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Table A.1 Density and Baume of Pure Sucrose Solutions (at 20°C)

<i>DS</i> (% m/m)	Density			Baume (degree)	<i>DS</i> % (m/m)	Density			Baume (degree)
	(kg/m ³)	(lb/ft ³)	(lb/ga)			(kg/m ³)	(lb/ft ³)	(lb/ga)	
0	1000.00	62.25	8.32	0.0	11	1044.13	65.00	8.69	6.1
1	1003.89	62.49	8.35	0.6	12	1048.31	65.28	8.72	6.7
2	1007.79	62.73	8.39	1.1	13	1052.52	65.52	8.76	7.2
3	1011.72	62.98	8.42	1.7	14	1056.77	65.79	8.79	7.8
4	1015.67	63.23	8.45	2.2	15	1061.04	66.05	8.83	8.3
5	1017.85	63.47	8.49	2.8	16	1065.34	66.32	8.87	8.9
6	1023.66	63.72	8.52	3.4	17	1069.68	66.59	8.90	9.5
7	1027.70	63.97	8.55	3.9	18	1074.04	66.86	8.94	10.0
8	1031.76	64.23	8.59	4.5	19	1078.44	67.14	8.98	10.6
9	1035.86	64.48	8.62	5.0	20	1082.87	67.41	9.01	11.1
10	1039.98	64.74	8.66	5.6	21	1087.33	67.69	9.05	11.7

Table A.1 Continued

<i>DS</i> (% m/m)	Density			Baume (degree)	<i>DS</i> % (m/m)	Density			Baume (degree)
	(kg/m ³)	(lb/ft ³)	(lb/ga)			(kg/m ³)	(lb/ft ³)	(lb/ga)	
22	1091.83	67.97	9.09	12.2	61	1294.64	80.61	10.78	33.0
23	1096.36	68.26	9.13	12.7	62	1300.59	80.98	10.83	33.5
24	1100.92	68.54	9.16	13.3	63	1306.57	81.35	10.88	34.0
25	1105.51	68.82	9.20	13.8	64	1312.60	81.73	10.93	34.5
26	1110.14	69.11	9.24	14.4	65	1318.66	82.11	10.98	35.0
27	1114.80	69.40	9.28	14.9	66	1324.76	82.49	11.03	35.6
28	1119.49	69.70	9.32	15.5	67	1330.90	82.87	11.08	36.1
29	1124.22	69.99	9.36	16.0	68	1337.08	83.25	11.13	36.6
30	1128.98	70.29	9.40	16.6	69	1343.30	83.64	11.18	37.1
31	1133.78	70.59	9.44	17.1	70	1349.56	84.03	11.23	37.6
32	1138.61	70.89	9.48	17.7	71	1355.85	84.42	11.29	38.1
33	1143.47	71.19	9.52	18.2	72	1362.18	84.82	11.34	38.6
34	1148.37	71.50	9.56	18.7	73	1368.58	85.22	11.39	39.1
35	1153.31	71.80	9.60	19.3	74	1374.96	85.61	11.45	39.5
36	1158.28	72.11	9.64	19.8	75	1381.41	86.02	11.50	40.0
37	1163.29	72.42	9.68	20.4	76	1387.90	86.42	11.55	40.5
38	1168.33	72.74	9.72	20.9	77	1394.42	86.83	11.61	41.0
39	1173.41	73.06	9.77	21.4	78	1400.98	87.24	11.66	41.5
40	1178.53	73.37	9.81	22.0	79	1407.58	87.65	11.72	42.0
41	1183.68	73.70	9.85	22.5	80	1414.21	88.06	11.77	42.5
42	1188.87	74.02	9.90	23.0	81	1420.88	88.48	11.83	43.0
43	1194.10	74.34	9.94	23.6	82	1427.59	88.89	11.88	43.4
44	1199.36	74.67	9.98	24.1	83	1434.34	89.31	11.94	43.9
45	1204.67	75.00	10.03	24.6	84	1441.12	89.74	12.00	44.4
46	1210.01	75.33	10.07	25.2	85	1447.94	90.16	12.05	44.9
47	1215.38	75.67	10.12	25.7	86	1454.80	90.59	12.11	45.3
48	1220.80	76.01	10.16	26.2	87	1461.70	91.02	12.17	45.8
49	1226.25	76.35	10.21	26.8	88	1468.62	91.45	12.23	46.3
50	1231.74	76.69	10.25	27.3	89	1475.59	91.89	12.28	46.7
51	1237.27	77.03	10.30	27.8	90	1482.59	92.32	12.34	47.2
52	1242.84	77.38	10.35	28.3	91	1489.63	92.76	12.40	47.7
53	1248.44	77.73	10.39	28.9	92	1496.71	93.20	12.46	48.1
54	1254.08	78.08	10.44	29.4	93	1503.81	93.64	12.52	48.6
55	1259.76	78.44	10.49	29.9	94	1510.96	94.09	12.58	49.0
56	1265.48	78.79	10.53	30.4	95	1518.14	94.54	12.64	49.5
57	1271.23	79.15	10.58	30.9	96	1525.35	94.99	12.70	49.9
58	1277.03	79.51	10.63	31.5	97	1532.60	95.44	12.76	50.4
59	1282.86	79.88	10.68	32.0	98	1539.88	95.89	12.82	50.8
60	1288.73	80.43	10.75	32.5	99	1547.19	96.35	12.88	51.3

Source: U.S. National Bureau of Standard, Circular C440

Table A.2 Sucrose Solubility in Pure Sucrose Solutions

Temperature (°C)	Sucrose Solubility		Temperature (°C)	Sucrose Solubility		Temperature (°C)	Sucrose Solubility	
	(g/g)	(% m/m)		(g/g)	(% m/m)		(g/g)	(% m/m)
1	1.82	64.53	41	2.37	70.30	81	3.73	78.88
2	1.83	64.62	42	2.39	70.49	82	3.79	79.11
3	1.83	64.71	43	2.41	70.68	83	3.84	79.32
4	1.84	64.80	44	2.43	70.88	84	3.89	79.53
5	1.85	64.90	45	2.46	71.08	85	3.94	79.74
6	1.86	65.00	46	2.48	71.29	86	3.99	79.95
7	1.87	65.10	47	2.51	71.50	87	4.04	80.16
8	1.87	65.21	48	2.53	71.71	88	4.09	80.37
9	1.88	65.32	49	2.56	71.92	89	4.15	80.57
10	1.89	65.43	50	2.59	72.13	90	4.20	80.77
11	1.90	65.55	51	2.61	72.33	91	4.25	80.97
12	1.91	65.67	52	2.64	72.54	92	4.31	81.17
13	1.92	65.79	53	2.67	72.75	93	4.37	81.37
14	1.93	65.91	54	2.70	72.96	94	4.42	81.56
15	1.94	66.04	55	2.73	73.18	95	4.48	81.74
16	1.96	66.18	56	2.76	73.39	96	4.53	81.92
17	1.97	66.31	57	2.79	73.61	97	4.59	82.10
18	1.98	66.45	58	2.82	73.83	98	4.65	82.30
19	1.99	66.59	59	2.85	74.05	99	4.71	82.48
20	2.01	66.74	60	2.89	74.27	100	4.77	82.66
21	2.02	66.86	61	2.92	74.48			
22	2.03	67.01	62	2.95	74.70			
23	2.04	67.16	63	2.99	74.92			
24	2.06	67.31	64	3.02	75.14			
25	2.07	67.47	65	3.06	75.36			
26	2.09	67.63	66	3.10	75.59			
27	2.10	67.79	67	3.14	75.82			
28	2.12	67.95	68	3.17	76.04			
29	2.14	68.13	69	3.21	76.27			
30	2.15	68.30	70	3.25	76.48			
31	2.17	68.47	71	3.29	76.70			
32	2.19	68.64	72	3.33	76.92			
33	2.21	68.81	73	3.37	77.13			
34	2.23	69.00	74	3.42	77.36			
35	2.24	69.18	75	3.46	77.58			
36	2.26	69.35	76	3.51	77.81			
37	2.28	69.54	77	3.55	78.04			
38	2.30	69.73	78	3.60	78.25			
39	2.32	69.92	79	3.64	78.46			
40	2.34	70.10	80	3.69	78.68			

Calculated based on Eq. (3.16.2)

Table A.3 Sucrose Solubility in Impure Sucrose Solutions (g sucrose/g water)

Purity (%)	Temperature (°C)														
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
100	2.01	2.07	2.15	2.24	2.34	2.46	2.59	2.73	2.89	3.06	3.21	3.46	3.69	3.94	4.20
99	2.00	2.06	2.14	2.23	2.33	2.44	2.57	2.71	2.87	3.04	3.25	3.43	3.66	3.90	4.16
98	1.99	2.05	2.13	2.22	2.32	2.43	2.56	2.69	2.85	3.02	3.19	3.41	3.63	3.87	4.13
97	1.98	2.04	2.12	2.21	2.31	2.42	2.54	2.68	2.83	3.00	3.17	3.39	3.61	3.85	4.11
96	1.97	2.03	2.11	2.20	2.30	2.41	2.53	2.67	2.82	2.99	3.16	3.38	3.60	3.83	4.09
95	1.96	2.03	2.11	2.19	2.29	2.40	2.52	2.66	2.81	2.98	3.15	3.36	3.59	3.82	4.08
94	1.96	2.02	2.10	2.19	2.28	2.39	2.52	2.65	2.81	2.97	3.14	3.36	3.58	3.82	4.07
93	1.95	2.02	2.10	2.18	2.28	2.39	2.51	2.65	2.80	2.97	3.14	3.35	3.58	3.81	4.07
92	1.95	2.01	2.09	2.18	2.27	2.38	2.51	2.64	2.80	2.96	3.13	3.35	3.57	3.81	4.07
91	1.95	2.01	2.09	2.18	2.27	2.38	2.51	2.64	2.80	2.96	3.13	3.35	3.58	3.82	4.08
90	1.94	2.01	2.09	2.17	2.27	2.38	2.51	2.64	2.80	2.96	3.14	3.36	3.58	3.82	4.09
89	1.94	2.01	2.09	2.17	2.27	2.38	2.51	2.64	2.80	2.97	3.14	3.36	3.59	3.83	4.10
88	1.94	2.01	2.09	2.17	2.27	2.38	2.51	2.65	2.80	2.97	3.14	3.37	3.60	3.85	4.11
87	1.94	2.01	2.09	2.18	2.27	2.38	2.51	2.65	2.81	2.98	3.15	3.38	3.61	3.86	4.13
86	1.94	2.01	2.09	2.18	2.28	2.39	2.52	2.66	2.81	2.98	3.16	3.39	3.62	3.88	4.15
85	1.95	2.01	2.09	2.18	2.28	2.39	2.52	2.66	2.82	2.99	3.17	3.40	3.64	3.90	4.17
84	1.95	2.02	2.09	2.18	2.28	2.40	2.53	2.67	2.83	3.00	3.18	3.42	3.66	3.92	4.20
83	1.95	2.02	2.10	2.19	2.29	2.40	2.53	2.68	2.84	3.01	3.19	3.43	3.67	3.94	4.22
82	1.95	2.02	2.10	2.19	2.29	2.41	2.54	2.68	2.85	3.02	3.21	3.45	3.69	3.96	4.25
81	1.96	2.03	2.11	2.20	2.30	2.41	2.55	2.69	2.86	3.04	3.22	3.46	3.71	3.98	4.28
80	1.96	2.03	2.11	2.20	2.30	2.42	2.56	2.70	2.87	3.05	3.24	3.48	3.74	4.01	4.31
79	1.97	2.04	2.12	2.21	2.31	2.43	2.57	2.71	2.88	3.06	3.25	3.50	3.76	4.03	4.34
78	1.97	2.04	2.12	2.22	2.32	2.44	2.57	2.72	2.89	3.08	3.27	3.52	3.78	4.06	4.37
77	1.98	2.05	2.13	2.22	2.33	2.45	2.58	2.74	2.91	3.09	3.29	3.54	3.80	4.11	4.40
76	1.98	2.05	2.14	2.23	2.34	2.46	2.60	2.75	2.92	3.11	3.30	3.56	3.83	4.18	4.54

Table A.3 Continued

Purity (%)	Temperature (°C)															
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	
75	1.99	2.06	2.14	2.24	2.34	2.47	2.61	2.76	2.93	3.13	3.34	3.62	3.90	4.26	4.62	
74	1.99	2.07	2.15	2.25	2.35	2.48	2.62	2.77	2.95	3.14	3.36	3.65	3.93	4.30	4.69	
73	2.00	2.07	2.16	2.25	2.36	2.49	2.63	2.79	2.96	3.16	3.38	3.67	4.02	4.36	4.75	
72	2.01	2.08	2.17	2.26	2.37	2.50	2.64	2.80	2.98	3.18	3.47	3.69	4.09	4.46	4.86	
71	2.01	2.09	2.17	2.27	2.38	2.51	2.65	2.81	2.99	3.20	3.50	3.77	4.15	4.53	4.94	
70	2.02	2.09	2.18	2.28	2.39	2.52	2.67	2.83	3.05	3.30	3.57	3.88				
69	2.03	2.10	2.19	2.29	2.40	2.53	2.68	2.84	3.10	3.32	3.60	3.93				
68	2.04	2.11	2.20	2.30	2.41	2.54	2.69	2.86	3.14	3.34	3.68	4.02				
67	2.04	2.12	2.21	2.31	2.42	2.55	2.71	2.87	3.18	3.36	3.75	4.09				
66	2.05	2.13	2.22	2.32	2.44	2.57	2.78	2.98	3.22	3.44	3.82	4.16				
65	2.06	2.17	2.27	2.38	2.52	2.66	2.83	3.05	3.28	3.56	3.89	4.27				
64	2.07	2.19	2.29	2.42	2.55	2.71	2.88	3.10	3.32	3.64	3.94	4.37				
63	2.08	2.21	2.31	2.44	2.58	2.74	2.92	3.14	3.37	3.72	4.04	4.46				
62	2.14	2.23	2.34	2.47	2.61	2.78	2.97	3.20	3.44	3.77	4.14	4.56				
61	2.16	2.26	2.36	2.49	2.64	2.81	3.02	3.25	3.52	3.85	4.23	4.69				
60	2.19	2.28	2.40	2.53	2.69	2.87	3.08	3.32	3.61	3.95	4.35	4.81				
59	2.20	2.30	2.43	2.57	2.73	2.92	3.13	3.39	3.69	4.04	4.46	4.95				
58	2.23	2.34	2.47	2.61	2.76	2.97	3.20	3.46	3.78	4.15	4.58	5.11				
57	2.26	2.38	2.50	2.65	2.81	3.02	3.26	3.54	3.87	4.26	4.72	5.27				

Calculated based on Eq. (3.16.5)

Table A.4 Boiling Point Elevation (*BPE*) of Pure Sucrose Solutions

<i>DS</i> (% m/m)	Boiling Point of Water (°C)						
	60	70	80	90	100	110	120
10	0.08	0.08	0.09	0.09	0.10	0.11	0.12
15	0.15	0.16	0.18	0.19	0.21	0.22	0.24
20	0.25	0.27	0.29	0.31	0.34	0.35	0.37
25	0.37	0.39	0.42	0.45	0.48	0.51	0.54
30	0.50	0.54	0.56	0.62	0.66	0.71	0.75
35	0.63	0.70	0.75	0.81	0.86	0.92	0.98
40	0.84	0.90	0.96	1.04	1.11	1.20	1.28
45	1.07	1.16	1.24	1.34	1.42	1.52	1.64
50	1.37	1.46	1.57	1.66	1.79	1.91	2.04
55	1.82	1.92	2.04	2.22	2.36	2.50	2.68
60	2.34	2.52	2.70	2.89	3.09	3.31	3.54
62	2.52	2.71	2.90	3.11	3.33	3.56	3.80
64	2.74	2.95	3.16	3.39	3.62	3.88	4.14
66	3.02	3.24	3.48	3.73	3.99	4.27	4.56
68	3.36	3.61	3.87	4.15	4.44	4.75	5.07
70	3.77	4.05	4.34	4.65	4.98	5.33	5.69
72	4.26	4.57	4.91	5.26	5.63	6.02	6.43
74	4.84	5.19	5.57	5.97	6.39	6.83	7.30
76	5.51	5.92	6.35	6.81	7.28	7.79	8.32
78	6.30	6.76	7.26	7.77	8.32	8.90	9.51
80		7.74	8.30	8.89	9.52	10.20	10.90
82			9.5	10.2	10.9	11.6	12.4
84				11.6	12.4	13.3	14.2
86					14.2	15.2	16.2
88						17.3	18.5
90							21.0

Source: From U.S. National Bureau of Standard, Circular C440 and abstracted from *Sugar Technologists Manual* with the permission of Bartens

Table A.5 Boiling Point Elevation (*BPE*) of Impure Sucrose Solutions

Purity (%)	<i>DS</i> (% m/m)	Boiling Point of Water (°C)						
		60	70	80	90	100	110	120
90	10	0.09	0.09	0.10	0.11	0.11	0.12	0.13
	20	0.29	0.31	0.33	0.36	0.38	0.41	0.43
	30	0.57	0.61	0.66	0.71	0.76	0.81	0.86
	40	0.97	1.04	1.12	1.20	1.28	1.37	1.47
	50	1.59	1.71	1.83	1.96	2.10	2.25	2.40
	60	2.65	2.85	3.05	3.27	3.50	3.75	4.00
	65	3.24	3.48	3.74	4.00	4.29	4.58	4.90
	70	4.22	4.54	4.87	5.21	5.58	5.97	6.38
	75	5.73	6.16	6.60	7.08	7.57	8.10	8.65
	80		8.52	9.14	9.79	10.5	11.2	12.0
80	85				13.6	14.5	15.5	16.6
	90							22.8
	10	0.10	0.11	0.12	0.12	0.13	0.14	0.15
	20	0.34	0.36	0.39	0.41	0.44	0.47	0.51
	30	0.67	0.72	0.77	0.82	0.88	0.94	1.01
	40	1.13	1.22	1.31	1.40	1.50	1.60	1.71
	50	1.85	1.99	2.14	2.29	2.45	2.62	2.80
	60	3.02	3.24	3.48	3.73	3.99	4.27	4.56
	65	3.69	3.96	4.25	4.56	4.88	5.21	5.57
	70	4.79	5.14	5.52	5.91	6.33	6.77	7.23
70	75	6.47	6.95	7.45	7.99	8.55	9.14	9.77
	80	8.91	9.57	10.3	11.0	11.8	12.6	13.5
	85			14.2	15.2	16.3	17.4	18.6
	90						23.8	25.5
	10	0.12	0.13	0.14	0.15	0.16	0.17	0.18
	20	0.40	0.43	0.46	0.49	0.53	0.56	0.60
	30	0.79	0.84	0.91	0.97	1.04	1.11	1.19
	40	1.33	1.43	1.53	1.64	1.76	1.88	2.01
	50	2.18	2.35	2.52	2.70	2.89	3.09	3.30
	60	3.46	3.71	3.98	4.27	4.57	4.88	5.22
70	65	4.22	4.53	4.86	5.21	5.58	5.96	6.37
	70	5.47	5.88	6.31	6.76	7.23	7.73	8.26
	75	7.39	7.94	8.51	9.12	9.76	10.40	11.20
	80	10.2	10.9	11.7	12.6	13.4	14.4	15.4
	85		15.1	17.2	18.5	19.8	21.1	22.6
	90				23.7	25.4	27.2	29.0

Source: From *Sugar Technologists Manual* with the permission of Bartens

Table A.6 Specific Heat Capacity (C_p) of Pure Sucrose Solutions (kJ/kg.°C)

Temperature (°C)	Sucrose Content (%)								
	0	10	20	30	40	50	60	70	80
0	4.19	3.94	3.69	3.43	3.18	2.93	2.68	2.43	2.18
10	4.19	3.94	3.70	3.46	3.21	2.97	2.73	2.48	2.24
20	4.19	3.95	3.72	3.48	3.24	3.01	2.77	2.54	2.30
30	4.19	3.96	3.73	3.50	3.27	3.04	2.82	2.59	2.36
40	4.19	3.97	3.75	3.52	3.30	3.08	2.86	2.64	2.42
50	4.19	3.97	3.76	3.55	3.33	3.12	2.91	2.69	2.48
60	4.19	3.98	3.78	3.57	3.36	3.16	2.95	2.75	2.54
70	4.19	3.99	3.79	3.59	3.39	3.19	3.00	2.80	2.60
80	4.19	4.00	3.81	3.61	3.42	3.23	3.04	2.85	2.66
90	4.19	4.00	3.82	3.64	3.45	3.27	3.09	2.90	2.72
100	4.20	4.01	3.83	3.66	3.48	3.30	3.12	2.95	2.77
110	4.21	4.02	3.85	3.68	3.51	3.33	3.15	3.00	2.83
120	4.22	4.03	3.87	3.70	3.54	3.36	3.18	3.05	2.89
130	4.23	4.04	3.89	3.72	3.57	3.39	3.21	3.10	2.95

Note: Values for $T > 90^\circ\text{C}$ were obtained by interpolation of the graph
 Calculated based on Eq. (1.18)

Table A.7 Specific Heat Capacity (C_p) of Impure Sucrose Solutions (kJ/kg·°C)

Temp. (°C)	Purity (P) = 90%										Purity (P) = 80%												
	Dry-Substance Content (%)					Dry-Substance Content (%)					Dry-Substance Content (%)					Dry-Substance Content (%)							
	10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80	10	20	30	40	50	60	70
0	3.93	3.68	3.42	3.16	2.91	2.65	2.40	2.14	4.26	3.67	3.41	3.15	2.89	2.63	2.37	2.11							
10	3.94	3.69	3.44	3.19	2.95	2.70	2.45	2.20	3.93	3.68	3.43	3.18	2.92	2.67	2.42	2.17							
20	3.95	3.71	3.47	3.22	2.98	2.74	2.50	2.26	3.94	3.70	3.45	3.21	2.96	2.72	2.47	2.23							
30	3.95	3.72	3.49	3.25	3.02	2.79	2.56	2.32	3.95	3.71	3.47	3.24	3.00	2.76	2.52	2.29							
40	3.96	3.74	3.51	3.28	3.06	2.83	2.61	2.38	3.96	3.73	3.50	3.27	3.04	2.81	2.58	2.35							
50	3.97	3.75	3.53	3.31	3.10	2.88	2.66	2.44	3.96	3.74	3.52	3.30	3.07	2.85	2.63	2.41							
60	3.98	3.77	3.56	3.34	3.13	2.92	2.71	2.50	3.97	3.76	3.54	3.33	3.11	2.90	2.68	2.47							
70	3.98	3.78	3.58	3.37	3.17	2.97	2.77	2.56	3.98	3.77	3.56	3.36	3.15	2.94	2.73	2.53							
80	3.99	3.80	3.60	3.40	3.21	3.01	2.82	2.62	3.99	3.79	3.59	3.39	3.19	2.99	2.79	2.59							
90	4.00	3.81	3.62	3.43	3.25	3.06	2.87	2.68	3.99	3.80	3.61	3.42	3.22	3.03	2.84	2.65							
100	4.01	3.83	3.65	3.46	3.28	3.10	2.92	2.74	4.00	3.82	3.63	3.45	3.26	3.08	2.89	2.71							
110	4.01	3.84	3.67	3.49	3.32	3.15	2.98	2.80	4.01	3.83	3.65	3.48	3.30	3.12	2.94	2.77							
120	4.02	3.86	3.69	3.52	3.36	3.19	3.03	2.86	4.02	3.85	3.68	3.51	3.34	3.17	3.00	2.83							
130	4.03	3.87	3.71	3.55	3.40	3.24	3.08	2.92	4.02	3.86	3.70	3.54	3.37	3.21	3.05	2.89							

Table A.7 Continued

Temp. (°C)	Purity (P) = 70%										Purity (P) = 90%													
	Dry-Substance Content (%)					Dry-Substance Content (%)					Dry-Substance Content (%)					Dry-Substance Content (%)								
	10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80
0	3.92	3.66	3.39	3.13	2.86	2.60	2.33	2.07	3.92	3.65	3.38	3.11	2.84	2.57	2.30	2.03	3.92	3.65	3.38	3.11	2.84	2.57	2.30	2.03
10	3.93	3.67	3.42	3.16	2.90	2.64	2.39	2.13	3.93	3.66	3.40	3.14	2.88	2.62	2.35	2.09	3.93	3.66	3.40	3.14	2.88	2.62	2.35	2.09
20	3.94	3.69	3.44	3.19	2.94	2.69	2.44	2.19	3.93	3.68	3.42	3.17	2.92	2.66	2.41	2.15	3.93	3.68	3.42	3.17	2.92	2.66	2.41	2.15
30	3.94	3.70	3.46	3.22	2.98	2.73	2.49	2.25	3.94	3.69	3.45	3.20	2.95	2.71	2.46	2.21	3.94	3.69	3.45	3.20	2.95	2.71	2.46	2.21
40	3.95	3.72	3.48	3.25	3.01	2.78	2.54	2.31	3.95	3.71	3.47	3.23	2.99	2.75	2.51	2.27	3.95	3.71	3.47	3.23	2.99	2.75	2.51	2.27
50	3.96	3.73	3.51	3.28	3.05	2.82	2.60	2.37	3.96	3.72	3.49	3.26	3.03	2.80	2.56	2.33	3.96	3.72	3.49	3.26	3.03	2.80	2.56	2.33
60	3.97	3.75	3.53	3.31	3.09	2.87	2.65	2.43	3.96	3.74	3.51	3.29	3.07	2.84	2.62	2.39	3.96	3.74	3.51	3.29	3.07	2.84	2.62	2.39
70	3.97	3.76	3.55	3.34	3.13	2.91	2.70	2.49	3.97	3.75	3.54	3.32	3.10	2.89	2.67	2.45	3.97	3.75	3.54	3.32	3.10	2.89	2.67	2.45
80	3.98	3.78	3.57	3.37	3.16	2.96	2.75	2.55	3.98	3.77	3.56	3.35	3.14	2.93	2.72	2.51	3.98	3.77	3.56	3.35	3.14	2.93	2.72	2.51
90	3.99	3.79	3.60	3.40	3.20	3.00	2.81	2.61	3.99	3.78	3.58	3.38	3.18	2.98	2.77	2.57	3.99	3.78	3.58	3.38	3.18	2.98	2.77	2.57
100	4.00	3.81	3.62	3.43	3.24	3.05	2.86	2.67	3.99	3.80	3.60	3.41	3.22	3.02	2.83	2.63	3.99	3.80	3.60	3.41	3.22	3.02	2.83	2.63
110	4.00	3.82	3.64	3.46	3.28	3.09	2.91	2.73	4.00	3.81	3.63	3.44	3.25	3.07	2.88	2.69	4.00	3.81	3.63	3.44	3.25	3.07	2.88	2.69
120	4.01	3.84	3.66	3.49	3.31	3.14	2.96	2.79	4.01	3.83	3.65	3.47	3.29	3.11	2.93	2.75	4.01	3.83	3.65	3.47	3.29	3.11	2.93	2.75
130	4.02	3.85	3.69	3.52	3.35	3.18	3.02	2.85	4.02	3.84	3.67	3.50	3.33	3.16	2.98	2.81	4.02	3.84	3.67	3.50	3.33	3.16	2.98	2.81

Calculated based on Eq. (1.18)

Table A.8 Specific Enthalpy (H) of Pure Sucrose Solutions (kJ/kg)

Temp. (°C)	Sucrose Content (%)								
	0	10	20	30	40	50	60	70	80
10	41.9	39.4	36.9	34.5	32.0	29.5	27.0	24.6	22.1
20	83.7	78.9	74.0	69.1	64.3	59.4	54.5	49.7	44.8
30	125.6	118.4	111.2	104.0	96.8	89.6	82.5	75.3	68.1
40	167.5	158.0	148.6	139.2	129.7	120.3	110.8	101.4	92.0
50	209.4	197.7	186.1	174.5	162.9	151.3	139.7	128.1	116.5
60	251.2	237.5	223.8	210.1	196.4	182.7	169.0	155.3	141.5
70	293.1	277.4	261.6	245.9	230.2	214.4	198.7	183.0	167.2
80	335.0	317.3	299.6	281.9	264.2	246.6	228.9	211.2	193.5
90	376.8	357.3	337.7	318.2	298.6	279.1	259.5	240.0	220.4
100	418.7	397.4	376.0	354.7	333.3	312.0	290.6	269.3	247.9
110	462	437	414	392	367	345	322	299	275
120	506	477	452	429	403	378	353	329	304
130	549	517	490	466	438	412	386	359	333

Note: Values for $T > 100^\circ\text{C}$ were obtained by interpolation of the graph
 Calculated based on Eq. (1.19)

Table A.9 Specific Enthalpy (*H*) of Impure Sucrose Solutions (kJ/kg·°C)

Temp. (°C)	Purity (<i>P</i>) = 90%										Purity (<i>P</i>) = 80%									
	Dry-Substance Content (%)										Dry-Substance Content (%)									
	10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80				
10	39	37	34	32	29	27	24	22	39	37	34	32	29	26	24	21				
20	79	74	69	64	59	54	49	44	79	74	69	64	58	53	48	43				
30	118	111	104	96	89	82	74	67	118	111	103	96	88	81	73	66				
40	158	148	139	129	119	110	100	90	158	148	138	128	118	109	99	89				
50	198	186	174	162	150	138	126	115	197	185	173	161	149	137	125	113				
60	237	223	209	195	181	167	153	139	237	223	208	194	180	166	151	137				
70	277	261	245	229	213	197	181	165	277	260	244	228	211	195	178	162				
80	317	299	281	263	245	227	209	191	317	298	280	261	243	224	206	188				
90	357	337	317	297	277	257	237	217	356	336	316	295	275	255	234	214				
100	397	375	353	331	310	288	266	244	396	374	352	330	307	285	263	241				
110	437	413	390	366	343	319	296	272	436	412	388	364	340	316	292	268				
120	477	452	427	401	376	351	326	300	477	451	425	399	373	347	322	296				
130	517	491	464	437	410	383	356	329	517	489	462	434	407	379	352	324				

Table A.9 Continued

Temp. (°C)	Purity (P) = 70%										Purity (P) = 90%													
	Dry-Substance Content (%)					Dry-Substance Content (%)					Dry-Substance Content (%)					Dry-Substance Content (%)								
	10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80	10	20	30	40	50	60	70	80
10	39	37	34	31	29	26	24	21	39	37	34	31	29	26	23	21	39	37	34	31	29	26	23	21
20	79	73	68	63	58	53	48	43	79	73	68	63	58	52	47	42	79	73	68	63	58	52	47	42
30	118	110	103	95	88	80	72	65	118	110	102	95	87	79	71	64	118	110	102	95	87	79	71	64
40	157	147	138	128	118	108	98	88	157	147	137	127	117	106	96	86	157	147	137	127	117	106	96	86
50	197	185	172	160	148	136	123	111	197	184	172	159	147	134	122	109	197	184	172	159	147	134	122	109
60	237	222	208	193	179	164	149	135	236	222	207	192	177	162	148	133	236	222	207	192	177	162	148	133
70	276	260	243	226	210	193	176	160	276	259	242	225	208	191	174	157	276	259	242	225	208	191	174	157
80	316	297	279	260	241	222	203	185	316	297	278	258	239	220	201	182	316	297	278	258	239	220	201	182
90	356	335	314	294	273	252	231	210	356	334	313	292	271	250	228	207	356	334	313	292	271	250	228	207
100	396	373	351	328	305	282	260	237	396	372	349	326	303	280	256	233	396	372	349	326	303	280	256	233
110	436	411	387	362	338	313	288	264	435	410	385	360	335	310	285	260	435	410	385	360	335	310	285	260
120	476	450	423	397	371	344	318	291	476	449	422	395	368	341	314	287	476	449	422	395	368	341	314	287
130	516	488	460	432	404	376	348	320	516	487	458	430	401	372	344	315	516	487	458	430	401	372	344	315

Calculated based on Eq. (1.19)

Table A.10 Properties of Saturated Steam and Water (in Metric and English systems)

Tem- perature (°C)	Enthalpy					Vapo- rization (λ) (kJ/kg)	Vapo- rization (λ) (Btu/lb)
	Vapor pressure (kPa)	Saturated Vapor (H_v) (kJ/kg)	Liquid (H_c) (kJ/kg)	Liquid (H_c) (Btu/lb)	Saturated Vapor (H_v) (Btu/lb)		
0	0.6	2501.6	0.0	0.0	1075.4	0.0	1075.4
5	0.9	2510.7	21.0	2489.7	1076.7	3.0	1073.7
10	1.2	2519.9	42.0	2477.9	1078.9	8.0	1070.9
15	1.7	2528.9	62.9	2466.0	1081.1	13.0	1068.1
20	2.2	2538.2	83.9	2454.3	1083.3	18.1	1065.2
25	3.2	2547.3	104.8	2442.5	1085.5	23.1	1062.4
30	4.3	2556.3	125.8	2430.5	1087.7	28.1	1059.6
35	5.6	2565.4	146.6	2418.8	1089.9	33.1	1056.8
40	7.4	2574.3	167.6	2406.7	1092.0	38.1	1053.9
45	9.6	2583.2	188.5	2394.7	1094.2	43.1	1051.1
50	12.4	2592.1	209.3	2382.8	1096.4	48.1	1048.3
55	15.8	2600.9	230.2	2370.7	1098.6	53.1	1045.5
60	19.9	2609.6	251.1	2358.5	1100.7	58.1	1042.6
65	25.0	2618.3	272.1	2346.2	1102.9	63.1	1039.8
70	31.2	2626.8	293.0	2333.8	1105.0	68.1	1037.0
75	38.6	2635.3	313.9	2321.4	1109.3	78.0	1031.3
80	47.4	2643.7	334.9	2308.8	1113.5	88.0	1025.5
85	57.8	2651.9	355.9	2296.0	1117.8	98.0	1019.8
90	70.1	2660.1	376.9	2283.2	1121.9	108.0	1013.9
95	84.6	2668.1	398.0	2270.1	1126.1	118.0	1008.1
100	101.4	2676.1	419.0	2257.1	1130.1	128.0	1002.1

Table A.10 Continued

Tem- perature (°C)	Enthalpy					Vapo- rization (λ) (kJ/kg)	Tem- perature (°F)	Vapor pressure (lb/in. ²)	Enthalpy		
	Vapor pressure (kPa)	Saturated Vapor (H_v) (kJ/kg)	Liquid (H_C) (kJ/kg)	Saturated Vapor (H_v) (Btu/lb)	Liquid (H_C) (Btu/lb)				Vapo- rization (λ) (Btu/lb)		
105	120.8	2683.8	440.2	2243.7	170	6.0	1134.2	138.0	996.2		
110	143.3	2691.5	461.3	2230.2	180	7.5	1138.2	148.0	990.2		
115	169.1	2699.0	482.5	2216.5	190	9.3	1142.1	158.0	984.1		
120	198.5	2706.3	503.7	2202.6	200	11.5	1145.9	168.1	977.8		
125	232.1	2713.5	525.0	2188.5	210	14.1	1149.7	178.1	971.6		
130	270.1	2720.5	546.3	2174.2	220	17.2	1153.5	188.2	965.3		
135	313.0	2727.3	567.7	2159.6	230	20.8	1157.1	198.3	958.8		
140	316.3	2733.9	589.1	2144.8	240	25.0	1160.7	208.4	952.3		
145	415.4	2740.3	610.6	2129.7	250	29.8	1164.2	218.6	945.6		
150	475.8	2746.5	632.2	2114.3	260	35.4	1167.6	228.8	938.8		
155	543.1	2752.4	653.8	2098.6	270	41.9	1170.9	239.0	932.0		
160	617.8	2758.1	675.6	2082.6	280	49.2	1174.1	249.2	924.9		
165	700.5	2763.5	697.3	2066.2	290	57.5	1177.2	259.4	917.8		
170	791.7	2768.7	719.2	2049.5	300	67.0	1180.2	269.7	910.5		
175	892.0	2773.6	741.2	2032.4	310	77.6	1183.0	280.1	902.9		
180	1002	2778.2	763.2	2015.0	320	89.6	1185.8	290.4	895.4		
190	1254	2786.4	807.6	1978.8	340	117.9	1190.8	311.3	879.5		
200	1554	2793.2	852.5	1940.8	350	134.5	1193.1	321.8	871.3		
225	2548	2803.3	966.8	1836.5	360	152.9	1195.2	332.4	862.9		
250	3973	2801.5	1085.4	1716.1	370	173.2	1197.2	343.0	854.2		
275	5942	2785.0	1210.1	1574.9	380	195.6	1199.0	353.6	845.4		
300	8581	2749.0	1344.0	1405.0	390	220.2	1200.6	364.3	836.3		

Source: Abstracted from *Steam Tables* by Keenan et al. (1969), with the permission of John Wiley and Sons, Inc.

Table A.11 Density (kg/m³) of Masseccutes at Different Crystal Contents and Temperatures

<i>DS</i> Masseccuite (% m/m)	<i>DS</i> Mother Liquor (% m/m)	Crystal Content (%)	Temperature (°C)						
			40	50	60	70	80	90	
88	75	52.0	1472.4	1468.4	1464.3				
	76	50.0	1471.9	1467.8	1463.6	1459.2			
	77	47.8	1471.2	1467.1	1462.8	1458.4			
	78	45.5	1470.5	1466.3	1461.9	1457.4	1452.8		
	79	42.9	1469.7	1465.4	1460.9	1456.3	1451.6		
89	80	40.0	1468.8	1464.4	1459.8	1455.1	1450.3	1445.5	
	76	54.2	1480.6	1476.7	1472.6	1468.5			
	77	52.2	1480.0	1476.0	1471.9	1467.7			
	78	50.0	1479.3	1475.3	1471.1	1466.8	1462.4		
	79	47.6	1478.6	1474.4	1470.1	1465.8	1461.3		
90	80	45.0	1477.7	1473.5	1469.1	1464.6	1460.1	1455.5	
	81	42.1	1476.8	1472.5	1468.0	1463.4	1458.7	1454.1	
	77	56.5	1488.8	1485.0	1481.1	1477.1			
	78	54.5	1488.2	1484.4	1480.4	1476.3	1472.1		
	79	52.4	1487.5	1483.6	1479.5	1475.3	1471.1		
91	80	50.0	1486.8	1482.7	1478.6	1474.3	1470.0	1465.7	
	81	47.4	1485.9	1481.8	1477.5	1473.2	1468.7	1464.3	
	82	44.4	1485.0	1480.7	1476.4	1471.9	1467.3	1462.8	
	78	59.1	1497.3	1493.6	1489.8	1485.9	1482.0		
	79	57.1	1496.6	1492.9	1489.0	1485.1	1481.0		
92	80	55.0	1495.9	1492.1	1488.2	1484.1	1480.0	1475.9	
	81	52.6	1495.2	1491.2	1487.2	1483.1	1478.9	1474.7	
	82	50.0	1494.3	1490.3	1486.1	1481.9	1477.6	1473.3	
	83	47.1	1493.3	1489.2	1484.9	1480.6	1476.2	1471.8	
	79	61.9	1505.8	1502.3	1498.6	1494.9	1491.1		
93	80	60.0	1505.2	1501.6	1497.9	1494.1	1490.2	1486.3	
	81	57.9	1504.5	1500.8	1497.0	1493.1	1489.2	1485.2	
	82	55.6	1503.7	1499.9	1496.0	1492.1	1488.0	1484.0	
	83	52.9	1502.8	1498.9	1494.9	1490.9	1486.7	1482.6	
	84	50.0	1501.8	1498.7	1493.7	1489.5	1485.3	1481.0	
94	81	63.2	1514.0	1510.5	1506.9	1503.3	1499.6	1495.9	
	82	61.1	1513.3	1509.7	1506.1	1502.3	1498.6	1494.8	
	83	58.8	1512.5	1508.8	1505.1	1501.3	1497.4	1493.6	
	84	56.3	1511.6	1507.8	1504.0	1500.1	1496.1	1492.2	
	85	53.3	1510.5	1506.7	1502.7	1498.7	1494.6	1490.6	
94	86	50.0		1505.4	1501.3	1497.1	1492.9	1488.8	
	84	62.5	1521.5	1518.0	1514.4	1510.8	1507.2	1503.5	
	85	60.0	1520.6	1517.0	1513.4	1509.6	1505.9	1502.1	
	86	57.1		1515.9	1512.1	1508.3	1504.4	1500.5	
	87	53.8			1510.6	1506.7	1502.7	1498.7	
94	88	50.0			1508.9	1504.8	1500.6	1496.5	
	89	45.5				1502.6	1498.2	1494.0	

Source: From *Sugar Technologists Manual* with the permission of Bartens

Table A.12 Viscosity (in cp) of Pure Sucrose Solutions

<i>DS</i> (% m/m)	Temperature (°C)								
	0	5	10	15	20	25	30	35	40
20	3.8	3.2	2.7	2.3	2.0	1.7	1.5	1.3	1.2
21	4.0	3.3	2.8	2.4	2.0	1.8	1.6	1.4	1.2
22	4.2	3.5	2.9	2.5	2.1	1.9	1.6	1.4	1.3
23	4.4	3.7	3.1	2.6	2.2	1.9	1.7	1.5	1.3
24	4.7	3.9	3.2	2.7	2.3	2.0	1.8	1.6	1.4
25	5.0	4.1	3.4	2.9	2.5	2.1	1.9	1.6	1.5
26	5.3	4.3	3.6	3.0	2.6	2.2	2.0	1.7	1.5
27	5.6	4.6	3.8	3.2	2.7	2.4	2.1	1.8	1.6
28	5.9	4.8	4.0	3.4	2.9	2.5	2.2	1.9	1.7
29	6.3	5.1	4.3	3.6	3.0	2.6	2.3	2.0	1.8
30	6.7	5.5	4.5	3.8	3.2	2.8	2.4	2.1	1.8
31	7.2	5.8	4.8	4.0	3.3	2.9	2.5	2.2	1.9
32	7.7	6.2	5.1	4.3	3.6	3.1	2.7	2.3	2.0
33	8.3	6.7	5.5	4.6	3.8	3.3	2.8	2.5	2.2
34	8.9	7.2	5.8	4.9	4.1	3.5	3.0	2.6	2.3
35	9.6	7.7	6.3	5.2	4.4	3.7	3.2	2.7	2.4
36	10.4	8.3	6.7	5.6	4.7	3.9	3.4	2.9	2.5
37	11.3	9.0	7.3	6.0	5.0	4.2	3.6	3.1	2.7
38	12.3	9.7	7.8	6.4	5.4	4.5	3.8	3.3	2.9
39	13.4	10.6	8.5	6.9	5.8	4.8	4.1	3.5	3.0
40	14.7	11.5	9.2	7.5	6.2	5.2	4.4	3.8	3.3
41	16.1	12.6	10.1	8.2	6.7	5.6	4.7	4.0	3.5
42	17.8	13.9	11.0	8.9	7.3	6.1	5.1	4.3	3.7
43	19.7	15.3	12.1	9.7	7.9	6.6	5.5	4.7	4.0
44	21.9	16.9	13.3	10.6	8.6	7.1	6.0	5.0	4.3
45	24.5	18.7	14.7	11.7	9.4	7.8	6.4	5.4	4.6
46	27.4	20.9	16.2	12.9	10.4	8.5	7.0	5.9	5.0
47	30.8	23.3	18.0	14.2	11.4	9.2	7.7	6.4	5.4
48	34.8	26.2	20.1	15.8	12.6	10.2	8.4	7.0	5.9
49	39.5	29.5	22.6	17.6	14.0	11.3	9.2	7.7	6.4
50	45.1	33.4	25.4	19.7	15.5	12.5	10.2	8.4	7.0
51	51.6	38.0	28.7	22.1	17.4	13.9	11.3	9.2	7.7
52	59.5	43.5	32.6	24.9	19.5	15.5	12.5	10.2	8.5
53	69.0	50.0	37.2	28.3	22.0	17.4	13.9	11.4	9.4
54	80.5	57.8	42.7	32.2	24.9	19.5	15.6	12.7	10.4
55	94.5	67.3	49.3	36.9	28.3	22.1	17.6	14.2	11.6
56	111.8	78.8	57.2	42.5	32.4	25.1	19.8	15.9	13.0
57	133.2	93.0	66.9	49.3	37.2	28.7	22.5	18.0	14.5
58	160.1	110.0	78.7	57.6	43.1	33.0	25.7	20.4	16.4
59	193.9	132.0	93.4	67.6	50.2	38.1	29.5	23.2	18.6
60	237.4	160.0	111.7	80.1	58.9	44.5	34.1	26.7	21.2
61	293.7	195.6	134.7	95.6	69.7	52.0	39.6	30.8	24.3
62	367.2	241.2	164.1	115.1	83.0	61.4	46.4	35.7	28.0
63	464.9	300.7	201.8	139.9	99.8	73.0	54.7	41.8	32.5
64	595.7	379.2	250.8	171.6	121.0	87.6	65.0	49.2	38.0

Table A.12 Continued

<i>DS</i> (% m/m)	Temperature (°C)								
	0	5	10	15	20	25	30	35	40
65	773.1	484.1	315.3	212.8	148.2	106.1	77.9	58.4	44.7
66	1020	626	401	267	183.3	129.7	94.1	69.9	53.0
67	1365	822	517	339	229.4	160.2	114.9	84.2	63.4
68	1859	1096	677	436	290.5	200.1	141.7	103.0	76.5
69	2579	1486	899	568	372.7	252.9	176.8	126.9	93.2
70	3654	2052	1214	752	485.0	323.9	223.2	158.1	114.8

Source: U.S. National Bureau of Standard, Circular C440

Note: Boldface values are extrapolated

Table A.13 Viscosity (in Pa.s) of Masseccites at Different Crystal Contents (CC) and Temperatures

<i>DS</i> Masseccite (% m/m)	<i>DS</i> Mother Liquor (%)	<i>CC</i> Masseccite (%)	Temperature (°C)					
			40	50	60	70	80	90
Purity = 90%								
90	76	58.3	199	97	52	30		
	77	56.5	155	73	38	22	13	
	78	54.6		58	29	16	9.5	
	79	52.4		48	23	12	7.1	4.4
91	82	50.0				73	38	21
	83	47.1				53	26	14
	84	43.8					20	10
92	83	52.9				53	26	14
	84	50.0					20	10
	85	46.7						7.6
93	83	58.8				300	151	82
	84	56.3					91	48
	85	53.3						30
Purity = 80%								
90	78	54.6	116	54	28	16		
	79	52.6	99	44	22	12	7.0	
	80	50.0	89	38	18	10	5.4	2.6
91	80	55.0	296	122	59	31	18	
	81	52.6		99	46	23	13	7.5
	82	50.0		84	37	18	9.7	5.5
92	82	55.6		318	140	69	37	21
	83	52.9			105	49	25	14
93	84	56.3				177	87	46
	85	53.3				120	57	29

Table A.13 Continued

DS Masseccuite (% m/m)	DS Mother Liquor (%)	CC Masseccuite (%)	Temperature (°C)					
			40	50	60	70	80	90
Purity = 70%								
90	80	50.0	80	35	17	9.2		
	81	47.4	74	31	15	7.6		
	82	44.4	73	29	13	6.6	3.6	
91	81	52.6	214	90	43	22		
	82	50.0	190	76	34	17	9.3	
	83	47.1	178	68	29	14	7.4	
92	83	52.9	587	224	97	47	24	
	84	50.0		186	77	35	18	
93	85	53.3		652	254	112	54	28
	86	50.0			196	82	38	19
94	88	50.0				219	90	41
Purity = 60%								
90	82	44.4	64	27	12			
	83	41.2	66	26	11			
	84	37.5	71	26	11	5.2		
91	84	43.8	153	57	24	11		
	85	40.0	162	57	23	10		
	86	35.7	182	60	23	9.7		
92	84	50.0	445	165	70	33		
	85	46.7	418	146	59	27		
93	86	50.0		461	175	75		
	87	46.2		408	145	59	27	
94	88	50.0			423	150	60	27

Source: Abstracted from *Sugar Technologists Manual* with the permission of Bartens

Table A.14 Refractive Index (*RI*) of Pure Sucrose Solutions (at 20°C)

DS (% m/m)	<i>RI</i>	DS (% m/m)	<i>RI</i>	DS (% m/m)	<i>RI</i>	DS (% m/m)	<i>RI</i>	DS (% m/m)	<i>RI</i>
0.0	1.3330	1.6	1.3353	3.2	1.3376	4.8	1.3400	6.4	1.3424
0.2	1.3333	1.8	1.3356	3.4	1.3379	5.0	1.3403	6.6	1.3427
0.4	1.3336	2.0	1.3359	3.6	1.3382	5.2	1.3406	6.8	1.3430
0.6	1.3339	2.2	1.3362	3.8	1.3385	5.4	1.3409	7.0	1.3433
0.8	1.3341	2.4	1.3365	4.0	1.3388	5.6	1.3412	7.2	1.3436
1.0	1.3344	2.6	1.3368	4.2	1.3391	5.8	1.3415	7.4	1.3439
1.2	1.3347	2.8	1.3370	4.4	1.3394	6.0	1.3418	7.6	1.3442
1.4	1.3350	3.0	1.3373	4.6	1.3397	6.2	1.3421	7.8	1.3445

Table A.14 Continued

<i>DS</i> (% m/m)	<i>RI</i>	<i>DS</i> (% m/m)	<i>RI</i>	<i>DS</i> (% m/m)	<i>RI</i>	<i>DS</i> (% m/m)	<i>RI</i>	<i>DS</i> (% m/m)	<i>RI</i>
8.0	1.3448	16.6	1.3583	23.2	1.3692	31.8	1.3843	40.4	1.4005
8.2	1.3451	16.8	1.3586	23.4	1.3696	32.0	1.3847	40.6	1.4008
8.4	1.3454	17.0	1.3589	23.6	1.3699	32.2	1.3851	40.8	1.4012
8.6	1.3457	17.2	1.3592	23.8	1.3703	32.4	1.3854	41.0	1.4016
8.8	1.3460	17.4	1.3596	24.0	1.3706	32.6	1.3858	41.2	1.4020
9.0	1.3463	17.6	1.3599	24.2	1.3709	32.8	1.3861	41.4	1.4024
9.2	1.3466	17.8	1.3602	24.4	1.3713	33.0	1.3865	41.6	1.4028
9.4	1.3469	18.0	1.3605	24.6	1.3716	33.2	1.3869	41.8	1.4032
9.6	1.3472	18.2	1.3609	24.8	1.3720	33.4	1.3872	42.0	1.4036
9.8	1.3475	18.4	1.3612	25.0	1.3723	33.6	1.3876	42.2	1.4040
10.0	1.3478	18.6	1.3615	25.2	1.3726	33.8	1.3879	42.4	1.4044
10.2	1.3481	18.8	1.3619	25.4	1.3730	34.0	1.3883	42.6	1.4048
10.4	1.3485	19.0	1.3622	25.6	1.3733	34.2	1.3887	42.8	1.4052
10.6	1.3488	19.2	1.3625	25.8	1.3737	34.4	1.3891	43.0	1.4056
10.8	1.3491	19.4	1.3628	26.0	1.3740	34.6	1.3894	43.2	1.4060
11.0	1.3494	19.6	1.3632	26.2	1.3744	34.8	1.3898	43.4	1.4064
11.2	1.3497	19.8	1.3635	26.4	1.3747	35.0	1.3902	43.6	1.4068
11.4	1.3500	20.0	1.3638	26.6	1.3751	35.2	1.3906	43.8	1.4072
11.6	1.3503	20.2	1.3642	26.8	1.3754	35.4	1.3909	44.0	1.4076
11.8	1.3506	20.4	1.3645	27.0	1.3758	35.6	1.3913	44.2	1.4080
12.0	1.3509	20.6	1.3648	27.2	1.3760	35.8	1.3916	44.4	1.4084
12.2	1.3512	20.8	1.3652	27.4	1.3765	36.0	1.3920	44.6	1.4086
12.4	1.3516	21.0	1.3655	27.6	1.3768	36.2	1.3924	44.8	1.4092
12.6	1.3519	21.2	1.3659	27.8	1.3772	36.4	1.3928	45.0	1.4096
12.8	1.3522	21.4	1.3662	28.0	1.3775	36.6	1.3931	45.2	1.4100
13.0	1.3525	21.6	1.3665	28.2	1.3779	36.8	1.3935	45.4	1.4104
13.2	1.3528	21.8	1.3669	28.4	1.3782	37.0	1.3939	45.6	1.4109
13.4	1.3531	22.0	1.3673	28.6	1.3786	37.2	1.3943	45.8	1.4113
13.6	1.3535	22.2	1.3677	28.8	1.3789	37.4	1.3947	46.0	1.4117
13.8	1.3538	22.4	1.3681	29.0	1.3793	37.6	1.3950	46.2	1.4121
14.0	1.3541	22.6	1.3685	29.2	1.3797	37.8	1.3954	46.4	1.4125
14.2	1.3544	22.8	1.3689	29.4	1.3800	38.0	1.3958	46.6	1.4129
14.4	1.3547	23.0	1.3693	29.6	1.3804	38.2	1.3962	46.8	1.4133
14.6	1.3550	23.2	1.3697	29.8	1.3808	38.4	1.3966	47.0	1.4137
14.8	1.3554	23.4	1.3701	30.0	1.3811	38.6	1.3970	47.2	1.4141
15.0	1.3557	23.6	1.3705	30.2	1.3815	38.8	1.3974	47.4	1.4145
15.2	1.3560	23.8	1.3709	30.4	1.3818	39.0	1.3978	47.6	1.4150
15.4	1.3563	24.0	1.3713	30.6	1.3822	39.2	1.3982	47.8	1.4154
15.6	1.3566	24.2	1.3717	30.8	1.3825	39.4	1.3986	48.0	1.4158
15.8	1.3570	24.4	1.3721	31.0	1.3829	39.6	1.3989		
16.0	1.3573	24.6	1.3725	31.2	1.3833	39.8	1.3993		
16.2	1.3576	24.8	1.3729	31.4	1.3836	40.0	1.3997		
16.4	1.3579	25.0	1.3733	31.6	1.3840	40.2	1.4001		

Source: U.S. National Bureau of Standard, Circular C440

Table A.15 Bulk Density of Materials Used in Sugar Production

	kg/m ³	lb/ft ³
Beet seed	700	44
Beets, washed	660	41
Beet tare:		
Soil and sand, wet	2100	131
Soil and sand, dry	1600	100
Stones	1400	87
Trash	300	19
Limestone	1500	94
Coke	400	25
Carbonation gas	1.5	0.1
Coal	750	47

Note: Values are approximate

Table A.16 Bulk Density of Products and By-products of a Beet-Sugar Factory

	kg/m ³	lb/ft ³	lb/ga
Granulated-refined sugar	900	56	
Powdered sugar	450	28	
Brown sugar	850	53	
Molasses, 80% <i>DS</i>	1400	87	12
Betaine, 55% <i>DS</i>	1300	81	11
Raffinate, 60% <i>DS</i>	1250	78	10
Pulp:			
Pressed	620	39	
Dry pulp, 90% <i>DS</i>	220	14	
Dry molasses, 90% <i>DS</i>	200	12	
Pellets, 90% <i>DS</i>	650	41	
Carbonation lime residue, 70% <i>DS</i>	1100	69	

Note: Values are approximate

Table A.17 Conversion Factors**Acceleration**

$$1 \text{ ft/s}^2 = 0.3048 \text{ m/s}^2$$

$$\begin{aligned} \text{Acceleration of gravity (gravitational force)} \\ = 32.19 \text{ ft/s}^2 = 9.81 \text{ m/s}^2 \end{aligned}$$

Area

$$1 \text{ ft}^2 = 0.2832 \text{ m}^2$$

$$1 \text{ acre} = 4047 \text{ m}^2 = 43515 \text{ ft}^2 = 0.405 \text{ hectare}$$

$$1 \text{ hectare} = 10^4 \text{ m}^2 = 2.471 \text{ acre}$$

$$1 \text{ in.}^2 = 6.452 \times 10^{-4} \text{ m}^2 = 645.16 \text{ mm}^2$$

$$1 \text{ yd}^2 = 9 \text{ ft}^2 = 0.837 \text{ m}^2$$

Density

$$1 \text{ lb/ft}^3 = 16.019 \text{ kg/m}^3$$

$$1 \text{ lb/ga} = 1.198 \times 10^2 \text{ kg/m}^3$$

$$1 \text{ kg/m}^3 = 0.062 \text{ lb/ft}^3 = 0.0083 \text{ lb/ga}$$

Diffusivity

$$1 \text{ ft}^2/\text{hr} = 2.581 \times 10^{-5} \text{ m}^2/\text{s}$$

Energy

$$1 \text{ Btu} = 1.055 \text{ kJ} = 252.16 \text{ cal} = 0.252 \text{ kcal}$$

$$1 \text{ kcal} = 4.184 \text{ kJ}$$

$$1 \text{ J} = 1 \text{ N}\cdot\text{m} = 1 \text{ kg}\cdot\text{m}^2/\text{s}^2$$

$$1 \text{ kWh} = 3.6 \times 10^3 \text{ kJ}$$

Enthalpy

$$1 \text{ Btu/lb} = 2.326 \text{ kJ/kg}$$

Force(*f*)

$$1 \text{ lbf} = 4.448 \text{ N}$$

$$1 \text{ N} = 1 \text{ kg}\cdot\text{m}/\text{s}^2$$

$$1 \text{ dyne} = 1 \text{ g}\cdot\text{cm}/\text{s}^2 = 10^{-5} \text{ kg}\cdot\text{m}/\text{s}^2$$

Heat flow

$$1 \text{ Btu/h} = 0.293 \text{ W}$$

$$1 \text{ Btu/min} = 17.58 \text{ W}$$

$$1 \text{ kJ/h} = 2.778 \times 10^{-4} \text{ kW}$$

$$1 \text{ J/s} = 1 \text{ W}$$

Heat flux

$$1 \text{ Btu/h}\cdot\text{ft}^2 = 3.155 \text{ W/m}^2$$

Heat transfer coefficient

$$1 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F} = 5.678 \text{ W/m}^2\cdot^\circ\text{C} = 5.678 \text{ kJ/m}^2\cdot^\circ\text{C}$$

$$1 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F} = 1.357 \times 10^{-4} \text{ cal/s}\cdot\text{cm}^2\cdot^\circ\text{C}$$

Length

$$1 \text{ ft} = 0.3048 \text{ m}$$

$$1 \text{ in.} = 2.54 \times 10^{-2} \text{ m} = 2.54 \text{ cm} = 25.4 \text{ mm}$$

$$1 \text{ micron} = 1 \mu\text{m} = 10^{-6} \text{ m}$$

$$1 \text{ nm} = 10^{-9} \text{ m}$$

$$1 \text{ \AA} = 1 \mu\text{m} = 10^{-10} \text{ m}$$

$$1 \text{ mile} = 1.6093 \times 10^3 \text{ m}$$

Mass

$$1 \text{ lb} = 0.45359 \text{ kg} = 16 \text{ oz}$$

$$1 \text{ oz} = 28.35 \text{ g}$$

$$1 \text{ metric ton} = 10^3 \text{ kg} = 0.9078 \text{ short ton}$$

$$1 \text{ g} = 10^3 \text{ mg} = 61 \times 10^{22} \text{ Dalton}$$

Power

$$1 \text{ hp} = 745.71 \text{ W} = 550 \text{ ft}\cdot\text{lb}/\text{s} = 0.707 \text{ Btu}/\text{s}$$

$$1 \text{ W} = 1 \text{ J}/\text{s} = 14.34 \text{ cal}/\text{min}$$

$$1 \text{ kWh} = 3412 \text{ BTU}$$

$$1 \text{ Btu}/\text{h} = 0.293 \text{ W}$$

Pressure

$$1 \text{ psi} = \text{psig} + 14.7$$

$$1 \text{ psi} = 6.895 \text{ kPa} = 0.069 \text{ bar} = 6895 \times 10^3 \text{ N}/\text{m}^2$$

$$1 \text{ bar} = 10^5 \text{ Pa} = 10^5 \text{ N}/\text{m}^2$$

$$1 \text{ Pa} = 1 \text{ N}/\text{m}^2$$

$$1 \text{ atm} = 1.0133 \text{ bar} = 14.7 \text{ psi}$$

$$1 \text{ atm} = 1.0133 \times 10^5 \text{ Pa} = 101.33 \text{ kPa} = 760 \text{ atm}$$

$$1 \text{ lb}/\text{ft}^2 = 4.788 \times 10^2 \text{ dyne}/\text{cm}^2 = 47.88 \text{ N}/\text{m}^2$$

Specific heat

$$1 \text{ Btu}/\text{lb}\cdot^\circ\text{F} = 4186 \text{ J}/\text{kg}\cdot^\circ\text{C} = 10^3 \text{ cal}/\text{kg}\cdot^\circ\text{C}$$

Temperature

$$T_F = 1.8 \times T_C + 32$$

$$T_C = (T_F - 32)/1.8$$

$$K = ^\circ\text{C} + 273$$

Thermal conductivity

$$1 \text{ Btu}/\text{h}\cdot\text{ft}\cdot^\circ\text{F} = 1.731 \text{ W}/\text{m}\cdot\text{K}$$

$$1 \text{ Btu}\cdot\text{in.}/\text{ft}\cdot\text{h}\cdot^\circ\text{F} = 1.442 \times 10^{-2} \text{ W}/\text{m}^2\cdot\text{K}$$

Velocity

$$1 \text{ ft}/\text{s} = 0.3048 \text{ m}/\text{s}^2$$

Viscosity

$$1 \text{ cp} = 10^{-2} \text{ g}/\text{cm}\cdot\text{s} = 10^{-3} \text{ kg}/\text{m}\cdot\text{s}$$

$$1 \text{ cp} = 10^{-2} \text{ poise} = 10^{-3} \text{ Pa}\cdot\text{s} = 10^{-3} \text{ N}\cdot\text{s}/\text{m}^2$$

$$1 \text{ lb}/\text{ft}\cdot\text{h} = 0.413 \text{ cp}$$

$$1 \text{ lb}/\text{ft}\cdot\text{s} = 1488.16 \text{ cp}$$

$$1 \text{ N}\cdot\text{s}/\text{m}^2 = 1 \text{ Pa}\cdot\text{s} = 1 \text{ kg}/\text{m}\cdot\text{s}$$

Volume

$$1 \text{ ft}^3 = 7.481 \text{ U.S. ga}$$

$$1 \text{ U.S. ga} = 4 \text{ qt} = 0.083 \text{ British ga}$$

$$1 \text{ U.S. ga} = 3.785 \text{ L} = 3.785 \times 10^{-3} \text{ m}^3$$

$$1 \text{ ft}^3 = 0.028 \text{ m}^3 = 28.32 \text{ L} = 18.28 \text{ in.}^2$$

$$1 \text{ qt} = 0.946 \text{ L}$$

$$1 \text{ oz} = 29.55 \text{ ml}$$

$$1 \text{ m}^3 = 10^3 \text{ L} = 35.31 \text{ ft}^3$$

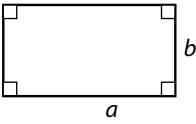
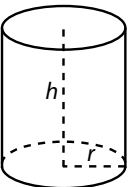
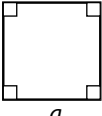
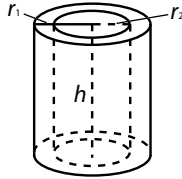
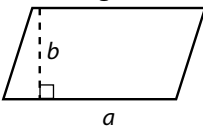
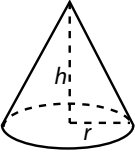
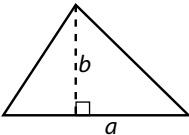
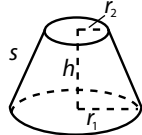
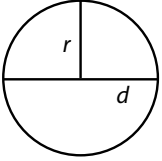
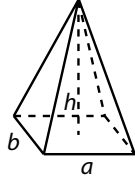
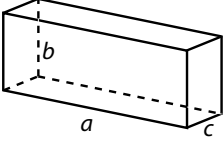
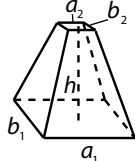
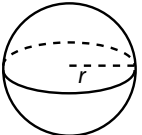
$$1 \text{ L} = 10^3 \text{ cm}^3 = 10^3 \text{ ml}$$

Work

$$1 \text{ hp}\cdot\text{h} = 0.746 \text{ kWh} = 2.6845 \text{ J} = 2544.5 \text{ Btu}$$

$$1 \text{ ft}\cdot\text{lb} = 1.356 \text{ J}$$

Table A.18 Useful Formulas from Geometry

<p>Rectangle</p>  <p>A: area $A = ab$ Perimeter = sum of all sides</p>	<p>Cylinder</p>  <p>$V = \pi r^2 h$</p>
<p>Square</p>  <p>$A = a^2$</p>	<p>Hollow cylinder</p>  <p>$V = \pi h (r_1^2 - r_2^2)$</p>
<p>Parallelogram</p>  <p>$A = ab$</p>	<p>Cone</p>  <p>$V = \frac{\pi r^2 h}{3}$</p>
<p>Triangle</p>  <p>$A = \frac{ab}{2}$</p>	<p>Truncated cone</p>  <p>$V = \frac{\pi h}{3} (r_1^2 + r_2^2 + r_1 r_2)$</p>
<p>Circle</p>  <p>$\pi = 3.14$ r: radius d: diameter C: circumference $A = \pi r^2$ $d = 2r$ $C = \pi d$</p>	<p>Pyramid</p>  <p>$V = \frac{abh}{3}$</p>
<p>Rectangular solid</p>  <p>V: volume S: surface area $V = abc$ $S = 2(ab + ac + bc)$</p>	<p>Truncated pyramid</p>  <p>$V = \frac{h(a_1 b_1 + a_2 b_2 + \sqrt{a_1 b_1 a_2 b_2})}{3}$</p>
<p>Sphere</p>  <p>$V = \frac{4\pi r^3}{3}$ $V = \frac{\pi d^3}{6}$</p>	