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Deicers: Melting away winter woes

PART I: A STUDY IN THE MELTING EFFECTIVENESS OF SOLID CHEMICAL DEICERS

Cities around the United States use thousands of tons of road deicer to help keep roads safe during winter weather. The cost of these products is very important to cities to minimize road snow-clearing costs. The City of Fort Collins, Colo., was faced with this problem two years ago. Two products on the market advertised similar snow-clearing performance, but the costs between the two were significantly different. Obviously, the less expensive product would save the city money initially — but only if it were as effective as the more expensive product. If not, the city would be better off spending a little more for the more effective deicer. To make an educated decision, the city needed to know which of the two deicers was more effective.

The two products the city was considering were Kansas Rock Salt and Ice Slicer. Kansas Rock Salt is a complex chloride-based product containing mostly sodium chloride, magnesium chloride and calcium chloride. The overall appearance is a gray mixture containing mainly white granules and other black granules. Ice Slicer is also a complex chloride but contains less sodium chloride than Kansas Rock Salt and more calcium chloride. Ice Slicer is reddish in color.

Putting them to the test

The City of Fort Collins contacted Colorado State University to perform melting tests on the two products to discover which would perform best in the laboratory, and hopefully provide insight regarding the products' performance in the field. Researchers chose the SHRP (Strategic Highway Research Program) H-205.1 protocol obtained from the Colorado Department of Transportation Materials Laboratory for the tests.

Following SHRP H-205.1 protocol, researchers studied a sheet of ice of uniform thickness, frozen in a flat, circular Plexiglas dish. After equilibration to the desired temperature, they spread deicer particles over the ice. At 10-minute intervals, they tilted the testing dish to 10 degrees from vertical and collected the brine at the perimeter of the dish with a syringe. Then they measured the brine volumes and reintroduced them to the testing plate. They repeated this process for 60 minutes.

Under control

Following the guidelines of the SHRP H-205.1, mandatory controlled variables include ice composition and thickness, ice surface condition, deicer amount, deicer particle size, deicer and ice temperature, environmental conditions and time allotted for melting.

Ice composition and thickness is controlled by using 260 mL of deionized water, which will correspond with 0.25 inch of ice. Deionized water is used to eliminate trace chemicals and other variables. After the water has frozen, the ice surface is prepared by rotating a 0.50-inch aluminum disk, which is at room temperature, on the surface of the ice for five seconds, melting the surface and creating a smooth, flat testing surface. The uniform surface is achieved by melting the ice for five seconds, which is the point at which a free flowing film of water develops. The water on the surface is then distributed evenly and allowed to refreeze for one hour. The recommended sample size — from the protocol — of solid deicer is 4.17 g +/- 0.005 grams. This sample size results in a larger application rate that is normally used in the field, but is necessary to ensure statistically measurable quantities of brine melt. The uniform particle size for these samples is achieved by passing a standard ASTM #10 (2.0 mm +/- 0.070 mm) sieve and being retained on a standard ASTM #16 sieve (1.18 mm +/- 0.045 mm). A uniform particle size is important to ensure that particle size itself is not the major factor in deicer performance. This particle size was chosen in order to once again ensure statistically measurable quantities of brine melt. The sample of deicer is also acclimated to the testing temperature by placing it in the walk-in freezer for one hour prior to testing. Environmental conditions are kept the same between the two deicers by conducting melting tests at relatively the same time in a walk-in freezer. Finally, the SHRP protocol calls for taking brine measurements every 10 minutes for one hour. Tests can be longer than one hour if researchers are testing for brine refreezing and effectiveness of diluted deicer.

Table 1
AVERAGE BRINE DECANTED FROM SURFACE (mL)

Time (min)	5°F		15°F		25°F	
	ICE	KRS	ICE	KRS	ICE	KRS
10	1.5	1.3	2.9	4.1	6.8	9.9
20	2.2	2.5	5.4	8.6	16.2	20.8
30	2.7	3.2	7.7	12.0	22.0	29.9
40	3.0	3.6	9.3	15.2	25.4	37.5
50	3.2	3.8	10.5	16.8	28.7	43.7
60	3.3	4.0	11.2	18.0	30.4	47.6

Seeing results

Researchers conducted a total of 16 separate tests at three different temperatures: 5°F, 15°F and 25°F. In every test, Kansas Rock Salt (KRS) produced more brine than Ice Slicer (ICE). The average volume of brine decanted from the surfaces of the ice for each temperature are summarized in Table 1 (above).

From these results, it was concluded that the less expensive Kansas Rock Salt is more effective in melting performance than Ice Slicer. The Kansas Rock Salt consistently produced more brine than Ice Slicer in every test, although the difference of volumes may not be statistically significant. This testing does not take into consideration all of the real world factors, including penetration of deicer, sunlight effects, deicer crushing by tires, the relative humidity, pavement types, how well the pavement drains and the type of precipitation. Further laboratory testing is planned, and will include different particle sizes; solid deicers in conjunction with liquid deicers, such as magnesium chloride solution and Caliber M2000; and solid deicer penetration testing. Researchers plan to perform additional tests experimenting with both products on similar road sections with similar traffic conditions this winter.

PART II: CORROSIVE PROPERTIES OF CHEMICAL DEICERS

One major problem public works departments face is the selection of a chemical road deicer product that effectively melts the snow, is cost effective and has low corrosively. Corrosion of vehicles caused by chemical deicers is a problem wherever chemical deicers are used. Many product literature claims lower corrosion without citing actual data from testing. And while it's hard to compare these products to each other, the City of Fort Collins, Colo., rectified this problem by contacting Colorado State University to perform corrosion tests on the two products they use for snow and ice removal to discover which one performs best in the laboratory, and hopefully gain an understanding of the products' corrosiveness in the field.

Composition class

Most chemical deicers are composed of mixtures of complex chlorides. In general, complex chlorides are known to cause corrosion. Their corrosive effects are related to their composition of minerals and ions. In this particular research, the two products tested were Kansas Rock Salt and Ice Slicer. Kansas Rock Salt contains mostly sodium chloride, magnesium chloride and calcium chloride. Ice Slicer is similar in composition but contains less sodium chloride than Kansas Rock Salt and contains more calcium chloride. A chemical analysis of a single grab sample of each product performed by the Soil, Water, and Plant Testing Laboratory at Colorado State University gave the following results of the composition of both Kansas Rock Salt and Ice Slicer. (See Table 2, below.)

Testing the waters

For the corrosion tests, researchers chose to follow the SHRP (Strategic Highway Research Program) H-205.7 protocol obtained from the Colorado Department of Transportation Materials Laboratory. As directed by this protocol, researchers used mild steel test coupons submerged in a standardized solution of chemical deicer and deionized water. The introduced air to the solution by pumps in order to create an environment conducive to natural corrosion. They recorded the testing coupons' masses before and after each exposure time to determine the percentage of the mass lost; this percentage represents the corrosive effect of each deicer. The SHRP protocol allows for different exposure times; researchers chose one-week, two-week, four-week and six-week exposure times.

The standard solutions are 3 percent by weight. The following equation was used to calculate how much deicer is needed for a given amount of deionized water. Variable “X” is the sample mass in grams.

Grams of deicer ÷ grams of solution = % by weight = x ÷ 750g (H_2O) + X

The deicer sample was weighed with an analytical balance to the nearest 0.005 grams. Since Colorado State University was also conducting melting effectiveness studies on the same products using a specific grain size, the same grain sized was used for the test samples in the corrosion tests. The grain size used for this testing was particles passing a standard ASTM #10 (2.0mm +/- 0.070mm) sieve and retained on a standard ASTM #16 sieve (1.18 mm +/- 0.045).

The SHRP protocol goes into great length on the test procedure. This is just a summary of the actual protocol. The tests used a clean 1000 mL beaker filled with 750 mL of deionized water. The deicer sample was thoroughly dissolved in the water. Then researchers measured the pH level while stirring the solution. After these initial steps were taken, they placed a clean divider constructed from Plexiglas into the beaker. This divider segments the beaker into four cells, three of which are used for the exposure of the steel and one that allows air to be pumped into the solution. The test coupons were cleaned with reagent grade acetone and completely dry. After weighing them, researchers suspended the coupons in the deicer solution with nylon fishing line. An air pump with a hose provided a constant supply of air. They maintained the solution levels by refilling them to the proper level everyday with deionized water.

The results are in

As demonstrated in Tables 3 and 4, page 9, and Figure 1, page 9, the difference in percent of metal lost between the Ice Slicer and Kansas Rock Salt is very small and probably statistically insignificant.

Therefore, researchers concluded that Kansas Rock Salt and Ice Slicer are almost identical in corrosion performance. In fact, there is only a difference of 2 to 3 percent between the tests. These findings are not surprising due to their similarity in composition discussed in Table 2.

Researchers are planning further testing on these products that will include changing the particle sizes, adding chemical corrosion inhibitors to the solution and combining liquid and solid deicers together. These tests are planned for fall 2002.

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