

## Shipping, Storage and Handling of Soda Ash Customer Manual

### Shipping of Soda Ash

#### Introduction

Solvay Chemicals can ship soda ash in any one of several containers depending on the customer's needs and facilities. Solvay Chemicals can ship bulk soda ash in rail cars and trucks and in bags of various sizes. The information below explains the details of each of these modes of shipment.

#### Shipment by Bulk Rail Cars

Shipment of soda ash by covered hopper car is the most common transportation method. Solvay Chemicals owns and leases a large fleet of covered hopper railcars to ensure reliable delivery to our customers.

#### Discussion of Gravity Bottom Dump Rail Cars

The most common type of hopper railcar is the nominal 100 ton gravity bottom dump railcar. The most common gravity dump railcar has a gross weight of 263,000 pounds and a volume capacity of 4,750 cubic feet. A typical gravity bottom dump railcar has a weather tight steel roof with six (6) loading hatches and three (3) railcar compartments. The sloping bottoms of the railcar compartments feed rectangular outlets. Discharge from the railcar outlets is controlled by horizontal slide gates operated by a rack-and-pinion mechanism. The outline dimensions of the gravity bottom dump railcar and car bottom outlets are available on request from Solvay Chemicals.

#### Discussion of Gravity-Pneumatic Railcars

A second type of hopper railcar is the gravity-pneumatic car which features outlets incorporating nozzles that allow the attachment of vacuum pneumatic unloading systems. These railcars are often dedicated to specific customers with vacuum pneumatic railcar unloading systems. The capacity, hatch configuration and compartment arrangement of the gravity-pneumatic railcar are the same as the gravity bottom dump railcar. The difference between the two types of railcars is the bottom outlet gate arrangement. The gravity-pneumatic railcar has a similar rack and pinion discharge gate located above a pneumatic outlet pipe. Below the pneumatic outlet pipe there is a second sanitary gate that can be opened to discharge out the bottom of the railcar. This discharge gate arrangement allows connection of the vacuum pneumatic unloading system with a 6" quick connect coupling. The outline dimensions of the gravity-pneumatic railcar, railcar discharge gates and pneumatic connections are available on request from Solvay Chemicals.

#### Discussion of Pressure Differential (PD) Railcars

Pressure differential (PD) railcars are a third type of railcar in soda ash service. This type of railcar is relatively uncommon due to the higher shipping cost associated with increased railcar weight. The maximum capacity of a PD railcar is approximately 90 tons because of this increased tare weight.

PD railcars are unloaded by pressurizing the railcar with an external air supply that forces the soda ash out of bottom pneumatic discharge valves. The discharge valve arrangement allows railcar fluidization and discharge into a customer's pneumatic piping. The outline dimensions of the pressure differential (PD) railcars and pneumatic connections are available on request from Solvay Chemicals.



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### Shipment by Bulk Transport Trucks

Self-contained bulk pneumatic transport trucks with an auxiliary trailer (or pup) can carry up to 70,000 pounds of soda ash depending on state highway limits. The auxiliary trailer accounts for approximately 10 tons of this capacity and the truck trailer accounts for approximately 25 tons of this capacity. The tractor on the transport truck is equipped with a blower system that pressurizes the truck trailer and pneumatically conveys the soda ash to discharge with system of valves and hoses. Depending on the customers pipeline configuration and conveying distance the truck can be unloaded in 1 to 2 hours.

Bottom dump transport trucks with capacities up to 80,000 pounds are also in use. Again state highway load limits may dictate the truck capacity limit.

### Shipment in Bags and Bulk Sacks

Soda ash is available from Solvay Chemicals in 50 pound and 100 pound bags that are palletized and shrink-wrapped. A full pallet of 50 pound bags contains 49 bags and weighs 2,450 pounds. A full pallet of 100 pound bags contains 25 bags and weighs 2,500 pounds.

Solvay Chemicals also distributes soda ash in 2,000 pound and 3,000 pound bulk sacks. The bulk sacks have lifting straps and an 18" X 18" discharge spout that is tied closed on the bottom of the bulk sack.

### Identification of Shipping Problems

Solvay Chemicals goes to great lengths to insure that the soda ash product reaches the customer per specification and that the method of shipment does not affect the product quality. Manufacturing procedures are stringent and quality checks are conducted throughout the soda ash production. Every railcar is inspected before loading and lab analysis conducted of loaded product. However, there are occasions when problems arise and it is helpful if the customer is able to identify and communicate the problem to Solvay Chemicals. This information is used for railcar repair and identifying overall quality in shipping problems.

### Unloading Rail Hopper Cars

Typically hopper railcars are spotted with the car gate over the appropriate unloading point and a dust boot is attached to minimize dusting to atmosphere when gravity unloading. The railcar gate is then opened with a bar or mechanical device.

Soda ash will normally commence flowing, but if difficulty is experienced in maintaining flow, electrical or pneumatic railcar vibrators may be used to promote flow. Hopper railcars feature a standard grooved bracket which allows attachment of the railcar vibrator to the side of the outlet. It is recommended that the vibrator be used intermittently to initiate flow on the compartment being emptied and turned off when the compartment is empty. If a vibrator is operated on a compartment that is not being emptied it may tend to pack the soda ash material and if a vibrator is used on an empty hopper it may cause structural damage to the hopper. It is not recommended that the railcar walls or hopper be hammered to assist flow. If air lances are used through the top hatches of the railcar to promote flow, caution must be exercised to avoid damage to the railcar lining.

If the unloading installation is in a fixed location, car moving equipment such as a mobile railcar mover or electrical/hydraulic mechanism will be necessary to position each hopper over the unloading point.

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If a customer has a vacuum pneumatic unloading system, gravity bottom dump railcars can be fitted with a pneumatic unloading pan with hose and gravity pneumatic railcars can be fitted with a hose to a vacuum pneumatic header system. The railcar can then remain stationary and the pneumatic pan with hose or in the case of gravity pneumatic railcar the hose can be moved from compartment to compartment for unloading.

### **Unloading Bulk Pneumatic Trucks**

Bulk pneumatic trucks are self-contained with a blower and hoses suitable for pneumatically unloading soda ash directly into the customer's facility.

The customer must provide adequate access for the truck to the unloading point. The conveying pipe should be vertical to an angle of 30 degrees from vertical with a male 4" quick disconnect coupling terminating about 4' above the ground to allow the attachment of the trucks pneumatic hose without a tight bend.

### **Unloading Bags and Bulk Sacks**

Although there are many ways to enter 50 pound and 100 pound bags into a process, one convenient method is to use a bag splitter/grizzly arrangement to break open the bags and dump into solution or dry storage. The 2,000 pound and 3,000 pound bulk sacks have straps sewn into the top of the sack allowing lifting by forklift or bulk sack unloading equipment. Bulk sacks have a bottom dump spout that can be placed over bulk sack unloading equipment to meter the soda ash into the customer's process or opened to dump in their entirety into solution or dry storage.

## Design of Soda Ash Storage and Handling Systems

### **Introduction**

Since the individual customer needs are so variable, the information presented below on the design of soda ash storage and handling systems is necessarily general in nature. However, this information should be useful during the scoping phase of work and steer the customer away from common pitfalls and toward a successful material handling system.

### **Soda Ash Flow Characteristics - Jenike and Johanson Flow properties Test Report**

Solvay Chemicals has contracted with Jenike and Johanson, Inc., a highly reputable consulting firm that specializes in solids flow design to develop the technical data on the flow properties of soda ash. The soda ash flow properties test report is useful in the design and handling of soda ash in bins, chutes and hoppers for dependable flow. The Jenike and Johanson flow properties test report for soda ash is available on request from Solvay Chemicals.

### **Solvay Chemicals Equipment Specifications**

Solvay Chemicals equipment specifications are available on request to our soda ash customers. These specifications can serve as the basis for the development of the individual customer specifications, tailored to satisfy customer's preferences and site specific requirements. Information on material handling equipment vendors with soda ash experience is also available on request.

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### Dry Soda Ash Handling Systems

#### General Description

There are three basic types of systems for handling dry soda ash. The system deemed most suitable will depend on the individual customer's site conditions and process requirements.

#### Mechanical Systems

Soda ash can be transported by a system of belt conveyors, drag conveyors, screw conveyors, bucket elevators, air slides, chutes and other dry mechanical material handling systems. The advantage of mechanical systems is high transfer rates, the low degradation of soda ash particles and low equipment life cycle cost. The disadvantages are relatively high initial cost and decreasing economic viability as transport distances increase.

#### Dilute Phase Pneumatic Conveying Systems

In this type of system, soda ash is conveyed by suspension in a low pressure (5 psi-15 psi) air stream in a pipe line. The dilute phase pneumatic system consists of a blower system to generate the air stream, a device to introduce the soda ash into the air stream, piping and a means to separate the soda ash from the air stream at the end point. Advantages of this type of system are relatively low initial cost, the ability to convey soda ash over long distances, and the ability to have multiple pickup/receiving points. The disadvantages are higher energy costs over mechanical systems and severe reduction in particle size. If the customer's process is not sensitive to particle size reduction, dilute phase pneumatic conveying may be a satisfactory option.

#### Dense Phase Pneumatic Conveying Systems

Another type of pneumatic conveying system moves material in a batch process from a pressure vessel in slugs through a pipe line in a "dense phase" using compressed air. Like the dilute phase conveying system the advantages are the ability to pickup and deposit material at one or several points. Dense phase pneumatic conveying also transports the soda ash relatively long distances with low particle size reduction. The particle size reduction with this type of conveying system is between a mechanical system and a dilute phase pneumatic conveying system. The disadvantages are the intermittent consumption of high energy cost compressed air and the initial costs of this type of system are higher than a dilute phase system.

### Wet Soda Ash Handling Systems

#### General Description

To make the most effective use of product storage soda ash should be stored as a dry powder. Soda Ash can also be stored as a solution or slurry when wetted.

A soda ash solution storage system consists of a storage tank, a means for mixing the bulk soda ash, and a means to replenish the solution by adding steam or water to the solution tank. Soda ash solution storage tanks and piping can be made from mild steel. Dilution water should be softened or treated, as carbonate sludge can form requiring periodic tank clean-outs.

When a quantity of soda ash is mixed with water the soda ash will dissolve to form a solution. At a certain temperature, based on the soda ash phase diagram (figure 1), the solution will reach concentration where the un-dissolved portion will settle to the bottom of the tank as fluid non-hardening monohydrate slurry. Slurry volume should not occupy more than 75% of the storage tank volume.

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Because the soda ash can lump and cake, which impairs its conversion to monohydrate, a slurring device must wet each particle of soda ash entering the solution tank. The slurring device is dependant on the type of system introducing the dry soda ash into solution. Gravity feed systems can use a wash down cone. Pneumatic feed systems must remove the air of transport from the soda ash by wet scrubber arrangements. The slurring device can use a recirculation stream of the concentrated solution to wet the soda ash.

The saturated sodium carbonate solution and the sodium carbonate monohydrate must be kept above 97°F to prevent the formation of hepta and decahydrates, which are extremely difficult to re-dissolve. The slurry storage tank should be insulated and equipped with heating coils or a sparger system to maintain an operating temperature between 115°-130°F. Theoretically, water added to the slurry may be as low as 35°F below the slurry bed temperature without cooling the mixture; however it is not recommended because localized cooling could lead to the formation of the higher hydrates.

Saturated soda ash solution is continuously withdrawn from the slurry storage tank by decanting from the clear liquid layer on top of the slurry. Water addition to the bottom of the slurry needs to be warmed and must equal the volume of saturated solution withdrawn. This can be achieved through the use of level control devices. A nozzle array or inverted cone at the bottom of the tank is necessary to distribute incoming dilution water through the crystal bed. Saturated solution above the monohydrate crystals remains uniform in strength at operating temperatures based on the soda ash phase diagram. Ordinary liquid metering devices can be used for flow control. Because saturated solution is susceptible to crystallization below 97°F, the transfer of the saturated solution to the process or the slurring devices must be conducted without heat loss.

Depending on process requirements, various combinations of dry shipping and unloading systems can be used to transport and handle soda ash to dry bulk storage for subsequent slurring or solution tanks directly. Significant cost savings may be realized by the conversion of existing equipment and facilities where applicable.

### **Materials of Construction**

Soda ash can be handled by a wide variety of metals, polymers, epoxies and rubbers. Carbon Steel is most commonly used where iron contamination is not a critical problem. Epoxy, polyethylene and stainless steel are used to line bins to maintain product integrity and to aid in flow properties. Materials such as PVC, TFE, polyester-fiberglass and other plastics can be employed within the allowable stress and temperature limits prescribed for each material. Neoprene, EPDM, Viton and other types of rubbers may be used on belt conveyors, diaphragms and pneumatic hoses. Aluminum may also be used in dry cool soda ash. However, many soda ash users avoid aluminum because of the potential for contact with wetted and/or hot soda ash. Brass, copper and bronze materials should be avoided where contact with the soda ash is possible.

### **Solvay Chemicals Review of Customer Designs**

Solvay Chemicals has a highly qualified and experienced engineering staff with the ability to review customer soda ash designs on request. Also, a site visit by a member of our engineering staff can be arranged to review the customer's site location and proposed layout infrastructure to avoid potential problems with the handling of soda ash.

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### Soda Ash Characteristics

Solvay Chemicals has assembled the technical information required to handle soda ash as a solid, solution, or slurry from documents and published materials.

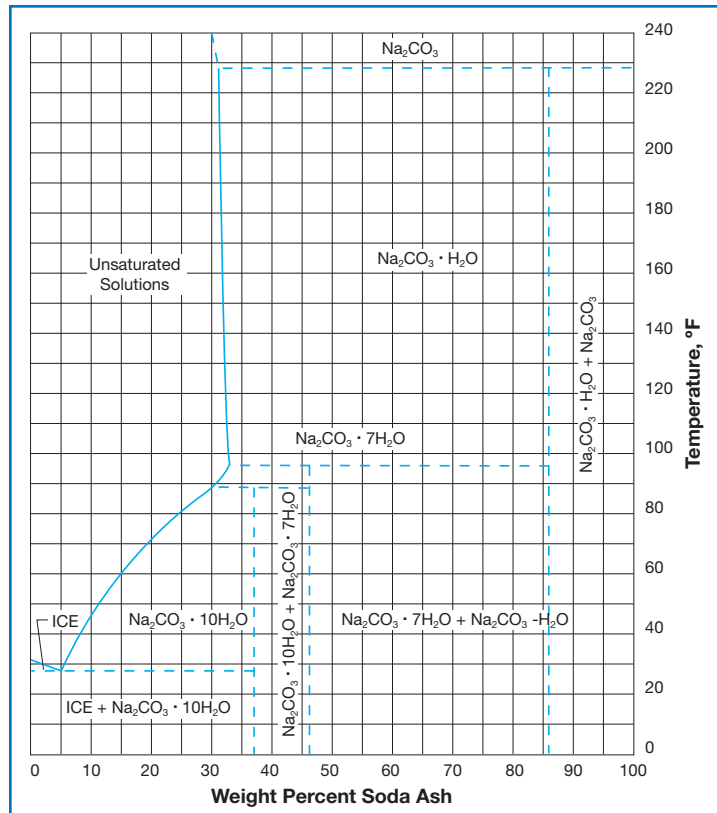
#### Physical and Chemical Properties of Soda Ash

The information on the Physical and Chemical Properties of Soda Ash identifies soda ash as a very pure crystal that melts at a high temperature. Soda ash in solution is alkaline.

#### Figure 1: Solubility of Soda Ash in Water

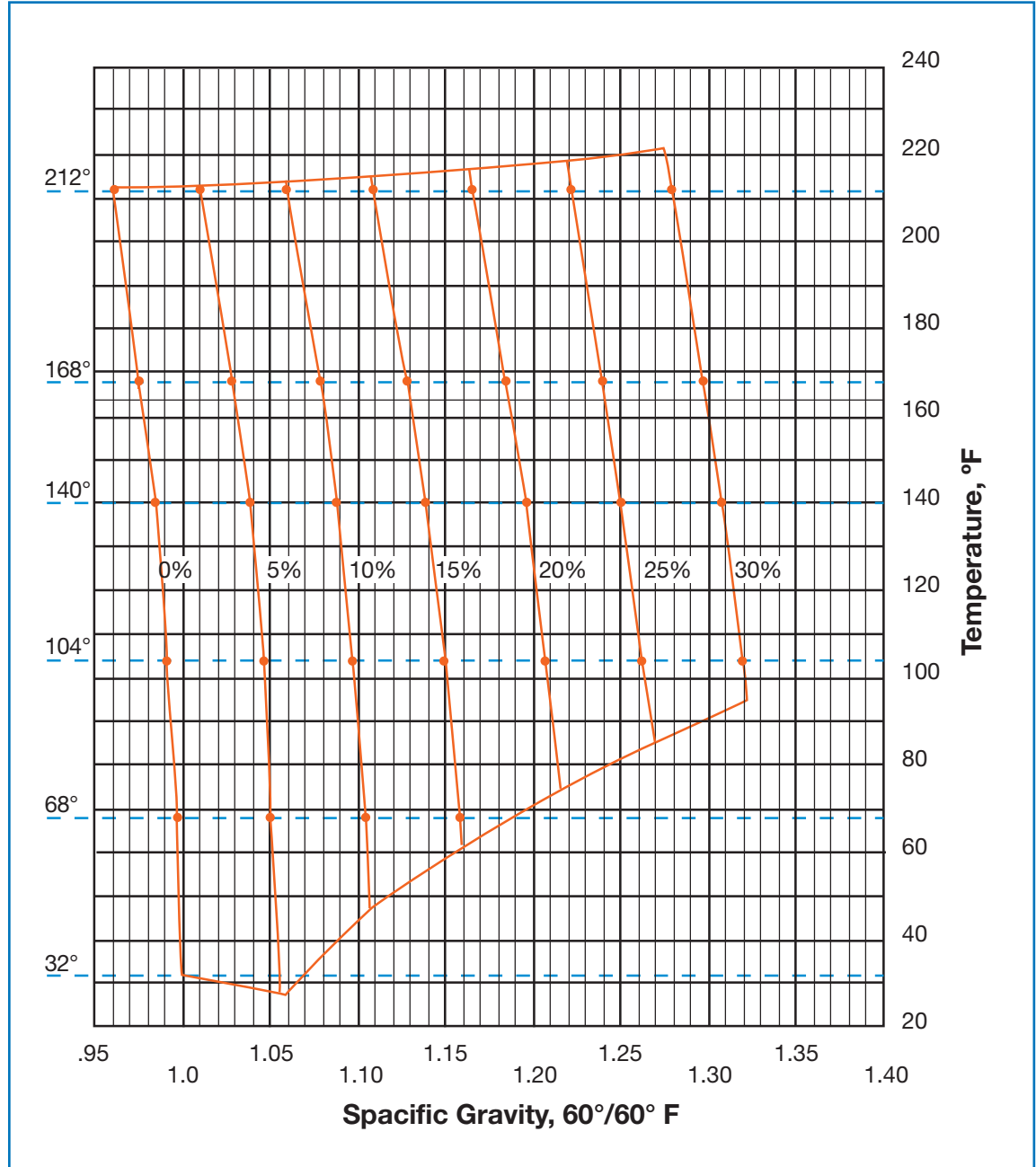
This phase diagram is extremely important to customers who intend to put soda ash into a solution or slurry. Soda ash dissolves readily in water to give a clear solution, however, it exhibits an unusual characteristic in that maximum solubility is at the low temperature of 97°F. At that point, a saturated solution contains 33.2%  $\text{Na}_2\text{CO}_3$  by weight. A 10% by weight soda ash solution is saturated at 49°F. It is recommended that a 30% by weight soda ash solution be stored at 120°F. This temperature includes a safety margin to preclude the formation of sodium carbonate heptahydrate and sodium carbonate decahydrate, which have endothermic heats of solution.

Soda ash can also be stored in slurries of soda ash monohydrate in a crystalline bed at the bottom of a storage tank with a saturated soda ash solution over the slurry bed. This characteristic enables the user to maximize available storage tank volumes. Similar to a saturated solution, soda ash slurry of monohydrates can form the hepta and decahydrates if the temperature drops below 97°F. The recommended storage tank temperature is 120°F.



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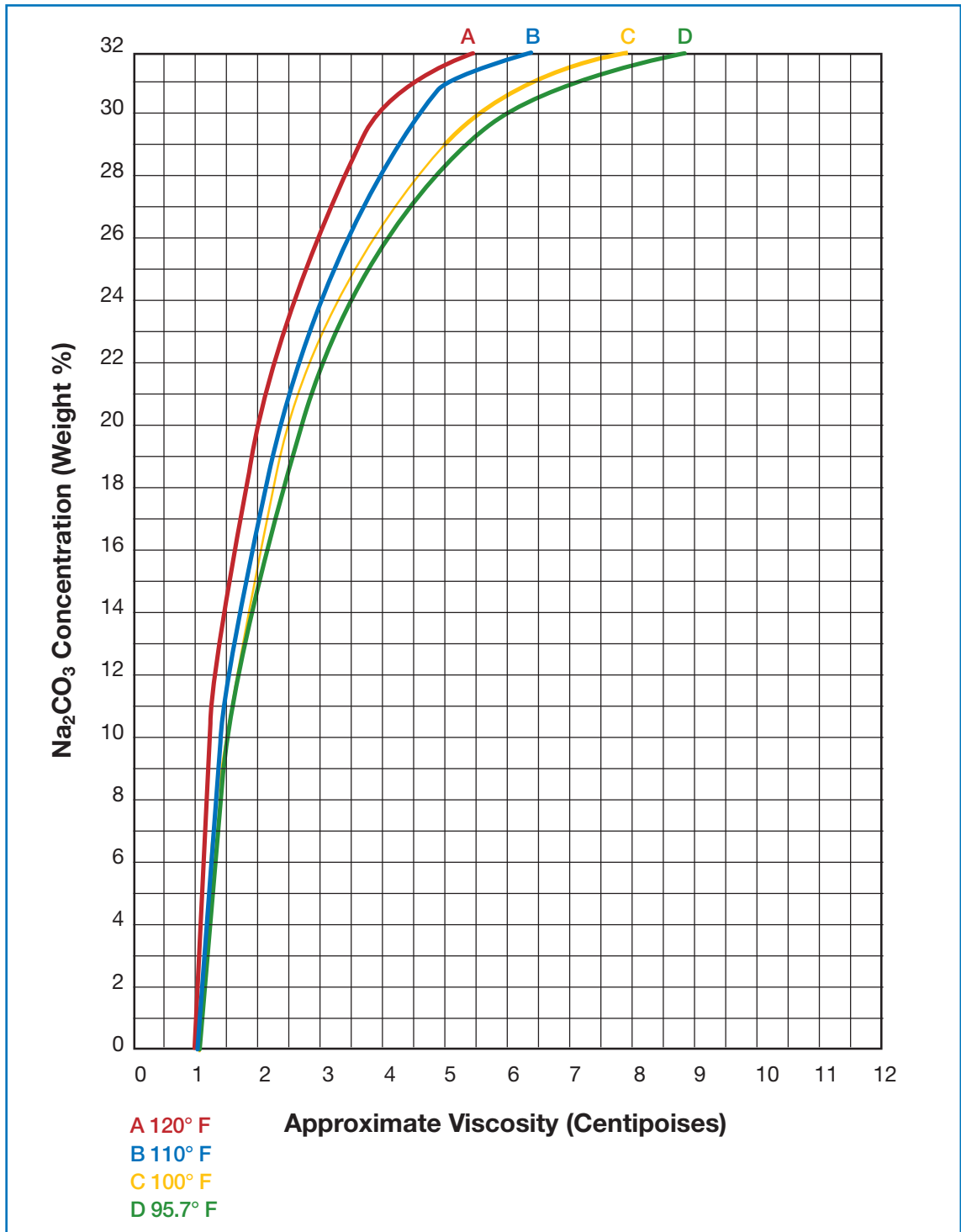
**Figure 2: Percent Concentrations and Specific Gravity of Soda Ash Solutions**  
Soda ash solution strengths can be quickly checked with this chart.



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**Figure 3: Viscosity of Soda Ash Solutions**

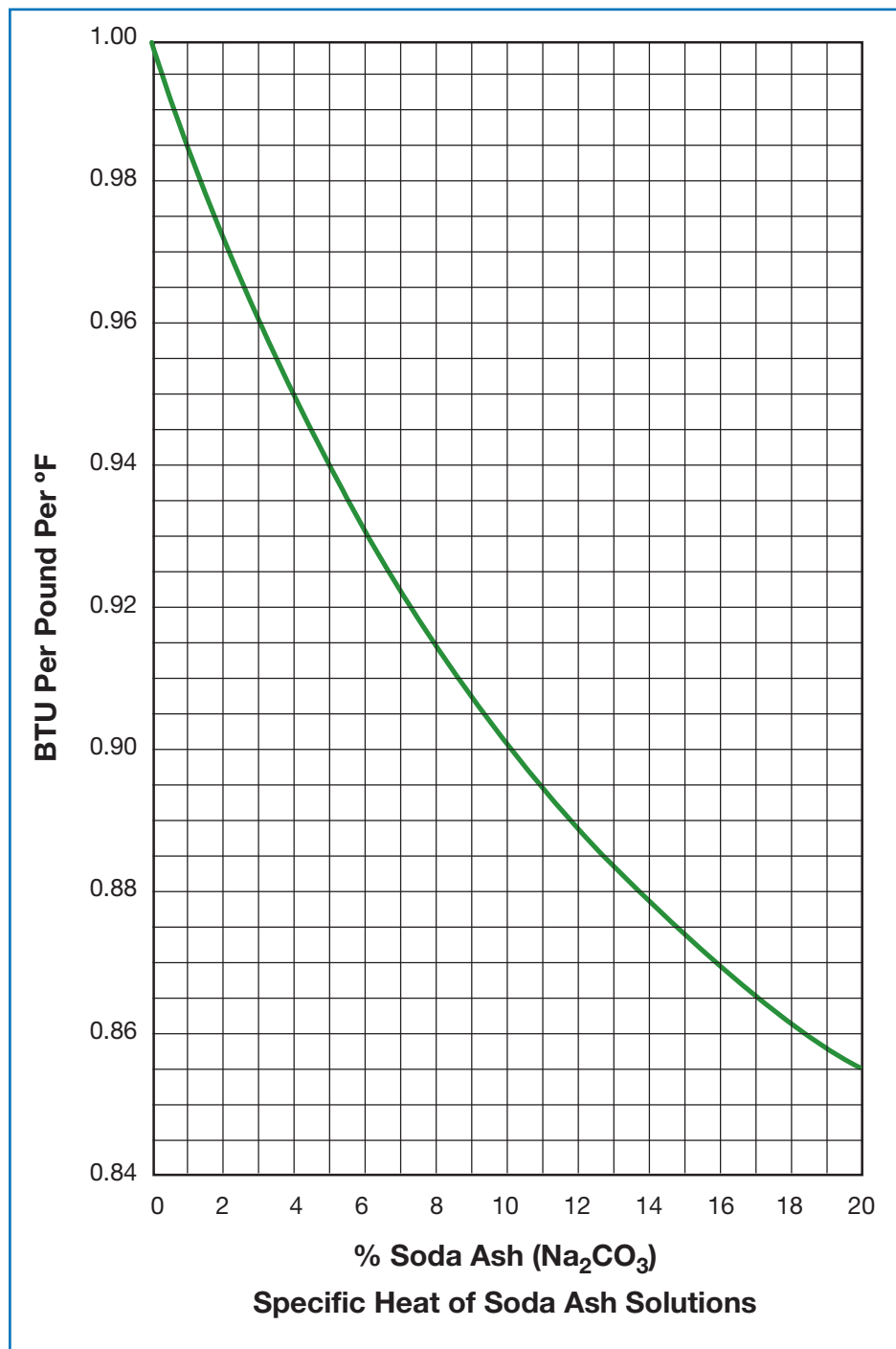
Soda ash solutions have viscosities slightly higher than water. Information on this chart can be used for equipment design and flow control devices.



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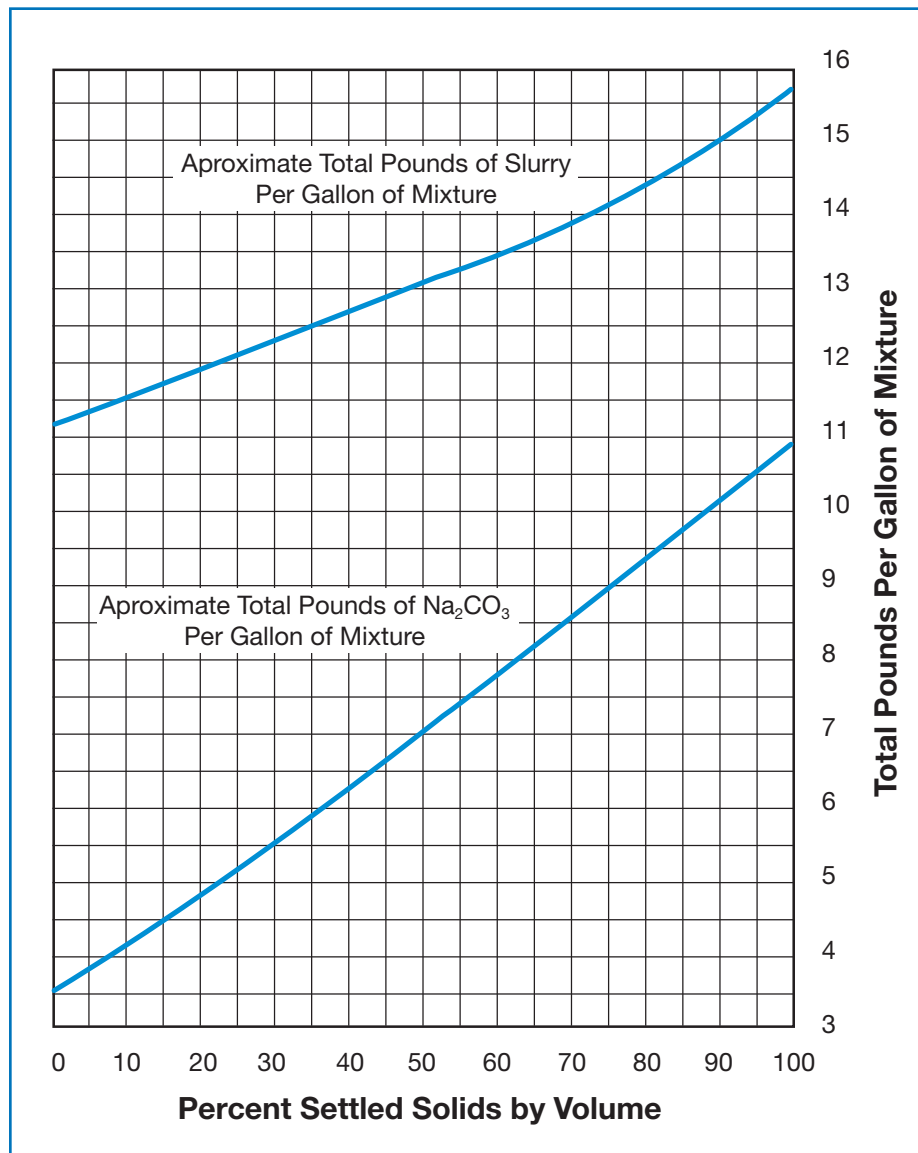
**Figure 4: Specific Heat of Soda Ash Solutions**

The amount of heat required to raise the temperature of a soda ash solution one degree per pound is charted.



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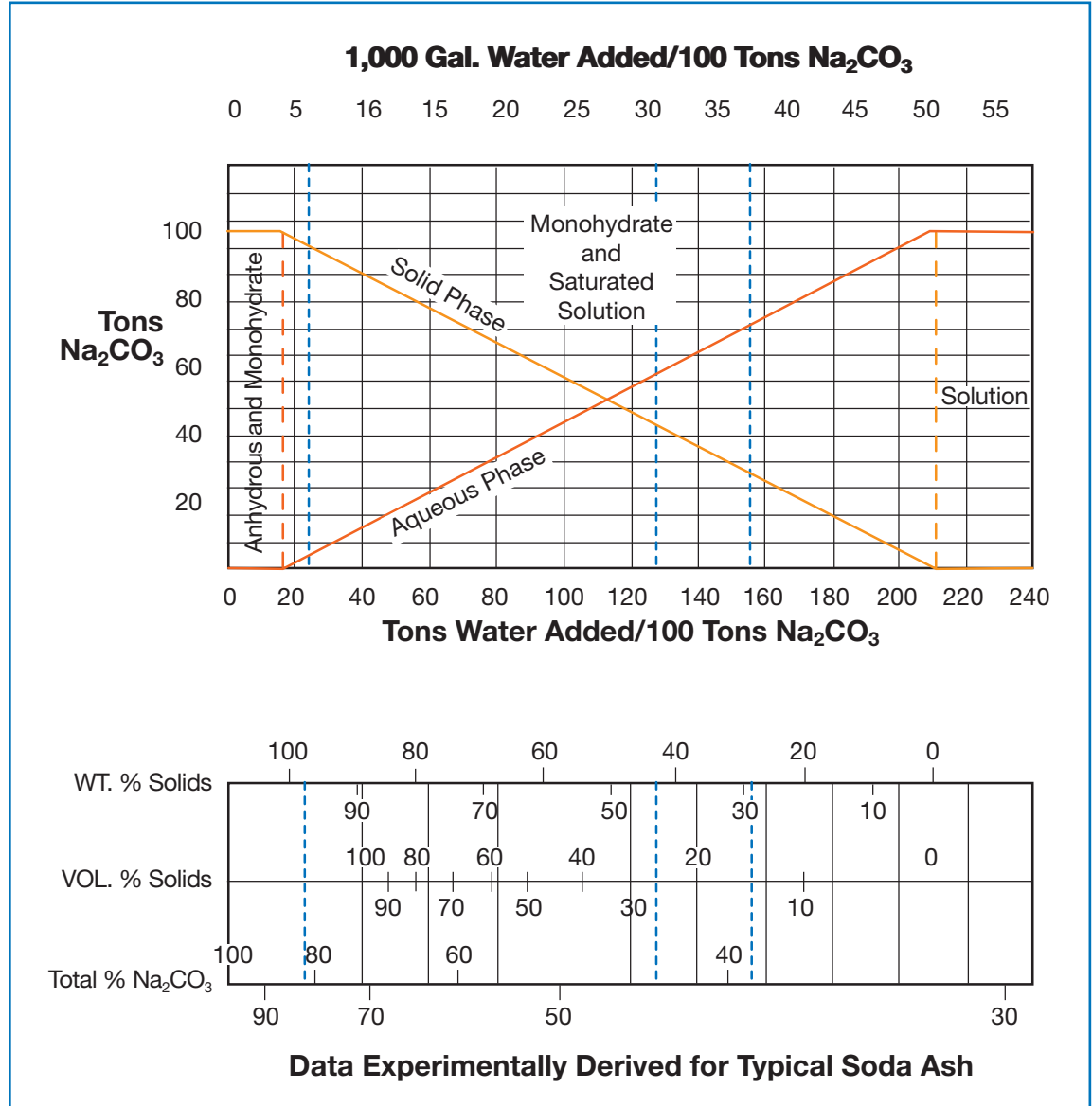
Figure 5: Soda Ash Slurry Concentrations



# Soda Ash

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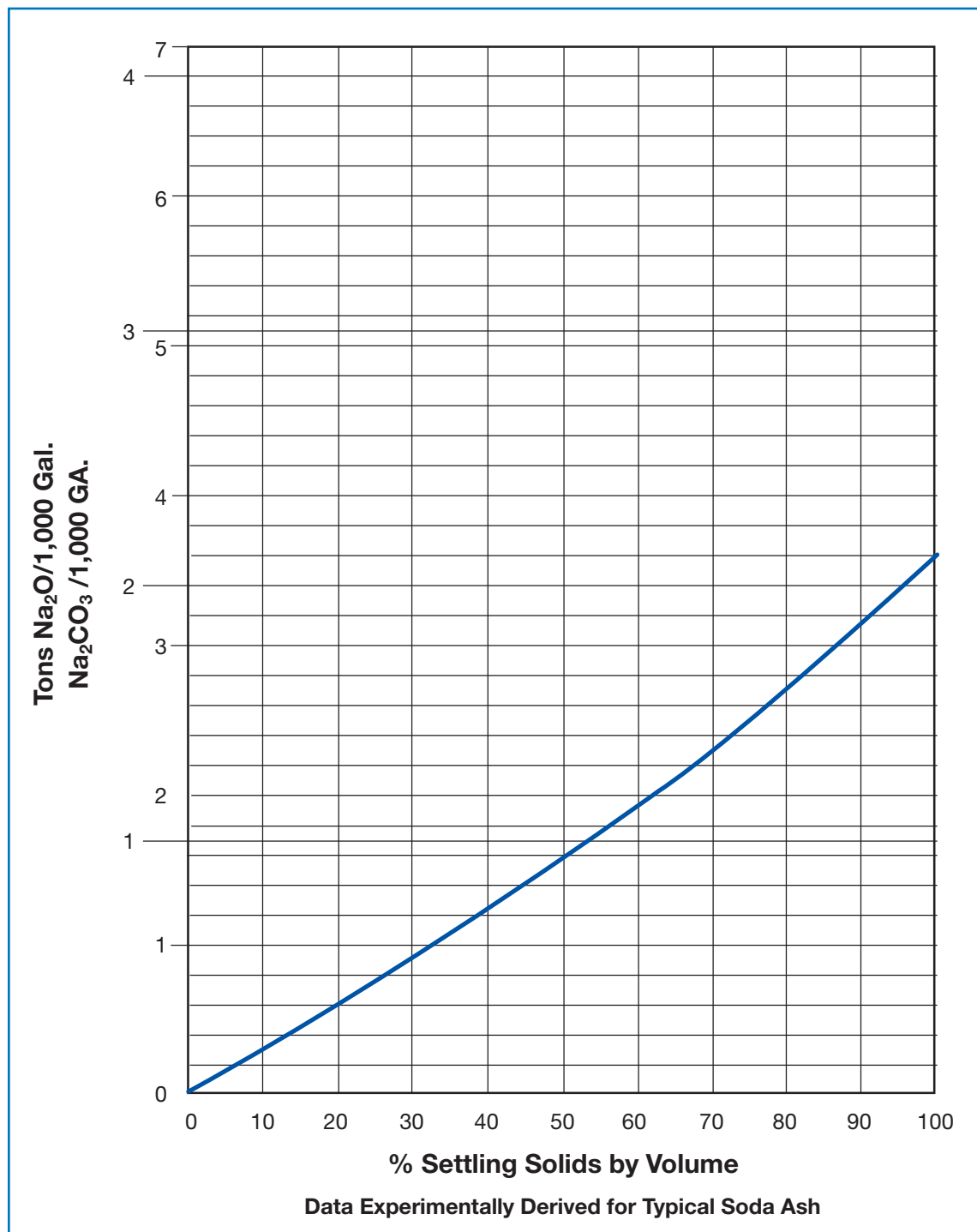
Figure 6: Na<sub>2</sub>CO<sub>3</sub> Content of Soda Ash Slurries



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**Figure 7: Soda Ash Slurry Storage Capacity**

These charts are provided to enable the user to make varying slurry strengths and to calculate soda ash inventories.



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### Physical & Chemical Properties of Soda Ash

#### Technical Data

Chemical Name	Sodium Carbonate, Anhydrous
CAS Name, Number	Disodium Carbonate (497-19-8)
Chemical Formula	Na <sub>2</sub> CO <sub>3</sub>
Molecular Wt.	105.99

#### Physical Properties

Appearance	White Crystal
Density	56-66 lb/ft <sup>3</sup>
Melting Point	1564°F (851°C)
Latent Heat of Fusion	136 BTU/LB.
Specific Heat	.249 BTU/LB./°F

#### Typical Chemical Analysis

Na <sub>2</sub> O, %	58.4
Na <sub>2</sub> CO <sub>3</sub> , %	99.8
Na <sub>2</sub> SO <sub>4</sub> , %	.01
NaCl, %	.03
Fe, ppm	2
Moisture, %	.10

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