Calcium Chloride

A working reference for the people who buy it, mix it and put it on the ground.

Calcium chloride pulls water out of the air, gives off heat as it dissolves, stays liquid to about minus 60 F, and carries density into a brine.

About this handbook

This is a general industry reference for calcium chloride as a material. It is not a product specification. Figures given here are representative of the material as the industry publishes it and will vary by grade and by lot. Certified specifications, certificates of analysis and safety data sheets for product TGI supplies are issued with quotation and with shipment, and those documents govern. Where this handbook and a supplied certificate differ, the certificate is correct.

The material

Calcium chloride is CaCl2, an ionic salt with a molar mass of 110.98 g/mol in the anhydrous form. It is not a performance chemical in the sense that a lubricant additive is. It is a commodity inorganic salt, and its entire commercial value comes from physical behaviour rather than from formulation.

It is sold as the anhydrous salt and as hydrates, and this is the single most common source of confusion on a purchase order. Assay is properly stated as percent CaCl2, not as percent of the hydrate, and the two numbers differ by about a third. Confirm the basis in writing before comparing two quotations.

Form	Molar mass, g/mol	Theoretical CaCl2 content
Anhydrous	110.98	100 percent
Monohydrate	129.0	86.0 percent
Dihydrate	147.0	75.5 percent
Tetrahydrate	183.0	60.6 percent
Hexahydrate	219.1	50.7 percent

Arithmetic off the molar masses. A commercial grade sits near, not at, the theoretical value for its hydrate, because free moisture and the balance of other salts move it.

Solubility is high and rises with temperature: roughly 59.5 g per 100 g of water at 0 C and 74.5 g at 20 C, which is about 37 and 43 percent by weight.

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What it does

1. It pulls water out of the air

Calcium chloride begins absorbing atmospheric moisture at a deliquescence relative humidity of about 30 percent at 25 C. Sodium chloride sits at about 75 percent, above ambient humidity for most of the year in most places, and magnesium chloride at about 33 percent. That gap of roughly 45 humidity points against rock salt is the whole story behind dust control, and it is why calcium chloride starts working on a cold dry pavement instead of waiting for traffic to wet it. It is also why it is the most demanding of the three to store.

2. It gives off heat as it dissolves

Dissolution of the anhydrous form releases roughly 83 kJ/mol, about 320 BTU per pound of contained CaCl2. The dihydrate releases far less, roughly 36 BTU per pound, and the hexahydrate absorbs heat rather than releasing it. Sodium chloride's dissolution is mildly endothermic, so it cools the surface it is trying to melt. Calcium chloride warms the brine film it creates. In a mixing tank the same property is a process consideration rather than a benefit, which is where the order of addition rule comes from.

3. It stays liquid to about minus 60 F

Three ions per formula unit depress the freezing point harder than a two-ion salt at equal molar concentration. The calcium chloride and water system reaches a eutectic of about minus 51 C, which is minus 60 F, at roughly 29.8 percent CaCl2.

Salt	Eutectic temperature	At concentration
Calcium chloride	minus 51 C / minus 60 F	about 29.8 percent
Magnesium chloride	about minus 33 C	about 21.6 percent
Sodium chloride	minus 21 C	23.3 percent

Two things the table does not tell you
First, freezing point depression reverses above the eutectic. Below it the solution throws ice; above it the solution throws calcium chloride hexahydrate and the crystallization temperature climbs steeply. Adding more salt past the eutectic raises the freeze point rather than lowering it. Second, the eutectic is a phase boundary, not an operating temperature. Melt rate and dissolution rate degrade well above it, and common winter maintenance practice treats about minus 25 F as the practical working floor.

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4. It carries density into a brine

Clear calcium chloride brines are blended to a target density, which is why the oilfield buys the material by the weight it delivers rather than by the pound of product. Crystallization temperature is the second specification on every brine order, alongside density. A brine that crystallizes in the tubing is a fishing job.

Choosing a form

Form is a handling and economics decision more than a chemistry decision. The material is the same. What changes is who pays for the dissolution step, how it meters, how it stores and how much water you are paying freight on.

Form	What it is	Where it fits
Flake	Thin plates, high surface area	Fast dissolution, tank makeup, anywhere with a mixing vessel
Pellet or prill	Round, dense, free flowing	Mechanical spreaders and augers, penetrating down through a layer
Powder or granular	Fine, for blending	Batch processes that take the material into solution
Liquid	Solution, ready to dose	Receiving sites with tank capacity and no mixing interest

- **Dissolution step:** buying liquid means paying someone else to dissolve it, and paying freight on the water. Buying dry means owning the mixing, the heat and the labour.
- **Freight arithmetic:** one dry truck of 94 percent product carries roughly three times the contained calcium chloride of one tanker of 32 percent solution. The ratio is simply 0.94 divided by 0.32.
- **Metering:** pellet flows and resists bridging. Flake is faster into solution but dustier and more prone to pack.
- **Weight before cube:** dry product weighs out long before it cubes out, at roughly 55 to 65 lb per cubic foot for pellet and 48 to 56 for flake, typical. A carrier quoting by cube quotes wrong.

How to buy it

> **The only honest comparison**
> Comparing a 94 percent calcium chloride pellet against a 47 percent magnesium chloride hexahydrate flake on price per ton is not a comparison. The only defensible basis is delivered cost per pound of contained active: delivered cost per ton, divided by 2,000, divided by the assay expressed as a decimal. Run both quotations through it before you decide anything.

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Product mass required to deliver 1,000 lb of contained CaCl2:

Assay	Product required
94 percent	about 1,064 lb
83 percent	about 1,205 lb
77 percent	about 1,299 lb
38 percent liquid	about 2,632 lb
32 percent liquid	about 3,125 lb

Arithmetic off the assay. The assay figures shown are common commercial reference points, not a statement of what any particular shipment contains.

Put these on the RFQ

- Form, and assay stated on the CaCl2 basis, not the hydrate basis
- Other chlorides, alkalinity as Ca(OH)2, sulfate, water-insoluble matter
- Moisture, particle size and fines content
- pH of a 10 percent solution
- For liquid: weight percent, specific gravity at 60 F, pounds per gallon, crystallization point, suspended solids

Ask which you are being given: a typical analysis describes what a product usually is, a certificate of analysis describes what this lot is. They are not interchangeable, and for a process stream the difference matters.

Making and handling brine

> **Solid into water. Never water onto solid.**
> Charge the water first and get agitation running before the first pound goes in. Feed continuously through a screened hopper or an eductor rather than dumping. Start cool, watch the temperature, and use feed rate as the control. Dissolution heat is real: a fast, unstaged addition can lift a batch by well over a hundred degrees.

Starting material	Yield of 32 percent brine	Water consumed
1 short ton, 94 percent	about 534 gallons	about 465 gallons
1 short ton, 77 percent flake	about 437 gallons	

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- Pounds per gallon is specific gravity times 8.345. Typical actives per gallon run about 3.25 lb at 30 percent, 3.5 at 32 percent, 4.0 at 35 percent and 4.4 at 38 percent. Verify against the density of the grade actually shipped.
- **Hot brine reads low on a hydrometer,** because density falls with temperature. Correct every reading back to the table's reference temperature, typically 60 F. Put the correction on the mixing card, not in a footnote.
- **A tank rated for water is not automatically rated for brine** at roughly 1.32 specific gravity. Check the rating.
- **The tote trap:** standard IBC cages are rated by specific gravity, commonly 1.2 or 1.5. A 32 percent brine at about 1.32 exceeds the lower rating. Confirm before filling, every time.
- **Water chemistry first:** calcium ion drops out with carbonate, bicarbonate, sulfate, phosphate and fluoride. Use low-hardness, low-sulfate, low-bicarbonate makeup water, never co-inject a calcium stream and a sulfate or carbonate stream at a common tee, and jar test before committing a blend.

Storage, handling and materials

Shelf life here is a packaging question, not a chemistry question. Calcium chloride does not decompose or go off. A stated shelf life describes the bag, the liner and the closure. Write the storage specification against how product actually gets ruined, which in order of frequency is roof drips and condensate off overhead lines, slab moisture, wall sweat, forklift damage, and only then ambient humidity through an imperfect closure.

- Moisture uptake costs three things in sequence: assay falls, flow dies, packaging fails.
- Moisture caking and pressure caking look identical on the floor and have different fixes. Establish which one you have before changing anything.
- Air conveyed into a silo must be dry. A humid-morning unload glazes product against the line and the silo wall and bridges the silo a month later. Design bulk dry storage for turnover, not for holding.
- A calcium chloride spill stays wet. Dry sweep or vacuum first, then a damp wipe and rinse to drain. Hosing it makes brine and spreads the problem.

Materials of construction

Chloride attacks carbon steel, aluminium, zinc and galvanized surfaces, and the austenitic stainless grades are vulnerable to pitting and to chloride stress corrosion cracking, with risk rising sharply with temperature. FRP, HDPE, polypropylene, PVC, PVDF, rubber-lined and properly coated steel are the common answers.

> **The honest position on corrosion**
> Corrosion is dose driven. Total chloride delivered and dwell time set the outcome far more than the choice between one chloride salt and another. The defensible argument for calcium chloride is working temperature and the fact that a lower application rate can deliver the same result, not an inherently lower corrosivity. Treat any claim to the contrary with suspicion, including one made in your favour.

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Exposure

Conventional practice at a mixing or transfer station is eye protection, gloves and covered skin. The mechanism worth knowing: solid product trapped against wet skin hydrates in place and releases heat, which is why the injuries happen under a glove cuff or a boot top rather than on an open hand. Brush dry solid off before flushing. First aid, exposure limits and disposal are governed by the safety data sheet for the grade supplied, and that document, not this one, is the authority.

Applications

Oilfield: completion brines and drilling fluids

Calcium chloride is blended into clear completion and workover brines to a target density, alone or in combination with other salts. Above the calcium chloride range the density ladder steps into bromides and the cost changes by an order of magnitude, which is why the top of this range is a commercially important place to be. In invert emulsion muds the internal brine phase is tuned so there is no osmotic driving force into a reactive shale. Specify density and crystallization temperature together, every time.

Dust control and road stabilization

On unpaved roads, haul roads, lease roads and yards, calcium chloride holds moisture in the running surface long after untreated aggregate has dried. The damp surface binds fines instead of losing them, which reduces aggregate replacement, blading frequency and airborne dust. Demand runs May through September.

De-icing and anti-icing

Three modes: direct dry application, liquid applied ahead of an event as anti-icing, and pre-wetting rock salt at the spinner. Pre-wetting is the one worth understanding, because it reframes calcium chloride from a competitor of rock salt into an enabler of it. The rock salt supplies cheap bulk chloride, the calcium chloride brine supplies the initial liquid film that gets the reaction started and keeps the spread on the road instead of in the ditch. Use your own rate sheet for application rates.

> **Say this to your crews**
> Heavy application in humid conditions above freezing can leave a slick film on pavement. This is a known behaviour of the material, not a product fault, and it is why experienced crews hold calcium chloride for genuinely cold events and reach for something else at the margins.

Public winter maintenance contracts are generally bid in late spring and summer for the following winter. If you are reading this in April, next winter is bought in June.

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Cement and concrete

As a set accelerator, calcium chloride shortens set time and builds early strength in cold-weather placement, where ambient temperature would otherwise stall the pour and hold up the schedule.

> **Where a chloride accelerator does not belong**
> Long-settled industry practice excludes chloride accelerators from prestressed concrete, from concrete containing embedded aluminium or galvanized steel, from work on permanent galvanized metal deck forms, and from any placement where the project specification sets a chloride ion ceiling. The ceiling itself is the project specification's to set. Worth stating plainly as well: at accelerator doses calcium chloride is not antifreeze and does not protect fresh concrete from freezing. Where chloride is excluded, non-chloride accelerators are an established product family and an appropriate substitution.

Refrigeration and secondary coolant loops

Calcium chloride brine is a long-standing secondary coolant. Field control is specific gravity by hydrometer, corrected for temperature, checked on a schedule, because dilution is cumulative and nobody notices it happening. The counterintuitive failure mode is worth repeating: adding salt past the eutectic raises the freeze point rather than lowering it.

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Supply

TGI supplies calcium chloride in every commercial form, flake, pellet, powder and liquid, in bags, bulk bags and supersacks, drums, totes, bulk truck and rail car. Orders start at one ton. Most of this market starts at a full truckload, so a first order does not have to be a commitment.

TGI also runs in-house engineering, specialty fabrication and field services, which means a brine makeup skid, a mixing station or a pneumatic receiving system can be quoted alongside the product rather than sourced separately.

Product specifications, certificates of analysis and safety data sheets are issued with quotation and with shipment.

Also available from TGI

- Glycols, for refrigeration and secondary loop service
- Water treatment chemistry: aluminium sulfate, sodium bisulfite, ferric chloride, sodium hypochlorite, caustic soda and hydrogen peroxide
- Cement, bitumen and construction materials, with logistics
- Drilling, completion and frack fluid systems

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