LIME

The Versatile Chemical

Fact Sheet

PROPERTIES OF TYPICAL COMMERCIAL LIME PRODUCTS

Quicklimes

	High Calcium	Dolomitic
Primary Constituents	CaO	CaO•MgO
Specific Gravity	3.2-3.4	3.2-3.4
Bulk Density (Pebble Lime), lb./cu. ft.	55-60*	55-60*
Specific Heat at 100° F., Btu/lb	0.19	0.21
Angle of Repose	55° **	55° **

Hydrates

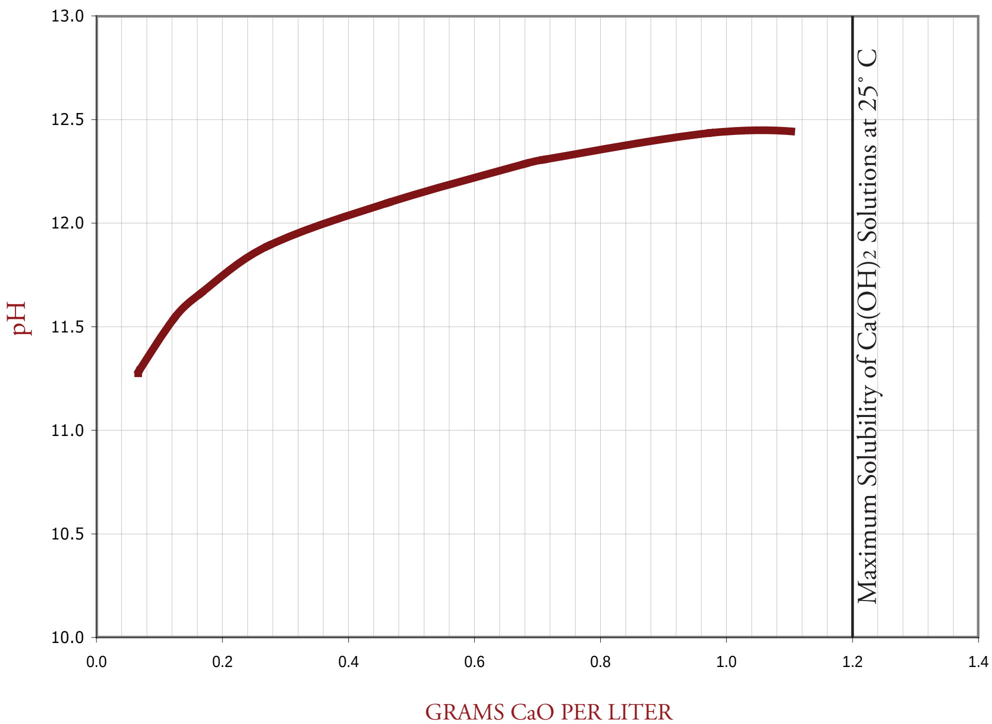
	High Calcium	Normal Dolomitic	Pressure Dolomitic
Primary Constituents	$Ca(OH)_2$	$Ca(OH)_2$•MgO	$Ca(OH)_2$ •$Mg(OH)_2$
Specific Gravity	2.3-2.4	2.7-2.9	2.4-2.6
Bulk Density, lb./cu. ft.	25-35 *	25-35 *	30-40 *
Specific Heat at 100° F., Btu/lb.	0.29	0.29	0.29
Angle of Repose	70° **	70° **	70° **

*/ In some instances these values may be extended. The test method described in ASTM C110 can be used for determining bulk density values. In calculating storage volume requirements, the lower figure should be used, whereas the higher value should be used for gross weight in designing safety factors.

**/ The angle of repose for both types of lime (hydrate in particular) varies considerably with mesh, moisture content, degree of aeration, and physical characteristics of the lime. (E.g., for quicklime it generally varies from 50 to 55 degrees and for hydrated lime it may range as much as 15 to 80 degrees.)

pH OF CALCIUM HYDROXIDE SOLUTIONS AT 25 DEGREES C.

Graph Showing pH Curve of Calcium Hydroxide Solutions at 25° C



CaO gms. per l.	pH
0.064	11.27
0.065	11.28
0.122	11.54
0.164	11.66
0.271	11.89
0.462	12.10
0.680	12.29
0.710	12.31
0.975	12.44
1.160	12.45

Because the solubility of lime decreases as the temperature increases (see page 3), the pH of lime solutions is correspondingly lower at higher temperatures (see page 4).

SOLUBILITY OF CALCIUM HYDROXIDE IN WATER

Grams per 100 gms. sat. sol.

t °C	CaO	$Ca(OH)_2$
0	0.140	0.185
10	0.133	0.176
20	0.125	0.165
25	0.120	0.159
30	0.116	0.153
40	0.106	0.140
50	0.097	0.128
60	0.088	0.116
70	0.079	0.104
80	0.070	0.092
90	0.061	0.081
100	0.054	0.071

The solubility of commercial limes in water does not vary more than 7% from the solubility of pure calcium hydroxide. The differences are probably due to the presence of traces of sodium and potassium hydroxide in commercial limes. The presence of magnesia, silica, and carbonate have no effect upon the solubility of ordinary lime, but may have a marked effect upon its rate of solution. Particle size may also inf uence solubility.

TEMPERATURE vs. pH OF
A SATURATED CALCIUM HYDROXIDE SOLUTION

Temperature °C	pH
0	13.423
5	13.207
10	13.003
15	12.810
20	12.627
25	12.454
30	12.289
35	12.133
40	11.984
45	11.841
50	11.705
55	11.574
60	11.449

Conversion Formula:

pH correction = [0.03 pH units/1.0 deg. C] x [Measured Temp deg. C - 25]

This equation indicates that for each degree difference between the measured temperature in degrees C and 25 degrees C, there is a change in pH of 0.03 units. Thus, for example, if a pH of 12 is measured at 20 degrees C, the pH at 25 degrees C is 11.85 [12 + (0.03 x -5)]. There is an inverse relationship between temperature and pH.

Note that the temperature correction controls on pH meters do NOT compensate for the changes in solubility created by changes in temperature. The pH meter controls address probe temperature and conductivity changes only.

STRENGTH OF LIME SUSPENSIONS

Milk-of-lime Suspensions		Lime Content*				% Solids $Ca(OH)_2$ in Water
Specific Gravity at 15 C.	Degrees Baumé (Bur. Stds. Scale)	Grams CaO per liter	Grams Ca(OH)2 per liter	Lbs. CaO per U.S. gal.	Lbs. CaO per cu. ft.	
1.010	1.44	11.7	15.5	.097	.07	1.6
1.020	2.84	24.4	32.2	.203	1.5	3.2
1.030	4.22	37.1	49.0	.309	2.3	4.8
1.040	5.58	49.8	65.8	.415	3.1	6.3
1.050	6.91	62.5	82.6	.520	3.9	7.9
1.060	8.21	75.2	99.4	.626	4.7	9.4
1.070	9.49	87.9	116	.732	5.5	10.8
1.080	10.74	100	132	.833	6.3	12.3
1.090	11.97	113	149	.941	7.1	13.7
1.100	13.18	126	166	1.05	7.9	15.2
1.110	14.37	138	182	1.15	8.7	16.4
1.120	15.54	152	201	1.27	9.5	18.0
1.130	16.68	164	217	1.37	10.3	19.3
1.140	17.81	177	234	1.47	11.1	20.5
1.150	18.91	190	251	1.58	11.9	21.8
1.160	20.00	203	268	1.69	12.7	23.1
1.170	21.07	216	285	1.80	13.5	24.4
1.180	22.12	229	303	1.91	14.3	25.6
1.190	23.15	242	320	2.02	15.1	27.0
1.200	24.17	255	337	2.12	15.9	28.0
1.210	25.16	268	354	2.23	16.7	29.2
1.220	26.15	281	371	2.34	17.6	30.4
1.230	27.11	294	388	2.45	18.4	31.6
1.240	28.06	307	406	2.56	19.2	32.8
1.250	29.00	321	424	2.67	20.0	33.8

*/ Data are based on a typical high calcium lime. In obtaining these data, the milk of lime was placed in a wide cylinder, slowly rotating to permit agitation. The hydrometer was inserted and allowed to sink slowly; the reading taken when it stopped. In the case of a thin slurry, the reading must be taken quickly before the lime settles, while in the case of a thick cream of lime, duplicate readings should be taken to assure the correct hydrometer value.

The table is for milk-of-lime suspensions. Above 30% solids some limes no longer show properties of a suspension and are quite stiff (paste). At 35% additives are often added to make the suspension pumpable. At 40% these limes are generally too stiff to pump.

Settling rates of commercial lime slurries vary widely and depend primarily upon the particle size of the lime. Finely pulverized pure limes settle slowly; on the other hand, coarse limes settle rapidly.

FORMULA FOR CALCULATING WEIGHTS OF SLURRY

For calculating the weights of slurry with varying percentages of water, the following formula may be used:

$$W = \frac{6237s}{100 - a + sa}$$

in which:

W = weight in pounds of slurry per cubic foot.
s = specif c gravity of dry lime solids.
a = per cent water in slurry.

The result may be divided by 62.37 to obtain the result in grams per cubic centimeter.

SOLUBILITY OF MAGNESIUM HYDROXIDE

Magnesium hydroxide is virtually insoluble in water. At 18 and 100 degrees C. the solubilities are, respectively, 0.0098 and 0.0042 gms. $Mg(OH)_2$ per liter of saturated solution. The presence of small quantities of NaCl and Na_2SO_4 in the aqueous solution will increase the solubility of $Mg(OH)_2$ slightly.

HEATS OF REACTION AT 25 DEGREES C.

Hydration or Slaking

$CaO + H_2O$	$= Ca(OH)_2$	heat evolved	= 15,300 cal/gram mol.
			273 cal/gram
			= 27,500 BTU/lb.mol.
			490 BTU/lb.
$MgO + H_2O$	$= Mg(OH)_2$	heat evolved	= 8,800 to 10,000 cal/gram mol.
			218 to 248 cal/gram
			= 14,400 to 18,000 BTU/lb. mol.
			357 to 446 BTU/lb.

COMPARISON OF COMMON ALKALIS IN TYPICAL CHEMICAL REACTIONS

Alkali Reactions with	100% Pure Reactant lbs.	Stoichimetric Quantities of 100% Pure Alkalis[1] Required for Reactions		
		CaO equiv. lbs.	NaOH lbs.	Na_2CO_3 lbs.
Sulfuric Acid	100	57.2	81.6	108.1
Hydrochloric Acid	100	76.9	109.7	145.3
Nitric Acid	100	44.5	63.5	84.1
Hydrofluoric Acid	100	140.1	200.0	264.3
Phosphoric Acid[2]	100	85.8	122.5	162.2
Sodium Cyanide and Chlorine[3]	100	228.8	326.5	
Chlorine[4]	100	79.1	112.8	

1/ Quantities specif ed do not include excess alkali for pH adjustment, etc., that may be required to complete reaction.

2/ Extent of reaction considered is the formation of the tribasic compounds, $Ca_3(PO_4)_2$ and Na_3PO_4.

3/ Cyanide destruction to the N_2 product, as:
$4Ca(OH)_2 + 2NaCN + 5Cl_2 \Rightarrow 4CaCl_2 + 2NaCl + N_2 + 2CO_2 + 4H_2O$.

4/ Extent of chlorination considered is the formation in water of the hypochlorites, $Ca(OCl)_2$ and NaOCl. $CaCl_2$ and NaCl are also produced in this reaction.

AKALI CONVERSION TABLE

The following table identif es equivalent weight ratios.

CaO	$Ca(OH)_2$	CaO . MgO	NaOH	Na_2CO_3
1	1.32	0.86	1.43	1.89
2	2.64	1.72	2.85	3.78
3	3.96	2.58	4.28	5.67
4	5.29	3.44	5.71	7.56
5	6.61	4.30	7.13	9.45
6	7.93	5.16	8.56	11.34
7	9.25	6.02	9.99	13.23
8	10.57	6.88	11.41	15.12
9	11.89	7.74	12.84	17.01
10	13.21	8.59	14.27	18.90
15	19.82	12.89	21.40	28.35
20	26.43	17.19	28.53	37.80
25	33.03	21.49	35.67	47.26
30	39.64	25.78	42.80	56.71
35	46.24	30.08	49.93	66.16
40	52.85	34.38	57.07	75.61
45	59.46	38.68	64.20	85.06
50	66.06	42.97	71.34	94.51
55	72.67	47.27	78.47	103.96
60	79.28	51.57	85.60	113.41
65	85.88	55.87	92.74	122.86
70	92.49	60.16	99.87	132.32
75	99.09	64.46	107.00	141.77
80	105.70	68.76	114.14	151.22
85	112.31	73.06	121.27	160.67
90	118.91	77.35	128.40	170.12
95	125.52	81.65	135.54	179.57
100	132.13	85.95	142.67	189.02

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