0.05	0.05	0.05	0.16	0.31	0.43	0.43	0.46	0.51	0.54	0.51	0.44	0.39	0.35	0.32	0.29	0.26	0.22	0.19	0.16	0.14	0.12	0.10	
SSW	M	0.11	0.09	0.08	0.07	0.06	0.08	0.16	0.26	0.38	0.48	0.55	0.57	0.54	0.48	0.43	0.39	0.35	0.30	0.25	0.21	0.18	0.16	0.14	0.12	0.11	
SSW	H	0.12	0.11	0.10	0.09	0.09	0.12	0.19	0.29	0.43	0.55	0.63	0.63	0.64	0.60	0.52	0.45	0.40	0.35	0.29	0.23	0.18	0.15	0.12	0.10	0.08	
SW	M	0.08	0.07	0.05	0.04	0.04	0.06	0.09	0.14	0.22	0.31	0.48	0.53	0.53	0.48	0.41	0.36	0.32	0.27	0.24	0.20	0.18	0.16	0.14	0.12	0.10	
SW	H	0.13	0.12	0.12	0.11	0.10	0.11	0.14	0.17	0.24	0.33	0.43	0.51	0.56	0.50	0.43	0.37	0.32	0.26	0.22	0.20	0.18	0.16	0.15	0.14	0.12	
SW	M	0.10	0.08	0.07	0.06	0.05	0.06	0.09	0.11	0.15	0.19	0.27	0.39	0.52	0.62	0.67	0.65	0.58	0.46	0.36	0.28	0.23	0.19	0.15	0.12	0.11	
SW	H	0.14	0.12	0.11	0.09	0.08	0.09	0.11	0.13	0.15	0.18	0.25	0.35	0.46	0.55	0.59	0.59	0.53	0.44	0.35	0.30	0.25	0.22	0.19	0.16	0.13	0.11
WSW	M	0.15	0.14	0.13	0.12	0.11	0.12	0.11	0.14	0.16	0.18	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49	0.40	0.32	0.26	0.23	0.20	0.18	0.16	0.14
WSW	H	0.15	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.14	0.16	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49	0.40	0.32	0.26	0.23	0.20	0.18	0.16	0.14
W	M	0.12	0.10	0.08	0.06	0.05	0.06	0.09	0.09	0.08	0.10	0.12	0.14	0.12	0.11	0.12	0.14	0.10	0.08	0.06	0.05	0.04	0.03	0.02	0.01	0.01	
W	H	0.15	0.13	0.11	0.10	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.13	0.14	0.14	0.15	0.12	0.10	0.08	0.06	0.05	0.04	0.03	0.02	0.01	0.01
WNW	M	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.07	0.09	0.10	0.12	0.13	0.15	0.17	0.22	0.25	0.27	0.29	0.30	0.33	0.34	0.34	0.33	0.32	0.31	0.30
WNW	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.23	0.26	0.27	0.28	0.31	0.34	0.34	0.33	0.32	0.31	0.30
HOR	M	0.11	0.09	0.08	0.06	0.05	0.07	0.07	0.11	0.14	0.24	0.36	0.48	0.58	0.66	0.72	0.74	0.73	0.67	0.59	0.47	0.37	0.29	0.22	0.18	0.14	0.13
HOR	H	0.16	0.15	0.14	0.13	0.12	0.13	0.15	0.20	0.28	0.36	0.45	0.52	0.59	0.62	0.64	0.62	0.58	0.51	0.42	0.35	0.29	0.26	0.23	0.21	0.19	0.17

L = Light construction: frame exterior wall, 50 mm, approximate mass per unit of floor area = 146 kg/m².

M = Medium construction: 100 mm concrete exterior wall, 100 mm concrete floor slab, approximate mass per unit area of floor = 340 kg/m².

H = Heavy construction: 150 mm concrete exterior wall, 150 mm concrete floor slab, approximate mass per unit area of floor = 630 kg/m².

Adapted by permission from ASHRAE Fundamentals, 1989, Table 36

TABLE 20 Cooling load temperature differences (CLTD) for conduction through glass

Solar time, h	CLTD, °C	Solar time, h	CLTD, °C
0100	1	1300	7
0200	0	1400	7
0300	-1	1500	8
0400	-1	1600	8
0500	-1	1700	7
0600	-1	1800	7
0700	-1	1900	6
0800	0	2000	4
0900	1	2100	3
1000	2	2200	2
1100	4	2300	2
1200	5	2400	1

TABLE 21 Shading coefficients for single glass and insulating glass^a

Type of glass	Nominal thickness ^b	Solar trans. ^b	A. Single Glass	
			$h_0 = 22.7$	$h_0 = 7.0$
Clear	3 mm	0.86	1.00	1.00
	6 mm	0.78	0.94	0.95
	10 mm	0.72	0.90	0.92
	13 mm	0.67	0.87	0.88
Heat absorbing	3 mm	0.64	0.83	0.85
	6 mm	0.46	0.69	0.73
	10 mm	0.33	0.60	0.64
	13 mm	0.24	0.53	0.58
B. Insulating Glass				
Clear out, Clear in	3 mm ^c	0.71 ^e	0.88	0.88
	6 mm	0.61	0.81	0.82
Heat absorbing ^d	6 mm	0.36	0.55	0.58
	Out, Clear in			

TABLE . 22 Design values of *a*

<i>a</i>	Furnishings and return	Air supply light fixture	Type of
0.45	Heavyweight, simple furnishings, no carpet	Low rate; supply and return below ceiling ($V \leq 2.5$) ^a	Recessed, not vented
0.55	Ordinary furniture, no carpet	Medium to high ventilation rate; supply and return below ceiling or through ceiling grill and space ($V \geq 2.5$) ^a	Recessed, not vented
0.65	Ordinary furniture, with or without carpet	Medium to high ventilation rate or fan coil or induction type air-conditioning terminal unit; supply through ceiling or wall diffuser; return around light fixtures and through ceiling space. ($V \geq 2.5$) ^a	Vented
0.75 or greater	Any type of furniture	Ducted returns through light fixtures	Vented or freehanging in air stream with ducted returns

^aV is room air supply rate in litres/s per square metre of floor area.

TABLE . 23 Design values of *b*

Room envelope construction ^a (mass of floor area, kg/m ²)	Room air circulation and type of supply and return ^b			
	Low	Medium	High	Very High
50 mm Wood Floor (50)	B	A	A	A
75 mm Concrete Floor (200)	B	B	B	A
150 mm Concrete Floor (370)	C	C	C	B
200 mm Concrete Floor (590)	D	D	C	C
300 mm Concrete Floor (780)	D	D	D	D

^aFloor covered with carpet and rubber pad; for a floor covered only with floor tile take next classification to the right in the same row.

^b*Low:* Low ventilation rate—minimum required to cope with cooling load from lights and occupants in interior zone. Supply through floor, wall or ceiling diffuser. Ceiling space not vented and $h = 2.3 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$ (where h = inside surface convection coefficient used in calculation of *b*).

Medium: Medium ventilation rate, supply through floor, wall or ceiling diffuser. Ceiling space not vented and $h = 3.4 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$.

High: Room air circulation induced by primary air of induction unit or by fan coil unit. Return through ceiling space and $h = 4.5 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$.

Very High: High room air circulation used to minimize temperature gradients in a room. Return through ceiling space and $h = 6.8 \text{ W}/(\text{m}^2 \cdot ^\circ\text{C})$.

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 42.

TABLE 24 Cooling load factors when lights are on for 8 hours

"a" Coef-ficients	"b" Classi-fication				Number of hours after lights are turned on																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
0.45	A	0.02	0.46	0.57	0.65	0.72	0.77	0.82	0.85	0.88	0.46	0.37	0.30	0.24	0.19	0.15	0.12	0.10	0.08	0.06	0.05	0.04	0.03	0.03	0.02
	B	0.07	0.51	0.56	0.61	0.65	0.68	0.71	0.74	0.77	0.34	0.31	0.28	0.25	0.22	0.20	0.18	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08
	C	0.11	0.55	0.58	0.60	0.63	0.65	0.67	0.69	0.71	0.28	0.26	0.25	0.23	0.22	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.12
	D	0.14	0.58	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.22	0.22	0.21	0.20	0.20	0.19	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.15	0.15
0.55	A	0.01	0.056	0.65	0.72	0.77	0.82	0.85	0.88	0.90	0.37	0.30	0.24	0.19	0.16	0.13	0.10	0.08	0.07	0.05	0.04	0.03	0.03	0.02	0.02
	B	0.06	0.60	0.64	0.68	0.71	0.74	0.76	0.79	0.81	0.28	0.25	0.23	0.20	0.18	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06
	C	0.09	0.63	0.66	0.68	0.70	0.71	0.73	0.75	0.76	0.23	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10	0.10
	D	0.11	0.66	0.67	0.68	0.69	0.70	0.71	0.72	0.72	0.18	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.12
0.65	A	0.01	0.66	0.73	0.78	0.82	0.86	0.88	0.91	0.93	0.29	0.23	0.19	0.15	0.12	0.10	0.08	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01
	B	0.04	0.69	0.72	0.75	0.77	0.80	0.82	0.84	0.85	0.22	0.19	0.18	0.16	0.14	0.13	0.12	0.10	0.09	0.08	0.08	0.07	0.06	0.06	0.05
	C	0.07	0.72	0.73	0.75	0.76	0.78	0.79	0.80	0.82	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.07	0.07
	D	0.09	0.73	0.74	0.75	0.76	0.77	0.77	0.78	0.79	0.14	0.14	0.13	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.09
0.75	A	0.01	0.76	0.80	0.84	0.87	0.90	0.92	0.93	0.95	0.21	0.17	0.13	0.11	0.09	0.07	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01
	B	0.03	0.78	0.80	0.82	0.84	0.85	0.87	0.88	0.89	0.15	0.14	0.13	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.04	0.04
	C	0.05	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.13	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.05	0.05
	D	0.06	0.81	0.82	0.82	0.83	0.83	0.84	0.84	0.85	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07

Adapted by permission from *ASHRAE Fundamentals*, 1989, Table 43.

TABLE 25 Cooling load factors when lights are on for 10 hours

"a" Coef-ficients	"b" Classi-fication				Number of hours after lights are turned on																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
0.45	A	0.03	0.47	0.58	0.66	0.73	0.78	0.82	0.86	0.88	0.91	0.93	0.49	0.39	0.32	0.26	0.21	0.17	0.13	0.11	0.09	0.07	0.06	0.05	0.04	
	B	0.10	0.54	0.59	0.63	0.66	0.70	0.73	0.76	0.78	0.80	0.82	0.39	0.35	0.32	0.28	0.26	0.23	0.21	0.19	0.17	0.15	0.14	0.12	0.11	
	C	0.15	0.59	0.61	0.64	0.66	0.68	0.70	0.72	0.73	0.75	0.76	0.36	0.31	0.29	0.27	0.26	0.24	0.23	0.21	0.20	0.19	0.18	0.17	0.16	
	D	0.18	0.62	0.63	0.64	0.66	0.67	0.68	0.69	0.70	0.71	0.72	0.27	0.26	0.26	0.25	0.24	0.23	0.23	0.22	0.21	0.20	0.19	0.19	0.19	
0.55	A	0.02	0.57	0.65	0.72	0.78	0.82	0.85	0.88	0.91	0.92	0.94	0.40	0.32	0.26	0.21	0.17	0.14	0.11	0.09	0.07	0.06	0.05	0.04	0.03	0.02
	B	0.08	0.62	0.66	0.69	0.73	0.75	0.78	0.80	0.82	0.84	0.85	0.32	0.29	0.26	0.23	0.21	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08
	C	0.12	0.66	0.68	0.70	0.72	0.74	0.75	0.77	0.78	0.79	0.81	0.27	0.25	0.24	0.22	0.21	0.20	0.19	0.17	0.16	0.15	0.14	0.14	0.13	0.13
	D	0.15	0.69	0.70	0.71	0.72	0.73	0.74	0.74	0.75	0.76	0.76	0.22	0.21	0.20	0.19	0.18	0.18	0.17	0.17	0.16	0.16	0.16	0.16	0.15	0.15
0.65	A	0.02	0.66	0.73	0.78	0.83	0.86	0.89	0.91	0.93	0.94	0.95	0.31	0.25	0.20	0.16	0.13	0.11	0.08	0.07	0.05	0.04	0.04	0.03	0.02	0.02
	B	0.06	0.71	0.74	0.76	0.79	0.81	0.83	0.84	0.86	0.87	0.89	0.25	0.22	0.20	0.18	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.06
	C	0.09	0.74	0.75	0.77	0.78	0.80	0.81	0.82	0.83	0.84	0.85	0.21	0.20	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10	0.10	0.10
	D	0.11	0.76	0.77	0.77	0.78	0.79	0.79	0.80	0.81	0.82	0.82	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.13	0.12	0.12	0.12	0.12
0.75	A	0.01	0.76	0.81	0.84	0.88	0.90	0.92	0.93	0.95	0.96	0.97	0.22	0.18	0.14	0.12	0.09	0.08	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.02
	B	0.04	0.79	0.81	0.83	0.85	0.86	0.88	0.89	0.90	0.91	0.92	0.18	0.16	0.14	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.05
	C	0.07	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.89	0.15	0.14	0.13	0.12	0.12	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07
	D	0.08	0.83	0.83	0.84	0.84	0.85	0.85	0.86	0.86	0.87	0.87	0.12	0.12	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09

Adapted by permission from *ASHRAE Fundamentals*, 1989, Table 44.

TABLE Cooling load factors when lights are on for 12 hours

"a" Coef- ficients	"b" Class- ification	Number of hours after lights are turned on																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.45	A	0.05	0.49	0.59	0.67	0.73	0.78	0.83	0.86	0.89	0.91	0.93	0.94	0.95	0.51	0.41	0.33	0.27	0.22	0.17	0.14	0.11	0.09	0.07	0.06
	B	0.13	0.57	0.61	0.65	0.69	0.72	0.75	0.77	0.79	0.82	0.83	0.85	0.87	0.43	0.39	0.35	0.31	0.28	0.25	0.23	0.21	0.18	0.17	0.15
	C	0.19	0.63	0.65	0.67	0.69	0.71	0.73	0.74	0.76	0.77	0.79	0.80	0.81	0.37	0.35	0.33	0.31	0.29	0.27	0.26	0.24	0.23	0.21	0.20
	D	0.22	0.66	0.67	0.68	0.69	0.70	0.71	0.72	0.73	0.74	0.75	0.76	0.77	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.23	
0.55	A	0.04	0.58	0.66	0.73	0.78	0.82	0.86	0.89	0.91	0.93	0.94	0.95	0.96	0.42	0.34	0.27	0.22	0.18	0.14	0.11	0.09	0.07	0.06	0.05
	B	0.11	0.65	0.68	0.72	0.74	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.89	0.35	0.32	0.28	0.26	0.23	0.21	0.19	0.17	0.15	0.14	0.12
	C	0.15	0.69	0.71	0.73	0.75	0.76	0.78	0.79	0.80	0.81	0.83	0.84	0.85	0.30	0.29	0.27	0.25	0.24	0.22	0.21	0.20	0.19	0.17	0.16
	D	0.18	0.72	0.73	0.74	0.75	0.76	0.76	0.77	0.78	0.79	0.80	0.80	0.80	0.26	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16
0.65	A	0.03	0.67	0.74	0.79	0.83	0.86	0.89	0.91	0.93	0.94	0.95	0.96	0.97	0.33	0.26	0.21	0.17	0.14	0.11	0.09	0.07	0.06	0.05	0.04
	B	0.09	0.73	0.75	0.78	0.80	0.82	0.84	0.85	0.87	0.88	0.89	0.90	0.91	0.27	0.25	0.22	0.20	0.18	0.16	0.15	0.13	0.12	0.11	0.10
	C	0.12	0.76	0.78	0.79	0.80	0.81	0.83	0.84	0.85	0.86	0.86	0.87	0.88	0.24	0.22	0.21	0.20	0.19	0.17	0.16	0.15	0.14	0.13	
	D	0.14	0.79	0.79	0.80	0.80	0.81	0.82	0.83	0.83	0.84	0.84	0.85	0.85	0.20	0.19	0.18	0.18	0.17	0.17	0.16	0.15	0.15	0.15	
0.75	A	0.02	0.77	0.81	0.85	0.88	0.90	0.92	0.94	0.95	0.96	0.97	0.97	0.98	0.23	0.19	0.15	0.12	0.10	0.08	0.06	0.05	0.04	0.03	0.03
	B	0.06	0.81	0.82	0.84	0.86	0.87	0.88	0.90	0.91	0.92	0.93	0.94	0.94	0.19	0.18	0.16	0.14	0.13	0.12	0.11	0.10	0.10	0.09	
	C	0.09	0.83	0.84	0.85	0.86	0.87	0.88	0.88	0.89	0.90	0.90	0.91	0.91	0.17	0.16	0.15	0.14	0.13	0.12	0.12	0.11	0.11	0.11	
	D	0.10	0.85	0.86	0.86	0.86	0.87	0.87	0.88	0.88	0.88	0.88	0.89	0.89	0.14	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11	0.11	

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 45.

TABLE Cooling load factors when lights are on for 14 hours

"a" Coef- ficients	"b" Class- ification	Number of hours after lights are turned on																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0.45	A	0.07	0.51	0.61	0.68	0.74	0.79	0.83	0.87	0.89	0.91	0.93	0.94	0.95	0.96	0.97	0.53	0.42	0.34	0.27	0.22	0.18	0.14	0.12	0.09
	B	0.18	0.61	0.65	0.68	0.72	0.74	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.89	0.90	0.46	0.41	0.37	0.34	0.30	0.27	0.24	0.22	0.20
	C	0.24	0.67	0.69	0.71	0.73	0.74	0.76	0.77	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.41	0.39	0.36	0.34	0.32	0.30	0.28	0.27	0.25
	D	0.26	0.71	0.72	0.72	0.73	0.74	0.75	0.76	0.77	0.78	0.78	0.79	0.80	0.80	0.80	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28
0.55	A	0.06	0.69	0.68	0.74	0.79	0.83	0.86	0.89	0.91	0.93	0.94	0.95	0.96	0.97	0.98	0.43	0.35	0.28	0.22	0.18	0.15	0.12	0.09	0.08
	B	0.15	0.68	0.71	0.74	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.90	0.91	0.92	0.38	0.34	0.32	0.30	0.28	0.26	0.25	0.22	0.20	0.18
	C	0.19	0.73	0.75	0.76	0.78	0.79	0.80	0.81	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.28
	D	0.22	0.76	0.77	0.77	0.78	0.79	0.79	0.80	0.81	0.82	0.82	0.83	0.83	0.84	0.84	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.22	0.21
0.65	A	0.05	0.69	0.75	0.80	0.84	0.87	0.89	0.92	0.93	0.95	0.96	0.96	0.97	0.98	0.34	0.27	0.22	0.17	0.14	0.11	0.09	0.07	0.06	
	B	0.11	0.75	0.78	0.80	0.82	0.84	0.85	0.86	0.87	0.88	0.89	0.89	0.90	0.91	0.26	0.25	0.23	0.22	0.20	0.19	0.18	0.17	0.16	
	C	0.15	0.79	0.80	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.88	0.89	0.89	0.90	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	
	D	0.17	0.81	0.82	0.83	0.83	0.84	0.84	0.85	0.85	0.86	0.86	0.87	0.87	0.87	0.23	0.22	0.21	0.21	0.20	0.19	0.18	0.17	0.16	
0.75	A	0.03	0.78	0.82	0.86	0.88	0.9!	0.92	0.94	0.95	0.96	0.97	0.97	0.98	0.99	0.24	0.19	0.16	0.12	0.10	0.08	0.07	0.05	0.04	
	B	0.08	0.82	0.84	0.86	0.87	0.88	0.90	0.91	0.92	0.93	0.94	0.94	0.95	0.96	0.21	0.19	0.17	0.15	0.14	0.13	0.12	0.11	0.10	
	C	0.11	0.85	0.86	0.87	0.88	0.88	0.89	0.90	0.91	0.91	0.92	0.93	0.93	0.94	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.13	0.13	
	D	0.12	0.87	0.87	0.87	0.88	0.88	0.88	0.89	0.89	0.89	0.90	0.90	0.90	0.91	0.16	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.13	

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 46.

TABLE 24 Cooling load factors when lights are on for 16 hours

"a" Coefficients	"b" Classification	Number of hours after lights are turned on																								
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
0.45	A	0.12	0.54	0.63	0.70	0.76	0.81	0.85	0.88	0.90	0.92	0.94	0.95	0.96	0.97	0.98	0.98	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	
	B	0.23	0.66	0.69	0.72	0.75	0.78	0.80	0.82	0.84	0.85	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.93	0.92	0.91	0.90	0.89	0.88	0.87	
	C	0.29	0.72	0.74	0.75	0.77	0.78	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.88	0.89	0.89	0.88	0.87	0.86	0.85	0.84	0.83	
	D	0.31	0.75	0.76	0.77	0.77	0.78	0.79	0.79	0.80	0.81	0.81	0.82	0.82	0.83	0.83	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
0.55	A	0.10	0.63	0.70	0.76	0.81	0.84	0.87	0.90	0.92	0.93	0.95	0.96	0.97	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
	B	0.19	0.72	0.75	0.77	0.80	0.82	0.84	0.85	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	
	C	0.24	0.77	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.88	0.89	0.90	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	
	D	0.26	0.80	0.80	0.81	0.82	0.82	0.83	0.83	0.84	0.84	0.85	0.85	0.86	0.86	0.86	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	
0.65	A	0.07	0.71	0.77	0.81	0.85	0.88	0.90	0.92	0.94	0.95	0.96	0.97	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
	B	0.15	0.78	0.81	0.82	0.84	0.86	0.87	0.88	0.90	0.91	0.92	0.93	0.94	0.94	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	
	C	0.18	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.92	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	
	D	0.20	0.84	0.85	0.85	0.86	0.86	0.87	0.87	0.88	0.88	0.88	0.89	0.89	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
0.75	A	0.05	0.79	0.83	0.87	0.89	0.91	0.93	0.94	0.95	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
	B	0.11	0.85	0.86	0.87	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	
	C	0.13	0.87	0.88	0.89	0.89	0.90	0.91	0.91	0.92	0.93	0.93	0.94	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	
	D	0.14	0.89	0.89	0.89	0.90	0.90	0.91	0.91	0.91	0.91	0.92	0.92	0.92	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	

CLF = 1.0 when cooling system operates only during occupied hours or when lights are on 24 h/day.

Adapted by permission from *ASHRAE Fundamentals*, 1989, Table 47.

TABLE 25 Sensible heat cooling load factors for appliances—hooded

Total operational hours	Hours after each entry into space																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
2	0.27	0.40	0.25	0.18	0.14	0.11	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	
4	0.28	0.41	0.51	0.59	0.39	0.30	0.24	0.19	0.16	0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	
6	0.29	0.42	0.52	0.59	0.65	0.70	0.48	0.37	0.30	0.25	0.21	0.18	0.16	0.14	0.12	0.11	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.04	
8	0.31	0.44	0.54	0.61	0.66	0.71	0.75	0.78	0.55	0.43	0.35	0.30	0.25	0.22	0.19	0.16	0.14	0.13	0.11	0.10	0.08	0.07	0.06	0.06	
10	0.33	0.46	0.55	0.62	0.68	0.72	0.76	0.79	0.81	0.84	0.60	0.48	0.39	0.33	0.28	0.24	0.21	0.18	0.16	0.14	0.12	0.11	0.09	0.08	
12	0.36	0.49	0.58	0.64	0.69	0.74	0.77	0.80	0.82	0.85	0.87	0.88	0.64	0.51	0.42	0.36	0.31	0.26	0.23	0.20	0.18	0.15	0.13	0.12	0.12
14	0.40	0.52	0.61	0.67	0.72	0.76	0.79	0.82	0.84	0.86	0.86	0.88	0.89	0.91	0.92	0.67	0.54	0.45	0.38	0.32	0.28	0.24	0.21	0.19	0.16
16	0.45	0.57	0.65	0.70	0.75	0.78	0.81	0.84	0.86	0.87	0.89	0.90	0.92	0.93	0.94	0.94	0.69	0.56	0.46	0.39	0.34	0.29	0.25	0.22	0.22
18	0.52	0.63	0.70	0.75	0.79	0.82	0.84	0.86	0.88	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.96	0.96	0.71	0.58	0.48	0.41	0.35	0.30	

Adapted by permission from *ASHRAE Fundamentals*, 1989, Table 48.

TABLE 26 Sensible heat cooling load factors for appliances—unhooded

Total operational hours	Hours after appliances are on																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2	0.56	0.64	0.75	0.81	0.88	0.97	0.96	0.95	0.94	0.93	0.93	0.92	0.92	0.92	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	
4	0.57	0.65	0.71	0.75	0.83	0.98	0.94	0.93	0.92	0.91	0.91	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
6	0.57	0.65	0.71	0.76	0.79	0.82	0.89	0.92	0.95	0.97	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
8	0.58	0.66	0.72	0.76	0.80	0.82	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
10	0.60	0.68	0.73	0.77	0.81	0.83	0.85	0.87	0.89	0.90	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	0.99	0.99	0.99	0.99	0.99	
12	0.62	0.69	0.75	0.79	0.82	0.84	0.86	0.88	0.89	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	0.99	0.99	0.99	0.99	0.99	
14	0.64	0.71	0.76	0.80	0.83	0.85	0.87	0.89	0.90	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
16	0.67	0.74	0.79	0.82	0.85	0.87	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
18	0.71	0.78	0.82	0.85	0.87	0.89	0.90	0.92	0.93	0.94	0.95	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 49.

TABLE 21 Sensible heat cooling load factors for people

Total hours in space	Hours after each entry into space												21	22	23	24
	1	2	3	4	5	6	7	8	9	10	11	12				
2	0.49	0.58	0.17	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.01	0.01
4	0.49	0.59	0.66	0.71	0.27	0.21	0.16	0.14	0.11	0.10	0.08	0.07	0.06	0.05	0.04	0.02
6	0.50	0.60	0.67	0.72	0.76	0.79	0.34	0.26	0.21	0.18	0.15	0.13	0.11	0.10	0.08	0.07
8	0.51	0.61	0.67	0.72	0.76	0.80	0.82	0.84	0.38	0.30	0.25	0.21	0.18	0.15	0.13	0.12
10	0.53	0.62	0.69	0.74	0.77	0.80	0.83	0.85	0.87	0.89	0.42	0.34	0.28	0.23	0.20	0.17
12	0.55	0.64	0.70	0.75	0.79	0.81	0.84	0.86	0.88	0.89	0.91	0.92	0.45	0.36	0.30	0.25
14	0.58	0.66	0.72	0.77	0.80	0.83	0.85	0.87	0.89	0.90	0.91	0.92	0.93	0.94	0.47	0.38
16	0.62	0.70	0.75	0.79	0.82	0.85	0.87	0.88	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.49
18	0.66	0.74	0.79	0.82	0.85	0.87	0.89	0.90	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.50

CLF = 1.0 for systems shutdown at night and for high occupant densities such as in theaters and auditoriums.

Adapted by permission from ASHRAE *Fundamentals*, 1989, Table 40.

TABLE 28 Rates of heat gains from occupants in conditioned spaces

Degree of activity	Typical application	Total heat gain (W)	Total heat adjusted (W)	Sensible heat (W)	Latent heat (W)
Moderately active office work	Office, Hotels, Apartments	140	130	75	55
Standing, Light work; Walking	Departmental store, Retail store	160	130	75	55
Walking, Standing	Drug store, Bank	160	145	75	70
Light bench work	Factory	235	220	80	140
Walking 3 mph; light machine work	Factory	295	295	110	185
Heavy work	Factory	440	425	170	255
Athletics	Gymnasium	585	525	210	315

Adapted by permission from *ASHRAE Fundamentals*, 1993, p. 26.8.

*Tabulated values are based on 24°C room dry-bulb temperature, the total heat remains the same, but the sensible heat values should be decreased by approximately 20 percent, and the latent heat values increased accordingly.