MATERIALS MANAGEMENT
FOR SNOW AND ICE
CONTROL
CORNELL LOCAL ROADS PROGRAM
CENTRAL NEW YORK PLANNING AND
DEVELOPMENT BOARD
SUPPORTED BY
CORNELL LOCAL ROADS PROGRAM
Presenter’s Background

- Laborer and Equipment Operator
- NYSDOT 36 Years
  - Research
  - Claims and Litigation
  - Maintenance and Operations
- Consultant Since 1996
  - Training, Claims and Litigation Support,
  - Guidance Documents, Books, Research,
  - Plan and Policy, etc.
WE HAVE A TREAT FOR YOU TODAY—WE’VE BROUGHT IN A MOTIVATIONAL EXPERT!
AGENDA

- S&I Plan and Policy Documents
- Materials Management Plans
- S&I Materials (Including Organic Chemicals)
- Sand Versus Salt as a Treatment
- Prewetting Salt
AGENDA ctd.

• Material Application Techniques
• Calibration and Ground Speed Control
• Salt and the Environment
• S&I Strategies and Tactics
• S&I Treatment Design
Questions & Answers
When deciding on Level of Service goals, what is the most important:

A. Cost
B. Safety
C. Environmental Responsibility
D. All of the above
Sand piles with only 5% salt pose no environmental threat:

A. True
B. False
Solid ice control chemicals can be used to treat roads before a storm on high-speed, high-volume roads:

A. True

B. False
On a per treatment basis, sand:

A. Cost more than salt
B. Cost less than salt
C. Cost about the same as salt
For the same level of service, anti-icing cost less than de-icing:

A. True
B. False
A Comprehensive Snow Plan and Policy

WHY ????
Advantages of Written Policy

• Forced to Plan Ahead
• Liability Minimized
• All Agency on Same Page
• Public Understanding/Complaint Reduction
Written Policy

• WHAT DO YOU THINK SHOULD BE IN A WRITTEN MUNICIPAL SNOW AND ICE CONTROL PLAN AND POLICY
MINIMUM CONTENT

• LEVEL OF SERVICE
• TREATMENT TIMING AND SEQUENCE
• STUCK AND PRIVATE VEHICLES
• SIDEWALK AND ALLEY
• PARKING DURING STORM/CLEAN UP
• SNOW REMOVAL (HAULING)
• MATERIALS STORAGE & USE
MINIMUM CONTENT CTD.
(Appendix I)

- COMPLAINT AND FOLLOW-UP
- SEVERE CONDITIONS RESPONSE
- PROPERTY AND MAILBOX DAMAGE
- COMMERCIAL SNOW PLOWING
- CONTINGENCY RESPONSE PLANS
- INTERNAL & EXTERNAL COMMUNICATION
- ONE MORE!!!!!!!!!!!!!
ENVIRONMENTAL RESPONSIBILITY ISSUES
MATERIALS MANAGEMENT PLANS

(USING BEST PRACTICES)

- Materials specifications
- Storage and Yard Facilities
- Material handling & Loading
- Material spreading Patterns
- Material Application Rates
- Washing Equipment
- Disposal of Materials
- Strategies and Tactics in Support of Level of Service Goals
MATERIALS MANAGEMENT PLANS

• OBJECTIVES

• GUIDING PRINCIPLES

• FRAMEWORK
MATERIALS MANAGEMENT PLAN OBJECTIVES

- VEHICLE FOR COMMITMENT
- IMPLEMENT BEST MANAGEMENT PRACTICES
- APPLICABLE TO AGENCY STAFF AND HIRED RESOURCES

- http://www.twp.cranberry.pa.us/publicworks/
MMP GUIDING PRINCIPLES

• SAFETY
• ENVIRONMENTAL PROTECTION
• CONTINUAL IMPROVEMENT
• FISCALLY DRIVEN
• PROVIDE AN EFFICIENT TRANSPORTATION SYSTEM
MMP GUIDING PRINCIPLES
ctd.

• ACCOUNTABILITY
• MEASURABLE PROGRESS
• AGENCY BASED
• FOCUS ON COMMUNICATIONS
• KNOWLEDGEABLE & SKILLED WORKFORCE
FRAMEWORK FOR MMP’S

• POLICY AND OBJECTIVES
• SITUATIONAL ANALYSIS
• WRITTEN POLICY /DOCUMENTATION
• PROPOSED APPROACHES
FRAMEWORK FOR SMP’S ctd.

• TRAINING
• MONITORING, RECORD KEEPING, REPORTING AND ANALYSIS
• MANAGEMENT REVIEW
MMP PROCESS OF CONTINUAL IMPROVEMENT AND STAKEHOLDER CONSULTATION

• ENVIRONMENTAL POLICIES & GUIDING PRINCIPLES

• BACKGROUND REVIEW & ANALYSIS

• IMPLEMENTATION AND DOCUMENTATION

• EDUCATION & TRAINING

• MONITORING & ANALYSIS

• MANAGEMENT REVIEW

• CONTINUE THE CYCLE

• (SEE TRANSPORTATION ASSOCIATION OF CANADA WEB SITE’S “READING ROOM”)


Snow and Ice Control Materials
Common Road Treatment Materials

- 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
Advantages and Disadvantages of Chemicals and Abrasives

( PAGES 6-9)

✓ Develop lists
  1. Abrasives
  2. Chemicals
Advantages of Chemicals

- Melting action
- Relatively low cost
- No cleanup (as with abrasives)
Disadvantages of Chemicals

• Effectiveness drops with temperature
• Corrosive
• Environmental concerns
  – Excessive use
  – Improper Storage
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
• easily scattered off road
• windshield breakage
• air pollution
• water pollution
• tracking – sidewalks, into homes
• requires clean-up
• Not as safe as bare/wet road
The ‘true’ cost of Abrasives

• One application of abrasives is nearly equal to one application of salt considering equipment and labor costs
• Abrasives have to be applied more frequently than salt resulting in additional application costs
• Add required cleanup costs to the use of abrasives
Stopping Distance

- **Dry Surface:**
  - S.D. = D

- **Wet Surface:**
  - S.D. = 1.7D

- **Slush:**
  - S.D. = 2.0D

- **Soft, Loose Snow:**
  - S.D. = 3.0D

- **Compacted Snow:**
  - S.D. = 4.0D
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
Chemicals: How do they work?
(PAGES 5-6)

• Depress the freezing point of water, turning ice or snow into liquid or slush
• Solid salts dissolve to form brine solution
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
Salt: Anti-Caking Agents

- **Sodium Ferrocyanide: Yellow Prussiate of Soda (YPS)**
  - Non-toxic, approved for table salt
- **Ferric Ferrocyanide: Prussian Blue**
  - Non-toxic, used in blueprints, inks
- **Both added at 20-100 ppm**
Salt: Uses

- Pavement Treatment (Liquid)
- Snow/Ice Treatment (Solid or Pre–Wet Solid)
- Prewetting Liquid
- Add to Abrasives
  - stockpile conditioner
  - provide melting power
## Ice Control Chemicals

### Sodium chloride/Calcium chloride/Magnesium chloride

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Ice Melted per Unit of Chemical</th>
<th>Sodium</th>
<th>Calcium</th>
<th>Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
<td>46.3</td>
<td>31.1</td>
<td>47.8</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>14.4</td>
<td>10.4</td>
<td>15.4</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>8.6</td>
<td>6.8</td>
<td>10.0</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>6.3</td>
<td>5.5</td>
<td>7.9</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>4.9</td>
<td>4.8</td>
<td>6.8</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>4.1</td>
<td>4.4</td>
<td>6.1</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>3.7</td>
<td>4.0</td>
<td>5.5</td>
</tr>
<tr>
<td>-5</td>
<td></td>
<td>3.2</td>
<td>3.7</td>
<td>5.0</td>
</tr>
</tbody>
</table>
Ice Control Chemicals

Phase Diagrams - Chlorides

Temperature (°F) vs. % Chloride (by weight)

Sodium Chloride
Magnesium Chloride
Calcium Chloride
Solid vs Liquid Advantages

- **Solids**
  - Less costly
  - Easier to handle
  - Dilute slower (retention)
  - Initial skid resistance (salt)

- **Liquids**
  - Instant action
  - Not displaced by traffic
  - Residue remains effective
  - Versatile
    - Used directly
    - Treat solids
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
Mixtures of Solid and Liquid Chemicals

- Properties
- Operational characteristics
Prewetting Salt

• Prewetted Salt: Salt which has been coated with a liquid solution prior to being spread.
Prewetting Salt: Benefits

• Less bounce & scatter
• Faster reaction time
• More effective melting action
• Less salt needed resulting in:
  – reduced costs
  – reduced environmental concerns
PREWETTING TECHNIQUES

- Stockpile or Pre-Delivery (Salt or Sand)
- In Spreader Hopper or Dump Body
- On Loader Bucket
- On-Board Systems
- On-Road Procedures
LIQUID CHEMICALS that are added to SOLID CHEMICALS

- MgCl magnesium chloride & Organic Chem.
- CaCl₂ calcium chloride & Organic Chem.
- CaCl₂ calcium chloride & CMA
- MgCl magnesium chloride & CMA
- NaCl sodium chloride

ALL ARE MOSTLY WATER
Prewetting Salt

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

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

- 78% in center
- 9% off road
- 2% off road
- 1/3 of road

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.”

continued....
Wetted Salt Benefits

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

Public Technology, Inc.

Take this with a grain of salt - Dewey
Melting Action: Untreated Salt vs Prewetted Salt
Melting Action: Untreated Salt vs Prewetted Salt
Melting Action: Untreated Salt vs Prewetted Salt

[Image: Diagram showing a comparison between untreated salt and prewetted salt with labels pointing to each.]
Melting Action: Untreated Salt vs Prewetted Salt
ORGANIC
(CARBOHYDRATE ENHANCED)

LIQUID ICE CONTROL CHEMICALS
Organic Chemicals are a SUGAR by-product of a Process

Sugar Making
Beer and whiskey making
Corn Fermentation
Other Crop Fermentation or Processing
Advantages of Organic Chemicals

• Usual advantages of Pre Wetting
• Residual Effect between Storms
• Short Term Corrosion Protection (hwy.)
• Corrosion Protection on Equipment (cars ?)
• Environmental Marketing
Application Rate Control
(PAGES 3, AND 19-22)
Calibration
### CALIBRATION CHART

| Agency: | 
| Location: | 
| Truck No.: | 
| Date: | 
| Spreader No.: | 
| By: | 

#### POUNDS DISCHARGED PER MILE

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>MINUTES TO TRAVEL ONE MILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Setting</td>
<td>Shaft RPM (Loaded)</td>
<td>Discharge Per Revolution (Pounds)</td>
<td>Discharge Rate (Lbs/Min)</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Calibration**
## Calibration

### Table 8- Discharge and application rates

<table>
<thead>
<tr>
<th>Discharge Rate (pounds/mile)</th>
<th>Application Rate, pounds per lane-mile</th>
<th>Number of lanes being treated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>300</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>600</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>700</td>
<td>700</td>
<td>350</td>
</tr>
<tr>
<td>800</td>
<td>800</td>
<td>400</td>
</tr>
</tbody>
</table>
GROUND SPEED CONTROL
WHY?

• Higher Degree of Application Rate Control

• Cost Payback in LESS THAN ONE YEAR

• Material Savings 20 to 40 PERCENT
Application of Snow and Ice Control Materials
Roadway Elements

- Bridges
- Strong crosswinds
- Curves
- Change in jurisdiction
Worst Case Scenarios
SALT AND THE ENVIRONMENT

- GROUND AND SURFACE WATER
- VEGETATION
- WILDLIFE
- HUMAN HEALTH
STORING AND HANDLING

SALT
Major Points of Good Salt Storage

- Sufficient capacity
- Inside storage, if possible
- Outside piles properly shaped & covered
- Impermeable pads
- Proper drainage with containment as required
- Good housekeeping
Salt

50' diameter

1 inch

100 lbs. of Salt

Sand w/ 10% salt

50' diameter

1 inch

96 lbs. of Salt
Salt Storage
Potential Problems

• Moisture produces surface crust, which form lumps clogging equipment

• Runoff: Surface runoff and infiltration through soil - leachate

• Spillage during stockpiling or spreader loading
Improper storage...

...can only lead to problems!
Solid Material Storage

‘Open’ piles = Problems
Liquid Storage Tanks
Salt Institute’s Salt Storage Handbook

• A Practical Guide for Storing & Handling Deicing Salt
  – Valuable Info
  – Charts
  – Check List
SNOW, ICE AND ABRASIVES

DISPOSAL
SNOW AND ICE

- Local Regulations
- Other Unwanted Contaminants
- Silt Issues
- Trash Issues
- Groundwater issues
- Surface Water Quality Issues
ABRASIVES

- Surface Water Silt Loading Issues
- Other contaminants
- Reprocessing
- Air Quality Issues
Anti-icing

- Anti-icing is a proactive operation: Spreading material before the storm start; prevents snow and ice from bonding to the road and prevents frost versus

- Deicing is a reactive operation: Spreading material after storm starts; allows bonding of snow and ice to road causing use of more salt and more time to break the bond and achieve melting
Anti-icing Strategy

Figure 2  Anti–icing
Deicing Strategy

Figure 3  Deicing
Temporary Friction Improvement

18 cars and the effectiveness of abrasives is gone
Formation of Ice on Highway Bridges and other Cold Spots

- Pavement and Bridge Surface Temperature
- Non-Precipitation Events
- Precipitation Events
  - Snow
  - Freezing Rain
  - Sleet
Chemical and Abrasives Policies

“chemical priority policy”

vs.

“abrasive priority policy”

Having the same level of service goals
Chemical and Abrasives Policies

How much does it cost to treat a lane mile with:

- Abrasives
- Chemicals (salt)
## Salt vs. Sand

### Cost to treat one lane–mile with salt vs. abrasives

<table>
<thead>
<tr>
<th>Salt</th>
<th>Cost Factors</th>
<th>Abrasives</th>
</tr>
</thead>
<tbody>
<tr>
<td>$32.00</td>
<td>A  Purchase Cost/ton, $</td>
<td>$6.51</td>
</tr>
<tr>
<td></td>
<td>B  Cost of added salt/ton (7%)</td>
<td>$2.24</td>
</tr>
<tr>
<td></td>
<td>C  Mixing cost, $</td>
<td>$0.60</td>
</tr>
<tr>
<td>$32.00</td>
<td>D  Total Cost (per ton), $</td>
<td>$9.35</td>
</tr>
<tr>
<td>225</td>
<td>E  Pounds per lane mile</td>
<td>750</td>
</tr>
<tr>
<td><strong>$3.60</strong></td>
<td><strong>Cost / lane mile, $</strong></td>
<td><strong>$3.50</strong></td>
</tr>
</tbody>
</table>
Comparison of Salt vs. Sand

- New York State DOT (Watertown, 1998-99)

<table>
<thead>
<tr>
<th></th>
<th>Salt</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Used, Tons / lane mile</td>
<td>5.2</td>
<td>32.8</td>
</tr>
<tr>
<td>Salt Used, Tons / lane mile</td>
<td>23.7</td>
<td>22.2</td>
</tr>
<tr>
<td>Cost / lane mile @ $8 &amp; $30</td>
<td>$754</td>
<td>$929</td>
</tr>
<tr>
<td>Average Condition Index</td>
<td>3.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Total Materials Tons / lm</td>
<td>28.9</td>
<td>55.0</td>
</tr>
<tr>
<td>Average Traffic, VPH</td>
<td>&gt; 125</td>
<td>&gt; 125</td>
</tr>
</tbody>
</table>
# Comparison of Salt vs. Sand

**✓ Maine DOT**

<table>
<thead>
<tr>
<th></th>
<th>Salt</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sand Used, Tons / lane mile</strong></td>
<td>3.6</td>
<td>62.4</td>
</tr>
<tr>
<td><strong>Salt Used, Tons / lane mile</strong></td>
<td>6.4</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Cost/Im @ $9.60 &amp; $35.00</strong></td>
<td>$258</td>
<td>$771</td>
</tr>
<tr>
<td><strong>Average Condition Index</strong></td>
<td>2.8</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Materials Tons / lm</strong></td>
<td>10</td>
<td>67.3</td>
</tr>
<tr>
<td><strong>Average Traffic, VPH</strong></td>
<td>63</td>
<td>63</td>
</tr>
</tbody>
</table>

(7% Salt in Sand Mix)
Comparison of Salt vs. Sand

✓ New York State -- Warren County

(7% Salt in Sand Mix)

<table>
<thead>
<tr>
<th></th>
<th>Salt</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Used, Tons / lane mile</td>
<td>0.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Salt Used, Tons / lane mile</td>
<td>0.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Cost/Im @ $8 &amp; $30</td>
<td>$28</td>
<td>$86</td>
</tr>
<tr>
<td>Average Condition Index</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Total Materials tons / Im</td>
<td>1.2</td>
<td>4.6</td>
</tr>
<tr>
<td>Average Traffic, VPH</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
Using Chemical/Abrasives Mixtures

• Typical chemical/abrasives mixtures
• Conditions for use
  ✓ Level of service dependent
    ▪ Overall
    ▪ Within-storm
  ✓ Unpaved roads
  ✓ Low pavement temperature conditions
  ✓ Steep grades
Designing Snow and Ice Control Material Treatments
(Appendix V)

Level of service
Weather Conditions
Pavement conditions
Operational Conditions
Trends
Level of Service

DESIRED OR OBSERVED PAVEMENT CONDITIONS AT VARIOUS POINTS IN TIME DURING AND AFTER WINTER WEATHER EVENTS
Sources and Types of Road and Weather Information Available

DEVELOP LIST:
ROAD
WEATHER
Ice Control Treatment

Dilution potential and pavement temperature are key
Dilution Potential

- Weather conditions
- Pavement conditions
- Cycle time
- Traffic
- Trends
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 Condition at Time of Treatment

- Bond to pavement
- Residual snow or ice on pavement
- Pavement temperature
Operational Conditions

- Traffic Volume (± 125 VPH)
- Traffic Speed (± 35 MPH)
- Operational Cycle Time (1.5 and 3.0 HRS.)
# Precipitation Dilution Potential

<table>
<thead>
<tr>
<th>Precipitation type</th>
<th>Light</th>
<th>Moderate</th>
<th>Heavy</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Snow (powder)</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>2. Snow (ordinary)</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>3. Snow (wet/heavy)</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>4. Snow (unknown)</td>
<td>–</td>
<td>Medium</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5. Rain</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>6. Freezing rain</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>7. Sleet</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>8. Blowing snow</td>
<td>–</td>
<td>Medium</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>9. Snow with blowing snow</td>
<td></td>
<td>(Same as type of snow)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Freezing rain with sleet</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>11. None</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If wheel path area condition is:

- Dry or damp
- Wet
- Frost or black ice (thin ice)
- Slush or loose snow
- Packed snow or thick ice

Not applicable Low Medium High

High
Adjustments to Precipitation Dilution Potential

<table>
<thead>
<tr>
<th>Adjustments to Precipitation Dilution Potential</th>
<th>Increase precipitation dilution potential above by number of levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Wheel path area condition when precipitation is present</td>
<td></td>
</tr>
<tr>
<td>Bare</td>
<td>0</td>
</tr>
<tr>
<td>Frost or thin ice</td>
<td>0</td>
</tr>
<tr>
<td>Slush, loose snow, packed snow, or thick ice</td>
<td>1</td>
</tr>
<tr>
<td>b) Cycle time</td>
<td></td>
</tr>
<tr>
<td>0 - 1.5 hrs</td>
<td>0</td>
</tr>
<tr>
<td>1.6 - 3.0 hrs</td>
<td>1</td>
</tr>
<tr>
<td>Over 3.0 hrs</td>
<td>2</td>
</tr>
<tr>
<td>c) Traffic volume at traffic speeds &gt; 35 mph</td>
<td></td>
</tr>
<tr>
<td>Less than 125 vph</td>
<td>0</td>
</tr>
<tr>
<td>More than 125 vph</td>
<td>1</td>
</tr>
</tbody>
</table>
# Application Rates for Solid, Prewetted Solid, and Liquid Sodium Chloride

<table>
<thead>
<tr>
<th>Pavement Temperature (°F)</th>
<th>Adjusted dilution potential</th>
<th>Ice pavement bond</th>
<th>Application rate</th>
<th>Application rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 32</td>
<td>Low</td>
<td>No</td>
<td>90 (3)</td>
<td>40 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>200</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>No</td>
<td>100 (3)</td>
<td>44 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>225</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>No</td>
<td>110 (3)</td>
<td>48 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>250</td>
<td>NR (4)</td>
</tr>
<tr>
<td>30 to 32</td>
<td>Low</td>
<td>No</td>
<td>130</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>275</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>No</td>
<td>150</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>300</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>No</td>
<td>160</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>325</td>
<td>NR (4)</td>
</tr>
<tr>
<td>25 to 30</td>
<td>Low</td>
<td>Yes</td>
<td>350</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>180</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>Yes</td>
<td>375</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>190</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Yes</td>
<td>400</td>
<td>NR (4)</td>
</tr>
<tr>
<td>20 to 25</td>
<td>Low</td>
<td>No</td>
<td>200</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>425</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>No</td>
<td>210</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>450</td>
<td>NR (4)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>No</td>
<td>220</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yes</td>
<td>475</td>
<td>NR</td>
</tr>
</tbody>
</table>
### Application Rates for Solid, Prewetted Solid, and Liquid Sodium Chloride (Cont.)

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 to 20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>No</td>
<td>230</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>500</td>
<td>NR</td>
</tr>
<tr>
<td>Medium</td>
<td>No</td>
<td>240</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>525</td>
<td>NR</td>
</tr>
<tr>
<td>High</td>
<td>No</td>
<td>250</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>550</td>
<td>NR</td>
</tr>
<tr>
<td>10 to 15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>No</td>
<td>260</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>575</td>
<td>NR</td>
</tr>
<tr>
<td>Medium</td>
<td>No</td>
<td>270</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>600</td>
<td>NR</td>
</tr>
<tr>
<td>High</td>
<td>No</td>
<td>280</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>625</td>
<td>NR</td>
</tr>
</tbody>
</table>

Below 10°F

A. If unbonded, try mechanical removal without chemical.
B. If bonded, apply chemical at 700 lb/L-M. Plow when slushy. Repeat as necessary.
C. Apply abrasives as necessary.

NR = Not recommended

### Specific Notes:
1. Values for “solid” also apply to prewet solid and include the equivalent dry chemical weight in prewetting solutions.
2. Liquid values are shown for the 23-percent concentration solution.
3. In unbonded, try mechanical removal without applying chemicals. If pretreating, use this application rate.
4. If very thin ice, liquids may be applied at the unbonded rates.
5. These application rates are starting points. Local experience should refine these recommendations.
6. Prewetting chemicals should allow application rates to be reduced by up to about 20% depending on such primary factors as spread pattern and spreading speed.
7. Application rates for chemicals other than sodium chloride will need to be adjusted using the guidance in Table 5.
8. Before applying any ice control chemical, the surface should be cleared of as much snow and ice as possible.
STEP BY STEP

- Determine Precipitation Dilution Potential
- Adjust for Operational and Pavement Conditions (Adjusted Dilution Potential)
- Determine Pavement Temperature
- Determine Ice/Pavement Bond
- Select application rate
IF YOU USE THE “PROPER” AMOUNT OF ICE CONTROL CHEMICAL EACH TIME, RATHER THAN A PRESCRIBED AMOUNT, YOU WILL USE LESS CHEMICAL OVERALL AND PROVIDE A CONSISTANTLY HIGH LEVEL OF SERVICE
QUESTIONS
Thank you for your participation!