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Maine Department of Transportation

Transportation Research Division

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Comparison Tests of Liquid Calcium and Salt Brine: A Controlled Experimental Evaluation of Rock Salt Pre-Wetting Liquids

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Transportation Research Division

Comparison Tests of Liquid Calcium and Salt Brine: A Controlled Experimental Evaluation of Different Pre-Wetting Liquids When Combined with Rock Salt and Salt

Liquid calcium increased the melting rate of rock salt during the initial 5 to 10 minutes of application. This effect, however, decreases at lower temperatures, and, under laboratory conditions salt brine performed as well as liquid calcium at 12^{o}F. At this temperature and concentration (8 gallons of liquid deicer per ton of rock salt) liquid calcium provided no increase in melting ability at all.

Introduction

The Maine Department of Transportation, like other state transportation agencies in the northern U.S., utilizes solid salt to maintain bare pavement condition on its roads and bridges during winter. In recent years more emphasis has been placed on anti-icing and deicing strategies. MDOT has also experimented with liquid deicers. Anti-icing strategies for winter storm treatments include early application of ice-melting chemicals to prevent the bonding (freezing-on) of ice and snow to the pavement. Research has shown that it is more cost-effective to treat the roads early to prevent this bonding. Several studies, including MDOT research in Cumberland & Yarmouth, show that 25-30% less salt (per lane mile) is required to return the roads to a bare condition using anti-icing and deicing strategies. Research has also shown that liquid chemicals such as salt brine and liquid calcium speed up the melting action because water is available to “jump start” the melting action. The mixing of liquid chemicals with solid chemicals has another beneficial effect. This procedure, called pre-wetting, reduces the bounce and scatter of the material as it exits the spreader behind the truck. This serves to keep the solid salt on the pavement and not scattered to the side of the road where it is wasted.

Figure 1. Nozzles Mounted on the Salt Chute

Figure 2. Application Rates are Controlled by these Units

Problem Statement

Several liquids can be used for pre-treating rock salt as it is applied to the roads. The most popular liquids are salt brine and liquid calcium. Some agencies use one or both of these chemicals for pre-wetting. There is, however, a large cost difference between the two. Salt brine can be made for about eight cents per gallon, whereas liquid calcium costs from $0.75-$1.00 per gallon. Traditionally liquid calcium has been used because it is claimed to be more effective at lower temperatures than salt. These claims are due to the different chemical properties of the two liquids. There is no doubt that liquid calcium by itself has superior ice melting abilities due to its chemical nature. At the low concentrations found in prewetted rock salt, however, the benefits are unclear. The goal of this research is to evaluate the use of liquid calcium as a pre-wetting liquid in an effort to determine if there is a performance advantage in the melting action. Other benefits of liquid calcium, however, such as resistance to freezing in the supply lines and pumps were not addressed in this test. The first step in this research was to conduct a controlled laboratory test in order to investigate combined melting effects. It is expected that the next phase of this research may be to conduct field tests in several locations during the winter of 2003-2004.

Laboratory Test of Ice Melting Performance

A testing protocol was developed by the MDOT laboratory that required spreading both pretreated and untreated rock salt on ice blocks in separate aluminum tares (flat containers). The ice blocks were formed by freezing measured amounts of water in each tare (1000 mL). At timed intervals the melt water generated in each of the tares was poured off and weighed. The melted water was returned to the tares so that no salt or calcium was lost from the individual containers; the concentration of the mixture, therefore would only change due to the increased water melted from ice in the individual tare.

Although it was not the intent of this experiment to mimic the conditions of an ice covered highway, some similarities exist. Naturally, the concentration of the deicing chemicals in the tares declined over time as water was generated. This would be similar to what happens on the road as melting snow or ice dilute the salt mixture. In addition, pouring the melted water back onto the tares, might also simulate the mixing action caused by traffic on the highway. It is well known by field crews that mixing by passing traffic enhances the melting action of deicing chemicals.

The research protocol followed in this experiment is quite similar, (though less rigorous), than the procedure developed under the Strategic Highway Research Program for testing the effectiveness of deicing chemicals, (SHRP 205.1). That procedure was used in a published comparison test done at Colorado State University for the City of Fort Collins, where two solid deicing compounds containing complex chloride complexes of sodium chloride, magnesium chloride and calcium chloride were evaluated.

Results

The results of the tests are shown in the following graphs. Figure 3 shows the decline in melting rate in each of the tares at lower temperature.

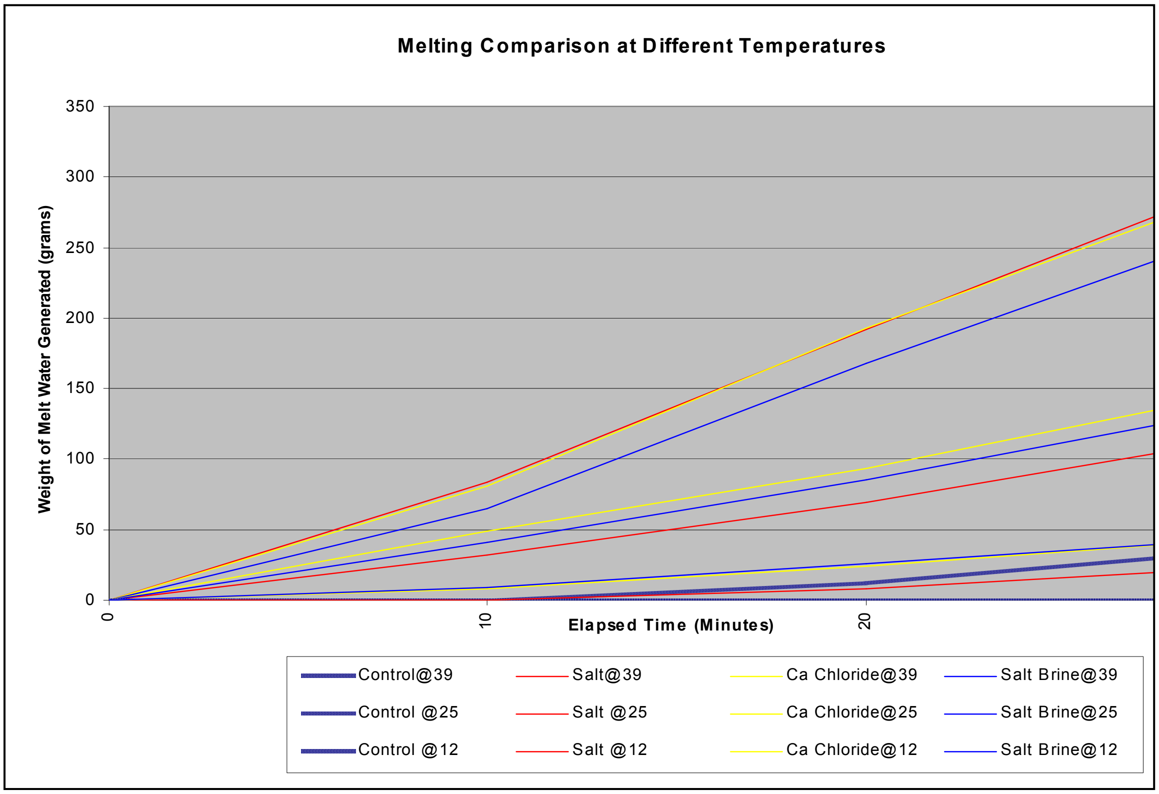
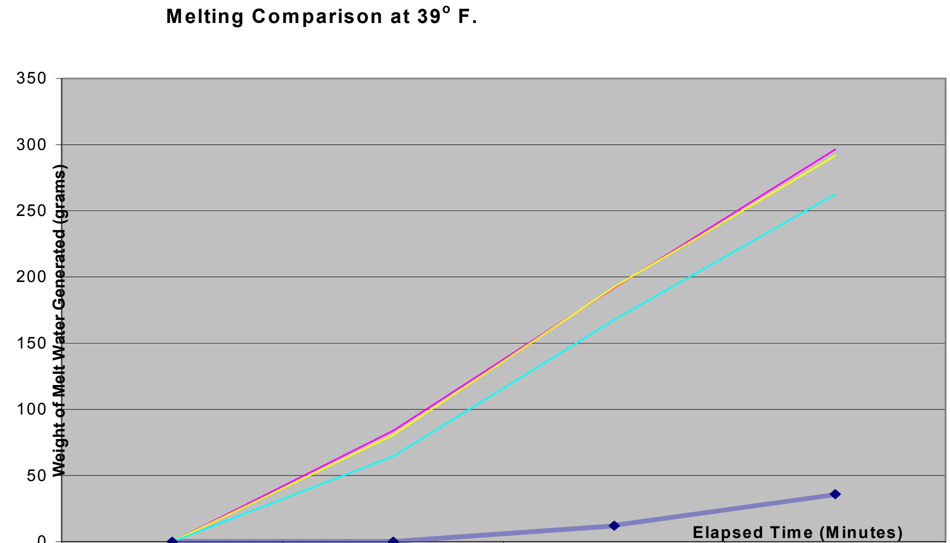


Figure 3

It is apparent from Figure 3. that at 39°F, dry untreated salt works as well as liquid calcium. It was anticipated, however, that salt brine would be as effective as calcium at this temperature. This was not the case. It may have been because there was plenty of water available at this temperature to get the brine action going, and the small amount of additional water only diluted the salt even further making it a little less effective.

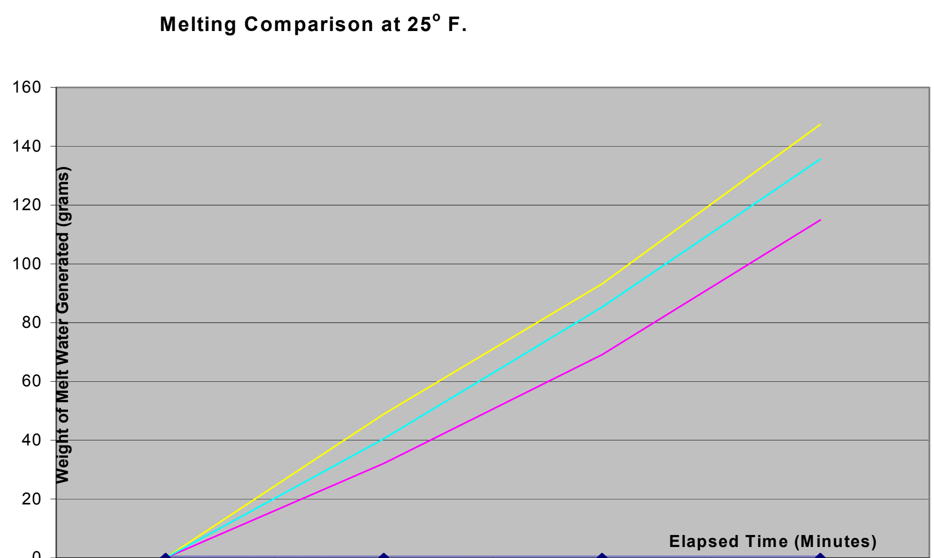
Figure 3 also shows that at 25°F liquid calcium provided additional melting capacity over salt brine. This was not a surprise and is supported by the literature discussing the low temperature effects of liquid calcium. Despite this fact. the lower set of lines in Figure 3. show that at 12°F salt brine worked almost as well as calcium. This was a surprise. It may be that at the concentrations used in this test, the available calcium was not sufficient to generate enough heat to melt effectively. These results are however, consistent with the CSU tests mentioned earlier, in particular, the compound with the higher sodium content worked better than the other compound even though calcium was present in both compounds. The presence of calcium alone didn't necessarily produce better melting effectiveness, in our test or in the CSU study. Figure 3 also shows that the melting effectiveness of the concentrations used in these tests are less than a third as effective at 12°F as at 25°F. At these lower temperatures, it is likely that more calcium will be needed to provide the boost that salt would need to work at all. At least one state agency has recommended application rates up to 10 gallons per yard.

The charts below show the results of these tests in more detail.



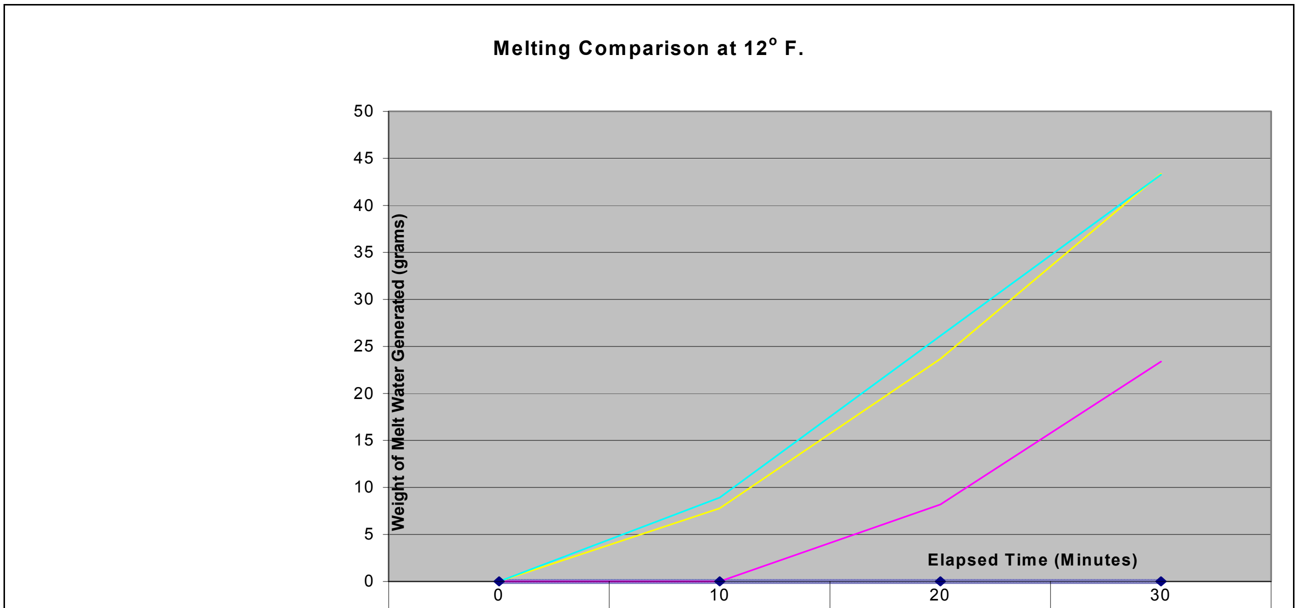
	0	10	20	30
Control	0	0	12.16	35.86
Salt	0	83.89	191.78	296.41
Calcium Chloride (Inhibited for Corrosion)	0	80.7	192.41	291.8
Salt Brine	0	64.48	167.58	262.59

Figure 4.



	0	10	20	30
Control	0	0	0	0
Salt	0	32.11	69.1	114.93
Calcium Chloride (Inhibited for Corrosion)	0	48.92	93.13	147.46
Salt Brine	0	40.48	85.27	135.62

Figure 5.



	0	10	20	30
Control	0	0	0	0
Salt	0	0	8.18	23.38
Calcium Chloride (Inhibited for Corrosion)	0	7.76	23.66	43.37
Salt Brine	0	8.91	26.12	43.25

Figure 6.

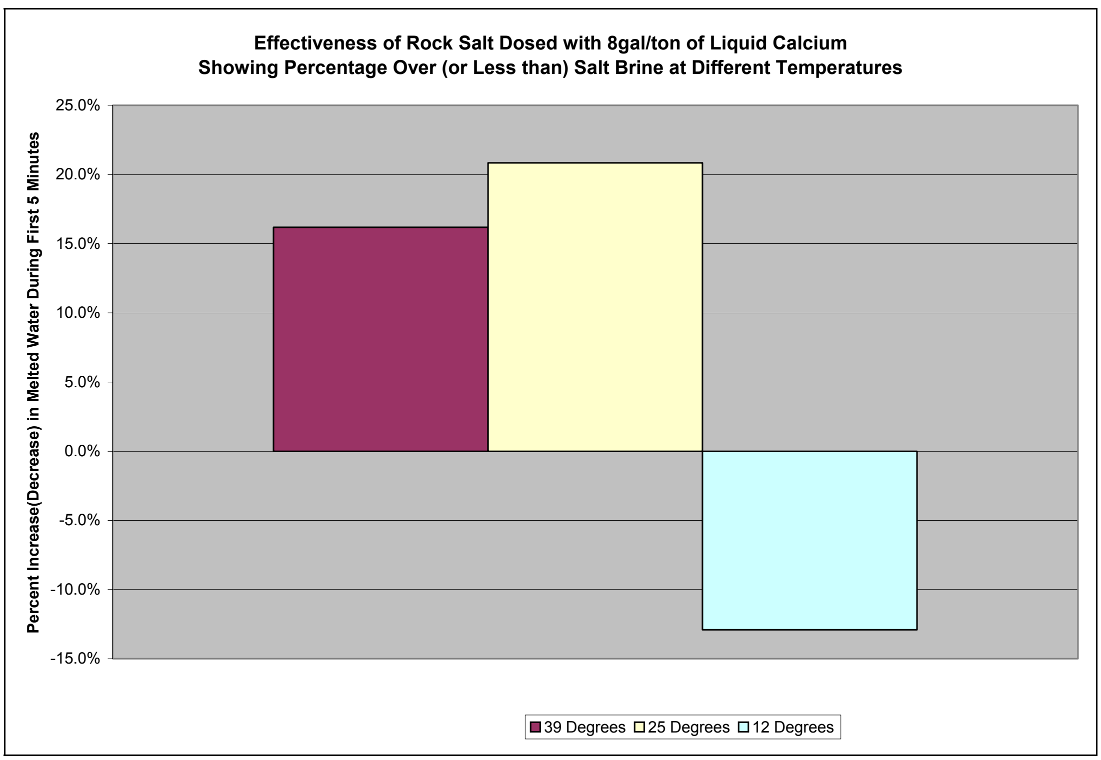


Figure 7.

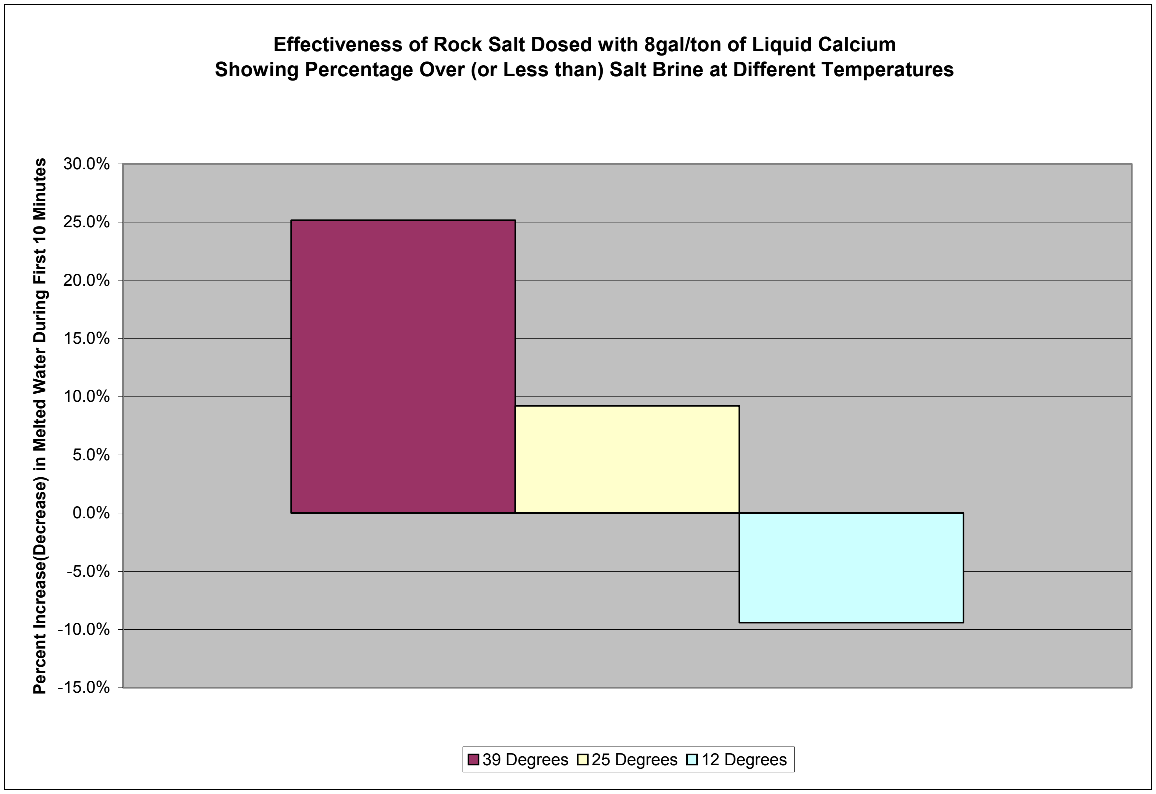


Figure 8.

Photos

The following photographs show the testing procedure.

Figure 9. Salt Applied to Trays of Ice

Figure 10. Water Forming on the Ice

Figure 11. Water Was Decanted from Each Tray


Figure 12. Weight of Water was Recorded at Intervals


Figure 13. Remaining Ice in the Tray Containing Calcium.

Note the broken appearance of the ice; the ice was completely broken up in the tray with liquid calcium.

Figure 14. Remaining Ice in the Tray where Salt Brine was added.

Figure 15. Remaining Ice in the Control Tray (Plain Ice-No Salt Added)

Figure 16. Trays placed in Freezer for $25^{o} \pm$ Test

Figure 17. Pouring Melted Water Back onto Trays

Figure 18. Ice Tray at the End of the Freezer Test

Conclusions

It appears that liquid calcium rapidly encourages melting at 8 gallons per ton, however, at colder temperatures liquid calcium did not help significantly, precisely when it would be expected to perform better than salt brine. Field tests will be conducted during the winter of 2003-04 to extend this research. .

In this experiment liquid calcium did not provide enough increase in performance to justify the additional expense (for routine use), unless the initial gain during the first 5 to 10 minutes is critical. It must be emphasized that this experiment did not investigate the use of straight liquid calcium applied to the roadway. The performance benefits of using a 32 % liquid calcium are well known, and were not investigated here. In addition, past experience during severe ice storms has shown that it is worthwhile to have liquid calcium available to use when needed.

In addition, this experiment did not look at higher rates of calcium applied to salt. At least one state recommends up to 10 gallons of calcium per ton of salt. MDOT has used much higher rates in emergencies. During an ice storm in January 1994, 20 gallons of liquid calcium per yard of salt, and 10 gallons per yard of sand, were applied at the rate of about 1500 lbs. per lane mile to remove a 2 to 4 inch thick ice & snow pack on I-95 in Pittsfield while temperatures were around 0^{o} F. In another case 11 gallons of liquid calcium per ton of rock salt, were placed at 125 lbs. per center lane mile to effectively treat the Caribou Route 1 By-Pass after an ice storm in January 1999. These higher rates of liquid calcium can only be economically justified under severe conditions.

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