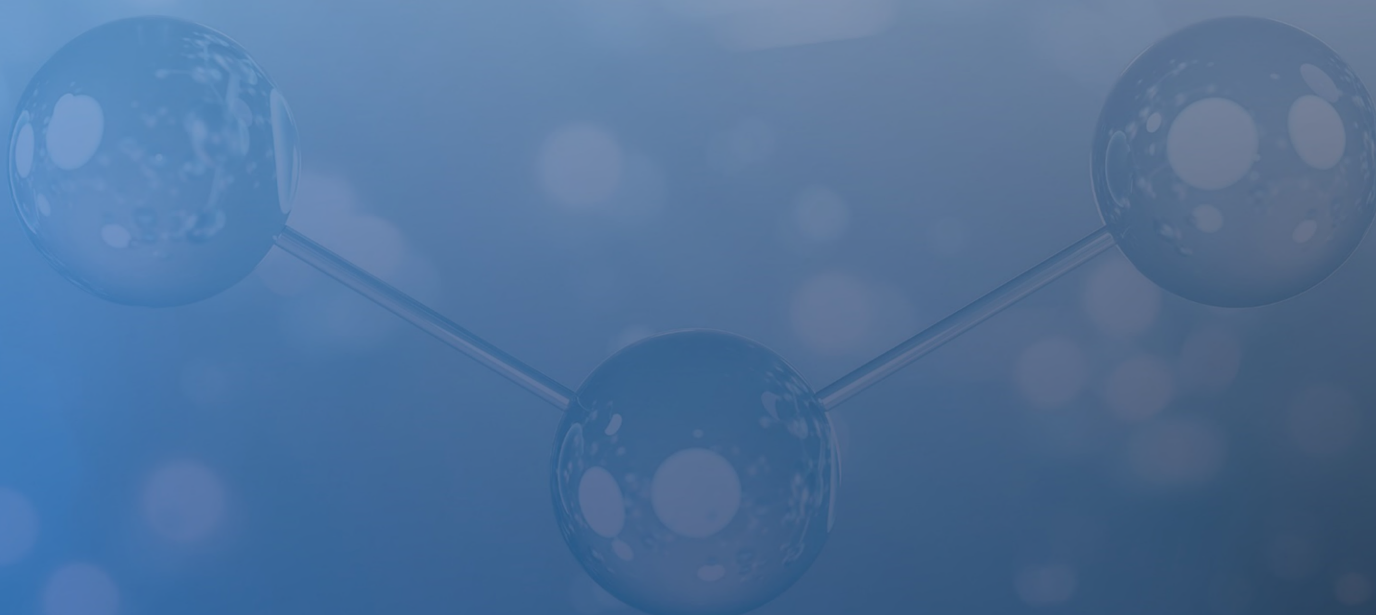
CALCIUM CHLORIDE HANDBOOK



OxyChem®

Occidental Chemical Corporation (OxyChem) is a leading North American manufacturer of calcium chloride, polyvinyl chloride (PVC) resins, chlorine, and caustic soda – key building blocks for a variety of indispensable products such as plastics, pharmaceuticals and water treatment chemicals. Other OxyChem products include caustic potash, chlorinated organics, sodium silicates, and chlorinated isocyanurates. OxyChem's market position is among the top three producers in the United States for the principal products it manufactures and markets. Based in Dallas, Texas, the company has manufacturing facilities in the U.S., Canada, and Latin America.

OxyChem has been an active participant in the American Chemistry Council's Responsible Care® initiative since its inception in 1988. Demonstrating their commitment to attaining the highest levels of safety and environmental achievement, Responsible Care® companies implement world-class management systems, measure performance based on industry-wide metrics, and are subject to review by independent auditors.

Foreword

This handbook outlines recommended methods for handling and storing calcium chloride. It also includes information on the manufacture, physical properties, and safety considerations for calcium chloride. Additional information and contacts can be found on the internet at www.oxycalciumchloride.com.

TABLE OF CONTENTS

INTRODUCTION

Calcium chloride products from OxyChem are refined from natural brines found in sandstone formations underground. OxyChem produces calcium chloride in three forms: liquid, flake, and pellet. Liquid calcium chloride is available in concentrations ranging from 28% to 42%. Specifications sheets for OxyChem's calcium chloride products can be found on our website www.oxycalciumchloride.com.

The largest applications for calcium chloride are:

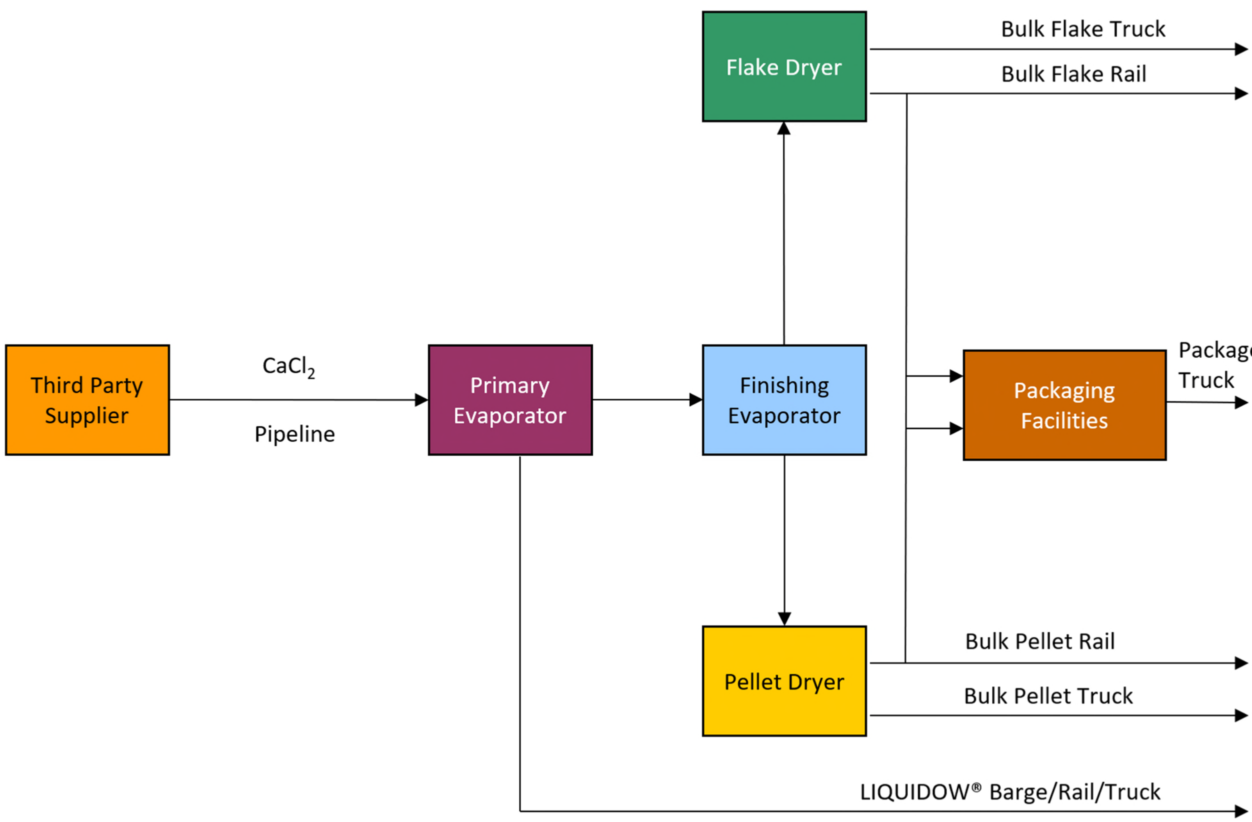
- ice melting for sidewalks, roads, and highways,
- dust suppression on unpaved roads, and
- as a drilling fluid additive.

Smaller calcium chloride applications include the food industry, refrigeration, hydrocarbon dehydration, and concrete acceleration.

MANUFACTURING PROCESS

Calcium chloride is produced by OxyChem using the natural brine process. Aqueous brine is extracted from natural underground deposits by a third-party company. This company adds lime to the brine to precipitate magnesium as magnesium hydroxide, which is removed by filtration and clarification. The remaining calcium chloride-rich brine is transferred via pipeline to OxyChem's Ludington, Michigan facility, where it is concentrated by water evaporation and purified. The concentrated calcium chloride solution is diluted with water to the desired concentration and shipped via bulk truck, railcar, or barge.

To produce solid products, the concentrated brine is fed to a dryer where white, free-flowing pellets or flakes of low water content are produced. After sieving to control particle size distribution, the pellets or flakes are sold in bulk form or transported to a third-party company for packaging and distribution.



SHIPPING METHODS

Liquid calcium chloride is available from OxyChem in tank trucks, railcars, and barges. Each form of transportation has its own advantages.

Tank trucks should meet DOT requirements for MC 303, 304, 306, 307, 311 or 312. Recommended materials of construction are lined carbon steel, lined stainless steel, or aluminum 5454 AL for the shell and 6061 AL for the piping.

OxyChem offers bulk shipments of both pellet and flake calcium chloride in both hopper cars and trucks.

Packaged products are typically shipped via van and flatbed trailers. Available package type, size, and configuration will vary by product.

Calcium chloride is not regulated by the U.S. Department of Transportation (DOT).

SAFE HANDLING

Before handling calcium chloride, personnel should read and understand the latest Safety Data Sheet (SDS). The most recent version of SDSs are available on our website, www.oxycalciumchloride.com. Further, personnel should understand two key properties of calcium chloride:

1. Calcium chloride brines are electrically conductive. Electric shock is possible if energized electrical equipment is handled with hands or fabric gloves that are wet with brine.
2. Calcium chloride has an exothermic heat of solution. Solid products release a large amount of heat when dissolved in water.

UNLOADING LIQUID CALCIUM CHLORIDE

The configurations of transportation equipment and unloading stations vary on a case-by-case basis. ***It is the sole responsibility of the end user to develop detailed procedures that are safe, effective and in full compliance with applicable regulations.*** An overview of important considerations is provided below.

Precautions

- Only responsible and professionally trained personnel should unload liquid calcium chloride. Unloading operations should be monitored while the railcar or truck is connected.
- Unloading lines should be insulated and heated when used to transfer liquid calcium chloride to storage in cold climates. The preferred method of heating is to provide electric or steam heat tracing around the unloading line, under the insulation.

Unloading Railcars

This section provides precautions for unloading liquid calcium chloride from railcars, considerations for unloading railcars in cold weather, and comments on unloading two ways: 1) via the bottom outlet valve (BOV); or 2) top unloaded through the well line using pad pressure.

Precautions

- A railcar may be sampled from the top manway. Sampling from the bottom unload piping is not recommended. If a railcar has partially frozen and has been thawed, special sampling techniques may be required due to stratified concentrations that may be present.
- Because of inherent shaking and jarring experienced by the railcar and contents during the shipping process, gaskets and joints can loosen up and customers should be cautious of that possibility. If pressure unloading, particular areas to watch are the manway gasket, the bottom flange gasket (when bottom unloading), and the top operator stuffing box gland area for the bottom outlet valve (BOV), if so equipped.
- The top operated bottom outlet valve reach rods can, in rare instances, come detached during transit. There have been reports that these detached rods can be pushed up from a railcar if unloading pressures greater than 30 psig are used.

Handling in Cold Weather

As calcium chloride concentration increases, so does the crystallization temperature (freeze point) of the solution. For example, a 32% calcium chloride solution freezes at -17°F (-27°C), while a 42% calcium chloride solution freezes at 69°F (21°C). Freezing points are provided in Tables 3a and 3b.

Therefore, depending on calcium chloride concentration, partial crystallization may take place in cold weather. To prevent this crystallization, OxyChem recommends ordering a lower calcium chloride concentration during colder weather. For an evaluation of acceptable shipping concentrations during the winter months to your specific location, contact OxyChem Technical Service at calciumchloride@oxy.com or 888-293-2336.

If the ambient temperature is above the crystallization temperature, but product will not flow from the bottom outlet valve (BOV), try applying a steam lance or warm air for a few minutes to BOV and auxiliary valve. See Figure 2.

This uninsulated piping area is prone to freezing. Attempting to force open a frozen valve may result in equipment damage.

All liquid railcars are insulated and fitted with steam coils to allow heating of the product prior to off-loading. If freezing has occurred and steam is available, the following procedure should be used:

1. Vent the railcar – OxyChem recommends opening the railcar manway cover.
2. Connect a steam line to the bottom coil connection pipe. Do not exceed a steam pressure of 15 psig on the jacket. This is to protect the lining from excessive spot heating, which will damage the lining.
3. Connect a condensate return line at the steam condensate outlet pipe. If a condensate return line is not used, the condensate must be disposed of or otherwise utilized in a manner compliant with all environmental regulations.

While using steam to heat railcars, the following precautions must be observed:

- Do not keep steam on while emptying the railcar. Exposing the steam coils without fluid present to dissipate the heat can damage the lining due to local heating.
- Keep the calcium chloride solution temperature well below 170°F (77°C).
- Never attempt to increase product temperature by blowing steam directly into the liquid.

Bottom Unloading – Gravity

Note: See Figure 1 for an example setup for Bottom Unloading using gravity feed to an unloading pump and then to a storage tank.

1. Vent the railcar. OxyChem recommends opening the vent valve and the railcar manway cover. CAUTION: do not attempt to open the manway cover unless it is certain that the railcar is NOT under pressure. Failure to properly vent the sending and/or receiving tanks during liquid transfer can result in rupture or collapse of the tank.
2. Refer to Figure 2. Ensure the internal BOV is closed tightly. If a top operated BOV, the valve rod which operates the BOV has a handle on it which is located at the top of the railcar.
3. Remove the plug from the auxiliary valve, then attach the appropriate fitting and unloading line. A thick-walled, flexible hose is typically used.
4. Check the downstream unloading line to see that all valves are in the proper position for unloading to the storage tank.
5. Open the bottom auxiliary valve, then the internal BOV by either rotating the handle 90° if it is a bottom operated BOV, or by turning the top operator to allow contents to begin flowing by gravity to the pump or tank. If the BOV does not open upon application of light pressure, frozen calcium chloride is possibly present in the bottom of the railcar. Application of steam to the BOV area via a steam lance, or hookup to the heat coils may be necessary. See "Handling in Cold Weather."
6. When the railcar is empty and the discharge pipe has completely drained, close the internal BOV and the auxiliary valve.
7. Disconnect the unloading fittings and hose and install the plug tool tight in the auxiliary valve. Close the manway cover and secure all bolts tool tight. Close the vent valve and install the plug tool tight.
8. Prepare the railcar for return.

Figure 1: Bottom Unloading to Storage

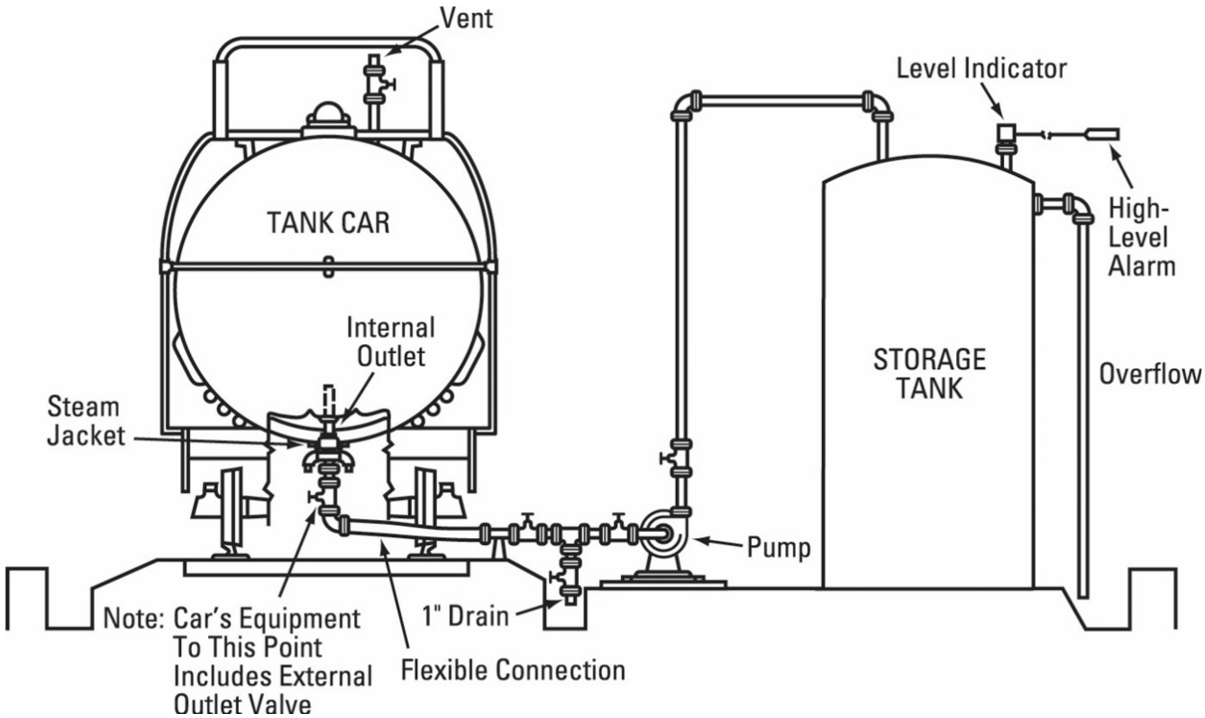
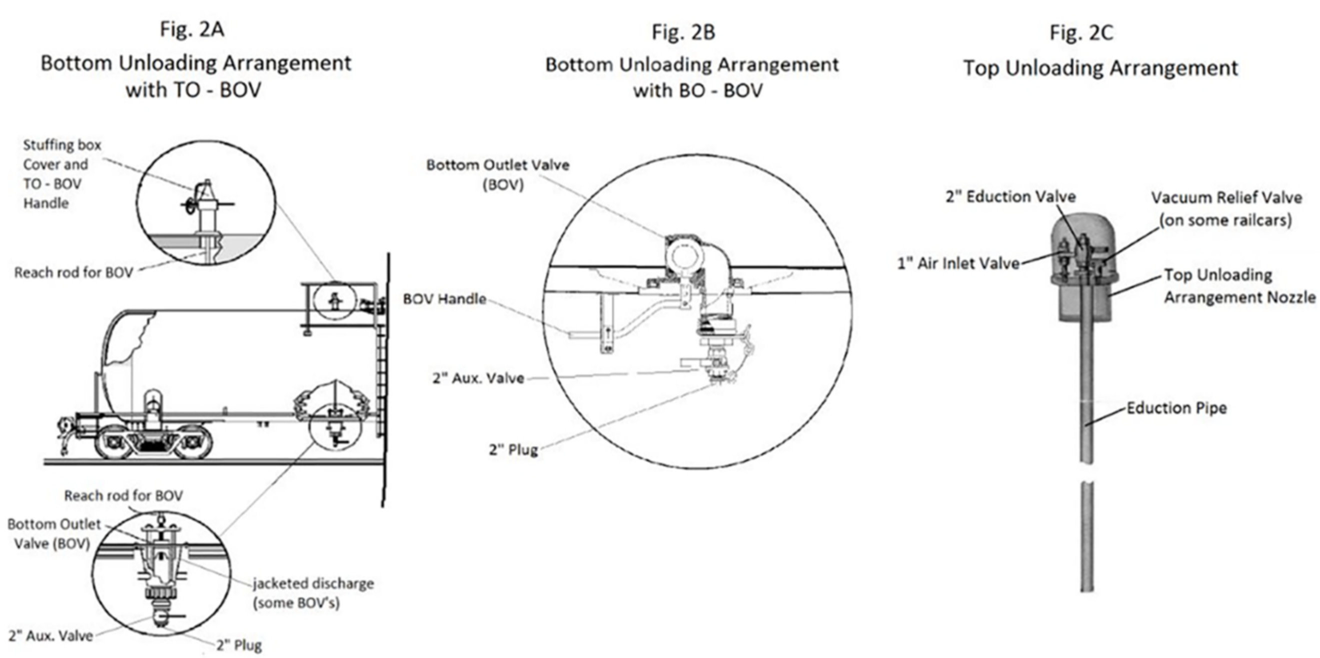


Figure 2: Unloading Arrangements on Railcars



Top Unloading Through the Eduction (Well) Line – Pad Pressure

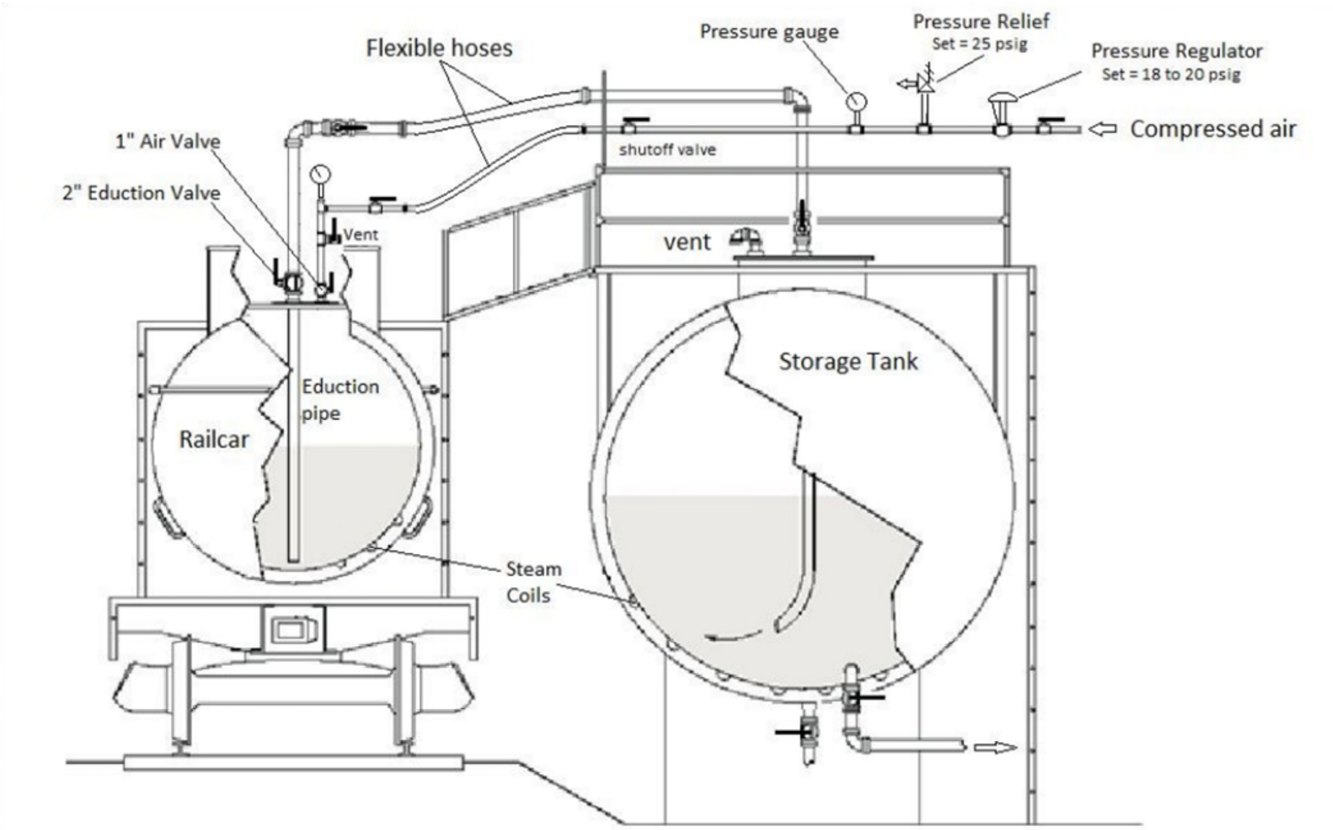
A properly designed and equipped padding system must be used if the railcar will be pad-pressure unloaded. Compressed air is the most common padding gas. Nitrogen can also be used but has the additional hazard of being an asphyxiant gas, thus extra precautions are required. All fittings used for padding a railcar should be inspected for defects before each use.

The air supply system should be oil free, have a pressure relief valve set at 25 psig and a pressure regulator set at 18 to 20 psig. The removable connection piping used on the railcar vent valve should also have a pressure gauge, a release (vent) valve and a shut-off valve.

See Figure 3 for an example set up for top unloading to a storage tank.

1. Refer to Figure 2C. Open the housing cover protecting the top unloading valves.
2. Remove the plug from the vent valve and connect the air supply piping and flexible hose to it.
3. Open the eduction valve and any other valves necessary to the storage tank.
4. Open the vent valve and apply air pressure slowly to the railcar until there is a normal flow of liquid to the storage tank. The pressure should be maintained until the railcar is completely empty. OxyChem recommends use of 20-25 psig max. A drop in air pressure or the sound of air rushing through the unloading line indicates that the railcar is empty.
5. When the railcar is empty, shut off the air supply to the railcar and allow the residual air pad to vent from the railcar either through the unloading line or through the vent valve on the air system piping – venting the pad from the railcar to a safe location.
6. When the railcar is at atmospheric pressure, close the eduction valve and disconnect the unloading line from the railcar.
7. Close the vent valve and disconnect the air supply from the railcar.
8. If desired, open the manway cover to verify the railcar is empty. Do not enter the railcar to make an inspection.
9. Replace both plugs in their respective valves tool tight and secure the protective housing cover.

Figure 3: Top Unloading to Storage



Preparing an Empty Railcar for Return

1. Ensure the railcar is empty.
2. Ensure both top valves are closed and plugs are installed tool tight. Secure the cover over the valves.
3. Close the manway cover taking care to ensure the gasket does not shift, fold, or fall into the railcar. Ensure all manway cover bolts are tool tight.
4. Disconnect any steam lines used to heat the railcar. Do not place any caps or closures on the railcar steam pipes.
5. Make sure the bottom outlet valve and auxiliary valve are closed, and the plug is installed tool tight.
6. Return the empty railcar promptly in accordance with the shipper's instructions. The shipper's routing directions must be followed in all instances.

Unloading Tank Trucks

Tank trucks may be unloaded by gravity, by customer's unloading pump, by truck-mounted pump or by compressed air.

1. Connect the unloading hose (typically a thick-walled, flexible hose 15 to 30 feet in length) to the discharge outlet on the tank truck.
2. Connect the other end of the unloading hose to the storage tank fill line.
3. Verify all valves to the storage tank are properly set and then open the unloading valves.
4. Start the pump or start pressurizing the tank truck, depending on the type of equipment used.

5. Open the valves on the truck discharge line.
6. Standby until the truck is completely unloaded.
7. If compressed air is used, allow the air to flush out the lines to the storage tank and then close and disconnect the air supply.
8. Close the truck discharge valves and the customer unloading valve.
9. Drain the hose to an appropriate container and disconnect from truck and customer unloading connection points.
10. Reapply any flange cover to cap the customer line.
11. Cap the discharge line and secure both hoses in the carrier tubes or tray.

If unloading is by customer's compressed air, the line used to supply air to the tank truck should be equipped with a pressure reducing valve, a pressure relief valve, a pressure gauge and a block valve. The relief valve should be set at a maximum pressure of 20 psig and the pressure reducing valve should be set at 2 to 3 pounds lower.

UNLOADING BULK FLAKE OR PELLET CALCIUM CHLORIDE

OxyChem offers bulk shipments of both pellet and flake calcium chloride in both railcars and trucks.

Bulk solid calcium chloride can be handled in one of two ways: by pneumatic conveying or mechanical conveying. Calcium chloride transfer equipment should be designed to shield the product from rain and snow. It is recommended the product be transferred in one continuous operation.

In pneumatic transfer, the product is transferred from the bulk container to storage using air. In dry climates, it may be possible to transfer using ambient air. In very humid climates, it is advisable to use clean, dry air to minimize the exposure to moisture. The pneumatic conveying system must be designed to minimize product degradation. Provisions to minimize product degradation must be considered when pneumatic conveying equipment is used frequently.

Mechanical conveying systems may include series of conveyors and elevators to convey product from the bulk container to the storage hopper.

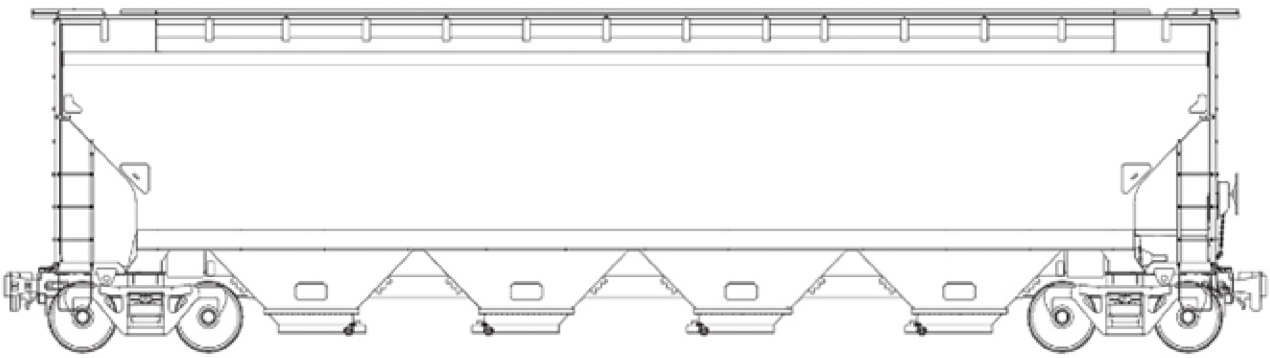
In general, hot-dipped, galvanized, and stainless steels are materials that have been shown to work well for solids-handling equipment operating at ambient temperatures. After formation of a rust-colored surface layer, these materials are typically resistant to generalized corrosion. Stainless steels may not be suitable for handling hot bulk solids (>100°F [>38°C]), since they are susceptible to chloride stress cracking at elevated temperatures.

Unloading Hopper Cars

See Figure 4 for a diagram of a typical hopper car.

1. Spot the hopper car for unloading one compartment. Each hopper car has four compartments (also known as hoppers).
2. Open the bottom hatch of the compartment to be unloaded. Calcium chloride is a free-flowing product which should flow easily.
3. Once the first compartment is completely empty, close the hopper car gate. Spot the hopper car for unloading the next compartment.

Figure 4: Typical Hopper Car Diagram



Troubleshooting Tips

It is recommended to use a pneumatic gate wrench to open the hopper car gates. NEVER use a cheater bar or other similar device to assist in opening the bottom gate, as these are a safety hazard.

Since many bulk commodities tend to compact in transit and may not flow freely at destination, mechanical assistance is sometimes required in unloading hopper cars. Various devices are available that assist in unloading while protecting the hopper car itself. Unloading personnel should be familiar with the various methods in order to prevent damage to the hopper cars.

Vibrators

The most commonly used device to assist unloading is the vibrator. It also is the safest if used correctly. However, vibrators can damage the hopper car's structure if improperly used. There are vibrators that are operated by air, electricity, hydraulic drives, or internal combustion engines. Vibrators are fitted into a bracket or shoe found on the hopper car's side slope sheets. There are two types of vibrators in general use: piston and rotary. Because of the way the loads are applied, the hopper car's structure can tolerate a larger force output from the piston type.

In using a vibrator to help unload a hopper car, the following precautions should be taken:

1. Vibrators should be applied only to the vibrator bracket welded to the outlet slope sheets.
2. They should be used only on the compartment being unloaded and should not be operated continuously – only intermittently to initiate flow.
3. They must be turned off as soon as the compartment is empty. Continued operation may damage the hopper car body since there is no loading to absorb the vibration shock.

There are other, less commonly used methods of unloading, some of which are prohibited. See below.

Poling or Air Lancing

Poles or air lances are frequently used to dislodge hung-up calcium chloride or assist its flow to the outlet area. When the poles or air lances are used in lined hopper cars they should be fitted with rubber or plastic tips and extreme care should be exercised to make sure the hopper car's lining is not damaged. Personnel must consider all safety risks prior to applying efforts to dislodge product and must wear appropriate personal protective equipment.

Pressurization

Because they are not designed to withstand internal pressure, conventional center flow hopper cars cannot be pressurized safely. Pressurization of hopper cars is strictly prohibited.

Sledge Hammering

Using a sledgehammer (or any hammer) on the side of a hopper car to help unloading is strictly prohibited.

Car Shakers

Some unloading facilities will utilize car shakers, which are powerful devices that are affixed to the top or side of the hopper car. These are strictly prohibited as they may damage the hopper car's structure.

Preparing Railcar for Return Trip

Ensure all compartments are empty and any gates or hatches opened during unloading are closed. An unbalanced hopper car cannot be released to the railroad.

STORAGE

Proper storage of calcium chloride involves protecting the product from moisture, as calcium chloride is hygroscopic and deliquescent. This means that calcium chloride absorbs moisture from the air, which can cause clumping, caking, and a decrease in overall calcium chloride assay in solid products. This also means that solid products can absorb enough moisture from the air to become liquid.

When properly stored, the expected shelf life for all calcium chloride products is 36 months.

Bulk Liquid Storage

Materials of Construction

The preferred material of construction for large, liquid-storage tanks is carbon steel with an epoxy-based interior lining and epoxy-based exterior paint. Common stainless steels should not be used for liquid calcium chloride storage because they are subject to chloride stress cracking, even at temperatures as low as 100°F (38°C). Nonmetallic materials, such as fiberglass or plastic, may work well for smaller tanks at near ambient temperatures. The puncture resistance and structural strength of these materials, relative to carbon steel, should be evaluated.

Storage Tanks

Liquid calcium chloride may be stored in either open-top or closed-top tanks. Open-top tanks may be used when dilution either by precipitation or by humid air exposure is not an issue or is managed by mixing the solution. Closed-top storage tanks will remain uniform in concentration for long periods of time without additional mixing.

When periodic mixing is desired, it can be accomplished by pumped recirculation or by mechanical agitation. Air sparging can be used, however, product quality may be affected. Carbon dioxide in the sparging air can react with calcium chloride resulting in a calcium carbonate precipitate.

Tank Cleaning

Liquid calcium chloride tanks should be cleaned periodically to remove any solid deposits from the bottom of the tanks. These solids can come from different sources:

1. Sodium chloride that precipitates as liquid calcium chloride cools
2. Carbonate and sulfate found in the dilution water that precipitates on contact with calcium chloride
3. Carbonate that precipitates when calcium chloride reacts with carbon dioxide in air

Bulk Flake or Pellet Storage

Materials of Construction

The preferred material of construction for large hoppers is carbon steel with an internal epoxy-based lining and an exterior epoxy-based paint. Stainless steels that are resistant to stress cracking are effective for smaller surge hoppers, such as those that provide surge capacity for packaging systems. A rust-colored surface layer forms on the stainless steel; however, generalized corrosion under ambient conditions is typically low. Nonmetallic materials, such as fiberglass and common plastics, will not corrode in a calcium chloride service; however, their structural integrity could be in jeopardy from the heat release associated with dissolving solids if it becomes necessary to wash a large quantity of solids from the vessel.

Storage Hoppers

To prevent caking and clumping problems in storage, the hopper design should minimize product exposure to humid air. If uniform particle-size distribution is important, the design should consider the effects of hopper configuration on particle-size segregation, as sifting occurs while filling a hopper. The fine particles sift through the coarse particles, allowing the fines to concentrate in the center, while the coarse particles roll or slide to the outside. In a poorly designed hopper, solids will empty from the center of the pile while solids on the sides remain stagnant. In a well-designed “mass flow” hopper, all solid move downward together as the hopper is emptied, helping to maintain a more uniform particle-size distribution.

Packaged Product Storage

Packaged solid calcium chloride products come in a variety of package types, including bags, pails, and Flexible Intermediate Bulk Containers (FIBCs). Bags are made of plastic. Pails are made of high-density plastic with snap-on lids. FIBCs have a woven polymer exterior, a plastic liner, and a bottom spout for unloading.

Packaged products are delivered on wooden pallets, and most are either covered with a plastic shroud or stretch-wrapped. Palletized bags covered by an intact plastic shroud may be stored outdoors on a well-drained, asphalt or concrete surface. If the shroud is torn, pierced or removed, the palletized bags should be stored indoors or under a waterproof tarp. Full pallets of bags can typically be stacked three high in a 2-2-1 configuration, with the top row straddling the center line of the first two rows.

Individual bags should be stored indoors in a dry area. Unused bags with a valve-type closure should lie flat so that product presses the valve against the top panel of the bag to maintain a seal. Any package that has been opened, but only partially used, must be tightly resealed to prevent exposure to humid air that may lead to caking and liquid brine formation.

Products packaged in FIBCs are typically not shrouded. Therefore, these packaged products should be stored indoors or under a waterproof tarp. Pallets of FIBCs are typically stacked two high and two wide (2-2).

Palletized pails are stretch-wrapped but not shrouded. Because pails are watertight, they may be stored outdoors without a waterproof covering. Pallets of pails may be stacked three high and two wide (2-2-2).

TECHNICAL DATA

NOTE: The data in the physical properties tables 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 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.

Table 1: Properties of $CaCl_2$ Hydrates

$CaCl_2$ Concentration	$CaCl_2 \cdot 6H_2O$	$CaCl_2 \cdot 4H_2O$	$CaCl_2 \cdot 2H_2O$	$CaCl_2 \cdot H_2O$	$CaCl_2$
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)	29.9	45.3	176	187	773
(°F)	85.8	113.5	349	369	1424
Boiling Point[2] (°C)	-	-	174	183	1935
(°F)	-	-	345	361	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)	50	39	21	32	61.5
(BTU/lb)	90	70	38	58	110.6
Heat of Solution[3] in H_2O (cal/g)	17.2	-14.2	-72.8	-96.8	-176.2
(to infinite dilution) (BTU/lb)	31.0	-25.6	-131.1	-174.3	-317.2
Heat of Formation[3] at 25°C (77°F), kcal/mol	-623.3	-480.3	-335.58	-265.49	-190.10
Heat 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 points for hydrates
2) Temperature when dissociation pressure reaches one atmosphere for hydrates
3) Negative sign means that heat is evolved (process is exothermic)

Figure 5: Phase Diagram for $CaCl_2$-Water System

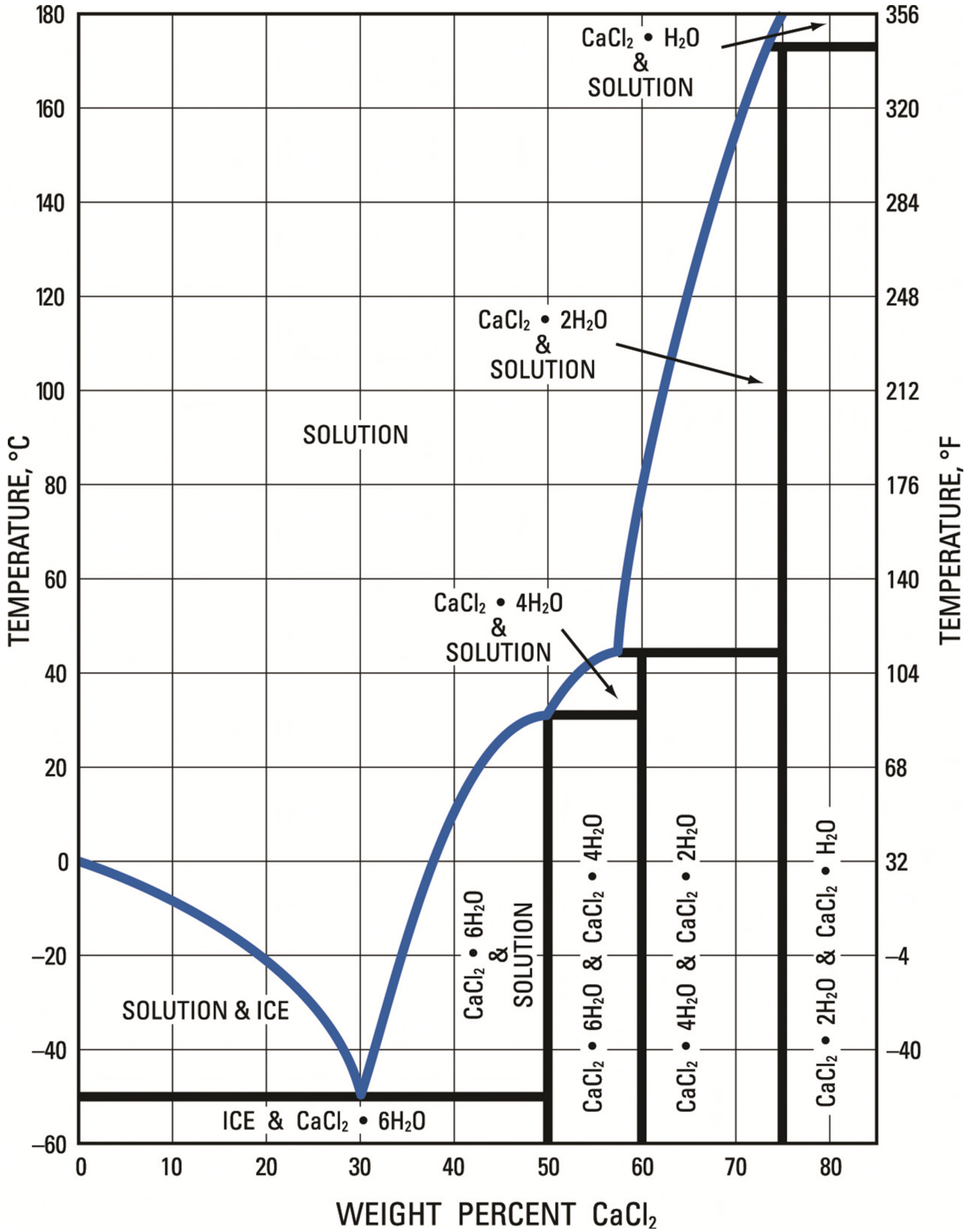


Table 2: Solution Density (lb/gal) at Various Temperatures and Concentrations

% $CaCl_2$	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

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	7,801	28	213
4	1.036	8.62	232	5,800	27	213
5	1.045	8.70	230	4,600	26	213
6	1.054	8.77	228	3,801	25	213
7	1.063	8.85	226	3,230	24	214
8	1.072	8.92	224	2,803	22	214
9	1.081	8.99	222	2,471	21	214
10	1.090	9.07	221	2,205	20	215
11	1.100	9.15	219	1,986	18	215
12	1.110	9.24	217	1,804	16	215
13	1.120	9.32	215	1,651	14	216
14	1.129	9.39	213	1,521	12	216
15	1.139	9.48	211	1,407	10	217
16	1.149	9.56	209	1,307	8	217
17	1.159	9.64	207	1,220	5	218
18	1.169	9.73	206	1,142	2	219
19	1.179	9.81	204	1,073	-1	219
20	1.189	9.89	202	1,011	-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/L)	Liters per 1000 kg Solution	Liters per 1000 kg Dry	Freeze Point (°C)	Boiling Point (°C)
0	1.000	0.997	1,003	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	9,202	-7	102
11	1.100	1.097	912	8,289	-8	102
12	1.110	1.107	904	7,530	-9	102
13	1.120	1.117	896	6,889	-10	102
14	1.129	1.126	888	6,346	-11	102
15	1.139	1.136	881	5,871	-12	103
16	1.149	1.146	873	5,456	-13	103
17	1.159	1.156	865	5,091	-15	103
18	1.169	1.165	858	4,767	-17	104
19	1.179	1.175	851	4,478	-18	104
20	1.189	1.185	844	4,218	-20	105
21	1.199	1.195	837	3,984	-22	105
22	1.209	1.205	830	3,771	-24	106
23	1.219	1.215	823	3,577	-27	106
24	1.228	1.224	817	3,403	-29	107
25	1.240	1.236	809	3,236	-32	107
26	1.251	1.247	802	3,084	-35	108
27	1.263	1.259	794	2,941	-39	108
28	1.275	1.271	787	2,810	-43	109
29	1.287	1.283	779	2,687	-47	110
29.6	1.294	1.290	775	2,619	-51	110
30	1.298	1.294	773	2,576	-47	111
31	1.310	1.306	766	2,470	-37	111
32	1.322	1.318	759	2,371	-27	112
33	1.334	1.330	752	2,278	-20	112
34	1.345	1.341	746	2,193	-12	113
35	1.357	1.353	739	2,112	-7	115
36	1.369	1.365	733	2,035	-1	115
37	1.381	1.377	726	1,963	4	115
38	1.392	1.388	721	1,896	9	116
39	1.404	1.400	714	1,832	13	116
40	1.416	1.412	708	1,771	16	120
41	1.428	1.424	702	1,713	18	121
42	1.439	1.435	697	1,660	21	122

Figure 6: Surface Tension of Pure $CaCl_2$ Solutions

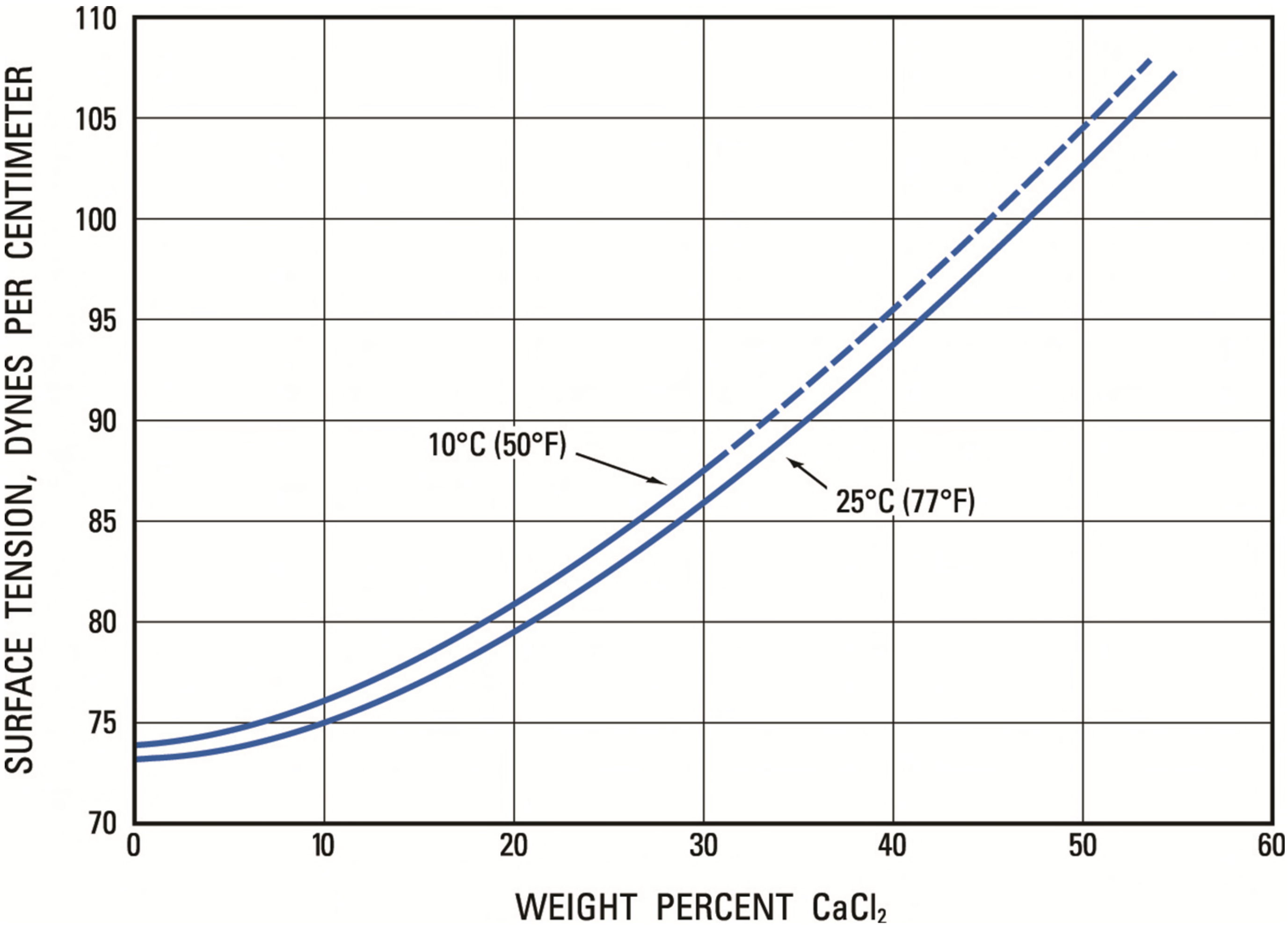


Figure 7: Specific Heat of Aqueous $CaCl_2$ Solutions

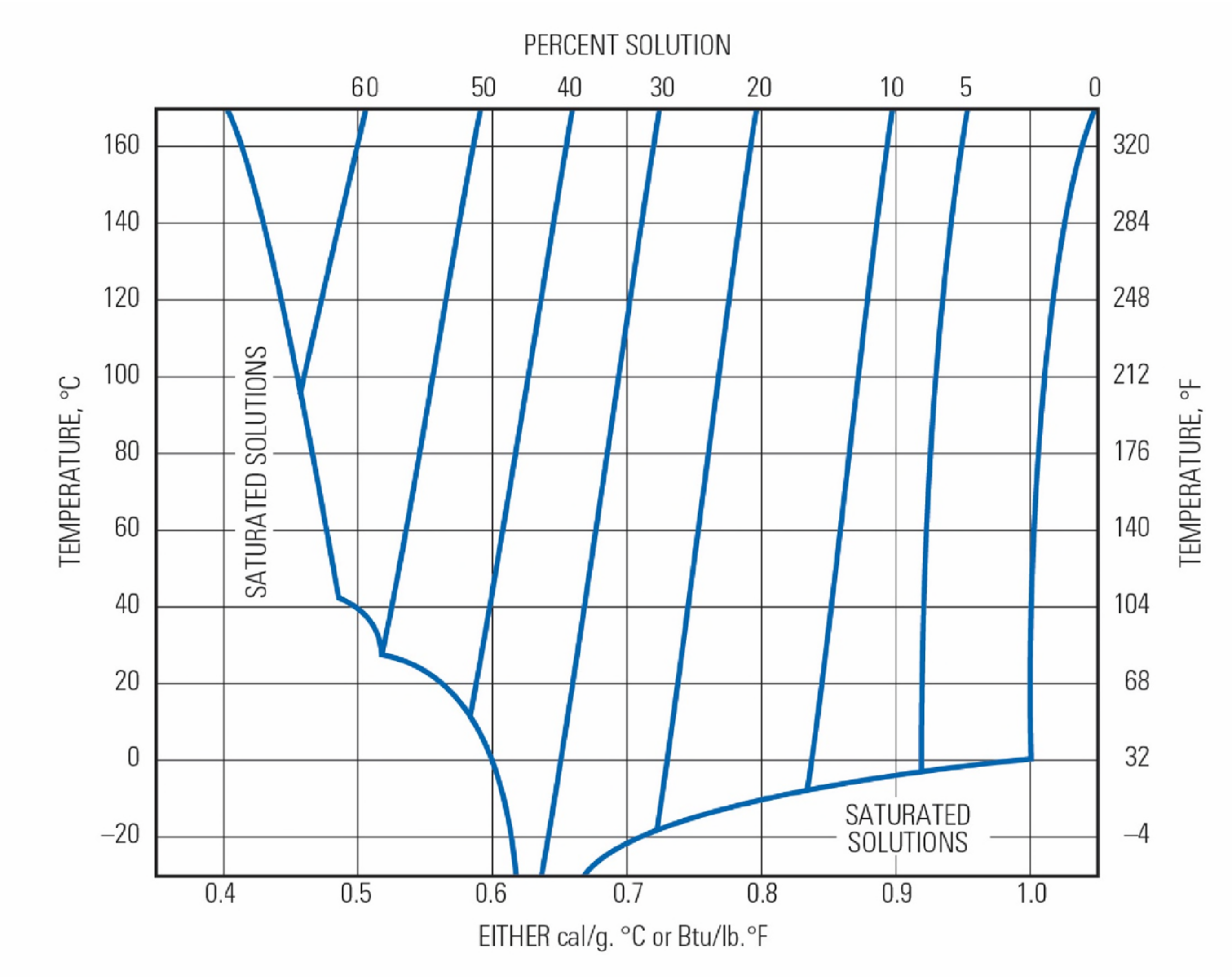


Figure 8: Viscosity of Pure $CaCl_2$ Solutions

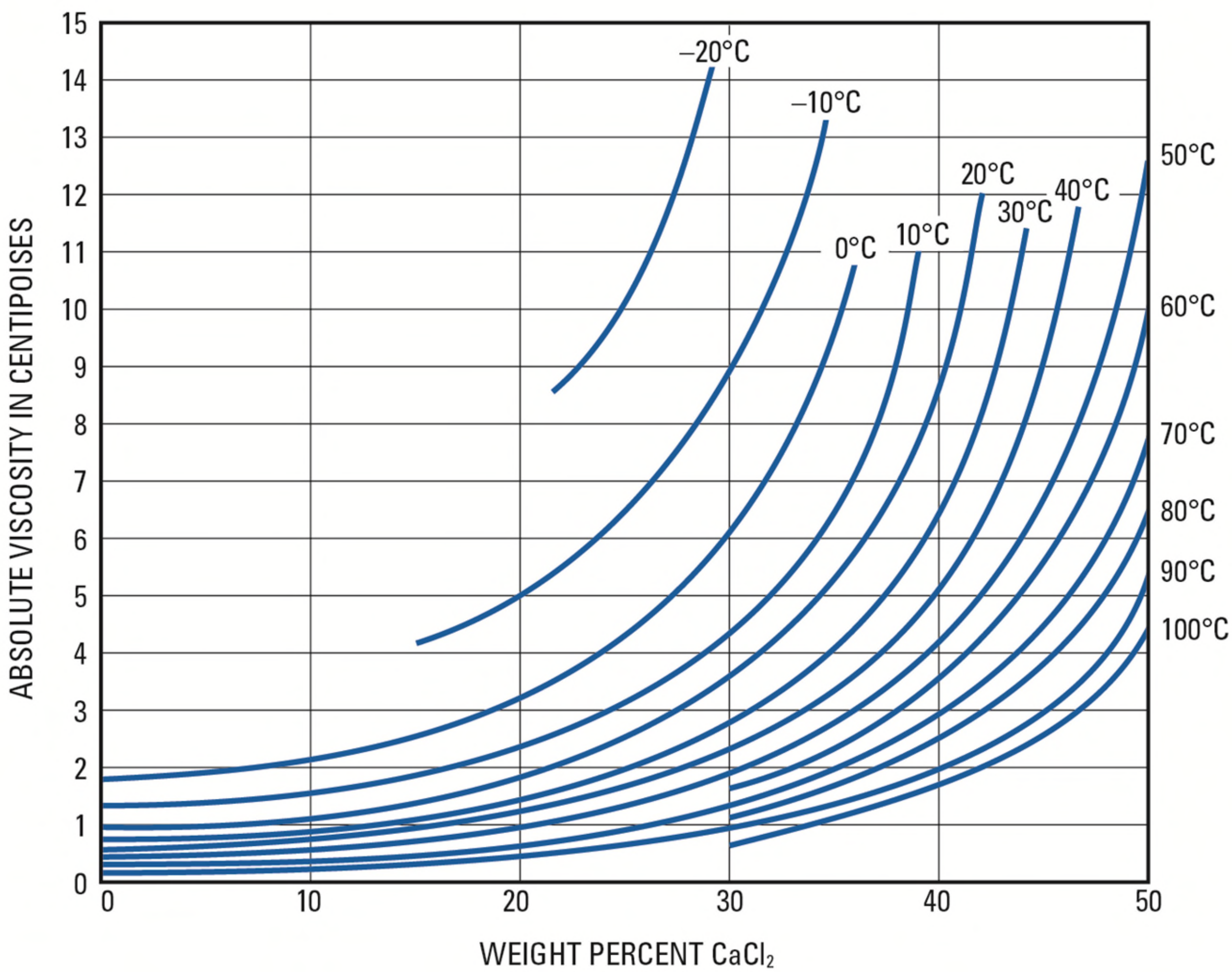


Table 4: Absolute Viscosity in Centipoises of $CaCl_2$ Solutions

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

Moisture Absorption

Calcium chloride is hygroscopic and deliquescent. 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 9 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 85°F (30°C), 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%, 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.

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:

$$Water\ Absorbed = \frac{Start\ \%}{End\ \%} - 1$$

Where:
Water absorbed equals water absorbed per pound of calcium chloride product.
Start percent equals stating concentration of calcium chloride product in decimal form.
End percent equals ending concentration of calcium chloride in decimal form. This is obtained from Figure 9 at the specified humidity and temperature conditions.

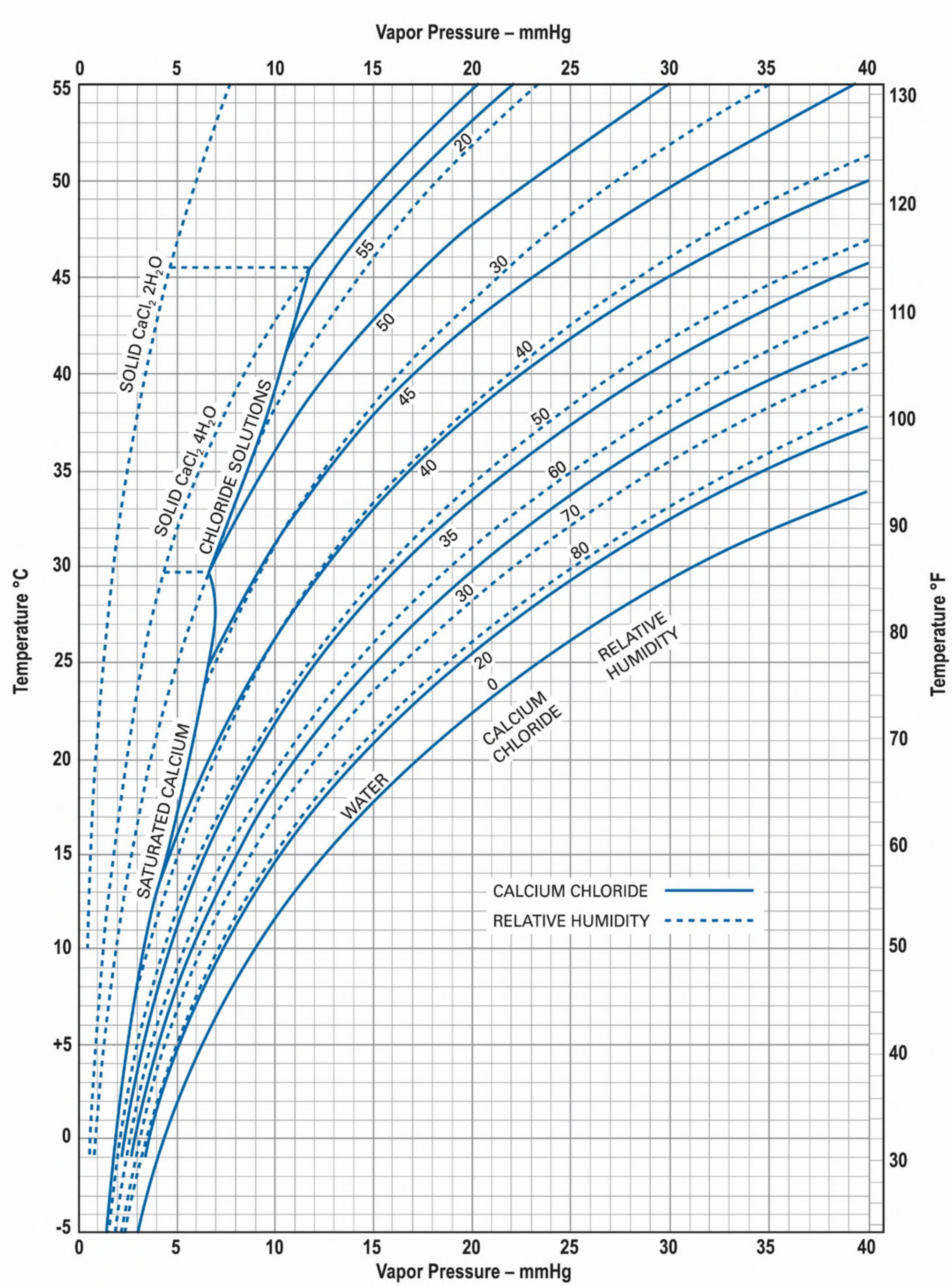
Example: How much water can be absorbed from air by 94% calcium chloride at 77°F and 70 percent relative humidity?

Starting percent = 0.94

From Figure 9, end percent = approximately 0.27

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

Figure 9: Vapor Pressure of $CaCl_2$



CONTACT INFORMATION

Headquarters

14555 Dallas Pkwy, Suite 400
Dallas, Texas 75254
www.oxychem.com

Emergency Numbers

(800) 733-3665

Sales/Technical Service

CalciumChloride@oxy.com

888-293-2336

www.OxyCalciumChloride.com

Customer Service

(800) 752-5151 (Toll Free, answered 24/7/365)

(972) 404-3700

OxySpecialityOrders@oxy.com