Calcium Chloride

A Guide to Physical Properties

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About This Guide

This guide presents information on the physical properties of calcium chloride products from Occidental Chemical Corporation (OxyChem). It is intended to complement other OxyChem literature on calcium chloride products. It is not intended to serve as a complete and comprehensive technical reference for the topics presented. It is the responsibility of the end user to determine the most appropriate way to apply this information to their specific situation.

OxyChem publishes and regularly updates Material Safety Data Sheets (MSDS) for each calcium chloride product it produces. These documents provide information on health and handling precautions, safety guidelines and product status relative to various government regulations.

Obtain Material Safety Data Sheets and other product and application information at www.oxycalciumchloride.com.

Physical Properties of Calcium Chloride

The data in the physical properties tables in this section are laboratory results typical of the products, and should not be confused with, or regarded as, specifications.

Literature data on the physical properties of calcium chloride, its hydrates and solutions generally refer to pure material. Pure calcium chloride, however, is only available in smaller quantities from chemical reagent supply houses.

Commercial grades of calcium chloride, such as those produced by OxyChem, contain other trace elements and impurities. The physical properties that have been determined only for pure calcium chloride may be applied to OxyChem commercial-grade calcium chloride products with an error of a few percent, which is typically accurate enough for most purposes.

Physical Properties of Calcium Chloride and Hydrates

Various physical properties of calcium chloride and its hydrates are listed in Table 1. Note that anhydrous calcium chloride and the lower hydrates release a large amount of heat when dissolved in water (negative values for Heat of Solution).

Solubility

Although calcium chloride is highly soluble in water at ordinary temperatures, crystallization will occur under certain temperature and concentration conditions.

These conditions are defined by the phase diagram of the calcium chloride-water system shown in Figure 1. This figure can be used to determine which phases are expected under different temperature and concentration conditions.

Concentrated solutions of calcium chloride have a marked tendency to supercool; i.e., the temperature of the solution may fall several degrees below the phase boundary without crystallization taking place. When crystals finally form in these supercooled solutions, the temperature of the mixture will rise to the limit defined by the phase diagram. Crystallization points of commercial calcium chloride brines will differ slightly from those of pure calcium chloride.

Figure 1: Phase Diagram for $CaCl_2$-Water System

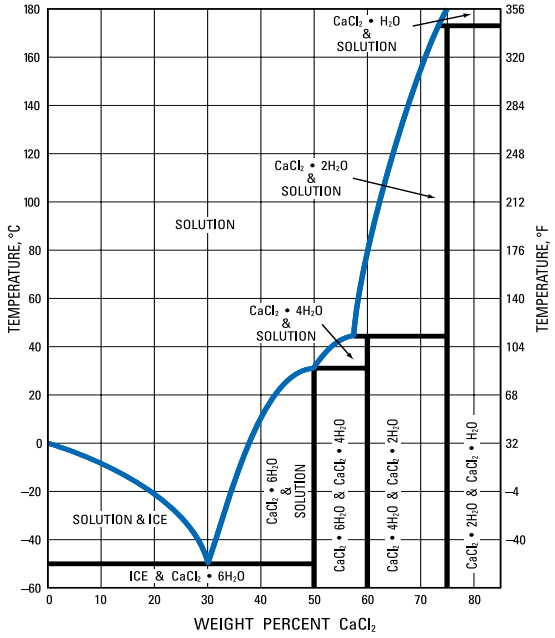


Table 1: Properties of $CaCl_2$ Hydrates

Property	$CaCl_2 \cdot 6H_2O$	$CaCl_2 \cdot 4H_2O$	$CaCl_2 \cdot 2H_2O$	$CaCl_2 \cdot H_2O$	$CaCl_2$
Composition (% $CaCl_2$)	50.66	60.63	75.49	86.03	100
Molecular Weight	219.09	183.05	147.02	129	110.99
Melting Point[1] (°C) (°F)	29.9 85.8	45.3 113.5	176 349	187 369	773 1424
Boiling Point[2] (°C) (°F)	– –	– –	174 345	183 361	1935 3515
Density at 25°C (77°F), g/cm^3	1.71	1.83	1.85	2.24	2.16
Heat of Fusion (cal/g) (BTU/lb)	50 90	39 70	21 38	32 58	61.5 110.6
Heat of Solution[3] in H_2O (cal/g) (to infinite dilution) (BTU/lb)	17.2 31.0	-14.2 -25.6	-72.8 -131.1	-96.8 -174.3	-176.2 -317.2
Heat of Formation[3] at 25°C (77°F), kcal/mole	-623.3	-480.3	-335.58	-265.49	-190.10
Heat of Capacity at 25°C (77°F), cal/g°C or BTU/lb°F	0.34	0.32	0.28	0.20	0.16

(1) Incongruent melting point for hydrates.
(2) Temperature when dissociation pressure reaches one atmosphere for hydrates.
(3) Negative sign means that heat is evolved (process is exothermic).

Table 2: Solution Density (lbs/gal) at Various Temperatures and Concentrations

% $CaCl_2$	0° F -17.8° C	10° F -12.2° C	20° F -6.7° C	30° F -1.1° C	40° F 4.4° C	50° F 10° C	60° F 15.6° C	70° F 21.1° C	80° F 26.7° C	90° F 32.2° C	100° F 37.8° C
2	–	–	–	–	8.56	8.54	8.51	8.48	8.45	8.42	8.40
4	–	–	–	8.74	8.71	8.69	8.66	8.63	8.60	8.57	8.55
6	–	–	–	8.89	8.86	8.84	8.81	8.78	8.75	8.72	8.70
8	–	–	–	9.04	9.01	8.99	8.96	8.93	8.90	8.87	8.85
10	–	–	–	9.19	9.16	9.14	9.11	9.08	9.05	9.02	9.00
11	–	–	9.30	9.27	9.24	9.22	9.19	9.16	9.13	9.10	9.08
12	–	–	9.38	9.35	9.32	9.30	9.27	9.24	9.21	9.18	9.16
13	–	–	9.47	9.44	9.41	9.39	9.36	9.33	9.30	9.27	9.25
14	–	–	9.54	9.51	9.48	9.46	9.43	9.40	9.37	9.34	9.32
15	–	–	9.63	9.60	9.57	9.55	9.52	9.49	9.46	9.43	9.41
16	–	9.74	9.71	9.68	9.65	9.63	9.60	9.57	9.54	9.51	9.49
17	–	9.82	9.79	9.76	9.73	9.71	9.68	9.65	9.62	9.59	9.57
18	–	9.90	9.87	9.84	9.81	9.79	9.76	9.73	9.70	9.67	9.65
19	10.01	9.99	9.96	9.93	9.90	9.88	9.85	9.82	9.79	9.76	9.74
20	10.09	10.07	10.04	10.01	9.98	9.96	9.93	9.90	9.87	9.84	9.82
21	10.17	10.15	10.12	10.09	10.06	10.04	10.01	9.98	9.95	9.92	9.90
22	10.26	10.24	10.21	10.18	10.15	10.13	10.10	10.07	10.04	10.01	9.99
23	10.34	10.32	10.29	10.26	10.23	10.21	10.18	10.15	10.12	10.09	10.07
24	10.41	10.39	10.36	10.33	10.30	10.28	10.25	10.22	10.19	10.16	10.14
25	10.51	10.49	10.46	10.43	10.40	10.38	10.35	10.32	10.29	10.26	10.24
26	10.61	10.59	10.56	10.53	10.50	10.48	10.45	10.42	10.39	10.36	10.34
27	10.71	10.69	10.66	10.63	10.60	10.58	10.55	10.52	10.49	10.46	10.44
28	10.81	10.79	10.76	10.73	10.70	10.68	10.65	10.62	10.59	10.56	10.54
29	10.90	10.88	10.85	10.82	10.79	10.77	10.74	10.71	10.68	10.65	10.63
30	11.00	10.98	10.95	10.92	10.89	10.87	10.84	10.81	10.78	10.75	10.73
31	11.10	11.08	11.05	11.02	10.99	10.97	10.94	10.91	10.88	10.85	10.83
32	11.20	11.18	11.15	11.12	11.09	11.07	11.04	11.01	10.98	10.95	10.93
33	11.30	11.28	11.25	11.22	11.19	11.17	11.14	11.11	11.08	11.05	11.03
34	–	–	11.34	11.31	11.28	11.26	11.23	11.20	11.17	11.14	11.12
35	–	–	–	11.41	11.38	11.36	11.33	11.30	11.27	11.24	11.22
36	–	–	–	–	11.48	11.46	11.43	11.40	11.37	11.34	11.32
37	–	–	–	–	11.58	11.56	11.53	11.50	11.47	11.44	11.42
38	–	–	–	–	–	11.65	11.62	11.59	11.56	11.53	11.51
39	–	–	–	–	–	–	11.72	11.69	11.66	11.63	11.61
40	–	–	–	–	–	–	–	11.79	11.76	11.73	11.71
41	–	–	–	–	–	–	–	11.89	11.86	11.83	11.81
42	–	–	–	–	–	–	–	11.98	11.95	11.92	11.90

Physical Properties of Calcium Chloride

Table 3a: Properties for Calcium Chloride Solutions in U.S. Units at 77°F

% $CaCl_2$	Specific Gravity	Density (lbs/gal)	Gallons per Solution Ton	Gallons per Dry Ton	Freeze Point (°F)	Boiling Point (°F)
0	1.000	8.32	240	n/a	32	212
1	1.009	8.40	238	23,822	31	212
2	1.018	8.47	236	11,805	30	212
3	1.027	8.55	234	7801	28	213
4	1.036	8.62	232	5800	27	213
5	1.045	8.70	230	4600	26	213
6	1.054	8.77	228	3801	25	213
7	1.063	8.85	226	3230	24	214
8	1.072	8.92	224	2803	22	214
9	1.081	8.99	222	2471	21	214
10	1.090	9.07	221	2205	20	215
11	1.100	9.15	219	1986	18	215
12	1.110	9.24	217	1804	16	215
13	1.120	9.32	215	1651	14	216
14	1.129	9.39	213	1521	12	216
15	1.139	9.48	211	1407	10	217
16	1.149	9.56	209	1307	8	217
17	1.159	9.64	207	1220	5	218
18	1.169	9.73	206	1142	2	219
19	1.179	9.81	204	1073	-1	219
20	1.189	9.89	202	1011	-4	220
21	1.199	9.98	200	955	-8	221
22	1.209	10.06	199	904	-12	222
23	1.219	10.14	197	857	-16	223
24	1.228	10.22	196	816	-20	224
25	1.240	10.32	194	775	-25	225
26	1.251	10.41	192	739	-31	226
27	1.263	10.51	190	705	-38	227
28	1.275	10.61	189	673	-46	228
29	1.287	10.71	187	644	-53	230
29.6	1.294	10.77	186	628	-60	230
30	1.298	10.80	185	617	-52	231
31	1.310	10.90	183	592	-34	232
32	1.322	11.00	182	568	-17	233
33	1.334	11.10	180	546	-4	234
34	1.345	11.19	179	526	10	235
35	1.357	11.29	177	506	20	238
36	1.369	11.39	176	488	30	239
37	1.381	11.49	174	470	39	240
38	1.392	11.58	173	454	48	240
39	1.404	11.68	171	439	55	241
40	1.416	11.78	170	424	61	247
41	1.428	11.88	168	411	65	249
42	1.439	11.97	167	398	69	251

Table 3b: Properties for Calcium Chloride Solutions in Metric Units at 25°C

% $CaCl_2$	Specific Gravity	Density (kg/liter)	Liters per 1000 kg Solution	Liters per 1000 kg Dry	Freeze Point (°C)	Boiling Point (°C)
0	1.000	0.997	1003	n/a	0	100
1	1.009	1.006	994	99,406	-1	100
2	1.018	1.015	985	49,264	-1	100
3	1.027	1.024	977	32,555	-2	100
4	1.036	1.033	968	24,204	-3	100
5	1.045	1.042	960	19,196	-4	101
6	1.054	1.051	952	15,860	-4	101
7	1.063	1.060	944	13,479	-5	101
8	1.072	1.069	936	11,696	-6	101
9	1.081	1.078	928	10,309	-6	101
10	1.090	1.087	920	9202	-7	102
11	1.100	1.097	912	8289	-8	102
12	1.110	1.107	904	7530	-9	102
13	1.120	1.117	896	6889	-10	102
14	1.129	1.126	888	6346	-11	102
15	1.139	1.136	881	5871	-12	103
16	1.149	1.146	873	5456	-13	103
17	1.159	1.156	865	5091	-15	103
18	1.169	1.165	858	4767	-17	104
19	1.179	1.175	851	4478	-18	104
20	1.189	1.185	844	4218	-20	105
21	1.199	1.195	837	3984	-22	105
22	1.209	1.205	830	3771	-24	106
23	1.219	1.215	823	3577	-27	106
24	1.228	1.224	817	3403	-29	107
25	1.240	1.236	809	3236	-32	107
26	1.251	1.247	802	3084	-35	108
27	1.263	1.259	794	2941	-39	108
28	1.275	1.271	787	2810	-43	109
29	1.287	1.283	779	2687	-47	110
29.6	1.294	1.290	775	2619	-51	110
30	1.298	1.294	773	2576	-47	111
31	1.310	1.306	766	2470	-37	111
32	1.322	1.318	759	2371	-27	112
33	1.334	1.330	752	2278	-20	112
34	1.345	1.341	746	2193	-12	113
35	1.357	1.353	739	2112	-7	115
36	1.369	1.365	733	2035	-1	115
37	1.381	1.377	726	1963	4	115
38	1.392	1.388	721	1896	9	116
39	1.404	1.400	714	1832	13	116
40	1.416	1.412	708	1771	16	120
41	1.428	1.424	702	1713	18	121
42	1.439	1.435	697	1660	21	122

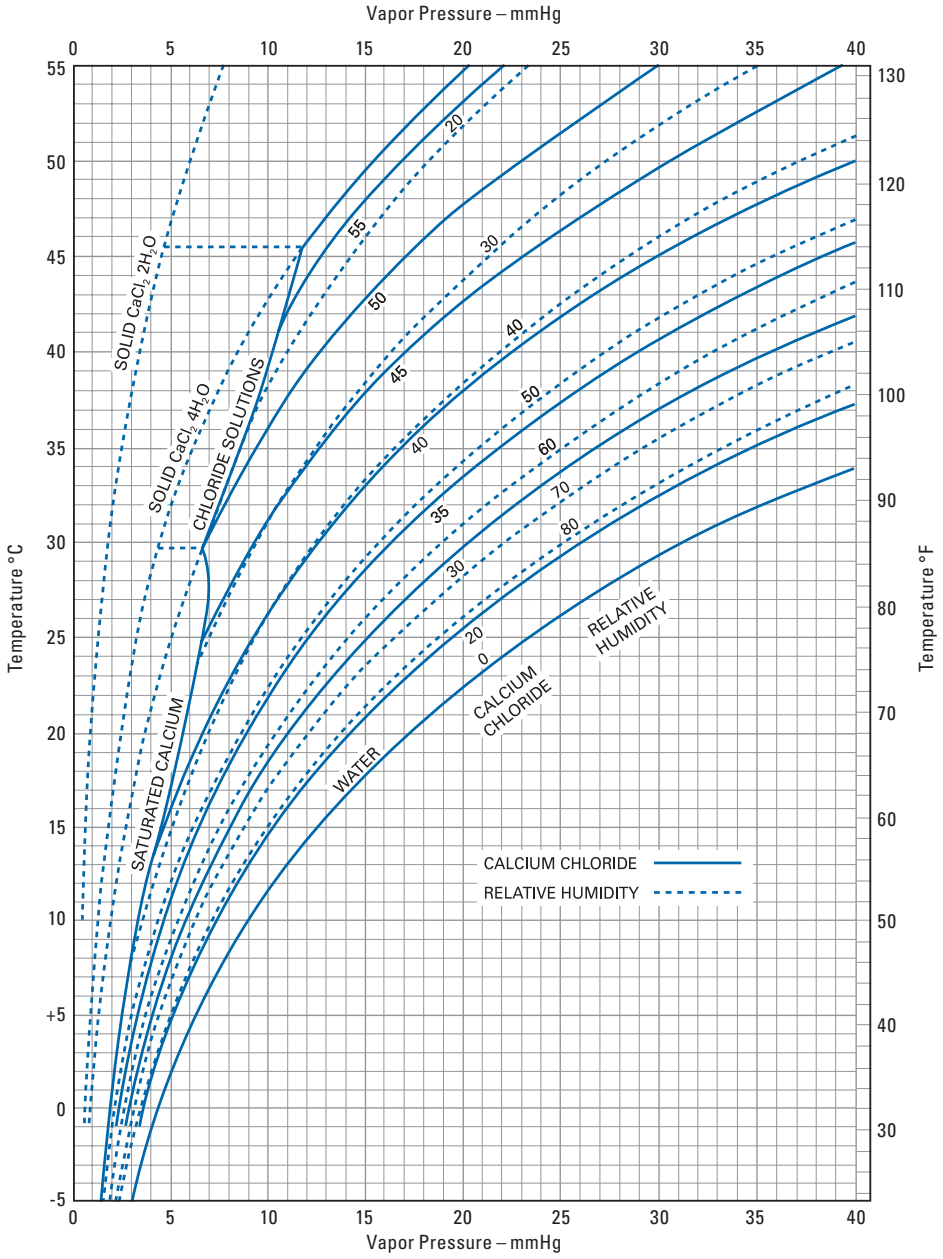
Physical Properties of Calcium Chloride

Moisture Absorption

Calcium chloride is both hygroscopic and deliquescent. Thus, under common ambient conditions, solid material will absorb moisture from the air until it dissolves. Calcium chloride solutions will absorb moisture until an equilibrium is reached between the water vapor pressure of the solution and that of the air. If the humidity of the air increases, more moisture is absorbed by the solution. If it decreases, water evaporates from the solution into the air. Figure 2 shows the equilibrium water vapor pressure of various forms of calcium chloride at various temperatures.

The saturated solution curve shows the temperature and humidity conditions under which calcium chloride transitions between solid and liquid phases. At 30°C (85°F), a typical summer temperature, the water vapor pressure needed to liquefy calcium chloride is 7 mmHg, corresponding to 22 percent relative humidity. Since summer humidities are usually higher than 22 percent, calcium chloride liquid, flakes or pellets will pick up water from the air and either dilute or dissolve. This property makes calcium chloride useful in dehumidification and dust control applications.

Figure 2: Vapor Pressure of $CaCl_2$



The rate at which moisture is absorbed by a given quantity of calcium chloride depends on application-specific variables that control the degree of contact between the air and the calcium chloride, such as surface area and air movement.

While it is difficult to estimate the rate at which moisture is absorbed, it is not difficult to determine the maximum amount of water that can be absorbed per pound of calcium chloride at any given humidity and temperature. This may be done with the following formula:

Water absorbed=(Start%/End%)-1

Where:

Water absorbed equals water absorbed per pound of calcium chloride product.

Start percent equals starting concentration of calcium chloride product in decimal form.

End percent equals ending concentration of calcium chloride in decimal form. This is obtained from Figure 2 at the specified humidity and temperature conditions.

Example:

How much water can be absorbed from air by 94 percent calcium chloride at 77°F and 70 percent relative humidity?

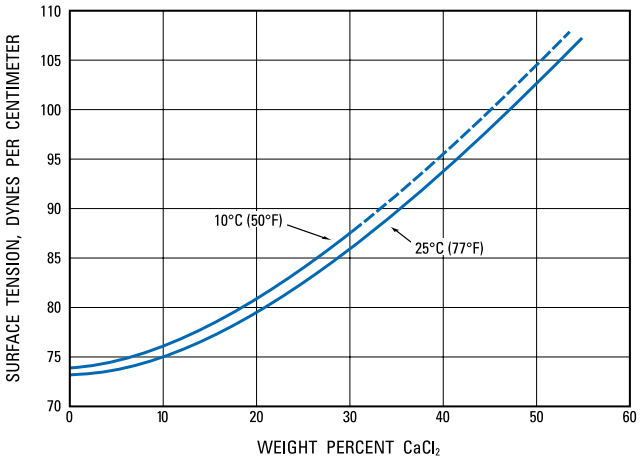
Start percent = 0.94
From Figure 2, end percent = approximately 0.27

Water absorbed is equal to (0.94/0.27)-1=2.5 lbs

Surface Tension

Surface tension is the force on the surface of a liquid that tends to diminish the surface area to a minimum. It is a result of differences in intermolecular attraction at the surface and in the interior of the liquid. At the surface, all the molecules are attracted inward; in the interior, the attraction is the same in all directions. Surface tension has an important effect on the wetting and penetration abilities of a liquid, and on its ability to form emulsions. The lower the surface tension, the greater the liquid's wetting and penetration ability, and its ability to form an emulsion. Figure 3 shows the surface tension of pure calcium chloride solutions at 10°C (50°F) and 25°C (77°F).

Figure 3: Surface Tension of Pure $CaCl_2$ Solutions

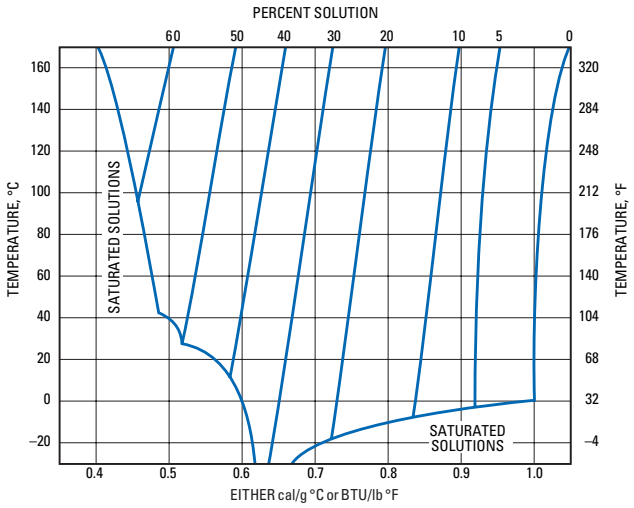


Physical Properties of Calcium Chloride

Specific Heat

Specific heat is the amount of heat required to raise a unit weight of a substance one degree in temperature at either constant pressure or constant volume. It can be expressed either as calories per gram per degree Celsius, or as British thermal units per pound per degree Fahrenheit, and the expressions are numerically equal. The specific heat of water is approximately one at ordinary temperatures. The specific heat of aqueous calcium chloride solutions of various concentrations is shown in Figure 4.

Figure 4: Specific Heat of Aqueous $CaCl_2$ Solutions



Viscosity

Viscosity is a measure of the internal friction of a liquid. As viscosity increases, the tendency to flow decreases. The viscosity of a solution of calcium chloride varies inversely with temperature at constant concentration, and increases with increasing concentration at constant temperature. Table 4 and Figure 5 show the viscosities of calcium chloride solutions at various temperatures. If desired, viscosity values can readily be converted from centipoises to centistokes by dividing the centipoises by the density of the solution in grams per milliliter at the indicated temperature.

Figure 5: Viscosity of Pure $CaCl_2$ Solutions

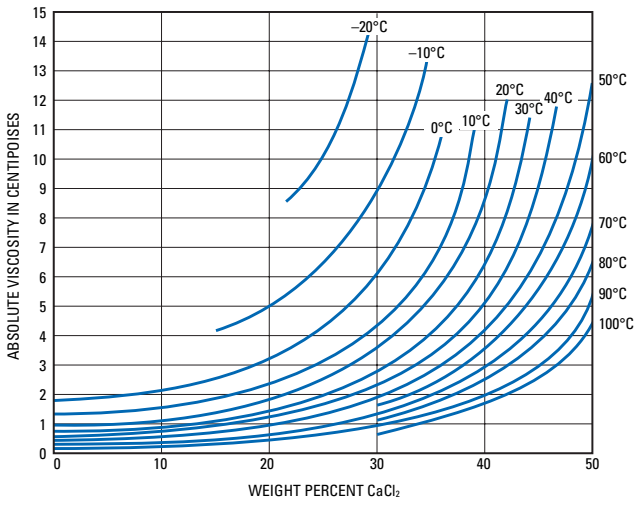


Table 4: Absolute Viscosity in Centipoises of $CaCl_2$ Solutions

Weight % $CaCl_2$	Temperature, °C												
	-20	-10	0	10	20	30	40	50	60	70	80	90	100
0	–	–	1.77	1.29	1.02	0.79	0.67	0.53	0.46	0.40	0.34	0.30	0.26
5	–	–	1.84	1.35	1.07	0.82	0.73	0.57	0.51	0.45	0.39	0.35	0.28
10	–	–	2.13	1.52	1.16	0.93	0.86	0.64	0.57	0.51	0.47	0.42	0.35
15	–	4.09	2.50	1.84	1.40	1.20	1.03	0.76	0.68	0.62	0.55	0.49	0.42
20	–	4.97	3.12	2.33	1.81	1.54	1.22	0.99	0.85	0.74	0.68	0.59	0.49
25	9.94	6.32	4.04	3.07	2.38	1.97	1.54	1.27	1.07	0.90	0.82	0.70	0.59
30	14.27	9.04	5.77	4.30	3.33	2.62	2.07	1.73	1.43	1.24	1.01	0.89	0.73
35	–	–	8.83	6.62	4.99	3.87	3.07	2.54	2.17	1.82	1.46	1.22	1.03
40	–	–	–	11.75	8.48	6.39	4.90	4.00	3.26	2.72	2.15	1.74	1.52
45	–	–	–	–	–	11.50	8.90	6.57	5.24	4.25	3.39	2.77	2.33
50	–	–	–	–	–	–	–	11.80	9.24	7.45	5.97	4.95	4.28

Summary

This guide provides a more extensive list of typical physical properties than the Material Safety Data Sheet for each OxyChem calcium chloride product. In addition, key properties are defined and addressed for more in-depth physical property information relevant to the most common applications for calcium chloride. While not to be construed as specifications, the data in this guide are offered in good faith to improve the understanding of these physical properties relative to the performance and safe and effective use of calcium chloride.

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