A Winter Balancing Act:
Salt, Snow, and Safety On Our Roads
David P. Orr, P. E.
Cornell Local Roads Program
Snow and Ice Control Operations for Local Highway Officials

Dewey Amsler, P.E.
FRINK AMERICA INC.
PRESENTS
PLOWING
TUG HILL
1939
Old Man Winter
Snowfall in New York State
Pavement condition goals
Pavement condition goals
Pavement condition goals
Pavement condition goals
Pavement condition goals
Pavement condition goals
Pavement condition goals
## Stopping Distance

<table>
<thead>
<tr>
<th>Road Surface Condition</th>
<th>Stopping Distance Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td></td>
</tr>
<tr>
<td>Wet</td>
<td></td>
</tr>
<tr>
<td>Slush or Sand on snow</td>
<td>~1 ¾</td>
</tr>
<tr>
<td>Soft loose snow</td>
<td>~2</td>
</tr>
<tr>
<td>Sand after lt. traffic</td>
<td>~3 ½</td>
</tr>
<tr>
<td>Snow pack</td>
<td>~4</td>
</tr>
<tr>
<td>Ice</td>
<td>~5+</td>
</tr>
<tr>
<td>Road Surface Condition</td>
<td>Equivalent Speed</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Dry</td>
<td></td>
</tr>
<tr>
<td>Wet</td>
<td></td>
</tr>
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<td>Slush or Sand on snow</td>
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</tr>
<tr>
<td>Soft loose snow</td>
<td></td>
</tr>
<tr>
<td>Sand after lt. traffic</td>
<td></td>
</tr>
<tr>
<td>Snow pack</td>
<td></td>
</tr>
<tr>
<td>Ice</td>
<td>30 or less!</td>
</tr>
</tbody>
</table>
Level of Service

All Roads
Level of Service

Highest Priority Roads
During Storm Plowing

Level of Service
Level of Service

Residential Streets
SLOW DOWN
or this may be the last thing you see!

The Highway Superintendent's Association of Lewis, Jefferson and Oswego Counties
Abrasives

- Acquisition of abrasives
- Quality considerations
- Storage and handling
- PM10
Abrasives

• 18 cars and the effectiveness of abrasives is gone
Ice Control Chemicals

- Dilution
- Exothermic
- Eutectic
- Endothermic
- Solution
Common Ice Control Chemicals

- Sodium chloride
- Calcium chloride
- Magnesium chloride
- Calcium magnesium acetate
- Organic based products
Ice Control Chemicals

How ice control chemicals work

Phase Diagram - Chlorides

Brine

Slush
(Solution & Ice)

Solution & Salt

% Chloride (by weight)

Temperature (°F)
Ice Control Chemicals

Phase Diagrams - Chlorides

Sodium Chloride
Magnesium Chloride
Calcium Chloride
## Melting Ability

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Ice Melted per Unit of Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sodium Chloride</td>
</tr>
<tr>
<td>30</td>
<td>46.3</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>
</tr>
<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>-5</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Melting Ability

![Graph showing the melting ability of different compounds](image-url)

- Sodium chloride
- Calcium chloride
- Magnesium chloride

- Temperature (°F)
- Melting ability (in arbitrary units)

Key:
- Blue line: sodium chloride
- Red dashed line: calcium chloride
- Green dashed line: magnesium chloride
Example

- 1 mile
- 20 ft. wide pavement
  - 2” snow
  - ¼” ice
- 24 °F

60 tons of ice
6 tons of salt!
<table>
<thead>
<tr>
<th>Food</th>
<th>Milligrams of Sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass of water containing 100 ppm sodium</td>
<td>16</td>
</tr>
<tr>
<td>Glass of milk</td>
<td>120</td>
</tr>
<tr>
<td>Slice whole wheat bread</td>
<td>130</td>
</tr>
<tr>
<td>Slice of pizza</td>
<td>380</td>
</tr>
<tr>
<td>Slice of American cheese</td>
<td>406</td>
</tr>
</tbody>
</table>
Deicing
Anti-icing
Dry Chemicals
Dry Salt on Dry Pavement

100% spread in center 1/3

15% 12% 46% 12% 15%

1/3 center 1/3 1/3
Prewetted Salt on Dry Pavement

1/3 spread in center 1/3

78%
9%
2%
2%
9%
9%
Mixtures of solid and liquid chemicals
Pre-wetting ice control equipment
1 inch

Salt

50' diameter

100 lbs. of Salt

Sand w/ 10% salt

50' diameter

96 lbs. of Salt
Why Prewet

• Reduce bounce and scatter

• Accelerate working of salt

• Environmental savings

• Corrosion reduction
Snow & Ice Control Strategies and Tactics

- Strategies
- Tactics
Designing Snow and Ice Control Material Treatment

- Climate
- Weather
- Precipitation
- Pavement conditions
- Storm characteristics
- Level of service
Chemical and Abrasives Policies

• Costs?
  ▪ Abrasives
  ▪ Chemicals (salt)
Chemical/Abrasives Mixtures

- Level of service dependent
  - Overall
  - Within-storm
- Unpaved roads
- Low pavement temperature conditions
- Steep grades
- Intersections
- Rail-road crossings
## Salt vs. Sand

### Cost to treat one lane–mile Salt vs. Sand

<table>
<thead>
<tr>
<th>Salt</th>
<th>Cost Factors</th>
<th>Sand Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>---</td>
<td><strong>A  Cost of sand, $/ton</strong></td>
<td>$ 6.40 (80%)</td>
</tr>
<tr>
<td>$51.16</td>
<td><strong>B  Cost of salt, $/ton</strong></td>
<td>$10.23 (20%)</td>
</tr>
<tr>
<td>---</td>
<td><strong>C  Mixing cost, $ /ton</strong></td>
<td>$0.95</td>
</tr>
<tr>
<td>$51.16</td>
<td><strong>D  Total Cost, $ /ton</strong></td>
<td>$17.58</td>
</tr>
<tr>
<td>225</td>
<td><strong>E  Pounds per lane-mi</strong></td>
<td>700 (140)</td>
</tr>
<tr>
<td>$ 5.76</td>
<td><strong>Cost / lane mile, $</strong></td>
<td>$6.15</td>
</tr>
<tr>
<td></td>
<td><strong>(E/2000 x D)</strong></td>
<td></td>
</tr>
</tbody>
</table>
Ice Control Treatment

• Dilution potential
• Pavement temperature
• Level of service
Dilution Potential

- Precipitation types
- Pavement conditions
- Cycle time
- Traffic
Precipitation Types

- Light rain
- Moderate rain
- Heavy rain
- Freezing rain
- Sleet

- Light Snow
- Moderate snow
- Heavy Snow
- Blowing Snow
- None
Pavement Conditions

- Dry
- Damp
- Wet
- Slush

- Loose snow
- Packed snow
- Frost
- Thin ice
- Thick ice
Pavement Conditions

- Bond to pavement
- Residual snow or ice on pavement
Pavement Temperature
Level of Service Considerations

- Pavement condition goals
- Cycle time and hours of operation capability
- Public expectation
<table>
<thead>
<tr>
<th>Probable Pavement Temperature at Treatment and Before Next Treatment</th>
<th>Ice Control Chemical Dilution Potential</th>
<th>Ice-Pavement Bond Characteristics Before Treatment</th>
<th>Application Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice Control Chemical Dilution Potential</td>
<td>Ice-Pavement Bond Characteristics Before Treatment</td>
<td>Application Rate</td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>Medium</td>
<td>Heavy</td>
<td>Light</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Solid (note 5)</td>
</tr>
<tr>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Bonded/Packed</td>
</tr>
<tr>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
</tbody>
</table>

**Notes:**

- NR = NOT RECOMMENDED

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**ICE CONTROL DILUTION POTENTIAL**

<table>
<thead>
<tr>
<th>Precipitation Type</th>
<th>Precipitation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>Medium</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

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**ADJUSTMENT TO DILUTION POTENTIAL**

(Not to exceed a value of “High”)

<table>
<thead>
<tr>
<th>Cycle Time, Hours</th>
<th>Levels to Add</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1.5</td>
<td>0</td>
</tr>
<tr>
<td>1.6 - 3.0</td>
<td>1</td>
</tr>
<tr>
<td>More than 3.0</td>
<td>2</td>
</tr>
</tbody>
</table>

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**For Traffic Speeds > 35 MPH**

<table>
<thead>
<tr>
<th>Traffic Volume, Vehicles per Hour</th>
<th>Levels to Add</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 125</td>
<td>0</td>
</tr>
<tr>
<td>More than 125</td>
<td>1</td>
</tr>
</tbody>
</table>

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**Residual Loose Snow/Ice on Road, Inches**

<table>
<thead>
<tr>
<th>Levels to Add</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.25</td>
</tr>
<tr>
<td>0.26 - 1.00</td>
</tr>
<tr>
<td>More than 1.00</td>
</tr>
</tbody>
</table>

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**This font is too small! I can’t read it.**

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**Don’t try to read it! The values are in the workbook.**
Chemical Rates (# per Lane-Mile)

- 50  Anti-icing above 23°F low dilution
- 225 Default value some snow bonding
- 500 De-icing above 12°F
- ??? Below 12°F
Roadway Elements
QUESTIONS ???????

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