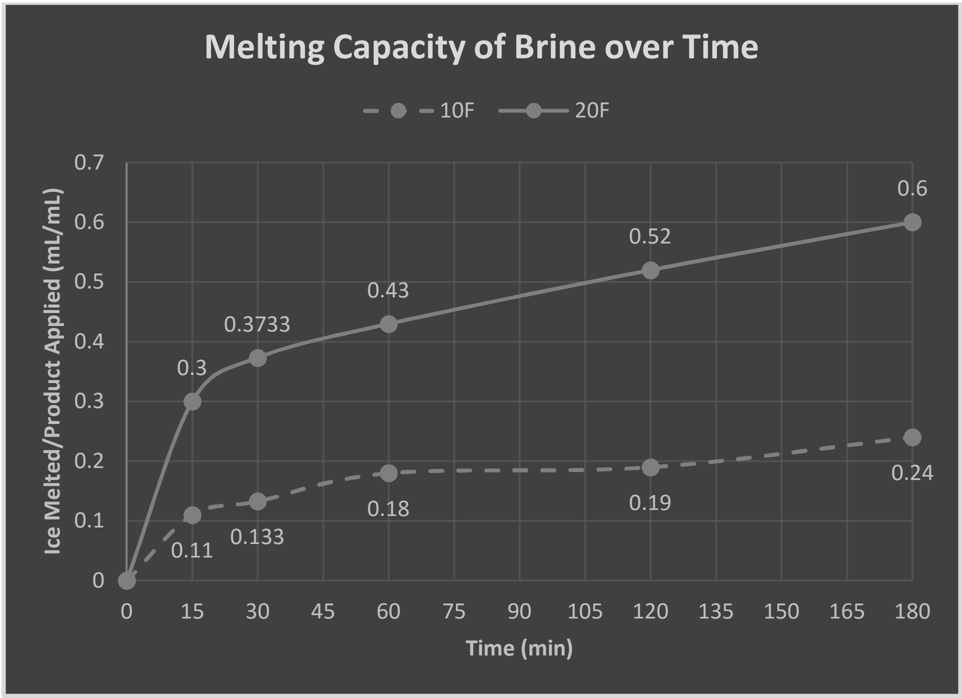
Effects of Additives on Salt Brine Melting Capacity

Sodium chloride brine has gained popularity as a roadway anti-icer and de-icer. However, sodium chloride has limitations. An EnviroTech Services, Inc. brine additive, AMP, can significantly increase the effectiveness of sodium chloride across two problem domains. The purpose of this white paper is to describe the increased effectiveness of sodium chloride brine treated with AMP over untreated brine.

Use of sodium chloride brine (23.3% NaCl) has increased as a winter road treatment over the last several years due to its ability to be used as both an anti-icier and a de-icer. Sodium chloride brine results in a higher coefficient of friction when applied to dry pavement than do magnesium chloride brine and calcium chloride brine (Gerbino-Bevins, 2011). Additionally, sodium chloride brine is inexpensive to produce on a local level. Bulk rock salt is widely available and brining is a simple operation. A Clear Roads report from Sept. 2015 estimates the average total production cost of sodium chloride brine is $0.16 per gallon, while uninhibited magnesium chloride is estimated at $1.20 per gallon (Fay, et al., 2015) (EnviroTech market research finds that the fully burdened cost of producing sodium chloride brine is $0.20, and magnesium chloride costing falls between $0.70 and $1.30 per gallon depending on geography). This renders brine a conservative choice for those responsible for the safety of motorist and the efficiency of trade transport while maintaining a budget.

Despite the many attractive features of sodium chloride brine ("brine"), it is not a complete utility product. The two major limitations explored here are the time-dependency of its melting capacity and its relatively high effective temperature range (Druschel, 2012). While time-dependent melting can be overcome with increased volume of product or frequency of application, neither of which are economical solutions when labor, equipment, and opportunity costs are regarded (Fay, et al., 2015), brine's relatively narrow effective temperature range cannot.

To illustrate the lag-time in brine's effectiveness with regard to melting capacity, EnviroTech Services, Inc. ("EnviroTech") conducted a modified SHRP-H-205.2 test. (See Appendix A for a summary of the experiment set-up.) The experiment's findings are summarized in the graph below for the melting capacity of brine over time. Note that at 20°F brine melts approximately one-third its application volume in ice after 15 minutes, and does not reach one-half its application volume in ice melted until two hours. The outlook is even bleaker at 10°F. A full three hours after application, brine does not reach one-quarter its application volume in ice melted at that low temperature.

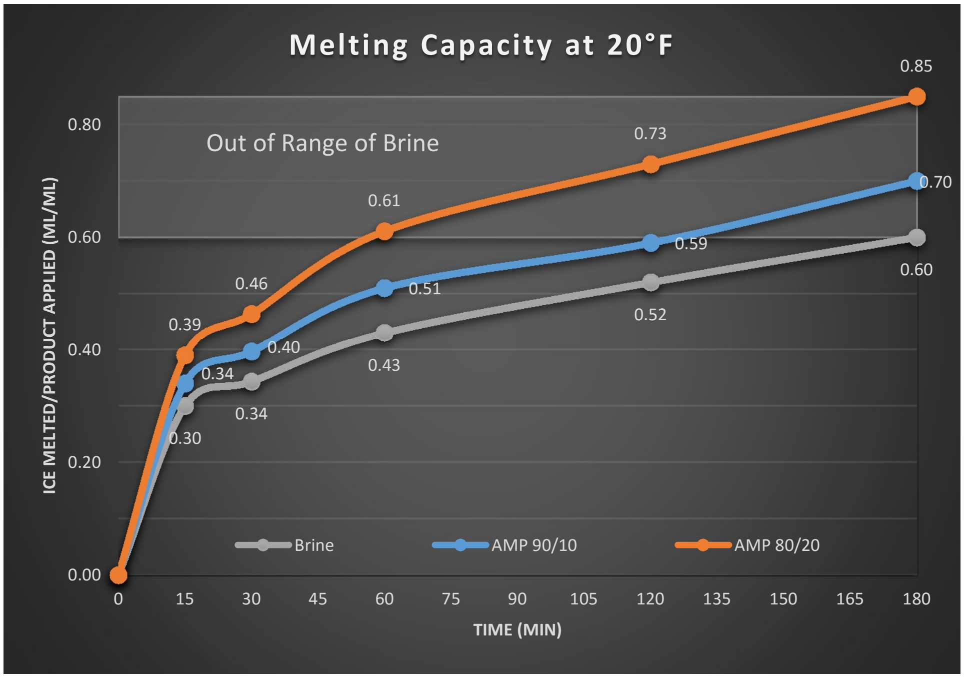


Graph 1: Melting Capacity of Brine over time at 10°F and 20°F.

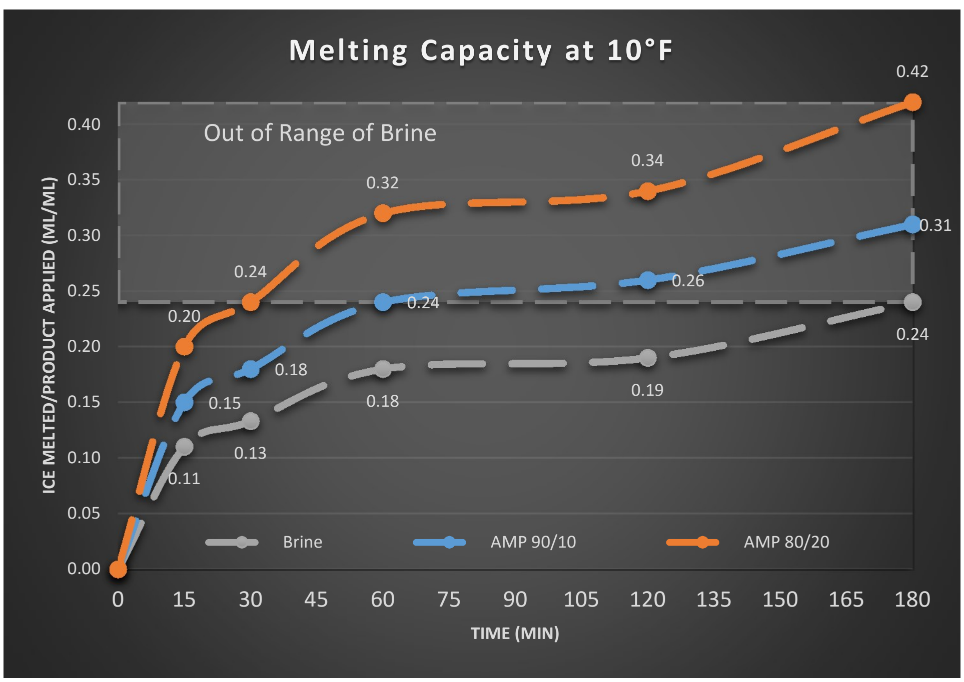
Reapplication of brine would be necessary for safe road conditions before time could have its effect on the melting capacity. Although materials for brine are inexpensive and reapplication is an option, labor costs and equipment usage for reapplication must not be overlooked.

EnviroTech developed AMP, a brine additive, to address an array of concerns and insufficiencies with conventional brine. AMP is manufactured and shipped as a clear, odorless liquid to be blended into brine at the user's facility. An 80/20 blended ratio of brine to AMP has been approved by the Pacific Northwest Snowfighters Association (PNS) for its corrosion inhibiting characteristics, and can be found on the PNS QPL while a 90/10 blended ratio is also often recommended for those who want a significant reduction in corrosion score (typically 40-45 on the PNS scale), but not necessarily the cost that comes with a corrosion score less than 30.

Using the same experimental set-up as cited above (see Appendix A), EnviroTech tested the melting capacity of AMP at 80/20 and 90/10 blended ratios over time at 20 °F and 10°F. The comparisons made here are of equal volumes; that is, if the application volume of brine is 10mL, the application volume of 80/20 brine/AMP is 10mL and that of 90/10 brine/AMP is 10mL. The results seen in Graph 2 provide compelling evidence that AMP significantly improves the performance of brine over time.



Graph 2: Melting Capacity over time of Brine, AMP (90/10) and AMP (80/20) at 20°F

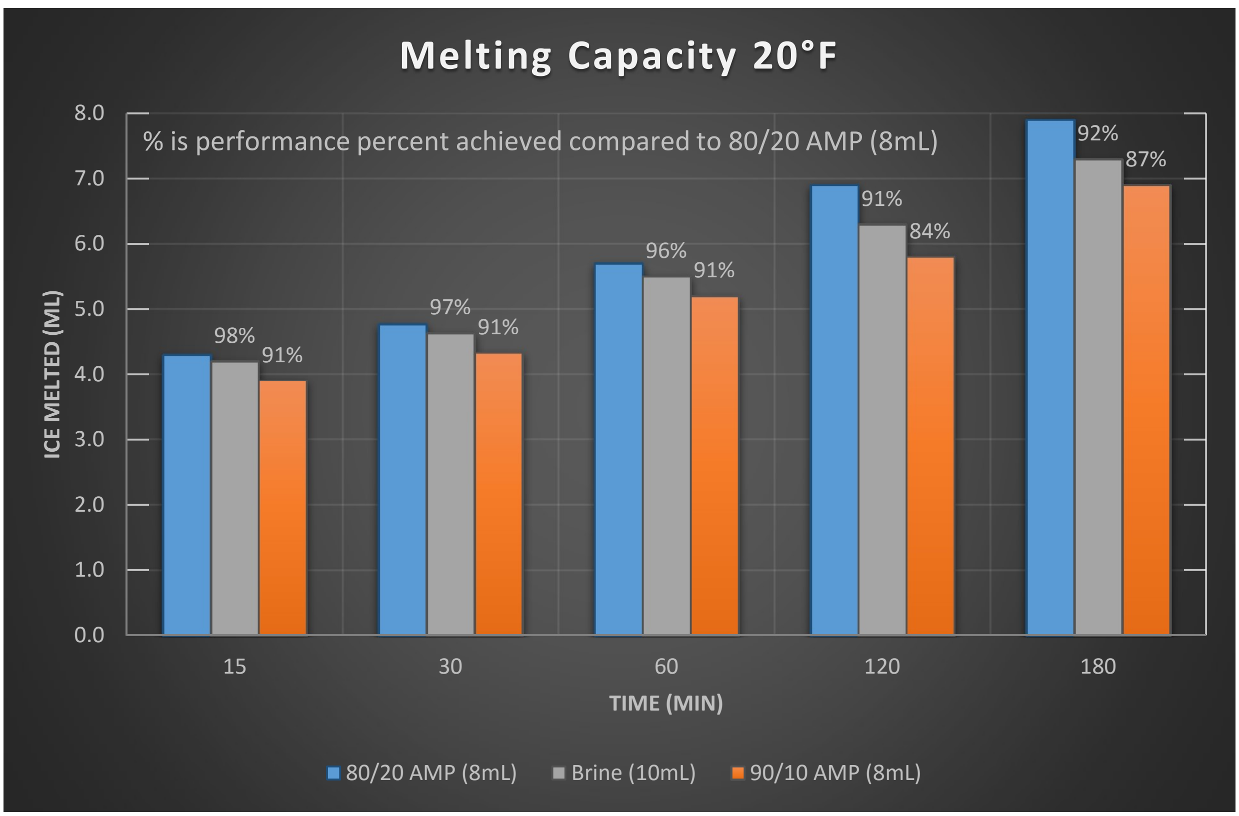


Graph 3: Melting Capacity over time of Brine, AMP (90/10) and AMP (80/20) at 10°F

As seen above, both 80/20 AMP and 90/10 AMP have greater melting capacities than brine from application through hour three at both 10°F and 20°F, respectively. Indeed, at 20°F the melting capacity of brine does not meet the 15 minute melting capacity of either 80/20 AMP or 90/10 AMP until more than 30 minutes. The three hour melting capacity of brine is surpassed by 90/10 AMP after two hours, and by 80/20 AMP after only one hour at that temperature (Graph 2).

At 10°F the results of the melting capacity test are equally compelling (Graph 3). Both 80/20 and 90/10 blended ratios are seen to improve brine at a temperature often considered to be below the effective temperature of brine. At this low temperature brine does not exceed the 15 minute melting capacity of 90/10 AMP until one hour, and does not reach that of 80/20 AMP until after two hours. The three-hour melting capacity of brine is surpassed by 90/10 AMP after one hour, and by 80/20 AMP at 30 minutes.

With such compelling results, it was of interest to understand the extent of increased melting capacity provided by AMP. The same blended ratios, 80/20 and 90/10 brine/AMP, were prepared again. In this round of testing at 20°F, 10mL of salt brine was applied at each time interval, while 8mL of AMP were applied. The results are shown in Graph 4, below. Note that the results are presented as a volume of ice melted, not as a ratio of product applied. This is done in order to present a fair comparison of results despite different input values.



Graph 4: Melting capacity of AMP at diminished volume vs. Brine

As seen above, the benefits of AMP are apparent. An 80/20 blended ratio of brine/AMP out-performs straight brine, even when the volume of brine/AMP is 80% that of brine alone. While 90/10 blended ratio of brine/AMP did not perform as well as brine, it is important to note that its performance was relatively close to that of brine alone, though the application volume was 20% lower. It is also important to note that AMP is clearly the component providing the benefit. This is seen in the consideration of the volume of brine in each application:

Solution	Volume of Solution (mL)	Volume of Brine (mL)	Volume of AMP (mL)
Brine	10	10	0
80/20 AMP	8	6.4	1.6
90/10 AMP	8	7.2	0.8

Through the melting capacity experiment results EnviroTech has shown that AMP is a beneficial brine additive when considered for effectiveness. By exploring the effectiveness of AMP, EnviroTech has found that AMP is the brine additive necessary to expand brine's utility.

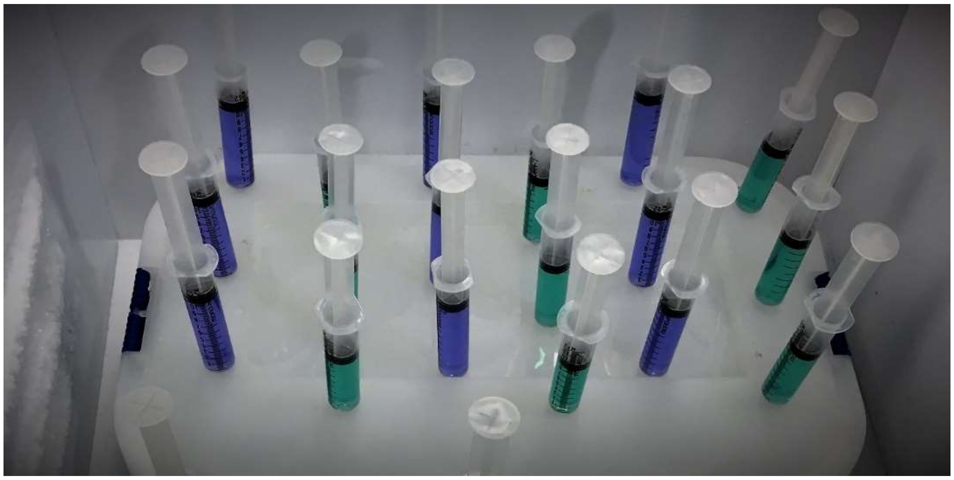
For more information regarding the modified SHRP experiment see Appendix A. For more information regarding AMP and EnviroTech Services, Inc., please visit EnviroTechServices.com.

Modified SHRP-H-205.2

Three ice samples per test product per time interval tested are prepared by freezing 100mL of water in individual plastic beakers for 48 hours in a freezer set to the test temperature (here 20°F and 10°F were used).

Three product samples per test product per time interval are prepared in syringes of the defined application volume and stored in the same freezer as the prepared ice. This creates a real-world scenario in which the product applied is the same temperature as the ice to which it is applied.

After 48 hours in the freezer, the test product is aligned over the ice samples. EnviroTech's test set-up can be seen in the photo below.



The test product here is treated with a water-soluble dye to ensure there is no leakage onto the ice sample below the syringe and to provide a visual difference in product to avoid confusion.

All syringes are depressed at the same time, applying the full volume of product onto all ice samples, and a timer is started. At each time interval defined, three ice samples are removed for each test product. The ice melted is poured off immediately and retained. The melted ice, which contains all the product applied, is measured, the volume of product applied is subtracted, and the resulting volume is the amount of ice melted by the product over that time interval. As there are three samples of each product at each time interval, an average can be calculated, which significantly improves data accuracy and statistical analysis.

Works Cited

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Fay, L., Veneziano, D., Muthumani, A., Shi, X., Kroon, A., Falero, C., . . . Petersen, S. (2015). *Benefit-Cost of Various Winter Maintenance Strategies.* St. Paul, MN: Minnesota Department of Transportation.

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