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FMC Soda Ash

Storage Options

And

Technical Data

November 2000

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Introduction

In Green River, Wyoming, FMC Corporation mines and processes the mineral trona (sodium sesquicarbonate) into many different products (see page 10 for a complete product listing). The principal product of the Green River operation is anhydrous sodium carbonate (soda ash). Though this bulletin focuses on soda ash, similar information on the other products produced at Green River is available.

The FMC Green River Plant, has been manufacturing sodium based products for over 50 years. The intention of this bulletin is to share with our present and future customers the knowledge we have gained over the years on the storing and handling of soda ash in bulk quantities. This will provide insight into the options available, while helping to sort out some economic factors, for evaluating the best storage option in new or existing systems. We have included phase diagrams, thermal data, physical data and other technical information about soda ash that one would need to design a system.

In addition to the data and information contained in the bulletin, FMC offers its customers, technical support in design, start-up, and trouble shooting soda ash handling systems. A Customer Support group is based out of Green River, and your sales representative can put you in touch with the appropriate person.

Economic Considerations

One rule of thumb that tends to hold true when purchasing commodity chemicals is “the smaller the container the higher the price per unit”. This rule holds true for soda ash, with few exceptions. This not the only factor one must take into account, usage rate and inventory turnover are also important factors when evaluating the storage options of large quantities of soda ash.

The “shelf life” of soda ash is dictated by the environment it in which it is stored. Customers that require soda ash to be a free flowing granule must consider the size and design of the bin or storage silo to be used. Sealed in a glass jar on a shelf, soda ash will remain free flowing indefinitely. When exposed to the atmosphere it can change. Soda ash is slightly hygroscopic thus capable of absorbing moisture from the air. Due to this characteristic the customer location must be taken into account when designing a bulk storage system. In humid areas it is best to turn over bulk inventory weekly, while arid locations could have three to four week inventory rotation targets.

Customers that dissolve soda ash for use in their process have an additional option for storage, as a slurry. This method takes away the shelf life concern, while raising other considerations that will be discussed later.

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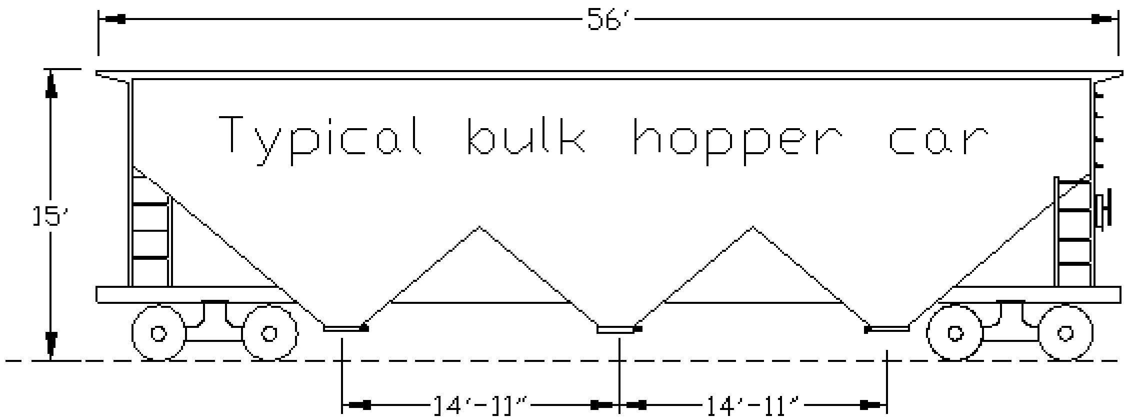
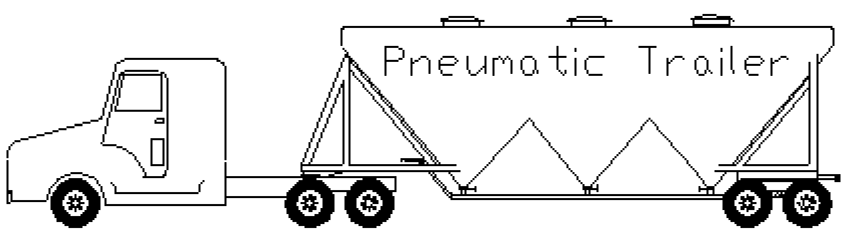
Soda Ash Delivery

Customers ordering soda ash in bulk quantities will typically receive it either in a railroad hopper car or hopper truck. The most common type of bulk soda ash transport is a bottom dump gravity discharge railroad car that holds a nominal 100 tons (200,000 lbs.) of dry soda ash. Illustrated below is a typical rail car (see page 15 for a list of different gate sizes used on the 2000+ rail cars FMC employs).



The second most widely used soda ash transport is the hopper truck. The most popular type is the pneumatic discharge, which holds a nominal 25 tons of soda ash. An illustration of a typical pneumatic trailer is also shown below.



When sizing and locating a bulk storage system, how the soda ash will be delivered to the site must be a key consideration.

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Unloading Systems

There are many ways to move soda ash from trucks or rail cars. The end use of the material plays a big role in the selection of the conveying equipment. If the end use is as a dry solid where minimum particle damage can be tolerated, then belts, screws and elevators are used. This mechanical conveying method can be sized to move large volumes of soda ash. When particle sizing is less of an issue, pneumatic transport is used. The drawings on pages 5 & 6 illustrate both methods of unloading a gravity rail car.

With pneumatic truck delivery, the truck driver requires little or no operator assistance to off load. Since the truck is equipped with a compressor the off loading is independent of the process. It typically takes 1-2 hours to "blow off" 25 tons of material. One example of a truck delivery system is shown on page 4.

Storage Vessels

Mild steel is an adequate material of construction for vessels to store soda ash either dry or in solution/slurry. There are some issues to be aware of when designing a soda ash storage vessel. For dry storage the ideal bin would have a first in first out flow pattern (plug flow). This will minimize any build up on the bin walls from the soda ash absorbing the moisture when the walls "sweat". The slope on the discharge cone walls is a key variable in promoting plug flow. Additionally the roof should also be designed to shed water so it does not find a way into the bin. Since soda ash is very soluble in water any build up that does occur can be washed out.

Soda ash can be stored as a solution or slurry. The tank size and design will vary slightly depending on usage rate and end use of the soda ash. A detailed explanation of slurry storage can be found on pages 7, 8 & 9.

FMC offers assistance to customers in selecting and designing storage systems. We will review applications, drawings and equipment selections before money has been spent with the intent of avoiding problems and unnecessary costs.

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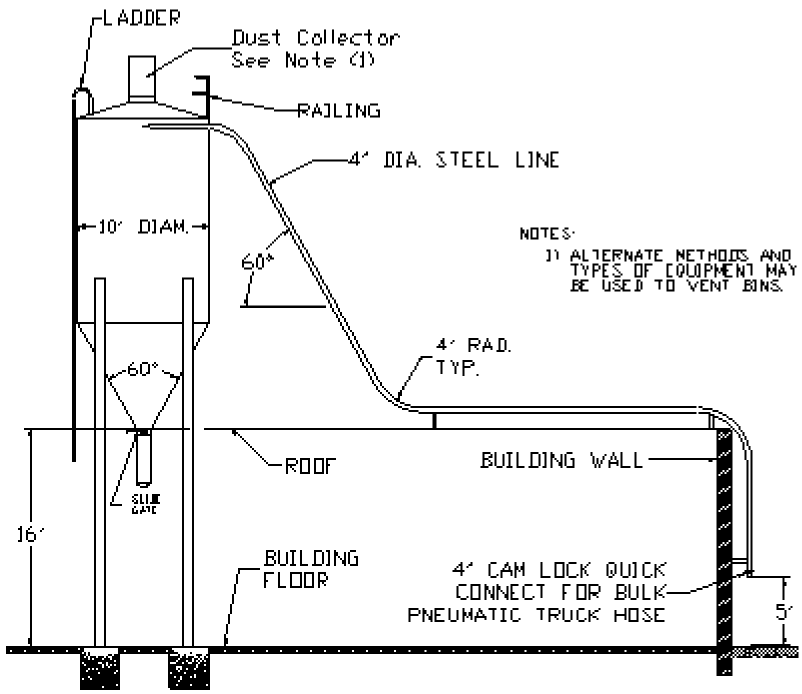
Soda Ash Delivered
by Pneumotic Truck



The above drawing is of a system designed to receive soda ash delivery via pneumatic trucks. The truck driver does not need to have operator assistance and does not even have to enter the process area to complete the off loading. Since the truck/trailer used is self contained, lighting of the unloading area is the only plant support the driver will need to complete his task.

Note that all direction changes in the 4" unloading line are made using long sweep elbows. This reduces the wear on the pipes and lessens the degradation of the soda ash particles. The length of the unloading line should be kept as short as practical. Lines in excess of about 100 feet reduce the unloading rate.

Not shown on the bin in the above drawing is a pressure relief outlet. Although this design is common in bulk storage, having pressure relief protection is always a good idea on bins or tanks receiving material via pneumatic transport.

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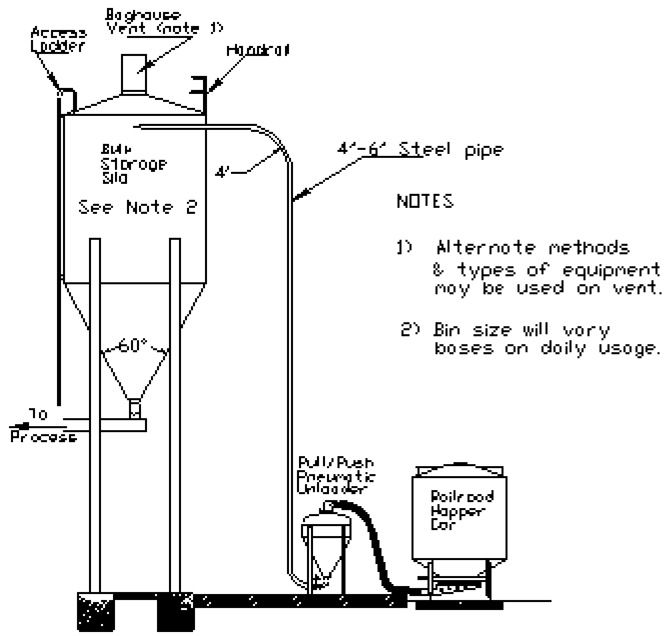
Pneumatic Unloading
of Soda Ash using
Pneumatic Conveying



The drawing above shows a dry bulk soda ash storage system where gravity flow railroad hopper cars are being unloaded with a pneumatic system. A pan is secured to the discharge gate on the hopper car and the gate opened. The transporter then pulls a vacuum and soda ash is sucked into the tank. Once the tank is full the valves switch and the tank is pressurized and the soda ash is blown into the top of the storage silo. This process continues until that section of the car is empty. The car or the unloading hose then must be repositioned to unload the next section.

This type of unloading system has a wide range of capacity. Some can convey as much as 25 tons per hour. Another advantage of this system is it can be designed to move material much further distances than a pneumatic truck.

The system shown in the above drawing is only one option available for bulk truck delivery. It is the one FMC has the most experience using for this application. Many different configurations are available. The bin shown does not have a pressure relief. Installing this protection is recommended for any vessel receiving material via pneumatic transport.

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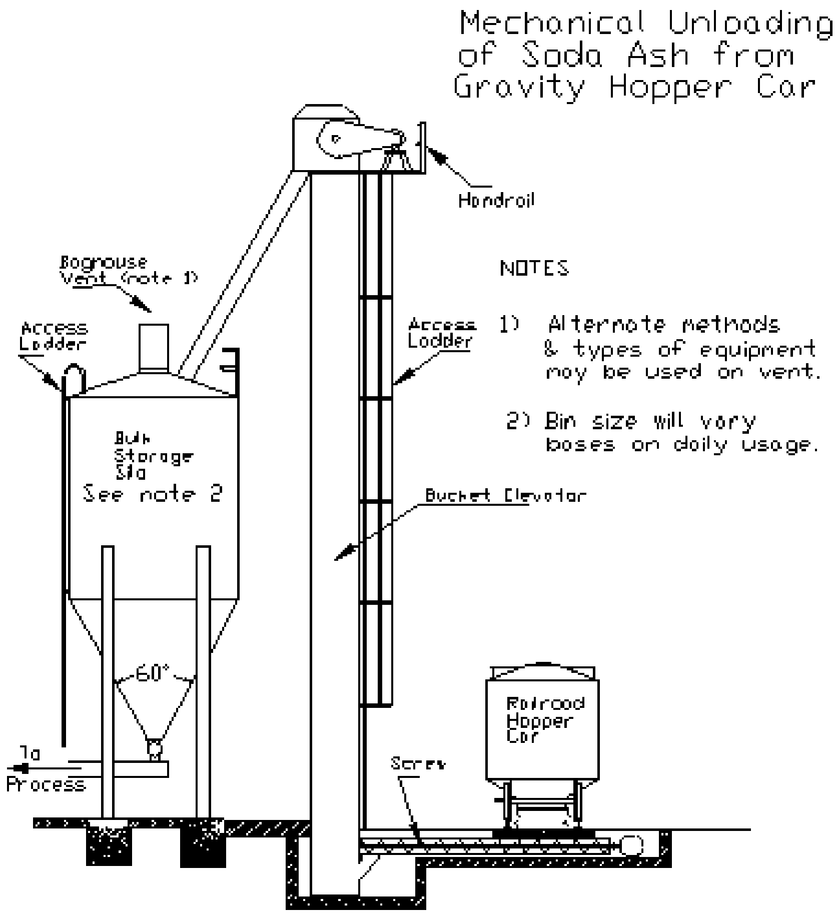

When daily usage rate exceeds 100 tons per day or if crystal damage must be kept to an absolute minimum, mechanical unloading should be considered (see above). This type of solids handling involves more equipment and operator attention than the other systems but the maximum unloading rate is almost unlimited. FMC has an extensive amount of experience with the type of system shown but there are many others available. Since each application is unique, the equipment type and configuration selected may be different for each location.

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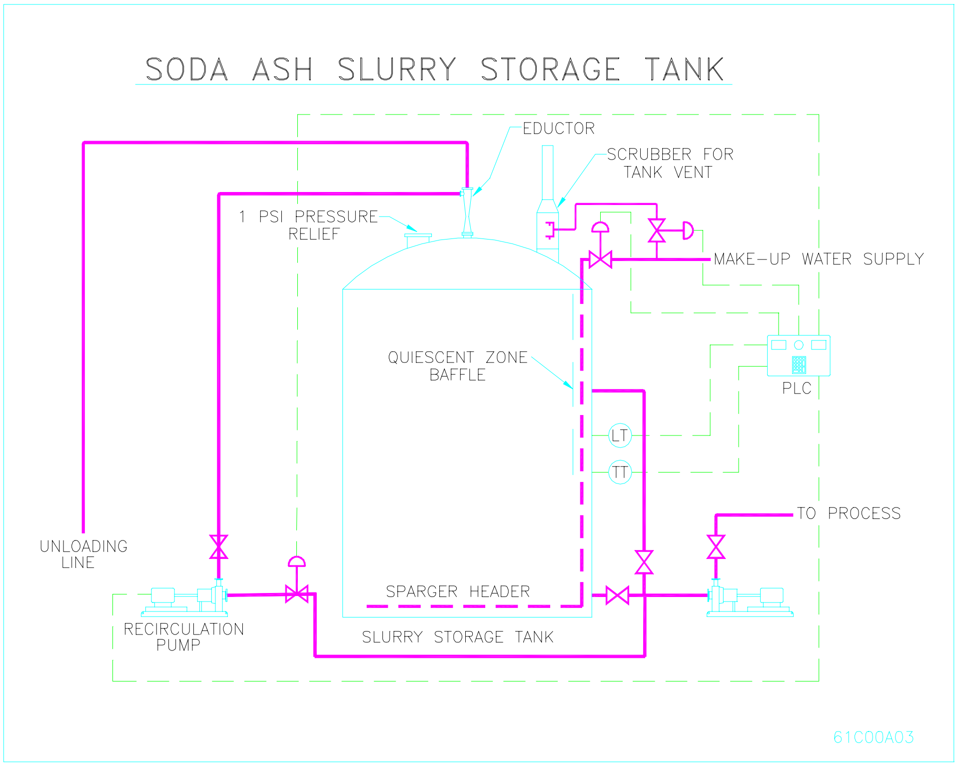

The above drawing depicts a typical soda ash slurry storage system. The make-up water is introduced to the tank at the bottom through a sparger network that distributes the fluid evenly across the tank. As the dilute liquid migrates up through the crystal bed, it begins to saturate as it dissolves soda ash crystals. Depending on the demand the using area has for solution volume and quality, the injected water should become saturated (31%) by the time it reaches the top of the crystal bed. If the liquid fails to reach saturation a recycle loop can be used to achieve this end.

The saturated soda ash solution is drawn off behind a baffle that prevents crystals from reaching the suction pipe during the unloading process. The solution used to create the suction on the unloading eductor is also drawn off behind the quiescent zone baffle.

Vessels that receive soda ash via pneumatic transport must have a vent to expel the air used in conveying. Because the exiting air will carry some fine soda ash particulate the gas stream must be treated to prevent environmental concerns. For liquid storage tanks, FMC has designed and builds a vent scrubber as shown on the drawing above. The water supply to the scrubber must be clean hot water.

The temperature of the contents in a solution or slurry storage system must be maintained above 100 °F to prevent formation of hepta and deca hydrates. Detail about this are

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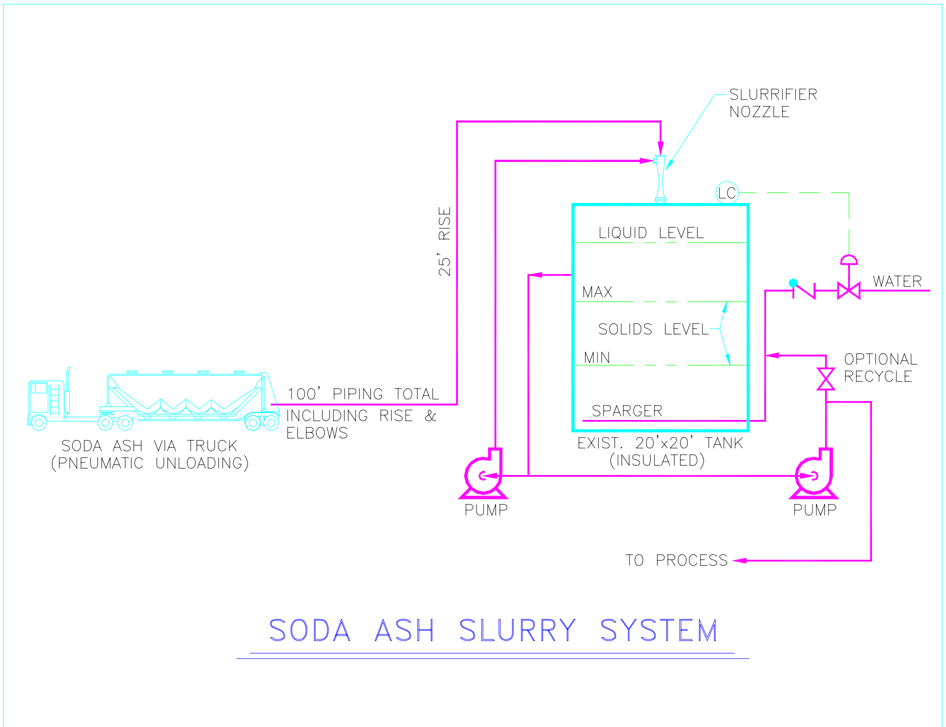
found on page 17. Another consideration is that softened makeup water should be used. When hard water is used the soda ash will react with calcium and magnesium in water to form insoluble carbonates that precipitate in the tank. These solids take up tank volume so the tank must be cleaned periodically.



This sketch is of a soda ash slurry storage system where the soda ash is delivered via pneumatic truck. The truck unloading line should be kept as short as possible. When the line length exceeds 100 feet as shown, the unloading time begins to increase and can run up the costs for truck time.

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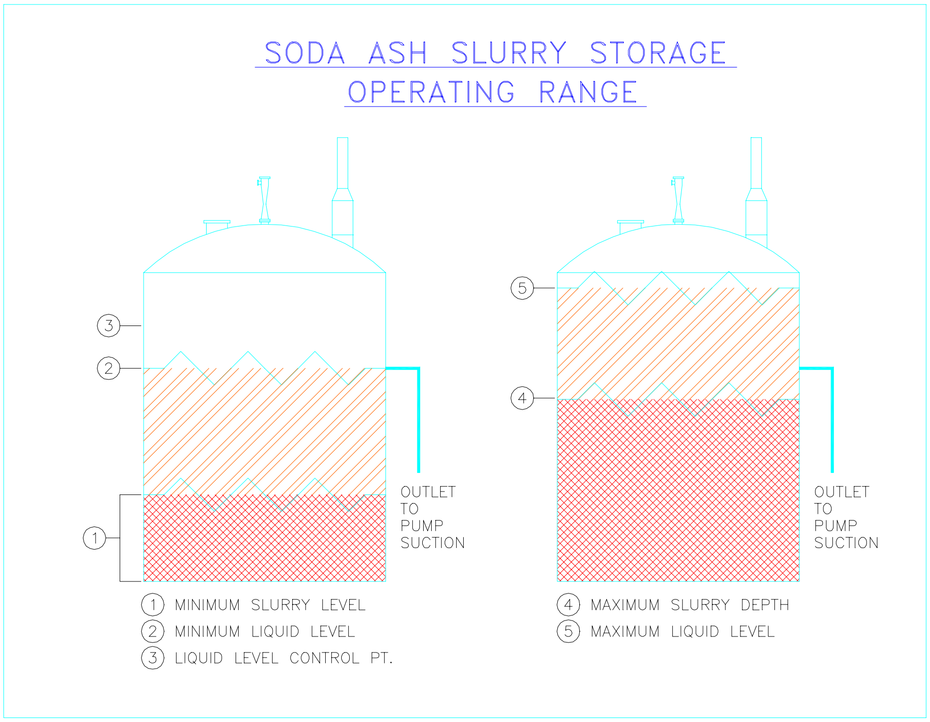

Soda ash slurry storage systems operate within a range for both slurry volume and liquid inventory. The above sketch shows the range of both the slurry and liquid levels. Management of both these parameters is key to successful operation of a slurry storage system. A Programmable Logic Controller (PLC) can supervise system operation so the liquid level and crystal bed depth are maintained within acceptable limits.

The system is design so that at normal operating liquid level there is still sufficient capacity to accommodate the volume increase associated with the addition of a shipment of dry soda ash. This will vary depending on the type of soda ash being added, but in general will result in an increase of approximately 200 gallons in the slurry bed per ton of soda ash added. Because the soda ash being added will absorb water from the solution the actual level in the tank will only increase about 100 gallons per ton of soda ash added.

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FMC Corporation
Green River, Wyoming
Sodium Based Products

Product Grade	General Description and Properties
Absorpta +	Light density (44 pcf) and highly absorptive soda ash with a high crystal pore volume
100	Light density soda ash (48 pcf) with a high pore volume in the crystal structure.
120	Medium density soda ash with low impurity level.
160	Dense soda ash with very low TOC content.
260	Dense soda ash.
010	Dense soda ash
111	Dense soda ash with very low impurity level.
800	Sodium sesquicarbonate.
820	Dense sodium sesquicarbonate.
Bicarb	USP sodium bicarbonate grades 1 thru 5, Hemodialysis, feed and industrial.
NaOH	50% caustic.
NaCN	30% sodium cyanide.
Phosphates	Multiple grades of sodium phosphates in both powder and granule form.

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General Terminology

Throughout this booklet there will be some terms used that may be new to the reader. The following is a list of some of those terms along with a brief definition:

TA	**T**otal **A**lkalinity is the expression of the alkaline equivalent in pure soda ash.
Soda Ash	Sodium Carbonate or Na_2CO_3
BD	Bulk Density or the loose weight per cubic foot for soda ash in a bulk storage container.
Phase Diagram	Graphical expression of the mixture of soda ash and water at standard conditions.
Temperature	In °C unless stated otherwise.
%	Weight percent i.e. 1% solution is one pound soda ash dissolved in 99 pounds of water.
Particle Size	This refers to the US screen analysis normally confined to +40 mesh (% retained on the screen), +100 mesh (% of total greater than 100 mesh) and -200 mesh (% that passes through a 200 mesh screen).
MW	Molecular weight

General Data

Soda ash	Na_2CO_3	MW = 106
Sodium Bicarbonate	$NaHCO_3$	MW = 84
Sodium sesquicarbonate	$Na_2CO_3 \bullet NaHCO_3 \bullet 2H_2O$	MW = 226
Caustic soda	NaOH	MW = 40

$$H_2O + Na_2C03 \Rightarrow 2NaOH + CO_2$$

18 106 2(40) 44 = 1.325 to 1 soda ash to caustic ratio for acid neutralization.

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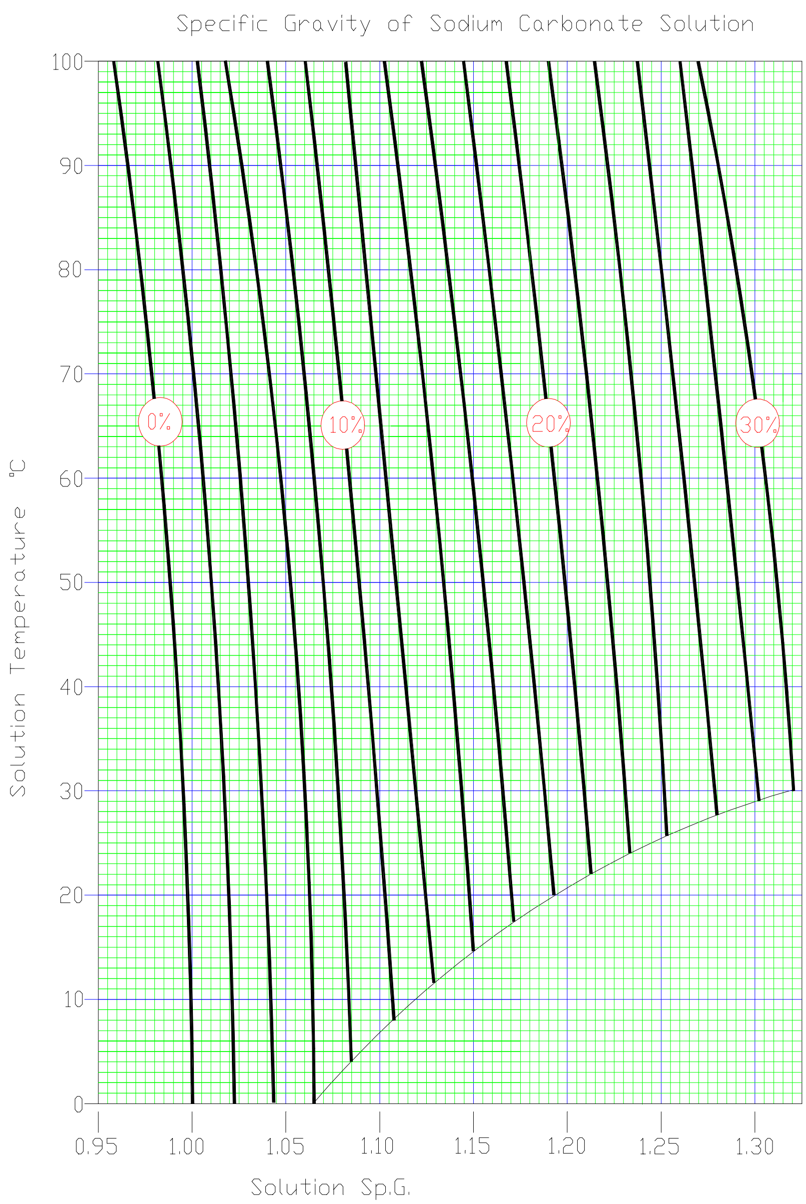
The relationship between the percent soda ash in solution and the liquid specific gravity is shown in the graph below. This graph is valid only until the solution is saturated with respect to soda ash.



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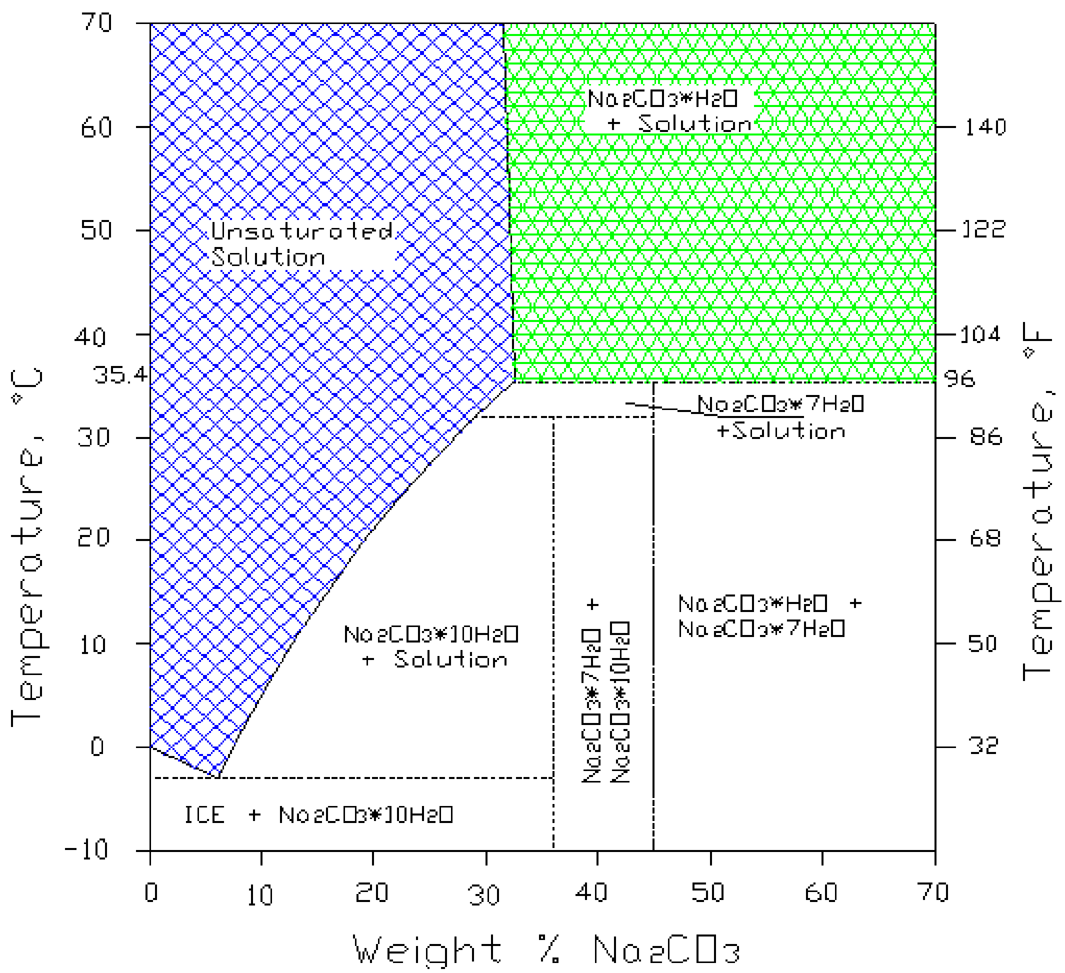
Soda ash will dissolve in water to a maximum concentration of about 33% by weight at a solution temperature of 35.4 °C. If more soda ash is added to the solution crystals will form and be in equilibrium with the saturated solution. The crystal composition is a function of solution temperature. Shown below is a phase diagram for soda ash and water showing and the different hydrate salts that can form if the slurry system temperature is not properly maintained. The green area is where a soda ash slurry storage system should function.



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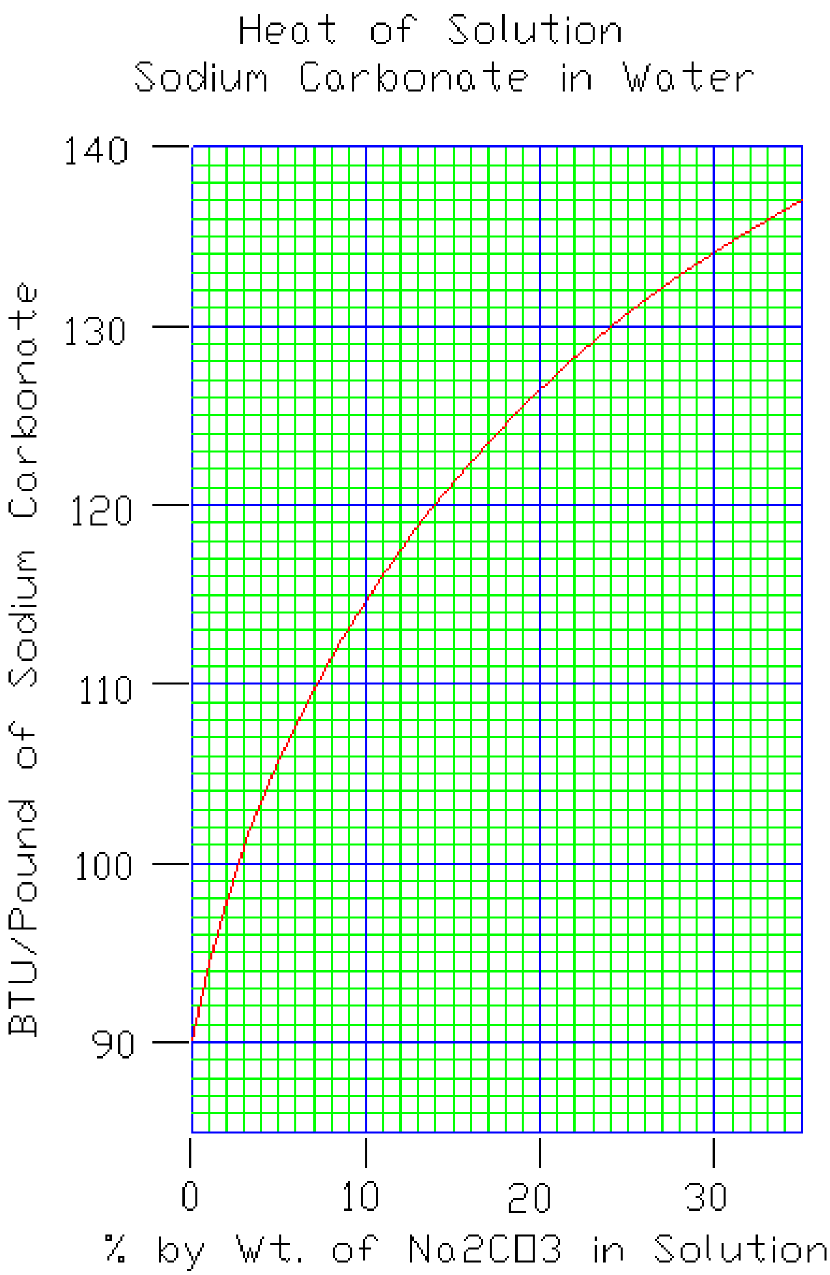
The dissolving of soda ash is an exothermic process. The graph below shows the heat evolved per pound of soda ash dissolved in fresh clean water. The hydration of soda ash is also exothermic thus as dry soda ash is added to a saturated solution the temperature of the solution will increase because of the heat evolved as the soda ash converts from anhydrous to monohydrate.



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FMC HOPPER CAR DIMENSIONS

SODA ASH HOPPER CARS

CAR SERIES	CAP	LENGTH	WIDTH	HEIGHT	* RAIL CLEAR	NO. OF GATES	GATE OPENINGS	APPROX. NO. IN SERVICE
SSIX	4650	51'-11"	10'-8"	15'-6"	11"	3	13 X 42	91
FMLX 45300	4650	51'-11"	10'-8"	15'-6"	11"	3	13 X 42	95
FMLX51000	5100	58'	10'-8"	15'-5"	10"	3	13 X 48	685
FMLX52000	5100	57'-8 1/2"	10'-7 3/4"	15'-6"	12"	3	13 X 42	500
ITLX 40000	4750	60'	10'-8"	15'	11"	3	24 X 30	495
PLCX	4750	57'-4"	10'-5"	14'-10"	11"	3	32 X 34	287
PTLX	4750	60'	10'-7"	15'	11"	3	32 X 34	157
USLX	4750	58'-1"	10'-8"	15'	11"	3	24 X 30	134
WCRC	5100	THESE CARS WILL BE RELEASED FROM SERVICE BY MID YEAR					34 X 34	250

* RAIL CLEARANCE – MEASURED FROM TOP OF RAIL TO THE BOTTOM OF THE GATE WHEN CAR IS EMPTY REDUCE BY APPROXIMATELY 1 1/2" WHEN CAR IS LOADED.

(1) TOTAL NO OF CARS WITH 24" X 30" GATE SIZE = 629
(2) TOTAL NO. OF CARS WITH 13" X 42" GATE SIZE = 686
(3) TOTAL NO. OF CARS WITH 13" X 48" GATE SIZE = 685
(4) TOTAL NO. OF CARS WITH 32" X 34" GATE SIZE = 444

NOTE: (1) (2) (3) & (4) – ARE ALL RACK & PINION TYPE SLIDE GATES
(2) = 91 CARS (SSIX SERIES) ARE DEDICATED SESQUI & WHITECAKE CARS
(2) = 39 CARS (FMLX 45300 SERIES) ARE GRAVITY / VACUUM TYPE GATES.

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The properties of sodium carbonate (Na_2CO_3) common to all forms of soda ash are listed below.

Molecular weight is 106.00, and the equivalent or combining weight is 53.00.

Alkali equivalent of 100% Na_2CO_3 is 58.48% Na_2O. A chart for the conversion of various percentages of sodium carbonate to equivalent weights of sodium hydroxide and sodium oxide is presented.

Acid equivalent of 1 pound of Na_2C0_3 is 0.6881 pounds HCI.

Melting point of anhydrous sodium carbonate is 1564°F (851°C). (3)

However, mixtures of sodium carbonate and other salts exhibit lower melting points. (4)

Sodium carbonate mixed: with 34.7% sodium chloride melts at 1204°F (651°C); with 51.5% potassium carbonate melts at 1330°F (721°C); with 39.8% sodium sulfate melts at 1510°F (821°C).

Specific gravity, which is the ratio of the weight of a volume of sodium carbonate at a specific temperature to the weight of the same volume of water at 4°C, not to be confused with bulk density-the weight of unit volume. The specific gravity of particles of anhydrous sodium carbonate at 68°F (20°C) is 2.533. (3)

Specific heat. The specific heat of anhydrous sodium carbonate at 113°F (45°C) is 1.07 joules per gram, which is equivalent to 0.256 calories per gram per °C, or 0.256 B.t.u. per pound per ° F. (5)

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Decomposition by heat. If anhydrous sodium carbonate is heated, loss in weight-due to dissociation and volatilization-begins at 725°F (400°C). Carbon dioxide is evolved, as indicated by the reaction equation.

$$Na_2CO_3 \longrightarrow Na_2O + CO_2$$

The following table lists the decomposition pressure at various temperatures. (4)

°F	° C	mm. Mercury
1616	880	10
1814	990	12
1850	1010	14
2012	1100	21
2102	1150	28
2156	1180	38
2192	1200	41
2732	1500	760

Latent heat of fusion of anhydrous sodium carbonate is 76 calories per gram of 136 B.t.u. per pound. (4)

Heat of formation of anhydrous sodium carbonate is 2547 calories per gram at 25°C; or 4590 B.t.u. per lb. at
77°F. (4)

Heats of hydration or the heats of formation of the solid hydrates of sodium carbonate from anhydrous sodium
carbonate and water in the liquid state are given in the following table. (6)

Hydrate	Chem. Formula		Cal./g of Na_2CO_3	B.t.u./lb. of Na_2CO_3
MONO	Na_2CO_3	H_2O	30	54
HEPTA	Na_2CO_3	7 H_20	157	282
DECA	Na_2CO_3	10 H_20	208	375

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Properties of the hydrates of sodium carbonate are listed below.

I. Sodium carbonate monohydrate Na_2CO_3-H_20

Contains 85.48% Na_2C0_3; 14.52% water of crystallization. Separates as small crystals from saturated aqueous solutions above 95.7°F (35.4°C), or may be formed by adding the calculated amount of water to soda ash at or above that temperature. Loses water on heating, and its solubility lessens somewhat on raising the temperature.At 228°F (109°C) in contact with its saturated solution, it changes to anhydrous Na_2C0_3.

II. Sodium carbonate heptahydrate Na_2CO_3-$7H_20$

Contains 45.7% Na_2CO_3; 54.3% water of crystallization. Is stable in contact with its saturated solution only in the very short temperature range of 89.6° to 95.7°F (32.0 to 35.4°C), so is of no practical value.

III. Sodium carbonate decahydrate Na_2C0_3-$10H_20$

Contains 37.06% Na_2CO_3 and 62.94% water of crystallization. Generally forms large coarse crystals from saturated water solutions between 28.2° and 89.6°F (-2.1 to 32.0°C). Commonly called "washing soda" or "sal soda." Melts at 95.7°F (35.4°C). The crystals effloresce in dry air to form the lower hydrates, especially the monohydrate.

Solubility of sodium carbonate: sodium carbonate is readily soluble in water, but exhibits an unusual characteristic in that it attains its maximum solubility at the temperature of 95.7°F (35.4°C). At this temperature, 100 parts of water dissolve 49.7 parts of Na_2C0_3 to give a solution containing 33.2% by weight of Na_2C0_3. Above and below this temperature, the solubility drops off eventually to a figure of 29% by weight. This means that saturation for various concentrations between 29 and 33.2% can be reached at two different temperatures, one below and one above the maximum solubility point.

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Densities and Concentrations of Aqueous Sodium Carbonate Solutions from 0.7% to 14.5% Na_2CO_3 at 60°F. (15.56°C.)

Degrees Baumé at 60°F Am. Std.	Degrees Twaddell at 60°F	Specific Gravity at 60°/60°F.	Temperature at which solution is saturated		Per Cent		Pounds Na_2CO_3		Grams Na_2CO_3 per liter at 60°F
			°F.	°C.	Sodium Carbonate (Na_2CO_3)	Equivalent Na_2O	Per Gal. of Solution at 60°F.	Per Cu. Ft. of Solution at 60°F	
1.0	1.4	1.007	31.6	-0.2	0.7	0.4	0.06	0.44	7.0
1.4	2.0	1.010	31.5	-0.3	1.0	0.6	0.08	0.63	10.1
2.0	2.8	1.014	31.3	-0.4	1.3	0.8	0.11	0.82	13.2
3.0	4.2	1.021	31.0	-0.6	2.0	1.2	0.17	1.27	20.4
4.0	5.6	1.028			2.7	1.6	0.23	1.73	27.8
4.4	6.3	1.032	30.0	-1.1	3.0	1.8	0.26	1.93	30.9
5.0	7.2	1.036			3.4	2.0	0.29	2.20	35.2
5.9	8.4	1.042	29.3	-1.5	4.0	2.3	0.35	2.60	41.7
6.0	8.6	1.043			4.1	2.4	0.36	2.67	42.8
7.0	10.2	1.051			4.8	2.8	0.42	3.14	50.4
7.2	10.5	1.053	28.9	-1.7	5.0	2.9	0.44	3.28	52.6
8.0	11.6	1.058	28.6	-1.9	5.5	3.2	0.49	3.63	58.2
8.6	12.6	1.063	29.8	-1.2	6.0	3.5	0.53	3.98	63.8
9.0	13.2	1.066			6.3	3.7	0.56	4.19	67.2
10.0	14.8	1.074	35.2	+1.8	7.0	4.1	0.63	4.69	75.2
11.0	16.4	1.082			7.8	4.6	0.70	5.27	84.4
11.3	16.8	1.084	40.6	4.2	8.0	4.7	0.72	5.41	86.7
12.0	18.0	1.090			8.5	5.0	0.77	5.78	92.7
12.6	19.0	1.095	44.1	6.7	9.0	5.3	0.82	6.15	98.6
13.0	19.8	1.099			9.4	5.5	0.86	6.45	103.3
13.9	21.1	1.106	47.3	8.5	10.0	5.8	0.92	6.90	110.6
14.0	21.4	1.107			10.1	5.9	0.93	6.98	111.8
15.0	23.0	1.115			10.9	6.4	1.01	7.58	121.5
15.1	23.3	1.116	50.7	10.4	11.0	6.4	1.02	7.66	122.8
16.0	24.8	1.124			11.7	6.8	1.10	8.21	131.5
16.4	25.5	1.127	53.8	12.1	12.0	7.0	1.13	8.44	135.3
17.0	26.6	1.133			12.5	7.3	1.18	8.84	141.6
17.6	27.7	1.138	56.5	13.6	13.0	7.6	1.23	9.24	148.0
18.0	28.4	1.142			13.3	7.8	1.27	9.48	151.9
18.8	29.9	1.149	59.0	15.0	14.0	8.2	1.34	10.04	160.9
19.0	30.2	1.151			14.2	8.3	1.36	10.20	163.4
19.4	30.9	1.155	60.8	16.0	14.5	8.5	1.40	10.45	167.5

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Densities and Concentrations of Sodium Carbonate Solutions from 10 to 28% Na_2CO_3 at 86° F. (30°C.)

Per Cent		Specific Gravity* at 30°/4°C.	Temperature at which solution, is saturated		Pounds Na_2CO_3		Grams Na_2C0_3 per liter at 30°C.
Sodium Carbonate (Na_2C0_3)	Equivalent Na_20		°F.	°C.	Per gallon of solution at 30°C.	Per cu. ft. of solution at 30°C.	
10	5.8	1.099	47.3	8.5	0.92	6.86	109.9
11	6.4	1.109	50.7	10.4	1.02	7.62	122.1
12	7.0	1.120	53,8	12.1	1.12	8.39	134.4
13	7.6	1.131	56.5	13.6	1.23	9.18	147.1
14	8.2	1.142	59,0	15.0	1.33	9.98	159.8
15	8.8	1.153	62.O	16.7	1.44	10.80	173.0
16	9.4	1.164	64.4	18.0	1.55	11.62	186.2
17	9.9	1.175	66.7	19.3	1.67	12.47	199.8
18	10.5	1.186	68.7	20.4	1.78	13.33	213.5
19	11.1	1.197	70.7	21.5	1.90	14.21	227.6
20	11.7	1.209	72.7	22.6	2.02	15.09	241.7
21	12.3	1.220	74.3	23.5	2.14	16.00	256.4
22	12.9	1.232	76.1	24.5	2.26	16.92	271.0
23	13.5	1.244	77.9	25.5	2.39	17.86	286.1
24	14.0	1.255	79.5	26.4	2.51	18.81	301.3
25	14.6	1.267	81.0	27.2	2.64	19.78	316.9
26	15.2	1.279	82.4	28.0	2.78	20.76	332.5
27	15.8	1.291	83.8	28.8	2.91	21.77	348.7
28	16.4	1.303	85.3	29.6	3.04	22.78	364.9
From 28 to 32% Na_2CO_3 at 104°F. (40°C.)							
		40°/4°C.			**At 40°C.**	**At 40°C.**	**At 40°C.**
28	16.4	1.295	85.3	29.6	3.03	22.63	362.5
29	1 7.0	1.306	86.5	30.3	3.16	23.65	378.9
30	17.5	1,318	88.0	31.1	3.30	24.69	395.4
31	18.1	1.330	89.1	31.7	3.44	25.73	412.2
32	18.7	1.342	91.9	33.3	3.58	26.80	429.3

*Weight of milliliter in grams at 30°C. and 40°C respectively
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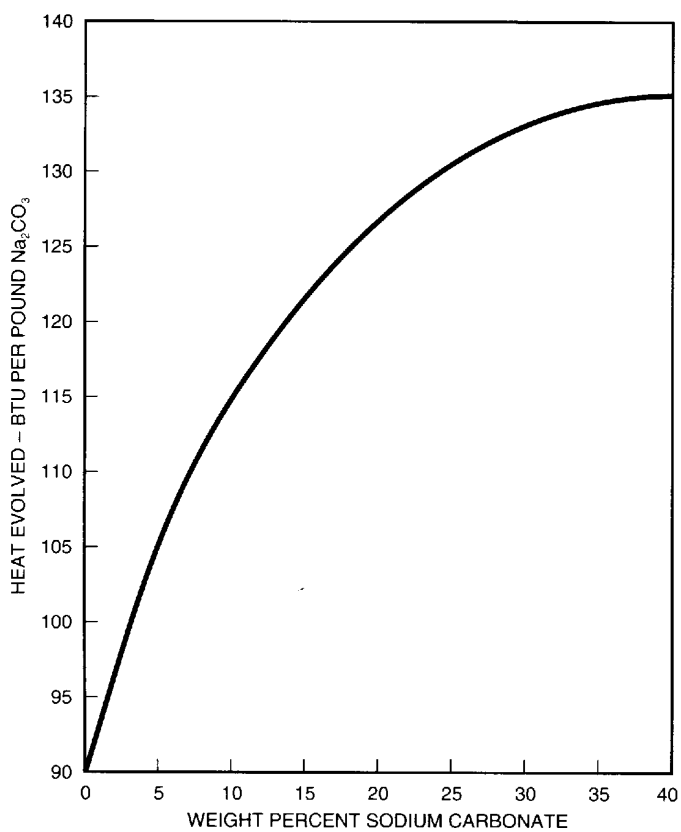
Heats of Solution and Dilution

SOLUTE	WATER			Heat Quantity
	moles	grams	% Na_2C_3 in solution	Btu per pound Na_2CO_3
Na_2CO_3,105.989 grams	15	270.2	28.17	133.0
	20	360.3	22.73	129.2
	25	450.4	19.05	126.0
	30	540.5	1 6.40	1 23.1
	50	900.8	10.53	115.4
	75	1,351.0	7.27	109.9
	100	1,802	5.56	108.3
	200	3,603	2.86	99.7
	400	7,206	1.45	95.1
$Na_2CO_3 \cdot H_20$, 124.004 grams	200	3.603	2.84	45.6
$Na_2CO_3 \cdot 7H_20$, 232.096 grams	200	3,603	2.76	-181.9*
$Na_2CO_3 \cdot 10H_20$, 286.142 grams	200	3,603	2.73	-276.1

*Endothemic; heat absorbed

Sodium Carbonate Heats of Solutions in Water



This table may be used to calculate heat absorbed when diluting a solution of Na_2CO_3. For instance, using Q_i as the initial, starting % Na_2C0_3 solution and Q_f as the final, ending concentration; then Q_i - Q_j = the Btu per pound of Na_2CO_3 of heat absorbed or generated. An example follows. If a 28.17% solution is diluted to 10.53%, the temperature will decrease through absorption of 133.0 -115.4 = 17.6 Btu per pound. If diluted to 1.45%, heat absorbed will be 133.0 - 95.1 = 37.9 Btu per pound. This is further illustrated below.

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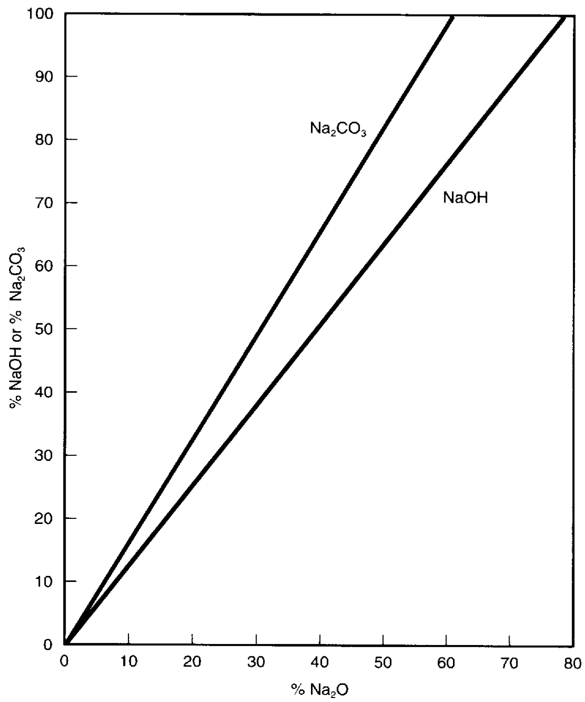
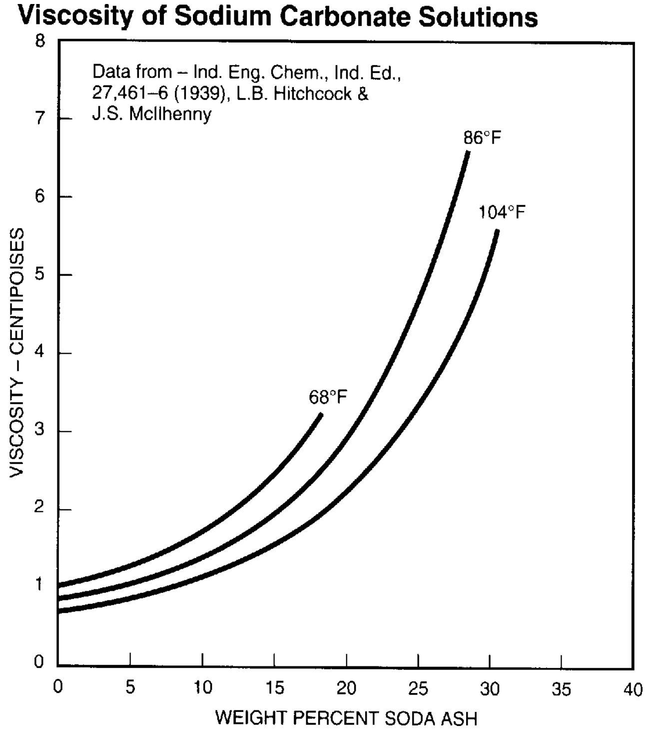
Alkali Conversion Chart



To convert equivalent percentages of caustic soda or soda ash to % Na_2O, locate the given percentage of caustic soda or soda ash on the ordinate, then read horizontally to the intersection with the "caustic soda" line or the "soda ash" line. Read the equivalent percentage of Na_2O on the abscissa.

1. Example: 50% NaOH = 38.8% Na_2O
2. Example: 70% Na_2C0_3 = 41 % Na_20

Viscosity of Sodium Carbonate Solutions



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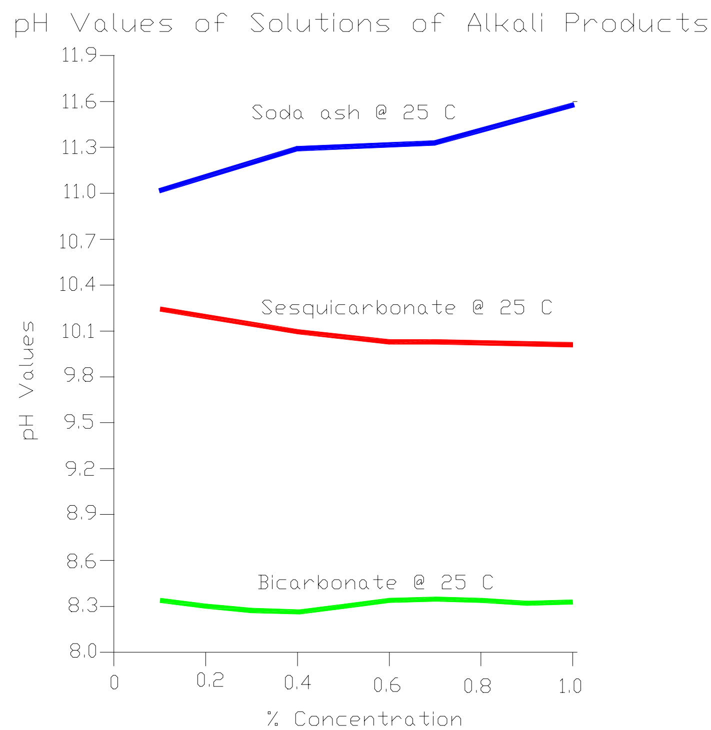

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