Liquid Deicers:
Choices, Characteristics, and Applications
Topics

• Ice melt properties of common deicing chemicals
• Properties of liquid deicers
• Understanding eutectic, freezing point, and ice melting capacity
• Corrosion
• Leaching
Deicer effectiveness @ 25F
Measured by SHRP H-205.1

Grams of ice melted per gram of deicer

Time (minutes)
Deicer effectiveness @ 15F
Measured by SHRP H-205.1

<table>
<thead>
<tr>
<th></th>
<th>CaCl2</th>
<th>MgCl2</th>
<th>KCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 minutes</td>
<td>3.5</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>20 minutes</td>
<td>3.0</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>30 minutes</td>
<td>2.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>40 minutes</td>
<td>2.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>50 minutes</td>
<td>1.5</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>60 minutes</td>
<td>1.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Time (minutes)
Deicer effectiveness @ 5F
Measured by SHRP H-205.1

[Graph showing the effectiveness of different deicers over time]
Effective Temperature Ranges

- Sodium Chloride down to ~ 15 °F
- Calcium and Magnesium Chloride Solid Deicers down to ~ -25 °F
- Solid calcium chloride melts more ice than solid magnesium chloride (mag chloride flake is ~ 53% water)
- *Liquid* mag chloride melts slightly more than liquid calcium chloride
Solids vs. Liquids

• Solids provide high ice melting capacity for most efficient deicing

• Liquids have less ice melting capacity and are most suitable for anti-icing or pre-wetting
Liquid Deicers
Sodium Chloride Brine

- Lowest Cost
- Saturated brine “freezes” at 32 °F
- Eutectic brine (23.3%) freezes at –6 °F
- Not hygroscopic (will dry out)
- No slipperiness formation
- Best used for
  - Anti-icing at warmer temps (> 25 °F)
  - Prewetting at the spinner
- Not a good choice for a stored, pre-treated salt product
Mag and Calcium Chloride Brines

- Higher Cost
- 30% mag chloride freezes at 2 °F
- 30% calcium chloride freezes at –60 °F
  - Very low fp is because 30% is the eutectic
- hygroscopic (will stay moist down to ~ 30% RH)
- Best used for anti-icing and prewetting at colder temps (< 25 °F)
- Best choice for a stored, pre-treated salt product (because of resistance to freezing and drying out)
Mixing Brines

• In general, avoid it!
• Mag chloride + calcium chloride -----> sulfate precipitation
• Mag/Calcium chloride + salt brine -----> salt crystal precipitation
• Mag/Calcium chloride + potassium acetate - -----> hydroxide precipitation
What is a Eutectic?

- Eutectic is not the same as freezing point
- Eutectic describes the particular ratio of components with the lowest freezing point
- This minimum freezing point of a deicer in water is often called the eutectic temperature or just “eutectic”
Some Common Misunderstandings

• The lower the eutectic, the better the deicer
• The lower the freezing point of a liquid, the better it will deice
• Liquid deicers work best at their eutectic concentration
WHY?

• If deicers work by lowering freezing point of water. . .
• And if lower eutectic means lower freezing point. . .
• Doesn’t that mean lower eutectic = better deicer. . . ?
• Or lower freezing point = better deicer?
Magnesium Chloride Solution

Water Freezing ----->

<----- Excess MgCl2 crystallizing

<----- water not freezing

% Magnesium Chloride

Freezing Point (degrees F)
Another Reason Eutectic Can Mislead

• Freezing point lowering is necessary but not sufficient for deicing
• Deicer must also act fast to be effective
• Speed of ice melting and freeze point lowering (eutectic) are completely unrelated
Evaluating Deicer Performance

- Eutectic can be misleading
- Best to measure actual *ice melting capacity*
- Standard test is SHRP H205.1-2
- Measures actual quantity of ice melted at a given temperature and time
- For ice melting – higher concentration is always better
Pounds Ice Melt per Pound Deicer Liquid Compared to Freeze Point/Eutectic

<table>
<thead>
<tr>
<th>Solution</th>
<th>F. P.</th>
<th>Ice Melt (15 °F)</th>
<th>Ice Melt (5 °F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30% MgCl₂</td>
<td>2 °F</td>
<td>0.94 lbs</td>
<td>0.43 lbs</td>
</tr>
<tr>
<td>15% MgCl₂ + 50% Ag additive</td>
<td>-50 °F</td>
<td>0.52 lbs</td>
<td>0.0 lbs</td>
</tr>
<tr>
<td>Solid</td>
<td>Eutectic</td>
<td>Ice Melt (15 °F)</td>
<td></td>
</tr>
<tr>
<td>NaCl</td>
<td>-6 °F</td>
<td>2.8 lbs</td>
<td></td>
</tr>
<tr>
<td>CMA</td>
<td>-18 °F</td>
<td>0.3 lbs</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: Ice melting cannot be simply predicted from freezing points or eutectic alone.
Development of Industry Corrosion Standards

• In 1992 the Strategic Highway Research Program published a Handbook of Test Methods for Evaluating Chemical Deicers

• The SHRP program developed a corrosion test for deicers, but it was never widely adopted by the industry.

• In 1998 Washington, Oregon, Montana, Idaho and British Columbia formed the Pacific Northwest Snow fighters (PNS) Association

• PNS developed a set of detailed specifications for deicing products, including a new corrosion test method.

• The PNS test procedures have become widely adopted by other highway maintenance agencies

• The PNS corrosion test is the closest thing to an official industry test at the moment
PNS Corrosion Tester
PNS Corrosion Tester
Corrosion Specifications

• Specs for most liquid deicers are based on PNS specs
• Standard spec is that the *liquid* additive in treated salt must be < 30% as corrosive as salt (in PNS test).
• The overall treated salt product (salt + liquid) usually will NOT meet the PNS spec
• Value of corrosion inhibitor in treated salt probably restricted to handling equipment
“Simulated Equipment Corrosion” Test

• We have developed our own test to estimate equipment corrosion

• Steel coupons directly immersed in piles of treated salt

• Salt treated with corrosion inhibited liquid mag chloride is ~ 67% less corrosive than salt wet with plain salt brine in direct contact with steel
Corrosion Rates of Deicer Solutions (0.513 M)
PNS Test Method

Corrosion rate (mils per year)

- H2O
- NaCl
- CaCl2
- MgCl2
- KCl
- urea
- KAc
Corrosion Conclusions

- All chlorides will be aggressive to mild steel – not a huge difference between them.
- Acetates and formates non-corrosive to mild steel but very corrosive towards galvanized.
- Corrosion inhibited deicers offer a middle ground option.
- Corrosion protection of standard pre-wetted products is probably primarily on equipment.
Leaching Tends to Increase

- As salt gradation becomes more coarse
- If salt is not well mixed with liquid
- If moisture/liquid content is too high
- As humidity and temperature increase
  - Critical humidity ~ 65%
Leaching of Old Vs. New Formula

Leach Test
80% RH, 75 degrees F

- 7.5 gal/T (old formula)
- 7.5 gal/T (new formula)
- 10 gal/T (new formula)

Time (days)

Leach Volume (mL)