Using Salt and Sand for Winter Road Maintenance

To make winter roads passable, maintenance personnel usually must either apply chemical deicers to melt ice and snow or spread sand to provide traction. Since chemicals and sand are costly and may have negative environmental impacts, you need to know how they work. This publication gives you basic information and practical tips on how to use deicing chemicals and sand.

Deicing with salt

Plowing is the best way to remove snow and slush from pavements. However, clearing winter roads to bare pavement usually requires deicing chemicals. In Wisconsin the most common chemical is salt (sodium chloride), usually mined rock salt that has been crushed, screened, and treated with an anti-caking agent. Rock salt is relatively light—about one ton per cubic yard—and comes as a mixture ranging from 3/8″ granules to fine crystals.

Deicing chemicals work by lowering the freezing point of water. A 23.3% concentration of salt water will remain liquid to -6°F. Before a dry deicing chemical can act it must dissolve into a brine solution. It uses moisture from water, snow or slush on the road surface.

Changing ice or snow into water also requires heat from the air, the sun, or the pavement. Chemicals only lower the melting temperature; it takes heat to change ice to water. Even when pavement is below freezing, it holds some heat which can help melt snow and ice.

Factors affecting deicing action

Many factors affect the process of melting snow and ice. Decisions on how and when to apply materials are best left to field supervisors and operators who can assess conditions and adjust to changes.

Concentration If too much chemical is used, not all of it will dissolve into solution, and some will be wasted. Too little chemical may not sufficiently lower the solution's freezing point. When salt is dissolved into brine on the road it is near 23% concentration and freezes at -6°F.

As snow and ice melt, the extra water dilutes the solution, raising its freezing point. For example, a 10% salt brine solution will stop melting ice and can refreeze at about 20°F, which may require more salt. The ice will not melt or melted snow may refreeze, wasting the chemical. See page 2 for more on spreading rates.

Temperature
Salt's effectiveness is directly related to the surface temperature of a snow- or ice-covered road. As temperatures go down, the amount of deicer needed to melt a given quantity of ice increases significantly. Figure 1 shows that salt can melt five times as much ice at 30°F as at 20°F. Small differences in pavement temperatures have a noticeable effect. Truck mounted temperature sensors give operators information to make better application decisions.

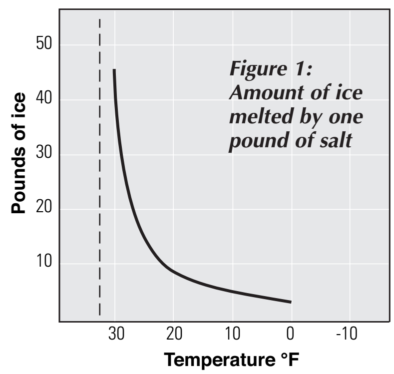

Figure 1: Amount of ice melted by one pound of salt

Time The longer a deicing chemical has to react, the greater the amount of melting. At temperatures above 20°F both salt and calcium chloride can melt ice in a reasonable time. However, at 10°F it takes an hour for salt to melt 1/8″ of ice.

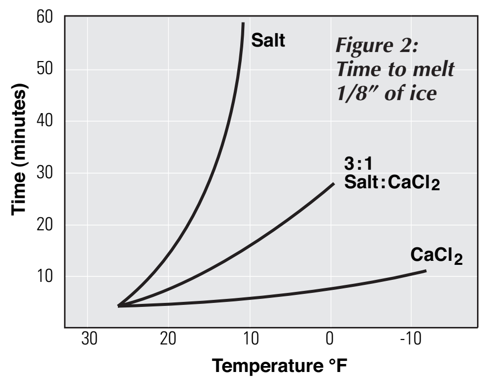

Figure 2: Time to melt 1/8″ of ice

Weather When sun warms the pavement, the heat speeds up melting. Radiant heat may raise pavement temperature 10°F or more above the air temperature. On clear nights, pavements will be colder than the air. Use less chemical when temperatures are rising and more when they are falling.

Applying chemicals during blowing snow and cold temperatures will cause drifting snow to stick to the pavement. If chemicals are not used, the dry snow is more likely to blow off the cold road surface.

Road surface type Snow and ice may melt more rapidly on a concrete surface because it gives up heat more rapidly. Because asphalt absorbs more solar radiation it may have more heat available for melting snow. This is why snow melts rapidly next to bare asphalt pavement areas. Bridges cool down and warm up faster than road surfaces because air reaches both sides of the deck. This can create varying conditions, such as icing on the bridge deck when the adjacent road is clear.

Topography Ice tends to form where topographic conditions, like high banks or dense vegetation, screen the road surface from the sun. The longer the area is shaded, the more likely that ice will form. Since pavement temperatures are lower in shaded areas, you may need more chemicals there. Road cuts may cause snow to drift and blow across the road; the snow will lower pavement temperatures.

Traffic effects Traffic aids deicing by spreading and mixing chemicals into the snow and ice. Tire action also breaks up ice layers weakened by salt and can throw slush off the road. Roads with light traffic can be more difficult to maintain because they lack this mixing and breaking action. However, traffic can also trap blowing snow or can melt snow and cause it to refreeze in the wheel tracks, if not treated again.

Application width Studies show that snow melts faster when salt is applied in narrow strips. The total amount of snow melted over several hours is the same, however, regardless of application width. If you concentrate spreading (windrowing), you can expose a portion of road surface to the sun quickly. It can then absorb heat and speed up the melting rate.

After a road is first plowed, deicing chemicals are usually applied in a windrow 2′-4′ wide down the middle of a two-lane road. To remove glare ice or keep snow in a plowable condition, you may want to apply chemicals across a broader portion of the roadway.

Timing of application Timing is the most important factor in successfully clearing snow by chemical treatment. Early application is critical. Spreading a small amount of chemical deicer when snow is loose and unpacked melts a little snow and turns the rest to slush. Traffic cannot pack down slushy snow which is 15% to 30% water. This lets plows remove it, and plowing is the best way to clear roads. If snow continues to fall, more salt may be needed.

Environmental impact

A major concern in using chemicals for winter road maintenance is environmental impact. Studies show that soils, vegetation, water, highway facilities, and vehicles are all affected, so it is very important to use these chemicals wisely. Most soil and vegetation impacts occur within 60′ of the road and are greatest close to the pavement.

Deicing chemicals are highly soluble and will tend to follow any water flow. Salt concentrations in Wisconsin's surface and ground water have increased since the early 1960s, the Department of Natural Resources reports, but aquatic life has not yet been affected that we know of. In drinking water sources, which the WDNR also monitors, salt concentrations are within recognized safe limits. In some reported cases, groundwater carrying deicing chemicals has contaminated wells and carried heavy salt concentrations into nearby streams.

Deicing chemicals can accelerate deterioration in concrete and steel structures. New construction methods are reducing this impact, but highways and bridges do suffer from chemical damage. Vehicle corrosion is also accelerated. Corrosion on vehicles and structures is estimated to be the largest cost impact of chloride-based chemicals. Even relatively small amounts of chloride will significantly accelerate existing corrosion.

Salt storage requirements

Localized environmental damage from salt has come largely from stockpile runoff due to the effect high concentrations of salt have on exposed environmental elements. For that reason, it is necessary to prevent stockpile runoff from contaminating ground or surface water by covering the salt and storing it on an impermeable base so rain or melt runoff can't seep in.

Wisconsin regulations require highway agencies to store salt inside a covered, waterproof structure. If this is not possible, facilities with stockpiles over 1,000 pounds must be covered with waterproof material, stored on an impermeable pad, and reported to the Wisconsin DOT.

Spreading

Spreading rates No two storms are alike, so no single set of standards will give the proper spreading rate for all storm conditions. Generally, however, only apply enough chemical deicer to permit plows to remove the snow or to melt glare ice. Experience shows it is most

effective to spread 100 to 300 pounds per single lane mile.

Do not use any deicer when temperatures are below its effective range. Normally, the lower limit for salt is 15° to 20°F. If deicing is necessary at lower temperatures, it will take more salt and melting will take much longer (see Figure 2). Alternative chemicals, such as calcium chloride or magnesium chloride, may be a better choice for low pavement temperatures.

Other conditions that affect salt application rates:

- ***Precipitation type*** Additional salt is helpful if the snowfall is heavy and the snow is wet, or if freezing rain is expected.
- ***Snow accumulation*** Roads already covered with snow or ice require more salt.
- ***Time before next application*** If it will be 2 hours or more until the next plowing and salting, the section will probably need extra salt.
- ***Service level*** More salt may be justified on a road with heavy traffic requiring a higher service level than on lower volume roads with slower speeds.

Melting action spreads across the pavement to lower areas, so concentrate deicers on the center (crown) of two lane roads and on the high side of curves.

Chute vs. spreader A spreader with a spinner is the most common way of applying deicers. A spinning circular plate throws the deicer out in a semicircle. Alternatively, a chute applicator can distribute the deicer in a windrow on the road, usually along or near its centerline.

Higher truck speeds will cause the salt to roll and spread further across the road. Tests have shown that a chute will do a better job of keeping salt on the road if spreading speed is 25 MPH or greater.

Spreaders can be equipped with automatic or ground-oriented controls. These adjust application rates to changing truck speeds, so the driver need not alter the spreader settings. They effectively cut waste and are recommended for spreading straight salt.

Spreader calibration It is important to apply the correct amount of salt for the current storm conditions. In order to control application rates, each spreader must be calibrated for each material you intend to use. Different materials will spread at different rates at the same spreader control setting, and individual spreaders, even identical models, can vary widely in how much they spread at the same control setting. Furthermore, spreaders operate in a very hostile environment—low temperature, lots of moisture, corrosive chemicals—so, they need to be cleaned and checked every year.

Alternative chemicals

Salt is the most efficient deicing chemical if road temperatures remain above 20°F. Calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) are common alternatives for use in colder temperatures. Figure 2 shows how effectively $CaCl_2$ melts ice at low temperatures. Since these alternative chemicals cost up to 10 times more than salt, mixing some dry $CaCl_2$ or $MgCl_2$ with dry salt can be an efficient approach.

Figure 2 shows the benefits of a mixture of 3 parts salt to one part $CaCl_2$. These alternative chemicals are effective at road temperatures below 0°F.

Dry calcium chloride and magnesium chloride require special handling. They actually give off heat when they dissolve into brine—a very beneficial characteristic. They also draw moisture from the air, providing water for the initial brine formation. These unique properties make them a valuable tool during severe conditions.

They are usually stored in moisture proof bags until needed. Otherwise their ability to draw moisture can cause the material to cake and form into large chunks.

Pre-wetting

Pre-wetting salt is becoming common. Wetting provides moisture to make brine. Faster melting action may be expected. In addition, the wet salt will be less likely to bounce or be blown off the road by traffic. Savings in lost or wasted salt of 20%-30% are possible.

Common pre-wetting liquids include salt brine, calcium chloride, and magnesium chloride. Some liquid pre-wetting chemicals may contain additives to inhibit corrosion. Applications of 8-10 gallons of liquid per cubic yard of salt are recommended.

Some agencies spray the salt as it is loaded into the truck or pre-treat the salt. However, it is most common to use truck-mounted equipment to spray the salt as it leaves the spreader.

Savings from losing less salt can more than pay for pre-wetting. However, these benefits only result if the operator actually reduces the application rates.

Anti-icing

Anti-icing is a pro-active road maintenance strategy that tries to keep the bond between ice and the pavement surface from forming. It involves applying ice control chemicals before or at the very beginning of a storm.

Using this strategy often reduces the total chemical used and allows a higher level of service to travelers.

The strategy most commonly used now is *deicing*—breaking the bond between the ice and pavement. Obviously, this technique is required once the snow or ice covers the pavement. More chemicals are needed to cut through the ice and break the bond than presumably would be needed to prevent the initial formation of the ice to pavement bond.

Various ice control chemicals are being used for anti-icing including liquid salt, liquid magnesium chloride, liquid calcium chloride, CMA, and potassium acetate. See Wisconsin Transportation Bulletin No. 22, *Pre-wetting and Anti-icing—Techniques for Winter Road Maintenance.*

Abrasives

Sand and other abrasives improve vehicle traction on snow- and ice-covered roads. They can be used at all temperatures and are especially valuable when it is too cold for chemical deicers to work. Abrasives are normally used on gravel roads because chemicals will soften the surface and cause plows to scrape off the gravel. Low volume roads commonly receive only abrasives. Sand is the most common abrasive, but slag, cinders, and bottom ash from power plants are also used.

Abrasive quality Some sand and abrasives perform better than others. For better traction, use material with crushed or angular particles. Rounded particles are less effective. Very small particles and dirt are actually harmful to traction. Material larger than the #50 sieve is most effective. To minimize windshield damage, use materials in which all particles are less than 3/8″ diameter.

Abrasive application Abrasives are usually applied only at hazardous locations such as curves, intersections, railroad crossings, and hills at rates of 500 pounds (0.18 cubic yard) to 2 cubic yards per mile. It is important to calibrate spreaders to control application rates.

Since abrasives must stay on the surface to be effective, they should not be used when they will be covered with snow or blown off quickly by traffic. Heavy traffic reduces their effectiveness, requiring repeat application.

Combining chemicals with sand Treating sand with 50-100 pounds of salt per cubic yard is necessary to prevent freezing and keep it workable. If slag, cinders or other abrasives are wet they also require salt, in the same amount, to be usable. Pre-wetting sand with a liquid deicing chemical just before spreading has proven effective in embedding the abrasive on icy pavements.

Some agencies mix more salt with their abrasive than is needed for freeze-proofing. This practice is often wasteful and ineffective. Blending does not produce a new material. It is still just salt that melts and sand that can aid traction if it stays between the tire and the ice.

In a blend, sand and salt often work against each other. *IF* the goal is for sand to stay on the surface for traction, the salt in the mix either blows off and gets wasted or does its job and melts the snow. However, tires can then push the sand down into the slush, making it ineffective for improving traction. *IF* the goal is for salt in the blend to melt snow and ice so plows can clear the pavement, then the sand gets removed too, wasting it. In addition, salt melts less ice when mixed with sand.

Avoid waste. Use straight salt when it will work best and apply freeze-proofed abrasive when salt is not effective or not needed.

Environmental impacts Abrasives used for winter road maintenance have some negative environmental impact. They can clog storm water inlets and sewers. Cleanup may be necessary in urban areas, on bridge decks, and in ditches. The materials may wash downstream and end up in streams and lakes which can have a negative impact on fish habitat.

Salt mixed with abrasives to keep them unfrozen and usable has the same potential impacts as described earlier. In particular, salt-treated abrasives can accelerate vehicle corrosion.

Documented pollution from particles less than 10 microns (pm 10) has led to concern about the impact of winter abrasive use on air quality. As a result, cleaner abrasives and quicker cleanup after storms are being required in areas with severe air pollution.

Abrasive storage requirements

Wisconsin regulations require that abrasives treated with salt meet certain storage requirements. All salt-treated abrasives must be covered from April 1 to October 1 each year. If the abrasive has more salt than 5% by weight (approximately 140 pounds per cubic yard), it is considered the same as salt and must be covered at all times and stored on an impermeable base.

Salt and abrasive storage facilities holding more than 1,000 pounds must be reported to the Wisconsin DOT which conducts an annual inspection.

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