Winter Maintenance
Preparing for Winter

Part Three
October 15, 2020 1:00 pm to 3:00 pm
Chemical and Abrasive usage
Objectives for Winter Maintenance
Part Three

- Gain an understand of how different chemicals works on both dry and snow-covered pavements,
- Describe what is meant by the term Phase Diagram,
- List the benefits of using Chemical on Paved Roadways,
- Explain the impact of using chemical and abrasives on your roadways
INTRODUCTION TO CHEMICALS
Common Road Treatment Materials

Chemicals:
- Salt (Sodium chloride)
- Calcium Chloride
- Magnesium Chloride
- Potassium Chloride
- Brines (by-product of gas production)
- Potassium Acetate
- Calcium Magnesium Acetate
- Urea
- Agricultural By-products
- Other Proprietary Materials
- Abrasives

Natural Occurring Salts
Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment

A Synthesis of Highway Practice
CHLORIDES

➢ Sodium Chloride
➢ Magnesium Chloride
➢ Calcium Chloride
Sodium Chloride

- Most common, Solid and Liquid used
- 210 Million Metric tons mined in world
- 45.3 Million metric tons mined in US
- 12.5 Million metric tones mined in Canada
- Approximately 80% used on Roads
Sodium Chloride

- Inexpensive and available
- Solids or “Rock Salt”
- In Solution or as a Brine
- Common in most all areas

Need Specification

- Size
- Moisture content
Sodium Chloride

- The highest eutectic temperature of the three major salts -6 F @ 23%
- Effective Temperature around 15 F
- Endothermic
- Corrosive
  - Used as Standard for other two chlorides
How much ice will a pound of salt melt

<table>
<thead>
<tr>
<th>Temperature Deg F</th>
<th>One pound NaCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>46.3 lbs of Ice</td>
</tr>
<tr>
<td>25</td>
<td>14.4</td>
</tr>
<tr>
<td>20</td>
<td>8.6</td>
</tr>
<tr>
<td>15</td>
<td>6.3</td>
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<tr>
<td>10</td>
<td>4.9</td>
</tr>
<tr>
<td>5</td>
<td>4.1</td>
</tr>
<tr>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>- 6</td>
<td>3.2 lbs of Ice</td>
</tr>
</tbody>
</table>
Application Rates

- Vary Widely with the State and Weather Conditions
- Rock Salt used as abrasive in some areas
- Mixture of sand and salt
- Brines used from 25 to 200 gallons/mile
In general: Any time you can use a pound of liquid instead of a pound of solid, you protect the environment.

One pound of brine approximately fills this pint glass

One pound of salt approximately fills this coffee mug
Magnesium Chloride

- Obtained from naturally occurring brines
- Major source in Northwest is Great Salt Lake
- More expensive than Sodium
- Used as a brine
- Application rates usually less
  - 20 to 60 gal per lane mile
Magnesium Chloride

The middle of the three chlorides for eutectic temperature -28°F @ 26%

**Exothermic**
- Gives off heat

**Hydroscopic**
- Attracts Moisture
Calcium Chloride

- Available to be used in colder climates
- Lowest eutectic temperature of the three chlorides: -60°F @ 30%
- Most Costly of the three Chlorides
- Exothermic
- Hydroscopic
- Corrosive
Chemicals

- Specifications
- Safety Data Sheets (SDS)
- Sample and test (certification)
- Talk to other users: effectiveness, concerns, problems
CORROSION

➢ All chloride chemicals are corrosive

➢ Effect different metals in various ways, and in severity

➢ Steels

➢ Aluminum Alloys

➢ Copper
Corrosion

More corrosive
☆ Calcium Chloride
☆ Sodium Chloride
☆ Magnesium Chloride
☆ CMA
☆ Urea

Less Corrosive
TEST METHODS

➢ MOISTURE CONTENT OF SOLID CHEMICAL PRODUCTS

➢ GRADATION

➢ VISUAL INSPECTION AND FIELD OBSERVATIONS
TEST METHODS

- INHIBITOR TEST SUPPLIED BY MANUFACTURER
- AMMONIA - NITROGEN
- TOTAL KJELDALH NITROGEN
- NITRATE AND NITRITE – NITROGEN
- BIOLOGICAL OXYGEN DEMAND
- CHEMICAL OXYGEN DEMAND
- FRICTIONAL ANALYSIS
- TOXICITY TEST
Chemicals: How do they work?

➢ Depress the freezing point of water, turning ice or snow into liquid or slush

➢ Solid salts dissolve to form brine solution
How do Chemicals Work

Training Clip from the Salt Institute
Chemicals

Chemicals applied to:

- prevent bonding of ice and snow to road surface
- prevent ice or frost from forming
- prevent buildup of snowpack
- melt ice that has formed
Evaluating Snow & Ice Control Chemicals

Performance (deicing mechanics)

- Effective temperature range
- Speed
- Quantity needed
- Duration of melting action
Evaluating Snow & Ice Control Chemicals

Use Criteria

- Equipment requirements
- Storage & handling needs
- Application versatility
- Safety & hygiene considerations
Evaluating Snow & Ice Control Chemicals

Infrastructure Impacts

- Structures (bridges, buildings)
- Roadway pavement & structure
- Vehicles & equipment
Evaluating Snow & Ice Control Chemicals

Environmental Impacts

- Soil
- Animals
- Vegetation
- Water
- Air
- Human Health
Evaluating Snow & Ice Control Chemicals

Availability

Cost

- Availability
- Alternatives
- Performance
- Use Criteria
- Infrastructure Impact
- Environmental Impact
Chemical: Advantages

Melting action

Relatively low cost

No cleanup (as with abrasives)

“Enhanced Safety & Reduced Liability”
Chemical Terms

Concentration
- % by weight of chemical in solution

Eutectic Temperature
- Lowest Temp solution will melt ice

Endothermic
- Requires heat when going into solution

Exothermic
- Gives off heat when going into solution

Hygroscopic
- Draws water from the air
Eutectic Temperature Curves
Magnesium Brine

% of concentration at various temperatures

<table>
<thead>
<tr>
<th>% by Weight</th>
<th>Specific Gravity</th>
<th>Freeze Point F</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>1.013</td>
<td>26.4</td>
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<td>6</td>
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<tr>
<td>30</td>
<td>1.283</td>
<td>3.1</td>
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Salt Brine

% of concentration at the eutectic temperature

<table>
<thead>
<tr>
<th>% Salt</th>
<th>Salometer Using 0 - 100%</th>
<th>Hydrometer Specific Gravity</th>
<th>Eutectic Temperature</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
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<td>7</td>
<td>1.014</td>
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<tr>
<td>3</td>
<td>11</td>
<td>1.021</td>
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</tr>
<tr>
<td>4</td>
<td>15</td>
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<tr>
<td>5</td>
<td>19</td>
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</tr>
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<tr>
<td>27</td>
<td>100</td>
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<td>32</td>
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# Chemical Comparison

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Eutectic Temp</th>
<th>Conc. % by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical</strong></td>
<td><strong>Temp</strong> °C/°F</td>
<td></td>
</tr>
<tr>
<td>NaCl (salt) sodium chloride</td>
<td>-21/-6</td>
<td>23</td>
</tr>
<tr>
<td>CaCl calcium chloride</td>
<td>-51/-60</td>
<td>30</td>
</tr>
<tr>
<td>MgCl magnesium chloride</td>
<td>-33/-28</td>
<td>22</td>
</tr>
<tr>
<td>KCl potassium chloride</td>
<td>-11/+13</td>
<td>20</td>
</tr>
<tr>
<td>KAc potassium acetate</td>
<td>-60/-76</td>
<td>49</td>
</tr>
<tr>
<td>CMA calcium magnesium acetate</td>
<td>-27/-17</td>
<td>32</td>
</tr>
<tr>
<td>Urea</td>
<td>-12/+10</td>
<td>33</td>
</tr>
</tbody>
</table>
## Chemical Comparison Eutectic vs Effective Temp

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Eutectic</th>
<th>Effective*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>³C</td>
<td>³F</td>
</tr>
<tr>
<td>NaCl (salt) sodium chloride</td>
<td>-21</td>
<td>-6</td>
</tr>
<tr>
<td>CaCl calcium chloride</td>
<td>-51</td>
<td>-60</td>
</tr>
<tr>
<td>MgCl magnesium chloride</td>
<td>-33</td>
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<td>+13</td>
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<tr>
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<td>-27</td>
<td>-17</td>
</tr>
<tr>
<td>Urea</td>
<td>-12</td>
<td>+10</td>
</tr>
</tbody>
</table>
Dilution

DISCUSSION ON TEMPERATURE/CONCENTRATION CURVE
Phase Diagrams of Three Brines
MATERIAL PERCENTAGE

➢ Determine percentage by specific gravity

➢ Water specific gravity is 1.00

➢ Adding salt increases the Sp Gr.

➢ 30% Magnesium Chloride is 1.283

➢ Table on slide 38
<table>
<thead>
<tr>
<th>% by Weight</th>
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</tr>
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</tr>
<tr>
<td>30</td>
<td>1.283</td>
<td>3.1</td>
</tr>
</tbody>
</table>
PRODUCT DELIVERY

BILL OF LADING

- NAME OF PRODUCT
- SUPPLIER AND MANUFACTURER
- DESTINATION
- QUANTITY (TONS, LITERS, GALS)
- LOT NUMBER
- TRANSPORTER INFORMATION
- LIQUIDS - %CONC AND SP. GRAVITY
- PRODUCT SDS
PRODUCT INVOICING

INFORMATION FROM THE BILL OF LADING PLUS THE FOLLOWING

- UNIT PRICE
- TOTAL PRICE
FIELD INSPECTION, UNLOADING, SAMPLING, AND TESTING

PRELIMINARY INSPECTION

- DOCUMENTATION
- VISUALLY INSPECT THE PRODUCT

PRIOR TO UNLOADING

- RECORD VOLUME IN STORAGE
- FIELD TEST A GRAB SAMPLE
- ACCEPT OR REJECT
# Magnesium Chloride Concentrations and Freezing Points

<table>
<thead>
<tr>
<th>Concentration wt % MgCl(_2)</th>
<th>Freezing Temperatures</th>
<th>Density Specific Gravity</th>
<th>lb./gal.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F°</td>
<td>C°</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>-23</td>
<td>-31</td>
<td>1.20</td>
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<td>36</td>
<td>91</td>
<td>33</td>
<td>1.36</td>
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</table>
ANTI-ICING VS DE-ICING
DE-ICING

- Removal of snow and ice from the roadway after accumulation
- Preformed during and after a storm event
- Application of solids and brines
ANTI-ICING

- Proactive activity to prevent snow and ice from building up on a road surface.
- Usually preformed before a storm event
- Normal application of brines
- Chemicals begin their dilution cycle when it begins to snow
ANTI & DE-ICING

- Techniques to apply chemicals before and during a storm event that will assist in breaking up the snow floor.
- Brine and solid combinations
- Delayed reaction of chemicals
Total Storm Management

➢ The selection of a series of operations that will yield the desired level of service at the lowest total cost.

➢ A planned process to prepare before the storm, provide the best service possible during the storm, and return to a desired level of service as soon as possible after the storm.
TOOLS IN OUR TOOLBOX

Plowing

Abrasives

Chloride Chemicals
  ◦ Solids
  ◦ Brines
  ◦ combinations
ABRASIVES

WHAT DO WE MEAN BY ABRASIVES
Abrasives

Sand, cinders, ashes, crushed rock

- Specifications
  - Size (gradation) of material
  - Type of material
  - Characteristics of material
  - Environmental concerns

Advantages / Disadvantages
Abrasives

❖ How effective are they
❖ When do you use them
❖ What are the costs
❖ Environmental concerns
Abrasives: Advantages

Relatively inexpensive (initial material cost)

Easy to apply

Skid resistance

Can be mixed with salt and/or prewetted with salt or other chemicals
Abrasives: Disadvantages

❖ No melting action
   ❖ “Safety”

❖ Easily scattered off road

❖ Windshield breakage

❖ Air pollution

❖ Water pollution

❖ Tracking – sidewalks, into homes

❖ Requires clean-up
# Solid vs Liquid Advantages

<table>
<thead>
<tr>
<th>Solids</th>
<th>Liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Less costly</td>
<td>• Instant action</td>
</tr>
<tr>
<td>• Easier to handle</td>
<td>• Not displaced by traffic</td>
</tr>
<tr>
<td>• Dilute slower (retention)</td>
<td>• Residue remains effective</td>
</tr>
<tr>
<td>• Initial skid resistance (salt)</td>
<td>• Versatile</td>
</tr>
<tr>
<td></td>
<td>• Used directly</td>
</tr>
<tr>
<td></td>
<td>• Treat solids</td>
</tr>
</tbody>
</table>
Solid vs Liquid Disadvantages

**Solid**
- Need moisture
- Takes time
- Not good for anti-icing (bounce & scatter, displaced by traffic)

**Liquid**
- Mostly water
- Not useful for thick ice
- Rain will wash off pavement
- Can cause slippery conditions
APPLYING CHEMICALS To the Roadway
Successful Application Depends On

Accurate weather forecasts

- Temperature
- Moisture

Information based strategies

Knowledge of how chemicals work
Solid Chemicals

- Sodium Chloride used as a solid
- Spinner bar used similar to a sanding truck.
- Use Rock Salt, granular material
- Spread across roadway, usually placed in middle of roadway and spreads to outside by traffic flow or melting and water flow.
USE SOLIDS

Low traffic volumes

Soft snow fall, conditions where the granular salt will adhere.

During a storm event. Temperatures above 15 F and rising
  ◦ Melting during storm
  ◦ Break up snow floor after storm
Liquid Chemicals (Brines)

Use tanker truck and apply through

- Spray Nozzles on a spray bar
  - Spreads brine out over large area
  - Overspray
  - Used with Sodium Chloride

- Streamer tubes below a header bar
  - Evenly distributed flow of chemicals just above pavement
  - Leaves “lines” of chemical that spreads out with melting.
ANTI-ICING TECHNIQUES

Prior to a storm event

Place brine directly on bare pavement
  • Use spray bar
  • Use streamer nozzles
ANTI-ICING TECHNIQUES

Melts snow as it falls

Maintains bare pavement as long as the dilution process continues.

Works within the eutectic curve, moisture and temperature

Stops working when the dilution reaches the freezing point
ANTI-ICING TECHNIQUES

If dilution of the first application is complete and snow begins to accumulate, an additional application can be put down. Or other techniques to deal with a snow floor can be employed.
APPLYING LIQUIDS TO SOLIDS
PREWETTING SOLIDS

Prewetting of sanding material

Prewetting of rock salt

- Both of these prewetted materials will work in different storm management situations.
Prewetting occurs when we add a small amount of a brine to a solid as it is spread on the road surface. The brine around the solid particle starts to melt the ice/snow around the particle, dilutes rapidly, and then refreezes, causing the solid particle to be frozen on the surface.
How to Use Liquid Anti-Icers

Pre-Wetting Solids

Dry Sand / Rock Salt Applied

Dry Material After a Few Cars Have Passed

Material Prewet With a Liquid Deicer

Roadway Surface

Snow Bottom or Ice
Prewetting: Benefits

Less bounce & scatter

Faster reaction time

More effective melting action

Less material needed resulting in:
  ◦ reduced costs
  ◦ reduced environmental concerns
Pre-wetting

Wetness provided by solutions does cause abrasive to stick to the road surface or embed more quickly into an icy surface, thereby keeping the deicing mixture or abrasive within the desired area.
Typical Scatter of Road Abrasives

100% salt spread in center 1/3 of road
Typical Scatter of Prewetted Road abrasives

100% prewetted salt spread in center 1/3 of road
Wetted Salt Benefits

“Wetted salt has.... less tendency to bounce and scatter.”

“Wetted salt begins immediately.... cleaning is achieved with less salt, less effort, and reduced operating costs.”

“....a 30% reduction of salt use taken as a reasonable minimum....”

Public Technology, Inc.
Melting Action: Untreated Salt vs Prewetted Salt
Melting Action: Untreated Salt vs Prewetted Salt
Melting Action: Untreated Salt vs Prewetted Salt
Melting Action: Untreated Salt vs Prewetted Salt
Advantages of Prewetting

- Reduced Abrasive usage
- Reduced cost of deicing materials
- Reduced labor costs
- Increased deicing efficiency and faster melting action
- Increased safety to motorists
Sanding Material

When there is a snow floor of ice on the road

- Prewetted sand will stick to the road surface
- The amount of sanding material can be reduced
- The abrasive effect of the sanding material will be increased
MAJOR STORM EVENT

When the storm event is large enough that there will be a snow floor develop, what techniques can we use to help remove the snow floor after the event

- Use conventional equipment, graders, plows
- Use application of brines that will freeze to the roadway before the storm
- Use rock salt early during the storm to put a layer of chloride on the road surface.
COMBINATION TREATMENTS
A combination of abrasives, brines, and solids may be necessary to manage a storm. Using each of the tools we have to produce the most safe condition on the roadway throughout the duration of the storm and the clean up effort afterwards.
## Cost of Snow Removal Economics

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of sand</td>
<td>Cost of Material</td>
</tr>
<tr>
<td>Cost of plows/sanders</td>
<td>Cost of spreading equipment</td>
</tr>
<tr>
<td>Storage of material</td>
<td>Storage</td>
</tr>
<tr>
<td>Labor</td>
<td>Labor</td>
</tr>
<tr>
<td>Clean up</td>
<td></td>
</tr>
</tbody>
</table>
Cost of Snow Removal Environmental

**Traditional**
- PM 10 dust particles
- Siltation of streams and rivers
- Ditch cleaning
- Lost material accumulation

**Chemicals**
- Chlorides/Chemicals in water table
- Harm to vegetation
Cost of Snow Removal Corrosion/harmful

Traditional
- Broken Windshields
- Dirty roadways

Chemicals
- Corrosion of Aluminum
- Corrosion of Steel
- Electrical failures
**Bottom Line**

<table>
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<tr>
<th>Traditional</th>
<th>Chemicals</th>
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<tbody>
<tr>
<td>◦ Snow floors</td>
<td>◦ Bare Pavement (faster)</td>
</tr>
<tr>
<td>◦ Vehicular accidents</td>
<td>◦ Reduction in accident rates</td>
</tr>
<tr>
<td>◦ Lost commerce</td>
<td>◦ Continued movement of products and services</td>
</tr>
</tbody>
</table>
Post Storm Benefits

- Easy snow floor removal
- Reduced environmental impact
- Less Cleanup
- Overall storm cost minimized
LEGAL

Agency Liability
- Causes of Liability
  - Level of Service
  - Proper application of materials
  - Expectations of the Public
Other Resources

Your Local Technical Assistance Program (LTAP).
- AASHTO’s RWIS/Anti-Icing CBT
- ClearRoads CBT

Bruce Drewes, LLC
bdrewes@3tgroup.org
Objectives for Winter Maintenance
Part Three

- Gain an understand of how different chemicals works on both dry and snow-covered pavements,
- Describe what is meant by the term Phase Diagram,
- List the benefits of using Chemical on Paved Roadways,
- Explain the impact of using chemical and abrasives on your roadways
THANK YOU