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Mixing it up in the fight against winter by blending liquid ice control chemicals

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Highway agencies and city streets departments have been using salt for 60 years and have added an array of other deicers to their winter operations arsenal in recent decades. As snowfighting becomes more sophisticated, managers seek to extend the temperature range where they can apply deicers while stretching precious budget dollars.

That salt's effectiveness diminishes with plunging temperatures is universally acknowledged and few agencies regularly use straight salt below 15° F (-9.4° C). The popularity of prewetting salt is due to its effect in reducing bounce and scatter losses by improving salt's stick-to-itiveness on the roadway and speeding conversion of dry salt to hard-working brine. By substituting a "hotter" deicer such as calcium chloride or magnesium chloride for a portion of sodium chloride brine, snowfighting managers hope to extend the effective working range of the salt they apply and avoid having to use abrasives with their attendant problems.

In recent years there has been considerable interest in trying to economize on the use of more expensive "hotter" deicers. Blending salt (sodium chloride) brine with these and other liquid ice control chemicals is thought to be one method of improving economy while maintaining low temperature performance properties. The most common chemical being tried for blending with salt brine is calcium chloride, but magnesium chloride is also used and a myriad of other products that are mixtures of mostly calcium chloride and a number of carbohydrate chemicals.

A survey of online information and a discussion on the University of New Hampshire's Winter Operations Trainers listserv offers some initial insights. The Transportation Research Board's Winter Maintenance Committee has agreed to recommend NCHRP funding for a more definitive investigation.

Little field and laboratory performance data are available. The most common laboratory test method used is ASTM D1177 (Standard Test Method for Freezing Point of

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Aqueous Engine Coolants), or a variant. Here the freezing point of the liquid is determined, while trying to minimize the effects of super cooling.

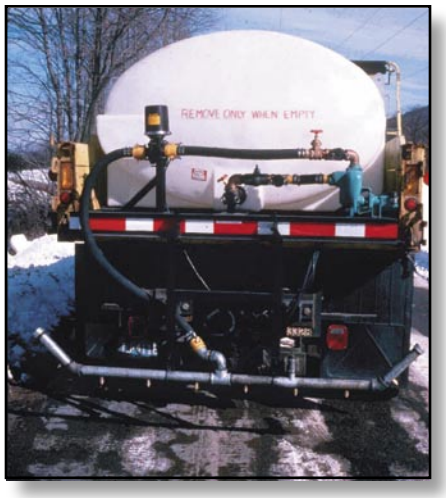
Deicing power, not freeze point depression

Though easy to understand, freeze point depression is probably not the most effective or telling laboratory method to assess the performance characteristics of the blended chemicals. Joe Althouse of Dow Chemical Company suggests that tests for melt volume of ice per unit of chemical at various temperatures would better indicate field performance. He also believes that tests for precipitation, fallout, or crystallization at various temperatures would more clearly represent performance in field storage.

To address the issue of precipitation, crystallization or fallout in liquid ice control chemicals, the Pacific Northwest Snowfighters Association (PNS) regional consortium has developed a test entitled "Percent Total Settleable Solids and Percent Solids Passing on a No. 10 Sieve" test. This test is performed at various "specified" temperatures. As with almost all laboratory performance-indicating tests, for a variety of reasons, this test is **not always** indicative of field performance.

Dr. David Wilkening of Redmond Minerals, Inc. tries to put the science in lay terms:

"To understand the technical side of deicer science, start with a review of 'colligative properties' in a general chemistry text. In a nutshell, the greater the concentration of 'particles' (for salts this is "ions") in solution, the lower the freezing point. The actual science is a bit more complex, as there is something called a 'van't Hoff factor' that enters the calculations of molal concentrations and must be determined empirically. It turns out that due to ionic interactions, the 'functional' number of ions in solution is less than expected; for example, NaCl doesn't give 2 ions per NaCl, but only about 1.9.



"Comparing deicers on a pound/gallon density basis as is commonly done can be misleading as it does not provide a measure of the active species, i.e. the 'ions' in solution. To obtain a working model of deicers, the melting power must be derived from the concentration of deicer in 'molal' units. Molality is calculated as:

(grams of deicer / formula wt. deicer) / kilograms solvent

"For example, a 23% solution of NaCl brine contains 230 grams of NaCl dissolved in 770 grams of water - the molality of this solution is (230/58)/0.77 = 5.15 molal.
A similar calculation for 30% $MgCl_2$ gives a molality of 4.50 – 13% LESS concentrated than NaCl brine! So why does $MgCl_2$ have a higher melting power on a weight basis?

"The answer lies in the fact that $MgCl_2$ contains 3 ions, whereas NaCl has only 2. If we multiply the molal concentration by the number of ions produced we approximate the actual 'deicing power' of each brine as: NaCl = 10.2 vs. $MgCl_2$ = 13.5. Applying this calculation for various deicers provides unexpected insight; for example at *equal 23% concentration* NaCl = 10.2 and $MgCl_2$ = 9.4. This is due to the lower molecular weight of NaCl providing more ions per unit weight. In a practical sense, application rates and effective deicing power are further influenced by solubility and eutectic behavior of the individual products.

"A common misconception is that NaCl brine can be 'enhanced' by addition of $MgCl_2$ or $CaCl_2$. While these chemicals are the most effective at increasing the concentration of ions in solution, the 'enhancement' is actually very small. At the concentrations typically used, the freezing point is only lowered by a degree or two. Another thing to consider is the common ion effect. Adding these brines may lead to precipitation problems."

Our only available field performance data, however, are all subjective or anecdotal – not necessarily invalid, but lacking the credibility of designed and controlled field studies that isolate variables and gather data in a systematic manner that lends itself to statistical analysis.

Mark DeVries of McHenry County (IL) Division of Transportation has been a leader in the blending of ice control chemicals. His goal was to acquire and use a cost-effective liquid ice control product that performed well under a variety of conditions in both the prewetting and direct liquid application. The low cost of using salt brine was an important consideration in product and mixing system development. The final product that is currently in use consists of 85% salt brine (23.3% solution), 5% calcium chloride brine (32% solution) and 10% of a sugar beet syrup (55% solution) and a small amount of anti-foam-

ing agent. McHenry County blends and mixes this product in an innovative in-house-designed and -constructed system that draws the proper amount of the individual constituents from storage tanks and places them into a large storage tank that has circulation capability. This mixture is drawn from this tank on an as-needed basis and circulated regularly.

McHenry County is committed to anti-icing as its primary strategy for winter maintenance. In support of that strategy, liquid ice control chemical mix is applied directly to roads before storms and, depending on storm character, within the storm. Solid salt that is pre-wet with liquid ice control chemical mix is used throughout most storms.

Possibly Effective down to 2° F (-16.7° C)

McHenry County has observed that the liquid mix when used to pre-wet solid salt at the rate of 7 gallons per ton, performs satisfactorily as low as the + 2° F (-16.7° C), pavement temperature range. The county sheriff's office has reported that the County roads are being maintained to a higher standard than prior to anti-icing and liquid chemical mix. Customers (road users and residents) have also provided favorable comments on the improved winter maintenance efforts.

What is the bottom line?

It appears that there is wide interest in enhancing the low temperature deicing effectiveness properties of salt brine. The low cost of salt brine as an ice control chemical makes it very attractive to roadway maintenance agencies. They are seeking ways to use and store this product at lower temperatures. Agencies today routinely stop using straight salt at pavement temperatures of 15° to 20° F (-9.4° to –6.7° C), but there is no guidance for when to cease using salt brine, or any other liquid chemicals, as a prewetting liquid. There is also general agreement that when treating storms using dry or pre-wet salt in the 12° F (-11.1° C), and lower range, one should consider switching to abrasives, plow only, or conduct a benefit/cost analysis on using the large amount of salt necessary to produce a satisfactory result.

Many of these questions will certainly be resolved by the research proposed to TRB. Until these data become available, we will have to continue to experiment with individual blends of salt brine and other products and laboratory performance indicators. There are virtually no true field performance data available. Once we have reliable laboratory tests, we will need to validate them with designed, controlled field experiments. Until we can define more precisely what deicing power is available at various operating temperatures by mixtures of liquid ice control chemicals, snowfighting managers will be well advised to "take with a grain of salt" the theoretical based claims of mixed deicers' working temperature range.

Deadline approaching for 2006 Excellence in Storage Award applications.
May 1, 2006 is the deadline for applications to reach the Salt Institute for this year's Excellence in Storage Award. Over the past 17 years, only 108 facilities have been honored for excellence including 37 honored in 2005 for "continued excellence." If yours is an excellent storage operation, you may want to find out about this recognition program at http://www.saltinstitute.org/40.html and use the application form as a checklist to determine if your program meets state-of-the-art standards of excellence.

Resource materials for snowfighting trainers.
The Salt Institute has a formal partnership with the National LTAP Association. LTAP centers are an FHWA-funded program with at least one center in each state dedicated to transportation technology transfer. NLTAPA has a listserv for winter maintenance trainers (e-mail WinOps.Trainers@lists.unh.edu). Many ideas offered on that listserv are handout materials for use in snowfighter training and these cannot be processed through the host computer at the University of New Hampshire. So the Salt Institute has agreed to provide those additional materials which are found on the Salt Institute website at http://www.saltinstitute.org/snowfighting/winop-resources/winops_resources.html.

BC snowfighters recycle stockpile runoff.
Diluted salt brine captured as runoff from salt storage facilities is being routinely recycled by snowfighting contractors to the British Columbia Ministry of Transportation and Highways, according to the agency's Rob Buchanan. For other storage tips, see the Ministry's website at http://www.env.gov.bc.ca/wat/wq/bmps/roadsalt.html#salt.
OK, we survived last winter. Now's the time to train for next season. The Salt Institute develops winter maintenance training materials in partnership with the National LTAP Association. In 2005, in the US, LTAP trainers conducted 1,434 winter maintenance sessions and trained 30,367 snowfighters. In Canada, the Institute has partnered with

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the Ontario Good Roads Association and the Transportation Association of Canada. Last fall, OGRA alone trained more than 600 snowfighters in 27 sessions and another 136 attended OGRA workshops to learn about salt management planning. TAC has been assisting Quebec's efforts to move snowfighting training into high gear. It's not too early to be planning seminars for this Fall.

Calibration's old hat, right?

Several Midwest state DOTs have created a winter maintenance research consortium, Clear Roads, which is conducting a project on "Calibration Accuracy of Manual and Ground-Speed Control Spreaders." Learn more at http://www.clearroads.org/Calibration%20Project%20Quarterly%20Report%204Q05.pdf. There is no such thing as "set it and forget it."

Will milder winters lessen salt usage?

This was the question dominating discussion at the February 8-9 "Winter Maintenance in a Changing Climate 2006 Symposium" in Ottawa. The conclusion: global warming may bring "milder" winters, but those winters will mean more precipitation with greater numbers of snow-ice events in northern and eastern Ontario (unchanged elsewhere). In northern climates, where "severe" winters meant dropping below freezing in November and not having a thaw until March or April, "milder" winters multiply the freeze-thaw cycle and increase the number of salting events for agencies charged with maintaining roadway safety. The Transportation Association of Canada is producing a "winter severity index" model being developed by Jeff Suggett of Synectics Transportation Consultants Inc., St. Catherines,
Ontario.

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You just enjoyed another electronic ***Salt and Highway Deicing*** Newsletter! It helps you make better decisions in your winter maintenance responsibilities and gives even more information by active links to www.saltinstitute.org <http://www.saltinstitute.org> with specific pages to further snowfighter information. Feel free to forward this newsletter to other interested persons so they can also enjoy this informative free quarterly. Be aware Salt Institute never sells or distributes any of your contact information to any outside source. Please sign up at: http://www.saltinstitute.org/subscribe/index.html