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Canadian Building Digest

Division of Building Research, National Research Council Canada

CBD 191

Chemicals for Snow and Ice Control Around Buildings

Originally published October 1977.

G.P. Williams

Please note

This publication is a part of a discontinued series and is archived here as an historical reference. Readers should consult design and regulatory experts for guidance on the applicability of the information to current construction practice.

Despite wide use of chemicals to control snow and ice on sidewalks, at store entrances, and on roadways and parking lots, there is much misunderstanding of their proper application. It is the purpose of this Digest to outline the general principles and practice of chemical control for those building superintendents, maintenance engineers, or landscape designers who may not be aware of the technical information available on this subject.

Principles

Common salt and other chemicals used to melt ice do so by lowering the freezing point of water. The amount of ice that will be melted by a given quantity of chemical decreases as the temperature of the mixture is lowered. At a certain limiting "eutectic" temperature, solutions of the salt cannot exist and melting action ceases.

The amount of chemical required to lower the freezing point to the eutectic temperature is called the eutectic concentration. At this temperature the melting rate is very slow. If too much salt is added (i.e., if the concentration is greater than the eutectic concentration), salt crystals will be precipitated with no further lowering of the melting point. Thus, too much salt is a waste, decreasing the efficiency of ice melting by chemical action.

The heat required to melt ice is obtained from the air and from the pavement under an ice or snow cover. When a chemical is first added to ice, the removal of the heat required for melting lowers the temperature of the mixture of ice and water until it is equal to that of the concentration of the salt solution. As more ice melts, however, the salt concentration is reduced and the equilibrium temperature increases (i.e., the freezing point is raised). Melting of ice by the addition of chemicals, therefore, causes an initial decrease of temperature, followed by a gradual increase as the ice melts.

The melting action of chemicals is complicated by the fact that some salt solutions produce heat during dissolution and others require it. This heat of dissolution can significantly affect the rate of melting or effectiveness of the chemical. The process is further complicated by

variations in air temperature and whether air temperature is increasing or decreasing at the time of application.

In summary, the practical implications of the basic process of ice melting by chemicals are:

1. Chemicals are effective only down to specific temperature limits that vary with different chemicals.
2. The higher the air temperature the more effective the melting action.
3. To obtain maximum effect, an exactly defined (eutectic) solution is needed. Salt concentrations greater than this waste salt.
4. The temperature of the air and pavement and the type of salt affect rate of melting.

Choice of chemical depends not only on which will be most effective at a given temperature but also on factors such as cost, equipment available for spreading, storage, and possible damage, i.e., corrosive effect. Sodium chloride and calcium chloride have been found to be the most satisfactory chemicals, particularly their availability in bulk at relatively low cost. Their major disadvantage is their potential for corrosion and damage, but with proper use the problems that arise can be kept to a minimum. These commonly used chemicals will be the main subject of this Digest.

Comparison of Sodium Chloride and Calcium Chloride

Sodium chloride (NaCl) is supplied as either coarse rock salt or fine-grained evaporated salt. The fine-grained salt tends to have a faster melting action but it also tends to cake more readily than rock salt. Calcium chloride (CaCl₂) is supplied as either pellets or flakes. Pellets are a more concentrated form and tend to melt ice more rapidly than flakes. Both chemicals can be applied in solution, but in general this has not proved to be either economical or advantageous.

The main differences between the two salts for melting ice are in their effective melting temperatures and heat of dissolution. In practice, NaCl is only effective above about 15°F (-10°C), becoming most effective near the melting point. CaCl₂ is effective to quite low temperatures (-20°F, -29°C), and tends to act more rapidly than NaCl because it releases heat as it goes into solution; in contrast, NaCl requires heat. Calcium chloride is, however, hygroscopic, attracting moisture from the air. Thus, after the pavement is bare it will continue to draw moisture from the air, keeping the surface moist and slippery. In contrast, sodium chloride leaves a dry, salt-covered pavement.

Figure 1 shows the theoretical amount of sodium and calcium chloride needed to melt one square yard of ice one inch thick (about one square metre of ice 2 cm thick). At temperatures near the freezing point (32°F, 0°C) both chemicals can melt several times their weight of ice. Although more CaCl₂ than NaCl is needed at temperatures near freezing, it can effectively melt ice at much lower temperatures. The amounts needed for complete melting of snow and ice become prohibitive at temperatures much below the freezing point of water.

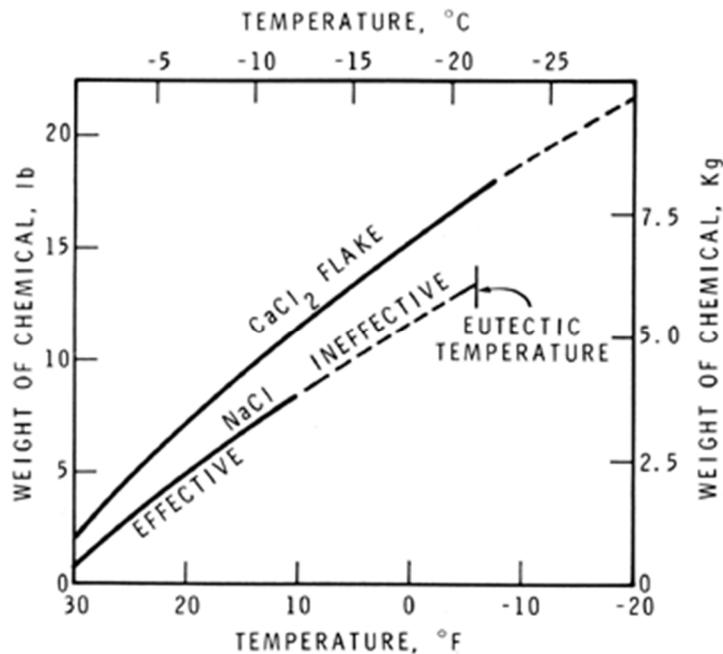


Figure 1. Weight of chemical required to melt 1 sq yd of ice 1 in. thick ($1\text{m}^2 \times 2\text{ cm}$) [Weight of ice 42.5 lb (19.2 kg)].

Mixtures of NaCl and CaCl₂

Mixtures of sodium chloride and calcium chloride are sometimes used together to combine the advantages of each chemical. The calcium chloride component provides more effective melting in colder weather; the sodium chloride component is less costly and requires less chemical at higher temperatures. Mixtures require some preparation. They must be well mixed and dry at the time of mixing to prevent caking and storage problems. Some maintenance organizations recommend a mixture of one part calcium chloride to three parts sodium chloride. If faster melting is required at lower temperatures the amount of calcium chloride can be increased to produce a 1:2 or 1:1 mixture.

CaCl₂ and NaCl Combined with Abrasives

Abrasives alone are often used to improve traction, particularly at low temperatures when chemicals are not very effective. The maximum size of abrasive particles is limited to about 0.5 in. (1.2 mm); the minimum to about 0.1 in. (0.25 mm). The effectiveness of abrasive can be improved by adding either CaCl₂ or NaCl, for the chemicals tend to melt into the surface, preventing particles from being swept away by wind or traffic. Mixing chemicals with abrasives has the added advantage of preventing particles from freezing into lumps during outside covered storage. Mixtures are also cheaper than chemicals alone and make uniform spreading easier because they are more visible. Unfortunately, use of abrasives results in greater spring clean up problems.

The mixing of chemicals and abrasives requires special care, especially if fairly large quantities are involved. About 100 lb (45 kg) of sodium chloride or 50 lb (22.5 kg) of calcium chloride should be added to each cubic yard (about 0.75 m^3) of sand or stone. Additional chemicals can be added at the time of spreading if it is desired to increase the melting action of the mixture.

Application of NaCl and CaCl₂ or Both

It is difficult to give specific rules for the application of these chemicals because so many variables affect the melting process, but general guidelines may be useful:

1. Quite large amounts of chemical are required to melt thick snow or ice covers completely (Figure 1). It is practical only at temperatures near the melting point.
2. Relatively low amounts of chemical are needed to remove thin layers of ice or snow crust or to improve surface traction. There is a wide range of recommended rates, ranging from as low as 1/10 lb/sq yd (50 gm/m²) for thin ice to as high as 1/2 lb/sq yd (250 gm/m²) for thicker ice layers and snow crust.
3. In general, it is good practice to use too little rather than too much salt. Smaller amounts will not completely melt the ice, but they will weaken it and its bond with the pavement, making it easier to break up. The broken, partially melted ice can be removed easily by scraping and shovelling.
4. Greater amounts of de-icing chemicals are needed for sections of pavement shaded from the sun because pavement temperatures here are usually much lower than those for sections exposed to the sun.
5. The most important factor contributing to the success of de-icing chemicals is timing. To prevent the bonding of ice layers to the surface or to facilitate mechanical removal methods, chemicals should be applied before or at the beginning of ice formation or new snowfall. A rate of about 1/10 lb/sq yd (50 gm/m²) or less is adequate.
6. Chemicals do not necessarily facilitate snow and ice removal in sections of pavement subject to drifting snow. The wet surface resulting from melting action can cause snow to stick to the surface, accelerating drift formation. An untreated surface may be kept clear of snow by wind action.
7. Use of CaCl₂ at temperatures below about 0°F (-18°C) is not always beneficial for the surface will tend to remain moist and slippery. A light application of abrasives, or chemicals mixed with abrasives, may prove more satisfactory.
8. Large-scale use of de-icing chemicals requires considerable planning. This includes special precautions in storage and special equipment for spreading. The training of maintenance personnel to ensure proper rate and time of application is especially important.
9. De-icing chemicals should be stored in water-tight containers in a dry location. Storage outside in bulk should be under protective coverings or in special storage bins.

Detrimental Effect of NaCl and CaCl₂

The harmful side effects of chemicals can be reduced by keeping their use to a minimum and by taking certain precautions, some of which are outlined.

Deterioration of Concrete

Most authorities agree that sodium chloride and calcium chloride can cause the deterioration of concrete. If good concrete practices are followed, damage can be kept to a minimum. These include using air-entrained concrete and sealing all cracks. Good surface drainage should be provided and snow and debris cleaned from gutters during the winter. Chemicals should not be used on concrete surfaces that are less than three months old.

Damage to Vegetation and Water Supplies

Most of the damage to vegetation appears to occur where chemicals are applied in large quantities and traffic splashes the brine on roadside vegetation or meltwater runs on lawns. Damage can be reduced by limiting the amount of chemical where vegetation can be affected; by using salt-resistant species (Kentucky 31 fescuegrass, poplar, aspen, elm, oak); and avoiding storage on lawns of snow contaminated with chemicals. Cedar hedges and other plant species easily damaged by exposure to salt should be planted as far as possible from roadways and should not be planted where contaminated surface run-off might collect. New lawns and plants should be planted in the spring at sites where potential damage might occur so that they can become established before being exposed to possible damage.

Damage to potable water supplies from de-icing chemicals will usually only occur where excessive amounts of salt have been applied or poor salt storage practice has been followed.

Corrosion of Metals

Corrosion caused by salt solutions splashed on metal parts of buildings, fences or railings can be reduced by good maintenance practice. This includes the washing down of exposed metal and the application of protective coats of paint and enamel. Special care should be taken in the storage and handling of de-icing chemicals near metal objects, especially inside buildings, because corrosion is accelerated at high temperatures.

Asphalt

No significant effects that can be attributed specifically to de-icing chemicals have been observed for asphalt pavements. It should be appreciated, however, that keeping a pavement surface free of ice and snow by any method, including the use of chemicals, may result in greater thermal stresses, deeper frost penetration, and a greater potential for pavement damage. It is good practice to seal cracks in asphalt pavements to prevent moisture from penetrating to the sub-base. It is not advisable to use chemicals for melting snow from asphalt roofs, particularly where there is metal flashing or metal eavestroughing.

Other Damage

De-icing chemicals tracked into buildings can produce bad stains on some flooring materials and fabrics. Leather also can be damaged. To keep damage to a minimum the chemicals used should be limited where heavy pedestrian traffic occurs. Frequent cleaning and washing of materials affected will remove salt and prevent permanent damage.

Non-Corrosive Chemicals

Non-corrosive chemicals can be used where no corrosive effect can be tolerated. They are, however, much more costly than calcium or sodium chloride and are usually not so effective as de-icing agents. Urea ($\text{NH}_2\text{CO.NH}_2$) is one such chemical that is reasonably effective and has, in addition, some use as a fertilizer. It is not effective below about 20-25°F (eutectic temperature = 12°F), and its unit price is greater than that of the chloride salts. It also requires considerably more salt to produce the same melting action.

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